Test Report

HELEM2402000055-1

FINAS Finnish Accreditation Service T004 (EN ISO/IEC 17025)

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 F REQUIREMENTS

Equipment Under Test:	Master Base Station of Indoor Positioning System
Trademark:	Iiwari
Model:	Master Base Station
Customer / Manufacturer:	Iiwari Tracking Solutions Oy Kidekuja 2 FI-88610 Vuokatti Finland
FCC Rule Part:	§15.517
KDB:	393764 D01 UWB FAQ v02r01

Date:	2 September 2024	Date:	2 September 2024
Issued by:		Checked by:	
	Henri Mäki Testing Engineer		Rauno Repo Senior EMC Specialist

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GENERAL REMARKS

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 30 days only.

RELEASE HISTORY

Version	Changes	Issued
1.0	Initial release	2 September 2024

PRODUCT DESCIPTION

Equipment Under Test

Trademark:	Iiwari
Model:	Master Base Station
Type:	-
Serial no:	ID: CD68-0249-0453-9C13
FCC ID:	2BFQ6MBS101
Radio module or chip:	Decawave DW1000

General Description

The equipment under test is a master base station for indoor positioning system. The positioning system is built by attaching the base stations to the ceiling or the walls. Tracked objects have a tracking tag that communicates with base stations using ultra-wideband signals.

Classification

Fixed device	☒
Mobile Device (Human body distance > 20 cm)	☐
Portable Device (Human body distance < 20 cm)	☐

Samples and Modifications

No.	Name	Description
1	Sample 1	Normal sample operated with a test software

Ratings and declarations

Nominal center frequency:	3993.6 MHz (UWB channel 2)
UWB bandwidth:	541.5 MHz (measured)
UWB device type:	Indoor UWB device
Antenna type:	Integral
Antenna gain:	+2.0 dBi
EUT dimensions:	52 x 140 x 140 mm, 0.2 kg
Power requirements:	12 - 48 VDC, 1 W, powered with AC/DC adapter or PoE
Operating temperature range:	-40…+60 °C

Ports and Cables

Cable / Port	Description
DC input	Connected to peripheral AC/DC adapter during testing

Peripherals

Peripheral	Description / Usage
AC/DC adapter	Ktec KSA-12W-120100VE, powering the EUT during testing

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§15.203	Antenna Requirement	**PASS**
§15.207(a)	AC Power-Line Conducted Emissions	**PASS**
§15.517(e), §15.521(g)	Peak Power Within a 50 MHz Bandwidth	**PASS**
§15.517(b)	10 dB Bandwidth	**PASS**
§15.517(c), §15.521(c)-(d)	Radiated Emissions 9 kHz – 960 MHz	**PASS**
§15.517(c)-(d), §15.521(c)-(d)	Radiated Emissions 960 MHz – 40 GHz	**PASS**

The decision rule applied for the tests results stated in this test report is according to the requirements of section 1.4 of ANSI C63.10-2020.

EUT Test Conditions during Testing

During the tests the configuration of the EUT was made to correspond to the actual assembling conditions as far as possible. During the tests EUT was set into continuous transmit mode by using a test software. Normal modulation and maximum transmit power was used during the tests.

All tests were performed as radiated measurements. Preliminary measurements were made in three orthogonal orientations to determine the worst-case orientation. Final measurements were performed in the worst-case orientation.

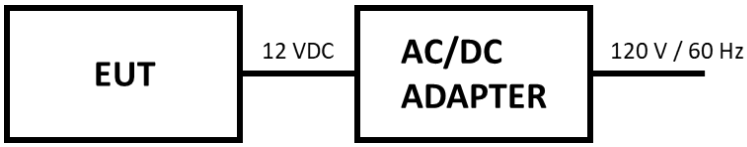

Figure 1: Test setup block diagram

Table 1: Test frequencies

UWB channel	Frequency [MHz]
2	3993.6

Test Facility

Testing Laboratory / address: FCC designation number: **FI0002** ISED CAB identifier: **T004**	SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND
Test Site:	☐ K10LAB, ISED Canada registration number: **8708A-1** ☒ K5LAB, ISED Canada registration number: **8708A-2** ☐ T10LAB

TEST RESULTS

Antenna Requirement

Standard: FCC Rule §15.203
Tested by: HEM
Date: 22 July 2024

FCC Rule: §15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

Specification	Requirement (at least one of the following shall be applied)	Conclusion
§15.203	1. Permanently attached antenna 2. Unique coupling to the intentional radiator 3. Professionally installed radio. The installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.	**PASS**
Note	Option 1 is used	

AC Power-Line Conducted Emissions

Standard:	ANSI C63.10-2020
Tested by:	HEM
Date:	25 July 2024
Temperature:	20 °C
Humidity:	64 %RH
Barometric pressure:	1011 hPa
Measurement uncertainty:	± 2.9 dB, level of confidence 95 % (k = 2)

FCC Rule: §15.207(a)

An 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 frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in §15.207(a), as measured using a 50 µH/50 ohms line impedance stabilization network (LISN).

For equipment that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the equipment.

Conducted disturbance voltage was measured with an artificial mains network from 150 kHz to 30 MHz with 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors.

Frequency of emission (MHz)	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.

Test Results

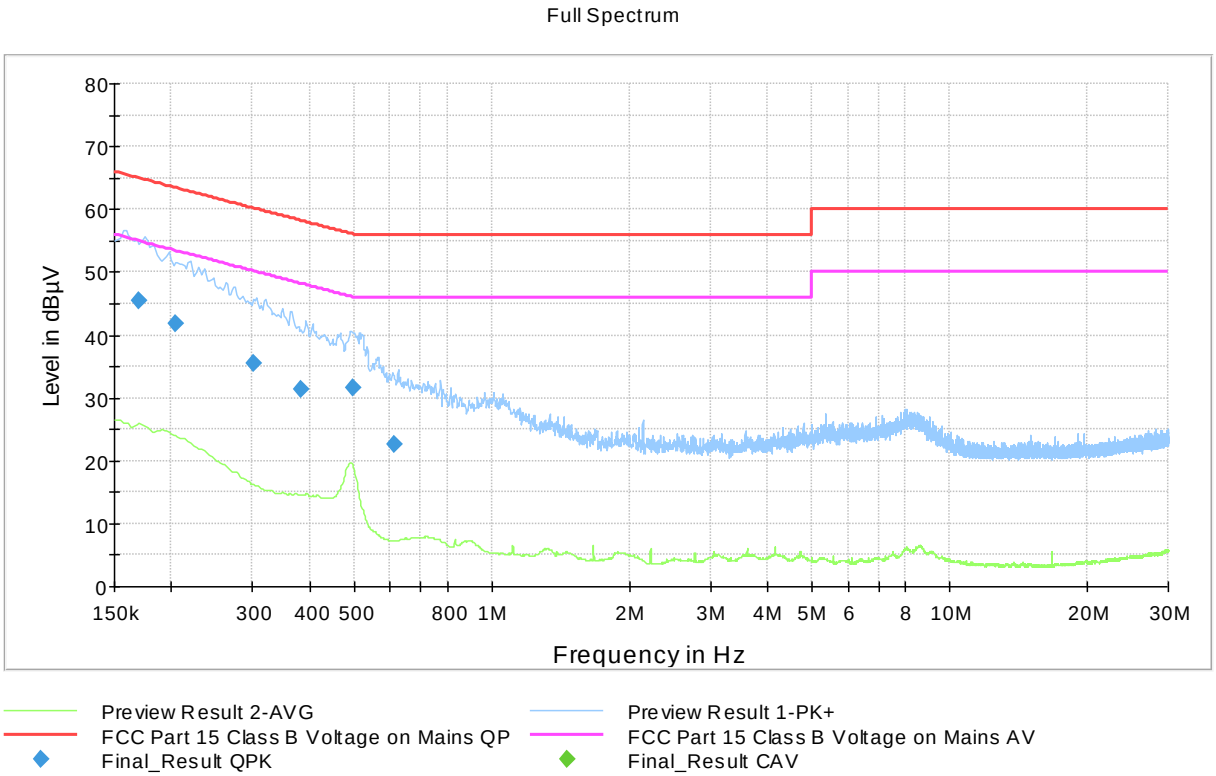

Figure 2: AC Power-Line Conducted Emissions

Table 2: Test results for AC Power-Line Conducted Emissions

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.170000	45.43	---	64.96	19.53	15 x 1000.0	9.000	N	9.7
0.204000	41.81	---	63.45	21.64	15 x 1000.0	9.000	L1	9.7
0.302000	35.41	---	60.19	24.78	15 x 1000.0	9.000	N	9.7
0.384000	31.25	---	58.19	26.94	15 x 1000.0	9.000	L1	9.7
0.498000	31.57	---	56.03	24.46	15 x 1000.0	9.000	N	9.7
0.612000	22.58	---	56.00	33.42	15 x 1000.0	9.000	N	9.7

The correction factor in the final result table contains the sum of the transducers (LISN + transient limiter + cables). The reported values include the correction factor.

Peak Power Within a 50 MHz Bandwidth

Standard:	ANSI C63.10-2020
Tested by:	HEM
Date:	22 July 2024
Temperature:	20 °C
Humidity:	61 %RH
Barometric pressure:	1014 hPa
Measurement uncertainty:	± 5.44 dB, level of confidence 95 % (k = 2)

FCC Rule: §15.517(e), §15.521(g)

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, f_M. That limit is 0 dBm EIRP. This may be converted to a peak field strength level at 3 meters using E(dBµV/m) = P(dBm EIRP) + 95.2.

Test results:

Table 3: Peak power within 50 MHz bandwidth

Frequency [MHz]	Height [cm]	Polarization	Azimuth [deg]	Level [dBµV/m]	Level [dBm]	Result
3998.000	200	H	300	94.22	-0.98	PASS

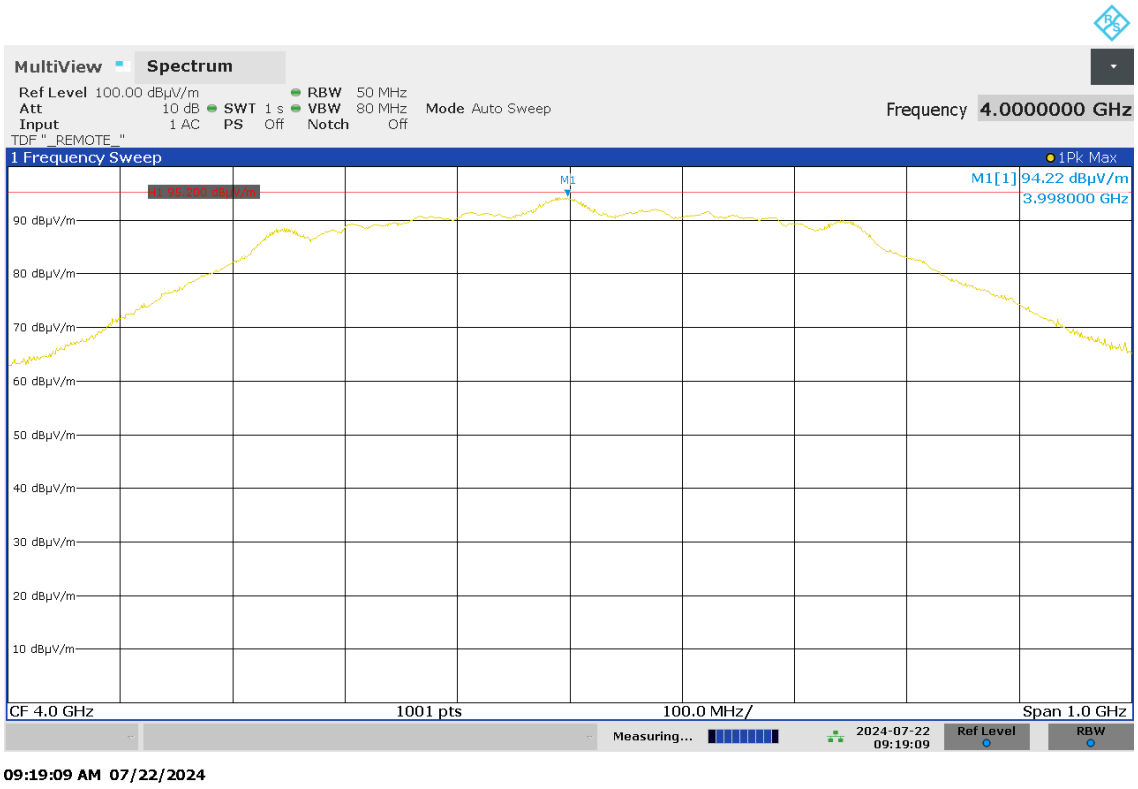

Figure 3: Peak Power Within a 50 MHz Bandwidth

10 dB Bandwidth

Standard:	ANSI C63.10-2020
Tested by:	HEM
Date:	22 July 2024
Temperature:	20 °C
Humidity:	61 %RH
Barometric pressure:	1014 hPa

FCC Rule: §15.517(b)

UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated f_H and the lower boundary is designated f_L. The frequency at which the highest radiated emission occurs is designated f_M. The UWB bandwidth must be contained between 3100 MHz and 10600 MHz.

A UWB transmitter is 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.

Test results:

Table 4: Test results for 10 dB Bandwidth

f_L [MHz]	f_H [MHz]	f_M [MHz]	f_C [MHz]	B_{-10} [MHz]	μ_{-10}	Result
3733.3	4274.7	4148.9	4004.0	541.5	0.135	PASS

$$f_C = (f_H + f_L)/2, \quad B_{-10} = f_H - f_L, \quad \mu_{-10} = B_{-10}/f_C$$

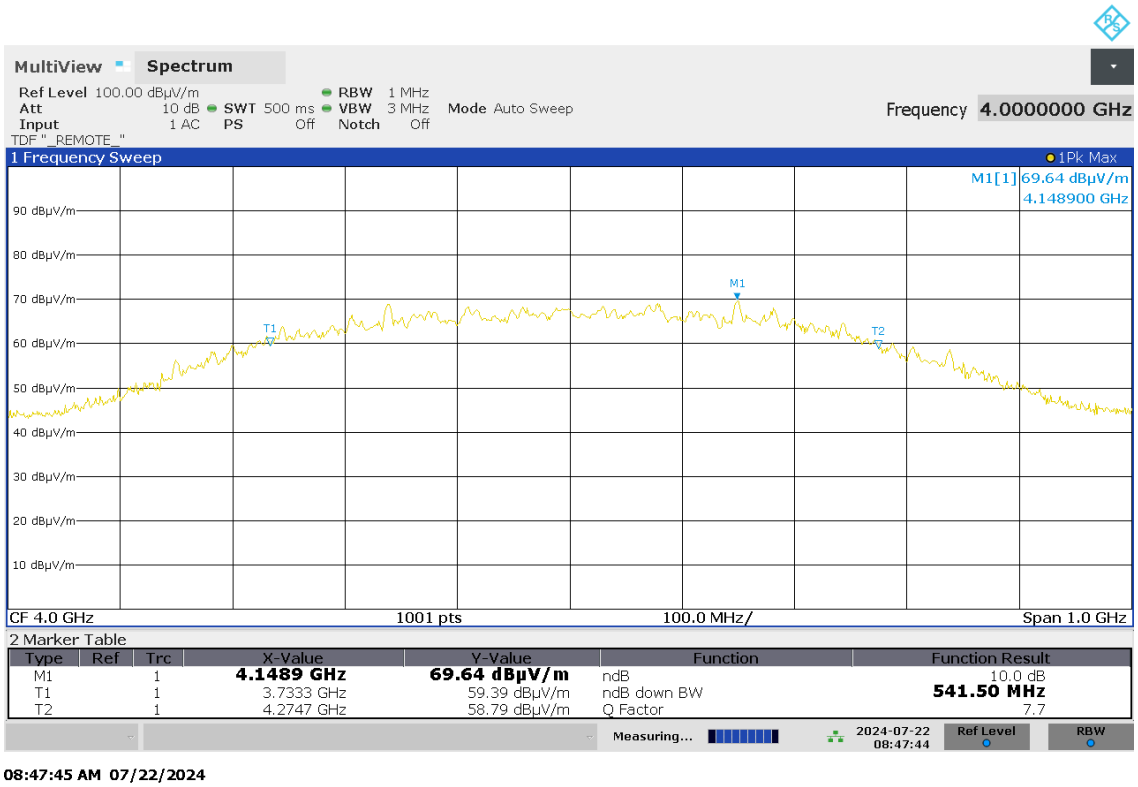

Figure 4: 10 dB Bandwidth

Radiated Emissions 9 kHz – 960 MHz

Standard:	ANSI C63.10-2020
Tested by:	HEM
Date:	24 July 2024
Temperature:	20 °C
Humidity:	64 %RH
Barometric pressure:	1013 hPa
Measurement uncertainty:	± 4.5 dB, level of confidence 95 % (k = 2)

FCC Rule: §15.517(c), §15.521(d)

The radiated emissions at or below 960 MHz from an indoor UWB system shall not exceed the emission levels in §15.209:

Frequency [MHz]	Field strength [µV/m]	Field strength [dBµV/m]	Measurement distance [m]
0.009-0.490	2400/F(kHz)	48.52-13.80	300
0.490-1.705	24000/F(kHz)	33.80-22.97	30
1.705-30	30	29.54	30
30-88	100	40.00	3
88-216	150	43.52	3
216-960	200	46.02	3

The measurements are performed at a distance of 3 meters. The results below 30 MHz are extrapolated to the specified distance by using the square of an inverse linear distance extrapolation factor (40 dB/decade).

Test results

Table 5: Test results for Radiated emissions 9 kHz – 960 MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
37.685000	**23.08**	**40.00**	**16.92**	**15 x 1000.0**	**120.000**	**100.0**	**V**	**317.0**	**16.7**
50.005000	**33.17**	**40.00**	**6.83**	**15 x 1000.0**	**120.000**	**100.0**	**V**	**300.0**	**17.8**
55.975000	**20.81**	**40.00**	**19.19**	**15 x 1000.0**	**120.000**	**105.0**	**V**	**180.0**	**17.8**
76.365000	**23.01**	**40.00**	**16.99**	**15 x 1000.0**	**120.000**	**100.0**	**V**	**2.0**	**14.4**
89.635000	**25.49**	**43.52**	**18.03**	**15 x 1000.0**	**120.000**	**100.0**	**V**	**214.0**	**12.3**
149.995000	**29.56**	**43.52**	**13.96**	**15 x 1000.0**	**120.000**	**100.0**	**V**	**141.0**	**18.7**

Note: The correction factor (dB/m) in the result table contains the sum of the transducers. The reported quasi-peak values include the correction factor.

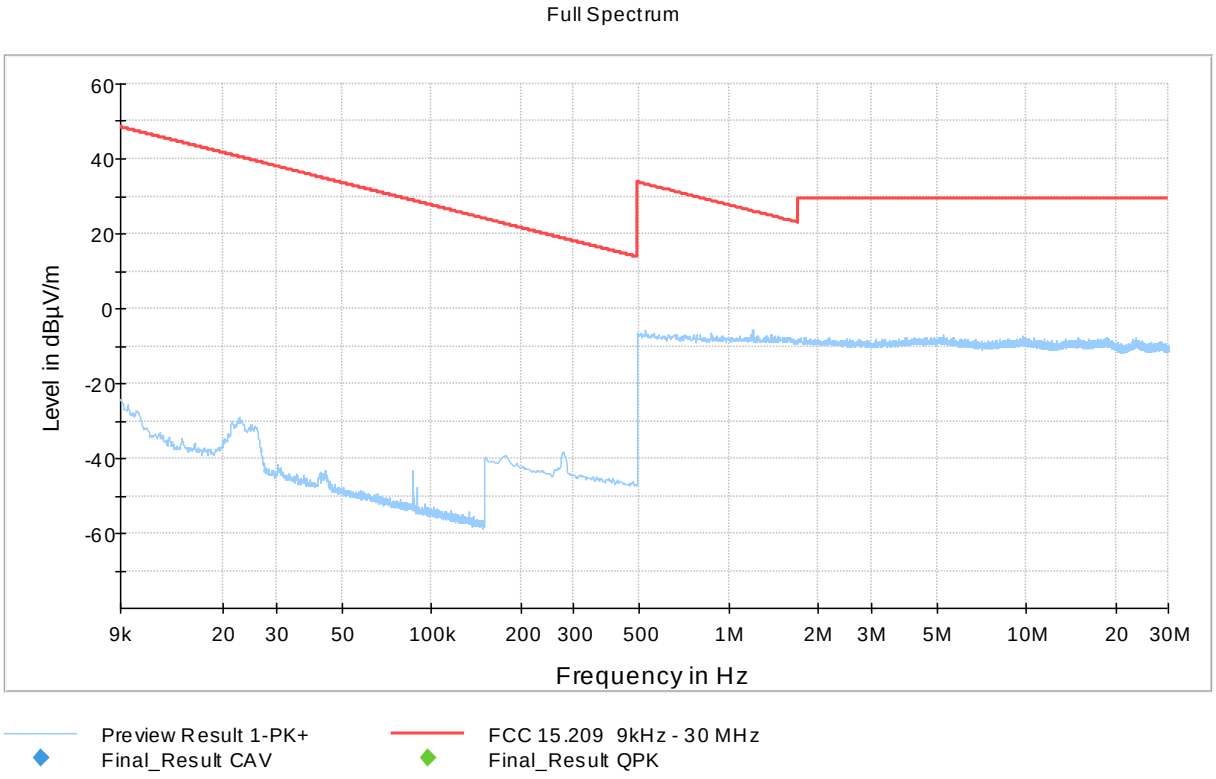

Figure 5: Radiated emissions 9 kHz – 30 MHz

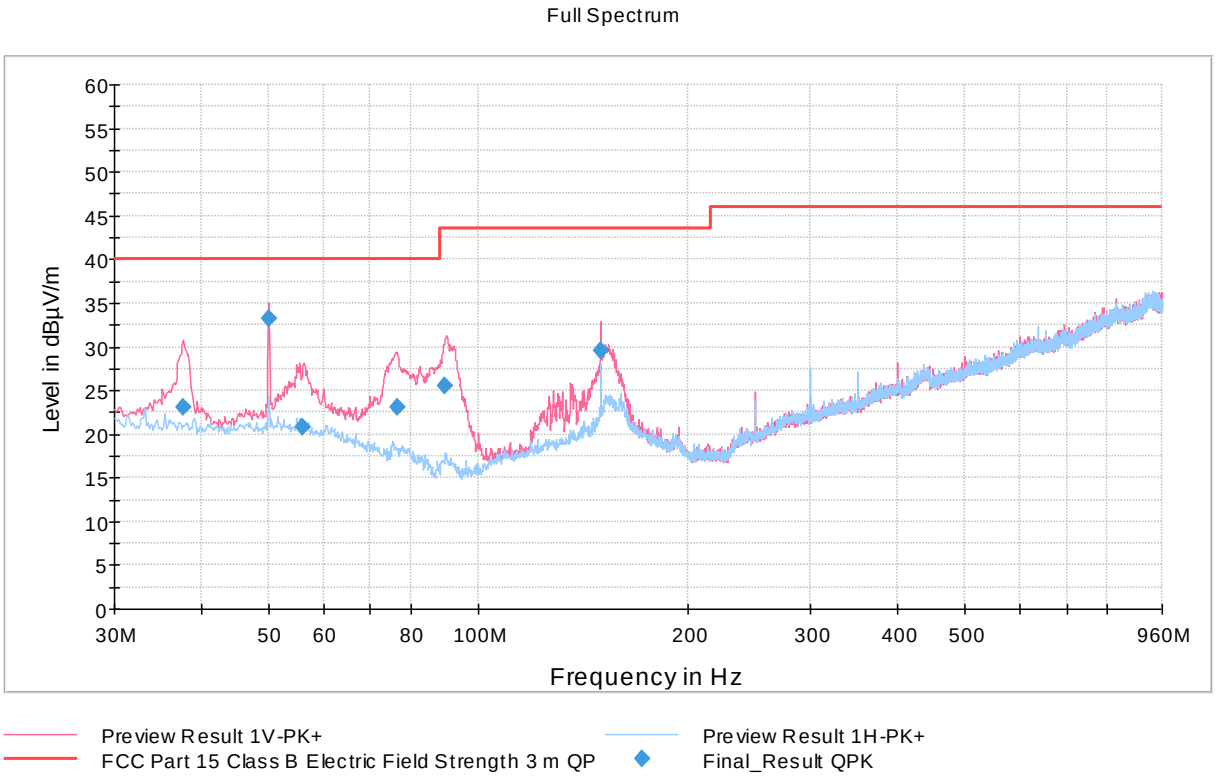

Figure 6: Radiated emissions 30 – 960 MHz

Radiated Emissions 960 MHz – 40 GHz

Standard:	ANSI C63.10-2020	
Tested by:	HEM	HEM
Date:	23 July 2024	24 July 2024
Temperature:	20 °C	20 °C
Humidity:	61 %RH	64 %RH
Barometric pressure:	1014 hPa	1013 hPa
Measurement uncertainty:	± 5.44 dB, level of confidence 95 % (k = 2)	

FCC Rule: §15.517(c)-(d), §15.521(c)-(d)

The radiated emissions above 960 MHz from an indoor UWB system shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency [MHz]	EIRP [dBm]	Field strength at 3 m [dBµV/m]	Field strength at 1 m [dBµV/m]	Field strength at 0.5 m [dBµV/m]
960-1610	-75.30	19.90	29.44	35.46
1610-1990	-53.30	41.90	51.44	57.46
1990-3100	-51.30	43.90	53.44	59.46
3100-10600	-41.30	53.90	63.44	69.46
Above 10600	-51.30	43.90	53.44	59.46

In addition, UWB transmitters shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency [MHz]	EIRP [dBm]	Field strength at 3 m [dBµV/m]
1164-1240	-85.30	9.90
1559-1610	-85.30	9.90

In the tables above the EIRP limit is converted to a field strength limit at 3 meters using the following formula:

$$E[\mathrm{dB\mu V/m}]_{3\ \mathrm{m}} = P[\mathrm{dBm\ EIRP}] + 95.2$$

The field strength limit at 3 meters is converted to other distances using the following formula:

$$E[\mathrm{dB\mu V/m}]_{x\ \mathrm{m}} = E[\mathrm{dB\mu V/m}]_{3\ \mathrm{m}} + 20\log(3/x)$$

The measurements were performed at following distances:

Frequency	Meas. distance [m]
960 – 1000 MHz	1
1000 – 1610 MHz	0.5
1610 – 3500 MHz	3
4.5 – 10.6 GHz	3
10.6 – 18 GHz	0.5
18 – 26.5 GHz	0.5
26.5 – 40 GHz	0.5
1164 – 1240 MHz (GPS band)	3
1559 – 1610 MHz (GPS band)	3

Test results

Table 6: Test results for radiated emissions within 960 MHz – 40 GHz (measured field strength)

Frequency (MHz)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
972.638000	23.21	29.44	6.23	15 x 1000.0	1000.000	400.0	H	116.0	6.1
1000.000000	26.84	35.46	8.62	15 x 1000.0	1000.000	132.0	V	150.0	0.1
1099.979000	24.01	35.46	11.45	15 x 1000.0	1000.000	132.0	V	172.0	-0.6
1200.188500	25.99	35.46	9.47	15 x 1000.0	1000.000	152.0	V	66.0	0.5
1882.718500	26.56	41.90	15.34	15 x 1000.0	1000.000	331.0	V	248.0	3.7
4760.175000	31.21	53.90	22.69	15 x 1000.0	1000.000	188.0	H	294.0	8.6
5924.805000	32.26	53.90	21.64	15 x 1000.0	1000.000	208.0	H	265.0	10.5
7987.265000	39.13	53.90	14.77	15 x 1000.0	1000.000	210.0	H	314.0	13.0
9375.855000	36.03	53.90	17.87	15 x 1000.0	1000.000	371.0	H	216.0	16.0
17990.640000	47.39	59.46	12.07	15 x 1000.0	1000.000	105.0	V	108.0	28.6
25961.950000	41.10	59.46	18.36	15 x 1000.0	1000.000	205.0	H	163.0	10.8
38720.755288	48.98	59.46	10.48	15 x 1000.0	1000.000	150.0	V	68.0	-0.3

Table 7: Test results for radiated emissions within 960 MHz – 40 GHz (conversion to EIRP)

Frequency (MHz)	RMS (dBµV/m)	Limit (dBµV/m)	Meas. Dist. (m)	RMS (dBm)	Limit (dBm)	Margin (dB)
972.638000	23.21	29.44	1	-81.53	-75.30	6.23
1000.000000	26.84	35.46	0.5	-83.92	-75.30	8.62
1099.979000	24.01	35.46	0.5	-86.75	-75.30	11.45
1200.188500	25.99	35.46	0.5	-84.77	-75.30	9.47
1882.718500	26.56	41.90	3	-68.64	-53.30	15.34
4760.175000	31.21	53.90	3	-63.99	-41.30	22.69
5924.805000	32.26	53.90	3	-62.94	-41.30	21.64
7987.265000	39.13	53.90	3	-56.07	-41.30	14.77
9375.855000	36.03	53.90	3	-59.17	-41.30	17.87
17990.640000	47.39	59.46	0.5	-63.37	-51.30	12.07
25961.950000	41.10	59.46	0.5	-69.66	-51.30	18.36
38720.755288	48.98	59.46	0.5	-61.78	-51.30	10.48

Table 8: Test results for radiated emissions within GPS bands (measured field strength)

Frequency (MHz)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1200.013400	2.95	9.90	6.95	15 x 1000.0	1.000	127.0	V	155.0	0.5

Table 9: Test results for radiated emissions within GPS bands (conversion to EIRP)

Frequency (MHz)	RMS (dBµV/m)	Limit (dBµV/m)	Meas. Dist. (m)	RMS (dBm)	Limit (dBm)	Margin (dB)
1200.013400	2.95	9.90	3	-92.25	-85.30	6.95

Note: The correction factor (dB/m) in the result table contains the sum of the transducers. The reported RMS values include the correction factor.

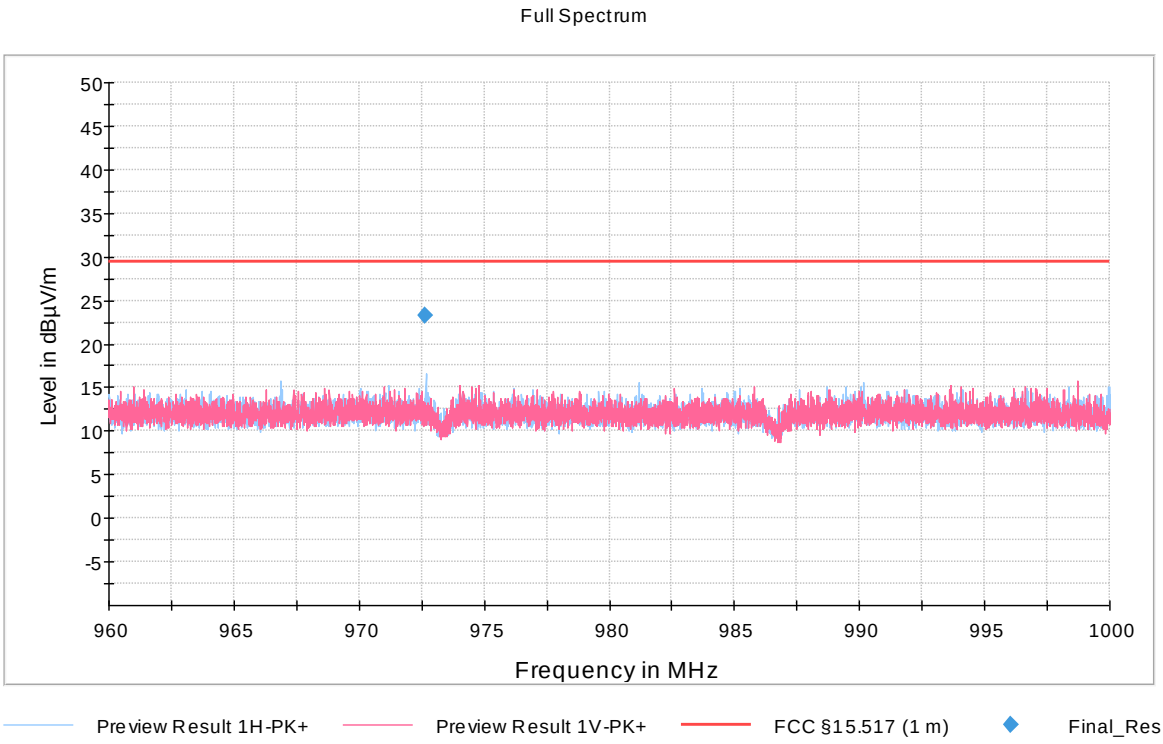

Figure 7: Radiated emissions 960 – 1000 MHz

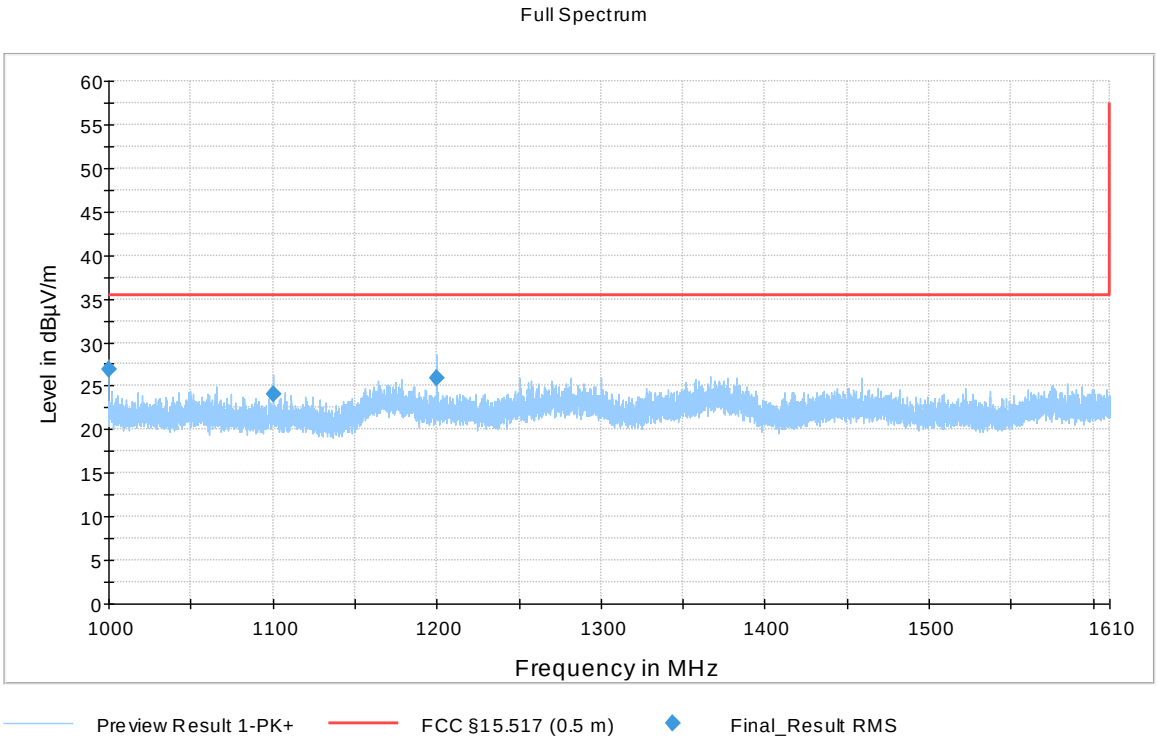

Figure 8: Radiated emissions 1000 – 1610 MHz

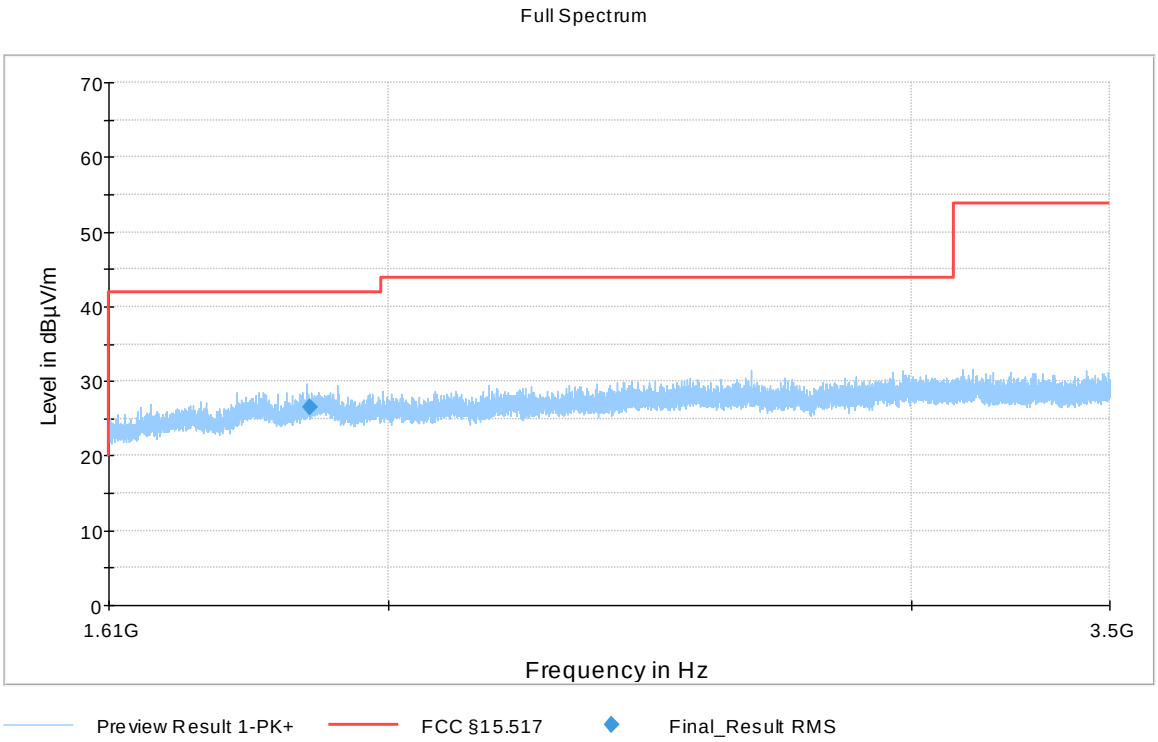

Figure 9: Radiated emissions 1610 – 3500 MHz

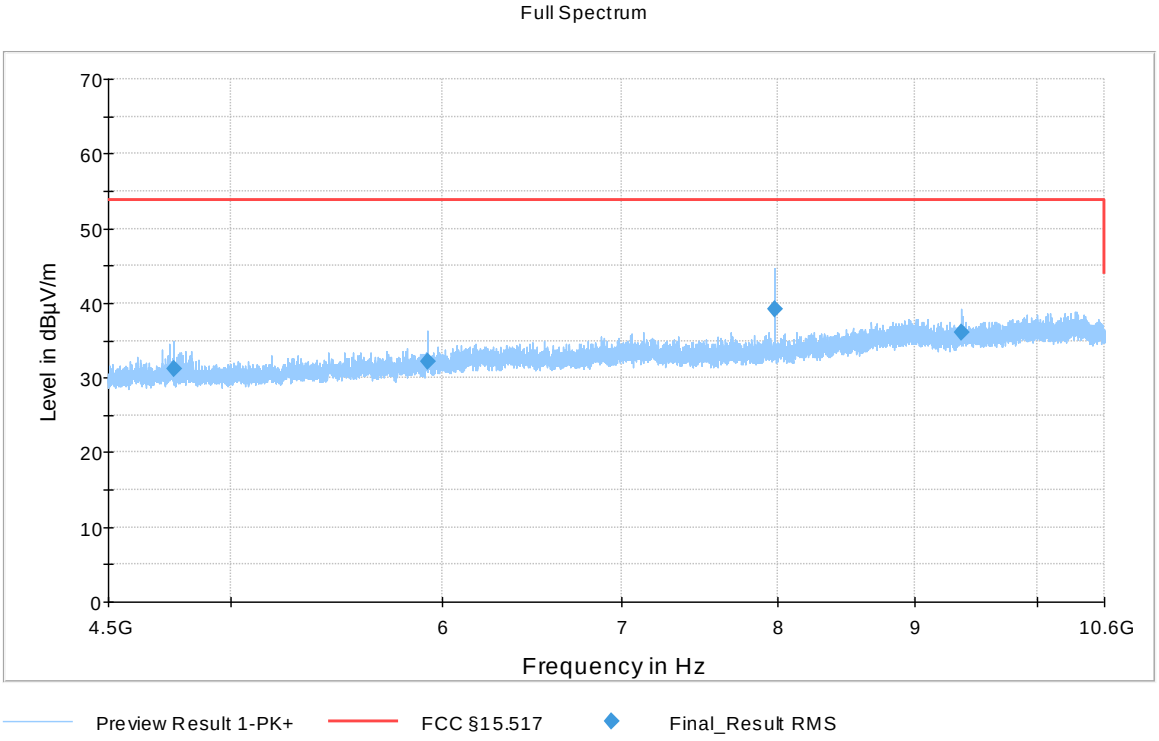

Figure 10: Radiated emissions 4.5 – 10.6 GHz

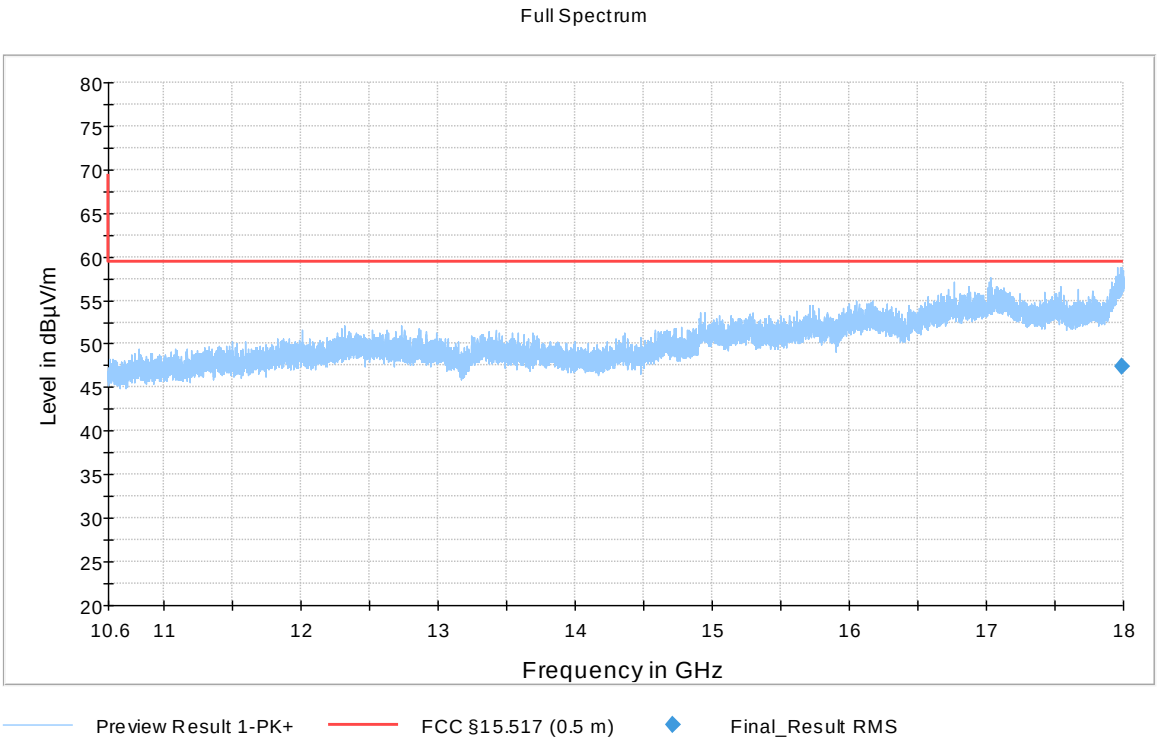

Figure 11: Radiated emissions 10.6 – 18 GHz

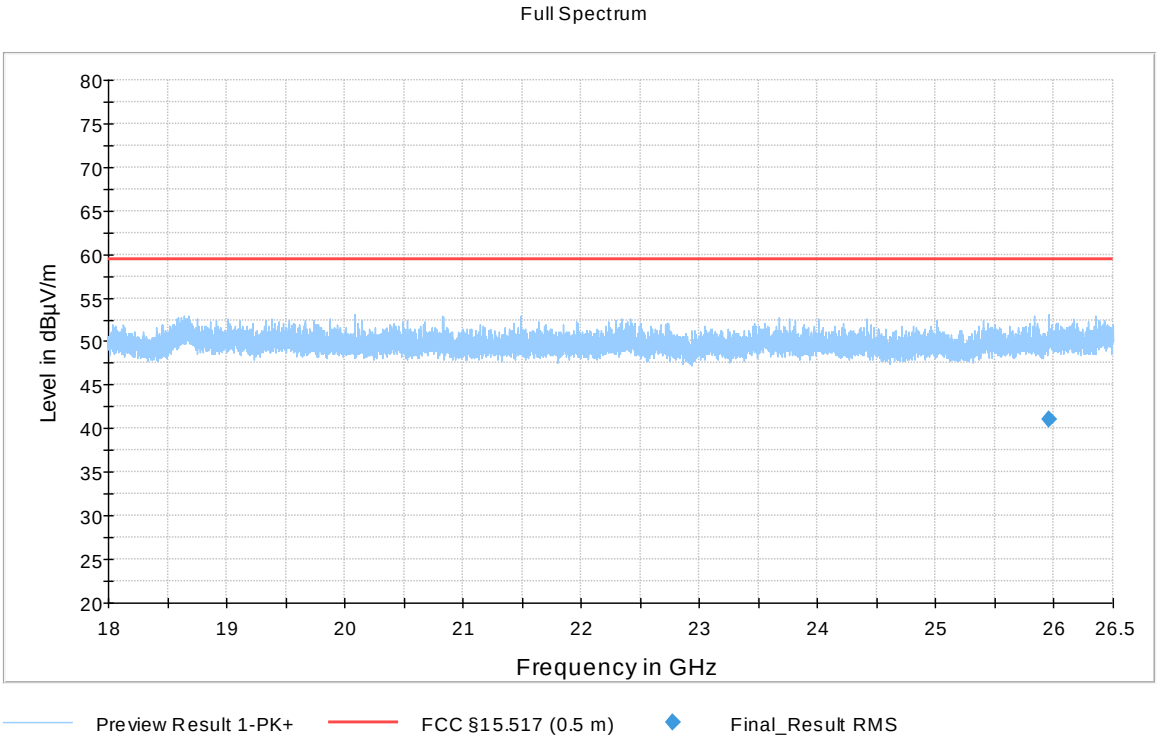

Figure 12: Radiated emissions 18 – 26.5 GHz

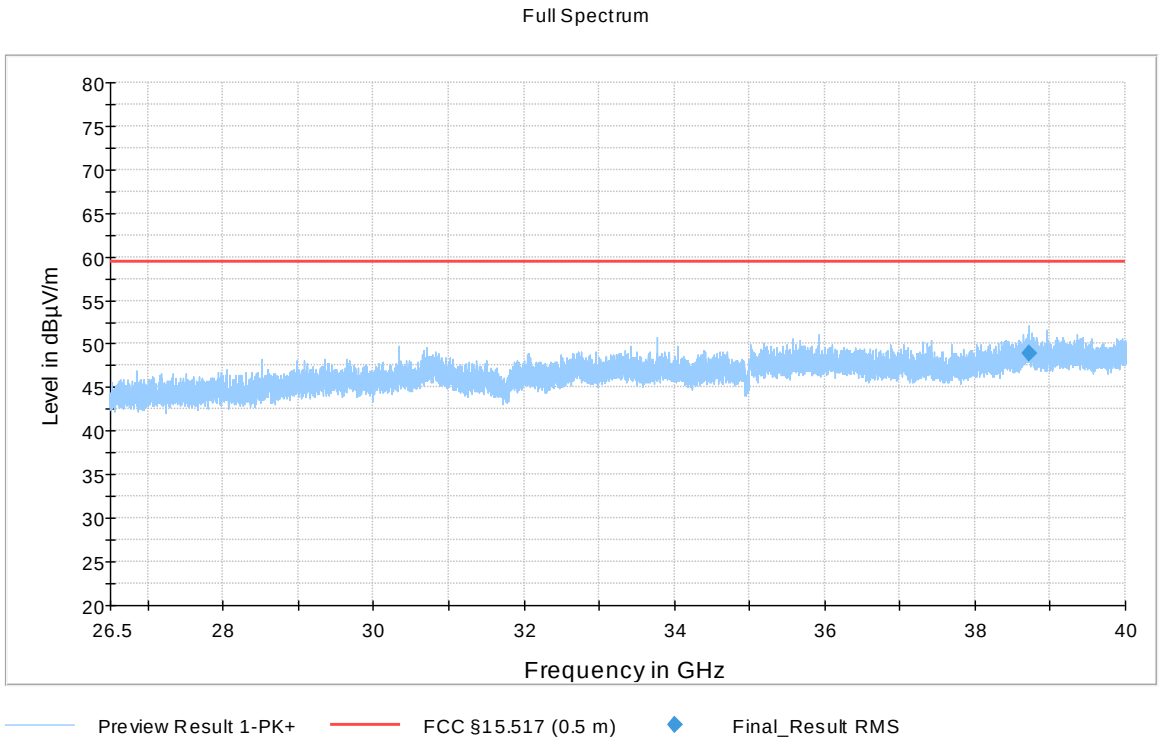

Figure 13: Radiated emissions 26.5 – 40 GHz

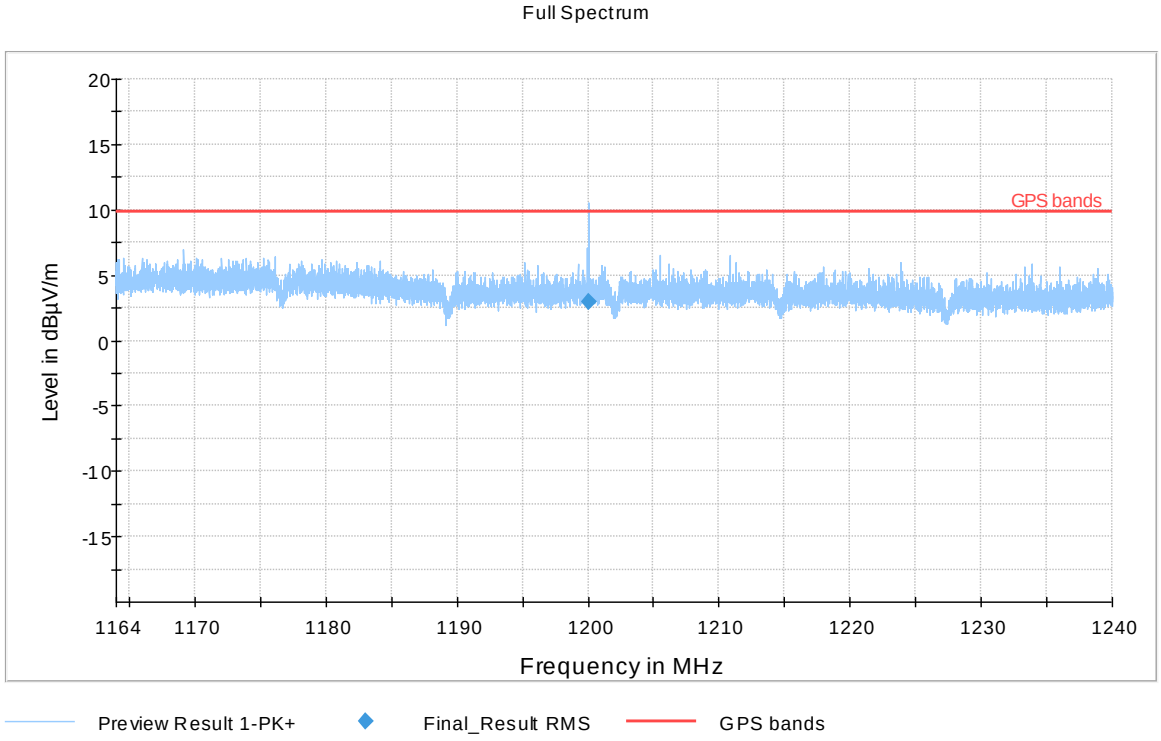

Figure 14: Radiated emissions 1164 – 1240 MHz (1 kHz RBW)

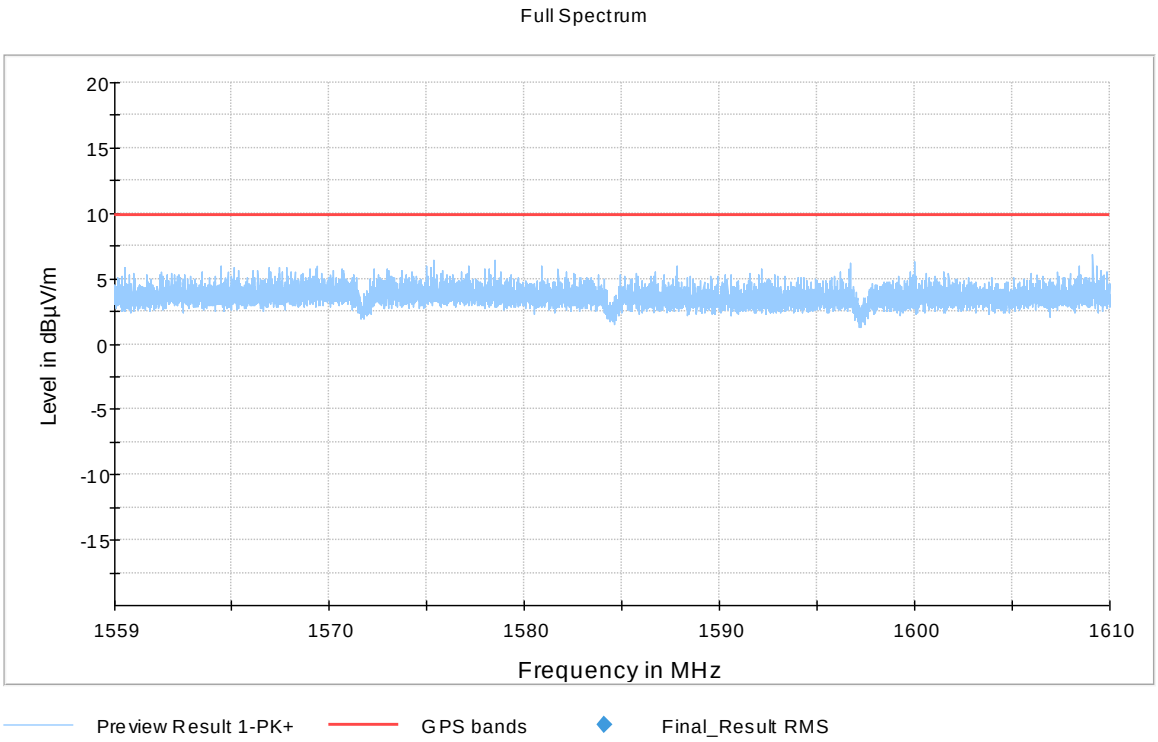

Figure 15: Radiated emissions 1559 – 1610 MHz (1 kHz RBW)

TEST EQUIPMENT

AC Power-Line Conducted Emissions

Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
COAX CHAIN K5 EMI CE 9kHz-30MHz	-	C054+FP1SF+C153	-	2024-03-28	2025-03-28
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv. 10679	2024-06-12	2025-06-11
LISN	ROHDE & SCHWARZ	ENV216	inv. 9611	2024-02-05	2025-02-05
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv. 7826	NCR	NCR
TEMPERATURE/HUMIDITY SENSOR	EDS	OW-ENV-TH, K5 SAC	inv. 10517	2023-10-30	2024-10-30
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-

Radiated Emissions

Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
ANTENNA	ROHDE & SCHWARZ	HFH2-Z2 , 335.4711.52	inv. 8013	2022-10-25	2024-10-25
ANTENNA	SCHWARZBECK	VULB 9168	inv. 8911	2022-11-29	2024-11-29
ANTENNA	EMCO	3160-09, emi 18-26.5GHz	inv. 7294	2024-01-31	2025-01-31
ANTENNA	ETS LINDGREN	3117	inv. 9569	2023-05-05	2025-05-05
ANTENNA	ETS LINDGREN	3160-10, emi 26.5-40GHz	inv. 9151	2024-05-31	2025-05-31
ANTENNA MAST	MATURO	TAM 4.0E	inv. 10181	NCR	NCR
ATTENUATOR	PASTERNACK	PE 7004-4 (4dB)	inv. 10126	2024-02-16	2025-02-16
CABLE	SUHNER	SUCOFLEX 102 (1m) 26.5-40GHz	inv. C113	2024-04-05	2025-04-05
CABLE	SUHNER	SUCOFLEX 126E 18-26.5GHz	inv. C134	2024-04-05	2025-04-05
CABLE	SUHNER	SUCOFLEX 126E 1-18GHz	inv. C137	2024-04-05	2025-04-05
CABLE	SUHNER	SUCOFLEX 102 (2m) 26.5-40GHz	inv. C114	2024-04-05	2025-05-05
COAX CHAIN K5 EMI < 1GHz	-	C053+FP3AirC+C138	-	2024-03-28	2025-03-28
COAX CHAIN K5 EMI 1GHz-26.5GHz	-	C135+C149	-	2024-03-28	2025-03-28
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv. 10679	2024-06-12	2025-06-11
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv. 10183	NCR	NCR
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv. 7826	NCR	NCR
RF PREAMPLIFIER	CIAO	CA1840-5019	inv. 10593	2023-09-15	2024-09-15
RF PREAMPLIFIER	CIAO	CA118-3123	inv. 10278	2023-09-15	2024-09-15
RF PREAMPLIFIER	SGS FIMKO	Module: ZFL-1000LN (20 dB)	inv. 8364	2024-02-07	2025-02-07
SPECTRUM ANALYZER	ROHDE & SCHWARZ	FSV40	inv. 9093	2024-06-13	2025-06-12
TEMPERATURE/ HUMIDITY SENSOR	EDS	OW-ENV-TH, K5 SAC	inv. 10517	2023-10-30	2024-10-30
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
TURNTABLE	MATURO	DS430 UPGRADED	inv. 10182	NCR	NCR

NCR = No Calibration Required

END OF REPORT