Partial Test Report

Test report no.: 22057367-27889-0
Date of issue: 2022-09-23

Test result: The test item **- passed - and complies** with below listed standards.

Applicant
Leica Geosystems AG

Manufacturer
Leica Geosystems AG

Test Item
60 GHz Radar Module / BLK2FLY

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices, Subpart C -
§15.255 Operation within the bands 57-71GHz

WAIVER

Tested by (name, function, signature)	*Sebastian Janoschka* *Lab Manager RF*	signature
Approved by (name, function, signature)	*Andreas Bender* *Deputy Managing Director*	signature

Applicant and Test item details	
Applicant	Leica Geosystems AG Heinrich-Wild-Strasse 9435, Heerbrugg, Switzerland Fon: +41 71 245 33 80 Fax: +41 71 245 33 81
Manufacturer	Leica Geosystems AG Heinrich-Wild-Strasse 9435, Heerbrugg, Switzerland
Test item description	60 GHz radar modules for object detection and collision avoidance for a drone
Model/Type reference	60 GHz Radar Module / BLK2FLY
FCC ID	RFD-BLK2FLY
Frequency	60 GHz to 64 GHz
Antenna	serial fed patch antenna
Power supply	14.0 to 17.0 V DC (nominal: 15.0 V DC)
Temperature range	-20 °C to +50 °C

Disclaimer and Notes

The content of this rest report relates to the mentioned test sample(s) only.
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The last valid version is available at TAMSys®.

Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

IBL-Lab GmbH does not take test samples. The samples used for testing are provided by the applicant.

Decision rule:
Decision rule based on simple acceptance without guard bands, binary statement, based on mutually agreed uncertainty tolerances with expansion factor k=2 according to ILAC-G8:09/2019

1 TABLE OF CONTENTS

2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de
Accreditation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Electronics D-PL-21375-01-01 • Electromagnetic Compatibility D-PL-21375-01-02 • Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-03 Testing Laboratory Designation Number DE0024 • Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-04 ISED Company Number 27156 Testing Laboratory CAB Identifier DE0020 • Telecommunication (TC) D-PL-21375-01-05 Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2022-08-25
Start – End of tests	2022-08-25 – 2022-09-02

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision History

-0 Initial Version

2.6 Further documents

List of further applicable documents belonging to the present test report:
– no additional documents –

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75% r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V AC ± 5%

3.2 Normal and extreme test conditions

	minimum	nominal	maximum
Temperature	-20 °C	20 °C	+50 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	14.0 V DC	15.0 V DC	17.0 V DC

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	**Description**
FCC 47 CFR Part 15	Radio Frequency Devices, Subpart C - §15.255 Operation within the bands 57-71GHz

Reference	**Description**
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Request for Waiver (2019-06-28)	Request for Waiver: Leica Geosystems AG requests a waiver of Section 15.255(b) of the Commission's rules to permit the marketing of a 60-64 GHz radar device that will be integrated in commercial Unmanned Aerial Vehicles (UAVs) used for visual capture of the outsides of structures. The radar will help to avoid collisions with stationary obstacles.

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

60 GHz radar modules for object detection and collision avoidance for a drone

5.2 Description of test item

Model name*	60 GHz Radar Module / BLK2FLY
Serial number*	3000349
PCB identifier*	N/A
Hardware status*	TBD
Software status*	TBD

*: as declared by applicant

5.3 Technical data of test item

Operational frequency band*	60 GHz to 64 GHz
Type of radio transmission*	modulated carrier
Modulation type*	FMCW
Number of channels*	1
Channel bandwidth*	<4 GHz
Channel spacing*	N/A
Receiver category*	N/A
Receiver bandwidth*	N/A
Duty cycle*	~15%
Antenna*	serial fed patch antenna
Rated RF output power*	<20 dBm
Power supply*	14.0 to 17.0 V DC (nominal: 15.0 V DC)
Temperature range*	-20 °C to +50 °C

*: as declared by applicant

5.4 Additional information

Model differences	none
Ancillaries tested with	EUT was integrated in Leica Geosystems AG, Model BLK2FLY, Art.No. 938405
Additional equipment used for testing	Notebook with special test software and battery adapter

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15.255

Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§15.255(e) / §2.1049	Occupied bandwidth (6dB/12dB bandwidth)	Normal	3704 MHz	P
§15.255(c)	Radiated EIRP	Normal	-2.7 dBm AVG 11.0 dBm Peak	P
§15.215(c) / §15.255(f)	Transmitter frequency stability	Normal/Extreme	-/-	N/P
§15.255(d) / §15.209(a)	Field strength of emissions (spurious & harmonics)	Normal	< Waver limit	P

Notes

FCC's Millimeter Wave Test Procedures:
I. A radiated method of measurements in order to demonstrate compliance with the various regulatory requirements has been chosen in consideration of test equipment availability and the limitations of many external harmonic mixers. A conducted method of measurement could be employed if EUT and mixer waveguides both are accessible and of the same type (WG number) and if waveguide sections and transitions can be found. Another potential problem is that the peak power output may exceed the +20 dBm input power limit of many commercially available mixers. For these reasons a radiated method is preferred.

Comments and observations

Testing was done according to Waiver (2019-06-28):
Request for Waiver: Leica Geosystems AG requests a waiver of Section 15.255(b) of the Commission's rules to permit the marketing of a 60-64 GHz radar device that will be integrated in commercial Unmanned Aerial Vehicles (UAVs) used for visual capture of the outsides of structures. The radar will help to avoid collisions with stationary obstacles.

Testing was done on CW carrier mid, according to request of the TCB.

7 TEST RESULTS

7.1 Occupied bandwidth (§2.1049)

Description

§2.1049 Measurements required: Occupied bandwidth.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

Limits

The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the 57-71GHz frequency band.

FCC §15.255 € (1):

For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

Test procedure

ANSI C63.10, 6.9.3

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Step a) through step c) might require iteration to adjust within the specified range.

e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Note

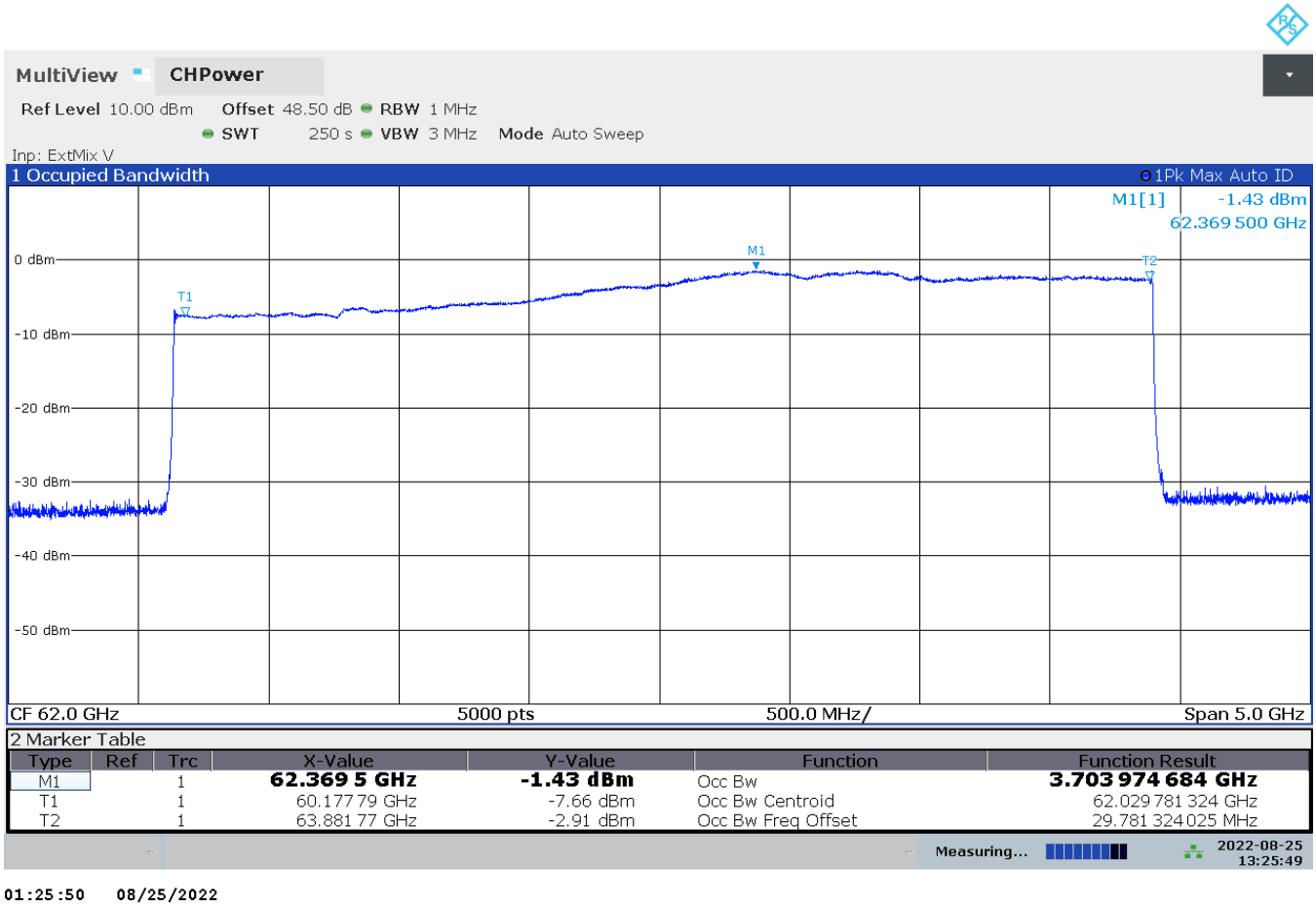
Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak detector will represent the worst-case results (see ANSI C63.10).

Test setup: 8.4

Test results under normal and extreme test conditions:				
EUT mode	**Test conditions**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [GHz]**
Normal operating	Normal - 6dB	-	-	-
Normal operating	Normal - 99%	60.178	63.882	3.704

Note: The 6 dB Bandwidth does not cover the full spectrum due to an uneven power spectral density and is therefore deemed insufficient, alternative measurements were made as worst-case considerations:

Plot no. 1: 99 % bandwidth



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7.2 Radiated EIRP

§ 15.255 (c) (4) The peak power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz. The average emission levels shall be measured over the actual time period during which transmission occurs.

Limits

The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm

Limits of Waiver

Average EIRP: 0 dBm
Peak EIRP: 18.7 dBm

Test procedure

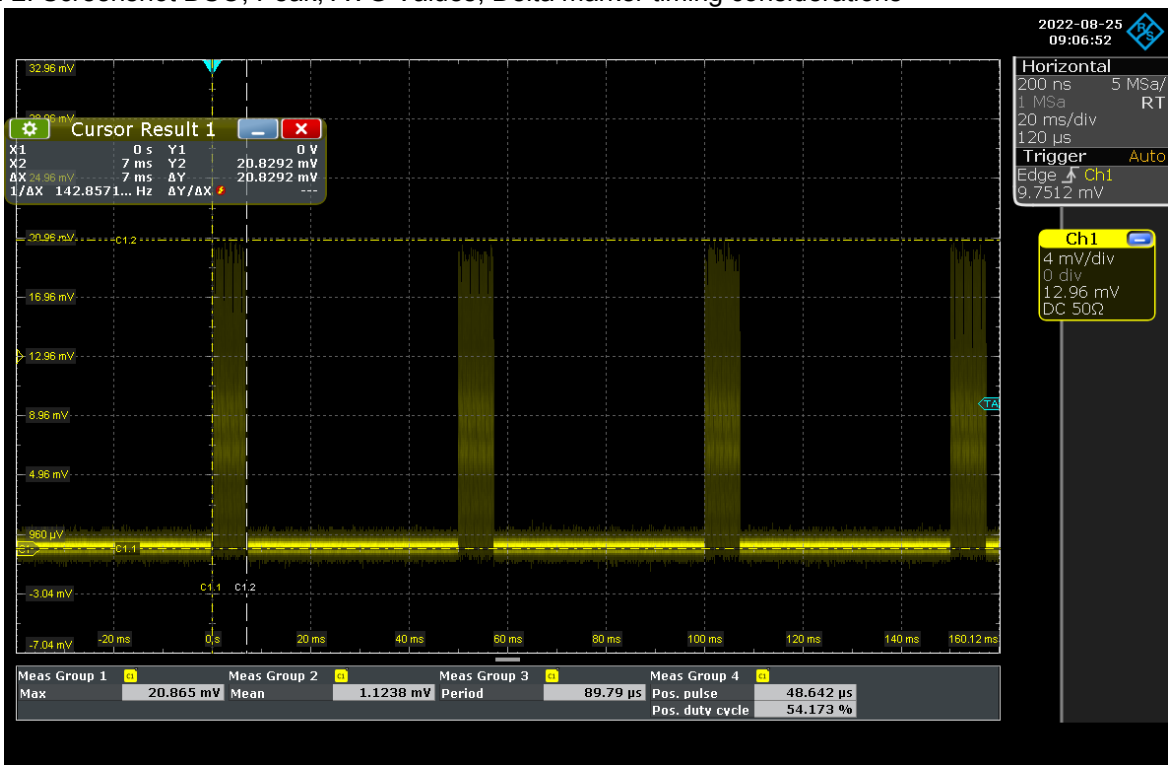
According to ANSI C63.10, 9.11 Measurement of the fundamental emission using an RF detector and substitution.

Test setup: 8.5

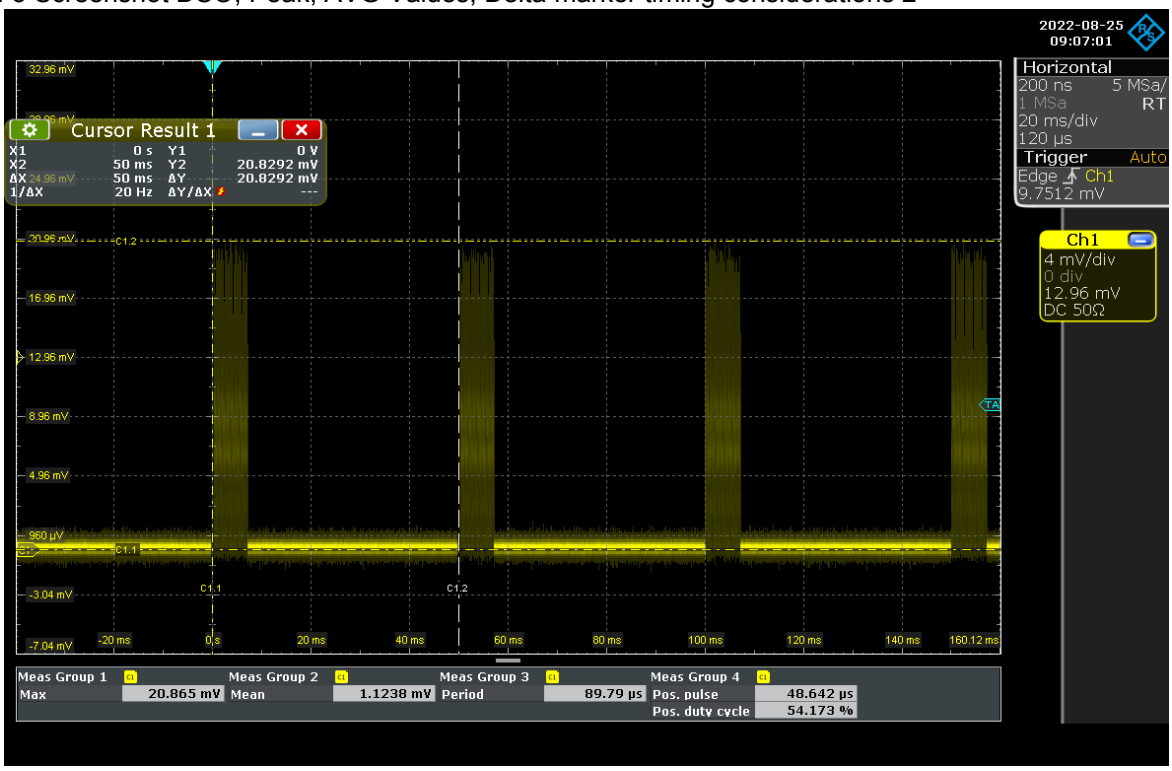
Test results:

EUT mode	Temperature / Voltage	Peak Power	Mean Power	Duty Cycle
Normal operating	T_{nom} / V_{nom}	**11.0 dBm**	**-2.7 dBm**	14 %

Plot no. 2: Screenshot DSO, Peak, AVG Values, Delta marker timing considerations



Plot no. 3 Screenshot DSO, Peak, AVG Values, Delta marker timing considerations 2



7.3 Field strength of emissions (spurious and harmonics)

Description / Limits

§15.255 (d) (1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

§15.255 (d) (2)

Radiated emissions below 40 GHz shall not exceed the general limits in § 15.209.:

Frequency	Field Strength	Measurement distance
0.009 – 0.490 MHz	2400/F[kHz] µV/m	300 m
0.490 – 1.705 MHz	24000/F[kHz] µV/m	30 m
1.705 – 30.0 MHz	30.0 µV/m / 29.5 dBµV/m	30 m
30 – 88 MHz	100 µV/m / 40.0 dBµV/m	3 m
88 – 216 MHz	150 µV/m / 43.5 dBµV/m	3 m
216 – 960 MHz	200 µV/m / 46.0 dBµV/m	3 m
960 – 100 000 MHz	500 µV/m / 54.0 dBµV/m	3 m

§15.255 (d) (3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters.

§15.255 (d) (4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

Limit of Waiver:

30 MHz – 200 GHz: -51.3 dBm

Test procedure

§15.31 (c) Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

§15.31 (m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range	Number of frequencies	Location
< 1MHz bandwidth	1	middle
1 – 10 MHz bandwidth	2	1 near bottom and 1 near top
> 10 MHz bandwidth	3	1 near bottom / middle / top

§15.35 (b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g.,see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

§15.35 (c) Unless otherwise specified, e.g., §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application

for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Calculation of the far field distance (Rayleigh distance):
The aperture dimensions of these horn antennas shall be small enough so that the measurement distance in meters is equal to or greater than the Rayleigh distance (i.e. $R_m = 2D^2 / \lambda$), where D is the largest linear dimension (i.e. width or height) of the antenna aperture in m and λ is the free-space wavelength in meters at the frequency of measurement.

Antenna type	Frequency range [GHz]	D [m]	Highest frequency in use [GHz]	Far field distance R_m [m]
20240-20	18.0 – 26.5	0.0520	26.5	0.478
22240-20	26.5 – 40.0	0.0342	40	0.312
23240-20	33.0 – 50.0	0.0280	50	0.261
24240-20	40.0 – 60.0	0.0230	60	0.212
25240-20	50.0 – 75.0	0.0185	75	0.171
26240-20	60.0 – 90.0	0.0150	90	0.135
27240-20	75.0 – 110	0.0124	110	0.113
28240-20	90.0 – 140	0.0100	140	0.093
29240-20	110 – 170	0.0085	170	0.082
30240-20	140 – 220	0.0068	220	0.068

Used test distances

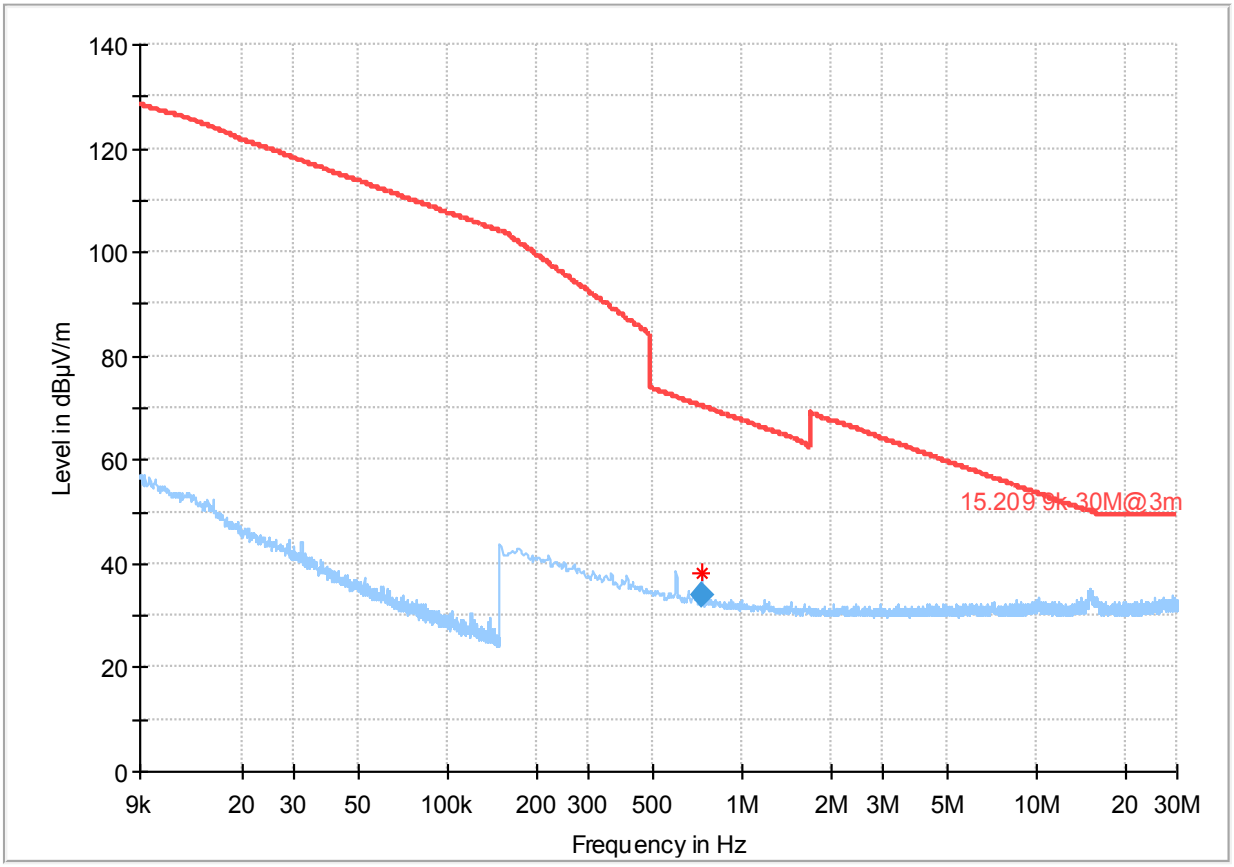
Up to 18 GHz: 3.00 m
18 – 40 GHz: 0.50 m
40 – 50 GHz: 0.35 m
50 – 60 GHz: 0.25 m
50 – 75 GHz: 0.5 m
75 – 90 GHz: 0.2 m
90 – 140 GHz: 0.5 m
140 – 200 GHz: 0.1 m

Test setup: 8.1 – 8.4
Test distance correction factor of 20dB/decade is already considered in the plots / result table.

Test results:

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
No critical emissions found, please refer to plots.						

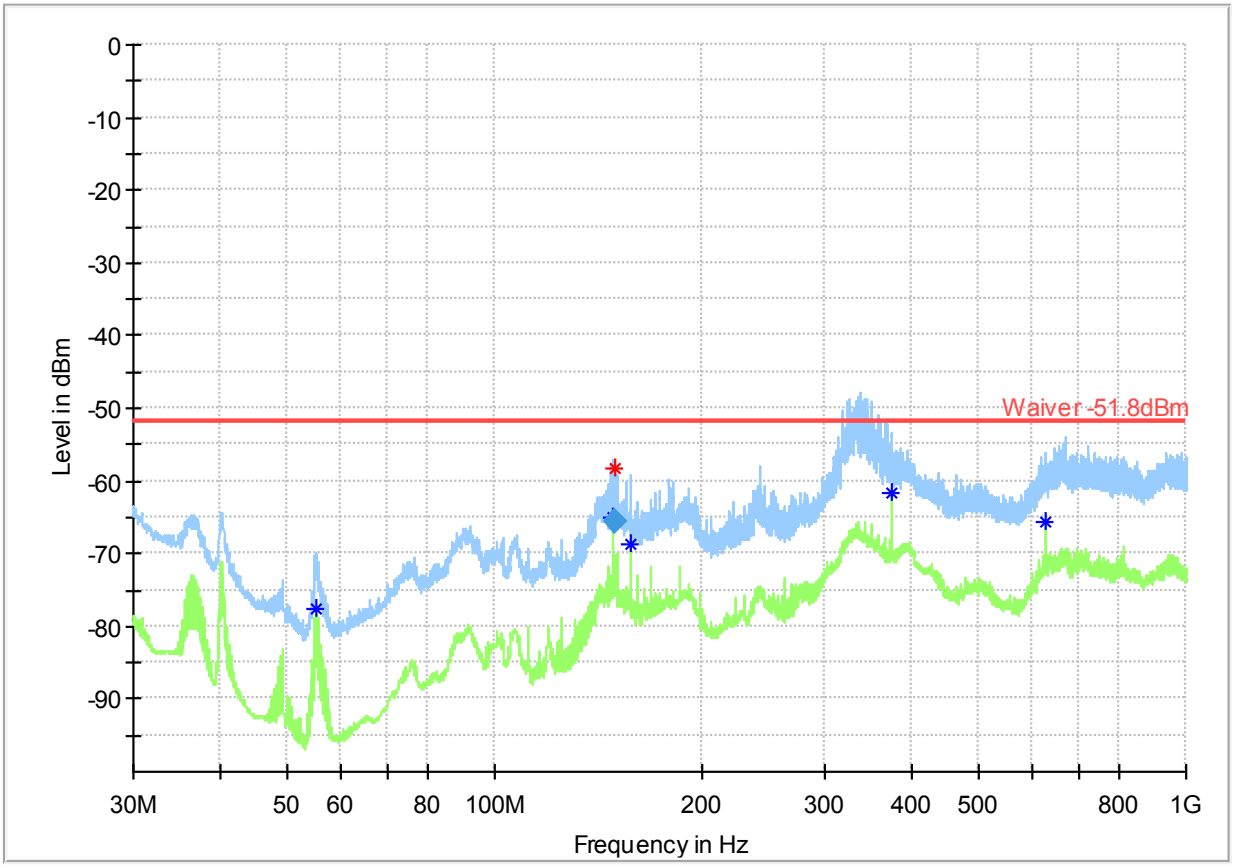
Plot no. 4: radiated emissions 9 kHz – 30 MHz, loop antenna, cw mid



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.732750	33.77	70.32	36.55	100.0	9.000	H	165.0	20.3

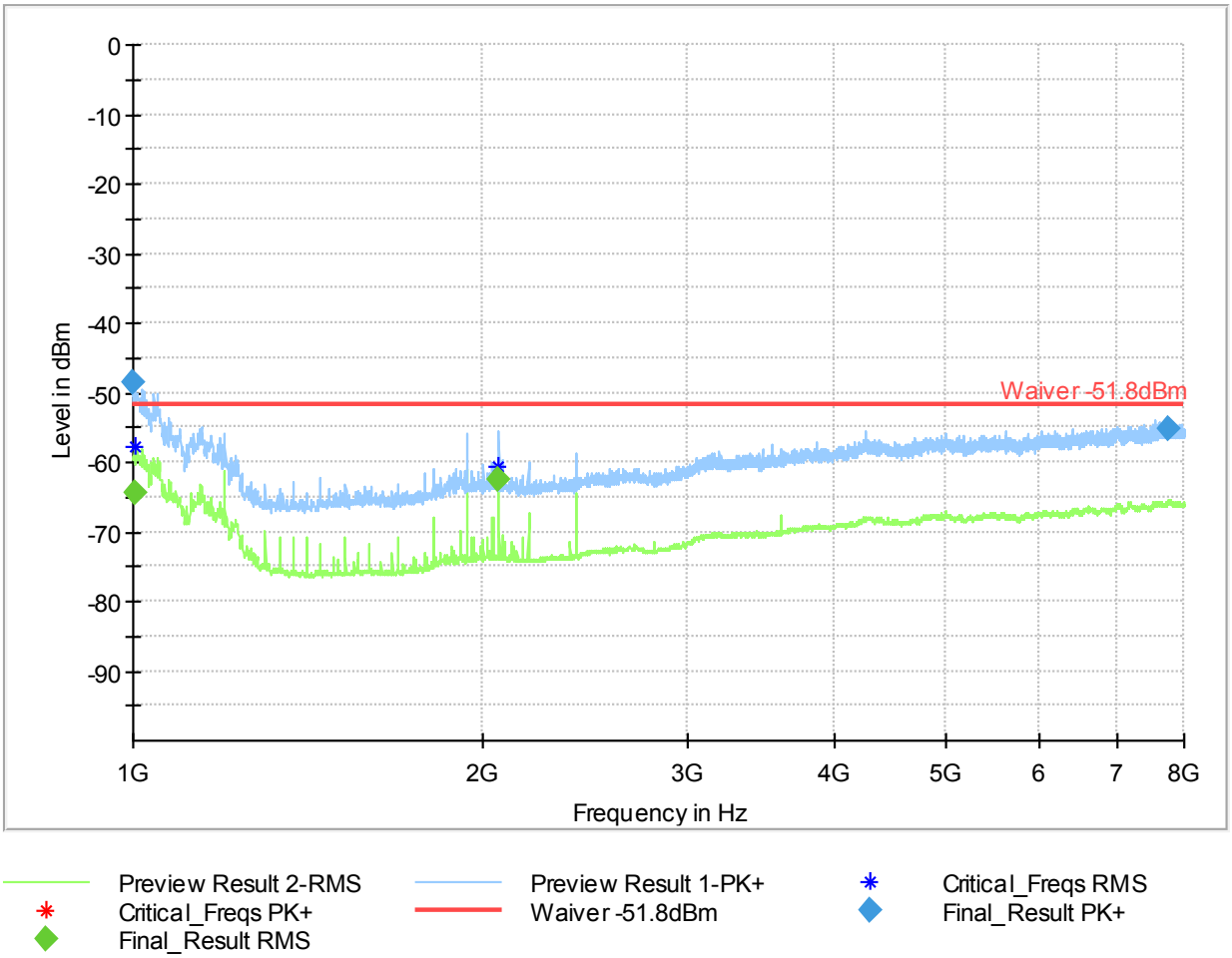
Plot no. 5: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, cw mid



Final_Result

Frequency (MHz)	QuasiPeak (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
148.890000	-65.51	-51.80	13.71	100.0	120.000	150.0	H	187.0	-85.0

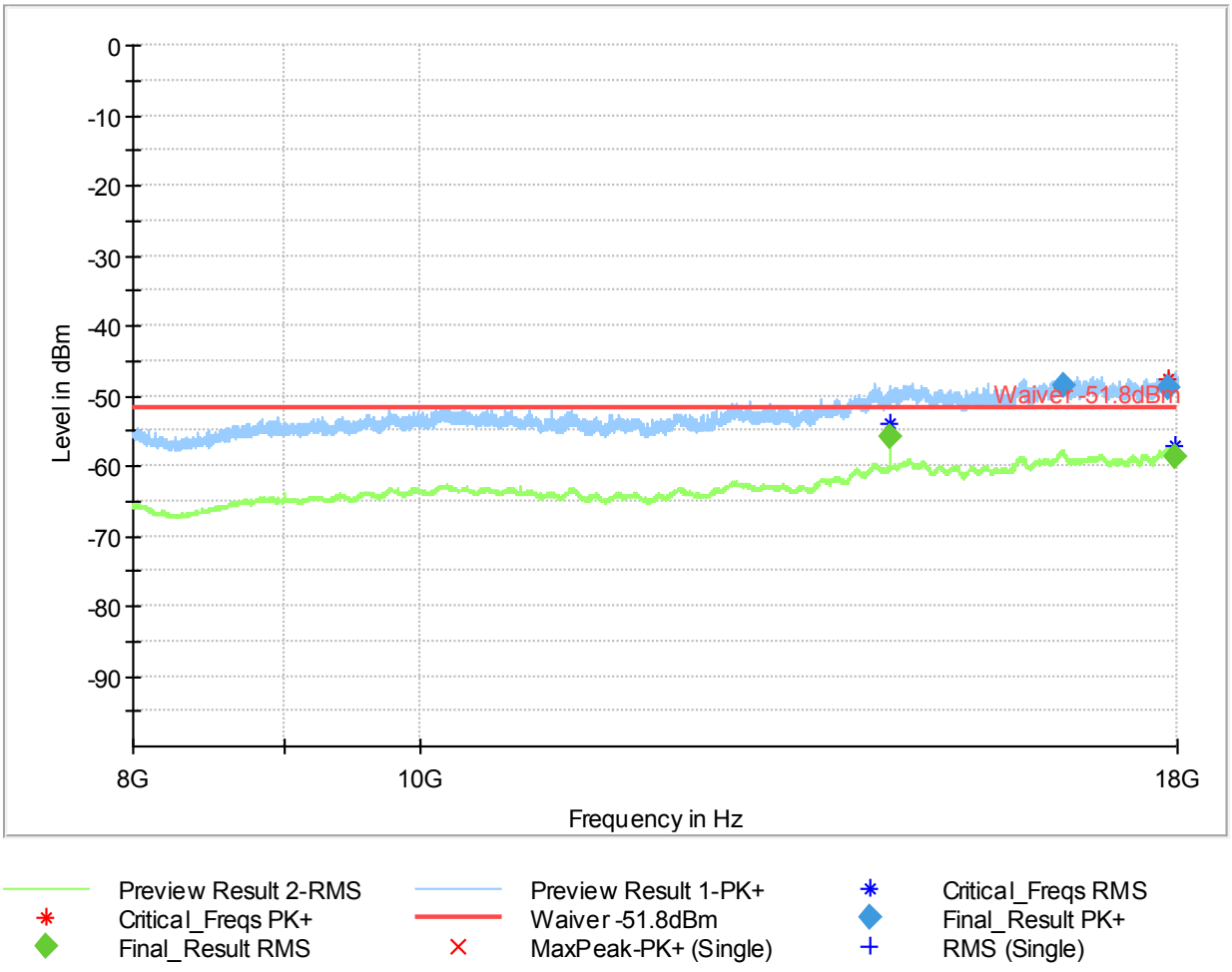
Plot no. 6: radiated emissions 1 GHz – 8 GHz, hor./vert. polarization, cw mid



Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
1000.000000	-48.58	---	---	---	100.0	1000.000	150.0	V
1002.625000	---	-64.57	-51.80	12.77	100.0	1000.000	150.0	V
2062.250000	---	-62.64	-51.80	10.84	100.0	1000.000	150.0	V
7772.000000	-55.11	---	---	---	100.0	1000.000	150.0	H

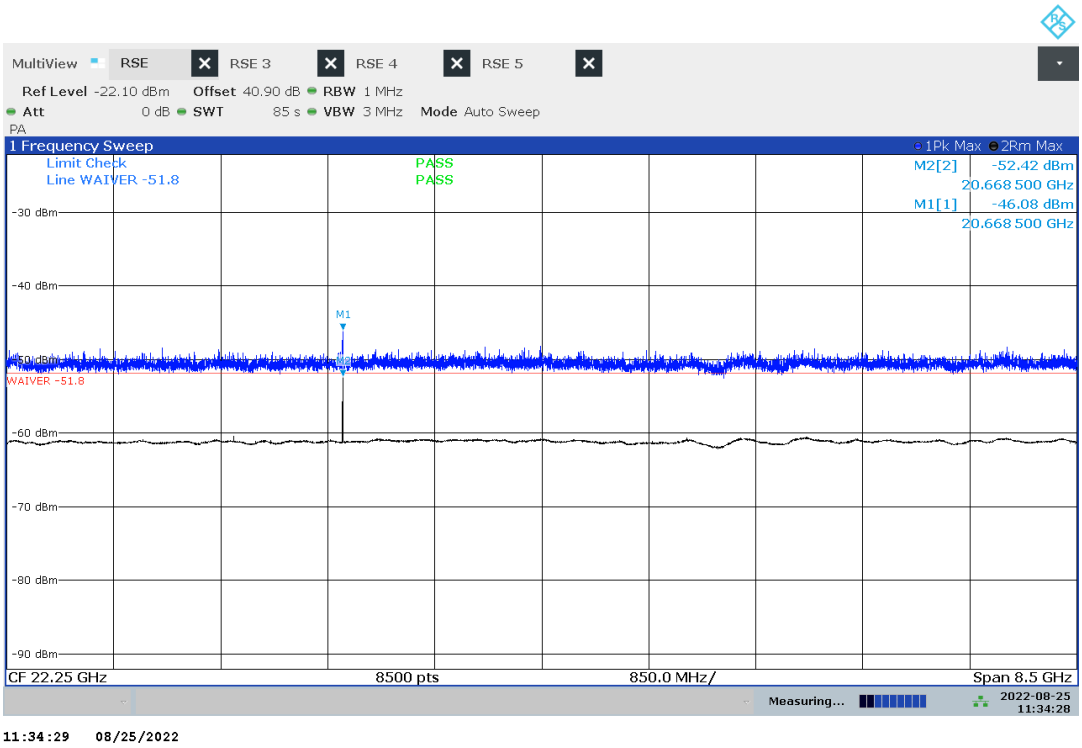
Plot no. 7: radiated emissions 8 GHz – 18 GHz, hor./vert. polarization, cw mid



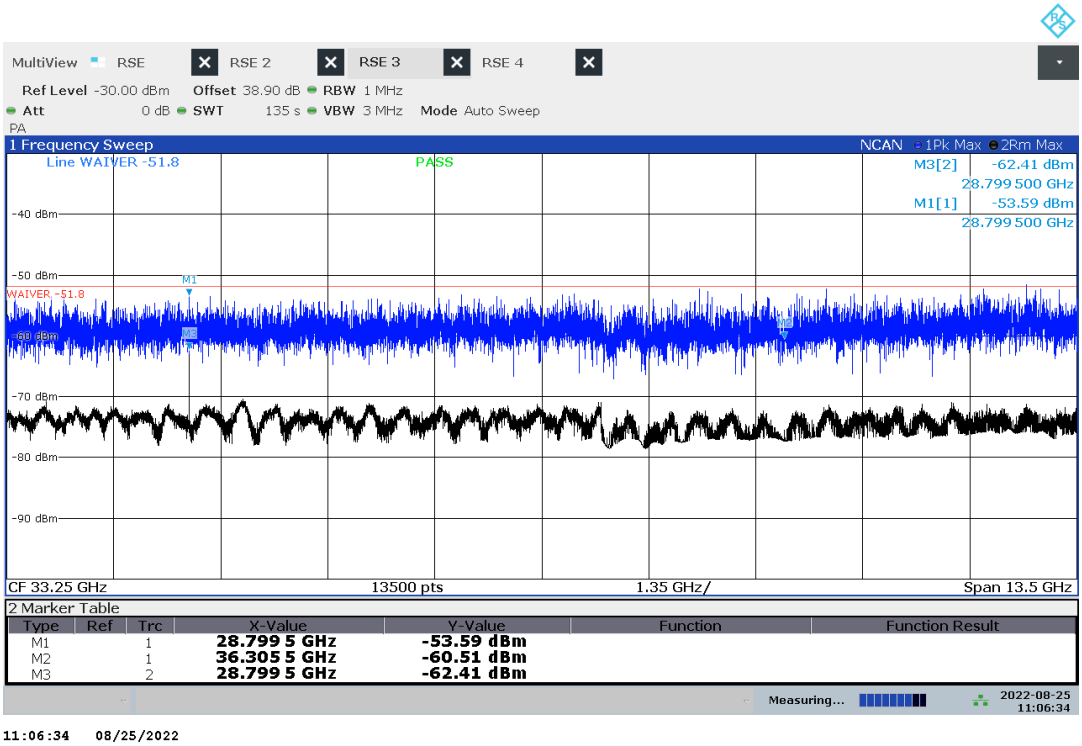
Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
14400.000000	---	-55.93	-51.80	4.13	100.0	1000.000	150.0	H
16474.500000	-48.59	---	---	---	100.0	1000.000	150.0	V
17878.750000	-48.79	---	---	---	100.0	1000.000	150.0	H
17980.000000	---	-58.81	-51.80	7.01	100.0	1000.000	150.0	H

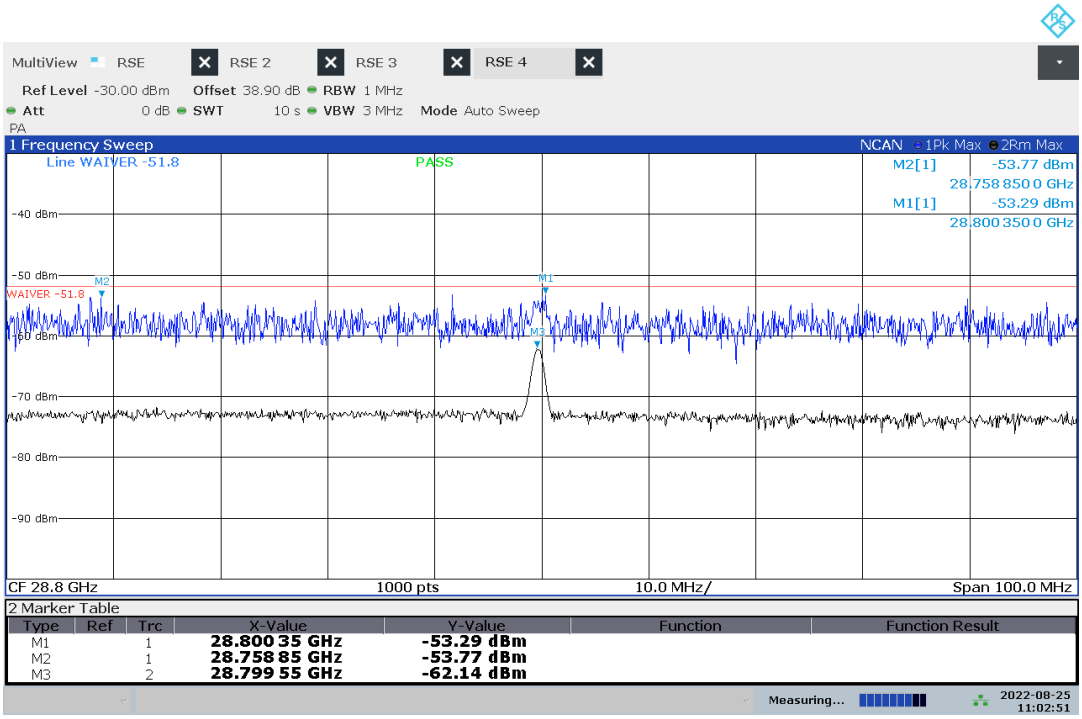
Plot no. 8: radiated emissions 18 GHz – 26.5 GHz, hor./vert. polarization, cw mid



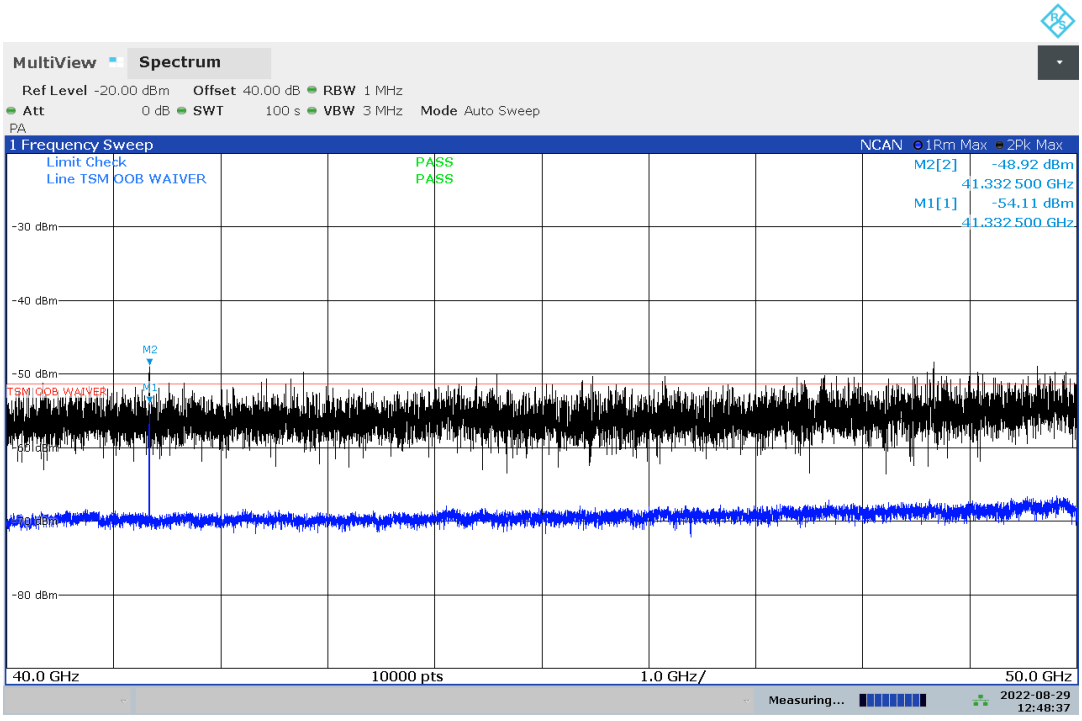
Plot no. 9: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, cw mid



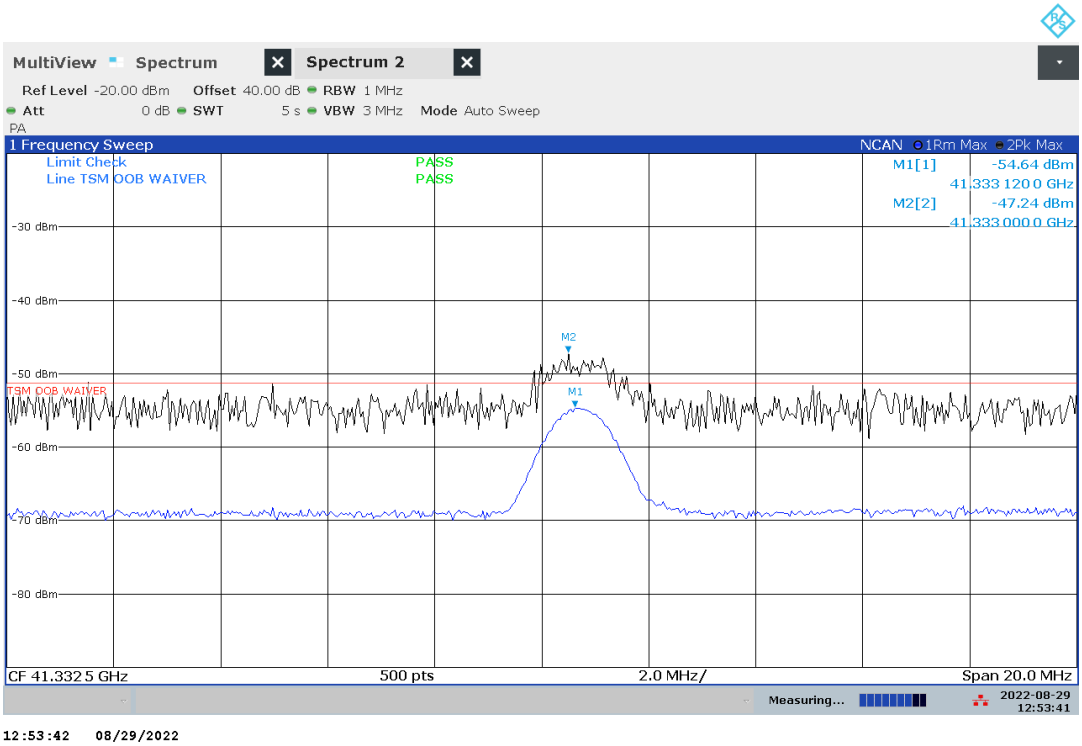
Plot no. 10: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, cw mid, zoomed on emission



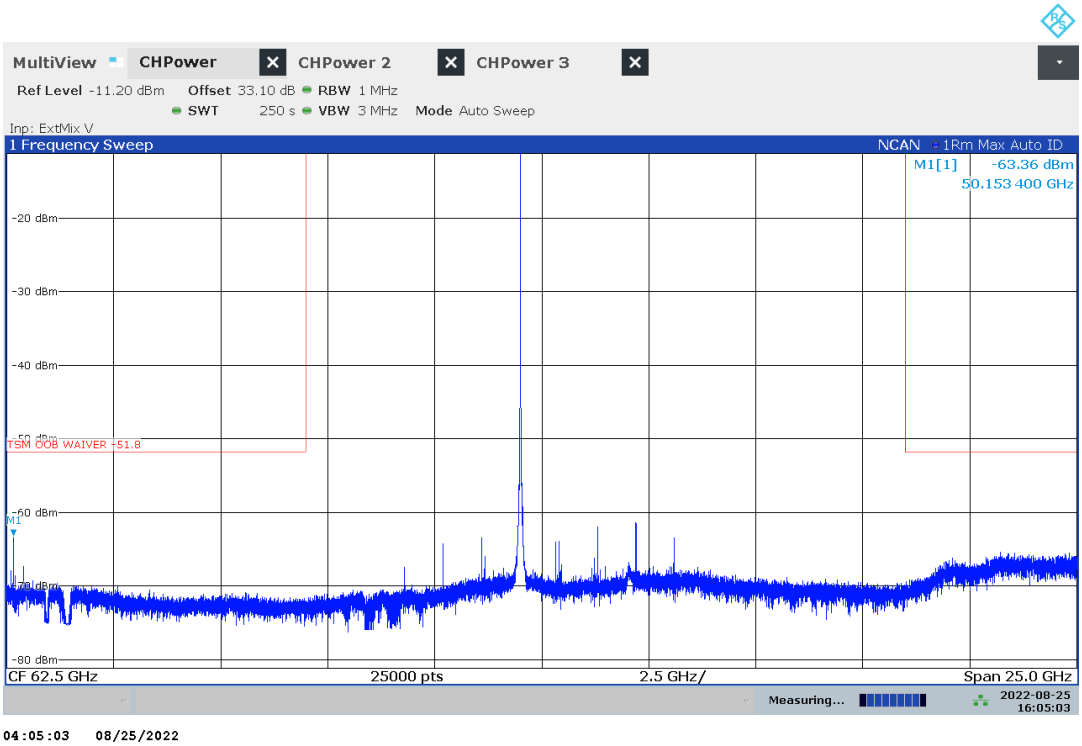
Plot no. 11: radiated emissions 40 GHz – 50 GHz, hor./vert. polarization, cw mid



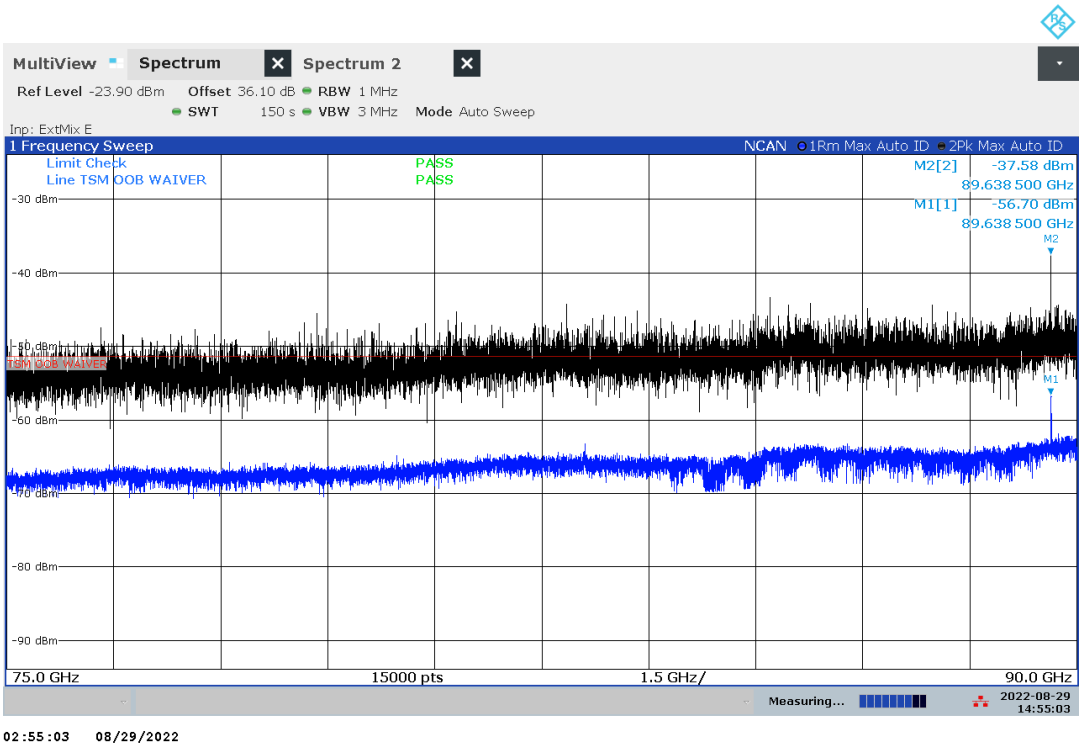
Plot no. 12: radiated emissions 40 GHz – 50 GHz, hor./vert. polarization, cw mid, zoomed on emission



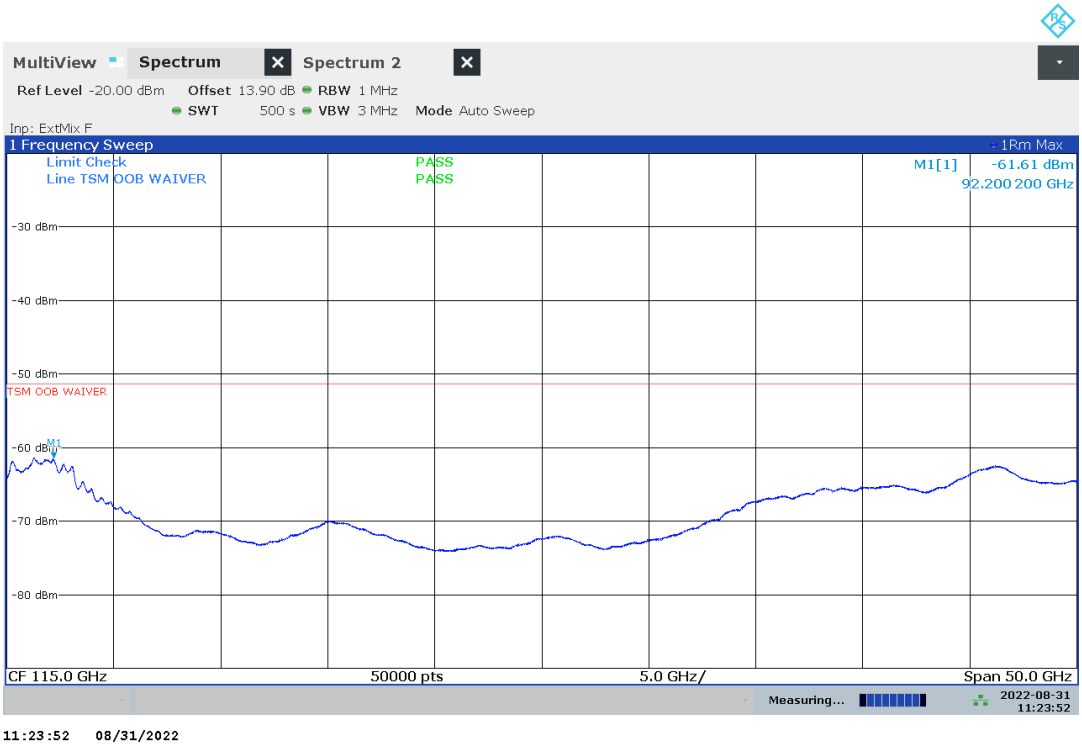
Plot no. 13: radiated emissions 50 GHz – 75 GHz, hor./vert. polarization, cw mid



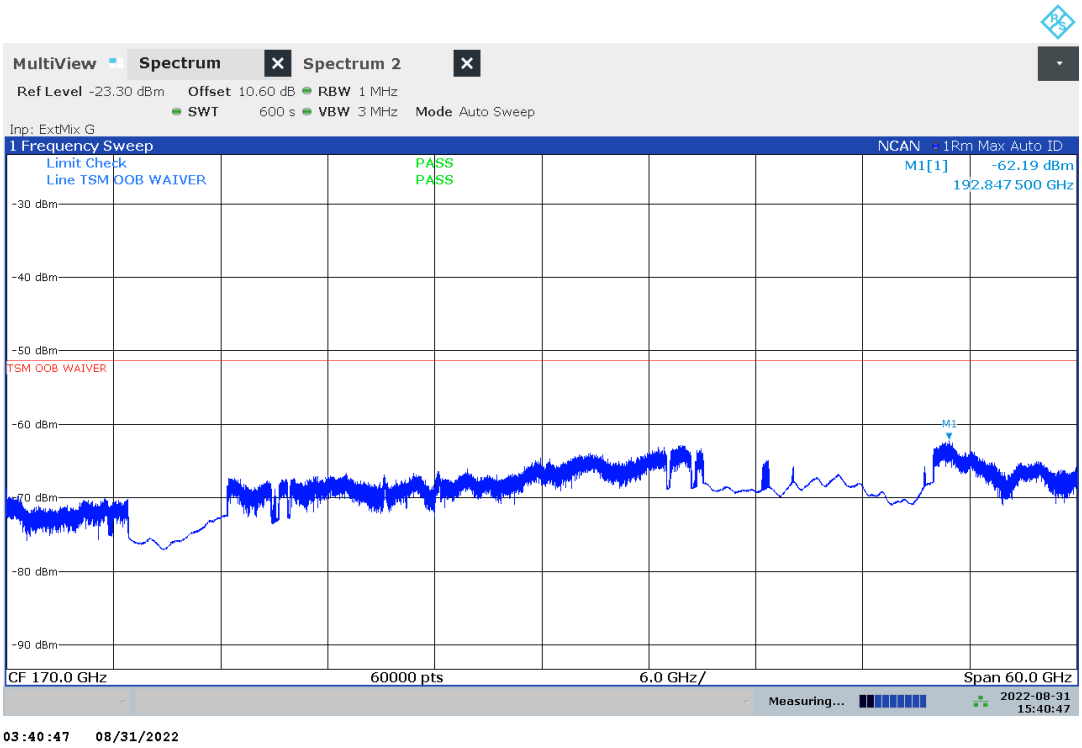
Plot no. 14: radiated emissions 75 GHz – 90 GHz, hor./vert. polarization, cw mid



Plot no. 15: radiated emissions 90 GHz – 140 GHz, hor./vert. polarization, cw mid



Plot no. 16: radiated emissions 140 GHz – 200 GHz, hor./vert. polarization, cw mid



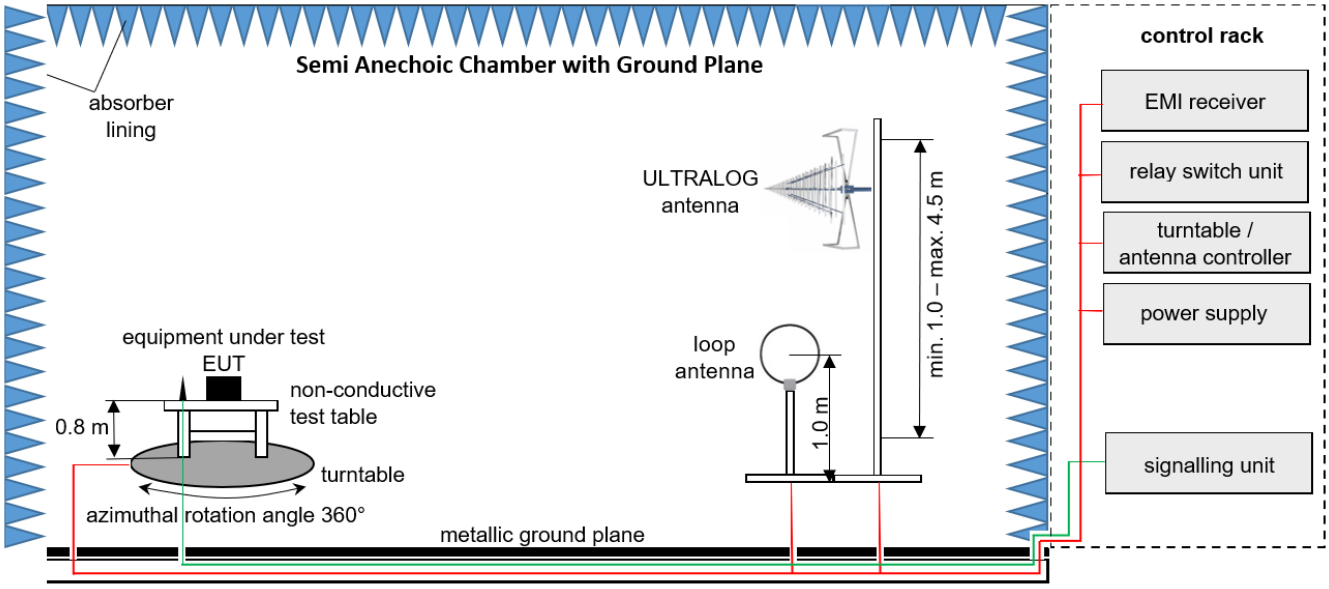
8 Test Setup Description

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Cyclically chamber inspections and range calibrations are performed. Where possible resp. necessary, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based frequency standard).

In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

8.1 Semi Anechoic Chamber with Ground Plane

Radiated measurements are performed in vertical and horizontal plane in the frequency range 30 MHz to 1 GHz in a Semi Anechoic Chamber with a metallic ground plane. The EUT is positioned on a non-conductive test table with a height of 0.80 m above the metallic ground plane that covers the whole chamber. The receiving antennas conform to specification ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. These antennas can be moved over the height range between 1.0 m and 4.5 m in order to search for maximum field strength emitted from the EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by a spectrum analyzer where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: ULTRALOG antenna 3 m; loop antenna 3 m
EMC32 software version: 11.20.00

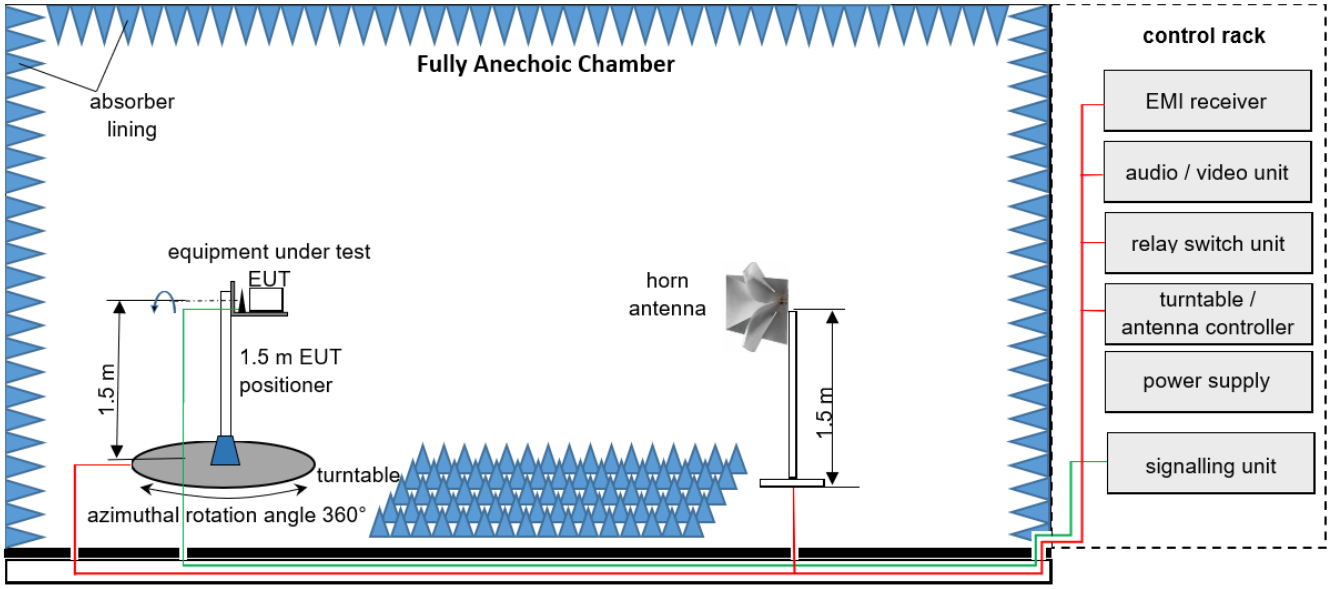
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NA	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NA	–
3	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NA	–
4	Compressed Air	Implotex	1-850-30	-	LAB000256	NA	–
5	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2022-07-07 → 12M → 2023-07-07
6	Semi-Anechoic Chamber (SAC)	Albatross Projects GmbH	SAC 5 (Babylon 5)	20168.PRB	LAB000235	CM	2020-08-24 → 36M → 2023-08-24
7	Measurement Software	Rohde & Schwarz	EMC32		LAB000226	NA	–
8	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NA	–
9	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NA	–
10	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NA	–
11	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NA	–
12	Power Supply	Elektro-Automatik GmbH & Co. KG	PS 2042-10 B	2878350292	LAB000191	NA	–
13	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	NA	–
14	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2020-04-23 → 36M → 2023-04-23
15	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2020-07-05 → 36M → 2023-07-05
16	Antenna	Rohde & Schwarz	HFH2-Z2E - Active Loop Antenna	100954	LAB000108	C	2020-03-25 → 36M → 2023-03-25
17	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	NA	–

8.2 Fully Anechoic Chamber



Measurement distance: horn antenna 3 m
EMC32 software version: 11.20.00

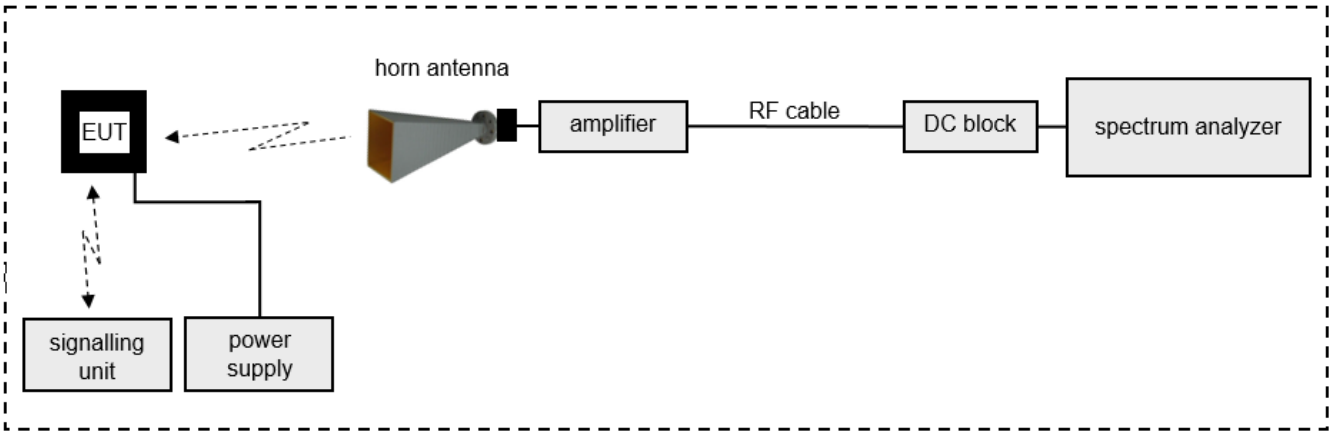
ROP = AV + D - G
(ROP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
ROP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 µW)

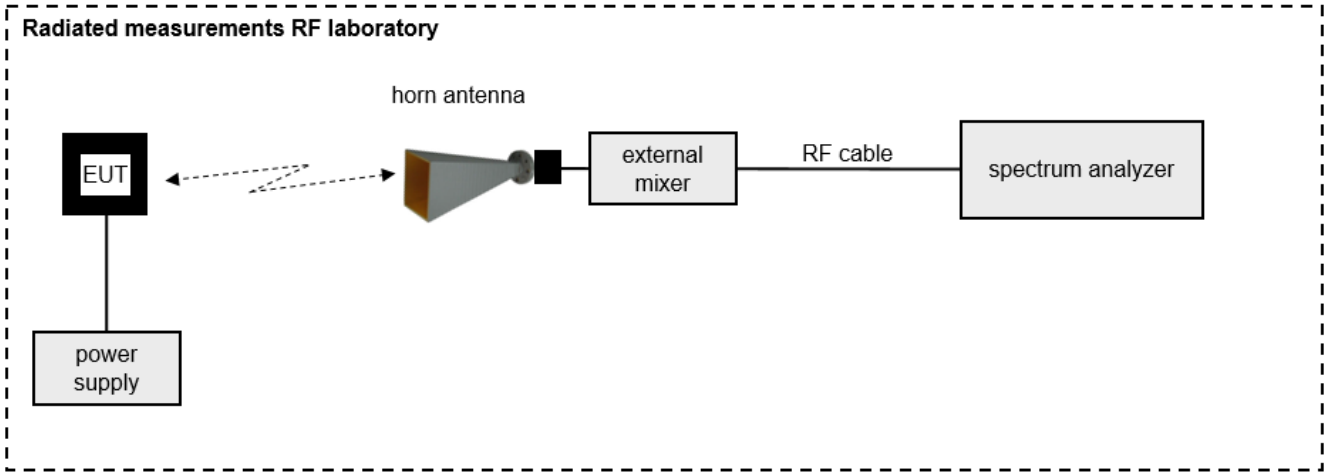
List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NA	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NA	–
3	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NA	–
4	Compressed Air	Implotex	1-850-30	-	LAB000256	NA	–
5	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2022-07-07 → 12M → 2023-07-07
6	Semi-Anechoic Chamber (SAC)	Albatross Projects GmbH	SAC 5 (Babylon 5)	20168.PRB	LAB000235	CM	2020-07-23 → 36M → 2023-07-23
7	Measurement Software	Rohde & Schwarz	EMC32		LAB000226	NA	–
8	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NA	–
9	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NA	–
10	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NA	–
11	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NA	–
12	Power Supply	Elektro-Automatik GmbH & Co. KG	PS 2042-10 B	2878350292	LAB000191	NA	–
13	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	NA	–
14	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2020-04-23 → 36M → 2023-04-23
15	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2020-07-05 → 36M → 2023-07-05
16	Antenna	Rohde & Schwarz	HFH2-Z2E - Active Loop Antenna	100954	LAB000108	C	2020-03-25 → 36M → 2023-03-25
17	Amplifier	B&Z Technologies	BZ-08001800-180855-202020	22105	LAB000297	NA	–
18	Amplifier	B&Z Technologies	BZ-01000900-111550-202320	24336	LAB000296	NA	–

8.3 Radiated measurements > 18 GHz



8.4 Radiated measurements > 50 GHz



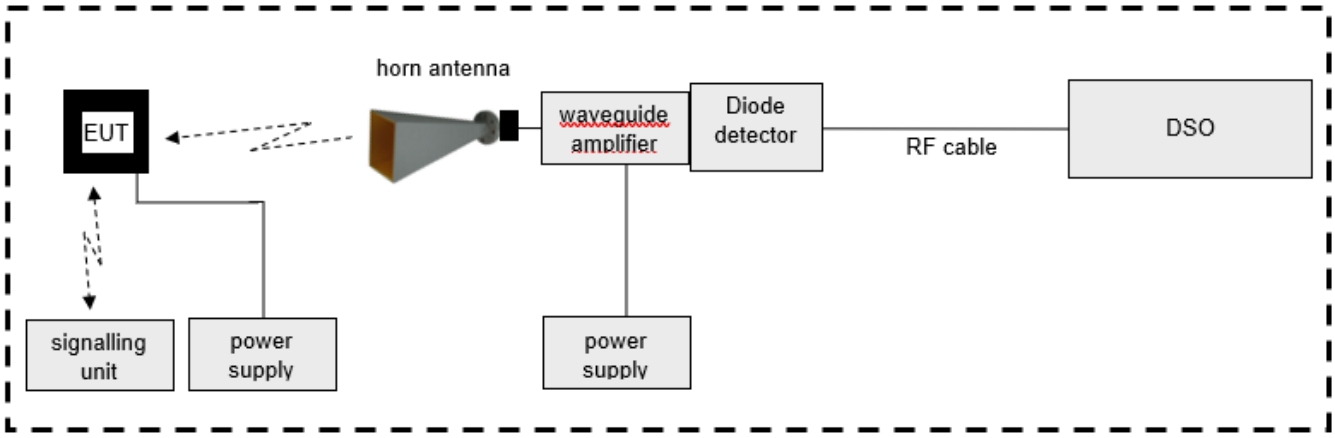
Measurement distance: Horn antenna e.g. 10 cm @ 170 GHz

ROP = AV + D - PA - G
(ROP-rad. output power; AV-analyzer value; PA preamplifier; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
ROP [dBm] = -72.63 [dBm] + 57.05 [dB] - 26.4 [dB] - 20.02 [dBi] = -62 [dBm]

Note: Conversion loss of mixer, as well as above mentioned values (e.g. PA, D, G) are already included in analyzer value, due to corresponding transducer file and given offset.
Values in plots are final measurement values.

8.5 Radiated measurements > EIRP power



According to ANSI 63.10 9.11 Measurement of the fundamental emission using an RF detector diode.

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Antenna Mast	Schwarzbeck Mess-Elektronik OHG	AM 9104	99	LAB000109	NA	–
2	Spectrum Analyser	Rohde & Schwarz	FSW50	101450	LAB000111	C	2022-07-28 → 12M → 2023-07-28
3	Harmonic Mixer	Rohde & Schwarz	FS-Z075	102015	LAB000112	C	2022-04-20 → 12M → 2023-04-20
4	Harmonic Mixer	Rohde & Schwarz	FS-Z090	102020	LAB000113	C	2022-04-05 → 12M → 2023-04-05
5	Harmonic Mixer	Rohde & Schwarz	FS-Z110	102000	LAB000114	C	2022-04-14 → 12M → 2023-04-14
6	Harmonic Mixer	Rohde & Schwarz	FS-Z140	101144	LAB000115	C	2022-03-28 → 12M → 2023-03-28
7	Harmonic Mixer	Rohde & Schwarz	FS-Z220	101039	LAB000116	C	2022-03-28 → 12M → 2023-03-28
8	Signal Generator	Rohde & Schwarz	SMA100-B-50	103838	LAB000118	C	2021-06-30 → 36M → 2024-06-30
9	Harmonic Mixer	Rohde & Schwarz	FS-Z170	100996	LAB000126	C	2022-04-12 → 12M → 2023-04-12
10	Antenna	Flann Microwave Ltd	20240-20	266403	LAB000128	C	2020-06-29 → 36M → 2023-06-29
11	Antenna	Flann Microwave Ltd	22240-20	270448	LAB000130	C	2020-06-29 → 36M → 2023-06-29
12	Antenna	Flann Microwave Ltd	25240-20	272860	LAB000133	CM	2020-07-01 → 36M → 2023-07-01
13	Antenna	Flann Microwave Ltd	26240-20	273417	LAB000135	CM	2020-08-01 → 36M → 2023-08-01
14	Antenna	Flann Microwave Ltd	27240-20	273367	LAB000137	CM	2020-08-01 → 36M → 2023-08-01
15	Antenna	Flann Microwave Ltd	29240-20	273382	LAB000139	CM	2020-08-01 → 36M → 2023-08-01
15	Antenna	Flann Microwave Ltd	29240-20	273382	LAB000139	CM	2020-08-01 → 36M → 2023-08-01
16	Coaxial Cable	Rosenberger	LU7-022-1000	33	LAB000153	NA	–
17	Coaxial Cable	Rosenberger	LU7-022-1000	34	LAB000154	NA	–
18	Coaxial Cable	Huber & Suhner	ST18/48"	2276454-02	LAB000158	CM	2022-05-31 → 12M → 2023-05-31
19	Coaxial Cable	Huber & Suhner	SF101/1.0m	503990/1	LAB000164	CM	2022-05-31 → 12M → 2023-05-31
20	Digital Oscilloscope	Rohde & Schwarz	RTE1204	300113	LAB000175	C	2021-06-02 → 24M → 2023-06-02
21	Antenna	Flann Microwave Ltd	28240-20	273371	LAB000176	CM	2021-09-01 → 36M → 2024-09-01
22	Antenna	Flann Microwave Ltd	30240-20	273390	LAB000178	CM	2021-09-01 → 36M → 2024-09-01
23	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273374	LAB000181	CM	2021-09-01 → 36M → 2024-09-01
24	WG-Coax-Adapter	Flann Microwave Ltd	22093-TF30 UG599/U	273263	LAB000183	CM	2021-09-01 → 36M → 2024-09-01
25	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350255	LAB000189	NA	–
26	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350263	LAB000190	NA	–
27	Multiplier	Rohde & Schwarz	SMZ110	100001	LAB000272	NA	–
28	Spectrum Analyser	Rohde & Schwarz	FSW43	101391	LAB000289	C	2022-06-10 → 12M → 2023-06-10
29	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	NA	–
30	Harmonic Mixer	Rohde & Schwarz	FS-Z060	101350	LAB000375	C	2022-03-18 → 12M → 2023-03-18
31	Antenna	Flann Microwave Ltd	24240-20	275176	LAB000376	CM	2021-09-01 → 36M → 2024-09-01
32	Detector Diode	Eravant	SFD-903144-08SF-P1	13795-01	LAB000437	NA	–
33	Pre-Amplifier	Eravant	SBL-9531443565-0808-E1	13790-01	LAB000439	CM	2021-10-21 → 12M → 2022-10-21
34	Amplifier	Radiometer Physics GmbH	GLNA 140-220-20-6	200145	LAB000440	CM	2021-12-06 → 12M → 2022-12-06

9 Measurement procedures

9.1 Radiated spurious emissions from 9 kHz to 30 MHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- For each turntable step the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated with special 3D adapter set to find maximum level of emissions.
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade of distance in the region closer than λ in m divided by 2π (i.e., λ/2π), and at 20 dB/decade of distance beyond that, using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the limit line of corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.2 Radiated spurious emissions from 30 MHz to 1 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable step / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.3 Radiated spurious emissions from 1 GHz to 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 315° in 45° steps.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable step / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.4 Radiated spurious emissions above 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- EUT is powered on and set into operation.
- Test distance depends on EUT size and test antenna size (farfield conditions shall be met).

Pre-scan

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and for different polarizations of the antenna.

Final measurement

- Significant emissions found during the pre-scan will be maximized, i.e. position and antenna orientation causing the highest emissions with Peak and RMS detector
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C63.4 / C63.10).
- Final plot showing measurement data, levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit is recorded.

Note

- In case of measurements with external harmonic mixers (e.g. above 50 GHz) special care is taken to avoid possible overloading of the external mixer's input.
- As external harmonic mixers may generate false images, care is taken to ensure that any emission measured by the spectrum analyzer is indeed radiated from the EUT and not internally generated by the external harmonic mixer. Signal identification feature of spectrum analyzer is used to eliminate/reduce images of the external harmonic mixer.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

10 MEASUREMENT UNCERTAINTIES

Radio frequency	≤ ± 10 ppm
Radiated emission	≤ ± 6 dB
Temperature	≤ ± 1 °C
Humidity	≤ ± 5 %
DC and low frequency voltages	≤ ± 3 %

The indicated expanded measurement uncertainty corresponds to the standard measurement uncertainty for the measurement results multiplied by the coverage factor k = 2. It was determined in accordance with EA-4/02 M:2013. The true value is located in the corresponding interval with a probability of 95 %.

Annex 1 EUT Photographs, external

Photo No. 1:

Photo No. 2:

Photo No. 3:

Photo No. 4:

Annex 2 EUT Photographs, internal

Photo No. 5:

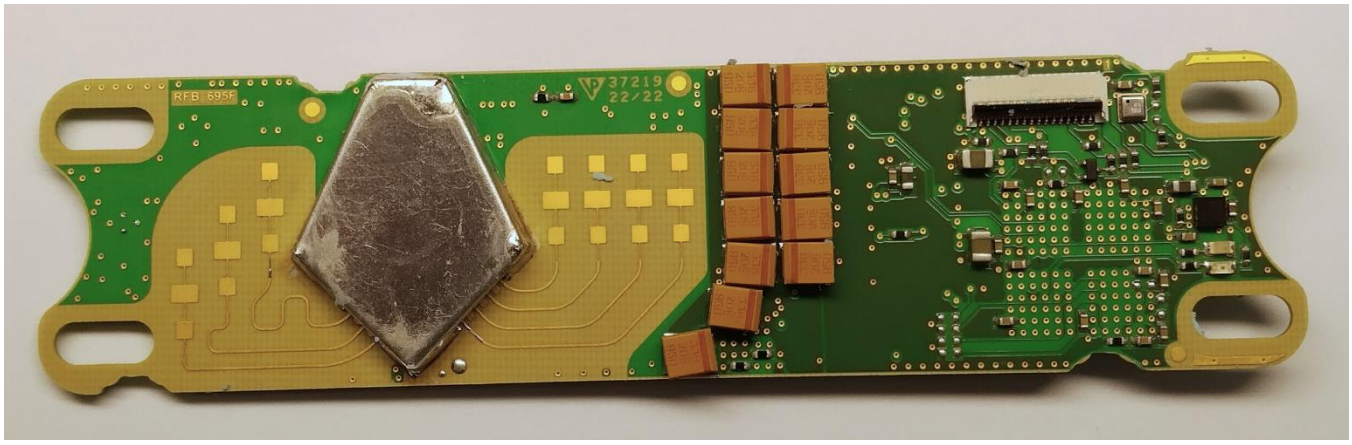


Photo No. 6:

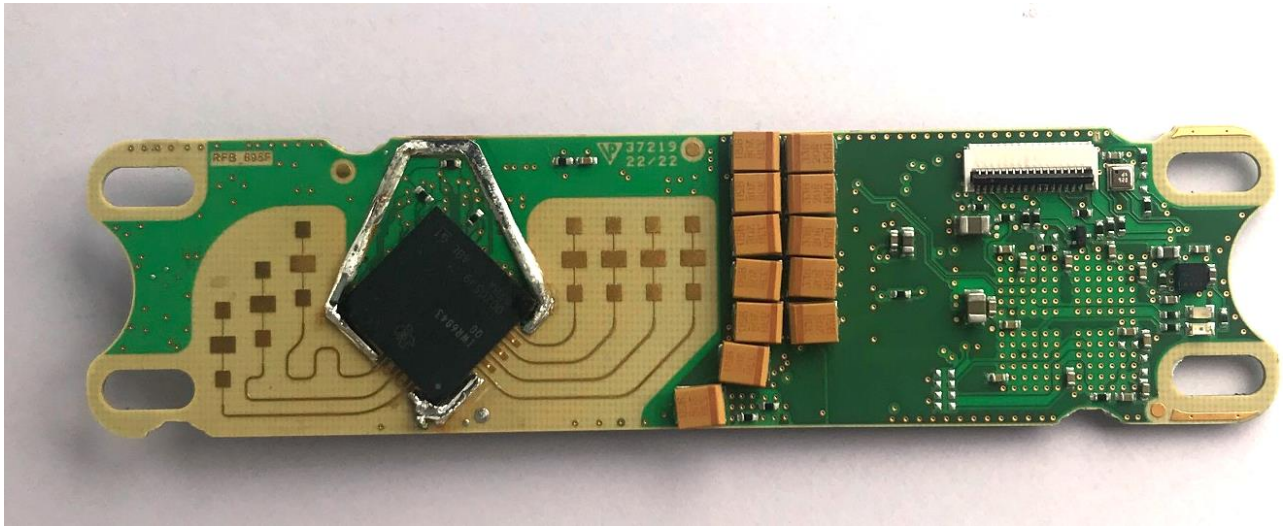


Photo No. 7:

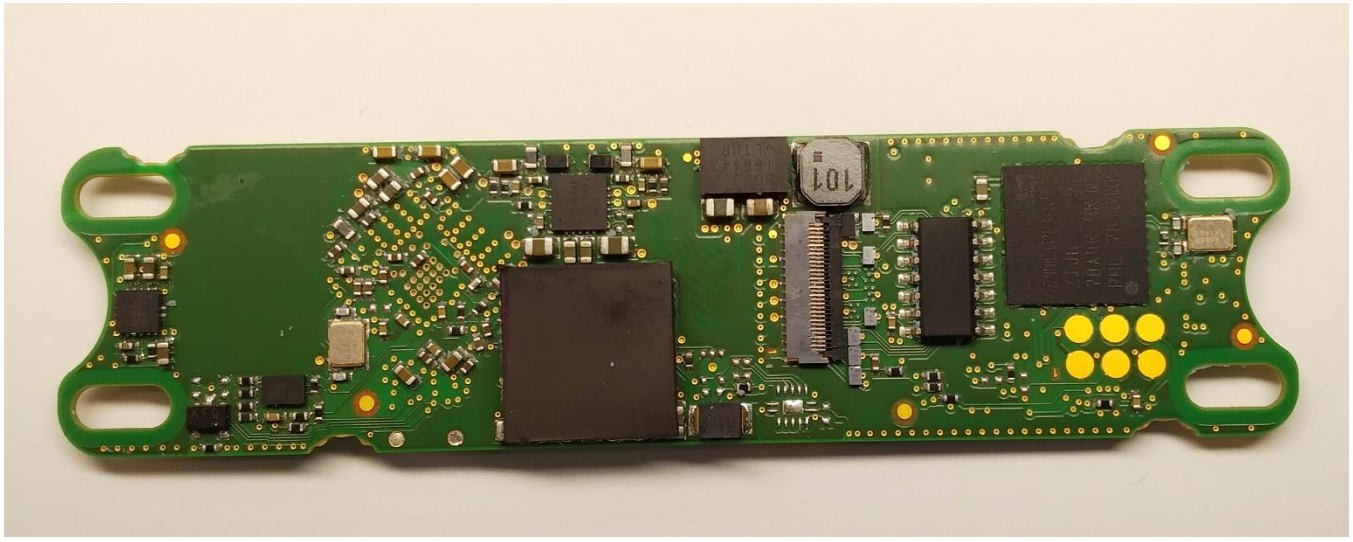
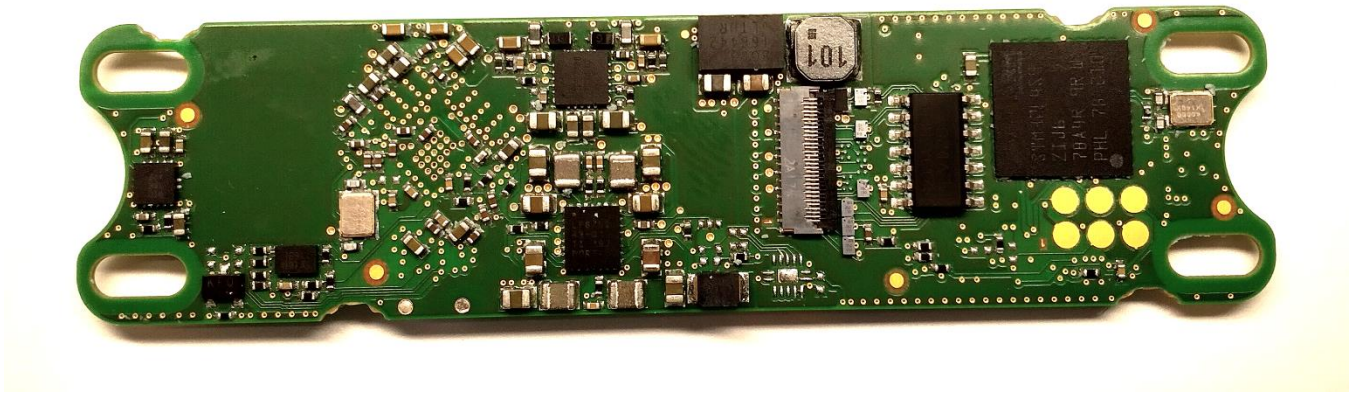


Photo No. 8:



Annex 3 Test Setup Photographs

Photo No. 9:

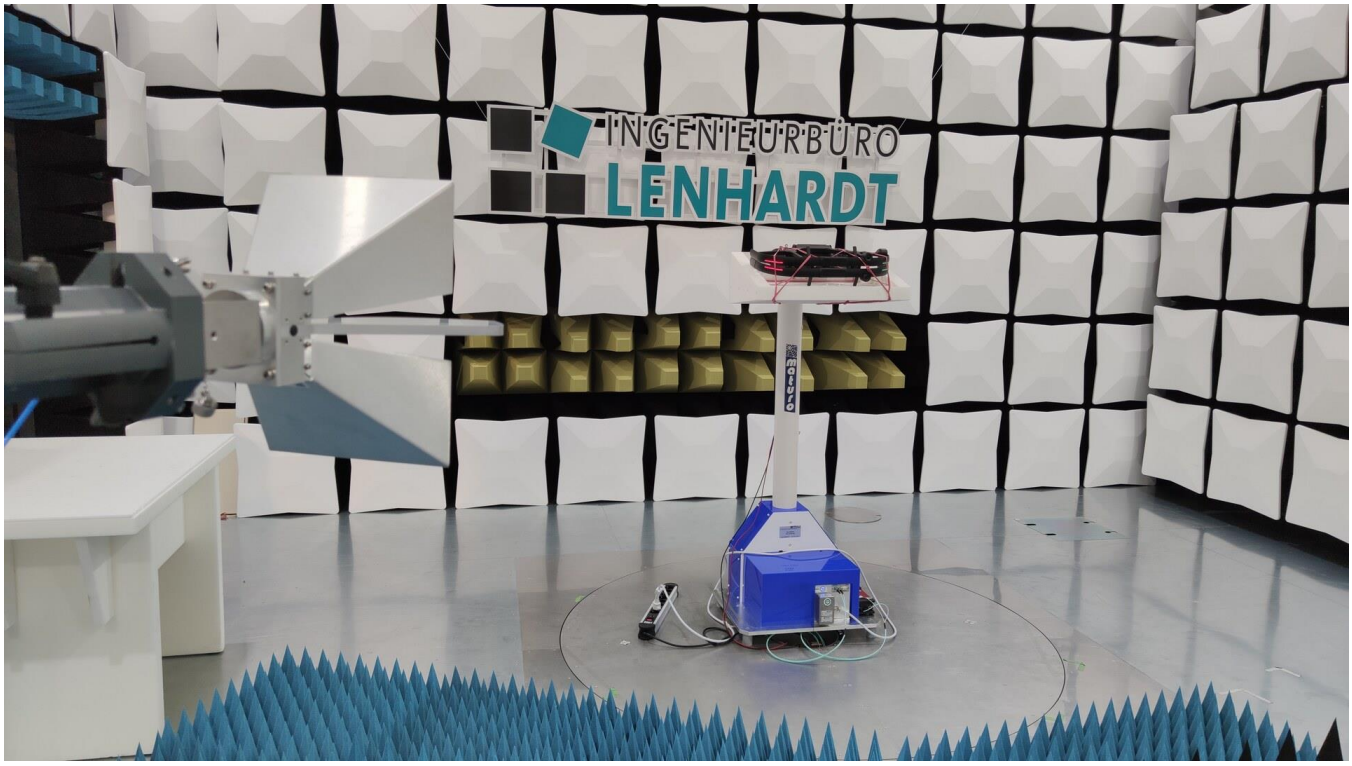


Photo No. 10:

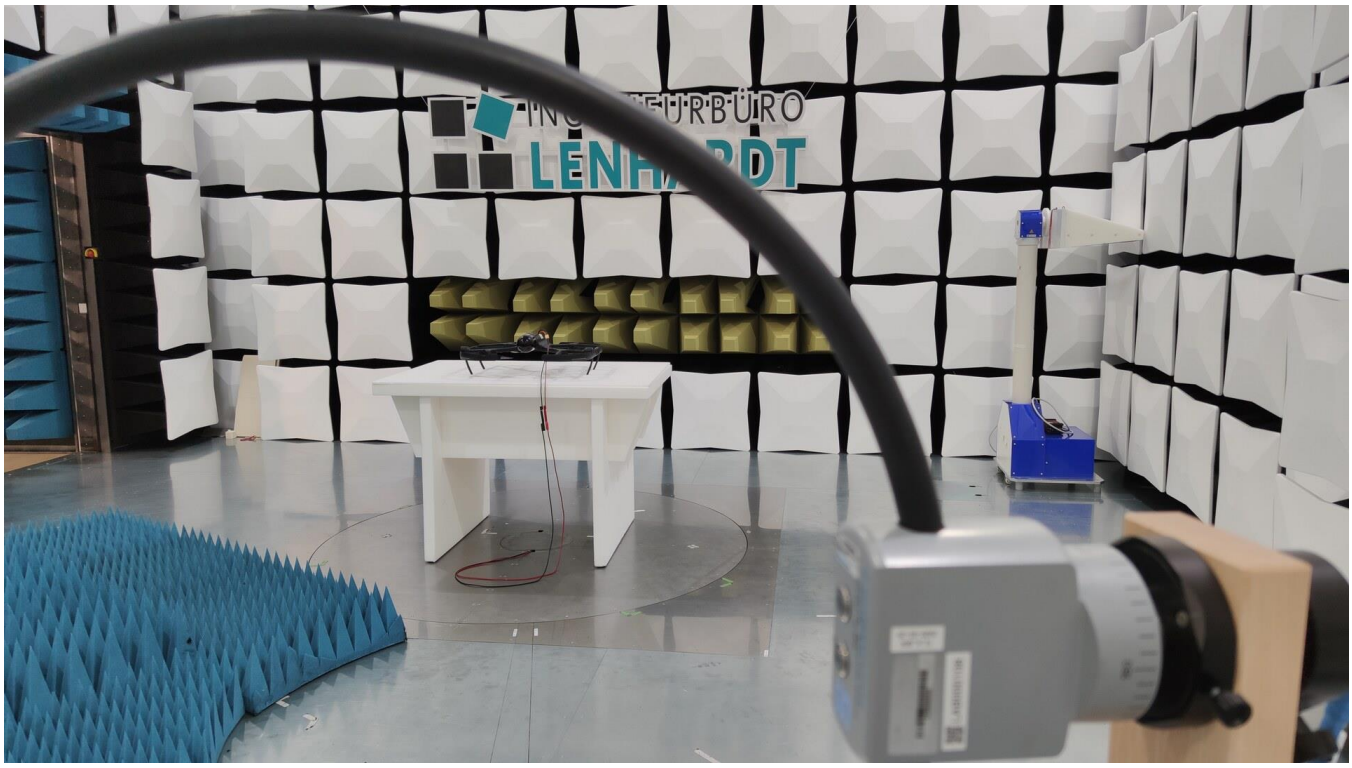


Photo No. 11:

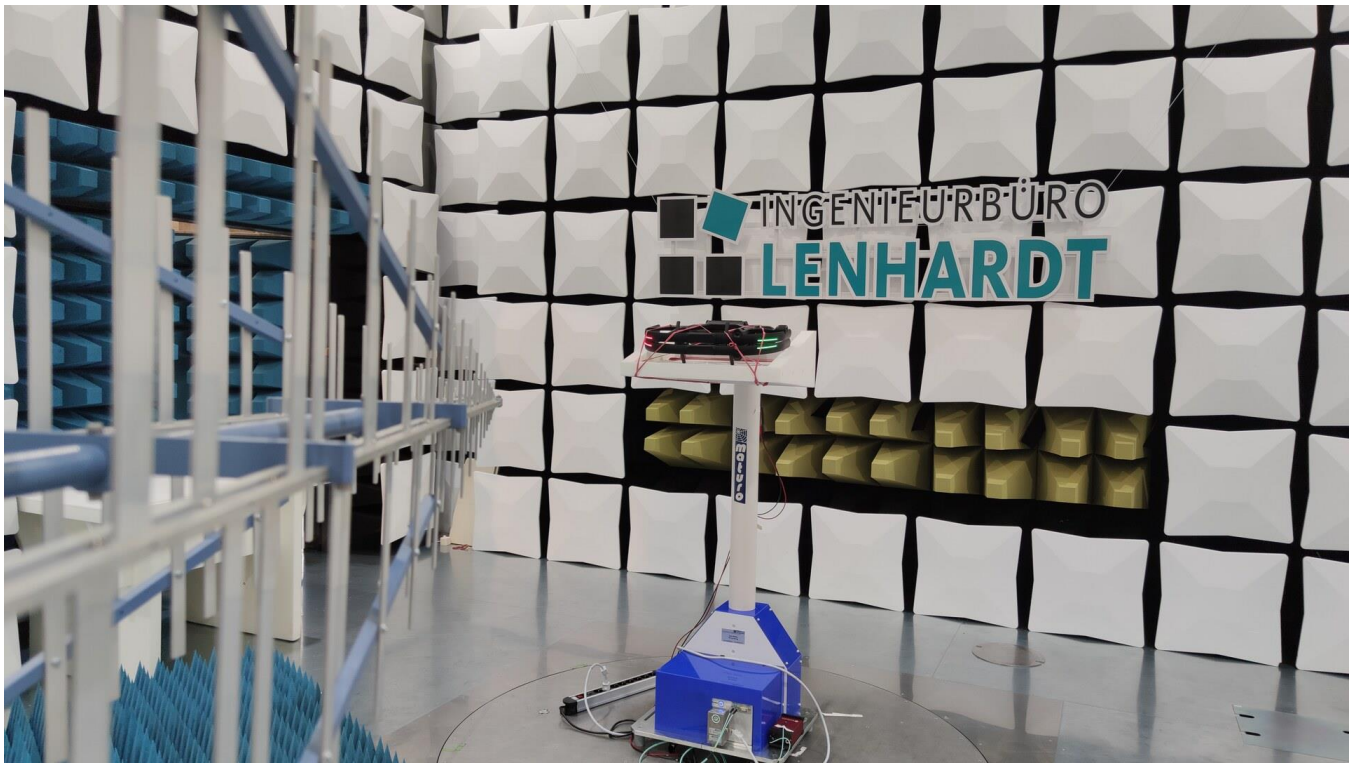


Photo No. 12:

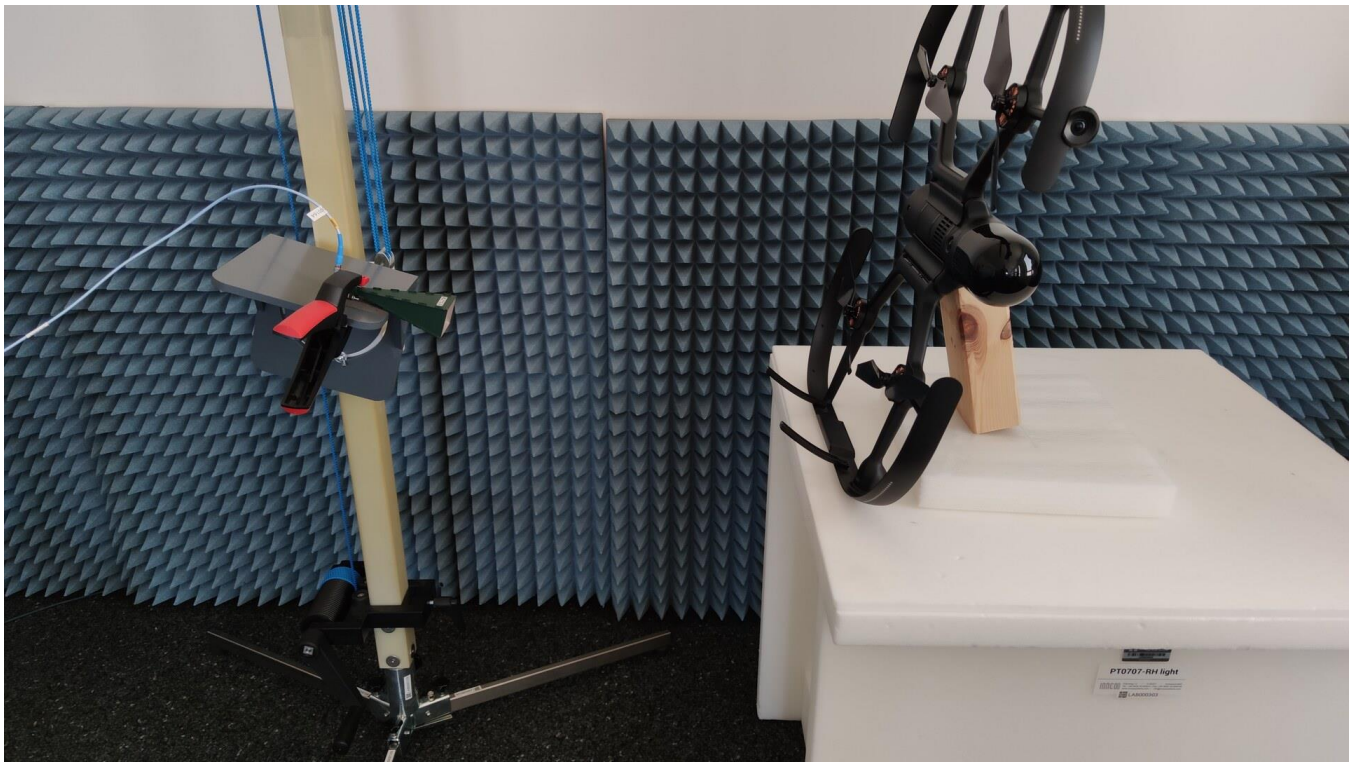
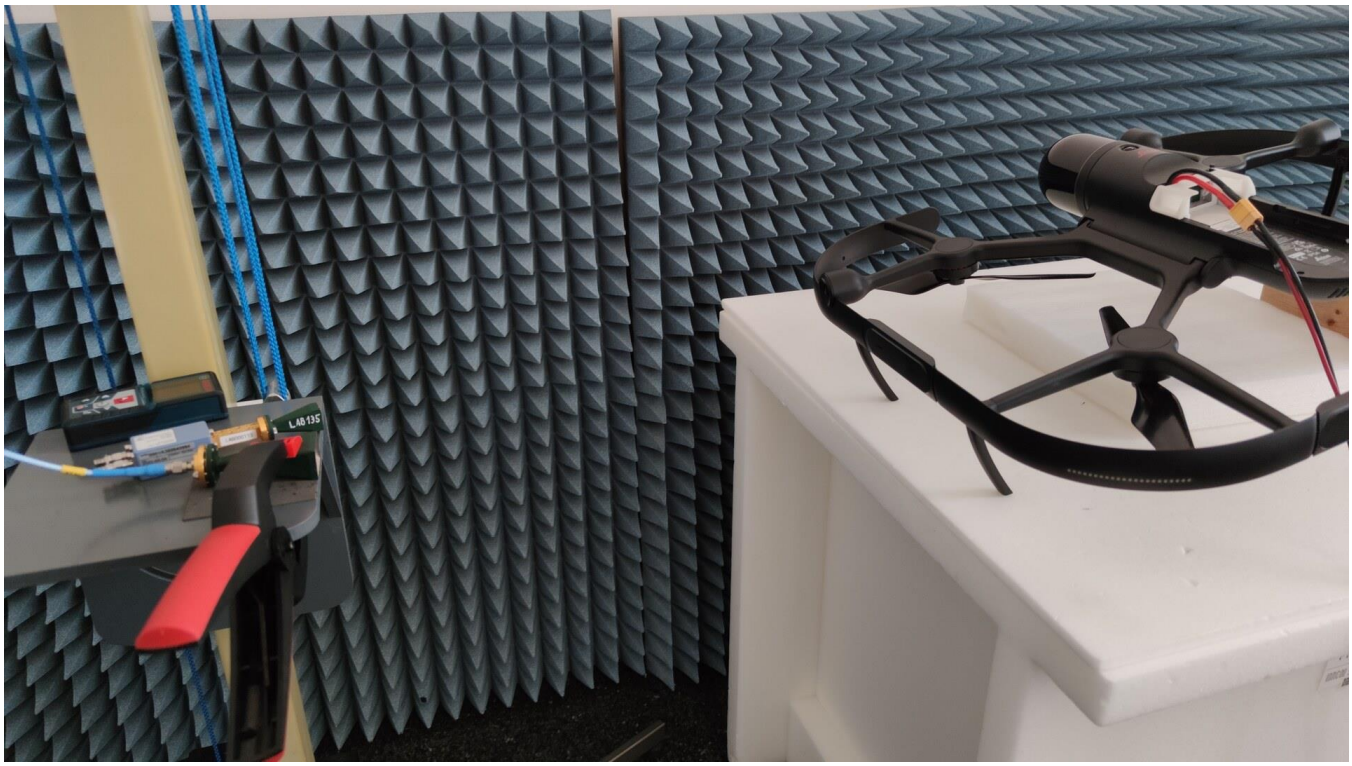


Photo No. 13:

Photo No. 14:



End of Test Report