Report on the FCC and IC Testing of the Hamilton Bonaduz AG Dissolved Oxygen Sensor Model: VisiFerm mA In accordance with FCC 47 CFR Part 15 B and ICES-003

Prepared for: Hamilton Bonaduz AG
Via Crusch 8
CH-7402 Bonaduz

COMMERCIAL-IN-CONFIDENCE

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Alex Fink	2020-06-15	SIGN-ID 368626
Authorised Signatory	Martin Steindl	2020-06-15	SIGN-ID 369103

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

Engineering Statement:
This measurement shown in this report were made in accordance with the procedures described on test pages.
All reporded testing was carried out on a sample equipment to demonstrate limited compilance with with FCC 47 CFR Part 15 B and ICES-003.
The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Alex Fink	2020-06-15	SIGN-ID 368626

Laboratory Accreditation	Laboratory recognition	Industry Canada test site registration
DAkkS Reg. No. D-PL-11321-11-02 DAkkS Reg. No. D-PL-11321-11-03	Registration No. BNetzA-CAB-16/21-15	3050A-2

Executive Statement:
A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15 B:2019 and ICES-003:2019

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Product Service

Content

Product Service

1 Report Summary

1.1 Modification Report

Alternations and additions of this report will be issued to the holders of each copy in the form of a complete document.

Issue	*Description of changes*	*Date of Issue*
1	First Issue	2020-06-15

Table 1: Report of Modifications

1.2 Introduction

Applicant	Hamilton Bonaduz AG
Manufacturer	Hamilton Bonaduz AG
Model Number(s)	VisiFerm mA
Serial Number(s)	SN 4049 SN 4051
Hardware Version(s)	---
Software Version(s)	---
Number of Samples Tested	1
Test Specification(s) / Issue / Date	FCC 47 CFR Part 15 B: 2019 and ICES-003: 2019
Test Plan/Issue/Date	2020-03-03
Order Number	---
Date	---
Date of Receipt of EUT	2020-04-22
Start of Test	2020-05-19
Finish of Test	2020-05-29
Name of Engineer(s)	Alex Fink, Patrick Müller
Related Document(s)	ANSI C63.4: 2014

Product Service

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15 B and ICES-003 is shown below.

Section	*Specification Clause*	*Test Description*	*Result*
Supplied by 24Vdc			
2.1	15.107	Conducted Disturbance at Mains Terminal	Pass
2.2	15.109	Radiated Disturbance	Pass

Table 2: Results according to FCC 47 CFR Part 15 B

Section	*Specification Clause*	*Test Description*	*Result*
Supplied by 24Vdc			
2.1	6.1	AC Power Line Conducted Emissions	Pass
2.2	6.2	Radiated Emissions	Pass

Table 3: Results according to ICES-003

Product Service

1.4 Product Information

1.4.1 Technical Description

VisiFerm mA sensors are intended for the measurement of dissolved oxygen (DO) and oxygen in gas phase. The VisiFerm mA sensors are designed for industrial environments. The measurement is based on optical technology.

Supply Voltage:	120 V
Supply Frequency:	60 Hz
Highest clock frequency:	2,4GHz (Internal frequency 32MHz)

If the EUT contains intentional radiating modules:

(Highest) Clock Frequencies of modules:	2,4GHz (Internal frequency 32MHz)
List of modules:	
FCC IDs of modules:	2AQYJVISIMA
IC IDs of modules:	24225-VISIMA

1.4.2 EUT Ports / Cables identification

Port	Max Cable Length specified	Usage	Type	Screened
Direct Test Mode				
1	1.8	USB to TTL Serial Cable (3.3V) - 1.8m from FTDI with JST connector	---	---
2	3.0	Sensor Cable M12/open end (355283)	---	---

Table 4

1.5 Test Configuration

Direct test mode - VisiFerm mA is in normal operation mode, supplied by 24 V DC.

1.6 Modes of Operation

Direct test mode - VisiFerm mA is in normal operation mode, supplied by 24 V DC.

1.7 Deviations from Standard

None

1.8 EUT Modifications Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	As supplied by the customer	Not Applicable	Not Applicable

Table 5

1.9 Test Location

TÜV SÜD Product Service conducted the following tests at our Straubing test laboratory:

Test Name	Name of Engineer(s)
Direct test mode - VisiFerm mA is in normal operation mode, supplied by 24 V DC.	
Conducted Disturbance at Mains Terminal	Alex Fink, Patrick Müller
Radiated Distubance	Alex Fink, Patrick Müller

Office Address:
Äußere Frühlingstraße 45
94315 Straubing
Germany

Product Service

2 Test Details

2.1 Conducted Emissions on Mains Terminals

2.1.1 Specification Reference

FCC 47 CFR Part 15 B, Clause 15.107
ICES-003, Clause 6.1

2.1.2 Equipment under Test and Modification State

VisiFerm mA, Normal Operation Mode – Modification State 0

2.1.3 Date of Test

2020-05-29

2.1.4 Environmental Conditions

Ambient Temperature	23 °C
Relative Humidity	38 %

2.1.5 Specification Limits

Required Specification Limits (Class A)			
Line Under Test	*Frequency Range (MHz)*	*Quasi-peak (dBµV)*	*Average (dBµV)*
AC Power Port	0.15 to 0.5	79	66
	0.5 to 30	73	60

Table 6 Class A emission limits

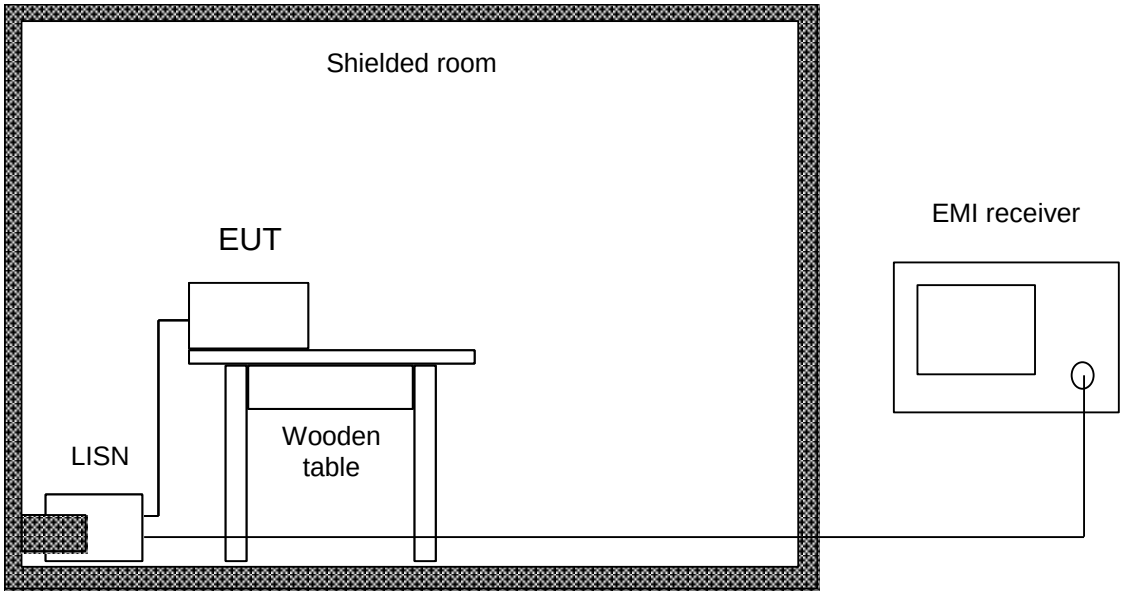
Required Specification Limits (Class B)			
Line Under Test	*Frequency Range (MHz)*	*Quasi-peak (dBµV)*	*Average (dBµV)*
AC Power Port	0.15 to 0.5	66 to 56*	56 to 46*
	0.5 to 5	56	46
	5 to 30	60	50
Supplementary information: *Decreases with the logarithm of the frequency.			

Table 7 Class B emission limits

Product Service

2.1.6 Test Method

The test was performed according to ANSI C63.4, sections 5.2 and 7.



The EUT was placed on a non-conductive table 0.8 m above a reference ground plane and 0.4 m away from a vertical coupling plane.
All power was connected to the EUT through an Line Impedance Stabilization Network (LISN). Conducted disturbance voltage measurements on mains lines were made at the output of the LISN. The LISN was placed 0.8 m from the boundary of the EUT and bounded to the reference ground plane. To simplify testing with quasi-peak and linear average (cispr-average) detector the following procedure is used:
First the whole spectrum of emission caused by the equipment under test (EUT) is recorded with the detectors set to peak and average using CISPR bandwidth of 10 kHz. After that all emission levels having less margin than 10 dB to or exceeding the average limit are retested with the detectors set to quasi-peak and average. If the average limit is kept with quasi-peak levels measurement with average detector is optional. In cases of emission levels between quasi-peak and average limit an additional measurement with average detector has to be performed.

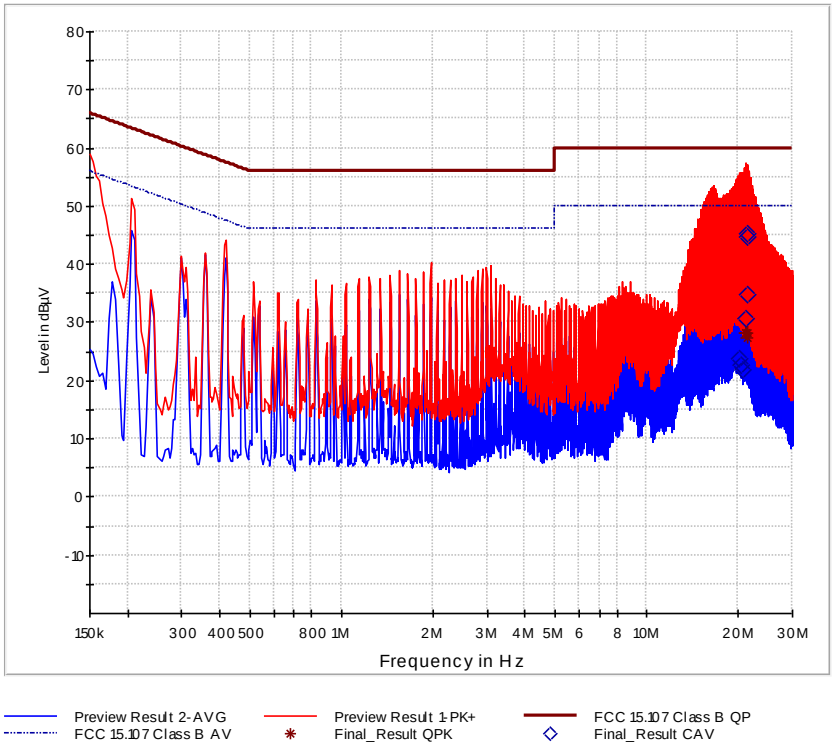
Product Service

2.1.7 Test Results

Sample calculation:

Final Value (dBµV) = Reading Value (dBµV) + (Cable attenuation (dB) + LISN Transducer (dB))

Line - L:

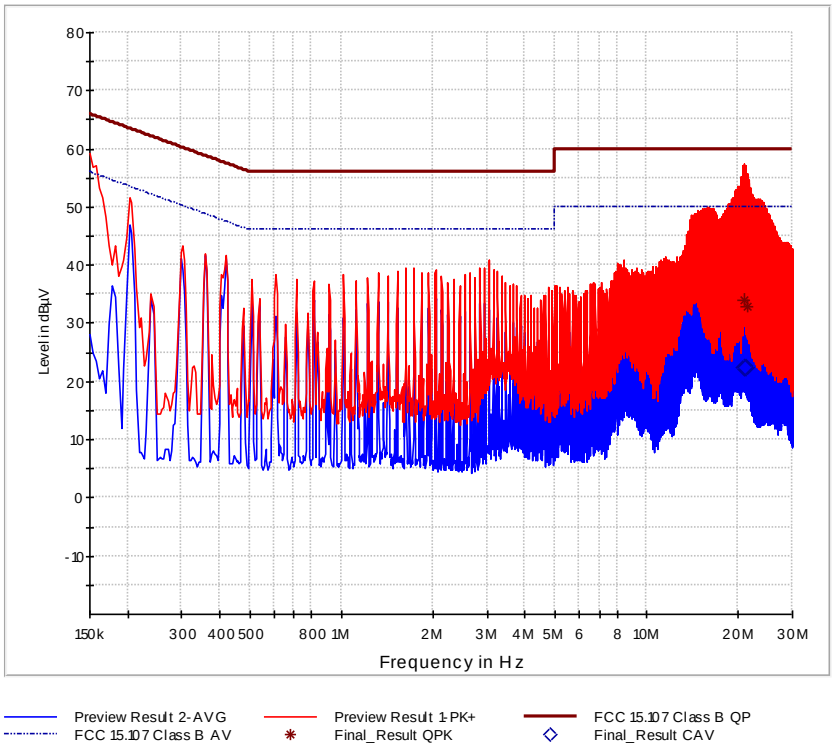


Final Results:

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Line*	*Filter*	*Corr. dB*
20.146000	---	23.91	50.00	26.09	1000.0	9.000	L1	OFF	10.4
20.350000	---	22.58	50.00	27.42	1000.0	9.000	L1	OFF	10.4
20.554000	---	21.90	50.00	28.10	1000.0	9.000	L1	OFF	10.4
21.066000	28.16	---	60.00	31.84	1000.0	9.000	L1	OFF	10.4
21.166000	28.18	---	60.00	31.82	1000.0	9.000	L1	OFF	10.4
21.170000	---	30.60	50.00	19.40	1000.0	9.000	L1	OFF	10.4
21.270000	---	34.86	50.00	15.14	1000.0	9.000	L1	OFF	10.4
21.274000	28.25	---	60.00	31.75	1000.0	9.000	L1	OFF	10.4
21.370000	27.51	---	60.00	32.49	1000.0	9.000	L1	OFF	10.4
21.374000	---	45.18	50.00	4.82	1000.0	9.000	L1	OFF	10.4
21.474000	---	44.69	50.00	5.31	1000.0	9.000	L1	OFF	10.4

Product Service

Line - N:



Final Results:

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Line*	*Filter*	*Corr. dB*
20.830000	---	22.35	50.00	27.65	1000.0	9.000	N	OFF	10.4
20.830000	34.07	---	60.00	25.93	1000.0	9.000	N	OFF	10.4
21.034000	---	22.39	50.00	27.61	1000.0	9.000	N	OFF	10.4
21.438000	32.77	---	60.00	27.23	1000.0	9.000	N	OFF	10.4

Product Service

2.1.8 Test Location and Test Equipment

The test was carried out in shielded cabin no.4.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI test receiver	Rhode & Schwarz	ESU8	19904	12	2021-01-31
V-Network	Rhode & Schwarz	ESH 3-Z5	18920	36	2020-06-30
Shielded room	Euroshield	No.4	19414	---	---
EMC Measurement Software	Rhode & Schwarz	EMC32 Software version 10.50.10	42986	---	---

Table 8

Product Service

2.2 Radiated Emissions

2.2.1 Specification Reference

FCC 47 CFR Part 15 B, Clause 15.109
ICES-003, Clause 6.2

2.2.2 Equipment under Test and Modification State

VisiFerm mA, Normal Operation Mode

2.2.3 Date of Test

2020-05-19 / 2020-05-29

2.2.4 Environmental Conditions

Ambient Temperature	23 °C
Relative Humidity	38 %

Product Service

2.2.5 Specification Limits

On any frequency below or equal to 1000 MHz, the limits shown are based on measureing equipment employing a CISPR quasi-peak detector function and related measurement bandwidths. As an alternative to CISPR quasi-peak measurements compliance may be demonstrated with the emission limits using measuring equipment employing a peak detector function as long as the same bandwidth as indicated for CISPR quasi-peak measurements are employed.
Above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified, there also is a limit on the peak level of the radio frequency emissions. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit. This peak limit applies to the total peak emission level radiated by the device.

Required Specification Limits (Class A)		
Frequency Range	*Field strength in 10 m distance*	
(MHz)	*(µV/m)*	*(dBµV/m)*
30 – 88	90	39
88 – 216	150	43.5
126 – 960	210	46.4
above 960	300	49.5

Table 9 Class A emission limits

Required Specification Limits (Class B)		
Frequency Range	*Field strength in e m distance*	
(MHz)	*(µV/m)*	*(dBµV/m)*
30 – 88	100	40
88 – 216	150	43.5
126 – 960	200	46
above 960	500	54

Table 10 Class B emission limits

As an alternative to the radiated emission limits shown above, digital devices may be shown comply with the standards contained in the 3rd Edition of CISPR 22. In addition: if measurements must be performed above 1000 MHz, compliance above 1000 MHz shall be demonstrated with the emission limits above. Measurements above 1000 MHz may be performed at the distance specified in the CISPR 22 publications for measurements below 1000 MHz provided the limits above are extrapolated to the new measurement distance using an inverse linear distance extrapolation factor (20 dB/decade), e.g., the radiated limit above 1000 MHz for Class B digital devices is 150 µV/m as measured at a distance of 10 meters.

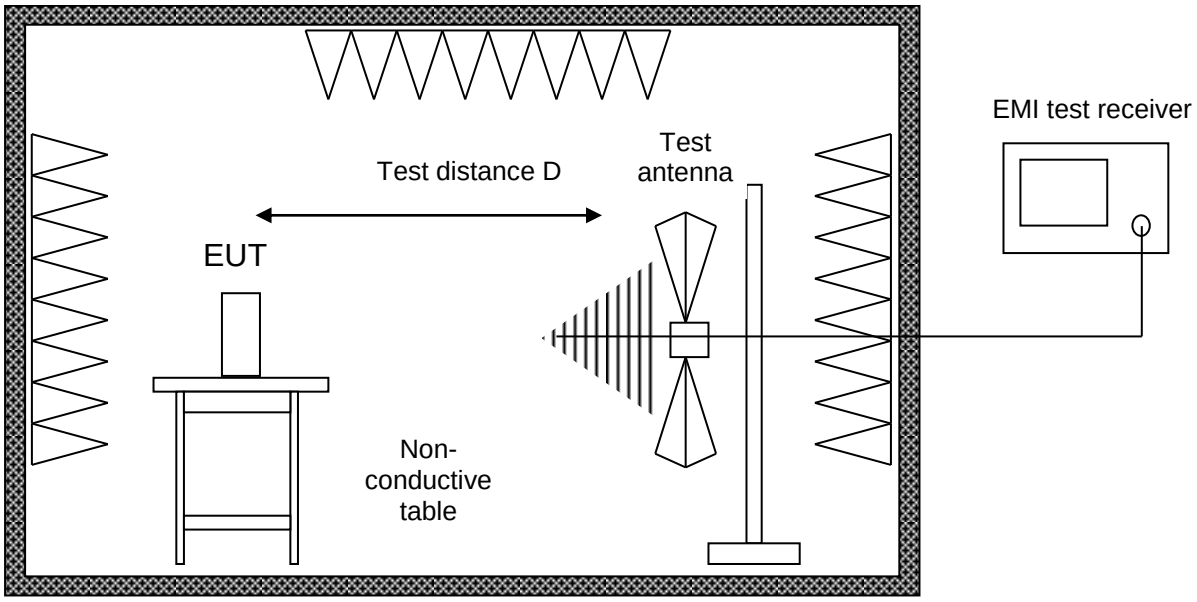
Product Service

2.2.6 Test Method

The test was performed according to ANSI C63.4, sections 5.4, 44 and 8.

The EUT was placed on a non-conductive table, 0.8 m above the ground plane.
Prescans are performed in six positions of the EUT to get the full spectrum of emission caused by the EUT with the measuring antenna raised and lowered from 1 m to 4 m with vertical and horizontal polarisation to find the combination of table position, antenna height and antenna polarisation for the maximum emission levels.
Data reduction is applied to these results to select those levels having less margin than 10 dB or exceeding the limit using subranges and limited number of maximums.
Further maximisation for adjusting the maximum position is following.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

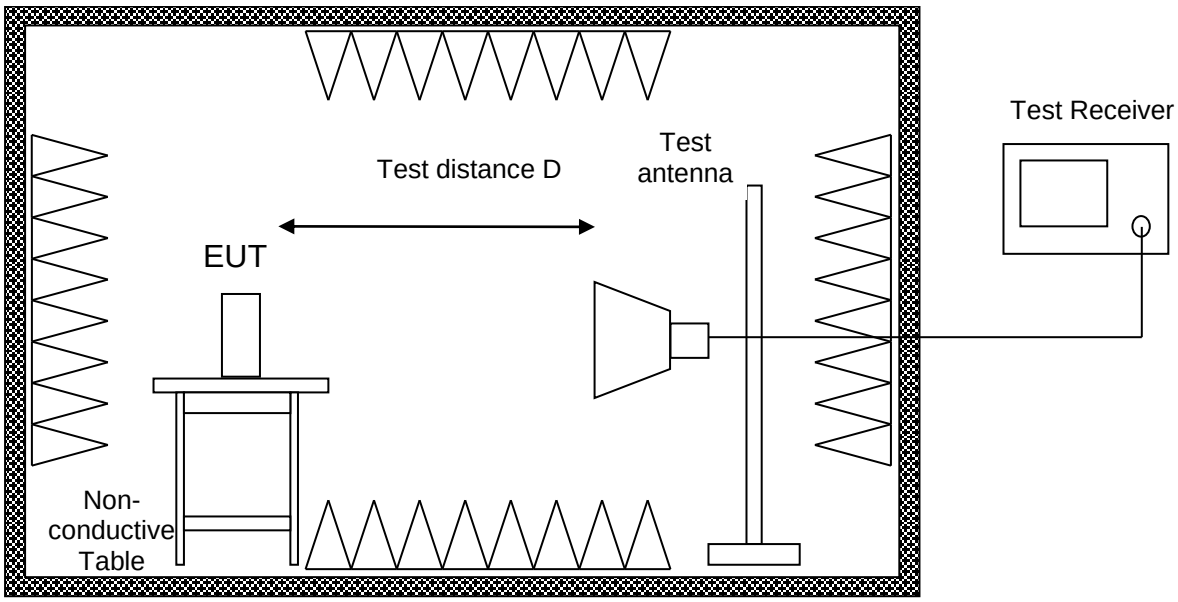
2.2.6.1 Frequency range 30 MHz – 1 GHz



Alternate test site (semi anechoic room)

Radiated emissions in the frequency rang 30 MHz – 1 GHz is measured within a semi-anechoic room with groundplane complying with the NSA requirements of ANSI C63.4. for alternative test sites. A linear polarised logarithmic periodic antenna combined with a 4:1 broadband dipole (“Trilog broadband antenna”) is used.
For prescan tests the test receiver is set to peak-detector with a bandwidth of 120 kHz.
With the measurement bandwidth of the test receiver set to 120 kHz CISPR quasi-peak detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.

2.2.6.2 Frequency range above 1 GHz



Fully anechoic room

Radiated emission tests above 1 GHz are performed in a fully anechoic room complying with the S_{VSWR} requirements of ANSI C63.4. Measurements are performed both in the horizontal and vertical planes of polarisation using a test receiver with the detector function set to peak and average and the resolution bandwidth set to 1 MHz. Testing above 1 GHz is performed with horn antennas with the EUT in boresight of the anntenna.
For prescan tests the test receiver is set to peak- and average-detector with a bandwidth of 1 MHz. With the measurement bandwidth of the test receiver set to 1 MHz and peak- and CISPR average-detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.

Product Service

2.2.7 Test Results

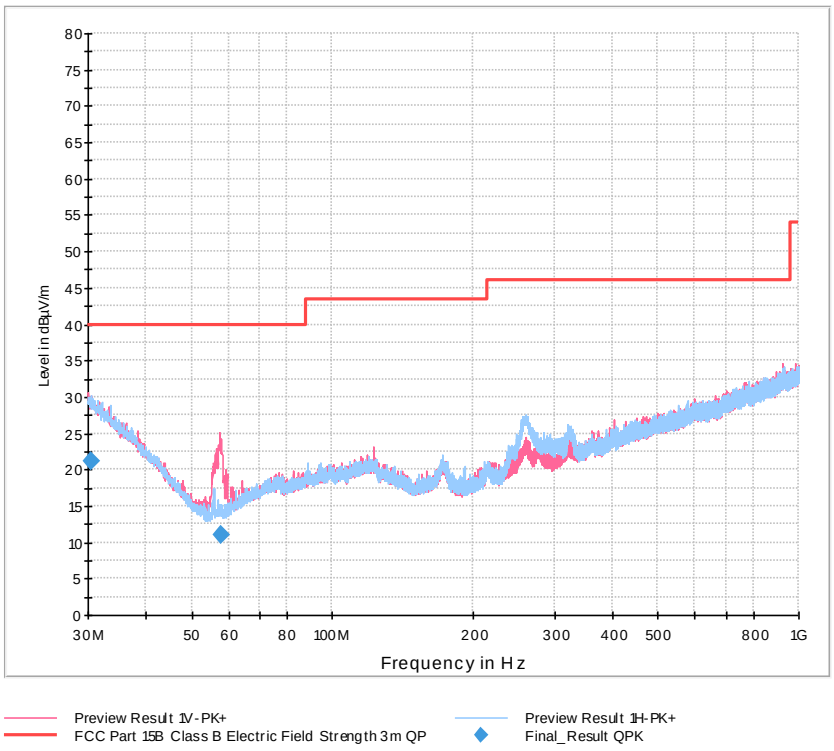
Frequency range	*Limit applied*	*Test distance*
30 MHz – 1 GHz	FCC Part 15B, Class B	3 m
1 GHz – 13 GHz	FCC Part 15B, Class B	3 m

Table 11

Sample calculation:

Final Value (dBµV/m) = Reading Value (dBµV) + (Cable attenuation (dB) + Antenna Transducer (dB(1/m)))

Frequency range 30 MHz – 1 GHz, 1. Axis:



Final Results:

Frequency MHz	*Qua-siPeak dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
30.480000	21.21	40.00	18.79	1000.0	120.000	300.0	V	165.0	25.5
57.840000	11.06	40.00	28.94	1000.0	120.000	156.0	V	-74.0	12.1

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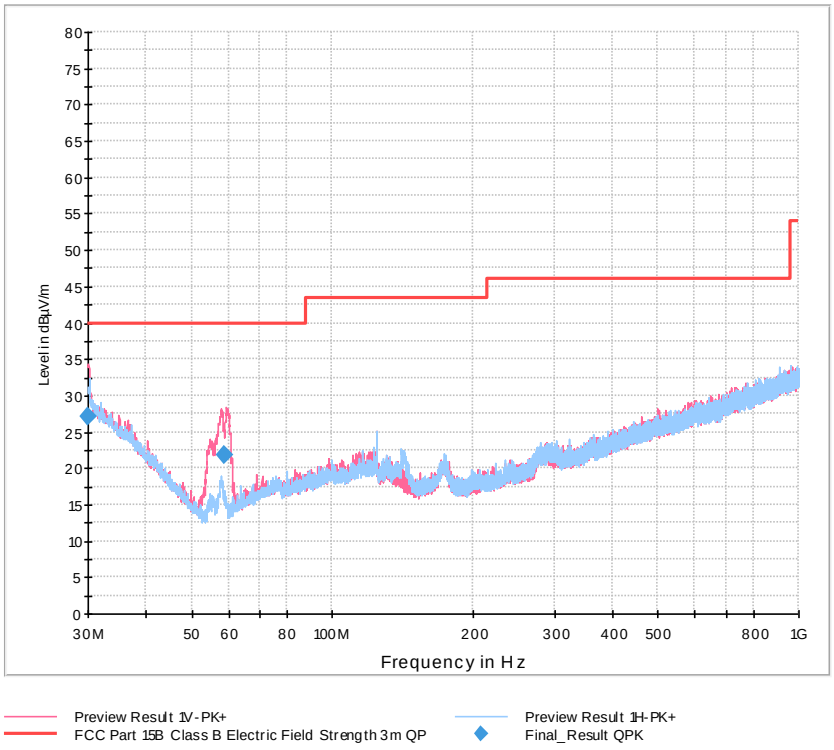
Frequency range 30 MHz – 1 GHz, 2. Axis:

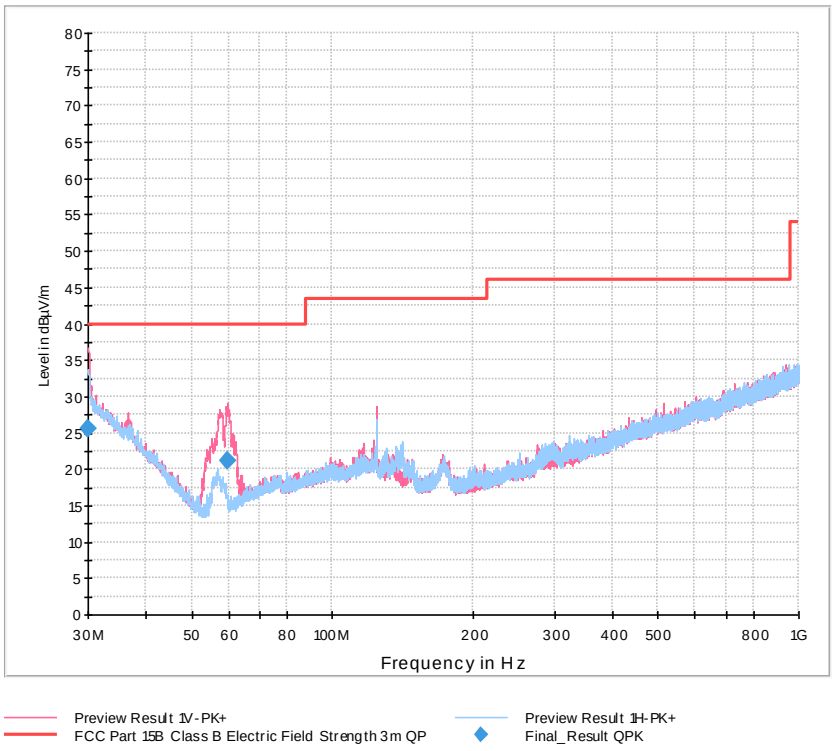


Final Results:

Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
30.000000	27.21	40.00	12.79	1000.0	120.000	196.0	V	-92.0	25.8
58.950000	21.84	40.00	18.16	1000.0	120.000	194.0	V	178.0	12.4

Product Service

Frequency range 30 MHz – 1 GHz, 3. Axis:



Final Results:

Frequency MHz	*Qua-siPeak dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
30.000000	25.64	40.00	14.36	1000.0	120.000	180.0	V	-149.0	25.8
59.520000	21.26	40.00	18.74	1000.0	120.000	179.0	V	-4.0	12.5

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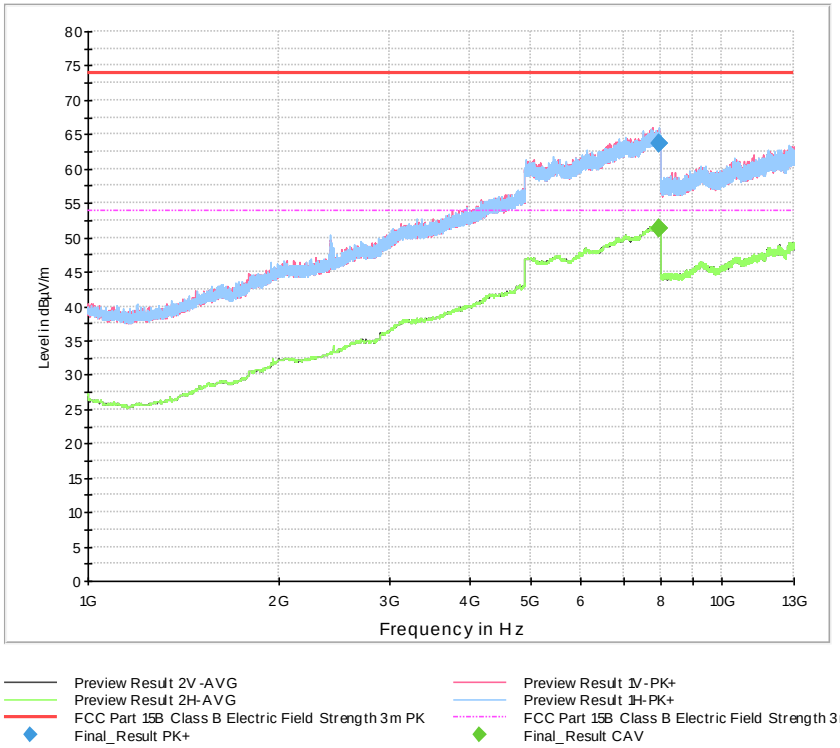
Frequency range 1 – 13 GHz, 1. Axis:

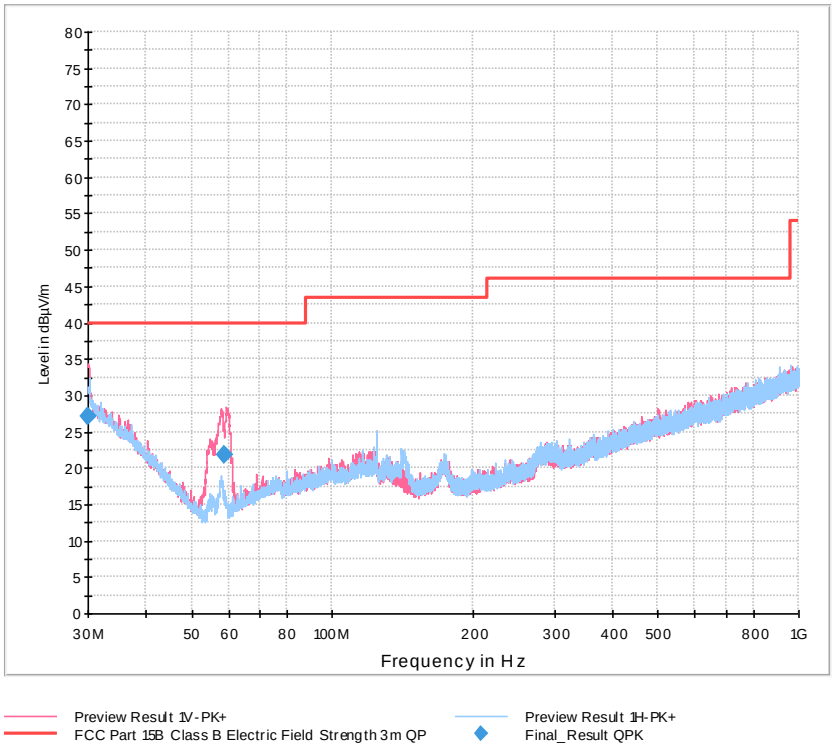


Final Results:

Frequency MHz	*Max-Peak dBµV/m*	*CAver-age dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
7950.500000	---	51.25	53.98	2.73	1000.0	1000.000	268.0	V	31.0	43.4
7950.500000	63.76	---	73.98	10.22	1000.0	1000.000	268.0	V	31.0	43.4
7967.250000	---	51.28	53.98	2.70	1000.0	1000.000	325.0	H	96.0	43.4
7967.250000	63.79	---	73.98	10.19	1000.0	1000.000	325.0	H	96.0	43.4

Product Service

Frequency range 1 – 13 GHz, 2. Axis:

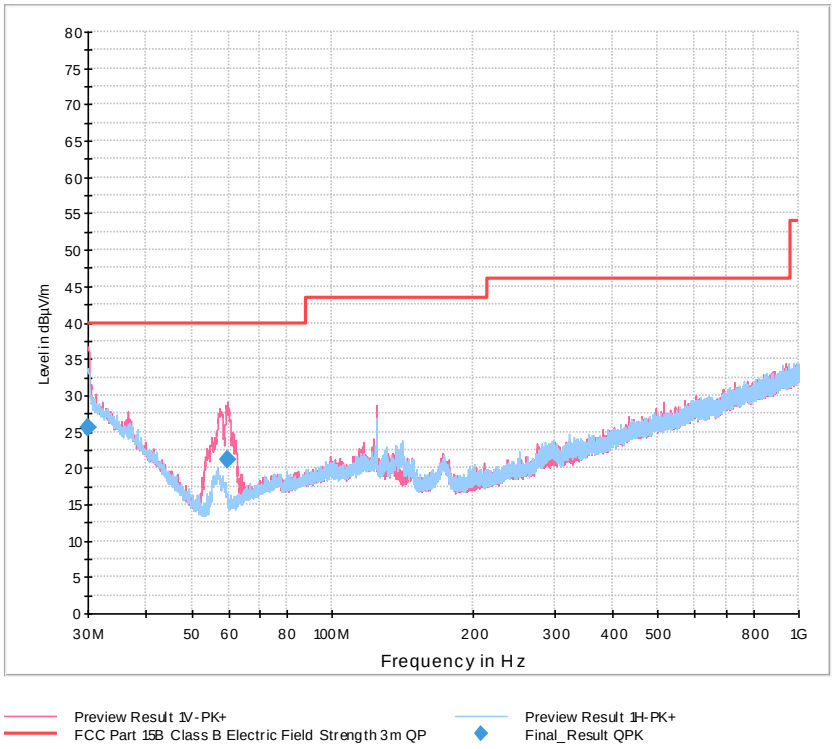


Final Results:

Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
30.000000	27.21	40.00	12.79	1000.0	120.000	196.0	V	-92.0	25.8
58.950000	21.84	40.00	18.16	1000.0	120.000	194.0	V	178.0	12.4

Product Service

Frequency range 1 – 13 GHz, 3. Axis:



Final Results:

Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB/m*
30.000000	25.64	40.00	14.36	1000.0	120.000	180.0	V	-149.0	25.8
59.520000	21.26	40.00	18.74	1000.0	120.000	179.0	V	-4.0	12.5

Product Service

2.2.8 Test Location and Test Equipment

The test was carried out in semi anechoic room, cabin no. 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
EMI test receiver	Rhode & Schwarz	ESW44	39897	12	2021-03-31
ULTRALOG Antenna	Rhode & Schwarz	HL562E	39969	36	2022-11-30
Doubled ridged horn Antenna	Rhode & Schwarz	HF907	40089	24	2021-02-28
Semi Anechoic Room	Frankonia	Cabin no. 11	42961	36	2022-08-31
EMC Measurement Software	Rhode & Schwarz	EMC32 Software version 10.50.10	42986	---	---

Table 11

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3 Measurement Uncertainty

The measurement uncertainty in the laboratory is less than or equal to the maximum measurement uncertainty according to CISPR16-4-2: 2011 + A1 + A2 + Cor1 (U_{CISPR}). This normative regulation means that the measured value is also the value to be assessed in relation to the limit value.

For a 95% confidence level. the measurement uncertainties for defined systems are:

Radio Interference Emission Testing			
Test Name	kp	Expanded Un-certainty	Note
Conducted Voltage Emission			
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB	1
100 kHz to 200 MHz (50Ω/5µH AMN)	2	± 3.6 dB	1
Discontinuous Conducted Emission			
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB	1
Conducted Current Emission			
9 kHz to 200 MHz	2	± 3.5 dB	1
Magnetic Fieldstrength			
9 kHz to 30 MHz (with loop antenna)	2	± 3.9 dB	1
9 kHz to 30 MHz (large-loop antenna 2 m)	2	± 3.5 dB	1
Radiated Emission			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 5.0 dB	1
1 GHz to 6 GHz	2	± 4.6 dB	1
Test distance 10 m			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 4.9 dB	1

Table 12

Note 1:
The expanded uncertainty reported according to CISPR16-4-2: 2011 + A1 + A2 + Cor1 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$. providing a level of confidence of p = 95.45%

Product Service

Photographs of Test Setup

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