TEST REPORT # EMCC-931028NAC, 2019-10-07

- This Test Report supersedes Test Report # EMCC-931028NAB, 2019-09-04 -

EQUIPMENT UNDER TEST:

Trade Name:	FSC
EUT Number, Type, Serial Number(s):	EUT#1, FSC 1/7, 110 EUT#2, FSC 1000, 113
Application:	Paint thickness gauge
FCC ID:	2AMBGMEMW02
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Address:	Königbacher Str. 15 94496 Ortenburg GERMANY
Name:	Maik Richter
Phone:	+49 8542 168-673
E-Mail:	Maik.Richter@micro-epsilon.de

RELEVANT STANDARD(S) : 47 CFR § 15.249

MEASUREMENT PROCEDURE: : ANSI C63.10-2013

TEST REPORT PREPARED BY:

Ludwig Kraft
EMCCons DR. RAŠEK GmbH & Co. KG
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Tested:

Patrick Reusch

Ludwig Kraft

Checked:

Reinhard Sauerschell
-Head of Laboratory –

CONTENTS PAGE

0 REVISION HISTORY

Project number	Issue date	Chapter	Description
931028NA	2019-08-14	n.a.	Initial issue
931028NAB	2019-09-04	4.1; 4.3	Antenna requirement and occupied Bandwidth measurement added, numbering of chapter 4 adjusted
931028NAC	2019-10-07	Title page; 2.1; Annex 1; Annex 2; Annex 3; Annex 4	FCC ID changed

1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance with the 47 CFR §15.249 requirements applicable to intentional radiators (subpart C).

1.2 Limits and Reservations

The test results in this report apply only to the particular equipment under test (EUT) as declared in this report. This test report shall not be reproduced except in full without the written permission of EMCCons DR. RAŠEK GmbH & Co. KG.

1.3 Test Laboratory

Test Laboratory:	EMCCons DR. RAŠEK GmbH & Co. KG
Accreditation No.:	D-PL-12067-01-04
Address of Labs I, II, III and Head Office:	EMCCons DR. RAŠEK GmbH & Co. KG Boelwiese 8 91320 Ebermannstadt GERMANY
Address of Labs IV and V:	EMCCons DR. RAŠEK GmbH & Co. KG Stoernhofer Berg 15 91364 Unterleinleiter GERMANY
Phone:	+49 9194 7262-0
Fax:	+49 9194 7262-199
E-Mail:	info@emcc.de
Web:	www.emcc.de

1.4 Customer

Company Name:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Street:	Königbacher Str. 15
City:	94496 Ortenburg
Country:	GERMANY
Name:	Mr Maik Richter
Phone:	+49 8542 168-673
Fax:	+49 8542 168-90
E-Mail:	Maik.Richter@micro-epsilon.de

1.5 Manufacturer

Company Name:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Street:	Königbacher Str. 15
City:	94496 Ortenburg
Country:	GERMANY
Phone:	+49 8542 168-673
E-Mail:	Maik.Richter@micro-epsilon.de

1.6 Dates and Test Location

Date of receipt of EUT: 2019-05-16
Test Date: CW 20 to 21/2019
Test Location: Lab IV

1.7 Ordering Information

Purchase Order: B154425
Date: 2019-03-26, 2019-08-06
Vendor-Number: 74586

1.8 Climatic Conditions

Date	Temperature	Relative Humidity	Air Pressure	Lab	Customer attended tests
--	°C	%	hPa	--	--
2019-05-16	23	32	974	IV	Yes, Mr Richter
2019-05-17	23	35	967	IV	Yes, Mr Richter
2019-05-20	24	42	961	IV	Yes, Mr Richter
2019-05-21	24	44	964	IV	Yes, Mr Richter

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

The following data is based on customer's information.

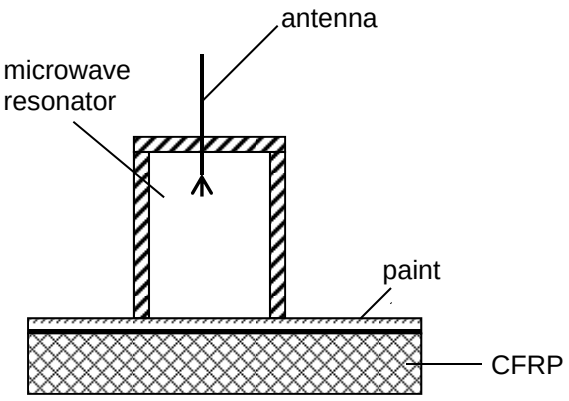
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type; EUT No, Serial No(s):	FSC 1/7; EUT#1, 110 FSC 1000; EUT#2, 113
Application:	Paint thickness gauge
No of variants:	1; FSC 1000 is a variant of FSC 1/7 with a different measurement range due to a different resonator dimension.
Firmware version:	8010182
Hardware version:	Gen2
FCC ID:	2AMBGMEMW02
Highest internal frequency:	24.245 GHz
TX operating frequency range:	24.005 .. 24.245 GHz
No of operating channels:	n/a
Used channels during test:	Fmin: 24.012 GHz Fmid: 24.125 GHz Fmax: 24.238 GHz
Power source:	External DC (5 V_{DC})
Voltage for testing:	5 V_{DC} (from USB-Connector connected to FSC1)
Ports:	USB Connector
Antenna:	Internal
Max. antenna gain:	n/a
Remarks:	None

The following information was delivered by the customer:
"

The FSC1/7 and FSC1000 are suitable to measure the paint thickness (dielectric layer) on CFRP with and without lightning protection as well as on metal.

The system consists of a sensor module (Sensor) and a control and display module (Controller).

The Sensor includes microwave circuit components. It is intended for measuring a resonant frequency which is determined by a dielectric layer on a base substrate. The main part of the measure system, the resonator, and its application is shown in the picture below.



- *A resonant cavity having a rotationally symmetrical wall and a plane wall on one end thereof, wherein the opposite end is open to be placed up on the dielectric layer on the substrate to form a wall of the resonant cavity on the opposite end.*
- *An antenna located within said resonant cavity and adapted to excite an electromagnetic field in the resonant cavity.*
- *A reflection meter connected to said antenna and adapted to measure the resonance frequency of the resonant cavity. The device operates in "frequency stepped continuous wave" (FSCW) mode. The measurements of all individual frequency steps are performed under steady state conditions. At the measurements no intermediate frequencies are generated. The receiver output signal is a dc signal at each individual frequency point.*
- *The Transceiver is driven in a way that frequencies only in the range from 24.010 to 24.240 GHz are adjustable.*
- *The output power of the transceiver is less than -15dBm. The output signal of the internal generator is only active during the measurement process, after that it is turned off.*
- *A processor connected to said reflection meter and adapted to determine the resonance frequency of the resonant cavity.*

"

2.2 Intended Use

The following information was delivered by the customer.

The FSC1/7 and FSC1000 are suitable to measure the paint thickness (dielectric layer) on CFRP with and without lightning protection as well as on metal.

2.3 EUT Peripherals/Simulators

The EUT was tested being connected via USB cable to an FSC1 Controller, 4112002, serial number 0113. The FSC1 Controller was connected to a power charger V-Charge ECO NIMH 2000.

2.4 Mode of operation during testing and test setup

The equipment under test (EUT) was operated during the tests under the following conditions:

Sweep mode:
the frequency was swept continuously sawtooth-shaped from the lowest to the highest settable frequency. This test mode simulates a cyclic repetition of a measurement in normal operation mode, with one measurement every 2 seconds. This mode was used for measurements up to 18 GHz.

Fixed CW frequency:
- Fmin = the transmitting frequency was set to the lowest settable frequency (24.012 GHz)
- Fmax = the transmitting frequency was set to the highest settable frequency (24.238 GHz)
- Fmid = the transmitting frequency was set in the center of the operating band (24.125 GHz)

Fmid was used for measurements above 18 GHz.
All tests were operated with a test software which provided these test modes.

All radiated measurements were done with FSC 1000, EUT #2. The measurements above 18 GHz were done with the FSC 1/7, EUT #1 in addition. The difference between both types is the resonator dimension which has no impact below the actual transmitter frequency.

2.5 Modifications required for compliance

None.

3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No. : FSC 1/7, 110
FSC 1000, 113

Requirement	47 CFR Section	Report Section	Tested EUT	Result
Antenna Requirement	§ 15.203	4.1	EUT#1 (SN 110) EUT#2 (SN 113)	Passed
AC Power Line Conducted Emissions	§ 15.207	4.2	EUT#2 (SN 113)	Passed
Occupied Bandwidth	§ 15.215	4.3	EUT#1 (SN 110) EUT#2 (SN 113)	Passed
Radiated Field Strength of Fundamental	§ 15.249	4.4	EUT#1 (SN 110) EUT#2 (SN 113)	Passed
Radiated Emissions 9kHz – 30 MHz	§ 15.209, § 15.249	4.5.4	EUT#2 (SN 113)	Passed
Radiated Emissions 30 MHz – 1000 MHz	§ 15.209, § 15.249	4.5.8	EUT#2 (SN 113)	Passed
Radiated Emissions 1 GHz – 100 GHz	§ 15.209, § 15.249	4.5.9 - 12	EUT#1 (SN 110)* EUT#2 (SN 113)	Passed

N.A. – not applicable; N.T. – Not tested acc. to applicant's order.
* used from 18 GHz to 100 GHz only

The client has made the determination that EUT Condition, Characterization, and Mode of Operation are representative of production units and meet the requirements of the specifications referenced herein.
Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) are factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.
The measurements contained in this report were made in accordance with the procedures described in ANSI C63.10-2013 and all applicable Public Notices received prior to the date of testing.All requirements were found to be within the limits outlined in this report.

The test results in this report apply only to the particular equipment under test (EUT) as declared in this report.

Test personnel: Ludwig Kraft
Issuance date: 2019-10-07

4 DETAILED TEST RESULTS

4.1 Antenna Requirement

4.1.1 Regulation

47 CFR §15.203 Antenna requirement

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. The use of a permanently attached antenna or of an antenna that uses 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 a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §§15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

4.1.2 Test Result

The EUT has an integrated antenna which part of the microwave resonator.

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No:	FSC 1/7, 110
	FSC 1000, 113
Test date:	2019-08-30
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.2 AC Power Line Conducted Emissions

4.2.1 Regulation

47 CFR § 15.207 Conducted limits

(a) Except as shown in paragraphs (b) and (c) of this section, for 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 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.

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.

4.2.2 Test Procedures

Testing is performed acc. to ANSI C63.10-2013.

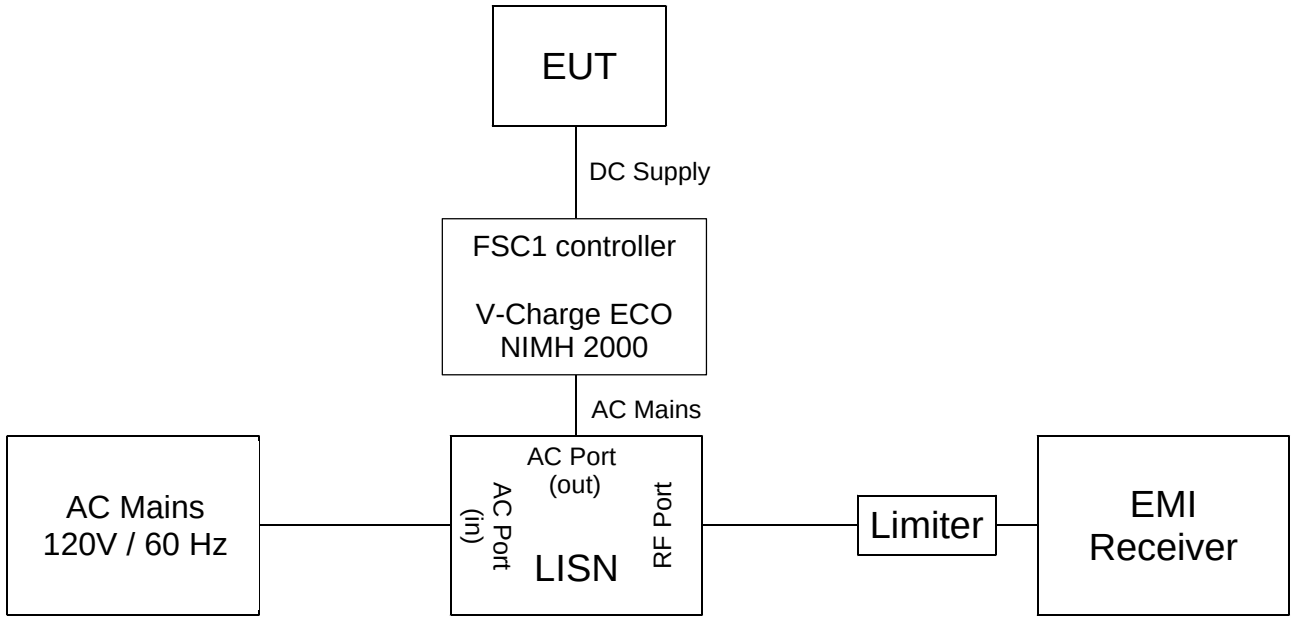
Tabletop and their ancillary devices are placed on a nonconducting table with nominal dimension of 1.0 m by 1.5 m, height 0.8 m above the ground plane. The EUT is centered laterally (left to right facing the tabletop) on the tabletop and its rear is flush with the rear of the table. Accessories or peripherals that are part of a system tested on a tabletop are being placed in a test arrangement on one or both sides of the host with a 10 cm separation between the nearest points of the cabinets.

Interconnecting cables that hang closer than 40 cm to the ground plane are folded back and forth in the center forming a bundle 30 cm to 40 cm long.

The EUT's DC port was connected to the FSC1 controller and the V-Charge ECO NIMH 2000, which was connected to a LISN supplied by 120 VAC / 60 Hz.

The measurement receiver is connected to the 50 Ω RF port of the LISN.

4.2.3 Test Setup

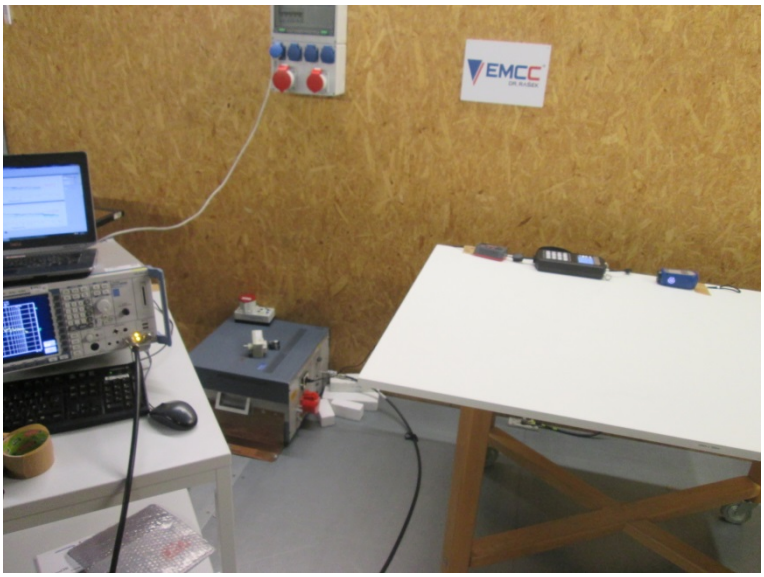


SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.207
Procedure: ANSI C63.10-2013

Power source: #001
Receiver: #3846
LISN: #1901

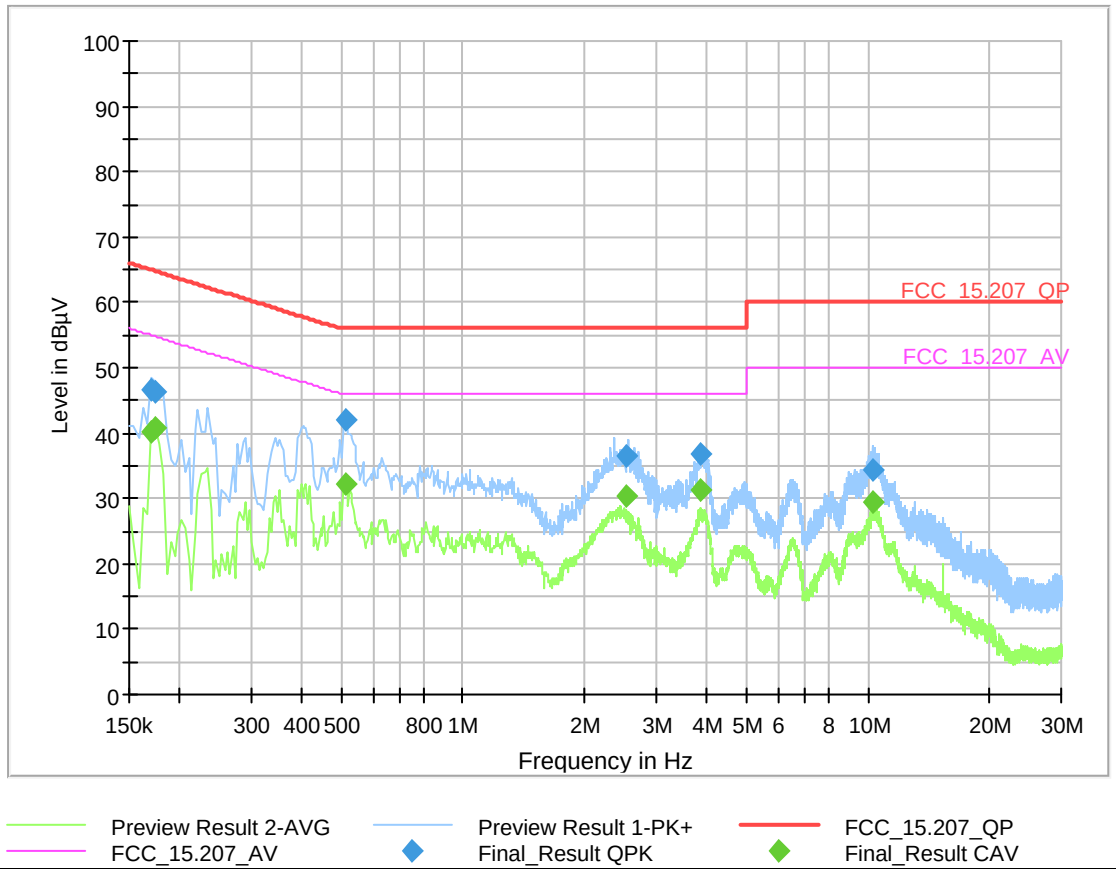
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 1890, 1901, 3148, 3846, 3880, 4524, 4597, 4717, 5392, 5551



Sample photo of setup

4.2.4 Detailed Test Data

Manufacturer: Type: Serial No: Mode: Line:	MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1000 113 Sweep (Accu 70-100% charged) L and N (max hold)



Final Result:

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.170	---	40.1	54.9	14.8	1000	9	L1	10.0
0.174	---	40.7	54.7	14.0	1000	9	L1	10.0
0.513	---	32.3	46.0	13.7	1000	9	L1	10.0
2.525	---	30.5	46.0	15.5	1000	9	L1	10.0
3.845	---	31.3	46.0	14.7	1000	9	L1	10.0
10.229	---	29.4	50.0	20.6	1000	9	L1	10.0

Worst case results listed, only.

4.2.5 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No.:	113
Test date:	2019-05-21
Test personnel:	Patrick Reusch

The EUT meets the requirements of this section.

4.3 Occupied Bandwidth

4.3.1 Regulation

47CFR § 15.215 Additional provisions to the general radiated emission limitations.

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

47CFR §15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHZ, and 24.0-24.25 GHz.

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

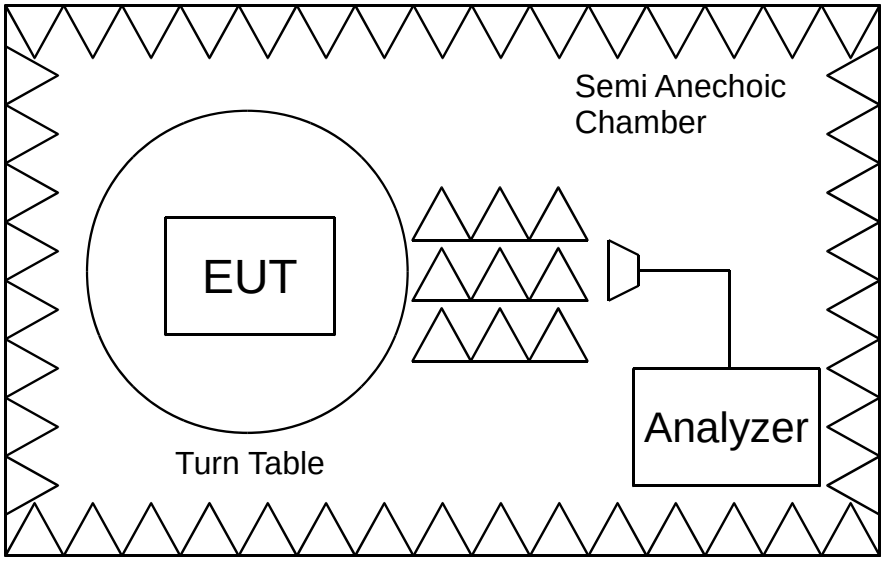
Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

4.3.2 Test Procedures

Testing is performed acc. to ANSI C63.10-2013.

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five 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 video bandwidth (VBW) shall be approximately three times 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) Steps a) through c) might require iteration to adjust within the specified tolerances.
e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "–xx dB down" requirement; that is, if the requirement calls for measuring the –20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
f) Set detection mode to peak and trace mode to max hold.
g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).
h) Determine the "–xx dB down amplitude" using [(reference value) – xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.
i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "–xx dB down amplitude" determined in step h). If a marker is below this "–xx dB down amplitude" value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "–xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.
k) 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).

4.3.3 Test Setup

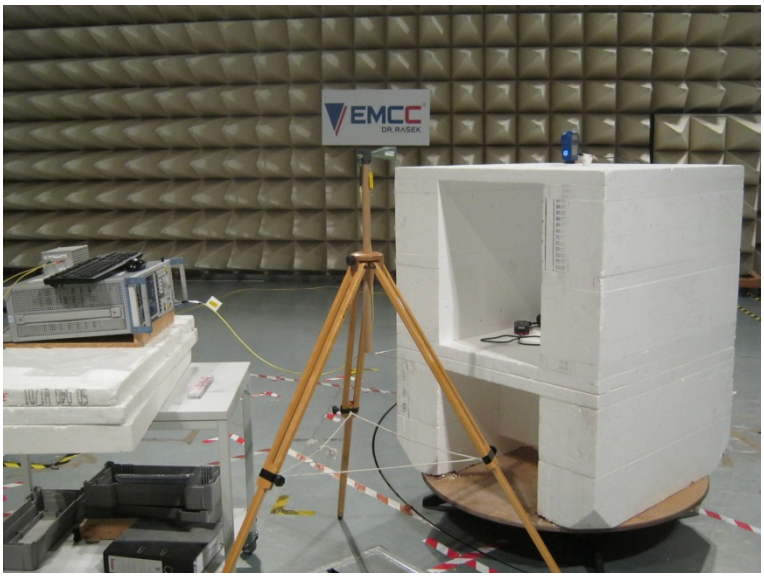


SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.215
Procedure: ANSI C63.10-2013

Test Distance: 1 m

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 1300, 1889, 3061, 3831, 4717, 4914, 5536

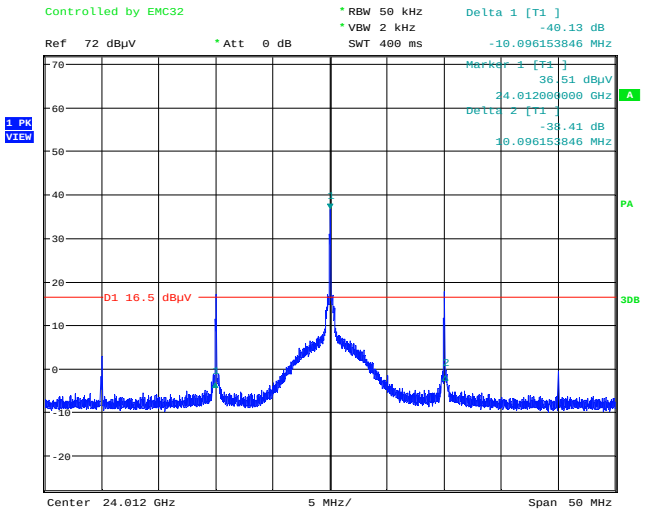


Sample photo of setup

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

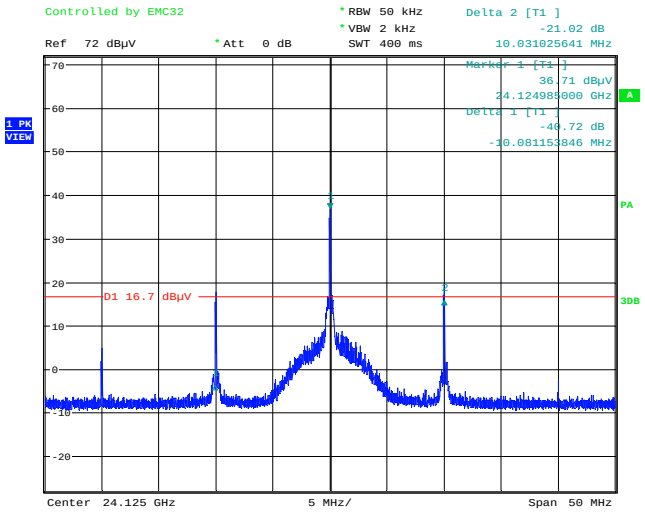
- **EUT #1; FSC 1/7; SN: 110**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin



FS1/7; Fmin
Date: 20.MAY.2019 12:04:54

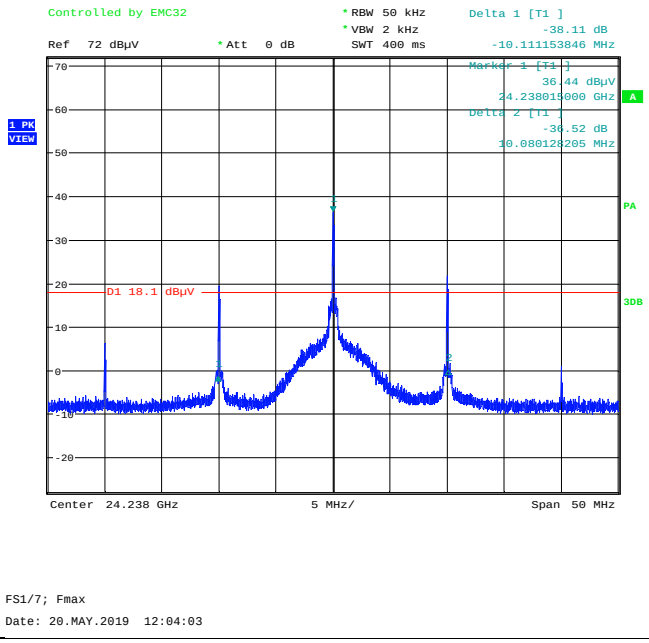
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid



FS1/7; Fmid
Date: 20.MAY.2019 12:02:34

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax



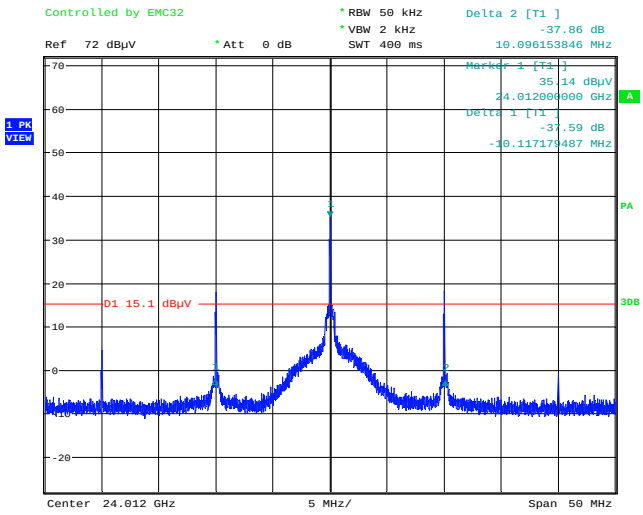
Final Result:

EUT mode	Center Frequency [GHz]	Lower 20 dB Freq. Edge [GHz]	Upper 20 dB Freq. Edge [GHz]	20 dB Bandwidth [MHz]	Limit ---
Fmin	24.012	24.002	24.022	20.19	Within band 24.0 – 24.25 GHz
Fmid	24.125	24.115	24.135	20.11	Within band 24.0 – 24.25 GHz
Fmax	24.238	24.228	24.248	20.19	Within band 24.0 – 24.25 GHz

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

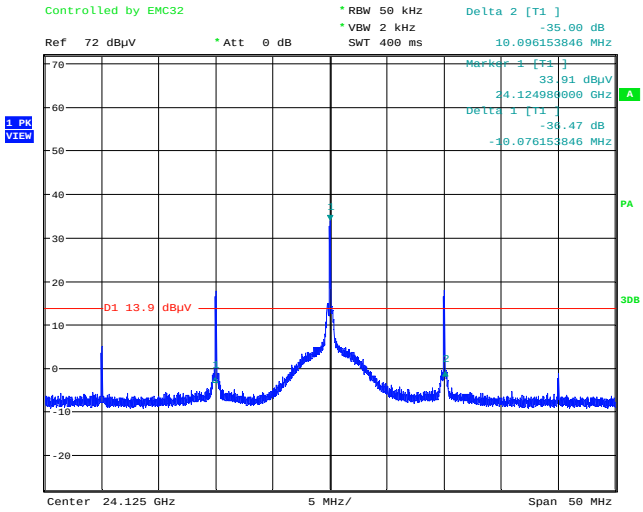
- **EUT #2; FSC 1000; SN: 113**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin



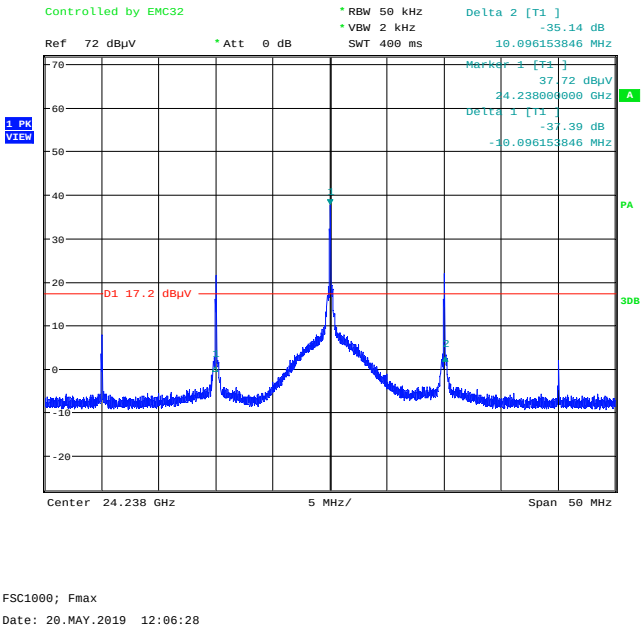
FSC1000; Fmin
Date: 20.MAY.2019 12:05:30

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid



FSC1000; Fmid
Date: 20.MAY.2019 12:06:00

Manufacturer: Type: Serial No: Mode:	MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1000 113 Fmax



Final Result:

EUT mode	Center Frequency [GHz]	Lower 20 dB Freq. Edge [GHz]	Upper 20 dB Freq. Edge [GHz]	20 dB Bandwidth [MHz]	Limit ---
Fmin	24.012	24.002	24.022	20.21	Within band 24.0 – 24.25 GHz
Fmid	24.125	24.115	24.135	20.17	Within band 24.0 – 24.25 GHz
Fmax	24.238	24.228	24.248	20.19	Within band 24.0 – 24.25 GHz

4.3.3.1 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No:	FSC 1/7, 110 FSC 1000, 113
Test date:	2019-05-20
Test personnel:	Patrick Reusch

The EUT meets the requirements of this section.

4.4 Radiated Field Strength of Fundamental

4.4.1 Regulation

47 CFR,§ 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 over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle.
1 to 10 MHz	2	1 near top and 1 near bottom.
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom.

47CFR § 15.33 Frequency range of radiated measurements

(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.
(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.
(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.

47 CFR § 15.35 Measurement detector functions and bandwidths.

(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.

47 CFR § 15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating 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, e.g., §§15.231 and 15.241.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

47 CFR, § 15.249

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (milivolts/meter)	Field strength of harmonics (microvolt/meters)
902 – 928 MHz	50	500
2400 – 2483.5 MHz	50	500
5725 – 5875 MHz	50	500
24.0 – 24.2.5 GHz	250	2500

(c) Field strength limits are specified at a distance of 3 meters.

4.4.1.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection upto the highest measurement frequency required (unless stated otherwise in the applicable requirements).

ANSI C63.10-2013, 6.6.4.3 Final radiated emissions measurements

The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.

If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.

As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.

Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	18 GHz – 26.5 GHz
Test distance	1 m (18 – 26.5 GHz)
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

4.4.2 Calculation of Field Strength Limits

E.g. radiated emissions field strength limits for the frequency band 24.0 – 24.25 GHz:

250 mV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (in dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (in µV/m)

A field strength limit of 250 mV/m corresponds with 108 dBµV/m.

Distance correction (limit)
Remark: The preferred method is the correction of the measured field strength (refer to 4.2.3) instead of limit correction. Only one correction method shall be applied to a particular measurement.

If a measurement is performed in a distance other than specified, the limit may be adjusted by a Distance Extrapolation Factor DF of 20 dB per decade, which is calculated by the following equation:

$DF = 20 \log (D_{test}/D_{specification})$
where

DF = Distance Extrapolation Factor (in dB)

D_{test} = Distance, where measurement was performed (in m)

$D_{specification}$ = Distance acc. to specification (in m)

Example: Assume a limit specified in 3 m and a measurement performed at 1 m: The distance correction factor is 20 log (3 / 1) = 9.5. This factor is mathematically added to the limit by the following equation:
$E_{dB\mu V/m\_new} = E_{dB\mu V/m} + DF$
where

$E_{dB\mu V/m}$ = Field Strength limit in logarithmic units (in dBµV/m)

$E_{dB\mu V/m\_new}$ = Corrected Field Strength limit in logarithmic units (in dBµV/m)

DF = Distance Extrapolation Factor (in dB)

Example: Assume a limit of 108 dBµV/m specified in 3 m distance and the measurement performed at 1 m. The limit is adjusted by the distance correction factor of 9.5 dB to the new limit of 117.5 dBµV/m.

4.4.3 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength (in dBµV/m)
RA = Receiver Amplitude (in dBµV)
AF = Antenna Factor (in dB (1/m))
CF = Cable Attenuation Factor (in dB)

Assume a receiver reading of 30 dBµV is obtained. The Antenna Factor of 10 dB(1/m) and a Cable Factor of 1.2 dB are added, giving a field strength of 41.2 dBµV/m in the measurement distance. The field strength of 41.2 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 30 + 10 + 1.2 = 41.2
Level (in µV/m) = Common Antilogarithm (41.2/20) = 114.8

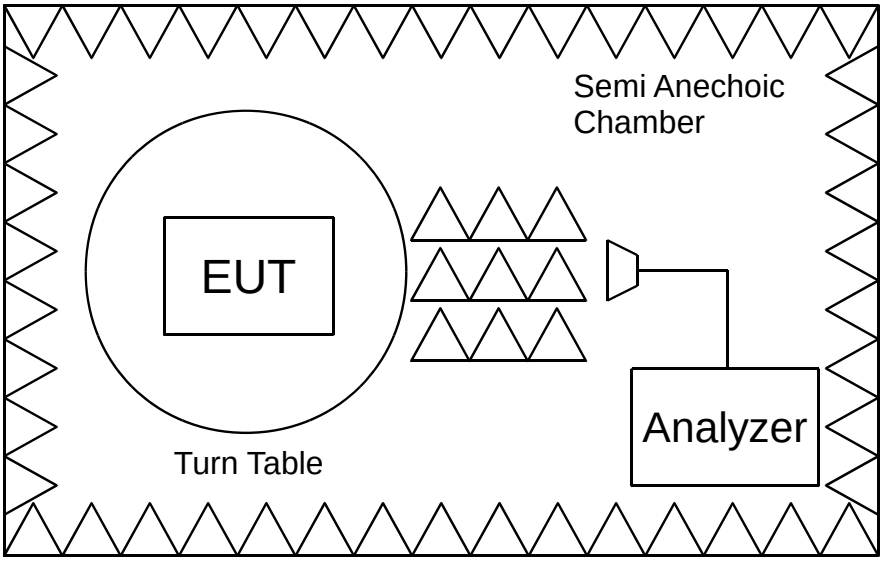
Distance correction (field strength)
Remark: The preferred method is the correction of the measured field strength instead of limit correction (refer to 4.2.2). Only one correction method shall be applied to a particular measurement..

If a measurement is performed at a different distance other than specified, the field strength at the specified distance can be obtained by the following equation:

$FS_{Dspecified} = FS_{Dtest} + 20 \log (D_{test}/D_{specified})$
where
$FS_{Dspecified}$ = Field Strength at specified distance $D_{specified}$ (in dBµV/m)
FS_{DTest} = Field Strength at specified distance D_{Test} (in dBµV/m)
D_{test} = Measurement distance where test was performed (in m)
$D_{specified}$ = Measurement distance as specified by the rules (in m)

Assuming a recorded field strength of 41.2 dBµV/m in a distance of 1 m. If the rules are specifying a limit in a distance of 3 m, the field strength recorded in 1 m is corrected by the distance. Therefore, the field strength $FS_{Dspecified}$ is 41.2 + 20 log (1 / 3) = 31.7 (in dBµV/m).
Remark: Using EMC32 software corrections are combined in the Corr. Factor as listed in the results' table.
"Result" represents the FS Result), "Corr." is the combined correction factor.

4.4.3.1 Test Setup



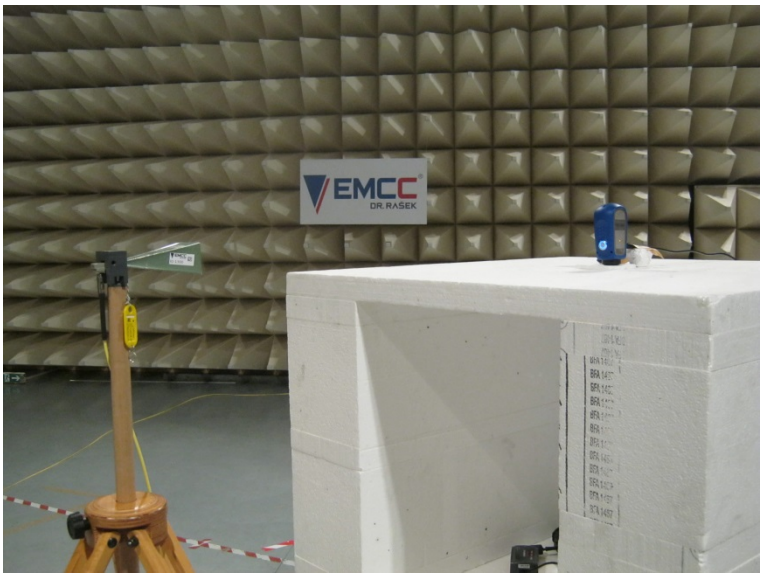
SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.249
Procedure: ANSI C63.10-2013

Receiver: #3831
Antenna: #1300 (18 – 26.5 GHz)

Test distance: 1 m (18 – 26.5 GHz)

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 553, 554, 1300, 1889, 3061, 3831, 4717, 4914, 5392, 5536

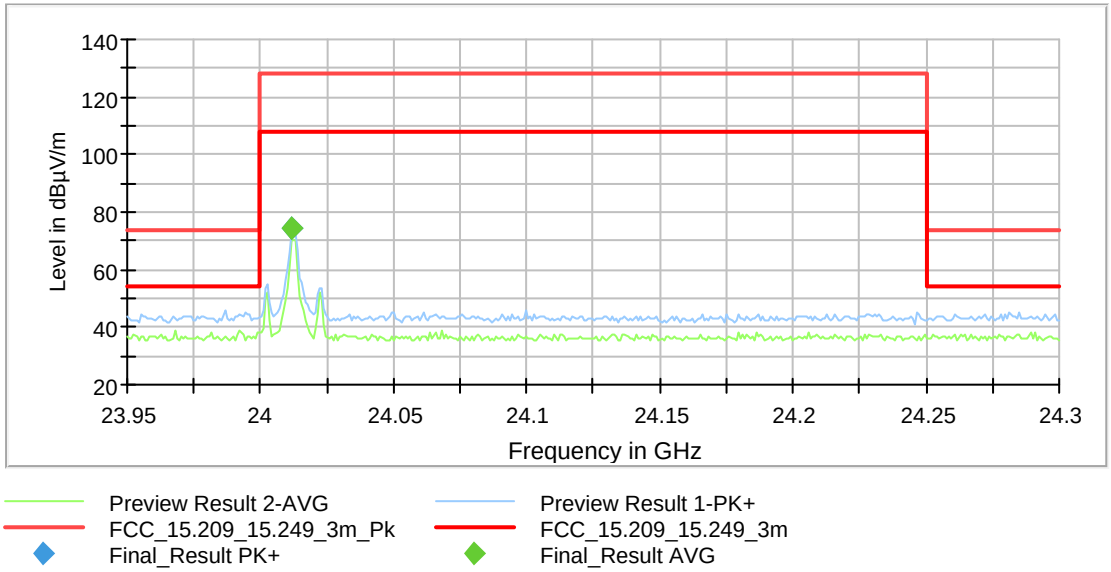


Sample photo of setup (18 – 26.5 GHz)

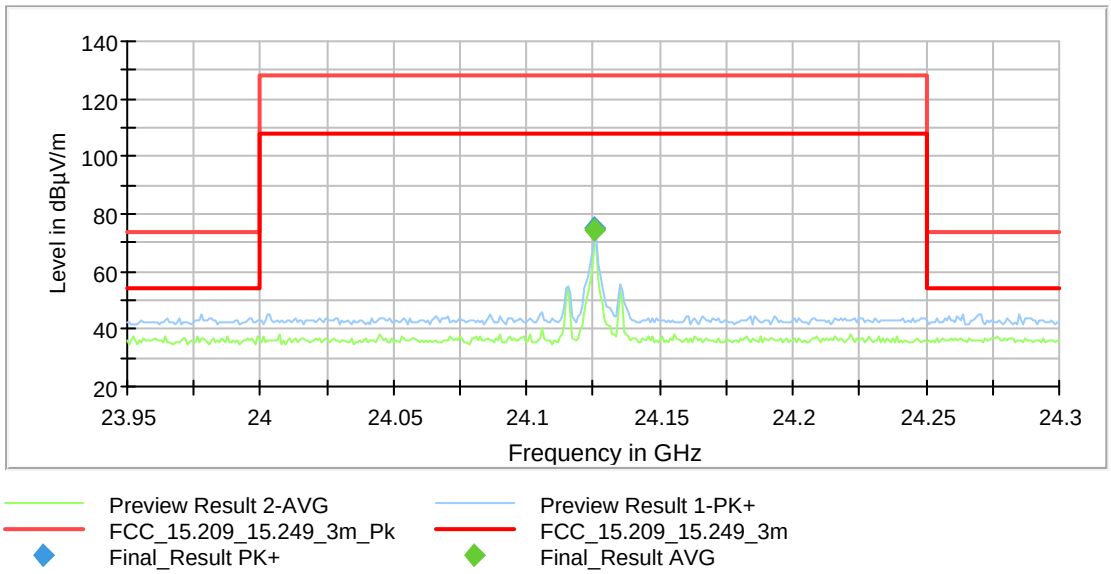
4.4.3.2 Detailed Test Data

- **EUT #1; FSC 1/7; SN: 110**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	1 (hor)

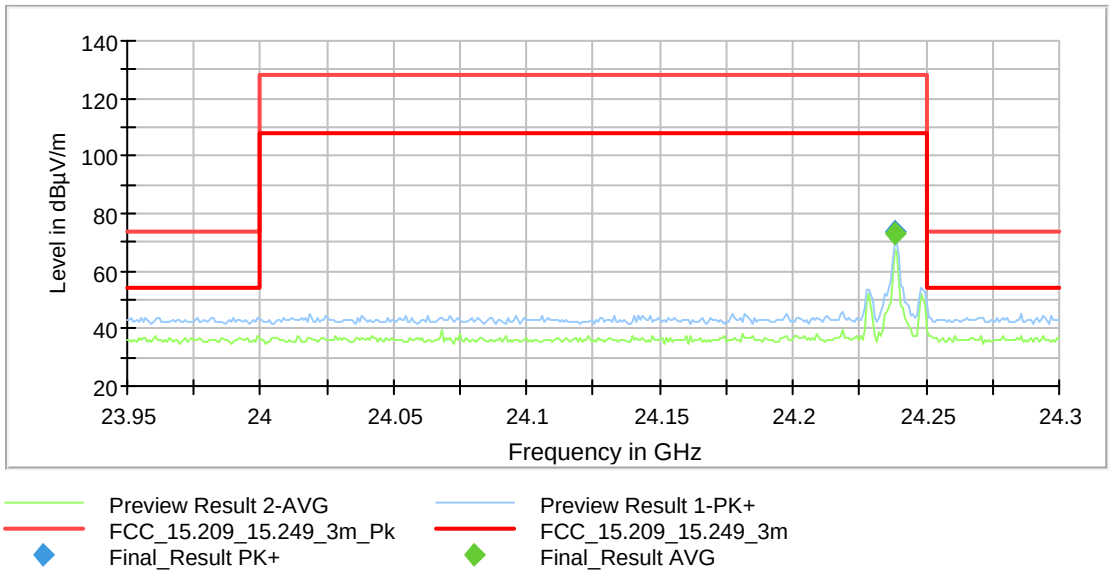


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	1 (hor)



Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	1 (hor)



Final Result EUT #1; FSC 1/7; SN: 110

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
24011.93	74.6	---	128.0	53.4	100	1000.0	150.0	V	236
24011.93	---	74.2	108.0	33.8	100	1000.0	150.0	V	236
24125.01	74.8	---	128.0	53.2	100	1000.0	150.0	V	236
24125.01	---	74.4	108.0	33.7	100	1000.0	150.0	V	236
24237.96	73.8	---	128.0	54.3	100	1000.0	150.0	V	235
24237.96	---	73.3	108.0	34.7	100	1000.0	150.0	V	235

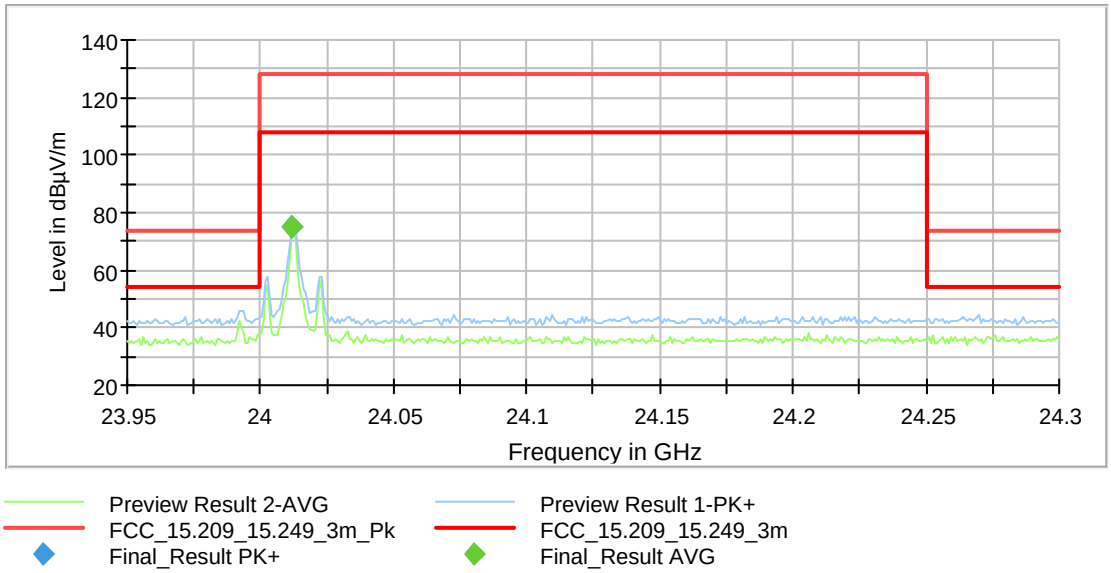
All tests performed at the distance of d = 1 m.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

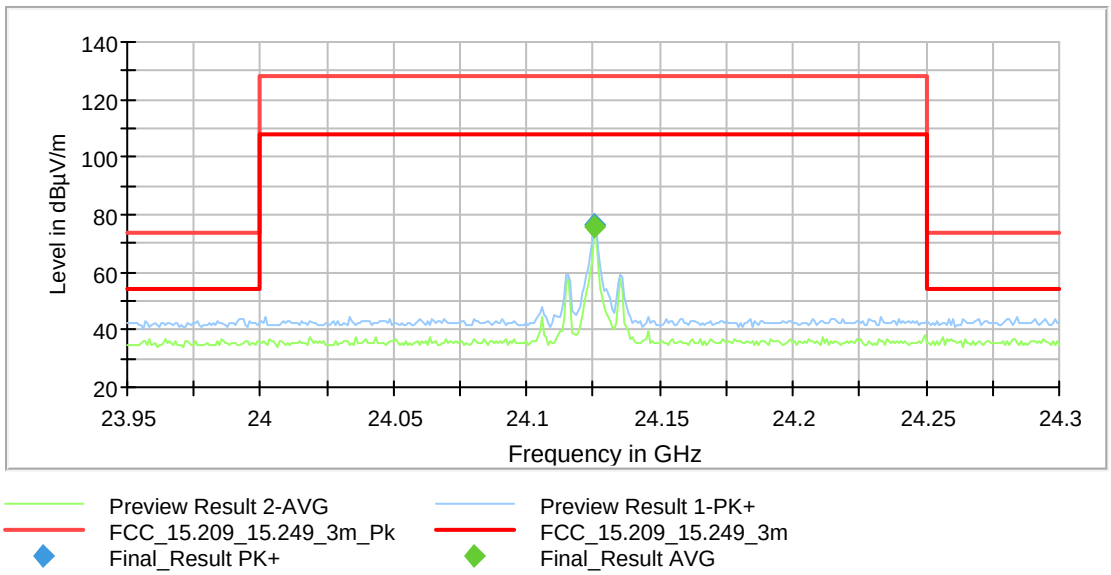
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

- **EUT #2; FSC 1000; SN: 113**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)

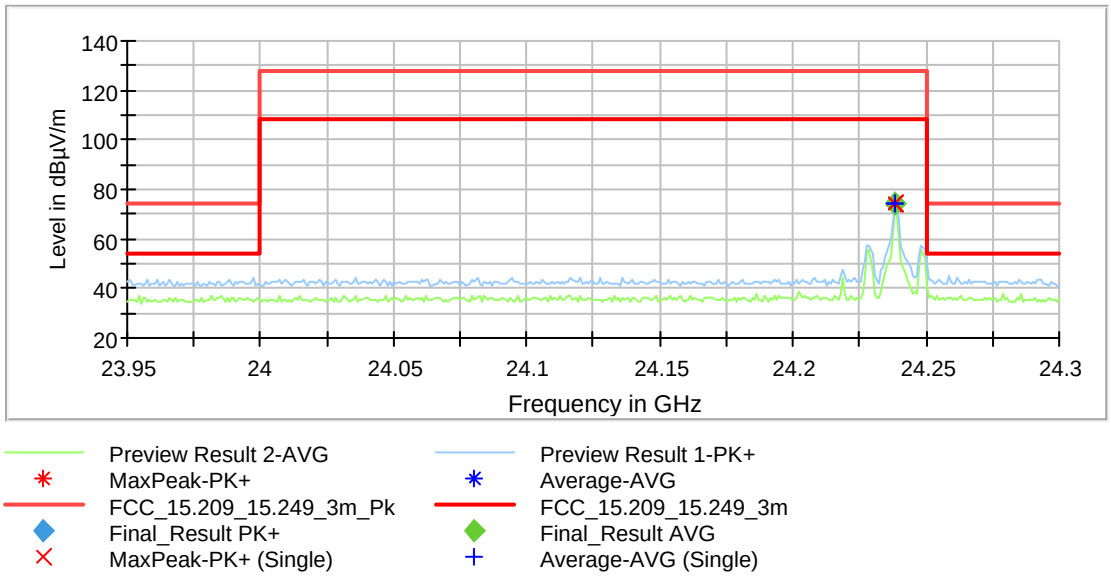


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	1 (hor)



Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)



Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
24012.01	75.3	---	128.0	52.7	100	1000	150	H	136
24012.01	---	75.0	108.0	33.0	100	1000	150	H	136
24125.02	76.4	---	128.0	51.6	100	1000	150	V	136
24125.02	---	76.1	108.0	31.9	100	1000	150	V	136
24238.02	74.4	---	128.0	53.7	100	1000	150	V	50
24238.02	---	74.0	108.0	34.0	100	1000	150	V	50

All tests performed at the distance of d = 1 m.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.4.3.3 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No:	FSC 1/7, 110
	FSC 1000, 113
Test date:	2019-05-17 / 2019-05-20
Test personnel:	Patrick Reusch, Ludwig Kraft

The EUT meets the requirements of this section.

4.5 Radiated Emissions

4.5.1 Regulation

47 CFR,§ 15.31

(f)(2) At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). This paragraph (f) shall not apply to Access BPL devices operating below 30 MHz.

(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 over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle.
1 to 10 MHz	2	1 near top and 1 near bottom.
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom.

47CFR § 15.33 Frequency range of radiated measurements

(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.
(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.
(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.

47 CFR § 15.35 Measurement detector functions and bandwidths.

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long at the same bandwidth as indicated for CISPR quasi-peak measurements are employed.
(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.

47 CFR § 15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating 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, e.g., §§15.231 and 15.241.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

47 CFR, § 15.249

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

4.5.2 Calculation of Field Strength Limits

E.g. radiated emissions field strength limits for the frequency band 1.705 - 30 MHz:

30 µV/m at 30 meters

Using the equation:

$E_{dB\mu V/m} = 20 \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (in dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (in µV/m)

A field strength limit of 30 µV/m corresponds with 29.5 dBµV/m.

Distance correction (limit)
Remark: The preferred method is the correction of the measured field strength (refer to 4.2.3) instead of limit correction. Only one correction method shall be applied to a particular measurement.

For radiated emission from 9 kHz to 30 MHz the prescan limit was adjusted by a Distance Extrapolation Factor DF of 40 dB per decade, which is calculated by the following equation:

$DF = 40 \log (D_{test}/D_{specification})$
where

DF = Distance Extrapolation Factor (in dB)

D_{test} = Distance, where measurement was performed (in m)

$D_{specification}$ = Distance acc. to specification (in m)

Example: Assume a limit specified in 30 m and a measurement performed at 3 m: The distance correction factor is 40 log (30 / 3) = 40 dB. This factor is mathematically added to the limit by the following equation:
$E_{dB\mu V/m\_new} = E_{dB\mu V/m} + DF$
where

$E_{dB\mu V/m}$ = Field Strength limit in logarithmic units (in dBµV/m)

$E_{dB\mu V/m\_new}$ = Corrected Field Strength limit in logarithmic units (in dBµV/m)

DF = Distance Extrapolation Factor (in dB)

Example: Assume a limit of 29.5 dBµV/m specified in 30 m distance and the measurement performed at 3 m. The limit is adjusted by the distance correction factor of 40 dB to the new limit of 69.5 dBµV/m.

4.5.3 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength (in dBµV/m)
RA = Receiver Amplitude (in dBµV)
AF = Antenna Factor (in dB (1/m))
CF = Cable Attenuation Factor (in dB)

Assume a receiver reading of 30 dBµV is obtained. The Antenna Factor of 10 dB(1/m) and a Cable Factor of 1.2 dB are added, giving a field strength of 41.2 dBµV/m in the measurement distance. The field strength of 41.2 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 30 + 10 + 1.2 = 41.2
Level (in µV/m) = Common Antilogarithm (41.2/20) = 114.8

Distance correction (field strength)
Remark: The preferred method is the correction of the measured field strength instead of limit correction (refer to 4.2.2). Only one correction method shall be applied to a particular measurement..

If a measurement is performed at a different distance other than specified, the field strength at the specified distance can be obtained by the following equation:

$FS_{Dspecified} = FS_{Dtest} + 20 \log (D_{test}/D_{specified})$
where
$FS_{Dspecified}$ = Field Strength at specified distance $D_{specified}$ (in dBµV/m)
FS_{DTest} = Field Strength at specified distance D_{Test} (in dBµV/m)
D_{test} = Measurement distance where test was performed (in m)
$D_{specified}$ = Measurement distance as specified by the rules (in m)

Assuming a recorded field strength of 41.2 dBµV/m in a distance of 1 m. If the rules are specifying a limit in a distance of 3 m, the field strength recorded in 1 m is corrected by the distance. Therefore, the field strength $FS_{Dspecified}$ is 41.2 + 20 log (1 / 3) = 31.7 (in dBµV/m).
Remark: Using EMC32 software corrections are combined in the Corr. Factor as listed in the results' table.
"Result" represents the FS Result), "Corr." is the combined correction factor.

4.5.4 Radiated Emissions 9 kHz – 30 MHz

4.5.4.1 Test Procedures

ANSI C63.10-2013, 6.4.3 Measuring antenna selection, location, and test distance
Radiated emission tests shall be performed in the frequency range of 9 kHz to 30 MHz, using a calibrated loop antenna as specified in 4.3.2, at a suitable site and measurement distance as specified in 5.3. This method is applicable for measuring radiated RF emissions from all units, cables, power cords, and interconnect cabling or wiring of the EUT, by applying the guidance provided in 5.10 along with guidance provided subsequently.

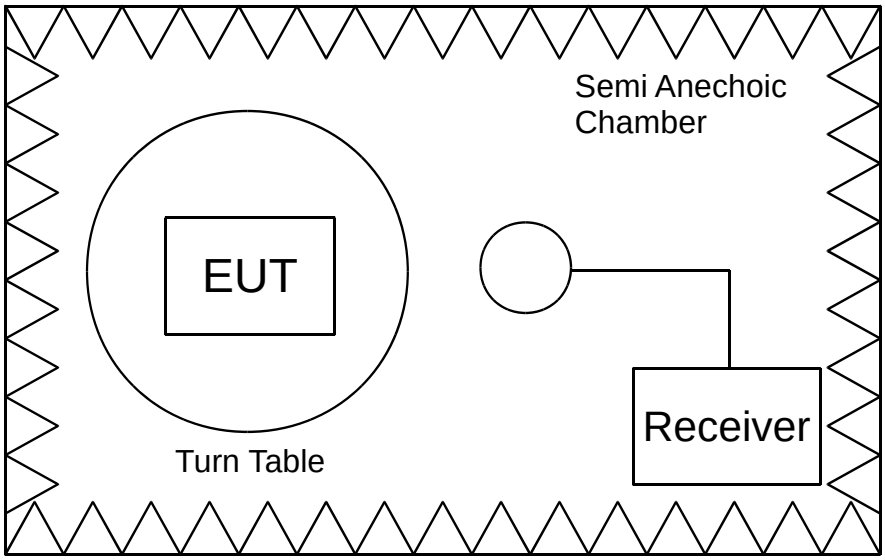
ANSI C63.10-2013, 6.4.6 Exploratory radiated emission tests
The tests shall be performed in the frequency range specified in 5.5 and 5.6, using the procedures in Clause 5, applying the appropriate modulating signal to the EUT, to determine cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit.
Exploratory measurements below 30 MHz are useful in determining the maximum level of emissions while manipulating and rotating the EUT; however, exploratory and final measurements may be made concurrently, provided care is taken to determine the maximum level of emissions for all configurations and orientations.
The test arrangement, measuring antenna guidelines and operational configurations in 6.3.1 and 6.3.2, shall be followed.
The measurement antenna shall be positioned with its plane perpendicular to the ground at the specified distance.
When perpendicular to the ground plane, the lowest height of the magnetic antenna shall be 1 m above the ground and shall be positioned at the specified distance from the EUT. When the EUT contains a loop antenna that can only be placed in a vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, and then orthogonal to the axis. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. When the EUT contains a loop antenna that can be placed in a horizontal or vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, orthogonal to the axis, and then with the measurement antenna horizontal. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. The report shall list the six emissions with the smallest margin relative to the limit, for each of the three antenna orientations (parallel, perpendicular, and ground-parallel) unless the margin is greater than 20 dB, then the following statement shall be made: “all emissions were greater than 20 dB below the limit.”

ANSI C63.10-2013, 6.4.7 Final radiated emission tests
Using the orientation and equipment arrangement of the EUT determined in 6.4.6, and applying the appropriate modulating signal to the EUT, perform final radiated emission measurements on the fundamental and highest spurious emissions.
Unless otherwise specified by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	9 kHz – 30 MHz
Test distance	3 m
Test instrumentation resolution bandwidth	200 Hz (< 150 kHz) 9 kHz (≥ 150 kHz)
Receive antenna height	1 m
Receive antenna orientations	2
Measurement chamber	Semi anechoic chamber (SAC)

Following the test procedure described in KDB 414788, an open field measurement has to be performed in addition to the measurements performed in a semi anechoic chamber to evaluate a correction of the open field measurement to the semi-anechoic chamber measurement.
Hence laboratory experience has shown, that the correction factor is always negative, resulting in a lower level at the open field, these open field measurements are omitted, if there are all measurement emissions more than 20 dB below the limit.

4.5.5 Test Setup



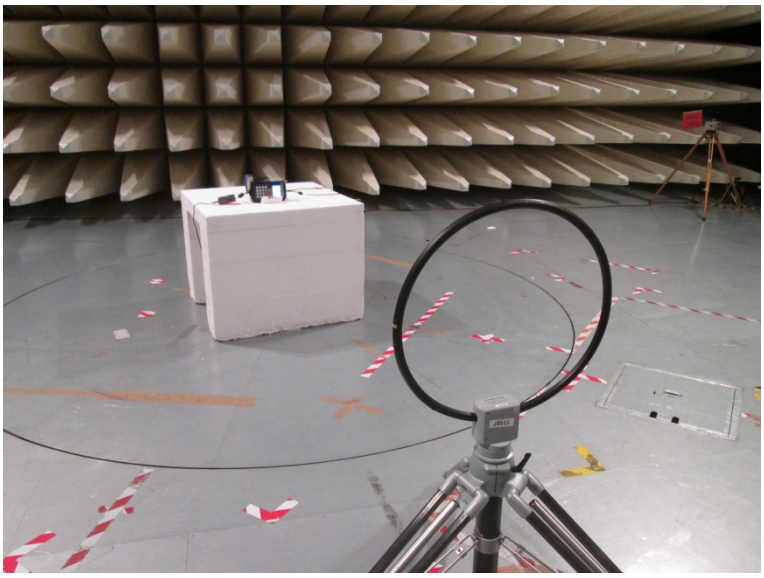
SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3831
Antenna: #374

Test distance: 3 m

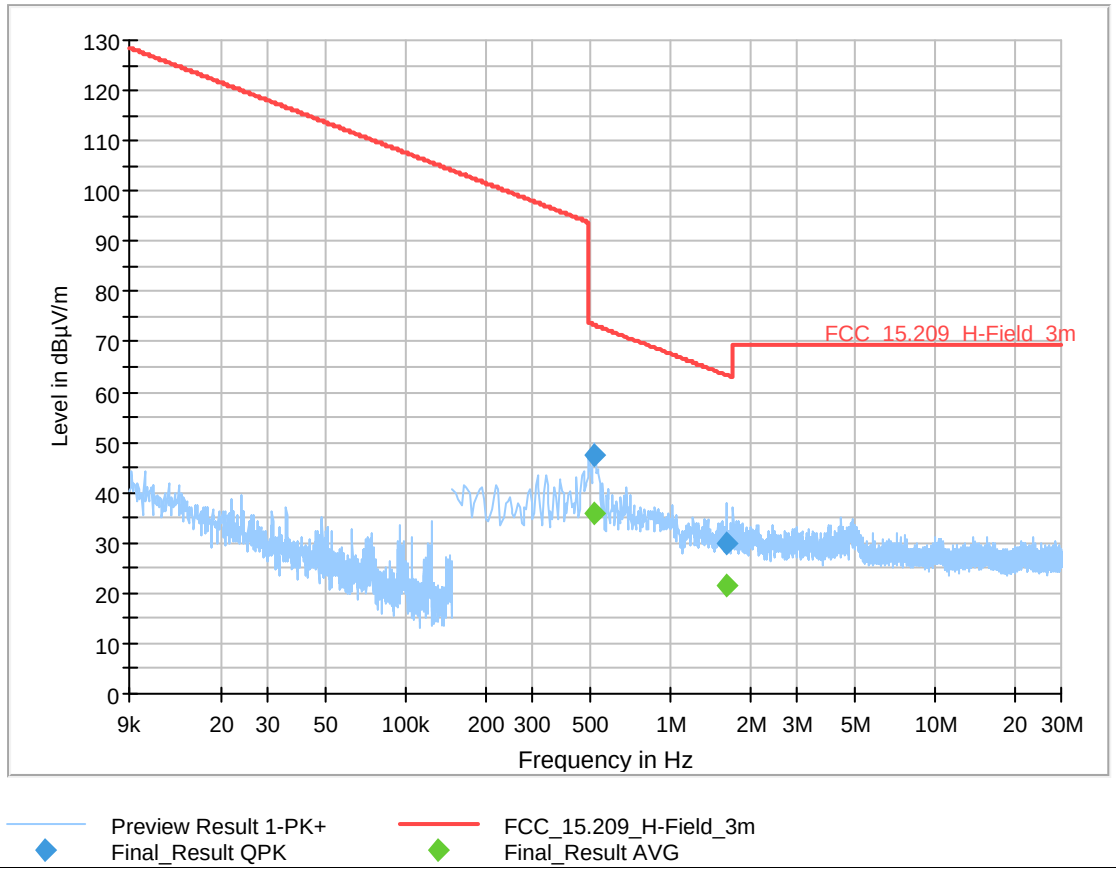
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 374, 1292, 1889, 3846, 4075, 4524, 4717, 5392



Sample photo of setup

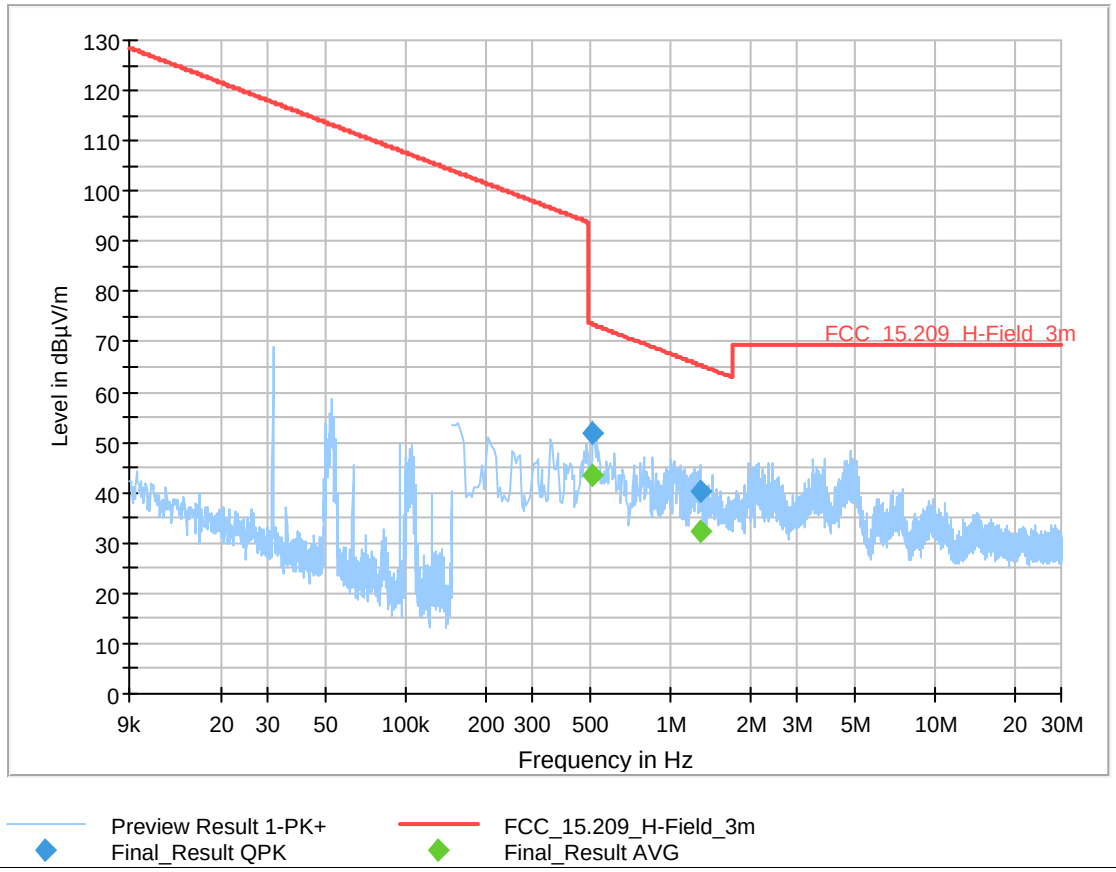
4.5.6 Detailed Test Data

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	1 (hor)



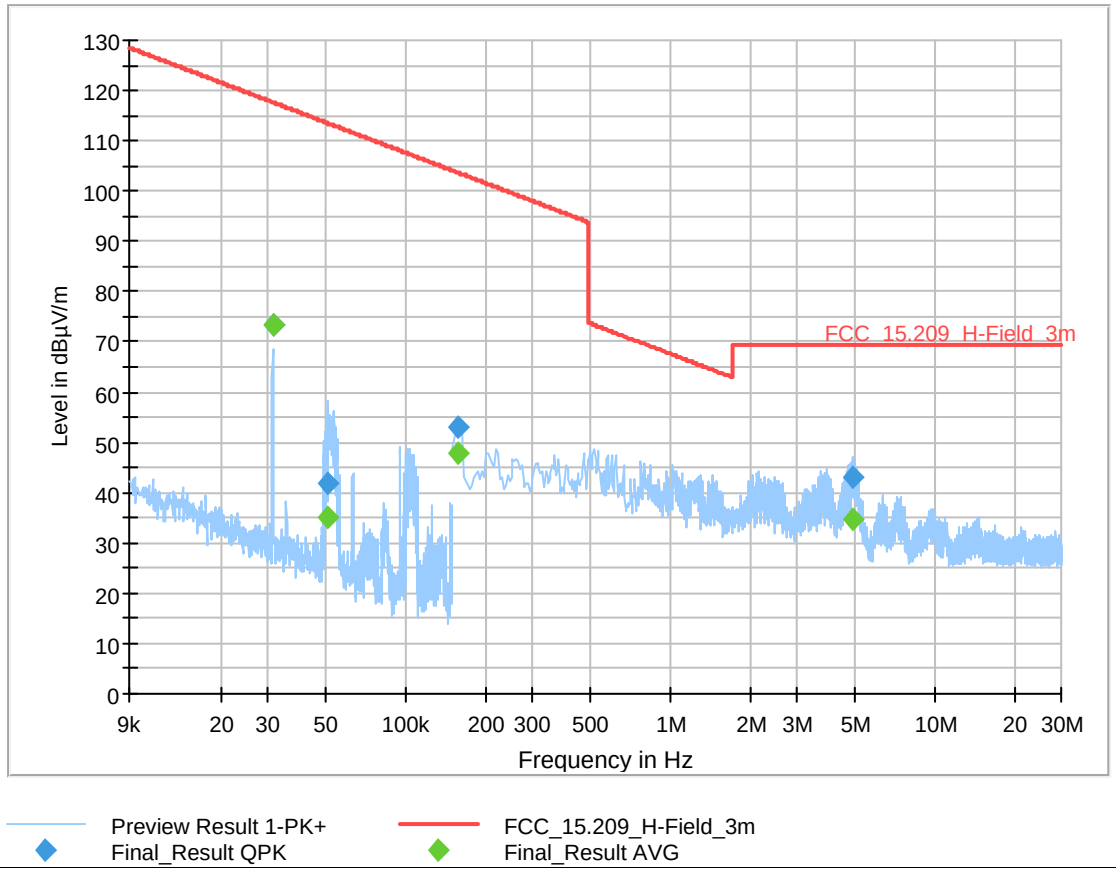
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	2 (vert)

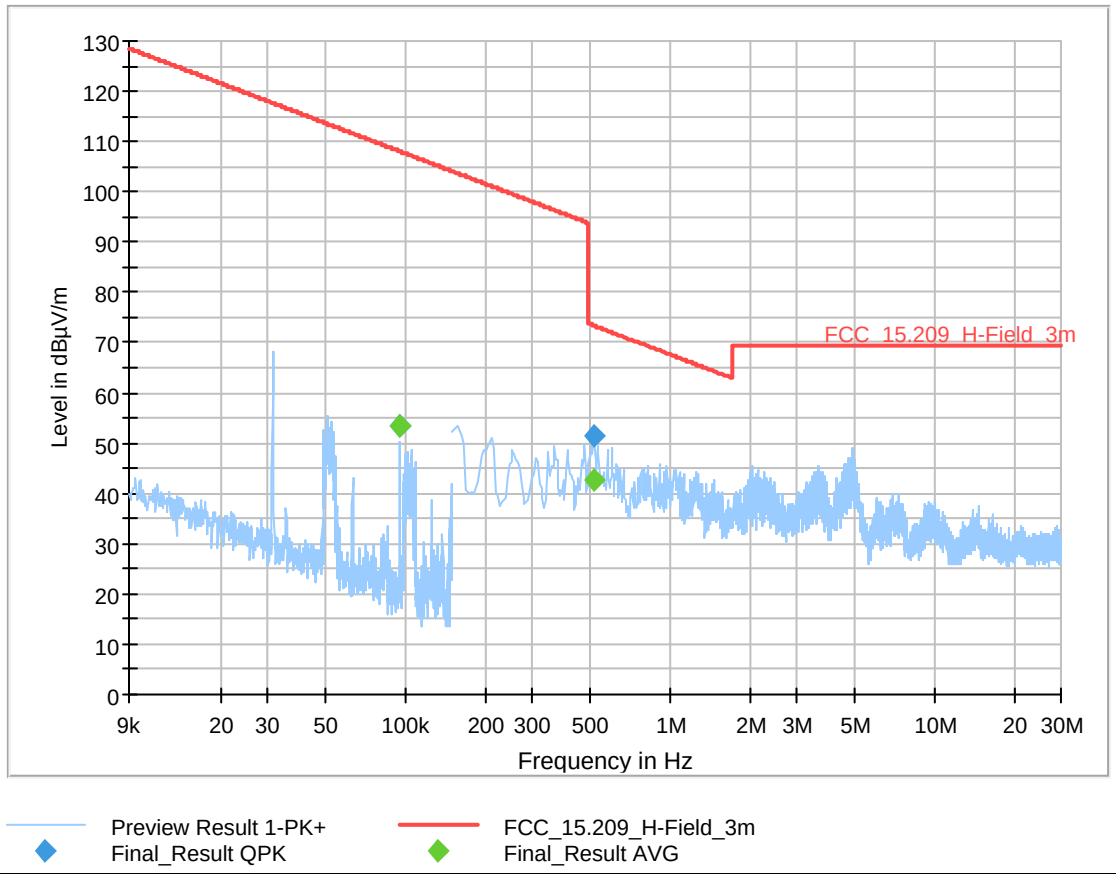


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)



Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)



Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
All prescan results more than 20 dB below limit, therefore no final measurement performed.								

4.5.7 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No.:	113
Test date:	2019-05-21
Test personnel:	Patrick Reusch

The EUT meets the requirements of this section.

4.5.8 Radiated Emissions 30 MHz – 1000 MHz

4.5.8.1 Test Procedures

ANSI C63.10-2013 6.5 Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to 1000 MHz

This subclause specifies conditions for compliance testing in the frequency range above 30 MHz and below 1 GHz. The following subclauses describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies between 30 MHz and 1000 MHz. Measurements may be performed at a distance closer than that specified in the requirements, provided the measuring antenna is beyond its near-field range as determined by the Rayleigh criteria.

ANSI C63.10-2013, 6.5.3 Exploratory radiated emission tests

Exploratory measurements are used to identify the frequencies and amplitudes of the emissions while manipulating and rotating the EUT.

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT. At near distances, for EUTs of comparably small size, it is relatively easy to determine the spectrum signature of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. Exploratory measurements shall be made on a test site per 5.2. Shielded rooms, not treated with RF absorption material, shall not be used for exploratory measurements.

For each mode of operation required to be tested, the frequency spectrum shall be monitored. The highest signal levels relative to the limit shall be determined by rotating the EUT from 0° to 360° and with varying the measurement antenna height between 1 m and 4 m in vertical and horizontal polarizations.

ANSI C63.10-2013, 6.5.4 Final radiated emission tests

Using the orientation and equipment arrangement of the EUT, and based on the measurement results found during the exploratory measurement in 6.5.3, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable) and the frequency and amplitude of the six highest spurious emissions relative to the limit; emissions more than 20 dB below the limit do not need to be reported.

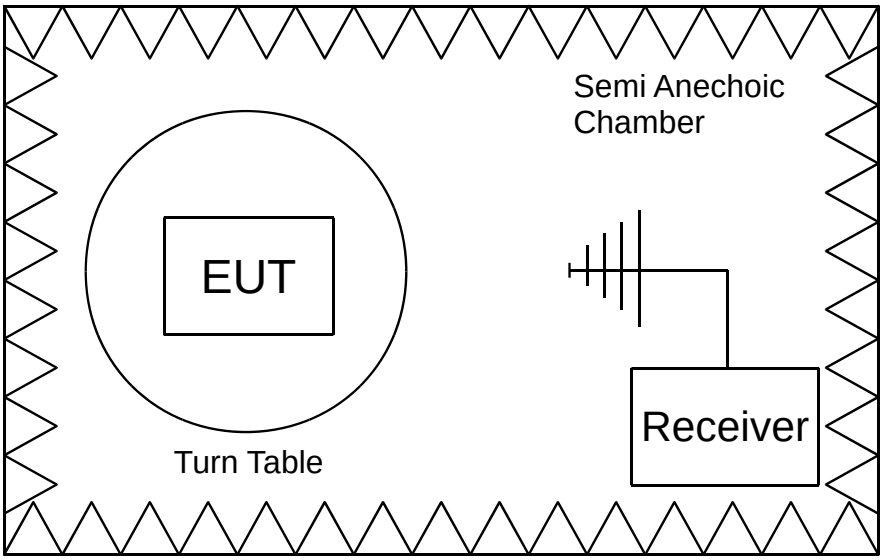
Measurements are performed with the EUT rotated from 0° to 360°, the antenna height scanned between 1 m and 4 m, and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations.

Variations in cable or wire placement shall be explored to maximize the measured emissions.

Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	30 MHz – 1000 MHz
Test distance	3 m
Test instrumentation resolution bandwidth	120 kHz
Receive antenna height	1 m - 4 m
Angular steps size during prescan:	90 °
Receive antenna polarization	Vertical/Horizontal
Measurement location	Semi Anechoic Chamber (SAC)

4.5.8.2 Test Setup



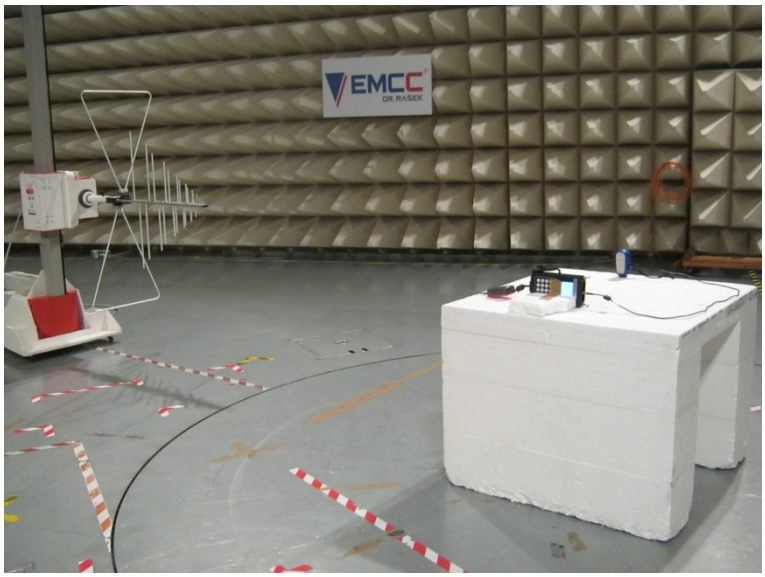
SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3846
Antenna: #6041

Test distance: 3 m

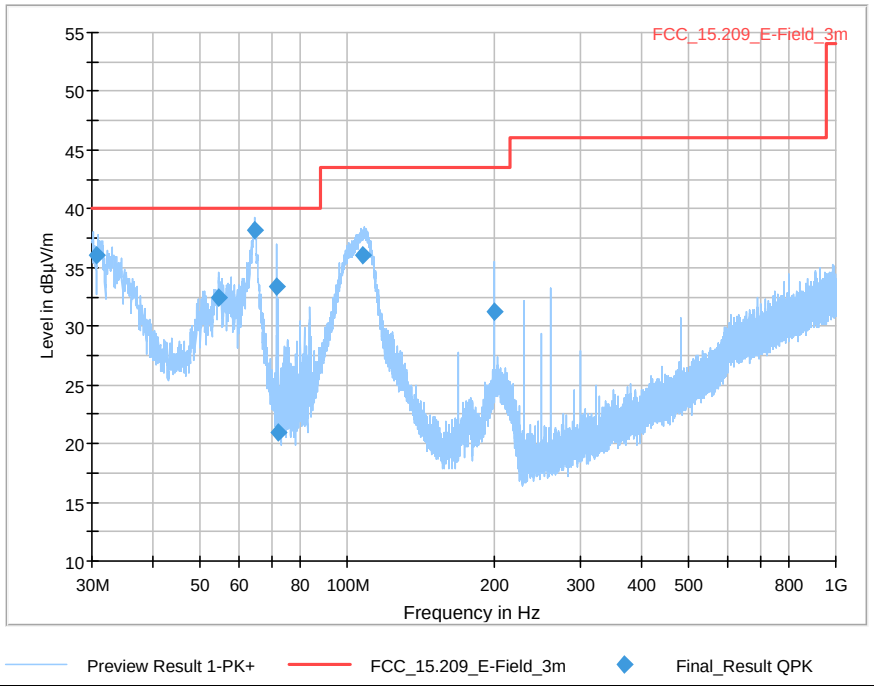
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 54, 553, 554, 1291, 1292, 1889, 2724, 3846, 4075, 4717, 5392, 6041



Sample photo of setup

4.5.8.3 Detailed Test Data

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	1 (hor)



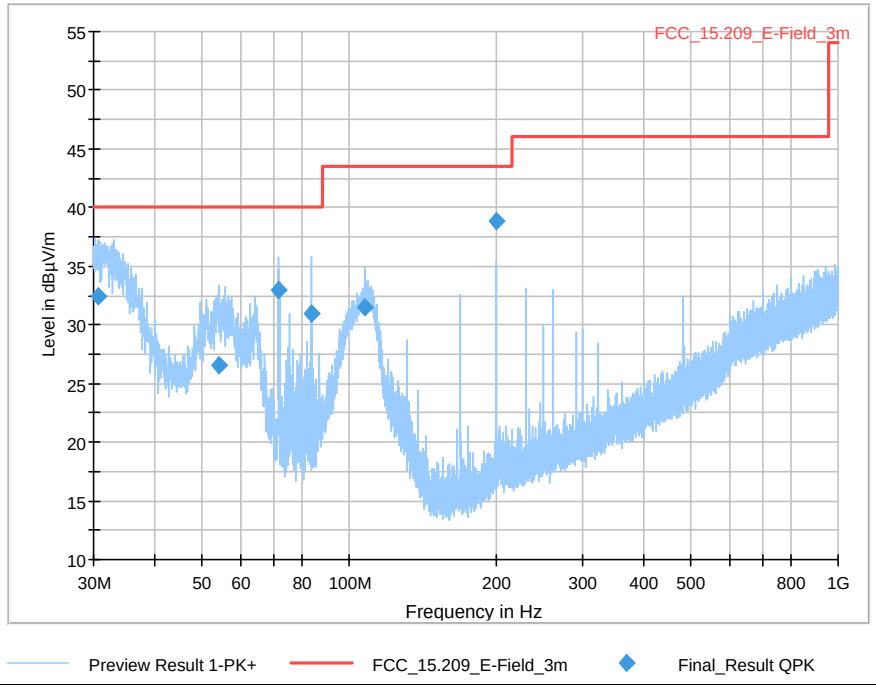
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.68	36.1	40.0	3.9	1000	120.0	100.0	V	61	16.5
54.50	32.5	40.0	7.5	1000	120.0	103.0	V	11	19.2
64.46	38.2	40.0	1.8	1000	120.0	104.0	V	108	17.4
71.98	21.0	40.0	19.0	1000	120.0	325.0	H	67	14.4
107.98	36.0	43.5	7.6	1000	120.0	300.0	H	86	17.5
199.98	31.2	43.5	12.3	1000	120.0	100.0	H	79	17.5

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)



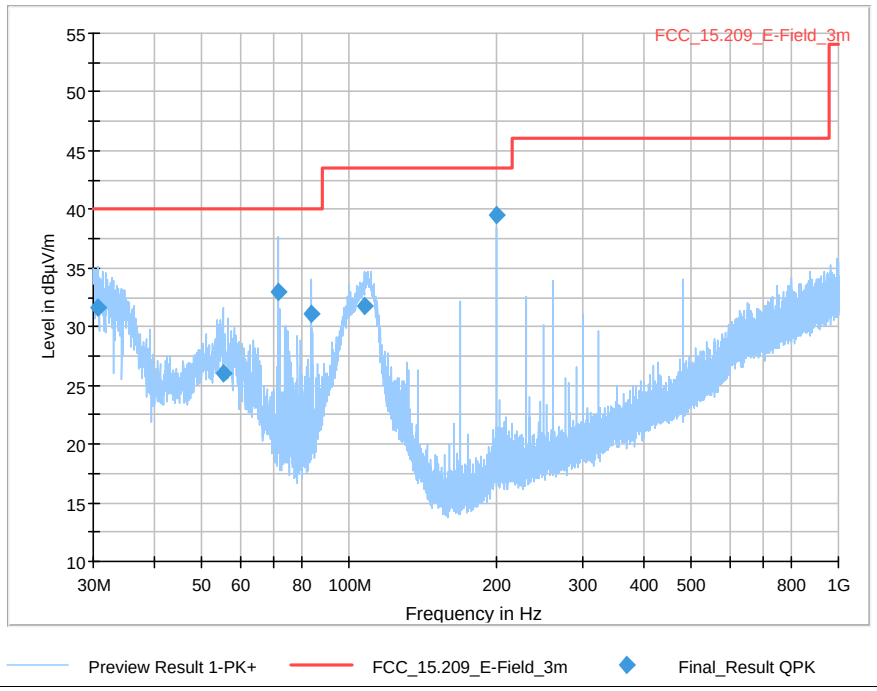
Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.56	32.5	40.0	7.5	1000	120.0	100.0	V	27	16.5
54.10	26.5	40.0	13.5	1000	120.0	114.0	V	34	19.3
71.90	32.9	40.0	7.1	1000	120.0	296.0	H	-84	14.5
83.78	30.9	40.0	9.1	1000	120.0	400.0	H	-85	14.1
107.86	31.4	43.5	12.1	1000	120.0	289.0	H	-106	17.5
199.98	38.8	43.5	4.7	1000	120.0	165.0	H	82	17.5

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	2 (vert)

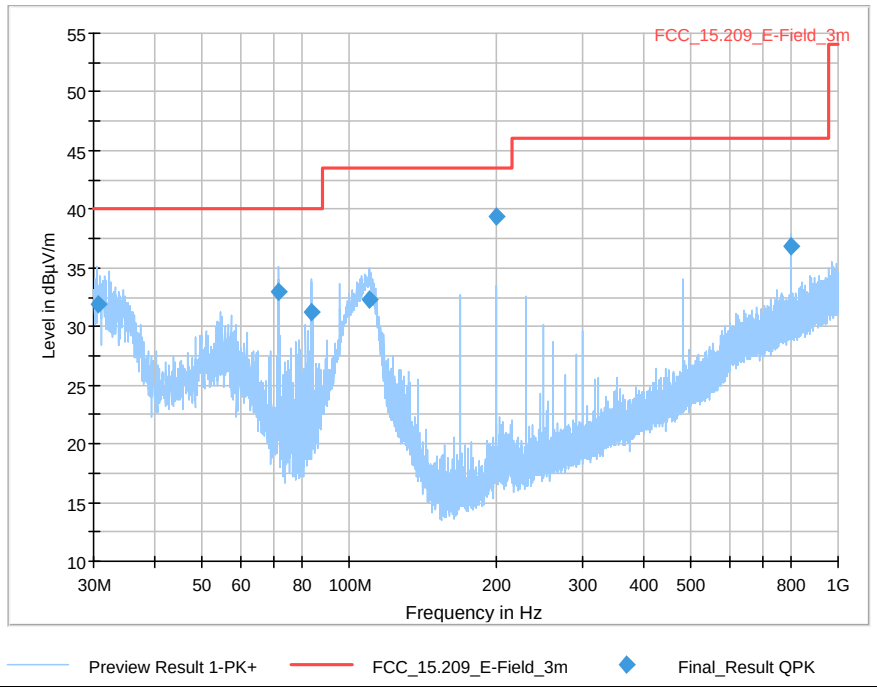


Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.66	31.6	40.0	8.4	1000	120.0	103.0	V	-1	16.5
55.34	26.1	40.0	13.9	1000	120.0	103.0	V	-19	19.0
71.90	32.9	40.0	7.1	1000	120.0	298.0	H	-65	14.5
83.90	31.1	40.0	9.0	1000	120.0	203.0	H	-62	14.2
107.90	31.7	43.5	11.8	1000	120.0	253.0	H	-112	17.5
200.02	39.5	43.5	4.1	1000	120.0	161.0	H	79	17.5

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)



Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.68	31.9	40.0	8.1	1000	120.0	100.0	V	22	16.5
71.90	33.0	40.0	7.0	1000	120.0	282.0	H	-90	14.5
83.82	31.3	40.0	8.7	1000	120.0	363.0	H	-89	14.1
110.02	32.4	43.5	11.1	1000	120.0	276.0	H	-124	17.3
200.02	39.4	43.5	4.1	1000	120.0	165.0	H	80	17.5
799.98	36.8	46.0	9.2	1000	120.0	100.0	H	67	28.6

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.5.8.4 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No.:	113
Test date:	2019-05-16
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.5.9 Radiated Emissions 1 – 6 GHz

4.5.9.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection upto the highest measurement frequency required (unless stated otherwise in the applicable requirements).

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10.2013, 6.6.4.3 Final radiated emissions measurements

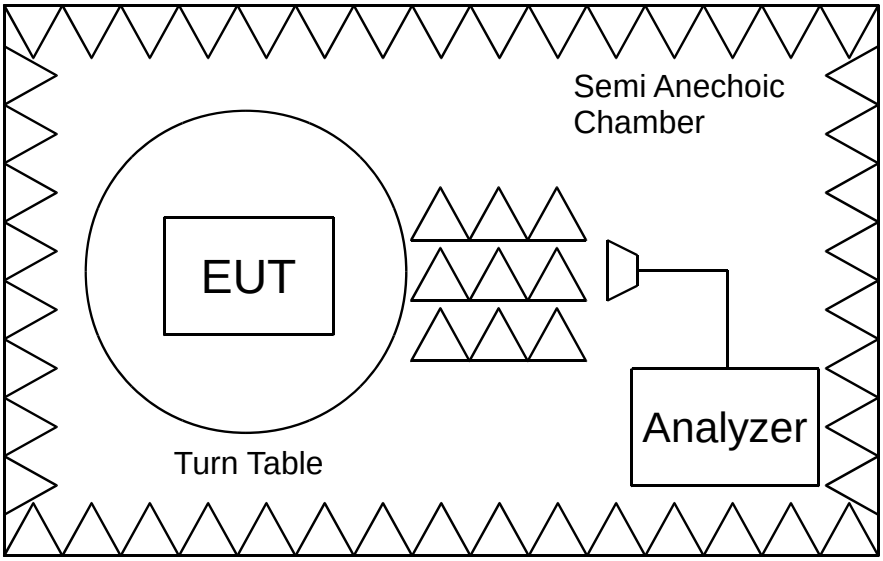
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.
If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.
As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.
Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 6 GHz
Test distance	3 m
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC) with rf absorbers on the floor

4.5.9.2 Test Setup



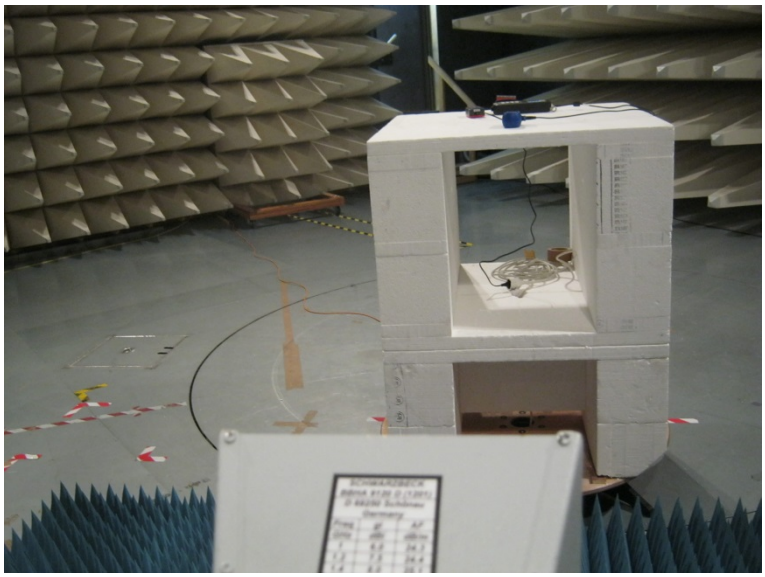
SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3846
Antenna: #3235

Test distance: 3 m

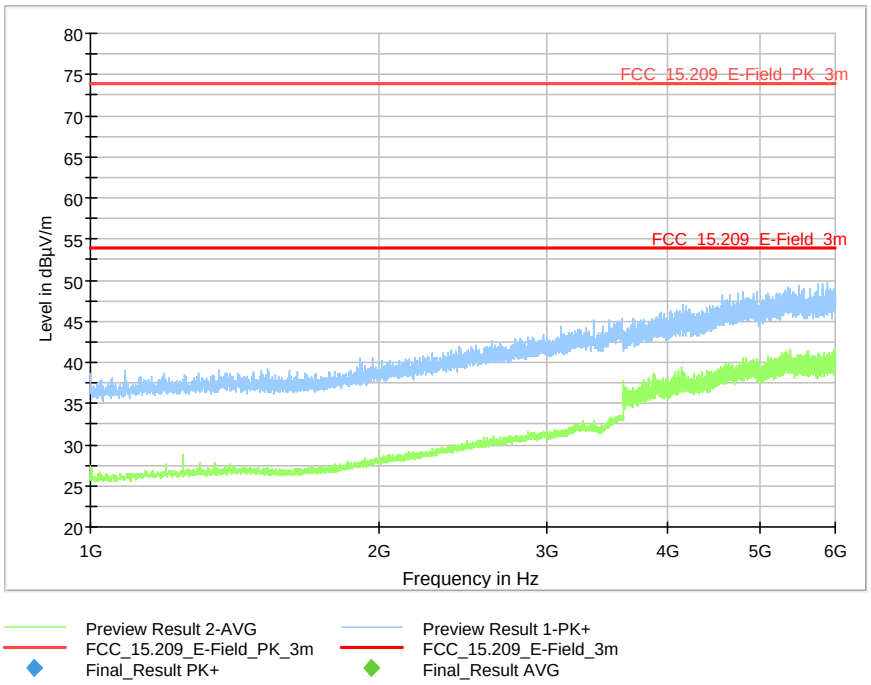
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 553, 554, 1889, 3235, 4075, 4717, 5392, 5535, 5536, 5544, 5545, 5615



Sample photo of setup

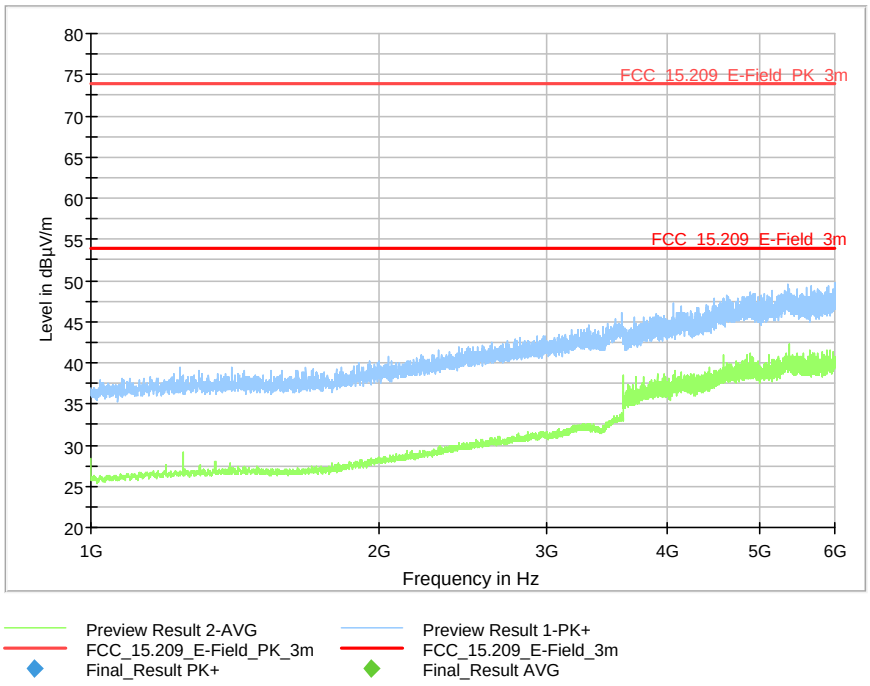
4.5.9.3 Detailed Test Data

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	1 (hor)

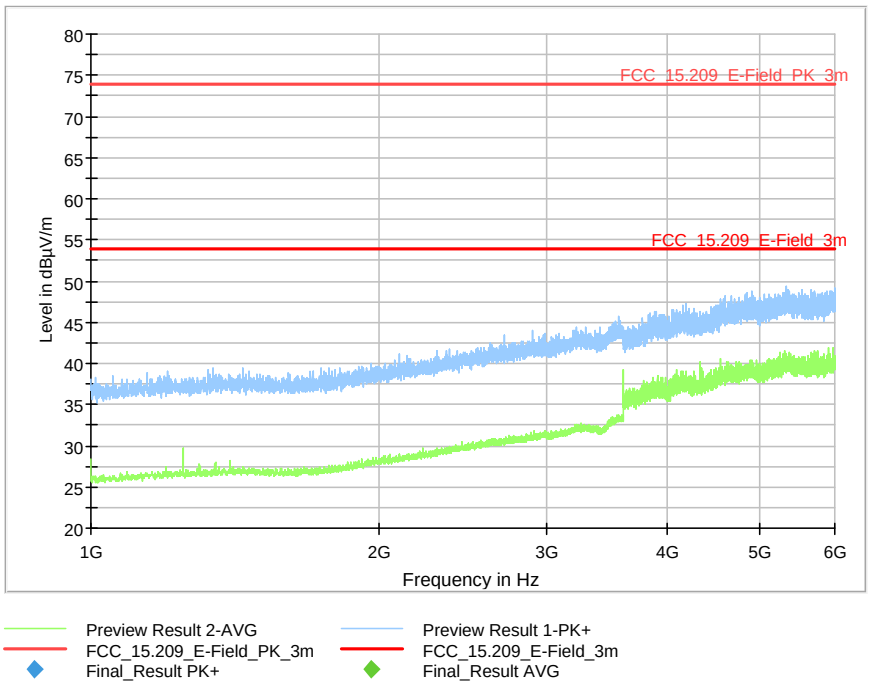


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)

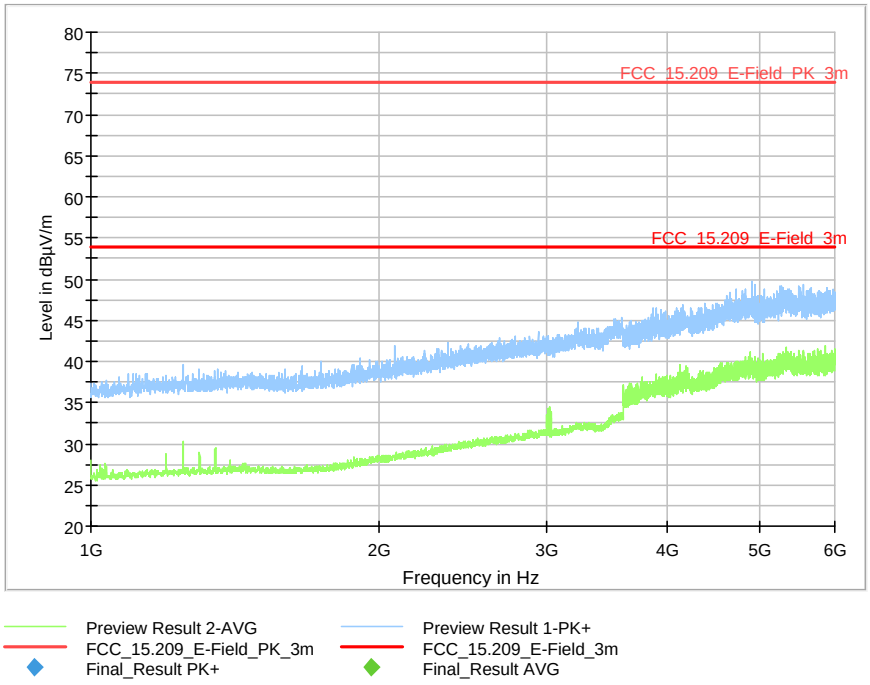


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)

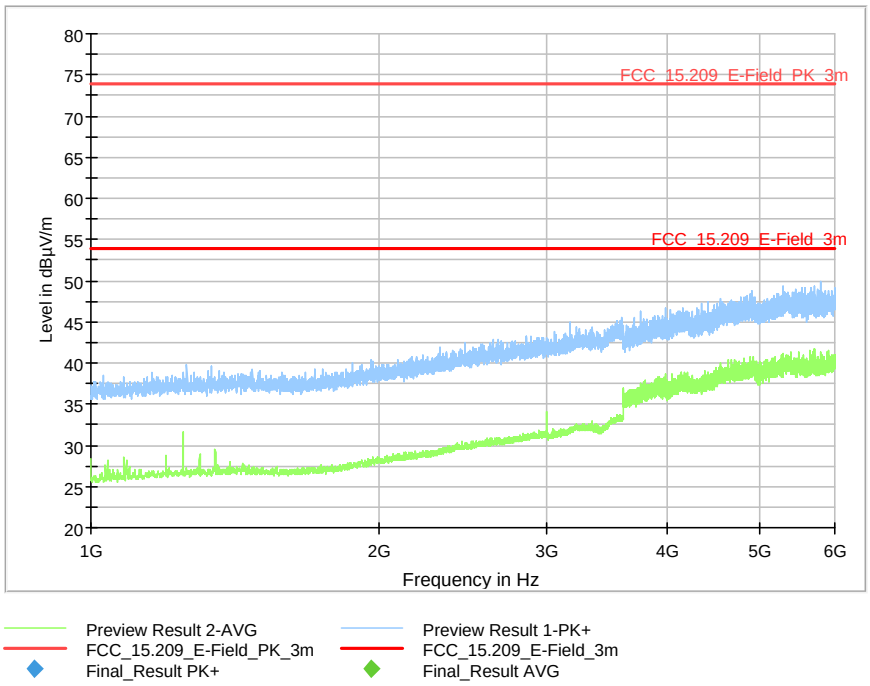


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	2 (vert)

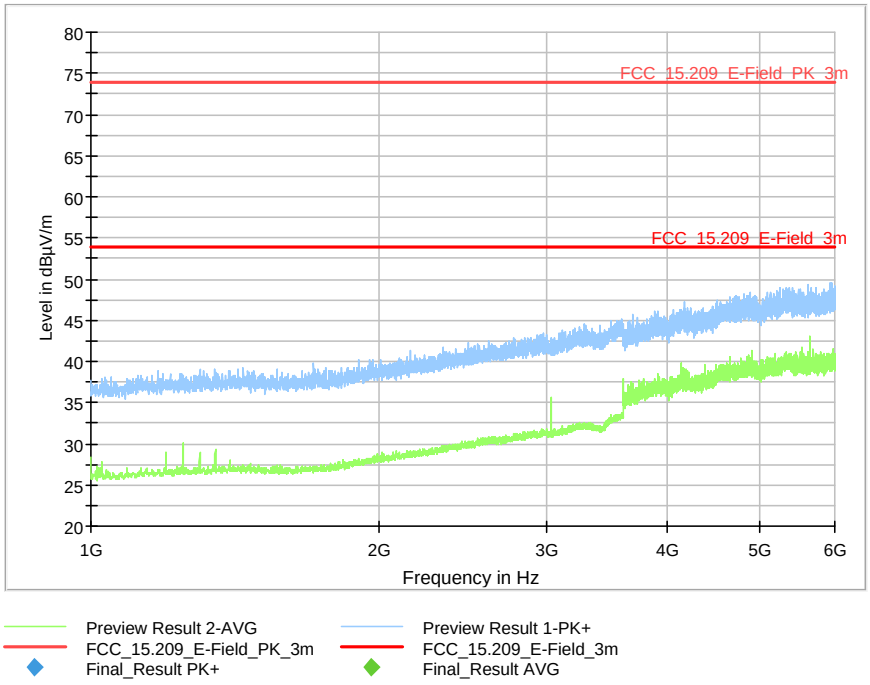


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	2 (vert)



Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)



Final Result:

Frequency MHz	MaxPeak dBµV/m	Average dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol --	Azimuth deg	Corr. dB/m

All peak emissions were below the average limit.
Therefore, no final measurement performed.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.5.9.4 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No.:	113
Test date:	2019-05-17
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.5.10 Radiated Emissions 6 – 18 GHz

4.5.10.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection upto the highest measurement frequency required (unless stated otherwise in the applicable requirements).

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10.2013, 6.6.4.3 Final radiated emissions measurements

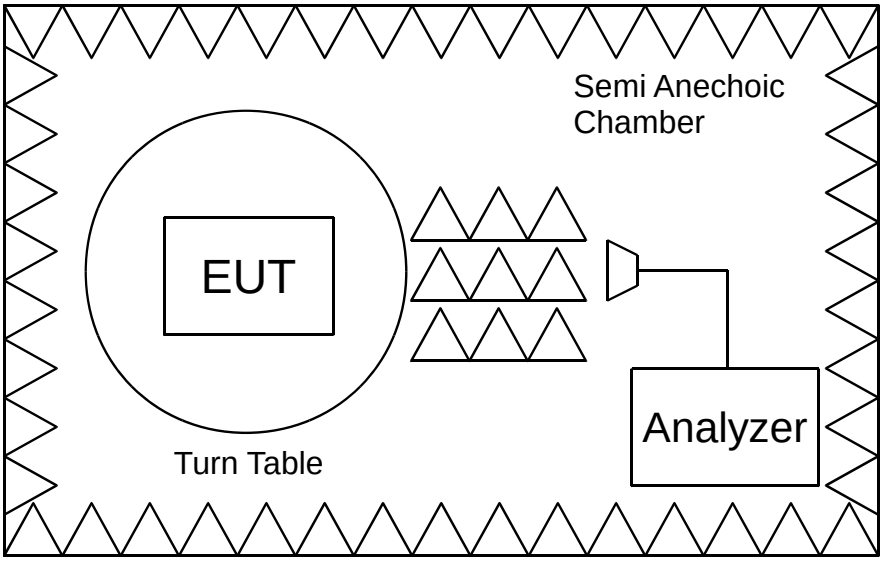
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.
If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.
As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.
Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	6 GHz – 18 GHz
Test distance	1 m
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

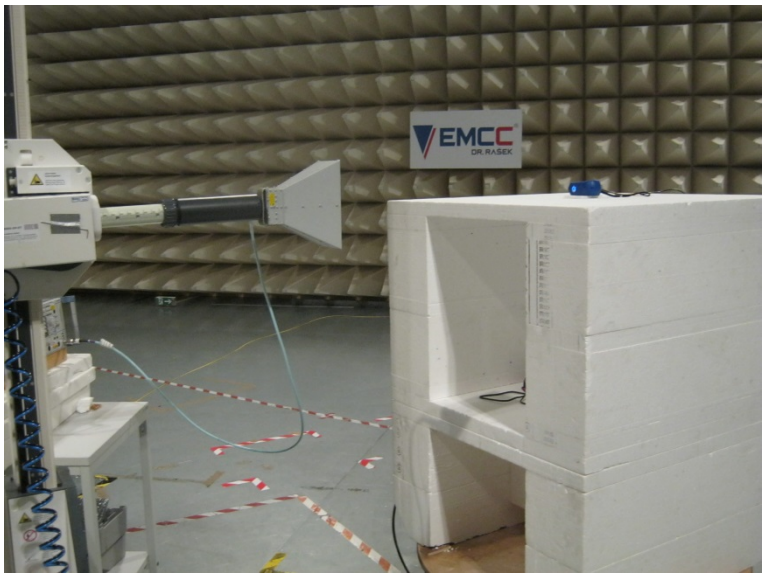
4.5.10.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209
Procedure:	ANSI C63.10-2013
Receiver:	#3831
Antenna:	#3235
Test distance:	1 m

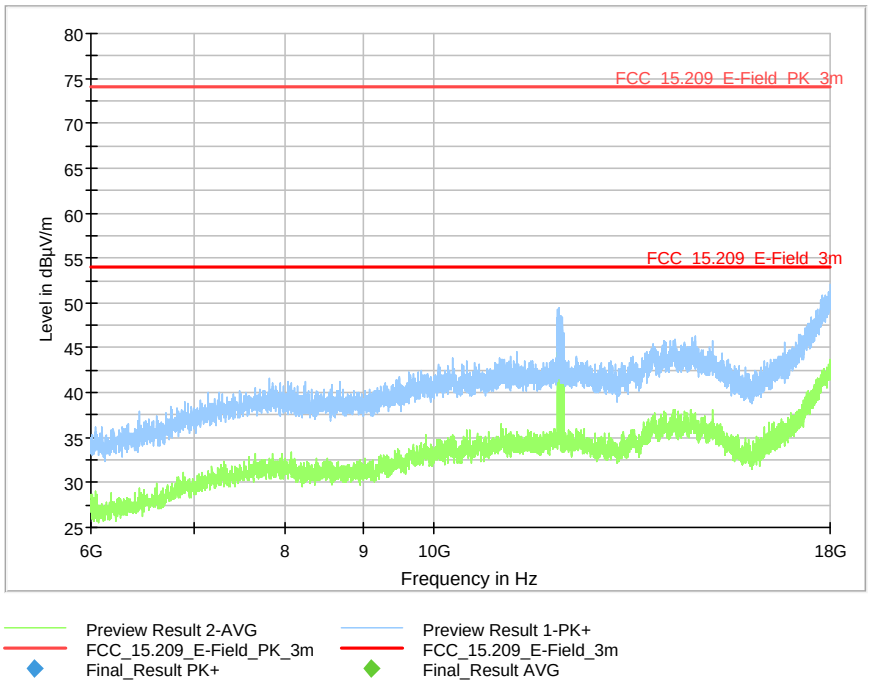
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 553, 554, 1889, 3235, 3831, 4075, 4717, 5392, 5535, 5536, 5544, 5545, 5620



Sample photo of setup

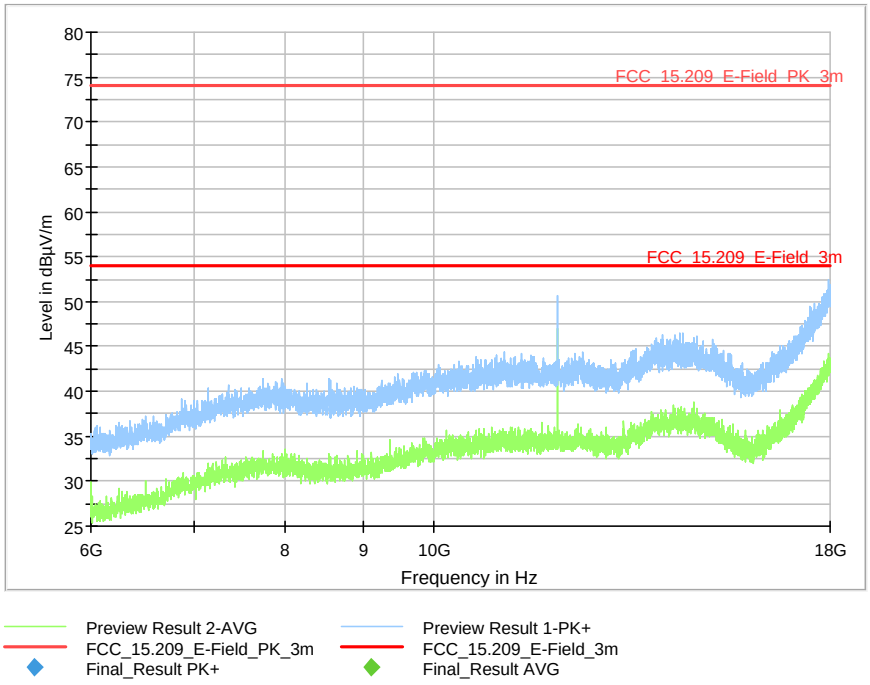
4.5.10.3 Detailed Test Data

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	2 (vert)

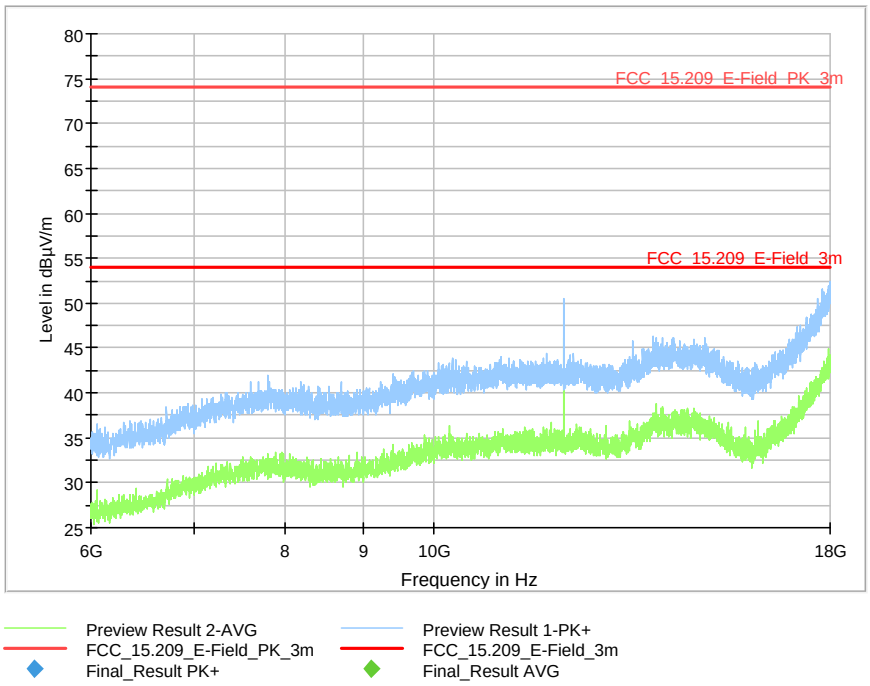


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	2 (vert)

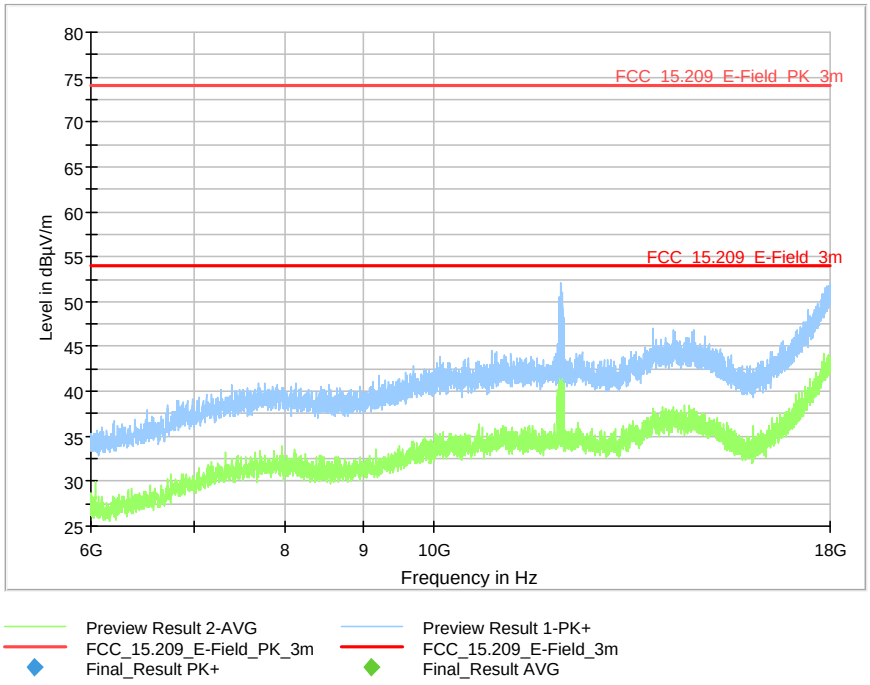


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)

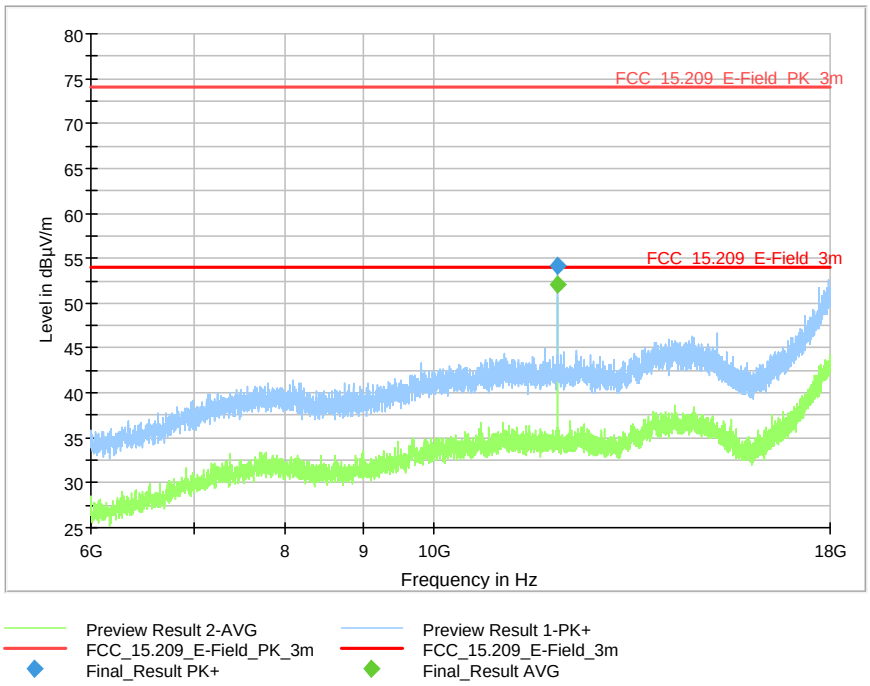


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Sweep
EUT Orientation:	1 (hor)

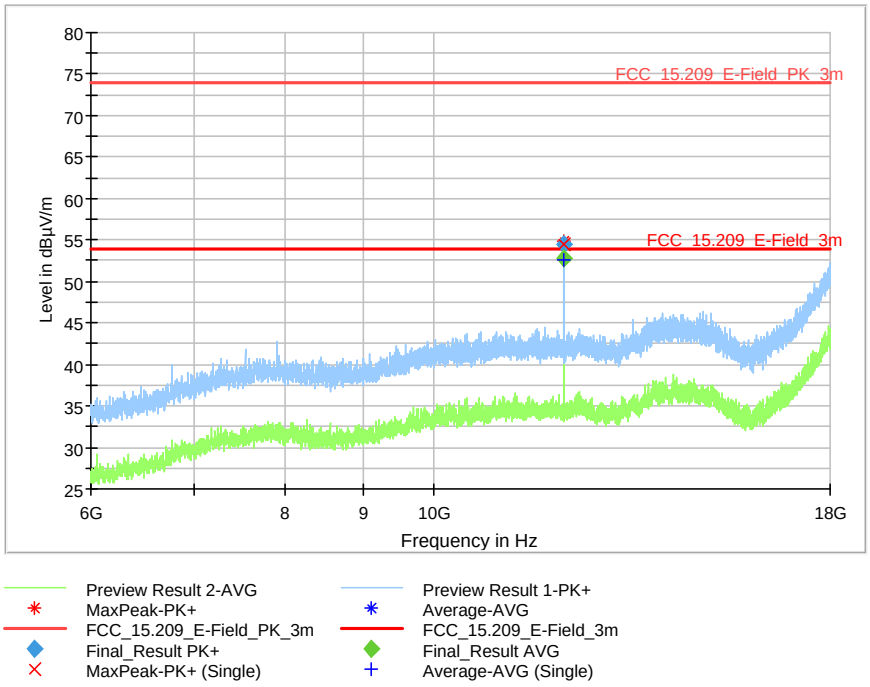


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)

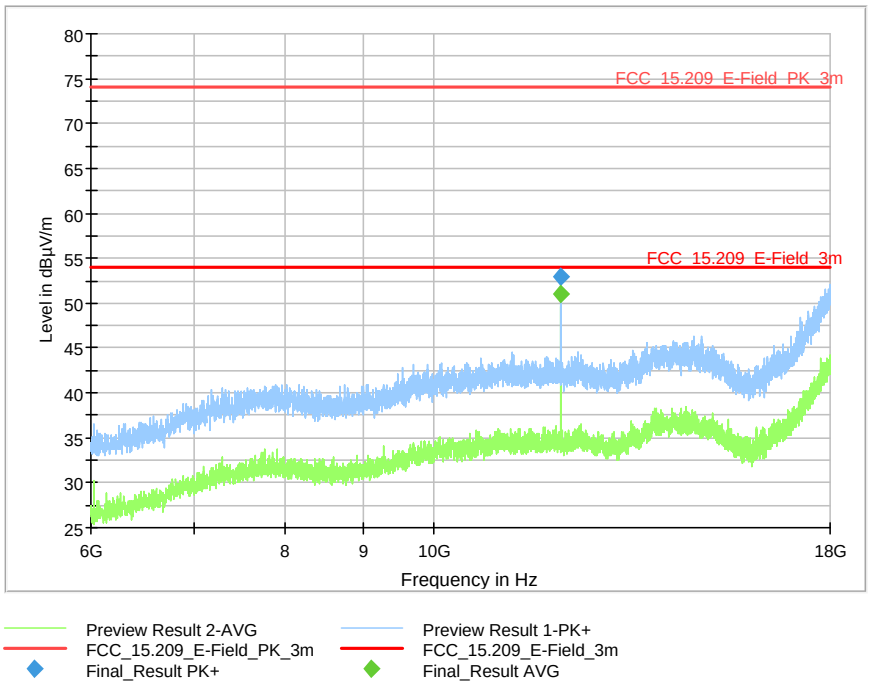


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)



Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	1 (hor)



Final Result:

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
12006.00	---	52.1	54.0	1.9	100	1000	150	H	117
12006.00	54.1	---	74.0	19.9	100	1000	150	H	117
12119.07	---	52.8	54.0	1.2	100	1000	149	H	120
12119.07	54.4	---	74.0	19.6	100	1000	149	H	120
12062.33	---	51.0	54.0	3.0	100	1000	148	H	121
12062.33	53.0	---	74.0	21.0	100	1000	148	H	121

All tests performed at the distance of d = 1 m.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.5.10.4 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No.:	113
Test date:	2019-05-17
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.5.11 Radiated Emissions 18 – 50 GHz

4.5.11.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection upto the highest measurement frequency required (unless stated otherwise in the applicable requirements).

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10.2013, 6.6.4.3 Final radiated emissions measurements

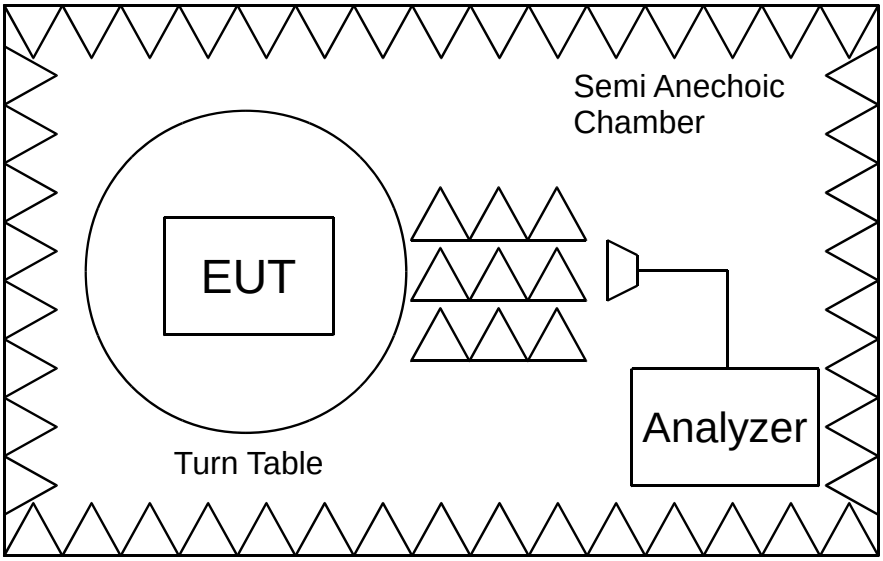
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.
If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.
As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.
Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	18 GHz – 50 GHz
Test distance	1 m (18 – 50 GHz)
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

4.5.11.2 Test Setup



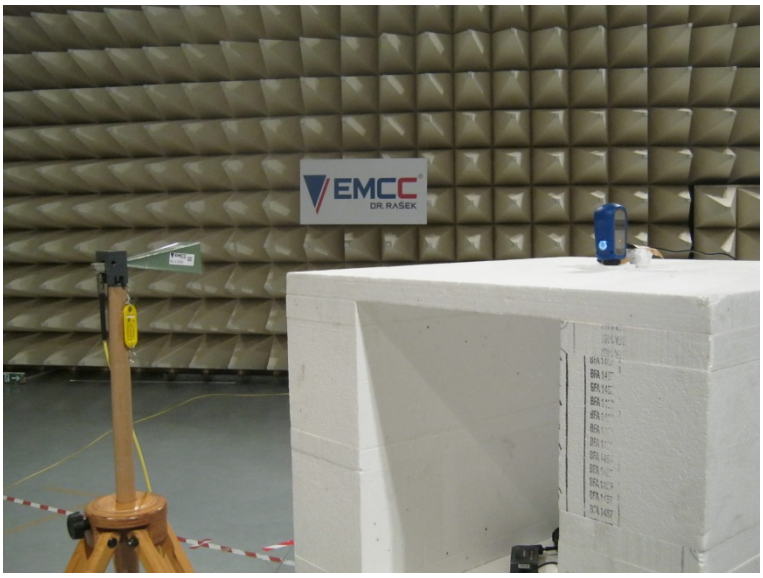
SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3831
Antenna: #1300 (18 – 26.5 GHz)
#1229 (26.5 – 40 GHz)
#2113 (40 – 50 GHz)

Test distance: 1 m (18 – 50 GHz)

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
001, 553, 554, 1229, 1300, 1348, 1889, 2111, 2113, 3061, 3831, 4717, 4914, 5392, 5612, 5536

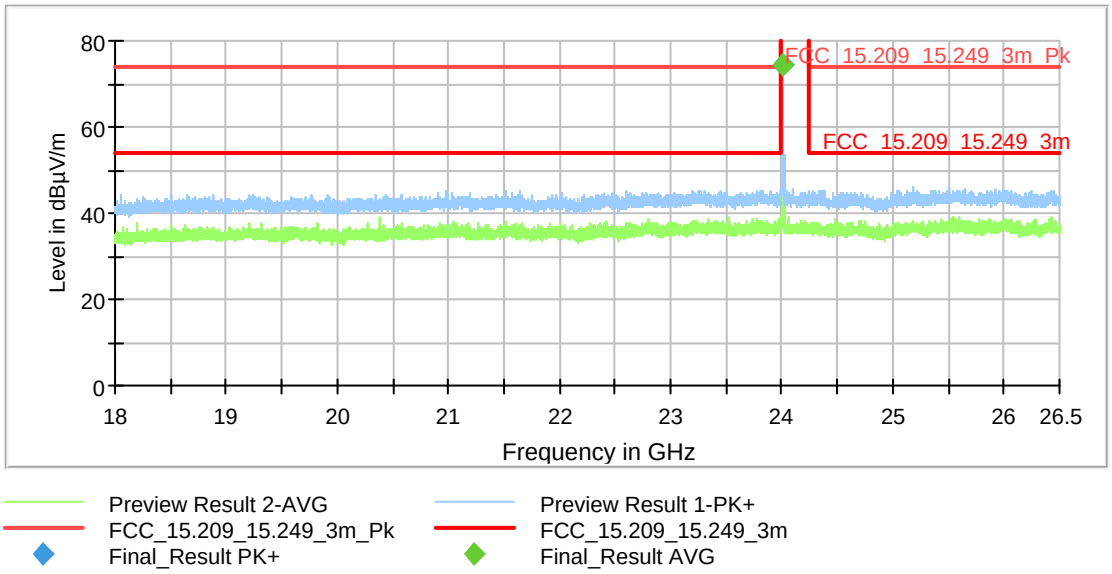


Sample photo of setup (18 – 26.5 GHz)

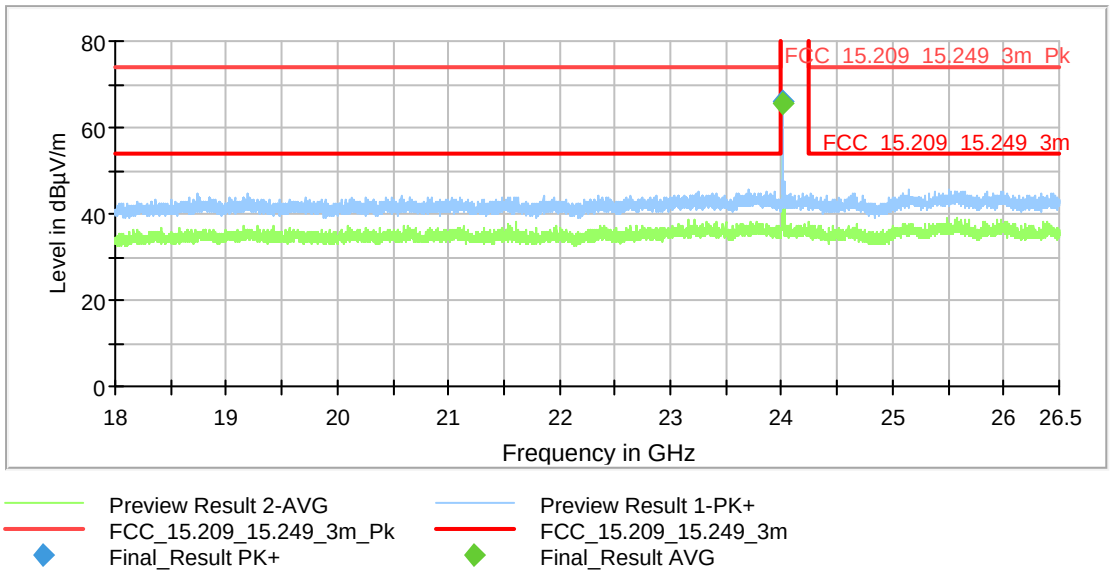
4.5.11.3 Detailed Test Data

- **EUT #1; FSC 1/7; SN: 110**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



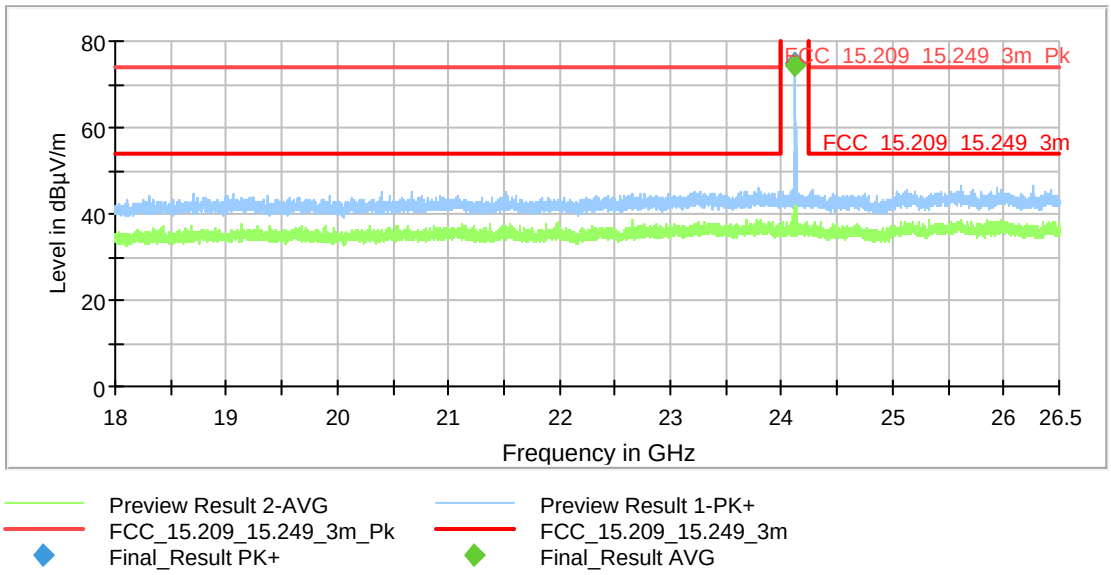
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



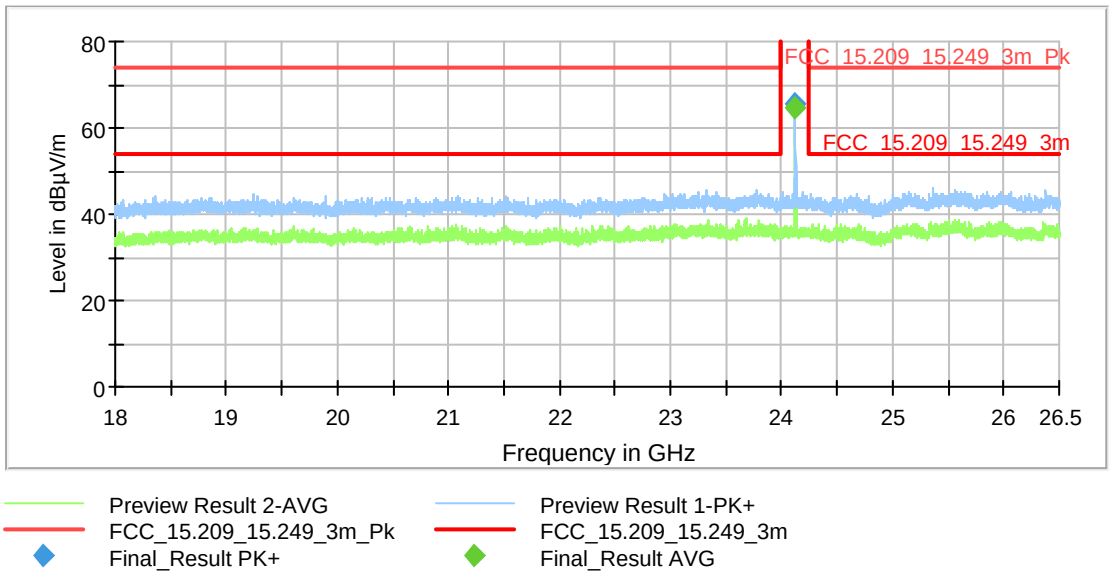
Note: the emission at 24.012 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



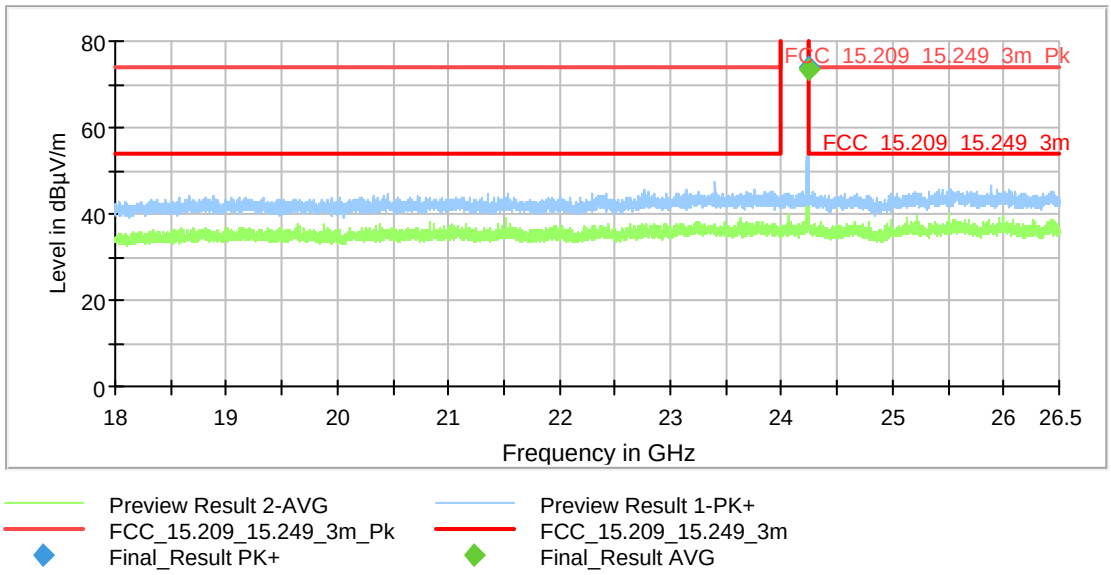
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



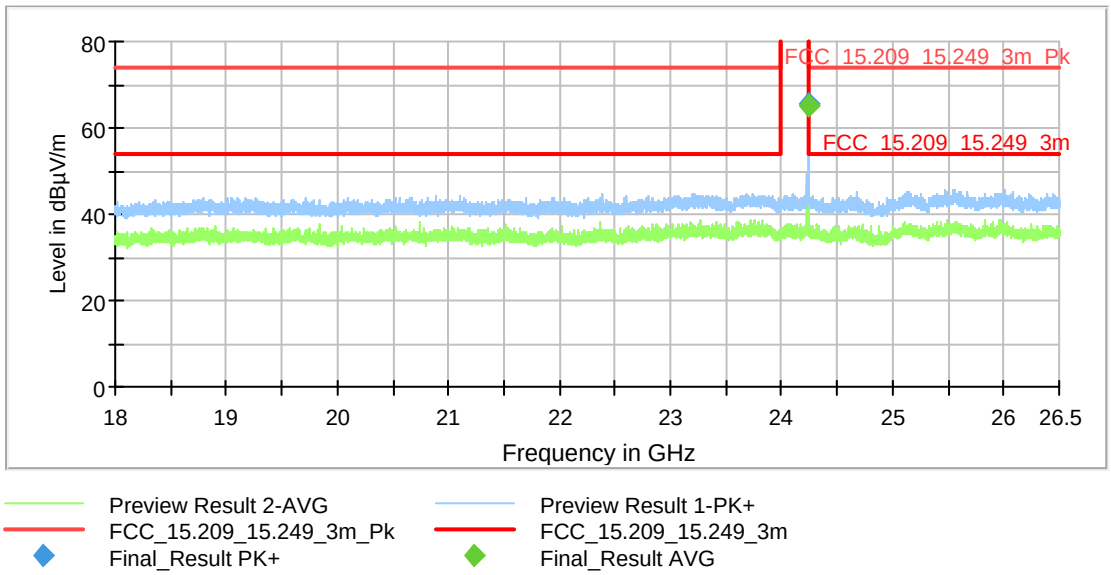
Note: the emission at 24.125 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



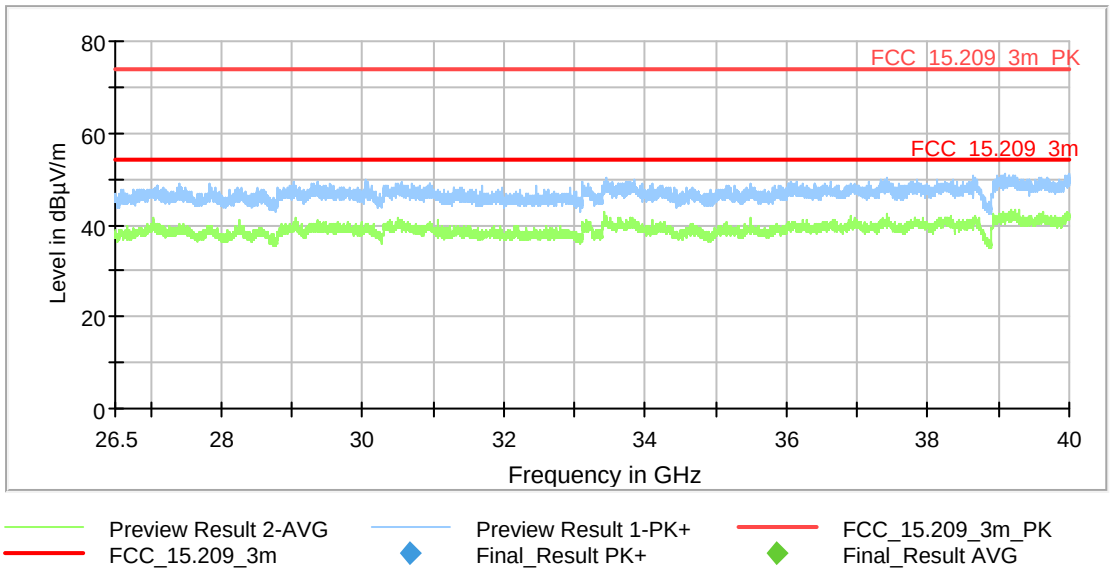
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



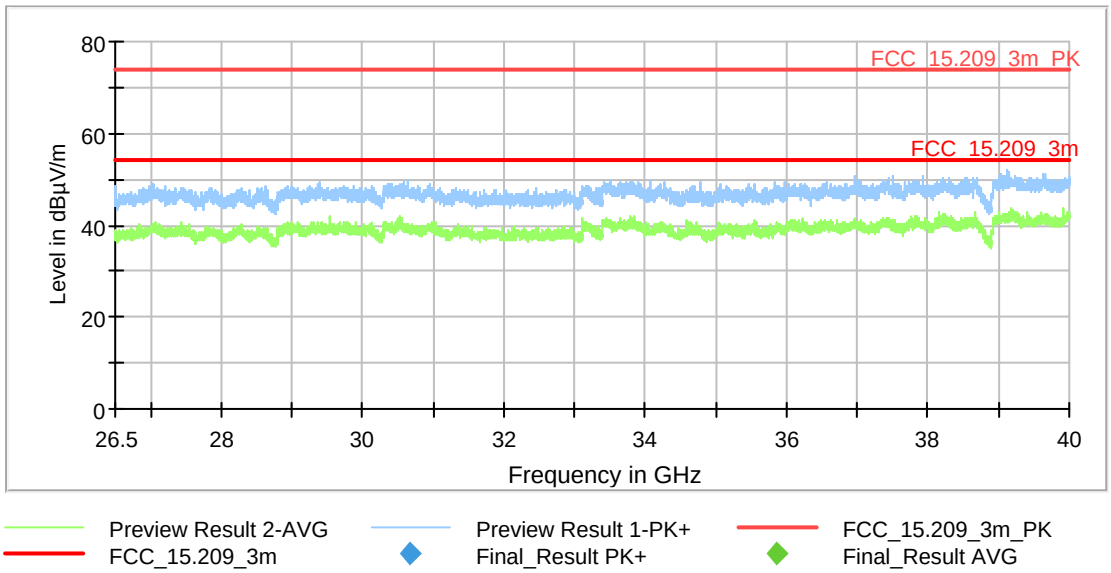
Note: the emission at 24.125 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

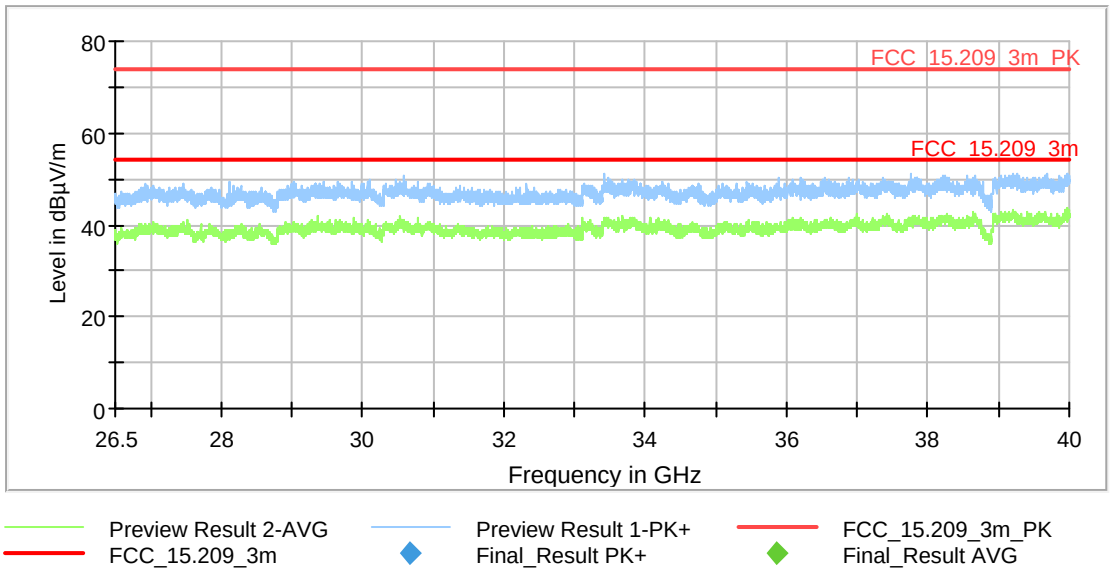


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

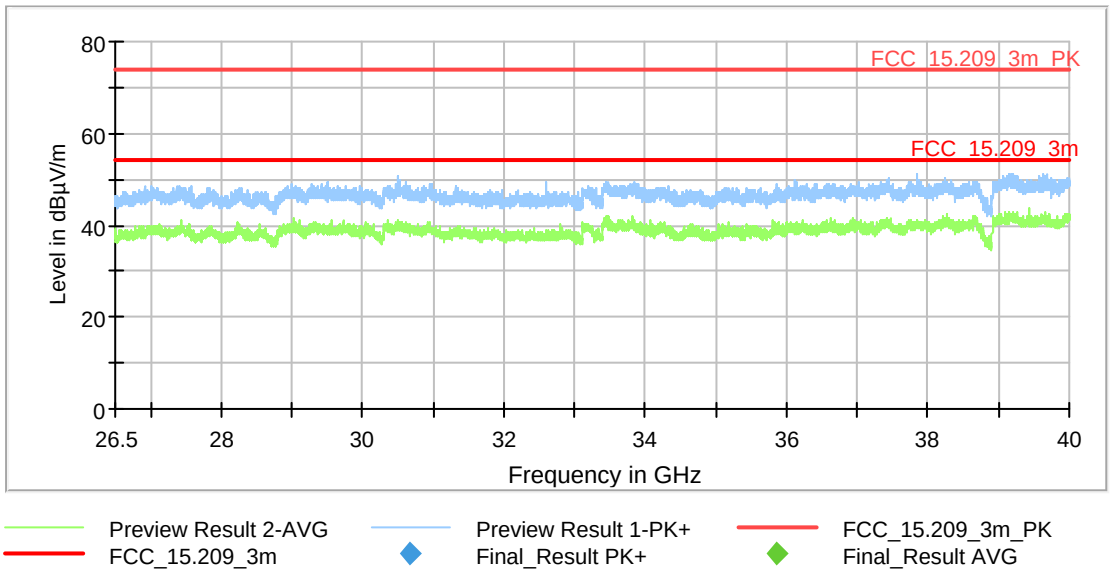


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

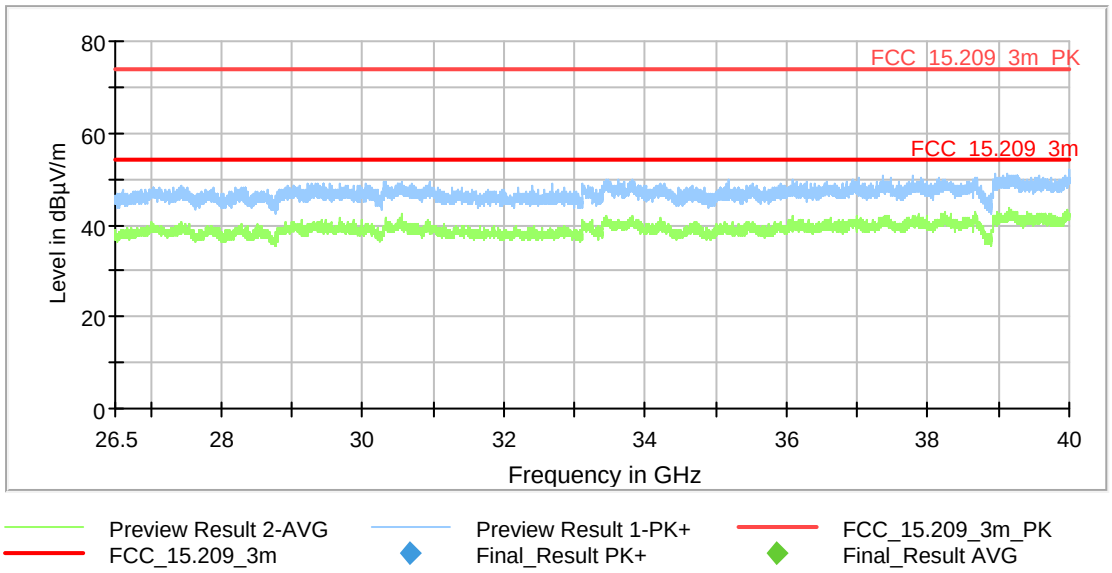


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

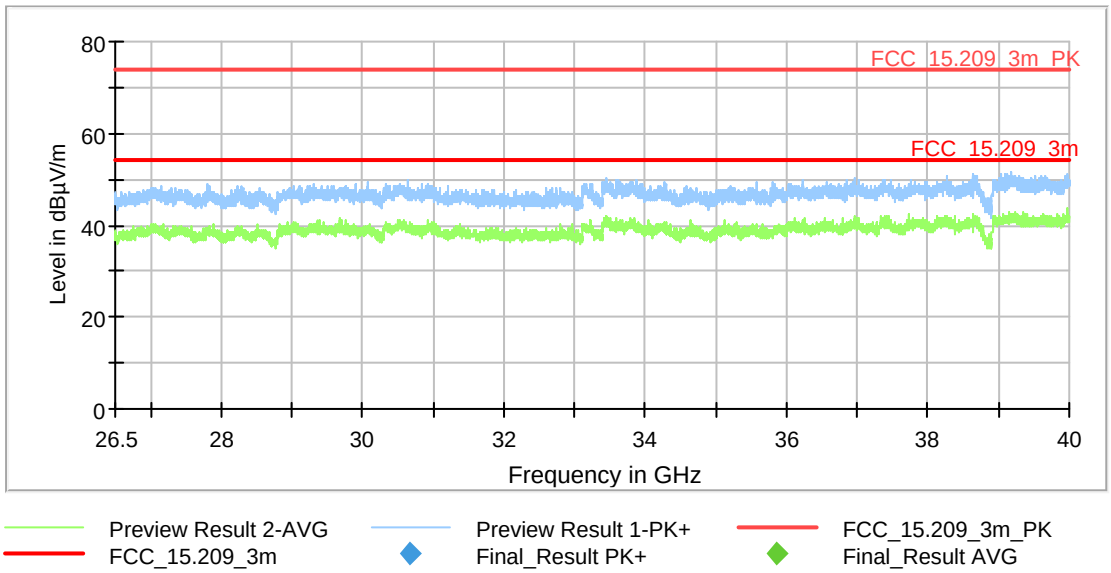


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

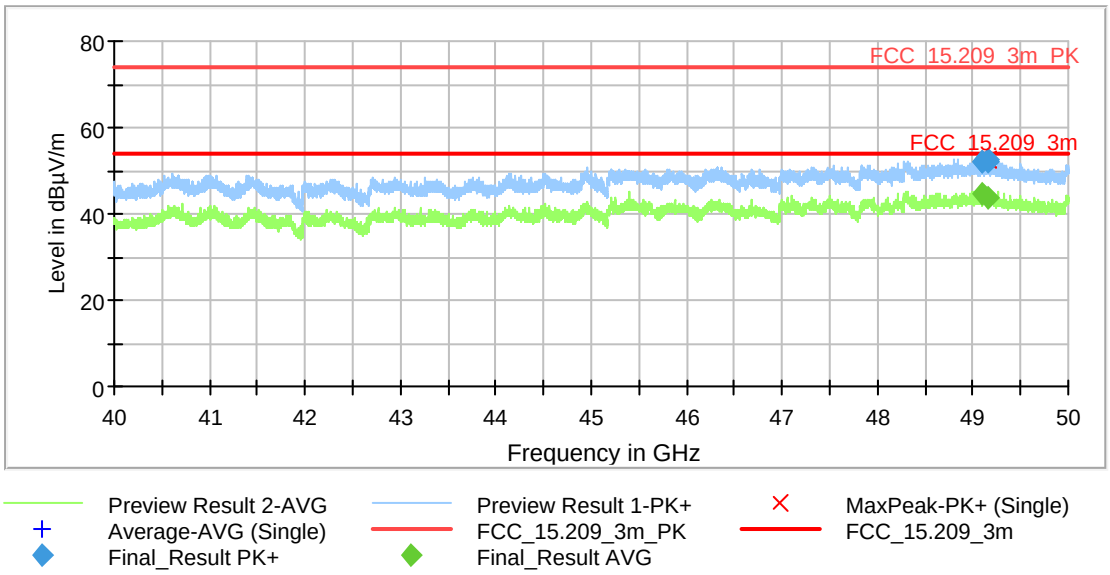


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

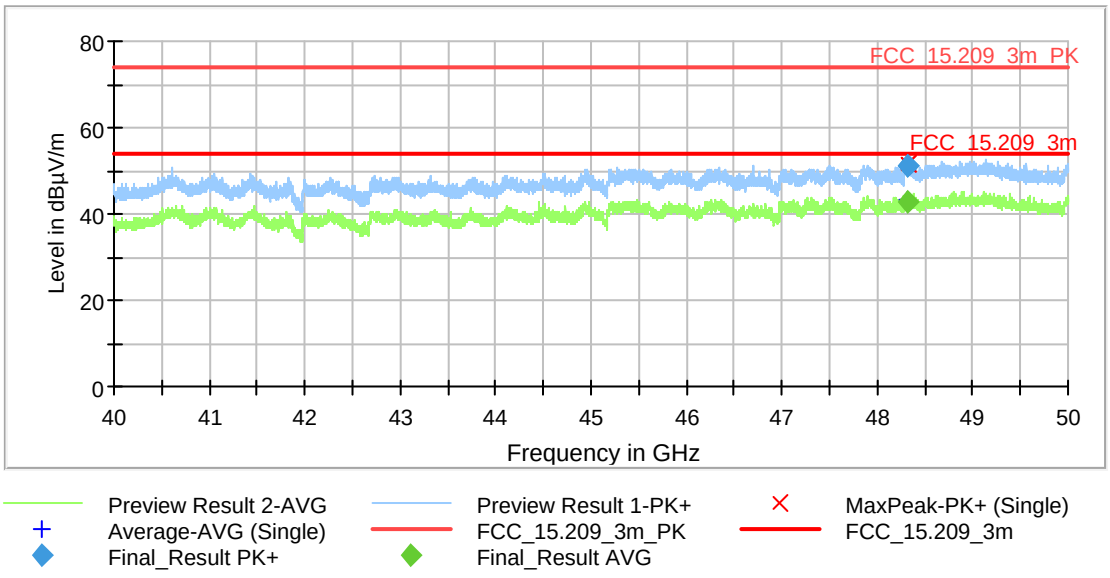


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	40 – 50 GHz

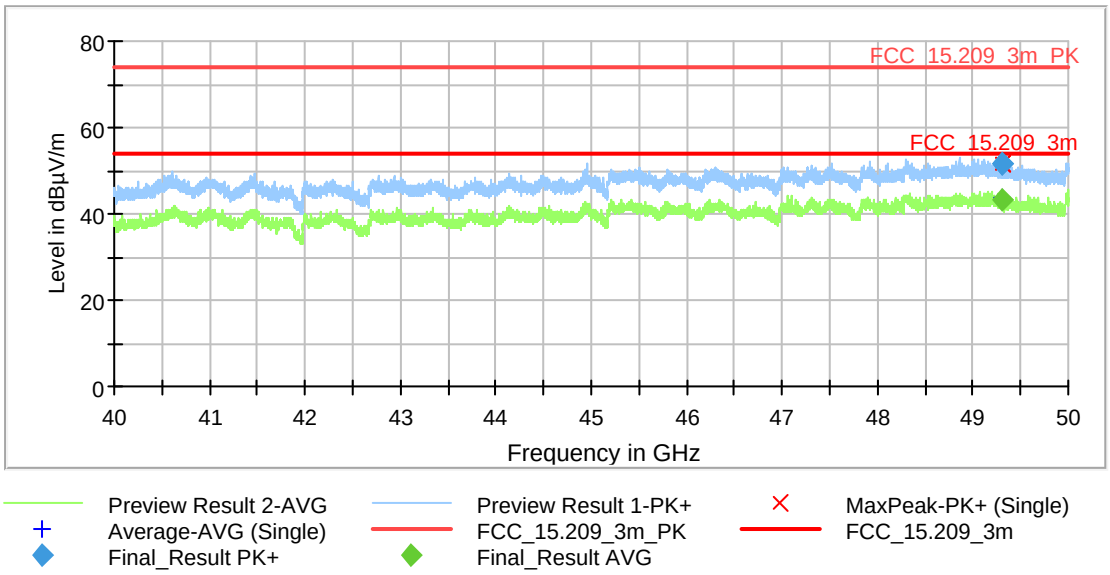


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz

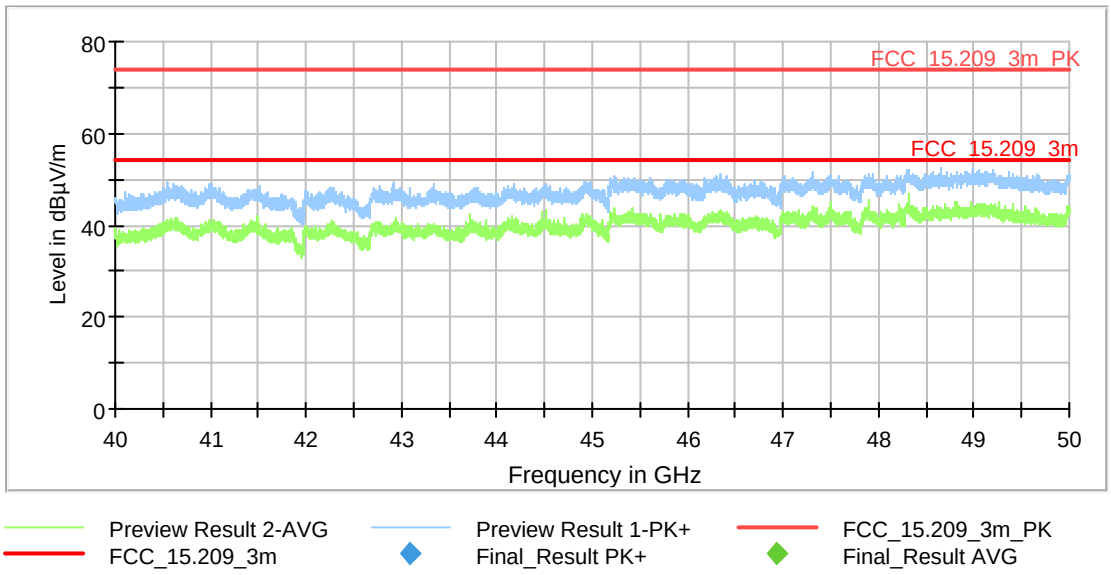


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	40 – 50 GHz

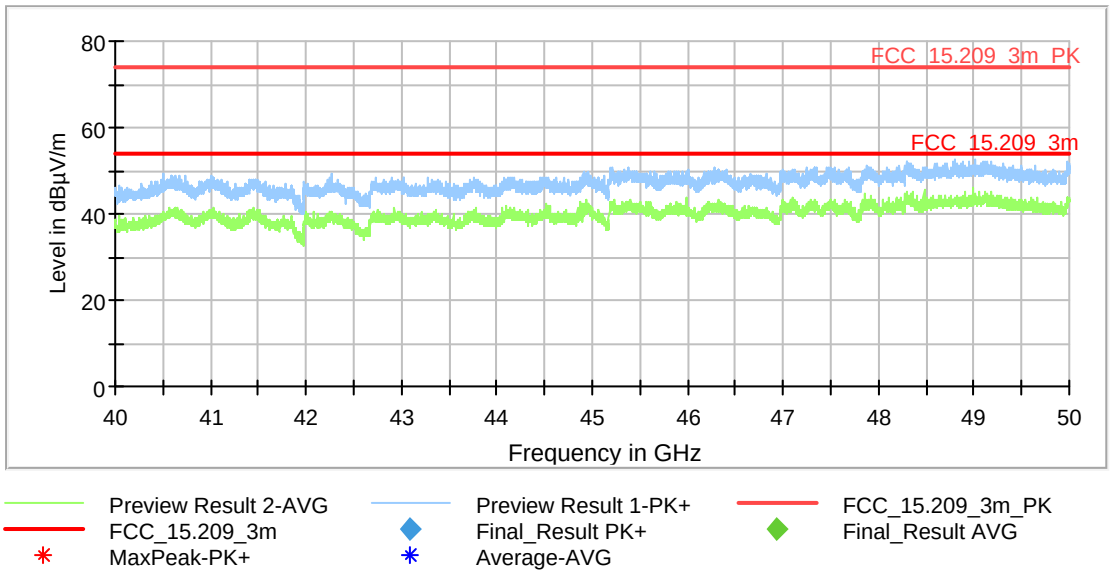


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz

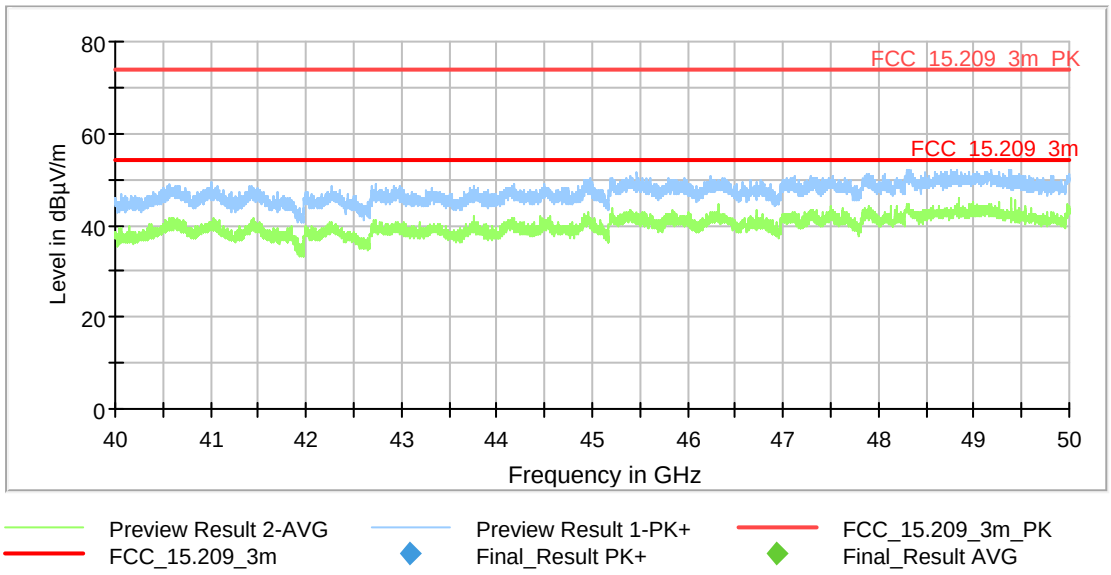


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	40 – 50 GHz



Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz



Final Result EUT #1; FSC 1/7; SN: 110

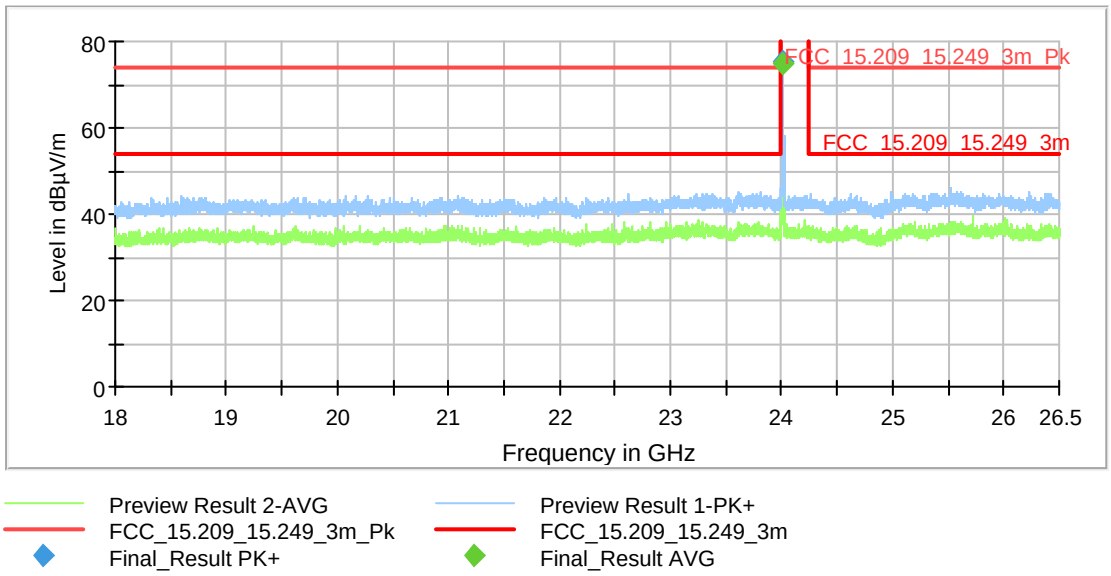
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
24011.93	74.6	---	128.0	53.4	100	1000.0	150.0	V	236
24011.93	---	74.2	108.0	33.8	100	1000.0	150.0	V	236
24125.01	74.8	---	128.0	53.2	100	1000.0	150.0	V	236
24125.01	---	74.4	108.0	33.7	100	1000.0	150.0	V	236
24237.96	73.8	---	128.0	54.3	100	1000.0	150.0	V	235
24237.96	---	73.3	108.0	34.7	100	1000.0	150.0	V	235
49086.95	---	44.6	54.0	9.4	100	1000.0	150.0	V	126
49155.72	---	43.7	54.0	10.3	100	1000.0	150.0	H	82

All tests performed at the distance of d = 1 m (18 – 50 GHz).

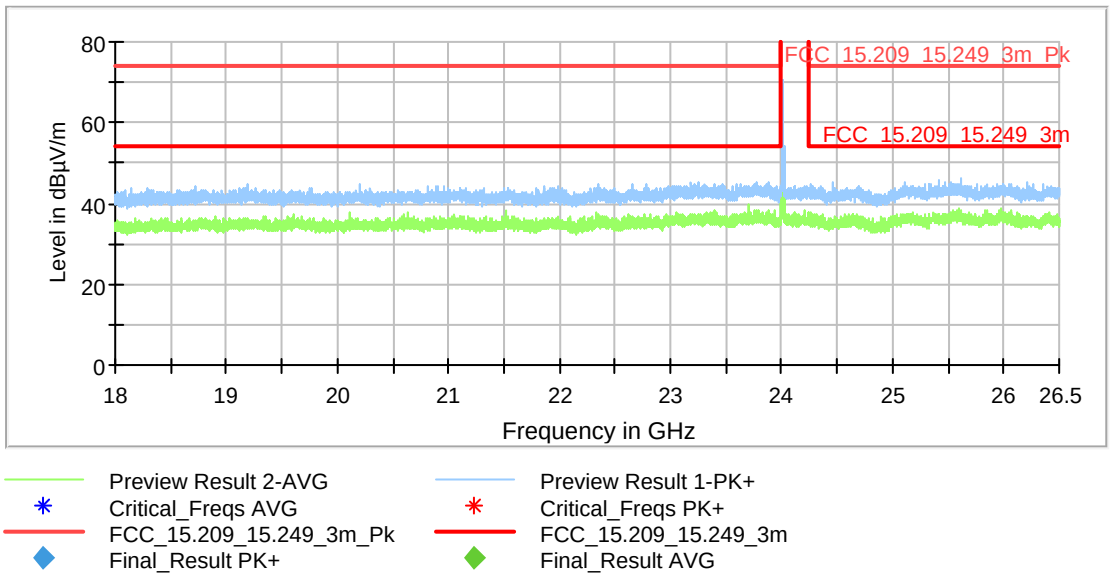
The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

- **EUT #2; FSC 1000; SN: 113**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



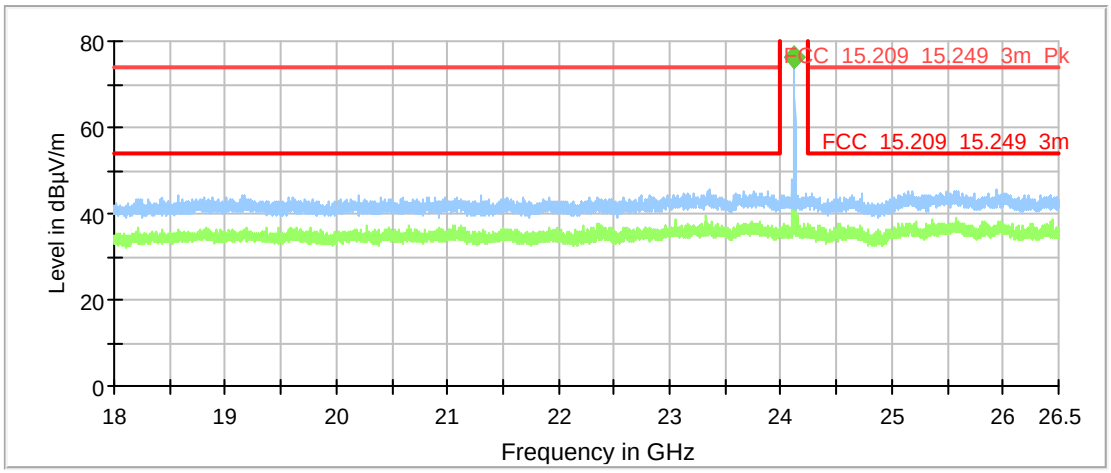
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



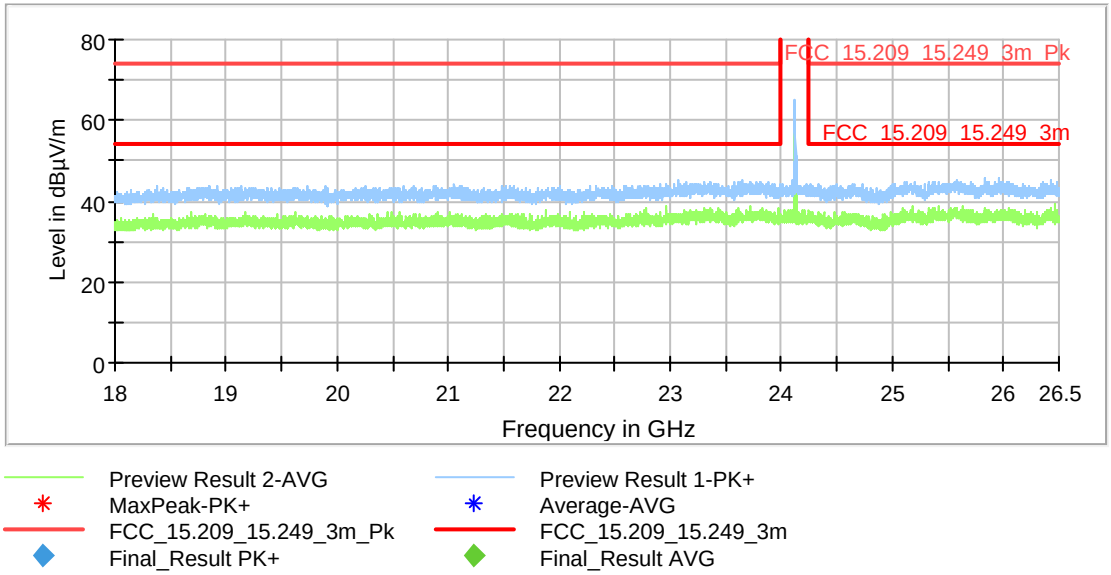
Note: the emission at 24.012 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



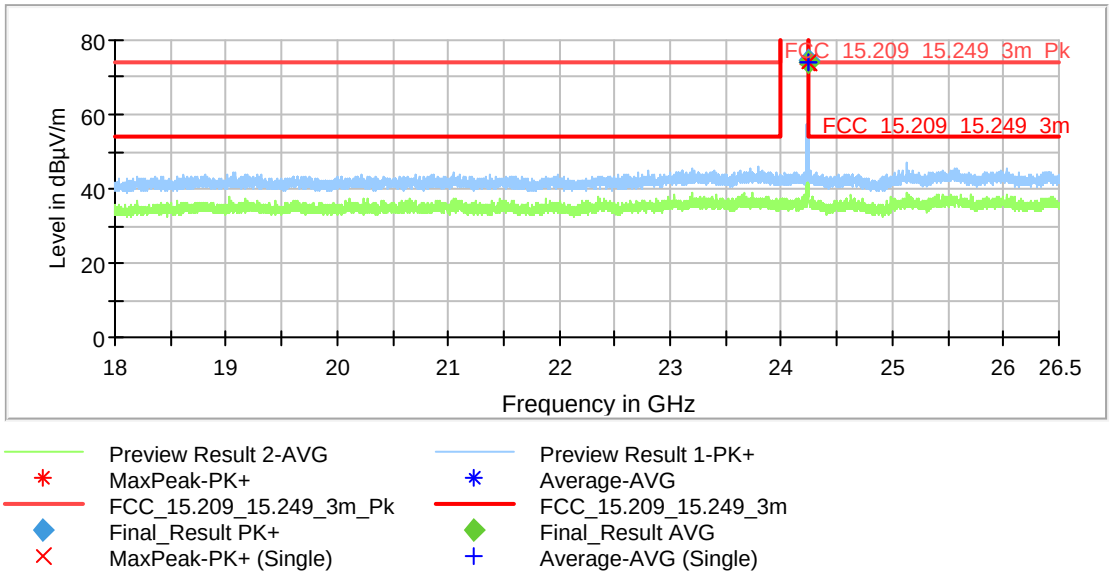
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



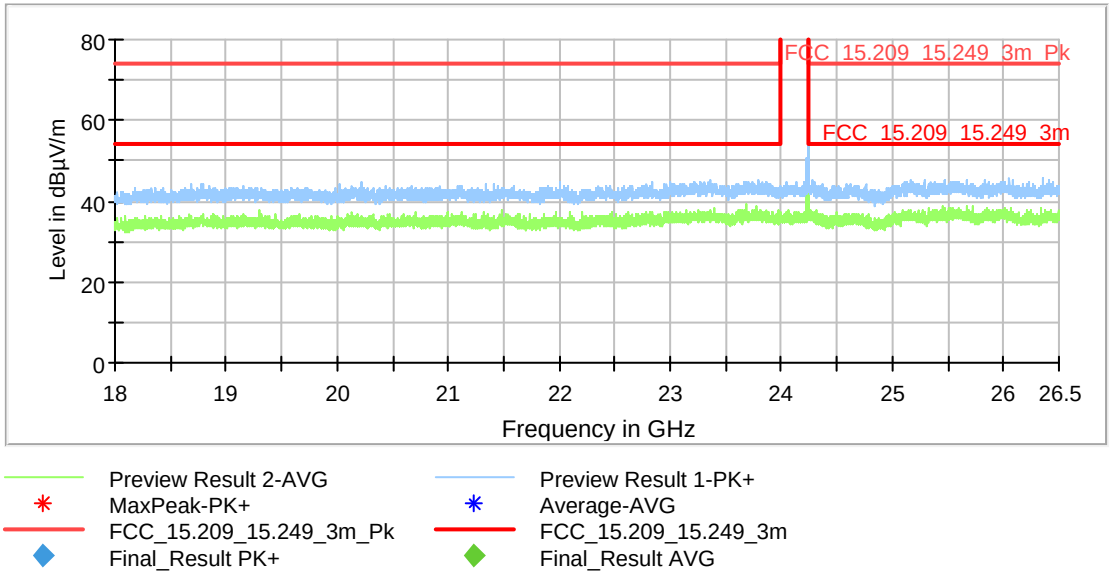
Note: the emission at 24.125 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	18 – 26.5 GHz



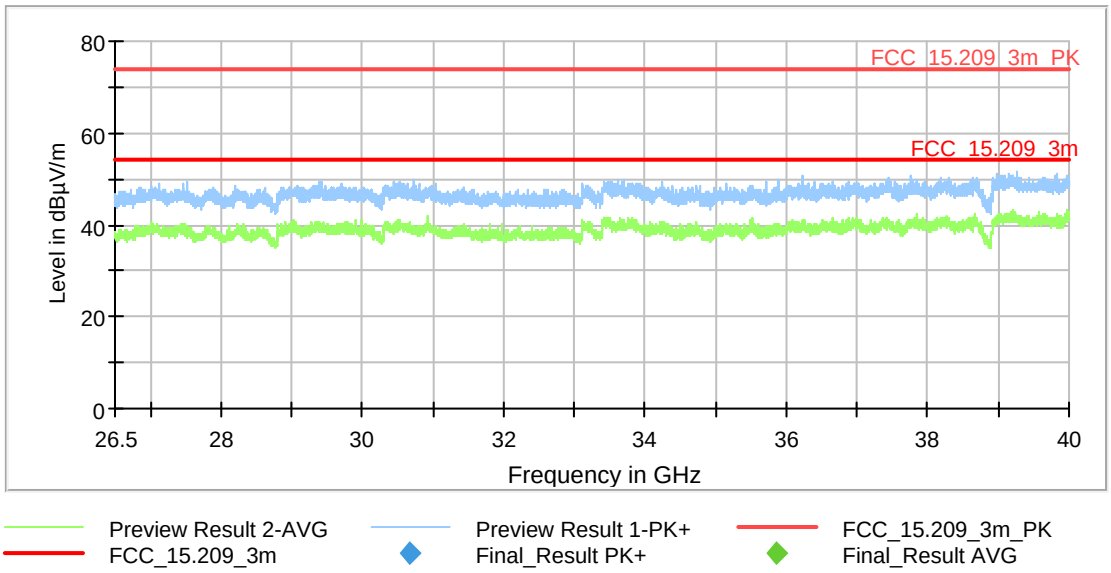
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	18 – 26.5 GHz



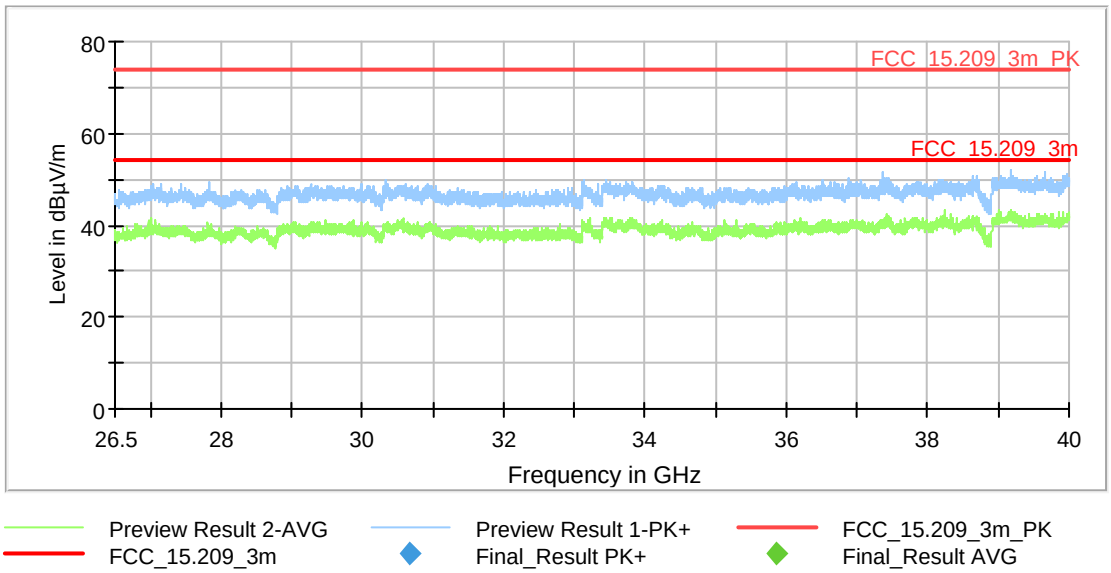
Note: the emission at 24.238 GHz is the carrier frequency.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

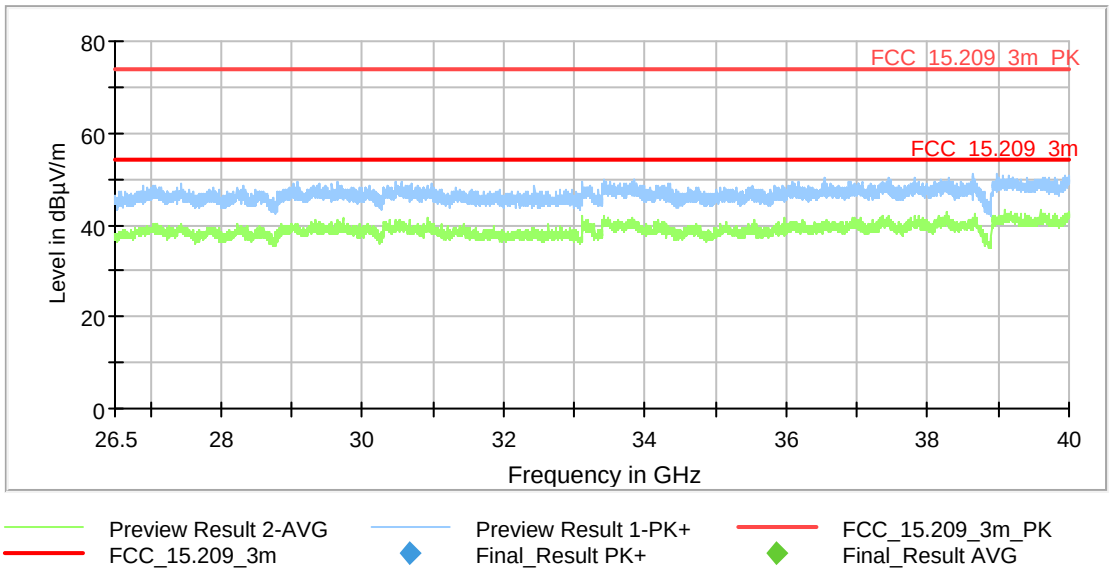


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

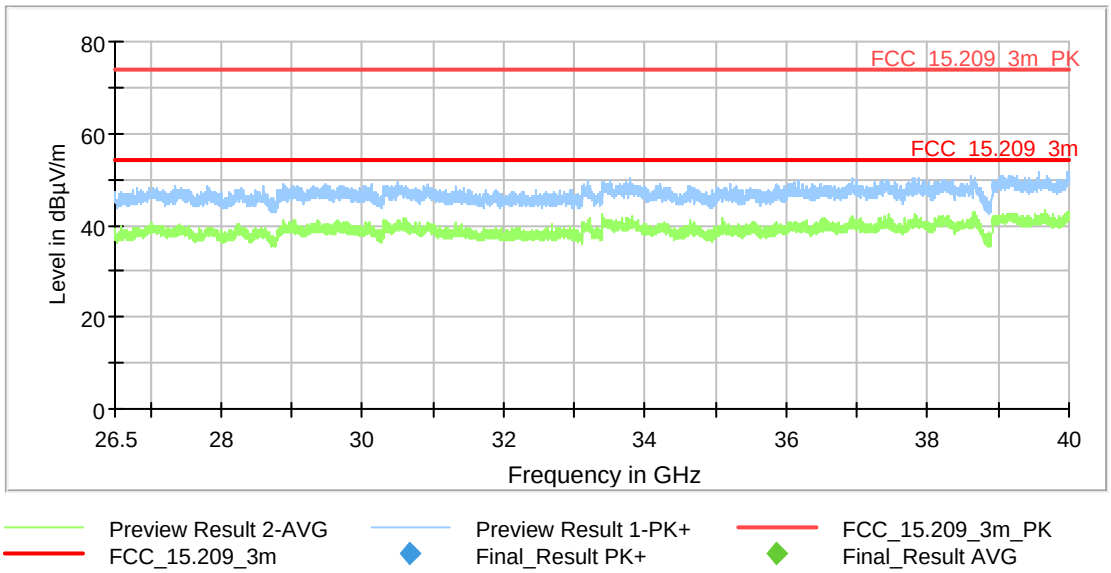


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

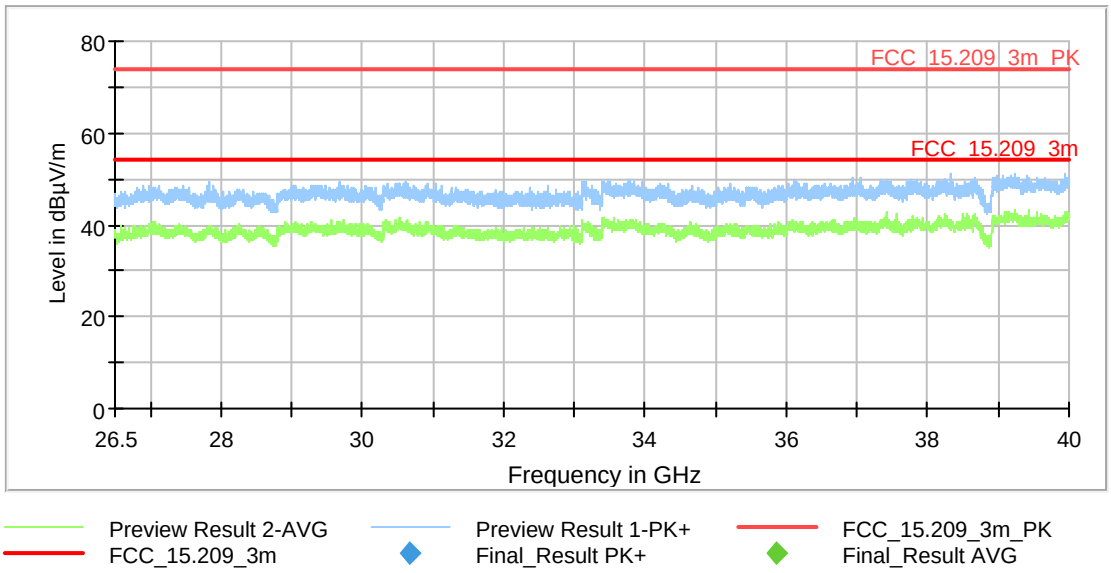


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

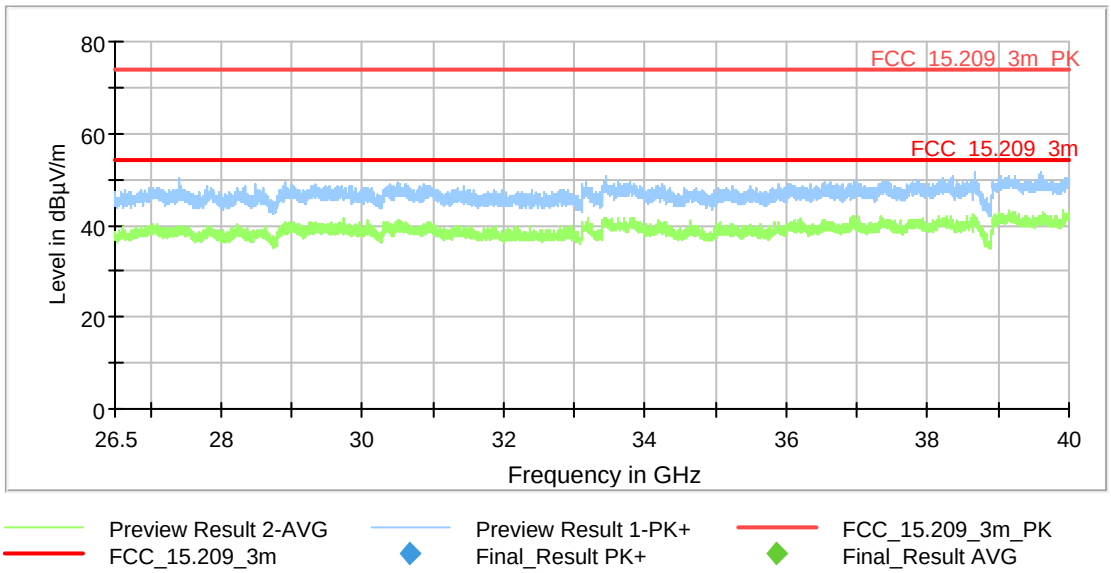


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	26.5 - 40 GHz

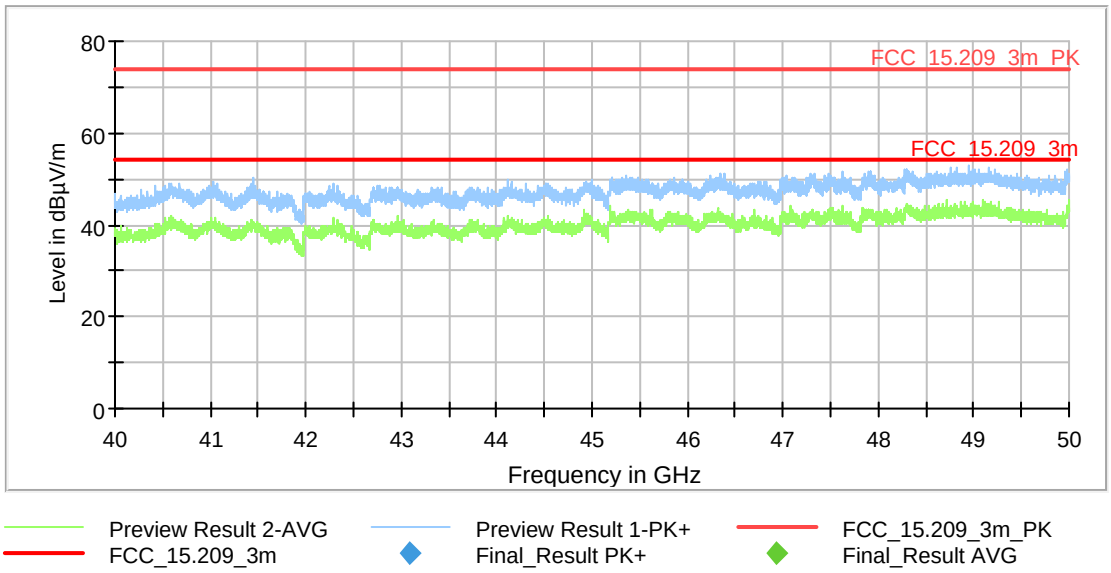


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	26.5 -40 GHz

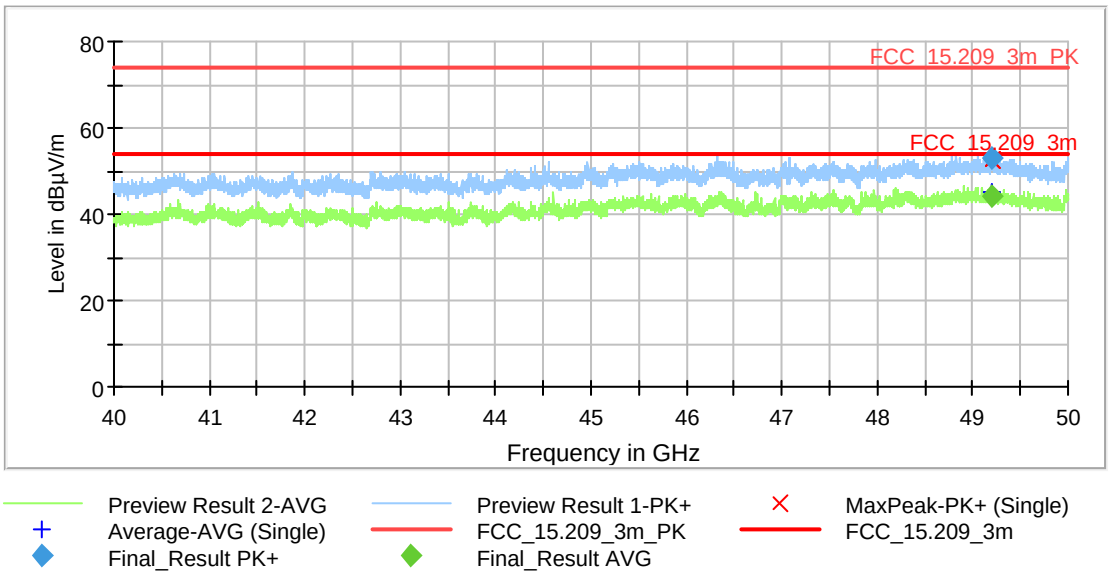


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	1 (hor)
Frequency range:	40 -50 GHz

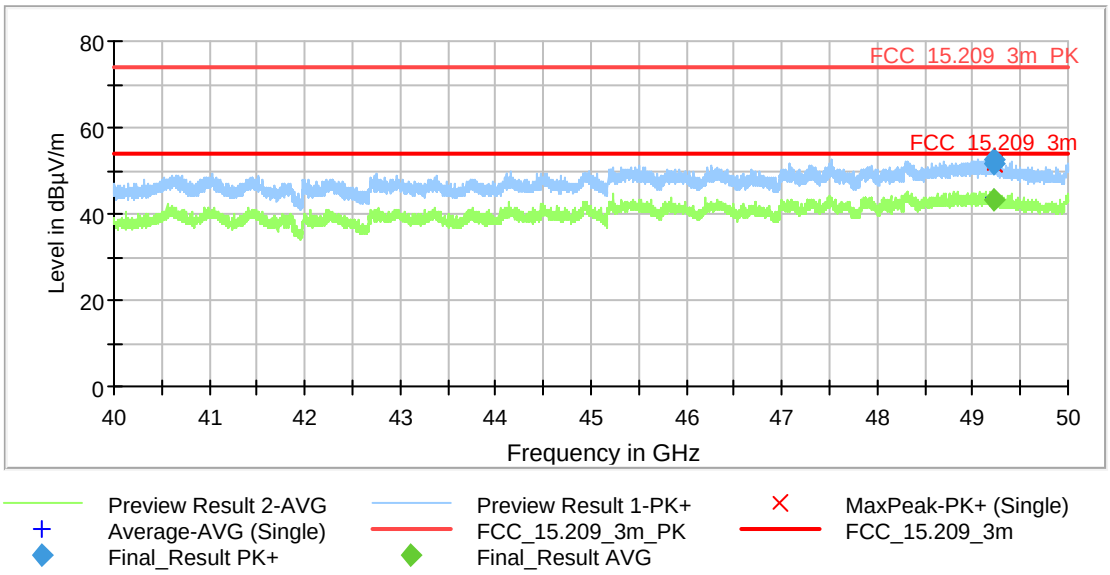


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz

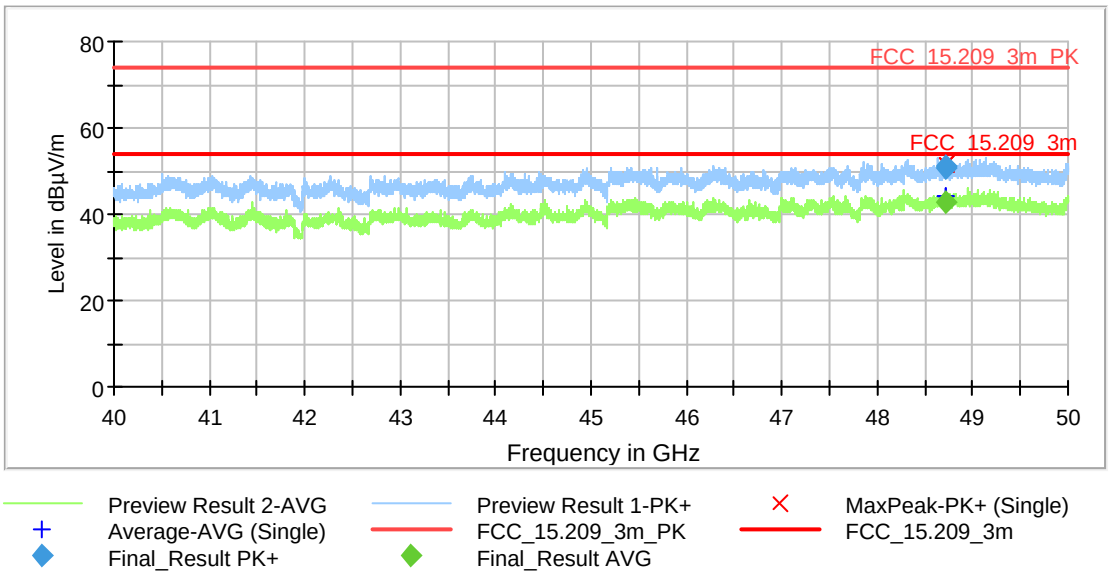


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	1 (hor)
Frequency range:	40 -50 GHz

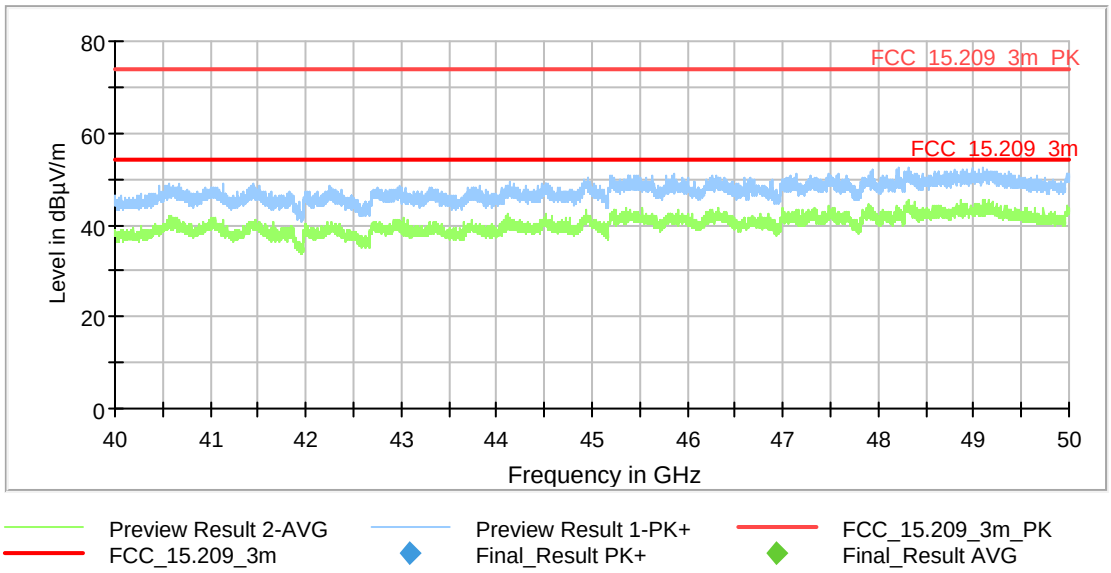


Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz

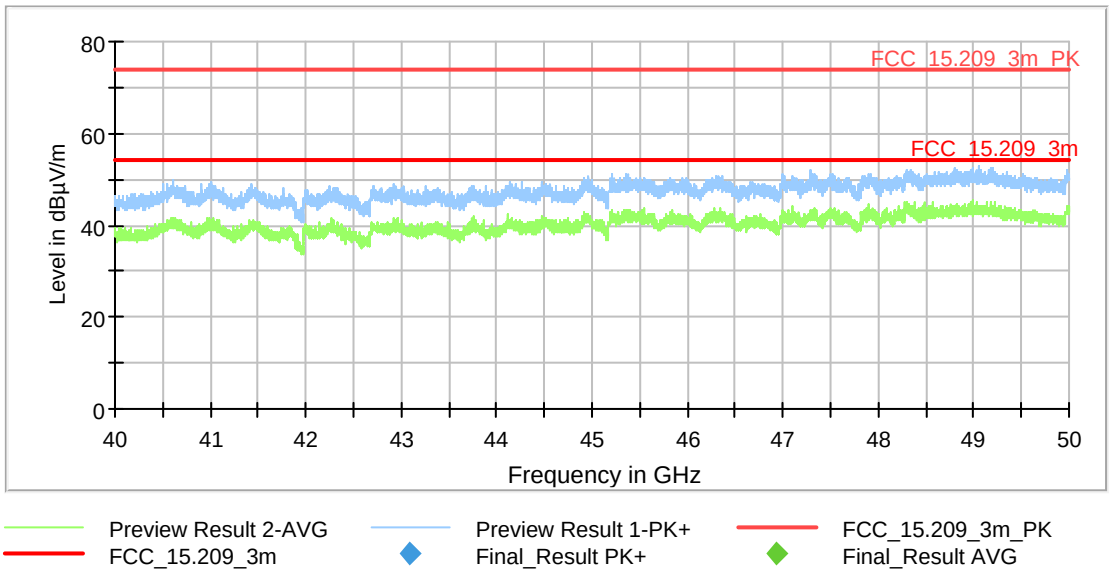


Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	1 (hor)
Frequency range:	40 -50 GHz



Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	2 (vert)
Frequency range:	40 - 50 GHz



Final Result EUT #2; FSC 1000; SN: 113

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
24012.01	75.3	---	128.0	52.7	100	1000	150	H	136
24012.01	---	75.0	108.0	33.0	100	1000	150	H	136
24125.02	76.4	---	128.0	51.6	100	1000	150	V	136
24125.02	---	76.1	108.0	31.9	100	1000	150	V	136
24238.02	74.4	---	128.0	53.7	100	1000	150	V	50
24238.02	---	74.0	108.0	34.0	100	1000	150	V	50
48714.91	---	42.7	54.0	11.3	100	1000.0	150.0	V	108
48714.91	51.3	---	74.0	22.7	100	1000.0	150.0	V	108
49203.40	52.9	---	74.0	21.1	100	1000	150	H	0
49203.40	---	44.0	54.0	10.0	100	1000	150	H	0
49215.65	---	43.4	54.0	10.6	100	1000.0	150.0	V	345
49215.65	51.8	---	74.0	22.2	100	1000.0	150.0	V	345

All tests performed at the distance of d = 1 m (18 – 50 GHz)

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.5.11.4 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No:	FSC 1/7, 110 FSC 1000, 113
Test date:	2019-05-17 / 2019-05-20
Test personnel:	Patrick Reusch, Ludwig Kraft

The EUT meets the requirements of this section.

4.5.12 Radiated Emissions 50 – 100 GHz

4.5.12.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection upto the highest measurement frequency required (unless stated otherwise in the applicable requirements).

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10.2013, 6.6.4.3 Final radiated emissions measurements

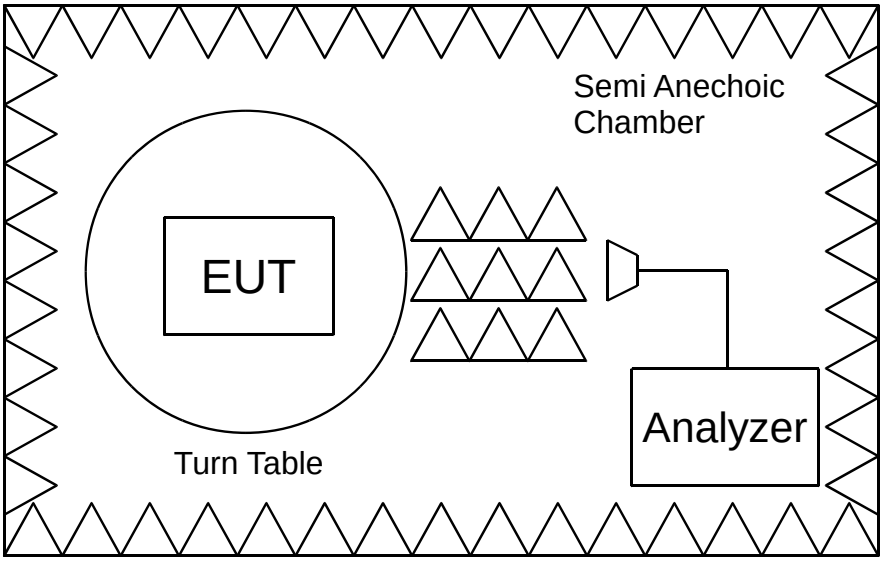
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.
If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.
As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.
Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	50 GHz – 100 GHz
Test distance	Explorative measurement in close distance
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

4.5.12.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209
Procedure:	ANSI C63.10-2013
Receiver:	#3831
Antenna:	#2591 (50 – 75 GHz) #2600 (75 – 100 GHz)
Test distance:	n/a

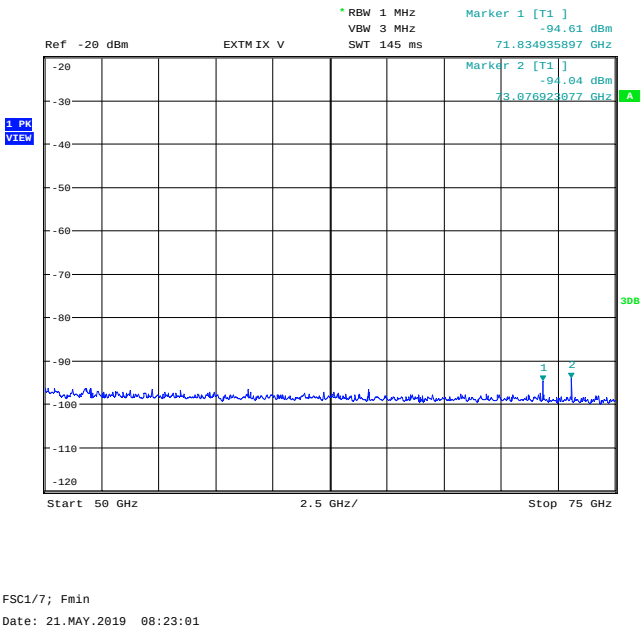
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
1546, 1548, 1889, 2591, 2597, 2600, 3831, 4717

Sample photo of setup

4.5.12.3 Detailed Test Data

- **EUT #1; FSC 1/7; SN: 110**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	all
Frequency range:	50 – 75 GHz

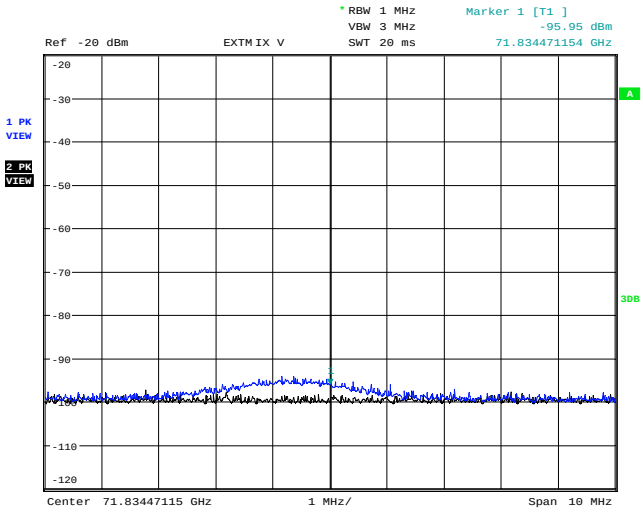


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

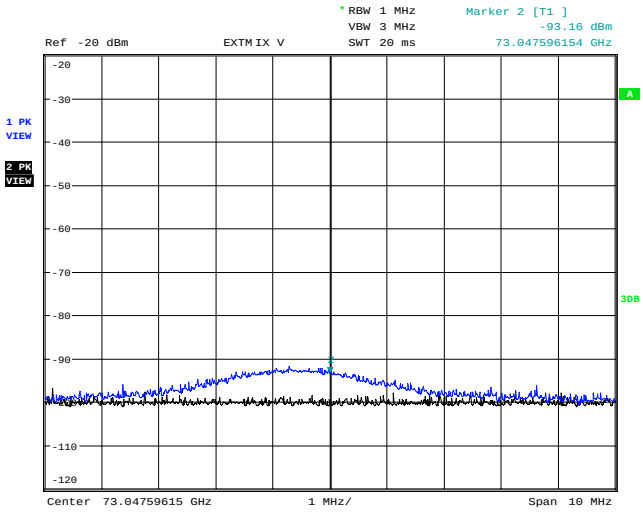
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	all
Frequency range:	50 – 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmin
Date: 21.MAY.2019 08:24:59

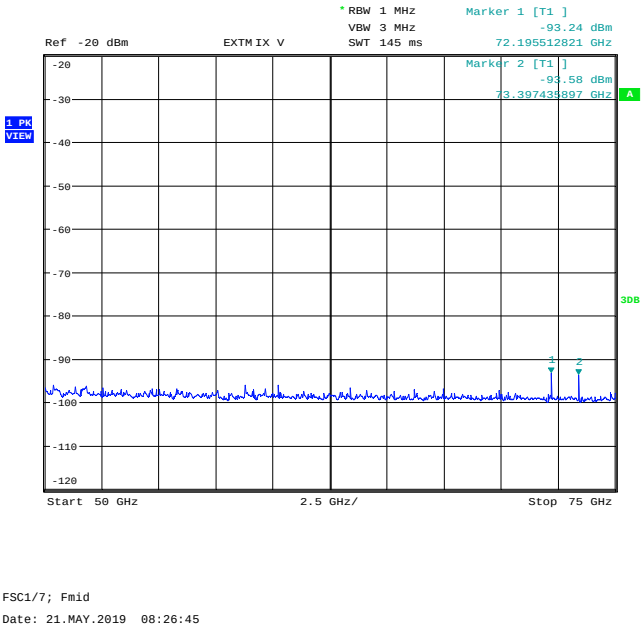
Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmin
Date: 21.MAY.2019 08:25:44

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	all
Frequency range:	50 – 75 GHz

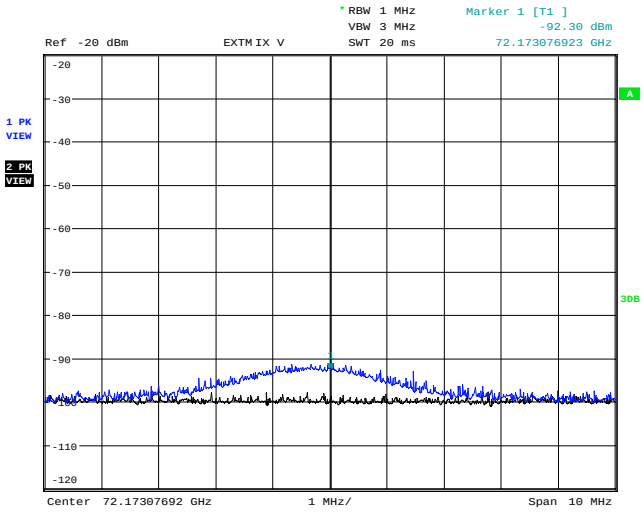


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

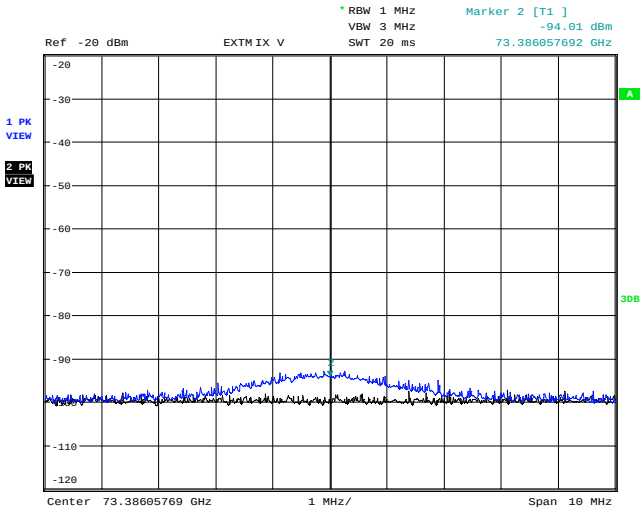
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	all
Frequency range:	50 – 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmid
Date: 21.MAY.2019 08:27:27

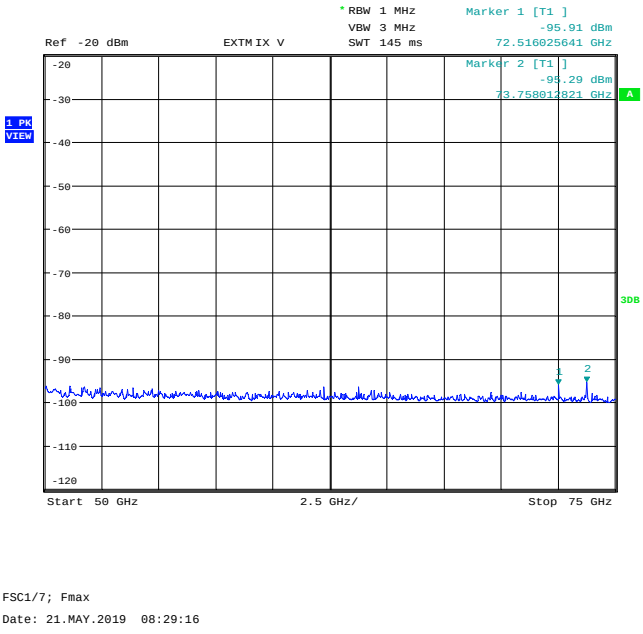
Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmid
Date: 21.MAY.2019 08:28:06

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	all
Frequency range:	50 – 75 GHz

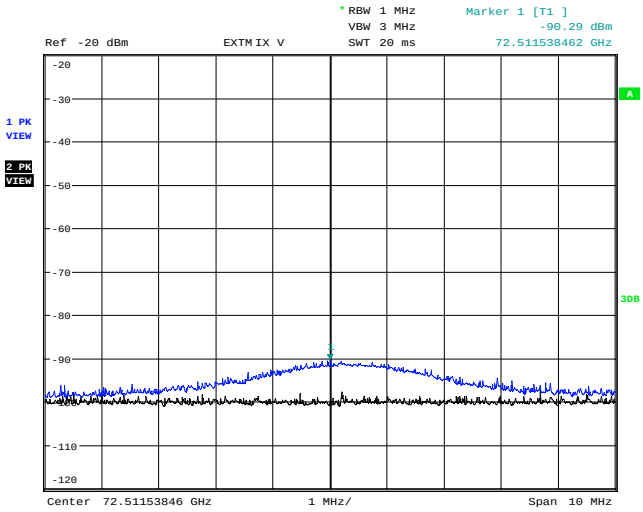


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

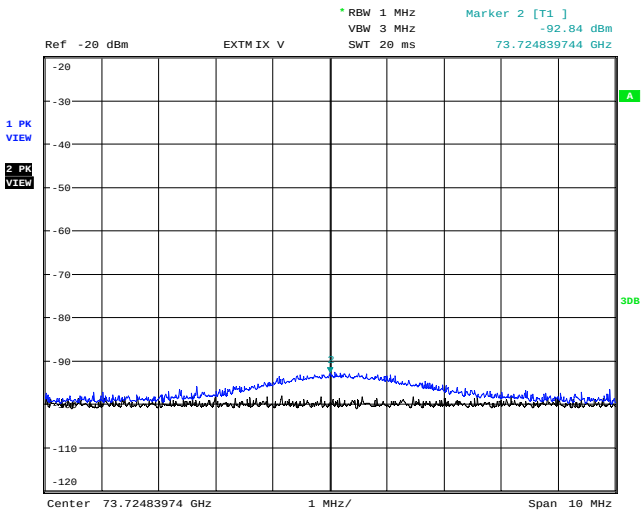
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	all
Frequency range:	50 – 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmax
Date: 21.MAY.2019 08:29:58

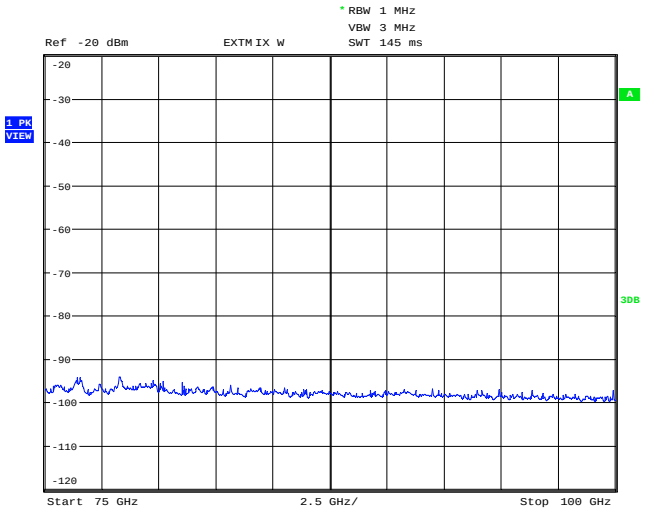
Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1/7; Fmax
Date: 21.MAY.2019 08:30:38

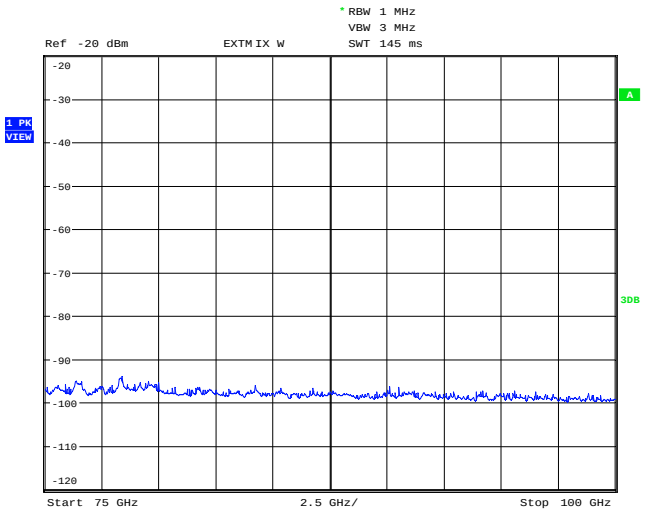
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmin
EUT Orientation:	all
Frequency range:	75 - 100 GHz



FSC1/7; Fmin
Date: 21.MAY.2019 08:58:59

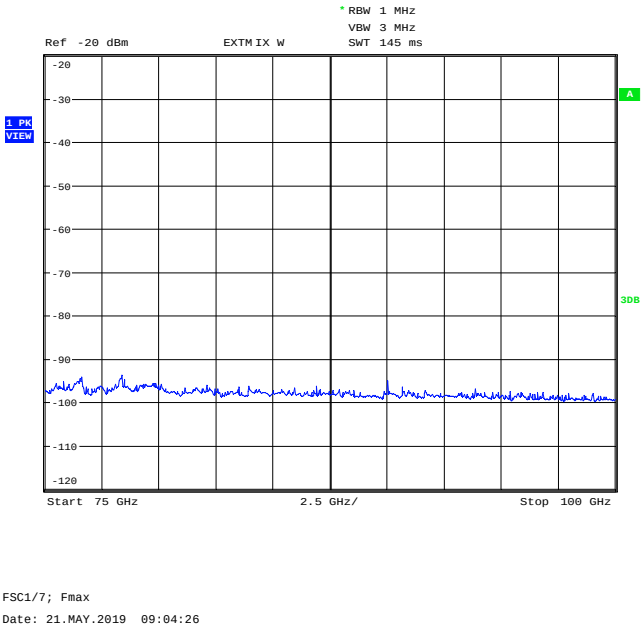
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmid
EUT Orientation:	all
Frequency range:	75 - 100 GHz



FSC1/7; Fmid
Date: 21.MAY.2019 09:02:34

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1/7
Serial No:	110
Mode:	Fmax
EUT Orientation:	all
Frequency range:	75 - 100 GHz



Final Result:

Frequency MHz	MaxPeak dBµV/m	Average dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol --	Azimuth deg	Corr. dB/m

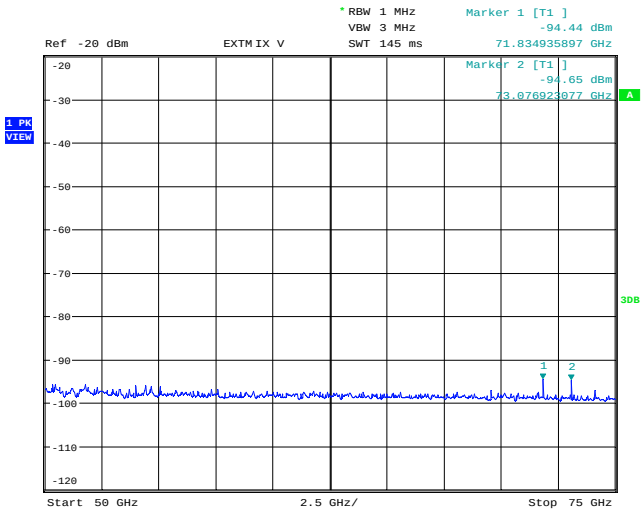
No emission identified with exploratory scan.
Therefore, no final measurement performed.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

- **EUT #2; FSC 1000; SN: 113**

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	all
Frequency range:	50 - 75 GHz

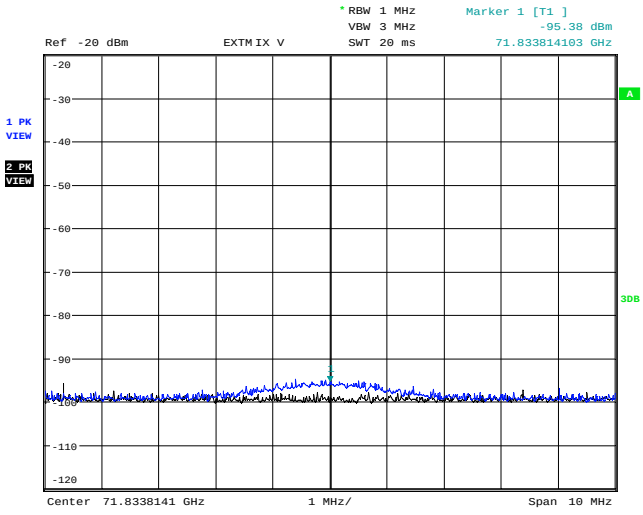


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

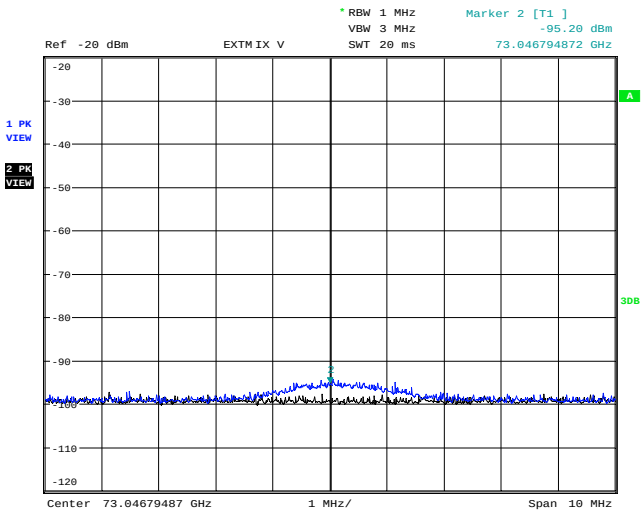
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	all
Frequency range:	50 - 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1000; Fmin
Date: 21.MAY.2019 08:34:10

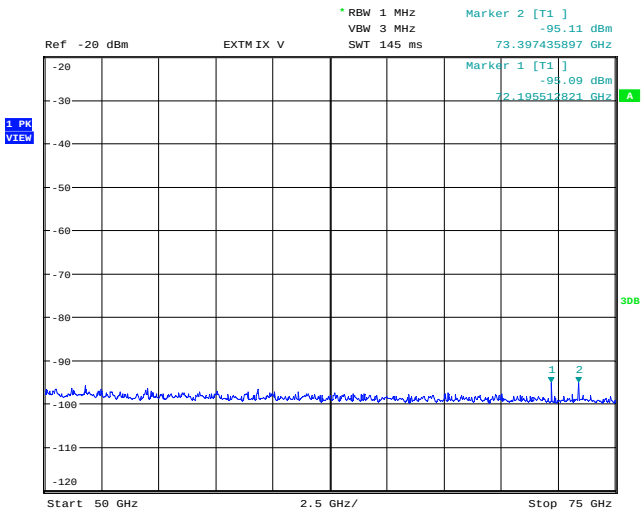
Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



FSC1000; Fmin
Date: 21.MAY.2019 08:35:24

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	all
Frequency range:	50 - 75 GHz

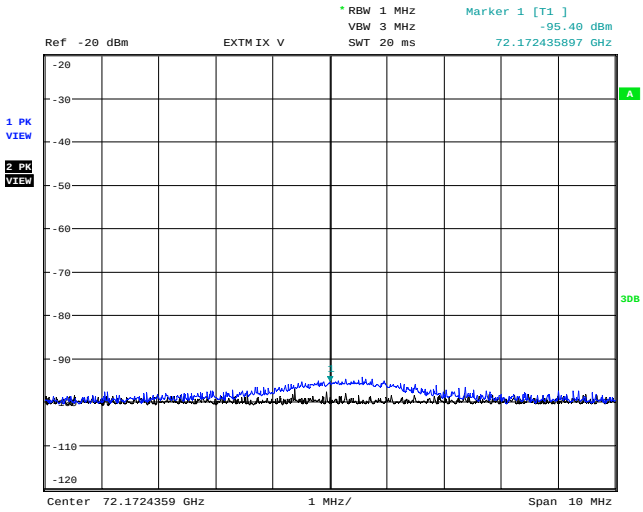


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

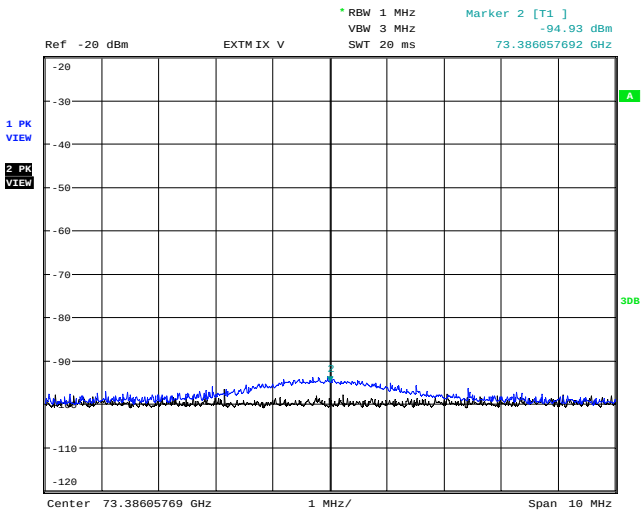
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	all
Frequency range:	50 - 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.

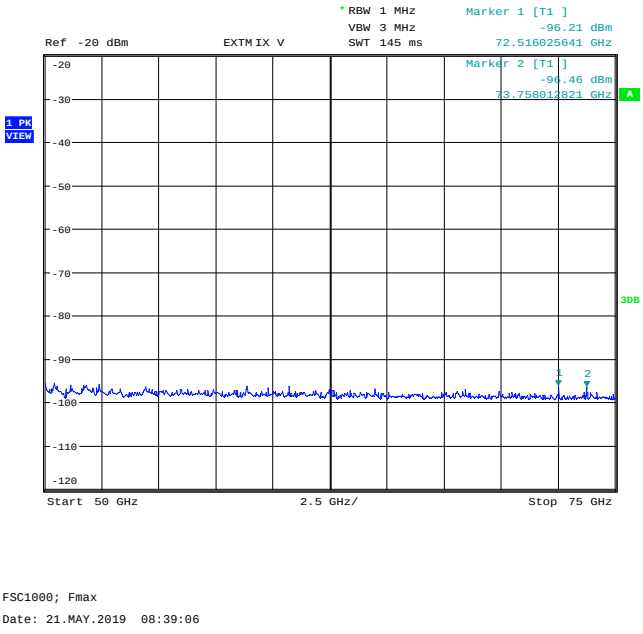


Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	all
Frequency range:	50 - 75 GHz

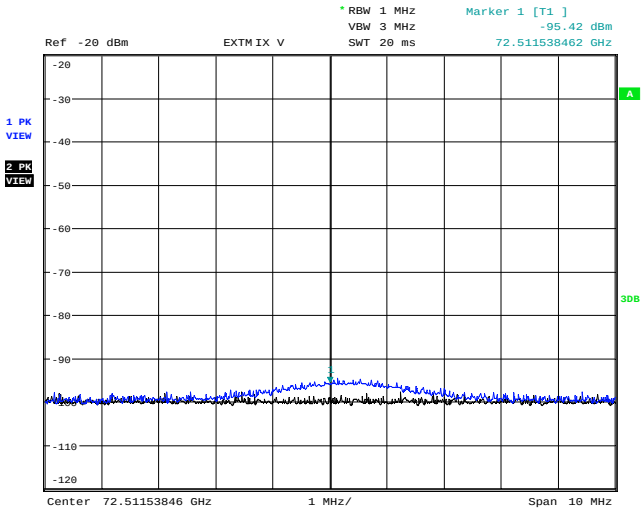


Note: prescan plots above are showing the measurement receiver's reading, only, without any transducer/correction factors applied. All emission detected were investigated in the following by use of SignalID-function to prove their validity. Please refer to the following plots for details.

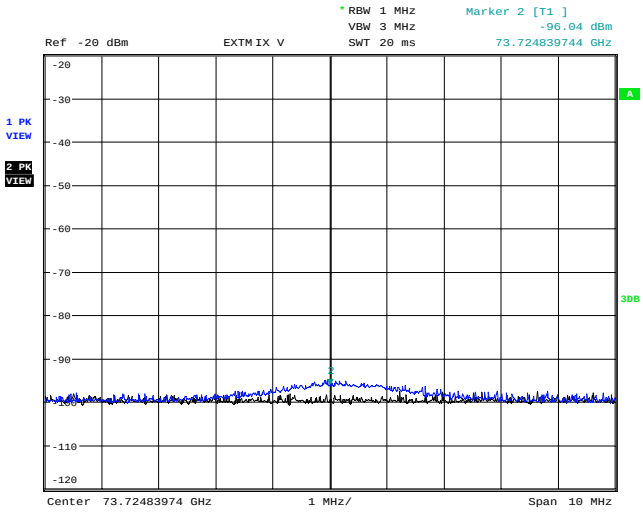
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	all
Frequency range:	50 - 75 GHz

Remarks:
Emission at Marker #1 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.

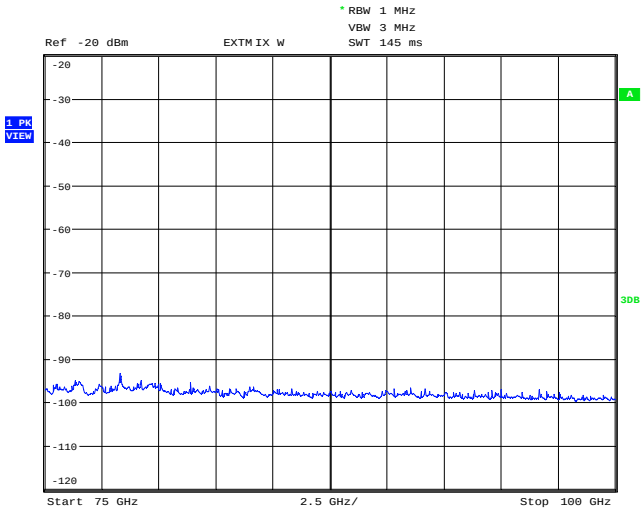


Remarks:
Emission at Marker #2 of plot 50-75GHz, investigated by use of SignalID-function.
Result: displayed emission is a mixing product and not real.



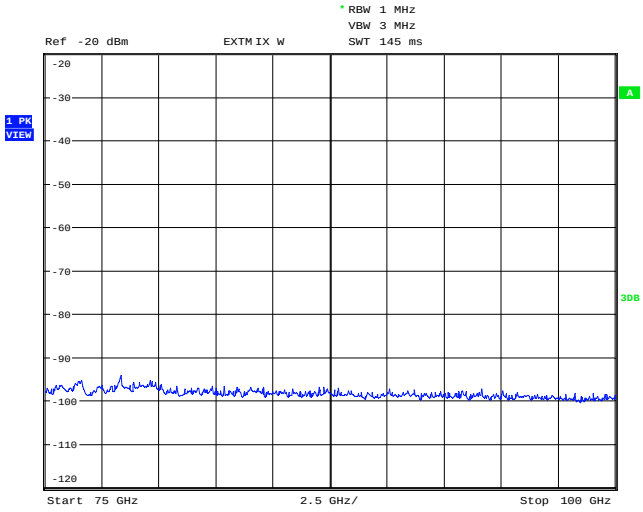
Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmin
EUT Orientation:	all
Frequency range:	75 - 100 GHz



FSC1000; Fmin
Date: 21.MAY.2019 08:52:18

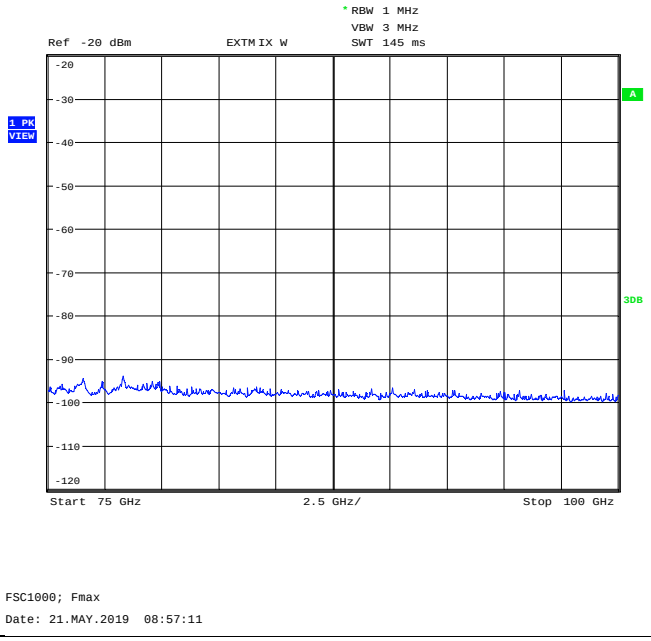
Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmid
EUT Orientation:	all
Frequency range:	75 - 100 GHz



FSC1000; Fmid
Date: 21.MAY.2019 08:55:56

Test on MICRO-EPSILON Messtechnik GmbH & Co. KG FSC 1/7and FSC 1000 to 47 CFR § 15.249

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type:	FSC 1000
Serial No:	113
Mode:	Fmax
EUT Orientation:	all
Frequency range:	75 - 100 GHz



Final Result:

Frequency MHz	MaxPeak dBµV/m	Average dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol --	Azimuth deg	Corr. dB/m

No emission identified with exploratory scan.
Therefore, no final measurement performed.

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.

4.5.12.4 Test Result

Manufacturer:	MICRO-EPSILON Messtechnik GmbH & Co. KG
Type, Serial No.:	FSC 1/7, 110 FSC 1000, 113
Test date:	2019-05-21
Test personnel:	Patrick Reusch

The EUT meets the requirements of this section.

5 TEST INSTRUMENTS

Ident#	Instrument	Manufacturer	Model No.	Last Calibration	Calibration valid until
001	60-Hz Converter	AEG	DAMK4/DAGK4	n/a	n/a
54	N-Cable N/50	Rohde & Schwarz	HFU2-Z5	n/a	n/a
374	Loop Antenna	Rohde & Schwarz	HFH 2-Z2	2018-11	2021-02
553	GPIB-140A	National Instruments	186135C-31	n/a	n/a
554	GPIB-140A	National Instruments	186135C-31	n/a	n/a
1229	Standard Gain Horn Antenna	Mid Century	MC 22/31B	2014-07	2024-07
1291	Antenna Mast	Frankonia	FAM4	n/a	n/a
1292	Multi Device Controller	Frankonia	FC02	n/a	n/a
1300	Standard Gain Horn Antenna	Mid Century	MC 20/31B	2014-07	2024-07
1348	Wav./Kf/SMAf-Adap., R-band	fmi/pro nova	22093-KF20	2018-09	2020-09
1546	Waveguide Mixer	Rohde & Schwarz	FS-Z110/WM782W	n/a	n/a
1548	Waveguide Mixer	Rohde & Schwarz	FS-Z75/WM782V	n/a	n/a
1889	SR-ULL-01, Semi-Anechoic Chamber (SAC)	EMCC/FRANK.	SAC-10	n/a	n/a
1890	SR-ULL-05,	EMCC / SIEM / FRANK	SC2-ULL	n/a	n/a
1901	V-LISN 50 ohms//(50 uH + 5 ohms)	Rohde & Schwarz	ESH2-Z5	2018-11	2019-11
2111	Tapered Transition	FMI/Pro NOVA	23000-24	n/a	n/a
2113	Standard Gain Horn Antenna	FMI/Pro NOVA	2424-25	n/a	n/a
2591	Standard Gain Horn Antenna	Electrof./Tho	WG25-25	n/a	n/a
2597	Thermistor Mount	Millitech	THM-15-RF000	2015-08	2020-08
2600	Standard Gain Horn Antenna	Electrof./Tho	WG27-25	n/a	n/a
2724	5 W Attenuator 6dB	Weinschel	2	2019-07	2021-07
3061	K-Cable K/50	Insulated Wire	KPS-1501-600-KPS	n/a	n/a
3148	8 W Termination	EMCC DR. RASEK	3V150	2017-11	2019-11
3235	Double Ridged Guide Antenna	Schwarzbeck	BBHA 9120D	2019-01	2021-01
3831	Spectrum Analyzer	Rohde & Schwarz	FSU50	2018-10	2019-10
3846	EMI Test Receiver	Rohde & Schwarz	ESU8	2019-02	2020-02
3880	Digital Multimeter	Agilent	U1241B	2018-07	2020-07
4075	Workstation	Dell	Optiplex 7010	n/a	n/a
4524	Notebook	Dell	Latitude E6430	n/a	n/a
4597	USB to GPIB adapter	National Instruments	GPIB-USB-HS with NI-488.2; 187965H-01L	n/a	n/a
4717	Web-Thermo-Hygrobarograph	Wiesemann & Theis GmbH WUT	57613 Web-T/Rh/P	2018-01	2020-01

Ident#	Instrument	Manufacturer	Model No.	Last Calibration	Calibration valid until
4914	Adaptor, Waveguide to Coax	FLANN	23093-TF30 UG-383/U	n/a	n/a
5392	EMC Measurement Software V10.35.02	Rohde & Schwarz	EMC32	n/a	n/a
5535	Positioning controller	Rohde & Schwarz	HCC	n/a	n/a
5536	Rotary table	Rohde & Schwarz	HCT12	n/a	n/a
5544	Antenna Mast	innco systems GmbH	MA 5000-XPET	n/a	n/a
5545	Antenna Mast Controller	innco systems GmbH	CO 3000-1D	n/a	n/a
5551	BNC cable	EMCC	BNC003m0	n/a	n/a
5612	RF cable assembly	Rosenberger	LA1-008-1400	n/a	n/a
5615	RF cable assembly	Rosenberger	LA2-025-7000	n/a	n/a
5620	RF cable assembly	Rosenberger	LA2-001-2000	n/a	n/a
6041	TRILOG Broadband Antenna	Schwarzbeck	VULB 9163	2017-09	2019-09

6 MEASUREMENT UNCERTAINTY

Measurement	Measurement Uncertainty
Conducted Emissions, AC mains (150 kHz – 30 MHz)	±3.5 dB
Radiated Emissions below 1000 MHz	±5.6 dB
Radiated Emissions above 1 GHz	±5.3 dB

The reported uncertainty values are based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of 95%.

The given values have been calculated on the basis of the following documents:

CISPR 16-4-2:2011+A1:2014, Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty.

JCGM 100:2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement.

7 LIST OF ANNEXES

The following annexes are separated parts from this test report.

Description	Pages
Annex 1: Photographs of test setup	7
Annex 2: External photographs of equipment under test	8
Annex 3: Internal photographs of equipment under test	8
Annex 4: Photographs of ancillary equipment	4