TECHNICAL REPORT # EMCC-040197BJB, 2015-12-21

Test Site Correlation for H Field Measurement in Semi-Anechoic Chamber (SAC)

Supporting Test Report # EMCC-040197BJ, 2015-05-08

RELEVANT STANDARD(S): 47 CFR 15.209

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ KDB 937606 ☐ Other

TECHNICAL REPORT PREPARED BY:

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1 GENERAL INFORMATION

1.1 Purpose

The purpose of this document is to provide a correlation of the H Field measurement in the FCC listed semi-anechoic chamber (SAC) site in 3m distance and an open field site measurement in 3 m and 30 m distance at the frequency of 16 kHz.

In addition the found correlation is used to proof that the H Field measurement result of the fundamental emission as reported in Test Report # EMCC-040197BJ, 2015-05-08 is compliant with the 47 CFR 15.209 requirements for the certification of licence-exempt 15C Intentional Radiator.

1.2 Limits and Reservations

1.3 Test Location

Test Laboratory:	EMCCons DR. RAŠEK GmbH & Co. KG
Accreditation No.:	D-PL-12067-01-00
Address of Labs I, II, III and Head Office:	EMCCons DR. RAŠEK GmbH & Co. KG Moggast, Boelwiese 8 91320 Ebermannstadt GERMANY
Address of Labs IV and V:	EMCCons DR. RAŠEK GmbH & Co. KG Stoernhofer Berg 15 91364 Unterleinleiter GERMANY
Laboratory:	Test Laboratory IV The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to the FCC and accepted in the letter dated December 24, 2013, Registration Number 878769.
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1.4 Dates and Test Location

Test Date: 2015-12-14/15
Test Location: Lab IV, open field site

1.5 Climatic Conditions

Date	Temperature [°C]	Relative Humidity [%]	Air Pressure [hPa]	Location
2015-12-14	22	37	981	Lab IV
2015-12-15	7	72	983	open field site

2 MEASUREMENT DESCRIPTION

2.1 Measurement Procedure

The measurement was performed with set-up consisting of a single turn loop antenna with a diameter of 0.85 m, feeded by a signal generator. The loop dimension was chosen to simulate the EUT described in Test Report # EMCC-040197BJ as far as possible. The signal generator was set to a fixed output level with a unmodulated 16 kHz sinusoidal signal.

The radiated H fieldstrength at 16 kHz generated by this set-up was measured with the same test setup as used in Test Report # EMCC-040197BJ in the SAC in 3 m distance first, and then repeated at the open field site in 3 m and 30 m distance.

3 MEASUREMENT RESULTS

3.1 Measurement in the SAC

3.1.1 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Antenna (9 kHz – 30 MHz)	Rohde & Schwarz HFH-Z2	374	2014-06	2016-06
Receiver (9 kHz - 1 GHz)	Rohde & Schwarz ESS	303	2015-03	2016-03
Arbitrary/Function Gen.	Stanford Research	3	2015-02	2017-02
Loop Antenna	EMCC / 0.85 m diameter single turn loop	none	n.a.	n.a.

3.1.2 Test Procedures

The measurement was performed in the semi-anechoic chamber at a test distance of 3 m. A calibrated loop antenna as specified in ANSI C63.10 clause 4.3.2 was positioned with its plane vertical at the test distance from the field generating loop antenna and rotated about its vertical axis for maximum response at each azimuth about the field generating loop antenna. The center of the calibrated loop antenna was 1 m above the ground.
The field generating loop antenna was fixed on a wooden support on the ground plane at a height similar to the EUT position in Test Report # EMCC-040197BJ. The loop plane was vertical.

The measurement performed at the maximum of the radiated field of the 16 kHz signal. The maximum obtained for a parallel orientation of both antennas.

Radiated Emissions Test Characteristics	
Frequency range	16 kHz
Test distance	3 m
Test instrumentation resolution bandwidth	200 Hz
Receive antenna height	1 m

3.1.3 Test Result SAC

Frequency	Detector	Distance	Result
[kHz]	-	[m]	[dBµV/m]
16.0	AV	3	107.4

Test Date: 2015-12-14

3.2 Measurement at the Open Field Site

3.2.1 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Antenna (9 kHz – 30 MHz)	Rohde & Schwarz HFH-Z2	374	2014-06	2016-06
Receiver (9 kHz - 1 GHz)	Rohde & Schwarz ESS	303	2015-03	2016-03
Arbitrary/Function Gen.	Stanford Research	3	2015-02	2017-02
Loop Antenna	EMCC / 0.85 m diameter single turn loop	none	n.a.	n.a.

3.2.2 Test Procedures

The measurement was performed in an open field site at a test distance of 3 m, 10 m and 30 m . A calibrated loop antenna as specified in ANSI C63.10 clause 4.3.2 was positioned with its plane vertical at the test distance from the field generating loop antenna and rotated about its vertical axis for maximum response at each azimuth about the field generating loop antenna. The center of the calibrated loop antenna was 1 m above the ground.
The field generating loop antenna was fixed on a wooden support on the ground plane at a height similar to the EUT position in Test Report # EMCC-040197BJ. The loop plane was vertical.

The measurement performed for each distance at the maximum of the radiated field of the 16 kHz signal. The maximum obtained for a parallel orientation of both antennas.

Radiated Emissions Test Characteristics	
Frequency range	16 kHz
Test distance	3 m, 10 m, 30 m
Test instrumentation resolution bandwidth	200 Hz
Receive antenna height	1 m

3.2.3 Test Result Open Field Site

Frequency	Detector	Distance	Result
[kHz]	-	[m]	[dBµV/m]
16.0	AV	3	105.6
16.0	AV	10	74.8
16.0	AV	30	46.0

Test Date: 2015-12-15

4 CORRELATION OF SAC AND OPEN FIELD MEASUREMENT

Procedure: ANSI C63.10-2013

4.1 Regulation

FCC 15.31 Measurement standards**.**

(d) Field strength measurements shall be made, to the extent possible, on an open field site. Test sites other than open field sites may be employed if they are properly calibrated so that the measurement results correspond to what would be obtained from an open field site.

KDB 937606:

…Test sites other than open field sites, such as anechoic chambers, may be employed only if calibrated so that the measurements correspond to those obtained on an open field site. Since there are no standards for validation of test sites below 30 MHz, calibration must be obtained by other means such as performing measurements at an alternate test site and comparing to measurements obtained on an open field site. Statistical analysis of the measurement data from several similar devices may be required to show correlation between the measurements from the alternate test site and an open field test site. The limit distance below 30 MHz is 30 meters or more and in most anechoic chambers it is not possible to perform measurements at such distances. This may make it difficult to show correlation between measurements made on an open field site at distances greater than the dimensions of the anechoic chamber and measurements made at the same distance in the anechoic chamber without further analysis and comprehensive testing. …

4.2 Procedure

The difference of the radiated emission measurement from the open field site and the SAC at 3 m is the correlation factor f_C.

$f_C = F_{open} - F_{SAC}$

f_C is correlation factor from SAC to open field site field strength
F_{open} measured field strength at open field site
F_{SAC} measured field strength at SAC

4.3 Result

Frequency	Detector	Distance	F_{SAC}	F_{open}	f_C
[kHz]		[m]	[dBµV/m]	[dBµV/m]	dB
16.0	AV	3	107.4	105.6	-1.8

This correlation factor has to be applied to the SAC measurement result to get the open field result.

$F_{open} = F_{SAC} + f_C$

5 REFINED FIELD STRENGTH CALCULATION FOR THE 16 KHZ RESULT ACC. TO TEST REPORT EMCC-040197BJ

5.1 1st approach - Extrapolation from the Measurement of a Single Point

5.1.1 Procedure

ANSI C63.10-2013: 6.4.4.2 Extrapolation from the measurement of a single point

If both the single point and the limit distance are equal to or closer to the EUT than λ/2π, then extrapolation to the limit distance shall be calculated using Equation (4):

$$FS_{limit} = FS_{max} - 40 \log \frac{d_{limit}}{d_{measure}}$$

where

FS_{limit} is the calculation of field strength at the limit distance, expressed in dBμV/m
FS_{max} is the measured field strength, expressed in dBμV/m at $d_{measure}$
$d_{measure}$ is the distance of the measurement point from the EUT
d_{limit} is the reference distance or the distance of the λ/2π point

Taking into account the additional SAC correlation factor:

$$FS_{limit} = FS_{max} + fc - 40 \log \frac{d_{limit}}{d_{measure}}$$

5.1.2 Result for 1st approach

Applying the simplified single point procedure the refined field strength result for the EUT tested in Test Report # EMCC-040197BJ will be as follows:

Frequency	Detector	3m Result SAC	Distance Correction	Correlation factor	300m Result	300m Limit	Margin
[MHz]	-	[dB(μV/m)]	[dB]	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
0.016	AV	121.1	-80	-1.8	39.4	43.7	4.4

5.2 2nd approach - Extrapolation of Field Strength from Two Point Measurement

5.2.1 Procedure

5.2.1.1 Calculation of extrapolation factor from two points (ANSI C63.10-2013 § 6.4.4.4)

If two measurement points and the limit distance are all at a distance equal to or greater than λ/2π and are used to determine the extrapolation value, or if the measurement points and the limit distance are within λ/2π, then Equation (5) shall be used to calculate the extrapolation factor in dB/decade of distance:

$$N = 20 \frac{\log (E_1/E_2)}{\log (d_1/d_2)}$$

where

E_1 is the field strength at the measurement distance closest to the radiating source, expressed in µV/m

E_2 is the field strength at the measurement distance farthest from the radiating source, expressed in µV/m

d_1 is the measurement distance closest to the radiating source

d_2 is the measurement distance farthest from the radiating source

N is the distance extrapolation factor in dB/decade of distance. The field strength at the limit distance shall then be calculated using the methods and formula described in 6.4.4.7.

If measurements of two or more points at distances greater than λ/2π are made, then it is not necessary to evaluate the field strength at distances closer than λ/2π or to determine the rate of decay of the field strength within the λ/2π boundary.

Frequency	**E_1 open field site at 3m**		**E_2 open field site at 30 m**		**N**
[kHz]	[dBµV/m]	[µV/m]	[dBµV/m]	[µV/m]	[dB]
16.0	105.6	190546	46.0	199.5	-59.6

5.2.1.2 Calculating field strength at the limit distance (ANSI C63.10-2013 § 6.4.4.7)

After a value of the extrapolation (N) is determined using the methods in 6.4.4.4 or 6.4.4.5, this value shall be used to estimate the value of field strength at a more distant point. This point shall generally be the reference distance specified in a regulation or standard, or it shall be the field strength at the λ/2π distance to be used for a second extrapolation to the reference distance. If two measurement points were used to calculate extrapolation, then either may be used to determine the field strength at the reference or λ/2π distance. If three or more points were used to determine extrapolation, then the point with the maximum field strength shall be used in Equation (8) to calculate the field strength at the reference or λ/2π distance:

$$FS_{limit} = FS_{max} - N \log \frac{d_{measure}}{d_{limit}}$$

where

N	is the value in dB/decade of distance determined using 6.4.4.4 or 6.4.4.5
FS_{limit}	is the estimate of field strength at the limit distance, expressed in dBµV/m
FS_{max}	is the maximum value of field strength, expressed in dBµV/m, measured during the measurement of the points used for extrapolation
$d_{measure}$	is the distance of the measurement point of FS_{max} from the radiating source
d_{limit}	is the limit reference distance

Taking into account the additional SAC correlation factor:

$$FS_{limit} = FS_{max} + fc - N \log \frac{d_{measure}}{d_{limit}}$$

5.2.2 Result for 2nd approach

Applying the procedure with the measured extrapolation factor the refined field strength result for the EUT tested in Test Report # EMCC-040197BJ will be as follows:

Frequency	Detector	3m Result SAC	Distance Correction	Correlation factor	300m Result	300m Limit	Margin
[MHz]	-	[dB(µV/m)]	[dB]	[dB]	[dB(µV/m)]	[dB(µV/m)]	[dB]
0.016	AV	121.1	-119.2	-1.8	0.1	43.7	44.6

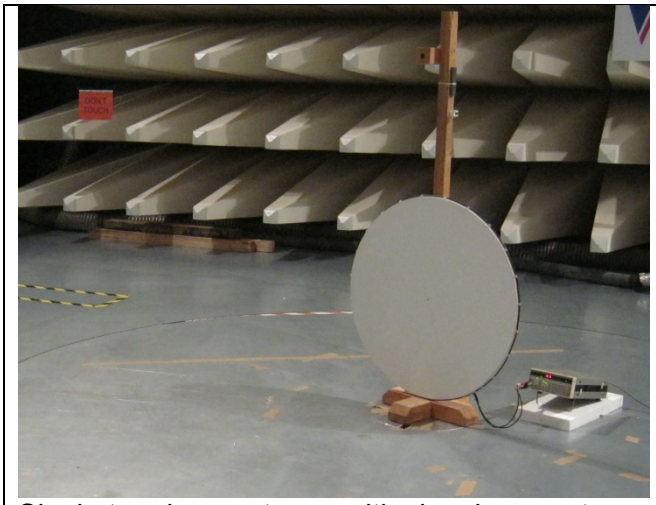
6 SUMMARY

The correlation of the SAC and open field site measurement results at 16 kHz and 3 m distance shows that the SAC measurement result is slightly higher (1.8 dB) than the result of the open field site measurement, obviously caused by the presence of the ground plane.
Refer also to ANSI C63.4-2014 §5.3: “If a reference ground plane is present, the measured level of emissions may be higher than if measurements were made without a ground plane.”

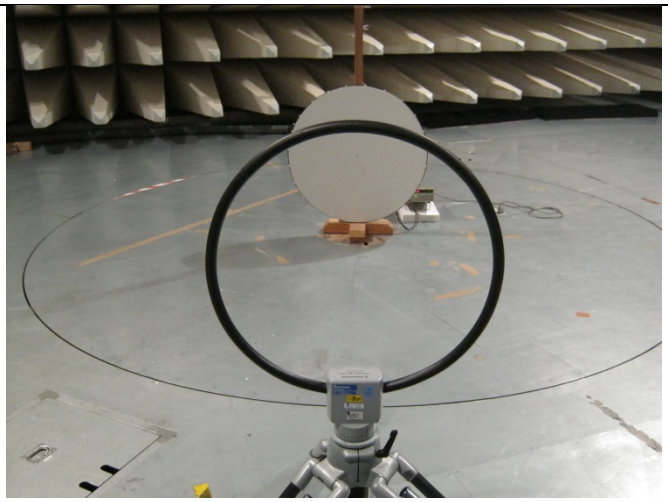
Further the extrapolation factor calculated from the open field site measurement at different distances show that the 40 dB/decade is a very conservative approach. The actual calculated extrapolation factor is significantly higher. The extrapolation factor that was found is close to the theoretical 60 dB extrapolation factor in the near field (see also ANSI C63.10-2013 Annex I Site considerations for measuring inductive-loop devices in the near field).

Depending on the approach (single point measurement with conservative 40 dB/decade extrapolation or two-point measurement with calculated extrapolation factor) and taking into account the correlation factor between SAC and open field site the measured fundamental H field strength from test report EMCC-040197BJ for 16 kHz can be refined resulting a final result being safely below specified limits.

7 PHOTOGRAPHS OF TEST SETUP



Single turn loop antenna with signal generator



H field measurement in SAC at 3 m distance

H field measurement at open field site at 3 m distance

H field measurement at open field site at 30 m distance