FCC Measurement/Technical Report on

Radio Identification Device
FS197 & FS1971
Part of system “37W”

FCC ID: NBGFS1971
IC: 2694A-FS1971

Report Reference: MDE_HELLA_1904_FCCa

Test Laboratory:
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Deutsche Akkreditierungsstelle D-PL-12140-01-00

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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator (Periodic operation in the band above 70 MHz)

Applicable FCC Rules

Edition of FCC Rules: October 1, 2018

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15. The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.231 Periodic operation in the band 40.66-40.70 MHz, above 70 MHz

Note: § 15.207 is not applicable because the EUT is battery powered.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for Momentarily (incl. Periodically) Operated Devices and Remote Control from FCC and IC

Radio equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Transmitter spurious radiated emissions	§ 15.231 (b) / (e)	RSS Gen Issue 5: 6.10/6.13/8.9/8.10; RSS-210 Issue 9: A1.1.2, A1.1.5
Duty cycle measurement (based on dwell time measurement)	§ 15.231 (a)	RSS-210 Issue 9: A1.1.1, A1.1.5
Maximum radiated field strength at fundamental frequency	§ 15.231 (b) / (e)	RSS-210 Issue 9: A1.1.2, A1.1.5; RSS Gen Issue 9: 6.12
Occupied bandwidth	§ 15.231 (c)	RSS-210 Issue 9: A1.1.3
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 9: 8.3
Receiver spurious emissions	–	RSS-210 Issue 9: 2.3 RSS Gen Issue 5: 5/7 *)

*) Receivers are exempted from certification besides if operating in stand-alone mode in the frequency range 30–960 MHz or if these are scanner receivers.

1.3 MEASUREMENT SUMMARY /SIGNATURES

FCC Part 15, Subpart C		**§ 15.207**	
Conducted emissions (AC power line)			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
		AC Port (power line)	N/A

FCC Part 15, Subpart C		**§ 15.231**	
Duty cycle measurement (based on dwell time measurement)			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 2	Setup_01	Enclosure	passed
op-mode 2	Setup_02	Enclosure	passed

FCC Part 15, Subpart C		**§ 15.231**	
Spurious Radiated Emissions			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 2	Setup_01	Enclosure	passed

FCC Part 15, Subpart C		**§ 15.231**	
Maximum radiated field strength at fundamental frequency			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	Enclosure	passed

FCC Part 15, Subpart C		**§ 15.231**	
Occupied Bandwidth			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	Enclosure	passed

N/A not applicable (the EUT is powered by internal CR2032 lithium battery)

(responsible for accreditation scope)
Dipl.-Ing. Marco Kullik

(responsible for testing and report)
Dipl.-Ing. Dobrin Dobrinov

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2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-00
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier:	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2019-02-12

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Dobrin Dobrinov
Date of Report:	2019-05-02
Testing Period:	2019-04-12 to 2019-04-30

2.3 APPLICANT DATA

Company Name:	HELLA GmbH & Co. KGaA
Address:	Beckumer Str. 130 59552 Lippstadt Germany
Contact Person:	Mr. Christian Elbers

2.4 MANUFACTURER DATA

Company Name:	Please see applicant
Address:	
Contact Person:	

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	The EUT is a handheld remote keyless transceiver 433 MHz technology
Product name	Radio Identification Device Part of system "37W"
Type	FS197 & FS1971
Declared EUT data by the supplier	
Voltage Type	DC, battery, Li coin cell
Normal Voltage	3.0 V
Low Voltage	2.25 V
High Voltage	3.2 V
Normal Temperature	20 °C
Low Temperature	-20 °C
High Temperature	+60 °C
Specific product description for the EUT	The EUT is a combined Identification and operational device from a Remote Keyless System of a vehicle, installed in a key-fob
Operating frequency	channel 1 (low) 433.46 MHz
	channel 2 (mid) 433.92 MHz
	channel 3 (high) 434.36 MHz
The EUT provides the following ports:	Enclosure
Special software used for testing	Provided by the manufacturer

The main components of the EUT are listed and described in Chapter 3.2.

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
EUT A	DE1232009aa01	radiated sample
Sample Parameter	**Value**	
Serial No.	N/A	
HW Version	16	
SW Version	Special test software based on series SW version 5	
Comment	Used for radiated measurements, continuously sending non-modulated carrier for Output Power measurement (CW) and continuously modulated carrier for Spurious emissions, and Occupied BW measurements.	

Sample Name	Sample Code	Description
EUT B	DE1232009ab01	radiated sample
Sample Parameter	**Value**	
Serial No.	N/A	
HW Version	16	
SW Version	Regular software version 5	
Comment	Used for the Duty cycle measurements	

General description of ancillary equipment

Device	Details (Manufacturer, Type Model, OUT Code)	Reason for using
---	---	---

General description of auxiliary equipment

Device	Details (Manufacturer, HW, SW, S/N)	Description
---	---	---

3.3 EUT SETUPS

This chapter describes the combination of EUTs and ancillary equipment used for testing.

Setup No.	Combination of EUTs	Description
Setup_01	EUT A	Setup for radiated measurements: Output power and Spurious emissions bellow 30 MHz, 30 MHz to 1 GHz, 1 to 6 GHz and Duty Cycle (PKE)
Setup_02	EUT B	Setup for Duty Cycle measurements (RKE only)

3.4 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

Op. Mode	Description of Operating Modes	Remarks
op-mode 1	Continuous transmission	Transmitter sends continuously CW or Modulated signal (RKE or PKE)
op-mode 2	Single burst	Transmitter sends shortly RKE signal

3.5 PRODUCT LABELLING

3.5.1 FCC ID label

NBGFS1971

3.5.2 IC Label

2694A-FS1971

3.5.3 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 DUTY CYCLE MEASUREMENT (BASED ON DWELL TIME MEASUREMENT)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the dwell time measurements. For analyzer settings please see measurement plots.

4.1.2 TEST REQUIREMENTS / LIMITS

Depending on the function of the EUT different paragraphs of FCC §15.231 apply:

Either
(a)(1): A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

Or
(a)(2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.

And
(a)(3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

Otherwise
(e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) of this section and may be employed for any type of operation [...].
In addition, [...] the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

This test is also performed to determine the pulse train of the transmitter and calculate the correction factor for pulse modulated transmitters according to FCC §15.35. This factor is used as a correction factor for the field strength measurements, both for
Spurious radiated emissions and Maximum radiated field strength at fundamental frequency.

4.1.3 TEST PROTOCOL

Temperature: 23 °C
Air Pressure: 1009 hPa
Humidity: 38 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

a) Determine the total duration of a transmission within 100 ms:

Duty cycle = ((L1*N1) + (L2*N2) + ... + (Ln*Nn)) / 100 ms or T, whichever is less
Correction factor = 20 * LOG (Duty cycle) [dB]

Step 1	Holdover time	Less than 5s
Step 2	Cycle to determine the on/off ratio within a cycle (period T)	100 ms
Step 3	Sweep of a data word to determine the on time within a data word (L1-LN)	L1 = 21.035 ms

PKE mode - Calculation of Duty Cycle / Correction Factor:
If T > 100 ms => T = 100 ms; L1 = 21.035 ms; N1 = 1;
(Plot 1) D2 + (D3 – D2) + (D6 – D5) + (D8 – D7) =
= 6.834 + 15.2 + 20.2 + 3.182 = 45.216 ms
In 100 ms T_{on} = 45.216 ms

Duty cycle = 45.216 / 100 = 0. 45216

CORRECTION FACTOR = 20*log(0. 45216) ≈ **-6.9 dB** (Plot 1)

b) Determine the period of periodic re-transmission, if any, or cease (deactivation) time:

The period of retransmission depends on how much LF interrogations are sent. Normally, after the answer (0.339 s), there are no more transmissions from the EUT.

Deactivation after **T_C = 0.339 s**, **Limit:** ≤ **5 s** (Plot 2)

c) Determine the total duration of periodic transmissions within 1 hour, if any:

Duration t_d of all pulses/bursts during T_R ("on-time"):

t_d = 0.149 s. (Plot 2)

d) If the result of c) exceeds 2 seconds/hour then paragraph (e) applies:

Determine the duration of each transmission (one complete pulse train) and silent time:
Duration t_{PT}, Limit: ≤ 1 s (Remark: t_{PT} is identical to t_d if T ≤ 100 ms).

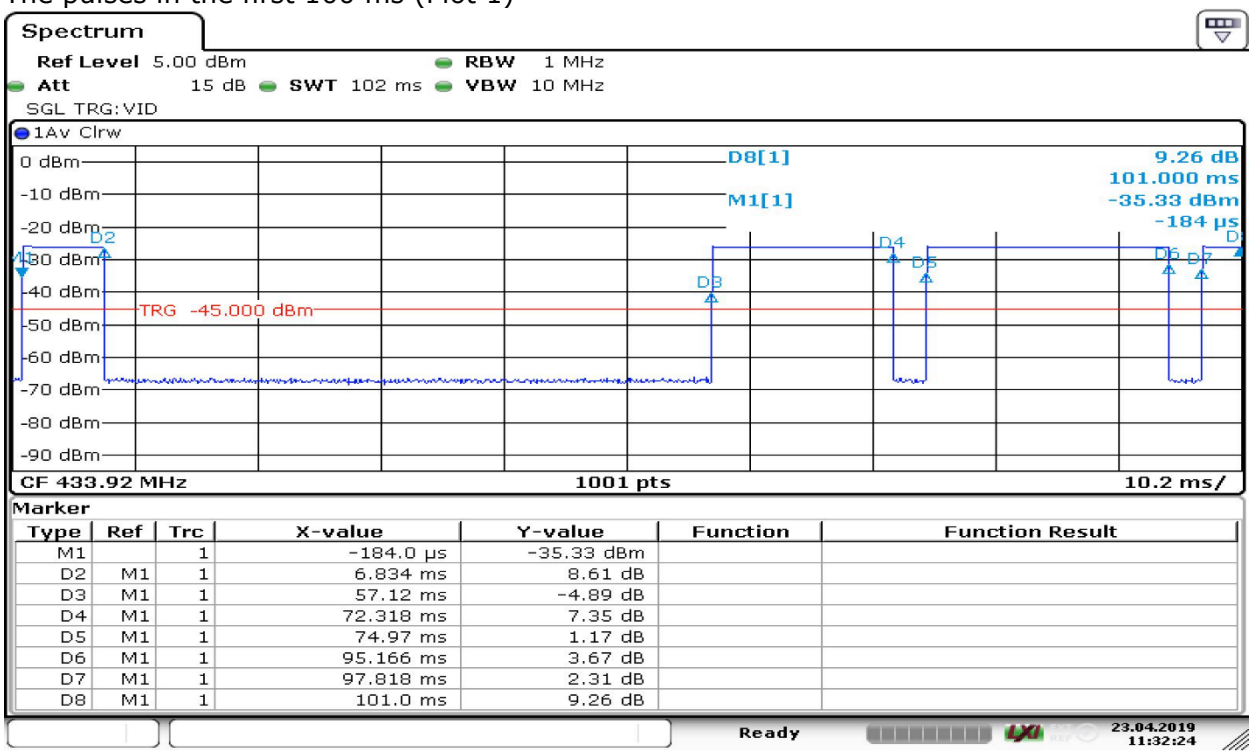
The duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

t_{PT} = **0.339 s** (≤ 1 s)

Silent time between transmissions**:** After the answer, there are no more transmissions.
Limit: ≤ Maximum (>10 s and >30*t_{PT}).

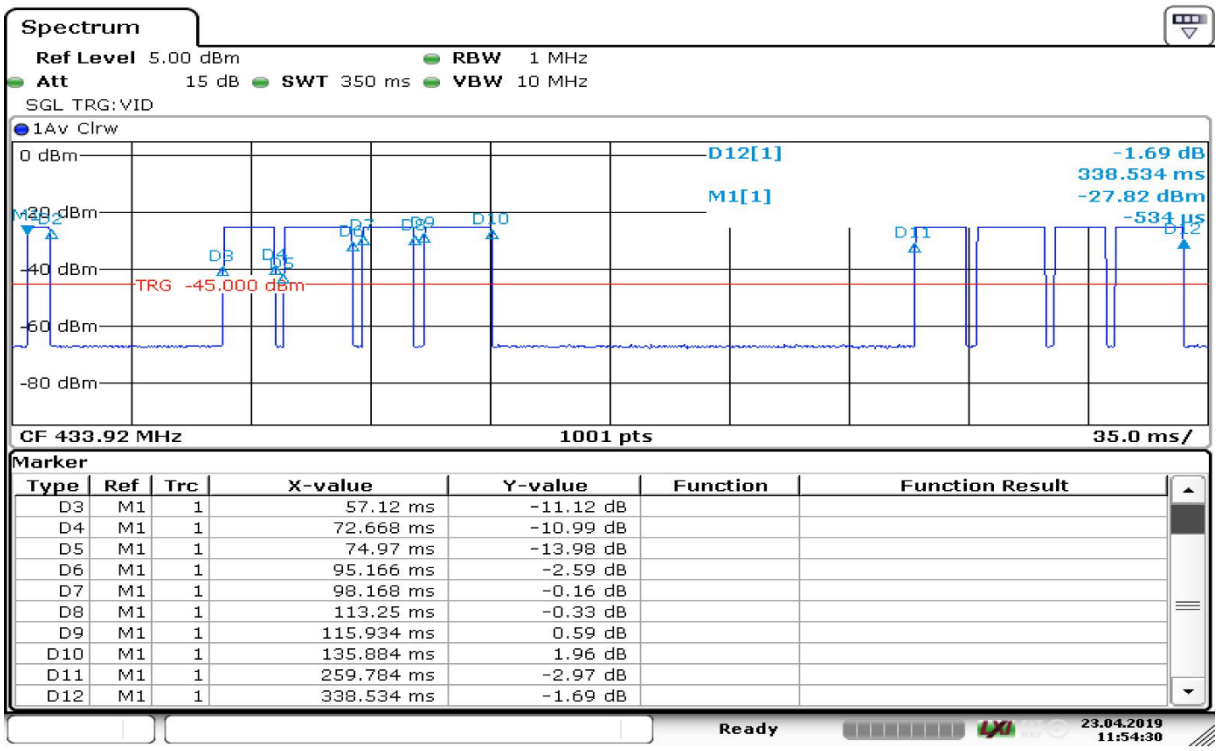
MEASUREMENT PLOTS DUTY CYCLE PKE MODE

The pulses in the first 100 ms (Plot 1)



Date: 23.APR.2019 11:32:25

The pulses of one burst (Plot 2)



Date: 23.APR.2019 11:54:29

Op. Mode	Setup	Port
op-mode 2	Setup_02	Enclosure

RKE mode - Calculation of Duty Cycle / Correction Factor:
If T > 100 ms => T = 100 ms; L1 = 45.59 ms; N1 = 1;

In 100 ms T_{on} = 45.59 ms

Duty cycle = 45.59 / 100 = 0.456

CORRECTION FACTOR = 20*log(0.456) = -**6.82 dB** (Plot 3)

b) Determine the period of periodic re-transmission, if any, or cease (deactivation) time:

The period of retransmission depends on how long any button is pressed.

Deactivation after **T_C = 0.349 s**, **Limit: ≤ 5 s**

c) Determine the total duration of periodic transmissions within 1 hour, if any:

Duration t_d of all pulses/bursts during T_R ("on-time"):

t_d = 0.184 s. (Plot 4)

d) If the result of c) exceeds 2 seconds/hour then paragraph (e) applies:

Determine the duration of each transmission (one complete pulse train) and silent time:
Duration t_{PT}, Limit: ≤ 1 s (Remark: t_{PT} is identical to t_d if T ≤ 100 ms).

The duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

t_{PT} = **0.349 s** (≤ 1 s)

Silent time between transmissions**:** If any button is not pressed, no more transmission ocure.
Limit: ≤ Maximum (>10 s and >30*t_{PT}).

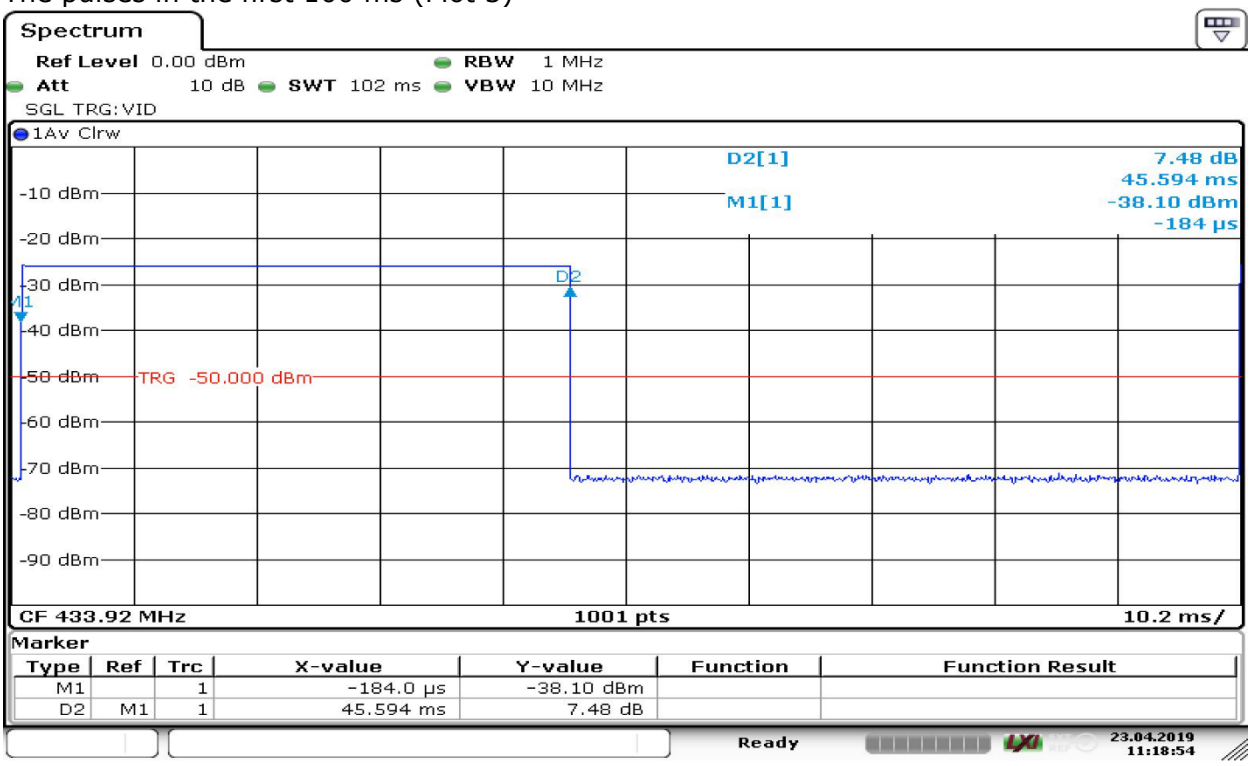
4.1.4 TEST RESULT: DUTY CYCLE / CORRECTION FACTOR

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed
	op-mode 2	passed

The "worst case" is **-6.82 dB** Duty Cycle Correction Factor

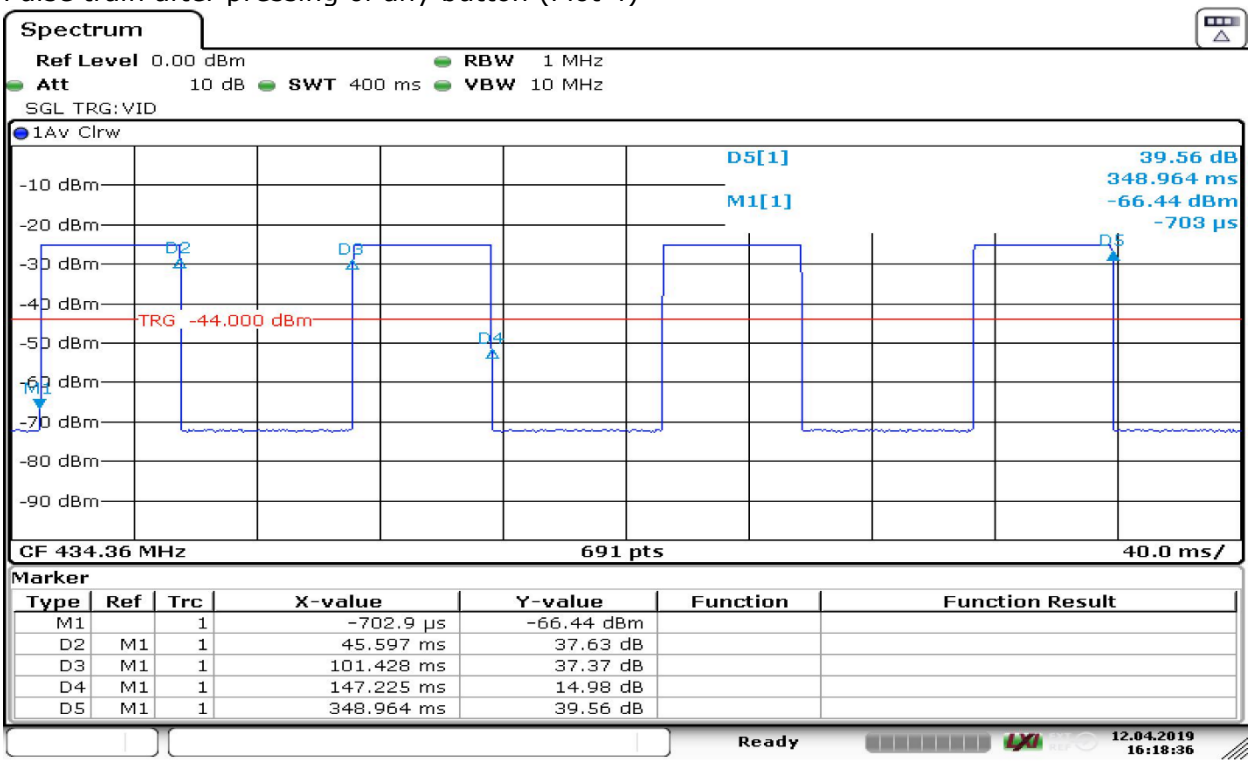
MEASUREMENT PLOTS DUTY CYCLE RKE MODE

The pulses in the first 100 ms (Plot 3)



Date: 23.APR.2019 11:18:55

Pulse train after pressing of any button (Plot 4)



Date: 12.APR.2019 16:18:36

4.2 SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10–2013

4.2.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement up to 30 MHz
The Loop antenna HFH2-Z2 is used.

Step 1: pre-measurement
- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement
For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.
- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)

- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by ± 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

3. Measurement above 1 GHz
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
Step 1:
The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height of the receiving antenna only.
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
Step 2:
Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.

The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
EMI receiver settings (for all steps):
- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:

Spectrum analyser settings for step 3:
- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.2.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.231 (b)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Calculate Limit (dBµV/m @10m)	Limit (dBµV/m) @10m
0.009 – 0.49	2400/F (kHz)	300	(48.5 – 13.8) + 59.1 dB	107.6 – 72.9
0.49 – 1.705	24000/F (kHz)	30	(33.8 – 23.0) + 19.1 dB	52.9 – 42.1
1.705 – 30	30	30	29.5 + 19.1 dB	39.5

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 – 88	100	3	40.0
88 – 216	150	3	43.5
216 – 960	200	3	46.0
above 960	500	3	54.0

§15.35(b)
..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit ...

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

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

§15.231 (b) emissions table

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66-40.70	2,250	225
70-130	1,250	125
130-174	[1]1,250 to 3,750	[1]125 to 375
174-260	3,750	375
260-470	[1]3,750 to 12,500	[1]375 to 1,250
Above 470	12,500	1,250

[1]Linear interpolations.

§15.231(b)(3)
The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator.
Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

Interpretation of the test laboratory:
The last subordinate clause of §15.231(b)(3) is overruled by §15.205/209, therefore within the restricted bands the limits defined at §15.205/209 and outside the restricted bands the limits defined at §15.231(b) resp. §15.231(e) are applied.

§15.231 (e) emissions table

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emission (microvolts/meter)
40.66-40.70	1,000	100
70-130	500	50
130-174	500 to 1,500[1]	50 to 150[1]
174-260	1,500	150
260-470	1,500 to 5,000[1]	150 to 500[1]
Above 470	5,000	500

[1]Linear interpolations.

4.2.3 TEST PROTOCOL

4.2.3.1 MEASUREMENT UP TO 30 MHz

Temperature: 24 °C
Air Pressure: 1009 hPa
Humidity: 35 %

Op. Mode	Setup	Port
op-mode 2	Setup_01	Enclosure

RKE modulated

Measuring Antenna Polarisation	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
0°	---	---	---	---	---	---	---	---	---
90°	---	---	---	---	---	---	---	---	---

PKE modulated

Measuring Antenna Polarisation	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
0°	---	---	---	---	---	---	---	---	---
90°	---	---	---	---	---	---	---	---	---

Remark: In step 1 no spurious emissions in the range 20 below the limit were found, using a peak detector, therefore step 2 (using a QP-detector) was not performed. For this test the EUT was sending a continuously modulated signal. Please see the measurement plots.

4.2.3.2 MEASUREMENT ABOVE 30 MHz TO 7 GHz

Temperature: 24 °C
Air Pressure: 1006 hPa
Humidity: 32 %

Op. Mode	Setup	Port
op-mode 2	Setup_01	Enclosure

RKE modulated

Polarisation of the antenna and the EUT	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
---	---	---	---	---	---	---	---	---	---

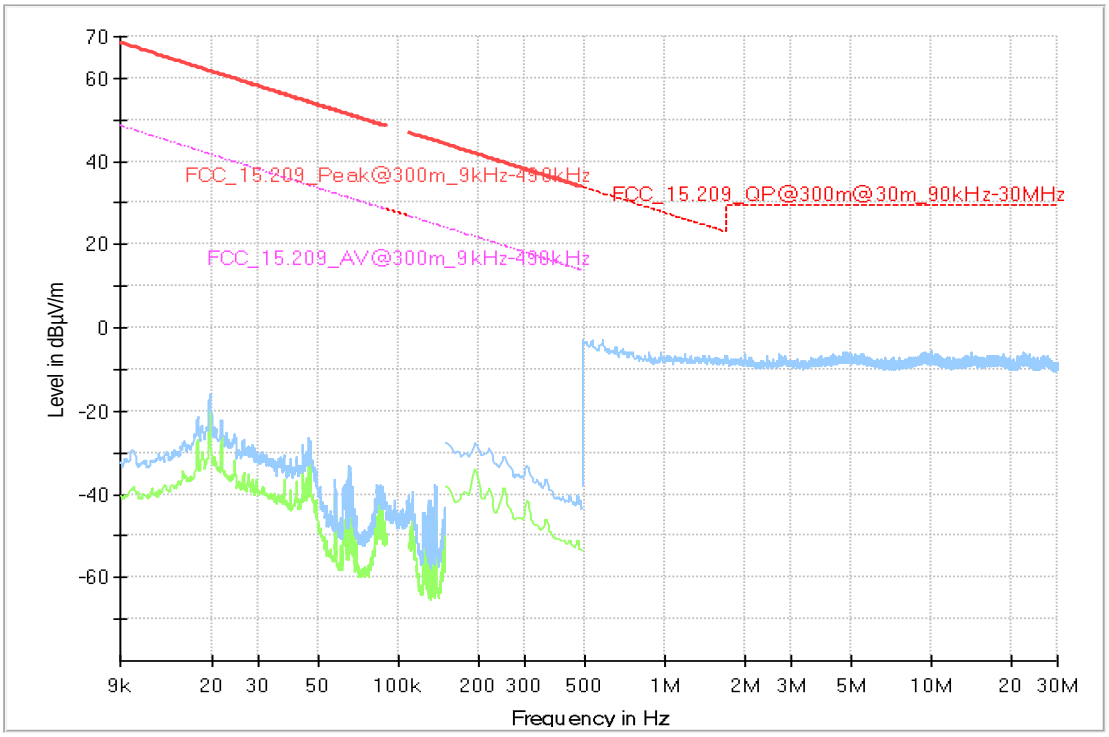
PKE modulated

Polarisation of the antenna and the EUT	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
---	---	---	---	---	---	---	---	---	---

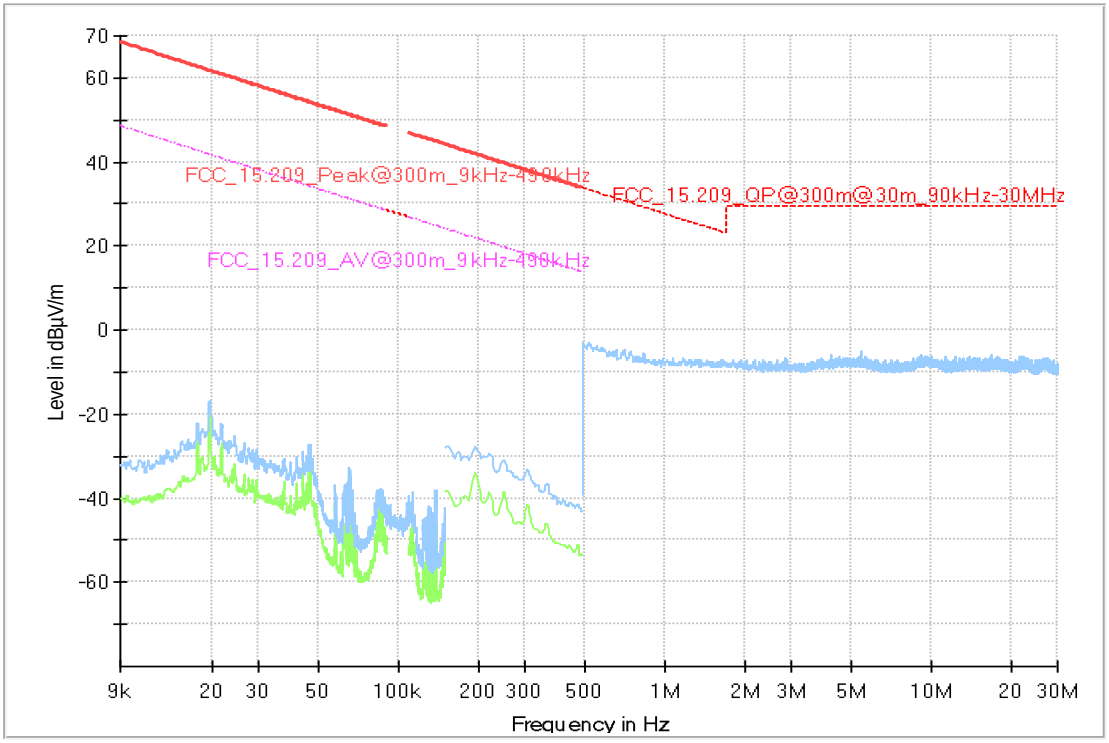
Remarks: - No more spurious emissions in the range 15 dB below the limit were found.
- The value in the table above is not corrected by using the Duty Cycle correction factor, calculated in clause 4.1.3.

4.2.4 MEASUREMENT PLOTS

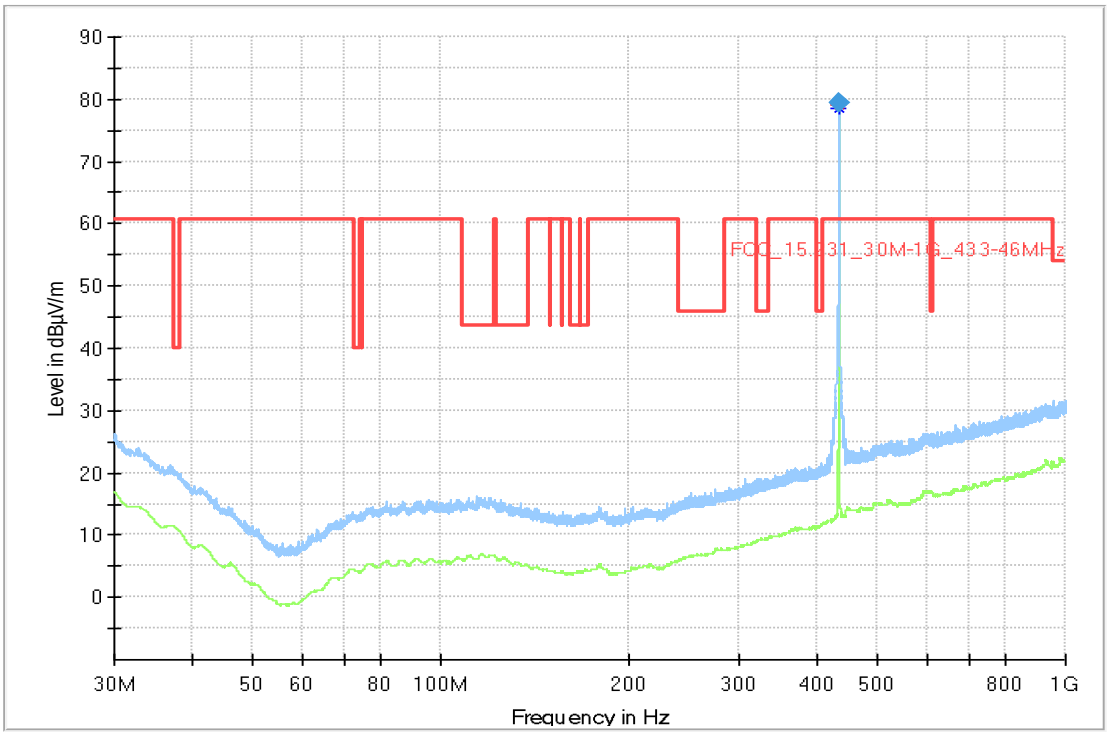
4.2.4.1 RADIATED EMISSIONS (f < 30 MHz) **RKE** mode, high channel



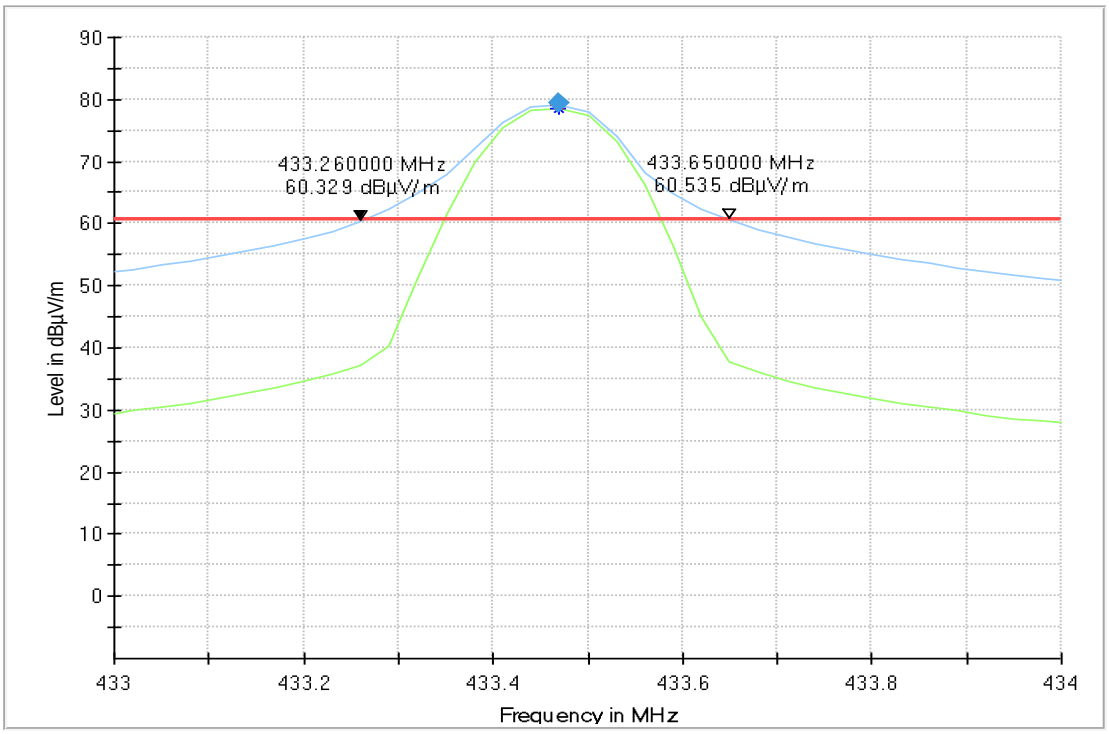
4.2.4.2 RADIATED EMISSIONS (f < 30 MHz) **PKE** mode, low channel



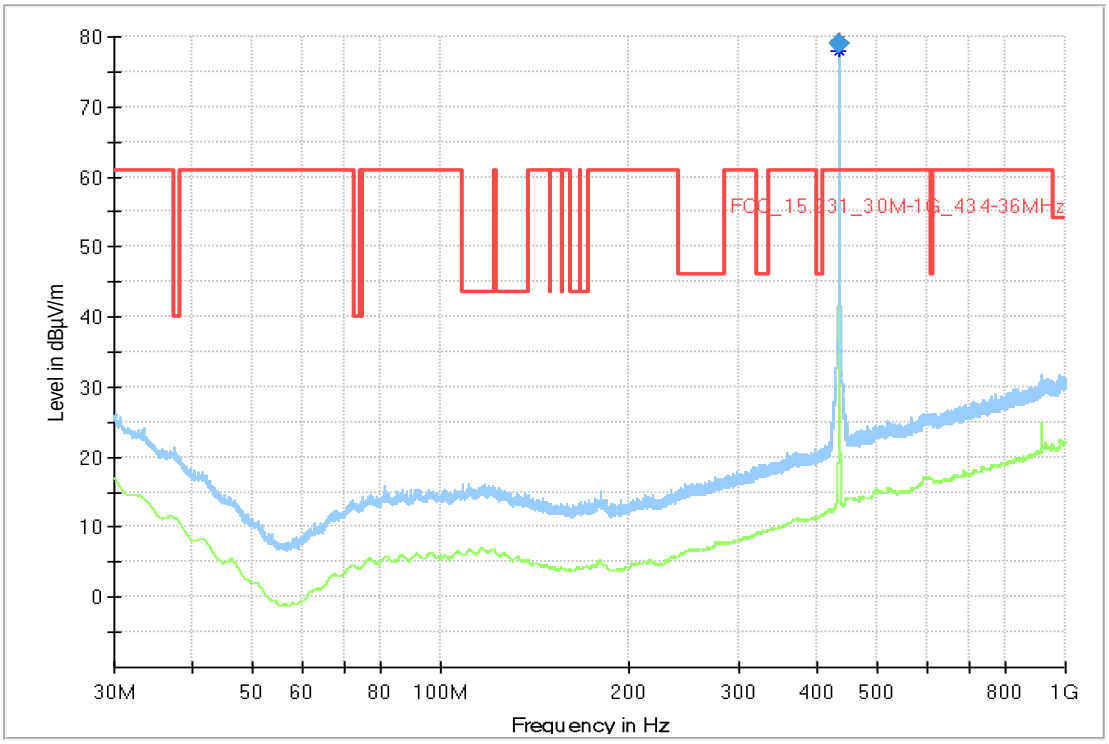
4.2.4.3 RADIATED EMISSIONS (30 MHz < f < 1 GHz) **RKE** mode, low channel



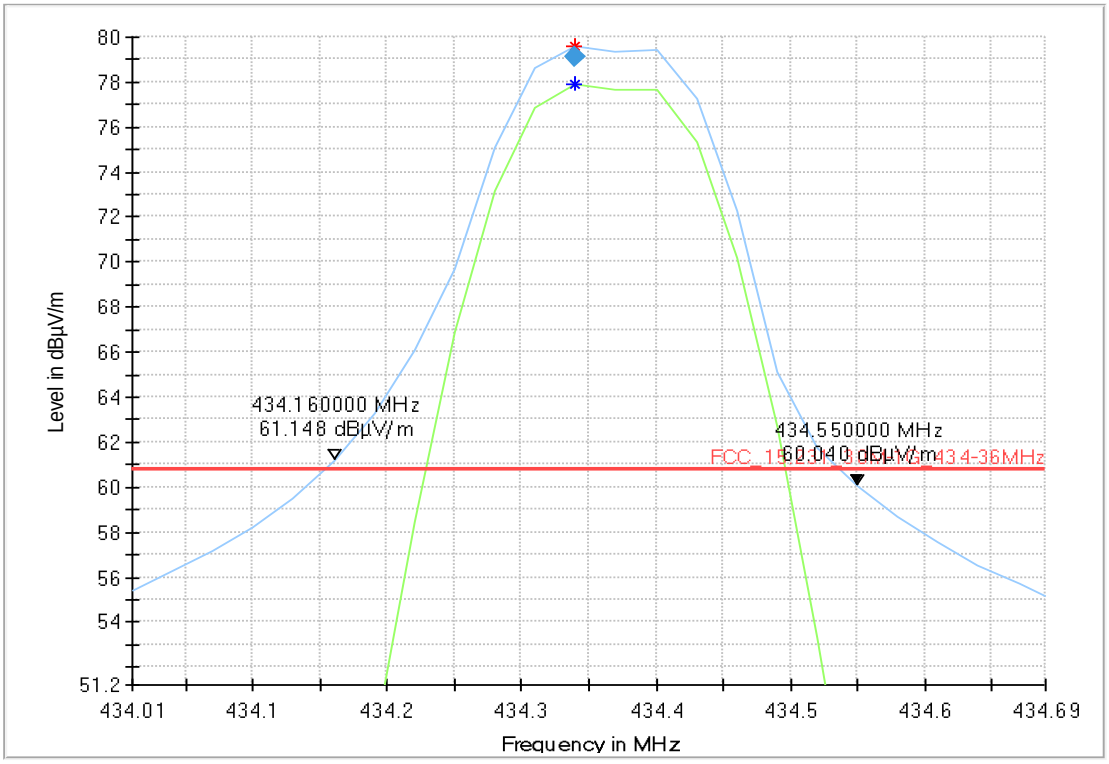
Note: The peak values are at the modulated carrier exclusion band. Below is a detailed plot of the band.



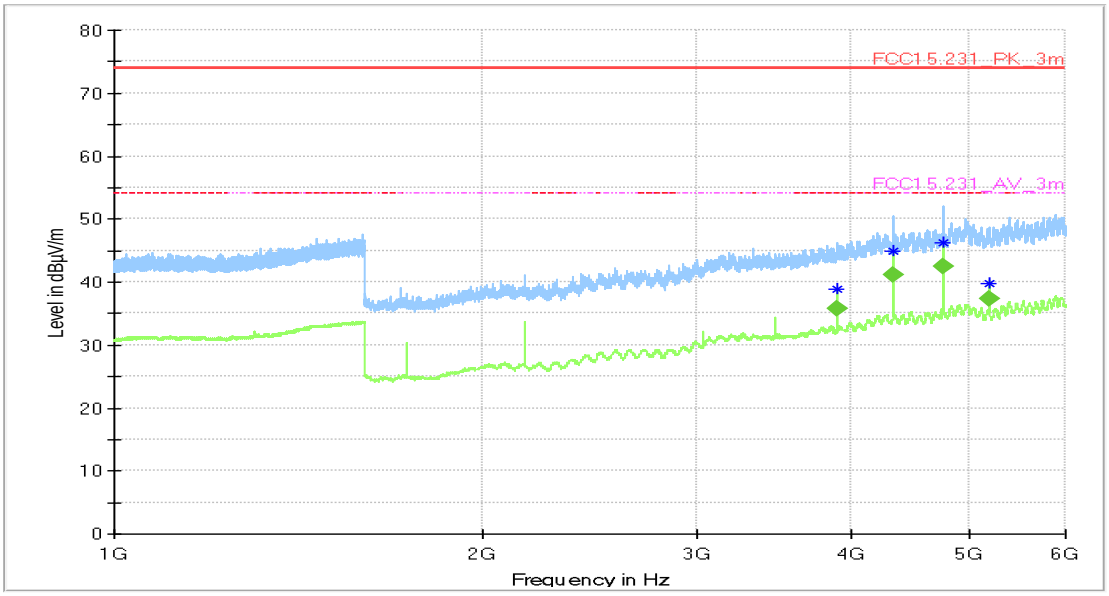
4.2.4.4 RADIATED EMISSIONS (30 MHz < f < 1 GHz) **PKE** mode, high channel



Note: The peak values are at the modulated carrier exclusion band. Below is a detailed plot of the band.



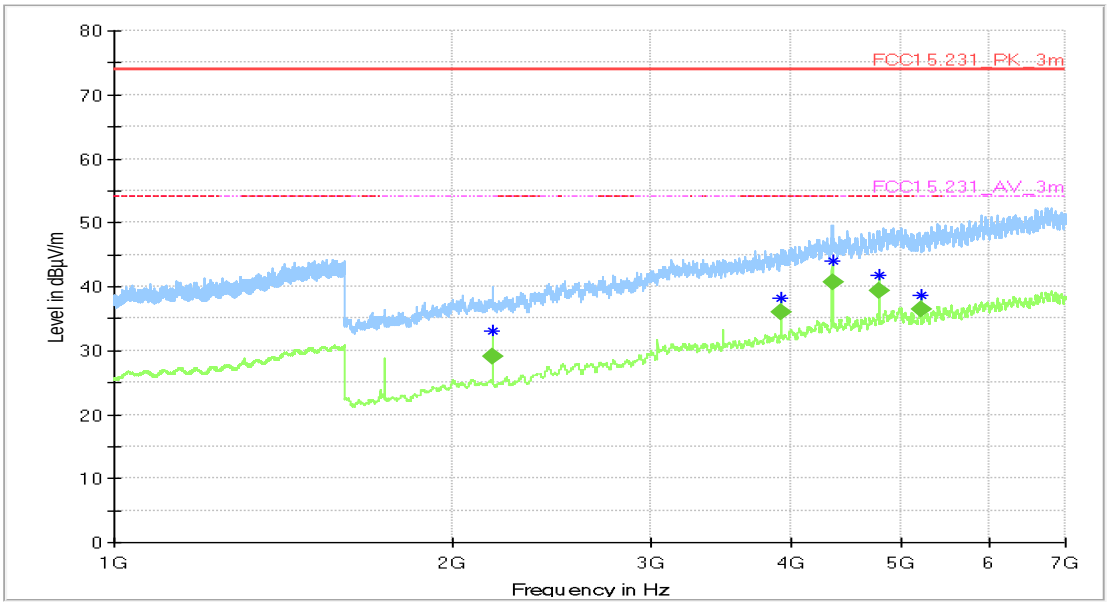
4.2.4.5 RADIATED EMISSIONS (1 GHz < f < 6 GHz) **RKE** mode, low channel



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
3901.200	---	35.8	53.98	18.22	1000.0	1000.000	150.0	V	-172.0	78.0
4334.600	---	41.1	53.98	12.87	1000.0	1000.000	150.0	V	-173.0	86.0
4768.000	---	42.5	53.98	11.50	1000.0	1000.000	150.0	V	-153.0	78.0
5201.400	---	37.3	53.98	16.63	1000.0	1000.000	150.0	V	-131.0	78.0

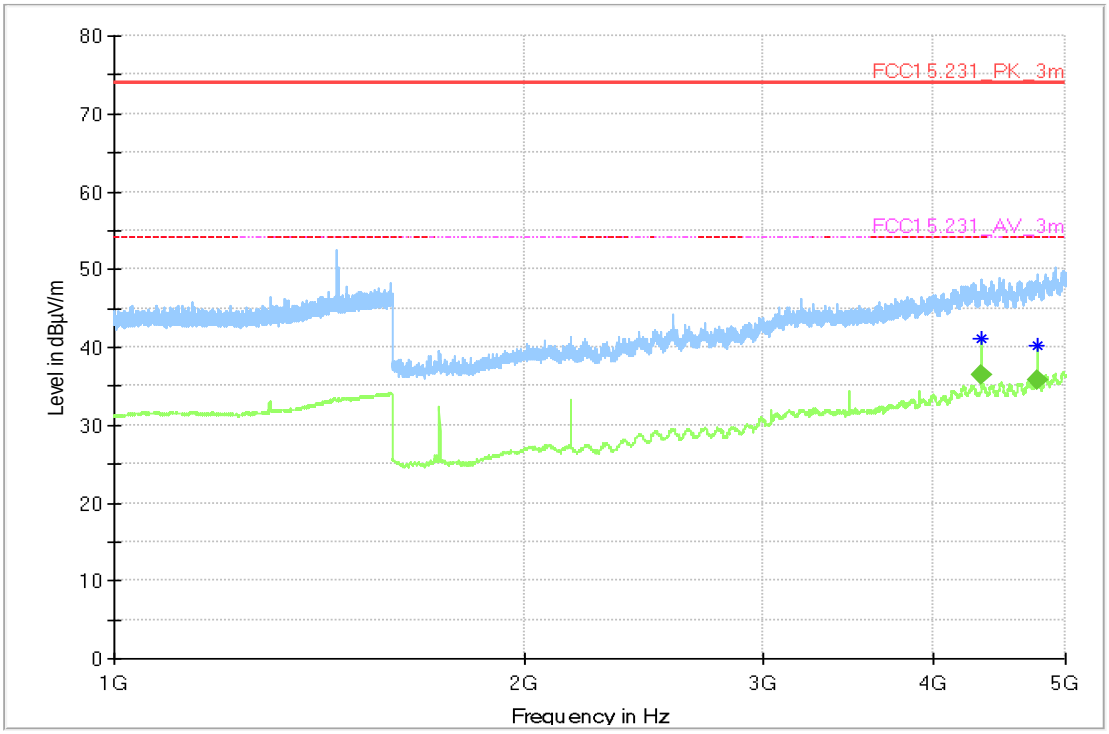
RKE mode, high channel



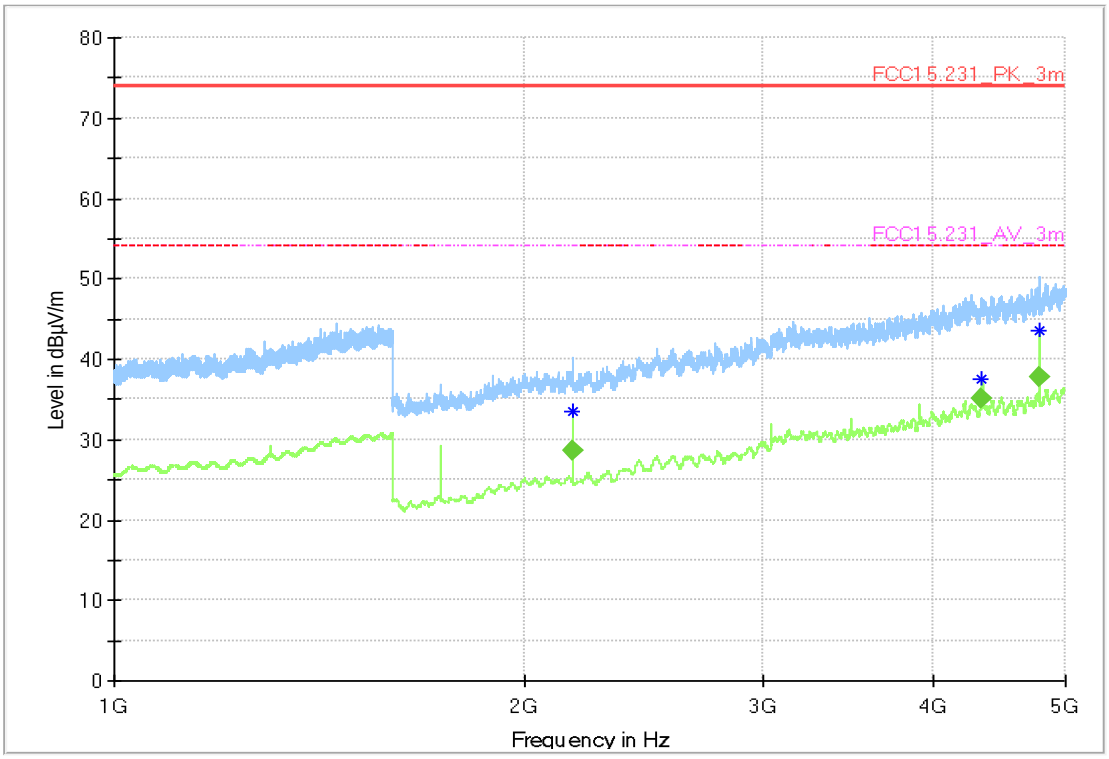
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)
3909.040	---	35.9	53.98	18.04	1000.0	1000.000	150.0	V	-175.0	93.0
4343.740	---	40.8	53.98	13.20	1000.0	1000.000	150.0	V	-179.0	85.0
4777.900	---	39.3	53.98	14.63	1000.0	1000.000	150.0	V	-174.0	78.0
5212.600	---	36.4	53.98	17.55	1000.0	1000.000	150.0	V	-169.0	85.0

4.2.4.6 RADIATED EMISSIONS (1 GHz < f < 7 GHz) **RKE** mode, low channel



PKE mode high channel



4.3 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

Standard FCC Part 15, Subpart C

The test was performed according to:
ANSI C63.10–2013

4.3.1 TEST DESCRIPTION

Please refer to sub-clause 4.1.1

4.3.2 TEST LIMITS

Please refer to sub-clause 4.1.2 FCC 15.231 b) applies

4.3.3 TEST PROTOCOL

Temperature: 24 °C
Air Pressure: 1009 hPa
Humidity: 38 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Frequency [MHz]	Output power [dBµV/m]	Limit [dBµV/m]	Margin to Limit [dB]	Remarks
433.470	74.48	80.81	6.33	Maximum radiated field strength at f_{c1} +$\Delta f_{c1\ PKE}$ frequency
433.950	74.69	80.83	6.14	Maximum radiated field strength at f_{c2} + $\Delta_{fc2\ PKE}$ frequency
434.370	74.74	80.84	6.10	Maximum radiated field strength at f_{c3} + $\Delta f_{c3\ PKE}$ frequency

Notes: The values shown in the table above are corrected by using the corresponding theDuty Cycle Correction Factors, calculated in 4.1.3
The EUT transmitted continuously non-modulated carrier.

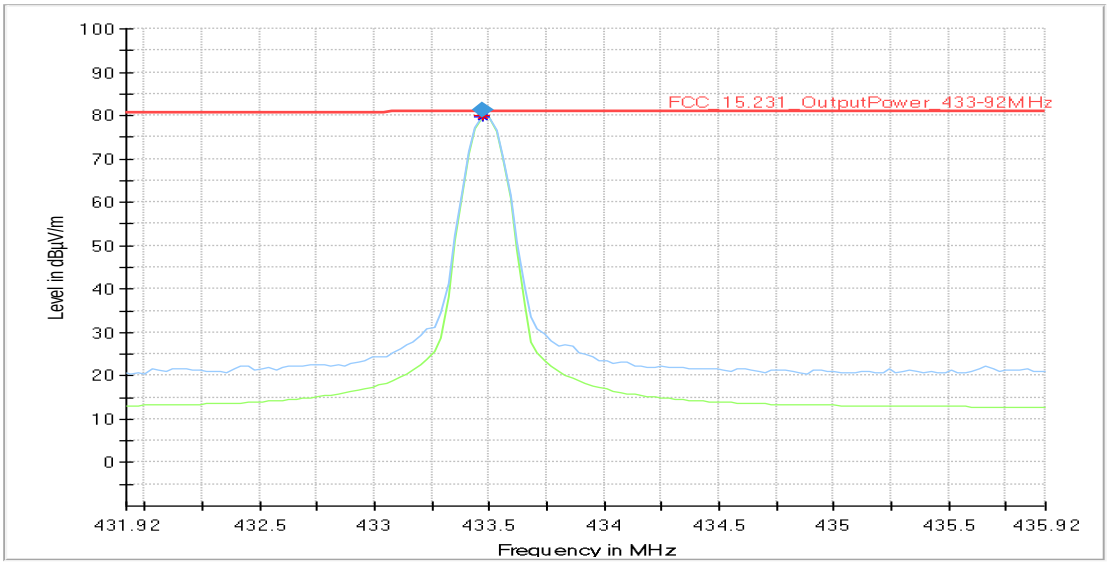
4.3.4 TEST RESULT:

MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

4.3.5 MEASUREMENT PLOTS

4.3.5.1 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY ch.1

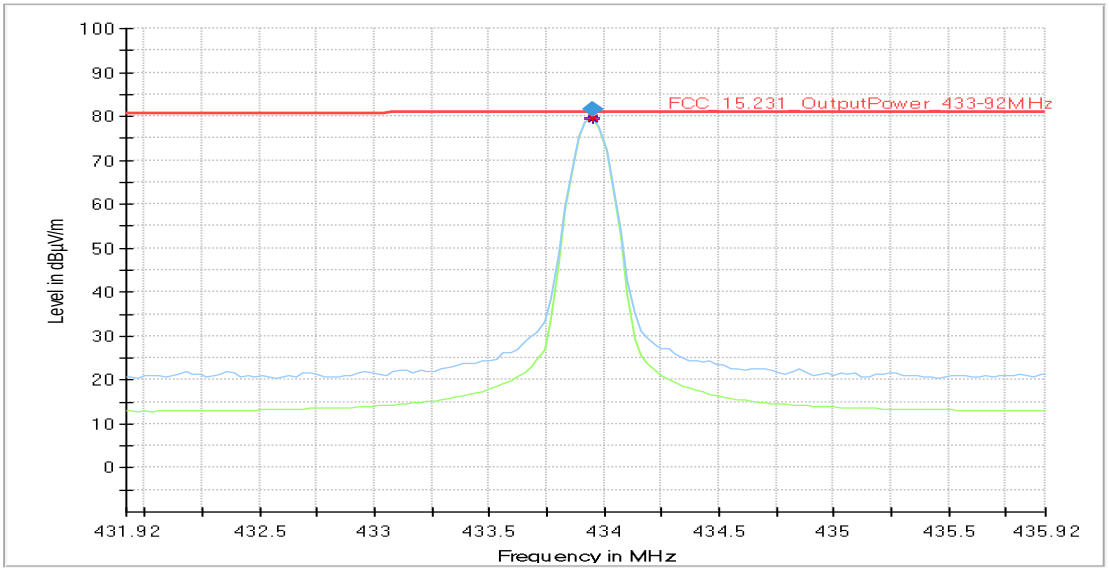


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Corr. Value (dBµV/m)	DC corr. factor	New Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
433.470000	81.30	80.81	**74.48**	**-6.82**	**6.33**	1000.0	120.000	117.0	V	67.0

Note: Duty Cycle correction factor, calculated in 4.1.3 is -**6.82** dB.
Hence, the maximum radiated field strength at fundamental frequency is:
81.30 – 6.82 = **74.48** dBµV/m. The margin to the limit corrected is **6.33** dB

4.3.5.2 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY Ch.2

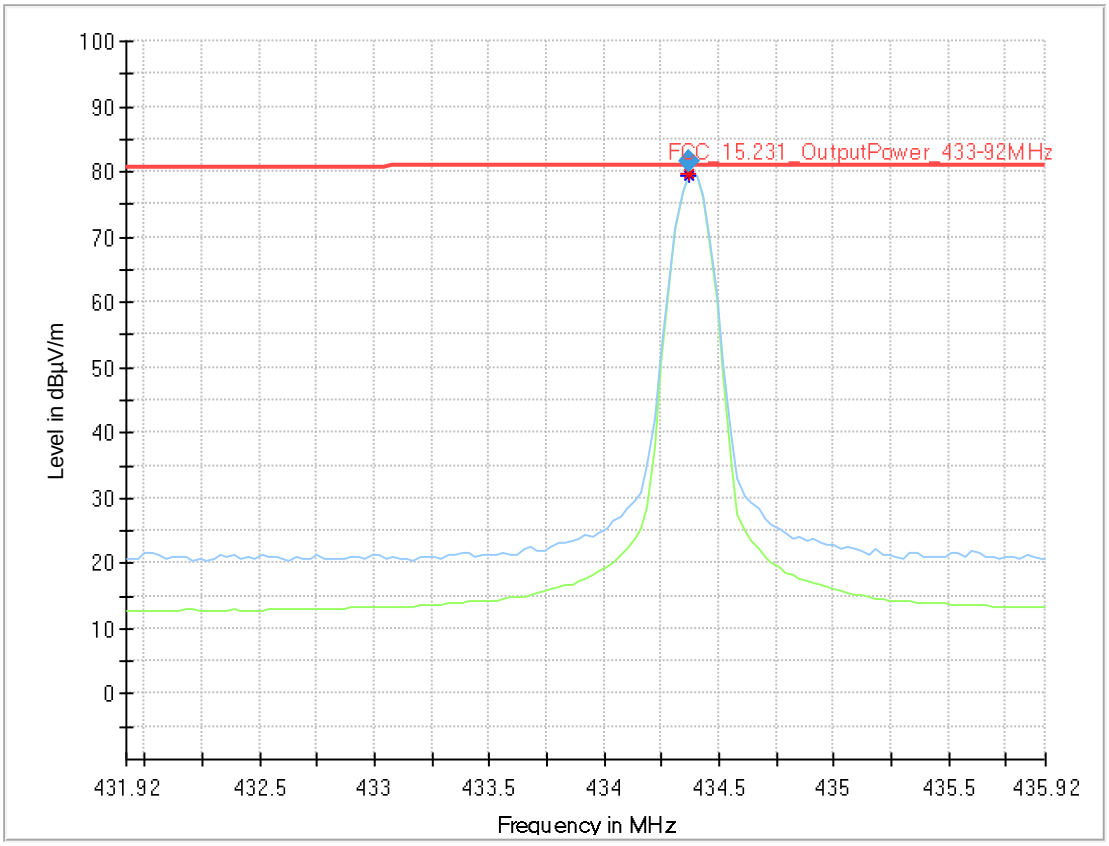


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Corr. Value (dBµV/m)	DC corr. factor	New Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
433.950000	**81.51**	**80.83**	**74.69**	**-6.82**	**6.14**	**1000.0**	**120.000**	**118.0**	**V**	**67.0**

Note: Duty Cycle correction factor, calculated in 4.1.3 is -**6.82** dB.
Hence, the maximum radiated field strength at fundamental frequency is:
81.51 – 6.82 = **74.69** dBµV/m. The margin to the limit corrected is **6.14** dB

4.3.5.3 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY ch.3



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Corr. Value (dBµV/m)	DC corr. factor	New Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
434.370000	81.56	80.84	74.74	-6.82	6.1	1000.0	120.000	119.0	V	99.0

Note: Duty Cycle correction factor, calculated in 4.1.3 is -**6.82** dB.
Hence, the maximum radiated field strength at fundamental frequency is:
81.56 – 6.82 = **74.74** dBµV/m. The margin to the limit corrected is **6.1** dB

4.4 OCCUPIED BANDWIDTH

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10–2013

4.4.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.
For analyzer settings please see the measurement plots.

4.4.2 TEST LIMITS

FCC Part 15, Subpart C, §15.231(c)
The maximum 20 dB bandwidth of a transmitter operating at a frequency range:
70 to 900 MHz is 0.25% of the centre frequency
above 900 MHz is 0.5% of the centre frequency

4.4.3 TEST PROTOCOL

Temperature: 23 °C
Air Pressure: 1009 hPa
Humidity: 42 %

Op. Mode	Setup	Port
op-mode 2	Setup_01	Enclosure

Mode	Cannel Frequency [MHz]	20 dB bandwidth [kHz]	99% bandwidth [kHz]	Limit [kHz]	Remarks
RKE	433.46	40.380	46.309	1083.6	Limit calculated as: 433.46 MHz (declared by applicant) * 0.25% = 1083.6 kHz.
	434.36	64.000	64.000	1085.9	
PKE	433.46	117.000	105.282	1083.6	the same as above
	434.36	155.000	115.050	1085.9	

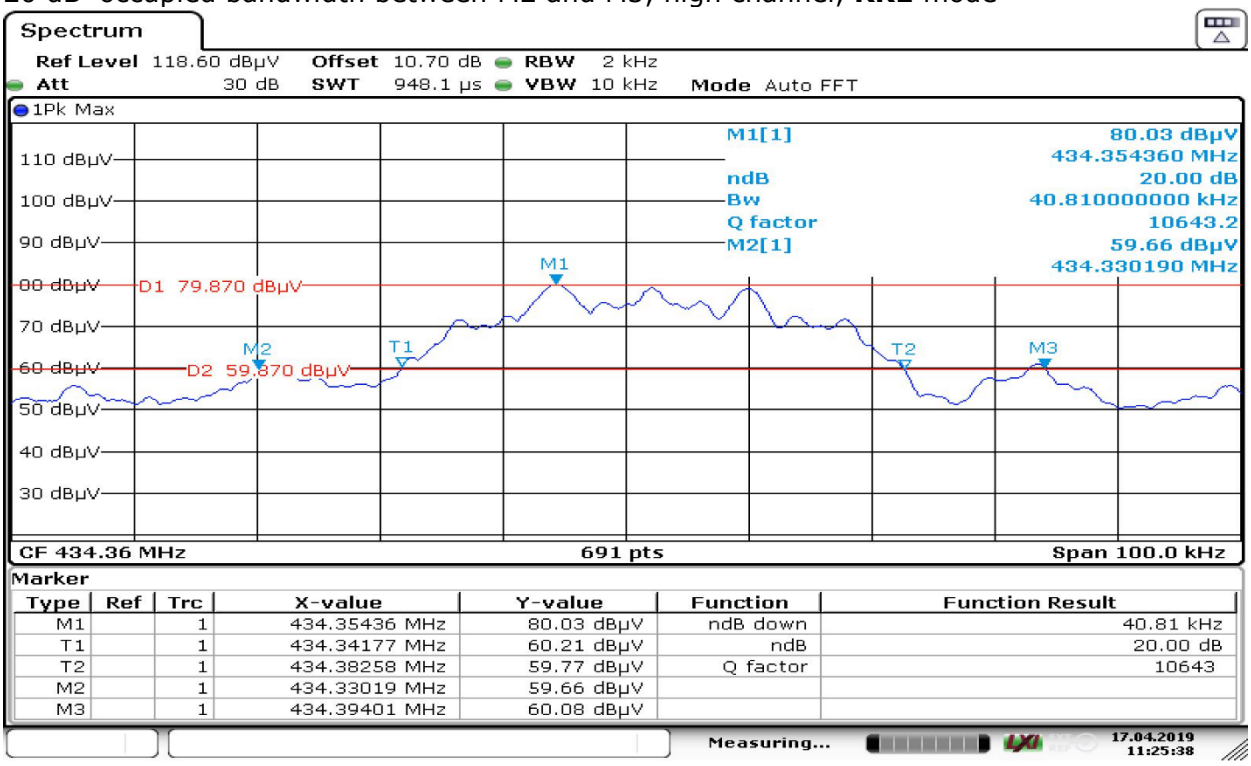
Remark: Please see the measurement plots.

4.4.4 TEST RESULT: OCCUPIED BANDWIDTH

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 2	passed

4.4.5 MEASUREMENT PLOTS OCCUPIED BANDWIDTH

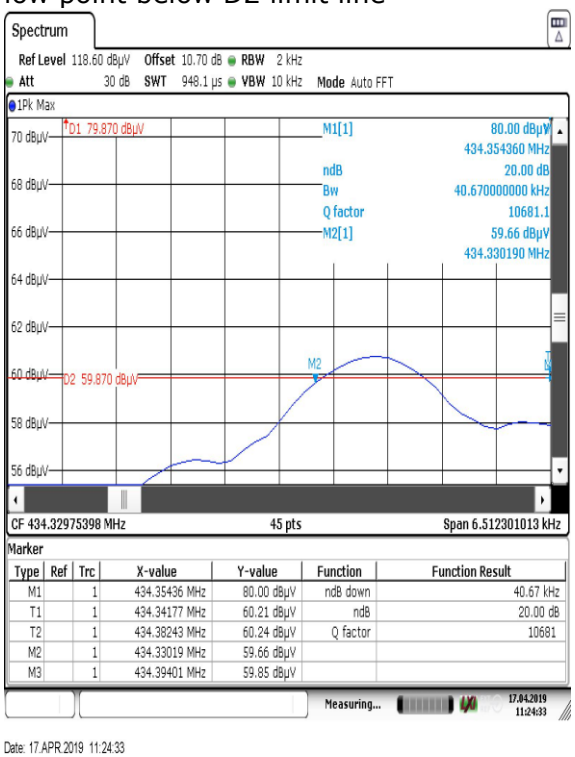
20 dB occupied bandwidth between M2 and M3, high channel, **RKE** mode



Date: 17.APR.2019 11:25:39

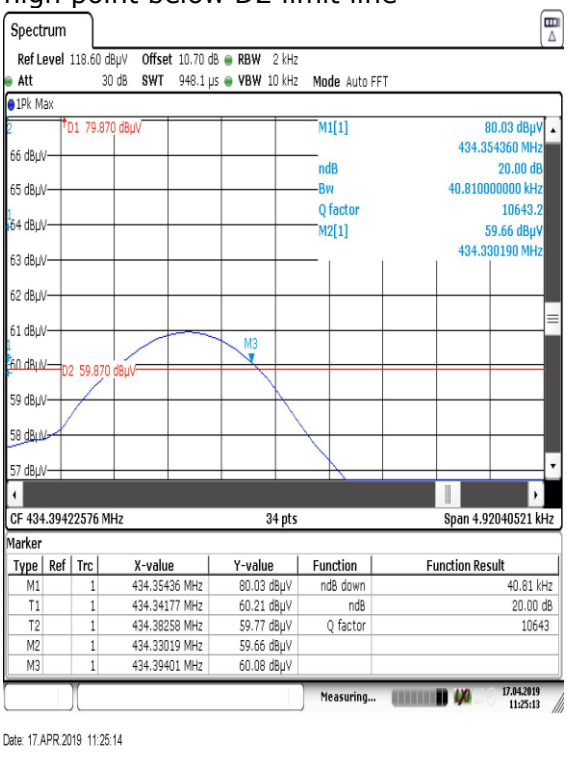
Zoomed low and high points to the limit line D2

low point below D2 limit line



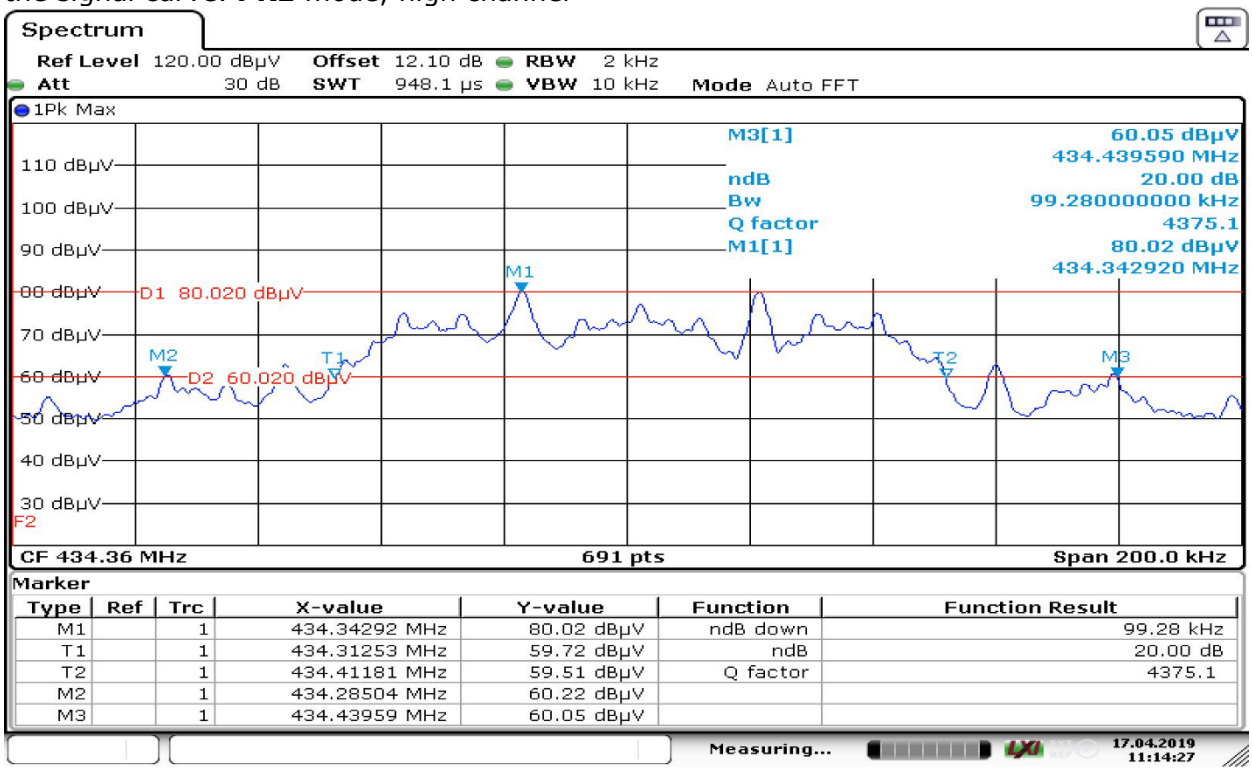
Date: 17.APR.2019 11:24:33

high point below D2 limit line



Date: 17.APR.2019 11:25:14

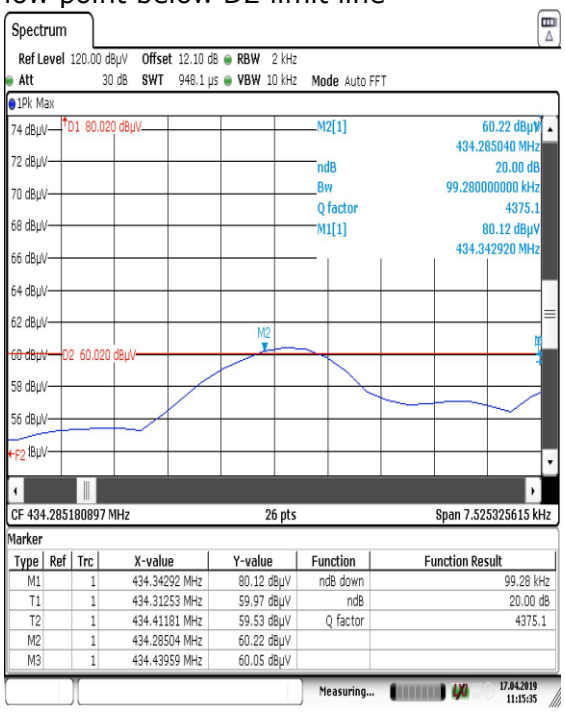
20 dB occupied bandwidth between Marks D2 and D3 set where the limit line D2 crosses the signal curve. **PKE** mode, high channel



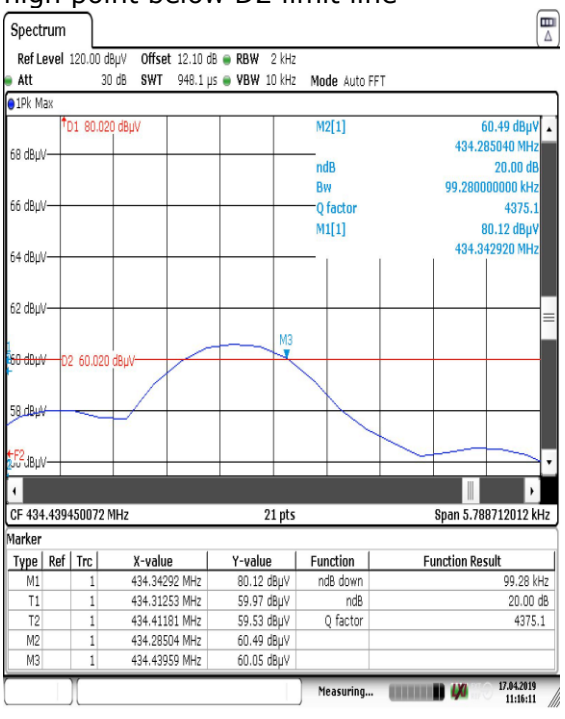
Date: 17.APR.2019 11:14:28

Zoomed low and high points to the limit line D2

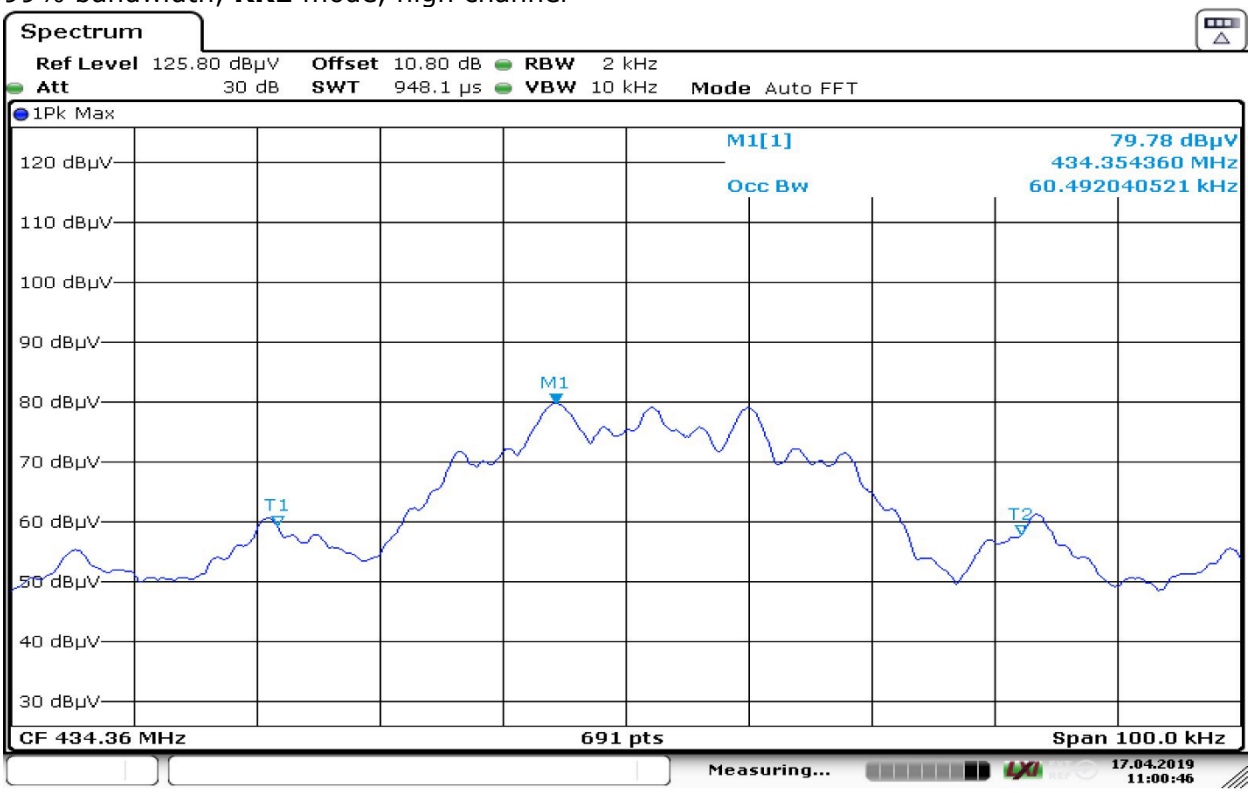
low point below D2 limit line



high point below D2 limit line

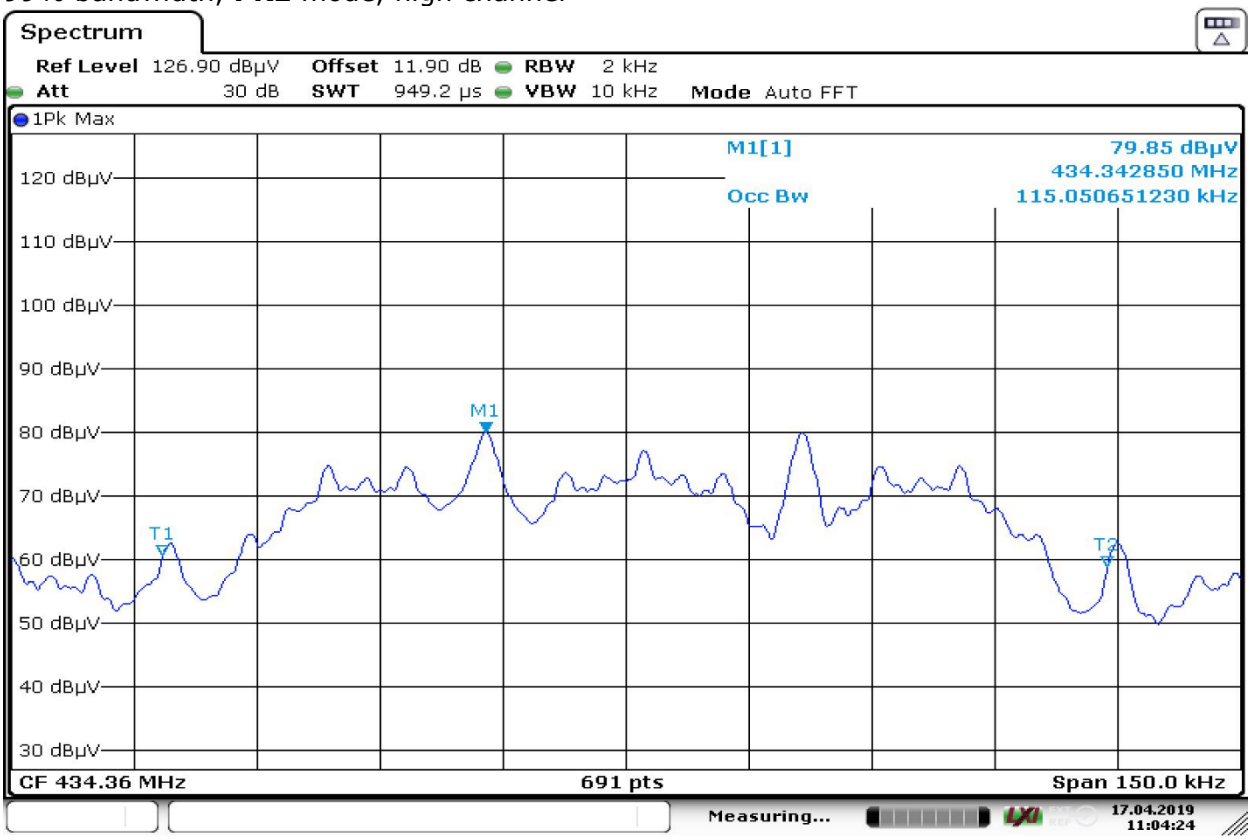


99% bandwidth, **RKE** mode, high channel



Date: 17.APR.2019 11:00:47

99% bandwidth, **PKE** mode, high channel



Date: 17.APR.2019 11:04:24

5 TEST EQUIPMENT

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	NRV-Z1	Sensor Head A	Rohde & Schwarz GmbH & Co. KG	827753/005		
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2020-10
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
1.4	ESW44	EMI Test Receiver	Rohde & Schwarz GmbH & Co. KG	101603	2018-05	2019-05
1.5	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none		
1.6	FS-Z60	Harmonic Mixer 40 - 60 GHz	Rohde & Schwarz Messgerätebau GmbH	100178	2016-12	2019-12
1.7	FS-Z220	Harmonic Mixer 140 - 220 GHz	Rohde & Schwarz Messgerätebau GmbH	101005	2017-03	2020-03
1.8	SGH-05	Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz)		075		
1.9	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
1.10	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.11	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.12	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2018-06	2020-06
1.13	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.14	NRVD	Power Meter	Rohde & Schwarz GmbH & Co. KG	828110/016		
1.15	HF 906	Double-ridged horn	Rohde & Schwarz	357357/002	2018-06	2021-06
1.16	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.17	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
1.18	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
1.19	SGH-19	Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)		093		
1.20	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
1.21	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.22	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		

1.23	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.24	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.25	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2018-07	2021-07
1.26	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03
1.27	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2017-03	2020-03
1.28	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675	2018-09	2021-09
1.29	SGH-08	Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)	RPG Radiometer Physics GmbH	064		
1.30	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)	RPG Radiometer Physics GmbH	326		
1.31	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
1.32	FS-Z140	Harmonic Mixer 90 -140 GHz	Rohde & Schwarz Messgerätebau GmbH	101007	2017-02	2020-02
1.33	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
1.34	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-04	2019-04
1.35	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2019-01	2020-01
1.36	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.37	AS 620 P	Antenna mast	HD GmbH	620/37		
1.38	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
1.39	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)	RPG Radiometer Physics GmbH	060		
1.40	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2017-03	2020-03
1.41	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2018-01	2020-01
1.42	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.43	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.44	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
1.45	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

2 Radio Lab

Conducted Radio Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
2.2	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2018-10	2020-10
2.3	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
2.4	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
2.5	SMP03	Signal Generator 2 GHz - 27 GHz	Rohde & Schwarz	833680/003	2017-09	2020-09
2.6	FSIQ26	Signal Analyser	Rohde & Schwarz	840061/005	2017-05	2019-05
2.7	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.8	VT 4002	Temperature Chamber	Vötsch	58566002150010	2018-04	2020-04
2.9	WA1515	Broadband Power Divider SMA	Weinschel Associates	A855		
2.10	A8455-4	4 Way Power Divider (SMA)		-		
2.11	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-04	2019-04
2.12	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

U_{LISN} (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

6.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

B µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
Receiver reading
Antenna factor
= sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
nce correction = -40 * LOG (d_{Limit}/ d_{used})
ar interpolation will be used for frequencies in between the values in the table.
e shows an extract of values

6.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

equency	AF S HL562	Corr.	le loss 1 inside amber)	le loss 2 outside amber)	e loss 3 tch unit)	loss 4 (to ceiver)	nce corr. 20 dB/ ecade)	d_{Limit} meas. nce (limit)	d_{used} meas. nce (used)
MHz	(1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 m)

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
eceiver reading
Antenna factor
= sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
ce correction = -20 * LOG (d_{Limit}/ d_{used})
interpolation will be used for frequencies in between the values in the table.
s show an extract of values.

6.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.
MHz	dB (1/m)	dB
18000	40.2	-23.5
18500	40.2	-23.2
19000	40.2	-22.0
19500	40.3	-21.3
20000	40.3	-20.3
20500	40.3	-19.9
21000	40.3	-19.1
21500	40.3	-19.1
22000	40.3	-18.7
22500	40.4	-19.0
23000	40.4	-19.5
23500	40.4	-19.3
24000	40.4	-19.8
24500	40.4	-19.5
25000	40.4	-19.3
25500	40.5	-20.4
26000	40.5	-21.3
26500	40.5	-21.1

cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
dB	dB	dB	dB	dB
0.72	-35.85	6.20	2.81	2.65
0.69	-35.71	6.46	2.76	2.59
0.76	-35.44	6.69	3.15	2.79
0.74	-35.07	7.04	3.11	2.91
0.72	-34.49	7.30	3.07	3.05
0.78	-34.46	7.48	3.12	3.15
0.87	-34.07	7.61	3.20	3.33
0.90	-33.96	7.47	3.28	3.19
0.89	-33.57	7.34	3.35	3.28
0.87	-33.66	7.06	3.75	2.94
0.88	-33.75	6.92	3.77	2.70
0.90	-33.35	6.99	3.52	2.66
0.88	-33.99	6.88	3.88	2.58
0.91	-33.89	7.01	3.93	2.51
0.88	-33.00	6.72	3.96	2.14
0.89	-34.07	6.90	3.66	2.22
0.86	-35.11	7.02	3.69	2.28
0.90	-35.20	7.15	3.91	2.36

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-15.6	3	0.5
27.0	43.4	-11.2	4.4				-15.6	3	0.5
28.0	43.4	-11.1	4.5				-15.6	3	0.5
29.0	43.5	-11.0	4.6				-15.6	3	0.5
30.0	43.5	-10.9	4.7				-15.6	3	0.5
31.0	43.5	-10.8	4.7				-15.6	3	0.5
32.0	43.5	-10.7	4.8				-15.6	3	0.5
33.0	43.6	-10.7	4.9				-15.6	3	0.5
34.0	43.6	-10.6	5.0				-15.6	3	0.5
35.0	43.6	-10.5	5.1				-15.6	3	0.5
36.0	43.6	-10.4	5.1				-15.6	3	0.5
37.0	43.7	-10.3	5.2				-15.6	3	0.5
38.0	43.7	-10.2	5.3				-15.6	3	0.5
39.0	43.7	-10.2	5.4				-15.6	3	0.5
40.0	43.8	-10.1	5.5				-15.6	3	0.5

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

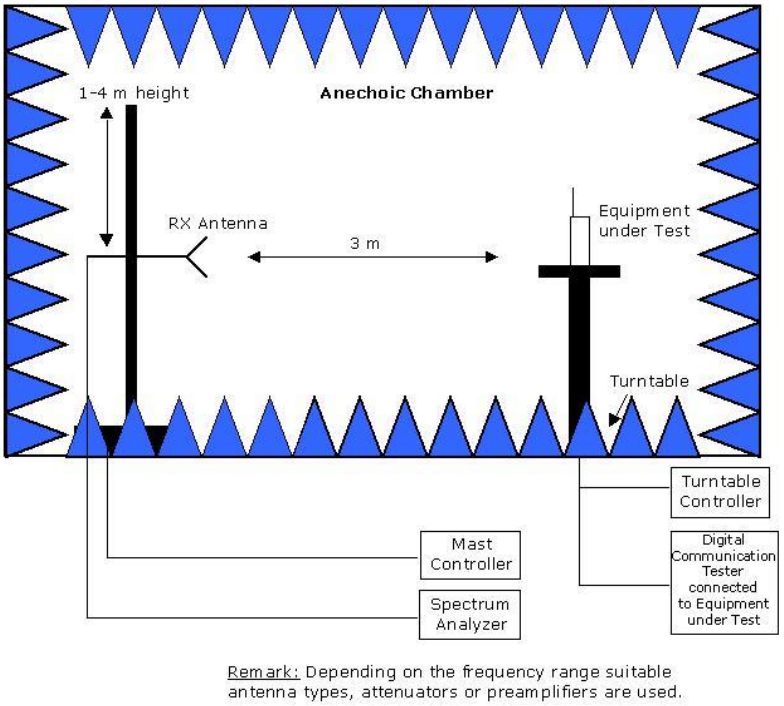
7 PHOTO REPORT

Photos are included in an external report.

MEASUREMENT UNCERTAINTIES

Parameter	Uncertainty
Radio frequency	± 0.5 ppm
Radiated emission of transmitter, valid up to 6 GHz	± 4.5 dB
Radiated emission of receiver, valid up to 6 GHz	± 4.5 dB
Occupied Bandwidth	± 4.5%
Temperature	± 0.3 °C
Humidity	± 3%

8 SETUP DRAWINGS



Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.