Test report

Customer:

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RF test report

170696-AU01+W01

Industry Canada Industrie Canada

Continental Automotive GmbH

A2C35029700

EMV TESTHAUS

DAkkS
Deutsche Akkreditierungsstelle
D-PL-12155-01-00

EMV **TESTHAUS** GmbH

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Accreditation:

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-12155-01-00

Test Firm Type “accredited”: Valid until 2019-05-06
MRA US-EU, FCC designation number: DE0010
BNetzA-CAB-02/21-02/04 Valid until 2018-11-27

Industry Canada test site numbers with registration expiry date:
3472A-1, expiring 2019-03-15
3472A-2, expiring 2019-03-15

Test laboratory:

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Gustav-Hertz-Straße 35
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Germany

The technical accuracy is guaranteed through the quality management of
EMV **TESTHAUS** GmbH.

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1 Summary of test results

47 CFR part and section	*Test*	*Equivalent to IC radio standard(s)*	*Page*	*Result*	*Note(s)*
15.207(a)	AC power line conducted emissions 150 kHz to 30 MHz	RSS-Gen, 7.4	---	Not applicable	---
15.231(b)	Field strength of the fundamental wave	RSS-210, A1.2 a	16	Passed	---
15.231(b)	Spurious emissions (magnetic field) 9 kHz – 30 MHz	RSS-210, A1.2 b	18	Passed	---
15.231(b)	Spurious emissions radiated (electrical field) 30 MHz – 10th harmonic	RSS-210, A1.2 b	18	Passed	---
15.231(b)2	Correction for pulse operation (duty cycle)	RSS-Gen 8.2	29	Passed	---
15.231(a)	Signal deactivation	RSS-210, A1.1(a)	39	Passed	---
15.231(c)	20 dB bandwidth	RSS-Gen, 6.7	33	Passed	---
	Occupied bandwidth (99 %)	RSS-Gen, 6.7	36	Passed	---

Straubing, July 17, 2018

Alexander Grill
Test engineer
EMV **TESTHAUS** GmbH

Konrad Graßl
Head of radio department
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2 Referenced publications

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A – General (November, 2017)	
Part 15, Subpart A, Section 15.31	Measurement Standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements
Part 15, Subpart A, Section 15.35	Measurement detector functions and bandwidths
FCC Rules and Regulations Part 15, Subpart C – Intentional Radiators (November, 2017)	
Part 15, Subpart C, Section 15.203	Antenna Requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.231	Periodic operation in the band 40.66 MHz - 40.7 MHz and above 70 MHz
OET Bulletin 65, 65A, 65B, 65C 97-01, August 1997 – Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields	
ANSI C63.10: 2013	Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-210 – Licence-Exempt Radio Apparatus: Category I Equipment (August, 2016)	
Annex A 1.1	*Types of Momentarily Operated Devices*
Annex A 1.2	*Field Strengths*
RSS-Gen Issue 5 – General Requirements for Compliance of Radio Apparatus	
Section 6.7	Occupied bandwidth (or 99% emission bandwidth) and x dB bandwidth

3 Equipment under test (EUT)

Product type:	Remote Keyless Entry
Model name:	A2C35029700
Serial number(s):	Prototype sample, Ch1_Tx_mod_rad Prototype sample, Ch2_Tx_mod_rad Prototype sample, Ch1_Tx_cw_con Prototype sample, Ch2_Tx_cw_con
Applicant:	Continental Automotive GmbH
Manufacturer:	Continental Automotive GmbH
Version:	Hardware: ---- Software: ----
Additional modifications:	None
Short description:	The EUT is a Remote Keyless Entry device which handles Comfort Access (CA), Remote Keyless Entry (RKE) and other remote functions. The EUT receives and controls the signals and works as wireless gateway between transmitter and central electronic module in the vehicle. Following remote functions are tested in this report: – SDS – RKE – CA old procedure RKE and CA old procedure both use the maximum transmission power. Therefore the measurement of the fundamental wave with maximum transmission power is used for both operation modes. See chapter 6.1.3 For SDS, another transmission power setting is used. See chapter 6.1.4.
FCC ID:	KR5A2C35029700
IC:	7812D-35029700
Application frequency band:	none
Frequency range:	260.00 MHz – 470.00 MHz
Operating frequencies:	433.20 MHz and 434.64 MHz
Channel spacing:	not specified
Number of RF channels:	2
System type:	Remote keyless entry
Modulation type(s):	2FSK
Antenna type(s):	PCB antenna

Antenna gain(s):	Not specified		
Power supply:	DC supply		
	Nominal voltage:	12 V	
	Minimum voltage:	8 V	
	Maximum voltage:	16 V	
	Nominal frequency:	---	
Temperature range:	-40 °C to +85 °C		
Device type:	☐ Portable	☒ Mobile	☐ Fixed

4 Test configuration and mode of operation

4.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
EUT			
Remote Keyless Entry	A2C35029700, BMW FBD 3 TRX 434 MHz	Prototype sample, Ch1_Tx_mod_rad	Continental Automotive GmbH
Remote Keyless Entry	A2C35029700, BMW FBD 3 TRX 434 MHz	Prototype sample, Ch2_Tx_mod_rad	Continental Automotive GmbH
Remote Keyless Entry	A2C35029700, BMW FBD 3 TRX 434 MHz	Prototype sample, Ch1_Tx_cw_con	Continental Automotive GmbH
Remote Keyless Entry	A2C35029700, BMW FBD 3 TRX 434 MHz	Prototype sample, Ch2_Tx_cw_con	Continental Automotive GmbH
Peripheral devices			
DC power supply	Statron 3252.1	1201211	Statron Gerätetechnik GmbH

Table 1: Devices used for testing

Port	*Classification*	*Cable type*	*Cable length*	
			used	*maximum*[1]
DC power	dc power	Unshielded	2.65 m	---

Table 2: Ports of EUT and appropriate cables

4.2 Mode of operation

EUT was tested in following mode(s) of operation:

Test mode/ EUT	*Behavior*
Prototype sample, Ch1_Tx_cw_con	Unmodulated carrier wave on channel 1 (433.20 MHz)
Prototype sample, Ch2_Tx_cw_con	Unmodulated carrier wave on channel 2 (434.64 MHz)
Prototype sample, Ch1_Tx_mod_rad	Modulated carrier wave on channel 1 (433.20 MHz)
Prototype sample, Ch2_Tx_mod_rad	Modulated carrier wave on channel 2 (434.64 MHz)

[1] As specified by applicant

5 Measurement Procedures

5.1 20 dB bandwidth

The 20 dB bandwidth test method refers to section 6.9.2 of ANSI C63.10 and shall be as follows:

Spectrum analyzer settings:
Spectrum analyzer center frequency = nominal EUT channel center frequency
Span = between two times and five times the OBW
IF filter bandwidth (3 dB RBW) = between 1 % to 5 % of the OBW
VBW ≥ 3 x RBW
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/RBW) dB above peak of spectral envelope

Measure the maximum width of the emission that is constrained by the frequencies associated with the two markers (upper and lower frequencies) that are at or slightly below the 20 dB down amplitude relative to the maximum level measured in the fundamental emission.
If possible, use the automatic bandwidth measurement capability of the spectrum analyzer using the X dB bandwidth mode with X set to 20 dB. Submit this plot(s).
The 20 dB bandwidth is the frequency difference between the two markers.

For test setup see clause 5.4.

5.2 Occupied bandwidth (99%)

The occupied bandwidth test method refers to section 6.9.3 of ANSI C63.10 and shall be as follows.

Spectrum analyzer settings:
Span = between 1.5 times and 5.0 times of the OBW, centered on a channel
RBW ≥ in the range of 1% to 5% of the OBW
VBW ≥ approximately three times the RBW
Sweep time = auto coupled
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/RBW) dB above peak of spectral envelope

Use the 99% power bandwidth function of the spectrum analyzer and report the measured bandwidth.

For test setup see clause 5.4.

5.3 Spurious radiated emissions 9 kHz to 10th harmonic

For test setup and test method see clause 5.4.

5.4 Radiated emissions

5.4.1 Radiated emissions below 30 MHz

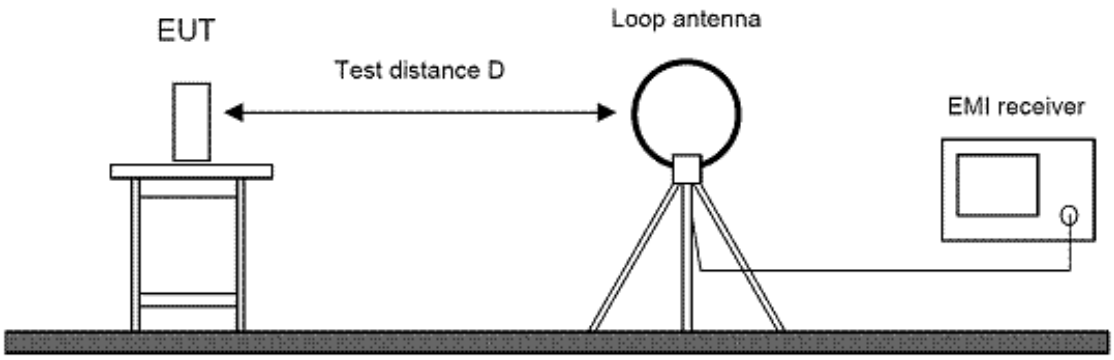

Figure 1: Setup for radiated emission test below 30 MHz

The test method for radiated emissions below 30 MHz refers to section 6.4 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The loop antenna is set in parallel with the antenna of the EUT.
4. The EMI receiver performs a scan from 9 kHz to 30 MHz with peak detector and measurement bandwidth set to 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above.
5. The turn table is rotated to 8 different positions (360° / 8).
6. The antenna is set in line with the antenna of the EUT and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS with 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz, where average detector applies.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The highest value for each frequency is recorded.

5.4.2 Radiated emissions from 30 MHz to 1 GHz

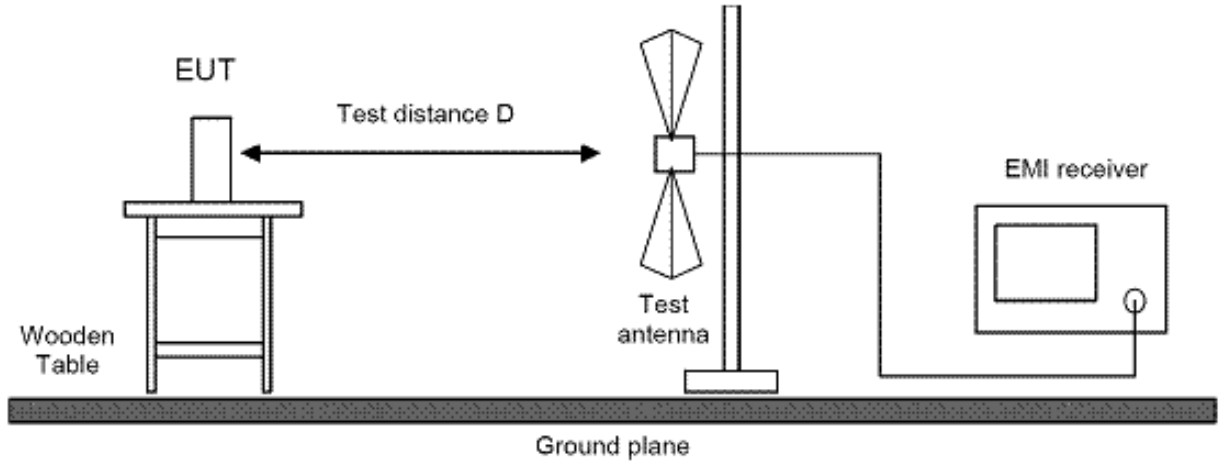

Figure 2: Setup for radiated emission test from 30 MHz to 1 GHz

The test method for radiated emissions from 30 MHz to 1 GHz refers to section 6.5 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The broadband antenna is set to vertical polarization.
4. The EMI receiver performs a scan from 30 MHz to 1000 MHz with peak detector and measurement bandwidth set to 120 kHz.
5. The turn table is rotated to 6 different positions (360° / 6).
6. The antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS at 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The height of the broadband receiving antenna is varied between 1 meter and 4 meters above ground to find the maximum emission field strength of both horizontal and vertical polarization.
10. The highest value for each frequency is recorded.

5.4.3 Radiated emissions above 1 GHz

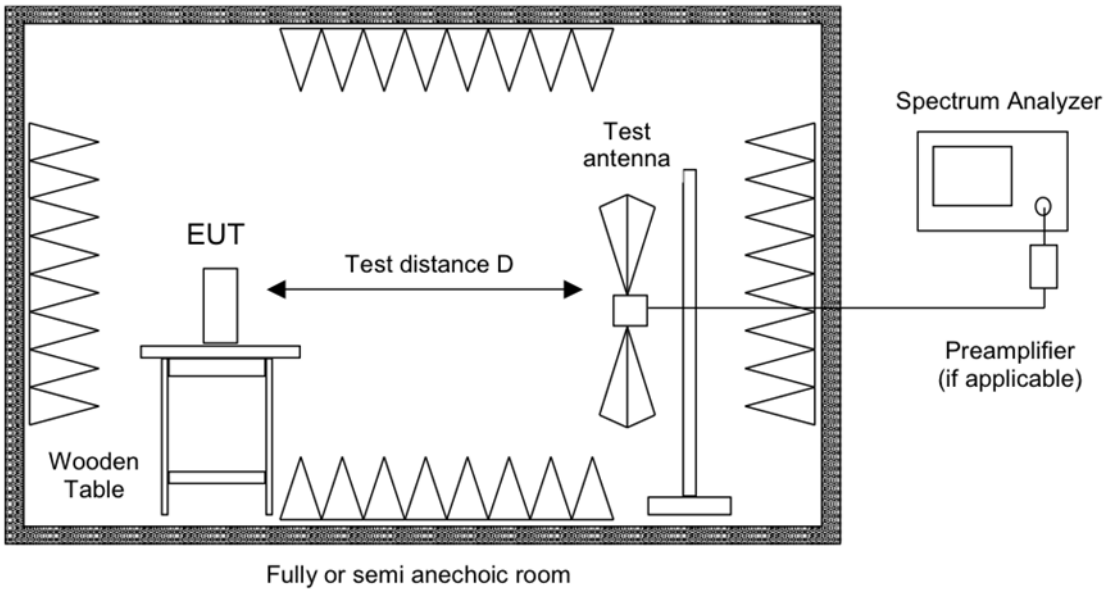

Figure 3: Setup for radiated emission test above 1 GHz

The test method for radiated emissions above 1 GHz refers to section 6.6 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 1.5 meter above ground. The test setup is placed inside a semi-anechoic chamber with RF absorbers on the floor.
2. EUT and all peripherals are powered on.
3. To identify the critical frequencies, extrapolatory radiated emission tests are performed at a closer distance than 3 meters (e.g. 1 meter). The critical frequencies found are noted.
4. For pre-scan the receiving antenna is located 3 meters from the EUT.
5. The broadband horn antenna is set to vertical polarization.
6. The EMI receiver performs a scan from 1 GHz to the 10th harmonic of the fundamental frequency with peak and average detector activated simultaneously and measurement bandwidth set to 1 MHz. The trace data is recorded using the max hold function.
7. The turntable is rotated in steps of 15°.
8. After a full turn by 360° the antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
9. After the scan all peak values over the limit or with less margin than 10 dB are marked. If critical frequencies recorded during extrapolatory radiated emission tests are not contained, they are added to this list.
10. Emission levels at listed frequencies are maximized by moving the turntable and varying the antenna height until maximum of emission is found.
11. The turntable is rotated by 360 degrees to determine the position of the highest radiation.

12. The height of the broadband receiving antenna is varied between 1 meter and the upper height above ground to find the maximum emission field strength of both horizontal and vertical polarization. For equipment that is tested in multiple orientations, the upper height is limited to 2.5 meters or 0.5 meters above the top of the EUT, whichever is higher. For all other equipment the upper height is 4 meters.
13. The highest value for each frequency is recorded.

6 Test results

This clause gives details about the test results as collected in the summary of test results on page 6.

6.1 Field strength of fundamental wave

47 CFR part and section:	15.231(b)
Equivalent to IC radio standard(s)	RSS-210, A1.2 a
Measurement procedure:	See 5.3

Performed by:	Alexander Grill	Date of test:	October 25, 2017
Result	☒ Test passed	☐ Test not passed	

6.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open Area Test Site (OATS)	---	EMV **TESTHAUS**	E00354
☒	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☐	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☐	Preamplifier	ALS05749	MIWEKO	W01007
☐	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Measurement software	E10	ib comPLAN	E00443
☒	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.1.2 Limit according to 15.231(b)

Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
40.66 – 40.70	2250	67	3
70 – 130	1250	62	3
130 – 174	1250 to 3750*	62 to 71.4*	3
174 – 260	3750	71.4	3
260 – 470	3750 to 12500*	71.4 to 81.9*	3
Above 470	12500	81.9	3

*Linear interpolation

6.1.3 Test Result – Max power

f [MHz]	Level PK [dBµV/m]	Limit PK [dBµV/m]	Margin PK [dB]	Duty cycle factor [dB]	Level AV [dBµV/m]	Limit AV [dBµV/m]	Margin AV [dB]
433.210500	97.41	100.8	3.39	-20.0	77.41	80.8	3.39
434.635500	97.35	100.8	3.45	-20.0	77.35	80.8	3.45

6.1.4 Test Result – SDS

f [MHz]	Level PK [dBµV/m]	Limit PK [dBµV/m]	Margin PK [dB]	Duty cycle factor [dB]	Level AV [dBµV/m]	Limit AV [dBµV/m]	Margin AV [dB]
433.2105	87.90	100.8	12.90	-11	76.90	80.8	3.90
434.6355	87.06	100.8	13.74	-11	76.06	80.8	4.74

6.2 Spurious radiated emissions 9 kHz to 10th harmonic

47 CFR part and section:	15.231(b)
Equivalent to IC radio standard(s)	RSS-210, A1.2 b
Measurement procedure:	See 5.3

Performed by:	Alexander Grill	Date of test:	October 25, 2017
Result	☒ Test passed	☐ Test not passed	

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open Area Test Site (OATS)	---	EMV **TESTHAUS**	E00354
☒	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☐	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☒	Preamplifier	ALS05749	MIWEKO	W01007
☒	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Measurement software	E10	ib comPLAN	E00443
☒	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.2.2 Limits < 1 GHz

Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
0.009 – 0.490	266.6 – 4.9	48.5 – 13.8	300
0.490 – 1.705	48.98 – 14.08	33.8 – 22.97	30
1.705 – 30.0	30	29.54	30
30 – 88	100	40	3
88 – 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

$d_{near\ field}$ = 47.77 / f_{MHz}, or

f_{MHz} = 47.77 / $d_{near\ field}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.

6.2.3 Limits > 1 GHz

< 54 dBµV/m (average detector) inside restricted bands
< 74 dBµV/m (peak detector) inside restricted bands

6.2.4 Test results from 9 kHz to 30 MHz – Max power

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ parallel	☐ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
9 kHz – 90 kHz	100 Hz	200 Hz	PK	AV	100 ms	2 s	20 dB
90 kHz – 110 kHz	100 Hz	200 Hz	PK	QPK	100 ms	2 s	20 dB
110 kHz – 150 kHz	100 Hz	200 Hz	PK	AV	100 ms	2 s	20 dB
150 kHz – 490 kHz	4.5 kHz	9 kHz	PK	AV	100 ms	2 s	20 dB
490 kHz – 30 MHz	4.5 kHz	9 kHz	PK	QPK	100 ms	2 s	20 dB

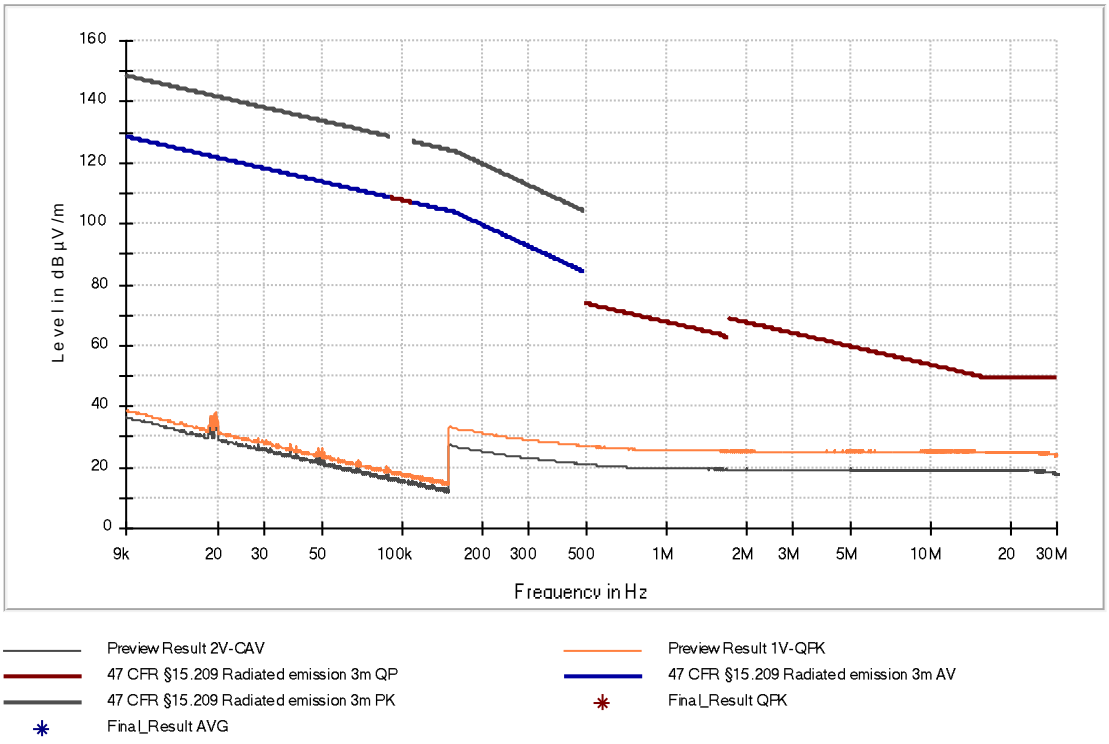

Figure 4: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel 1

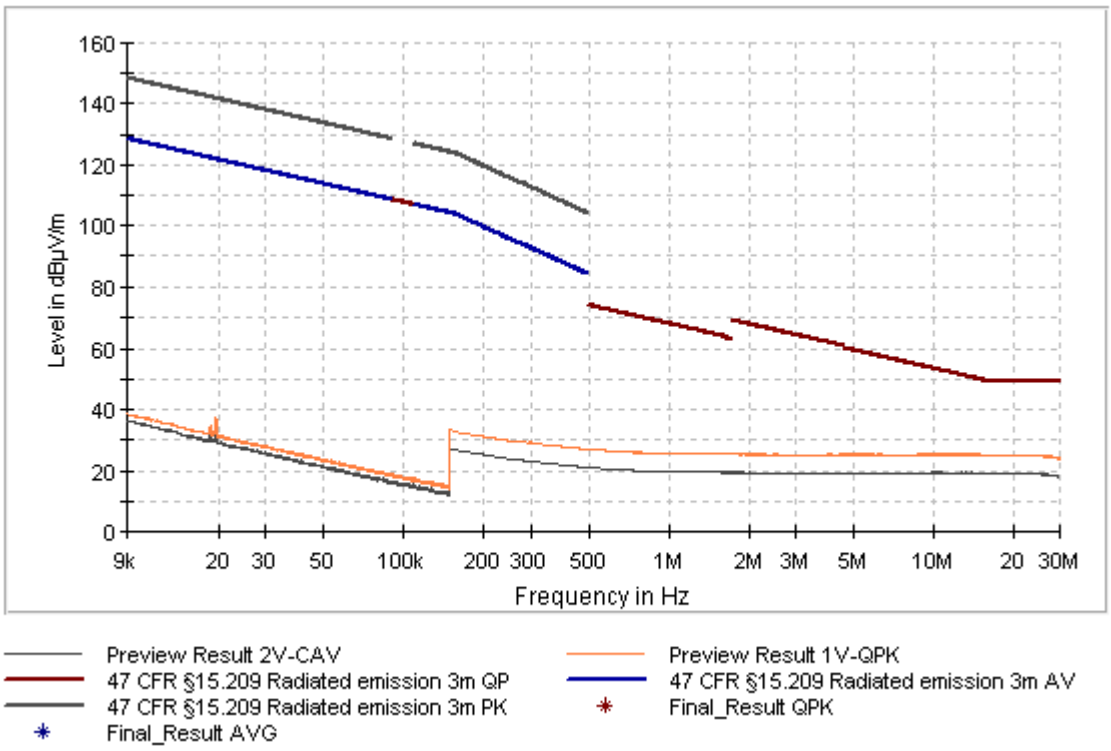

Figure 5: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel 2

Note: The level in the measurements above is the noise level. No emission could be detected.

6.2.5 Test results from 30 MHz to 1 GHz – Max power

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
30 MHz – 1 GHz	50 kHz	120 kHz	PK	PK	Coupled	1 s	20 dB

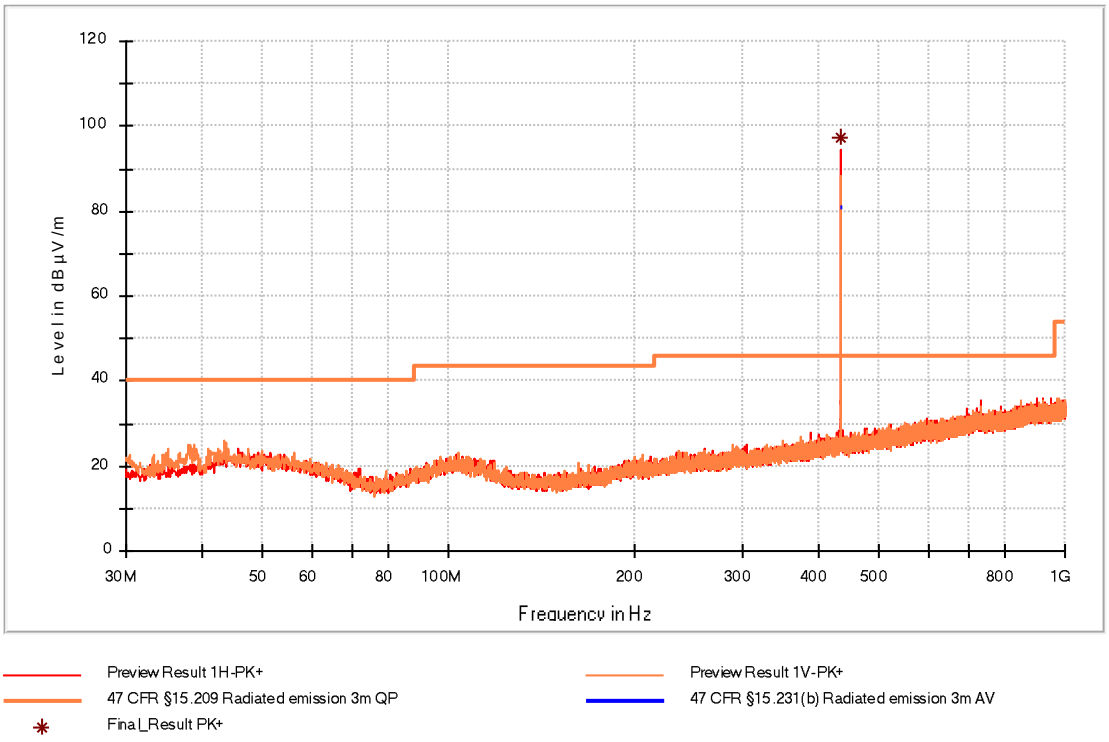

Figure 6: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 1 – Max power

Note: The level in the measurements above is the noise level. No emission, except the fundamental wave, could be detected.

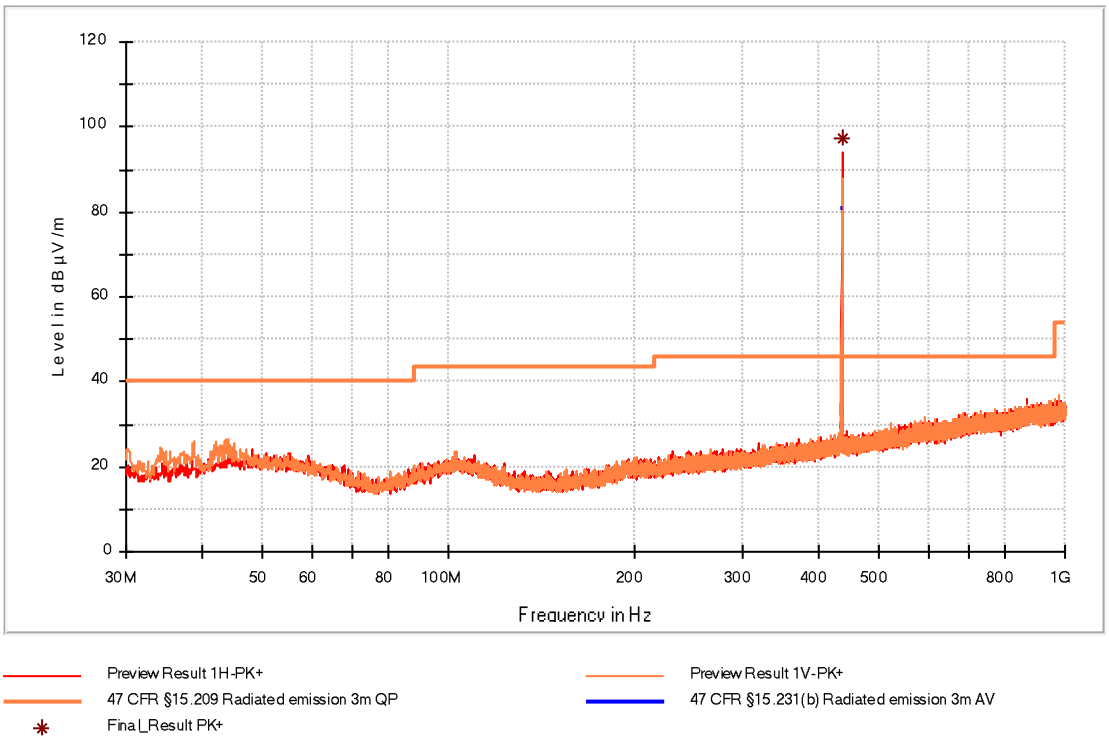

Figure 7: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 2 – Max power

Note: The level in the measurements above is the noise level. No emission, except the fundamental wave, could be detected.

6.2.6 Test results from 30 MHz to 1 GHz – SDS

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
30 MHz – 1 GHz	50 kHz	120 kHz	PK	PK	Coupled	1 s	20 dB

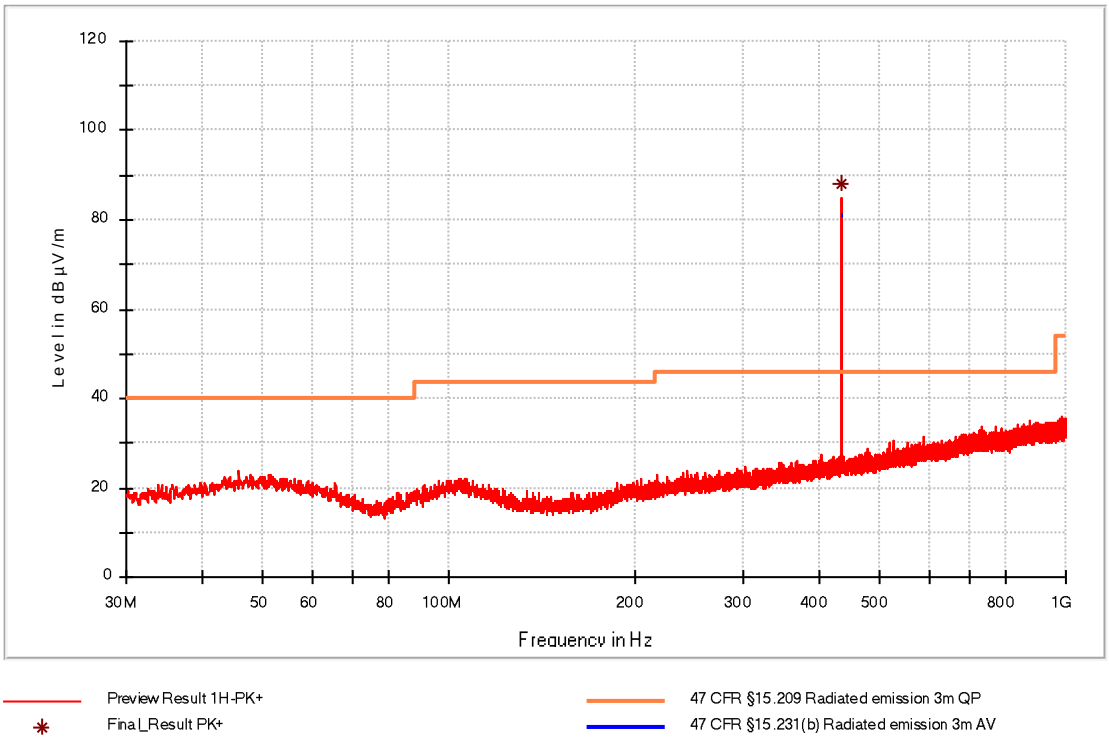

Figure 8: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 1 - SDS

Note: The level in the measurements above is the noise level. No emission, except the fundamental wave, could be detected.

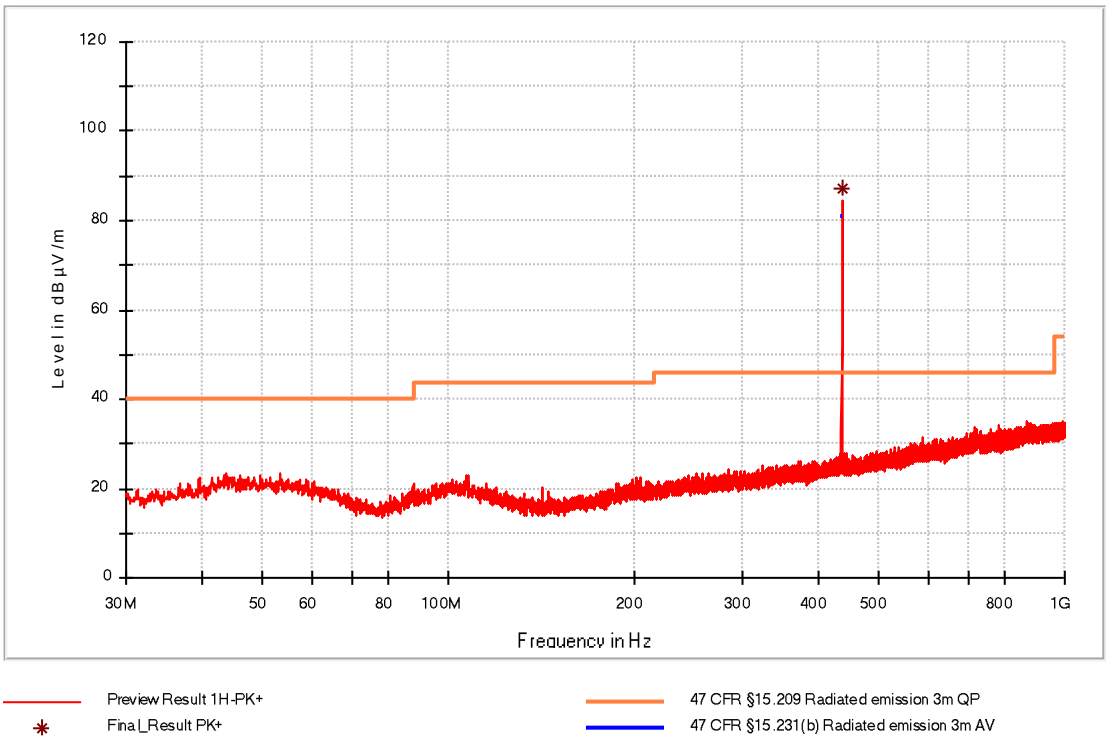

Figure 9: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 2 – SDS

Note: The level in the measurements above is the noise level. No emission, except the fundamental wave, could be detected.

6.2.7 Test results from 1 GHz to 10th harmonic – Max power

Test distance:	Prescan:	☐ 1 m	☒ 3 m	☐ ….. m
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
1 GHz – 5 GHz	250 kHz	1 MHz	PK	PK	50 ms	1000 ms	30 dB
1 GHz – 5 GHz	250 kHz	1 MHz	AV	AV	50 ms	1000 ms	30 dB

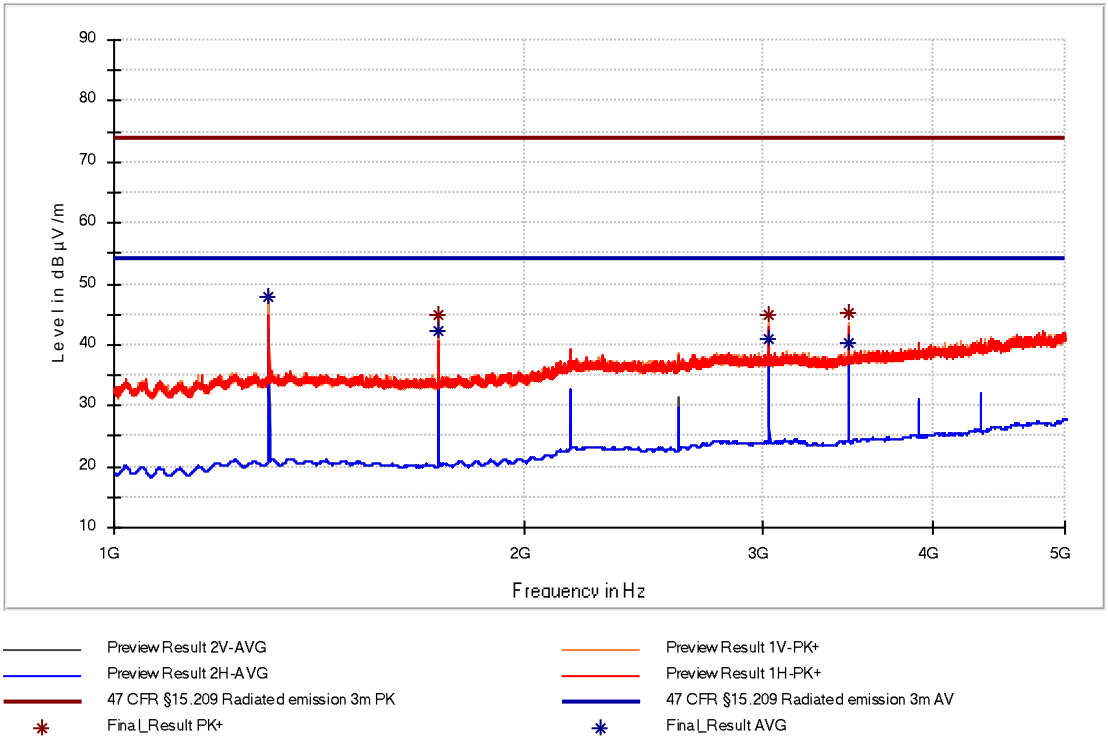

Figure 10: Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 1 – Max power

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1299.500000	---	47.83	54.00	6.17	1000.0	1000.000	100.0	V	335.0
1732.750000	---	42.40	54.00	11.60	1000.0	1000.000	191.0	V	328.0
1732.750000	44.80	---	74.00	29.20	1000.0	1000.000	191.0	V	328.0
3032.500000	---	40.96	54.00	13.04	1000.0	1000.000	391.0	V	340.0
3032.500000	44.97	---	74.00	29.03	1000.0	1000.000	391.0	V	340.0
3465.500000	---	40.21	54.00	13.79	1000.0	1000.000	394.0	V	336.0
3465.500000	45.24	---	74.00	28.76	1000.0	1000.000	394.0	V	336.0

Table 3: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel 1 – Max power

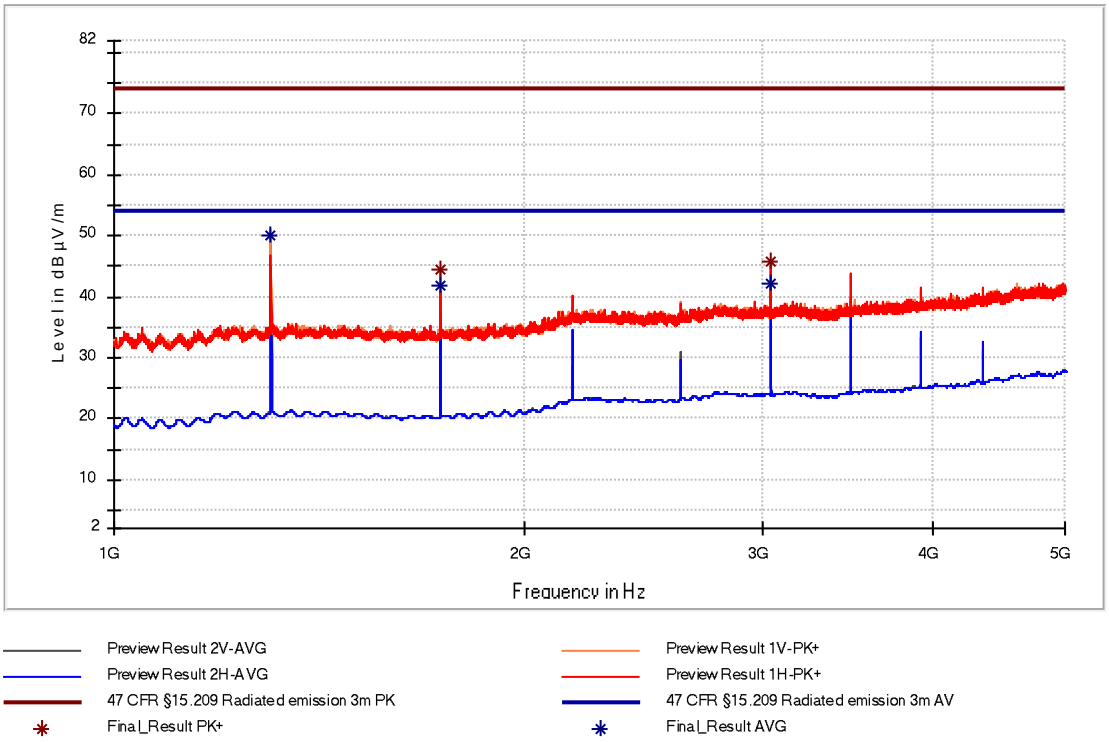

Figure 11: Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 2 – Max power

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1304.000000	---	50.18	54.00	3.82	1000.0	1000.000	100.0	V	335.0
1738.500000	44.40	---	74.00	29.60	1000.0	1000.000	192.0	V	329.0
1738.500000	---	41.75	54.00	12.25	1000.0	1000.000	192.0	V	329.0
3042.500000	45.86	---	74.00	28.14	1000.0	1000.000	316.0	V	0.0
3042.500000	---	42.30	54.00	11.70	1000.0	1000.000	316.0	V	0.0

Table 4: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel 2 – Max power

6.3 Correction for pulse operation (duty cycle)

47 CFR part and section:	15.231(b)2
Equivalent to IC radio standard(s)	---
Measurement procedure:	See 5.2

Performed by:	Alexander Grill	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012

6.3.2 Applicable standard

According to FCC Part 15C, Section 15.35(c):
The emissions from intentional radiators shall not exceed the effective field strength limits.

6.3.3 Description of measurement

The duty cycle is measured using stimulus signal from a car key as used in real application.
The duty cycle factor (dB) is calculated applying the following formula:

$$KE = 20\lg\frac{tiB * p}{\mathrm{Tw}}$$

K_E	pulse operation correction factor	(dB)
t_{iw}	pulse duration for one complete pulse track	(ms)
t_{ib}	pulse duration for one pulse	(ms)
T_w	a period of the pulse track	(ms)
P	number of pulses in one train	(ms)

6.3.4 Test results - RKE

$KE = 20\lg\frac{8.7ms}{100\text{ms}}$ =21.2 dB → 20 dB max.

Duty cycle	t_{iw} [ms]	T_w [ms]	t_{iB} [ms]	p	K_E [dB]
Within 100 ms	-	100.00	8.70	1	-20.0

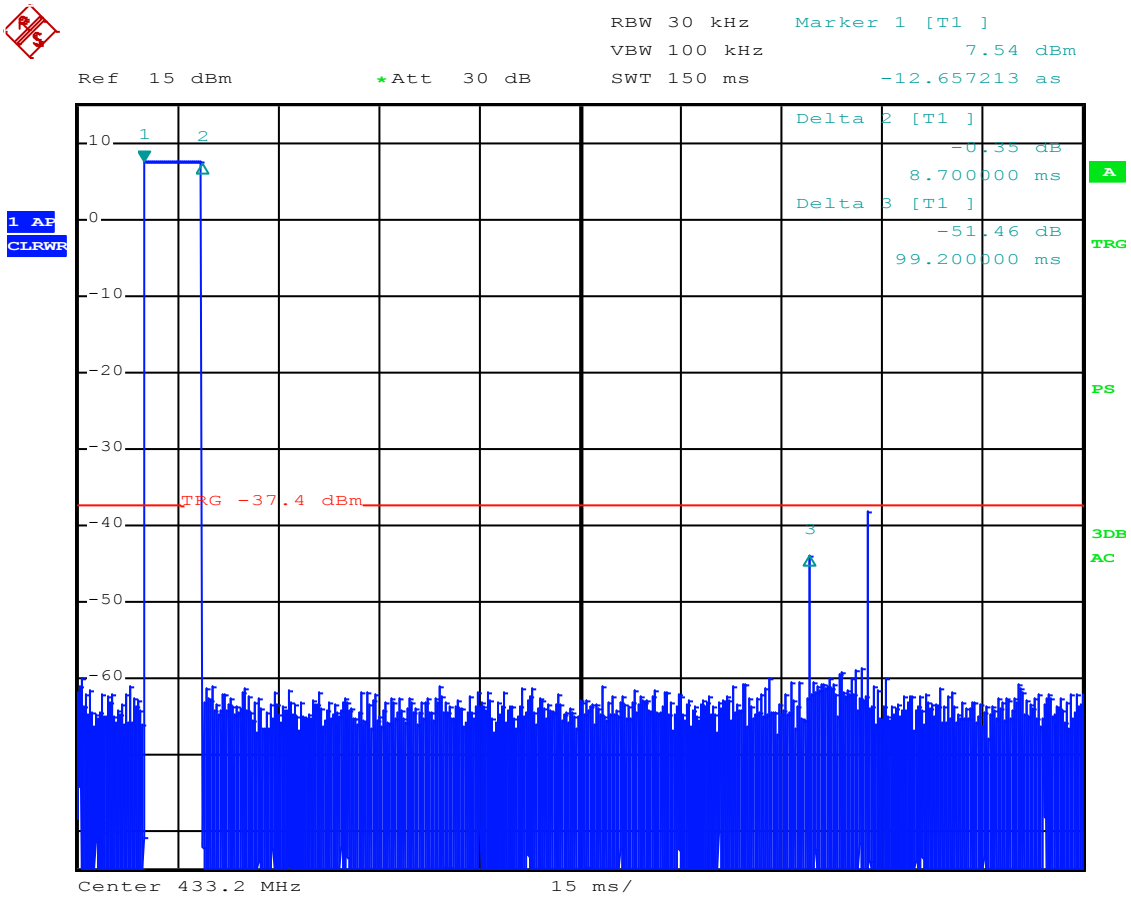

Figure 12: Test protocol correction for pulse operation (duty cycle) – RKE

6.3.6 Test results - CA old procedure

$KE = 20\lg\frac{7.2ms}{100\text{ms}}$ =22.85 dB → 20 dB max.

Duty cycle	t_{iw} [ms]	T_w [ms]	t_{iB} [ms]	p	K_E [dB]
Within 100 ms	-	100.00	7.20	1	-20.0

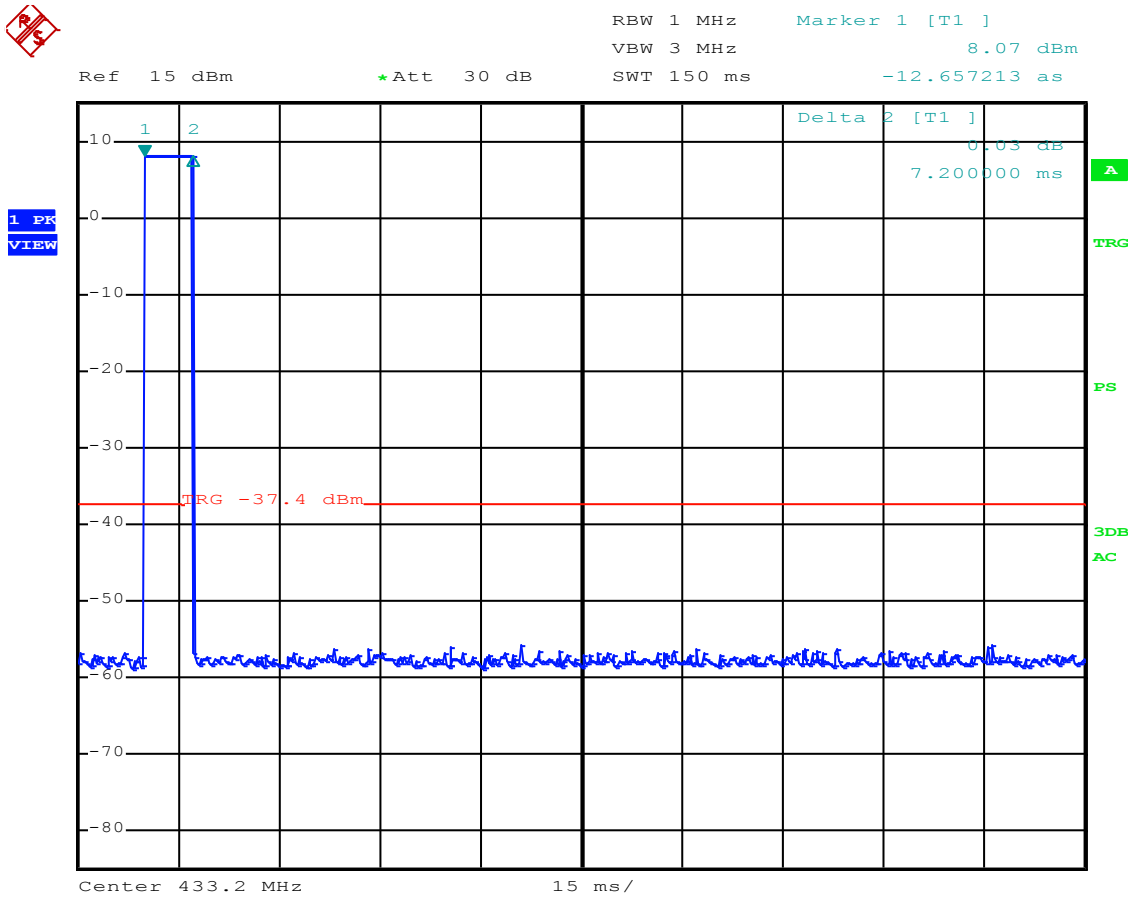

Figure 13: Test protocol correction for pulse operation (duty cycle) – CA old procedure

6.3.7 Test results - SDS

$$KE = 20\lg\frac{28.2ms}{100\text{ms}} = 11 \text{ dB}$$

Duty cycle	T_w [ms]	t_{iB} [ms]	p	K_E [dB]
Within 100 ms	100.00	28.20	1	-11

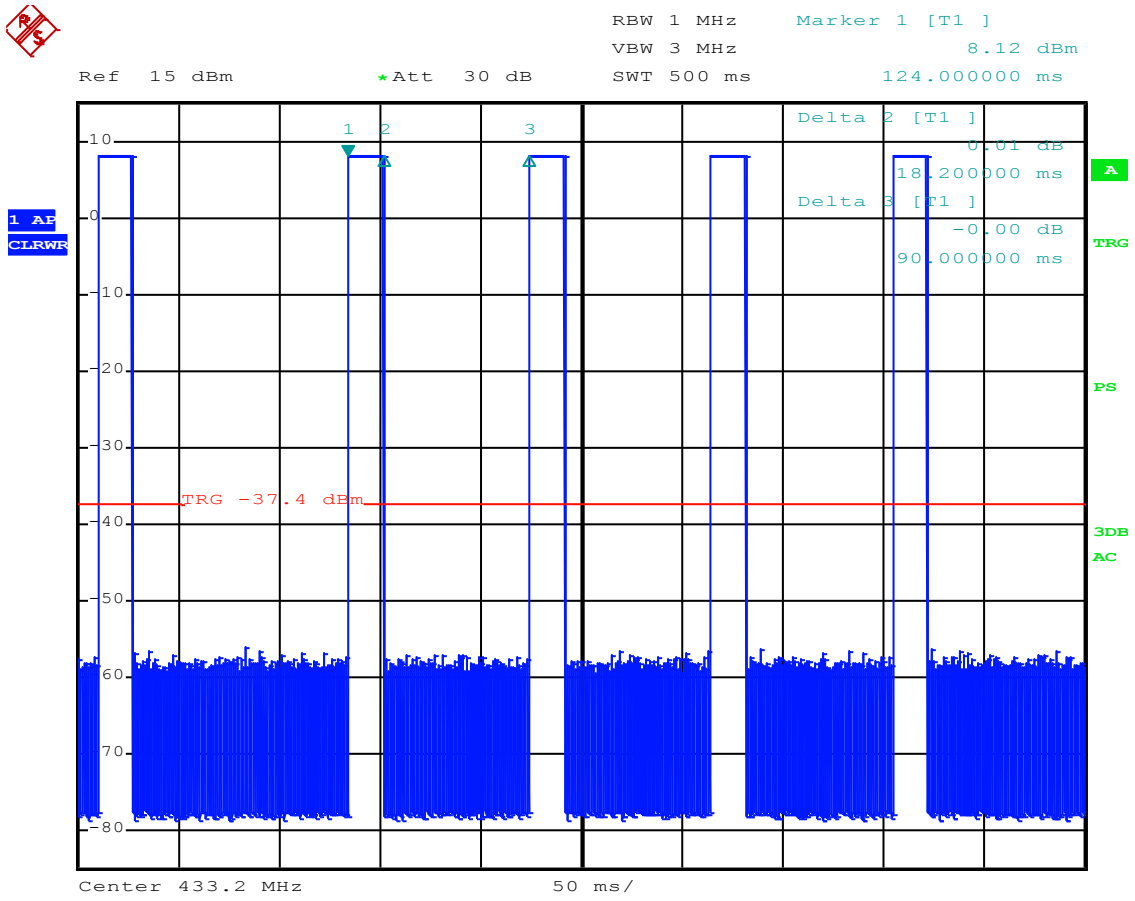

Figure 14: Test protocol correction for pulse operation (duty cycle) – SDS

Remark: A SDS telegram has a length of 18.2 ms. It can be sent each 90 ms. Therefore a maximum transmission time of 28.2 ms during 100 ms is possible.

6.4 20 dB bandwidth

47 CFR part and section: 15.231(c)
Equivalent to IC radio standard(s) ---
Measurement procedure (DTS): See 5.1

Performed by:	Alexander Grill	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.4.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012

6.4.2 Limits according to FCC Part 15C Section 15.231(c):

Frequency [MHz]	**20 dB BW limit dependent of the carrier [%]**
70 – 900	0.25
Above 900	0.50

6.4.3 Test results

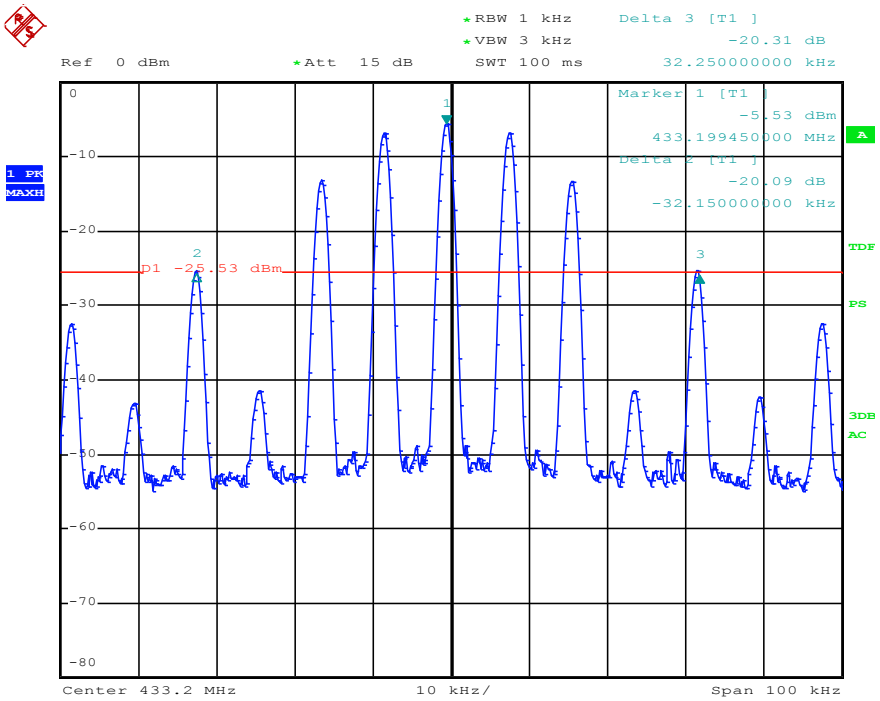

Figure 15: Chart of 20 dB bandwidth test, channel 1

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Limit [MHz]	Result
433.19945	64.40	433.1673	433.2317	1.083	Passed

Table 5: Final results of 20 dB bandwidth test, channel 1

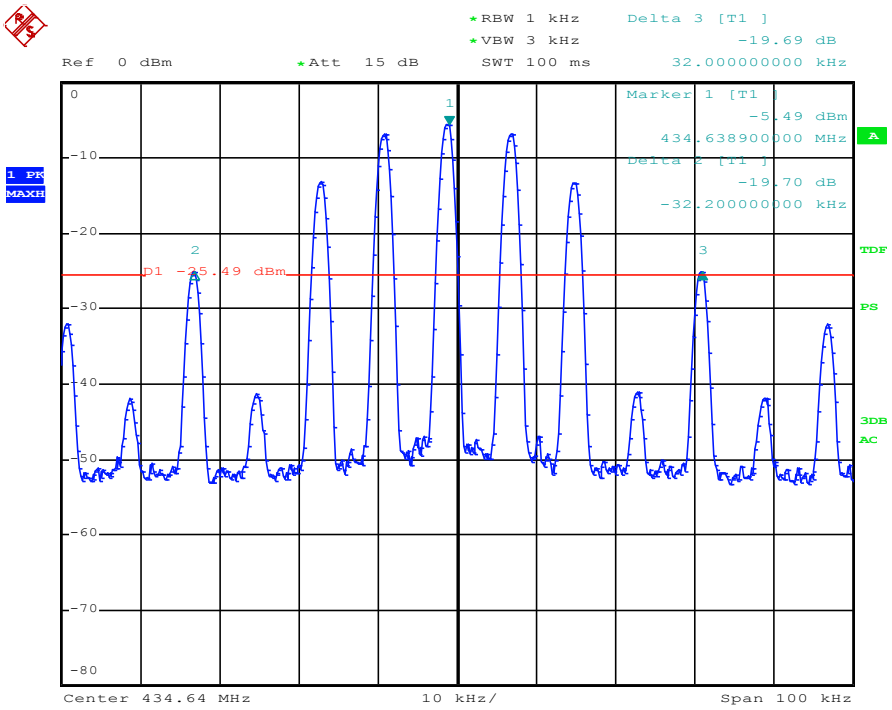

Figure 16: Chart of 20 dB bandwidth test, channel 2

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Limit [MHz]	Result
434.63890	64.20	434.6067	434.6709	1.0866	Passed

Table 6: Final results of 20 dB bandwidth test, channel 2

6.5 Occupied bandwidth

47 CFR part and section: ---

Equivalent to IC radio standard(s) RSS-Gen, 6.7

Measurement procedure: See 5.2

Performed by:	Alexander Grill	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.5.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012

6.5.2 Limits

None -> results recorded for setting the proper reference level.

6.5.3 Test results

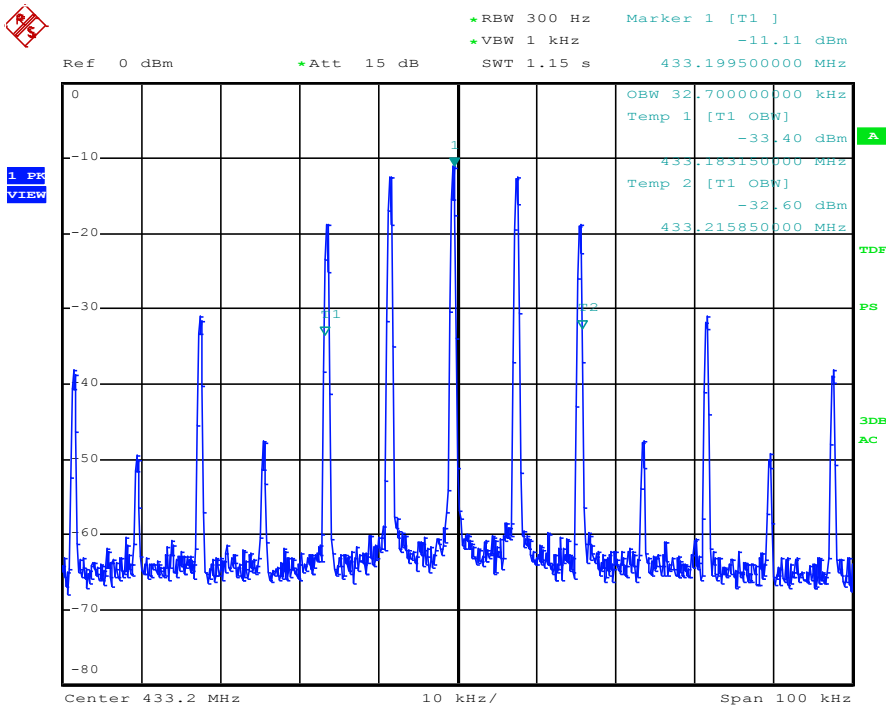

Figure 17: Chart of occupied bandwidth test, channel 1

f [MHz]	Occ. BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Result
433.1995	32.70	433.18315	433.21585	No limit

Table 7: Final results of occupied bandwidth test, channel 1

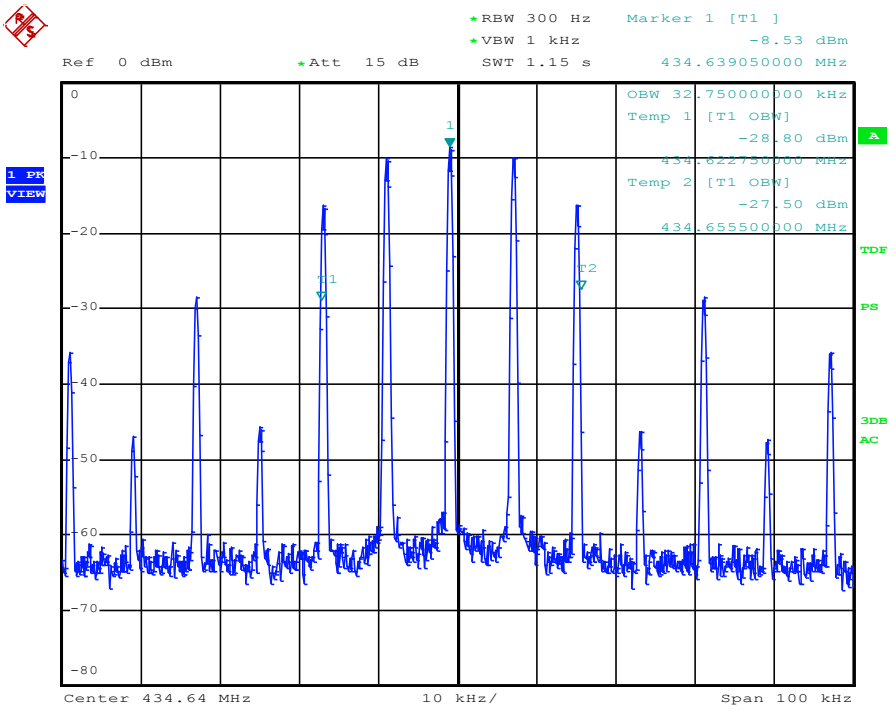

Figure 18: Chart of occupied bandwidth test, channel 2

f [MHz]	Occ. BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Result
434.63905	32.75	434.62275	434.65550	No limit

Table 8: Final results of occupied bandwidth test, channel 2

6.6 Signal deactivation (manually activated)

47 CFR part and section:	15.231(a)(1)
Equivalent to IC radio standard(s)	RSS-210, A1.1.(a)
Measurement procedure:	See 5.2

Performed by:	Alexander Grill	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.6.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012

6.6.2 Applicable standard

According to FCC Part 15C, Section 15.231(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.

6.6.3 Description of measurement

The duration of transmission is measured with the spectrum analyzer. The sweep points were set to maximum for higher time resolution. The signal is modulated; the marker of the analyzer is set to maximum amplitude at normal temperature and zero span. The analyzer is set to single sweep and video triggered, the marker is set to the edges in order to measure the duration time and then recorded.

6.6.4 Test results

Duration of transmission [ms]	Duration after deactivation [ms]
8.70	75 (as stated by manufacturer)

Limit according to FCC Part 15C, Section 12.231(a):
A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released and a transmitter activated automatically shall cease transmission within 5 seconds after activation.

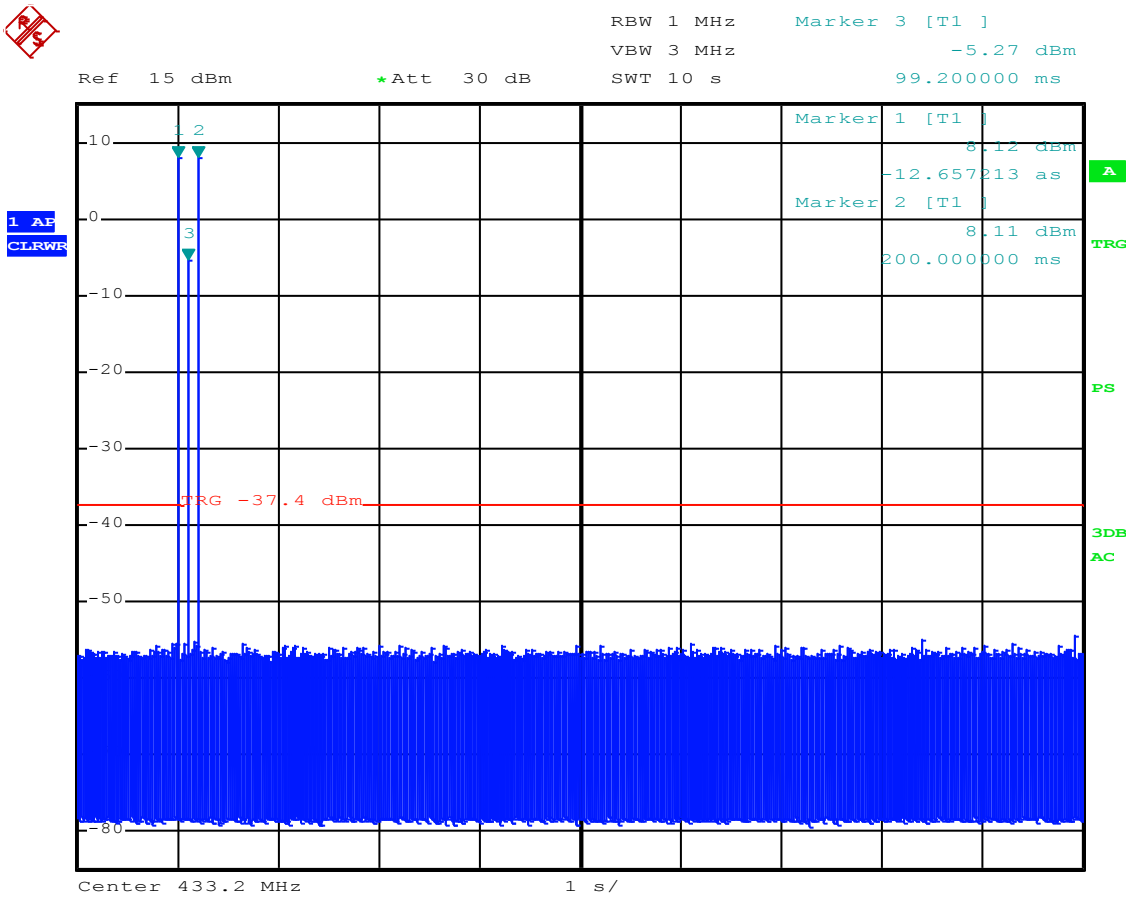

Figure 19: Test protocol of signal deactivation

7 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2018-04	2019-04
EMI test receiver	ESR7	101059	E00739	2018-05	2019-05
EMI test receiver	ESCI 3	100013	E00001	2018-05	2019-05
Preamplifier (1 GHz - 18 GHz)	ALS05749	001	W01007	2018-01	2019-01
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-10	2018-10
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2018-03	2021-03
TRILOG broadband antenna (CDC)	VULB 9163	9163-228	E00012	2016-04	2019-04
Horn antenna	BBHA 9120D	9120D-592	W00052	2017-04	2020-04
Horn antenna	BBHA 9170	9170-332	W00054	2017-04	2020-04
Measuring antenna set	---	---	A00088	N/A[3]	
Shielded room	P92007	B 83117 C 1109 T 211	E00107	N/A	
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69-2-0006	E00026	N/A	
Semi-anechoic chamber (SAC) with floor absorbers	FS-SAC	---	E00100	2018-03	2021-03
Semi-anechoic chamber (SAC)	SAC3	C62128-A520-A643-x-0006	E00716	2018-03	2021-03
Cable set CDC	RG214/U	---	E00446	2018-04	2019-04
	LCF12-50J	---	E01215	2018-04	2019-04
	LMR400	1718020006	E00920	2018-01	2019-01
	RG214 Hiflex	171802007	E00921	2018-01	2019-01
Cable set anechoic chamber	262-0942-1500	005	E00435	2018-10	2019-10
	SF104EA/2x11PC35-42/5m	11144/4EA	E00307	2017-12	2018-12
	262-0942-1500	003	E00433	2018-10	2019-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2017-12	2018-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01033	2017-12	2018-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2018-09	2019-09

Table 9: Equipment calibration status

Note 1: Industry Canada (test sites number 3472A-1 and 3472A-2): 2018-11
Note 2: Expiration date of test firm accreditation for SAC:
FCC test firm type “accredited”: 2019-05
Note 3: Only used for relative measurements.

8 Measurement uncertainties

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	± 4.1 dB	2
Carrier frequency separation Number of hopping frequencies Time of occupancy (dwell time)	± 5.0 %	2
Bandwidth tests	± 2.0 %	2
Maximum conducted output power	± 1.5 dB	2
Power spectral density	± 3.0 dB	2
Spurious RF conducted emissions	± 3.0 dB	2
Radiated emission open field or semi-anechoic chamber 9 kHz to 30 MHz 30 MHz to 300 MHz 300MHz to 1 GHz	 ± 4.8 dB ± 5.4 dB ± 5.9 dB	2
Radiated emission anechoic chamber (> 1000 MHz)	± 4.5 dB	2

Table 10: Measurement uncertainty

The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.

9 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2018-07-17	Alexander Grill	First edition

10 Additional documents

☒ Annex A: Pictures of test setup and EUT-positions
☒ Annex B: Pictures of EUT (external)
☒ Annex C: Pictures of EUT (internal)