Test report

Customer:

Continental Automotive GmbH

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RF test report

180598-AU01+W01

Continental Automotive GmbH

RF Transmitter

FS14T

EMV TESTHAUS

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

EMV **TESTHAUS** GmbH

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Germany
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Accreditation:

Test Firm Type “accredited”: Valid until 2019-06-05
MRA US-EU, FCC designation number: DE0010
BnetzA-CAB-02/21-02/5 Valid until 2023-11-26

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

Location of Testing:

EMV **TESTHAUS** GmbH
Gustav-Hertz-Straße 35
94315 Straubing
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, 8.8	---	Not applicable	---
15.231(b)	Field strength of the fundamental wave	RSS-210, A1.2 a	15	Passed	---
15.231(b)	Spurious emissions (magnetic field) 9 kHz – 30 MHz	RSS-210, A1.2 b	17	Passed	---
15.231(b)	Spurious emissions radiated (electrical field) 30 MHz – 10th harmonic	RSS-210, A1.2 b	17	Passed	---
15.231(b)2	Correction for pulse operation (duty cycle)	RSS-Gen 8.2	26	Passed	---
15.231(a)	Signal deactivation	RSS-210, A1.1.(a)	36	Passed	---
15.231(c)	20 dB bandwidth	RSS-Gen, 6.7	30	Passed	---
	Occupied bandwidth (99 %)	RSS-Gen, 6.7	33	Passed	---

Straubing, December 6, 2018

Jennifer Riedel
Test engineer
EMV **TESTHAUS** GmbH

Konrad Graßl
Head of radio department
EMV **TESTHAUS** GmbH

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
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*
Annex A 1.3	*Bandwidth of Momentary Signals*
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:	RF Transmitter	
Model name:	FS14T	
Variants:	The EUT is available in two variants: plastic caps (FS14TK) and chrome caps (FS14T) (see Annex B)	
Serial number(s):	Prototype	
Applicant:	Continental Automotive GmbH	
Manufacturer:	Continental Automotive GmbH	
Version:	Hardware: Software:	n/a n/a
Additional modifications:	None	
Short description:	The EUTs are transmitter designed to provide remote keyless entry, passive entry, passive engine start and immobilization functionality.	
FCC ID:	KR5FS14T	
IC registration number:	7812D-FS14T	
Frequency range:	Above 70 MHz	
Operating frequencies:	315 MHz	
Channel spacing:	not specified	
Number of RF channels:	1	
System type:	Remote control	
Modulation type(s):	ASK	
Antenna type(s):	PCB antenna	
Antenna gain(s):	-23 dBd	
Power supply:	Leclanché or lithium battery supply	
	Nominal voltage: Minimum voltage: Maximum voltage:	3.0 V 2.2 V 3.3 V
Temperature range:	-20 °C to +60 °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			
RF Transmitter with test mode with chrome caps	FS14T,version FS14T	Prototype	Continental Automotive GmbH
RF Transmitter with application mode with chrome caps	FS14T, version FS14T	Prototype	Continental Automotive GmbH
RF Transmitter with test mode with plastic caps	FS14T, version FS14TK	Prototype	Continental Automotive GmbH
RF Transmitter with application mode with plastic caps	FS14T, version FS14TK	Prototype	Continental Automotive GmbH

Table 1: Devices used for testing

4.2 Mode of operation

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

Test mode/ EUT	*Behavior*
Prototype sample, FS14T, version FS14T with test mode	Modulated carrier wave on 315 MHZ
Prototype sample, FS14T, version FS14T with application mode	Modulated carrier wave on 315 MHZ
Prototype sample, FS14T, version FS14TK with test mode	Modulated carrier wave on 315 MHZ
Prototype sample, FS14T, version FS14TK with application mode	Modulated carrier wave on 315 MHz

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

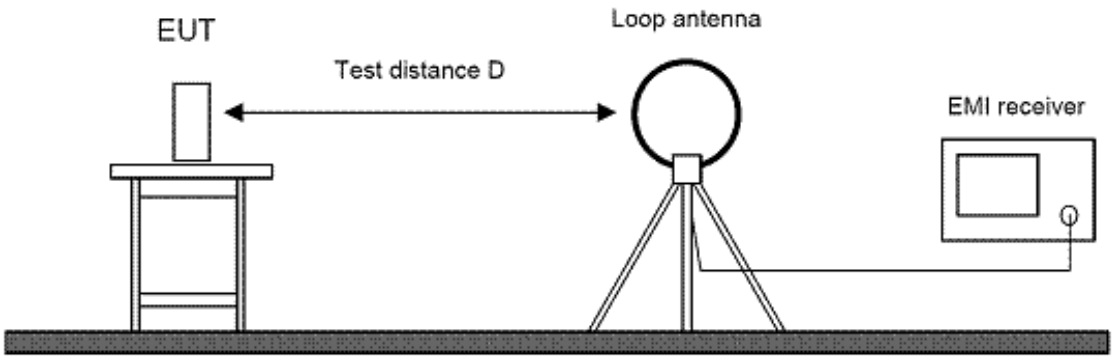


Figure 1: Setup for radiated emission test below 30 MHz

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB/m)	Level (dBµV/m)
10	20.00	19.59	0.33	19.92	39.92

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 20 dBµV + 19.92 dB/m = 39.92 dBµV/m

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

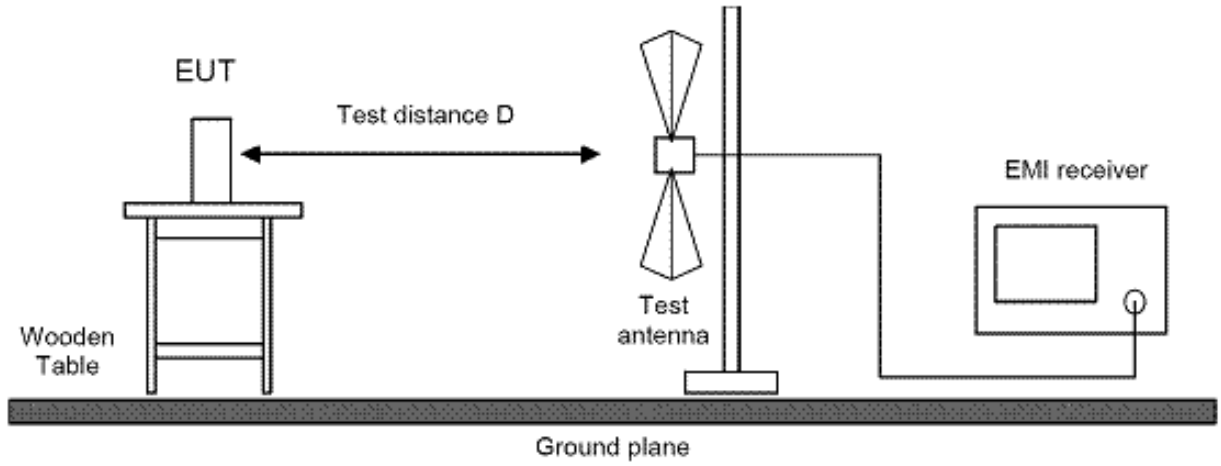


Figure 2: Setup for radiated emission test from 30 MHz to 1 GHz

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB/m)	Level (dBµV/m)
100	30.00	11.71	1.06	12.77	42.77

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 30 dBµV + 12.77 dB/m = 42.77 dBµV/m

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

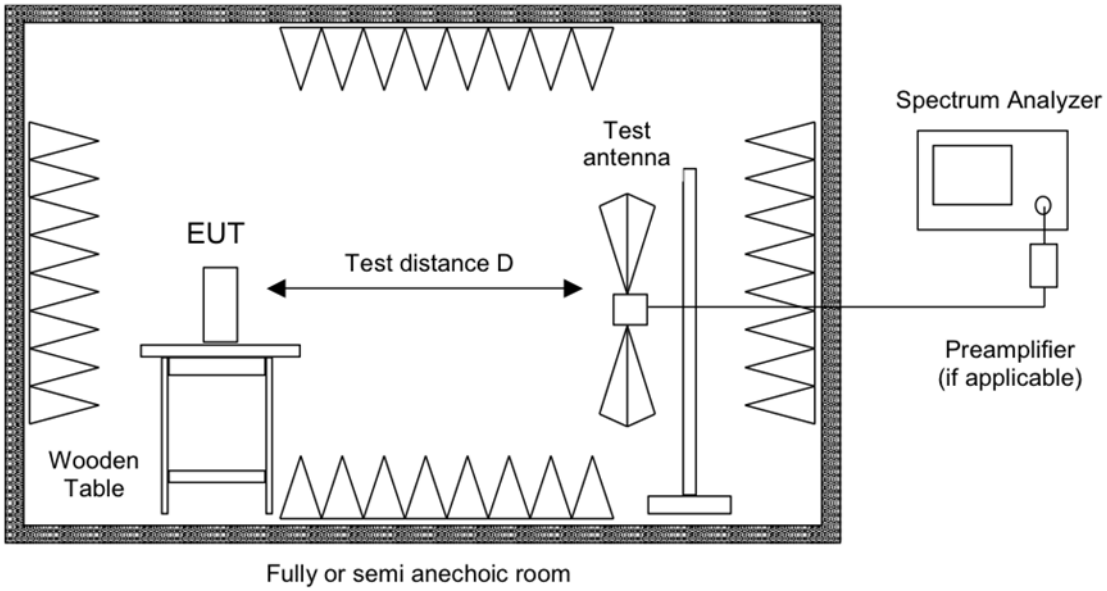


Figure 3: Setup for radiated emission test above 1 GHz

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Correction pre-amplifier (dB)	Cable attenuation (dB)	Correction factor (Corr.) (dB/m)	Level (dBµV/m)
2400	50.00	27.76	-47.91	5.24	-14.92	35.08

Correction factor = Antenna correction + Correction pre-amplifier + Cable attenuation

Level = Reading value + Correction factor = 50.00 dBµV - 14.92 dB/m = 35.08 dBµV/m

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 10^{th} 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:	Jennifer Riedel	Date of test:	October 18, 2018
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

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]
314.9860	81.31	95.6	14.29	-6.30	75.01	75.6	0.59

Table 2: Test result of field strength of fundamental wave of FS14T

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:	Jennifer Riedel	Date of test:	October 16 to October 18, 2018
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

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

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

Note: In this test report only the charts of the worst case positions are shown. These are found through premeasurements.

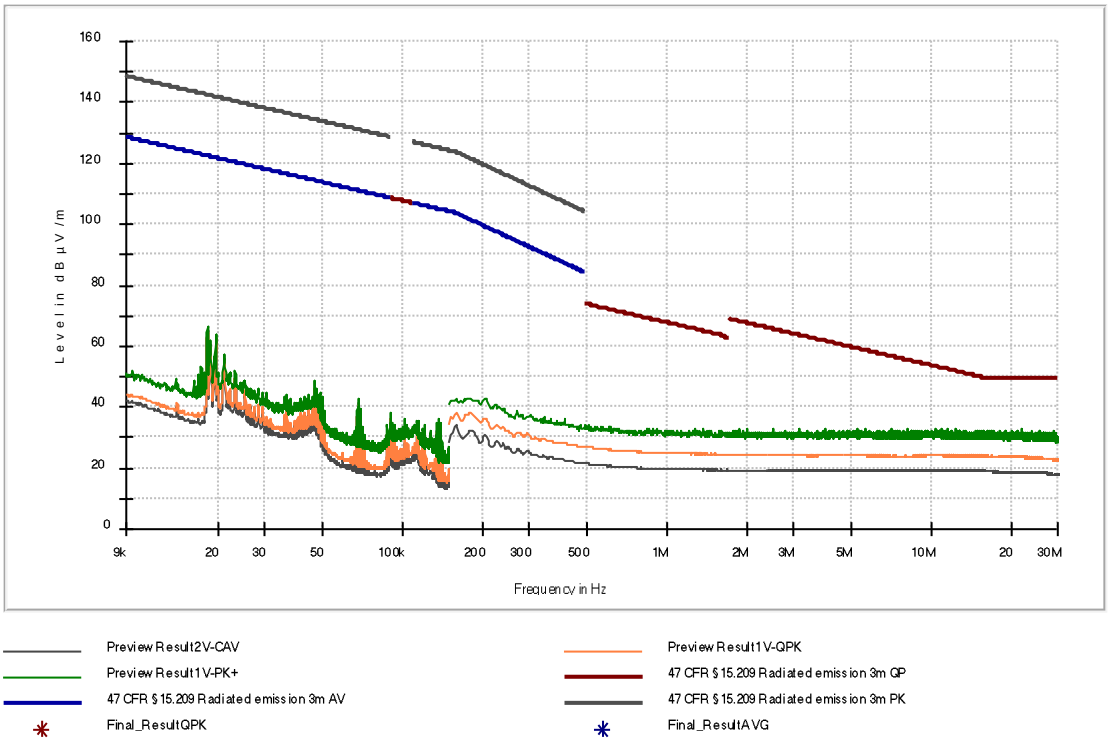


Figure 4: Chart of spurious radiated emission test 9 kHz - 30 MHz of FS14T, version FS14T

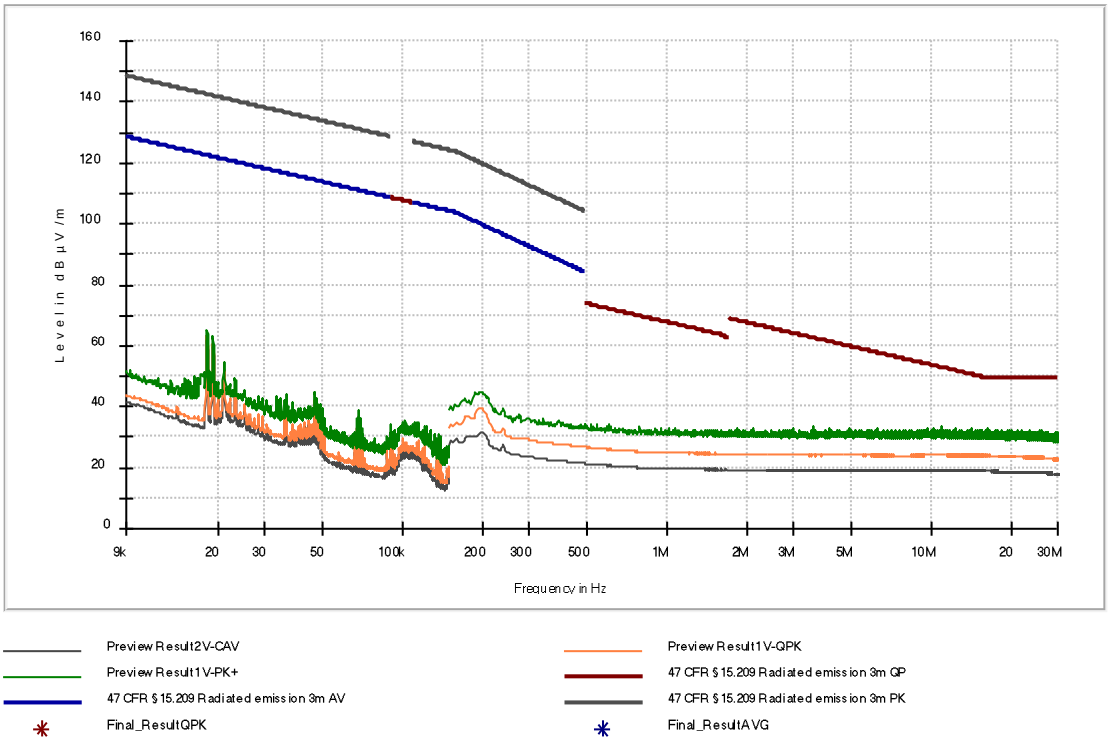


Figure 5: Chart of spurious radiated emission test 9 kHz - 30 MHz of FS14T, version FS14TK

6.2.5 Test results from 30 MHz to 1 GHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☒ Position X	☒ Position Y	☒ Position Z	

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

Note: In this test report only the charts of the worst case positions are shown. These are found through premeasurements

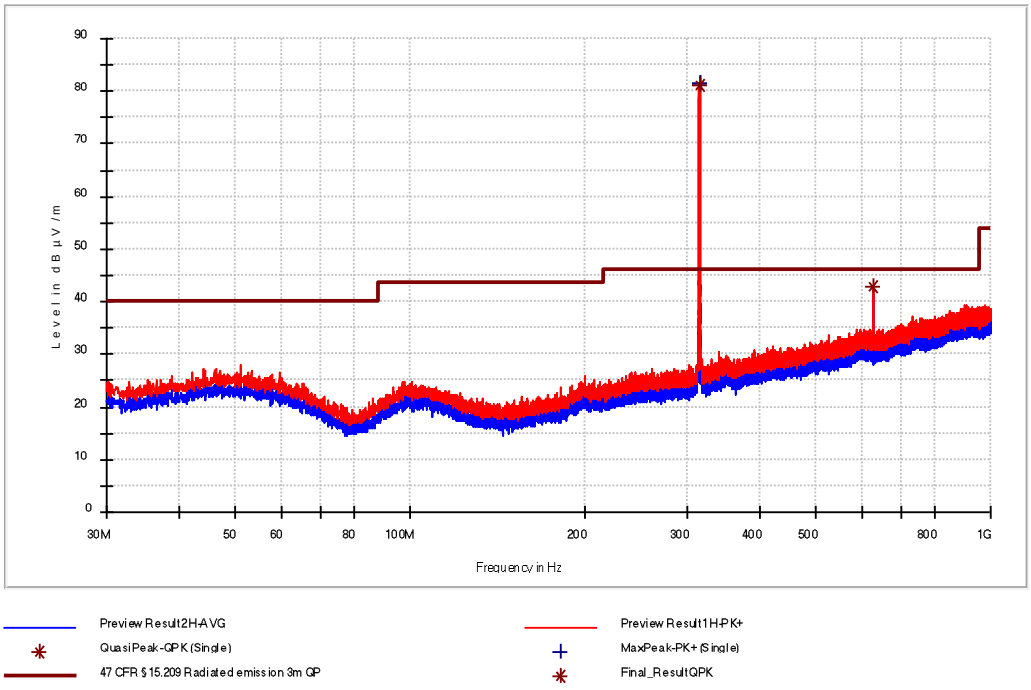


Figure 6: Chart of spurious radiated emission test 30 MHz - 1 GHz of FS14T, version FS14T in position X

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
314.986000	81.31	46.00	-35.31	1000.0	120.000	100.0	H	268.0
629.993500	43.03	46.00	2.97	1000.0	120.000	128.0	H	292.0

Table 3: Final result of spurious radiated emission test 30 MHz to 1 GHz of FS14T, version FS14T in position X

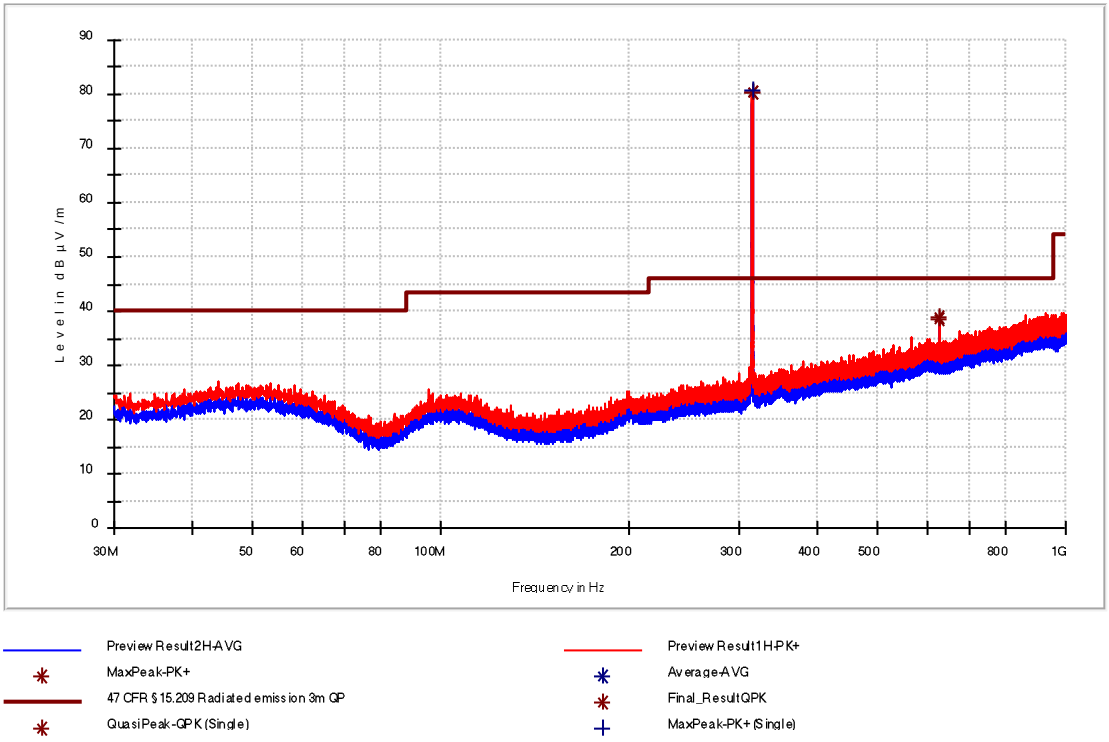


Figure 7: Chart of spurious radiated emission test 30 MHz - 1 GHz of FS14T, version FS14TK in position X

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
314.986000	80.55	46.00	-34.55	1000.0	120.000	100.0	H	264.0
629.993500	38.96	46.00	7.04	1000.0	120.000	128.0	H	288.0

Table 4: Final result of spurious radiated emission test 30 MHz to 1 GHz of FS14T, version FS14TK in position X

6.2.7 Test results from 1 GHz to 10th harmonic

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

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

Note: In this test report only the charts of the worst case positions are shown. These are found through premeasurements.

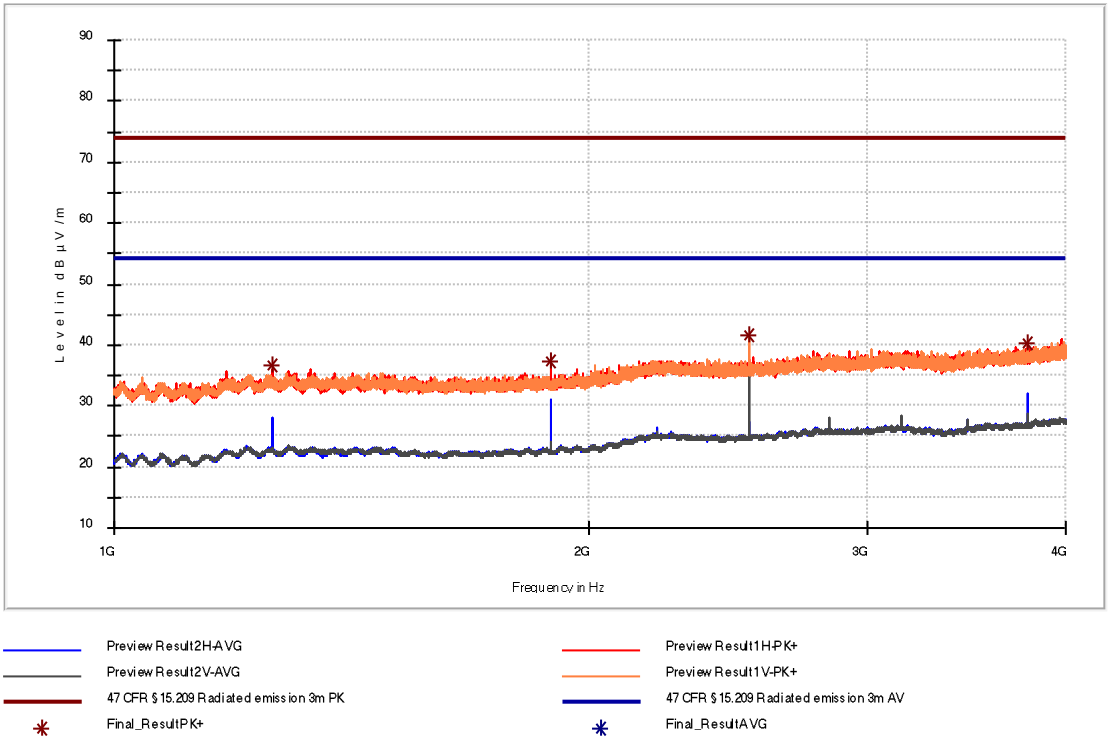


Figure 8: Chart of spurious radiated emission final test 1 GHz to 10th harmonic of FS14T, version FS14T in position X

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1259.95100	36.76	---	74.00	37.24	100.0	1000.000	267.0	H	105.0
1889.91600	37.35	---	74.00	36.65	100.0	1000.000	100.0	H	96.0
2519.91200	41.57	---	74.00	32.43	100.0	1000.000	213.0	V	183.0
3779.85400	40.24	---	74.00	33.76	100.0	1000.000	141.0	H	267.0

Table 5: Final result of spurious radiated emission test 1 GHz to 10th harmonic of FS14T, version FS14T in position X

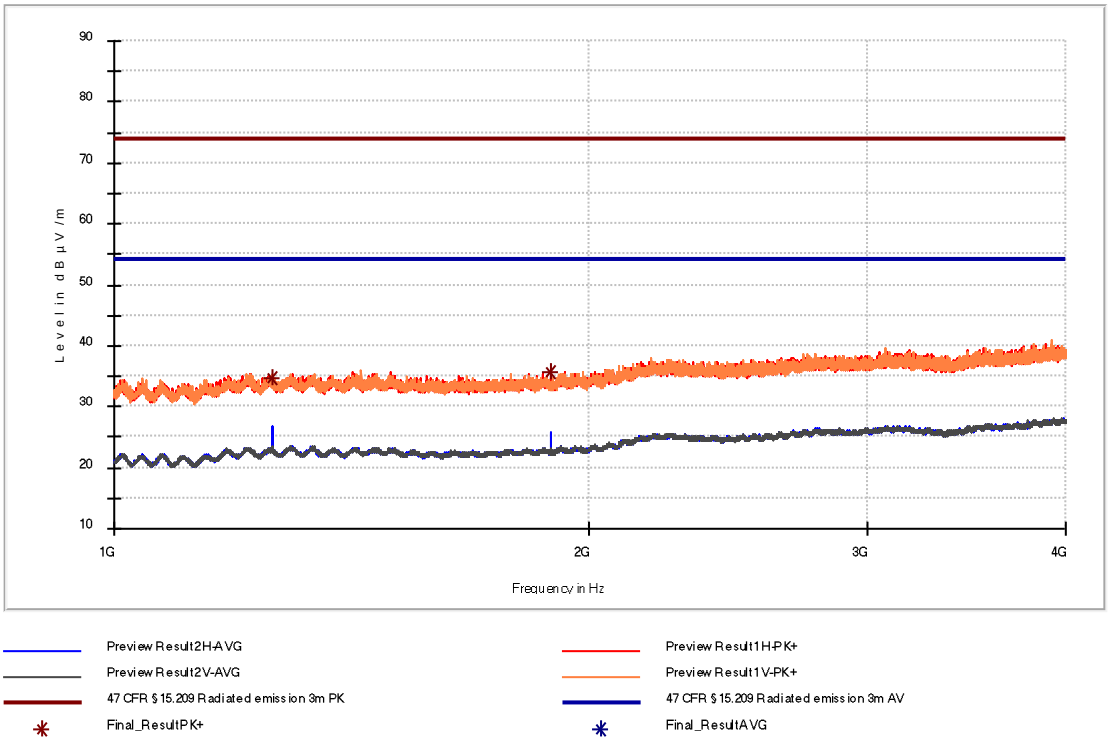


Figure 9: Chart of spurious radiated emission final test 1 GHz to 10th harmonic of FS14T, version FS14TK in position Z

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1259.946000	34.74	---	74.00	39.26	100.0	1000.000	258.0	H	340.0
1889.935000	35.65	---	74.00	38.35	100.0	1000.000	233.0	H	345.0

Table 6: Final result of spurious radiated emission test 1 GHz to 10th harmonic of FS14T, version FS14TK in position Z

6.3 Correction for pulse operation (duty cycle)

47 CFR part and section:	15.231(b)2
Equivalent to IC radio standard(s)	RSS-Gen 8.2
Measurement procedure:	See 5.2

Performed by:	Jennifer Riedel	Date of test:	December 4, 2018
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	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Measuring antenna set	---	---	A00088

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.

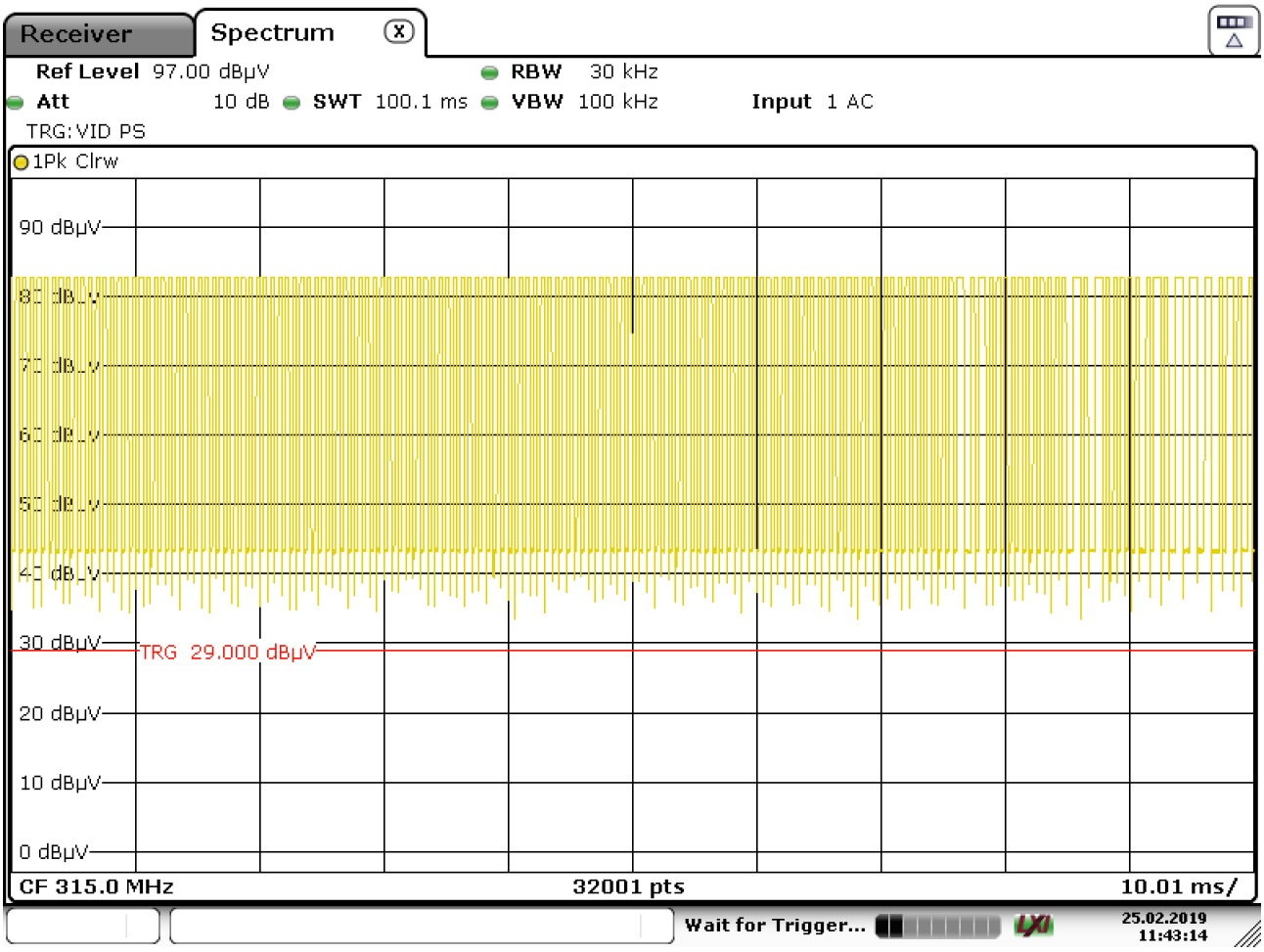
6.3.3 Description of measurement

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)

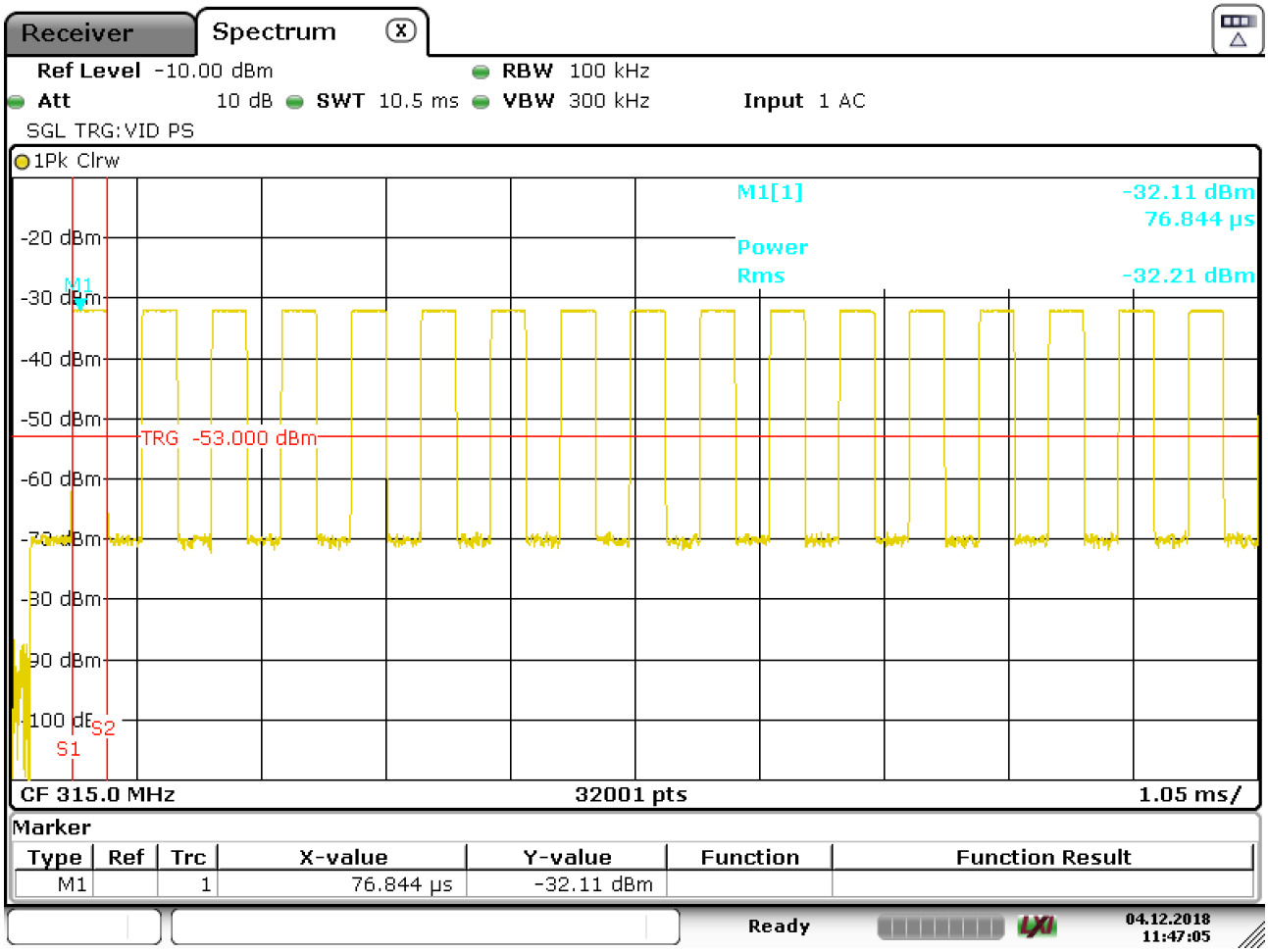
6.3.4 Test results



Date: 25.FEB.2019 11:43:15

Figure 10: Test protocol correction for pulse operation (duty cycle) on 315 MHz in 100 ms (Trigger-offset -0.1 ms)

As shown in Figure 10, there are many bursts in 100 ms. To see the bursts and breaks the sweep time was reduced to 10 ms (Figure 11).



Date: 4.DEC.2018 11:47:05

Figure 11: Detailed view of signal in 10 ms (Trigger-offset -0.5 ms)

In 10 ms there are 17 bursts. For calculating the Duty Cycle correction factor the duration of one pulse is needed (Figure 12).

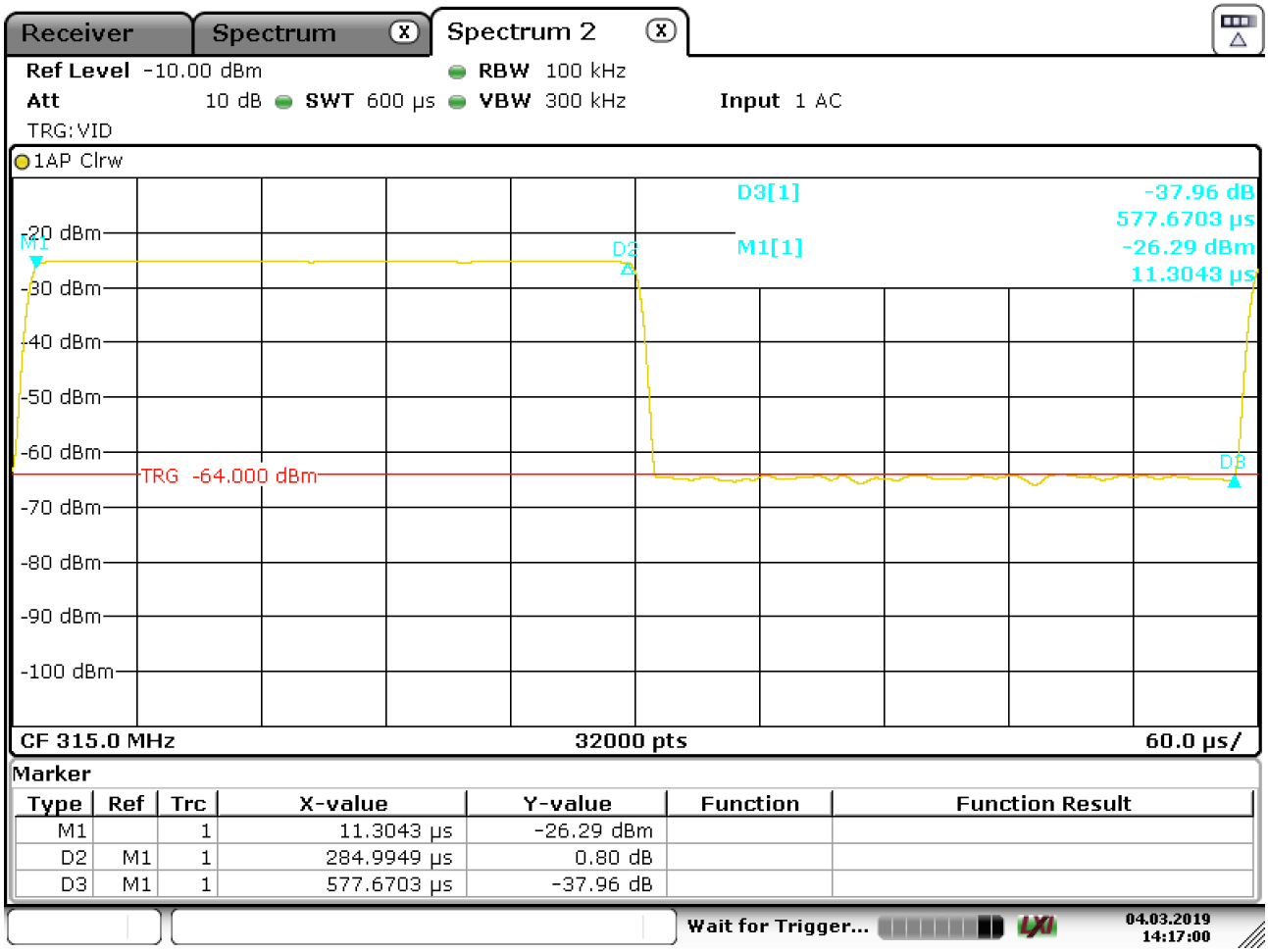


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Figure 12: Detailed view of one burst and one break in 600 µs

The duration of one burst is 285 µs.

Duty Cycle correction factor = $20 \cdot \log \frac{((amount\ of\ bursts) \cdot (duration\ of\ one\ burst))}{10\ ms}$

= $20 \cdot \log \frac{(17 \cdot 0.285\ ms)}{10\ ms}$ = -6.30 → Duty Cycle correction factor: **6.30 dB**

6.4 20 dB bandwidth

47 CFR part and section:	15.231(c)
Equivalent to IC radio standard(s)	RSS-Gen, 6.7
Measurement procedure (DTS):	See 5.1

Performed by:	Jennifer Riedel	Date of test:	October 4, 2018
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
☒	Measuring antenna set	---	---	A00088

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

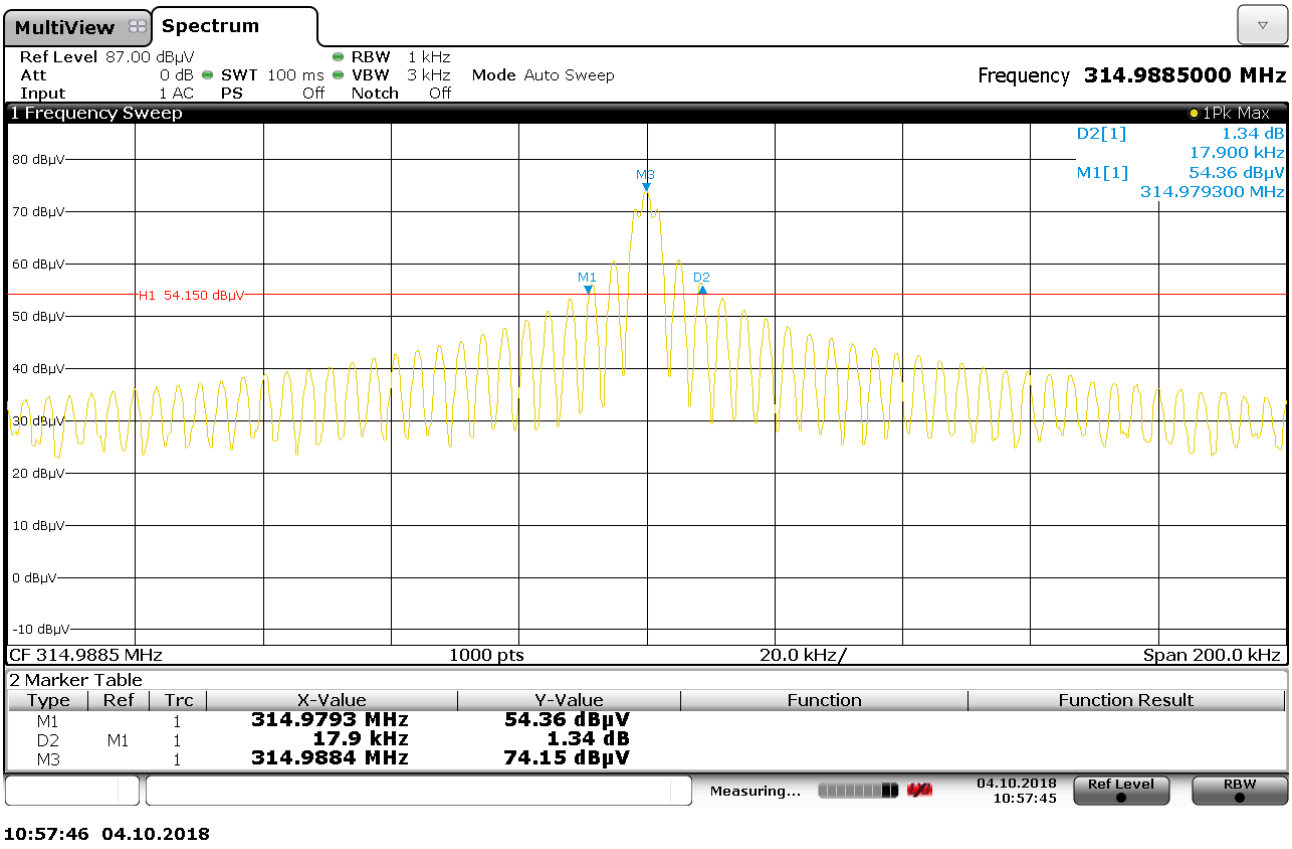


Figure 13: Chart of 20 dB bandwidth test of FS14T, version FS14T

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Limit [MHz]	Result
314.989	17.90	314.979	314.997	0.787	Passed

Table 7: Final results of 20 dB bandwidth test of FS14T, version FS14T

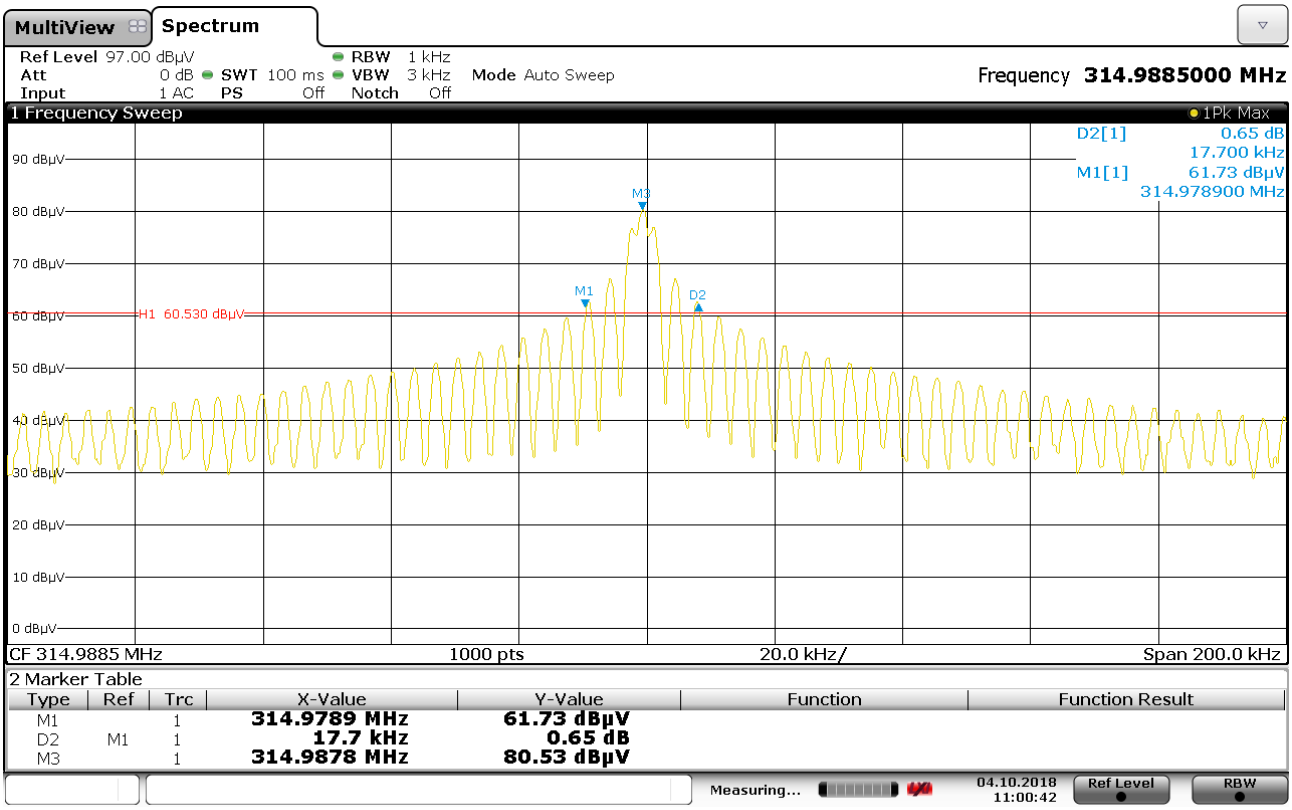


Figure 14: Chart of 20 dB bandwidth test of FS14T, version FS14TK

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Limit [MHz]	Result
314.988	17.70	314.979	314.997	0.787	Passed

Table 8: Final results of 20 dB bandwidth test of FS14T, version FS14TK

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:	Jennifer Riedel	Date of test:	October 4, 2018
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	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Measuring antenna set	---	---	A00088

6.5.2 Limits

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

6.5.3 Test results

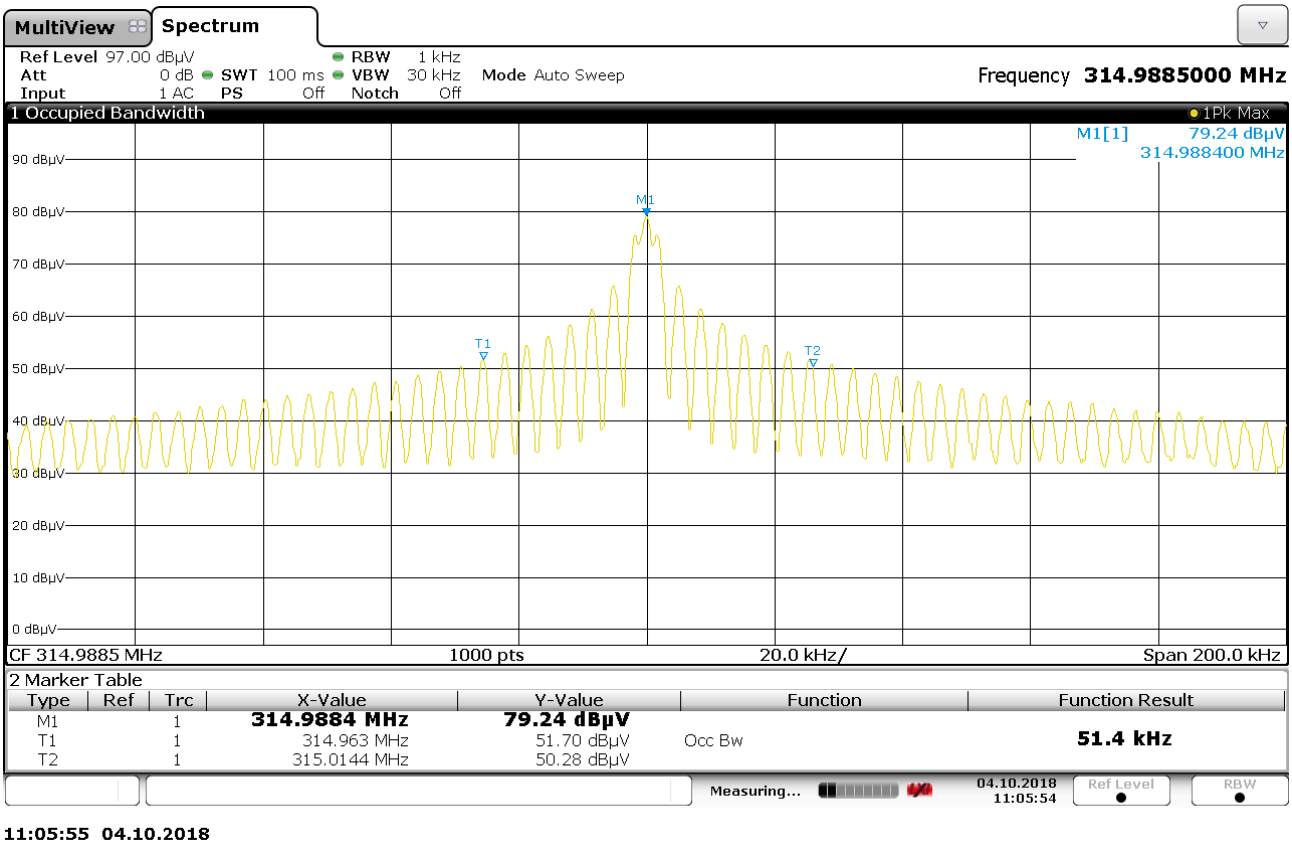


Figure 15: Chart of occupied bandwidth test of FS14T, version FS14T

f [MHz]	Occ. BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Result
314.989	51.4	314.963	315.014	No limit

Table 9: Final results of occupied bandwidth test of FS14T, version FS14T

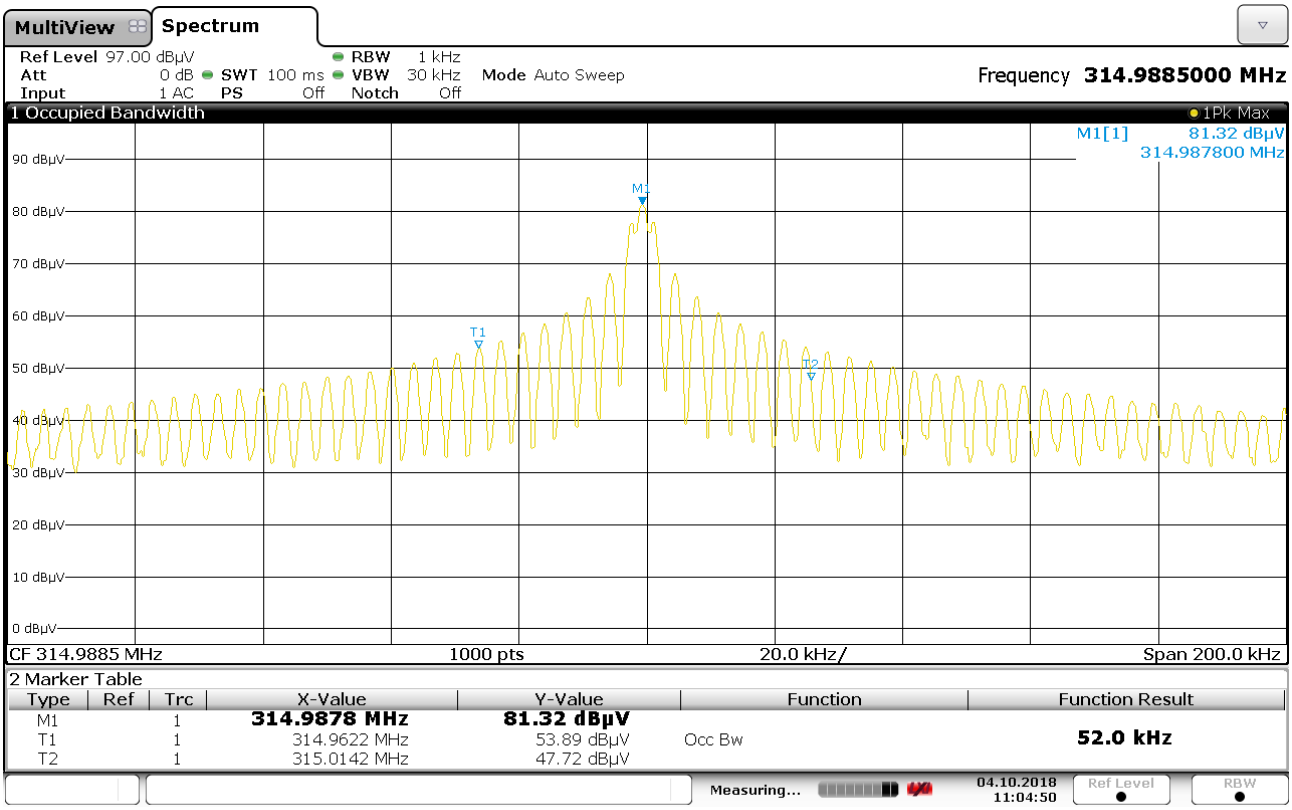


Figure 16: Chart of occupied bandwidth test of FS14T, version FS14TK

f [MHz]	Occ. BW [kHz]	f_{lower} [MHz]	f_{upper} [MHz]	Result
314.989	52.0	314.962	315.014	No limit

Table 10: Final results of occupied bandwidth test of FS14T, version FS14TK

6.6 Signal deactivation

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

Performed by:	Jennifer Riedel	Date of test:	December 4, 2018
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	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Measurement antenna 410 MHz	CV-400HW	Create Japan	A00088

6.6.2 Applicable standard

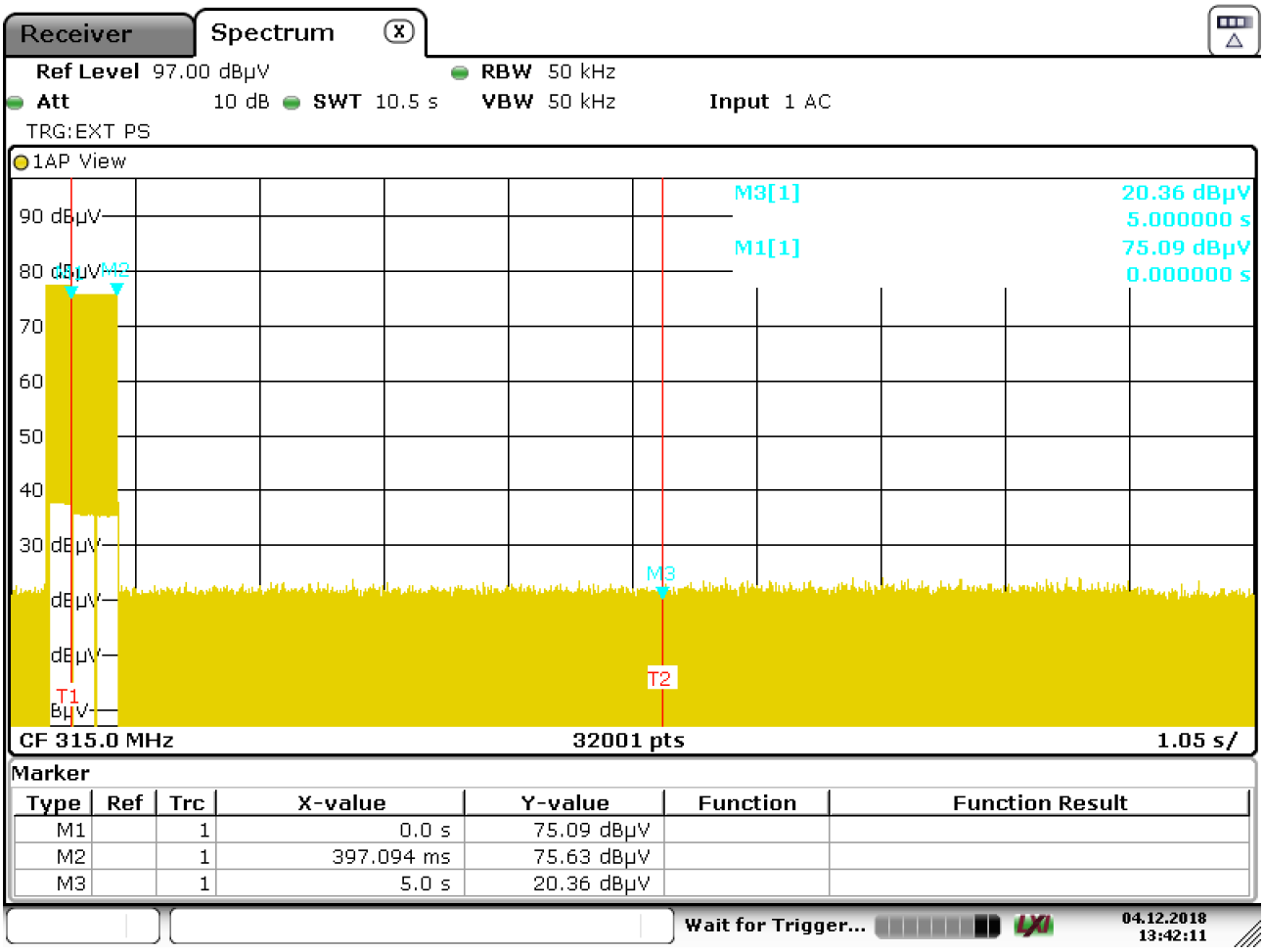
According to FCC Part 15C, Section 15.231(a)(2):
A transmitter activated automatically shall cease transmission within 5 seconds after activation.

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

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.



Date: 4.DEC.2018 13:42:10

Figure 17: Test protocol of signal deactivation

Note: The analyzer was triggered external by releasing the button.

Explanation: M1: Release of button (0 seconds)
M2: End of transmission (397.094 ms)
M3: Limit line (5 seconds)

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	2018-10	2020-10
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2018-03	2021-03
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	2018-12	2019-12
	262-0942-1500	003	E00433	2018-10	2019-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01033	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2018-09	2019-09

Table 11: Equipment calibration status

Note 1: Industry Canada (test sites number 3472A-1 and 3472A-2): 2019-03
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 12: 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	2018-12-06	Jennifer Riedel	First edition
1	2019-02-26	Jennifer Riedel	Duty Cycle measurement and correction of the referenced publications
2	2019-03-04	Jennifer Riedel	Duty Cycle measurement

10 Additional documents

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