

TEST REPORT

No. AR19-0042423-01

performed in accordance with
FCC Rules: Code of Federal Regulations (CFR) no. 47
Part 15 Subpart C Section 15.249

PRODUCT	IoT device for environmental monitoring with Z-Wave wireless communication
MODEL(s) TESTED	SENTIMATE
FCC ID	2AQ69SENTIMATE
TRADE MARK(s)	FAE TECHNOLOGY

APPLICANT	FAE TECHNOLOGY S.p.A. ~ Via C. Battisti, 136 ~ I-24025 Gazzaniga (BG)
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Tested by	Robertino Torri <i>[Laboratory technician]</i>	
Approved by	Giovanni Di Turi <i>[Laboratory manager]</i>	

Revision Sheet

Release No.	Date	Revision Description
Rev. 0	2019-09-25	First edition Digital signed - AR19-0042423-01_TR_FCC 15.249 - FAE TECHNOLOGY - SENTIMATE

The results of tests and checks reported in this Test Report refer exclusively to the samples tested and described in the Report itself.

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1. GENERAL DATA

SAMPLE		
Samples received on	2019-09-03	(Item(s) sampled and sent by applicant)
IMQ reference samples	BEM	96822
Samples tested No.	1	
Object under analysis recognition	Not carried out Except where stated, characteristics of products were taken from client description and were not verified by the laboratory	
Date of acceptance of test item	2019-09-03	
TEST LOCATION		
Testing dates	2019-09-05 ÷ 2019-09-25	
Testing laboratory.	IMQ S.p.A. - Via Quintiliano, 43 – I-20138 Milano	
Testing site	Via Quintiliano, 43 – I-20138 Milano	
ENVIRONMENTAL CONDITIONING		
<i>Parameter</i>	<i>Measured</i>	
Ambient Temperature	21.4 °C ÷ 23,8	
Relative Humidity	53 % ÷ 59%	
Atmospheric Pressure	940 ÷ 1005 mbar	
The laboratory is monitored by a continuous environmental conditions measurements system. Temperature, humidity and pressure data are recorded on a weekly basis and stored in local archive.		
REMARKS		
Throughout this report a point is used as the decimal separator. The ability or reliability of this product to perform its intended function in a particular application has not been investigated. Unless otherwise specified, warnings, installation instruction and/or user manual provided with the sample have been checked in Italian or English version only. IMQ declines any responsibility derived from missing or wrong information provided aside by the applicant.		

2. REFERENCE DOCUMENT

	DOCUMENT	DATE	TITLE
<input checked="" type="checkbox"/>	47 CFR Part 15	2015	Radio Frequency Device
<input checked="" type="checkbox"/>	ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
<input checked="" type="checkbox"/>	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

3. EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL DATA (according to manufacturer declaration)

MODEL (basic)	Description
SENTIMATE	Z-wave radio module integrate in IoT device with wireless communication functions
VARIANTS (derived)	Description
/	/

FCC ID	2AQ69SENTIMATE
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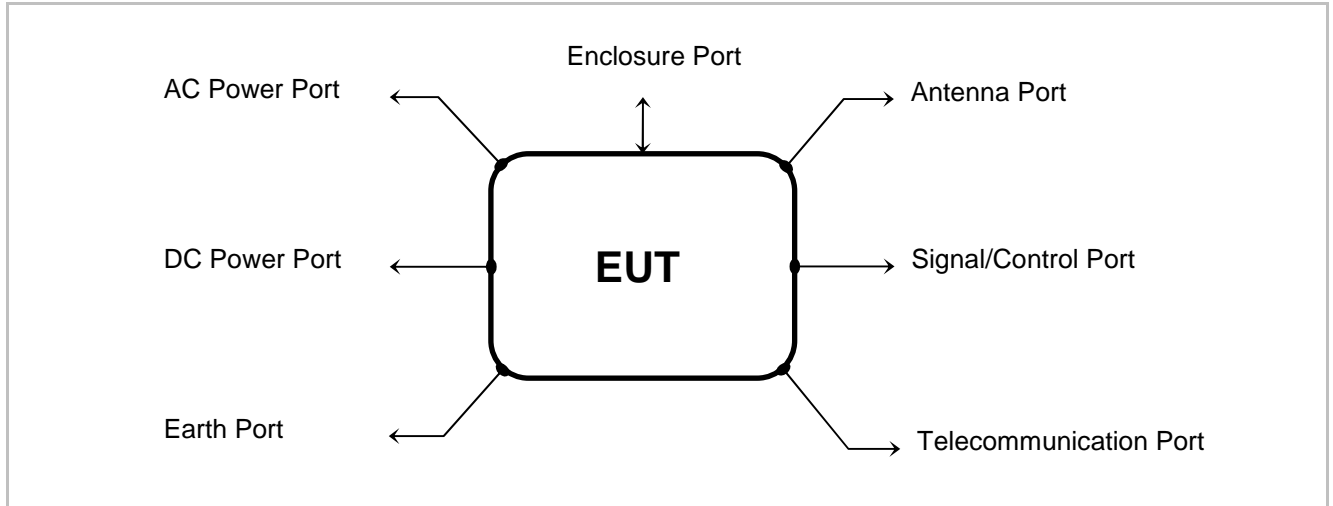
Manufacturer	FAE TECHNOLOGY S.p.A. – Via C. Battisti, 136 – IT-24025 Gazzaniga BG
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Equipment classification	According to the definition 15.3 (o) EUT is a Intentional Radiator operating within the bands 902 ÷ 928 MHz so it shall fulfill provisions of 47CFR Part 15 Subpart C – Intentional radiators – and Section 15.249
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Type of equipment	DTS - Digital transmission equipment
Operating frequency	908.4 MHz ; 908.42 MHz; 916 MHz
Field strength peak	90.96 dBµV/m @3m
Modulation	GFSK
Channel	3 channel (CH0: 916.00 MHz; CH1: 908.400MHz; CH2: 908.420MHz)
Antenna	Dedicated
Remarks	None

4. TEST CONFIGURATION OF UNIT UNDER TEST

EUT PORTS



Port	Description	Max length
Enclosure	Plastic	
AC power	/	/
DC power	Internal supply by 2 x 1.5 V size AA alkaline battery; External supply 5 to 40 V by external source.	/
Earth	/	/
Telecommunication	/	/
Signal & Control	/	/
Antenna	Dedicated	/

STATE OF THE EUT DURING TESTS

Ref.	Transmission Mode	Description
#1	CW	Continuous unmodulated transmission mode (constant tone)
#2	Modulated	Continuous modulated transmission (duty cycle close to 100%)
#3	Normal operating	Receiving mode / Normal transmission

SUPPORT EQUIPMENT

Defined as equipment needed for correct operation or loading of the EUT, but not considered as tested:

Equipment	Manufacturer	Model
PC with serial terminal software for RF transmission management	/	/

ELECTROMAGNETICALLY RELEVANT COMPONENTS

Component	No.	Manufacturer	Model
Z-wave module	1	SILICON LABS	ZGM130S
Main Board	1	FAE TECHNOLOGY	20190001_V3

RFI SUPPRESSION DEVICES

Component	No.	Manufacturer	Model
/	/	/	/

EMI PROTECTION DEVICES

Component	No.	Manufacturer	Model
/	/	/	/

EUT TECHNICAL DOCUMENTATION

Document	Reference
/	/

5. METHODS OF MEASUREMENT

All compliance measurements have been carried out using the procedures described in the standard ANSI C63.4-2014 (excluding sub-par. 4.1.5.2, 5.7.9 and 14) and Section 15.31 of CFR47 Part 15 – Subpart A (General).

Additional test requirements have been adopted according to the reference Section indicated in the Test Table.

FREQUENCY RANGE INVESTIGATED

Radiated emission tests: from 9 kHz to tenth harmonic of fundamental.

6. SUMMARY OF TEST RESULTS

POSSIBLE TEST CASE VERDICTS:	
Test object meets the requirement	PASS
Test object does not meet the requirement	FAIL
Test case does not apply to the test object	N.A.
Test not performed	N.P.

CFR47 Part 15	TITLE	RESULT
§ 15.203	Antenna Requirements	PASS
§ 15.205 (a)	Restricted band of operation	PASS
§ 15.205 (b) § 15.215 (b) § 15.249 (d)	Radiated Emission 9kHz to 30MHz 30MHz to 10GHz	PASS
§ 15.207 (a)	Conducted emission	N.A.
§ 15.215 (c)	Bandwidth of emission (20dB Bandwidth)	PASS
§ 15.249(a)	Field strength of fundamental	PASS
§ 15.249 (a)	Radiated emission measurement of harmonics	PASS

7. TEST RESULTS

7.1 ANTENNA REQUIREMENTS

TEST REQUIREMENT

According to CFR 47 Part 15, section 15.203 / 15.204.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

Testing dates	2019-09-06
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Antenna specifications

N° of authorized antenna types	1
Antenna type	Dedicated
Maximum total gain	1.4 dBi PK gain
External power amplifiers	Not present

TEST RESULT

The EUT meets the requirements of sections 15.203 and 15.204.

7.2 RESTRICTED BAND OF OPERATION

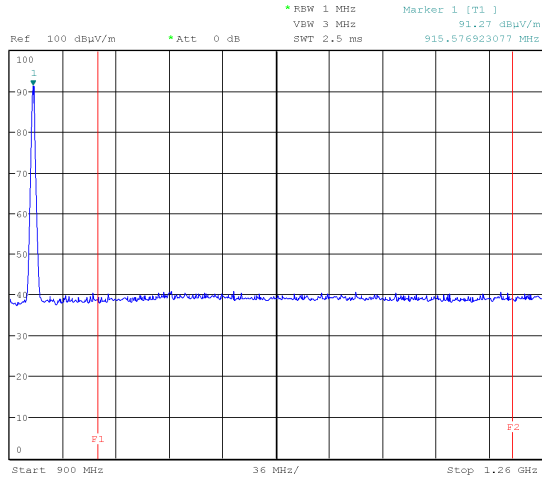
TEST REQUIREMENT	
Test setup	ANSI C63.4
Test facility	Semi-anechoic chamber
Test distance	3 m
Frequency range	960 ÷ 1240
RBW bandwidth	100 kHz
VBW bandwidth	300 kHz
Detector	Peak
EUT operating condition	#2
Testing dates	2019-09-06

LIMITS		
Band of operations	Peak (dB μ V/m)	Average Limit (dB μ V/m)
Restricted bands (§ 15.205)	74	54

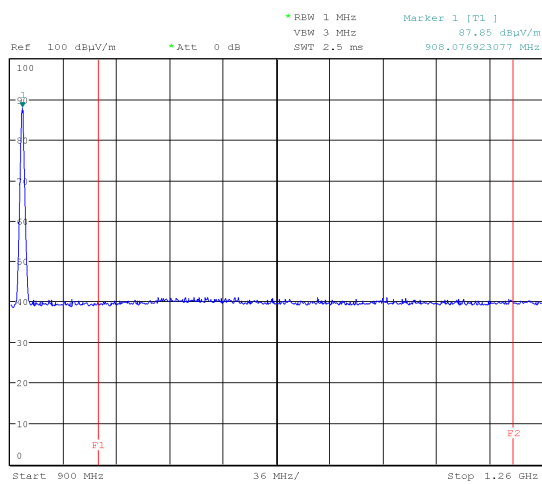
TEST PROCEDURE
<ol style="list-style-type: none"> 1) The EUT was placed on turntable which is 0.8 m above the ground plane 2) The turntable shall rotate from 0° to 360° degrees to determine the position of maximum emission level. 3) The EUT is positioned 3 m away from the receiving antenna which varied from 1 to 4 m to find the highest emission. 4) The measurements were made with EUT set to operate at 100% of duty cycle and maximum power with normal modulation 5) The receiving antenna was positioned in both horizontal and vertical polarization.

MEASUREMENTS RESULTS AT FREQUENCY TRANSMISSION

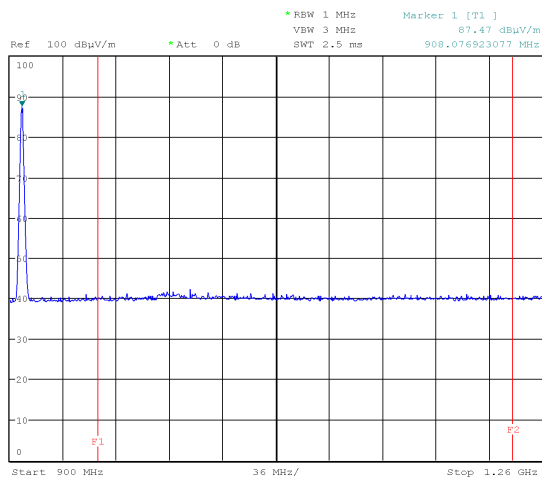
CH 0



CH 1



CH 2



TEST RESULT

The EUT meets the requirements of sections 15.205 (a)

7.3 RADIATED EMISSIONS

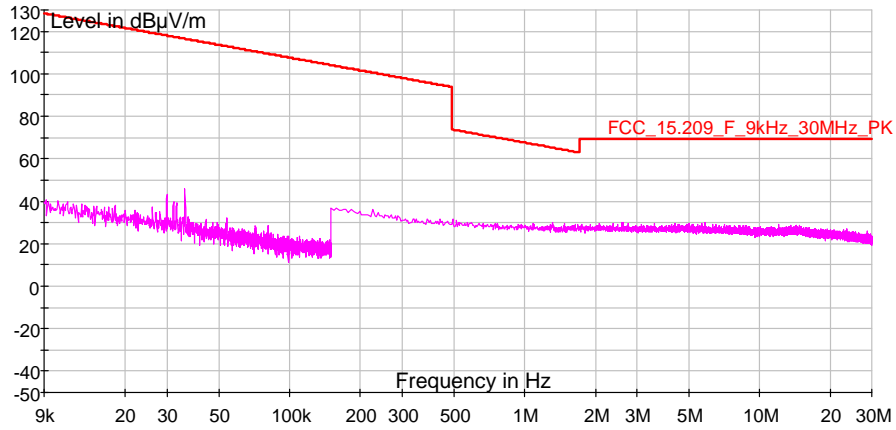
TEST REQUIREMENT	
Test setup	ANSI C63.4 § 5.5
Test facility	Semi-anechoic chamber below 1 GHz; for measurement above 1 GHz are used 2.4 m by 2.4 m RF absorbing material covering the ground plane between the antenna and the EUT
Test distance	3 meters
Frequency range	9 kHz to tenth harmonic of fundamental
IF bandwidth (below 30 MHz)	9 kHz
IF bandwidth (below 1,000 MHz)	120 kHz
IF bandwidth (above 1,000 MHz)	1 MHz
Deviation to test procedure	None
EUT operating condition	#1
Remark	(* In accordance with part 15.31 (f) (2), where the measurement distance was specified to be 30 or 300 meters, a correction factor was applied in order to permit measurement to be performed at a separation distance. The applied formula for limits at 3 meter is: Extrapolation (dB) = 40log (300meter / 3meter) = +80dB Extrapolation (dB) = 40log (30meter / 3meter) = +40dB
Testing dates	2019-09-09

LIMITS		
Band of operations	Peak Limit (dB μ V/m)	Average Limit (dB μ V/m)
Restricted bands (§ 15.205)	74	54
Other bands	According to § 15.209 or fundamental -50dB (whichever is the lesser attenuation)	According to § 15.209 or fundamental -50dB (whichever is the lesser attenuation)

TEST PROCEDURE
<ol style="list-style-type: none"> 1) The EUT was placed on turntable which is 0.8 m above the ground plane 2) The turntable shall rotate from 0° to 360° degrees to determine the position of maximum emission level. 3) The EUT is positioned 3 m away from the receiving antenna which varied from 1 to 4 m to find the highest emission. 4) The measurements were made with the detector set to PEAK amplitude within a bandwidth of 120 kHz below 1000 MHz and 1 MHz above 1000 MHz. 5) The receiving antenna was positioned in both horizontal and vertical polarization. 6) The measurements with Quasi-Peak detector, below 1000 MHz are performed only for frequencies for which the Peak values are \geq Q.P. limit - 6 dB (♦ mark symbol).

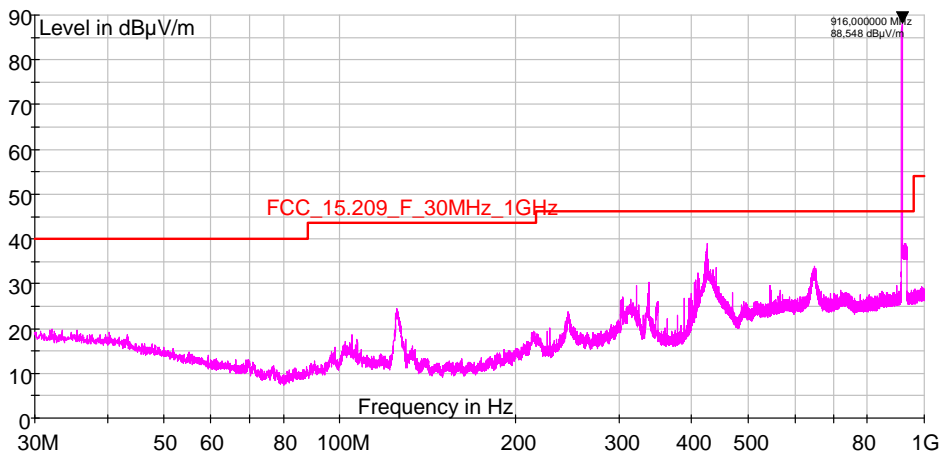
MEASUREMENTS RESULTS: CH 0

Range: 9kHz + 30 MHz



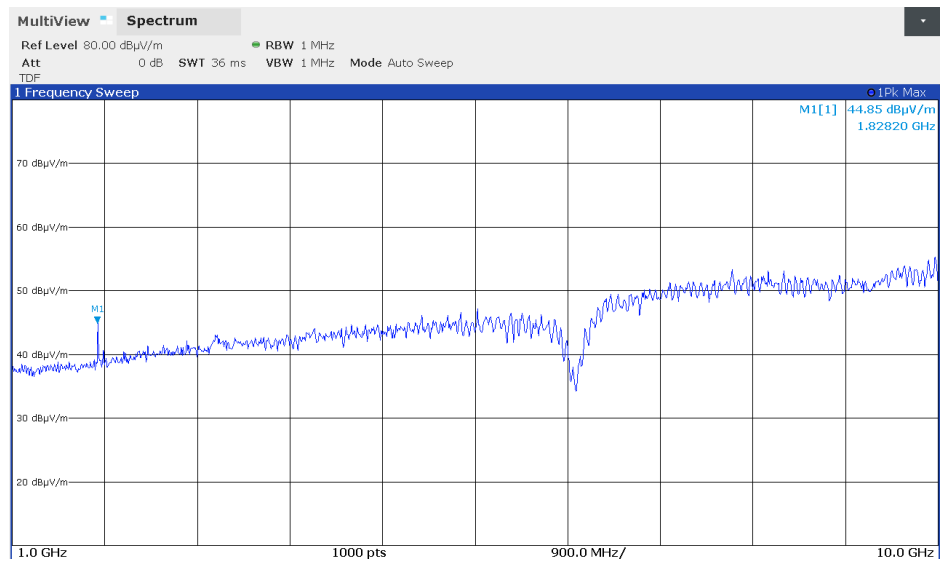
Range: 30 MHz + 1000 MHz

Antenna polarization: HORIZONTAL (worst case)



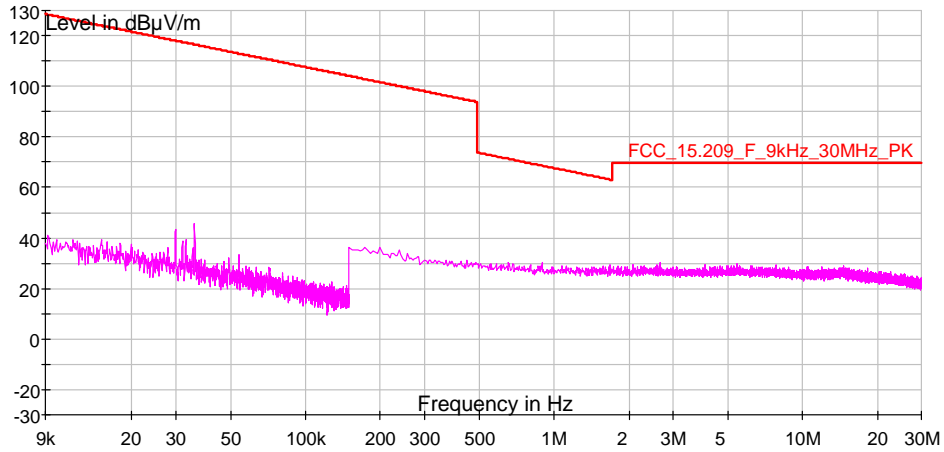
Range: 1000 MHz + 10000 MHz

Antenna polarization: HORIZONTAL (worst case)



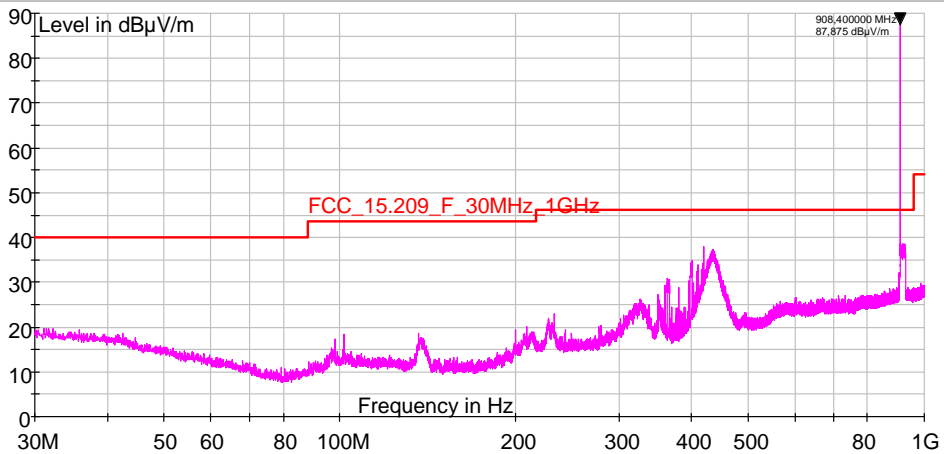
MEASUREMENTS RESULTS: CH 1

Range: 9kHz + 30 MHz



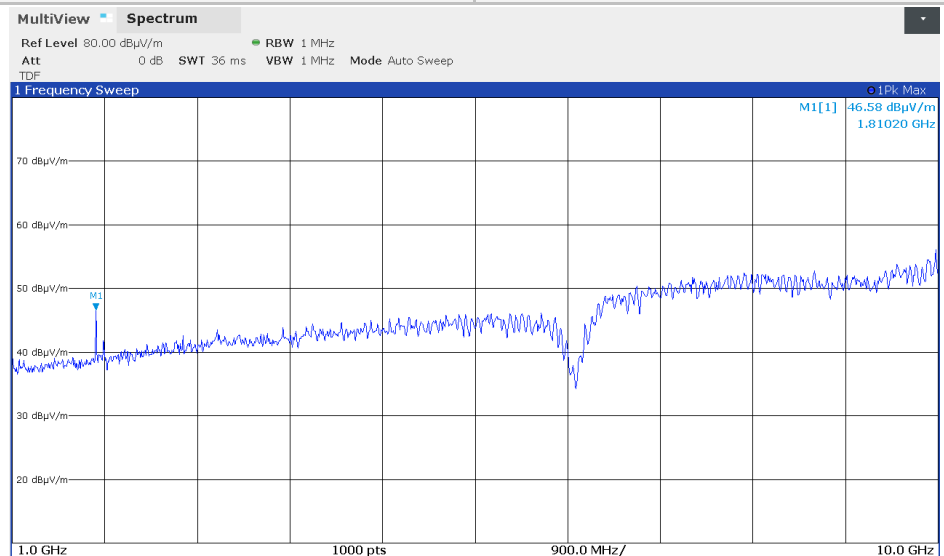
Range: 30 MHz + 1000 MHz

Antenna polarization: HORIZONTAL (worst case)



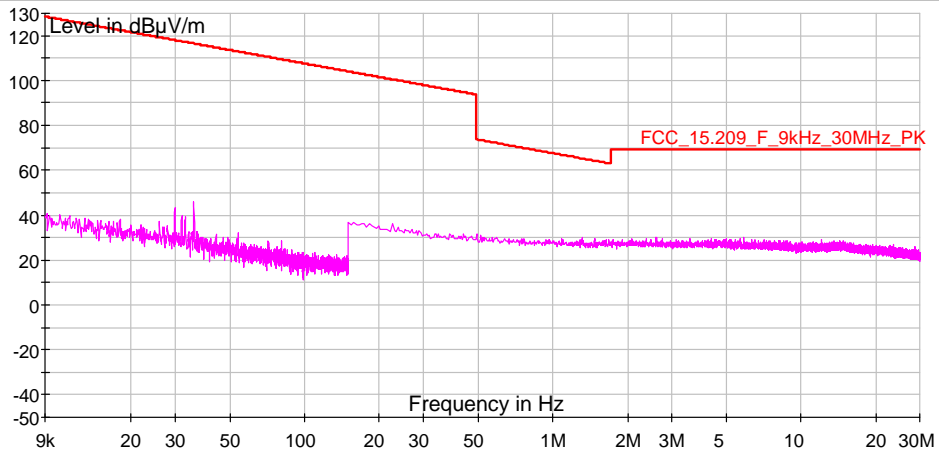
Range: 1000 MHz ÷ 10000 MHz

Antenna polarization: HORIZONTAL (worst case)



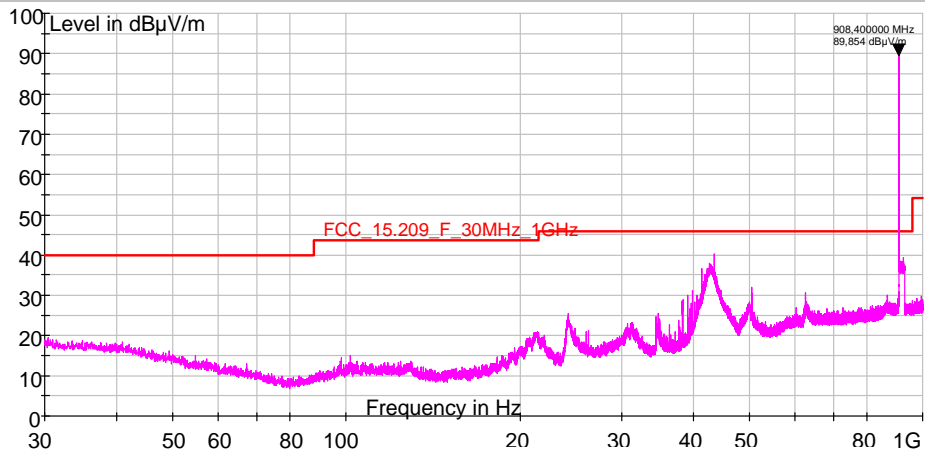
MEASUREMENTS RESULTS: CH 2

Range: 9kHz ÷ 30 MHz



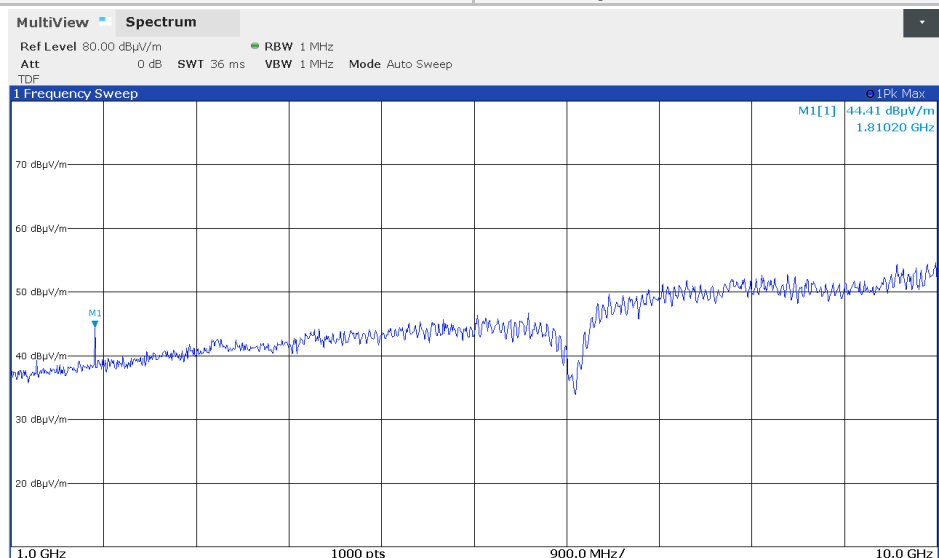
Range: 30 MHz ÷ 1000 MHz

Antenna polarization: HORIZONTAL (worst case)



Range: 1000 MHz ÷ 10000 MHz

Antenna polarization: HORIZONTAL (worst case)



TEST RESULT

The EUT has been tested in 3 orthogonal axes at the frequencies lowest, middle and highest for each modulation. The results reported are worst case. The measurement of spurious emission of EUT in receiver mode is deemed to be fulfilled as no limits are exceeded in transmitter mode (condition considered more burdensome). The EUT meets the requirements of sections 15.205 (b), 15.215 (b) and 15.249 (d).

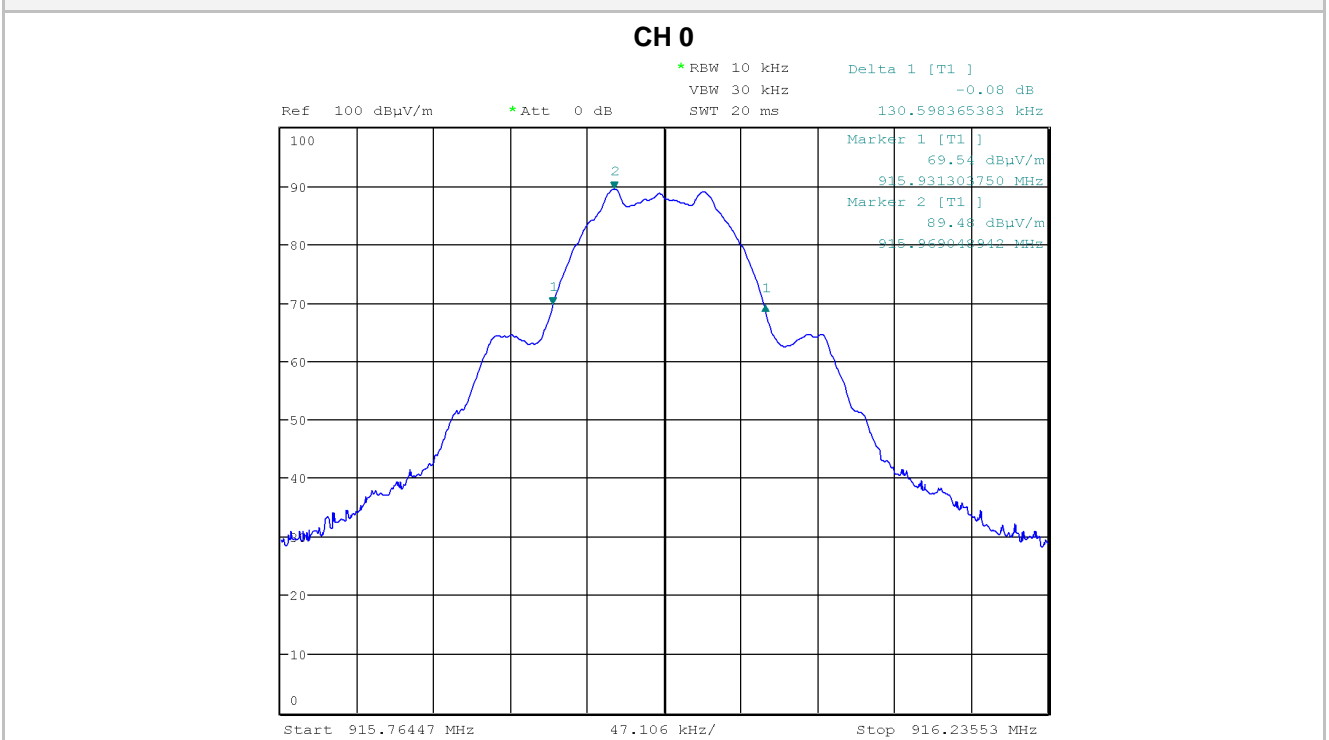
7.4 BANDWIDTH OF EMISSIONS (20 dB BANDWIDTH)

TEST REQUIREMENT	
Spectrum analyzer settings	
Span	Wide enough to capture the peak level of the emission operating on the channel
Resolution bandwidth (RBW)	10 kHz
Video bandwidth (VBW)	30 kHz
Sweep time (SWT)	Auto
Detector function	Peak
Trace	Max hold
Attenuator	/
Deviation to test procedure	None
EUT operating condition	#1
Remark	None
Testing dates	2019-09-06

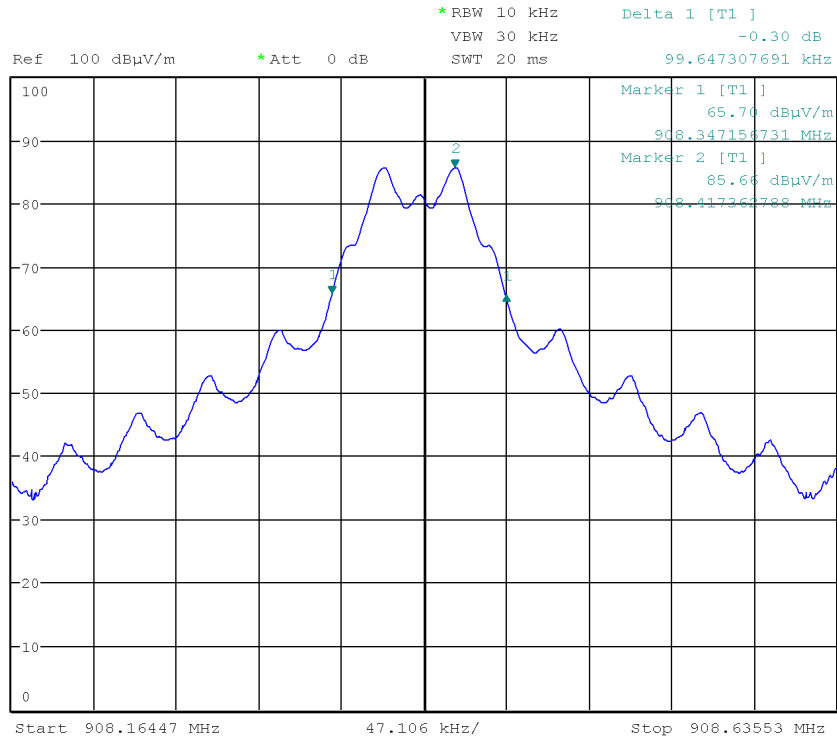
LIMITS

20 dB below peak output power

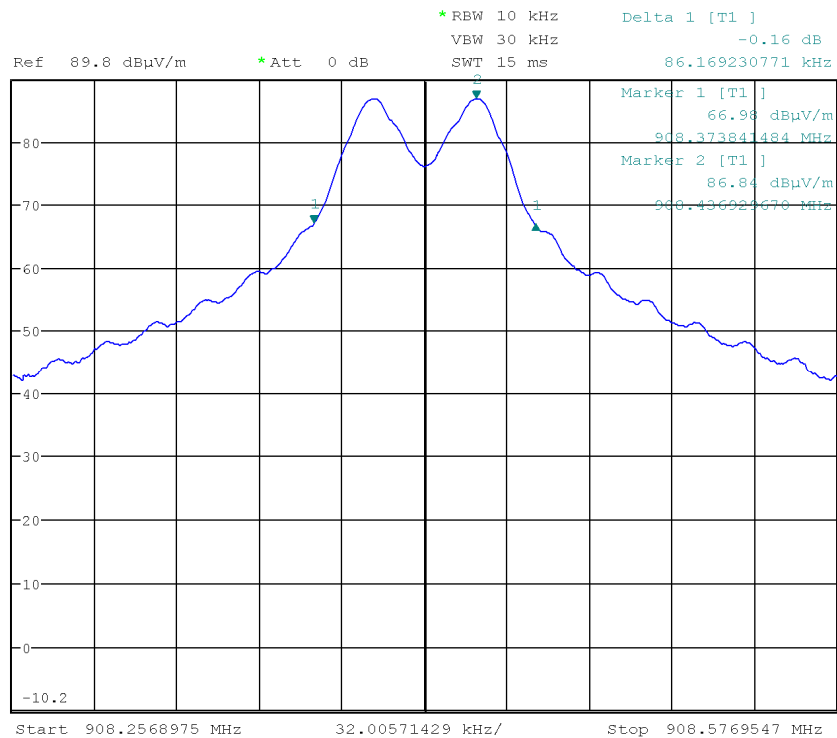
Channel frequency



CH 1



CH 2



TEST RESULT

All out of band spurious emissions are more 20 dB below the in band power of the fundamental in accordance to section 15.215 (c).

7.5 FIELD STRENGTH OF FUNDAMENTAL

TEST REQUIREMENT	
Spectrum analyzer settings	
Span	Wide enough to capture the peak level of the emission
Resolution bandwidth (RBW)	100 kHz
Video bandwidth (VBW)	Auto
Sweep time (SWT)	Auto
Detector function	Peak
Trace	Max hold
Attenuator	/
Deviation to test procedure	None
EUT operating condition	#2
Remark	None
Testing dates	2019-09-16

TEST PROCEDURE
<ol style="list-style-type: none"> 1) The EUT was placed on turntable which is 0.8 m above the ground plan 2) The turntable shall rotate from 0° to 360° degrees to determine the position of maximum emission level. 3) The EUT is positioned 3 m away from the receiving antenna which varied from 1 to 4 m to find the highest emission. 4) The measurements were made with the detector set to PEAK amplitude within a bandwidth of 100 kHz. 5) The receiving antenna was positioned in both horizontal and vertical polarization.

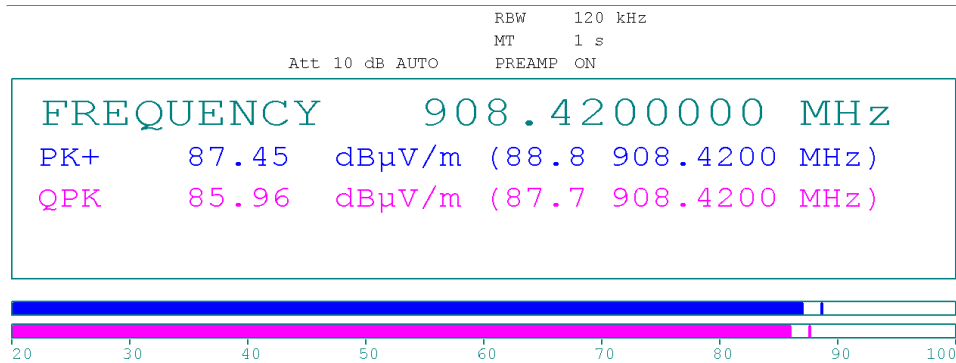
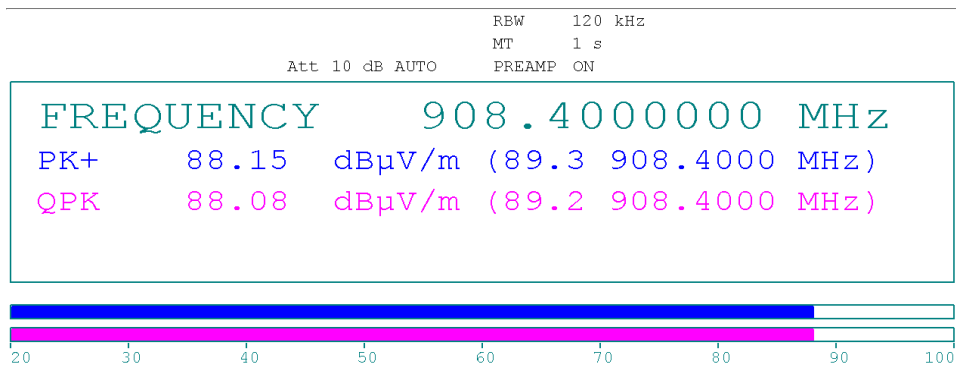
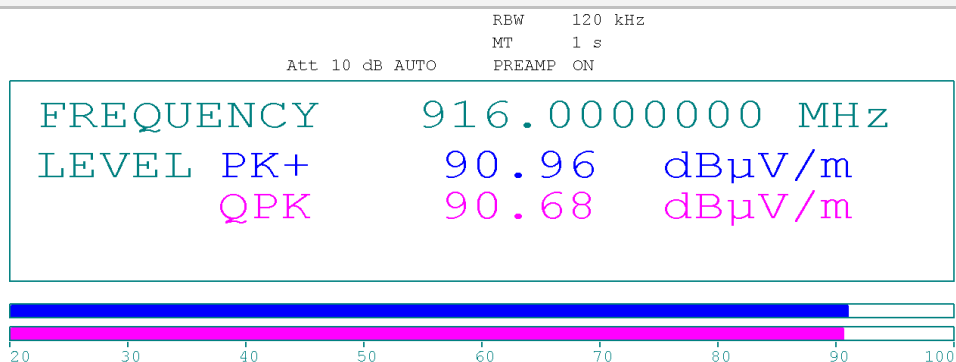
LIMITS
94 dB μ V/m

TEST RESULT
The EUT meets the requirements of sections 15.249 (a).

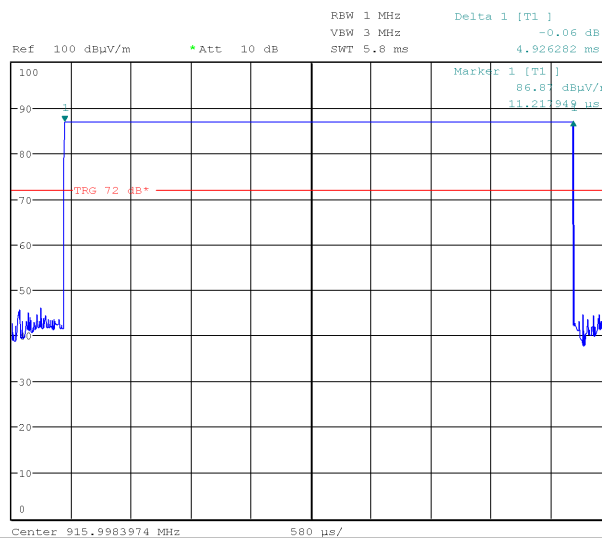
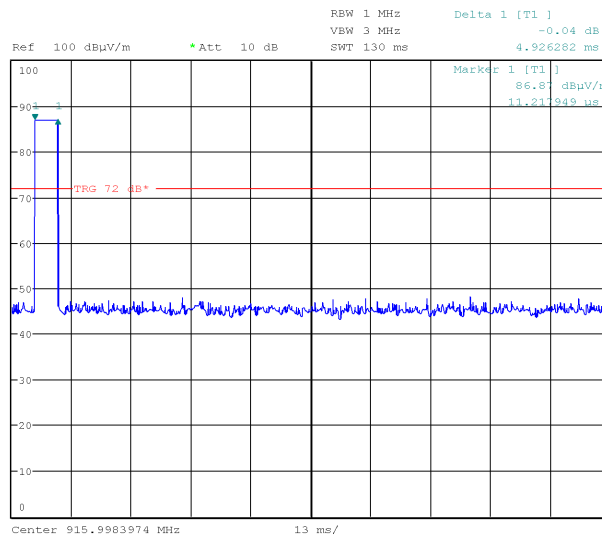
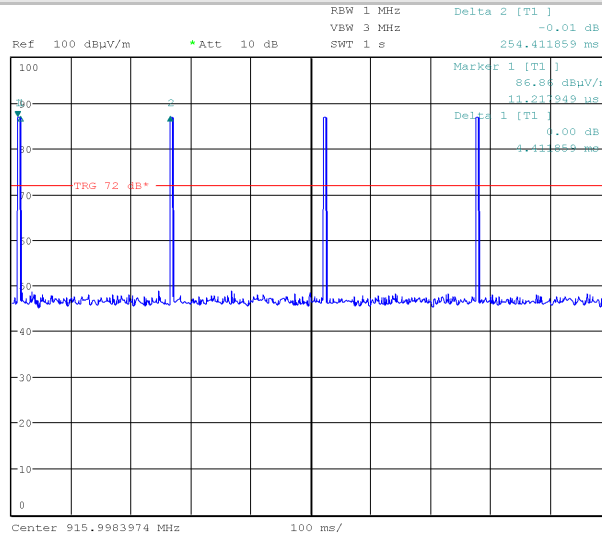
FIELDS STRENGTH RESULTS (RADIATED)

Channel (No.)	Frequency (MHz)	Detector	Antenna polarization (H or V)	Radiated Output Power (at 3m. distance) (dBµV/m)	Limit (dBµV/m)
0	916.000	QP	H	90.68	94.00
1	908.400	QP	H	89.20	94.00
2	908.420	QP	H	87.70	94.00

Plots

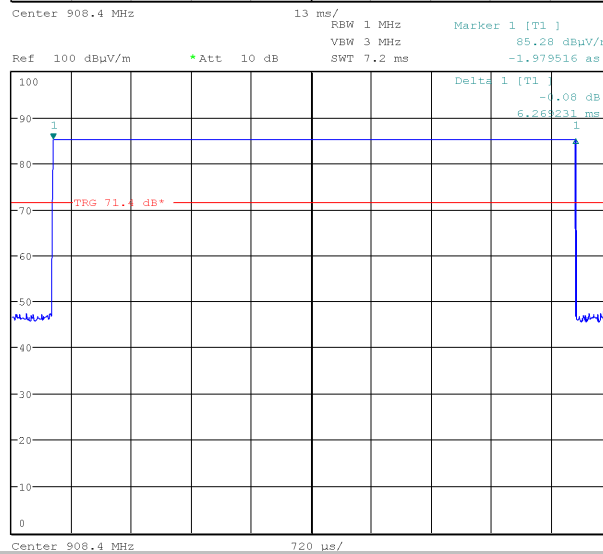
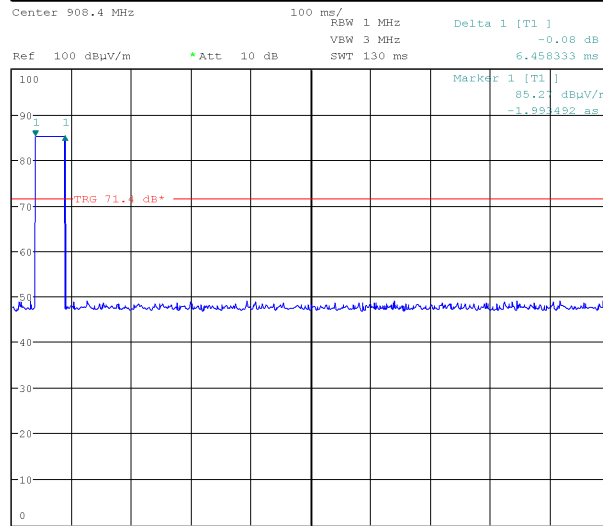
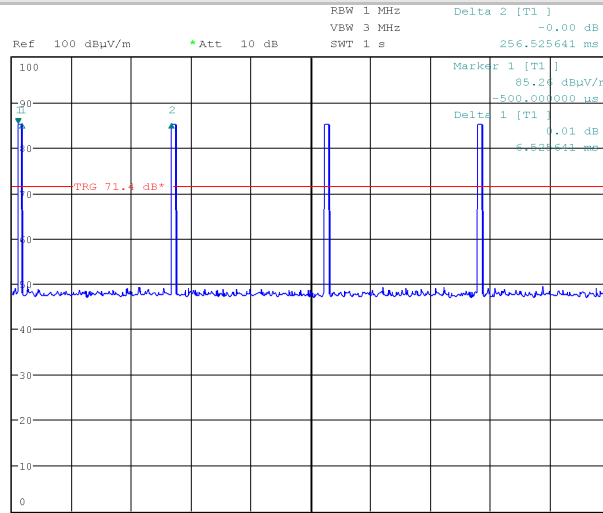


DUTY CYCLE CH 0



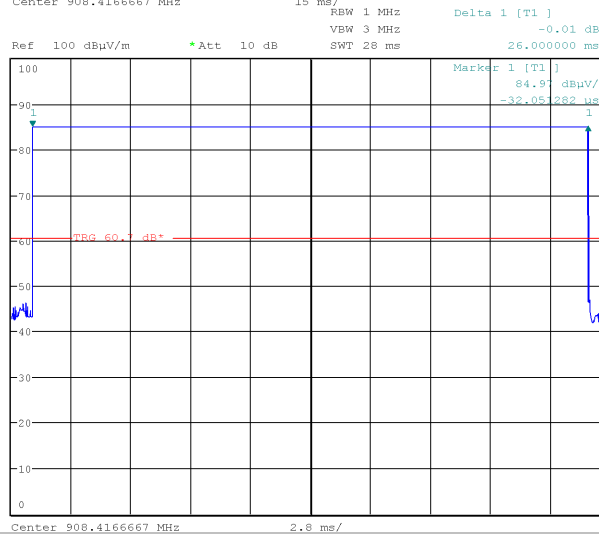
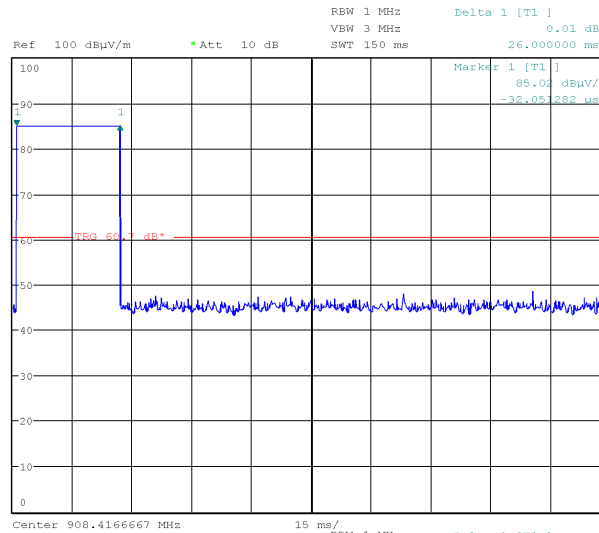
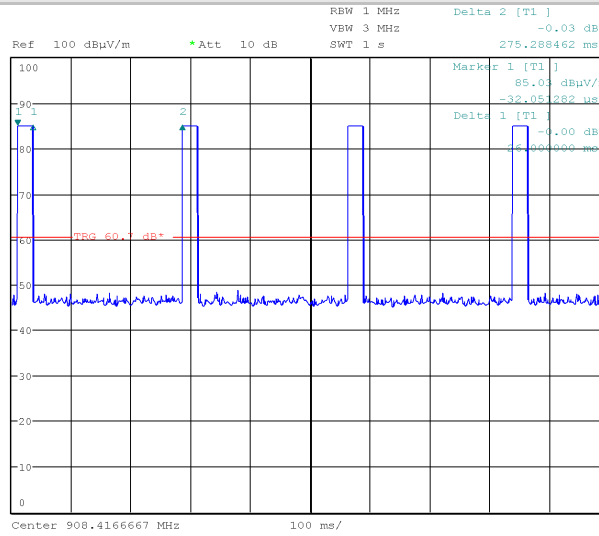
T ON pulse: 5 ms; T ON+OFF: 100.0 ms; Duty-cycle in 100ms = 5 / 100 = 0.05
Correction factor for duty cycle = 20 x log (0.05) = -26.02 dB

DUTY CYCLE CH 1



T ON pulse: 6.5 ms; T ON+OFF: 100.0 ms; Duty-cycle in 100ms = 6.5 / 100 = 0.065
Correction factor for duty cycle = 20 x log (0.065) = -23.74 dB

DUTY CYCLE CH 2



$T_{ON\ pulse} = 26\ ms;$ $T_{ON+OFF} = 100.0\ ms;$ Duty-cycle in 100ms = $26 / 100 = 0.26$
Correction factor for duty cycle = $20 \times \log(0.26) = -11.70\ dB$

7.7 FIELD STRENGTH OF HARMONICS

TEST REQUIREMENT	
Spectrum analyzer settings	
Resolution bandwidth (RBW)	1 MHz
Resolution bandwidth (RBW)	1 MHz / 10Hz
Detector function	Peak
Trace	Max hold
Attenuator	/
Deviation to test procedure	None
EUT operating condition	#2
Remark	None
Testing dates	2019-09-09

TEST PROCEDURE
<ol style="list-style-type: none"> 1) The EUT was placed on turntable which is 1.5m above the ground plan 2) The turntable shall rotate from 0° to 360° degrees to determine the position of maximum emission level. 3) The EUT is positioned 3 m away from the receiving antenna which varied from 1 to 4 m to find the highest emission. 4) The measurements were made with the detector set to PEAK amplitude within a bandwidth of 1 MHz. 5) The receiving antenna was positioned in both horizontal and vertical polarization.

PEAK MEASUREMENT RESULT (RBW 1MHz / VBW 1MHz)						
Frequency (MHz)	Antenna polarization (H or V)	Reading Value (dBµV)	Correction factor (dB)	Correcting reading (dBµV/m)	PK Limit (dBµV/m)	Margin (dB)
1832.00 (CH 0)	H	53.65	-7.39	46.26	74.00	27.74
1816.80 (CH1)	H	51.18	-7.39	43.79	74.00	30.21
1816.84 (CH2)	H	51.63	-7.39	44.24	74.00	29.76

AVERAGE MEASUREMENT RESULT (RBW 1MHz / VBW 10Hz)						
Frequency (MHz)	Antenna polarization (H or V)	Reading Value (dBµV)	Correction factor (dB)	Correcting reading (dBµV/m)	AV Limit (dBµV/m)	Margin (dB)
1832.00 (CH 0)	H	34.87	-7.39	27.48	54.00	26.52
1816.80 (CH1)	H	37.44	-7.39	30.05	54.00	23.95
1816.84 (CH2)	H	44.50	-7.39	37.11	54.00	16.89

NOTE: The measures above are the worst case on 3 axes X, Y and Z and both polarization. Only worst case are reported.

TEST RESULT
<p>All out of band spurious emissions are more 20 dB below the in band power of the fundamental. The EUT meets the requirements of sections 15.249 (a).</p>

8. TESTS UNCERTAINTY

Unless otherwise stated the uncertainties for the tests and measurements are evaluated in according to IMQ Operational Instruction IO-LAB-001 and IO-LAB-004. and requirement of NIST Technical Note 1297 and NIS 81: 1994 "The Treatment of Uncertainty in EMC Measurements"

The expanded uncertainty was calculated for all measurements and tests listed in this test report according to CISPR 16-4-2 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainty in EMC Measurements", with UKAS document LAB 34 and is documented in the quality system accordance to ISO/IEC 17025.

Internal Procedure PG-037 ensures that the requirements for traceability of calibrations, of all test equipment requiring calibration, and calibration intervals are met.

Methods/Standard	Parameter	Expanded Uncertainty	Unit	Confidence level
Continuous disturbance	QP detector 9 – 150 kHz	2,47	dB	95%
	QP detector 150 k – 30 MHz	2,61	dB	95%
	QP detector using Voltage Probe	2,45	dB	95%
	QP detector using ISN	3,15	dB	95%
	QP detector using Current Probe	2,15	dB	95%
Radiated disturbance	QP detector (30 MHz - 100 MHz) H polarization	4,33	dB	95%
	QP detector (30 MHz - 100 MHz) V polarization	4,22	dB	95%
	QP detector (100 MHz - 200 MHz) H polarization	3,40	dB	95%
	QP detector (100 MHz - 200 MHz) V polarization	4,76	dB	95%
	QP detector (200 MHz - 1000 MHz) H polarization	3,91	dB	95%
	QP detector (200 MHz - 1000 MHz) V polarization	3,82	dB	95%
	P detector 1-6 GHz	4,77	dB	95%
	P detector 6 – 18 GHz	5,14	dB	95%

9. LIST OF MEASURING EQUIPMENT AND CALIBRATION INFORMATION

IMQ Serial Number	Instrument	Manufacturer	Type	Last Cal.	Cal. Period.	Calibration Company
P01709	Shielded semi-anechoic chamber	SIDT	/	10-18	12	IMQ
P02486	Turntable controller unit	FRANKONIA	FCTAM01	/	/	/
P02488	Mast antenna	FRANKONIA	FAM4	/	/	/
S05562	EMI Receiver	Rohde & Schwarz	ESU 8	07-19	12	Rohde & Schwarz
S02122	Artificial Mains V-network	Rohde & Schwarz	ESH3-Z5	05-19	12	IMQ
S03511	Log antenna	ARA	LPB-2513	12-18	12	NPL
S03463	Horn Antenna	Schwarzbeck	BBHA 9120D	07-17	36	NPL
S03542	Preamplifier	Hewlett Packard	HP 8449B	03-19	12	IMQ
W00199/E	Software	Rohde & Schwarz	Emc32 Ver. 8.30	/	/	/
H00165	PC	/	/	/	/	/

END OF TEST REPORT