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TEST REPORT
No. AR19-0045638-01

performed in accordance with

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

PRODUCT	Electronic position indicator system
MODEL(s) TESTED	DD51R-E-RF
FCC ID	2AVRQ-DD51-E-RF
TRADE MARK(s)	elesa®

APPLICANT	ELESA S.p.A. - Via Pompei, 29 – 20900 Monza (MB)

Tested by	Alessandro Macrì *[Laboratory technician]*	
Approved by	Roberto Colombo *[Laboratory manager]*	

Revision Sheet

Release No.	Date	Revision Description
Rev. 0	2021-07-30	First edition Digital signed – AR19-0045638-01_ TR_FCC 15.249_Elesa_DD51R-E-RF

1. GENERAL DATA

SAMPLE		
Samples received on	**2020-12-15**	**(Item(s) sampled and sent by applicant)**
IMQ reference samples	**BEM**	**102171**
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	2021-01-29	
TEST LOCATION		
Testing dates	2021-01-29 ÷ 2021-02-01	
Testing laboratory.	IMQ S.p.A. - Via Quintiliano, 43 – I-20138 Milano	
Testing site	Via Quintiliano, 43 – I-20138 Milano	
ENVIRONMENTAL CONDITIONING		
Parameter	***Measured***	
Ambient Temperature	20.5 ÷ 22.7 °C	
Relative Humidity	43 ÷ 48 %	
Atmospheric Pressure	994 ÷ 1003 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. **IMQ declines any responsibility derived from missing or wrong information provided aside by the applicant**		

2. REFERENCE DOCUMENT

	DOCUMENT	DATE	TITLE
☒	47 CFR Part 15	2015	Radio Frequency Device
☒	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
☒	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

3. UNIT UNDER TEST (EUT) DETAILS

GENERAL DATA

MODEL (basic)	Description
DD51R-E-RF	Electronic position indicator system
VARIANTS (derived)	Description
/	/

FCC ID	2AVRQ-DD51-E-RF

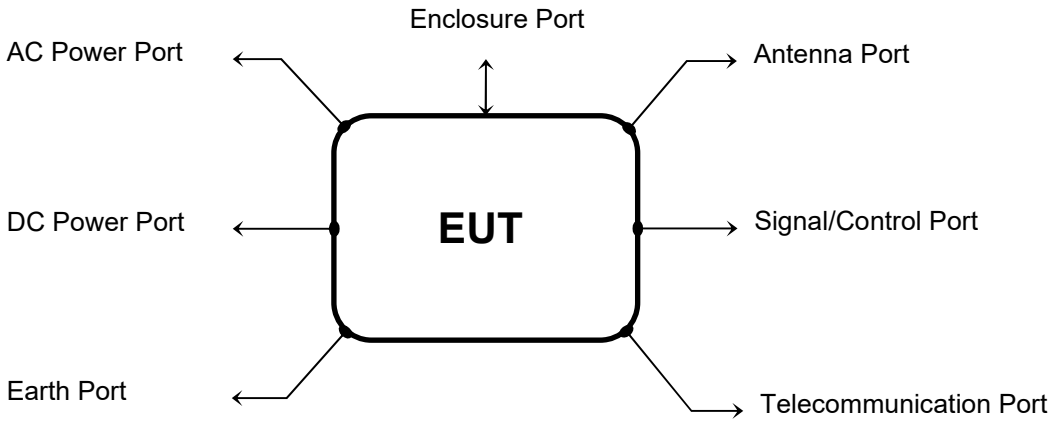
Manufacturer	ELESA S.p.A. - Via Pompei, 29 – 20900 Monza (MB)

Equipment classification	According to the definition 15.3 (o) EUT is a **Intentional Radiator operating within the bands 2400 ÷ 2483.5 MHz** so it shall fulfill provisions of 47CFR Part 15 Subpart C – Intentional radiators – and Section 15.249

Type of equipment	Electronic position indicator system with 2.4 GHz module integrated
Operating frequency:	2400 ÷ 2483.5 MHz
Maximum RF radiated power:	82.92 dBuV/m
Modulation:	MSK modulation
Channel Spacing:	200 kHz
Antenna:	Integral on PCB

4. TEST CONFIGURATION OF UNIT UNDER TEST

EUT PORTS



Port	Description	Max length
Enclosure	Plastic	
AC power	/	/
DC power	3 V DC	/
Earth	/	/
Telecommunication	/	/
Signal	/	/
Control	/	/
Antenna	Internal	/

STATE OF THE EUT DURING TESTS

Ref.	Mode	Description
#1	Operating	Continuous transmission (single channel transmission) 3V DC battery supply The EUT is in continuously transmitting at the highest power with 100% approximately duty cycle.

SUPPORT EQUIPMENT

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

Equipment	Manufacturer	Model
/	/	/

ELECTROMAGNETICALLY RELEVANT COMPONENTS

Component	No.	Manufacturer	Model
Main board	1	ELESA	T689 V1.0
Battery board	1	ELESA	T867 V1.0
Control board	1	ELESA	T690 V1.0
Radio module	1	TEXAS INSTRUMENTS	CC2500

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	2021-02-01

Antenna specifications	
N° of authorized antenna types	1
Antenna type	Integral on PCB
Maximum total 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	2400 ÷ 2483.5 MHz
RBW bandwidth	1 MHz
VBW bandwidth	3 MHz
Detector	Peak, Average
EUT operating condition	#1
Testing dates	2021-01-29

LIMITS

Band of operations	Peak (dBμV/m)	Average Limit (dBμV/m)
Restricted bands (§ 15.205)	74	54

TEST PROCEDURE

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.

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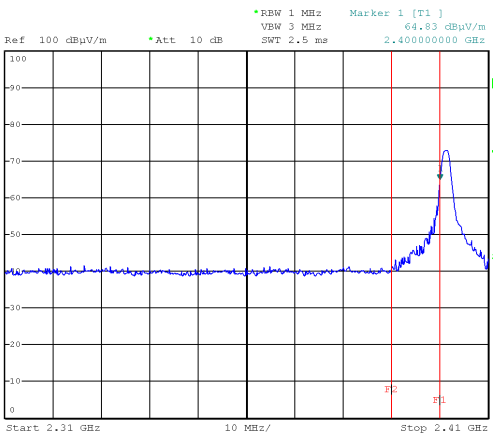
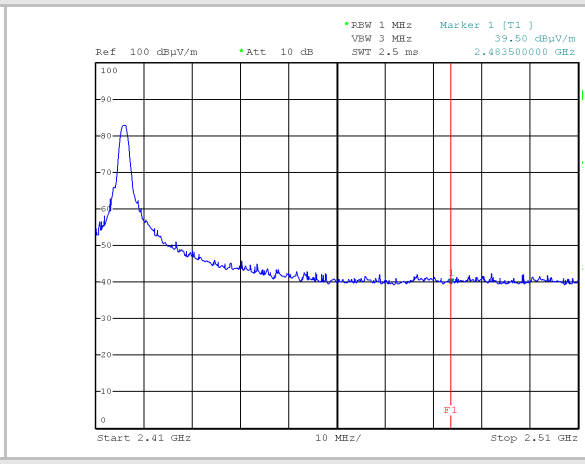
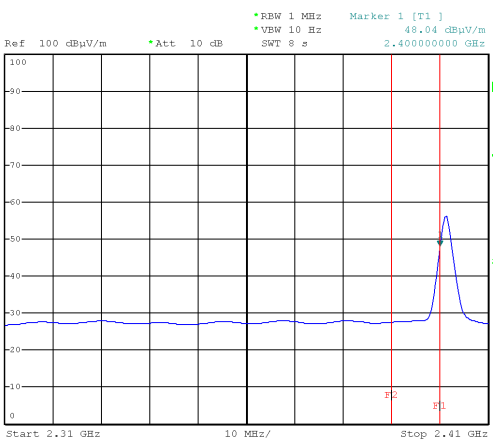
MEASUREMENTS RESULTS AT LOWEST AND HIGHEST FREQUENCY TRANSMISSION

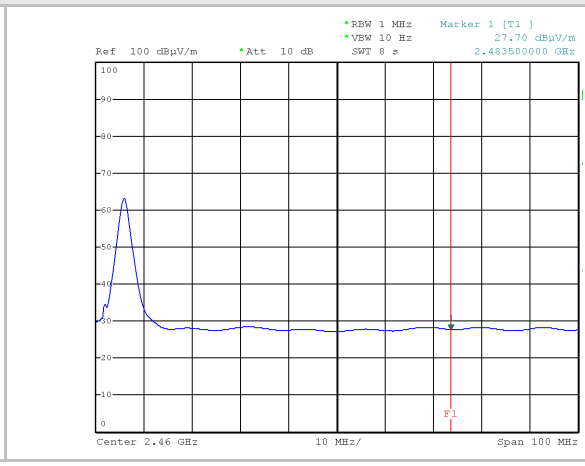
Peak measurements (V polarization)





Average measurements (V polarization)





Spurious Emission in restricted band near 2400-2483.5 MHz

Detector	Frequency (GHz)	Reading value (dBµV)	Antenna Factor (dB@3m)	Cable Loss (dB)	Pre-Amp. Gain (dB)	Correcting reading (dBµV/m)	PK Limit (µV/m)	PK Limit (dBµV/m)	Margin (dB)
PEAK	2.4000	59.74	27.3	5.18	-37.57	64.83	5000	74	9.17
	2.4835	34.51	27.4	5.18	-37.57	39.50	5000	74	34.50
AVERAGE	2.4000	42.95	27.3	5.18	-37.57	48.04	500	54	5.96
	2.4835	22.71	27.4	5.18	-37.57	27.70	500	54	26.30

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	2021-01-29 ÷ 2021-02-01

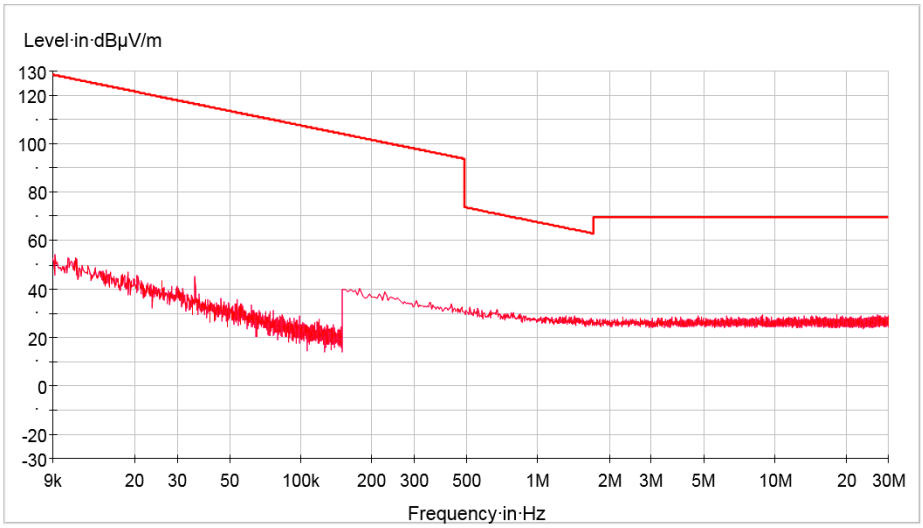
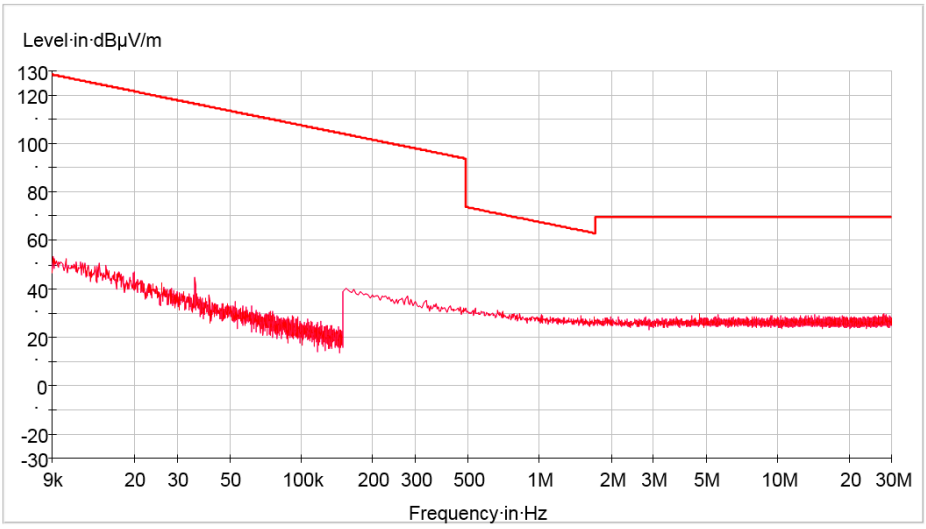
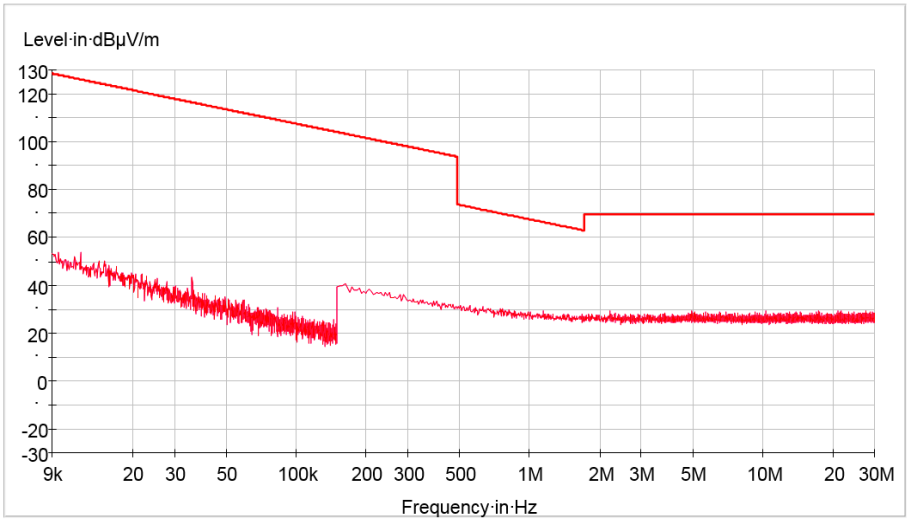
LIMITS		
Band of operations	**Peak Limit (dBµV/m)**	**Average Limit (dBµV/m)**
Restricted bands (§ 15.205)	74	54
Other bands	According to § 15.209 or fundamental – 50dB (whichever is the lesser attenuation)	According to § 15.209 or fundamental – 50dB (whichever is the lesser attenuation)

TEST PROCEDURE

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 ≥ Q.P. limit – 6 dB (♦ mark symbol).

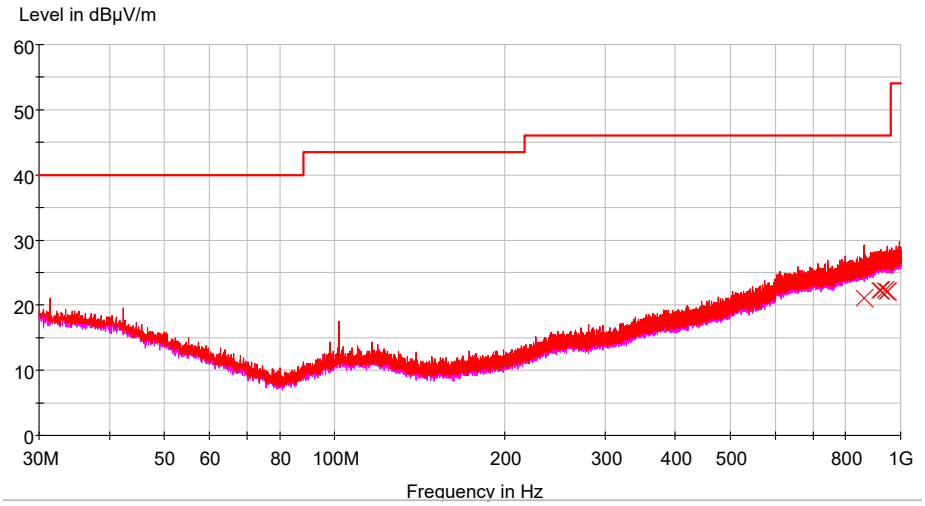
NOTE

The product falls into class A. In any case, class B limits are included in the report, which are more restrictive than class A.

Worst case measurement result 9 kHz÷30 MHz	
LOWER CHANNEL	
MIDDLE CHANNEL	
HIGHER CHANNEL	

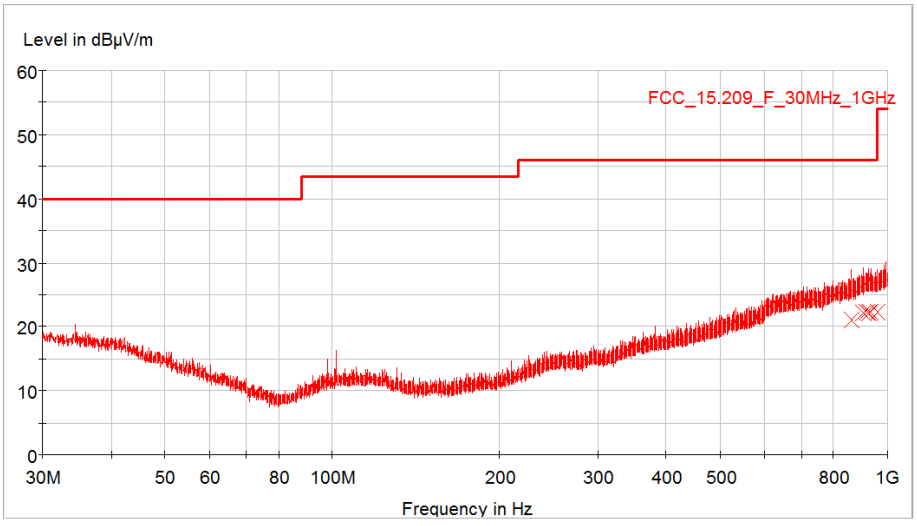
Worst case measurement result 30÷1,000 MHz

LOWER CHANNEL



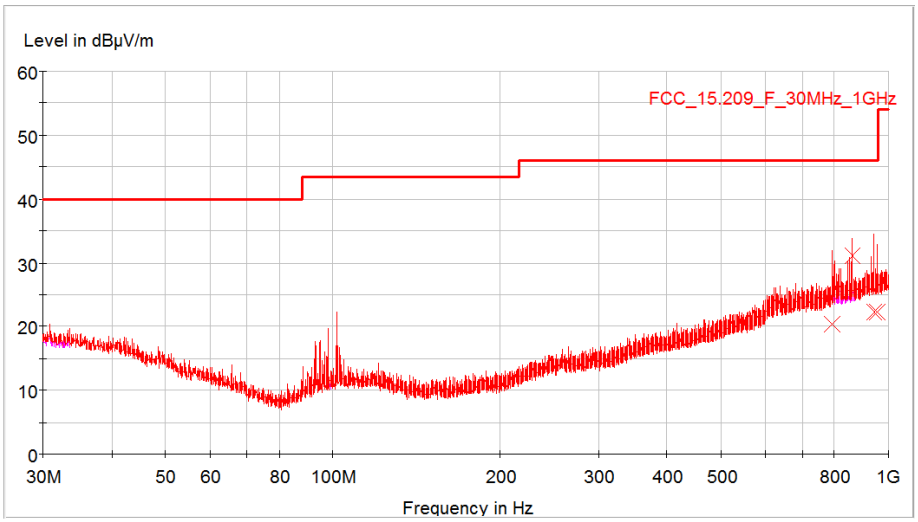
Frequency (MHz)	Peak (dBµV/m)	Polarization	Margin. (dB)
860.720000	21.1	H	24.9
918.000000	22.3	H	23.7
920.240000	22.3	H	23.7
938.560000	22.3	V	23.7
948.400000	22.2	H	23.8
949.320000	22.2	H	23.8

MIDDLE CHANNEL



Frequency (MHz)	Peak (dBµV/m)	Polarization	Margin. (dB)
860.720000	21.1	H	24.9
906.600000	22.0	H	24.0
916.840000	22.3	V	23.7
927.800000	22.2	H	23.8
931.040000	22.3	V	23.7
959.000000	22.2	H	23.8

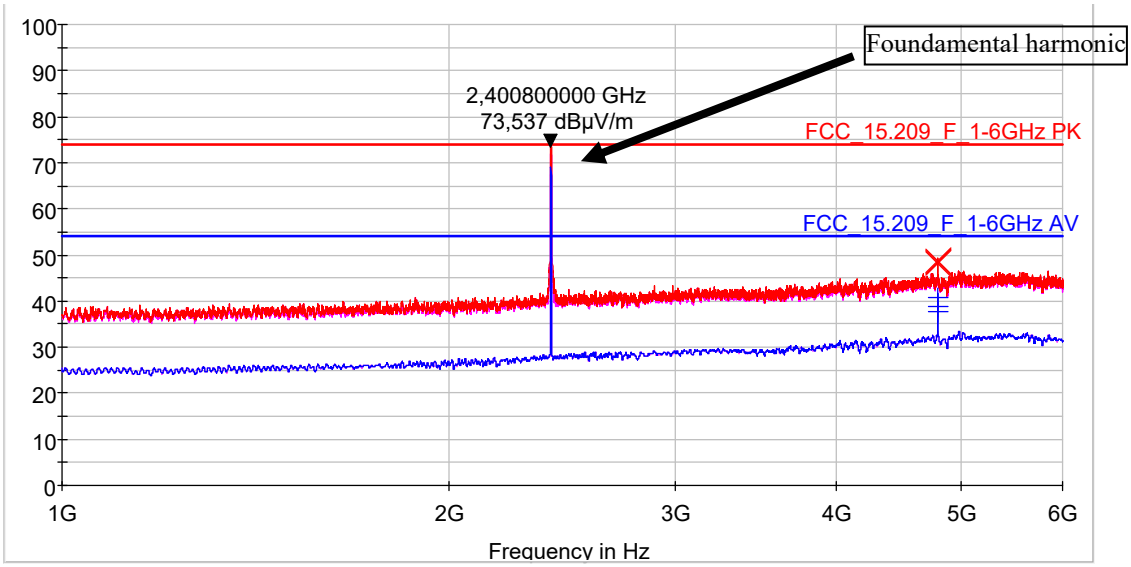
HIGHER CHANNEL



Frequency (MHz)	Peak (dBµV/m)	Polarization	Margin (dB)
791.200000	20.4	H	25.6
861.040000	31.1	H	14.9
942.000000	22.2	H	23.8
942.080000	22.2	H	23.8
956.560000	22.2	H	23.8
956.600000	22.3	H	23.7

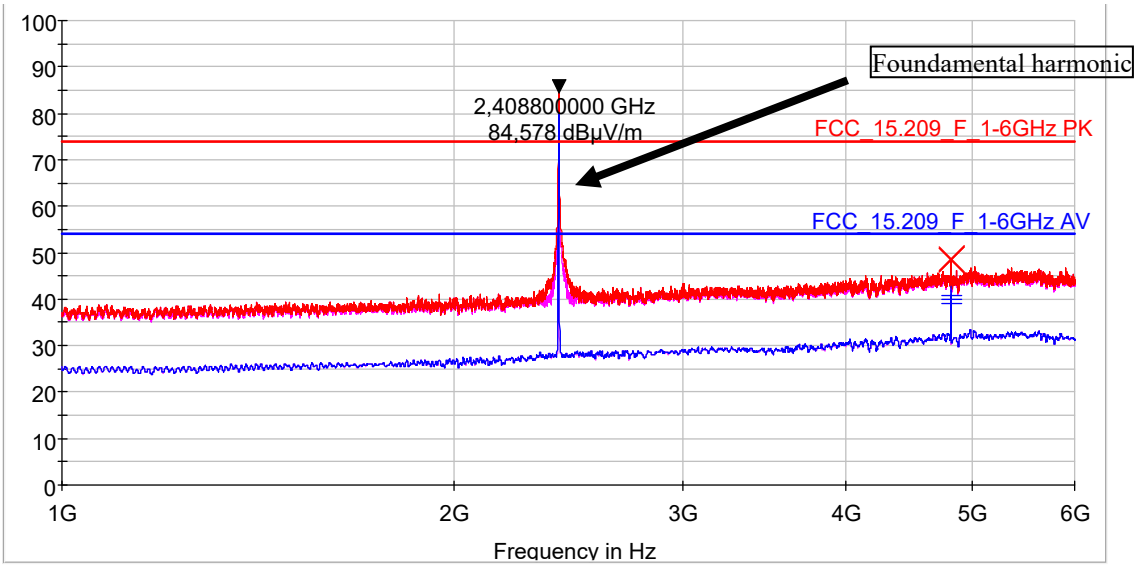
Worst case measurement result 1-6 GHz

LOWER CHANNEL



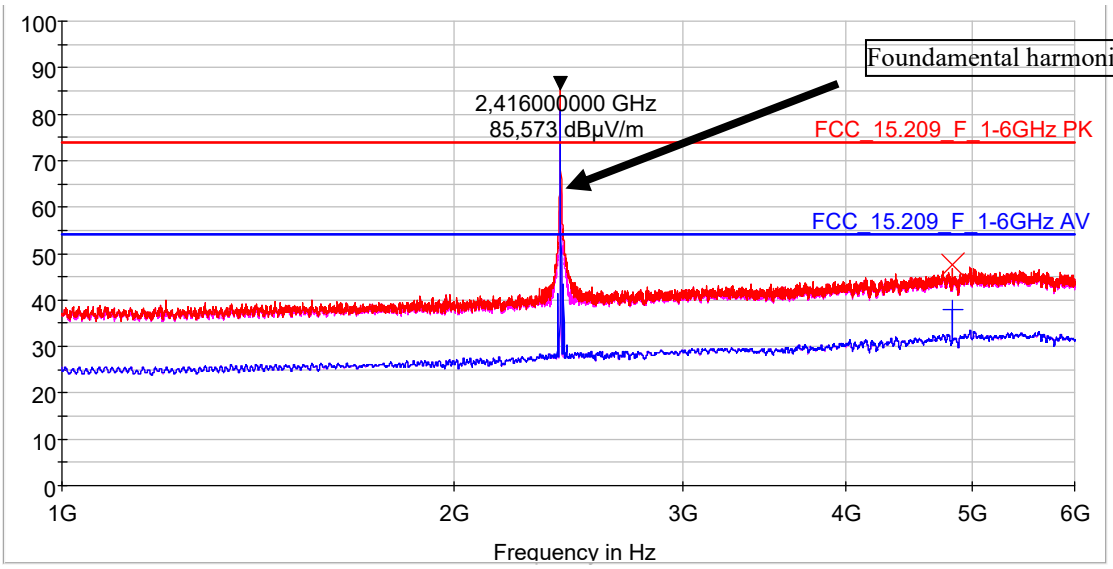
Frequency (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Polarization	Margin P (dB)	Margin AV (dB)
4802.000000	48.4	38.9	H	25.6	15.1
4802.400000	48.6	40.8	H	25.4	13.2
4802.800000	48.2	37.8	H	25.2	16.2

MIDDLE CHANNEL

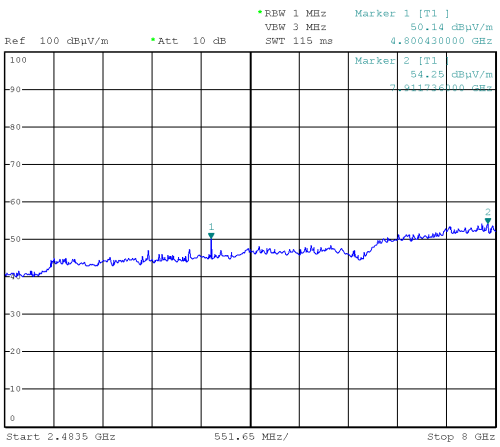
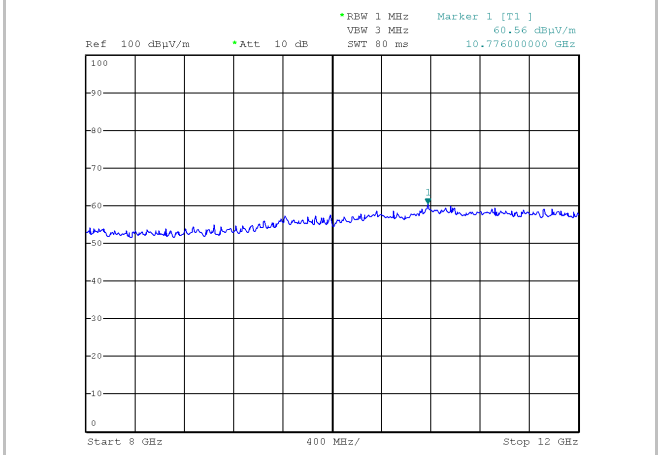
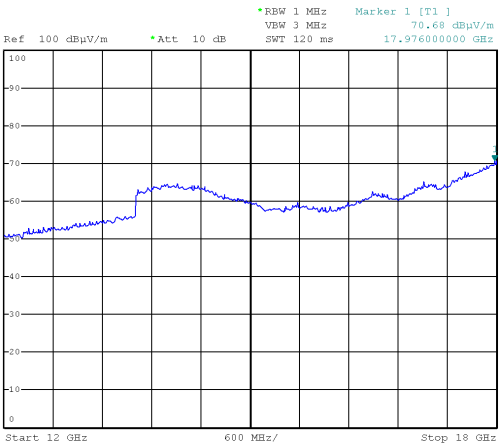
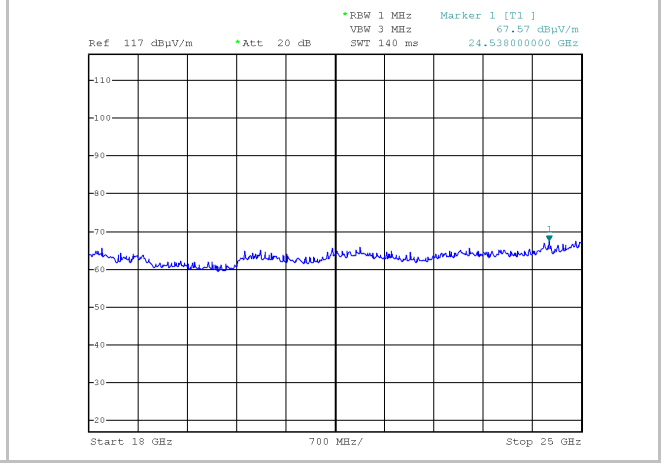


Frequency (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Polarization	Margin P (dB)	Margin AV (dB)
4817.200000	48.6	39.9	H	25.4	14.1
4817.600000	48.5	40.8	H	25.5	13.2
4818.000000	48.4	39.1	H	25.6	14.9

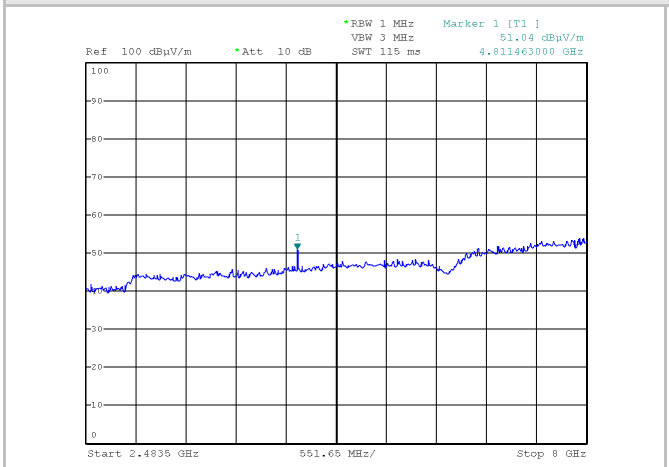
HIGHER CHANNEL

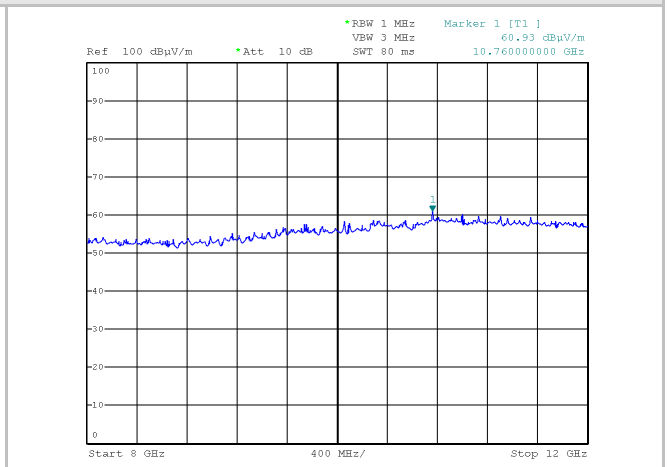


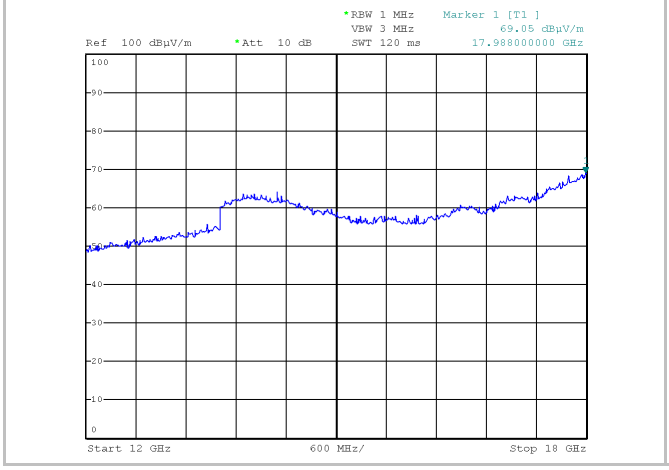
Frequency (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Polarization	Margin P (dB)	Margin AV (dB)
4832.000000	47.5	38.0	H	26.5	16.0

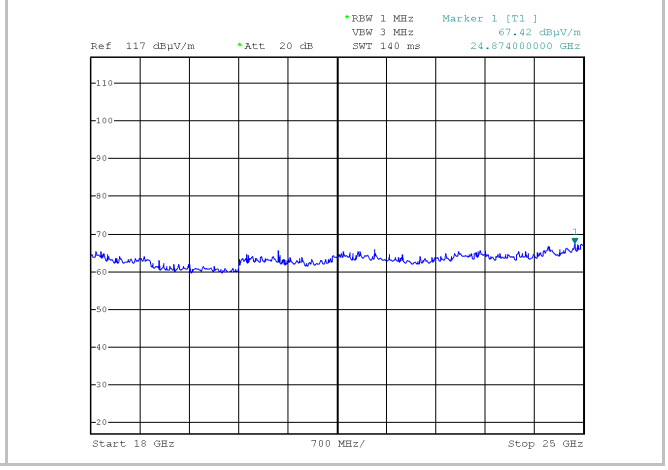
Worst case measurement result >6,000 MHz (Peak) (H polarization)	
LOWER channel	
	
	

MIDDLE channel









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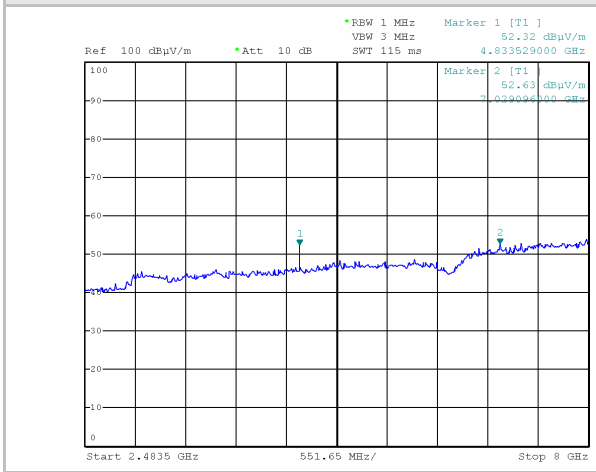
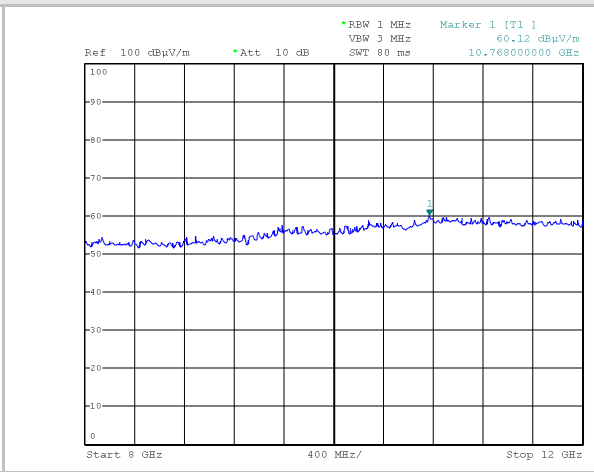
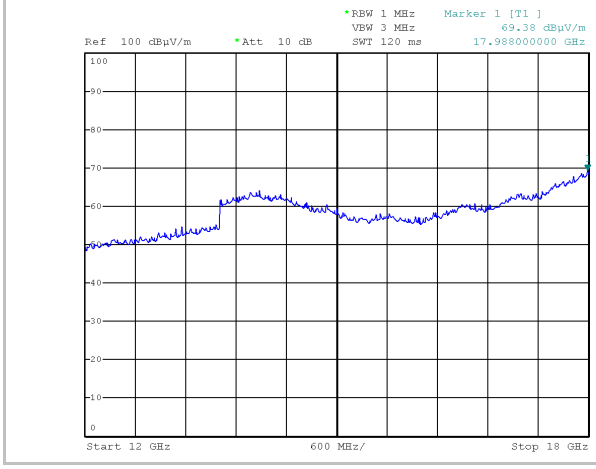
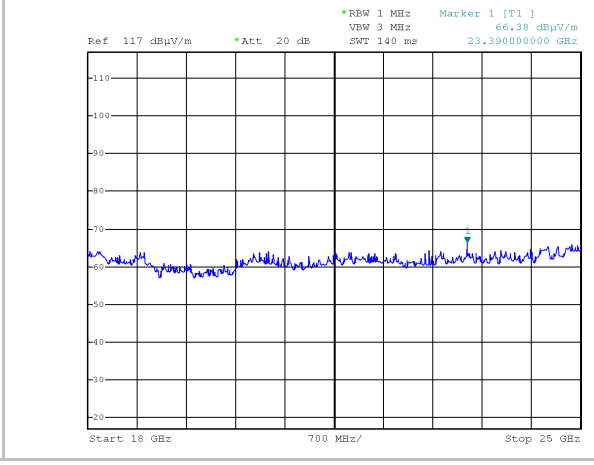
HIGHER channel



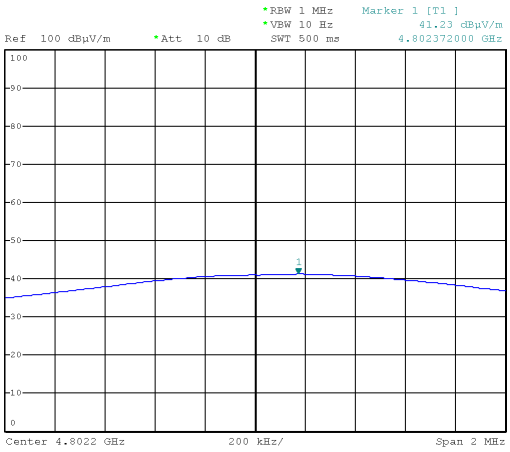


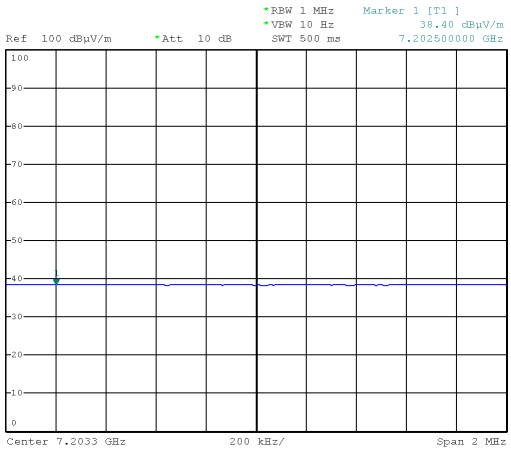




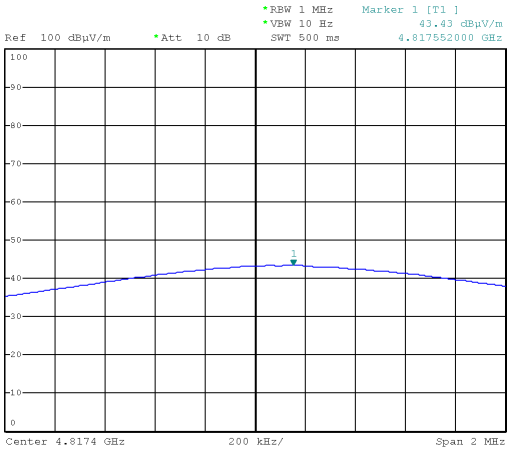
Worst case measurement result (Average)
(H polarization)

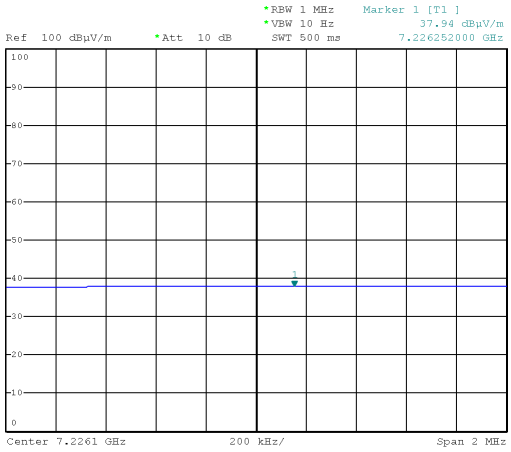
LOWER channel



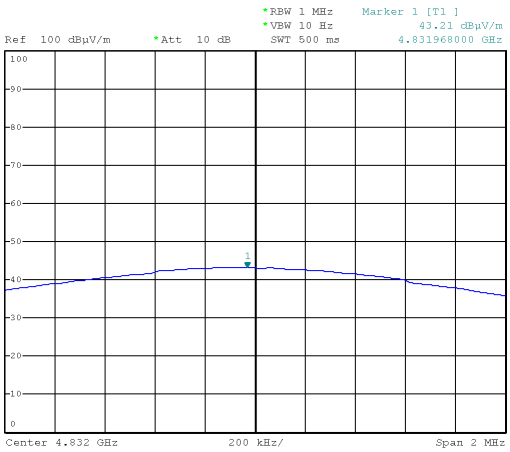


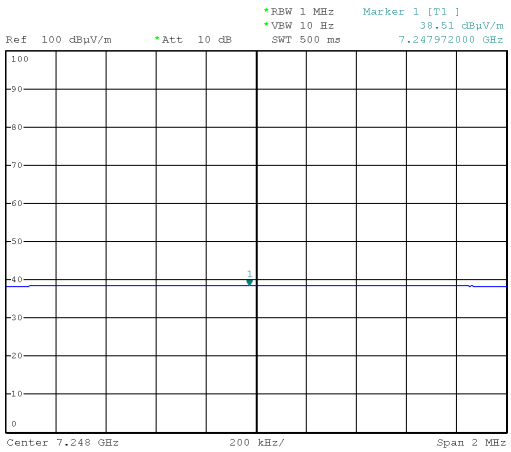
MIDDLE channel





HIGHER channel





Worst case measurement result >6,000 MHz (PK & AV)

PEAK RESULT (RBW=1MHz; VBW=3MHz)								
Frequency	Reading value	Antenna Factor	Cable Loss	Pre-Amp. Gain	Correct reading	PK Limit (AV + 20dB)		Margin
(MHz)	(dBµV)	(dB@3m)	(dB)	(dB)	(dBµV/m)	(µV/m)	(dBµV/m)	(dB)
f>6000 (lower channel)	No significant values were found					5000	74	/
f>6000 (middle channel)	No significant values were found					5000	74	/
f>6000 (higher channel)	No significant values were found					5000	74	/

AVERAGE RESULT (RBW=1MHz; VBW=10Hz)								
Frequency	Reading Value	Antenna Factor	Cable Loss	Pre-Amp. Gain	Correct reading	AV Limit		Margin
(MHz)	(dBµV)	(dB@3m)	(dB)	(dB)	(dBµV/m)	(µV/m)	(dBµV/m)	(dB)
f>6000 (lower channel)	No significant values were found (see also above plots)					500	54	/
f>6000 (middle channel)	No significant values were found (see also above plots)					500	54	/
f>6000 (higher channel)	No significant values were found (see also above plots)					500	54	/
See above the measurements plots.								

TEST RESULT

The EUT has been tested in 3 orthogonal axes at the frequencies lowest, middle and highest for each modulation with H and V polarization antenna.

The results reported are worst case.

The worst Average measures are reported. The whole radio spectrum was analyzed on Average up to 25 GHz without finding relevant spurious beyond the limits.

No significant values were found in receiver mode through careful preliminary scans.

The EUT meets the requirements.

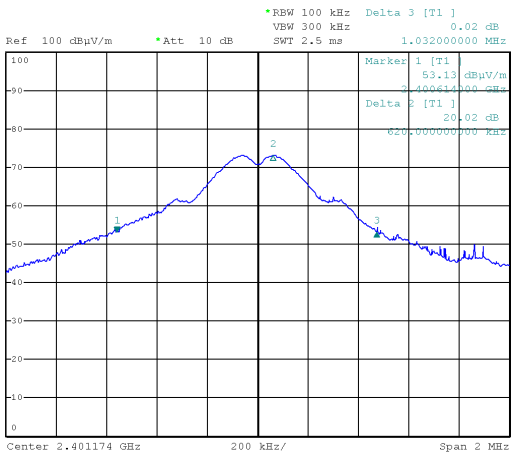
7.4 BANDWIDTH OF EMISSIONS (20 dB BANDWIDTH)

TEST REQUIREMENT	
Spectrum analyzer settings	
Span	Wide enough to capture the peak level of the emission operating on the channel
Resolution bandwidth (RBW)	100 kHz
Video bandwidth (VBW)	300 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	2021-01-29

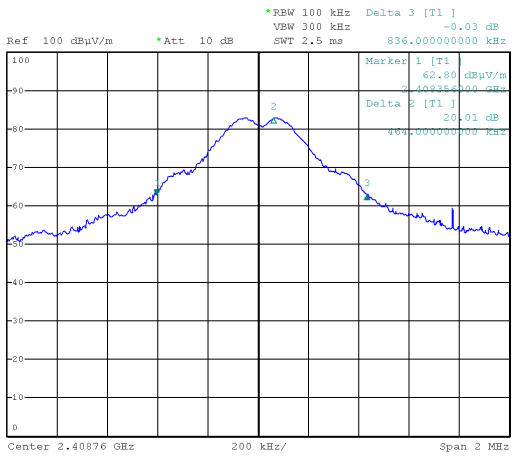
MEASUREMENTS RESULTS

Channel (No.)	Frequency (GHz)	Channel Bandwidth (MHz)	Plot (No.)
Low	2.401	1.032	1
Middle	2.407	0.836	2
High	2.416	0.916	3

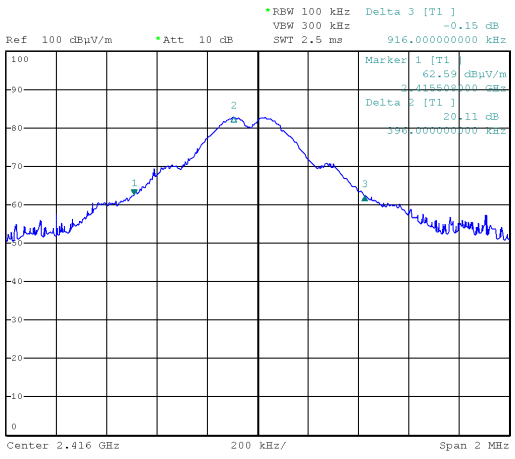
Lowest frequency



Middle frequency



Highest frequency



/

7.6 FIELD STRENGTH OF FUNDAMENTAL

TEST REQUIREMENT	
Spectrum analyzer settings	
Span	Wide enough to capture the peak level of the emission
Resolution bandwidth (RBW)	1 MHz
Video bandwidth (VBW)	Auto
Sweep time (SWT)	Auto
Detector function	Peak
Trace	Max hold
Attenuator	/
Deviation to test procedure	None
EUT operating condition	#1
Remark	None
2021-01-29	2021-01-29

TEST PROCEDURE

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 and EUT positioned in 3 orthogonal axes.
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.

LIMITS

94 dBµV/m

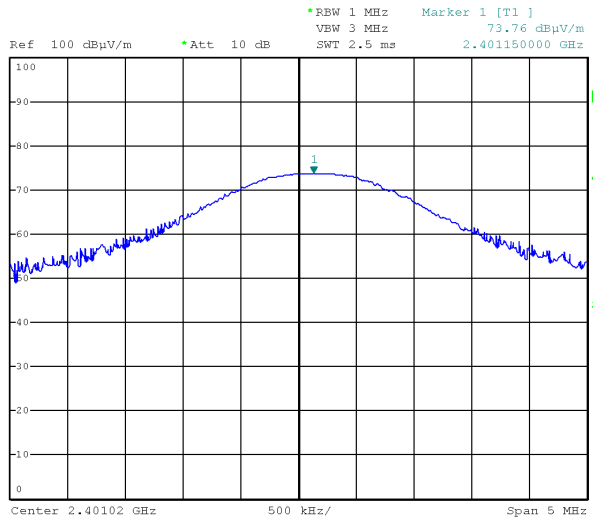
TEST RESULT

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

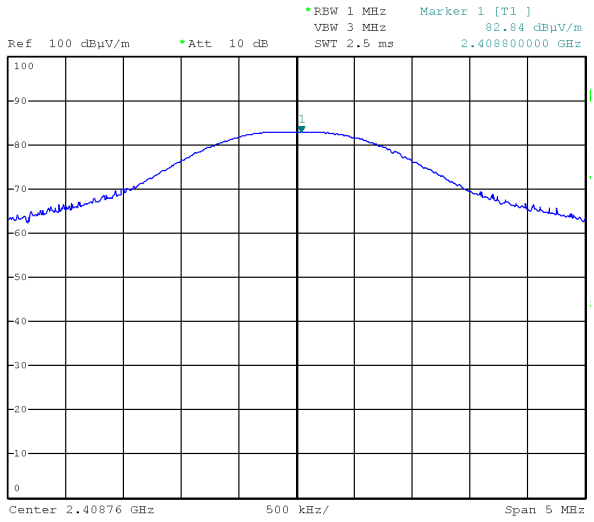
MEASUREMENTS RESULTS – WORST CASE VERTICAL POLARIZATION

Channel (No.)	Frequency (GHz)	Reading Power (dBm)	Correction Factor (dB)	Measured Output Power (dBm)	Output Power (dBuV/m)
Low	2.401	-28.79	7.32	-21.47	73.76
Middle	2.407	-19.24	6.85	-12.39	82.84
High	2.416	-19.40	7.09	-12.31	82.92

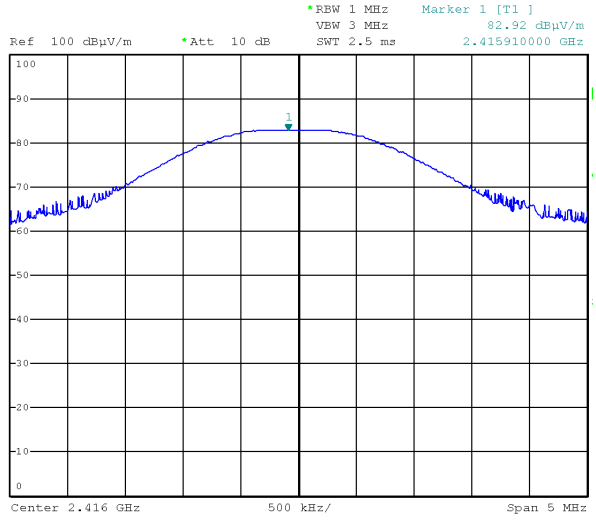
Lowest frequency



Middle frequency



Highest frequency



/

7.7 FIELD STRENGTH OF HARMONICS

TEST REQUIREMENT	
Spectrum analyzer settings	
Resolution bandwidth (RBW)	1 MHz
Detector function	Peak
Trace	Max hold
Attenuator	/
Deviation to test procedure	None
EUT operating condition	#1
Remark	None
Testing dates	2021-01-29

TEST PROCEDURE

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 1 MHz.
5) The receiving antenna was positioned in both horizontal and vertical polarization.

MEASUREMENTS RESULTS AT LOWEST FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4800	V	Peak	48.51	1.63	50.14	74	23.86

MEASUREMENTS RESULTS AT MIDDLE FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4822	V	Peak	49.36	1.68	51.04	74	22.96

MEASUREMENTS RESULTS AT HIGHEST FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4833	V	Peak	50.60	1.72	52.32	74	21.68

MEASUREMENTS RESULTS AT LOWEST FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4800	V	Average	40.30	1.63	41.93	54	12.07

MEASUREMENTS RESULTS AT MIDDLE FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4814	V	Average	41.66	1.68	43.34	54	10.66

MEASUREMENTS RESULTS AT HIGHEST FREQUENCY TRANSMISSION							
Frequency MHz	Antenna polarization	Detector	Receiver reading dBµV	Correction factor dB	Final value dBµV/m	Limit dBµV/m	Margin dB
4833	V	Average	41.49	1.72	43.21	54	10.79

TEST RESULT
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).

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.

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
Radiated disturbance	QP detector (30 MHz - 100 MHz) H polarization	4.0	dB	95%
	QP detector (30 MHz - 100 MHz) V polarization	3.9	dB	95%
	QP detector (100 MHz - 200 MHz) H polarization	2.9	dB	95%
	QP detector (100 MHz - 200 MHz) V polarization	4.0	dB	95%
	QP detector (200 MHz - 1000 MHz) H polarization	3.5	dB	95%
	QP detector (200 MHz - 1000 MHz) V polarization	3.4	dB	95%
	P detector 1-6 GHz	4.3	dB	95%
	P detector 6 – 18 GHz	4.8	dB	95%
	P detector 18-26 GHz	4.9	dB	95%

9. LIST OF MEASURING EQUIPMENT AND CALIBRATION INFORMATION

Instrument	Manufacturer	Model	IMQ Ref.	Cal. Date	Cal. Due
Shielded semi-anechoic chamber	SIDT	/	P01709	2019-10-21	2021-10-31
Turntable controller unit	FRANKONIA	FCTAM01	P02486	/	/
Mast antenna	FRANKONIA	FAM4	P02488	/	/
Log antenna	ARA	LPB-2513	S02385	2020-07-20	2021-07-31
Horn Antenna	SCHWARZBECK	BBHA 9120D	S03463	2020-07-06	2021-07-31
Loop Antenna	ROHDE & SCHWARZ	HFH2-Z2	S02508	2020-08-18	2021-08-31
Spectrum Analyzer	Rohde & Schwarz	FSP40	S03629	2020-12-10	2021-12-31
Preamplifier	Hewlett Packard	HP 8449B	S03542	2020-04-05	2021-04-30
Software	ROHDE & SCHWARZ	EMC32 Ver. 6.30	W-00199/E	/	/
PC	/	/	H-00165	/	/

END OF TEST REPORT