



Report No. 359040

FCC TEST REPORT / IC TEST REPORT

Product	Radio Data Modem	
Name and address of the applicant	Multiplex Modellsport GmbH & Co. KG Westliche Gewerbestr. 1 D – 75015 Bretten-Gölshausen (Germany)	
Name and address of the manufacturer	Multiplex Modellsport GmbH & Co. KG Westliche Gewerbestr. 1 D – 75015 Bretten-Gölshausen (Germany)	
Model	QBaseModem	
Rating	3.3 Vdc	
Trademark	MULTIPLEX	
Serial number	/	
Additional information	915 MHz FHSS Transceiver.	
Tested according to	FCC Part 15.247 Frequency Hopping Transmitters / Digital Transmission Systems Industry Canada RSS-247, Issue 2 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices	
Report number	359040	
Tested in period	2018-08-23 - 2018-11-14	
Issue date	2019-02-07	
Name and address of the testing laboratory	Nemko GmbH & Co. KG Reetzstraße 58 D-76327 Pfinztal Tel.: + 49 (0) 7240 – 63 - 0 Fax: + 49 (0) 7240 – 63 - 11	 Bundesnetzagentur ENetza-CAB-17/21-17 FCC No: 973501 IC OATS: 10921A-1
 Prepared by [Dipl.-Ing. M. Korny]  Approved by [Dipl.-Ing. P. Lukas]		

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1 INFORMATION

1.1 Test Item

Name :	Multiplex
FCC ID :	2APABQBASE
Industry Canada ID :	23810-QBASE
Model/version :	QBaseModem
Frequency Range :	902 - 928 MHz
Tunable Bands :	None
Number of Channels:	100
Operating Modes :	Transceiver
Type of Modulation :	FHSS / FSK
User Frequency Adjustment :	None
Output Power (radiated):	269.23 mW
Type of Power Supply Ground modem:	5Vdc (USB) via AC/DC converter with USB connector
Type of Power Supply Air modem:	6.4Vdc via LiFePo Battery with two cells
Antenna Connector :	SMA-RP (Ground modem) / fixed (Air modem)
Antenna Diversity Supported :	No

Description of Test Item

The EUT is a transceiver, operating in the 915 MHz band. It is designed for high performance data transmission over long distances. The EUT uses a standard TTL UART interface for Data communication. The EUT can be soldered onto two different supporting PCBs. A voltage regulator 5V dc to 3.3V dc, interface connector and RF connector is located on each supporting PCB. Communication is bi-directional.

Theory of Operation

The QBaseModem is a bidirectional FHSS-system with 100 channels. The Modem is hopping over 50 channels. The user can select using the lower 50 channels (1 to 50) or the upper 50 channels (51 to 100)

1.2 Normal test conditions

Temperature: 20 - 26 °C
Relative humidity: 45 - 55 %
Normal test voltage: 5.0 Vdc (Ground modem); 6.4 Vdc (Air modem)

The values are the limit registered during the test period. All tests were performed with fully charged batteries.

1.3 Test Engineer(s)

Markus Korny

1.4 Description of modification for Modification Filing

Not applicable.

1.5 Family List Rational

Not Applicable.

1.6 Antenna Requirement (Ground modem)

Is the antenna detachable?

☒ Yes ☐ No

If detachable, is the antenna connector non-standard?

☒ Yes ☐ No

Type of antenna connector: SMA-RP

Ref. FCC §15.203

1.7 Antenna Requirement (Air modem)

Is the antenna detachable?

☐ Yes ☒ No

If detachable, is the antenna connector non-standard?

☐ Yes ☐ No

Type of antenna connector: -

Ref. FCC §15.203

1.8 Worst-Case Configuration and Mode

Radiated Emissions was performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.

1.9 Test Setup Configuration

The EUT can be soldered onto two different supporting PCBs. Because the RF connector is located on the supporting PCB, two different setup configurations have been fully tested.

- 1.) Air modem setup:
Radio module soldered onto the supporting PCB (Air).
Supporting PCB contains voltage regulation, RF-connector, data connector and RF-ground plane. Power supply via fully charged LiFePo Battery with two cells (6.4 Vdc).
Radiated spurious emissions measured with 50Ohm terminator at the antenna port.
- 2.) Ground modem setup:
Radio module soldered onto the supporting PCB (Ground).
Supporting PCB contains voltage regulation, RF-connector, USB converter and USB connector. Power supply via AC/DC converter with USB connector.
Radiated spurious emissions measured with 50Ohm terminator at the antenna port.

1.10 Comments

And the output level is set to maximum in the software.

The radiated measurements are tested on three axes.

All ports were populated during spurious emission and power line conducted measurements.

At the Ground modem, the measurements were done with the EUT powered by 115 V AC. It was checked that power variations between 85% and 115% did not have any influence on the measurements.

2 TEST REPORT SUMMARY

2.1 General

All measurements are traceable to national standards.

The tests were conducted for the purpose of demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and Industry Canada RSS-247 Issue 2.

Tests were performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

Radiated tests were performed in a semi-anechoic shielded room ($f < 1$ GHz) and a fully-anechoic shielded room ($f > 1$ GHz) at a measuring distance of 3m.

A description of the test facility is on file with the FCC and Industry Canada.

☒ New Submission

☒ Production Unit

☐ Class II Permissive Change

☐ Pre-production Unit

DSS Equipment Code

☐ Family Listing



THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.

Deviations from, additions to, or exclusions from the test specifications are described in "Summary of Test Data".

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2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 2, RSS-GEN Issue 5 reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	Complies
Number of Operating Frequencies	15.31(m)	5.1 (6) (RSS-247)	Complies
Antenna Requirement	15.203	6.8 (RSS-GEN)	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	8.8 (RSS-GEN)	Complies
Channel Separation	15.247(a)(1)	5.1 (4) (RSS-247)	Complies
Pseudorandom Hopping Algorithm	15.247(a)(1)	5.1 (3) (RSS-247)	Complies
Time of Occupancy	15.247(a)(1)(i)	5.1 (5) (RSS-247)	Complies
Occupied Bandwidth	15.247(a)(1)	5.1 (7) (RSS-247)	Complies
99% OCC-BW	N/A	6.7 (RSS-GEN)	-
Minimum 6 dB Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	N/A ¹
Peak Power Output	15.247(b)	5.4 (RSS-247)	Complies
Power Spectral Density	15.247(d)	5.2 (2) (RSS-247)	N/A ¹
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	Complies
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 6.13 (RSS-GEN) 8.9 (RSS-GEN)	Complies

¹ Not applicable for FHSS equipment

- Only for information

3 TEST RESULTS

3.1 Power Line Conducted Emissions

Para. No.: 15.207 (a)/8.8

Test Performed By: Markus Korny

Date of Test: 2018-11-14

Measurement procedure: ANSI C63.4-2014 using 50 μ H/50 ohms LISN.

Test Results: Complies.

Measurement Data: See attached graph.

AC/DC adapter type: MPX Model: KSAPK0110110500150HE

Input voltage to AC/DC adapter: 115V/60Hz

Highest measured value (L1 and N):

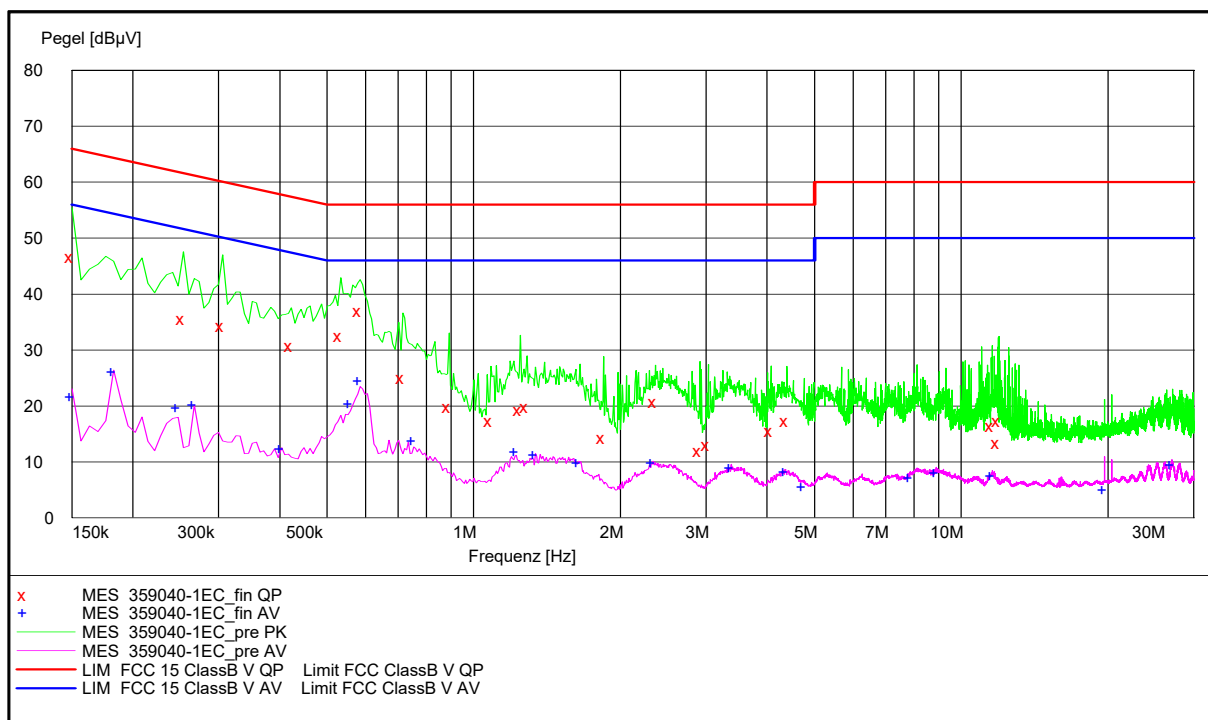


Diagram (Ground modem)

Final measurements QP with Quasi-Peak-Detector (Ground modem):

Frequenz MHz	Pegel dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.150000	46.60	10.00	66.00	19.40	L1	FLO
0.254000	35.60	10.00	61.60	26.10	N	FLO
0.306000	34.40	10.00	60.10	25.60	N	FLO
0.423000	30.80	10.00	57.40	26.60	N	FLO
0.533500	32.50	10.00	56.00	23.50	N	FLO
0.585500	37.00	10.00	56.00	19.00	L1	FLO
0.715500	25.10	10.00	56.00	30.90	N	FLO
0.891000	19.80	10.00	56.00	36.20	L1	FLO
1.086000	17.30	10.00	56.00	38.70	L1	FLO
1.248500	19.30	10.00	56.00	36.70	N	FLO
1.287500	19.90	10.00	56.00	36.10	N	FLO
1.846500	14.30	10.10	56.00	41.70	N	FLO
2.360000	20.70	10.10	56.00	35.30	L1	FLO
2.912500	12.10	10.10	56.00	43.90	N	FLO
3.029500	13.00	10.10	56.00	43.00	N	FLO
4.076000	15.50	10.20	56.00	40.50	L1	FLO
4.394500	17.40	10.20	56.00	38.60	N	FLO
11.583500	16.50	10.60	60.00	43.50	L1	FLO
11.915000	13.40	10.60	60.00	46.60	N	FLO
11.973500	17.30	10.60	60.00	42.70	L1	FLO

Final measurements AV with Average-Detector (Ground modem):

Frequenz MHz	Pegel dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.150000	21.60	10.00	56.00	34.40	L1	FLO
0.182500	26.10	10.00	54.40	28.30	N	FLO
0.247500	19.70	10.00	51.80	32.20	L1	FLO
0.267000	20.10	10.00	51.20	31.10	L1	FLO
0.403500	12.30	10.00	47.80	35.50	L1	FLO
0.559500	20.40	10.00	46.00	25.60	L1	FLO
0.585500	24.40	10.00	46.00	21.60	L1	FLO
0.754500	13.80	10.00	46.00	32.20	L1	FLO
1.222500	11.90	10.00	46.00	34.10	L1	FLO
1.339500	11.20	10.00	46.00	34.80	L1	FLO
1.645000	9.90	10.10	46.00	36.10	L1	FLO
2.334000	9.90	10.10	46.00	36.10	L1	FLO
3.380500	8.90	10.20	46.00	37.10	L1	FLO
4.362000	8.20	10.20	46.00	37.80	L1	FLO
4.758500	5.60	10.20	46.00	40.40	L1	FLO
7.865500	7.20	10.40	50.00	42.80	L1	FLO
8.892500	8.00	10.50	50.00	42.00	L1	FLO
11.603000	7.50	10.60	50.00	42.50	L1	FLO
19.676000	5.10	11.10	50.00	44.90	L1	FLO
27.099000	9.50	11.00	50.00	40.50	L1	FLO

3.2 Channel Separation

Para. No.: 15.247 (a)(1)

Test Performed By: Markus Korny	Date of Test: 2018-08-23, 2018-09-06
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Test Results: Complies

Measurement Data:

Ground modem:

Channel Separation	230.1 kHz
Nominal value for Channel Separation	230 kHz
20 dB BW of hopping channel 1, 903.213 MHz	131.69 kHz
20 dB BW of hopping channel 50, 914.483 MHz	111.43 kHz
20 dB BW of hopping channel 100, 927.008 MHz	136.76 kHz

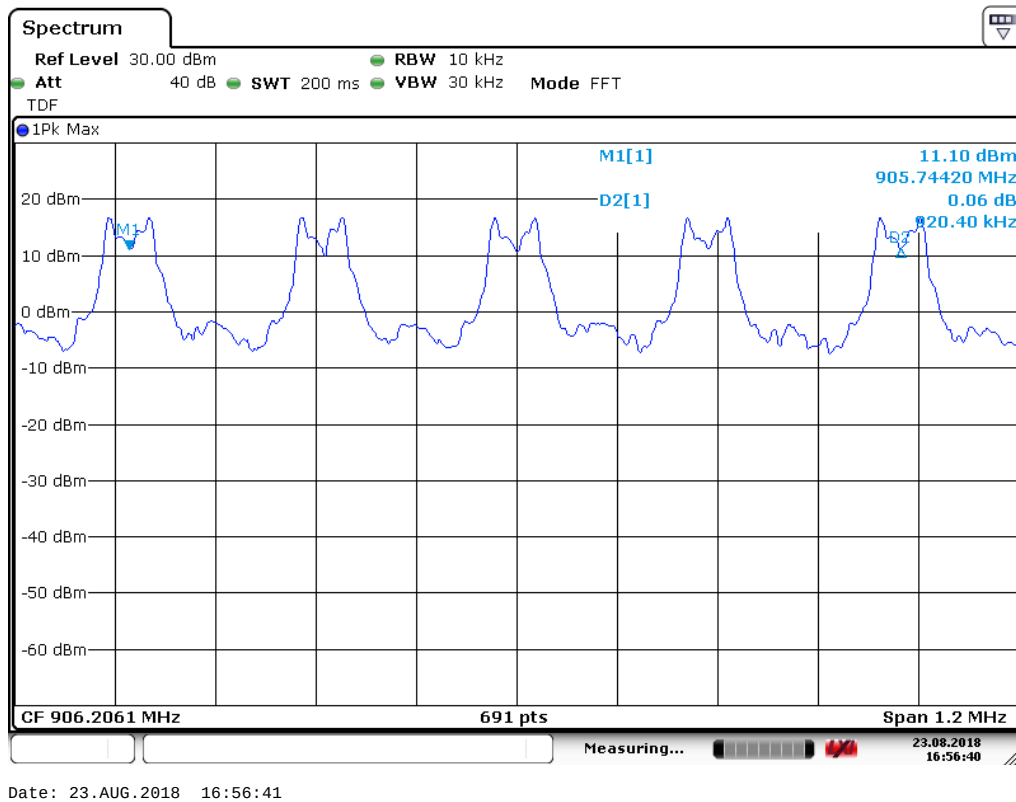
Air modem:

Channel Separation	230.1 kHz
Nominal value for Channel Separation	230 kHz
20 dB BW of hopping channel 1, 903.213 MHz	81.77 kHz
20 dB BW of hopping channel 50, 914.483 MHz	91.17 kHz
20 dB BW of hopping channel 100, 927.008 MHz	86.11 kHz

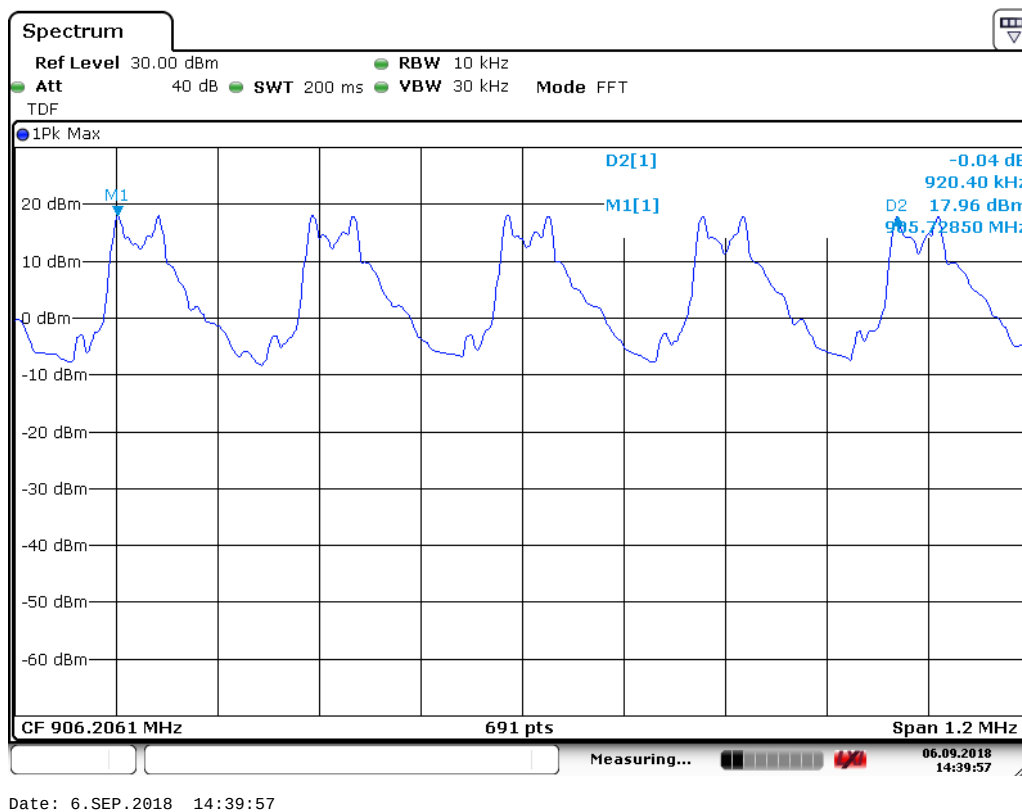
Fully charged battery is used

Requirements:

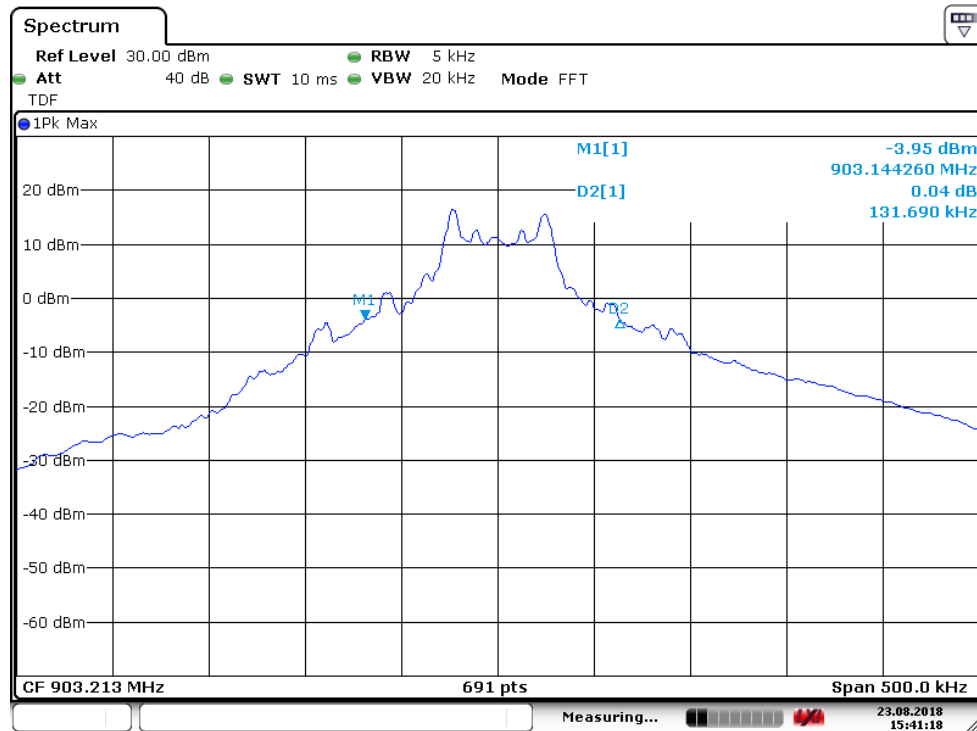
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.



Channel Separation (Ground modem)

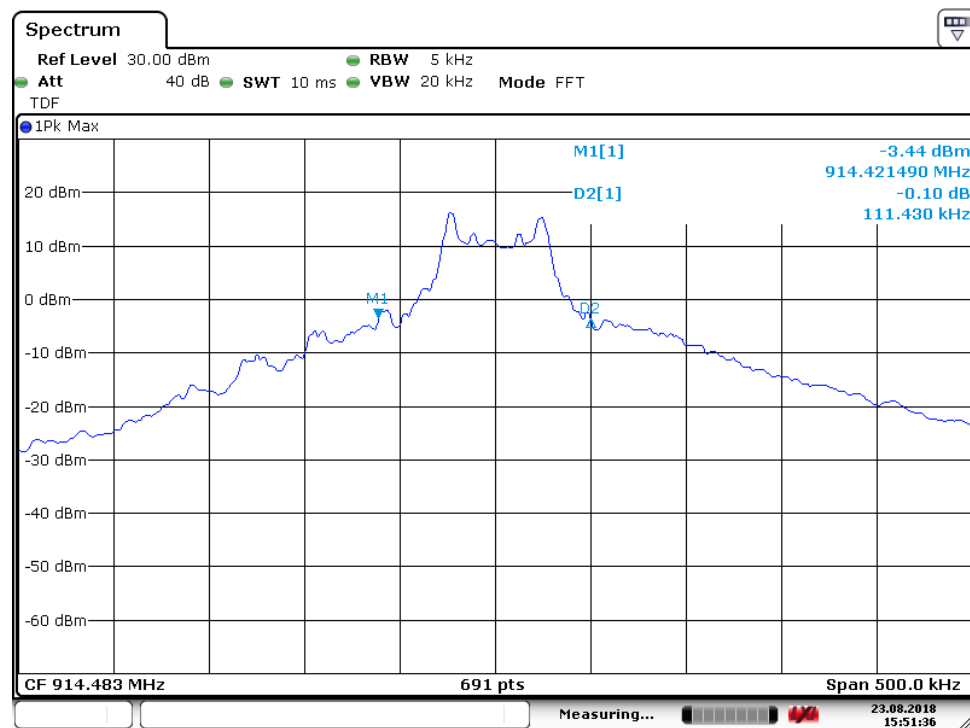


Channel Separation (Air modem)



Date: 23.AUG.2018 15:41:18

20 dB Bandwidth, ch1 (Ground modem)



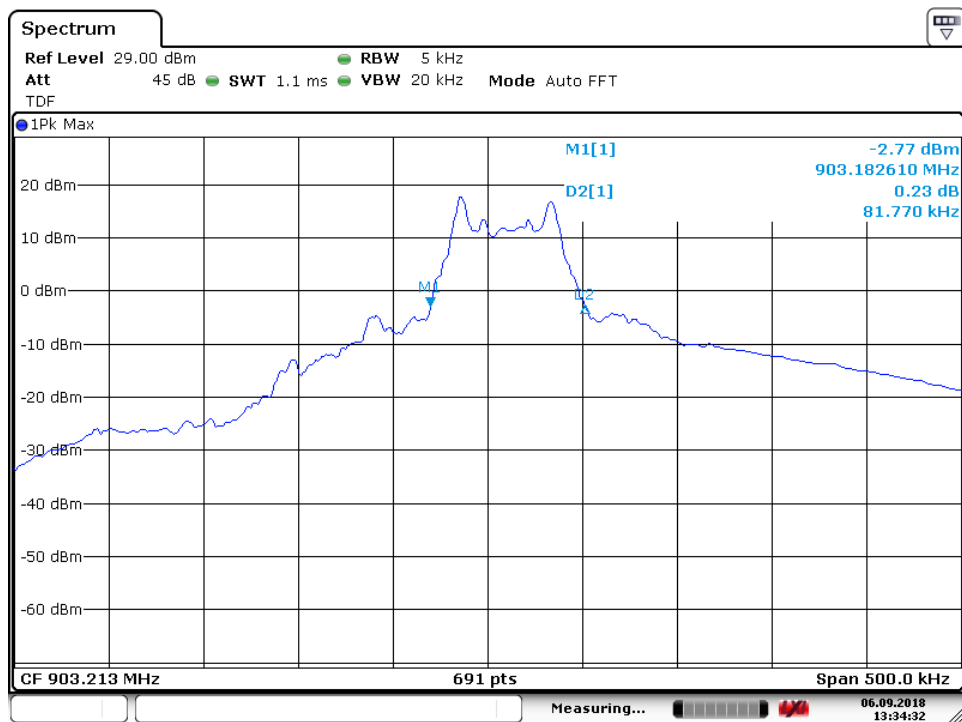
Date: 23.AUG.2018 15:51:37

20 dB Bandwidth, ch50 (Ground modem)



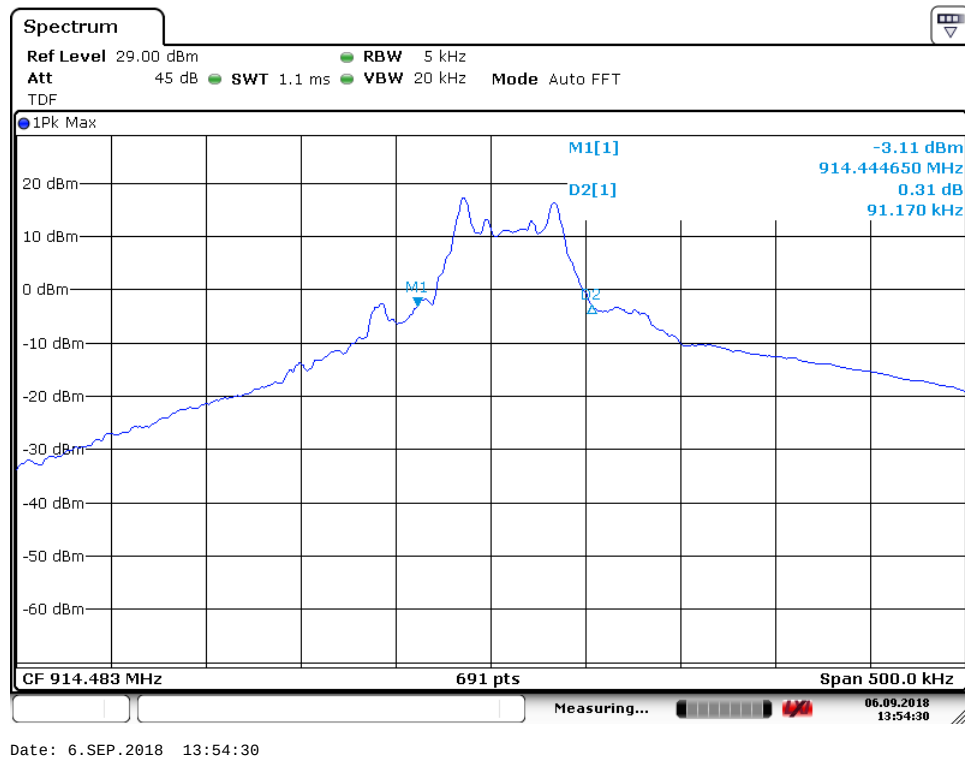
Date: 23.AUG.2018 15:09:21

20 dB Bandwidth, ch100 (Ground modem)

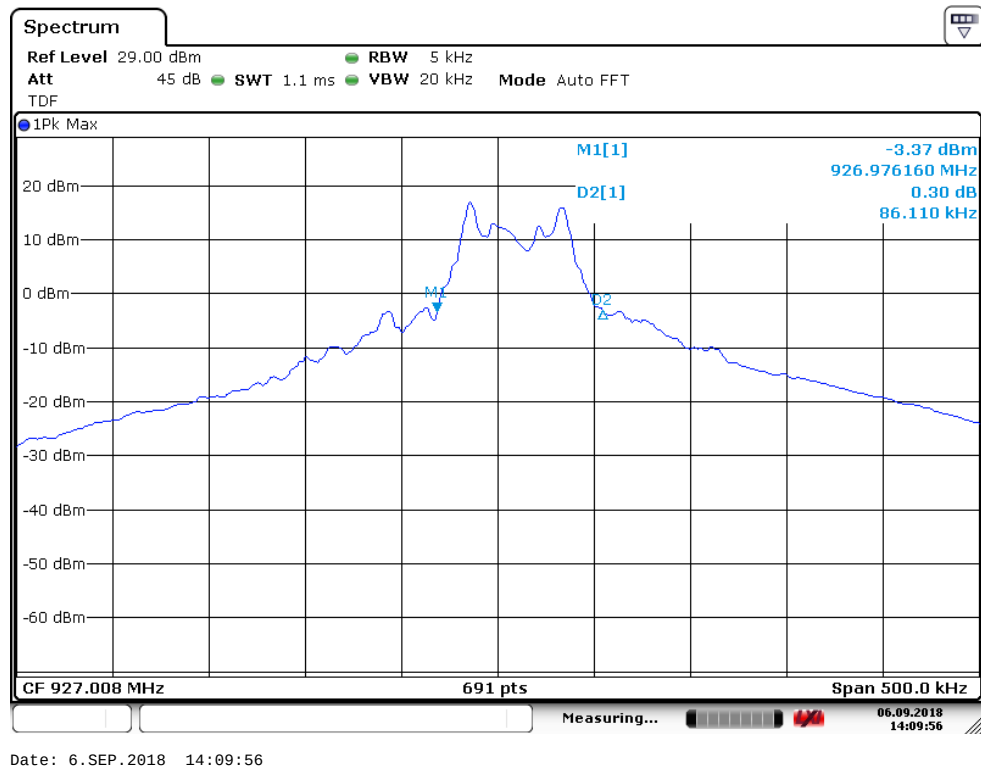


Date: 6.SEP.2018 13:34:32

20 dB Bandwidth, ch1 (Air modem)



20 dB Bandwidth, ch50 (Air modem)



20 dB Bandwidth, ch100 (Air modem)

3.3 Pseudorandom Hopping Algorithm

Para. No.: 15.247 (a)(1)

Test Results: Complies

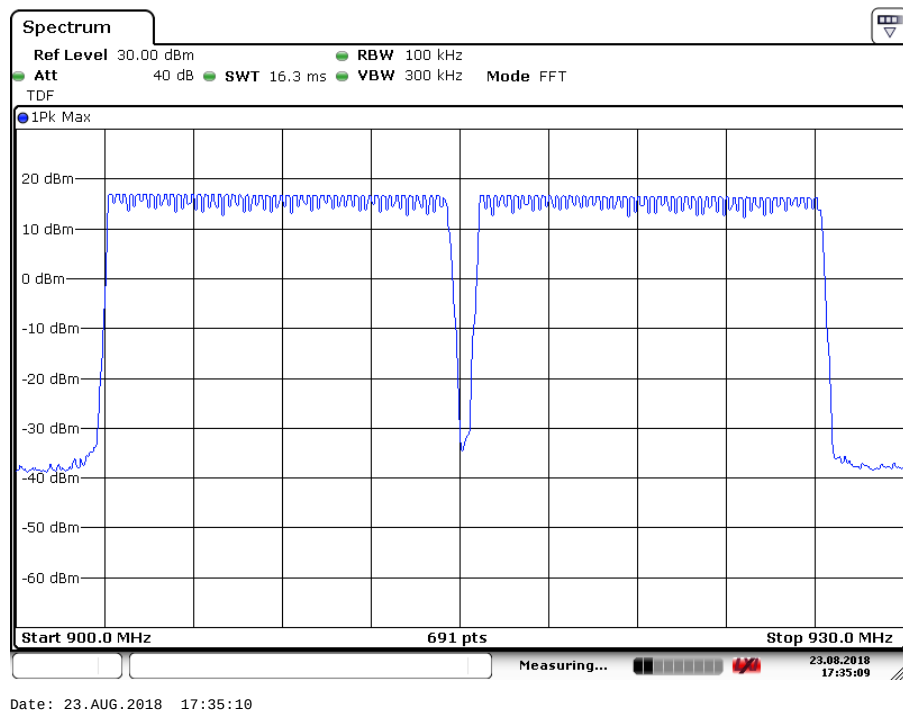
Measurement Data:

At the transceiver startup, a random hopping table is generated in the software by using non-deterministic, random data. The table ensures that all generated hopping sequences are evenly distributed and that all frequencies are used equally. The random data itself is created by a random generator within the software. The used algorithm ensures the randomness of the generated sequences as well as the selection of the sequence being used. It can be ensured, that each hopping sequence is unique and that the sequence of two transceivers will always differ from each other.

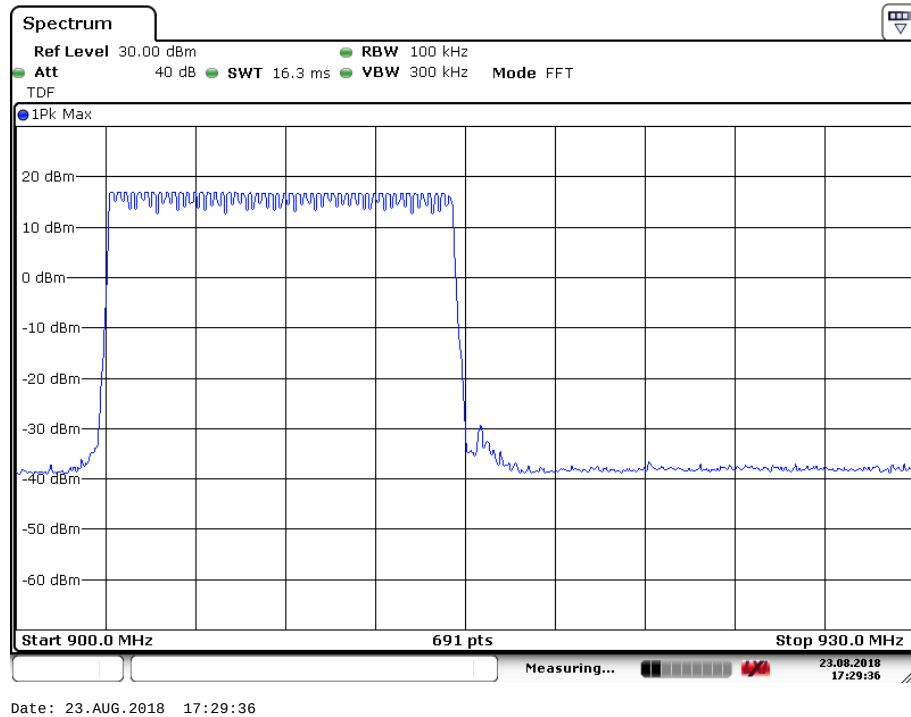
Requirements:

The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies. Each frequency must be used equally by the transmitter.

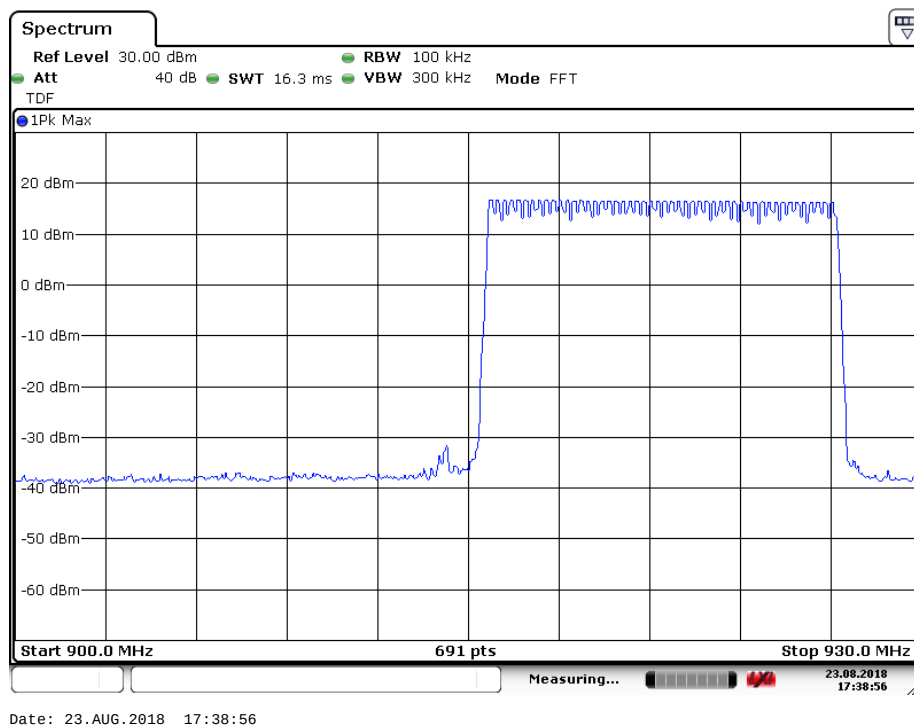
No requirements for Digital Transmission Systems.



100 channels low and high



50 channels low



50 channels high

3.4 Time of Occupancy

Para. No.: 15.247 (a)(1)(i)

Test Performed By: Markus Korny	Date of Test: 2018-08-23, 2018-09-06
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Test Results: Complies

Measurement Data:

Ground modem:

Number of RF Channels	50
Maximum length of RF burst pr. channel	5.84 ms
Time between RF burst on same RF channel	466 ms
Time of Occupancy	250.6 ms

Time between RF burst on the same channel: $9.32 \text{ ms} \times 50 = 466 \text{ ms}$

Time of occupancy: $(5.84 \text{ ms} \times 20000 \text{ ms}) / 466 \text{ ms} = 250.6 \text{ ms}$

Air modem:

Number of RF Channels	50
Maximum length of RF burst pr. channel	5.83 ms
Time between RF burst on same RF channel	468 ms
Time of Occupancy	249.1 ms

Fully charged battery is used

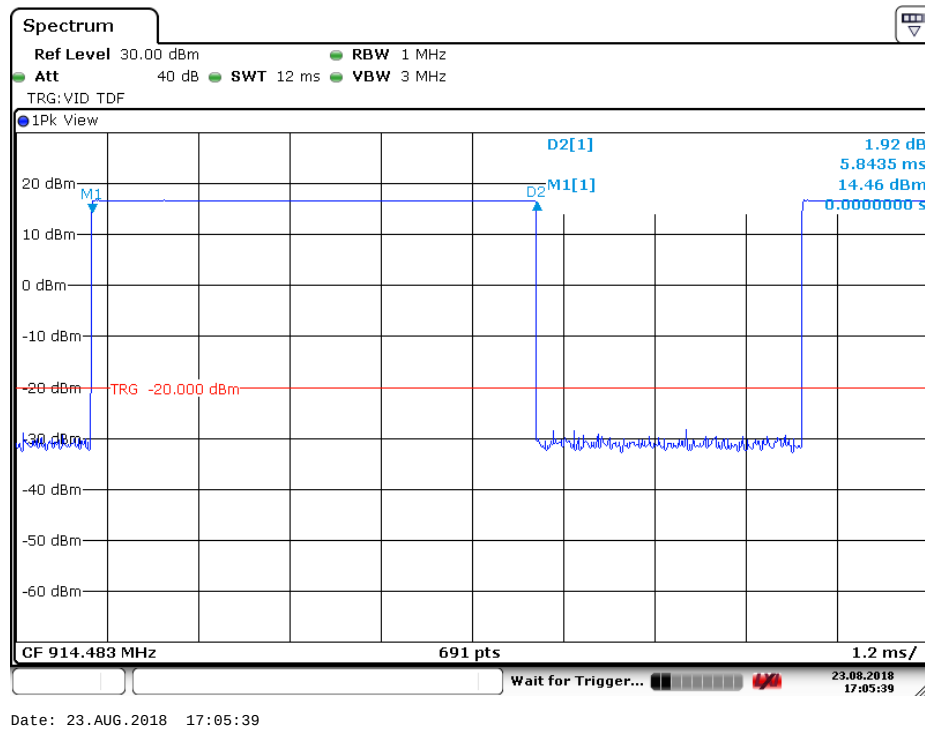
Time between RF burst on the same channel: $9.36 \text{ ms} \times 50 = 468 \text{ ms}$

Time of occupancy: $(5.83 \text{ ms} \times 20000 \text{ ms}) / 468 \text{ ms} = 249.1 \text{ ms}$

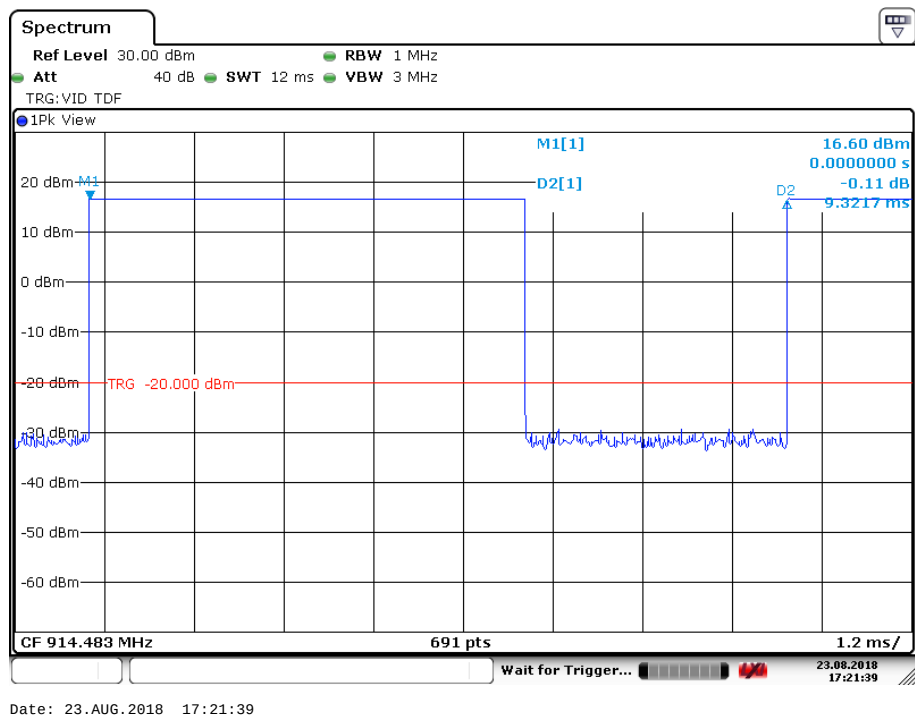
Requirements:

The system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a period of 20 seconds.

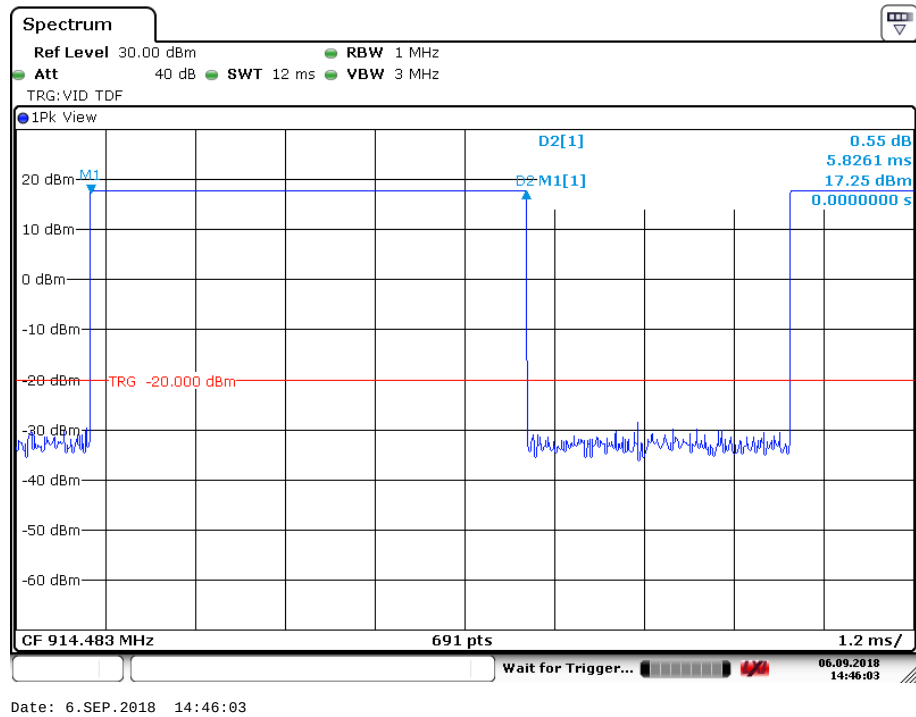
No requirements for Digital Transmission Systems.



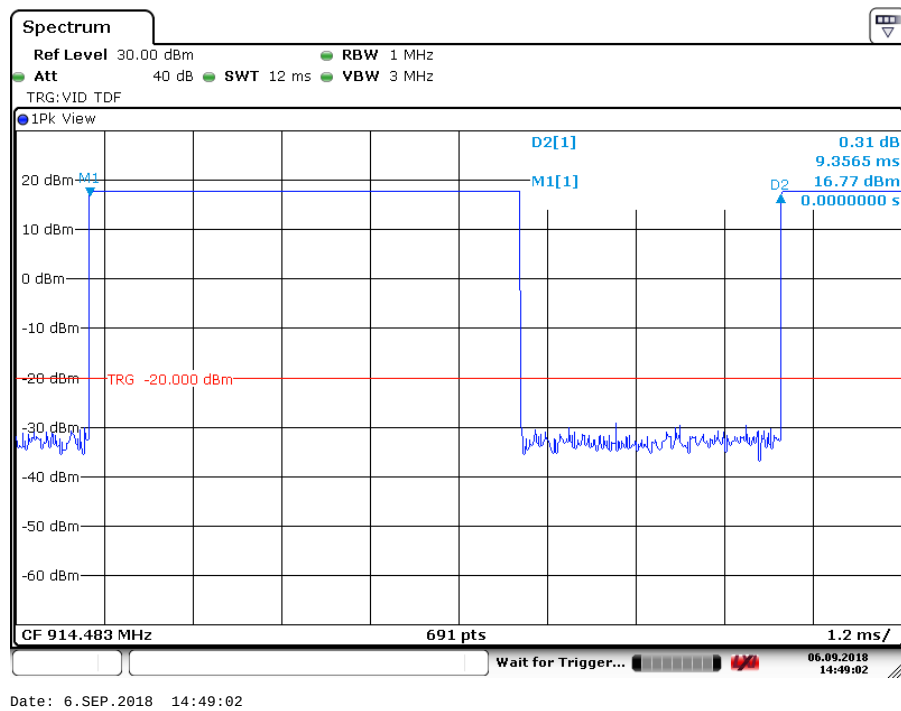
Burst length (Ground modem)



Sequence time (Ground modem)



Burst length (Air modem)



Sequence time (Air modem)

3.5 Occupied Bandwidth

Para. No.: 15.247 (a)(1)(i)

Para. No.: 6.6 RSS-Gen

Test Performed By: Markus Korny

Date of Test: 2018-08-23, 2018-09-06

Test Results: Complies

Measurement Data:

Ground Modem:

Number of RF Channels in use:	50
Channel Center Frequencies:	The channels are centered at each full 230 kHz from 903.213 to 914.483 MHz or from 915.738 to 927.008 MHz
20 dB Bandwidth *)	136.76 kHz
99 % Bandwidth (OBW)	175.83 kHz

*) see 3.1 channel separation

Air Modem:

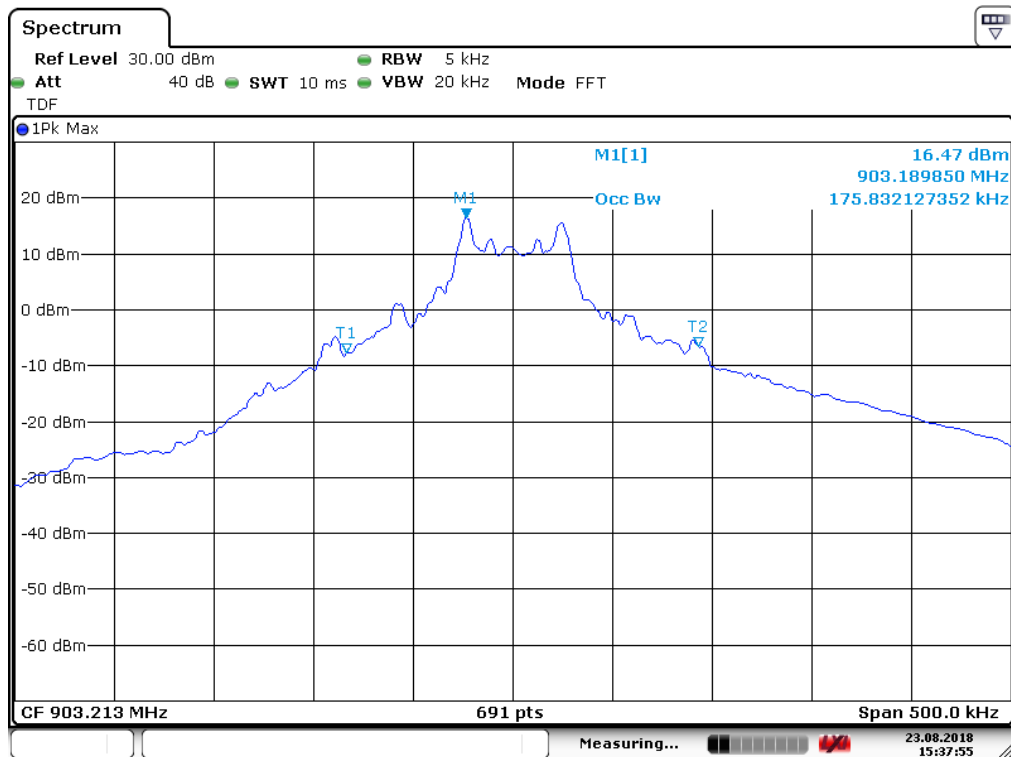
Number of RF Channels in use:	50
Channel Center Frequencies:	The channels are centered at each full 230 kHz from 903.213 to 914.483 MHz or from 915.738 to 927.008 MHz
20 dB Bandwidth *)	91.17 kHz
99 % Bandwidth (OBW)	150.51 kHz

*) see 3.1 channel separation

Fully charged battery is used

Requirements:

Frequency hopping systems in the 902 – 928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies.



Date: 23.AUG.2018 15:37:55

903.213 MHz – 99% OCC BW (Ground modem)



Date: 6.SEP.2018 13:28:06

903.213 MHz – 99% OCC BW (Air modem)

3.6 Peak Power Output

Para. No.: 15.247 (b)

Test Performed By: Markus Korny	Date of Test: 2018-09-20, 2018-09-21
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Test Results: Complies

Measurement Data:

Ground modem:

RF channel	903.213 MHz	914.483 MHz	927.008 MHz
Measured Maxium Field strength (dBµV/m)	114.53	114.19	115.61
Polarisation	HP	VP	HP
Calc. Radiated Power (dBm)	19.30	18.96	20.38
Calc. Radiated Power (mW)	85.14	78.73	109.17
Measured Conducted Power (dBm)	17.05	16.78	16.54
Measured Conducted Power (mW)	50.70	47.64	45.08
Calculated Antenna Gain (dBi)	2.3	2.2	3.8

Air modem:

RF channel	903.213 MHz	914.483 MHz	927.008 MHz
Measured Maxium Field strength (dBµV/m)	119.53	115.44	111.57
Polarisation	VP	VP	VP
Calc. Radiated Power (dBm)	24.30	20.21	16.34
Calc. Radiated Power (mW)	269.23	104.98	43.06
Measured Conducted Power (dBm)	18.10	17.68	17.33
Measured Conducted Power (mW)	64.57	58.61	54.08
Calculated Antenna Gain (dBi)	6.2	2.5	-1.0

Fully charged battery is used

Antenna gain = $10 \cdot \log(\text{EIRP} / \text{Conducted power})$ dBi

EIRP is calculated from measured field strength by the formulas in KDB 412172 D01 Determining ERP and EIRP v01.

The maximum field strength is obtained in XY plane and Vertical polarization

See attached graph.

Detachable antenna?

☒ Yes ☐ No

If detachable, is the antenna connector non-standard?

☒ Yes ☐ No

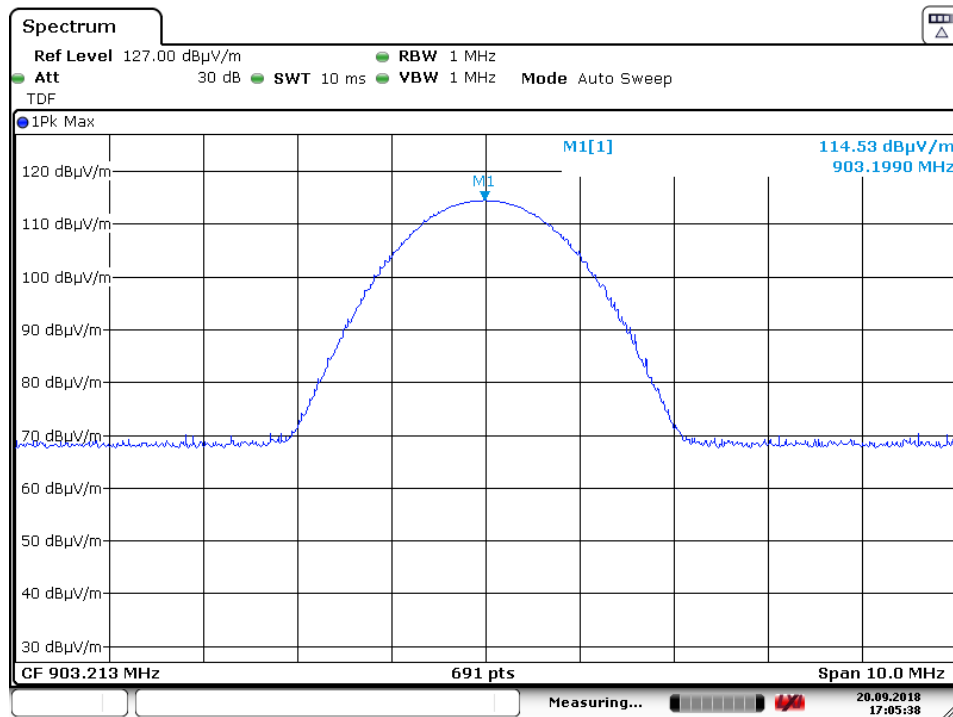
Type of antenna connector: SMA-RP

Requirements:

The maximum peak output power shall not exceed the following limits:

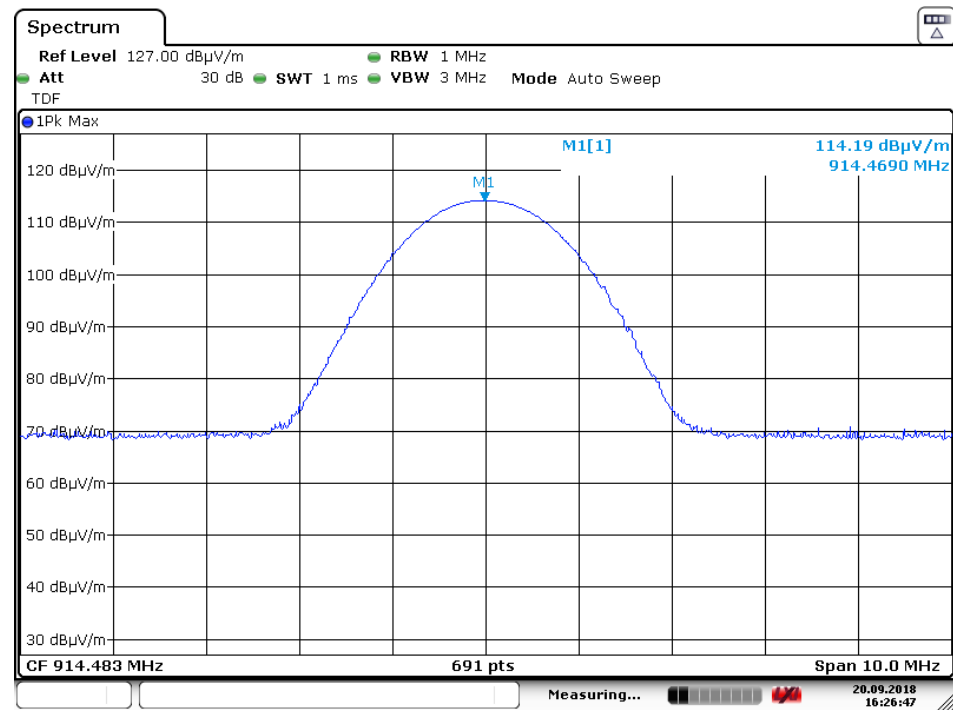
For frequency hopping systems employing at least 50 hopping channels: 1 Watt

If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



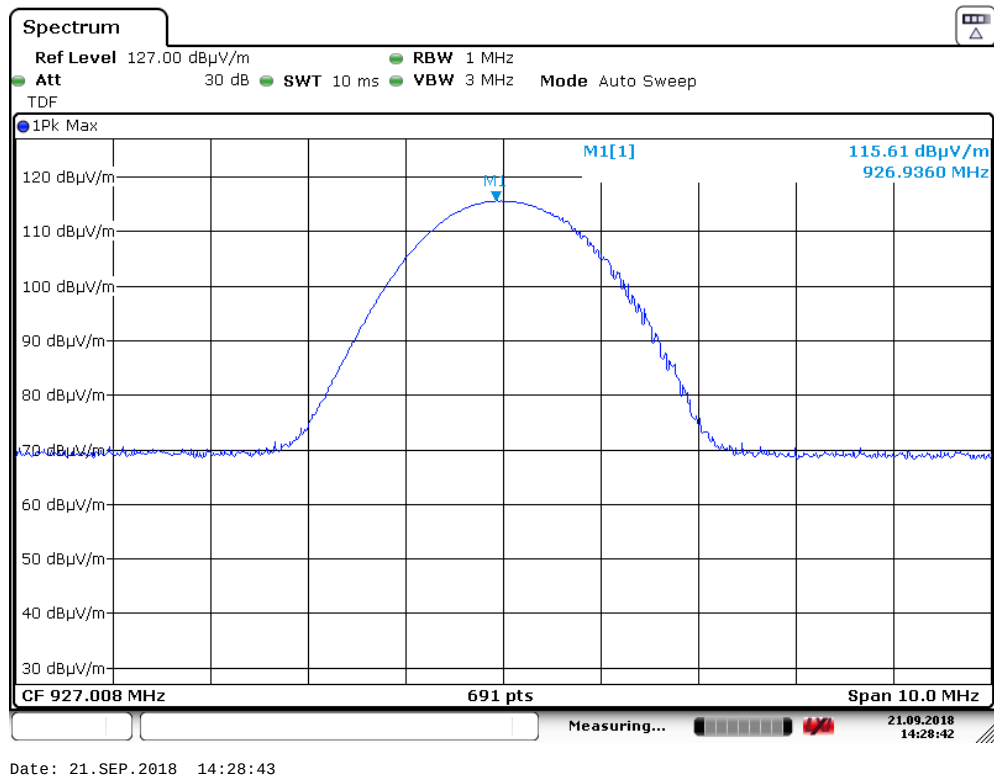
Date: 20.SEP.2018 17:05:38

Radiated field strength, HP, ch1 (Ground modem)

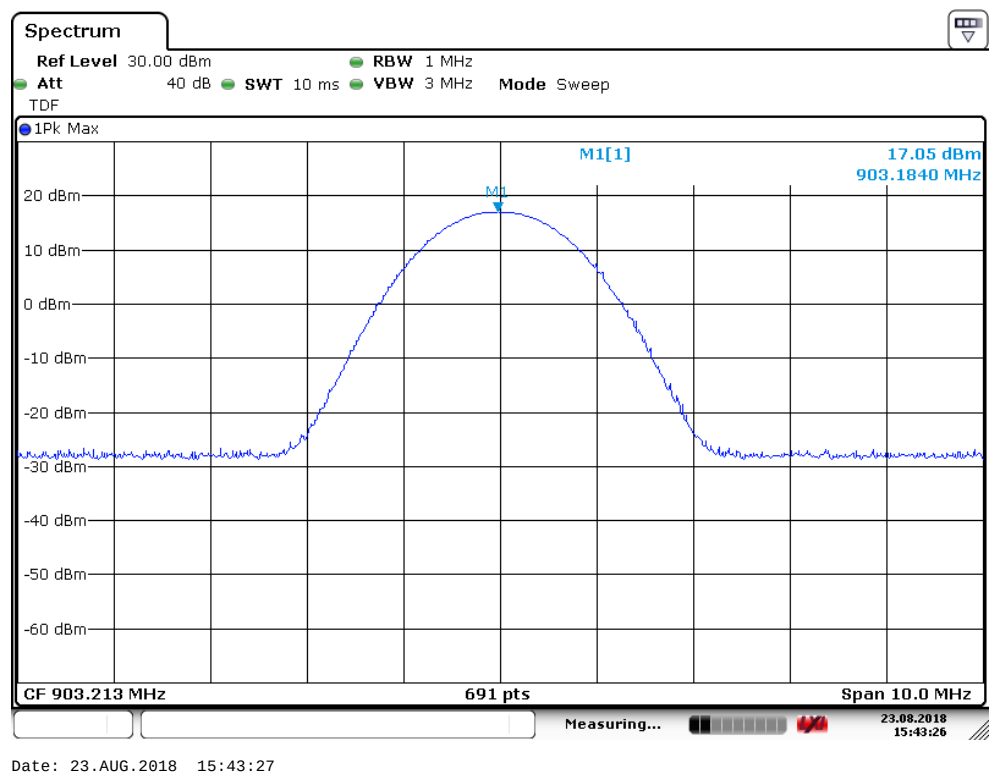


Date: 20.SEP.2018 16:26:47

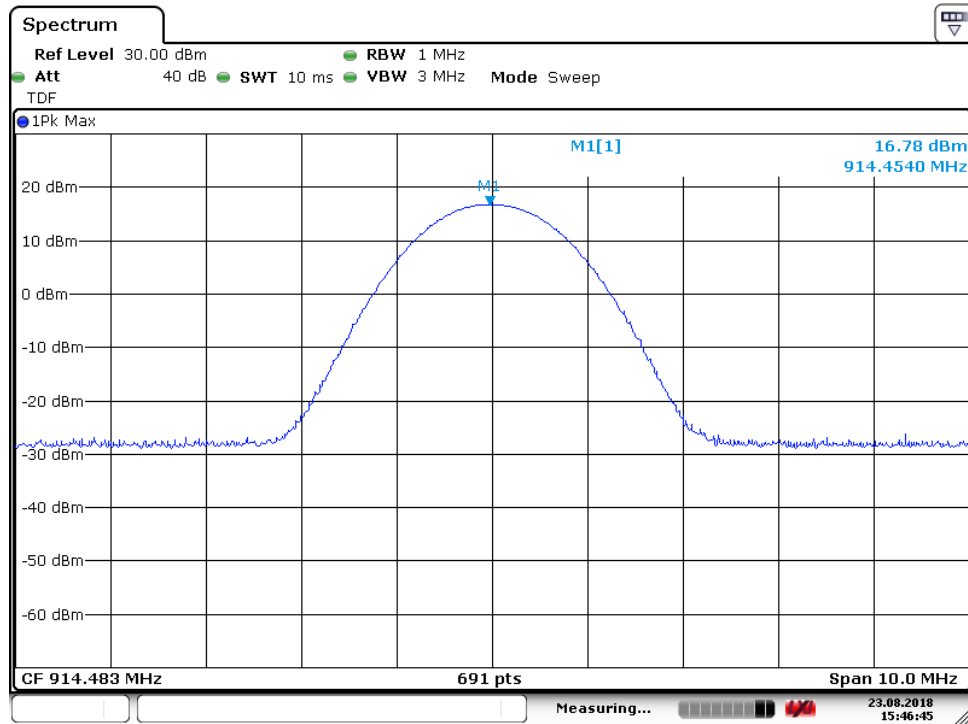
Radiated field strength, VP, ch50 (Ground modem)



Radiated field strength, HP, ch100 (Ground modem)

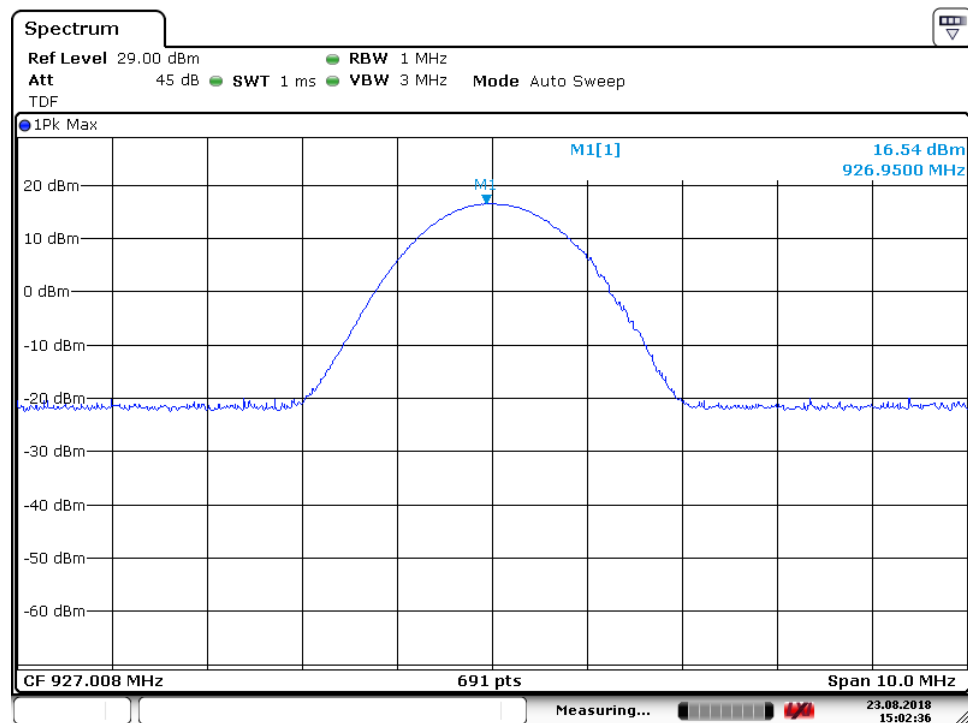


Conducted power – ch1 (Ground modem)



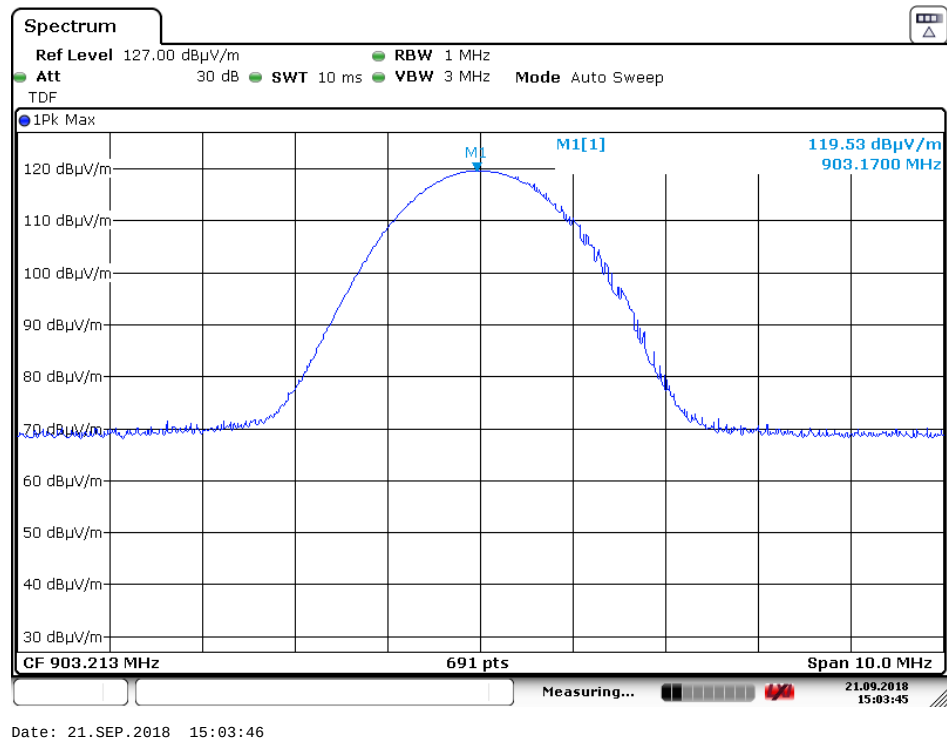
Date: 23.AUG.2018 15:46:45

Conducted power – ch50 (Ground modem)

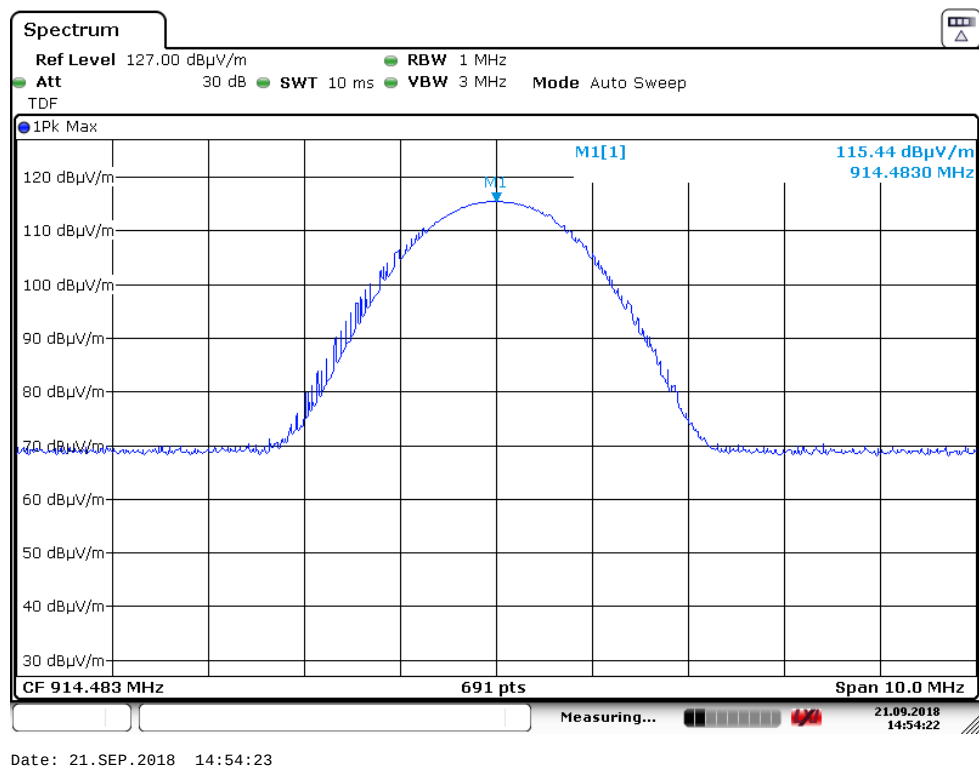


Date: 23.AUG.2018 15:02:36

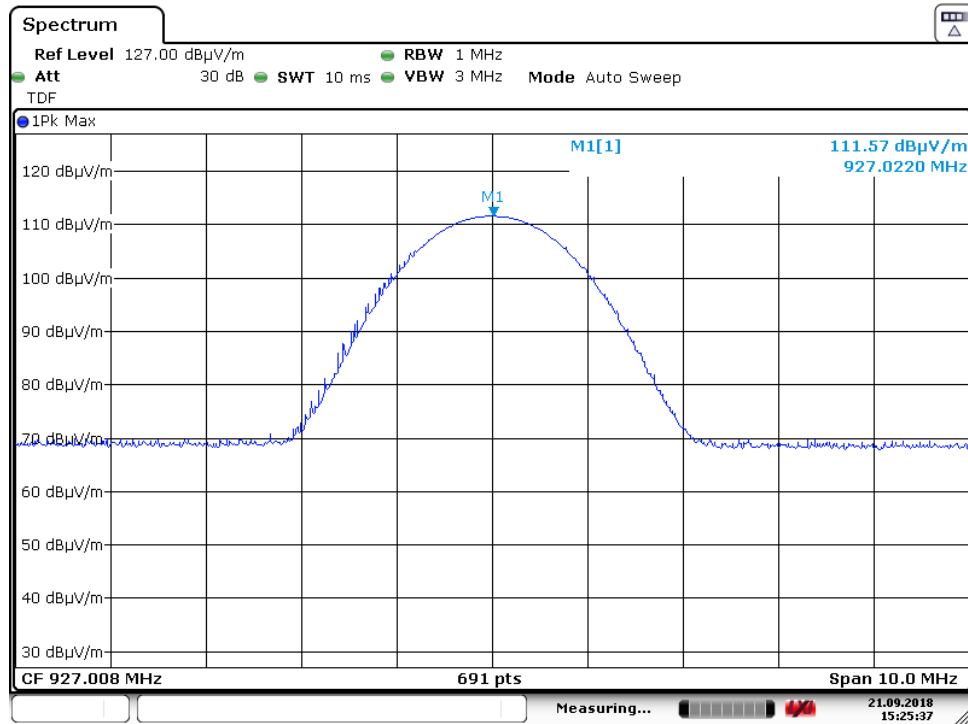
Conducted power – ch100 (Ground modem)



Radiated field strength, VP, ch1 (Air modem)

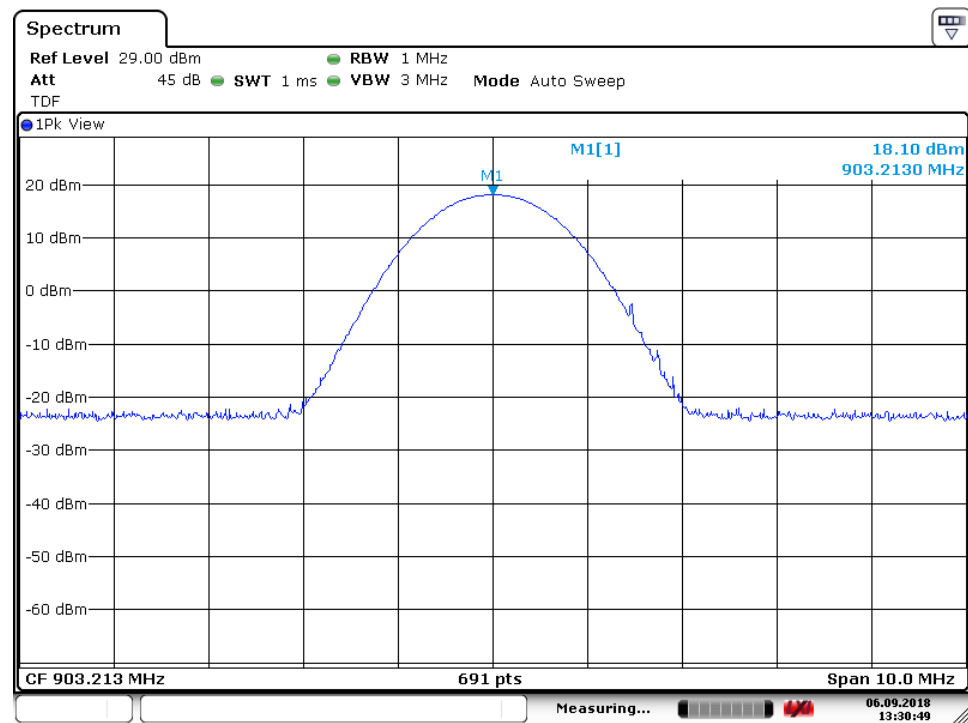


Radiated field strength, VP, ch50 (Air modem)



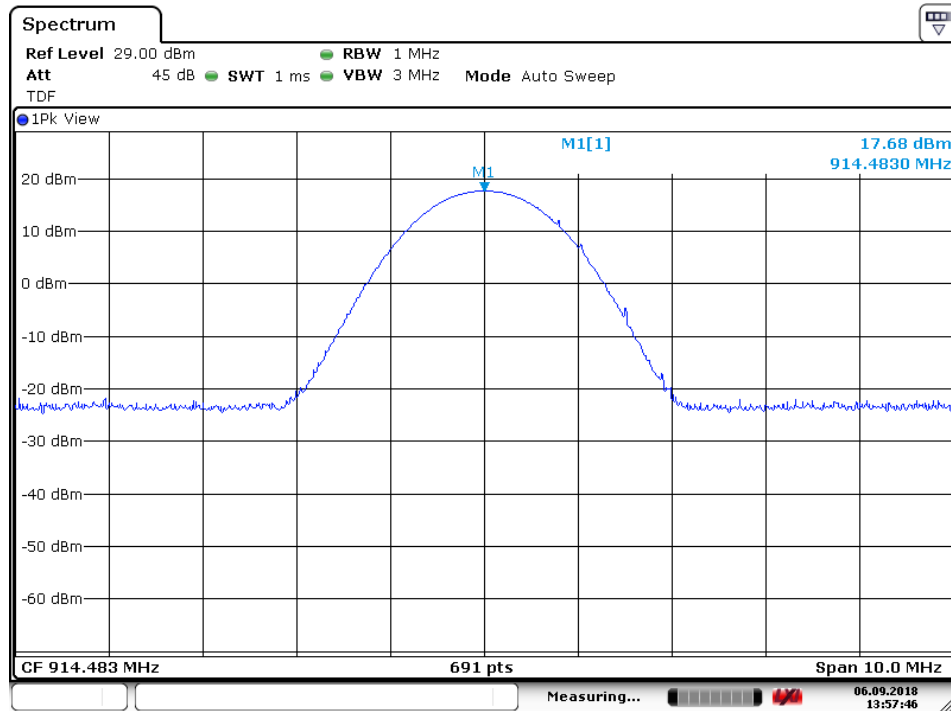
Date: 21.SEP.2018 15:25:38

Radiated field strength, VP, ch100 (Air modem)



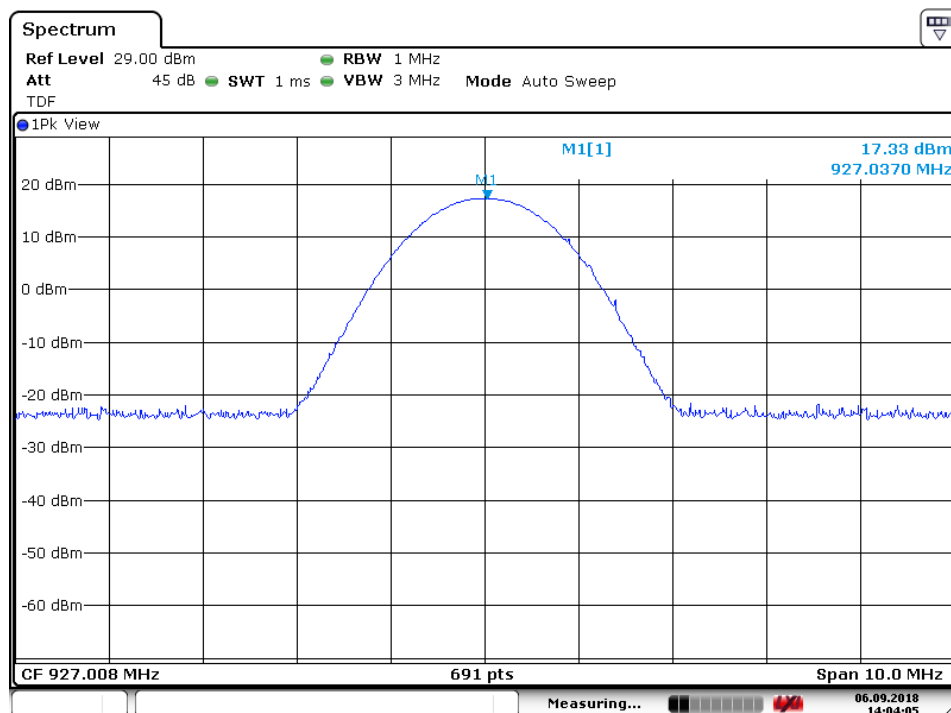
Date: 6.SEP.2018 13:30:49

Conducted power – ch1 (Air modem)



Date: 6.SEP.2018 13:57:46

Conducted power – ch50 (Air modem)



Date: 6.SEP.2018 14:04:05

Conducted power – ch100 (Air modem)

3.7 Spurious Emissions (Antenna Conducted)

Para. No.: 15.247 (d)

Test Performed By: Markus Korny	Date of Test: 2018-08-23, 2018-09-06
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Test Results: Complies

RF conducted power to 10 GHz see attached plots.

Maximum RF level outside operating band:

Ground modem:

RF ch 903.213MHz: 56 dB/C, margin >30 dB

RF ch 914.483MHz: 59 dB/C, margin >30 dB

RF ch 927.008MHz: 57 dB/C, margin >30 dB

Air modem:

RF ch 903.213MHz: 53 dB/C, margin >30 dB

RF ch 914.483MHz: 51 dB/C, margin >30 dB

RF ch 927.008MHz: 50 dB/C, margin >30 dB

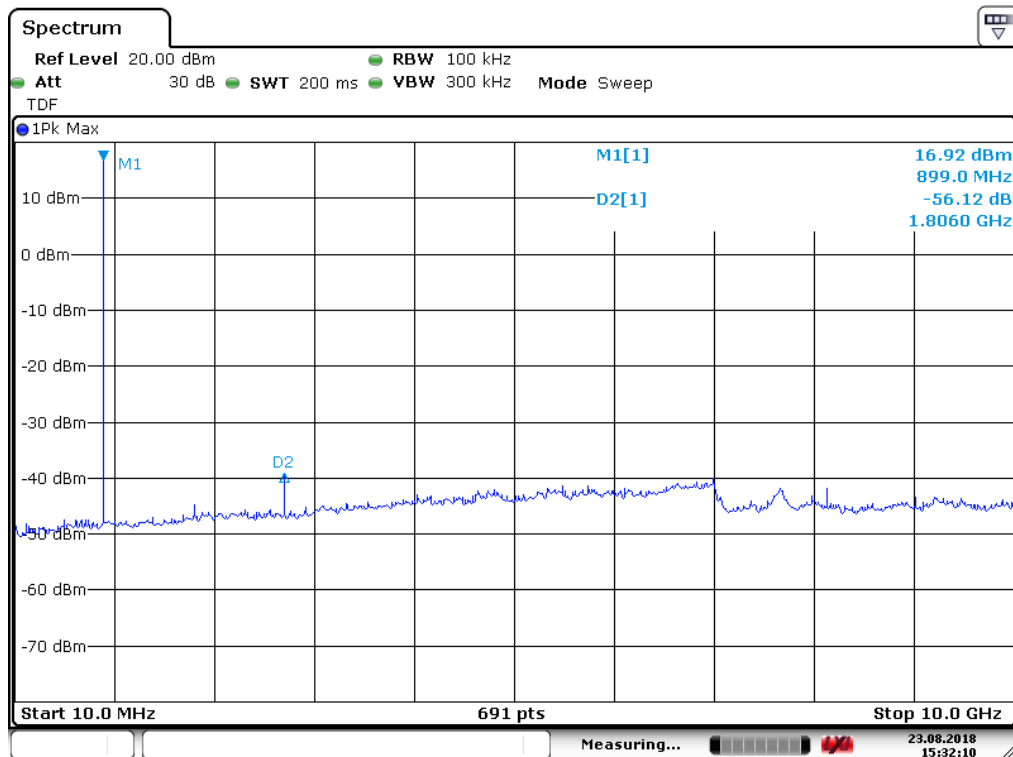
Fully charged battery is used

Limit

Peak measurement	RMS averaging
20 dBc or more in 100 kHz bandwidth	30 dBc or more in 100 kHz bandwidth

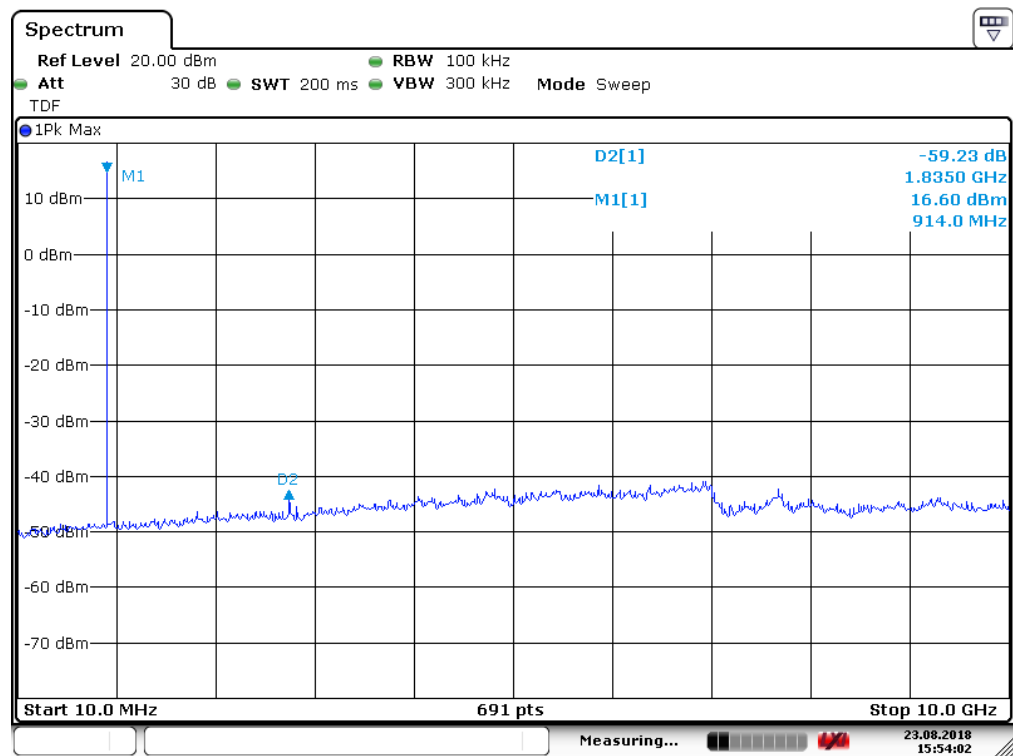
Detector type shall be the same as used for measuring Output Power.

Attenuation below the general limits specified in part 15.209(a) is not required.



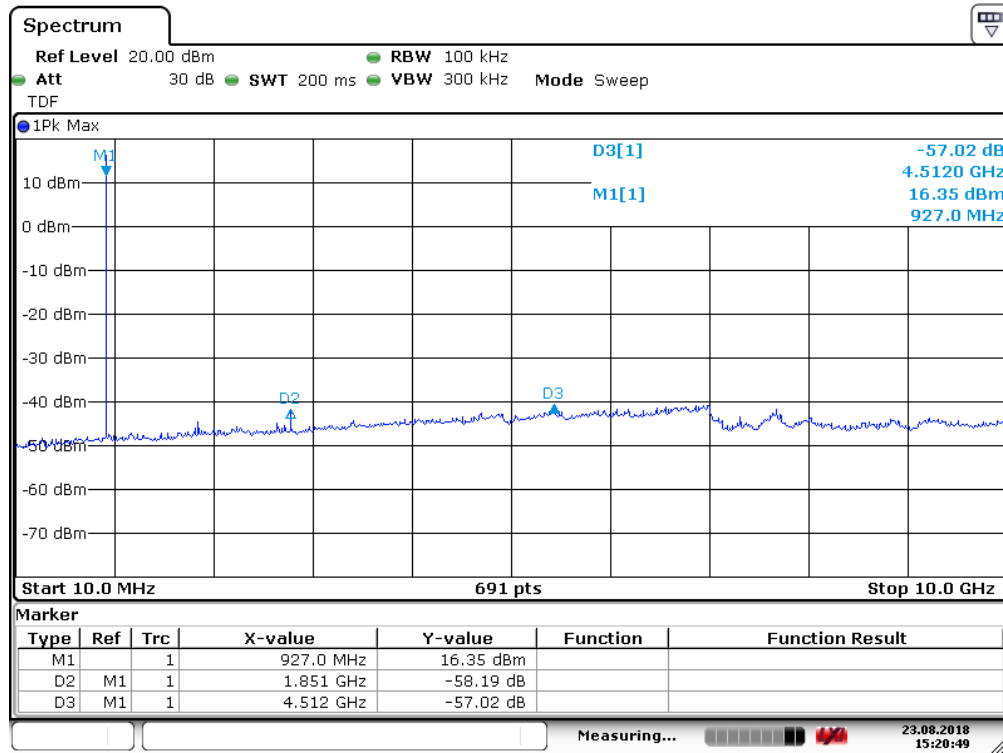
Date: 23.AUG.2018 15:32:11

Conductd spurious emission 10MHz – 10GHz – ch 1 (Ground modem)



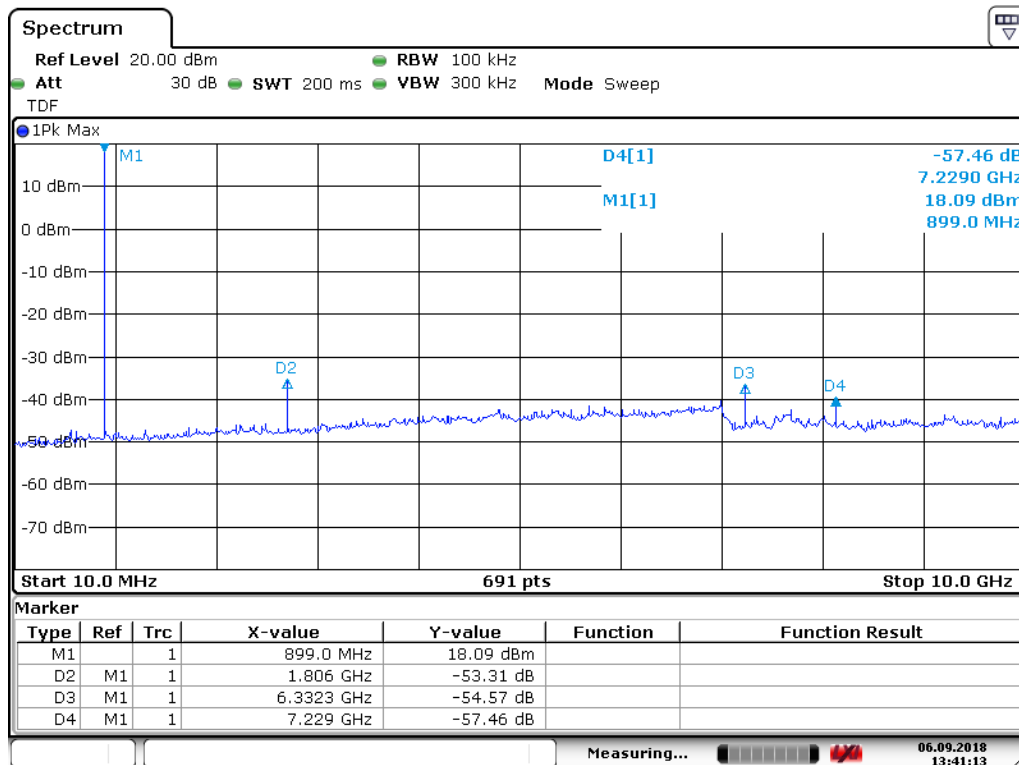
Date: 23.AUG.2018 15:54:03

Conductd spurious emission 10MHz – 10GHz – ch 50 (Ground modem)



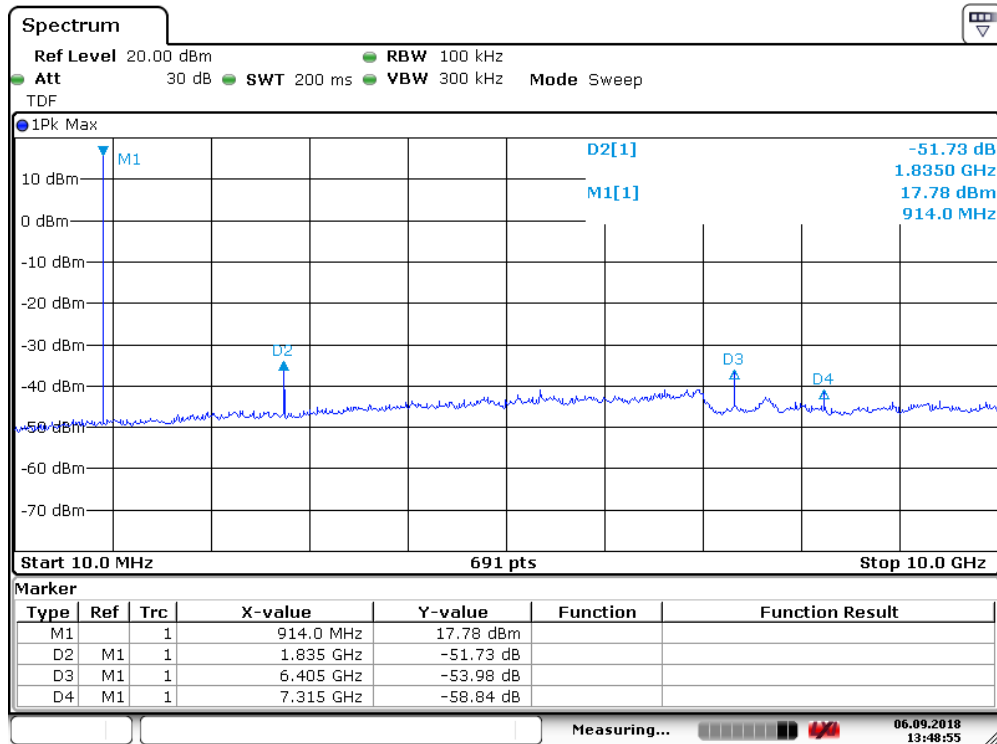
Date: 23.AUG.2018 15:20:50

Conductd spurious emission 10MHz – 10GHz – ch 100 (Ground modem)



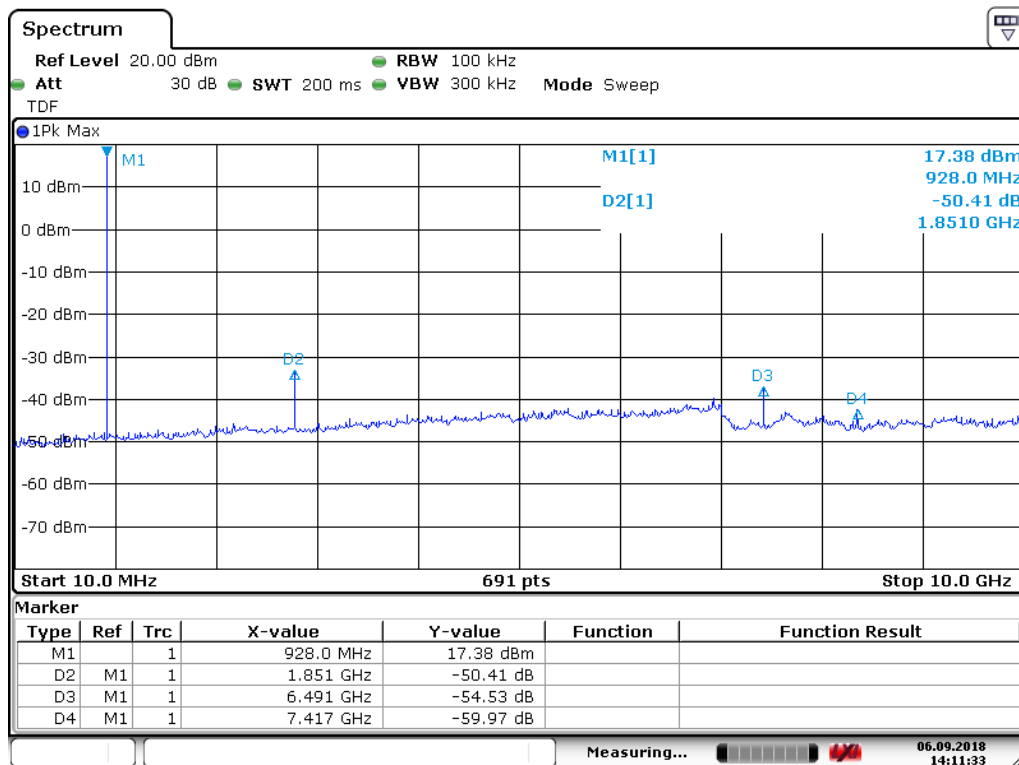
Date: 6.SEP.2018 13:41:14

Conductd spurious emission 10MHz – 10GHz – ch 1 (Air modem)



Date: 6.SEP.2018 13:48:55

Conductd spurious emission 10MHz – 10GHz – ch 50 (Air modem)



Date: 6.SEP.2018 14:11:33

Conductd spurious emission 10MHz – 10GHz – ch 100 (Air modem)

3.8 Restricted Bands of operation

Restricted Bands of operation for FCC and ISSED are defined in FCC Part 15.205 and ISSED RSS-GEN, Issue 4 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 4, clause 8.9.

FCC (MHz)	ISED (MHz)	FCC (GHz)	ISED (GHz)
0.090-0.110		0.96-1.24 1.3-1.427	0.96-1.427
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	1.660-1.710	
4.125-4.128		1.7188-1.7222	
4.17725-4.17775		2.2-2.3	
4.20725-4.20775		2.31-2.39	
	5.677-5.683	2.4835-2.5	
6.215-6.218		2.69-2.9	2.655-2.9
6.26775-6.26825		3.26-3.267	
6.31175-6.31225		3.332-3.339	
8.291-8.294		3.3458-3.358	
8.362-8.366		3.6-4.4	3.5-4.4
8.37625-8.38675		4.5-5.15	
8.41425-8.41475		5.35-5.46	
12.29-12.293		7.25-7.75	
12.51975-12.52025		8.025-8.5	
12.57675-12.57725		9.0-9.2	
13.36-13.41		9.3-9.5	
16.42-16.423		10.6-12.7	
16.69475-16.69525		13.25-13.4	
16.80425-16.80475		14.47-14.5	
25.5-25.67		15.35-16.2	
37.5-38.25		17.7-21.4	
73-74.6		22.01-23.12	
74.8-75.2		23.6-24.0	
108-121.94 123-138	108-138	31.2-31.8	
149.9-150.05		36.43-36.5	
156.52475-156.52525		Above 38.6	
156.7-156.9			
162.0125-167.17			
167.72-173.2			
240-285			
322-335.4			
399.9-410			
608-614			

Frequencies in **Bold** text are specific for FCC or ISSED, all other frequencies are common.

3.9 Spurious Emissions (Radiated)

Para. No.: 15.247 (c)

Test Performed By: Markus Korny	Date of Test: 2018-08-24 to 2018-09-07
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Test Results: Complies

Duty Cycle Correction Factor Calculation:

Duty Cycle = On Time / (Period * Number of Channels) = 5.84 ms / (9.32 ms * 50) = 0.0125

Duty Cycle Correction factor = -20 x log (Duty Cycle) = 38.0 dB

Maximum allowed Duty Cycle Correction: 20 dB

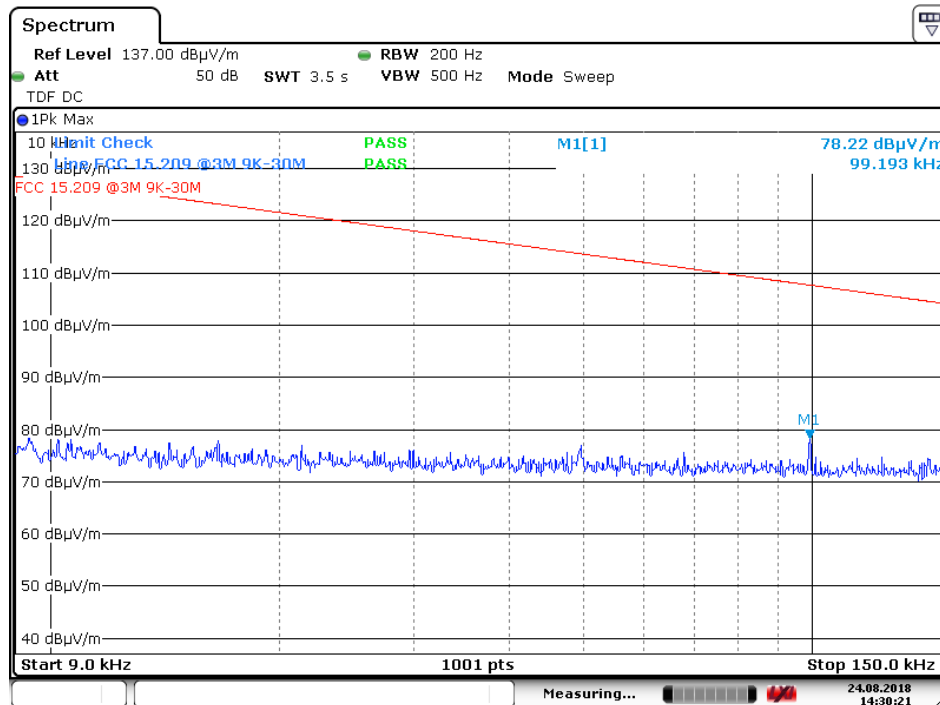
Plots see chapter 3.4.

Radiated emissions 10 kHz-30 MHz.

Measuring distance 3 m, measured with Peak detector.

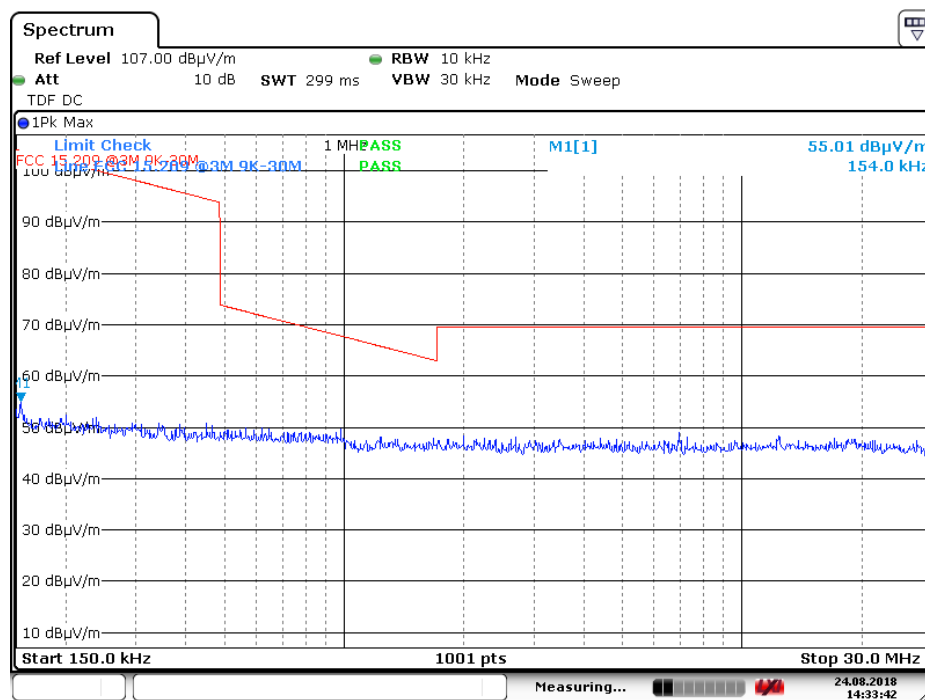
No component detected, see attached graph.

Limit is converted to 3 m using 40 dB/decade according to 15.31 (f) (2).



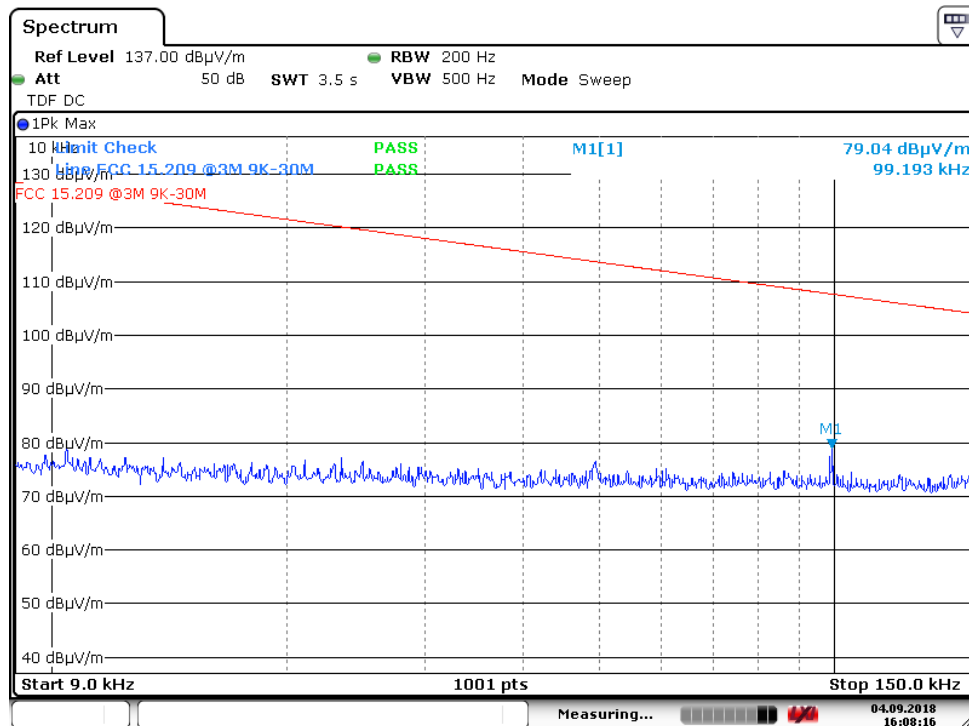
Date: 24.AUG.2018 14:30:21

Radiated Emissions, 9 kHz – 150 kHz @3m (Ground modem)



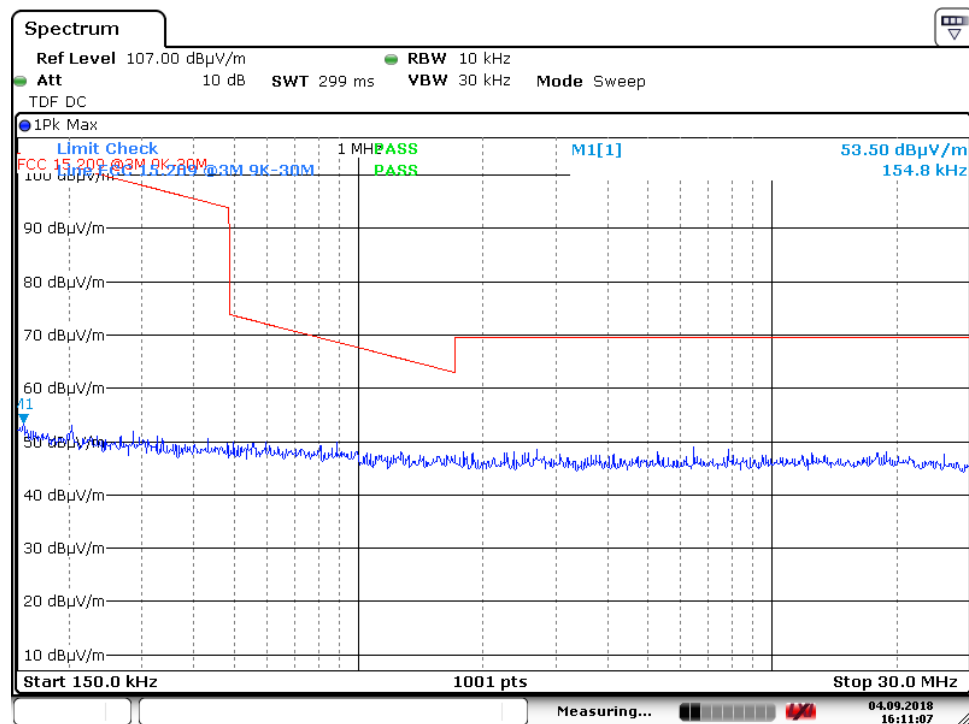
Date: 24.AUG.2018 14:33:42

Radiated Emissions, 150 kHz - 30MHz @3m (Ground modem)



Date: 4.SEP.2018 16:08:17

Radiated Emissions, 9 kHz – 150 kHz @3m (Air modem)



Date: 4.SEP.2018 16:11:08

Radiated Emissions, 150 kHz - 30MHz @3m (Air modem)

Radiated emission 30 – 1000 MHz.

Detector: Quasi-Peak

Measuring distance 3 m.

Grounding modem:

Frequency	Operational condition	Detector	Field strength	Measuring distance	Limit FCC15.209	Margin
MHz			dB μ V/m	metres	dB μ V/m	dB
/	TX on	PK	/	3	40.0	/

Air modem:

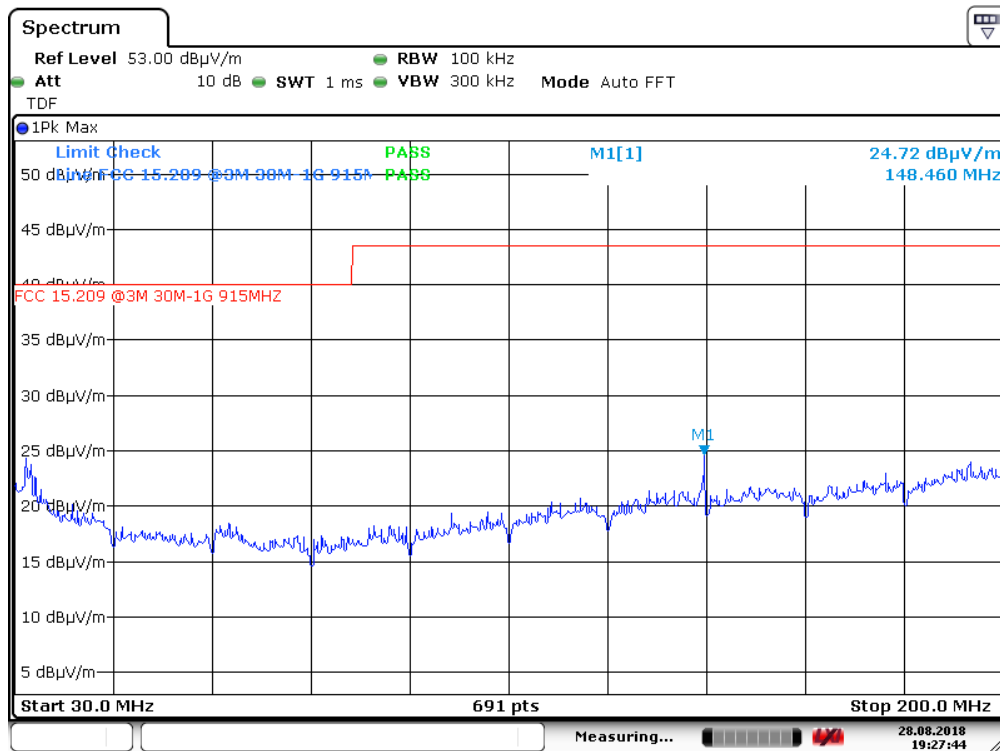
Frequency	Operational condition	Detector	Field strength	Measuring distance	Limit FCC15.209	Margin
MHz			dB μ V/m	metres	dB μ V/m	dB
/	TX on	PK	/	3	40.0	/

Fully charged battery is used

See attached graphs.

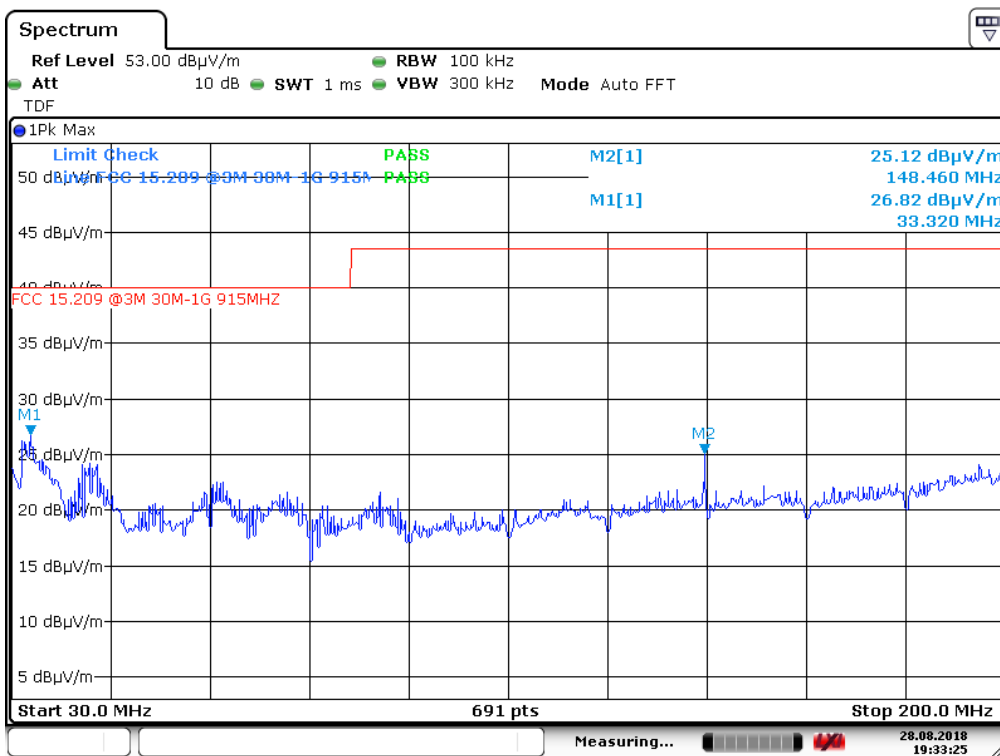
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	Quasi Peak (μV/m)	Quasi Peak (dBμV/m)
30 – 88	100	40.0
88 – 216	150	43.5
216 – 960	200	46.0
Above 960	500	54.0



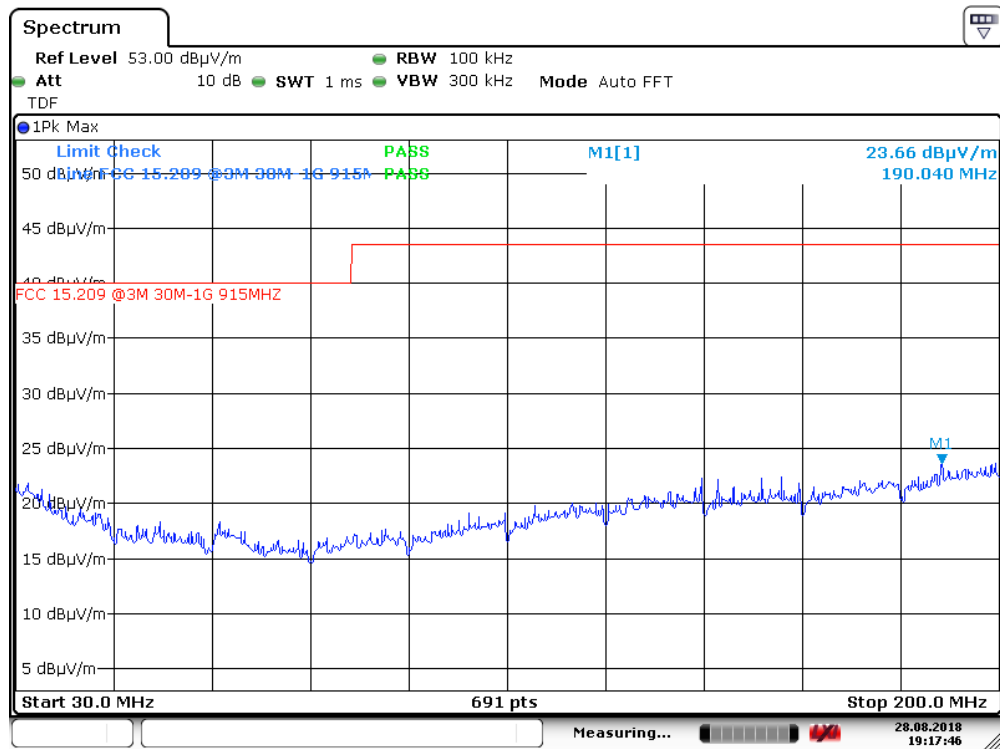
Date: 28.AUG.2018 19:27:44

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch1 (Ground modem)



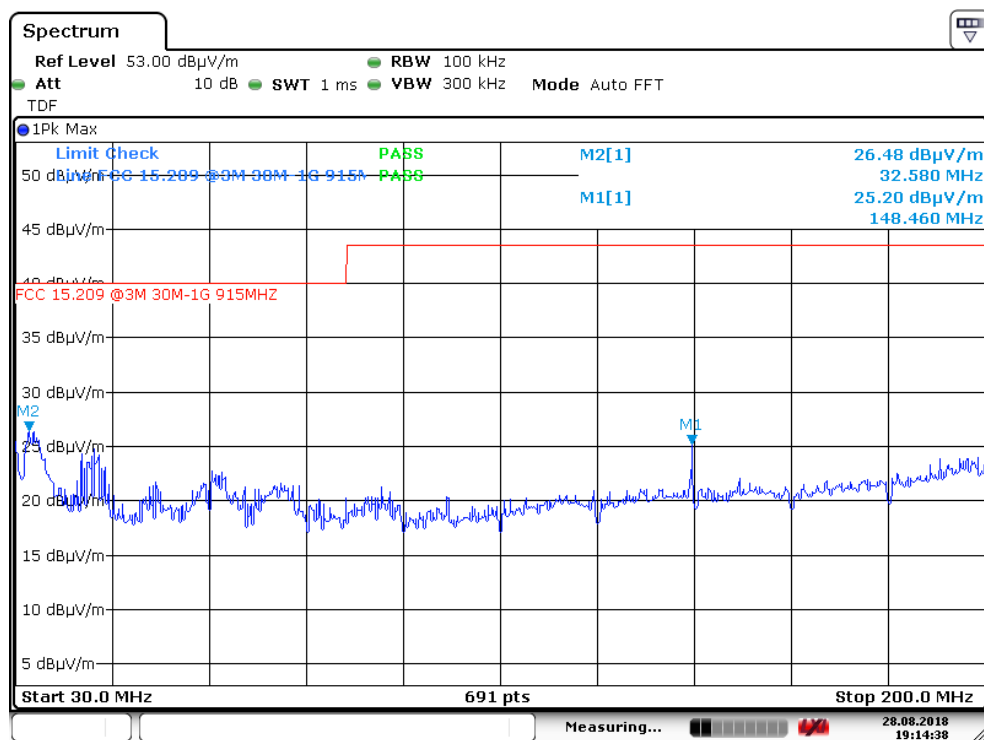
Date: 28.AUG.2018 19:33:25

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch1 (Ground modem)



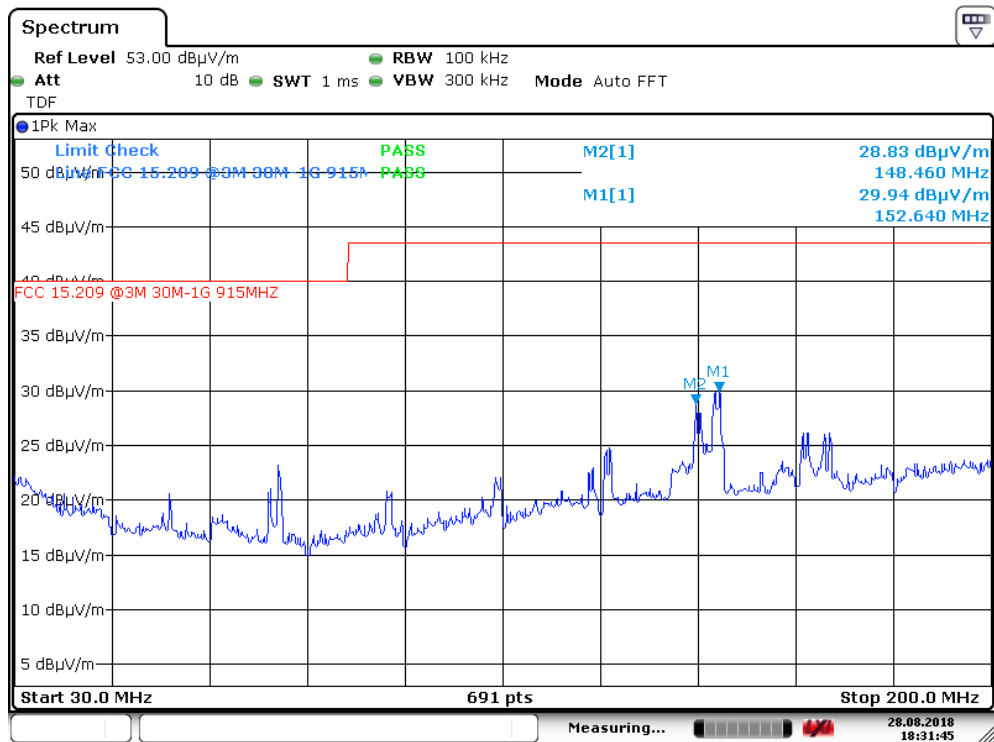
Date: 28.AUG.2018 19:17:46

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch50 (Ground modem)



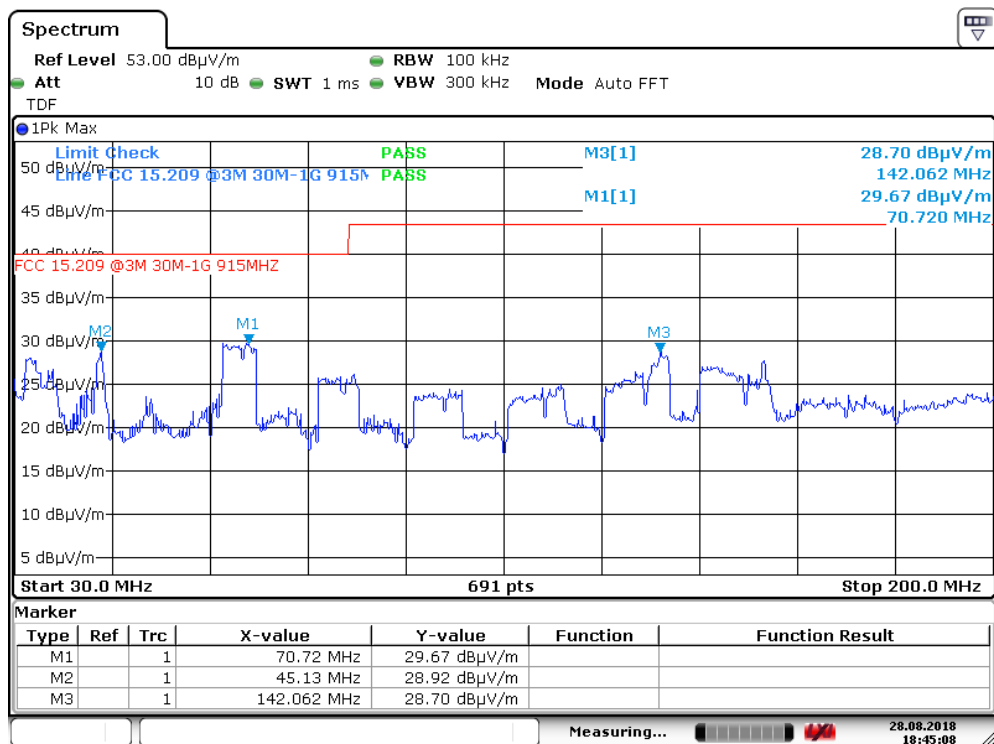
Date: 28.AUG.2018 19:14:38

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch50 (Ground modem)



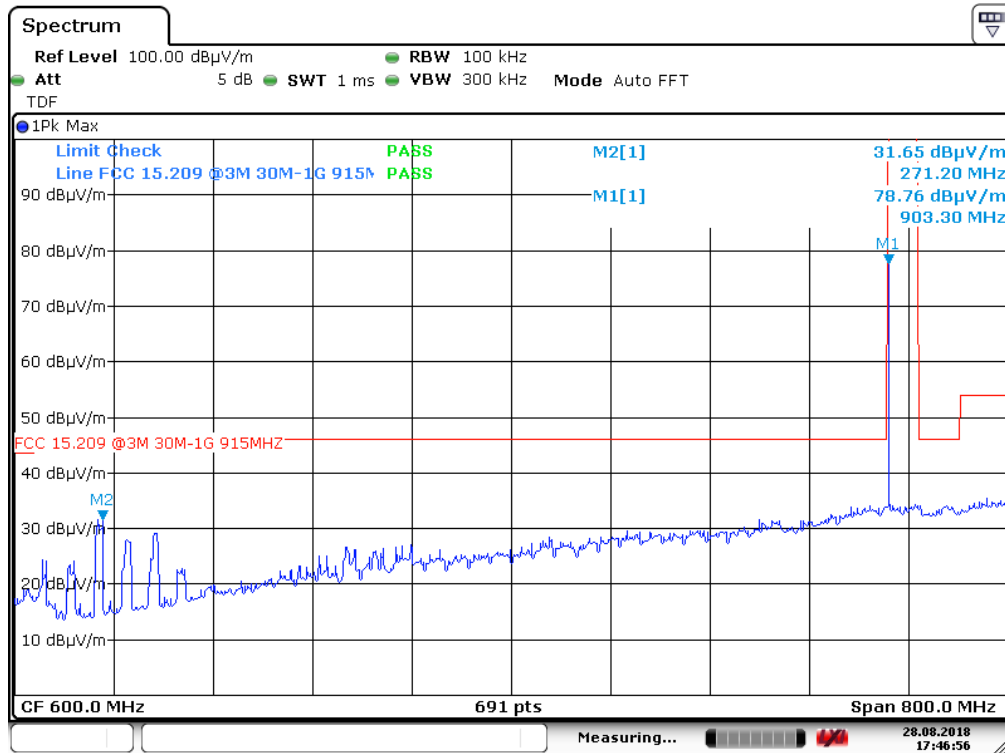
Date: 28.AUG.2018 18:31:46

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch100 (Ground modem)



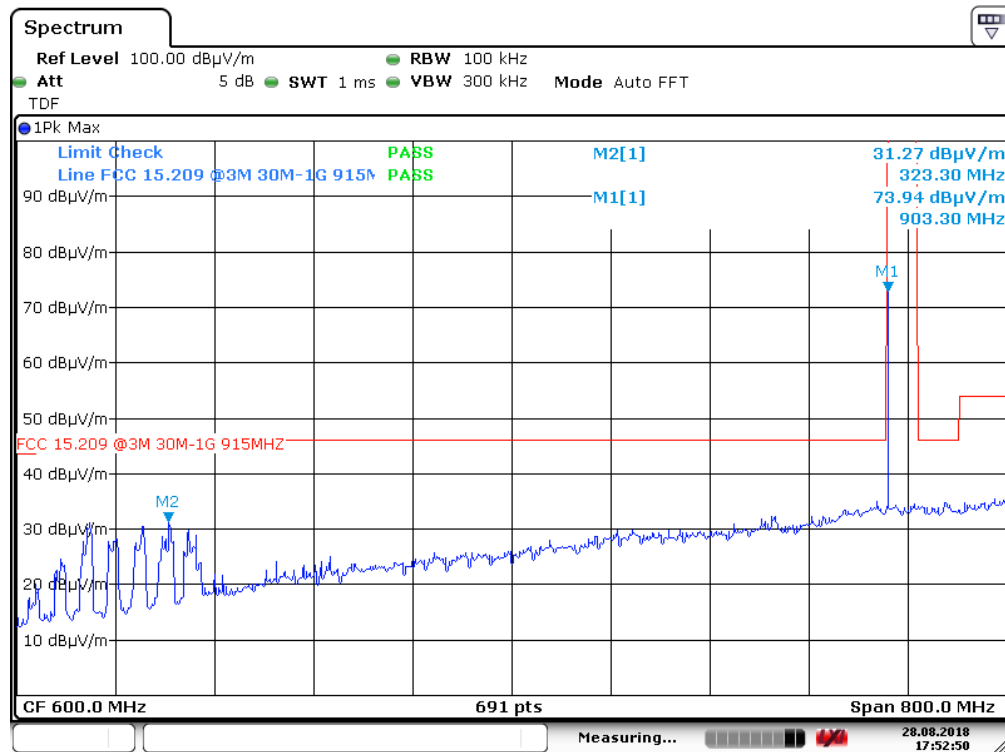
Date: 28.AUG.2018 18:45:08

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch100 (Ground modem)



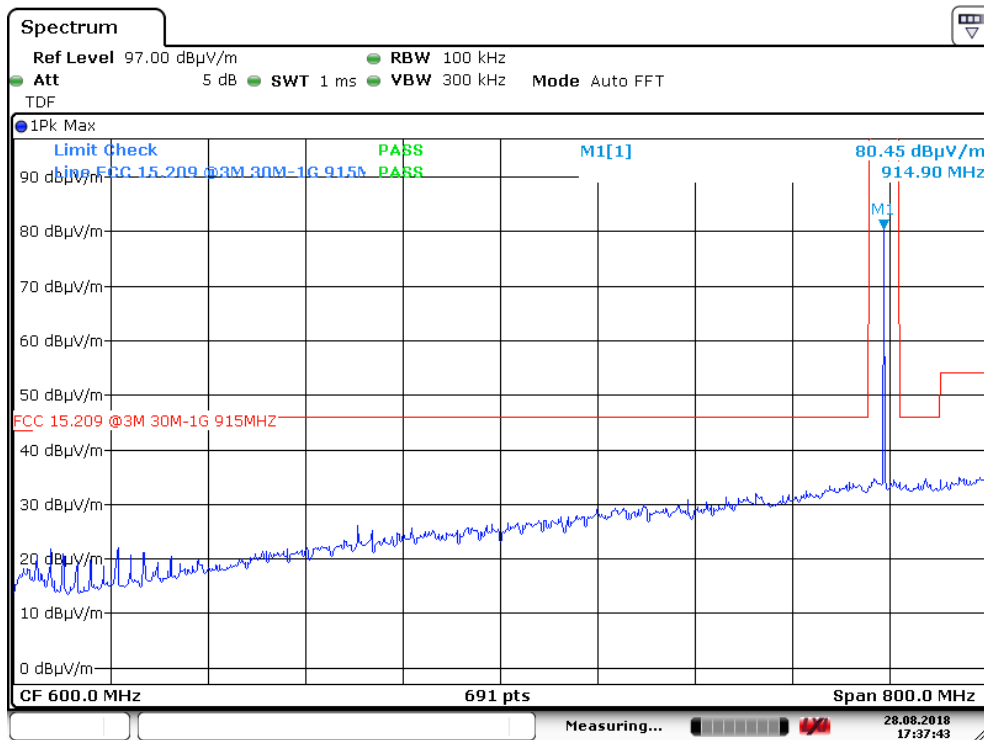
Date: 28.AUG.2018 17:46:57

Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch1 (Ground modem)



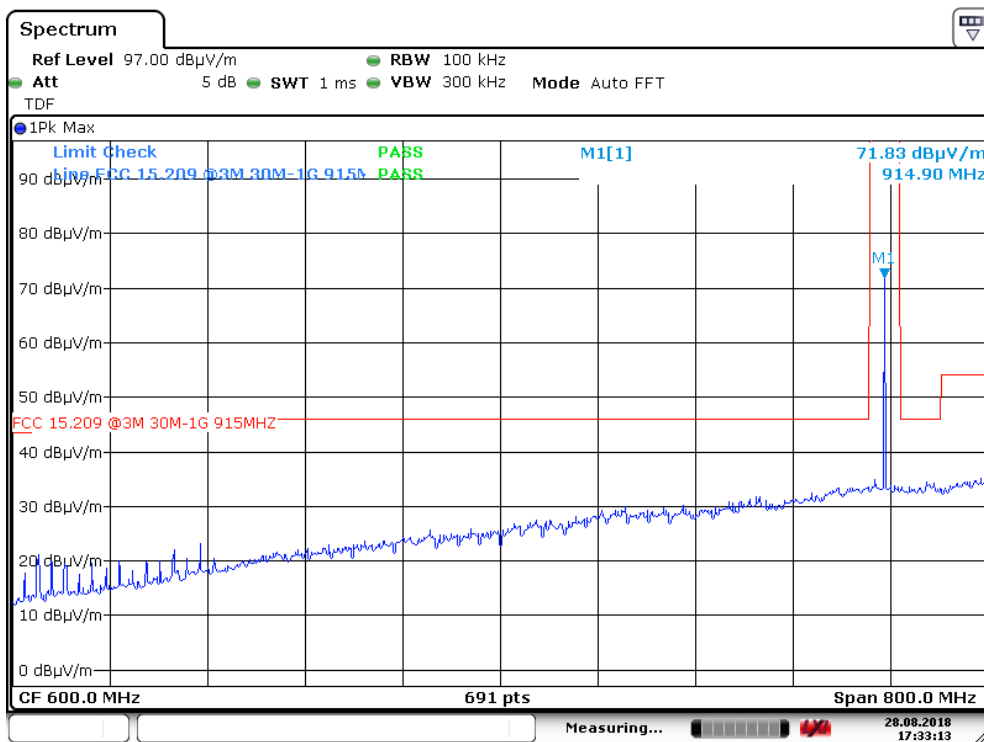
Date: 28.AUG.2018 17:52:50

Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch1 (Ground modem)



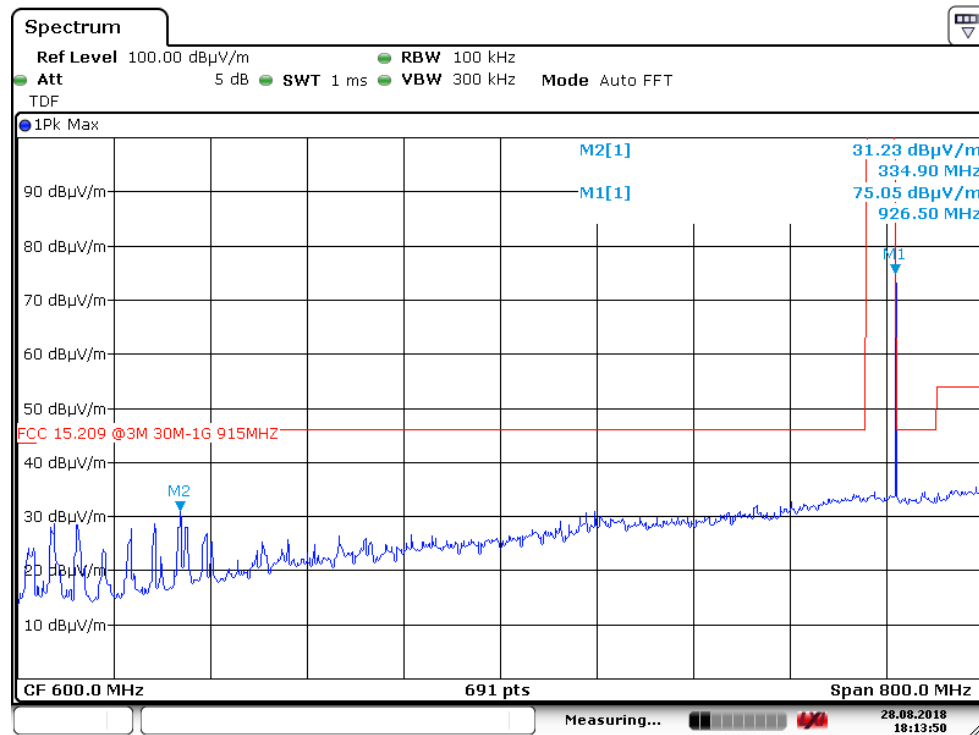
Date: 28.AUG.2018 17:37:43

Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch50 (Ground modem)



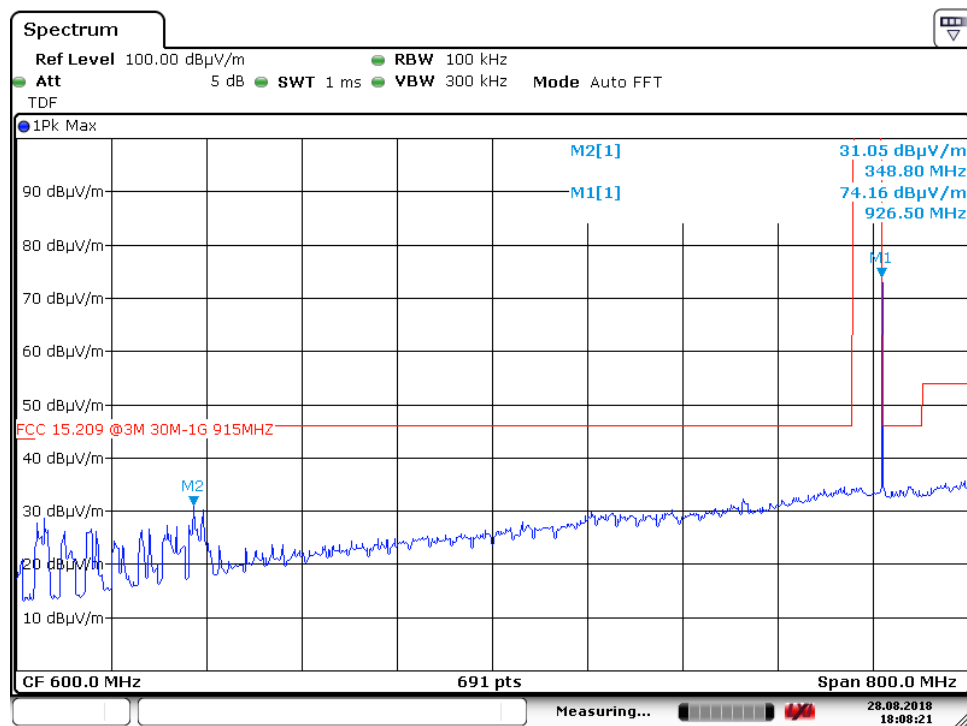
Date: 28.AUG.2018 17:33:13

Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch50 (Ground modem)



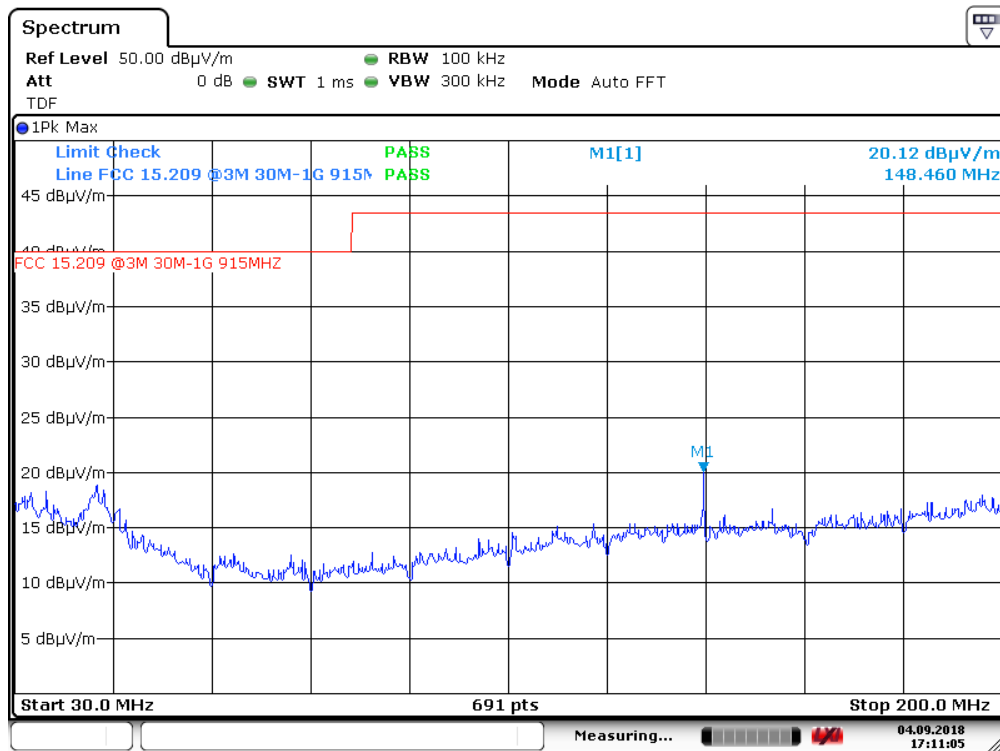
Date: 28.AUG.2018 18:13:50

Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch100 (Ground modem)



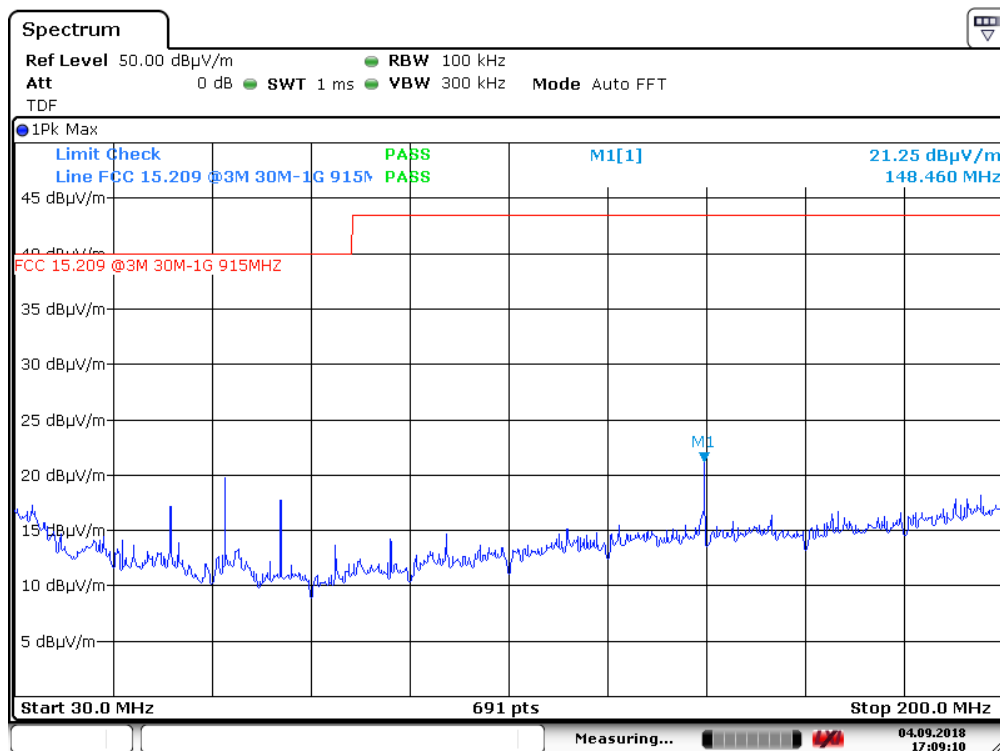
Date: 28.AUG.2018 18:08:22

Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch100 (Ground modem)



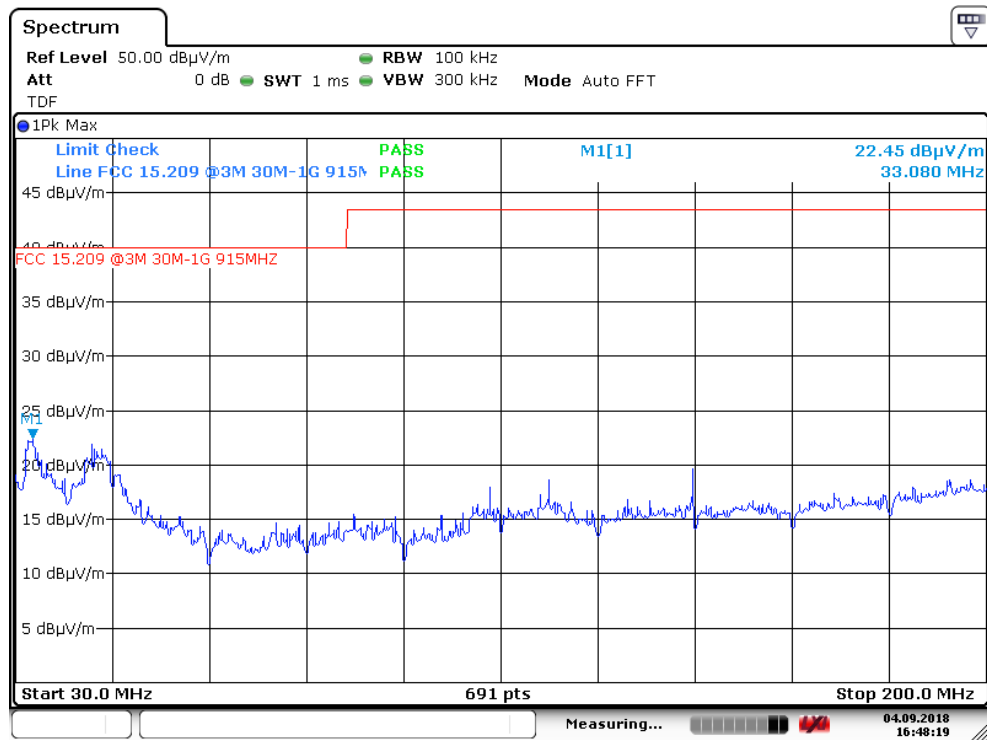
Date: 4.SEP.2018 17:11:06

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch1 (Air modem)



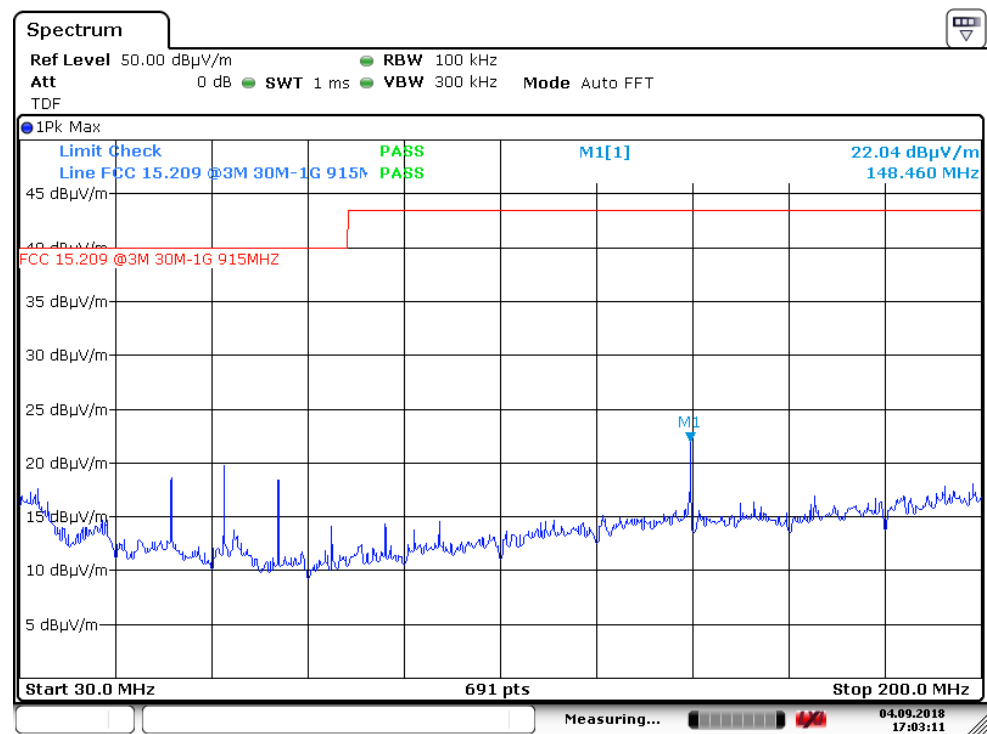
Date: 4.SEP.2018 17:09:11

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch1 (Air modem)



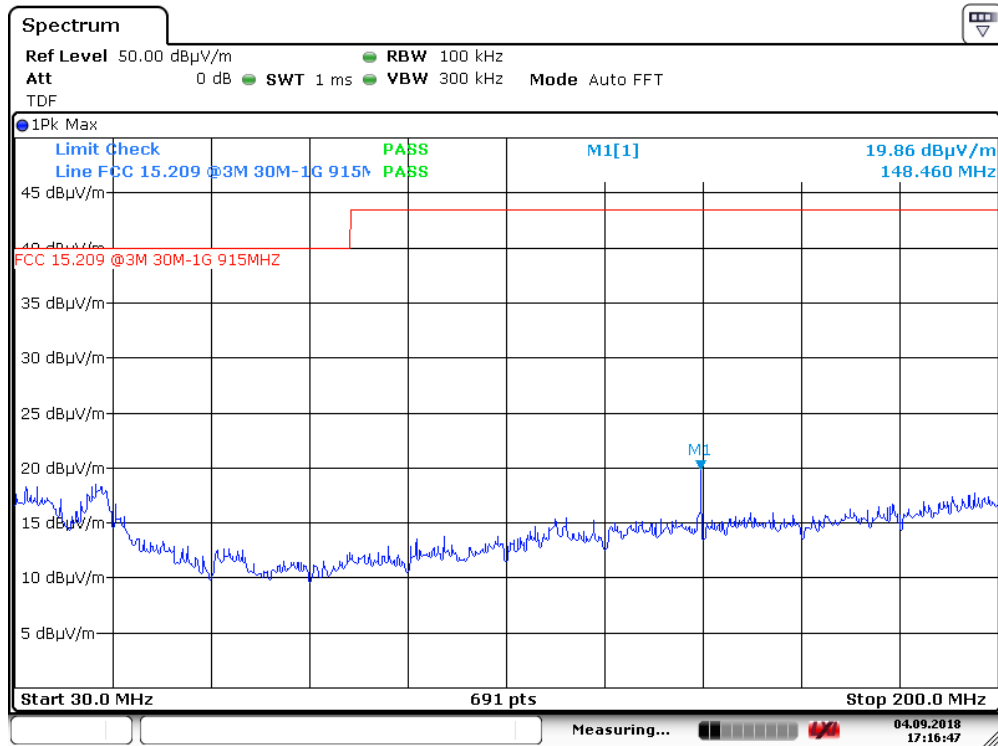
Date: 4.SEP.2018 16:48:20

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch50 (Air modem)



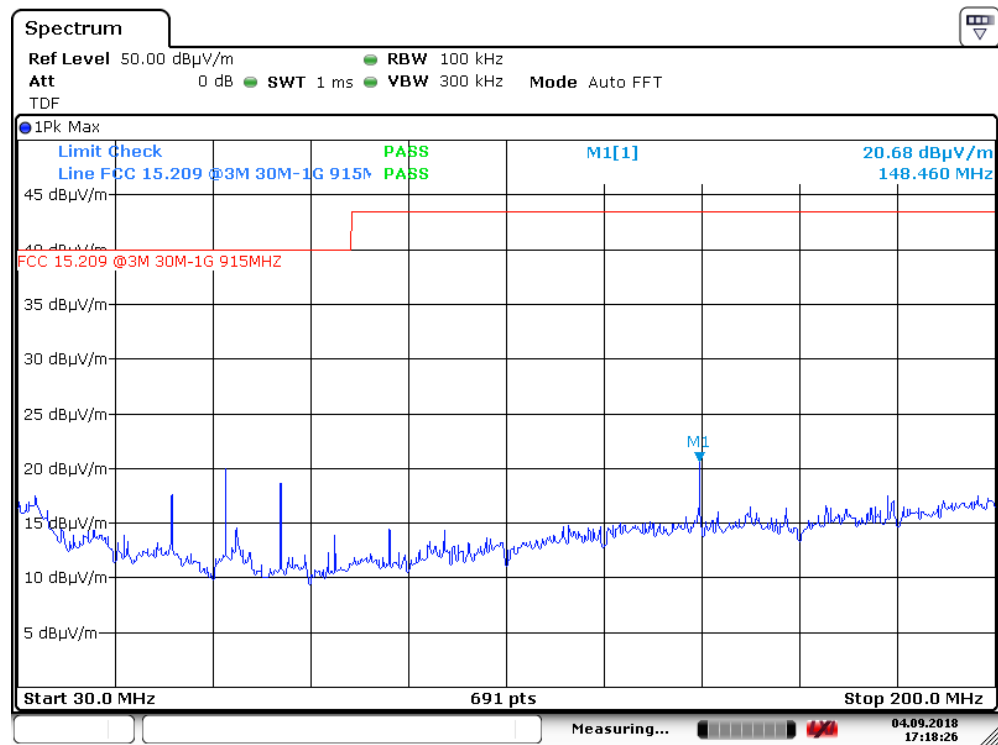
Date: 4.SEP.2018 17:03:12

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch50 (Air modem)



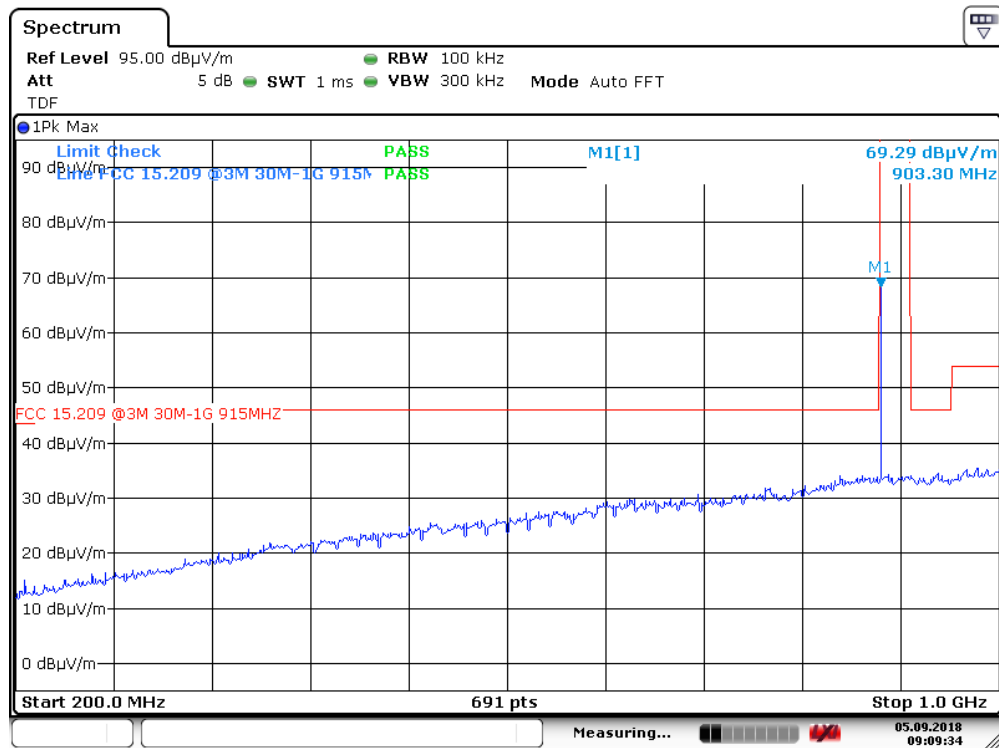
Date: 4.SEP.2018 17:16:48

Radiated Emissions, 30 – 200 MHz, HP, @3m, PK scan ch100 (Air modem)



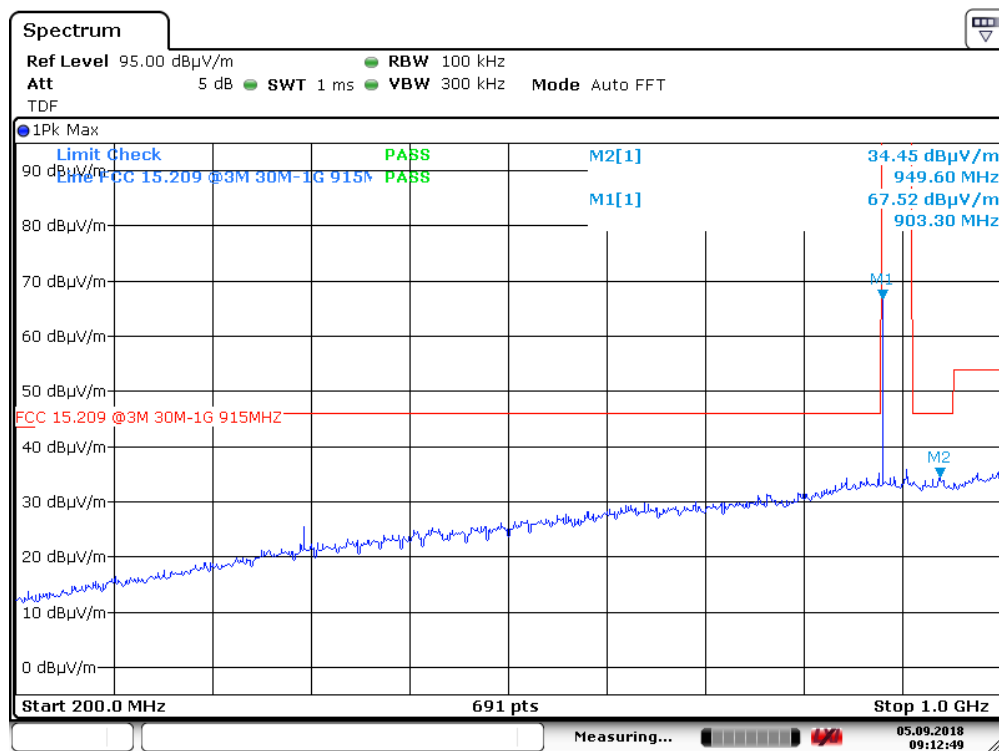
Date: 4.SEP.2018 17:18:27

Radiated Emissions, 30 – 200 MHz, VP, @3m, PK scan ch100 (Air modem)



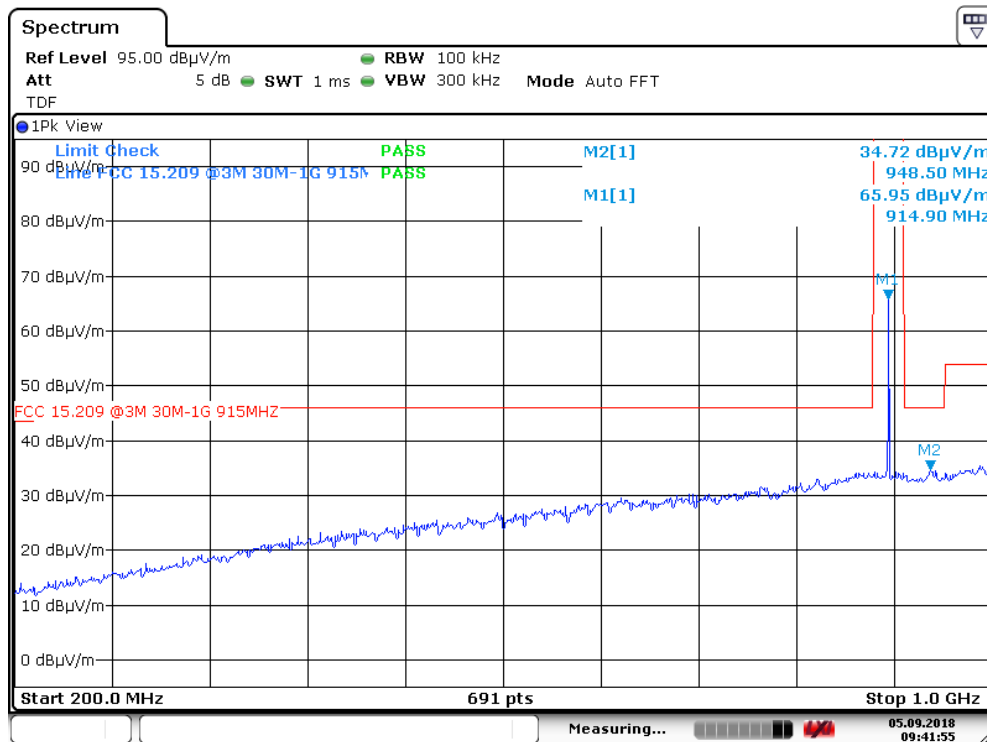
Date: 5.SEP.2018 09:09:34

Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch1 (Air modem)

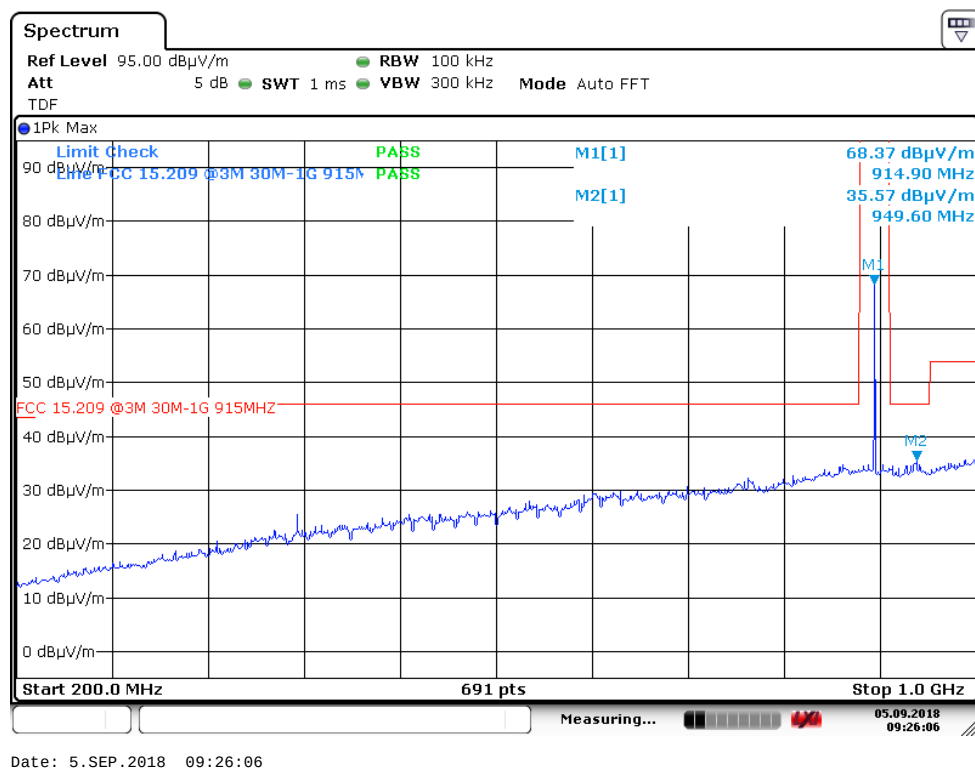


Date: 5.SEP.2018 09:12:49

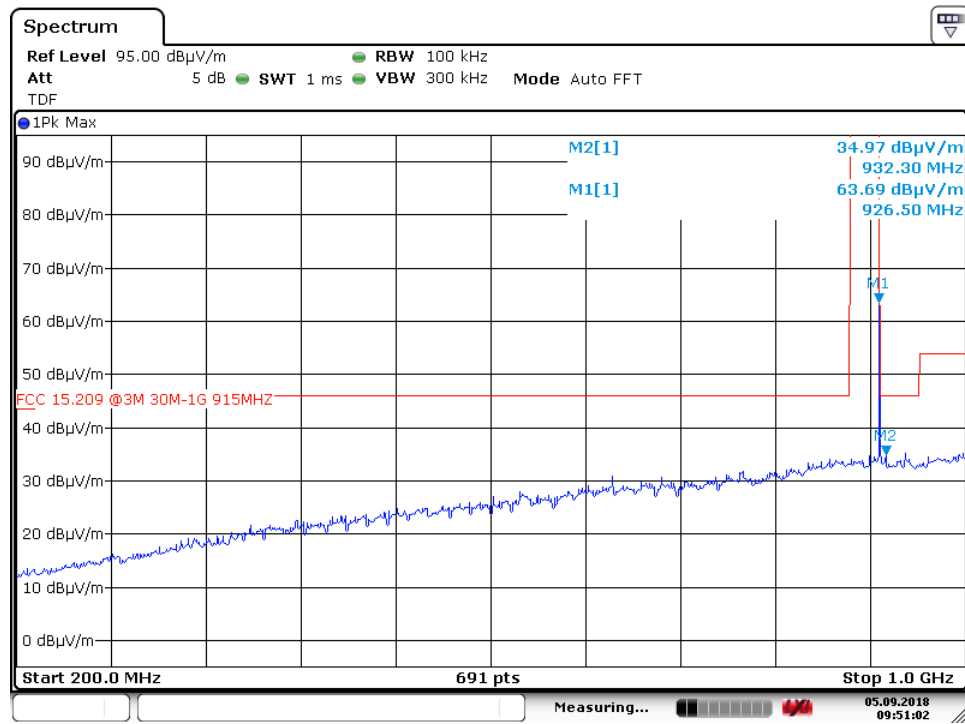
Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch1 (Air modem)



Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch50 (Air modem)

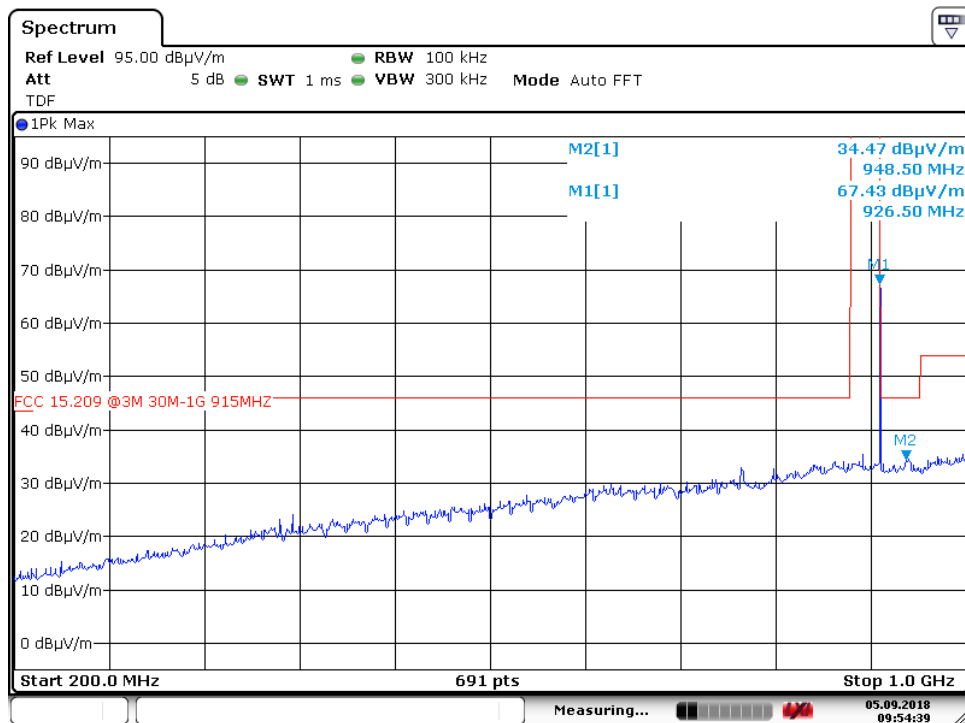


Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch50 (Air modem)



Date: 5.SEP.2018 09:51:02

Radiated Emissions, 200 – 1000 MHz, HP, @3m, PK scan ch100 (Air modem)



Date: 5.SEP.2018 09:54:39

Radiated Emissions, 200 – 1000 MHz, VP, @3m, PK scan ch100 (Air modem)

Radiated Emissions, 1-10 GHz

Measuring distance: 3m (1 – 10 GHz)

Peak Detector:

Ground modem:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
1.8064	L	0	56.44	0	74	17.56
1.8290	M	0	56.14	0	74	17.86
1.8540	H	0	57.54	0	74	16.46
2.7096	L	0	61.76	0	74	12.24
2.7435	M	0	61.97	0	74	12.03
2.7810	H	0	63.01	0	74	10.99
3.6129	L	0	68.31	0	74	5.69
3.6578	M	0	68.14	0	74	5.86
3.7080	H	0	68.39	0	74	5.61
4.5161	L	0	60.19	0	74	13.81
4.5724	M	0	60.75	0	74	13.25
4.6350	H	0	60.99	0	74	13.01
5.4193	L	0	65.43	0	74	8.57
5.4869	M	0	66.15	0	74	7.85
5.5620	H	0	65.07	0	74	8.93
6.3225	L	0	59.53	0	74	14.47
6.4014	M	0	58.31	0	74	15.69
Other freqs	L,M,H	/	< 54	0	74	>20

Peak Detector:

Air modem:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
2.7096	L	0	63.83	0	74	10.17
2.7435	M	0	61.97	0	74	12.03
2.7810	H	0	63.01	0	74	10.99
3.6129	L	0	65.68	0	74	8.32
3.6578	M	0	68.14	0	74	5.86
3.7080	H	0	68.39	0	74	5.61
4.5161	L	0	65.35	0	74	8.65
4.5724	M	0	60.75	0	74	13.25
4.6350	H	0	60.99	0	74	13.01
5.4193	L	0	65.43	0	74	8.57
5.4869	M	0	66.15	0	74	7.85
5.5620	H	0	65.07	0	74	8.93
6.3225	L	0	59.53	0	74	14.47
6.4014	M	0	58.31	0	74	15.69
Other freqs	L,M,H	/	< 54	0	74	>20

Fully charged battery is used

Average Detector:

Ground modem:

Frequency	RF channel	Dist. corr. factor	Field strength, Average Detector	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
1.8064	L	0	36.44 *)	20	54	17.56
1.8290	M	0	36.14 *)	20	54	17.86
1.8540	H	0	37.54 *)	20	54	16.46
2.7096	L	0	41.76 *)	20	54	12.24
2.7435	M	0	41.97 *)	20	54	12.03
2.7810	H	0	43.01 *)	20	54	10.99
3.6129	L	0	48.31 *)	20	54	5.69
3.6578	M	0	48.14 *)	20	54	5.86
3.7080	H	0	48.39 *)	20	54	5.61
4.5161	L	0	40.19 *)	20	54	13.81
4.5724	M	0	40.75 *)	20	54	13.25
4.6350	H	0	40.99 *)	20	54	13.01
5.4193	L	0	45.43 *)	20	54	8.57
5.4869	M	0	46.15 *)	20	54	7.85
5.5620	H	0	45.07 *)	20	54	8.93
6.3225	L	0	39.53 *)	20	54	14.47
6.4014	M	0	38.31 *)	20	54	15.69
Other freqs	L,M,H	/	/	0	54	/

*) Average Values are calculated from Peak Values by Duty Cycle Correction Factor.

Average Detector:

Air modem:

Frequency	RF channel	Dist. corr. factor	Field strength, Average Detector	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
2.7096	L	0	43.83 *)	20	54	10.17
2.7435	M	0	41.97 *)	20	54	12.03
2.7810	H	0	43.01 *)	20	54	10.99
3.6129	L	0	45.68 *)	20	54	8.32
3.6578	M	0	48.14 *)	20	54	5.86
3.7080	H	0	48.39 *)	20	54	5.61
4.5161	L	0	45.35 *)	20	54	8.65
4.5724	M	0	40.75 *)	20	54	13.25
4.6350	H	0	40.99 *)	20	54	13.01
5.4193	L	0	45.43 *)	20	54	8.57
5.4869	M	0	46.15 *)	20	54	7.85
5.5620	H	0	45.07 *)	20	54	8.93
6.3225	L	0	39.53 *)	20	54	14.47
6.4014	M	0	38.31 *)	20	54	15.69
Other freqs	L,M,H	/	/	0	54	/

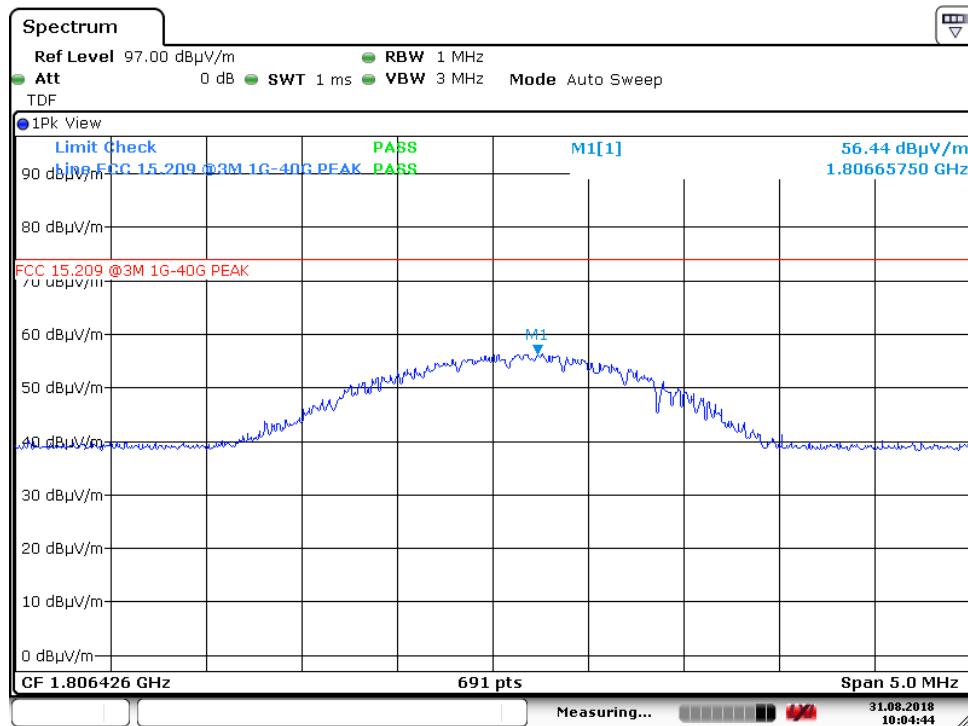
*) Average Values are calculated from Peak Values by Duty Cycle Correction Factor.

Fully charged battery is used

Tested according to KDB 558074 D01

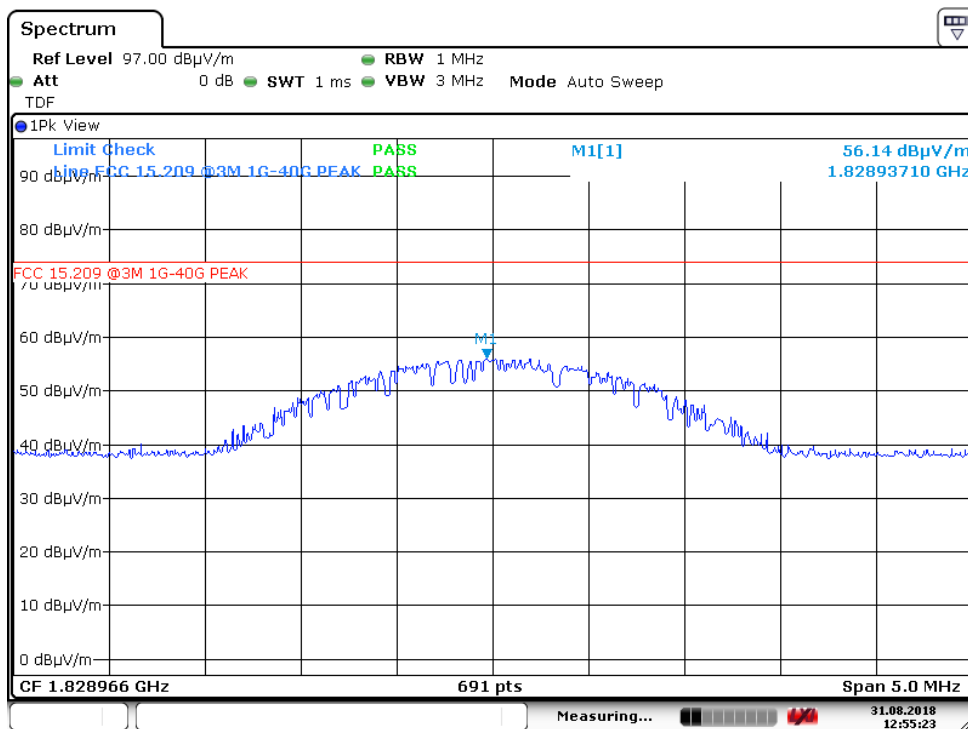
Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor".

See plots.



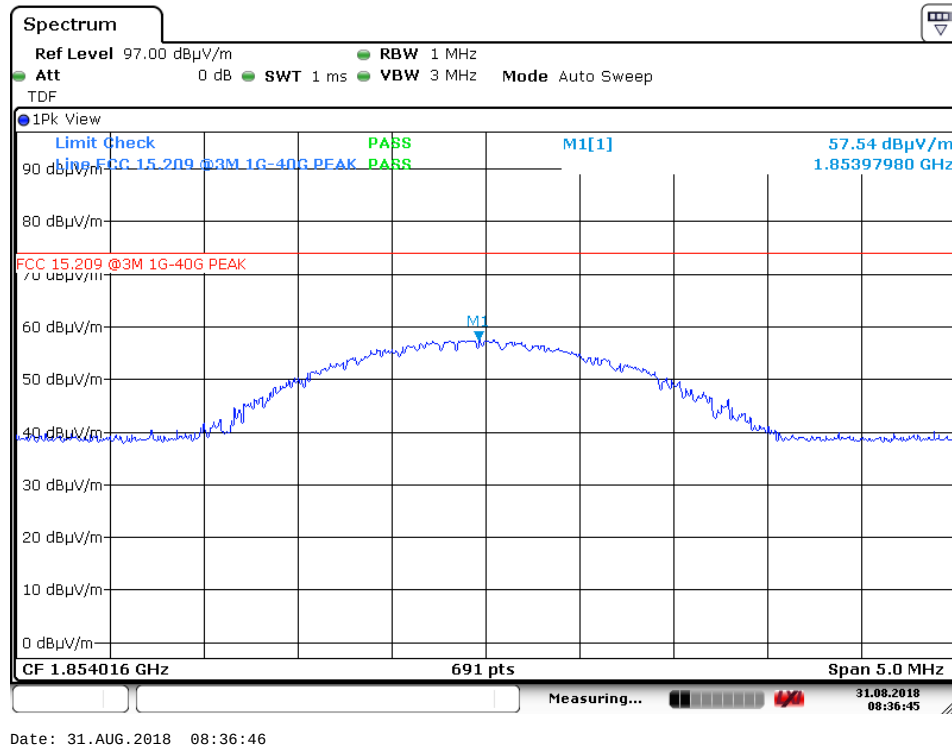
Date: 31.AUG.2018 10:04:45

2nd harmonic – ch1, HP – PK (Ground modem)

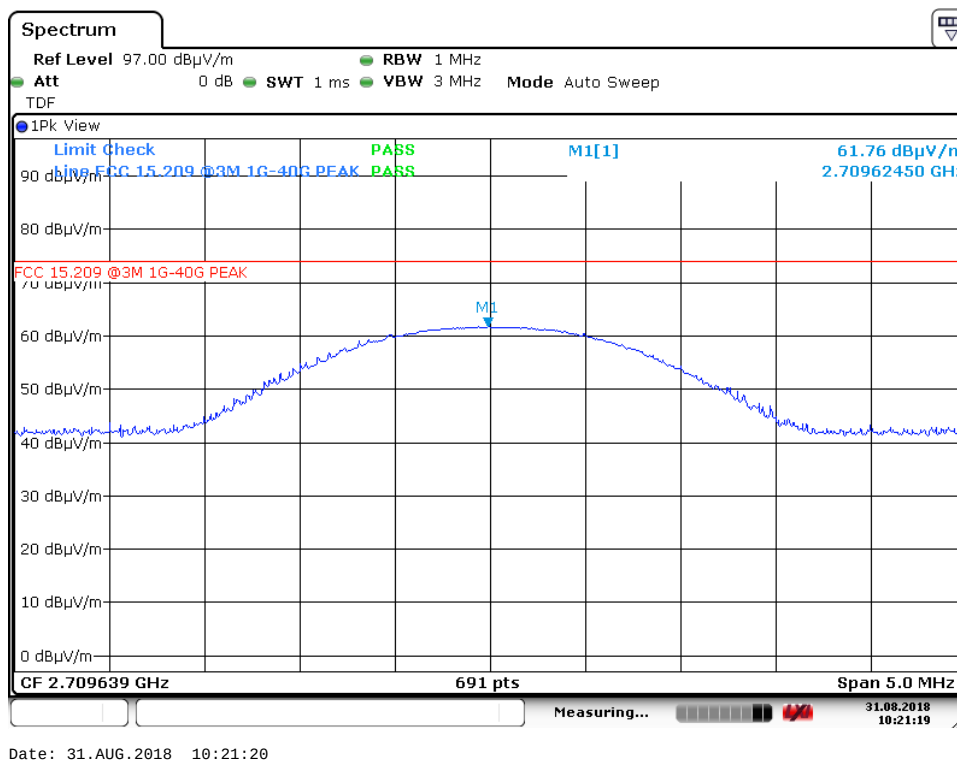


Date: 31.AUG.2018 12:55:24

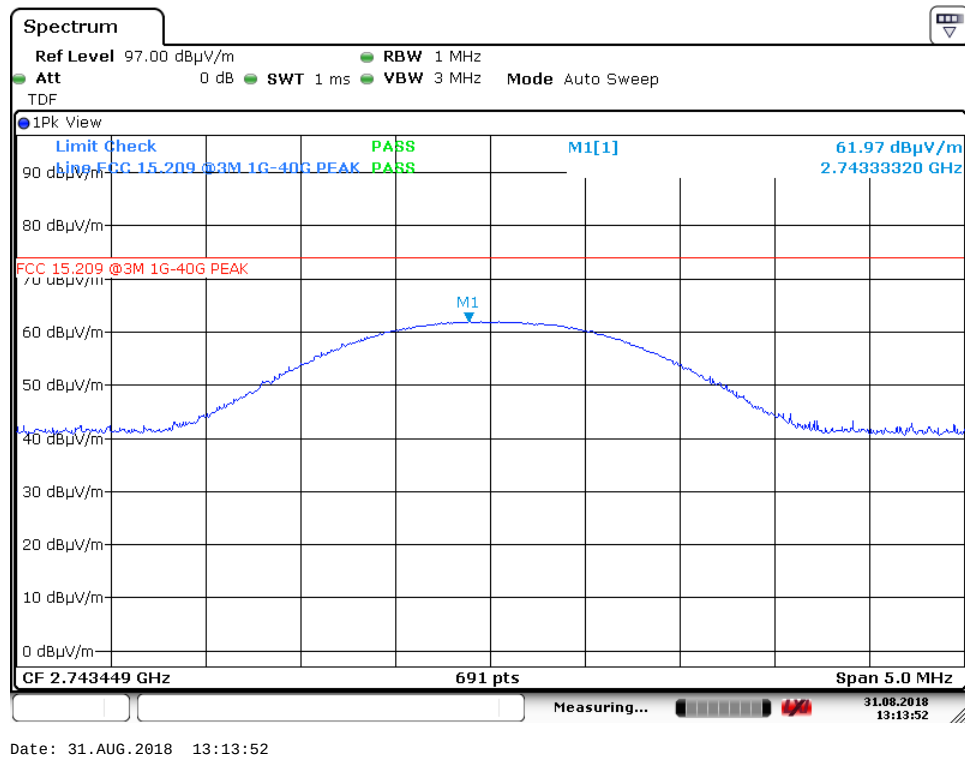
2nd harmonic – ch50, HP – PK (Ground modem)



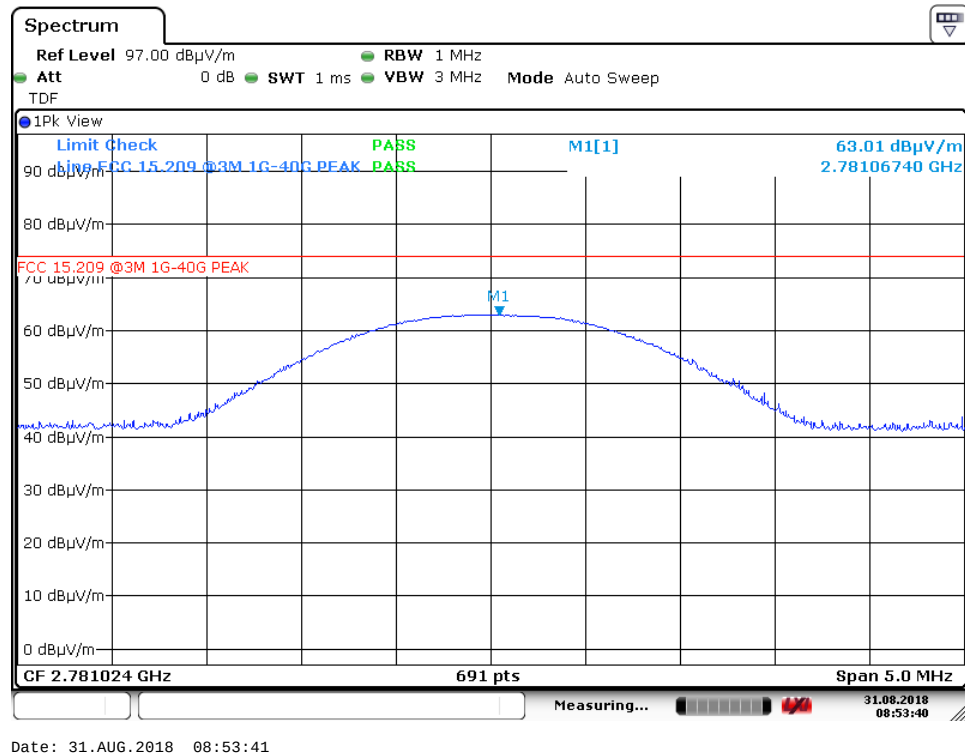
2nd harmonic – ch100, HP – PK (Ground modem)



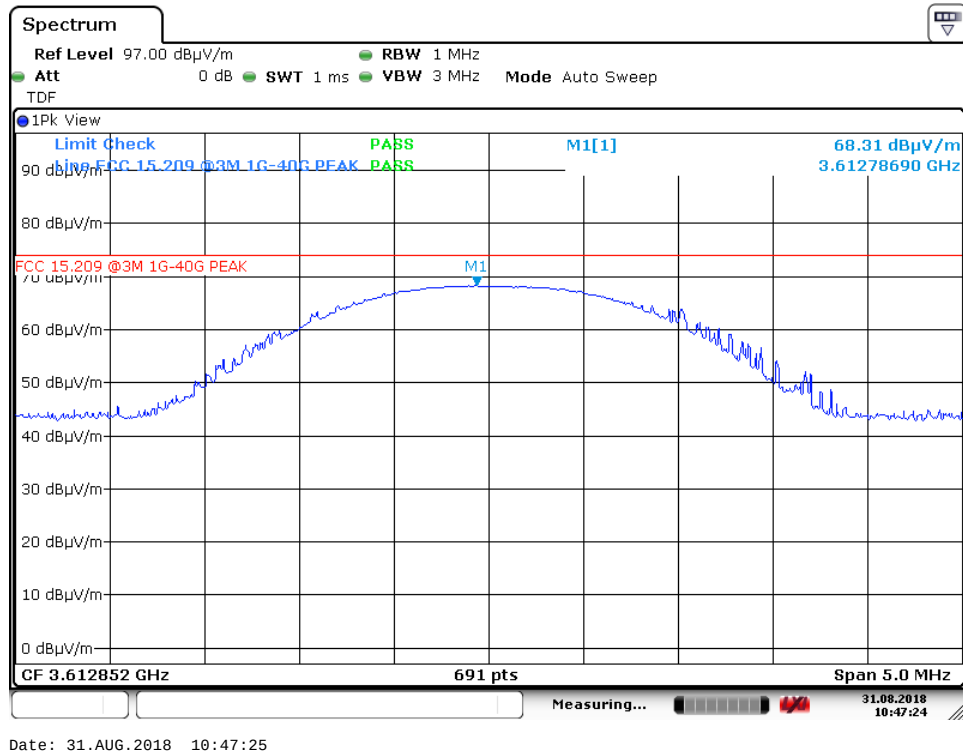
3rd harmonic – ch1, VP – PK (Ground modem)



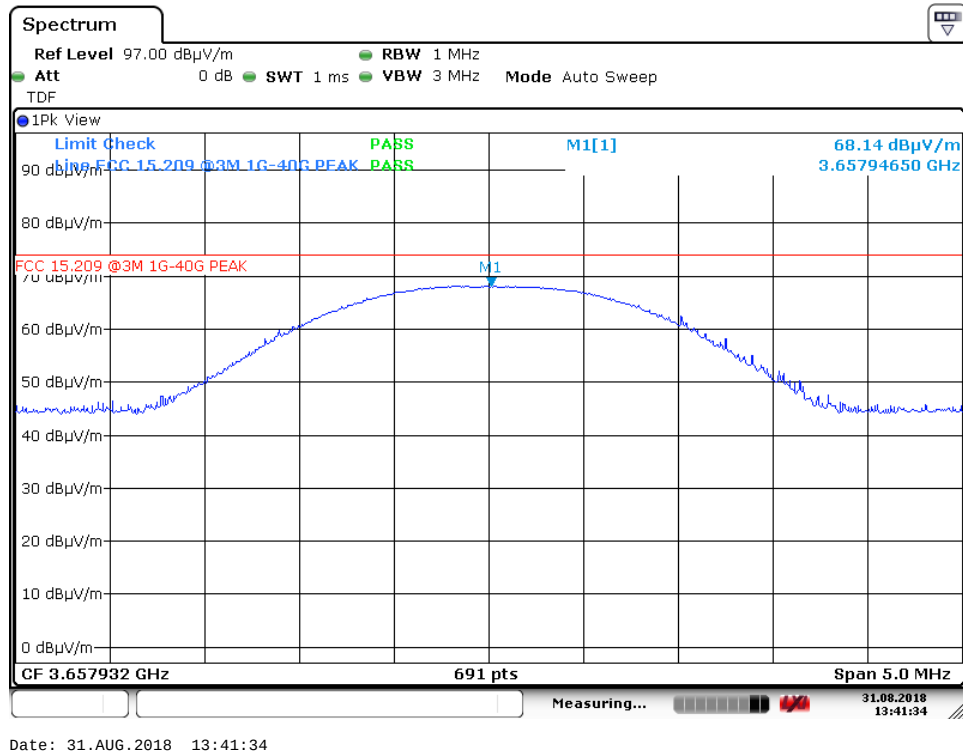
3rd harmonic – ch50, VP – PK (Ground modem)



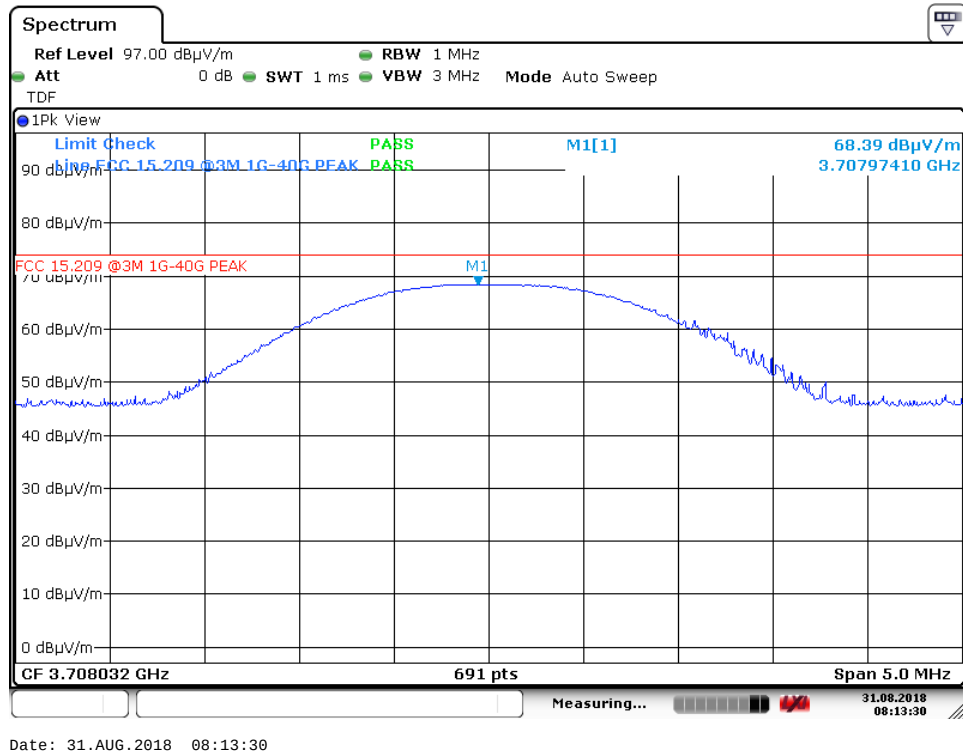
3rd harmonic – ch100, VP – PK (Ground modem)



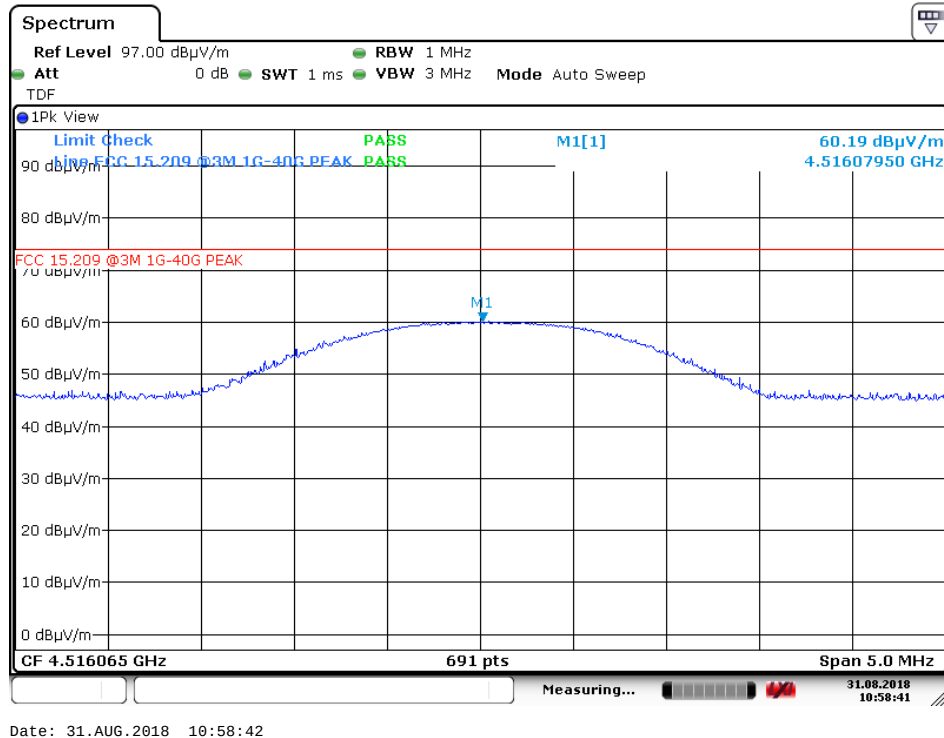
4th harmonic – ch1, VP – PK (Ground modem)



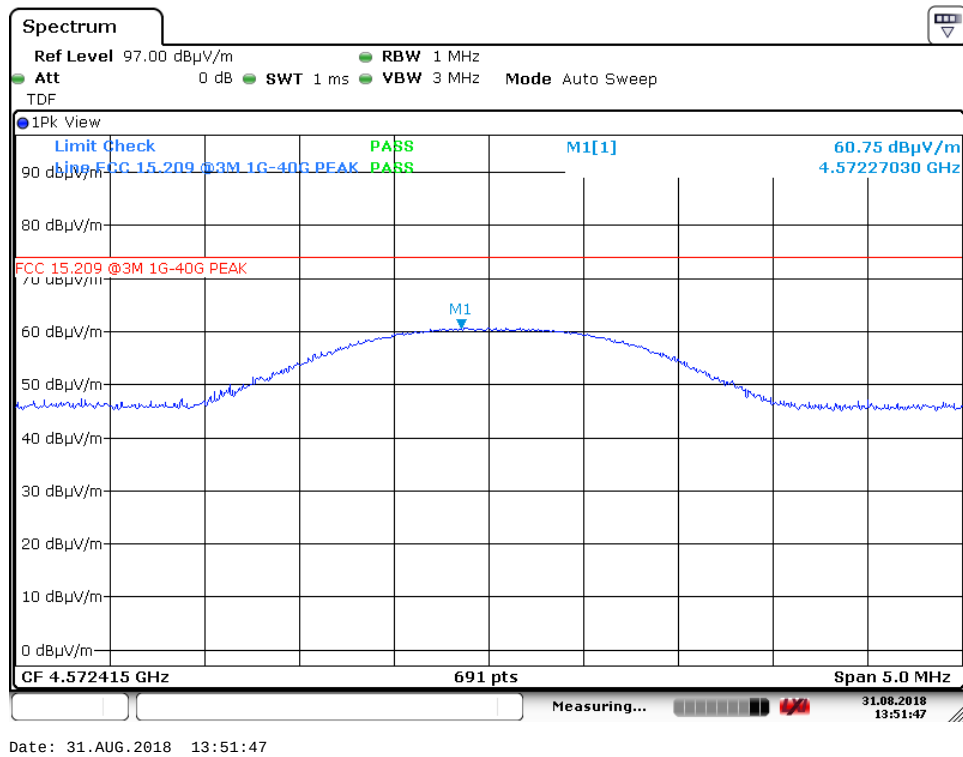
4th harmonic – ch50, VP – PK (Ground modem)



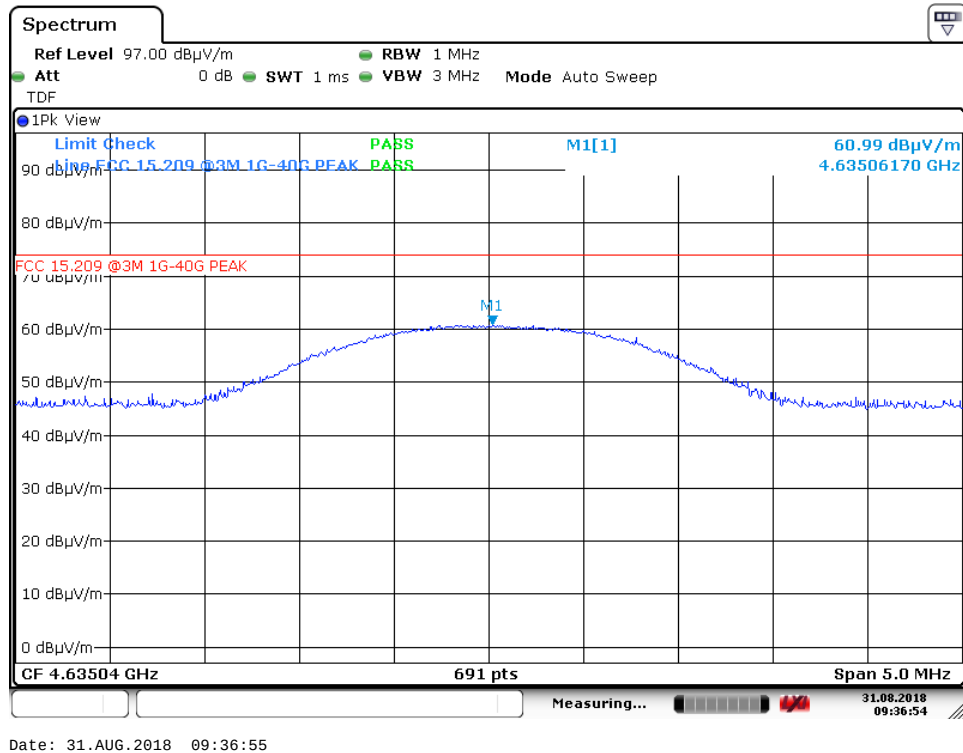
4th harmonic – ch100, VP – PK (Ground modem)



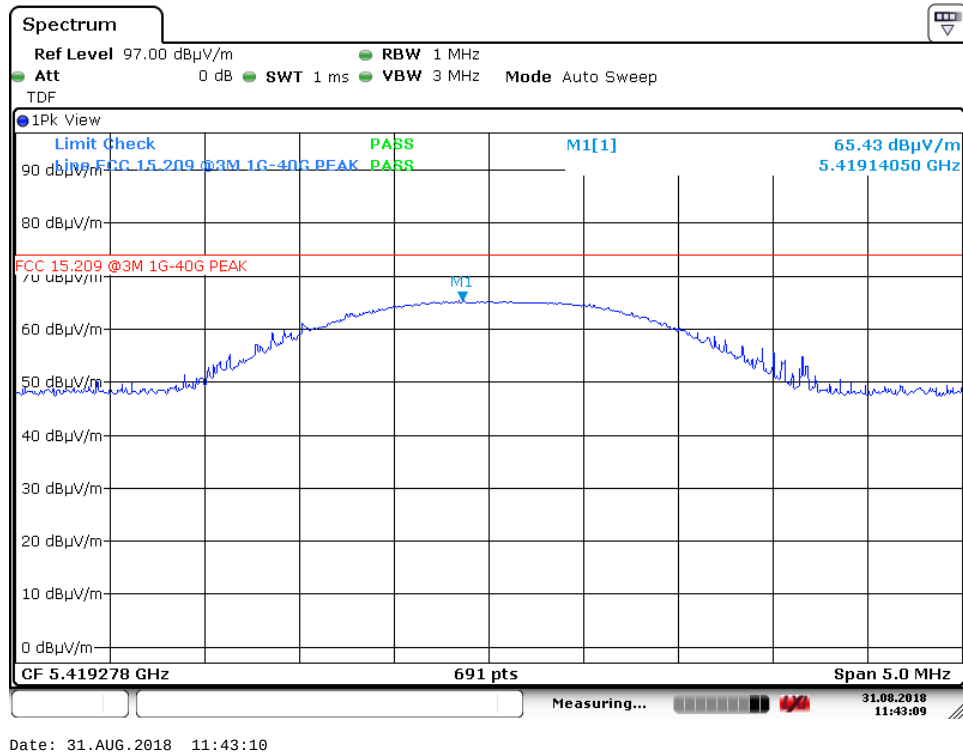
5th harmonic – ch1, VP – PK (Ground modem)



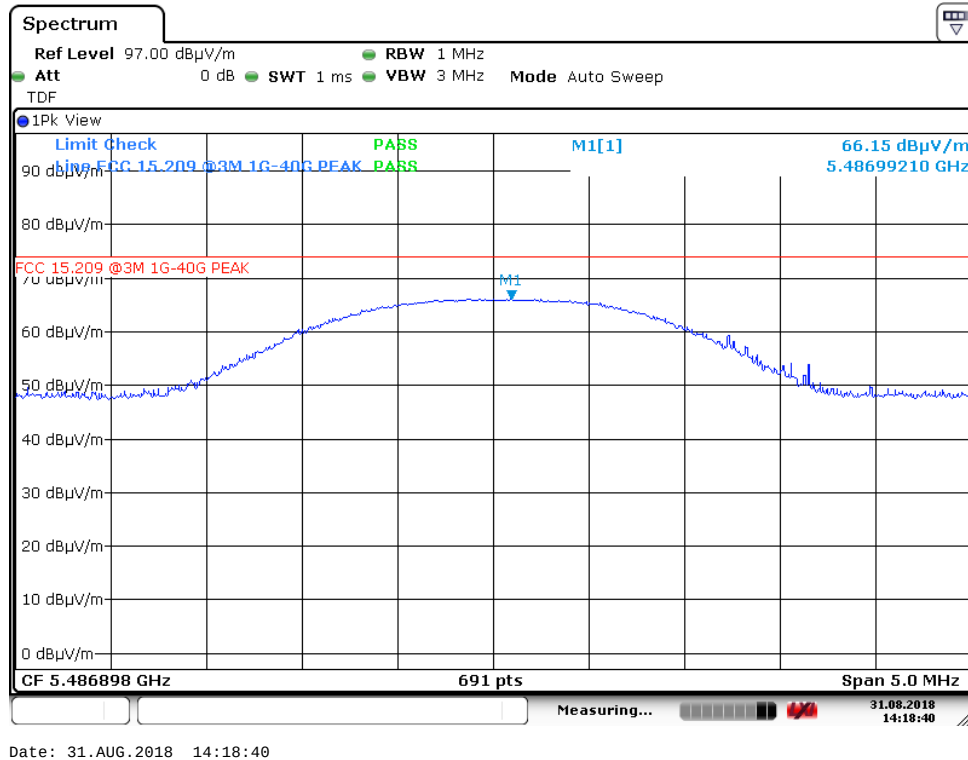
5th harmonic – ch50, VP – PK (Ground modem)



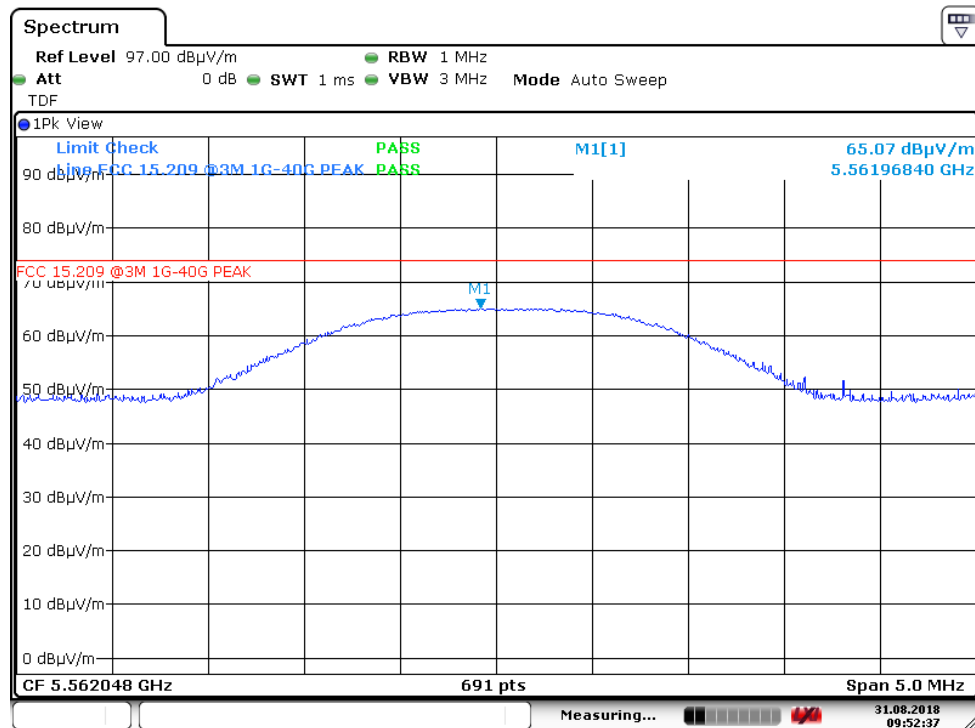
5th harmonic – ch100, VP – PK (Ground modem)



6th harmonic – ch1, HP – PK (Ground modem)

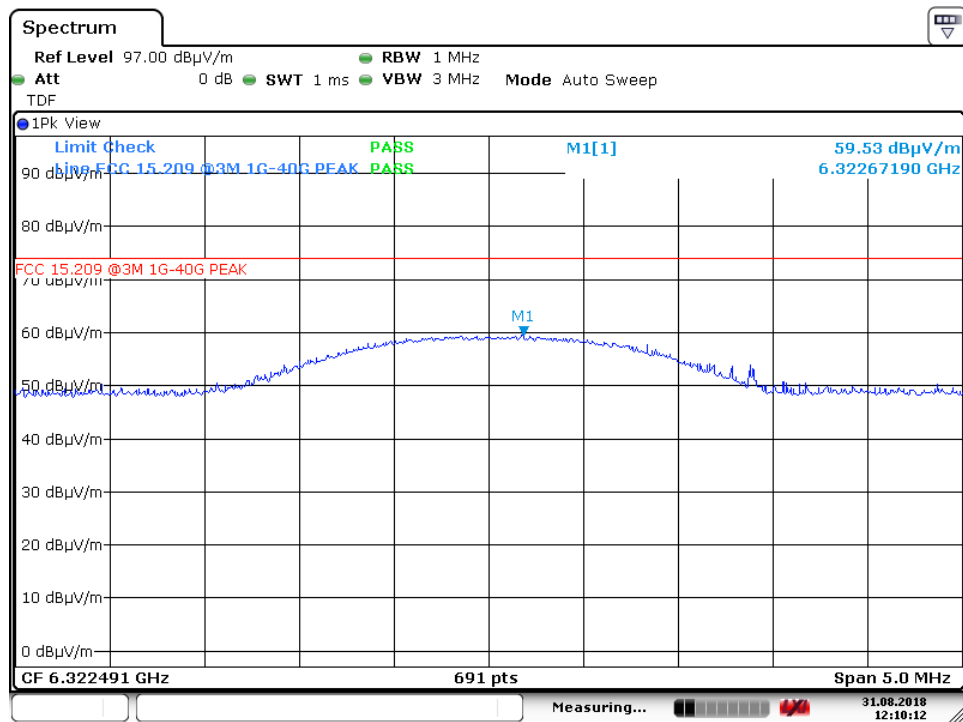


6th harmonic – ch50, HP – PK (Ground modem)



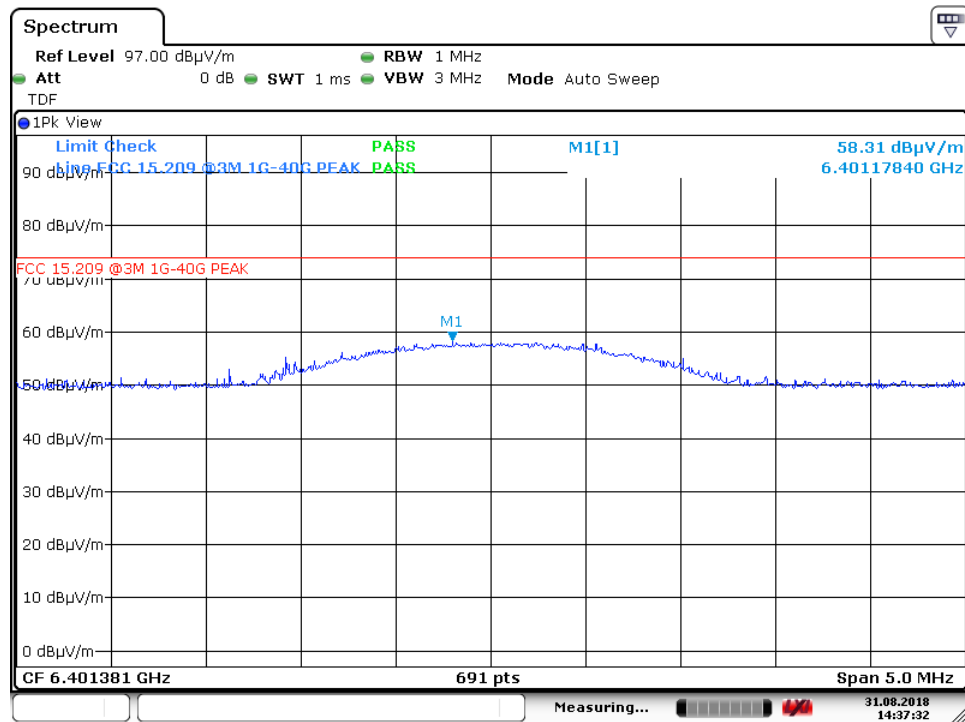
Date: 31.AUG.2018 09:52:38

6th harmonic – ch100, HP – PK (Ground modem)



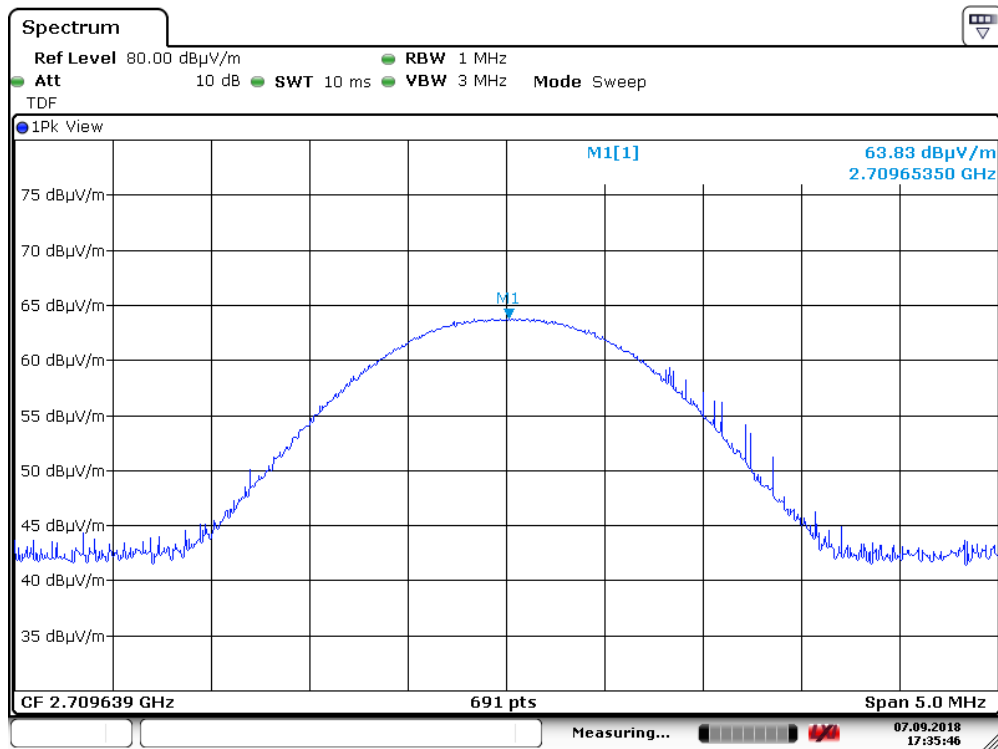
Date: 31.AUG.2018 12:10:13

7th harmonic – ch1, VP – PK (Ground modem)



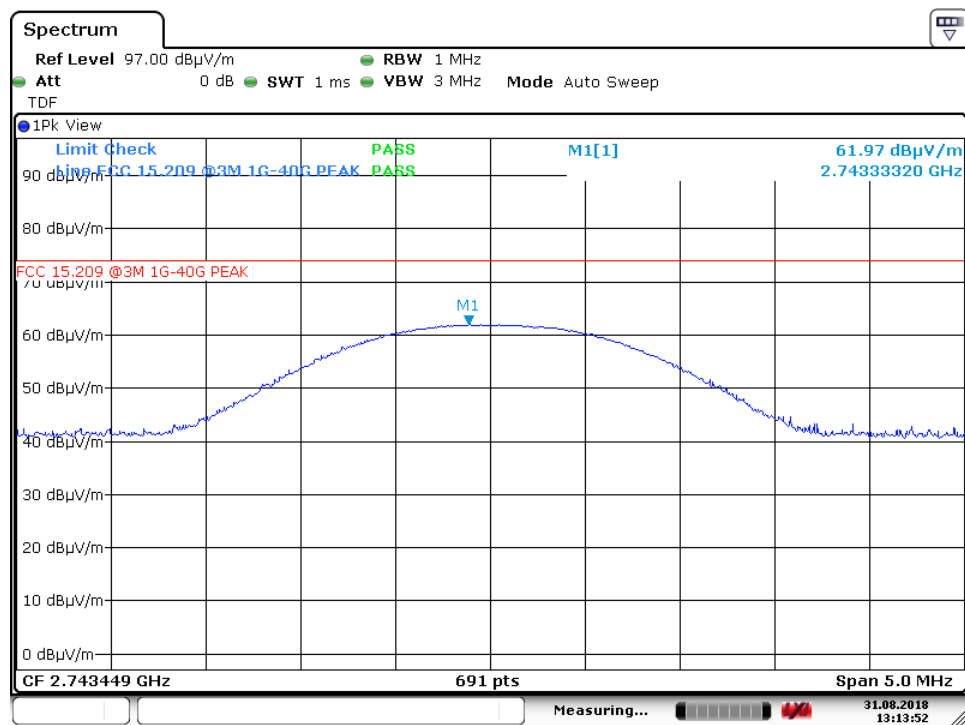
Date: 31.AUG.2018 14:37:32

7th harmonic – ch50, VP – PK (Ground modem)



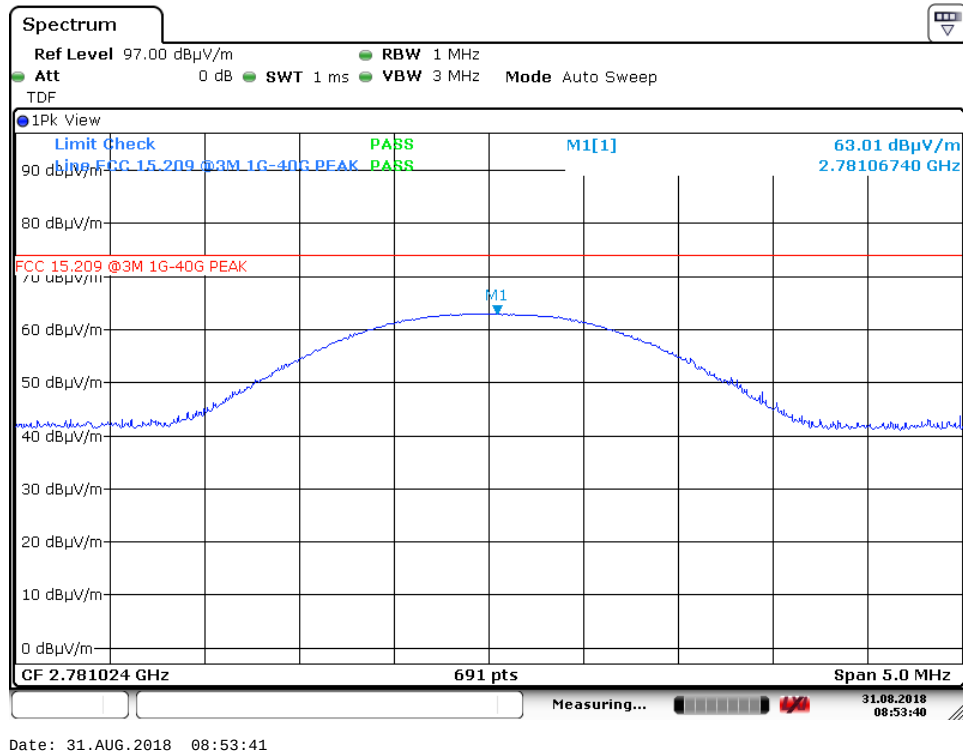
Date: 7.SEP.2018 17:35:46

3rd harmonic – ch1, VP – PK (Air modem)

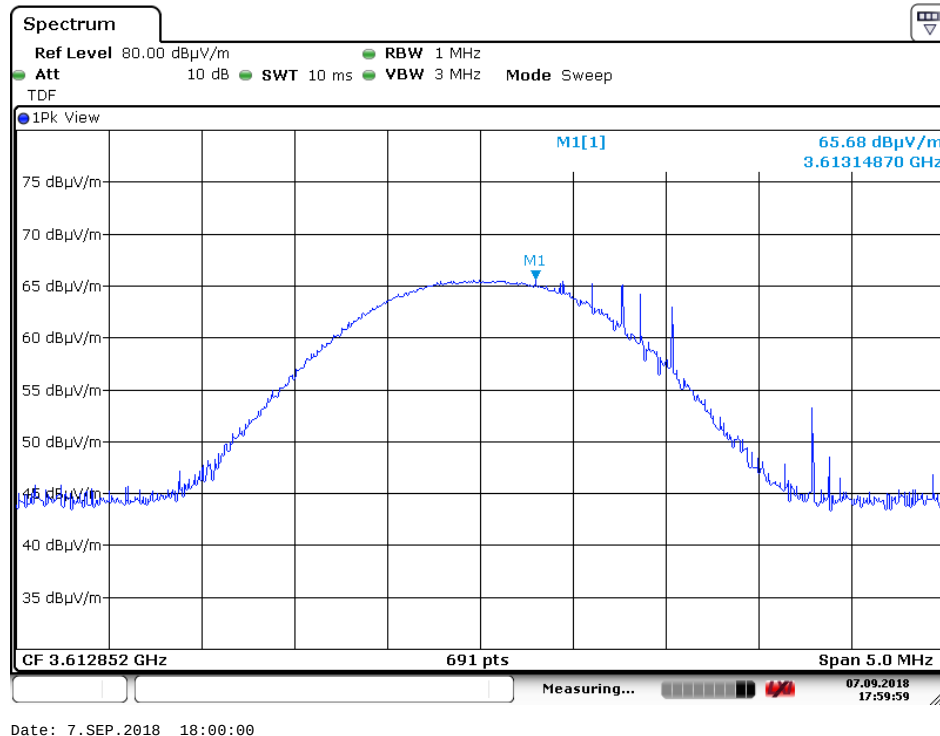


Date: 31.AUG.2018 13:13:52

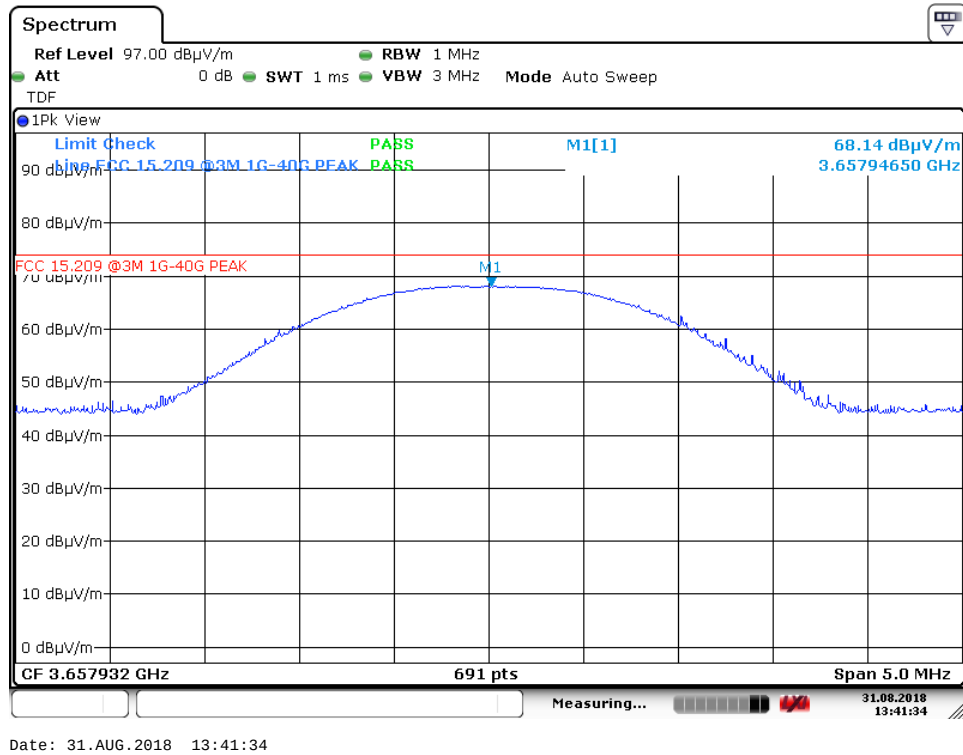
3rd harmonic – ch50, VP – PK (Air modem)



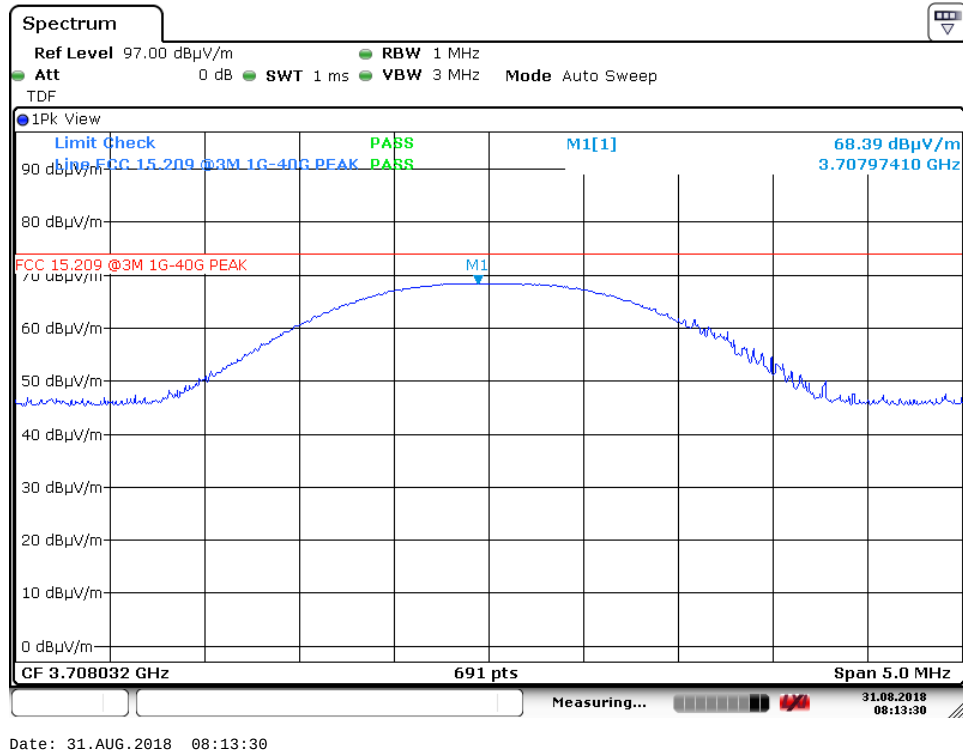
3rd harmonic – ch100, VP – PK (Air modem)



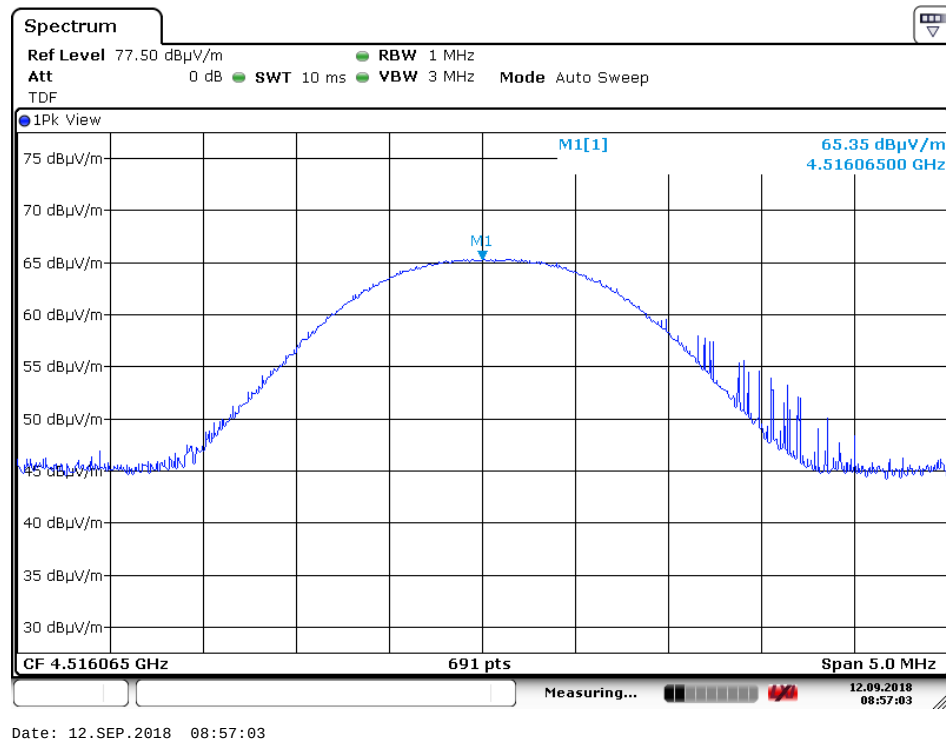
4th harmonic – ch1, VP – PK (Air modem)



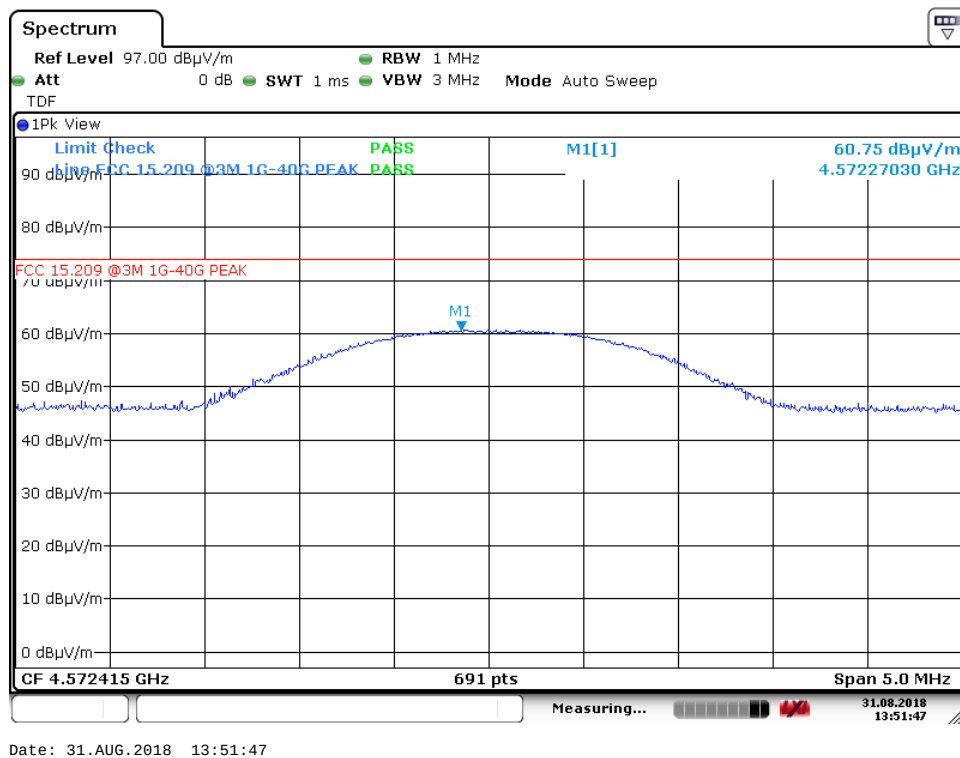
4th harmonic – ch50, VP – PK (Air modem)



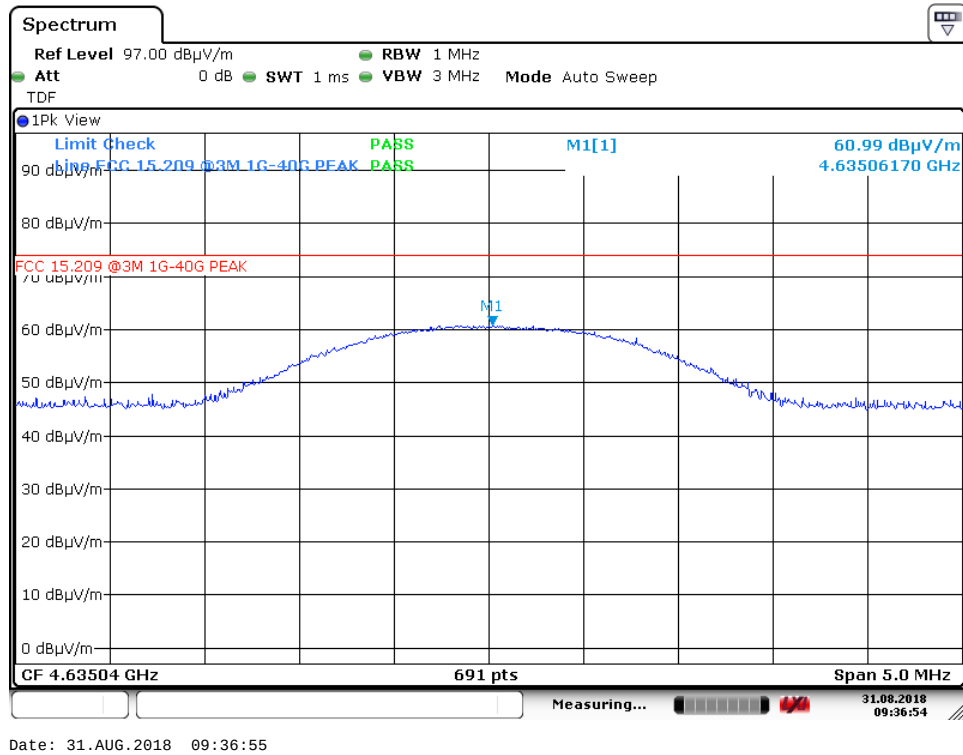
4th harmonic – ch100, VP – PK (Air modem)



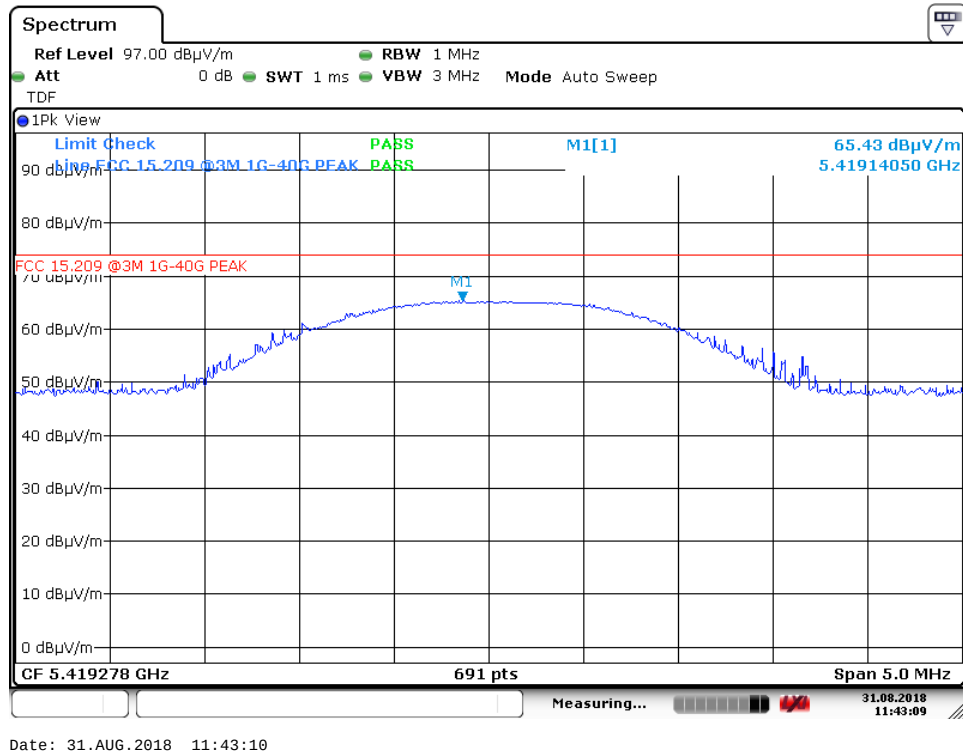
5th harmonic – ch1, VP – PK (Air modem)



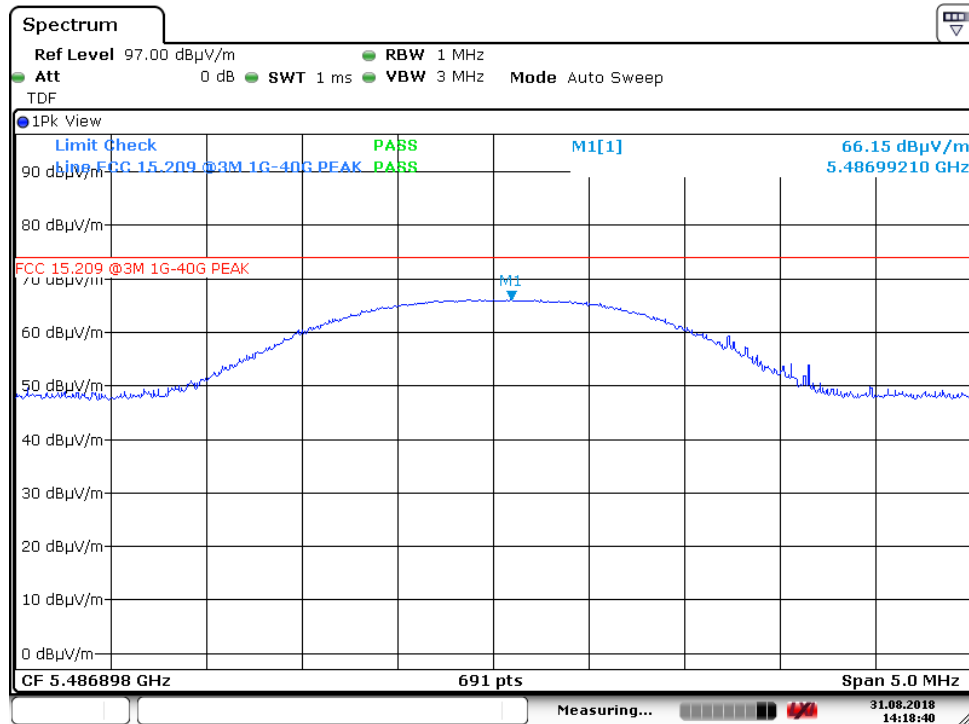
5th harmonic – ch50, VP – PK (Air modem)



5th harmonic – ch100, VP – PK (Air modem)

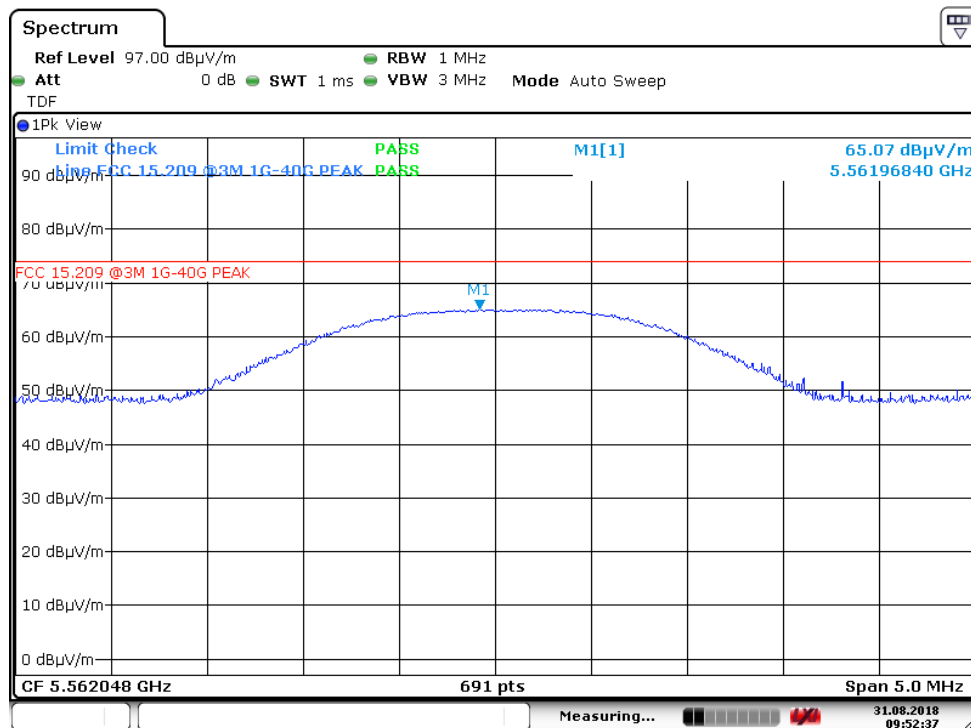


6th harmonic – ch1, HP – PK (Air modem)



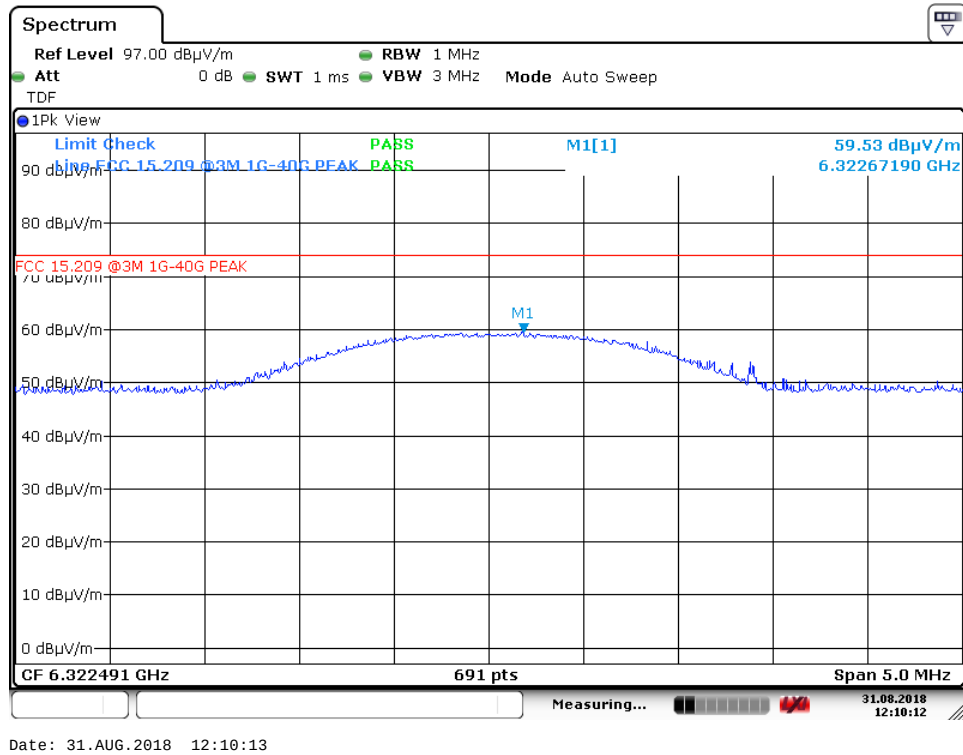
Date: 31.AUG.2018 14:18:40

6th harmonic – ch50, HP – PK (Air modem)

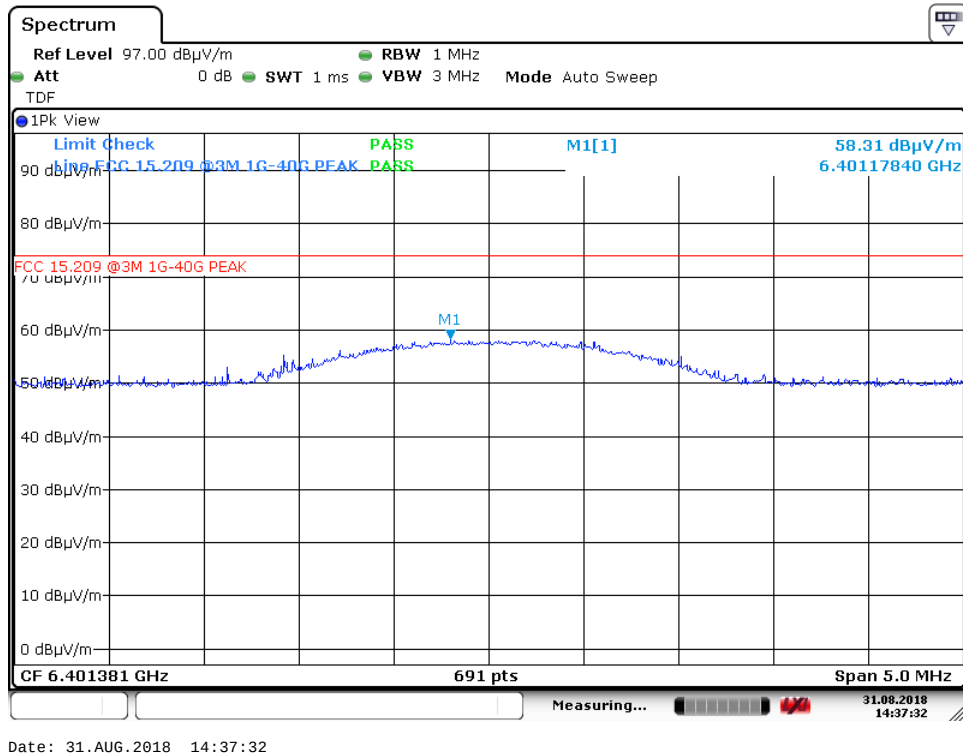


Date: 31.AUG.2018 09:52:38

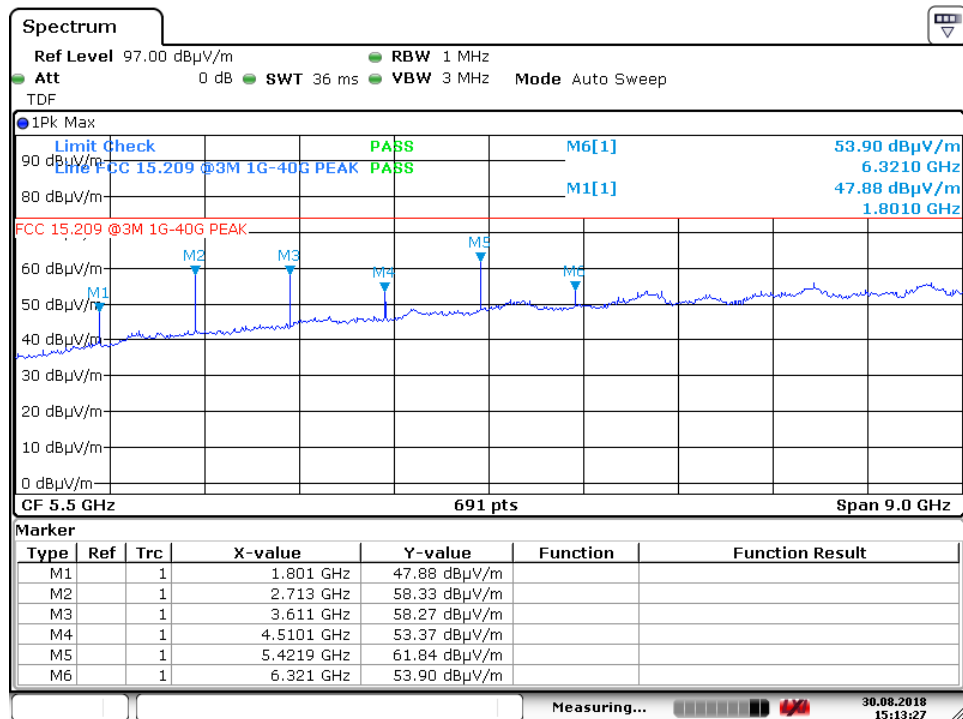
6th harmonic – ch100, HP – PK (Air modem)



7th harmonic – ch1, VP – PK (Air modem)

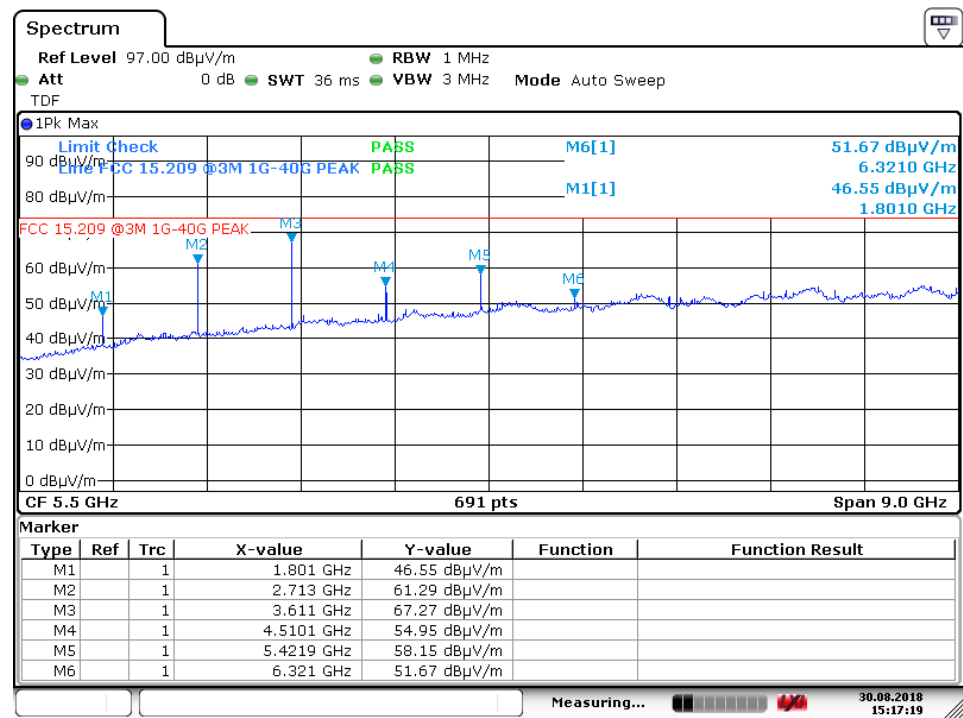


7th harmonic – ch50, VP – PK (Air modem)



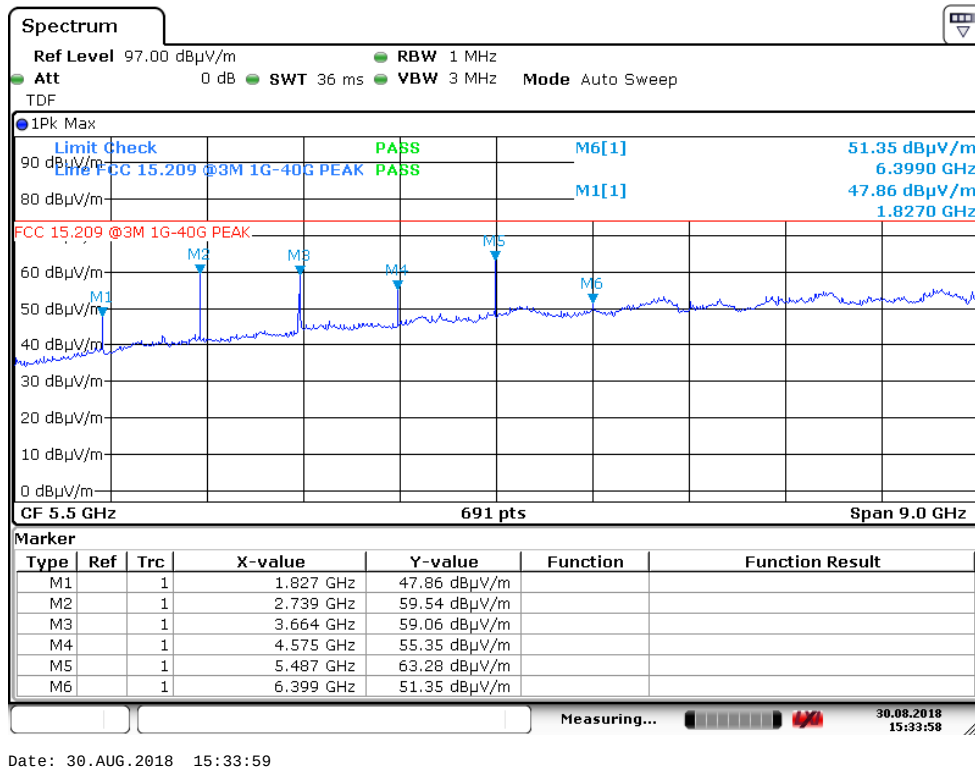
Date: 30.AUG.2018 15:13:28

Radiated Emissions, ch1, 1 – 10 GHz, HP, @3m – Pre-scan (Ground modem)



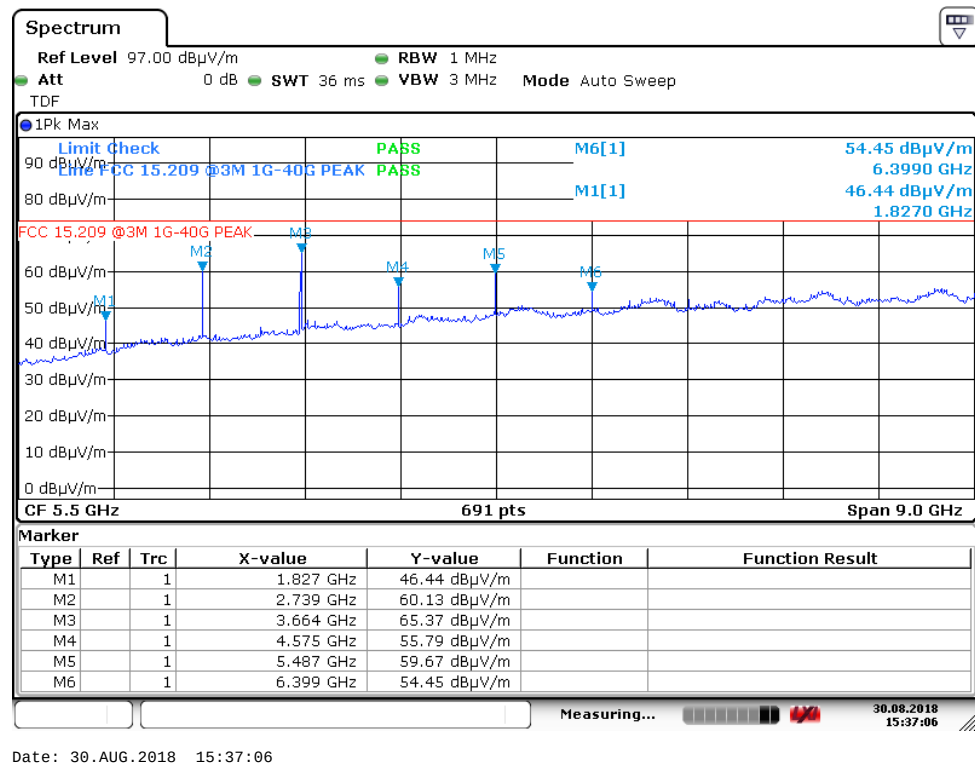
Date: 30.AUG.2018 15:17:20

Radiated Emissions, ch1, 1 – 10 GHz, VP, @3m – Pre-scan (Ground modem)



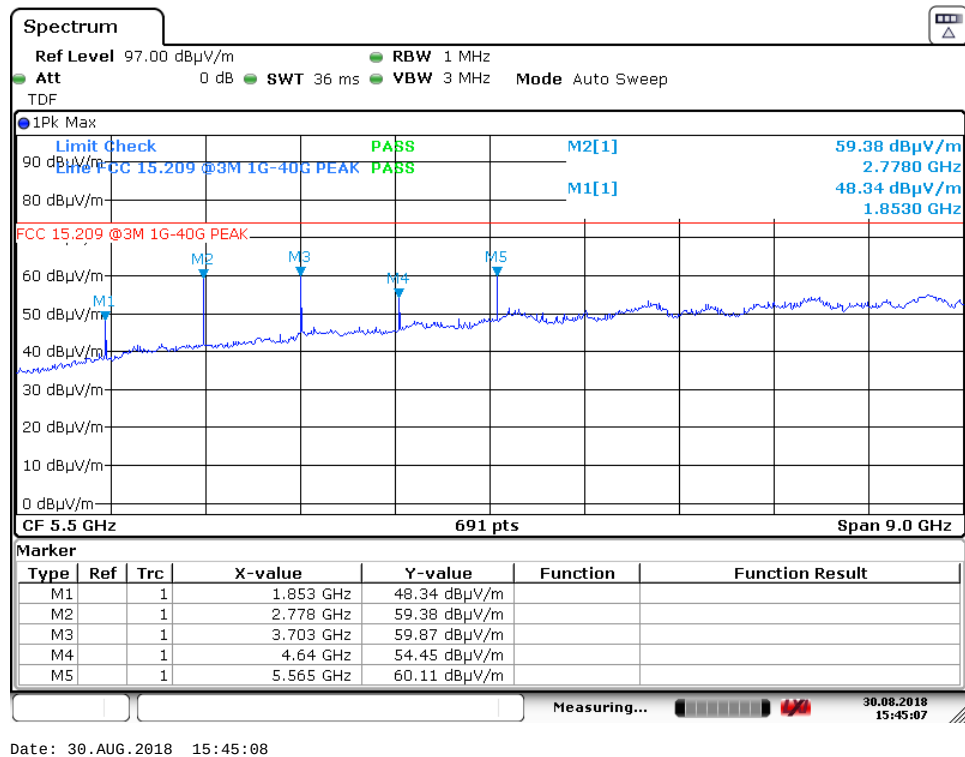
Date: 30.AUG.2018 15:33:59

Radiated Emissions, ch50, 1 – 10 GHz, HP, @3m – Pre-scan (Ground modem)

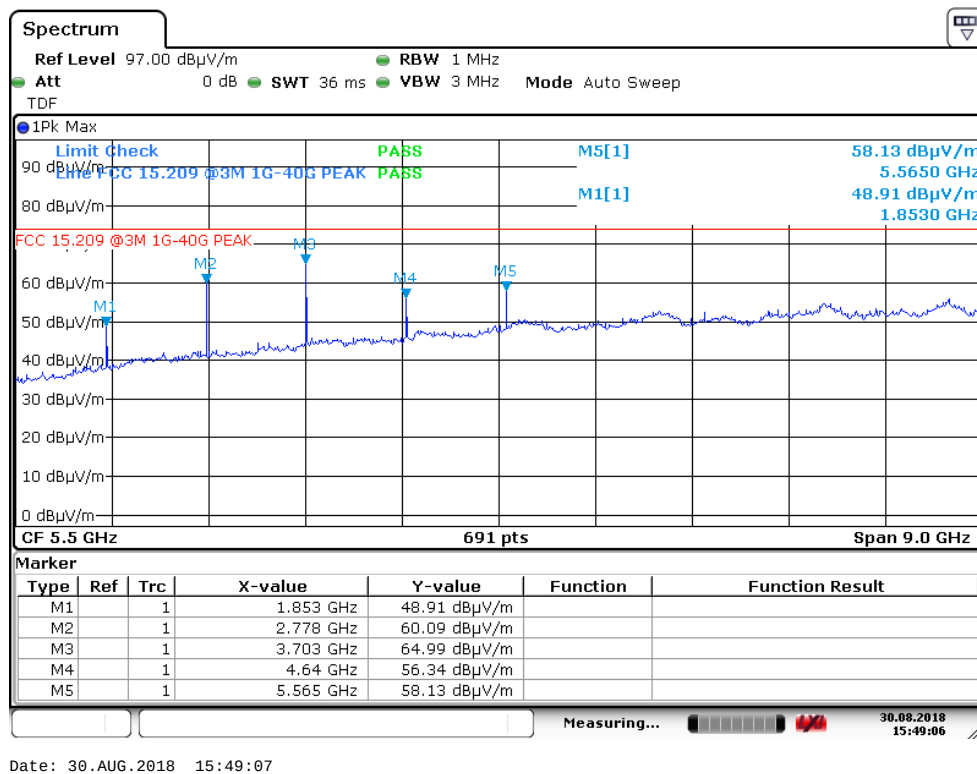


Date: 30.AUG.2018 15:37:06

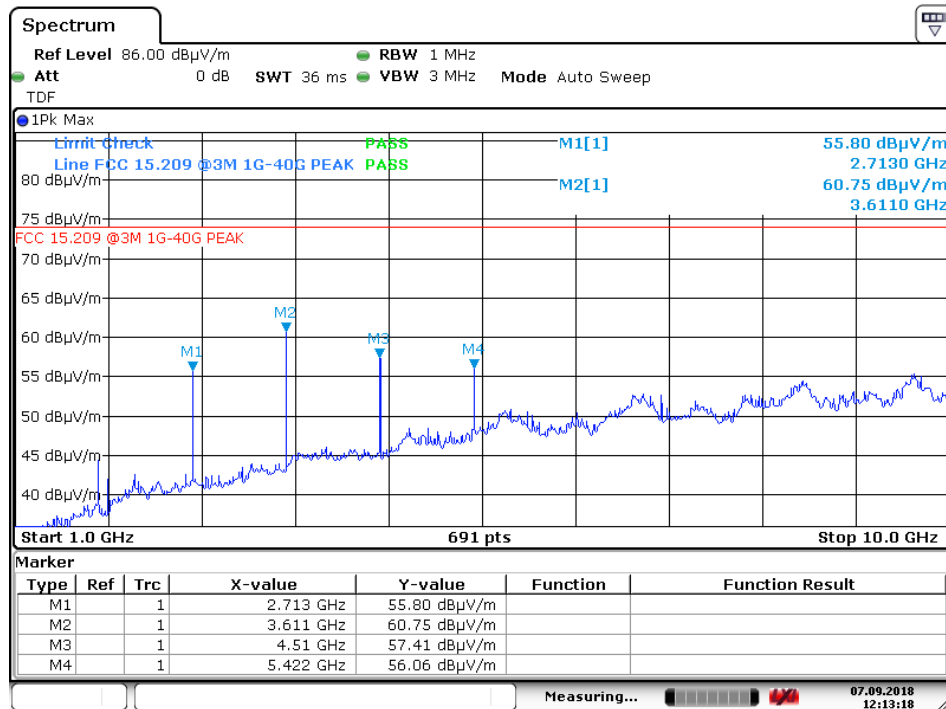
Radiated Emissions, ch50, 1 – 10 GHz, VP, @3m – Pre-scan (Ground modem)



Radiated Emissions, ch100, 1 – 10 GHz, HP, @3m – Pre-scan (Ground modem)

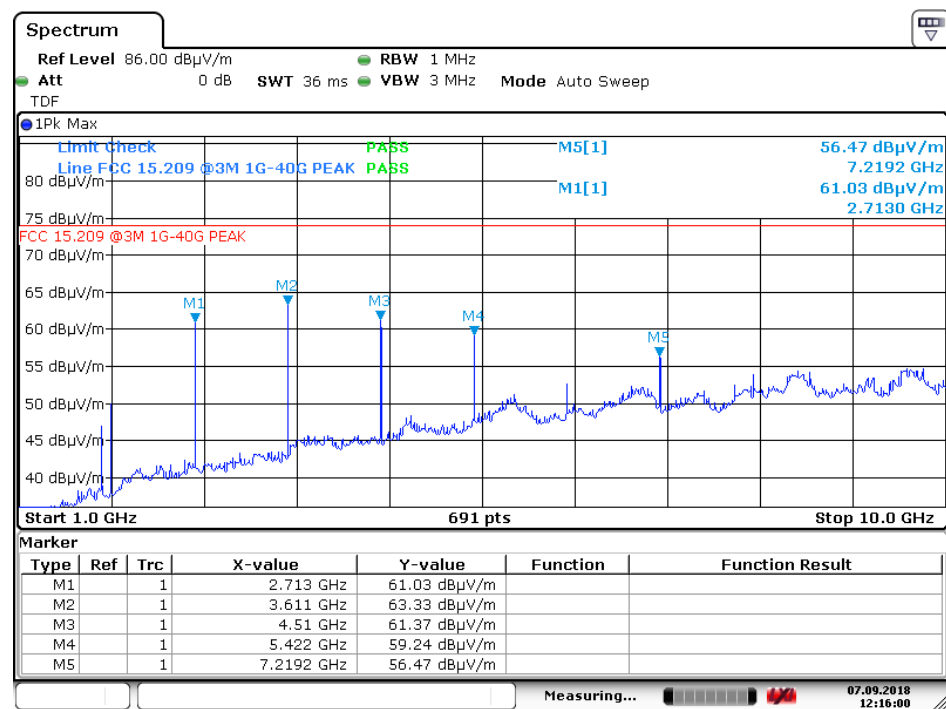


Radiated Emissions, ch100, 1 – 10 GHz, VP, @3m – Pre-scan (Ground modem)



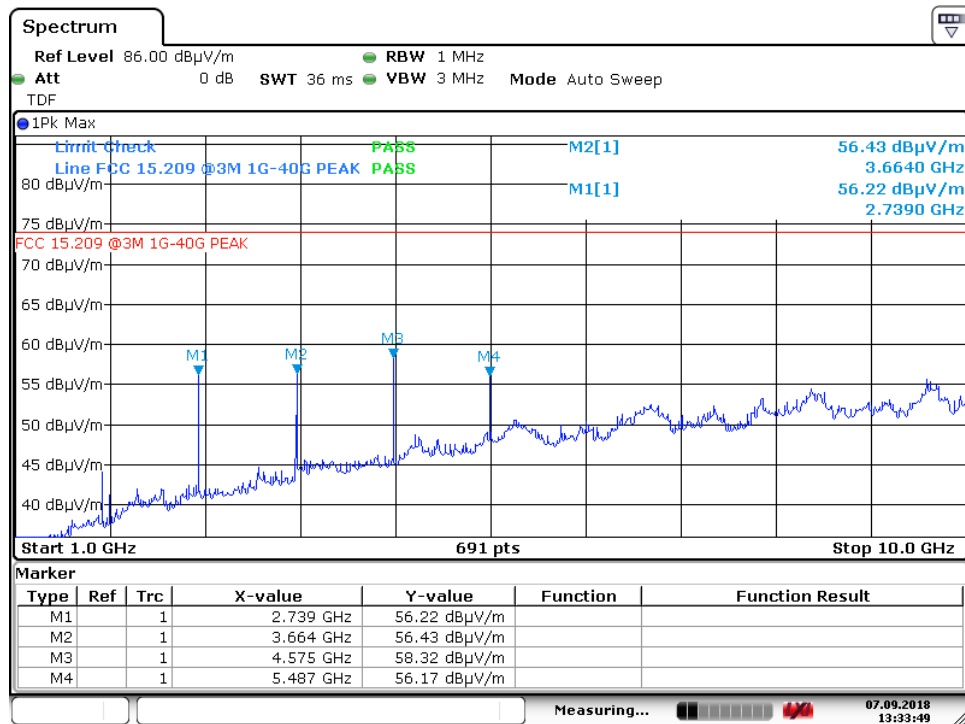
Date: 7.SEP.2018 12:13:18

Radiated Emissions, ch1, 1 – 10 GHz, HP, @3m – Pre-scan (Air modem)



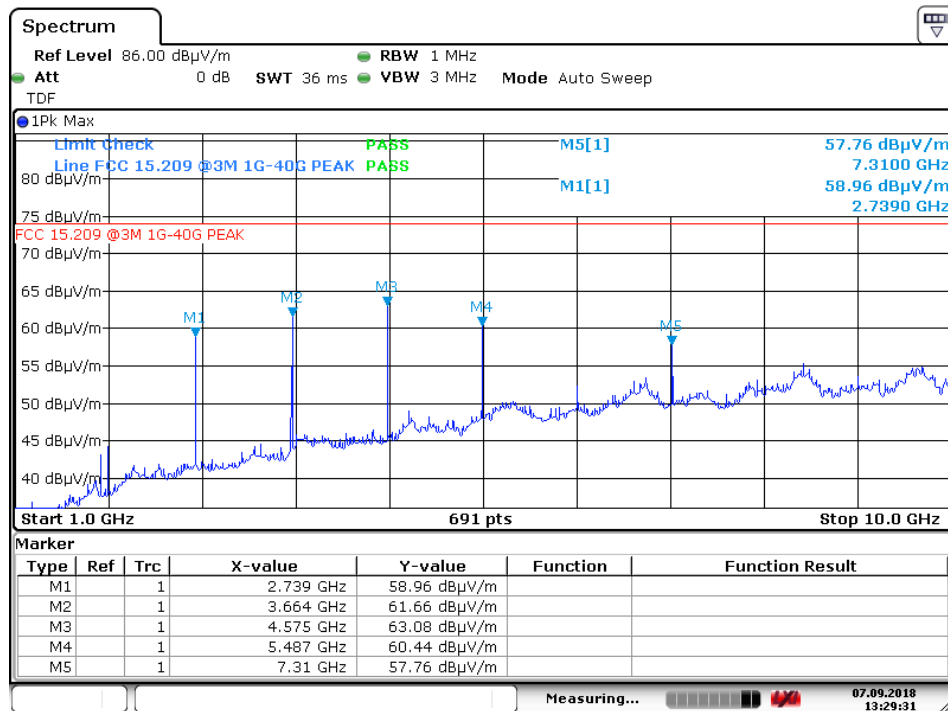
Date: 7.SEP.2018 12:16:00

Radiated Emissions, ch1, 1 – 10 GHz, VP, @3m – Pre-scan (Air modem)



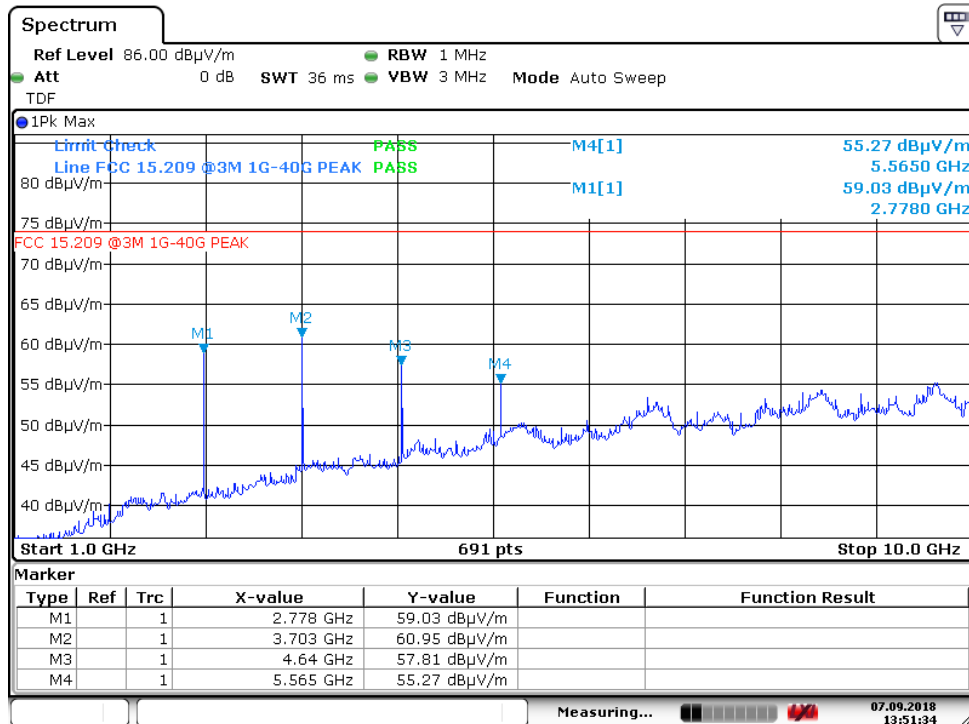
Date: 7.SEP.2018 13:33:49

Radiated Emissions, ch50, 1 – 10 GHz, HP, @3m – Pre-scan (Air modem)



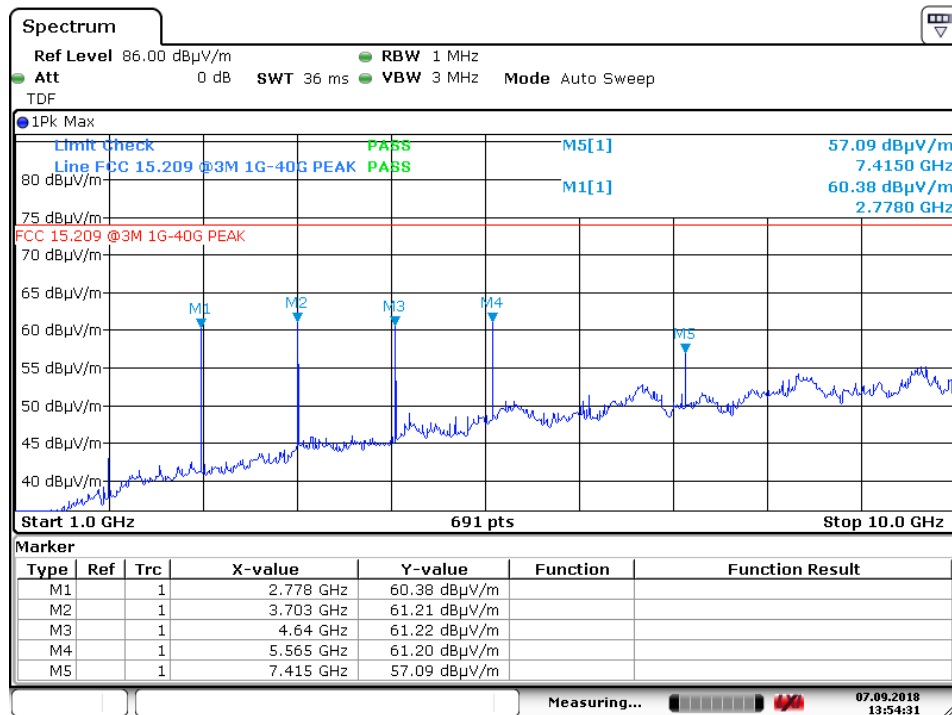
Date: 7.SEP.2018 13:29:32

Radiated Emissions, ch50, 1 – 10 GHz, VP, @3m – Pre-scan (Air modem)



Date: 7.SEP.2018 13:51:34

Radiated Emissions, ch100, 1 – 10 GHz, HP, @3m – Pre-scan (Air modem)



Date: 7.SEP.2018 13:54:32

Radiated Emissions, ch100, 1 – 10 GHz, VP, @3m – Pre-scan (Air modem)

4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		Uncertainty
Output Power		±0.8 dB
Power Spectral Density		±0.8 dB
Out of Band Emissions, Conducted	< 3.6 GHz	±0.8 dB
	> 3.6 GHz	±1.2 dB
Spurious Emissions, Radiated	< 200 MHz	±4.77 dB
	200 MHz - 1 GHz	±5.02 dB
	1 GHz – 18 GHz	±4.94 dB
	> 18 GHz	±5.91 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		±3.58 %
Spectrum Mask Measurements	Frequency	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

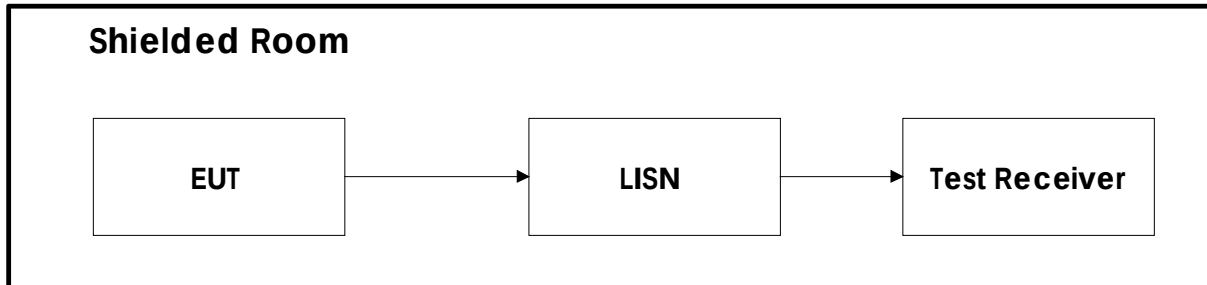
5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

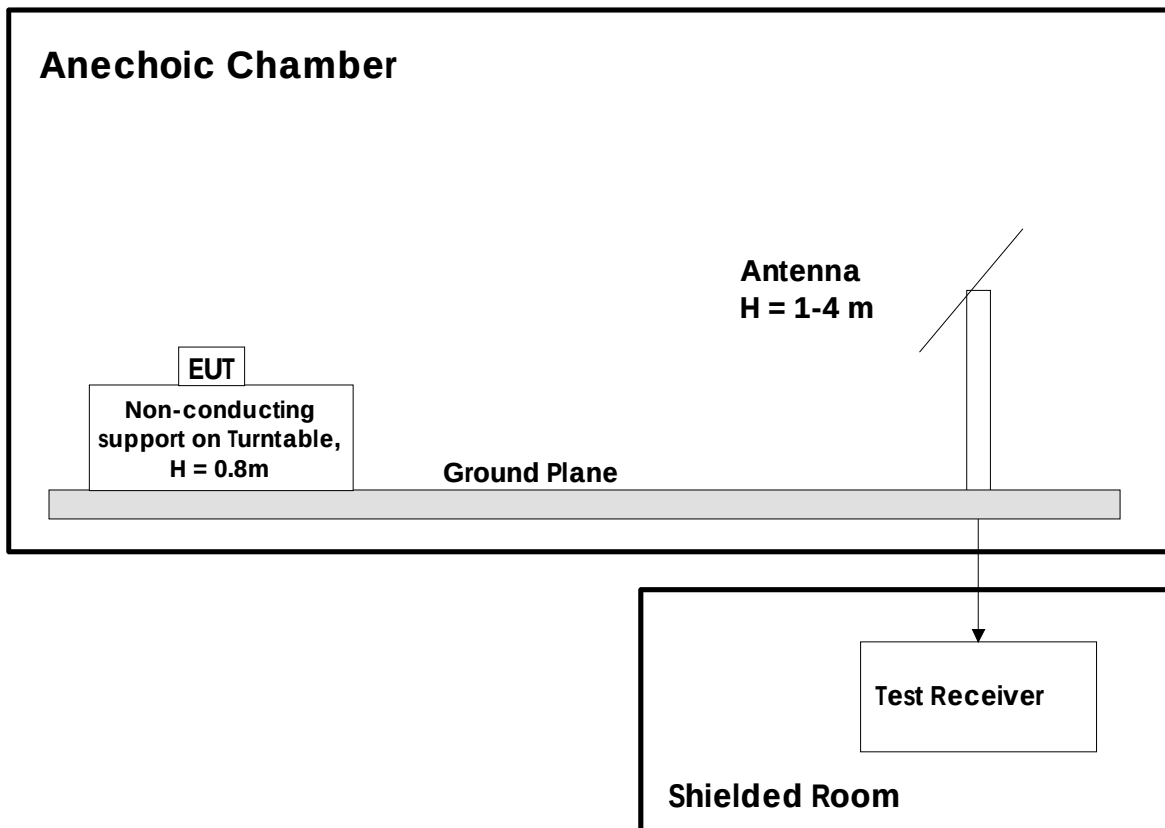
Ref No	Instrument/ ancillary	Manufacturer	Type of instrument/ ancillary	Cal. Date	Cal. Due
1-0039	Loop antenna	Rohde & Schwarz	HFH2-Z2	2018-09	2019-09
1-0040	Biconical antenna	Rohde & Schwarz	HK116	2017-07	2020-07
1-0055	LopPer antenna	Rohde & Schwarz	HL223	2017-07	2020-07
1-0080	Turntable	H. Deisel	DS 420	--	--
1-0256	Horn antenna	Schwarzbeck Mess-Elektronik	BBHA 9120	--	--
1-0361	Semi anechoic chamber	Reinhold & Mahla	3m	2017-06	2020-06
1-0364	Antenna cable 2	Kabelwerk Eupen	RF/Cord CMS / RG 214-N/7	2016-09	2019-09
1-0604	EMI test receiver	Rohde & Schwarz	ESU8	2018-09	2019-09
1-0611	Signal analyzer	Rohde & Schwarz	FSV 40	2018-09	2019-09
1-0614	Log.-per. antenna	Schwarzbeck Mess-Elektronik	STLP 9148 Stacked Log.-Per. Antenne	2016-11	2019-11
1-0615	Pre amplifier	Schwarzbeck Mess-Elektronik	BBV-9718 Broadband Preamplifier	2018-09	2019-09
1-0619	Coaxial cable (to SAC)	Huber+Suhner	SF106/2x11N-651/2m	2016-09	2019-09
1-0620	Antenna cable 3	Huber+Suhner	SF106/2x11N-651/3m	2016-09	2019-09
1-0771	Broadband Horn antenna	Schwarzbeck Mess-Elektronik	SHF-EHF Horn, 15-40GHz	2018-03	2021-03
1-0781	Pre amplifier	Schwarzbeck Mess-Elektronik	BBV 9721	2018-09	2019-09
1-0782	Antenna cable	Huber & Suhner	FB142A	2017-10	2020-10
1-0870	10 dB Attenuator	Mini Circuits	BW-N10W5+	2016-09	2019-09
1-0924	Cable 1m	---	SMA	2016-09	2019-09
1-0925	Cable 1m	---	SMA	2016-09	2019-09
1-0926	Cable 1m	Harbour Industries	SMA	2016-09	2019-09
1-0927	Cable 1m	Harbour Industries	SMA	2016-09	2019-09
1-0966	RF power meter	DARE	RPR3006W	2017-07	2019-01
1-0994	Attenuator	Mini Circuits	BW-N3W5+	2017-10	2020-10
1-1000	Pre amplifier	Nemko GmbH & Co. KG	BBV 30M1G Broadband Preamplifier	2018-09	2019-09
1-1017	High Pass Filter	Wainwright Instruments GmbH	WHKX10-3150-3500-18000-40SS	2018-06	2019-06
1-1018	High Pass Filter	Wainwright Instruments GmbH	WHKX8-5913-7300-18000-60SS	2018-06	2019-06
1-1019	High Pass Filter	Wainwright Instruments GmbH	WHKX12-915-1000-18000-40SS	2018-06	2019-06

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



Measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers.

Revision history

Version	Date	Comment	Sign
00	2018-11-16	First version	mk