SGS

Test Report

FINAS
Finnish Accreditation Service
T004 (EN ISO/IEC 17025)

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C

Equipment Under Test:	802.11 b/g/n Wi-Fi Module
Model:	WGM110-E
Manufacturer:	Silicon Laboratories Finland Oy Bertel Jungin aukio 3 FI-02600 ESPOO FINLAND
Customer:	Silicon Laboratories Finland Oy Bertel Jungin aukio 3 FI-02600 ESPOO FINLAND
FCC Rule Part:	15.247: 2015
IC Rule Part:	RSS-247, Issue 1, 2015 RSS-GEN Issue 4, 2014
KDB:	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 (June 9, 2015)

Date:	11 August 2016	Date:	11 August 2016
Issued by:	Emil Haverinen Testing Engineer	Checked by:	Rauno Repo Testing Engineer

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Equipment Under Test (EUT)

802.11 b/g/n Wi-Fi Module	
Model:	WGM110-E
Type:	-
Serial no:	-
FCC ID:	QOQ-WGM110
IC:	5123A-WGM110

Description of the EUT

The WGM110-E is an 802.11b/g/n radio module from the WGM110 series. WGM110 integrates 802.11b/g/n radio, a microcontroller, Wi-Fi and IP stacks, an HTTP server and multiple protocols such as TCP and UDP.

The -E variant is module with integrated mini coaxial connector. Conducted measurements were made while SMA adapter was connected to the EUT. Radiated measurements were done with antenna provided by the manufacturer.

Classification of the device

Fixed device	☐
Mobile Device (Human body distance > 20cm)	☒
Portable Device (Human body distance < 20cm)	☐

Modifications Incorporated in the EUT

Conducted output power measurements were performed with lowered power setting of the EUT which will be implemented to final product. Other measurements were performed while maximum RF power of the EUT was 16.48 dBm.

Ratings and declarations

Operating Frequency Range (OFR):	2412 - 2462 MHz
Channels:	11
Channel separation:	5 MHz
99% Channel bandwidth:	17.340 MHz
Conducted power:	15.74 dBm
Transmission technique:	DSSS
Modulation:	CCK, QPSK, OFDM
Antenna gain:	2.14 dBi

Power Supply

Operating voltage range:	2.7 - 4.8 VDC

AC/DC power supply was used powering the EUT when conducted emissions and radiated emission were tested.

Manufacturer:	Flextronics LPS
Model:	0012ADU00
Rated voltage:	100-240 VAC
Rated current:	~0.5 A max
Rated frequency:	50-60 Hz
Output voltage:	+5.2 VDC
Output current:	2.4 A

Mechanical Size of the EUT

Height: 2.0 mm	Width:14.4 mm	Length: 21 mm

Samples

Two samples were used in the testing. During the tests the EUT was set to transmit continuously and was set to the channel under test. Normal test modulation and maximum transmit power was used in all tests. A ferrite clamp was added to the USB cable of the AC/DC power supply.

Peripherals

- Flextronics LPS 0012ADU00 AC/DC power supply.

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§15.207(a) / RSS-GEN 8.8	Conducted Emissions on Power Supply Lines	**N/T**
§15.247(b)(3) / RSS-247 5.4(4)	Maximum Peak Conducted Output Power	**PASS**
§15.247(a)(2) / RSS-247 5.2(1)	6 dB Bandwidth	**N/T**
§15.247(e) / RSS-247 5.2(2)	Power Spectral Density	**N/T**
RSS-GEN 6.6	99% Occupied Bandwidth	**N/T**
§15.247(d) / RSS-247 5.5	100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions	**PASS**
§15.209(a), §15.247(d) / RSS-247 5.5	Radiated Emissions Within The Restricted Bands	**PASS**

Some tests were not performed; test report will be used to apply for C2PC. Unperformed tests marked as N/T (not tested).

EUT Test Conditions During Testing

The EUT was in continuous transmit mode during all the tests. The EUT was configured into the wanted channel. Normal modulation and 100% duty cycle was applied in all the tests.

Conducted emissions from the AC mains and radiated emissions were measured with EUT powered from 5V AC/DC adapter attached to the evaluation board.

The EUT was set to following channels during the tests:

Channel Low (Ch 1) = 2412 MHz
Channel Mid (Ch 6) = 2437 MHz
Channel High (Ch 11) = 2462 MHz

Test Facility

☐	Testing Location / address: FCC registration number: **90598**	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
☒	Testing Location / address: FCC registration number: **178986** Industry Canada registration number: **8708A-2**	SGS Fimko Ltd Karakaarenkuja 4 FI-02610, ESPOO FINLAND

TEST RESULTS

Average Conducted Output Power

Standard:	ANSI C63.10	(2013)
Tested by:	EHA	
Date:	5.8.2016	
Temperature:	23 °C	
Humidity:	60 %	
Measurement uncertainty	± 2.87dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(b)(3) RSS-247 5.4(4)

For systems using digital modulation in the 2400-2483.5 MHz bands the limit is 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Average conducted output power was measured with average power meter.

Results:

802.11b

Data rate [Mbps]	Conducted power [dBm]			Limit [dBm]	Result
	Low channel	Mid channel	High channel		
1	15.74	15.67	15.51	30	PASS
2	15.70	15.67	15.43	30	PASS
5.5	15.67	15.60	15.29	30	PASS
11	15.52	15.59	15.26	30	PASS

802.11g

Data rate [Mbps]	Conducted power [dBm]			Limit [dBm]	Result
	Low channel	Mid channel	High channel		
6	13.91	13.95	13.88	30	PASS
9	13.85	13.97	13.81	30	PASS
12	13.87	14.09	13.83	30	PASS
18	13.90	14.00	13.86	30	PASS
24	14.11	14.20	14.11	30	PASS
36	14.05	14.05	14.01	30	PASS
48	14.09	14.12	14.05	30	PASS
54	13.95	14.07	13.99	30	PASS

802.11n

Data rate [Mbps]	Conducted power [dBm]			Limit [dBm]	Result
	Low channel	Mid channel	High channel		
7.2	13.84	13.85	13.85	30	PASS
14.4	13.80	13.74	13.80	30	PASS
21.7	13.84	13.73	13.61	30	PASS
28.9	13.81	14.06	13.91	30	PASS
43.3	13.88	13.79	13.75	30	PASS
57.8	13.85	13.93	13.85	30	PASS
65	13.84	13.95	13.86	30	PASS
72.2	13.81	13.86	13.80	30	PASS

Transmitter Radiated Spurious Emissions 30 – 26500 MHz

Standard:	ANSI C63.10	(2013)
Tested by:	EHA	
Date:	20 - 23.6.2016	
Humidity:	44 - 51 %	
Temperature:	23 °C	
Measurement uncertainty	± 4.51 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a)
RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a)**.**

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables).
The Quasi-peak value is the measured value corrected with the correction factor.

Radiated spurious emissions measurements were tested with 1Mbps data rate.

Frequency range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector
30 - 80	100	40.0	Quasi-peak
88 - 216	150	43.5	Quasi-peak
216 - 960	200	46.0	Quasi-peak
960 - 1000	500	53.9	Quasi-peak
Above 1000	500	53.9	Average
Above 1000	5000	73.9	Peak

Low channel

Table 1: Quasi-peak results (1 Mbps / ch low)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
59.995000	38.1	1000.0	120.000	100.0	V	227.0	13.9	1.9	40.0
80.005000	27.1	1000.0	120.000	115.0	V	309.0	9.9	12.9	40.0
300.015000	39.0	1000.0	120.000	100.0	H	82.0	15.3	7.0	46.0
364.015000	37.3	1000.0	120.000	100.0	H	322.0	16.9	8.7	46.0
416.025000	31.9	1000.0	120.000	100.0	H	140.0	18.3	14.1	46.0
749.995000	31.4	1000.0	120.000	110.0	H	71.0	25.2	14.6	46.0

Table 2: Peak results (1 Mbps / ch low)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2376.725000	63.5	1000.0	1000.000	150.0	V	346.0	13.9	10.4	73.9
2390.000000	68.6	1000.0	1000.000	164.0	V	175.0	14.0	5.3	73.9
4824.300000	43.1	1000.0	1000.000	260.0	H	323.0	10.3	30.8	73.9
9648.100000	46.2	1000.0	1000.000	374.0	V	119.0	14.9	27.7	73.9
25795.60000	57.2	1000.0	1000.000	137.0	V	303.0	35.5	16.7	73.9

Table 3: Average results (1 Mbps / ch low)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2387.000000	43.8	1000.0	1000.000	204.0	V	175.0	14.0	10.1	53.9
4824.100000	31.0	1000.0	1000.000	237.0	H	278.0	10.3	22.9	53.9
9648.100000	35.9	1000.0	1000.000	229.0	V	357.0	14.9	18.0	53.9
23432.55000	41.5	1000.0	1000.000	128.0	H	329.0	31.1	12.4	53.9
25859.30000	43.3	1000.0	1000.000	337.0	V	22.0	34.8	10.6	53.9
26173.45000	44.0	1000.0	1000.000	150.0	V	87.0	34.8	9.9	53.9
26468.30000	43.4	1000.0	1000.000	129.0	H	97.0	35.7	10.5	53.9

Middle channel

Table 4: Quasi-peak results (1 Mbps / ch mid)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
59.995000	33.2	1000.0	120.000	100.0	V	222.0	13.9	6.8	40.0
300.015000	43.9	1000.0	120.000	110.0	H	91.0	15.3	2.1	46.0
364.015000	38.6	1000.0	120.000	100.0	H	333.0	16.9	7.4	46.0
416.025000	34.5	1000.0	120.000	100.0	H	304.0	18.3	11.5	46.0
420.015000	32.2	1000.0	120.000	100.0	H	273.0	18.4	13.8	46.0
958.445000	26.7	1000.0	120.000	333.0	V	156.0	27.8	19.3	46.0

Table 5: Peak results (1 Mbps / ch mid)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2394.625000	61.0	1000.0	1000.000	213.0	V	90.0	14.1	12.9	73.9
16584.10000	51.5	1000.0	1000.000	396.0	H	209.0	24.2	22.4	73.9
23315.10000	53.6	1000.0	1000.000	335.0	V	275.0	30.9	20.3	73.9
26246.70000	55.9	1000.0	1000.000	343.0	H	41.0	35.0	18.0	73.9

Table 6: Average results (1 Mbps / ch mid)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2389.800000	41.7	1000.0	1000.000	163.0	V	285.0	14.0	12.2	53.9
2487.900000	41.5	1000.0	1000.000	212.0	V	90.0	14.4	12.4	53.9
16697.000000	38.5	1000.0	1000.000	150.0	V	179.0	24.4	15.4	53.9
22093.300000	39.6	1000.0	1000.000	100.0	H	29.0	28.1	14.3	53.9
23649.350000	41.3	1000.0	1000.000	150.0	H	337.0	31.3	12.6	53.9
25763.750000	44.5	1000.0	1000.000	150.0	H	81.0	35.4	9.4	53.9

High channel

Table 7: Quasi-peak results (1 Mbps / ch high)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
59.995000	33.4	1000.0	120.000	100.0	V	205.0	13.9	6.6	40.0
80.005000	23.9	1000.0	120.000	100.0	V	297.0	9.9	16.1	40.0
300.015000	44.2	1000.0	120.000	100.0	H	93.0	15.3	1.8	46.0
364.015000	37.8	1000.0	120.000	100.0	H	337.0	16.9	8.2	46.0
416.025000	34.9	1000.0	120.000	100.0	H	297.0	18.3	11.1	46.0
420.035000	32.2	1000.0	120.000	100.0	H	276.0	18.4	13.8	46.0

Table 8: Peak results (1 Mbps / ch high)

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
2483.700000	67.1	1000.0	1000.000	172.0	V	85.0	4.4	6.8	73.9
17040.80000	51.7	1000.0	1000.000	256.0	V	144.0	24.5	22.2	73.9
25761.80000	57.4	1000.0	1000.000	100.0	V	94.0	35.4	16.5	73.9

Table 9: Average results (1 Mbps / ch high)

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1378.325000	33.8	1000.0	1000.000	178.0	V	82.0	-2.5	20.1	53.9
2483.500000	40.7	1000.0	1000.000	171.0	V	88.0	4.4	13.2	53.9
17150.80000	38.0	1000.0	1000.000	317.0	V	0.0	24.6	15.9	53.9
25706.75000	43.7	1000.0	1000.000	121.0	V	259.0	35.2	10.2	53.9

Transmitter Band Edge Measurement and Conducted Spurious Emissions

Standard:	ANSI C63.10	(2013)
Tested by:	EHA	
Date:	20.6.2016	
Humidity:	44 %	
Temperature:	23 °C	
Measurement uncertainty	± 2.87 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a)
RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

Table 1. Band edge attenuation 1mbps data rate.

Band Edge Attenuation	
Lower Band Edge	**Upper Band Edge**
-46.5 dBc	-47.8 dBc
Limit: -30dBc	

Table 2. Band edge attenuation 54mbps data rate.

Band Edge Attenuation	
Lower Band Edge	Upper Band Edge
-42.9 dBc	-43.8 dBc
Limit: -30dBc	

Table 3. Conducted spurious emissions.

Conducted Spurious Emissions					
Data Rate [Mbps]	**Channel**	**Frequency [MHz]**	**Measured Power [dBm]**	**Calculated limit [dBm]**	
1	low	2410.98847	5.60	-14.4	
54	low	2414.4918	1.92	-18.08	
Data Rate [Mbps]	**Channel**	**Frequency**	**Measured Power [dBm]**	**Margin [dB]**	**Result**
1	low	3667.245	-39.17	24.77	PASS
1	high	3784.522	-39.07	24.67	PASS
54	high	3790.053	-39.39	20.99	PASS

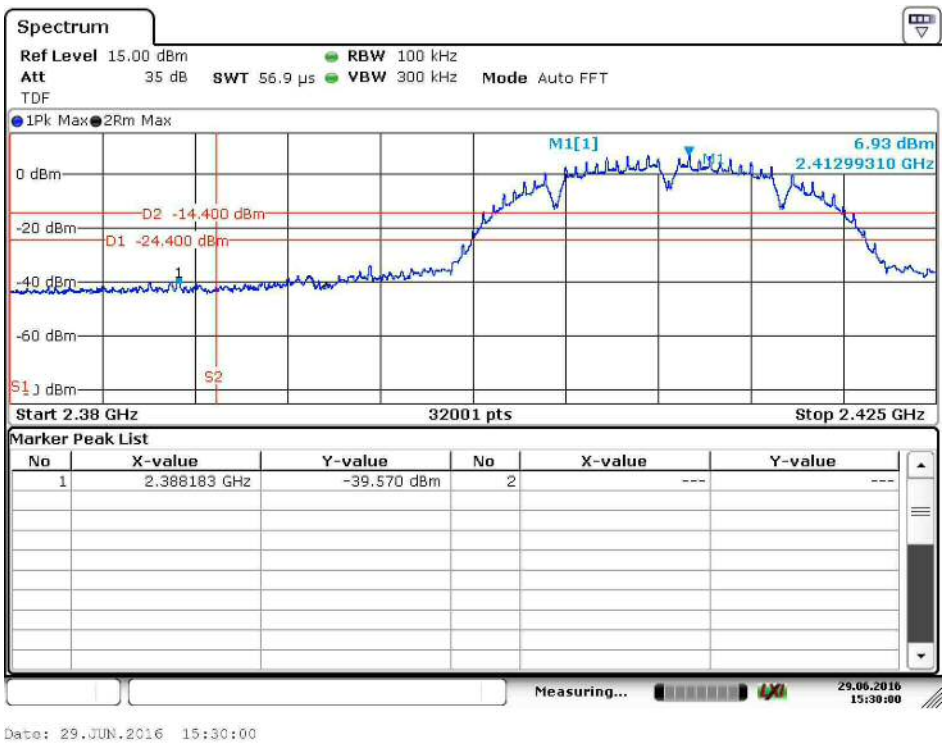

Figure 1. Lower Band Edge 1Mbps.

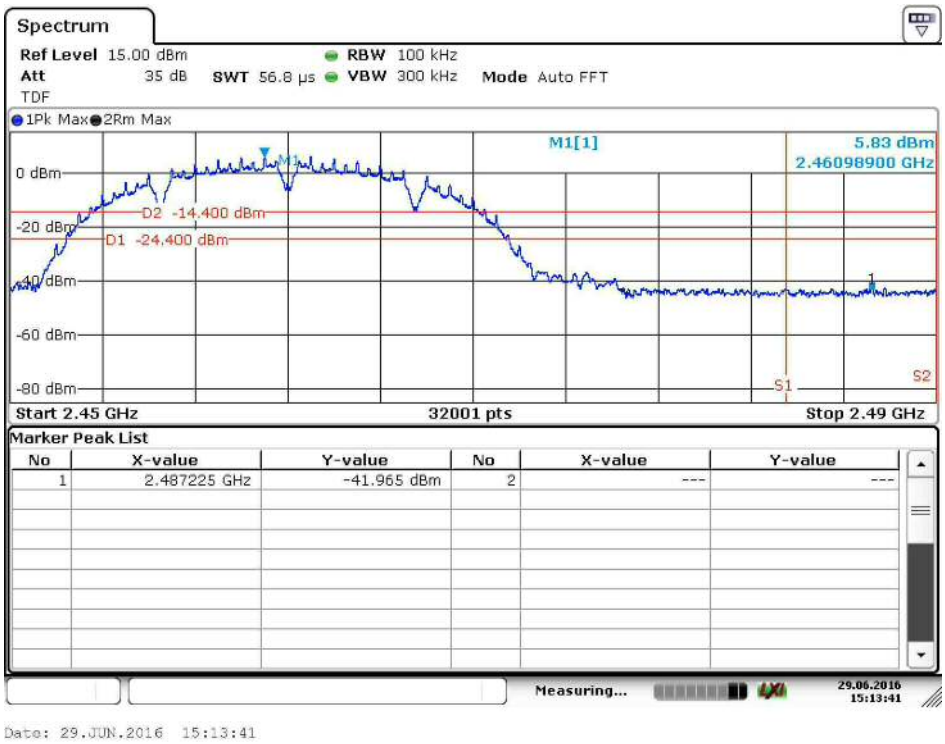

Figure 2. Upper Band Edge 1Mbps

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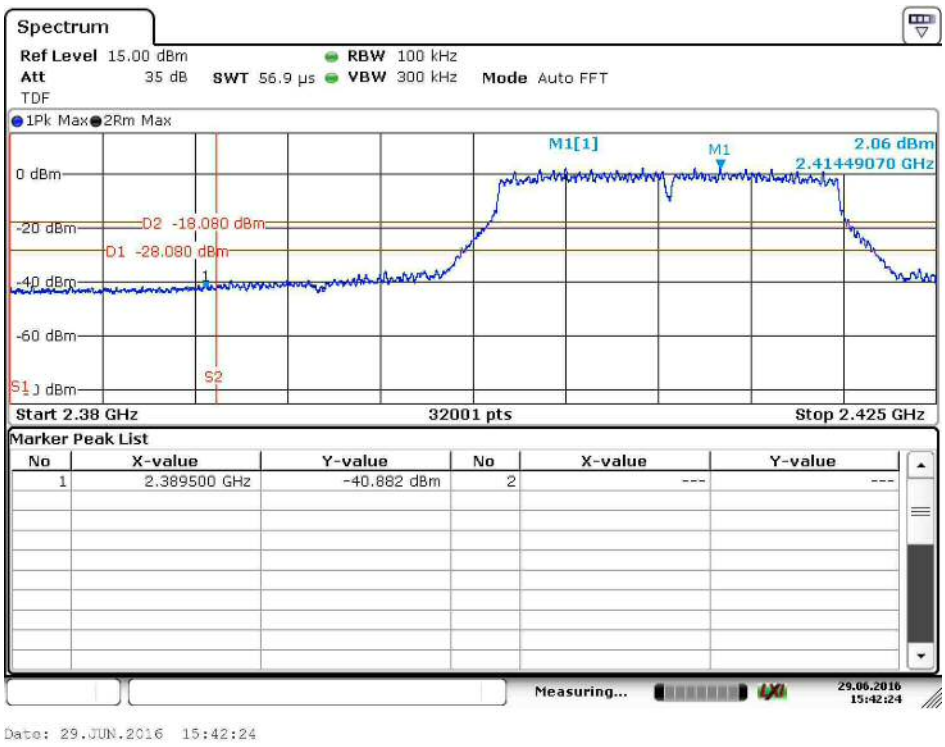

Figure 3. Lower Band Edge 54Mbps.

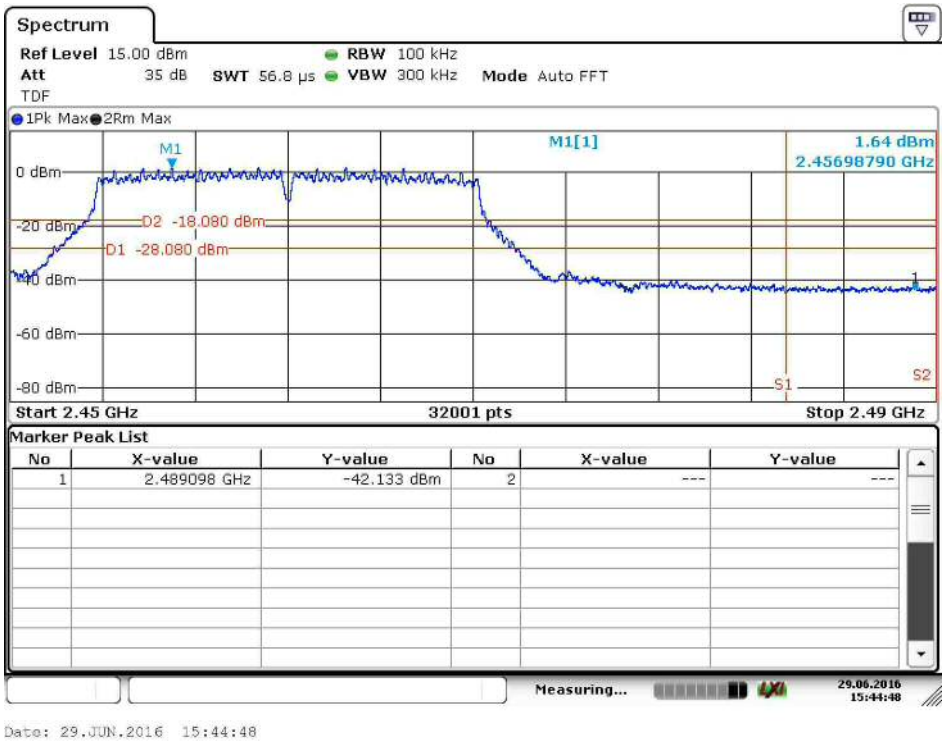

Figure 4. Upper Band Edge 54Mbps.

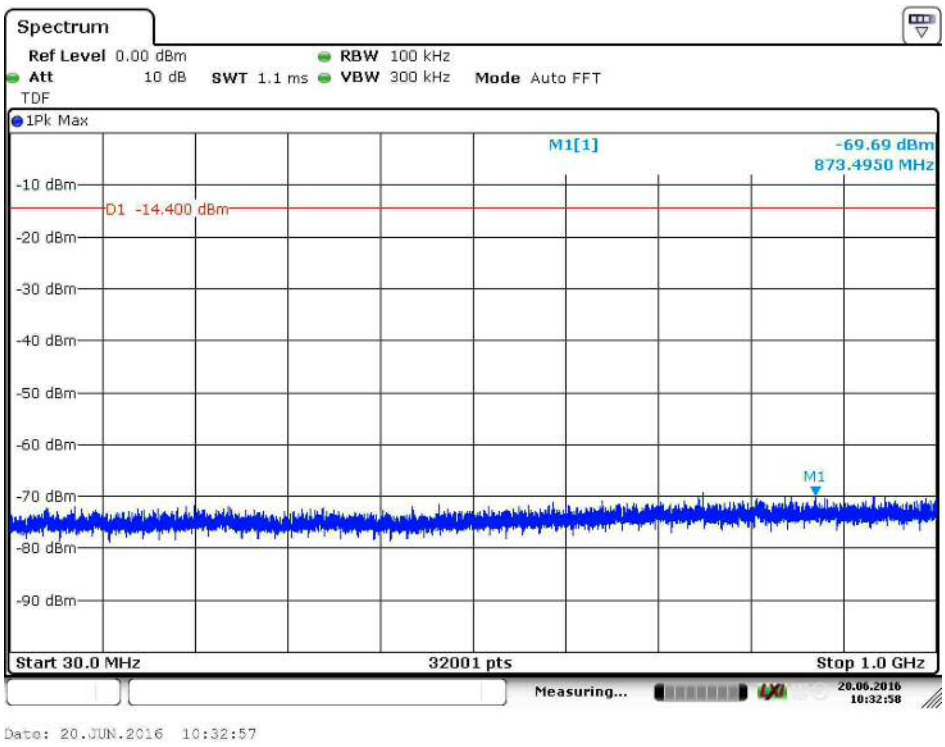

Figure 5. Conducted Spurious Emissions 30 – 1 000 MHz channel low 1 Mbps.

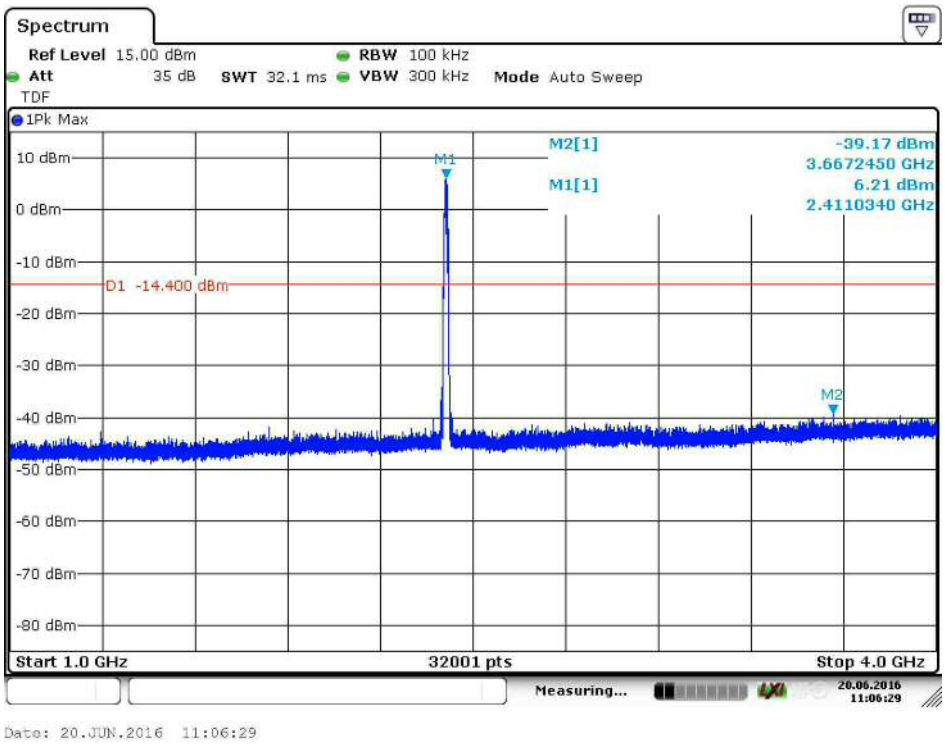

Figure 6. Conducted Spurious Emissions 1 000 – 4 000 MHz. channel low 1 Mbps.

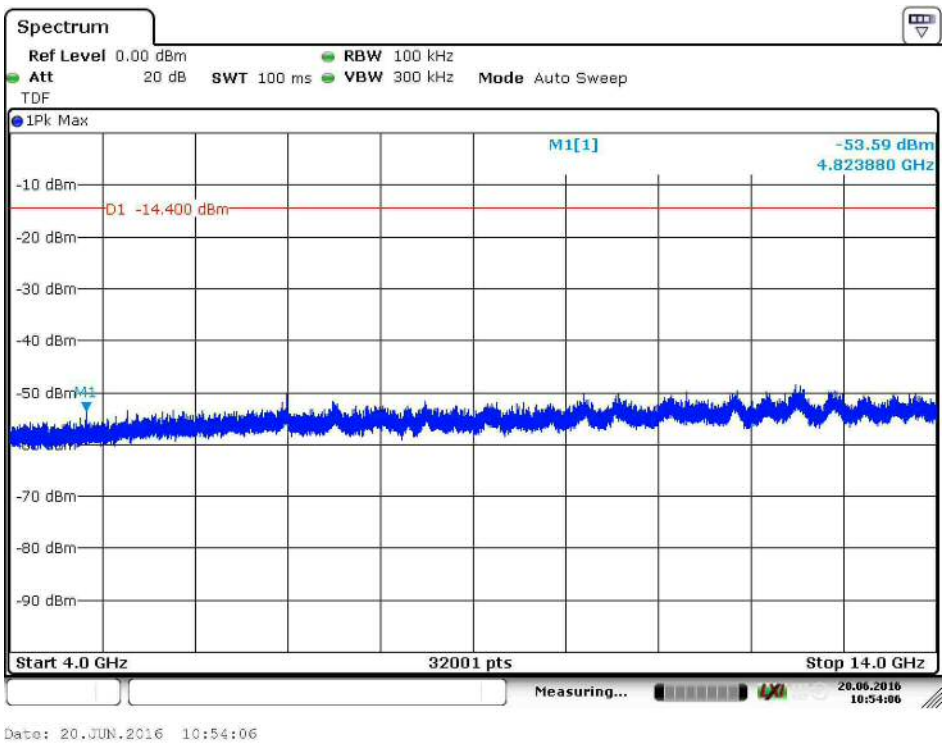

Figure 7. Conducted Spurious Emissions 4 000 – 14 000 MHz channel low 1 Mbps.

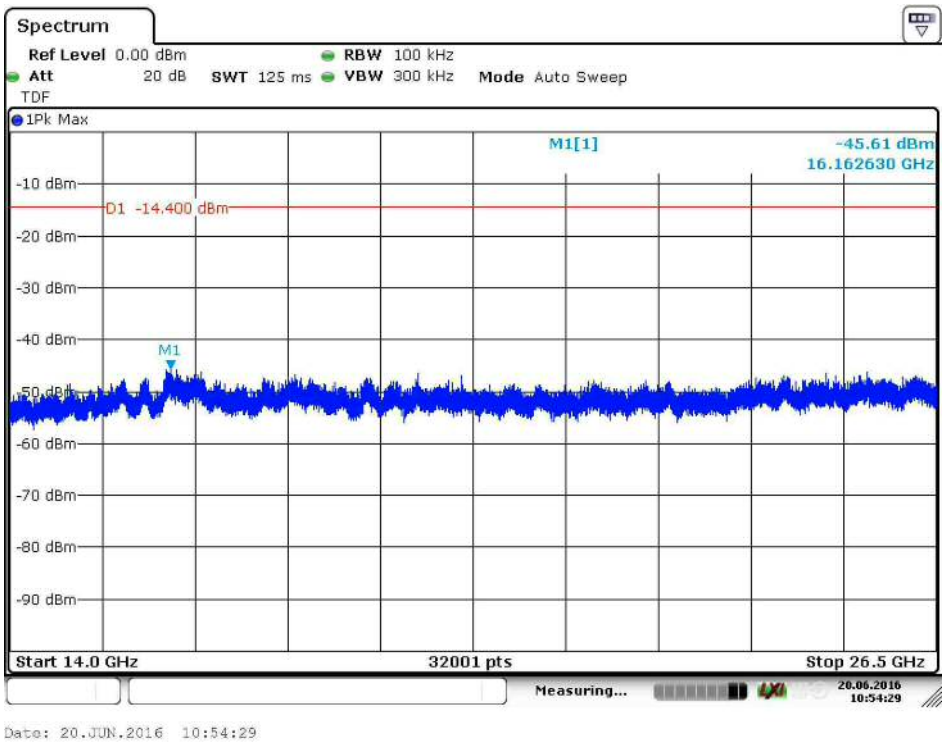

Figure 8. Conducted Spurious Emissions 14 000 – 26 500 MHz channel low 1 Mbps.

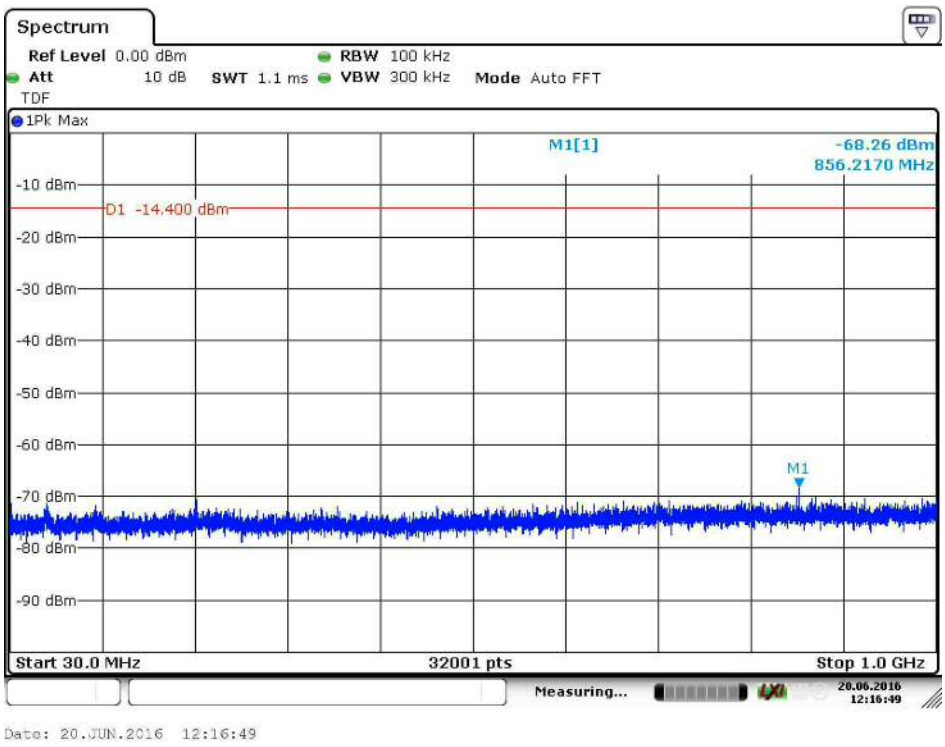

Figure 9. Conducted Spurious Emissions 30 – 1 000 MHz channel middle 1 Mbps.

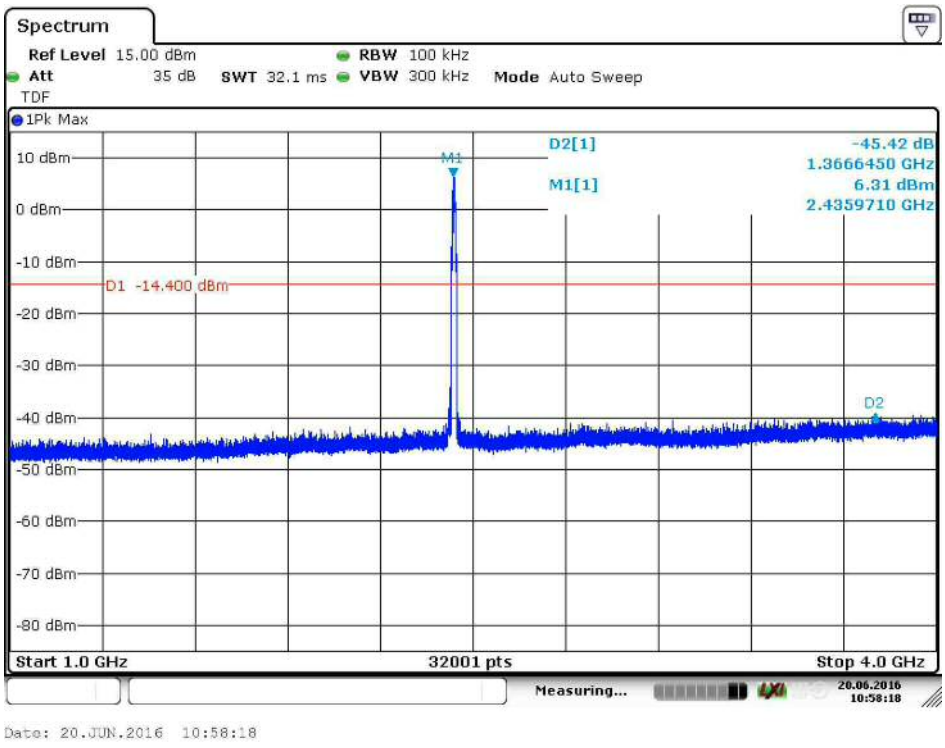

Figure 10. Conducted Spurious Emissions 1 000 – 4 000 MHz channel middle 1 Mbps.

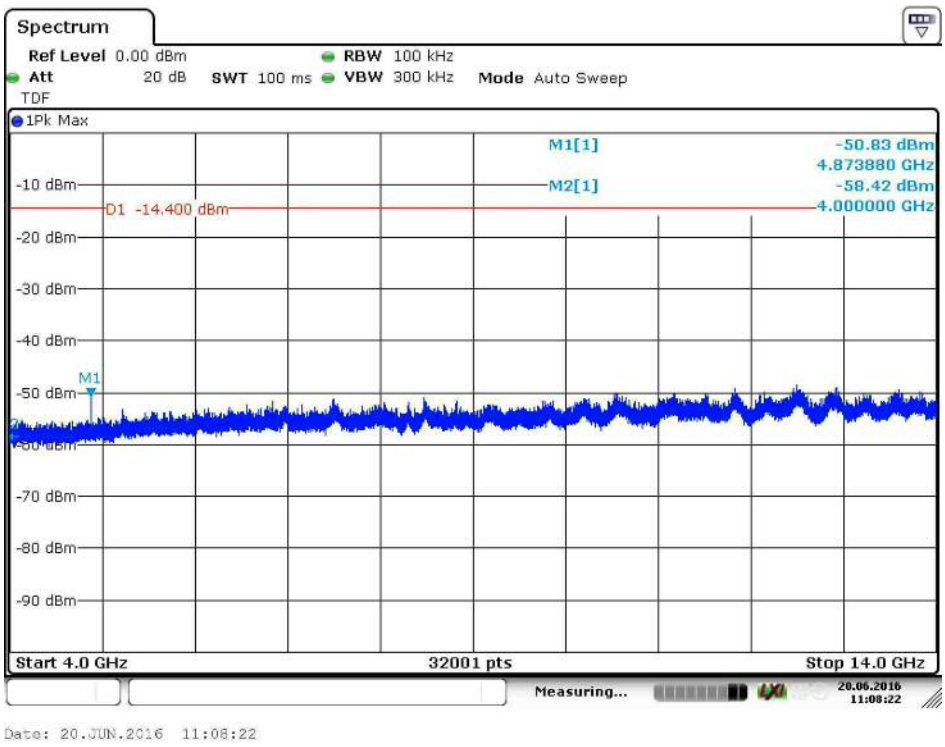

Figure 11. Conducted Spurious Emissions 4 000 – 14 000 MHz channel middle 1 Mbps.

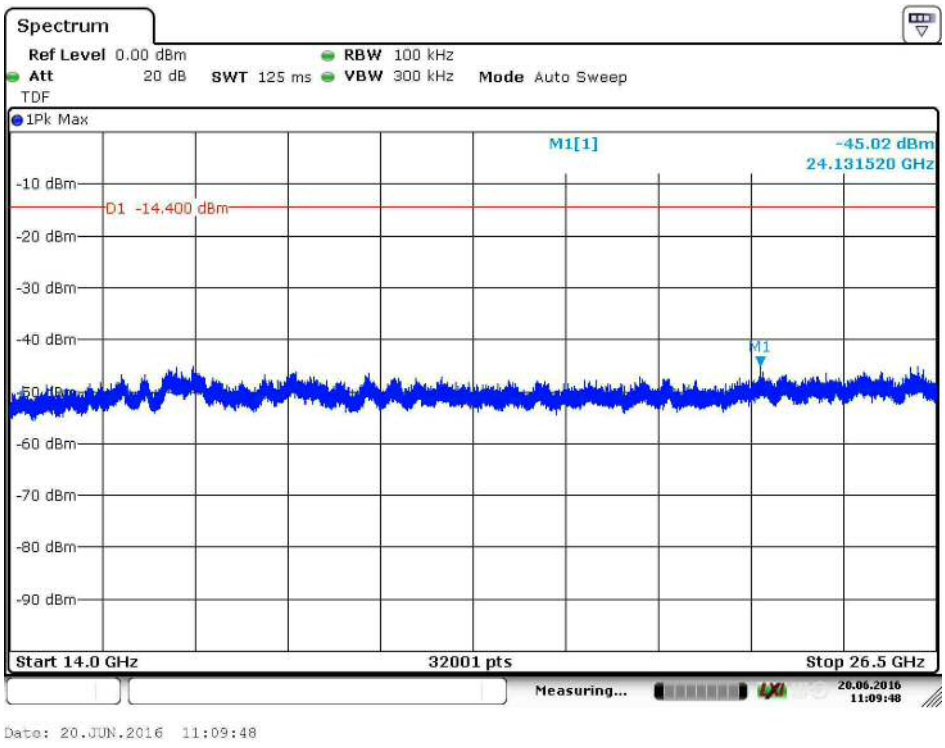

Figure 12. Conducted Spurious Emissions 14 000 – 26 500 MHz channel middle 1 Mbps.

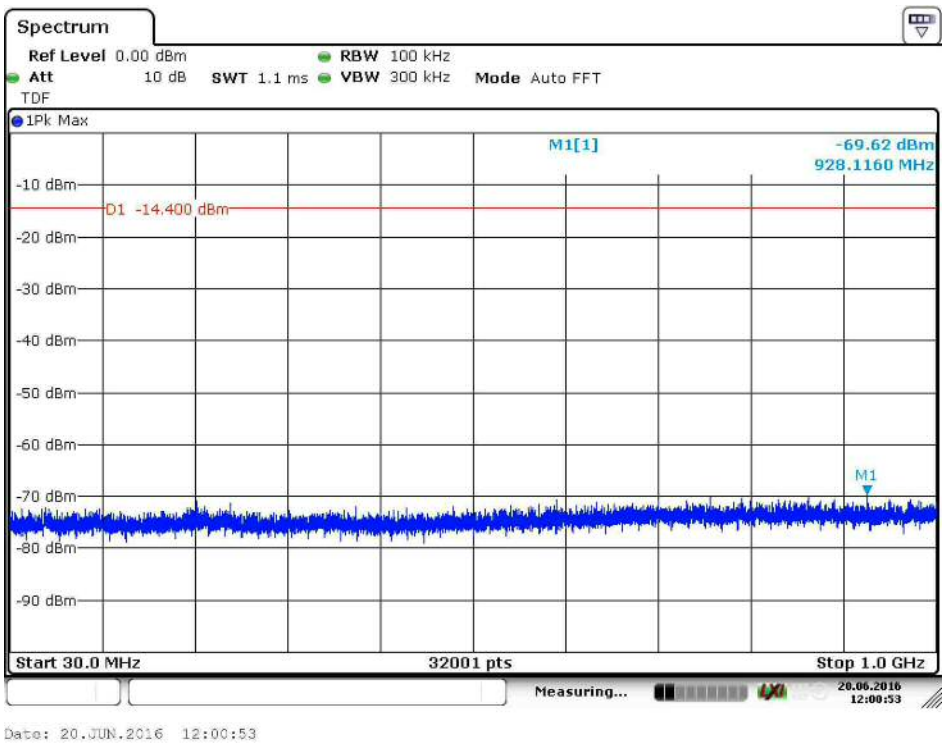

Figure 13. Conducted Spurious Emissions 30 – 1 000 MHz channel high 1 Mbps.

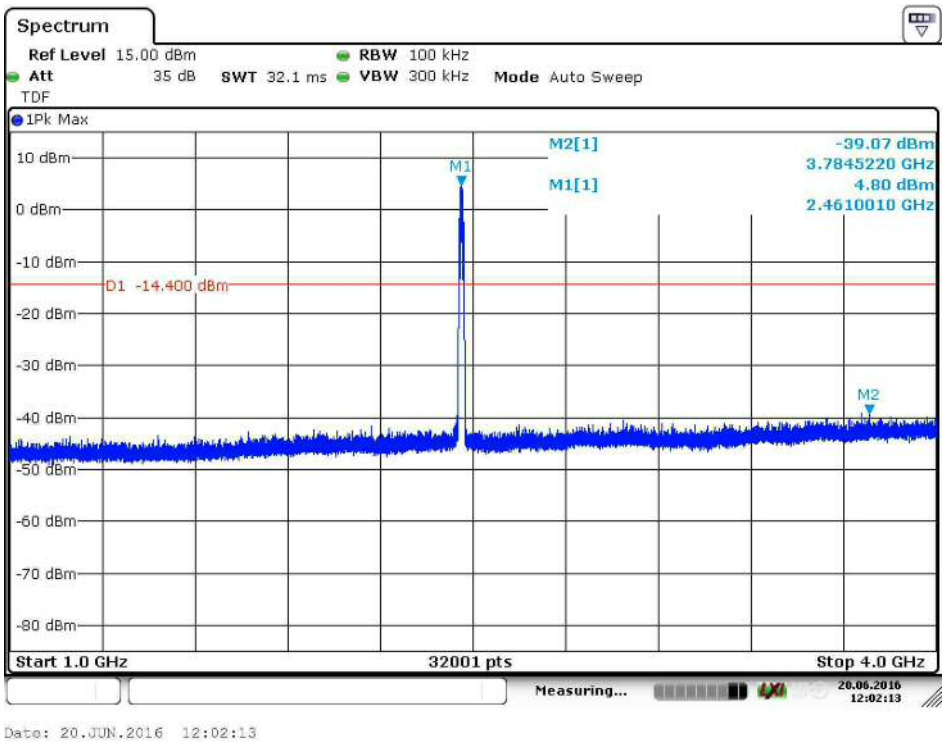

Figure 14. Conducted Spurious Emissions 1 000 – 4 000 MHz channel high 1 Mbps.

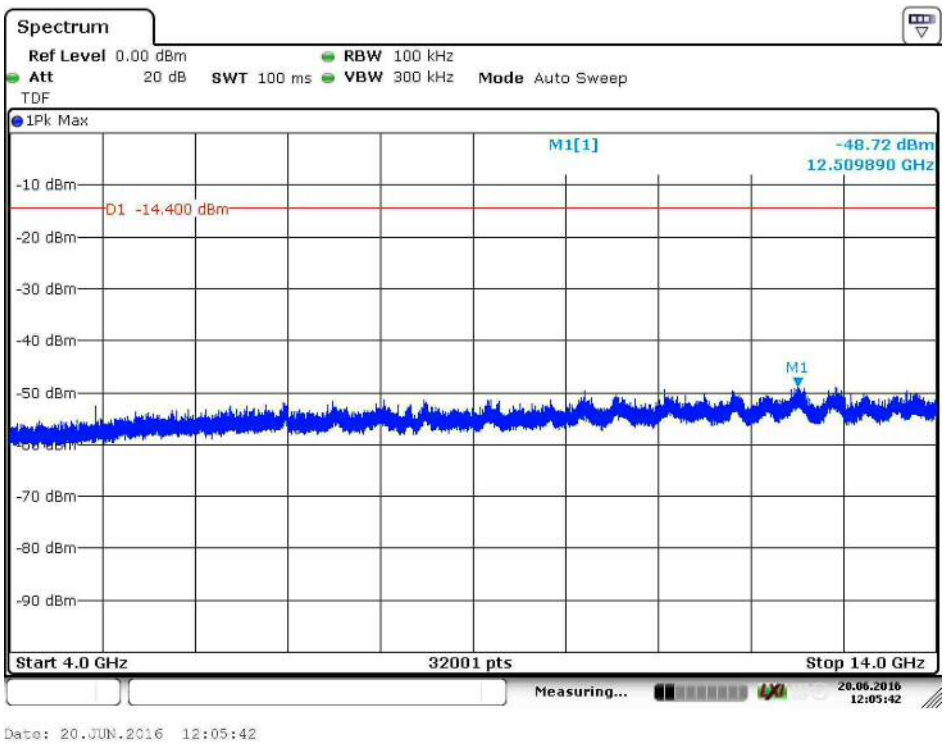

Figure 15. Conducted Spurious Emissions 4 000 – 14 000 MHz channel high 1 Mbps.

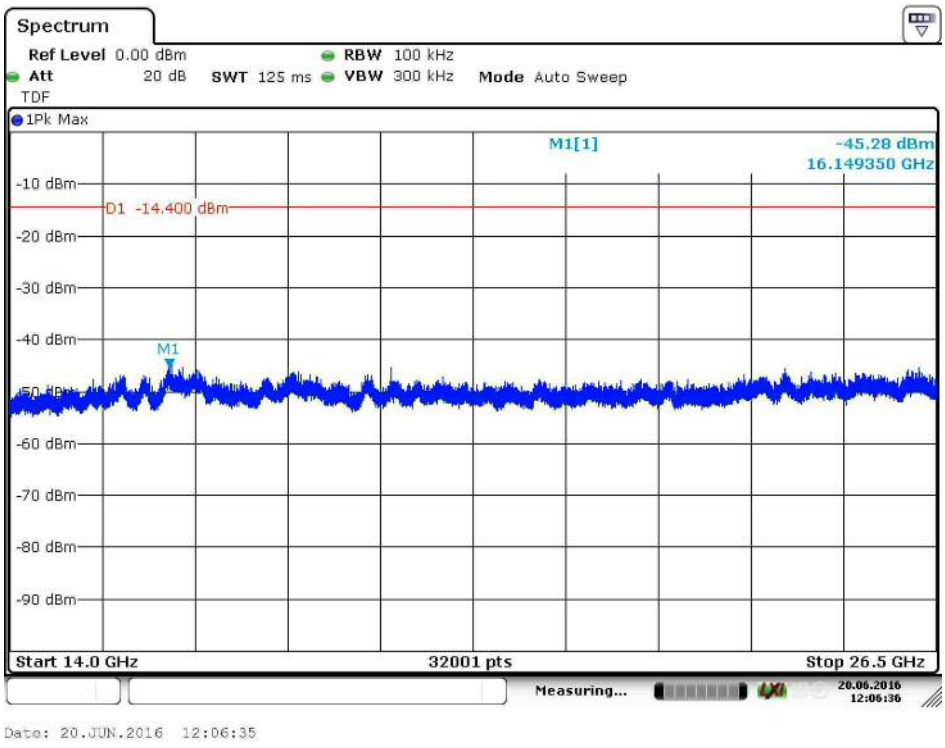

Figure 16. Conducted Spurious Emissions 14 000 – 26 500 MHz channel high 1 Mbps.

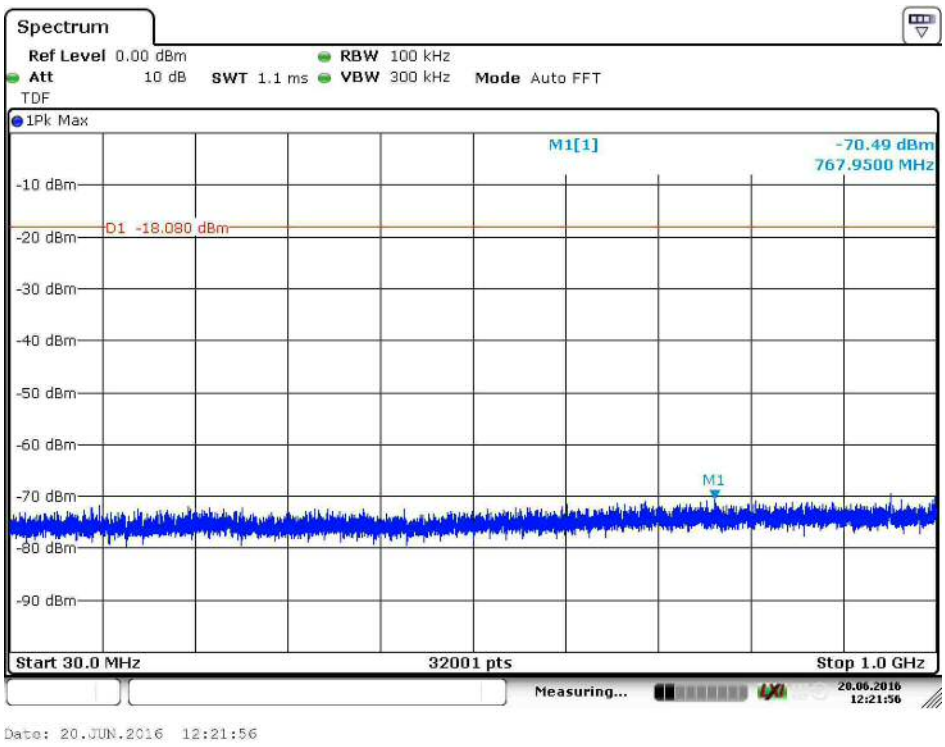

Figure 17. Conducted Spurious Emissions 30 – 1000 MHz channel low 54 Mbps.

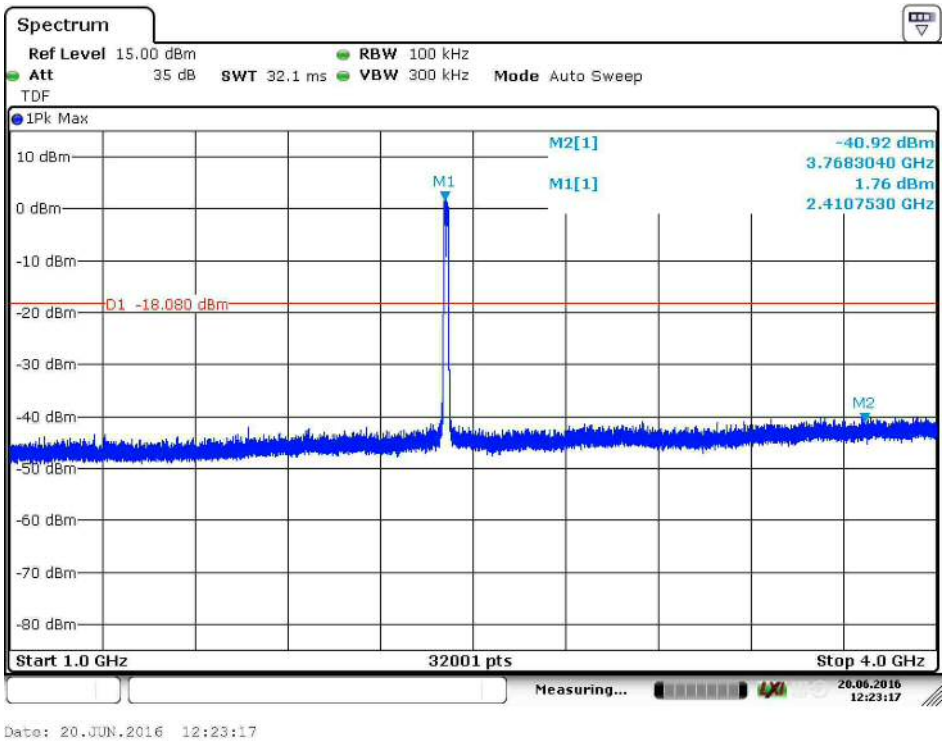

Figure 18. Conducted Spurious Emissions 1000 - 4000 MHz channel low 54 Mbps.

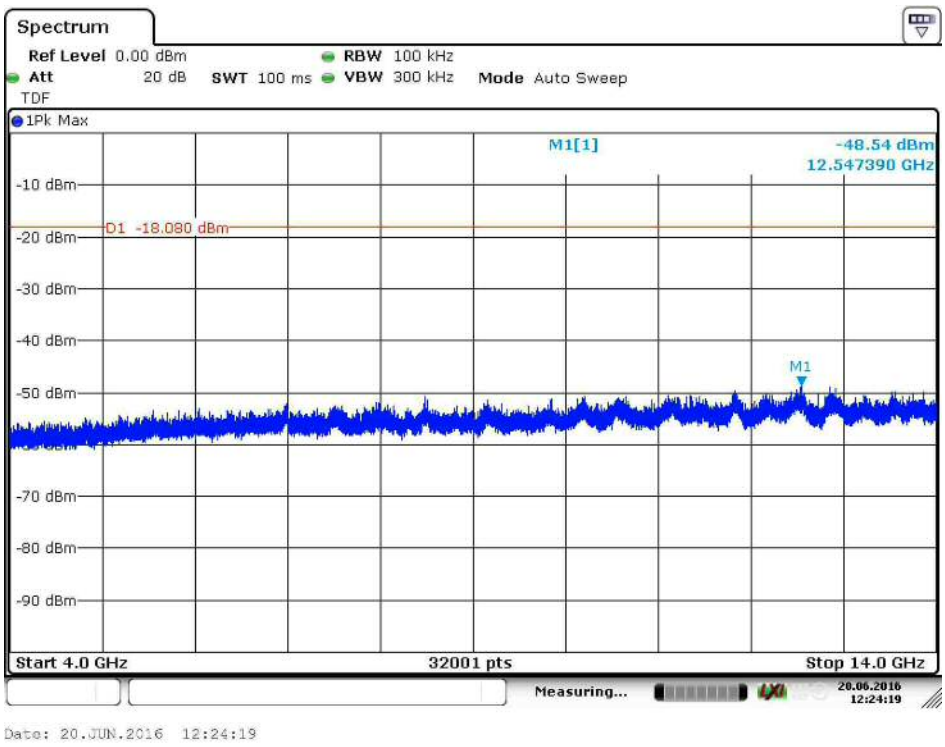

Figure 19. Conducted Spurious Emissions 4000 – 14 000 MHz channel low 54 Mbps.

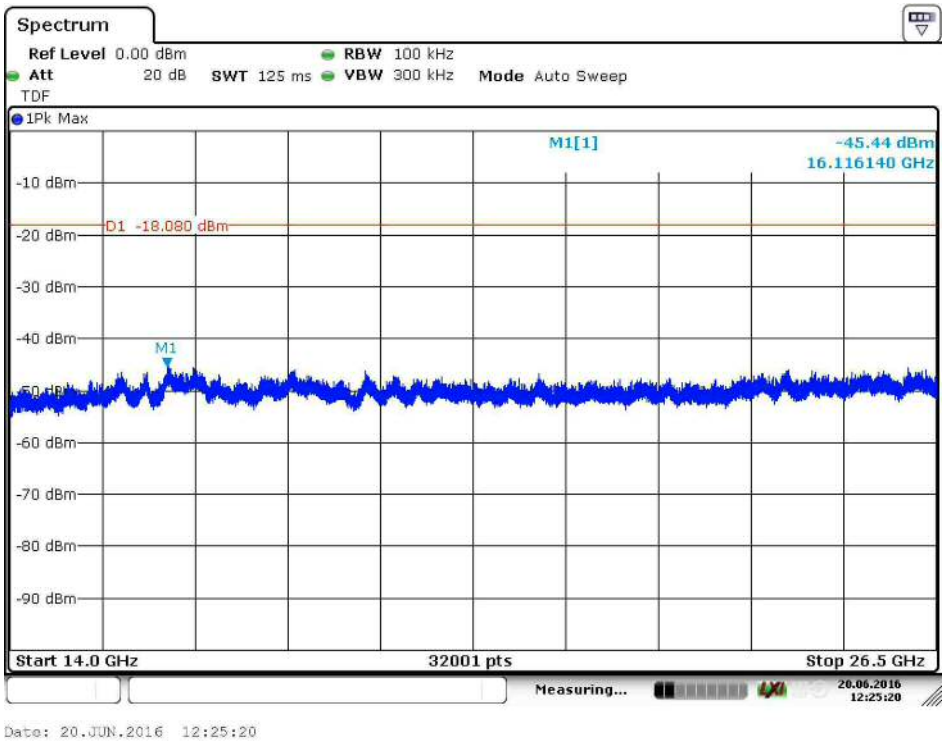

Figure 20. Conducted Spurious Emissions 14 000 – 26 500 MHz channel low 54 Mbps.

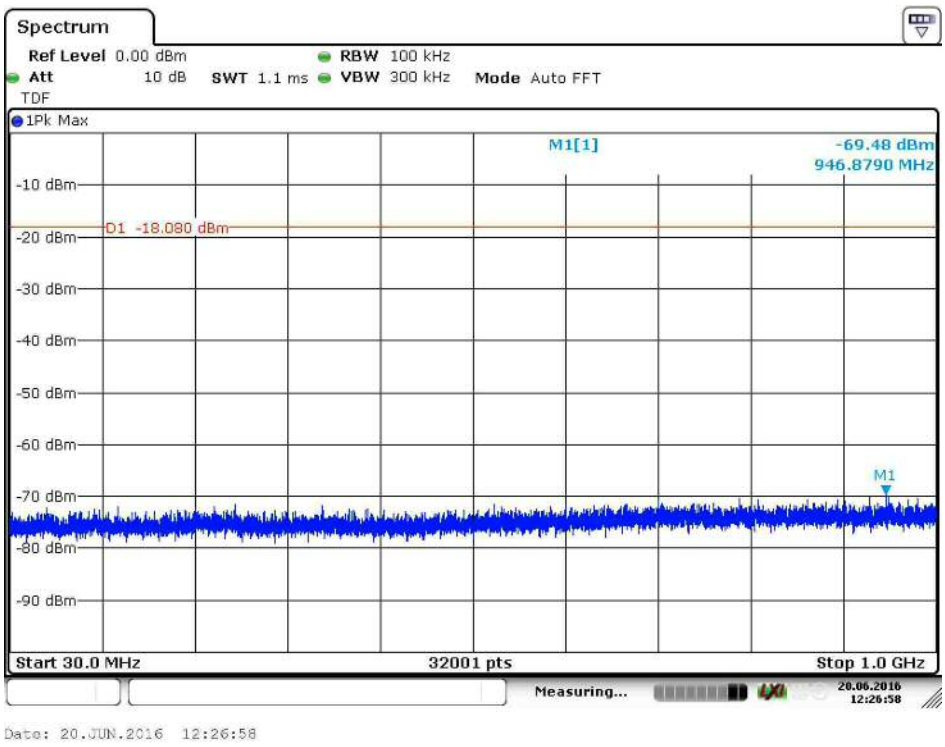

Figure 21. Conducted Spurious Emissions 30 – 1000 MHz channel middle 54Mbps.

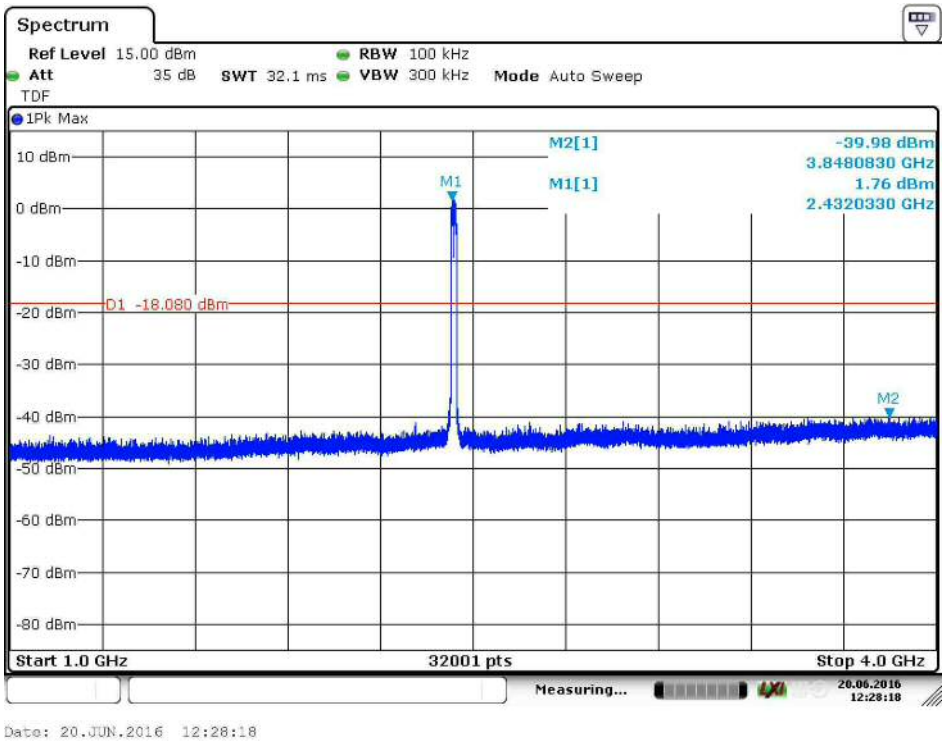

Figure 22. Conducted Spurious Emissions 1000 – 4000 MHz channel middle 54Mbps.

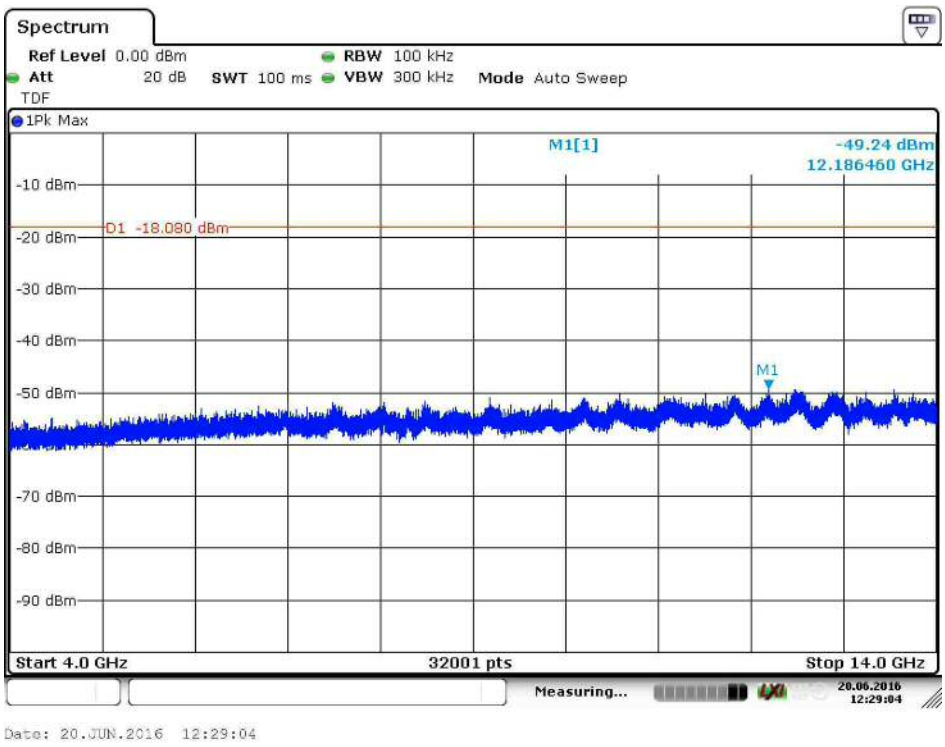

Figure 23. Conducted Spurious Emissions 4000 - 14 000 MHz channel middle 54Mbps.

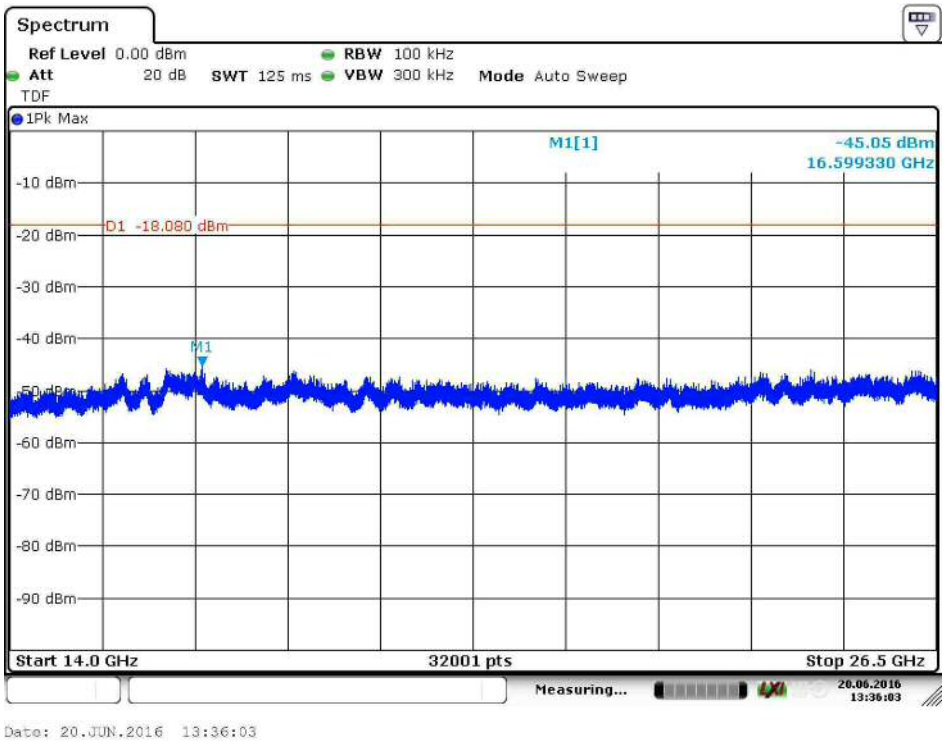

Figure 24. Conducted Spurious Emissions 14 000 – 26 500 MHz channel middle 54Mbps.

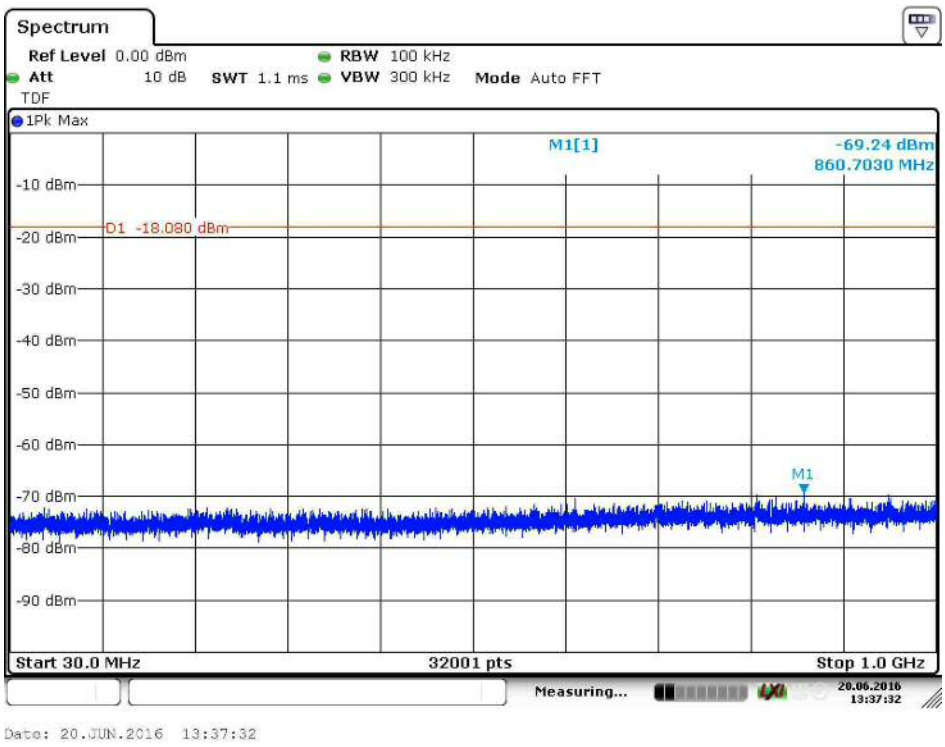

Figure 25. Conducted Spurious Emissions 30 – 1000 MHz channel high 54Mbps.

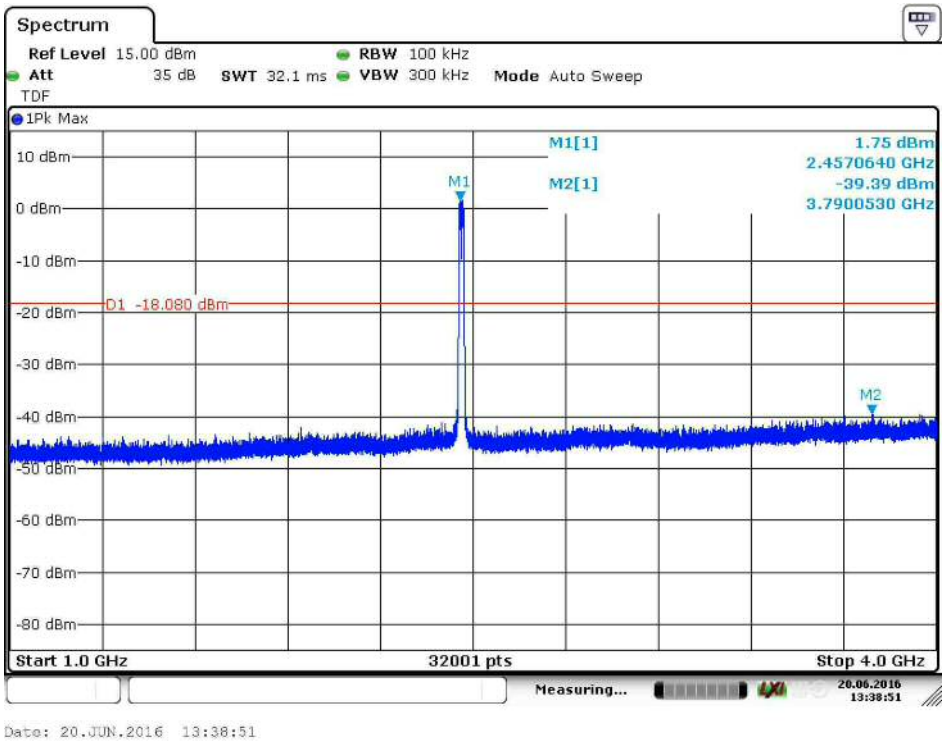

Figure 26. Conducted Spurious Emissions 1000 - 4000 MHz channel high 54Mbps.

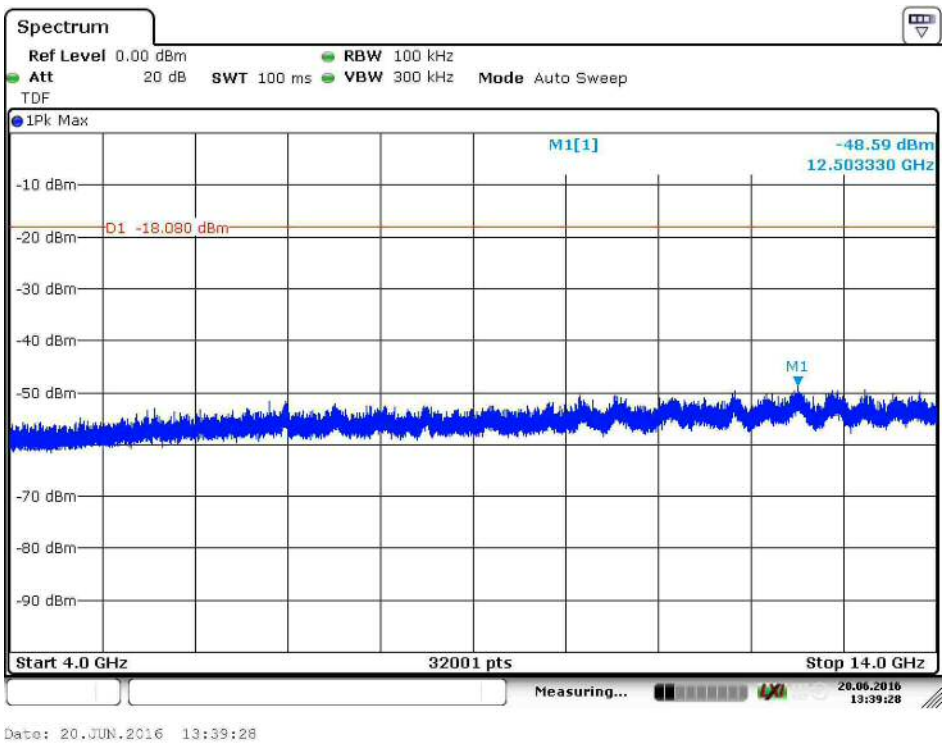

Figure 27. Conducted Spurious Emissions 4000 – 14 000 MHz channel high 54Mbps.

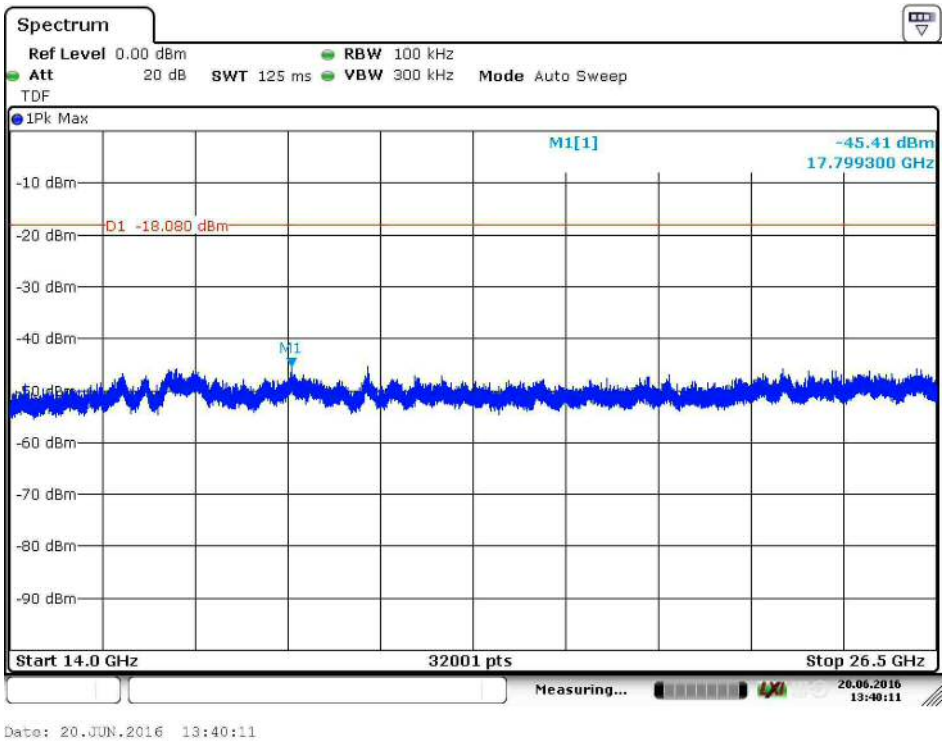

Figure 28. Conducted Spurious Emissions 14 000 – 26 500 MHz channel high 54Mbps.

TEST EQUIPMENT

Equipment	Manufacturer	Type	Serial no	Inv.no	Cal. due
EMI RECEIVER	ROHDE & SCHWARZ	ESU 26	100185	8453	2017-06-09
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	101068	9093	2017-06-09
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
AVG POWER SENSOR	ROHDE & SCHWARZ	NRP-Z91	100267	9878	2018-03-09
ANTENNA (30-1000 MHz)	SCHWARZBECK	VULB 9168	8168-503	8911	2016-11-04
ANTENNA MAST	DEISEL	MA240	240/455	5017	-
TURNTABLE	DEISEL	DS420	-	5015	-
CONTROLLER	COMTEST	HD100	100/457	5018	-
ANTENNA (1-18 GHz)	EMCO	3117	29617	7293	2017-03-03
ANTENNA (18-26.5 GHz)	EMCO	3160- 09	030232-022	7294	2017-03-16
PREAMPLIFIER (0.5-26GHz)	HP	83017A	3950M00102	5226	2017-02-03
ATTENUATOR 10 dB	HUBER & SUHNER	6810.17B	-	-	2016-08-26
HIGH PASS FILTER	WAINWRIGHT	WHKX	10	8267	2016-08-26
AC Power Source	CALIFORNIA INSTRUMENTS	5001 iX Series II	58209	7826	-

All used measurement equipment was calibrated (if required).