1 Introduction

The test was carried by Hermon Laboratories (HL) (Mr. Hay Nisim Abayev project 45570, Class A, Radiated emission) in Hadassah Neurim Youth Village, Beit Yanai, Israel. Temperature 17 ºC, relative humidity 39 %, air pressure 1016 hPa, power: 400 VAC 50 Hz. Site Coordinates: Latitude 32°22' 16'', North; Longitude: 34°51'45'' East; dates 25 and 27 January 2022. Measurements were carried out by Hermon Laboratories between 08:00 and 16:00 local time (UTC 6:00- 14:00); weather conditions: partly cloudy; suburban/rural area. Dr. Haim Mazar participated in the test and edited this Report.
The test vehicle was placed in center of the charging coils and was not moved during all tests. The magnetic and electric field strengths measurements were performed with both horizontal and vertical polarization of the measurement antenna (only at 30 – 1 000 MHz).

The measurement antenna height was 1 m and 2 m; the distance from the antenna to the charging coils was 3 and 10 m. The three RF tested bands are 9 – 150 kHz, 150 kHz – 30 MHz and 30 – 1 000 MHz were compared to the IEC 61980-1 Ed. 2.0 2020-11. The power required for single segment operation is 25kW 400 VAC/40A/50Hz/3ph Y-connection (natural-wire too).

Figure 1-1 The Higher bus in Neurim, 9 kHz – 30 MHz measurement loop antenna, rear side

Figure 1-2 The set up for radiated emission measurements, 30 – 1 000 MHz, front and right sides

The Table below details the HL test equipment.

Table 1—1 In situ test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./Check	Due Cal./Check
0446	Antenna, Loop, Active, 10 (9) kHz - 30 MHz	EMCO	6502	2857	28-Feb-21	28-Feb-22
1500	Cable RF, 15 m, N/N-type	Suhner Switzerland	RG 214/U	1500	09-Feb-21	09-Feb-22
4472	Mini-Bicon Antenna, 30 MHz to 1 GHz (cage elements), 30 MHz to 3 GHz (conical elements)	ETS Lindgren	3180B	00142218	14-Oct-20	14-Oct-22
4663	Spectrum Analyzer, 9 kHz - 1.5 GHz	Hewlett Packard	E7401A	US39150141	02-May-21	02-May-22

Antenna Positions are -45º, 0º, 45º, 90º; the titles of the following measurements plots specify the test-distance, equipment under test (EUT) Side (front, right, left and rear). This test was performed to measure radiated emissions from the WPT-EV charger. The test limits are given in the following Table.

The Table below specifies the radiated emission limits.

Table 1—2 Radiated emission limits

Test	Emissions limits			Requirement/ Method	Rationale
Emission requirements					
Radiated emission measurements (9 - 150 kHz)	**Frequency, kHz**	**QP limit @ 10m, dB(uA/m)**		IEC 61980-1 Ed 2.0: 2020-11	On-site at measurements @ 10m distance from 4 sides, at 1 m antenna height from the lowest point (1.3 m to center) and 3 antenna orientations about its vertical axis 0°, 45° & 90° with no ground plane. The antenna shall be 0.6 m loop as specified in CISPR 16-1- 4.
		~~**≤22 kW**~~	**>22 kW**		
	Table 5 - WPT, Class A equipment				
	9 - 19	~~42.0-38.8~~	42.0-38.8		
	19 - 21	~~97.0~~	107.0		
	21 - 79	~~37.6-32.7~~	37.6-32.7		
	79 - 90	~~92.8~~	102.8		
	90-150	~~32.2–30.0~~	32.2–30.0		
Radiated emission measurements (below 30 MHz)	**Frequency, MHz**	**QP limit, dB(uA/m)**		IEC 61980-1 Ed 2.0: 2020-11	On-site at measurements @ 3m distance from 4 sides, at 1 m antenna height from the lowest point (1.3 m to center) and 3 antenna
		D=3 m	~~**D=10 m**~~		
	Table 7 - WPT, Class A equipment*				
	0.15-0.49	82	~~57.5~~		

<table>
<tr><th>Test</th><th colspan="3">Emissions limits</th><th>Requirement/ Method</th><th>Rationale</th></tr>
<tr><td></td><td>0.49-1.705</td><td>72</td><td>~~47.5~~</td><td></td><td rowspan="6">orientations about its vertical axis 0°, 45° & 90° with no ground plane. The antenna shall be 0.6 m loop as specified in CISPR 16-1- 4.</td></tr>
<tr><td></td><td>1.705-2.194</td><td>77</td><td>~~52.5~~</td><td></td></tr>
<tr><td></td><td>2.194-3.95</td><td>68</td><td>~~43.5~~</td><td></td></tr>
<tr><td></td><td>3.95-11</td><td>(68-28.5)**</td><td>~~18.5~~</td><td></td></tr>
<tr><td></td><td>11-20</td><td>28.5</td><td>~~18.5~~</td><td></td></tr>
<tr><td></td><td>20-30</td><td>18.5</td><td>~~8.5~~</td><td></td></tr>
<tr><td rowspan="20">Radiated emission measurements (within 30 – 1 000 MHz)</td><td rowspan="2">Frequency, MHz</td><td colspan="2">QP limit, dB(uV/m)</td><td rowspan="20">CISPR 11:15 +A1:16+A2:19</td><td rowspan="20">The measurements will be performed on-site at 3m distance from the unit, in 4 azimuths around the unit at 2 m antenna height with no ground plane.</td></tr>
<tr><td>D=3 m</td><td>~~D=10 m~~</td></tr>
<tr><td colspan="3">Table 10 - Group 2, Class A equipment</td></tr>
<tr><td>Frequency, MHz</td><td>D=3 m</td><td>~~D=10 m~~</td></tr>
<tr><td>30-47</td><td>78</td><td>~~68~~</td></tr>
<tr><td>47-68</td><td>60</td><td>~~50~~</td></tr>
<tr><td>68-80.872</td><td>73</td><td>~~63~~</td></tr>
<tr><td>80.872-81.848</td><td>88</td><td>~~78~~</td></tr>
<tr><td>81.848-87</td><td>73</td><td>~~63~~</td></tr>
<tr><td>87-134.786</td><td>70</td><td>~~60~~</td></tr>
<tr><td>134.786-136.414</td><td>80</td><td>~~70~~</td></tr>
<tr><td>136.414-156</td><td>70</td><td>~~60~~</td></tr>
<tr><td>156-174</td><td>84</td><td>~~74~~</td></tr>
<tr><td>174-188.7</td><td>60</td><td>~~50~~</td></tr>
<tr><td>188.7-190.979</td><td>70</td><td>~~60~~</td></tr>
<tr><td>190.979-230</td><td>60</td><td>~~50~~</td></tr>
<tr><td>230-400</td><td>70</td><td>~~60~~</td></tr>
<tr><td>400-470</td><td>73</td><td>~~63~~</td></tr>
<tr><td>470-1000</td><td>70</td><td>~~60~~</td></tr>
</table>

Notes:

* Allowance of section 16.3.3.4 for harmonics: For radiated emissions of WPT system having a fundamental frequency up to 150 kHz at the second, third, fourth, and fifth integer harmonics of the fundamental frequency of the supply device, the limits in Table 5 may be relaxed by 10 dB. This relaxation shall only apply in the surrounding frequency interval with a bandwidth of up to 1 % of the respective harmonic frequency or of 4.5 kHz, whichever is smaller, centered on the respective integer multiple of the actual fundamental frequency of the supply device, excluding any frequencies within this interval that extend into the frequency bands in Table 5.

** The limit decreases linearly with the logarithm of frequency.

2 General test results: charging signal and unwanted emissions

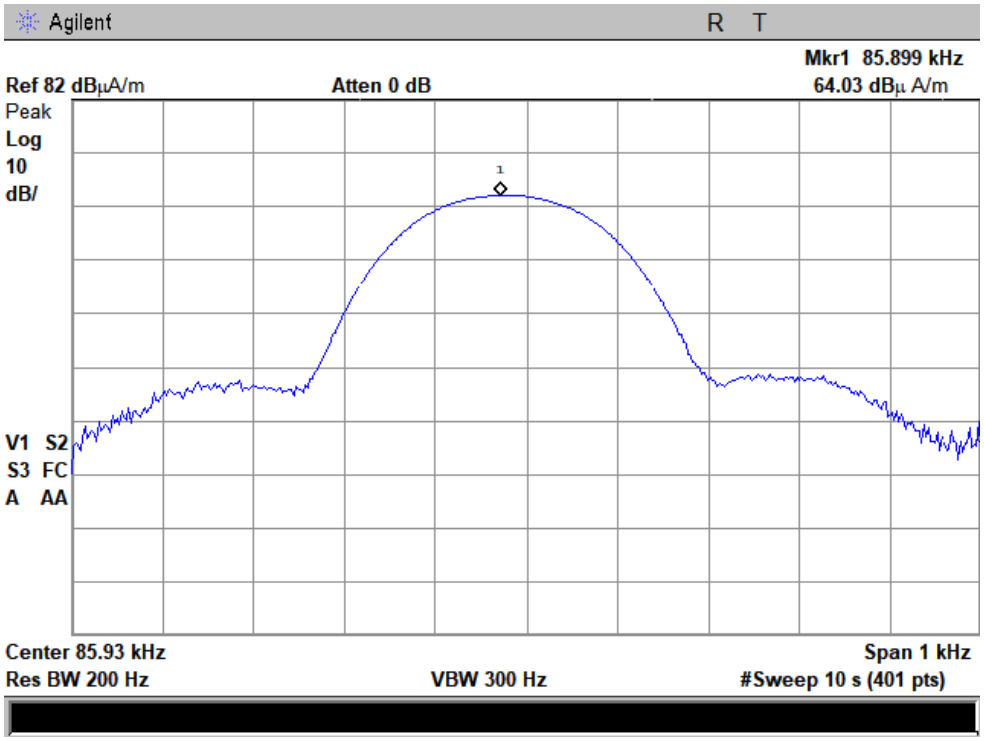
2.1 Compliance

Test specification:	**Radiated emissions, Class A**		
Test procedure:	IEC 61980-1 Ed 2.0: 2020-11; CISPR 11 Ed 6.2: 2015 + AMD1: 2016 + AMD2: 2019; TP Electreon MOC requirments		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	16-Jan-22, 25-Jan-22		
Temperature: 17 °C	**Relative Humidity:** 39 %	**Air Pressure:** 1016 hPa	**Power:** 400 VAC, 50 Hz
Remarks: On-site testing			

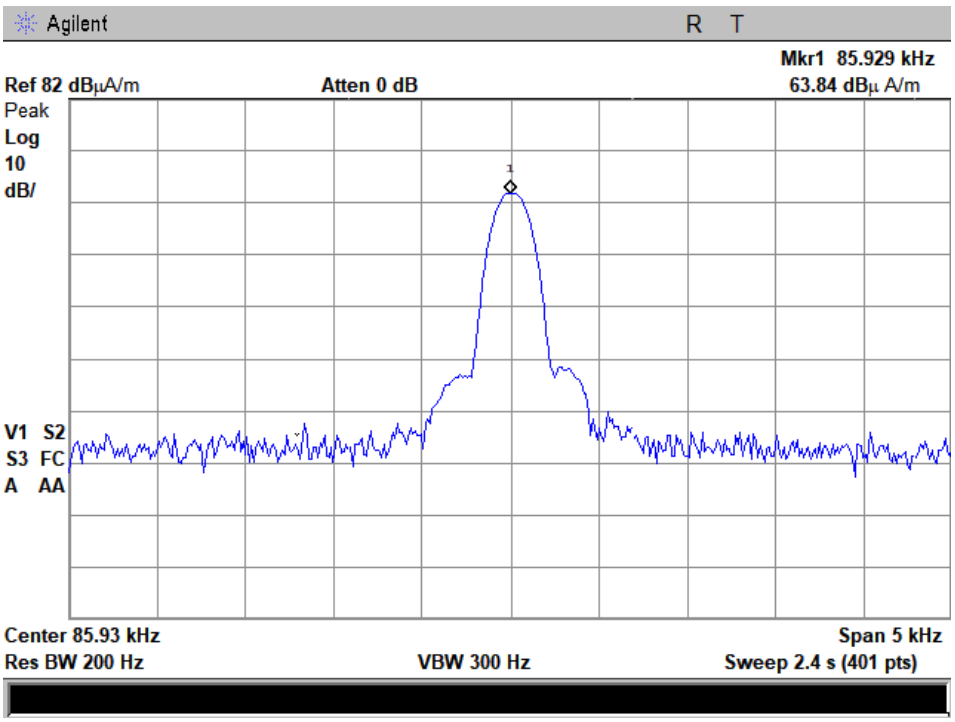
2.2 Charging signal, in-band plots, 1 and 10 kHz spans

The two Plots below depict the wanted-signal, in-band Plots

Plot 2-1 Center operating frequency, measurements with 1 kHz span



Plot 2-2 Center operating frequency, measurements with 5 kHz span



2.3 Measured levels of unwanted emissions 9 kHz – 30 MHz

Table 2—1 Radiated emission limits at the ranges 9 kHz – 150 kHz, 150 kHz – 30 MHz

TEST SITE: CUSTOMER PREMISES
CLASS: A
FREQUENCY RANGE: 9 kHz – 150 kHz
DETECTORS USED: PEAK / QUASI-PEAK
RESOLUTION BANDWIDTH: 200 Hz
TEST DISTANCE: 10 m

Frequency, kHz	Peak emission, dB(μA/m)	Quasi-peak			Antenna position	Antenna height, m	EUT position	Verdict
		Measured emission, dB(μA/m)	Limit, dB(μA/m)	Margin, dB*				
39.457	23.89	20.01	36.04	-16.03	-45°,0°,45°,90°	1.0	Front	Pass
131.516	31.72	27.59	30.68	-3.09	-45°,0°,45°,90°	1.0		
132.569	30.27	26.12	30.64	-4.52	-45°,0°,45°,90°	1.0		
41.829	34.06	31.53	35.84	-4.31	-45°,0°,45°,90°	1.0	Right	
128.922	27.82	24.22	30.77	-6.55	-45°,0°,45°,90°	1.0		
139.062	31.15	27.26	30.40	-3.14	-45°,0°,45°,90°	1.0		
47.796	20.23	17.38	35.34	-17.96	-45°,0°,45°,90°	1.0	Left	
128.409	16.36	13.98	30.79	-16.81	-45°,0°,45°,90°	1.0		
13.142	33.25	27.53	40.67	-13.14	-45°,0°,45°,90°	1.0	Rear	
40.586	36.21	32.13	35.95	-3.82	-45°,0°,45°,90°	1.0		
46.481	33.32	29.63	35.45	-5.82	-45°,0°,45°,90°	1.0		
126.883	32.78	28.16	30.85	-2.69	-45°,0°,45°,90°	1.0		

FREQUENCY RANGE: 150 kHz – 30 MHz
DETECTORS USED: PEAK / QUASI-PEAK
RESOLUTION BANDWIDTH: 9 kHz
TEST DISTANCE: 3 m

Frequency, MHz	Peak emission, dB(μA/m)	Quasi-peak			Antenna position	Antenna height, m	EUT position	Verdict
		Measured emission, dB(μA/m)	Limit, dB(μA/m)	Margin, dB*				
13.560	21.42	18.15	28.50	-10.35	-45°,0°,45°,90°	1.0	Front	Pass
0.253	73.69	70.69	82.00	-11.31	-45°,0°,45°,90°	1.0	Right	
13.560	26.62	23.18	28.50	-5.32	-45°,0°,45°,90°	1.0		
0.254	71.86	68.62	82.00	-13.38	-45°,0°,45°,90°	1.0	Left	
13.560	25.27	22.64	28.50	-5.86	-45°,0°,45°,90°	1.0		
0.254	69.13	65.86	82.00	-16.14	-45°,0°,45°,90°	1.0	Rear	
13.560	26.18	23.34	28.50	-5.16	-45°,0°,45°,90°	1.0		

FREQUENCY RANGE: 30 MHz – 1000 MHz
DETECTORS USED: PEAK / QUASI-PEAK
RESOLUTION BANDWIDTH: 120 kHz
TEST DISTANCE: 3 m

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	EUT position	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
60.360	51.31	47.18	60.00	-12.82	Horizontal	2.0	Rear	Pass

*- Margin = Measured emission – specification limit.
**- EUT front panel refers to 0 degrees position of turntable.

Note: the 60.360 MHz is above 30 MHz.

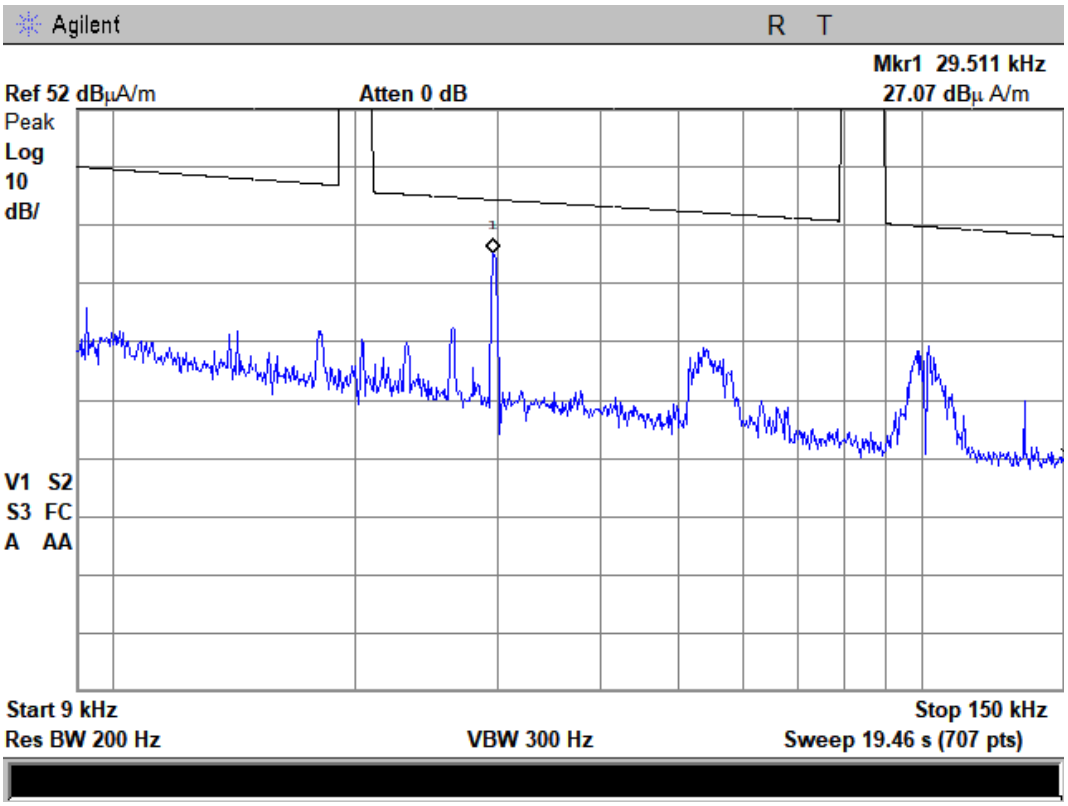
3 Test Results; front, right, left and rear

3.1 Range 9 – 150 kHz range

Note: The following Plots depict at 9 – 150 kHz the Low Frequency (LF band 30 to 300 kHz) audio broadcasting operating at 148.5 – 283.5 kHz.

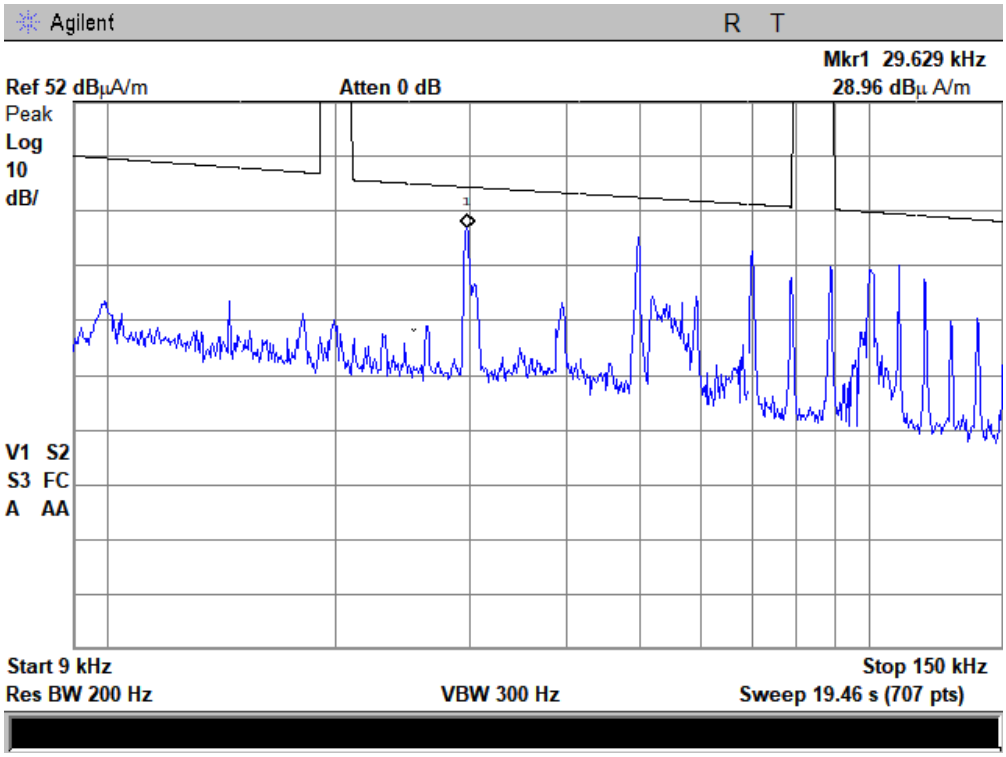
3.1.1 Ambient noise- plots

Plot 3-1 Radiated emission measurements in 9 kHz – 150 kHz, ambient; front, 10 m test distance

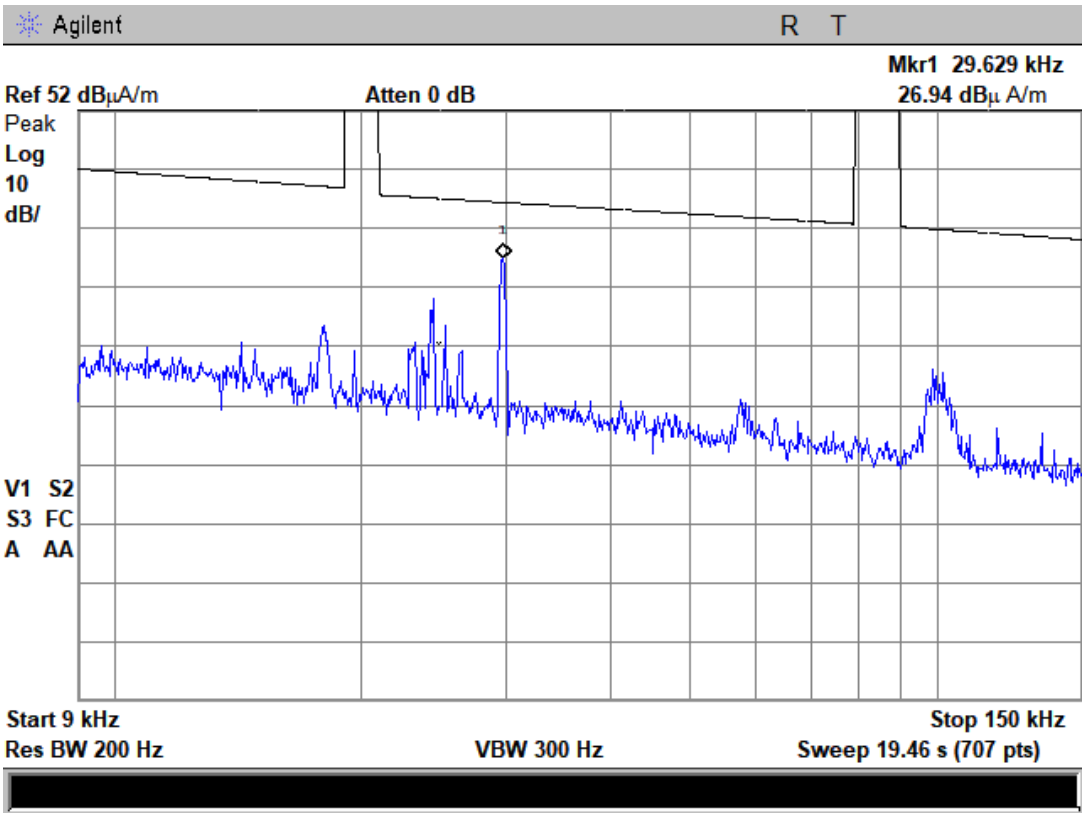


Note: in all Plots 9 to 150 kHz, the top of the 85 kHz 'chimney' equals 102.8 (dBµA/m).

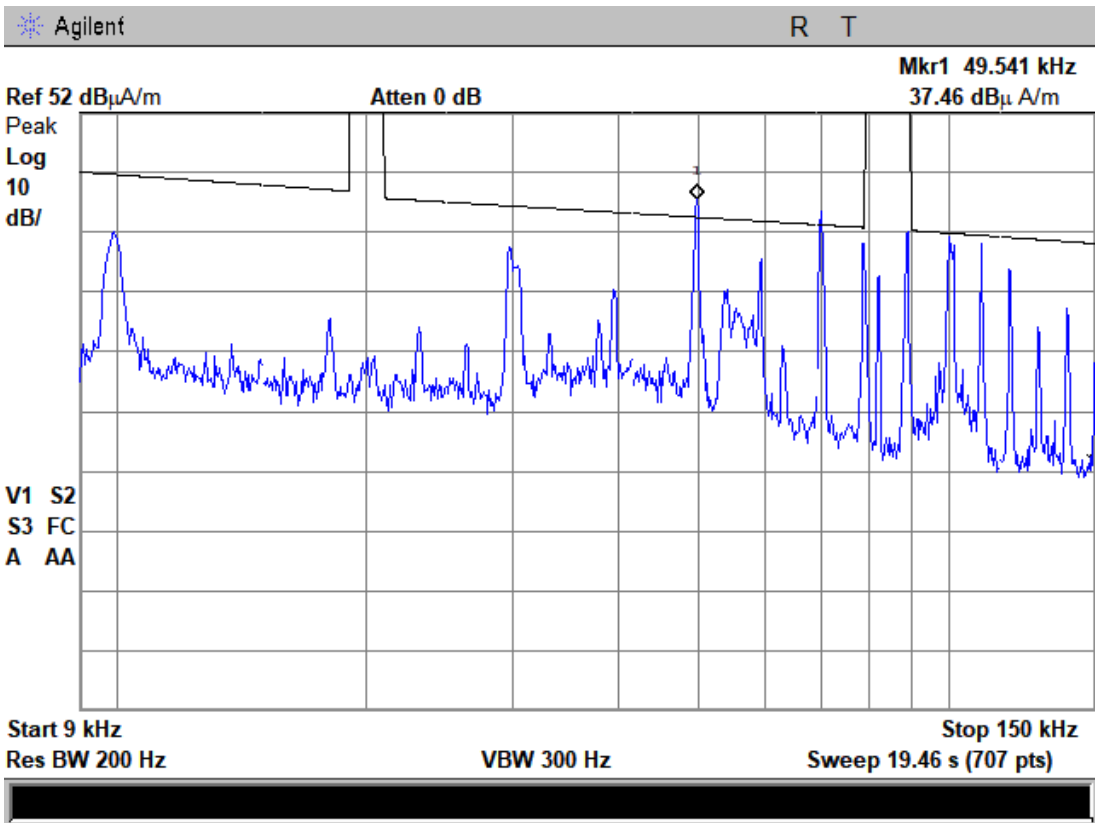
Plot 3-2 Radiated emission measurements in 9 kHz – 150 kHz range, ambient; right, 10 m



Plot 3-3 Radiated emission measurements in 9 kHz – 150 kHz range, ambient; left, 10 m



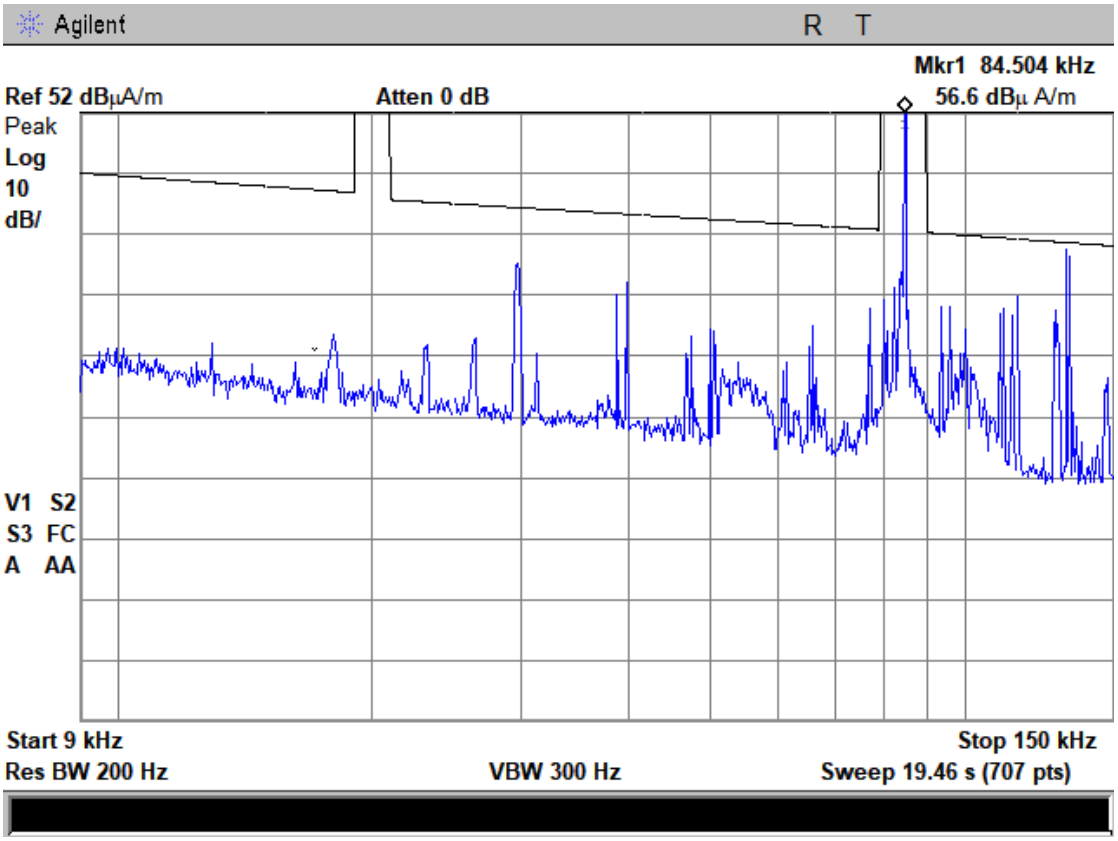
Plot 3-4 Radiated emission measurements in 9 kHz – 150 kHz range, ambient; rear, 10 m



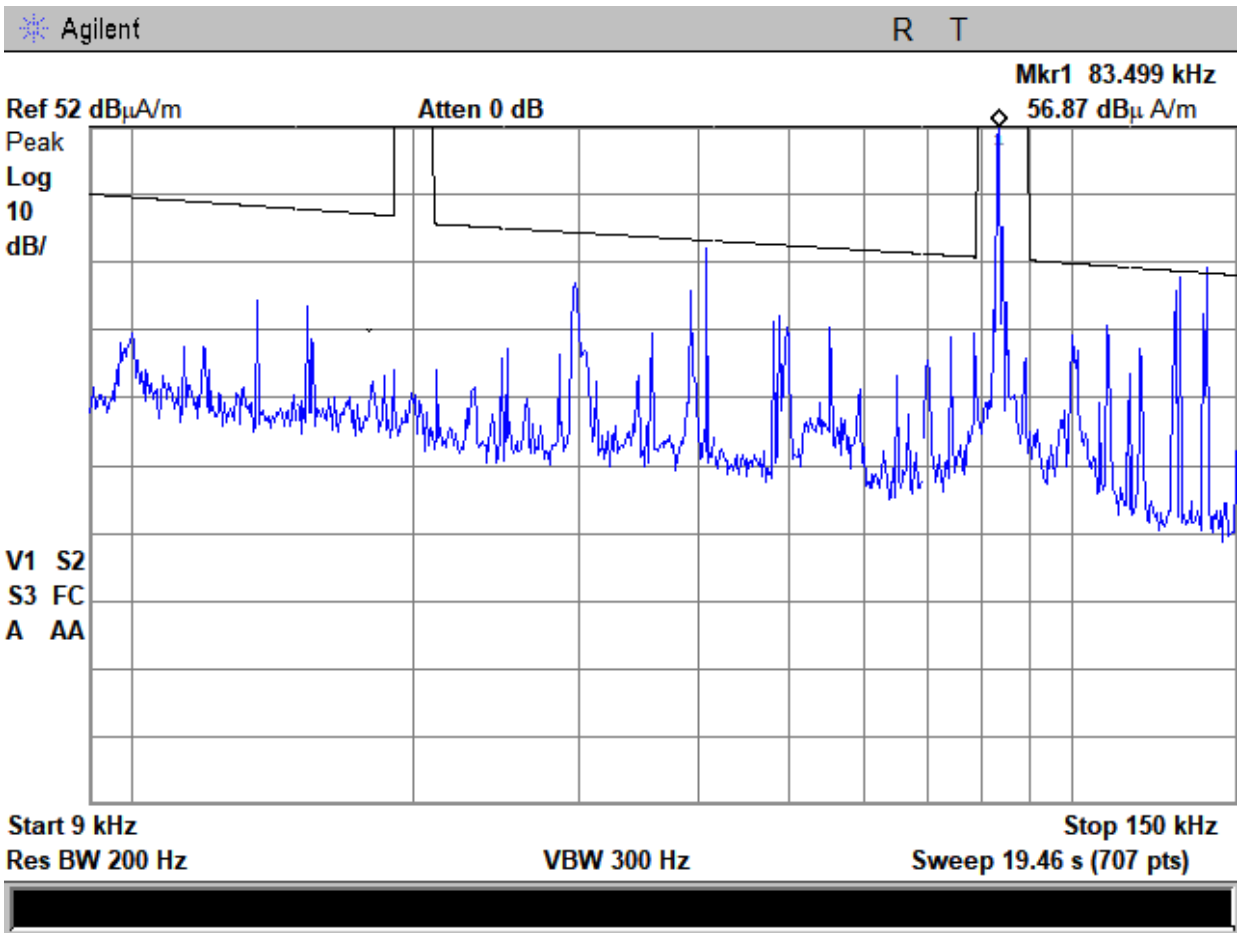
Note: the peaks in Plot 3-4 (49.541 KHz 37.46 dBµA/m, even in ambient mode) and Plot 3-8 (40.591 kHz 36.13 dBµA/m) overflow the mask; measurement on measured on 25 January 2022 of the old version 1.0.0.30 (measured rear and right side) of the field-programmable gate array (FPGA) firmware version (FW). After improving the FW switching noise, FPGA new version 1.0.0.63, **front** and **left** measurements depict lower values; see the following Plot 3-5 (front side) and
Plot 3-7 (left side), measured on 27 January 2022.

3.1.2 Plots of wanted signal and unwanted emissions 9 kHz – 150 kHz range during charging

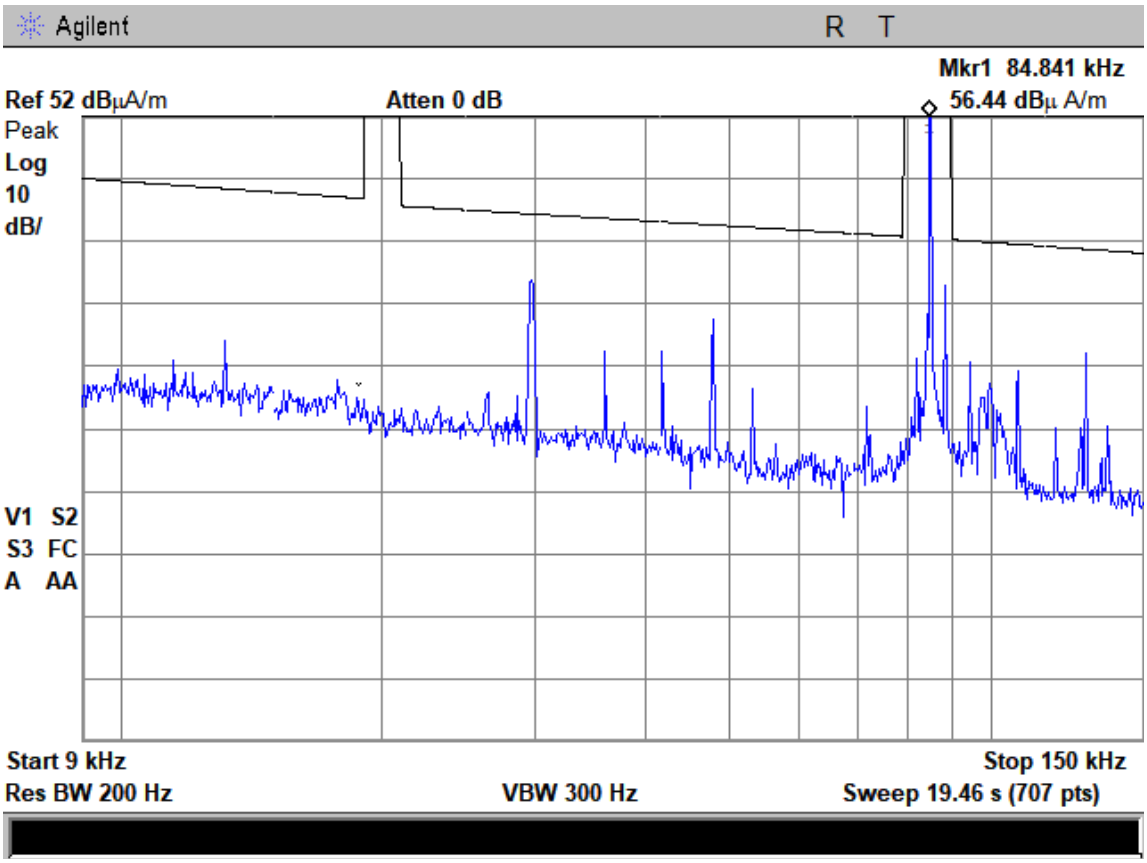
Plot 3-5 Radiated emission measurements in 9 kHz – 150 kHz range; front , 10 m test distance



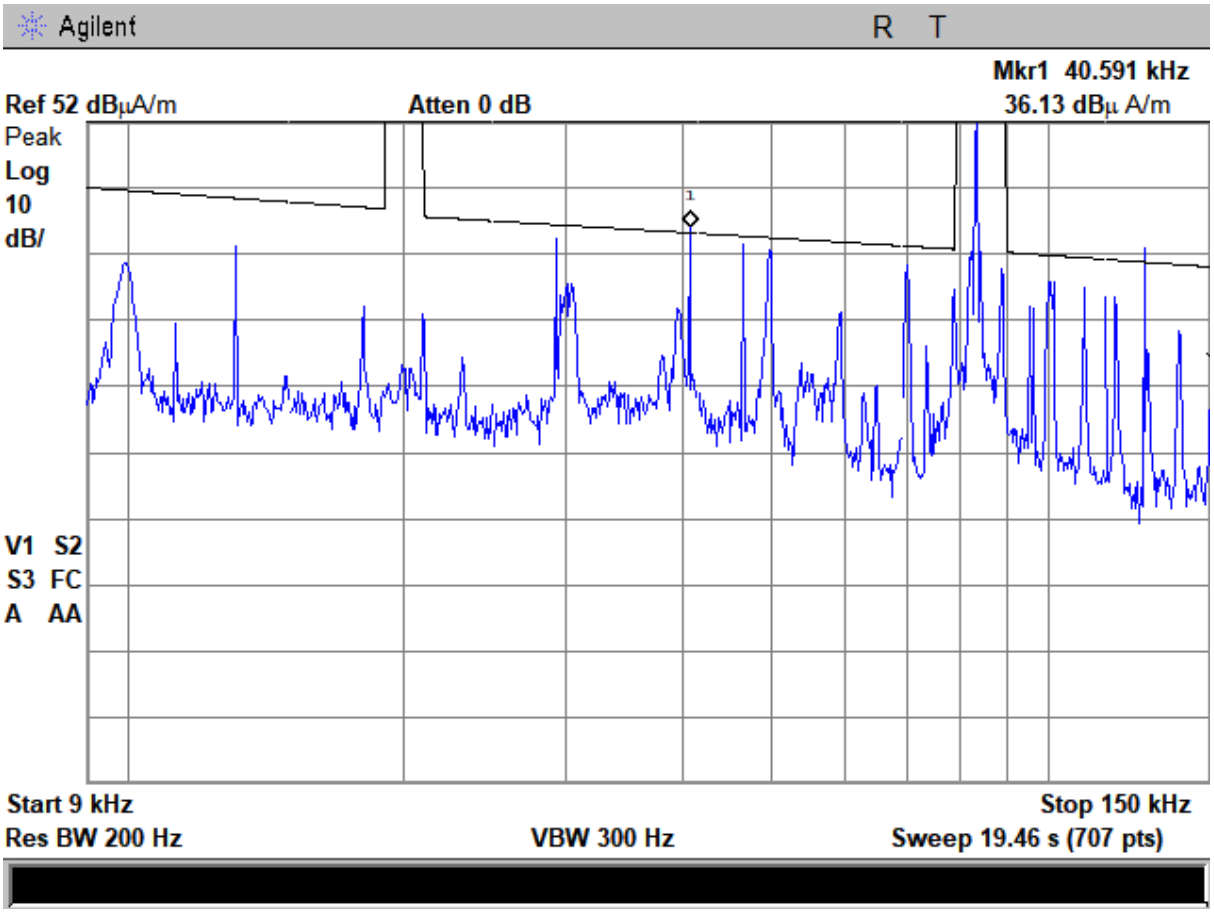
Plot 3-6 Radiated emission measurements in 9 kHz – 150 kHz range; right, 10 m



Plot 3-7 Radiated emission measurements in 9 kHz – 150 kHz range; left, 10 m



Plot 3-8 Radiated emission measurements in 9 kHz – 150 kHz range; rear, 10 m

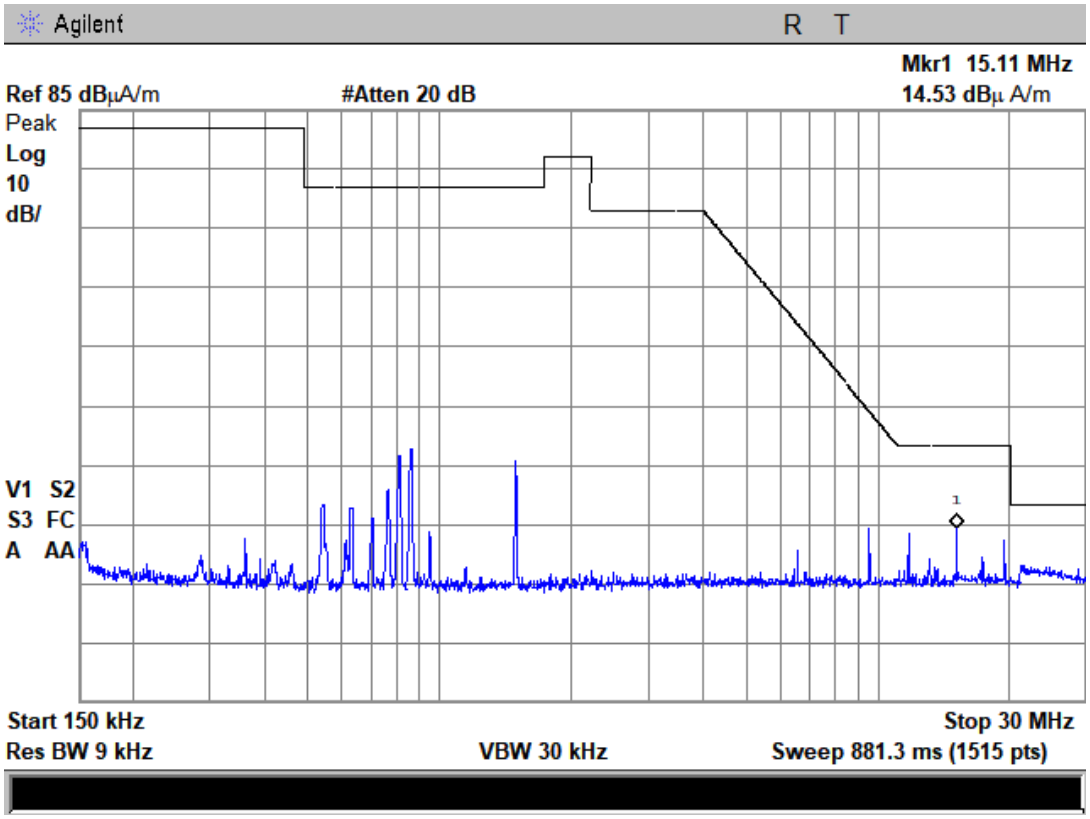


3.2 Range 150 kHz – 30 MHz

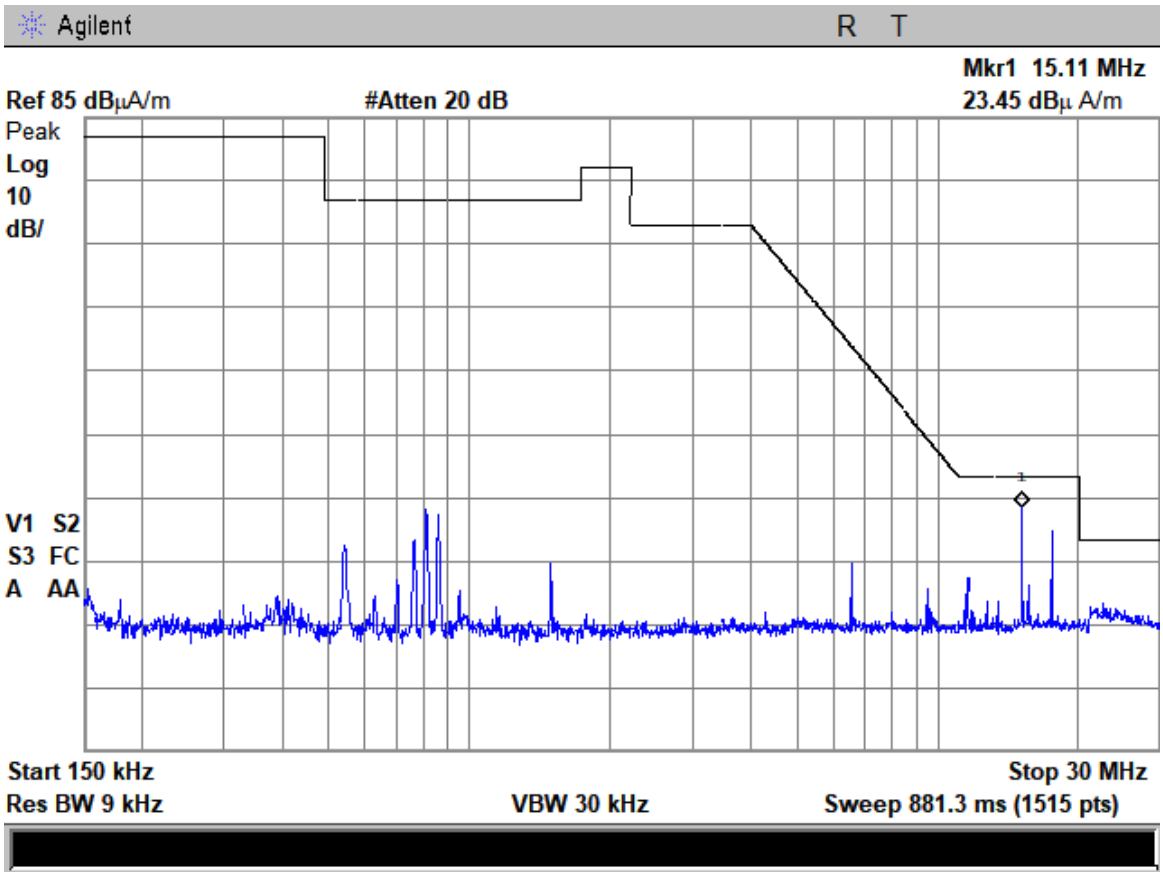
Note: The following plots also depict at 150 kHz – 30 MHz the Low Frequency (LF band 30 to 300 kHz) audio broadcasting operating at 148.5-283.5 kHz.

3.2.1 Ambient noise- plots, 150 kHz – 30 MHz

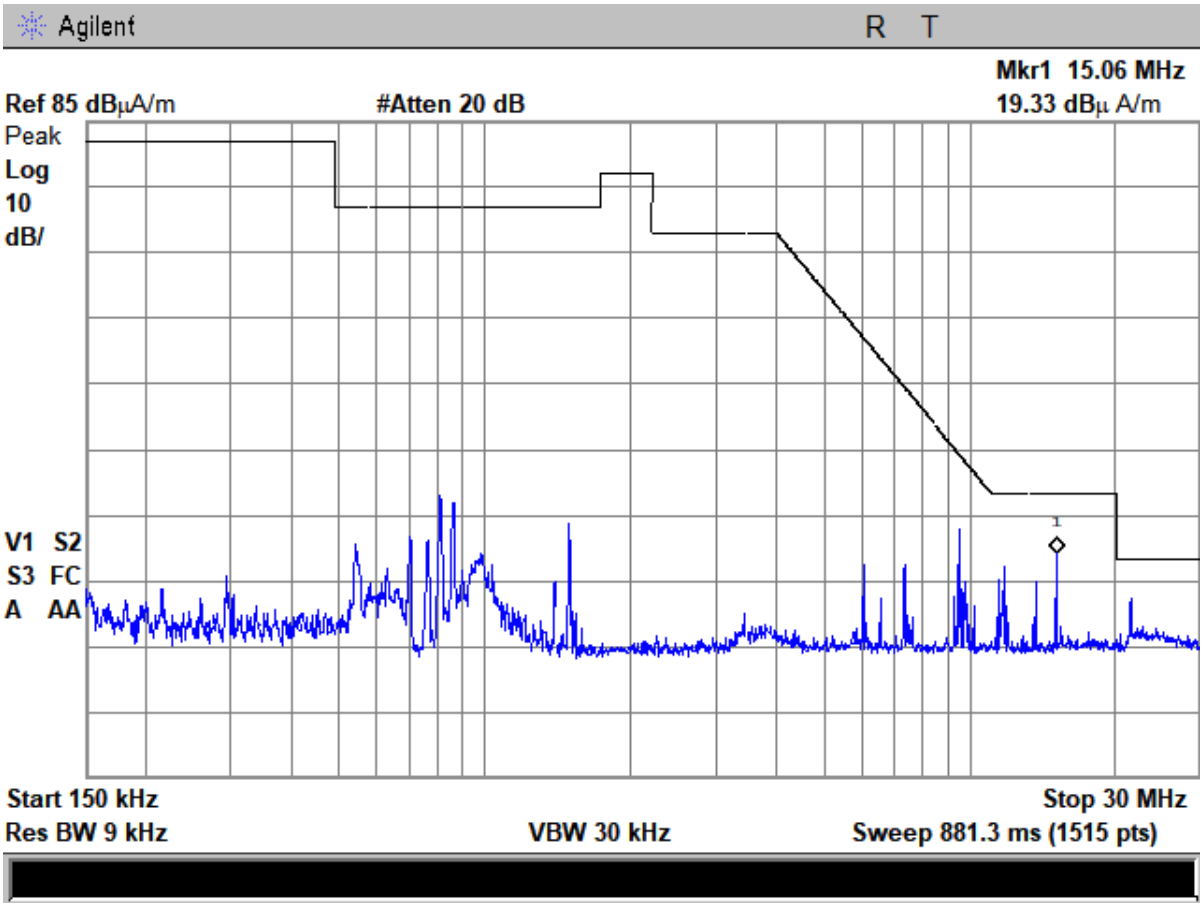
Plot 3-9 Radiated emission measurements in 150 kHz – 30 MHz range, ambient; front, 3 m test distance



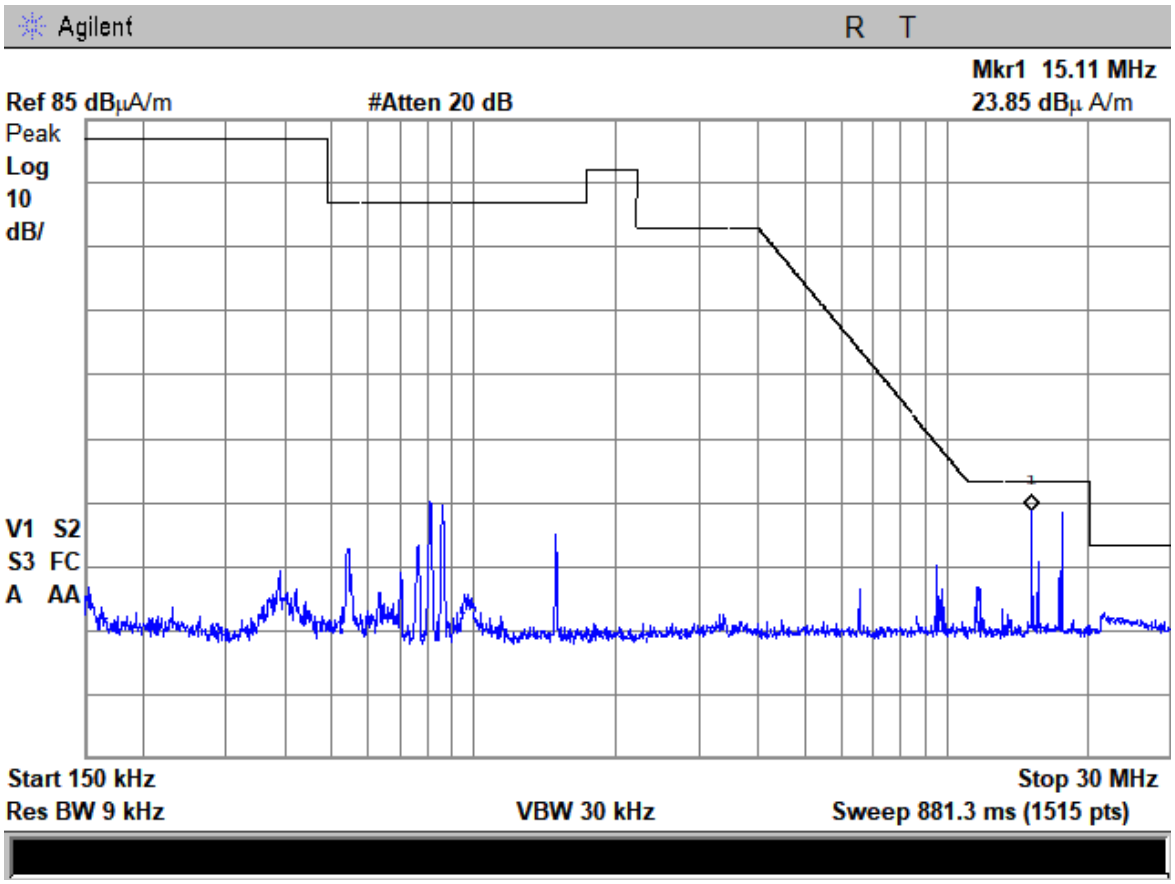
Plot 3-10 Radiated emission measurements in 150 kHz – 30 MHz range, ambient; right, 3 m



Plot 3-11 Radiated emission measurements in 150 kHz – 30 MHz range, ambient; left, 3 m

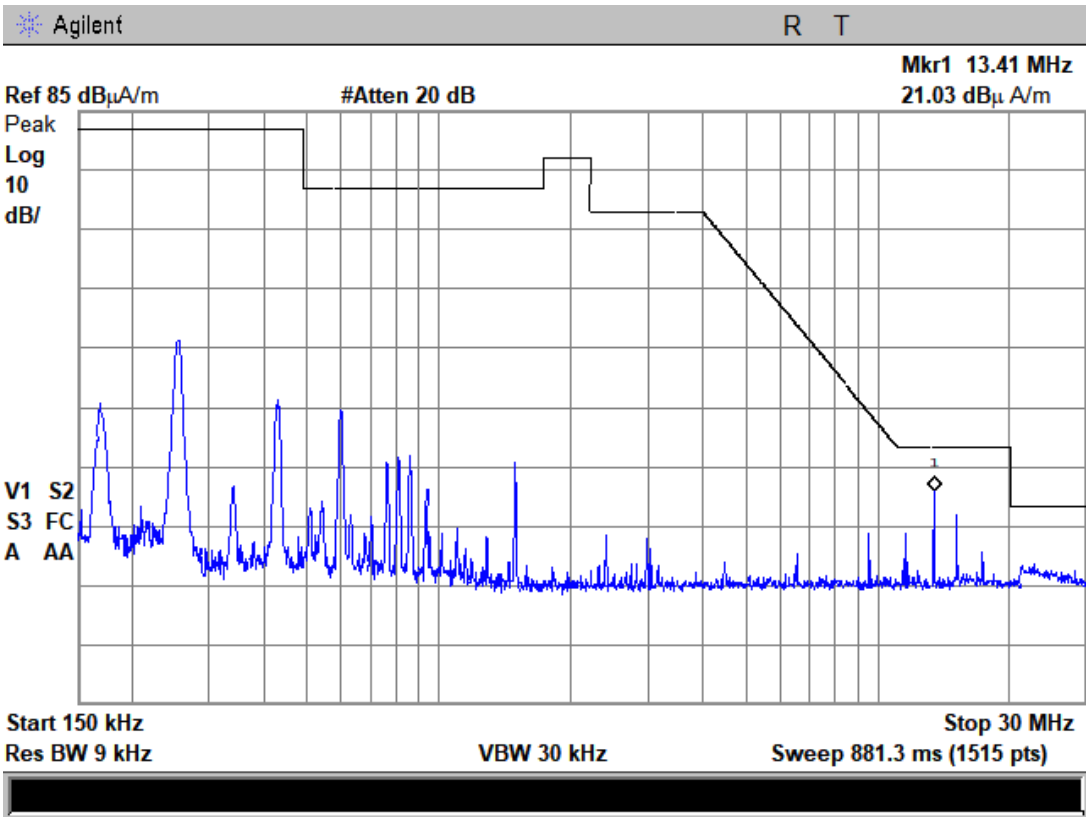


Plot 3-12 Radiated emission measurements in 150 kHz – 30 MHz range, ambient; rear, 3 m



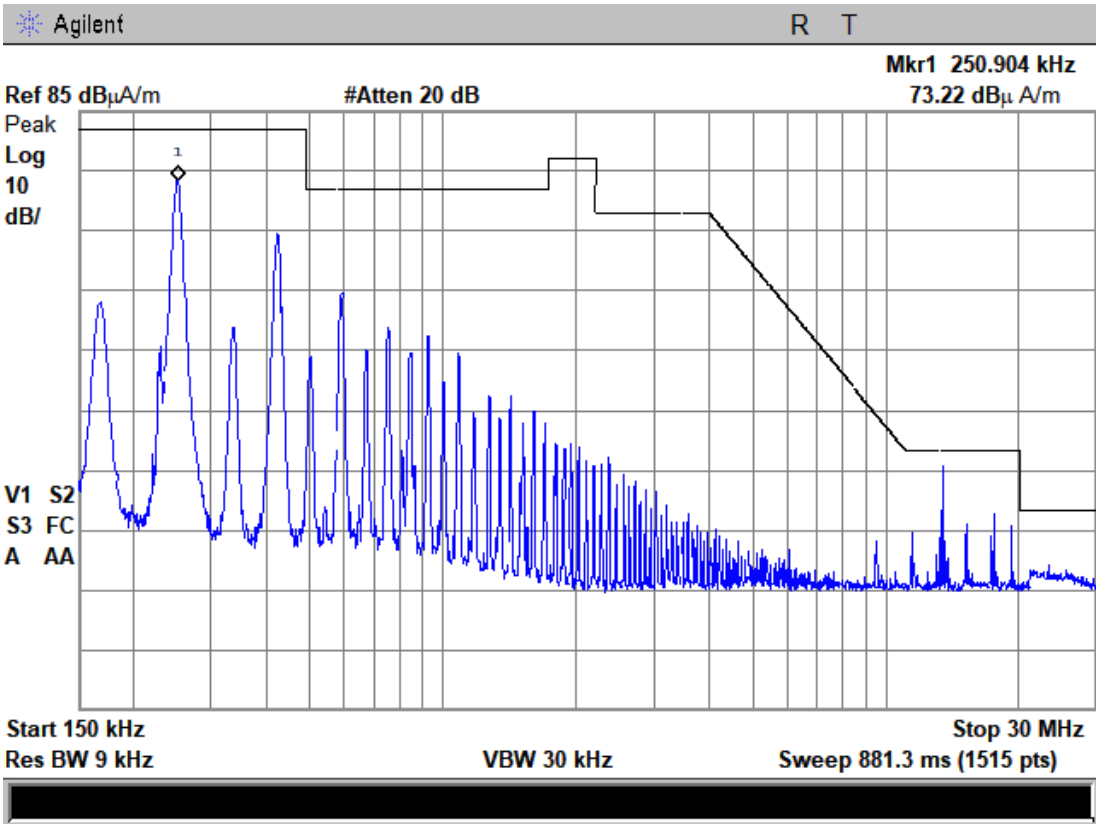
3.2.2 Plots of unwanted emissions 150 kHz – 30 MHz during charging

Plot 3-13 Radiated emission measurements in 150 kHz – 30 MHz range; front, 3 m test distance

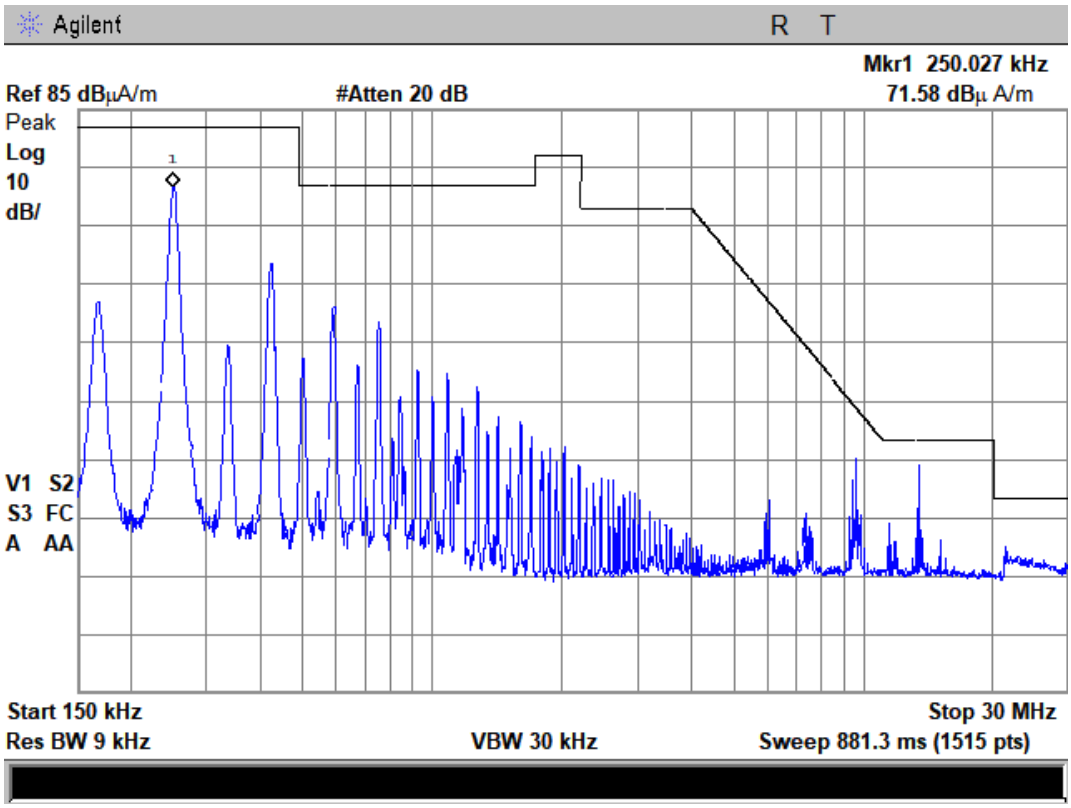


Note: future versions of FPGA will reduce the high measured harmonics and oscillations below 2 MHz, in the Plot above, Plot 3-13, Plot 3-14, Plot 3-15 and Plot 3-16.

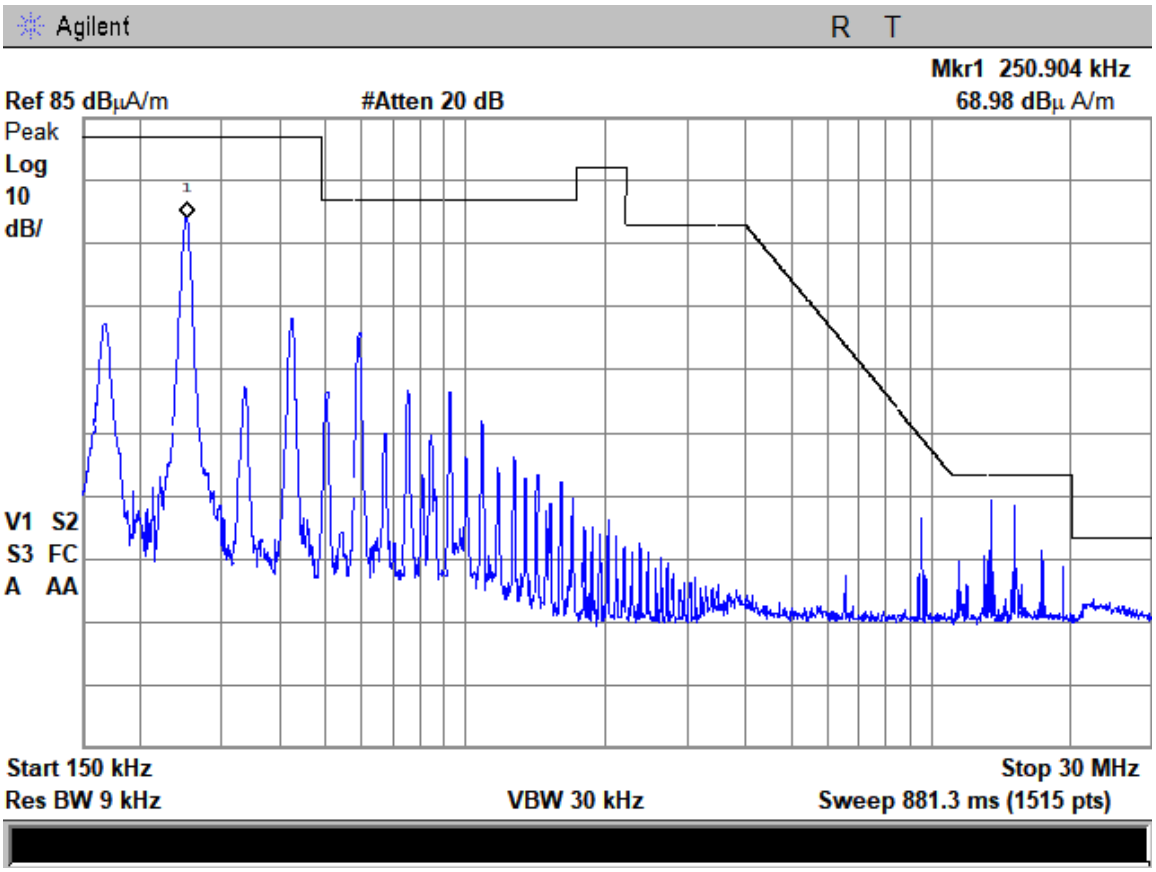
Plot 3-14 Radiated emission measurements in 150 kHz – 30 MHz range; right side, 3 m



Plot 3-15 Radiated emission measurements in 150 kHz – 30 MHz range; left, 3 m.



Plot 3-16 Radiated emission measurements in 150 kHz – 30 MHz range rear, 3 m.



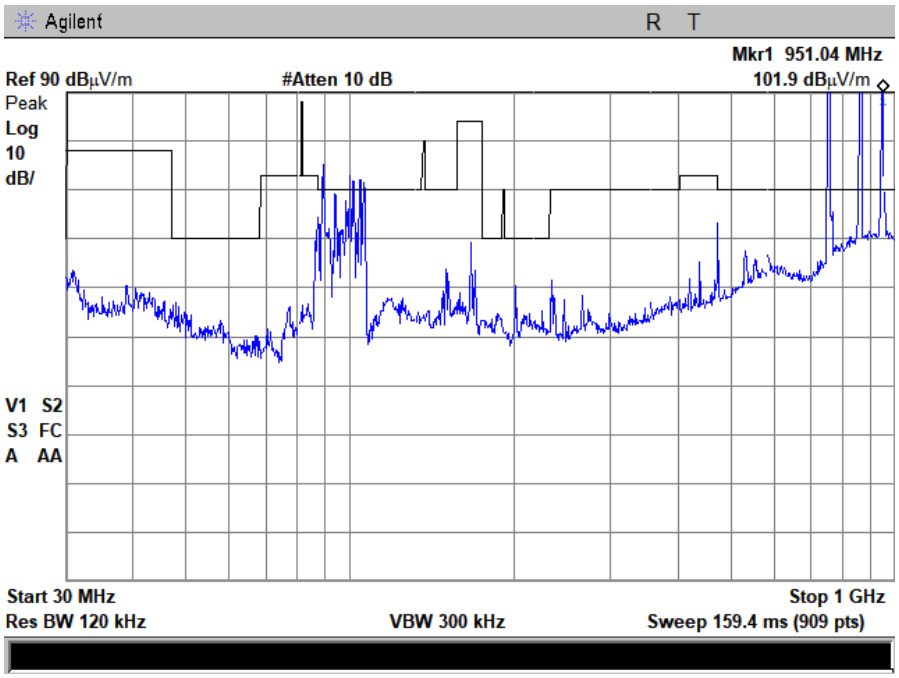
3.3 Range 30 – 1 000 MHz

Note: The following plots depict strong signals at 30 – 1 000 MHz, some of them above the limit!

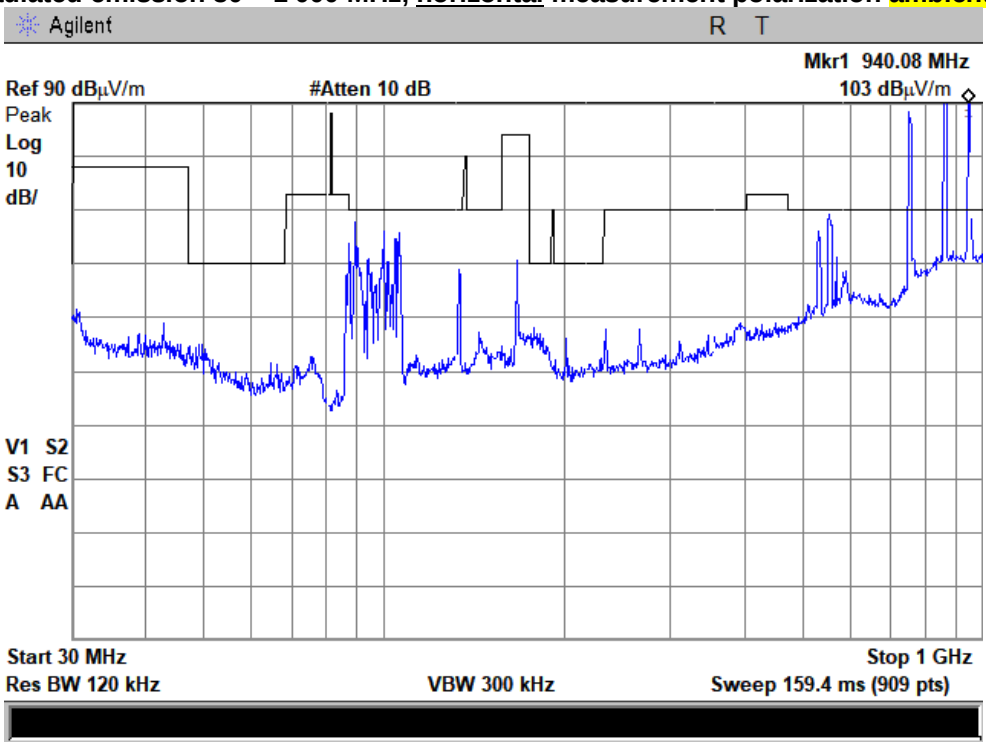
- Audio FM broadcasting (88–108 MHz) operating at **vertical** polarization;
- Video broadcasting operating at **horizontal** polarization: Band I 41–68 MHz, Band III 162–230 MHz, Band IV 470–582 MHz and Band V 582–960 MHz[1];
- **Cellular** (and trunking) **downlinks** and uplinks operating at **vertical/horizontal and +- 45^0** polarizations, 890–960 MHz.

3.3.1 Ambient noise- plots, 30 – 1 000 MHz

Plot 3-17 Radiated emission 30 – 1 000 MHz, vertical polarization ambient; front, 3 m. test distance

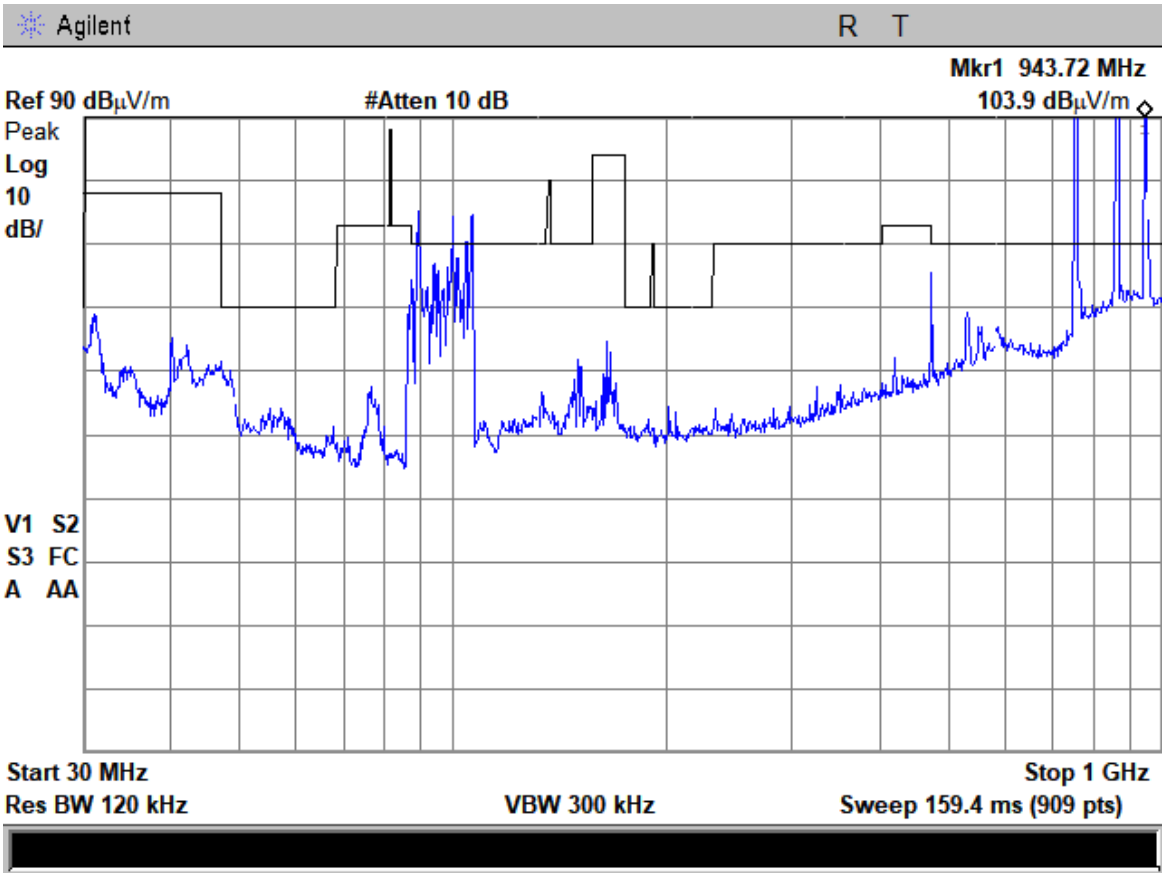


Plot 3-18 Radiated emission 30 – 1 000 MHz, horizontal measurement polarization ambient; front, 3 m.

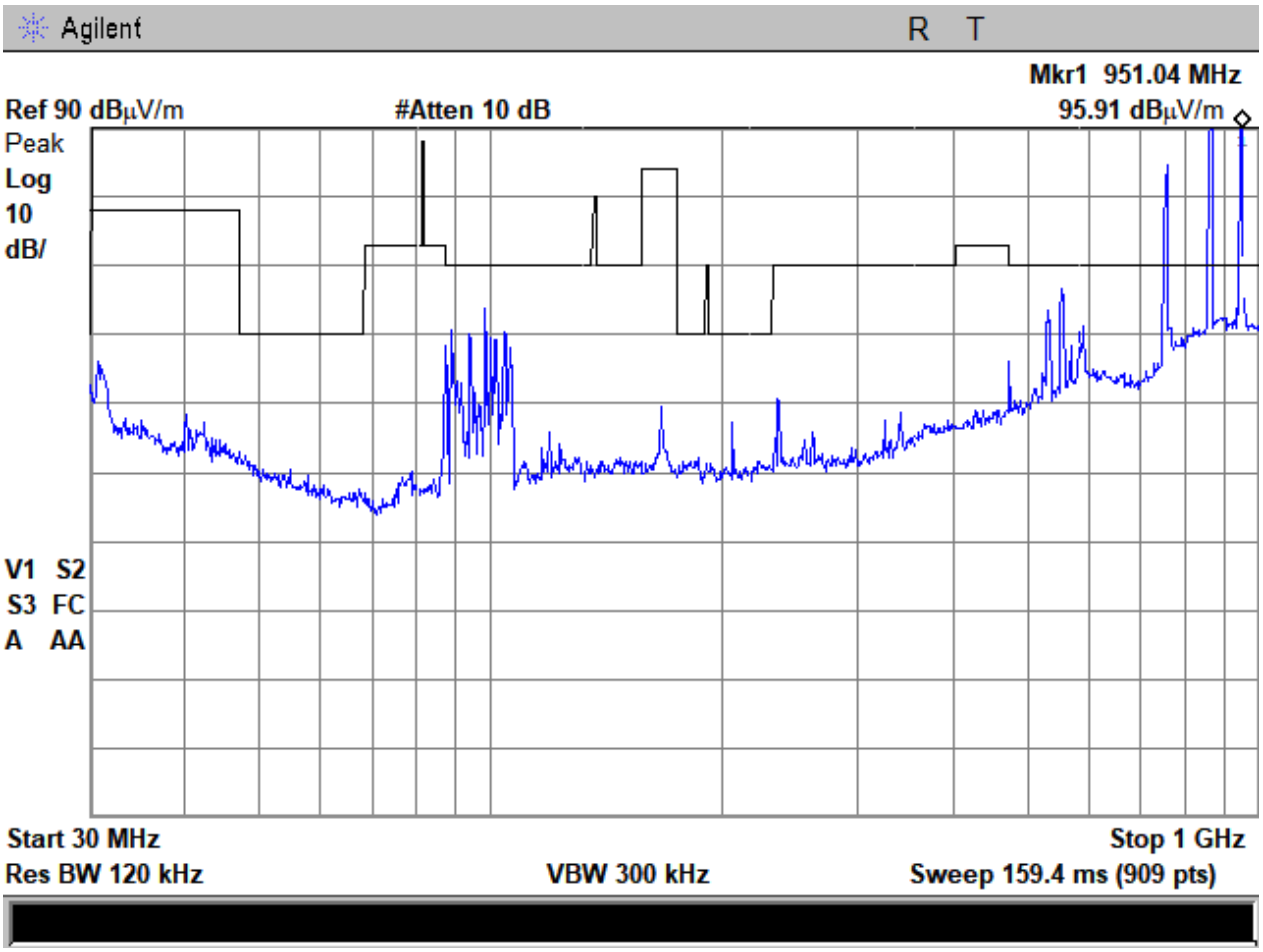


[1] The Middle East follows the designations of the 'European Broadcasting Area concerning the use of Frequencies by the Broadcasting Service in the VHF and UHF Bands (Stockholm 1961).

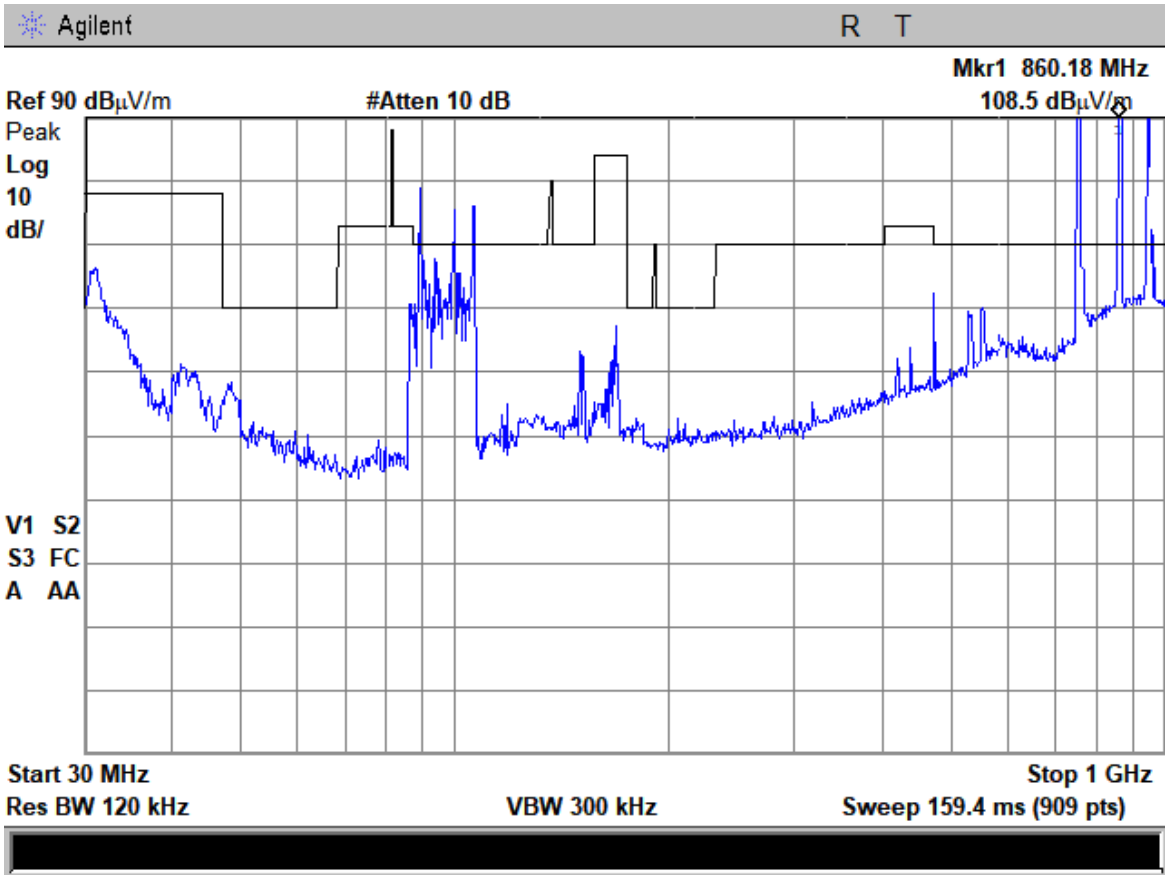
Plot 3-19 Measurements in 30–1 000 MHz range, vertical polarization ambient; right-side, 3 m.



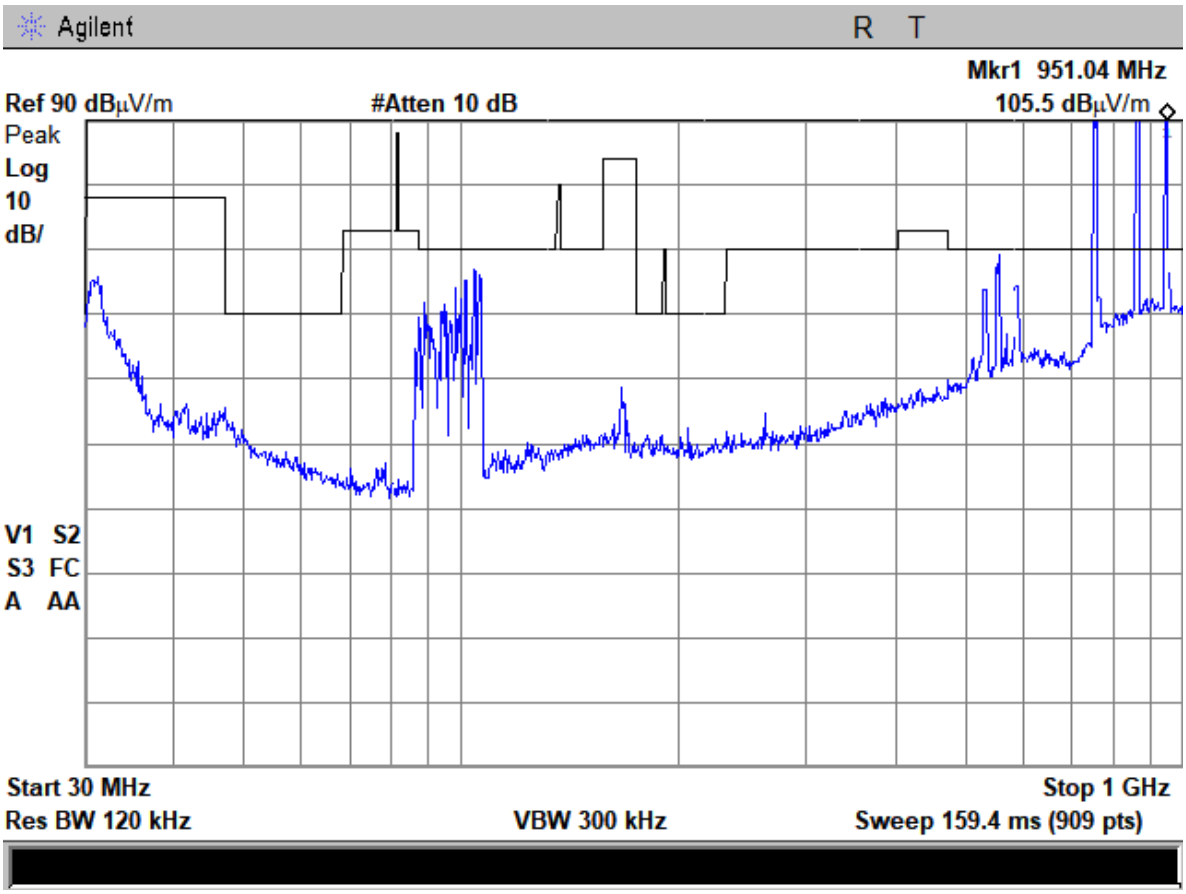
Plot 3-20 Radiated emission measurements, horizontal polarization ambient; right-side, 3 m.



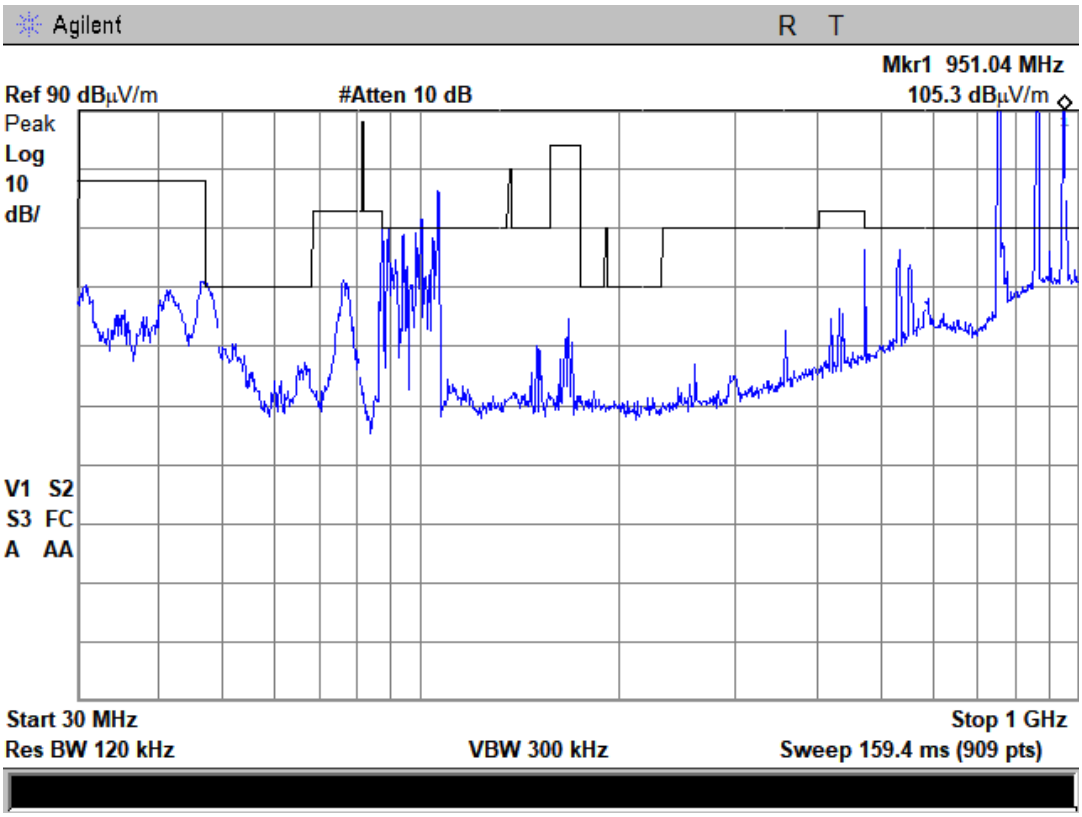
Plot 3-21 Measurements 30–1 000 MHz, vertical antenna polarization ambient; left-side, 3 m.



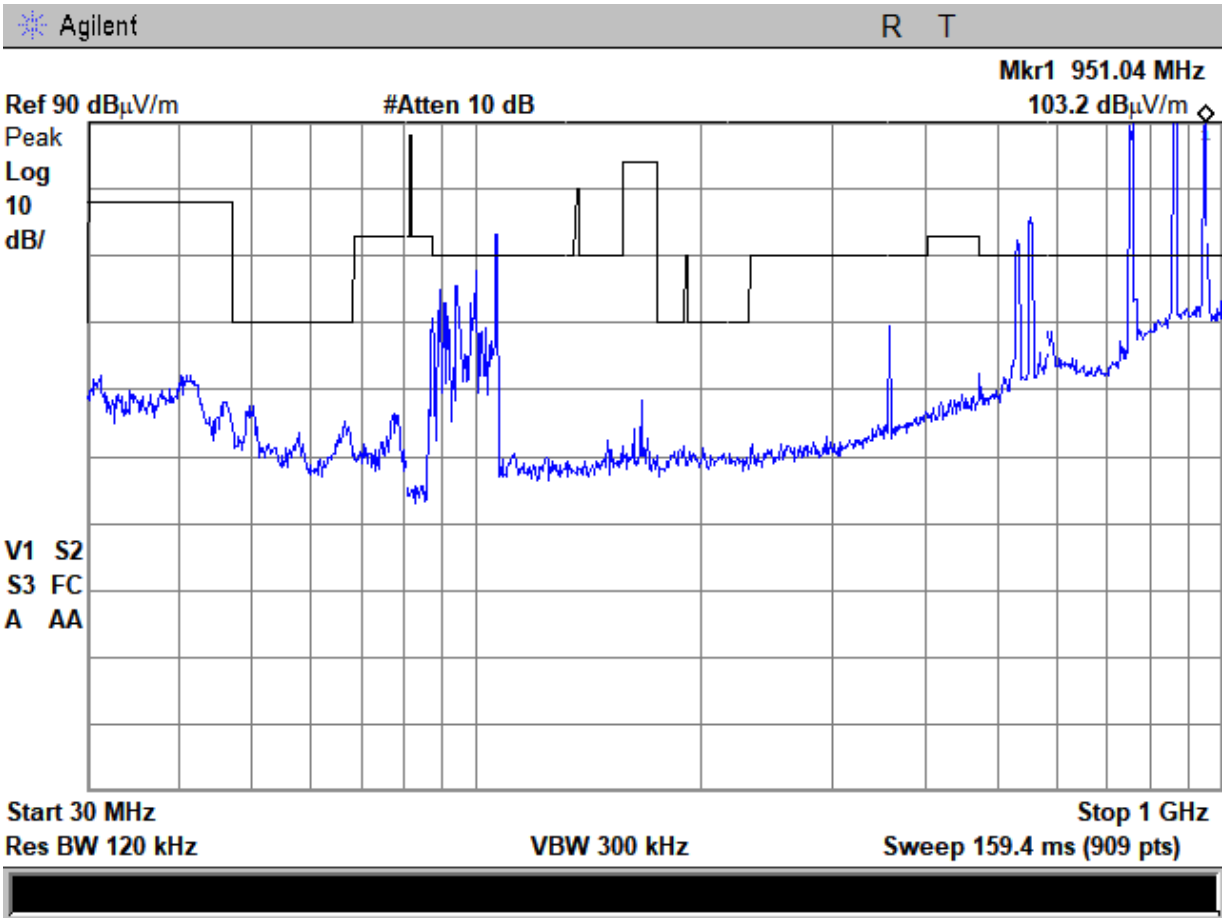
Plot 3-22 Measurements 30–1 000 MHz range, horizontal antenna polarization ambient; left-side, 3 m.



Plot 3-23 Measurements in 30–1 000 MHz, vertical antenna polarization, ambient; rear, 3 m.

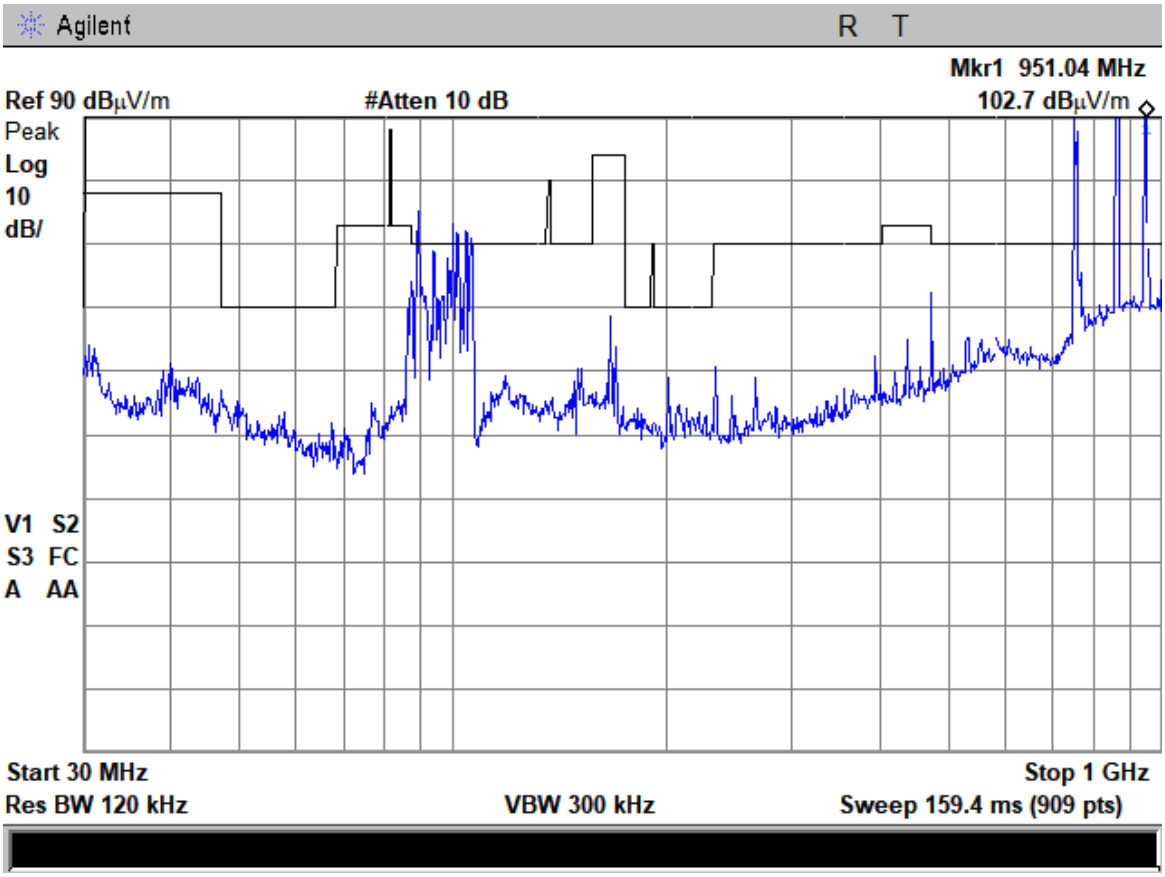


Plot 3-24 Measurements 30–1 000 MHz, horizontal antenna polarization, ambient; rear, 3 m.

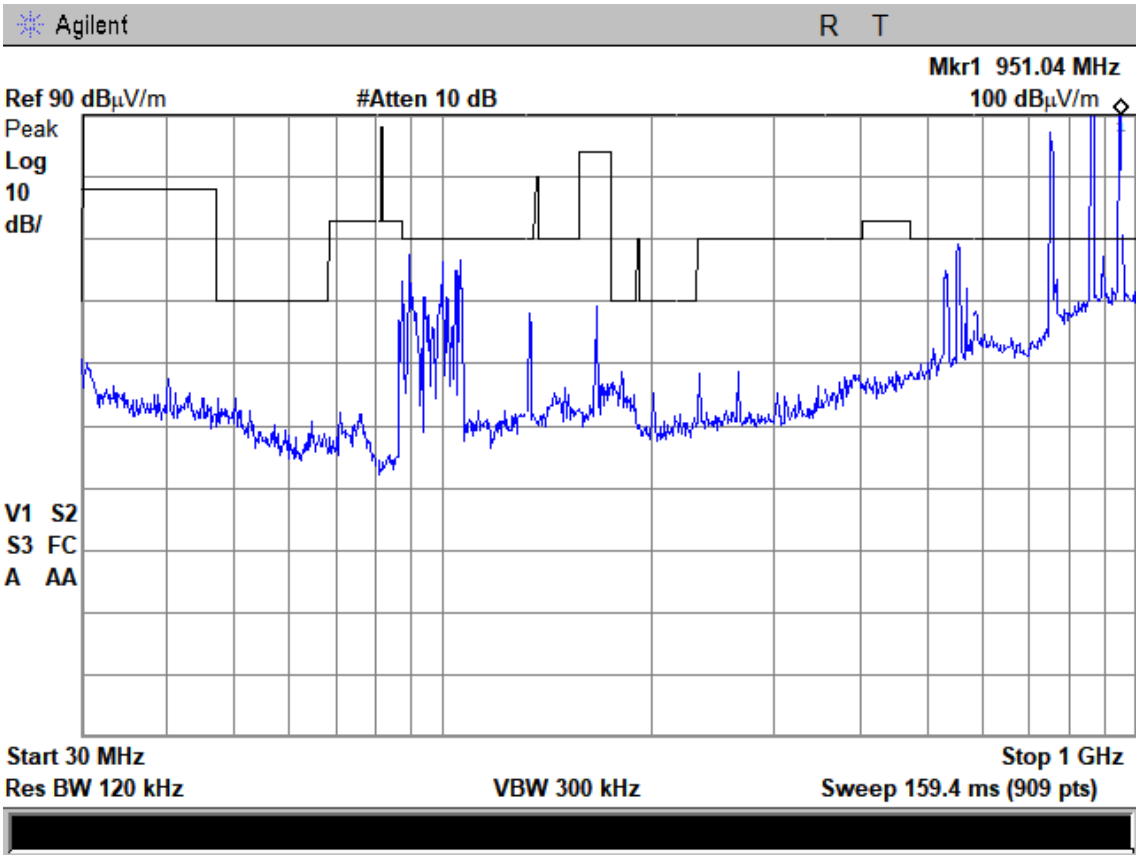


3.3.2 Plots unwanted emissions 30–1 000 MHz during charging

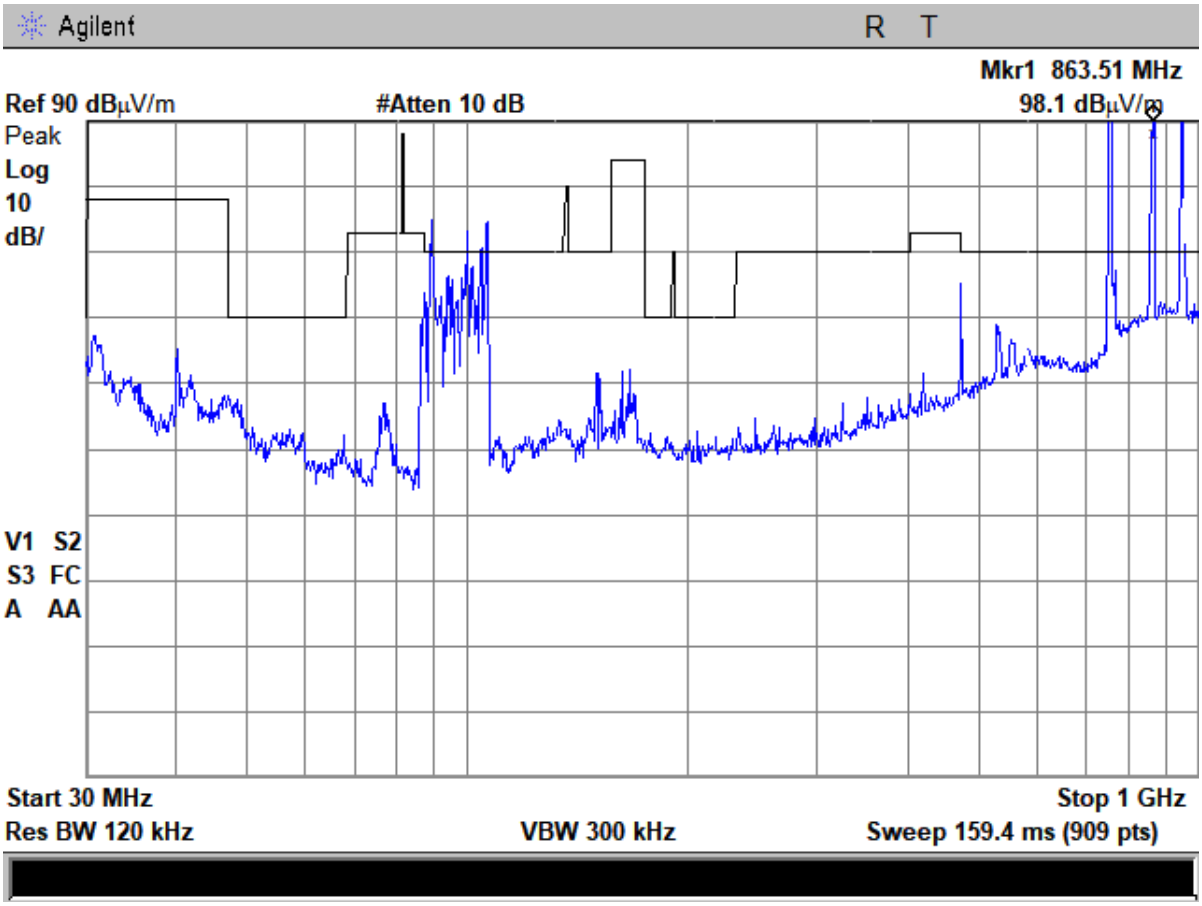
Plot 3-25 Measurements 30–1 000 MHz range, <u>vertical</u> polarization; front, 3 m.



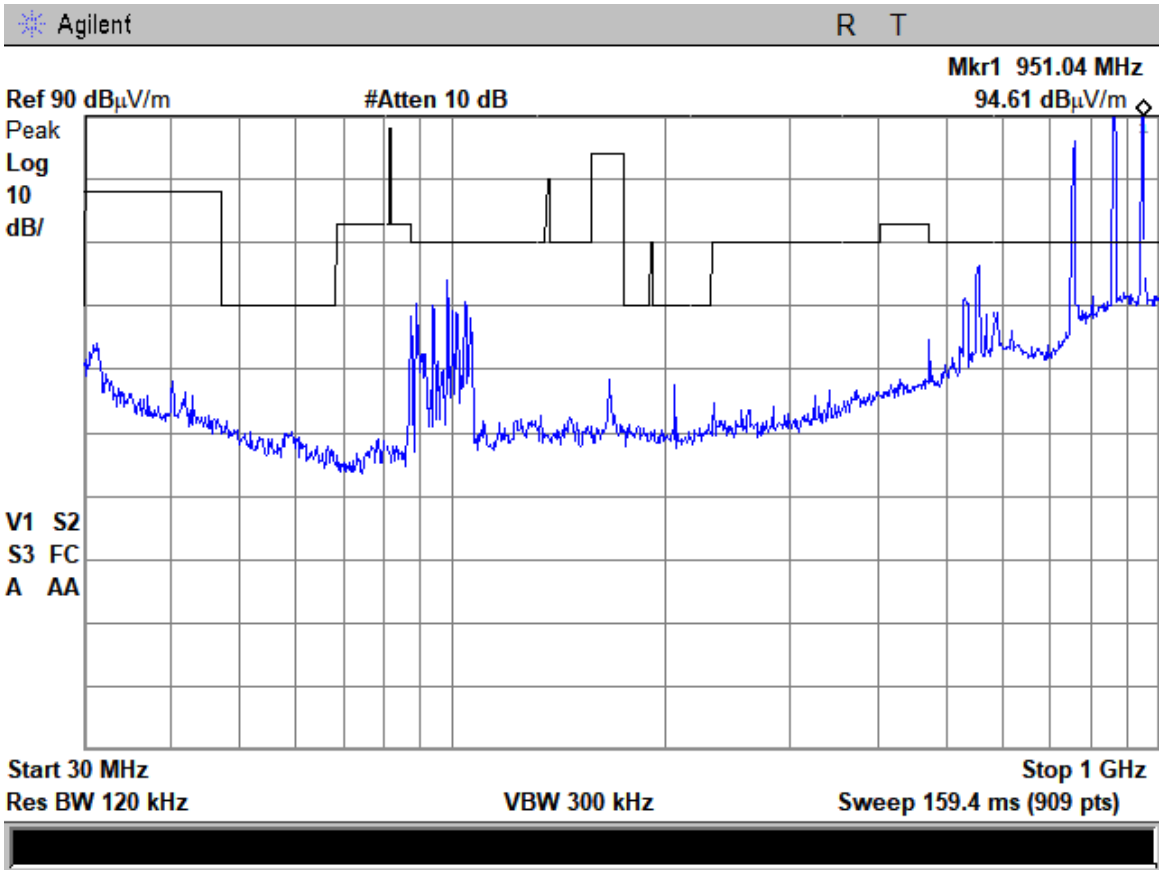
Plot 3-26 Radiated emission measurements in 30 – 1 000 MHz, <u>horizontal</u> antenna polarization; front, 3 m.



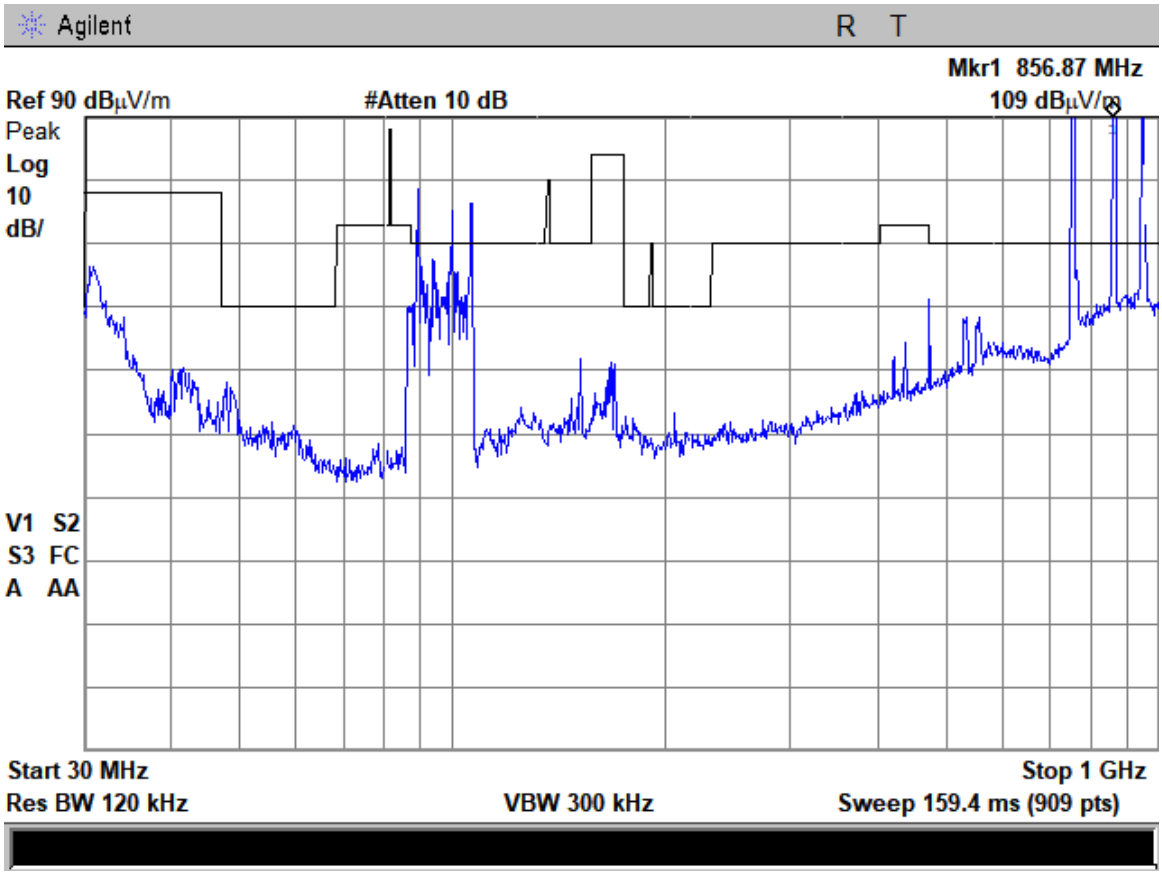
Plot 3-27 Measurements in 30–1 000 MHz, <u>vertical</u> polarization; right, 3 m.



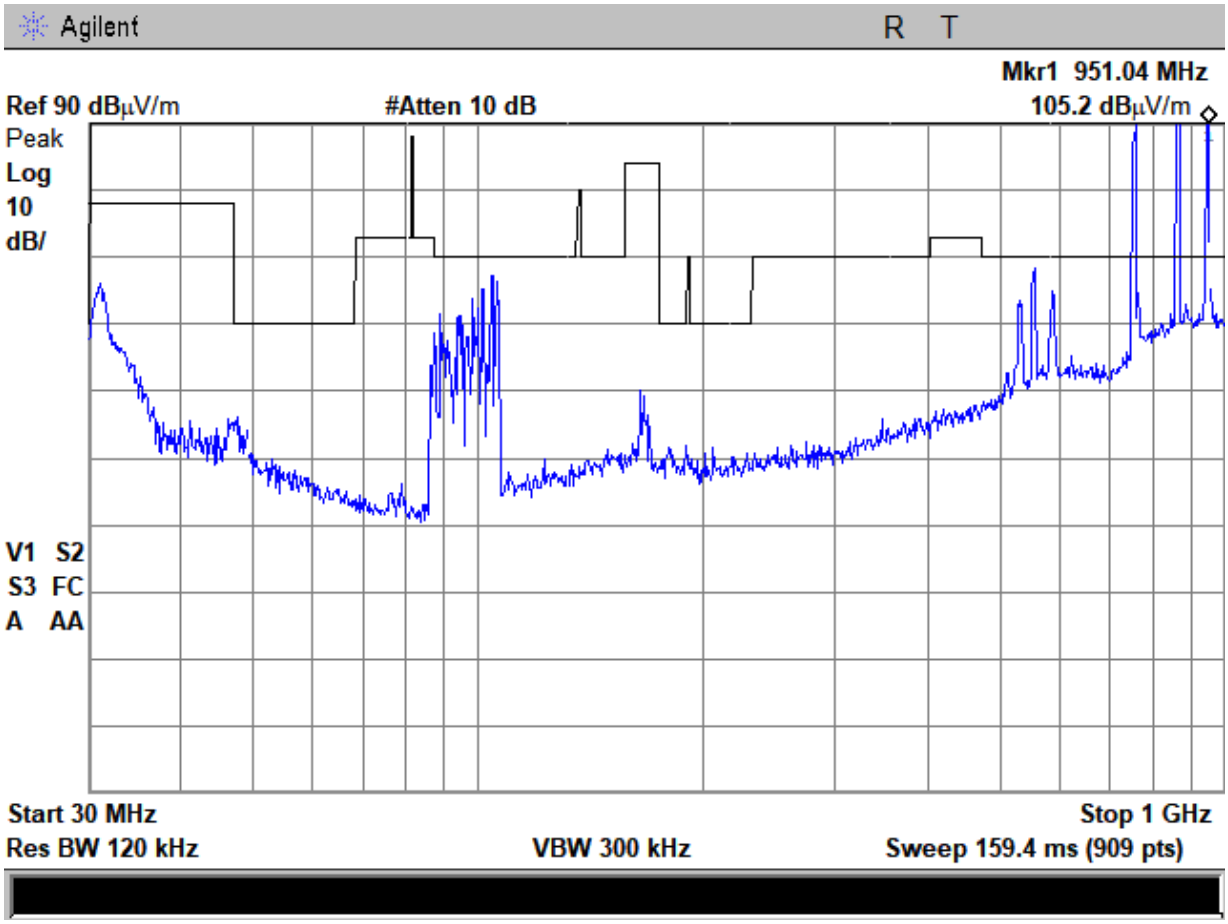
Plot 3-28 Radiated emission measurements in 30 – 1 000 MHz range, <u>horizontal</u> polarization; right, 3 m.



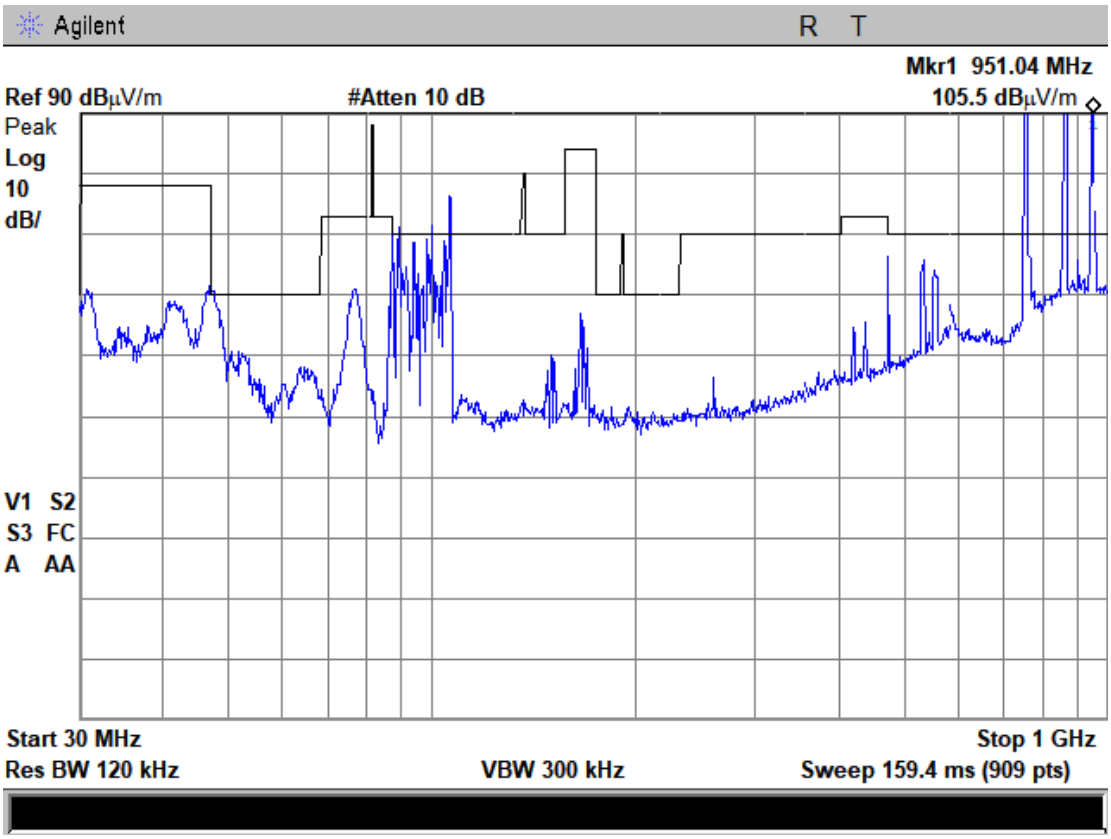
Plot 3-29 Radiated emission measurements in 30–1 000 MHz, vertical polarization; left, 3 m.



Plot 3-30 Measurements in 30–1 000 MHz range, horizontal polarization; left, 3 m.



Plot 3-31 Measurements in 30–1 000 MHz, vertical polarization; rear, 3 m.



Plot 3-32 Radiated emission measurements in 30 – 1 000 MHz range, horizontal polarization; rear, 3 m.