Test data, continued

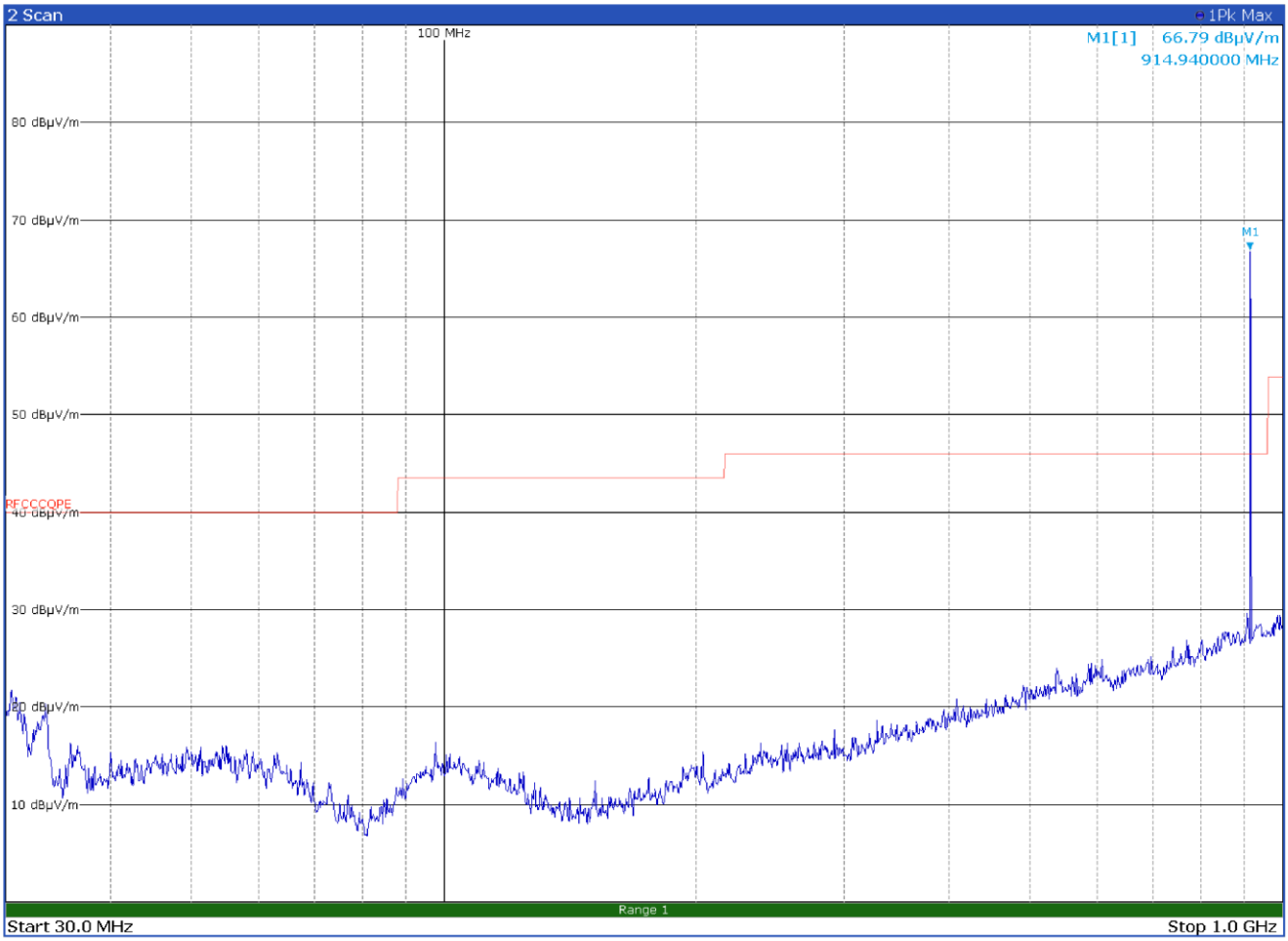


Figure 8.9-10: *Radiated spurious emissions on high channel - LoRa 125 kHz BW – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

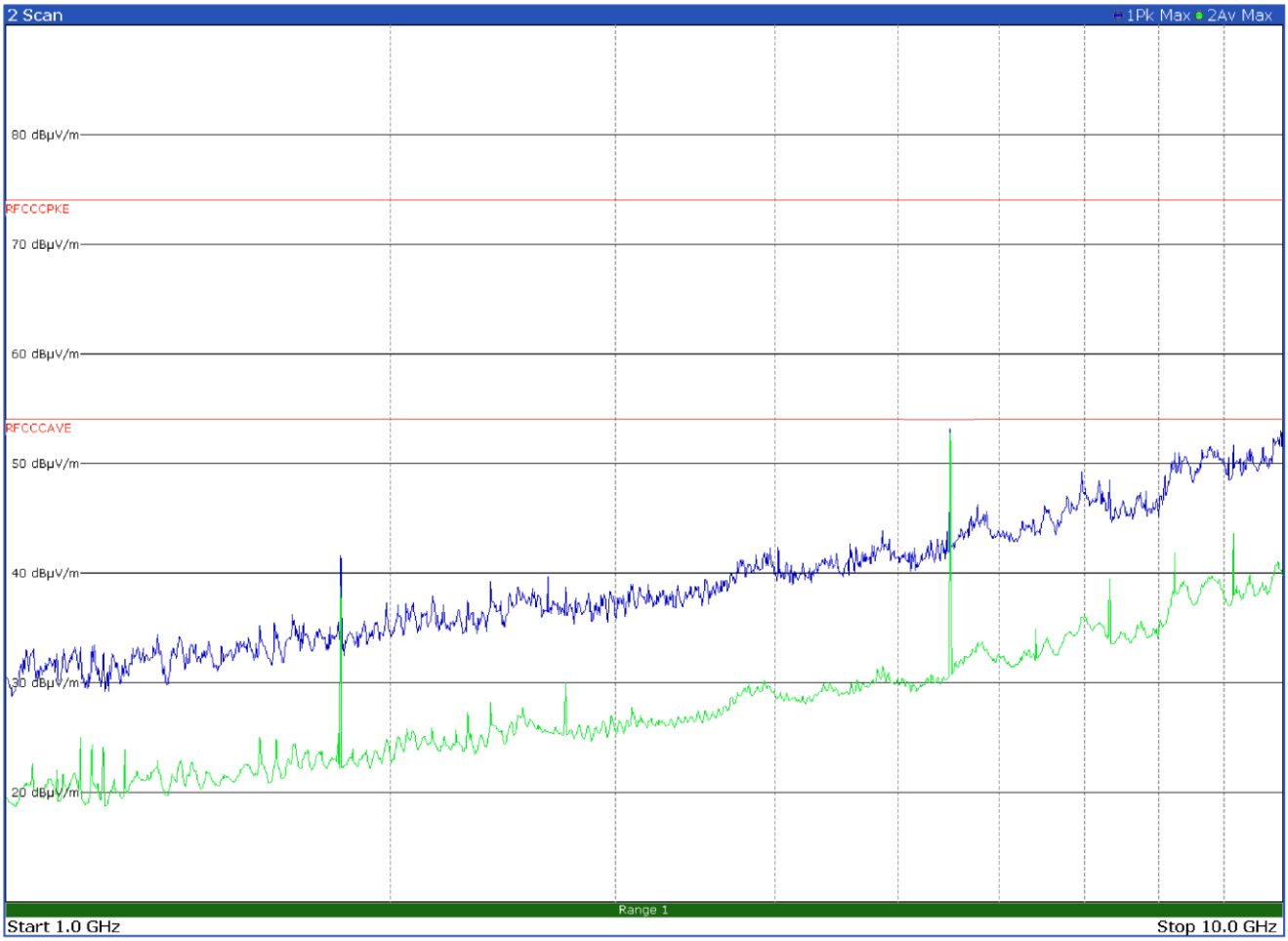


Figure 8.9-11: *Radiated spurious emissions on high channel - LoRa 125 kHz BW – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
1829.7500	41.9	96.0	-54.1	Av
5489.5000	53.8	96.0	-42.2	Av
7319.5000	49.5	54.0	-4.5	Av
9149.5000	51.6	54.0	-2.4	Av

Test data, continued

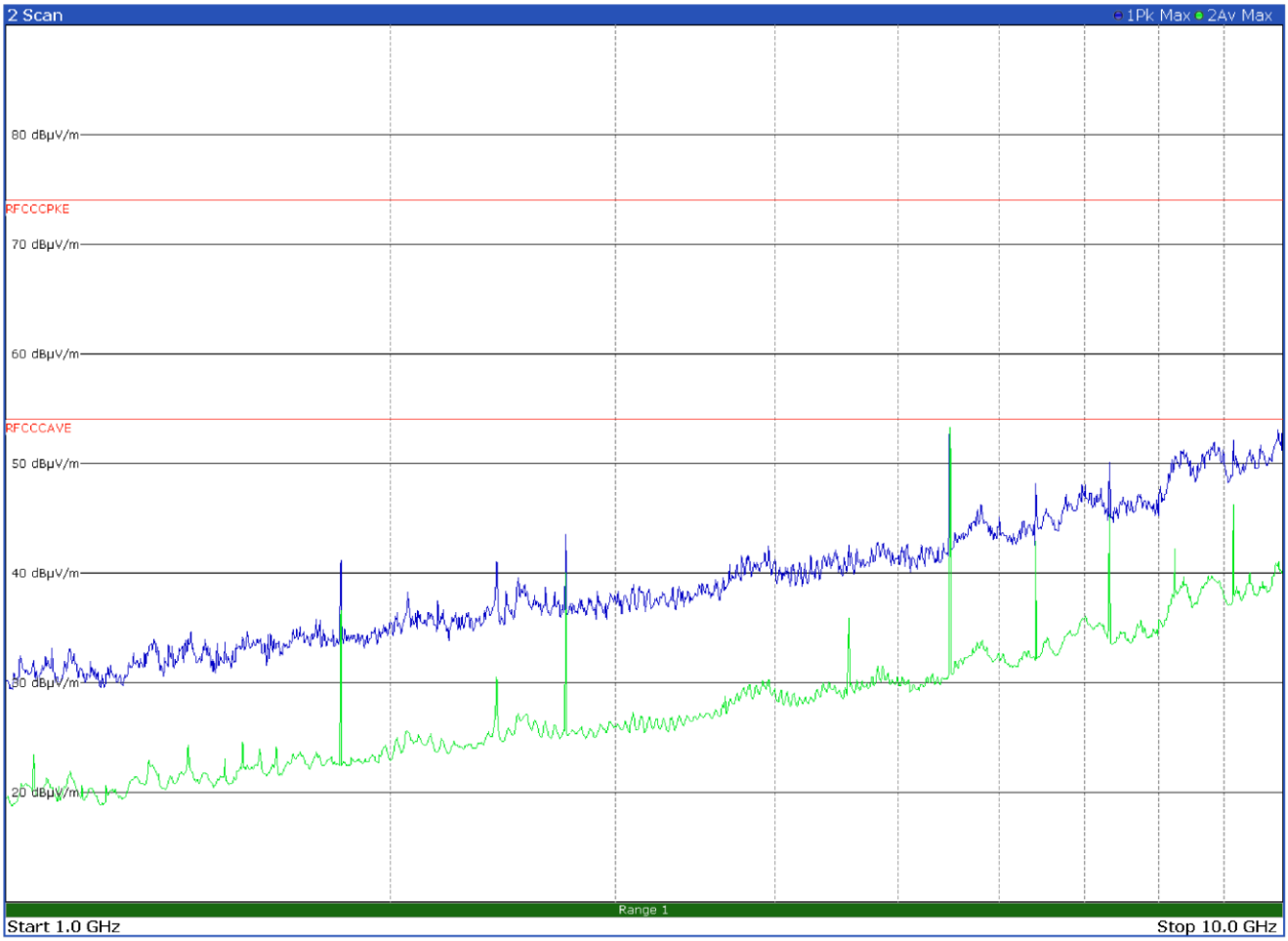


Figure 8.9-12: *Radiated spurious emissions on high channel - LoRa 125 kHz BW – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
1830.0000	40.6	96.0	-55.4	Av
2744.5000	42.0	96.0	-54.0	Av
4574.2500	40.9	54.0	-13.1	Av
5489.2500	53.8	96.0	-42.2	Av
6404.2500	46.0	96.0	-50.0	Av
7319.0000	50.4	54.0	-3.6	Av
8234.2500	51.2	54.0	-2.8	Av
9149.5000	51.3	54.0	-2.7	Av

Test data, continued

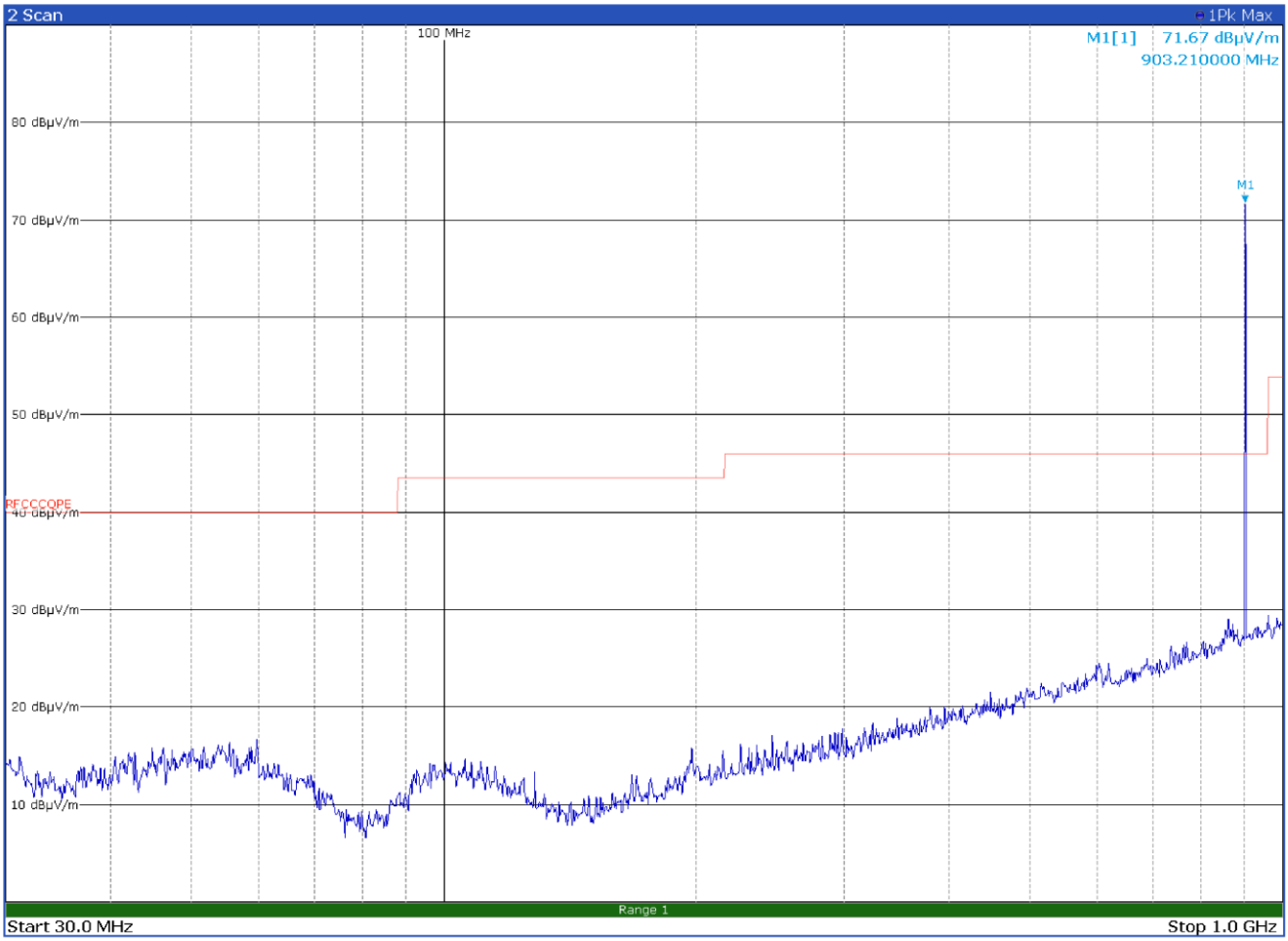


Figure 8.9-13: *Radiated spurious emissions on low channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

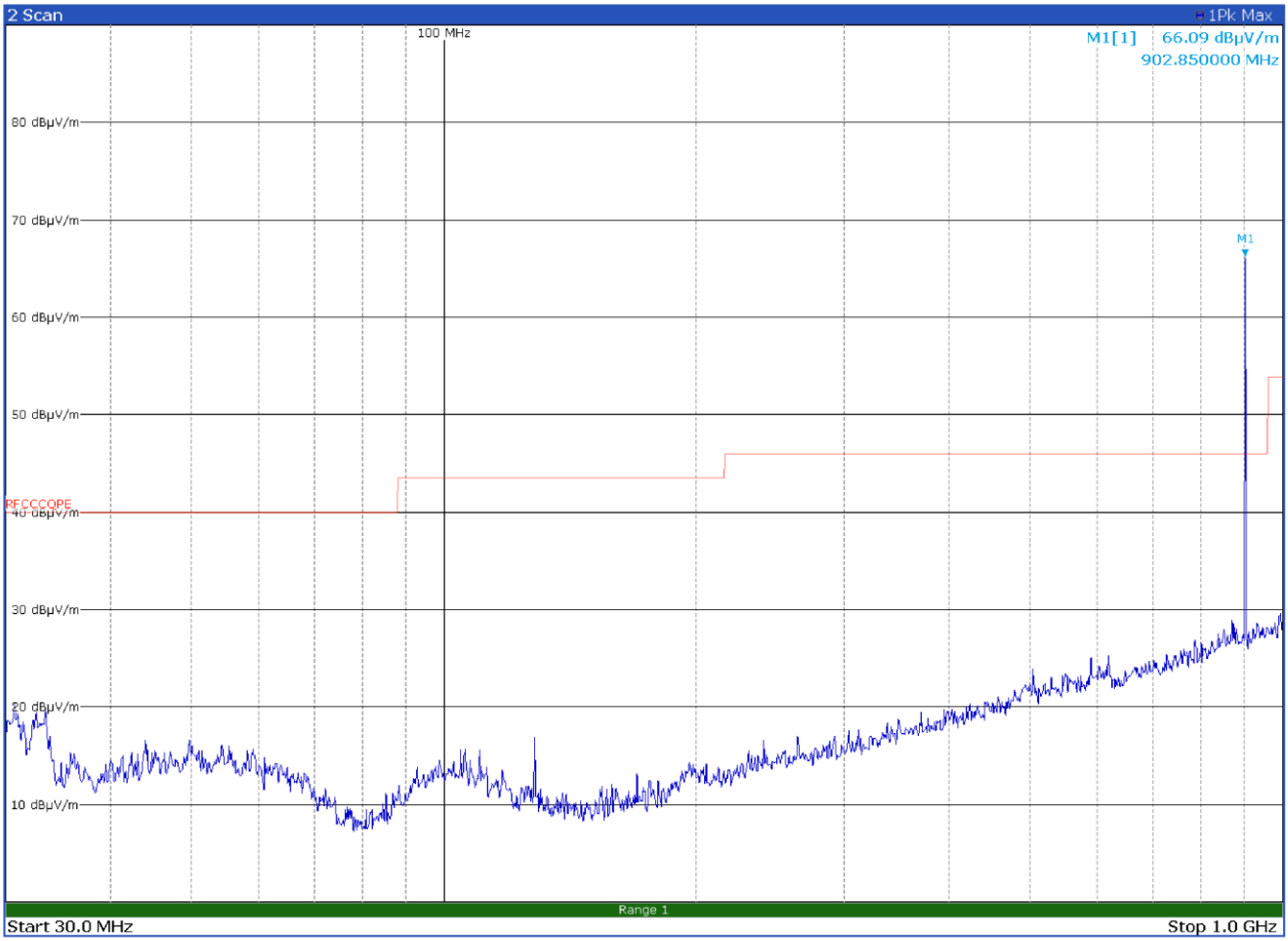


Figure 8.9-14: *Radiated spurious emissions on low channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

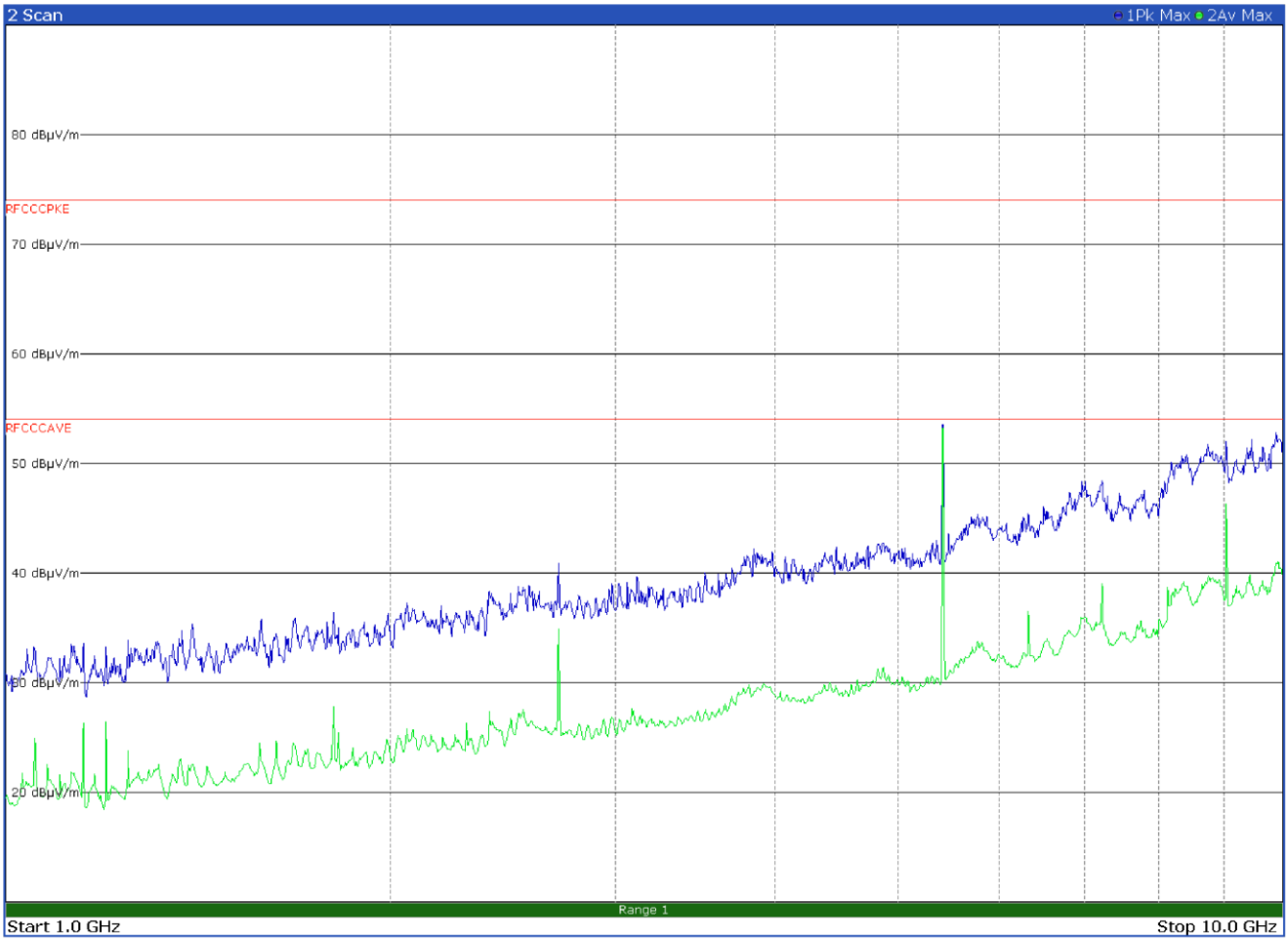


Figure 8.9-15: *Radiated spurious emissions on low channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
2708.5000	40.0	54.0	-14.0	Av
5417.7500	53.7	54.0	-0.3	Av
7224.0000	49.0	86.0	-37.0	Av
9031.0000	51.4	54.0	-2.6	Av

Test data, continued

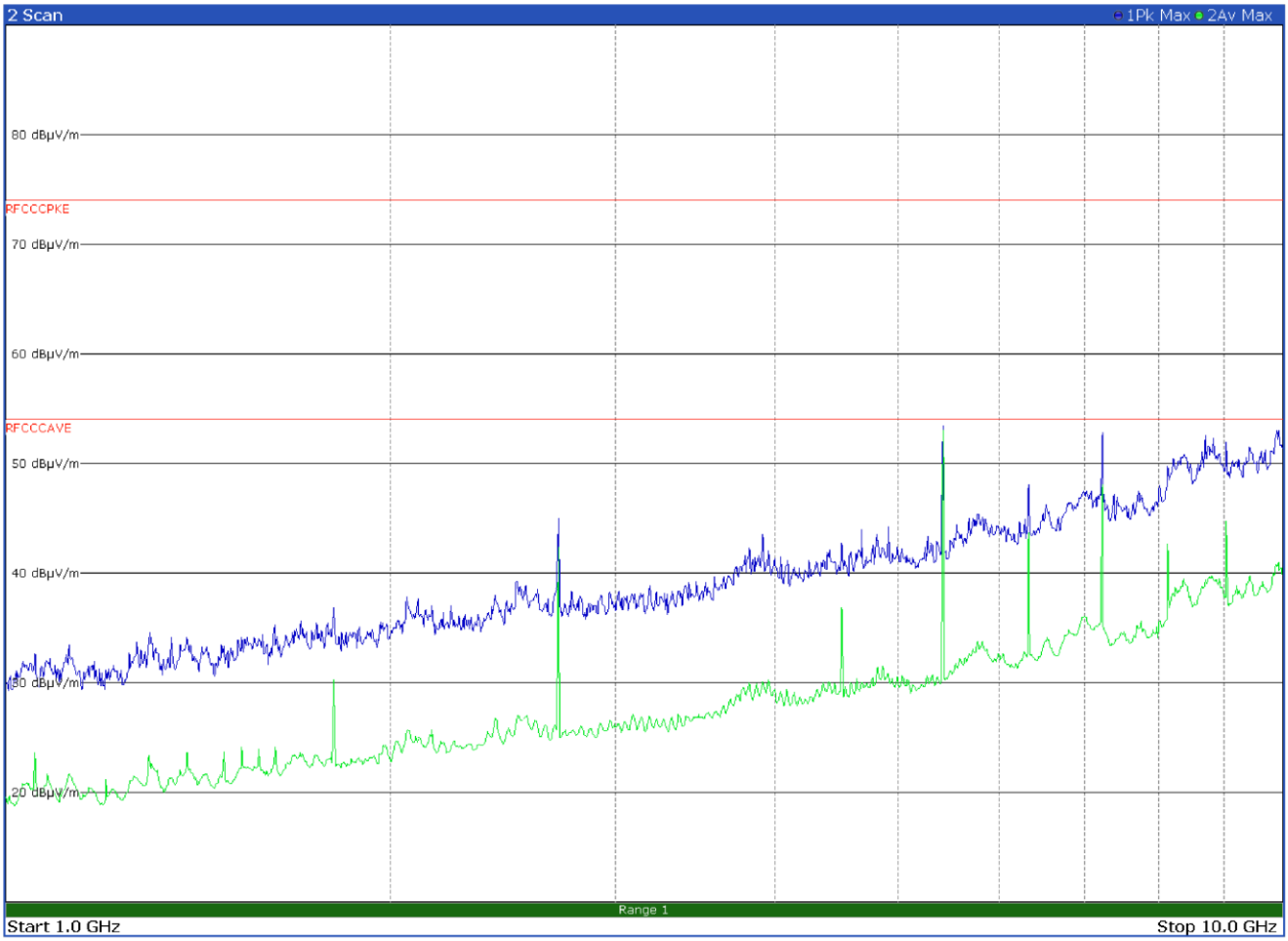


Figure 8.9-16: *Radiated spurious emissions on low channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
2708.5000	44.4	54.0	-9.6	Av
4515.7500	41.9	54.0	-12.1	Av
5418.7500	53.7	54.0	-0.3	Av
6322.2500	47.7	86.0	-38.3	Av
7225.0000	53.6	86.0	-32.4	Av
8127.0000	50.6	54.0	-3.4	Av
9030.5000	51.8	54.0	-2.2	Av

Test data, continued

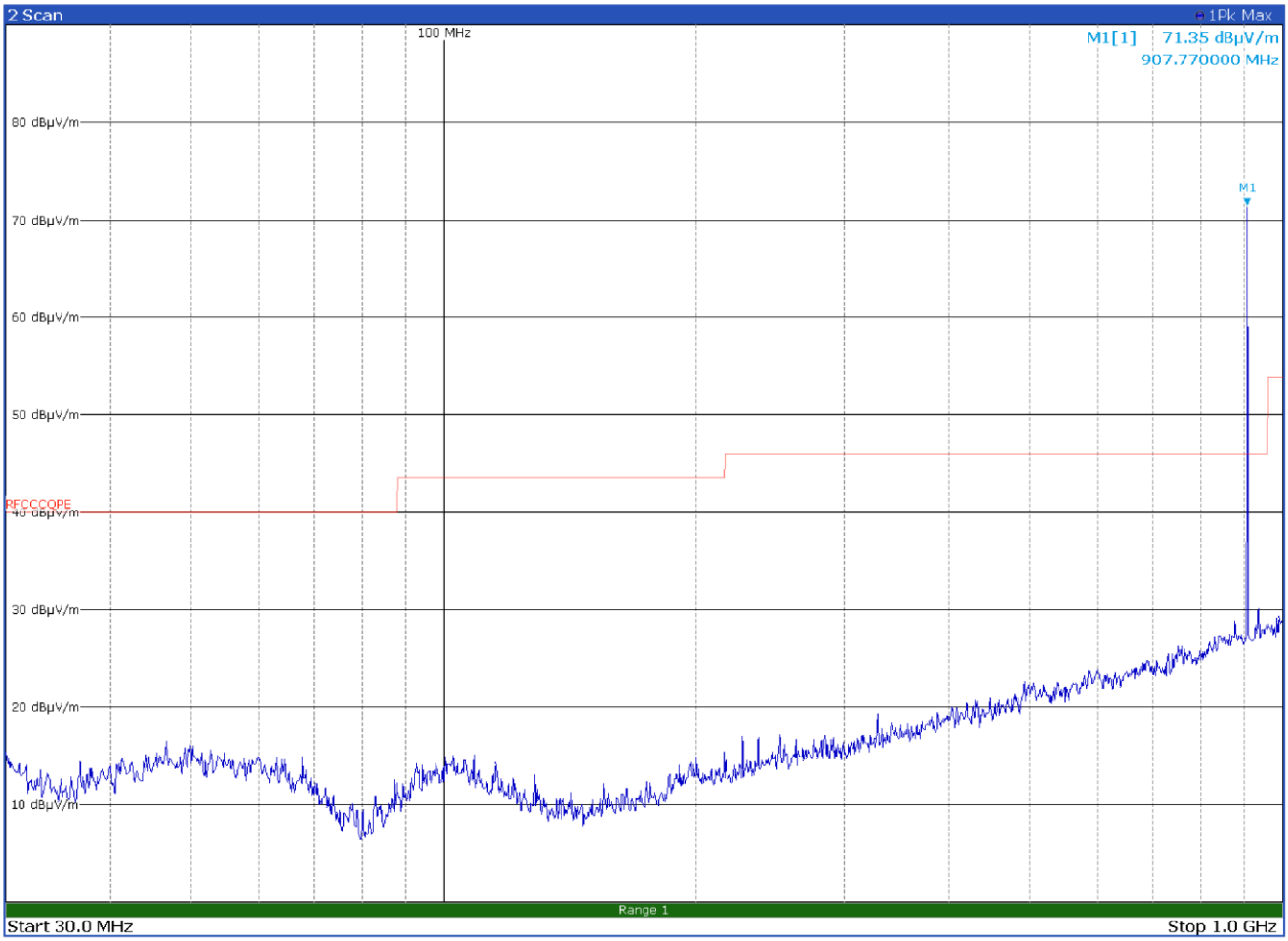


Figure 8.9-17: *Radiated spurious emissions on mid channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

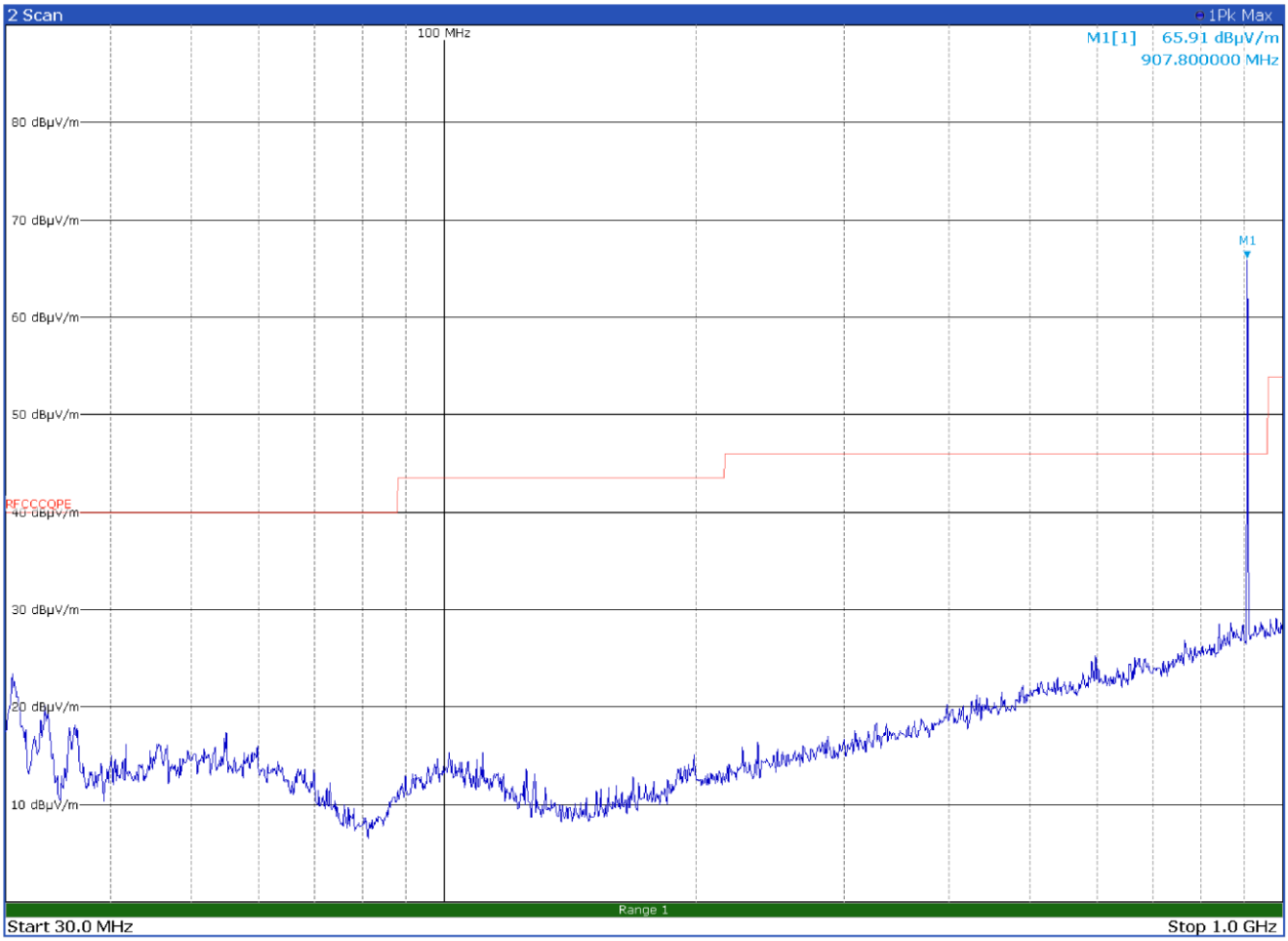


Figure 8.9-18: *Radiated spurious emissions on mid channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

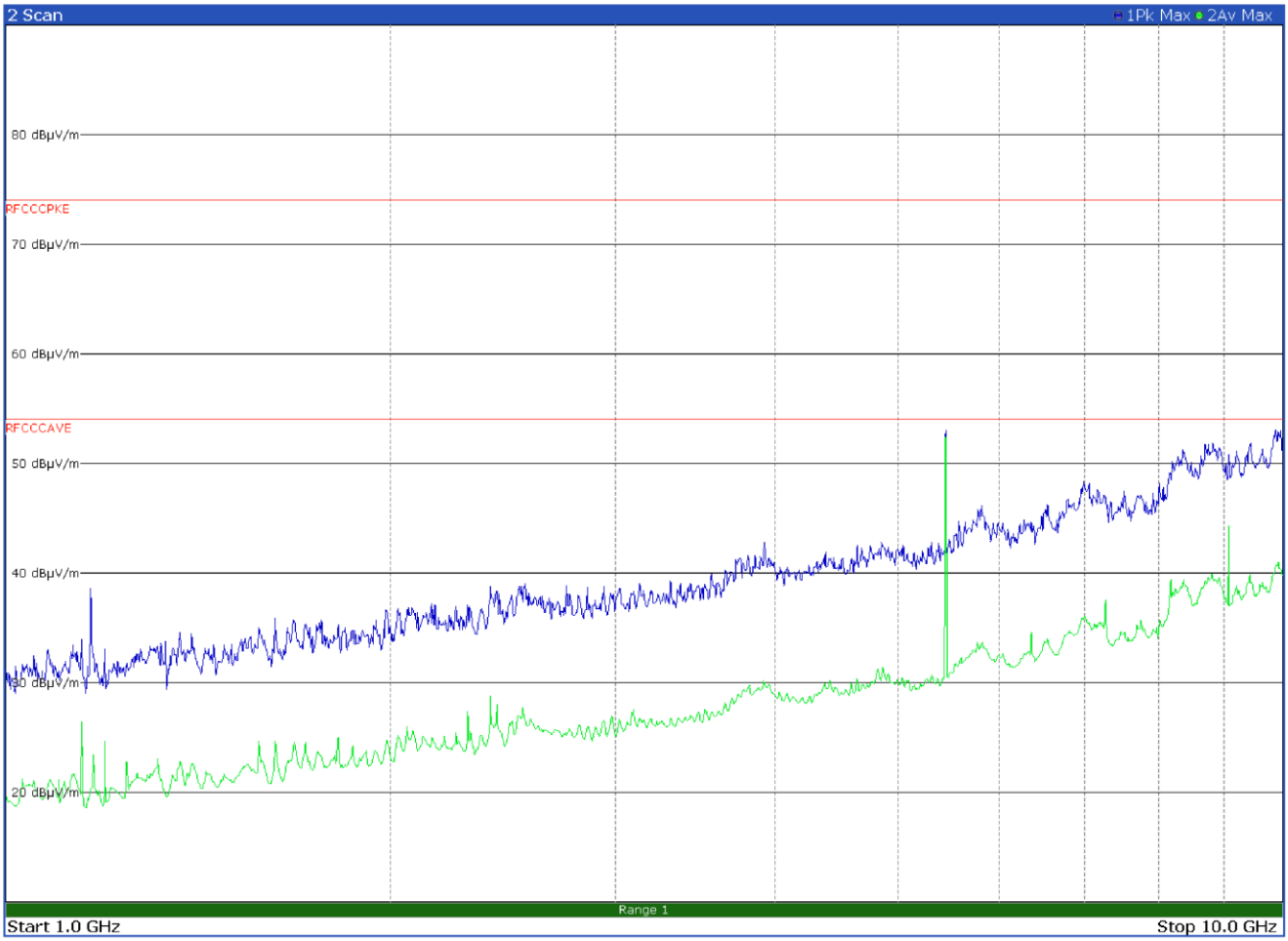


Figure 8.9-19: *Radiated spurious emissions on mid channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
5446.0000	53.6	54.0	-0.4	Av
9078.0000	50.5	54.0	-3.5	Av

Test data, continued

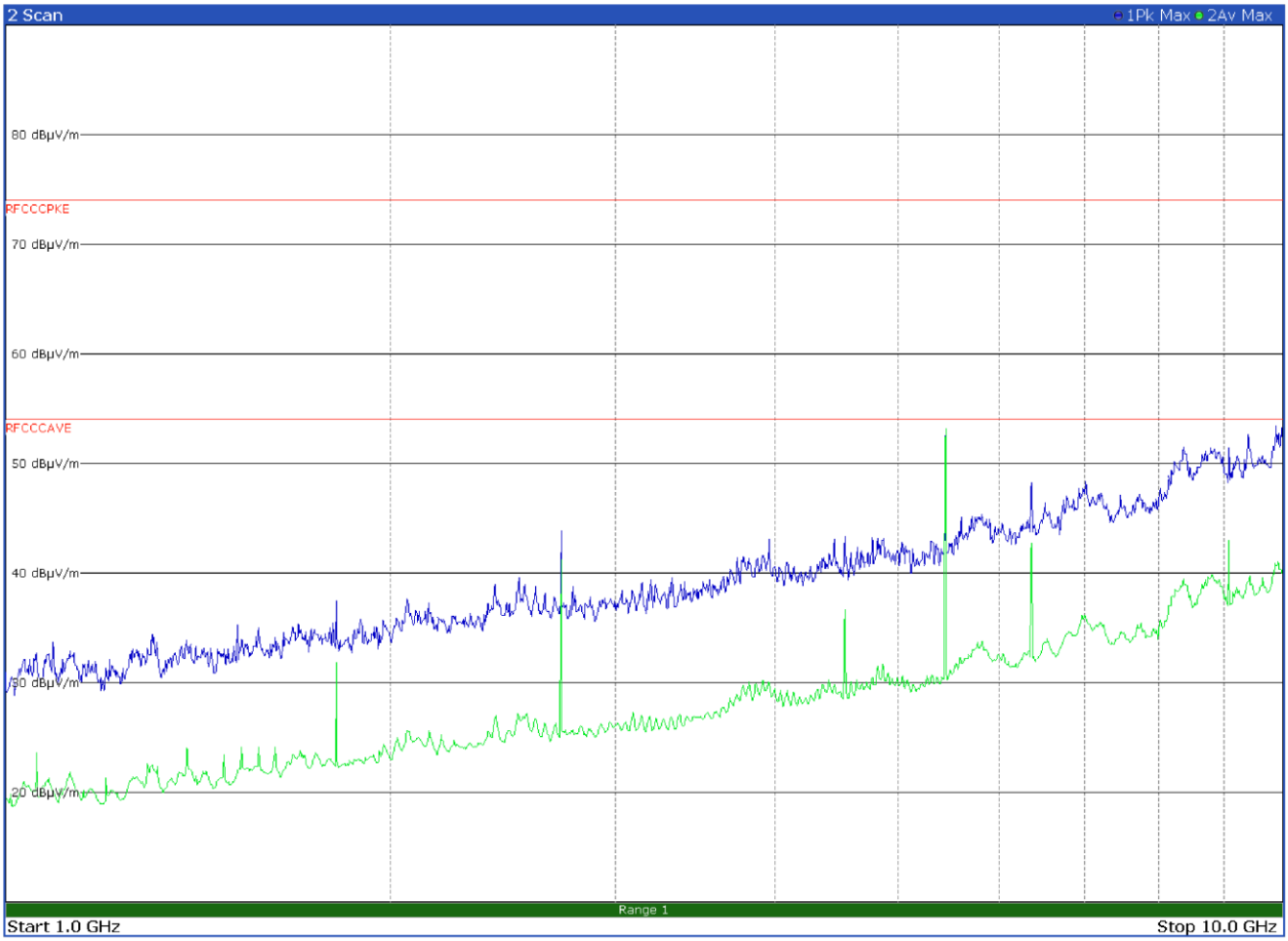


Figure 8.9-20: *Radiated spurious emissions on mid channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
2723.7500	42.2	54.0	-11.8	Av
4539.7500	41.7	54.0	-12.3	Av
5448.0000	53.6	86.0	-32.4	Av
6355.2500	47.8	86.0	-38.2	Av
9078.2500	50.7	54.0	-3.3	Av
9080.2500	43.0	54.0	-11.0	Av

Test data, continued

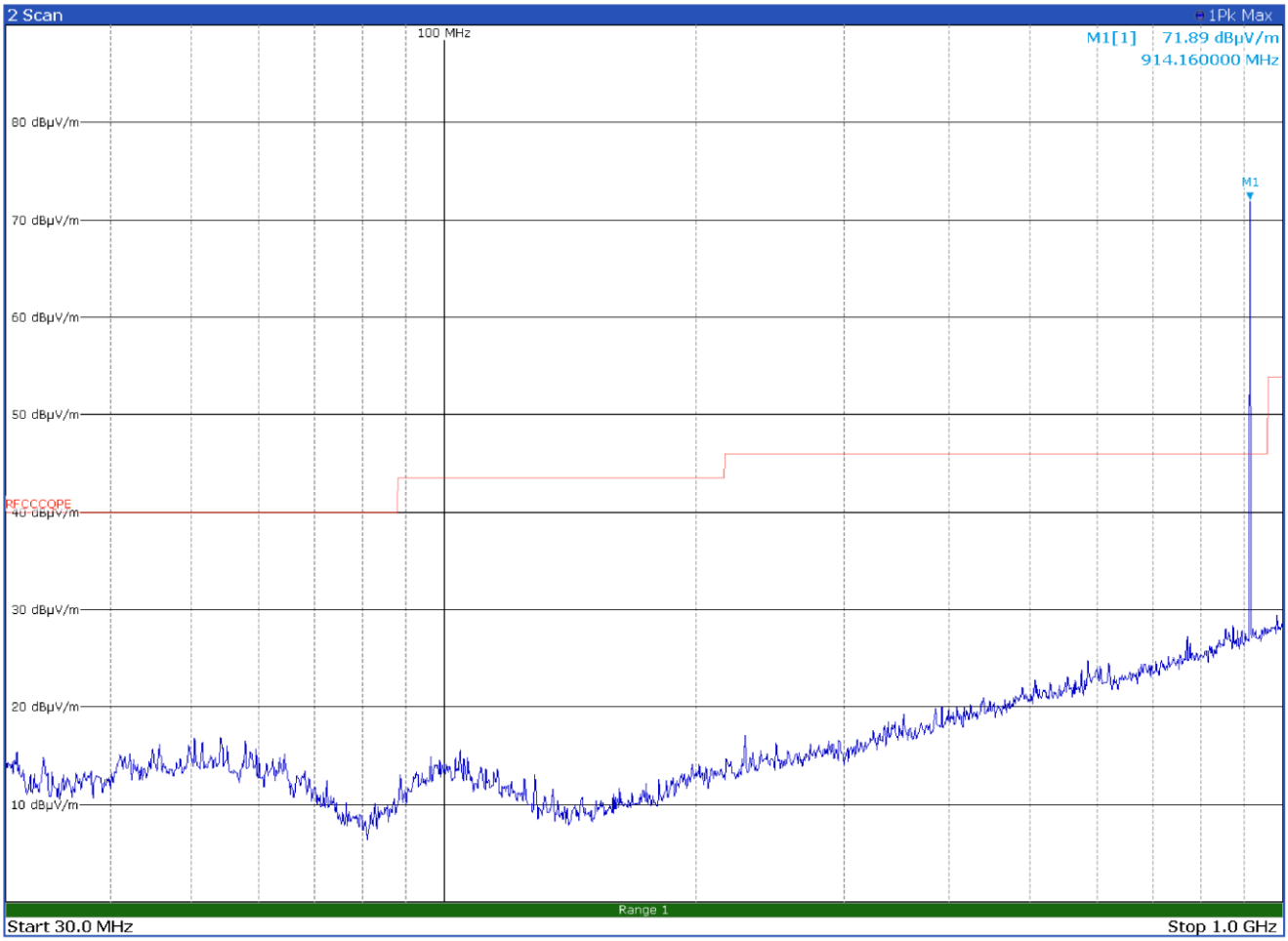


Figure 8.9-21: *Radiated spurious emissions on high channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

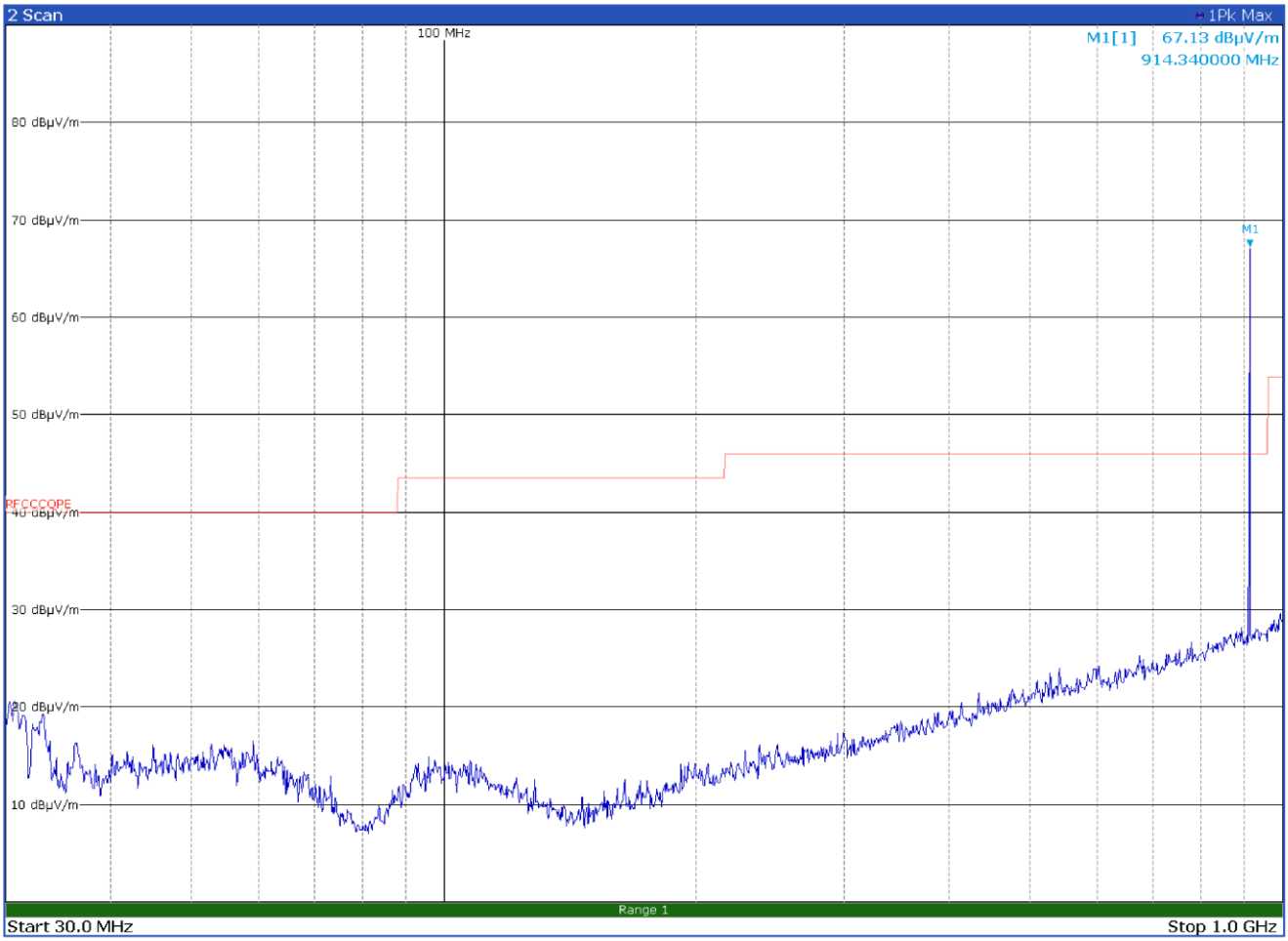


Figure 8.9-22: *Radiated spurious emissions on high channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

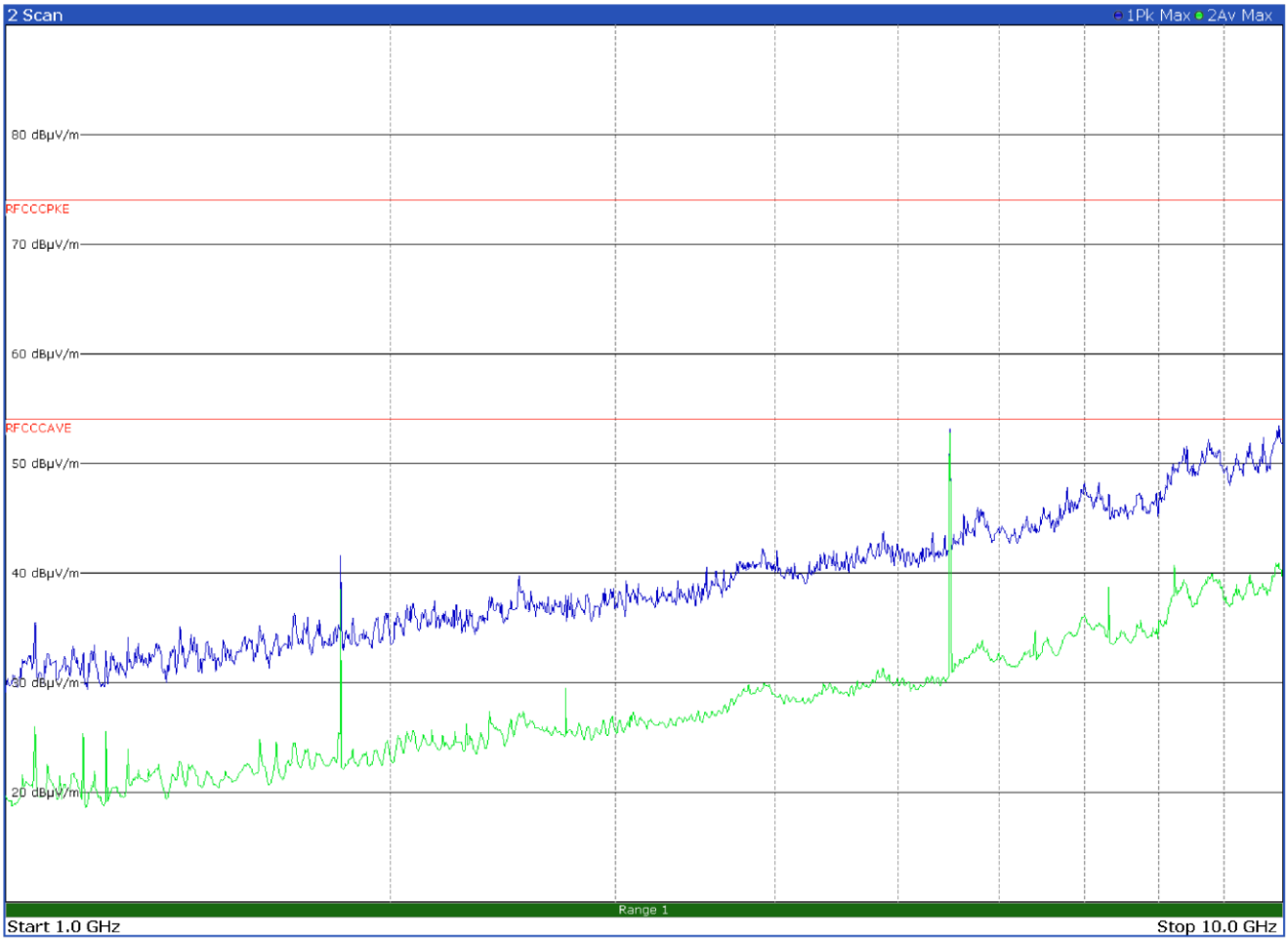


Figure 8.9-23: *Radiated spurious emissions on high channel - LoRa 500 kHz BW – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
1828.2500	41.5	86.0	-44.5	Av
5484.7500	53.6	86.0	-32.4	Av
9924.5000	40.9	86.0	-45.1	Av

Test data, continued

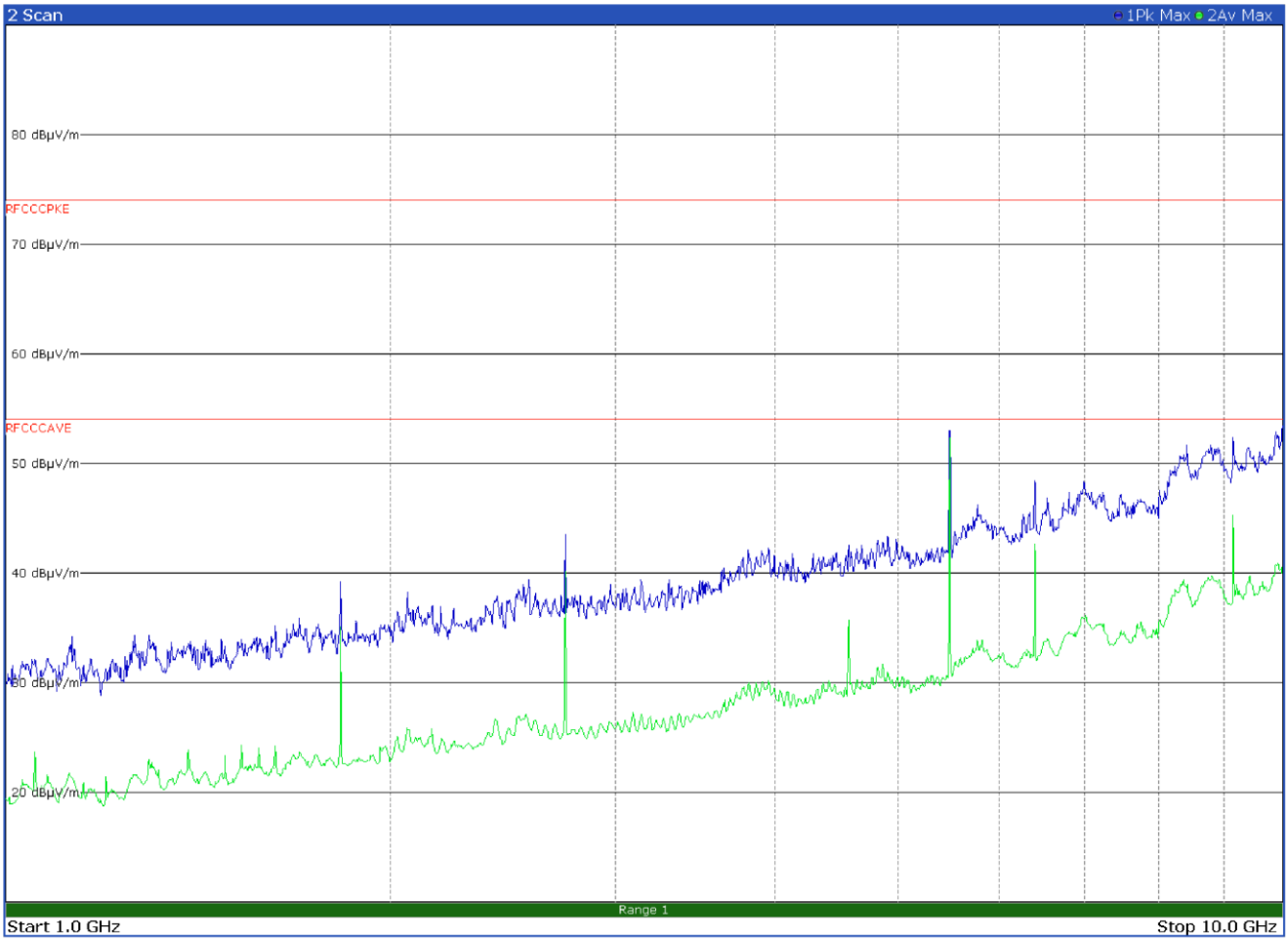


Figure 8.9-24: *Radiated spurious emissions on high channel - LoRa 500 kHz BW – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
1828.2500	48.2	86.0	-37.8	Av
2743.0000	42.2	54.0	-11.8	Av
4572.0000	41.7	54.0	-12.3	Av
5483.7500	53.7	86.0	-32.3	Av
6398.2500	47.7	86.0	-38.3	Av
9142.7500	52.8	54.0	-1.2	Av

Test data, continued

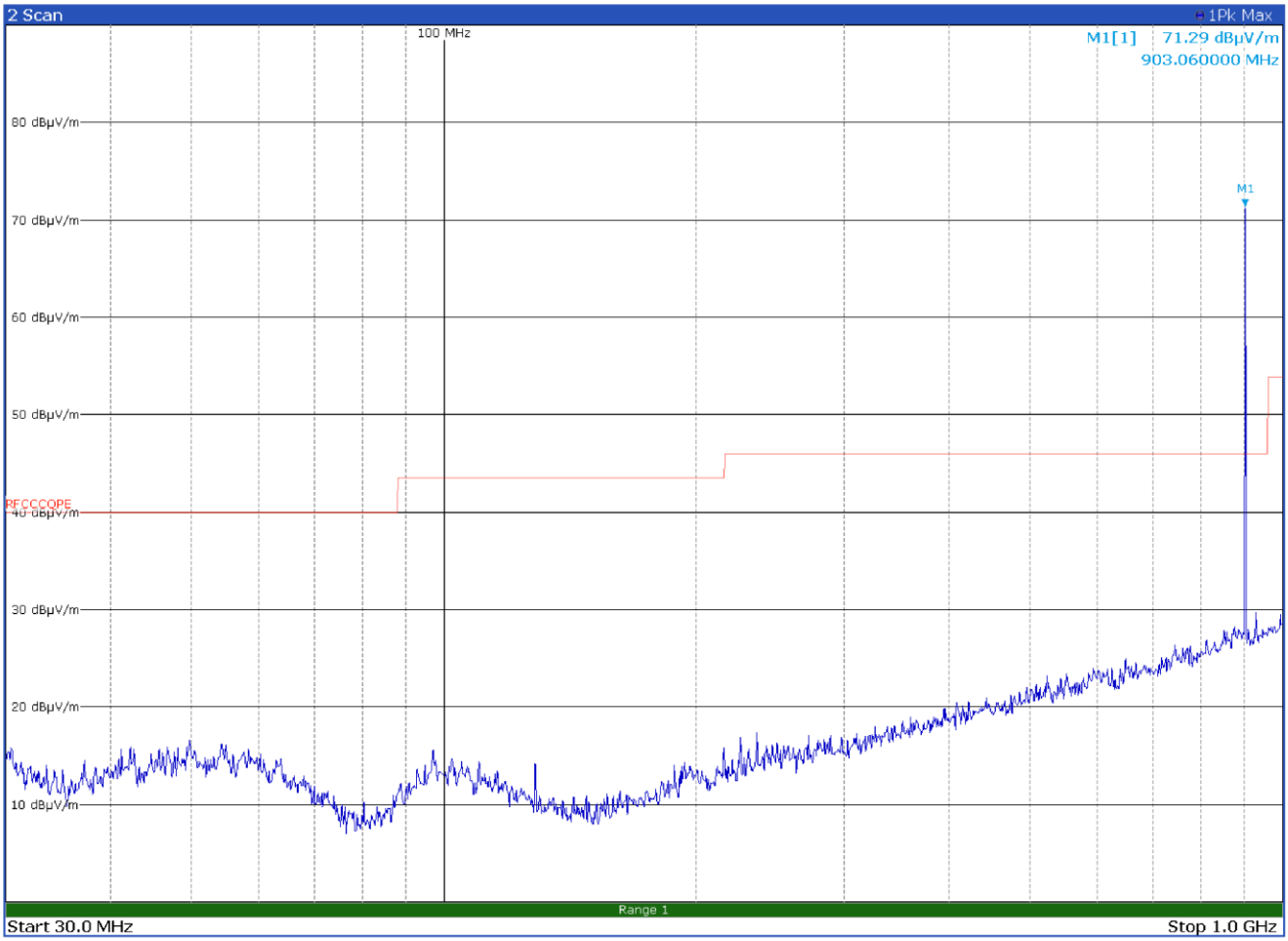


Figure 8.9-25: *Radiated spurious emissions on low channel - LR-FHSS – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

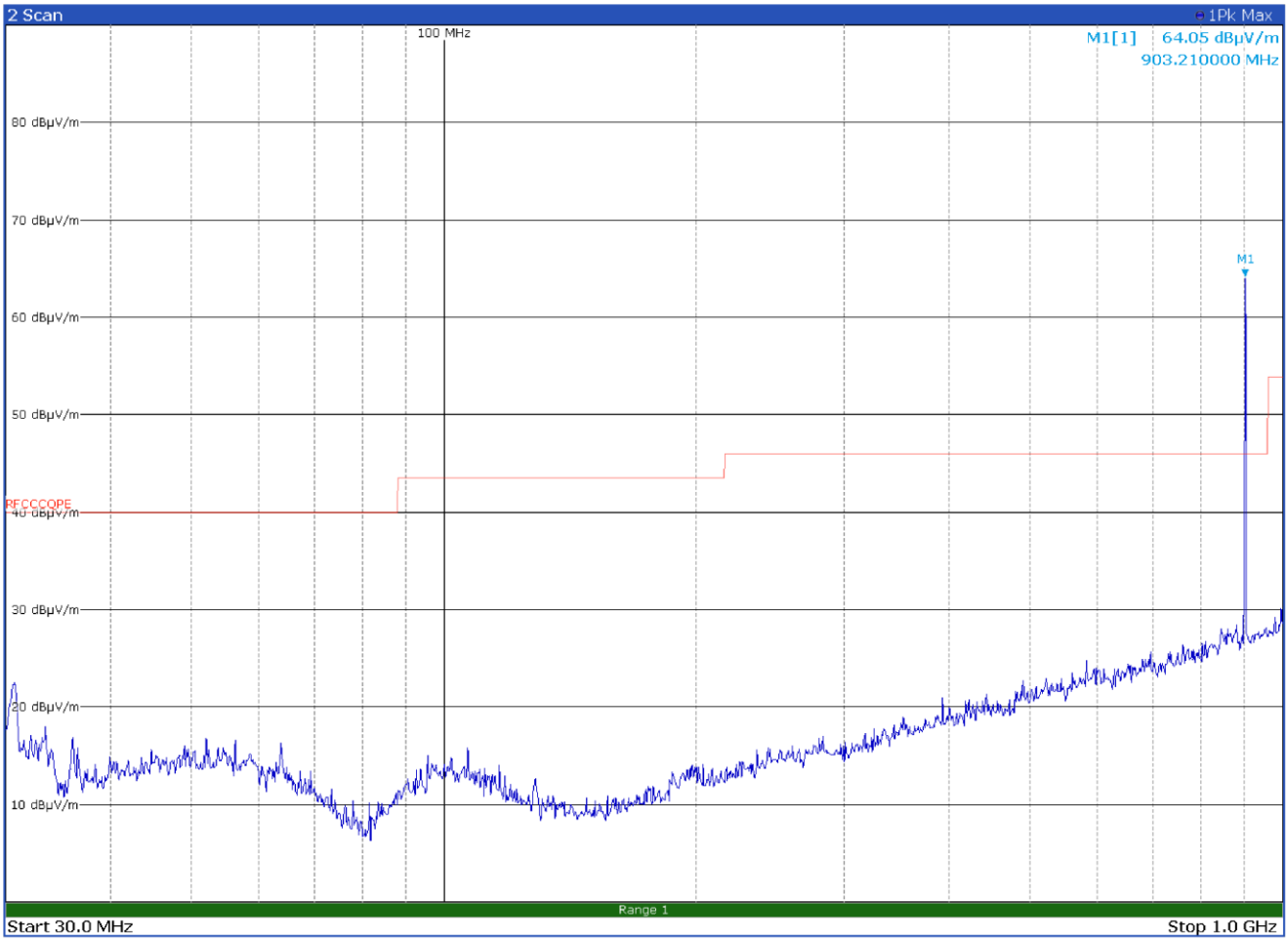


Figure 8.9-26: *Radiated spurious emissions on low channel - LR-FHSS – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

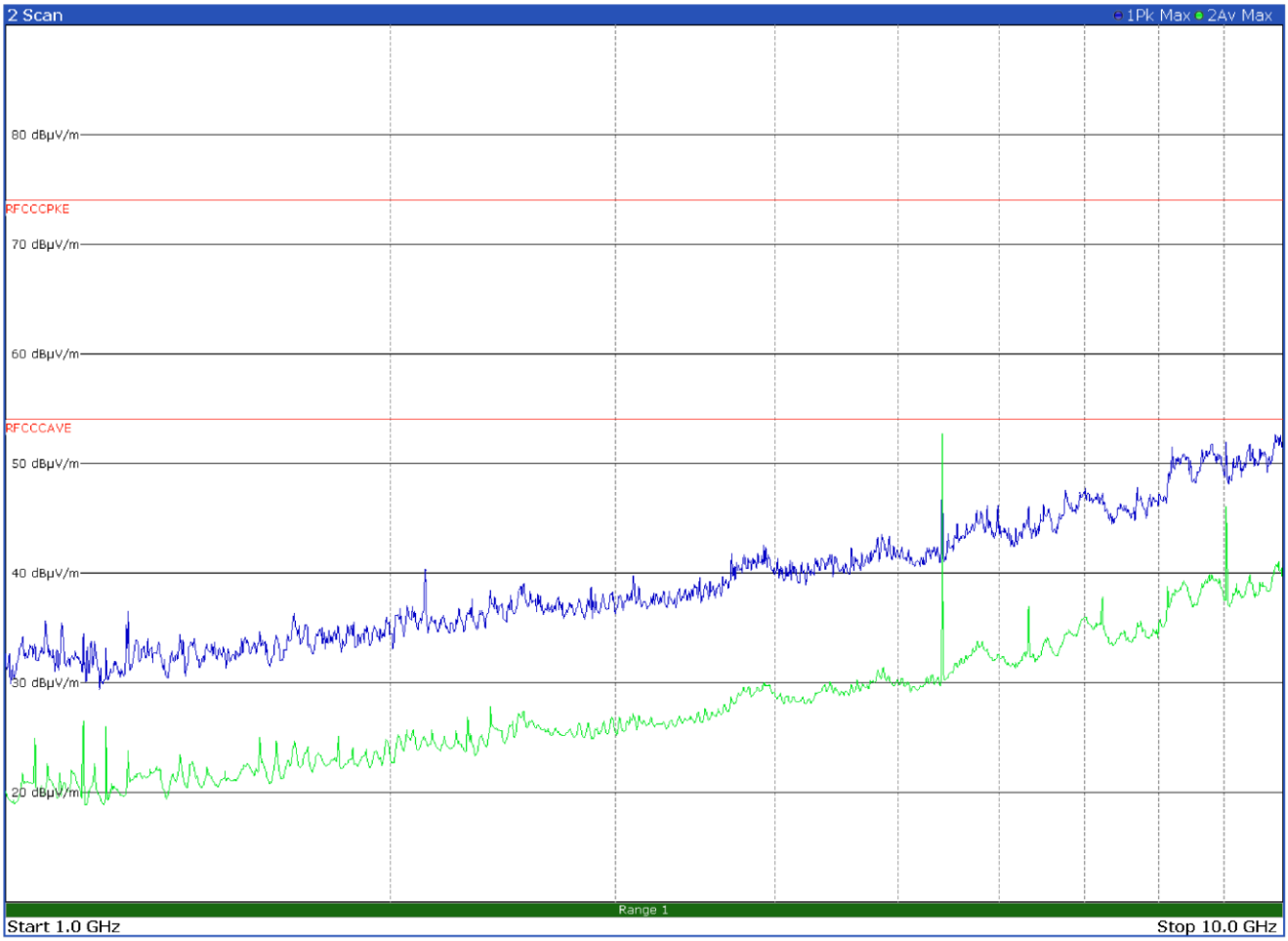


Figure 8.9-27: *Radiated spurious emissions on low channel - LR-FHSS – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
5416.7500	53.3	54.0	-0.7	Av
9030.0000	52.4	54.0	-1.6	Av

Test data, continued

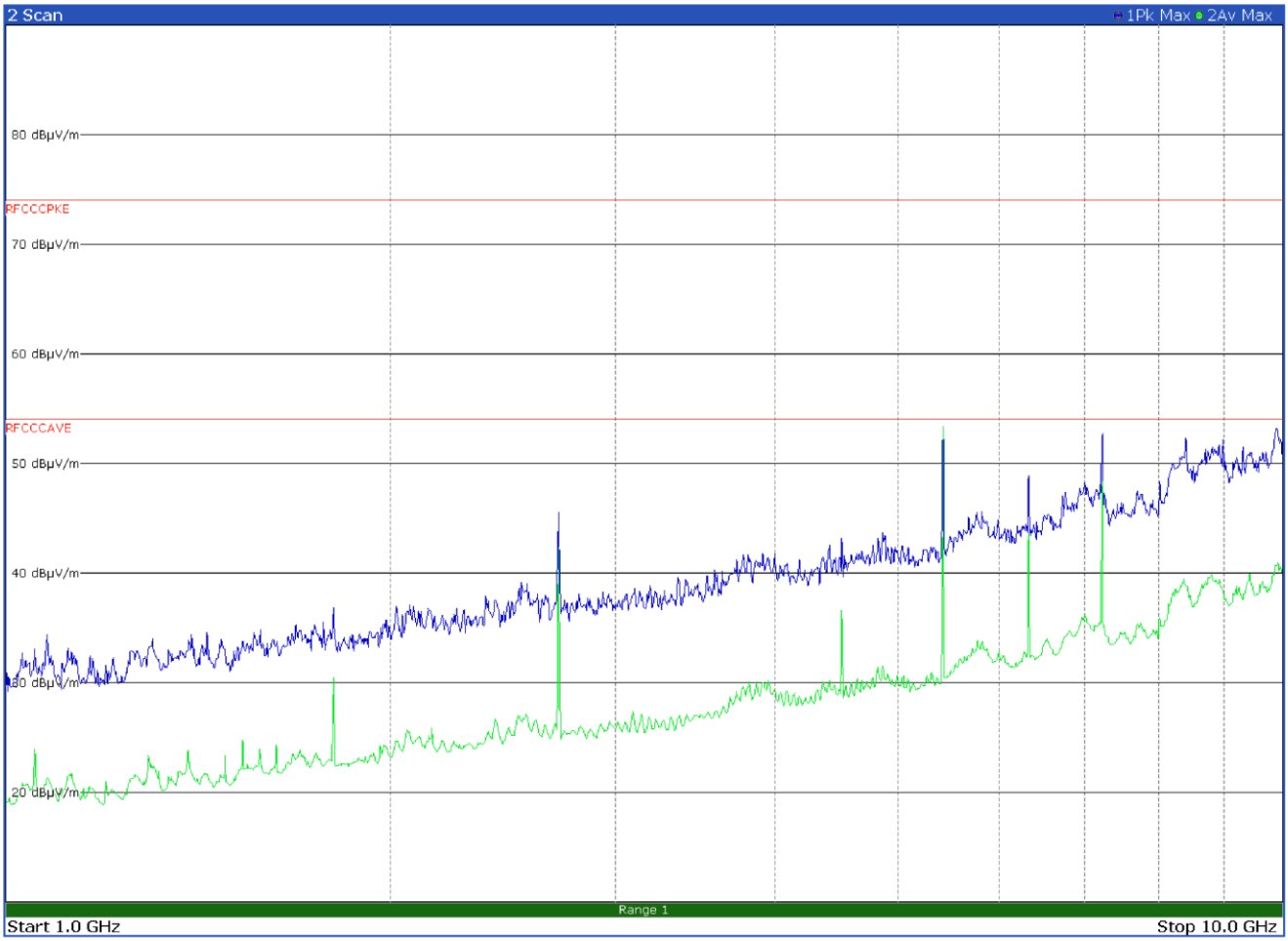


Figure 8.9-28: *Radiated spurious emissions on low channel - LR-FHSS – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
2708.5000	45.4	54.0	-8.6	Av
4514.5000	42.7	54.0	-11.3	Av
5418.7500	53.6	54.0	-0.4	Av
6322.2500	48.6	86.0	-37.4	Av
7225.2500	53.5	86.0	-32.5	Av
9920.2500	50.3	86.0	-35.7	Av

Test data, continued

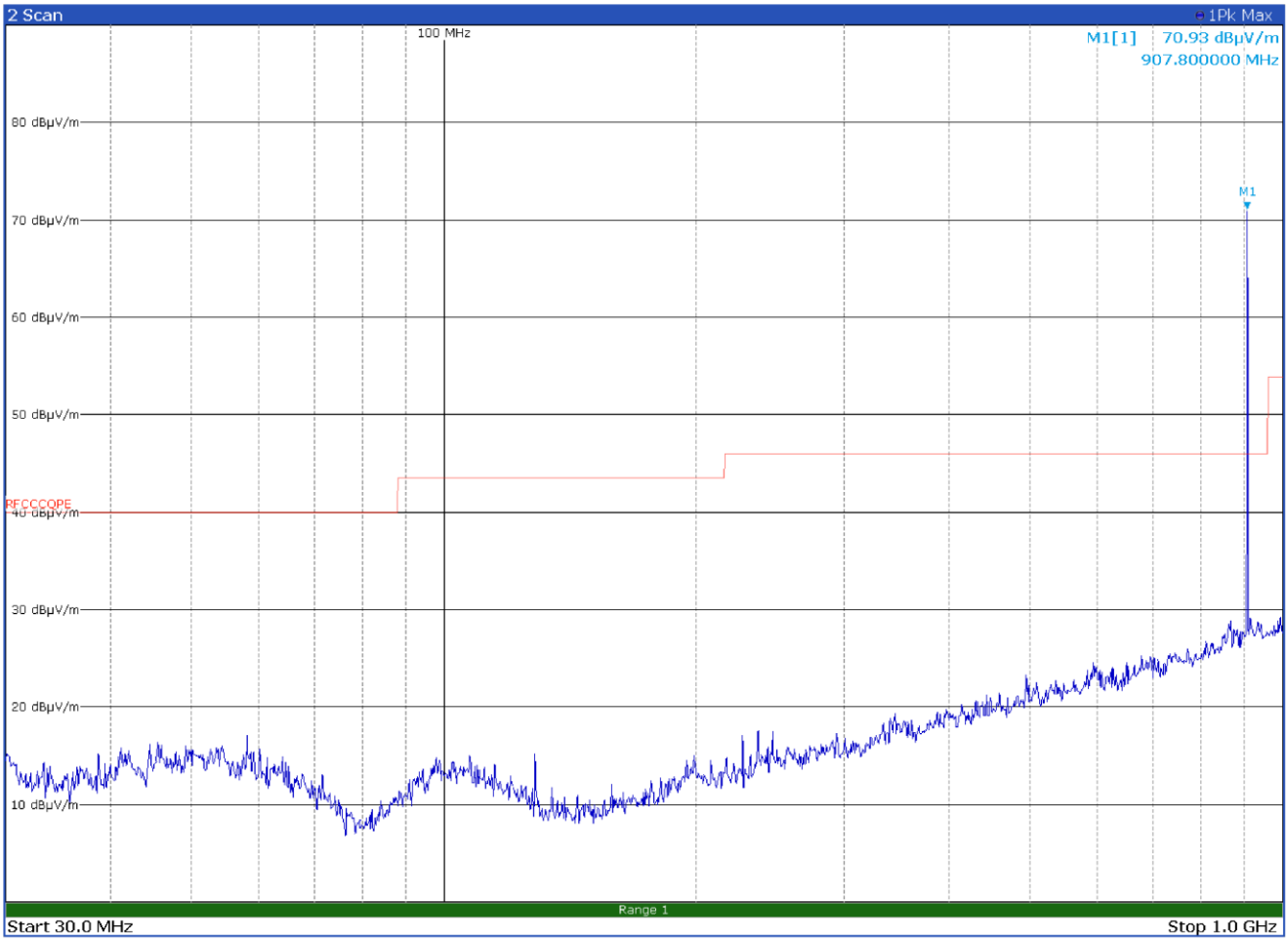


Figure 8.9-29: *Radiated spurious emissions on mid channel - LR-FHSS – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

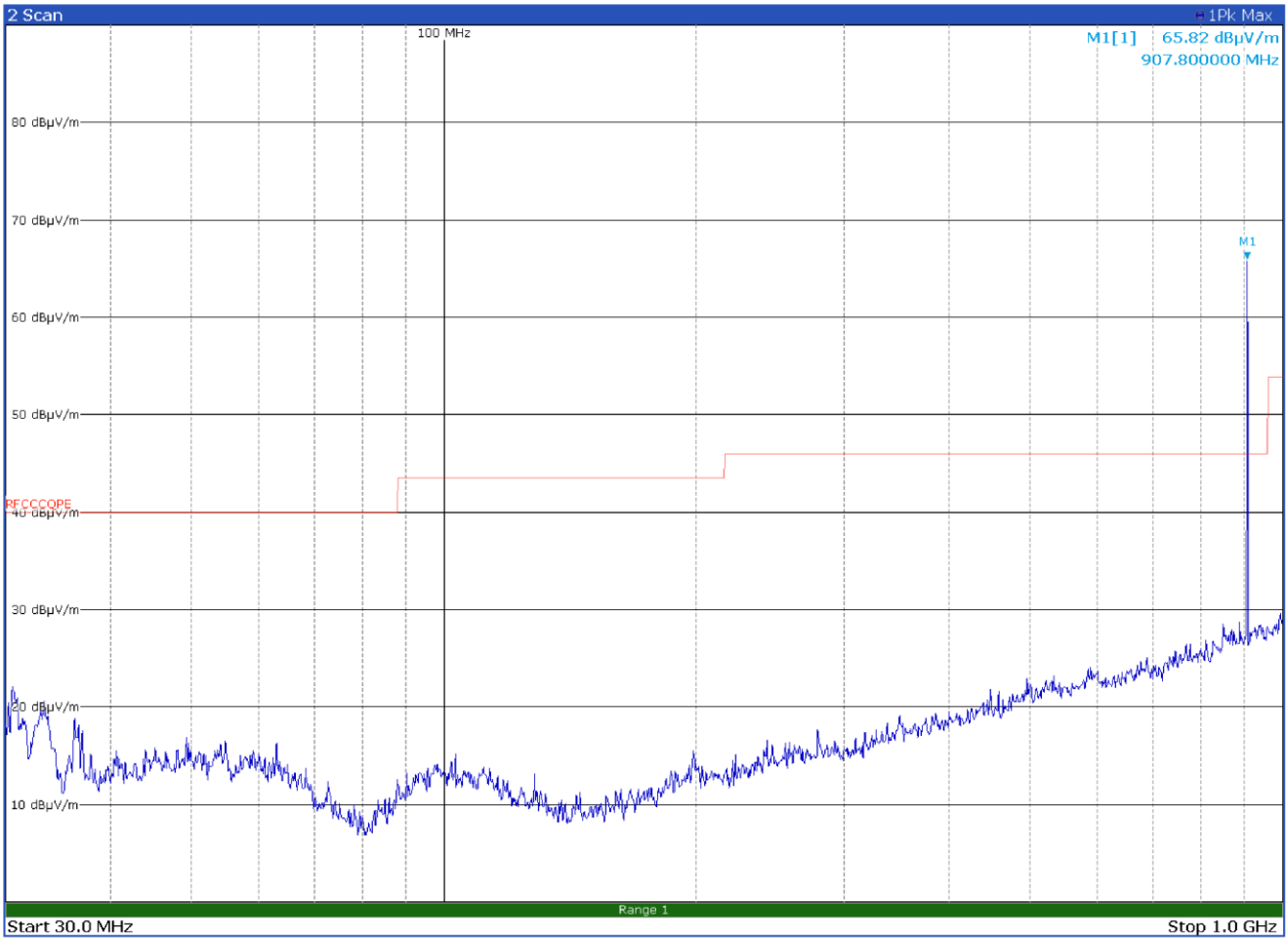


Figure 8.9-30: *Radiated spurious emissions on mid channel - LR-FHSS – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

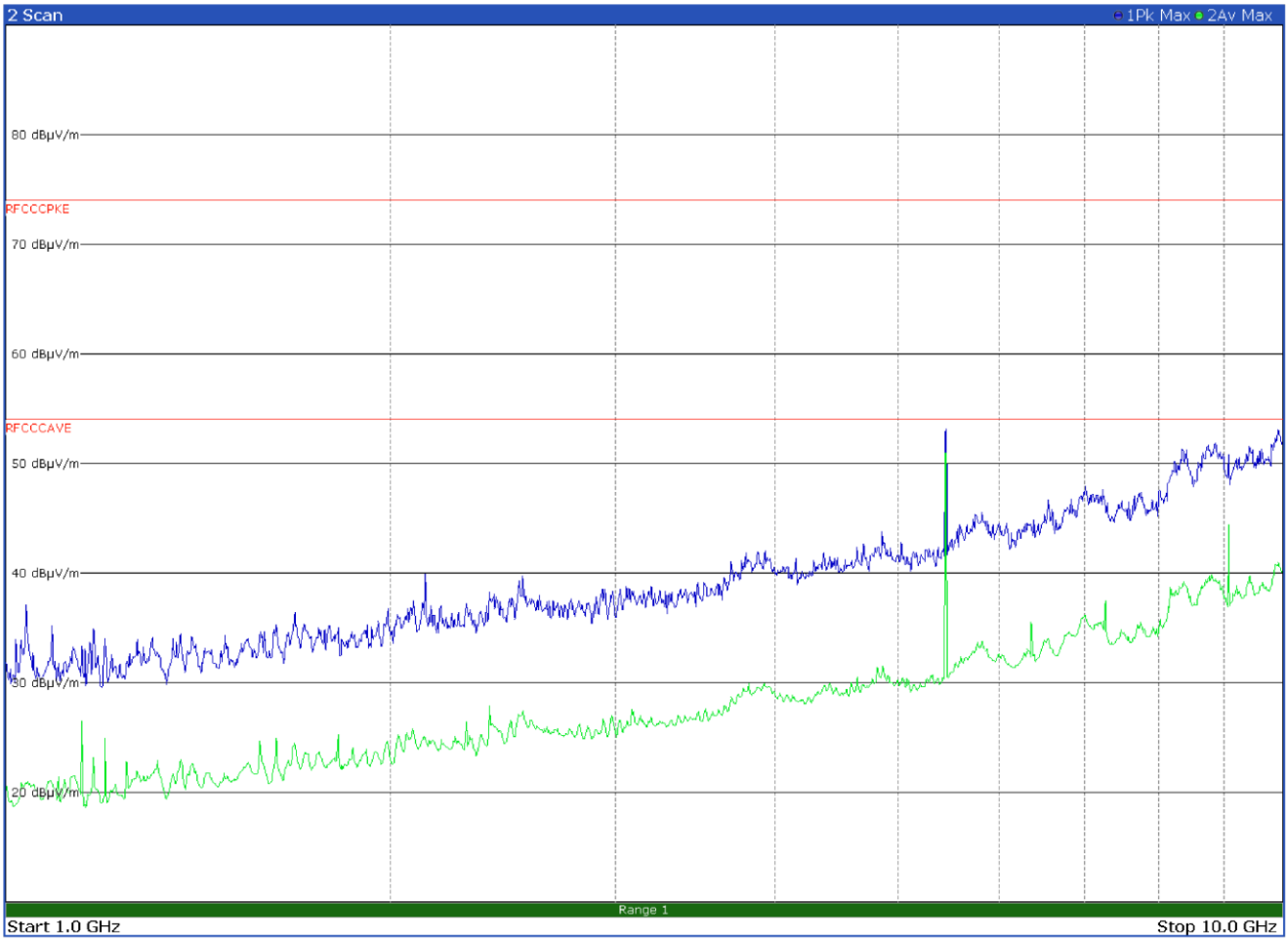


Figure 8.9-31: *Radiated spurious emissions on mid channel - LR-FHSS – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
5445.5000	53.7	54.0	-0.3	Av
9077.5000	50.1	54.0	-3.9	Av

Test data, continued

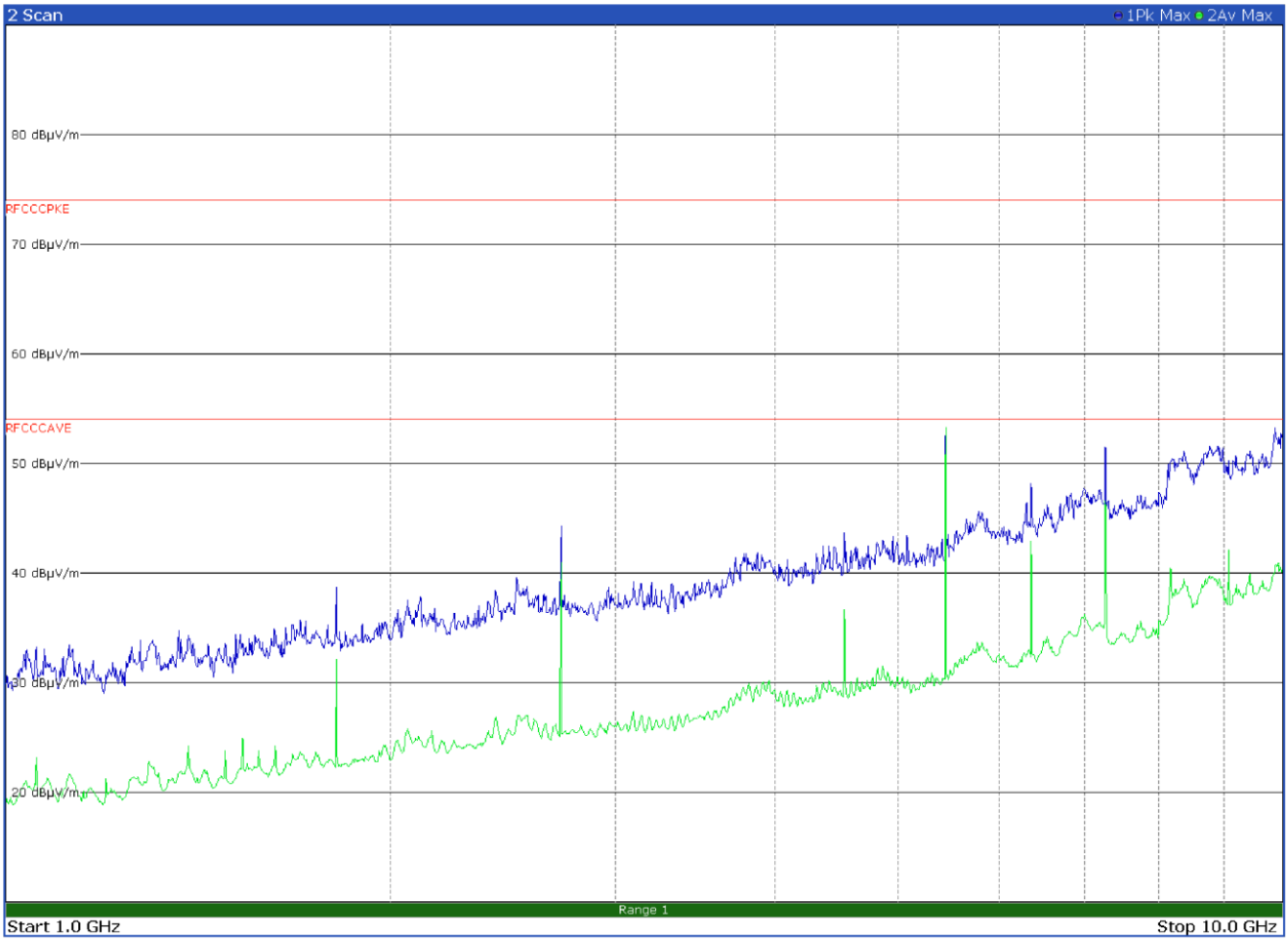


Figure 8.9-32: *Radiated spurious emissions on mid channel - LR-FHSS – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
2722.7500	43.0	54.0	-11.0	Av
4538.5000	42.7	54.0	-11.3	Av
5447.7500	53.7	54.0	-0.3	Av
6353.2500	48.0	86.0	-38.0	Av
7262.0000	51.9	54.0	-2.1	Av
9076.0000	50.8	54.0	-3.2	Av

Test data, continued

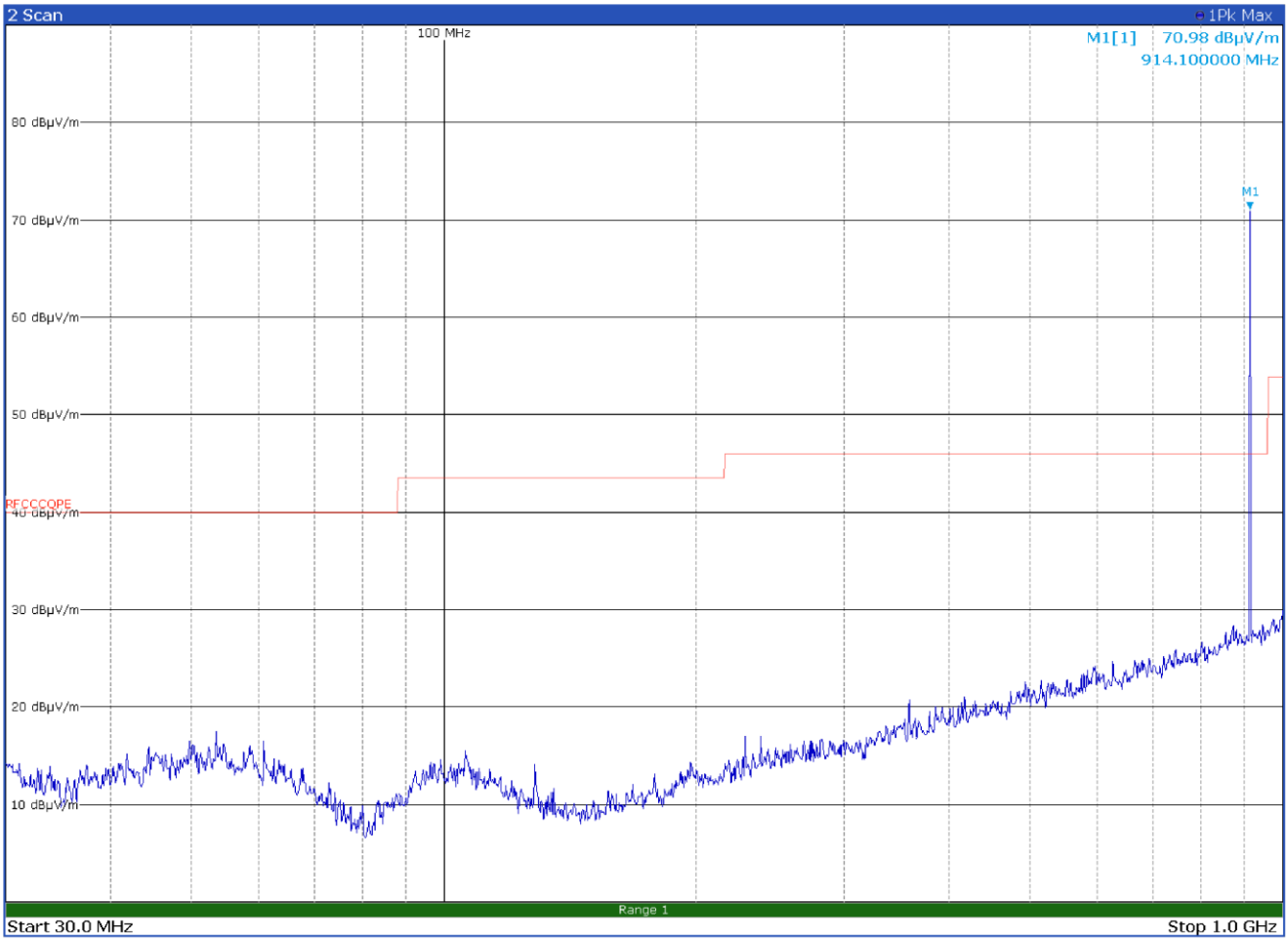


Figure 8.9-33: *Radiated spurious emissions on high channel - LR-FHSS – Antenna in horizontal polarization*

Limit exceeded by the carrier

Test data, continued

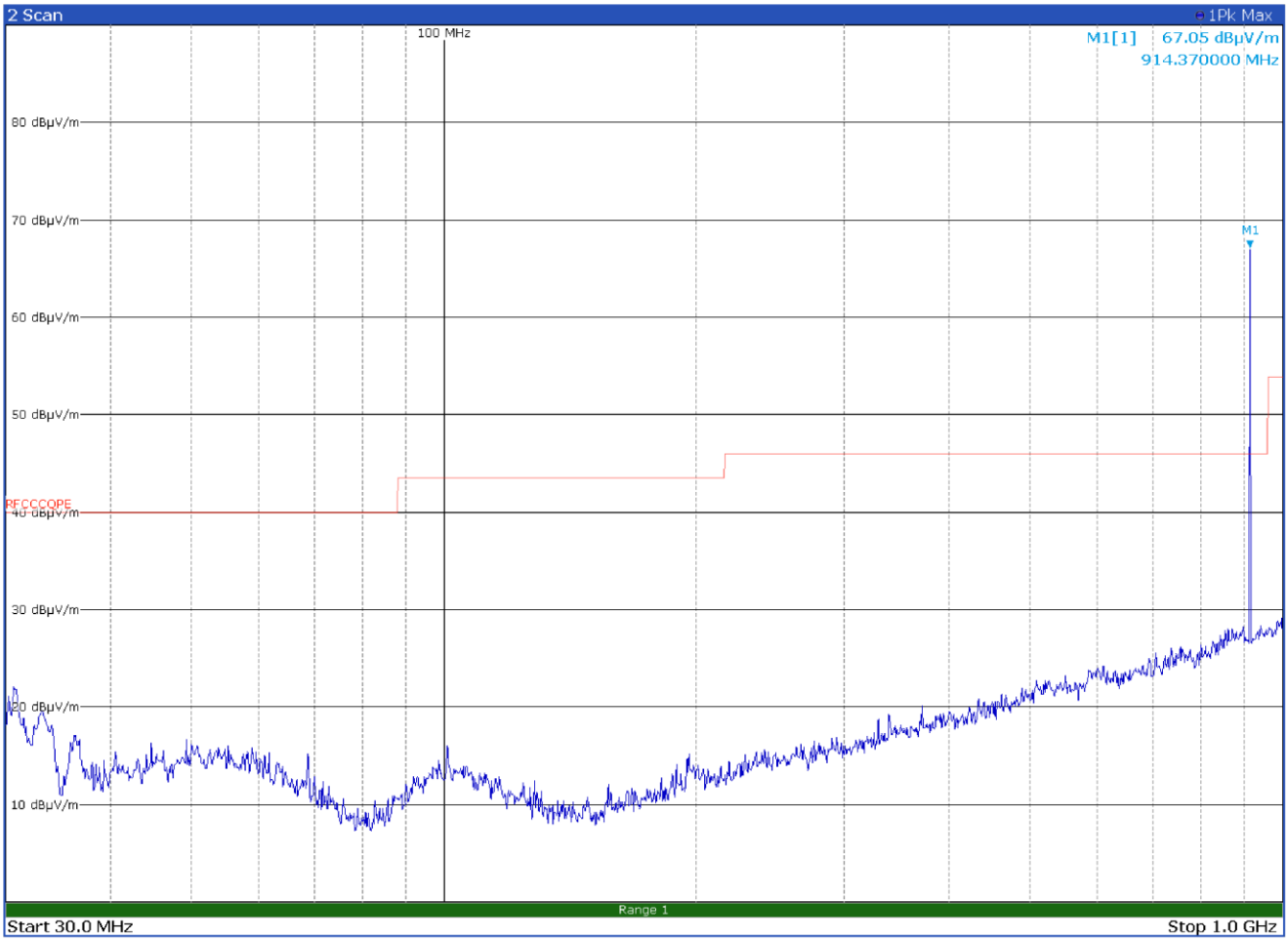


Figure 8.9-34: *Radiated spurious emissions on high channel - LR-FHSS – Antenna in vertical polarization*

Limit exceeded by the carrier

Test data, continued

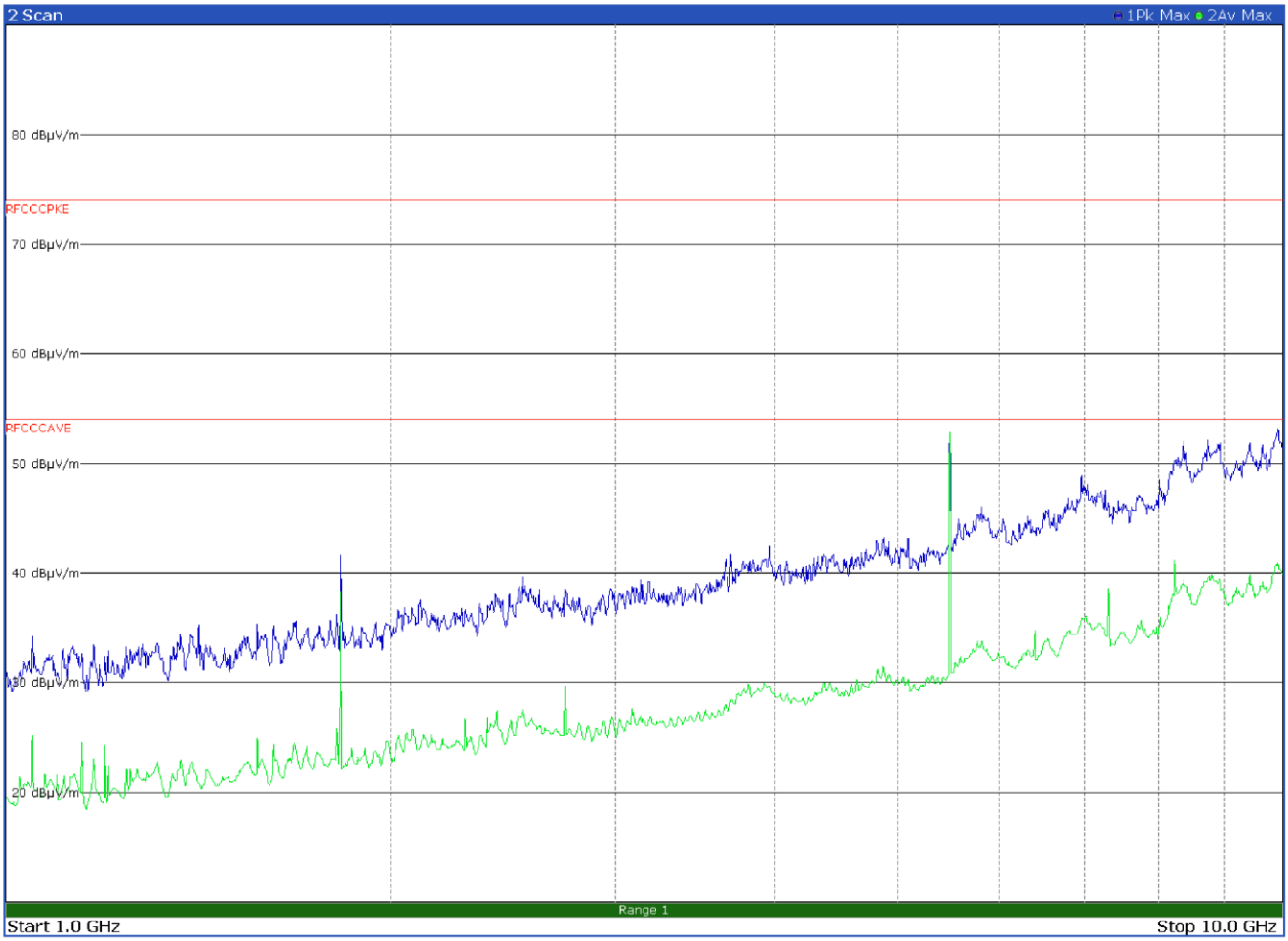


Figure 8.9-35: *Radiated spurious emissions on high channel - LR-FHSS – Antenna in horizontal polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
1828.2500	40.9	86.0	-45.1	Av
5484.2500	53.6	86.0	-32.4	Av
8226.0000	52.8	54.0	-1.2	Av

Test data, continued

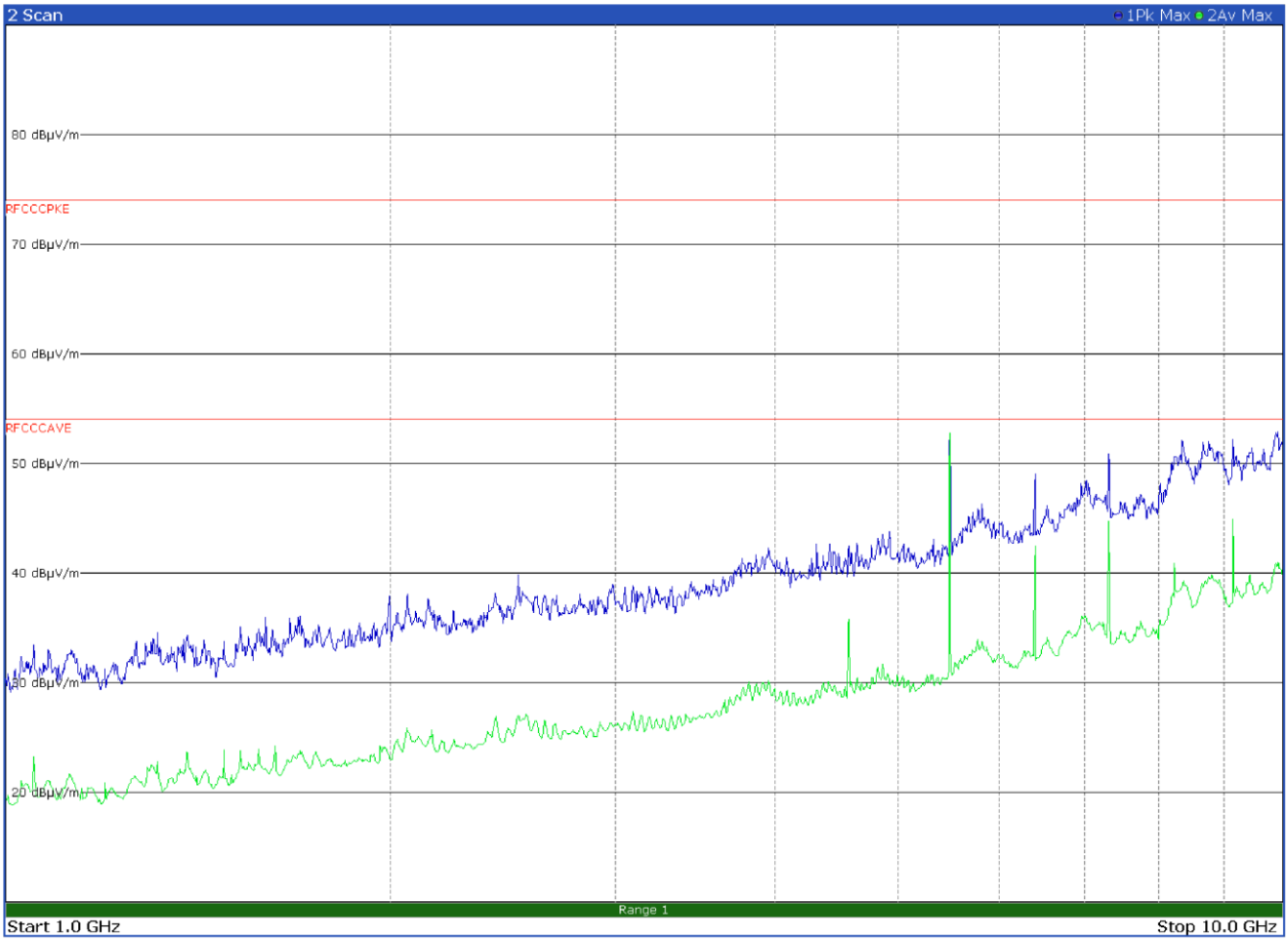


Figure 8.9-36: *Radiated spurious emissions on high channel - LR-FHSS – Antenna in vertical polarization*

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
4571.5000	42.8	54.0	-11.2	Av
5485.0000	53.5	86.0	-32.5	Av
6400.7500	48.5	86.0	-37.5	Av
7311.7500	50.1	54.0	-3.9	Av
9141.2500	52.2	54.0	-1.8	Av

Test data, continued

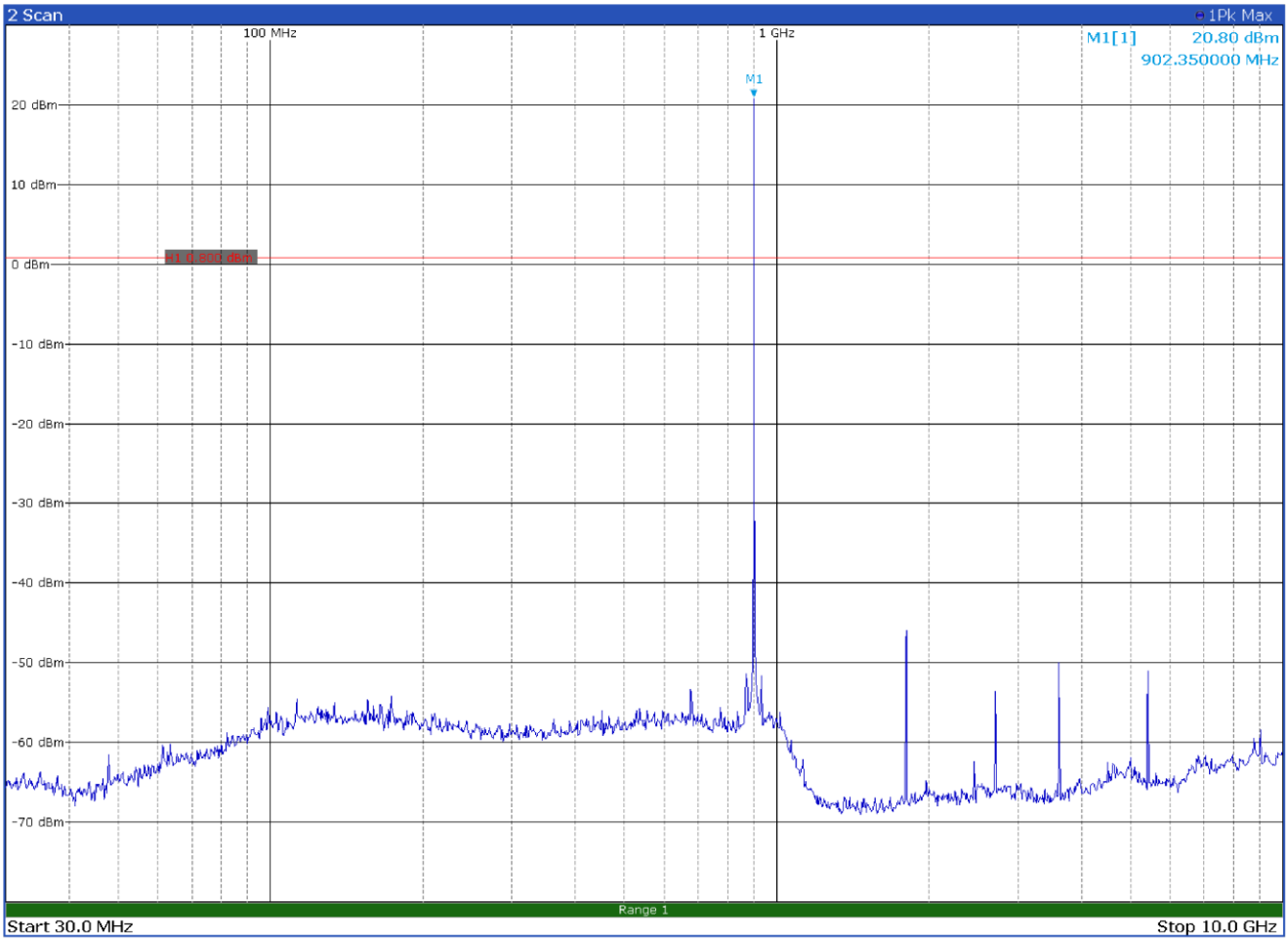


Figure 8.9-37: *Conducted spurious emissions on low channel - LoRa 125 kHz BW*

Limit exceeded by the carrier

Test data, continued

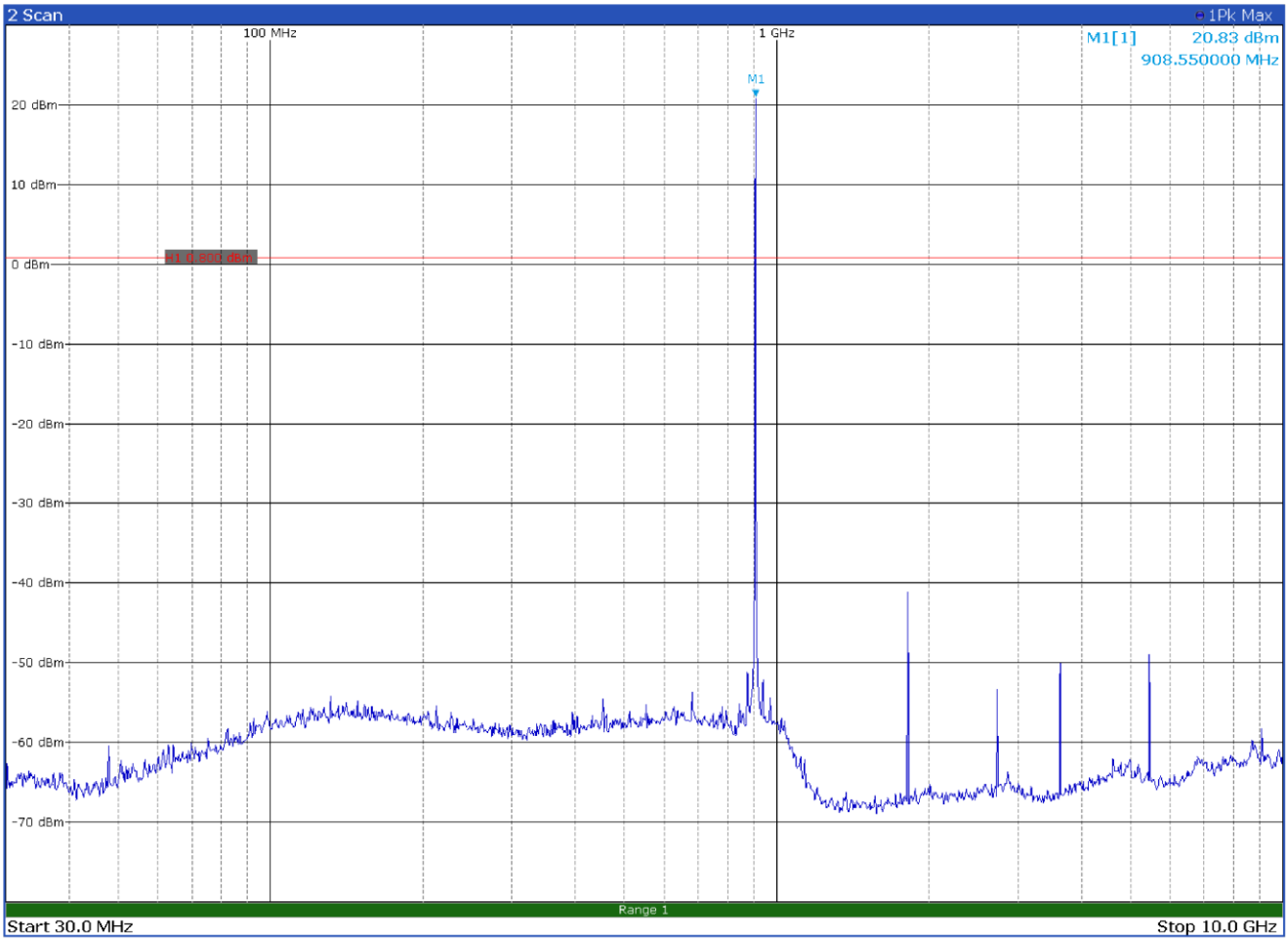


Figure 8.9-38: *Conducted spurious emissions on mid channel - LoRa 125 kHz BW*

Limit exceeded by the carrier

Test data, continued

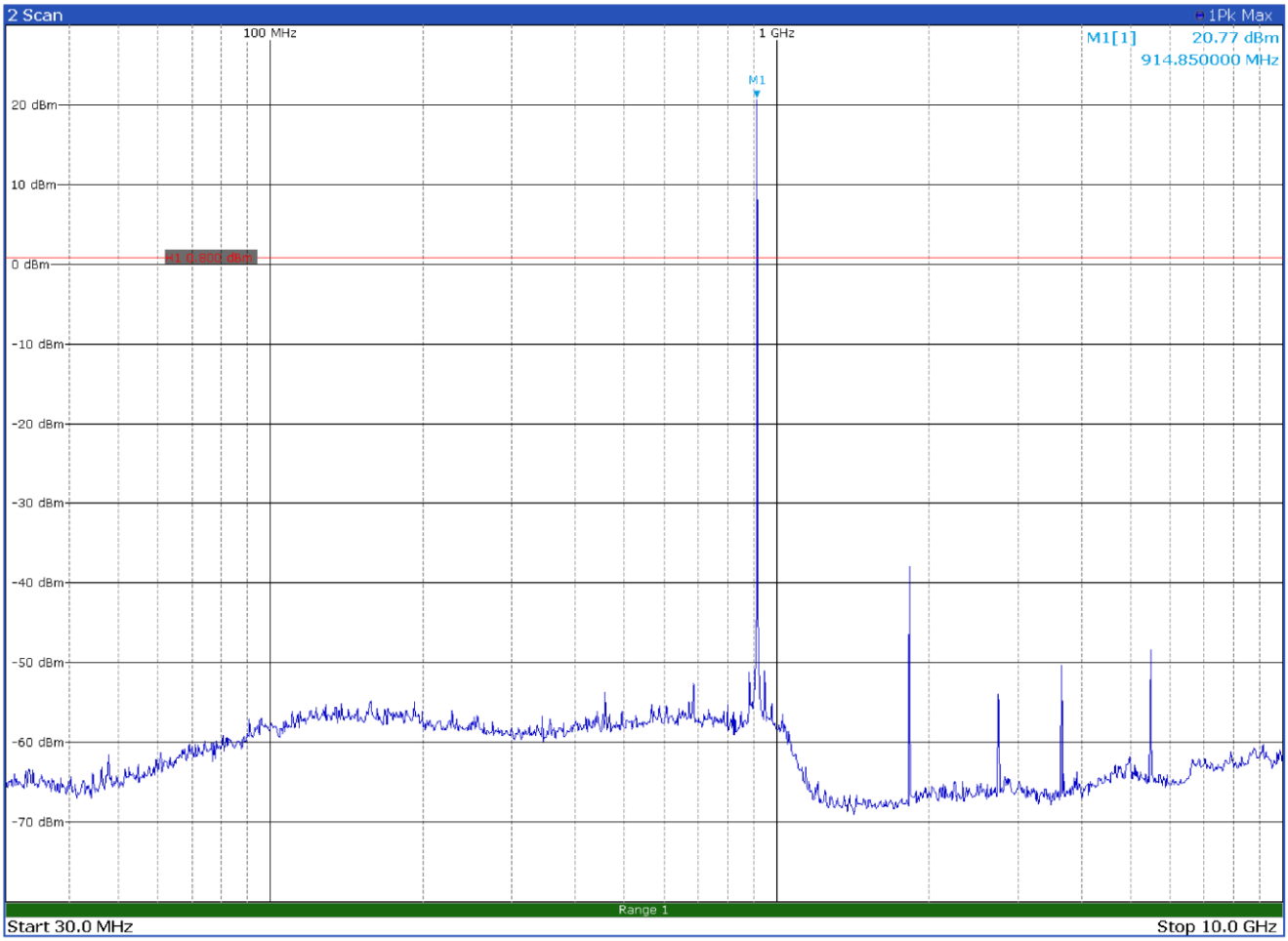


Figure 8.9-39: *Conducted spurious emissions on high channel - LoRa 125 kHz BW*

Limit exceeded by the carrier

Test data, continued

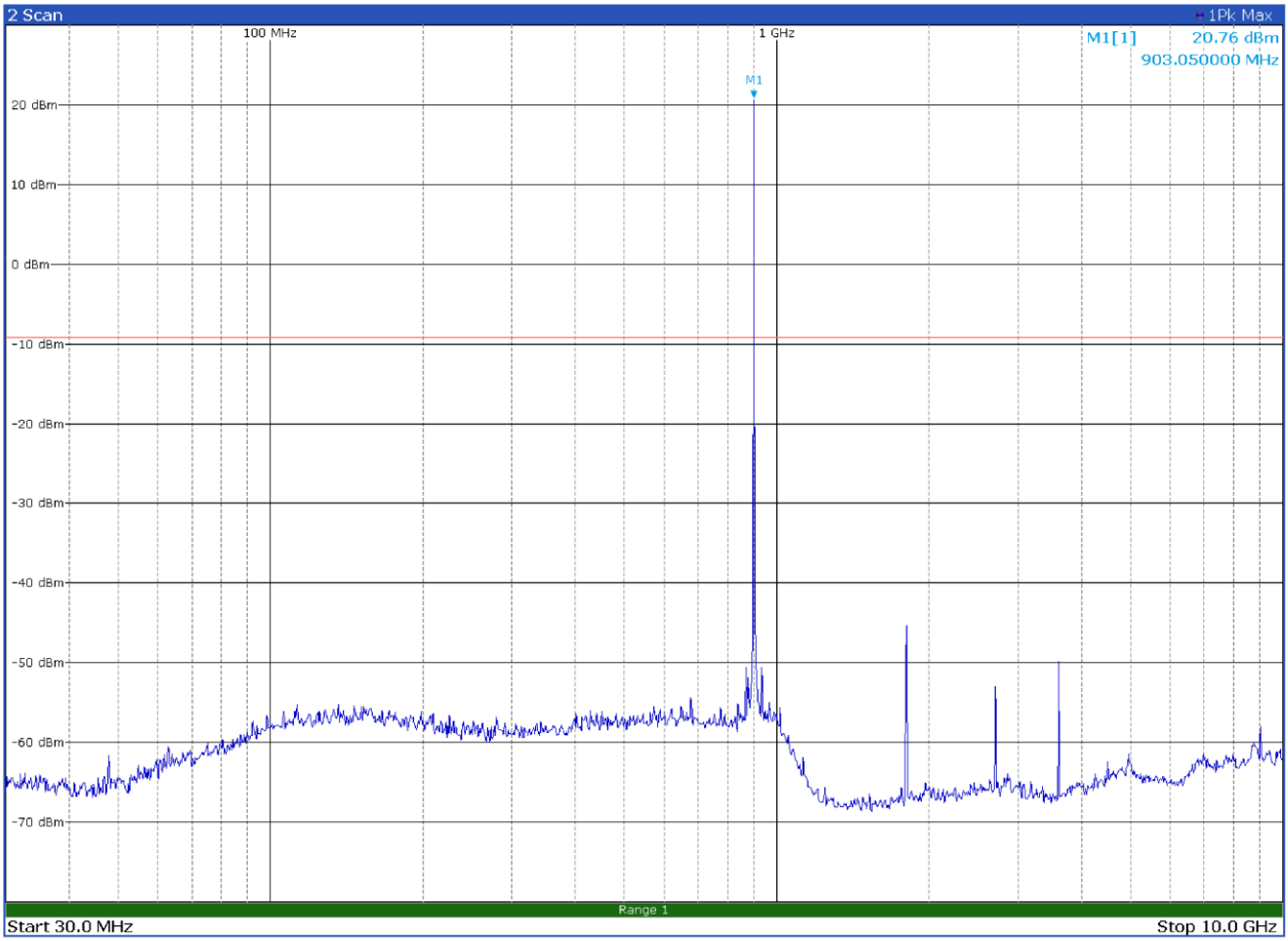


Figure 8.9-40: *Conducted spurious emissions on low channel - LoRa 500 kHz BW*

Limit exceeded by the carrier

Test data, continued

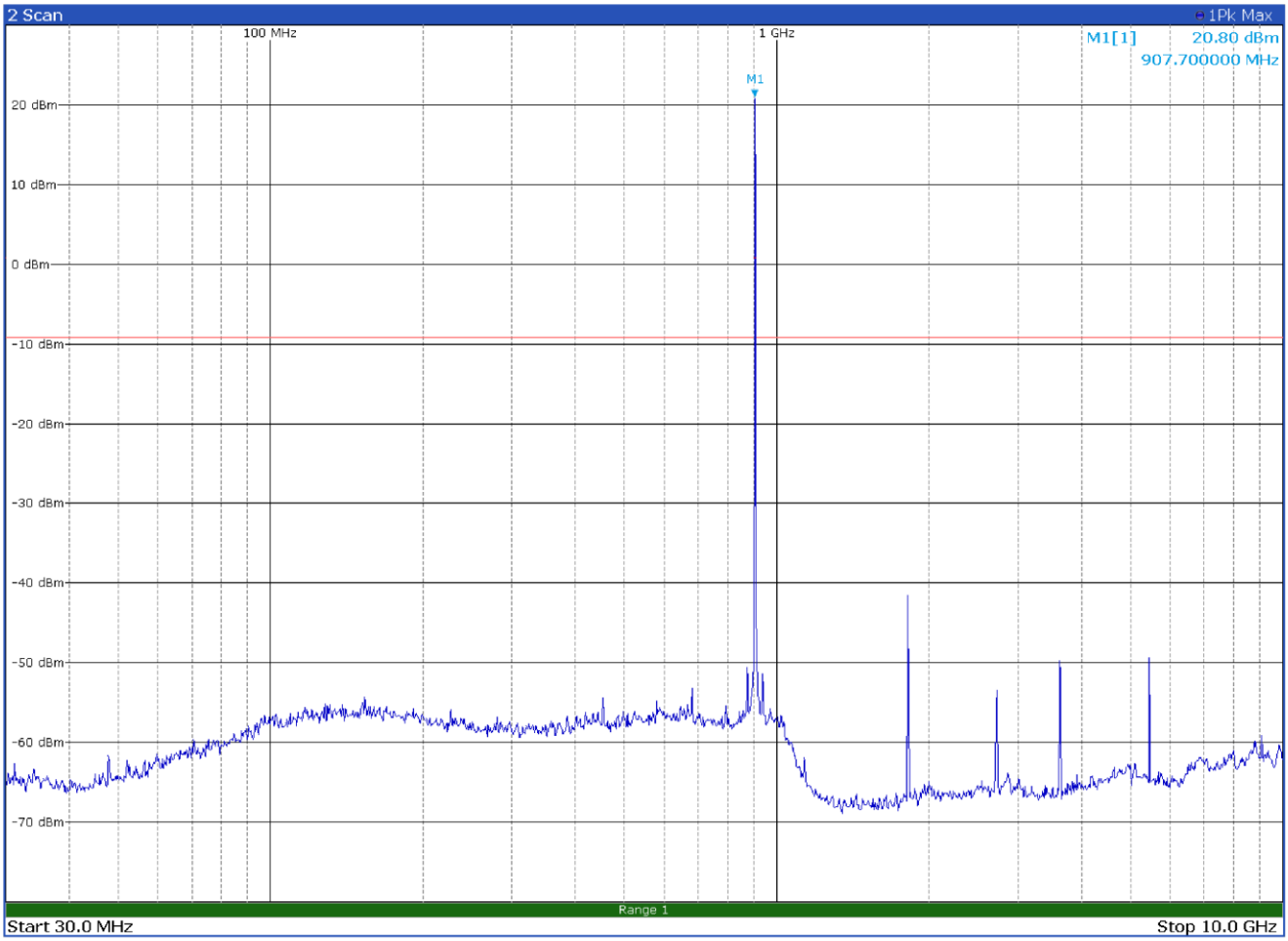


Figure 8.9-41: *Conducted spurious emissions on mid channel - LoRa 500 kHz BW*

Limit exceeded by the carrier

Test data, continued

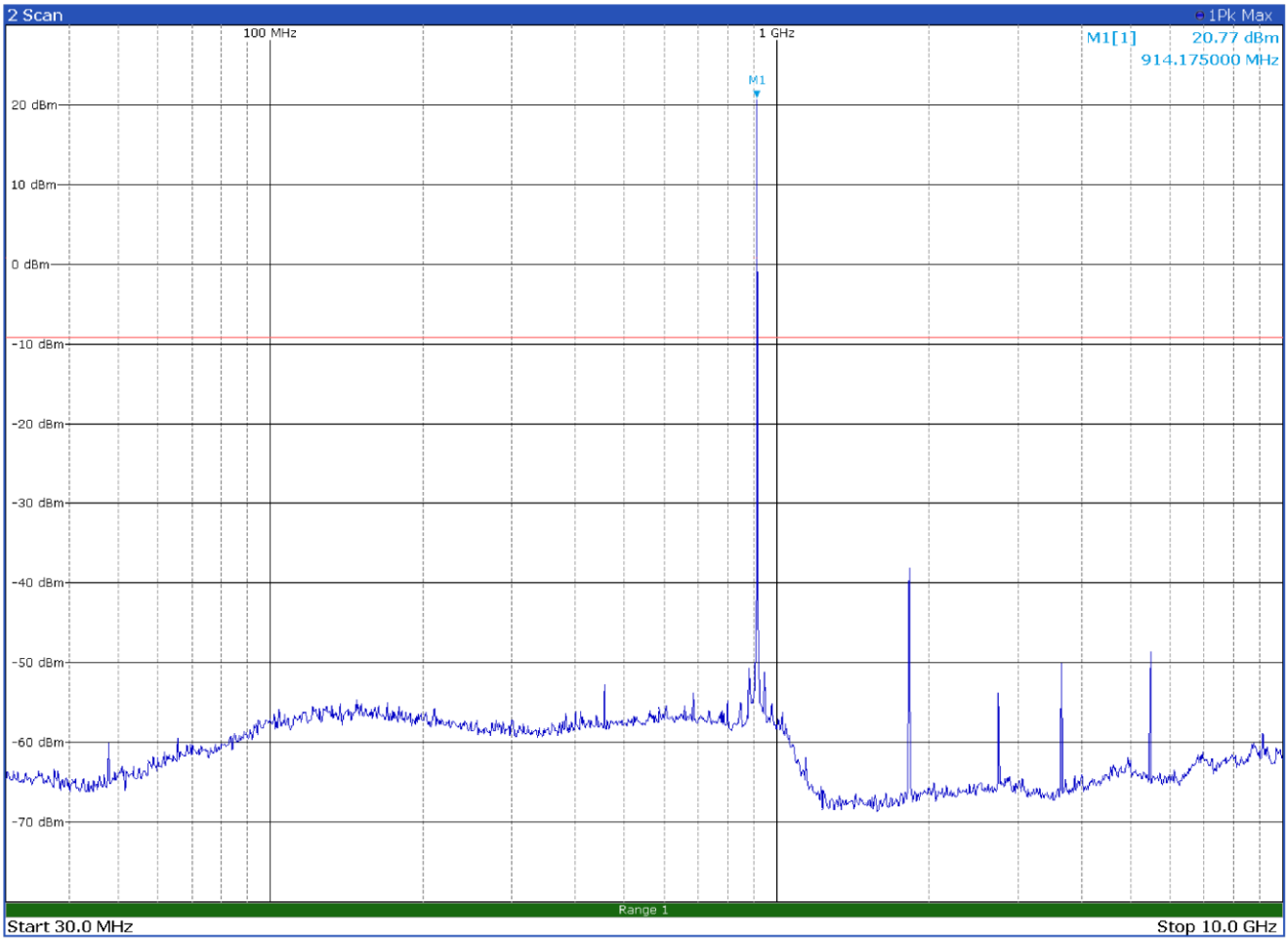


Figure 8.9-42: *Conducted spurious emissions on high channel - LoRa 500 kHz BW*

Limit exceeded by the carrier

Test data, continued

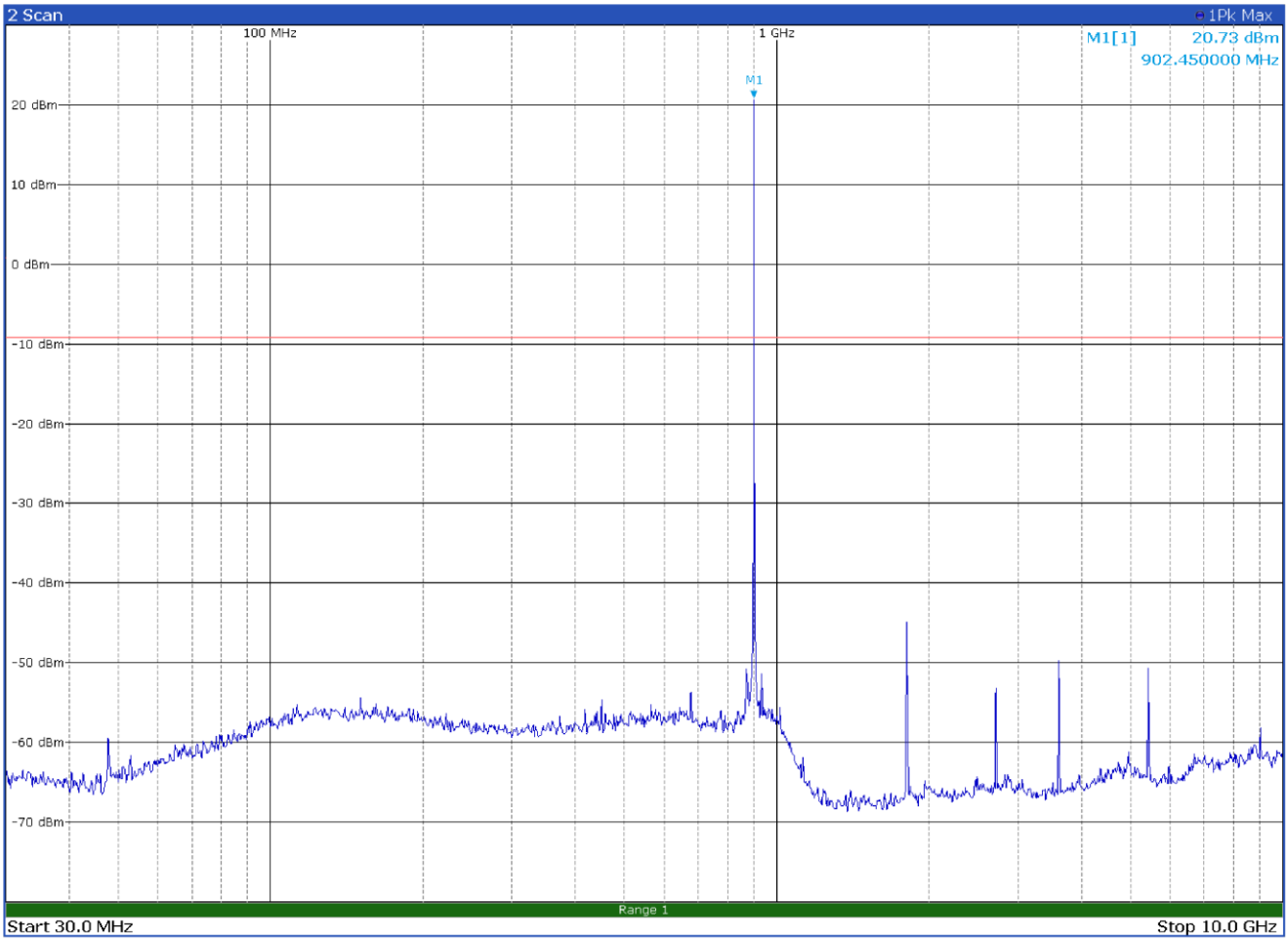


Figure 8.9-43: *Conducted spurious emissions on low channel – LR-FHSS*

Limit exceeded by the carrier

Test data, continued

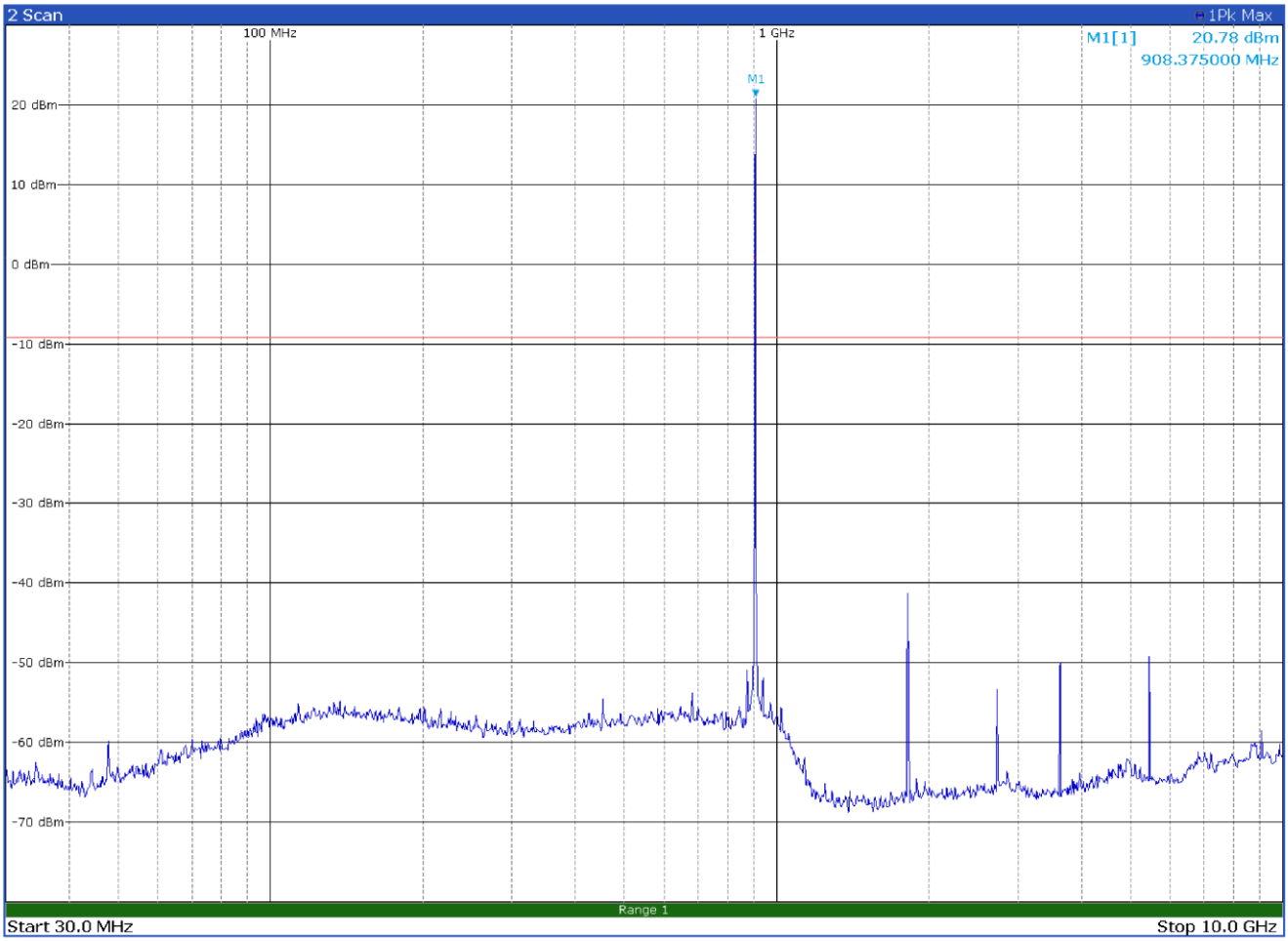


Figure 8.9-44: *Conducted spurious emissions on mid channel - LR-FHSS*

Limit exceeded by the carrier

Test data, continued

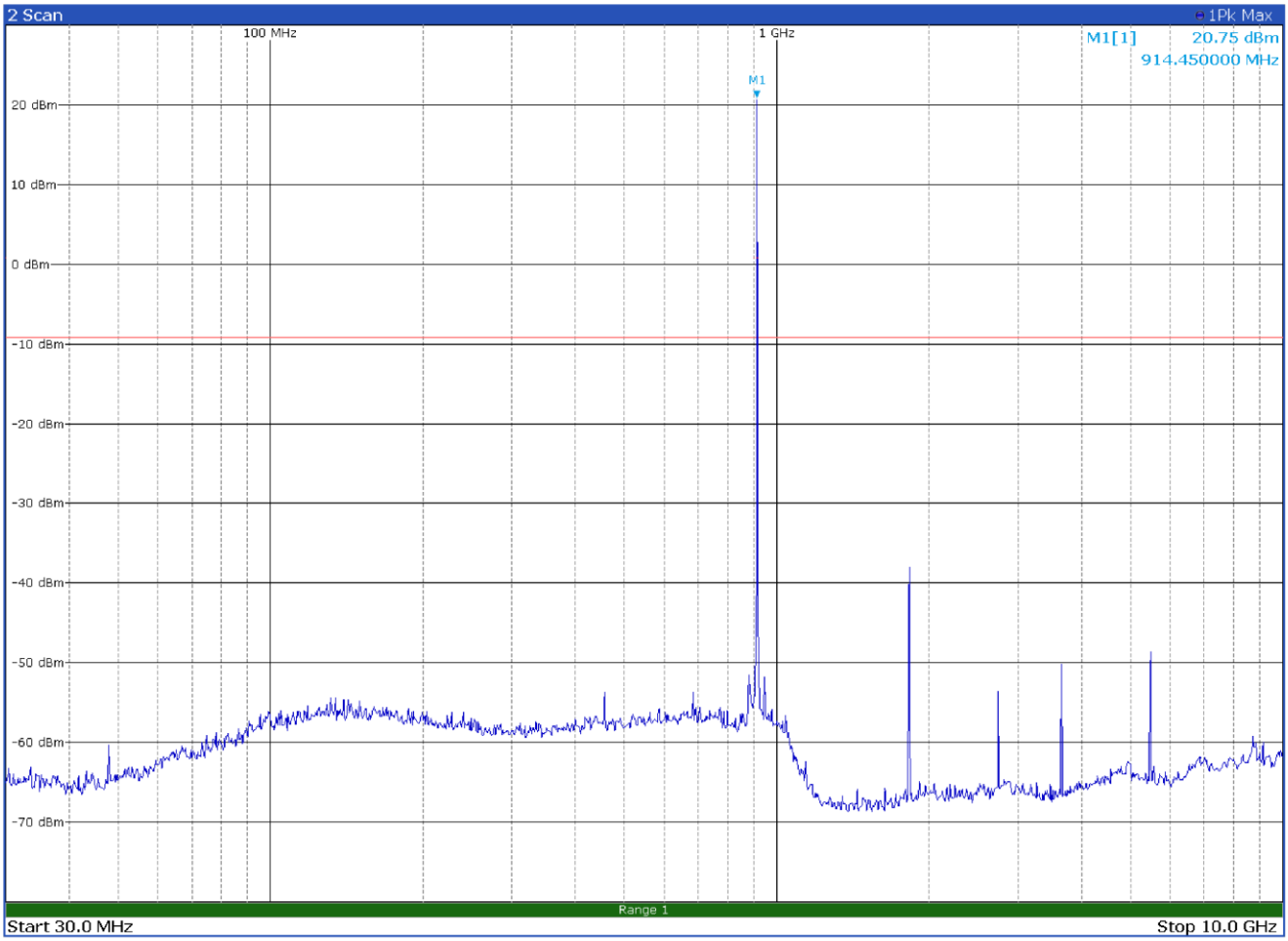


Figure 8.9-45: *Conducted spurious emissions on high channel - LR-FHSS*

Limit exceeded by the carrier

Test data, continued

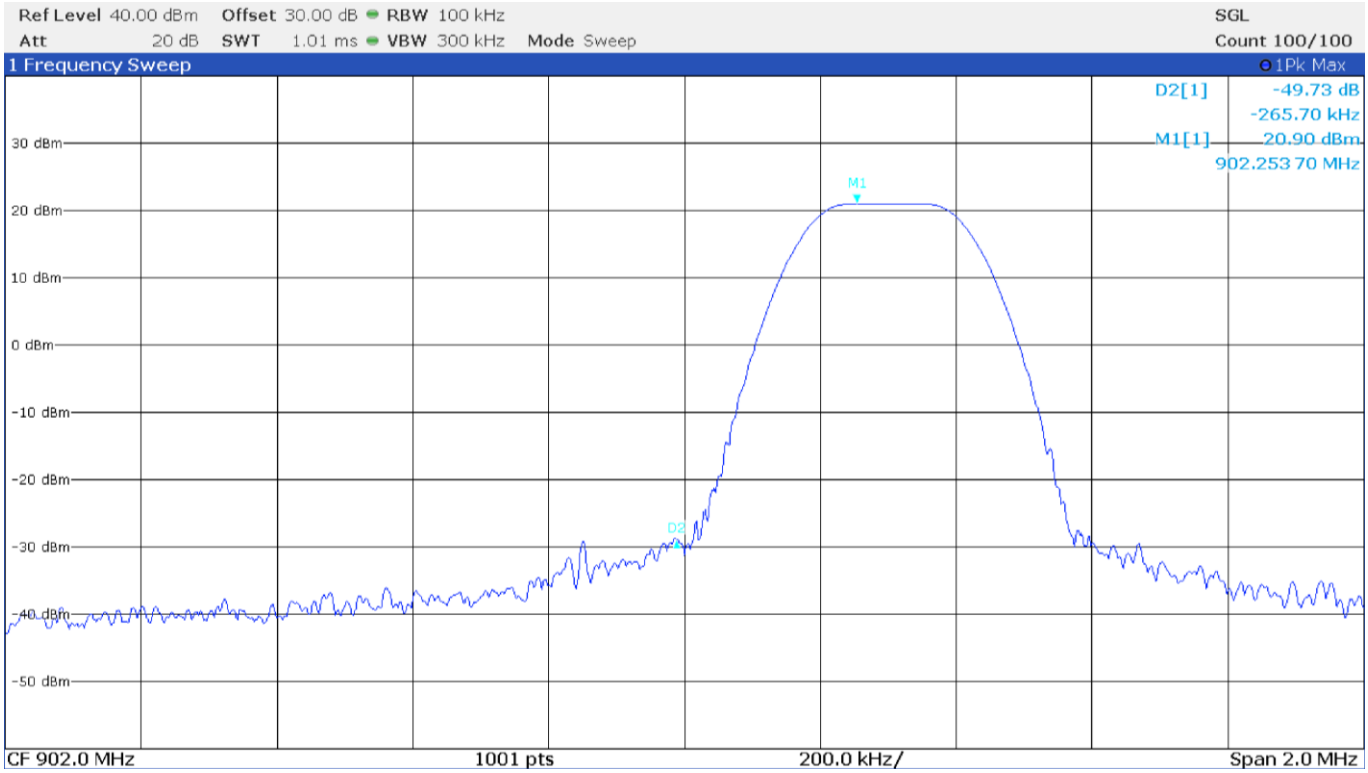


Figure 8.9-46: *Band edge spurious emissions at 902 MHz - LoRa 125 kHz BW*

Test data, continued

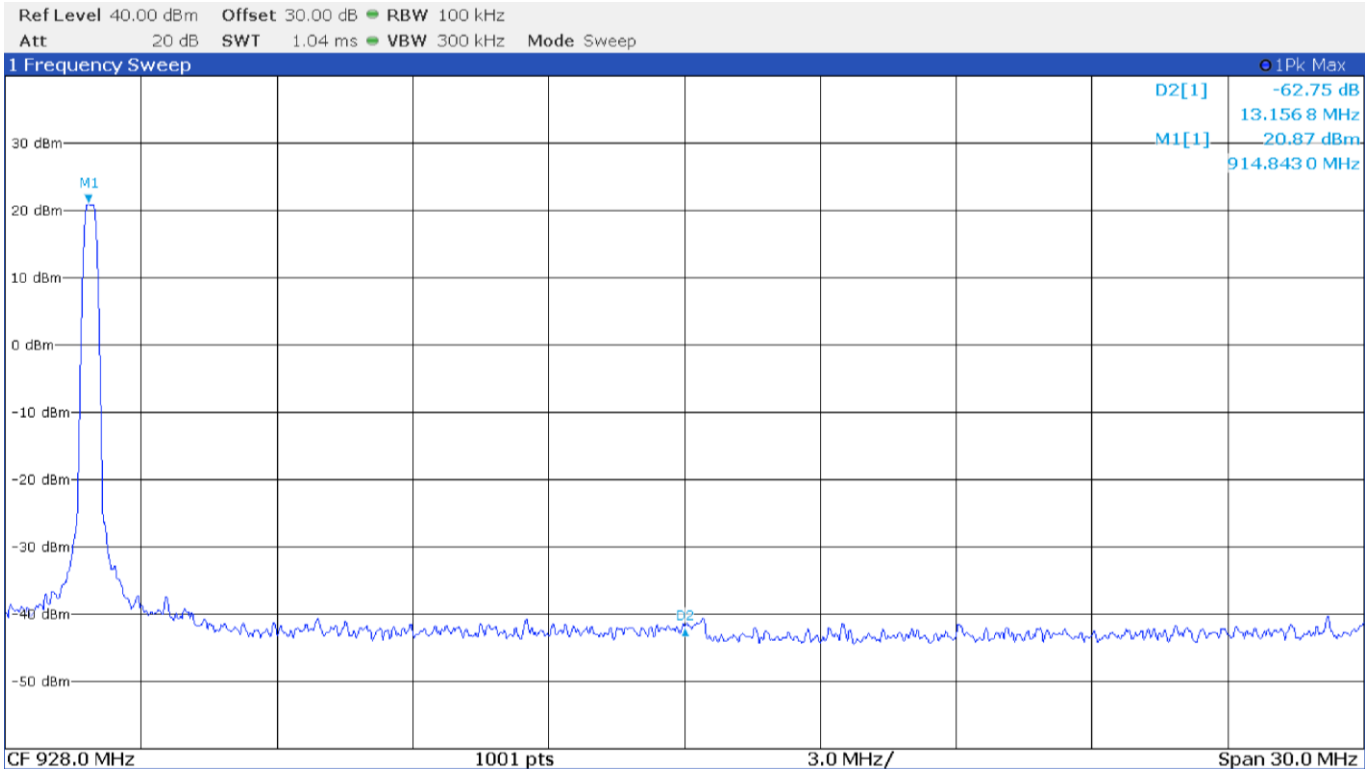


Figure 8.9-47: *Band edge spurious emissions at 928 MHz - LoRa 125 kHz BW*

Test data, continued

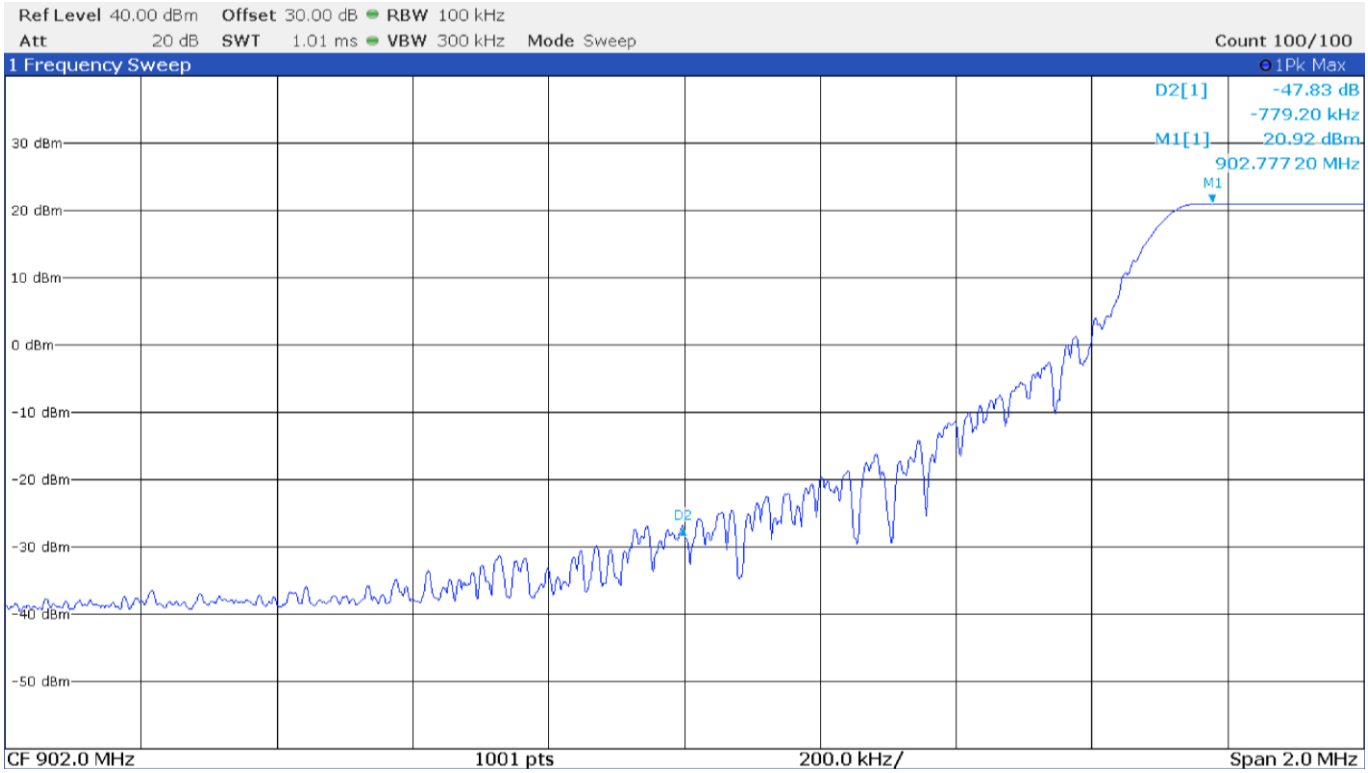


Figure 8.9-48: *Band edge spurious emissions at 902 MHz - LoRa 500 kHz BW*

Test data, continued

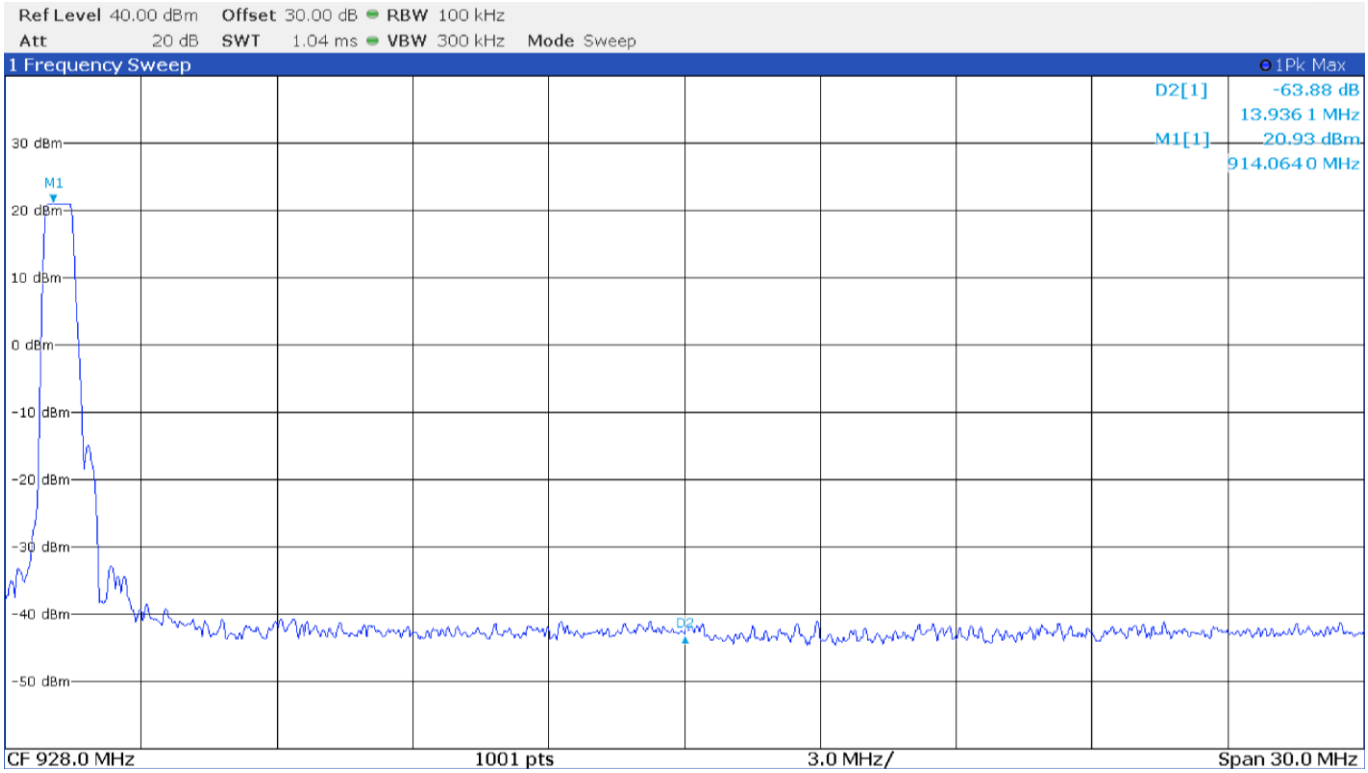


Figure 8.9-49: *Band edge spurious emissions at 928 MHz - LoRa 500 kHz BW*

Test data, continued

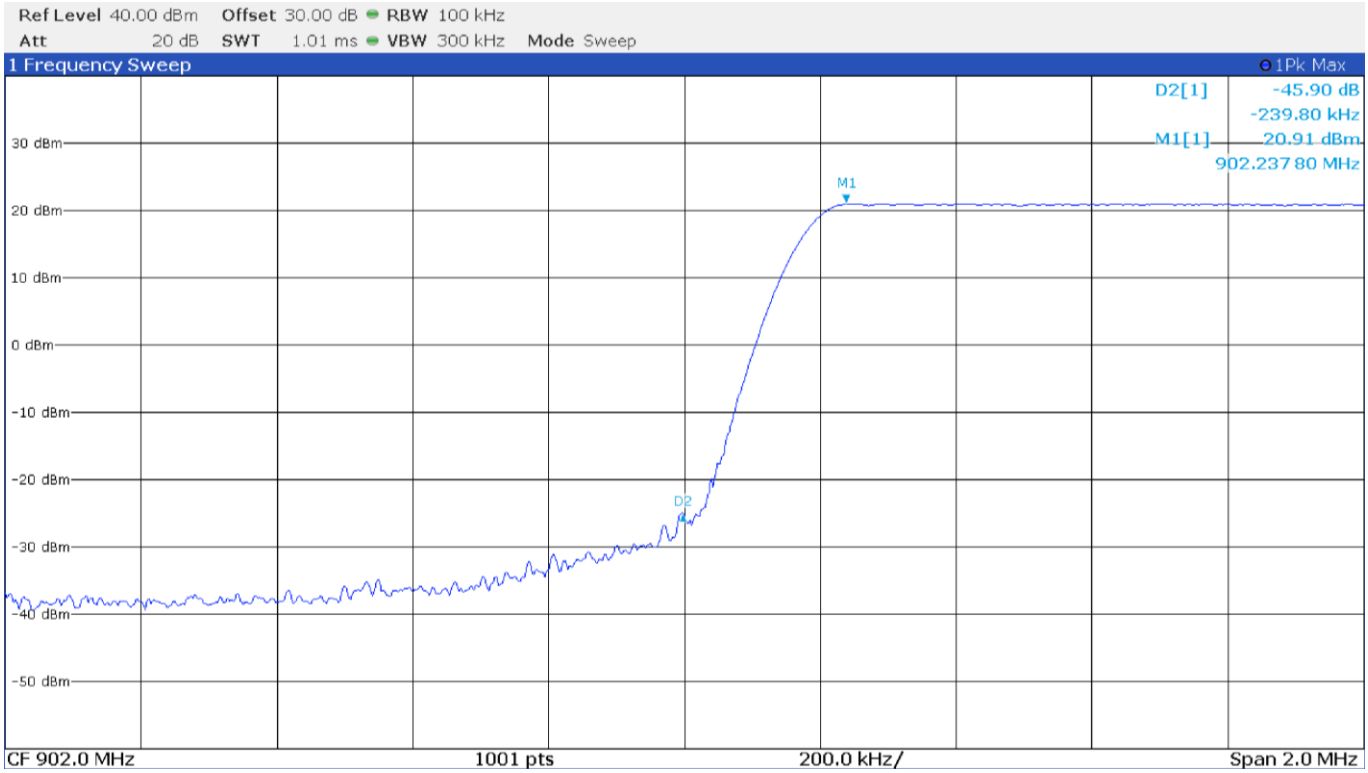


Figure 8.9-50: *Band edge spurious emissions at 902 MHz – LR-FHSS*

Test data, continued

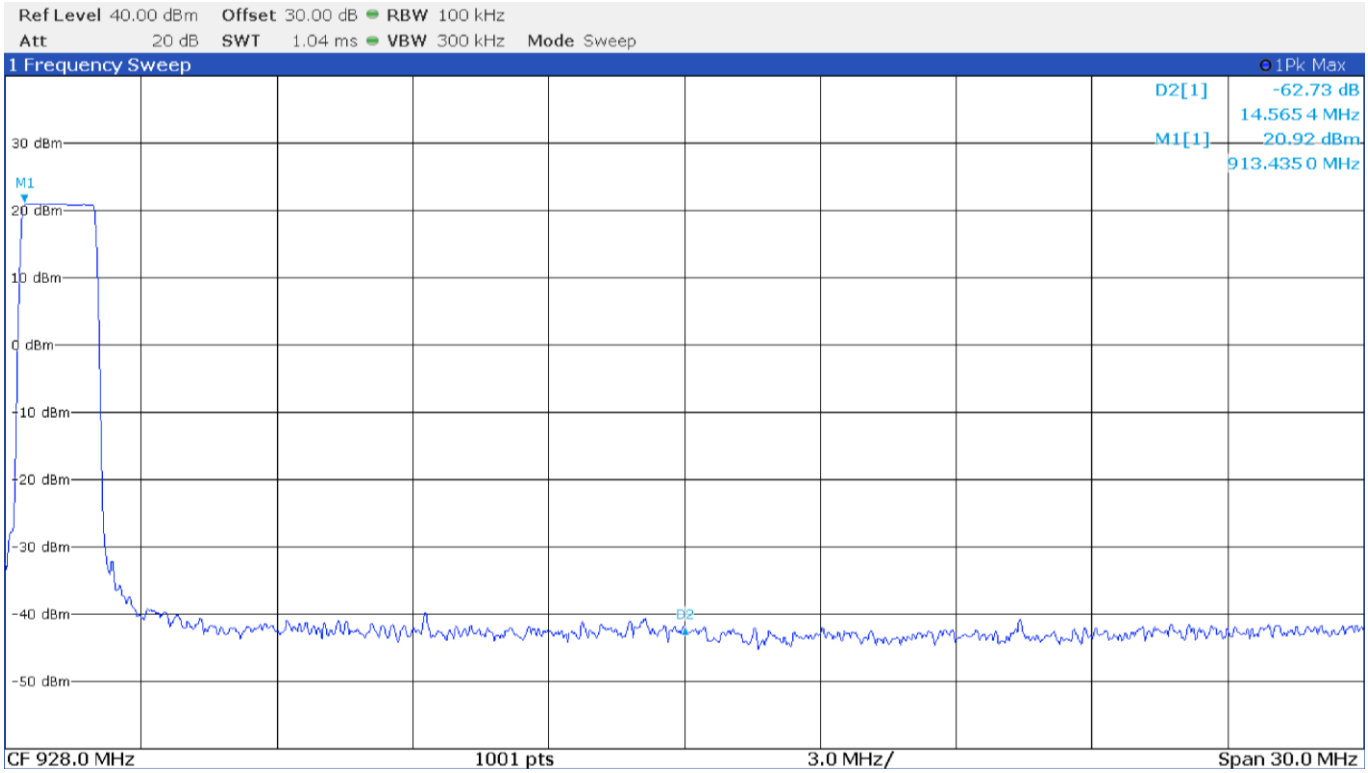


Figure 8.9-51: *Band edge spurious emissions at 928 MHz – LR-FHSS*

8.10 Power spectral density for digitally modulated devices

8.10.1 References, definitions and limits

FCC §15.247:

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RSS-247, Clause 5.2:

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

b. The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

RSS-247, Clause 5.3:

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

b. With the frequency hopping turned off, the digital transmission operation shall comply with the power spectral density requirements for digital modulation systems set out in of section 5.2(b) or section 6.2.4 for hybrid devices operating in the band 5725–5850 MHz.

8.10.2 Test summary

Verdict	Pass		
Tested by	P. Barbieri	Test date	June 12, 2024

8.10.3 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10.
The test was performed using method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep).
Spectrum analyser settings:

Resolution bandwidth:	3 kHz ≤ RBW ≤ 100 kHz
Video bandwidth:	≥3 × RBW
Frequency span:	1.5 times the OBW (Average)
Detector mode:	RMS
Trace mode:	Average
Averaging sweeps number:	100

8.10.4 Test equipment used

Equipment	Manufacturer	Model no.	Asset no.
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767

8.10.5 Test data

Table 8.10-1: *PSD results (antenna port measurement)*

Modulation	Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
LoRa 500 kHz BW	903.0	7.0	8.0	-1.0
	907.8	6.4	8.0	-1.6
	914.2	6.8	8.0	-1.2
LR-FHSS	903.0	6.9	8.0	-1.1
	907.8	6.9	8.0	-1.1
	914.2	6.9	8.0	-1.1

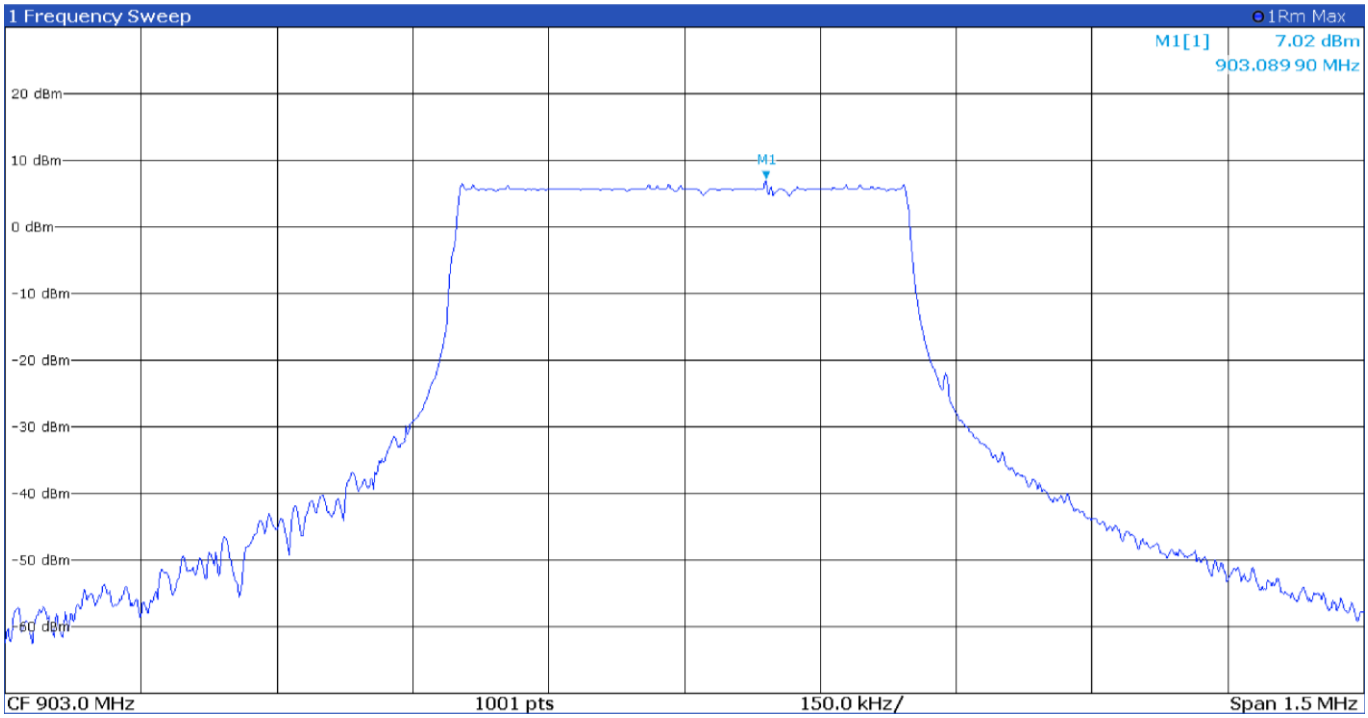


Figure 8.10-1: *PSD on low channel - LoRa 500 kHz BW*

Test data, continued

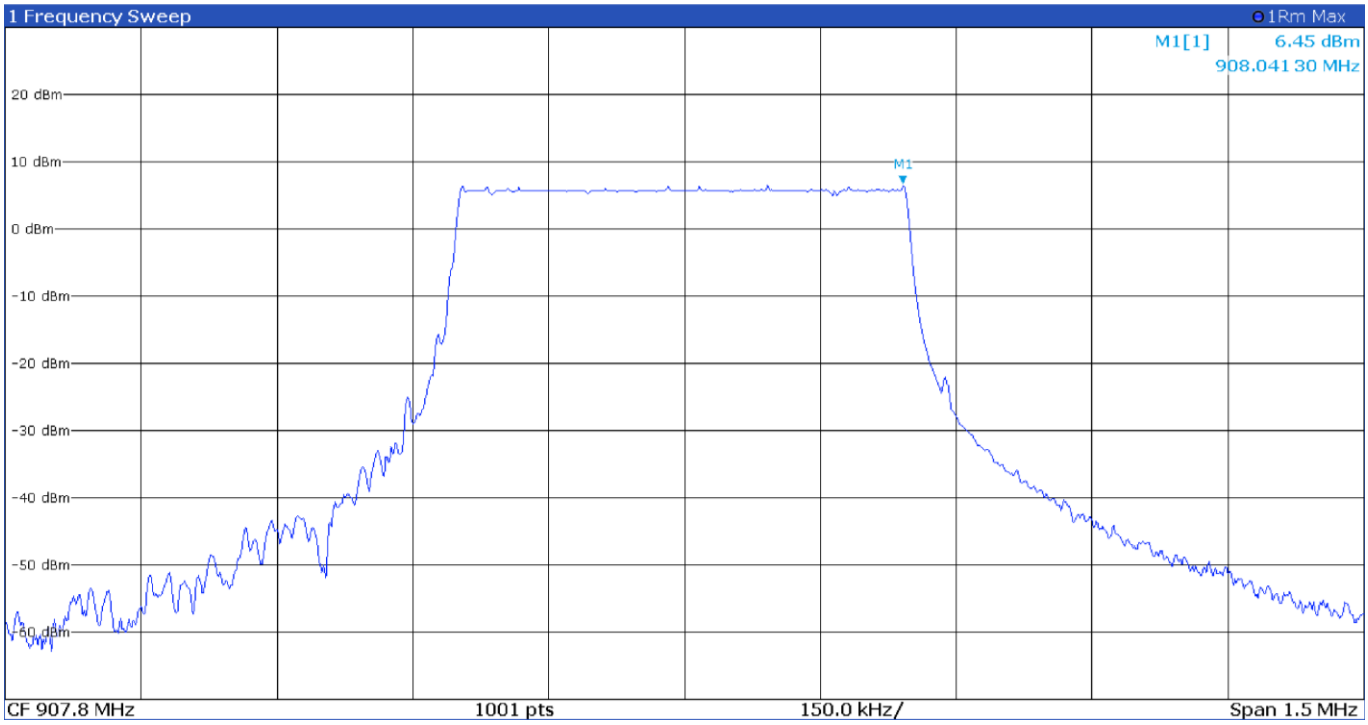


Figure 8.10-2: *PSD on mid channel - LoRa 500 kHz BW*

Test data, continued

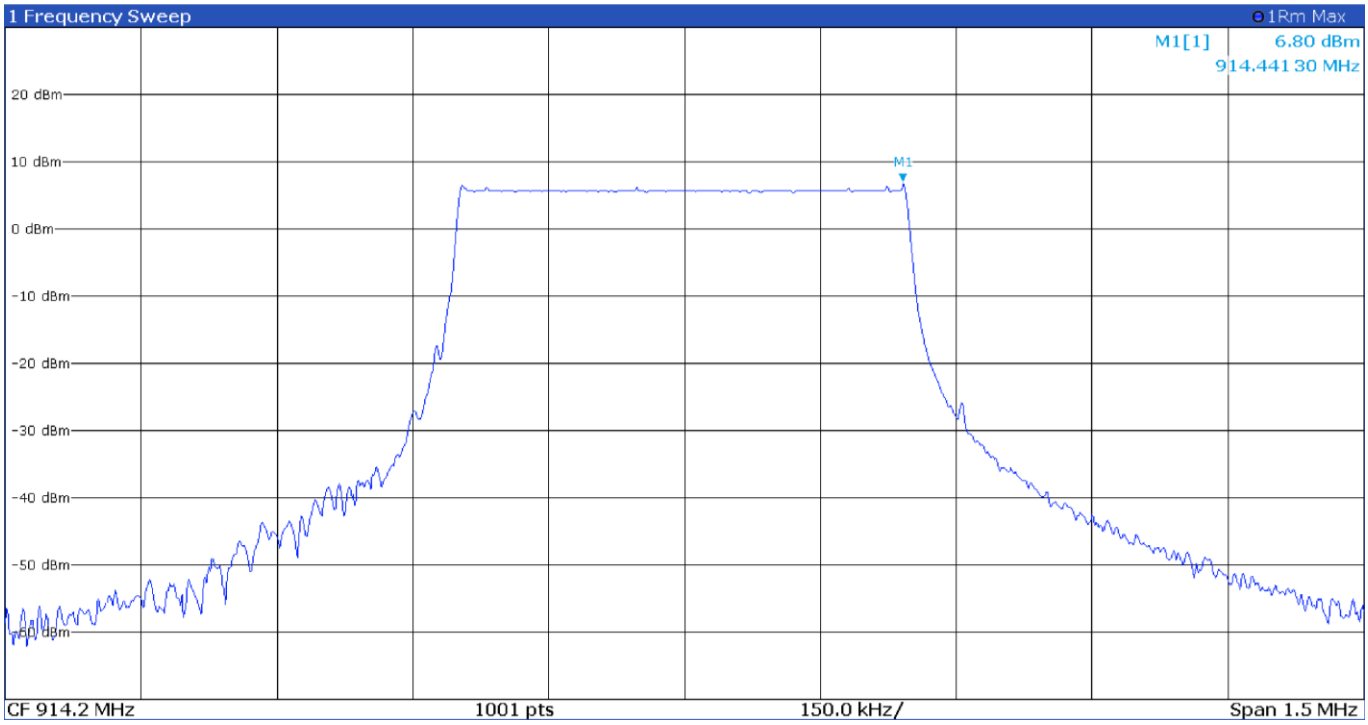


Figure 8.10-3: *PSD on high channel - LoRa 500 kHz BW*

Test data, continued

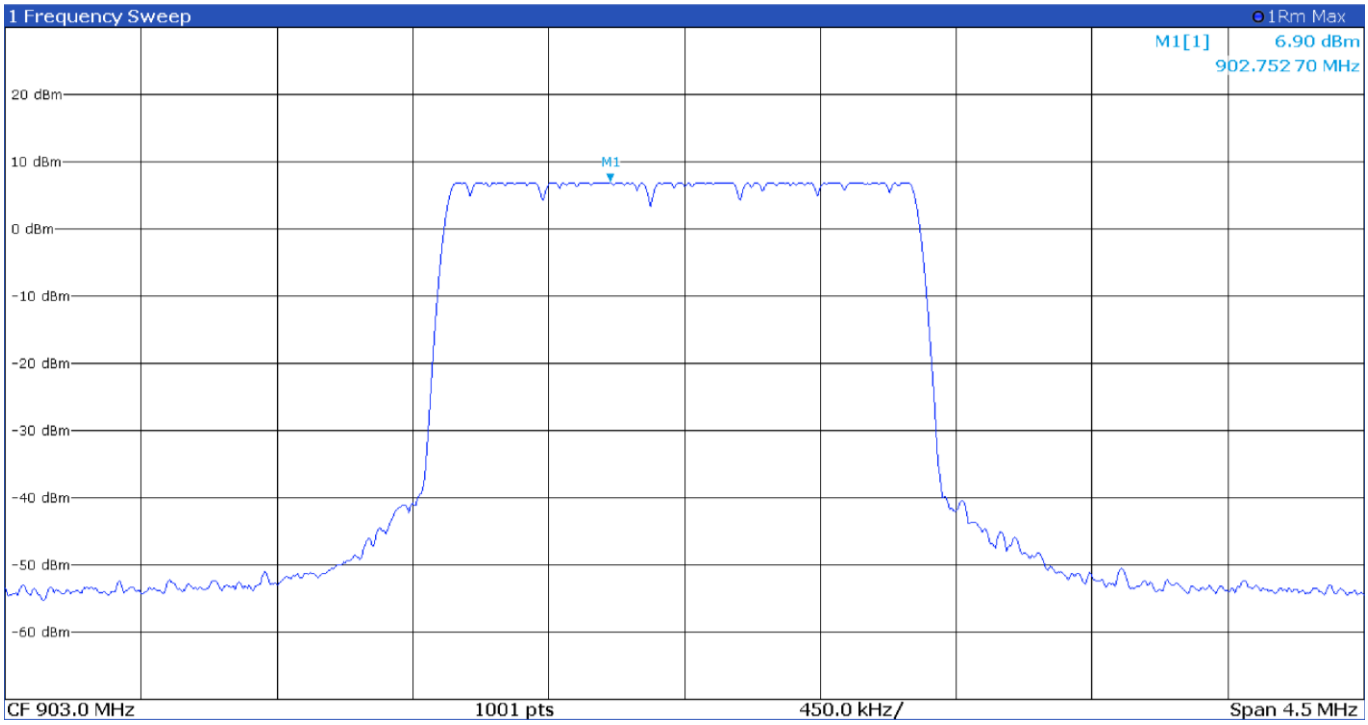


Figure 8.10-4: *PSD on low channel – LR-FHSS*

Test data, continued

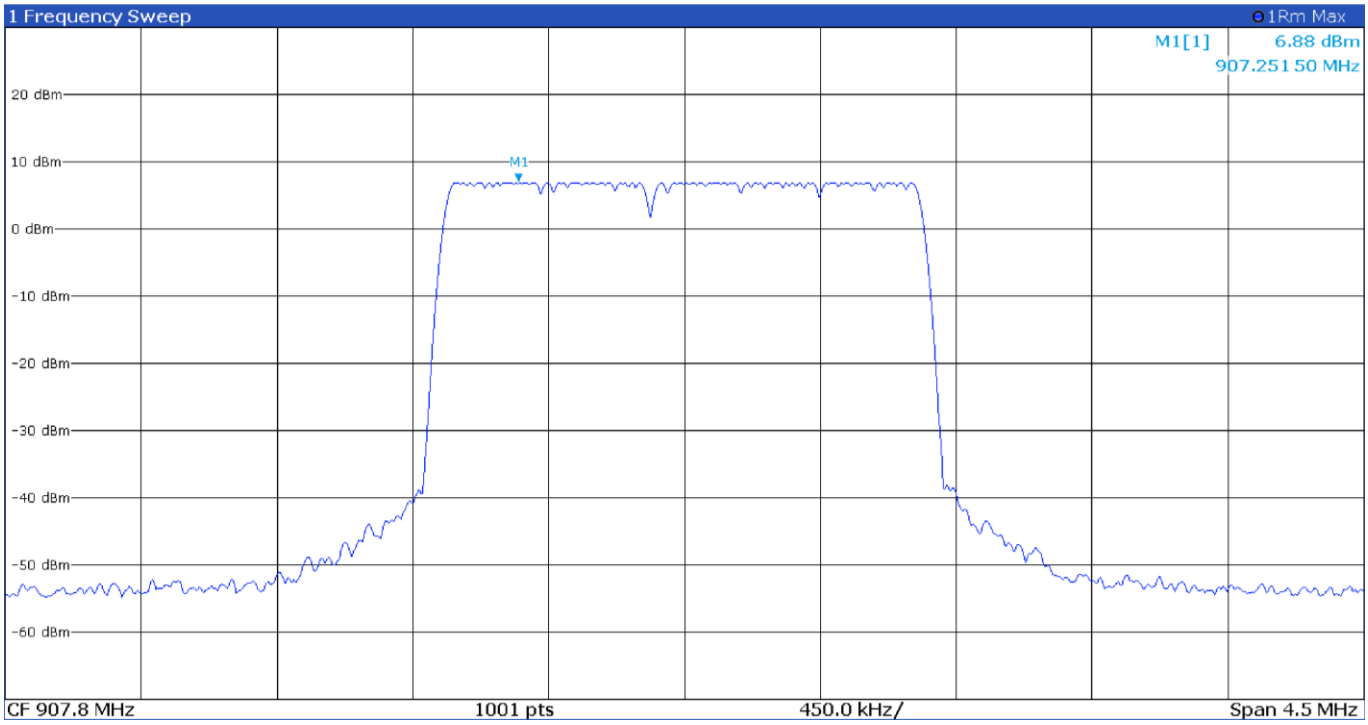


Figure 8.10-5: *PSD on mid channel – LR-FHSS*

Test data, continued

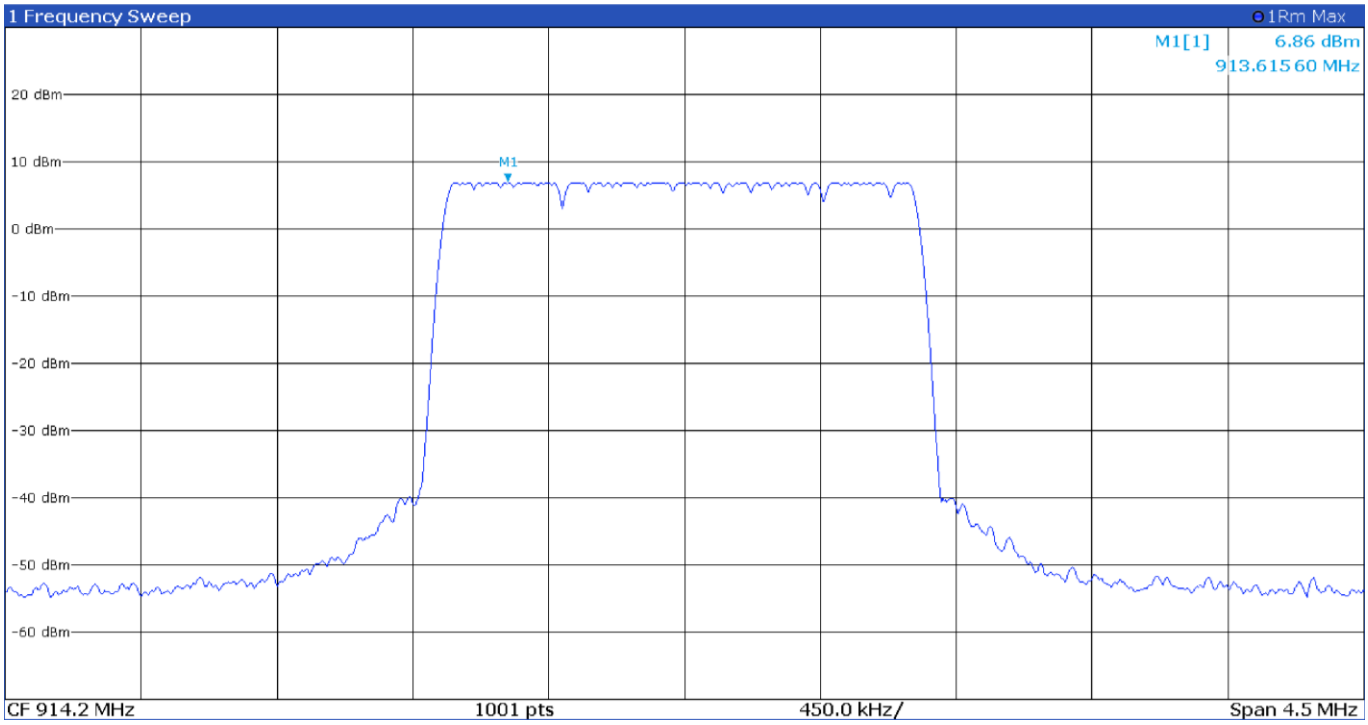
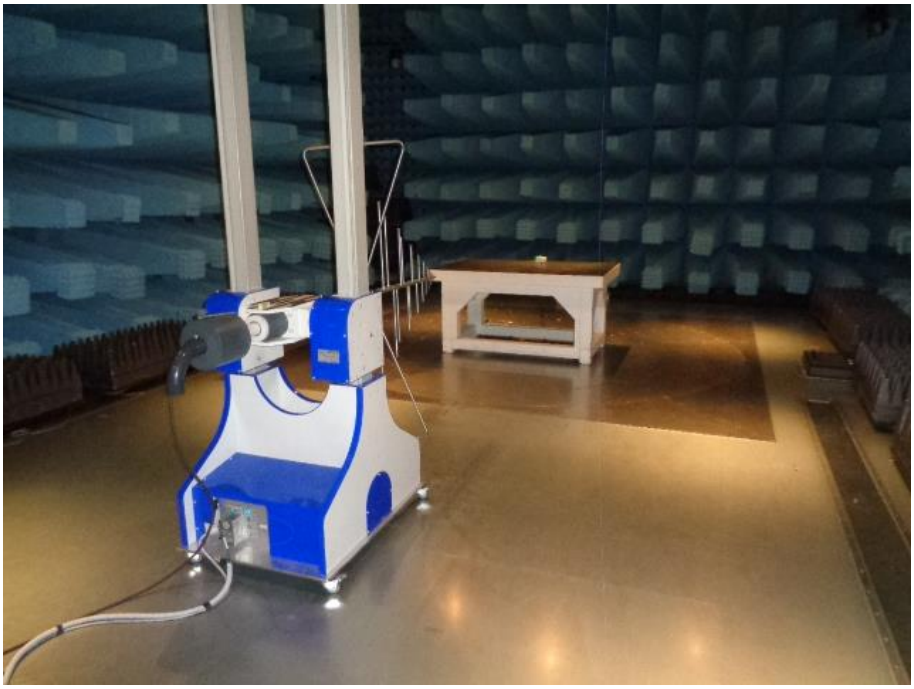


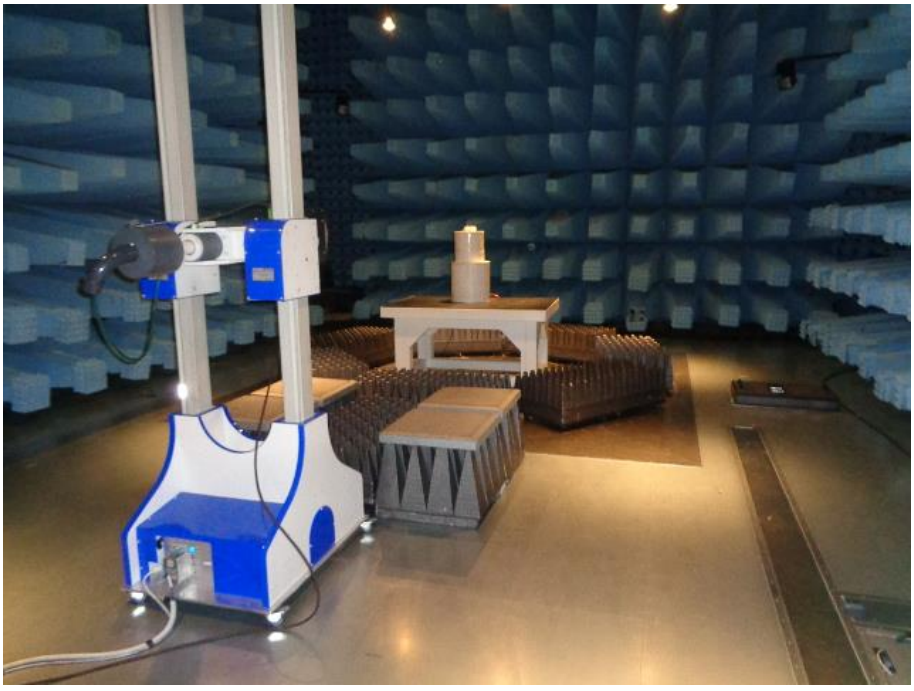
Figure 8.10-6: *PSD on high channel – LR-FHSS*

Section 9 EUT photos

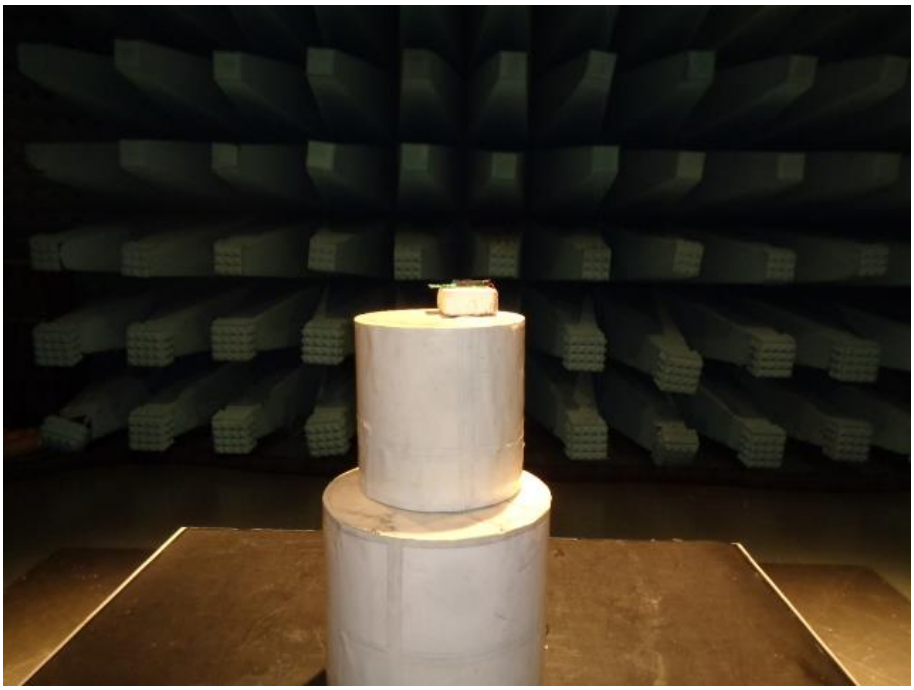
9.1 Set-up photos



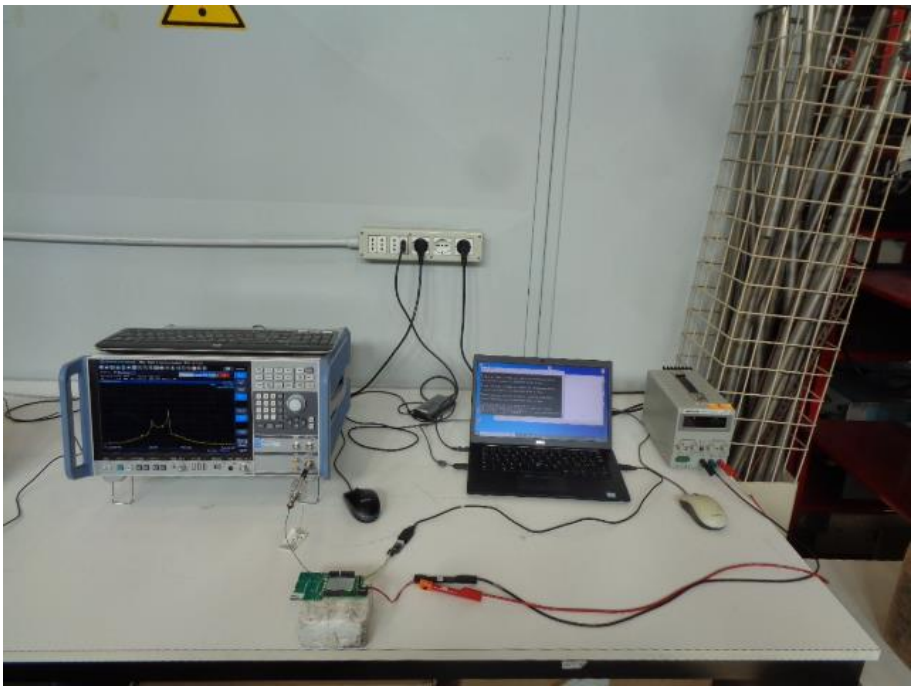
Test set-up for radiated emission test below 1 GHz



Test set-up for radiated emission test above 1 GHz

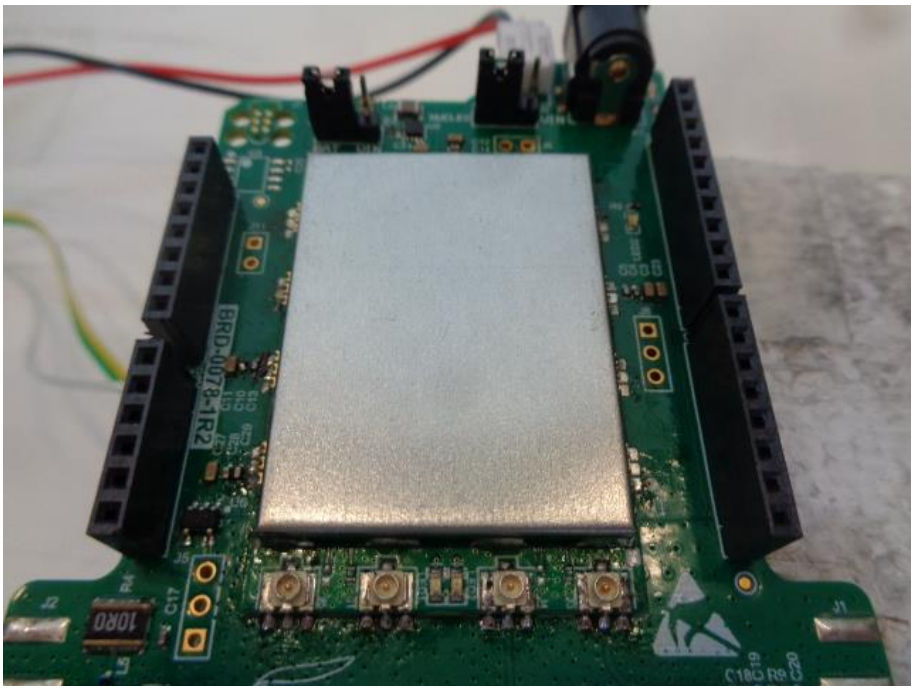


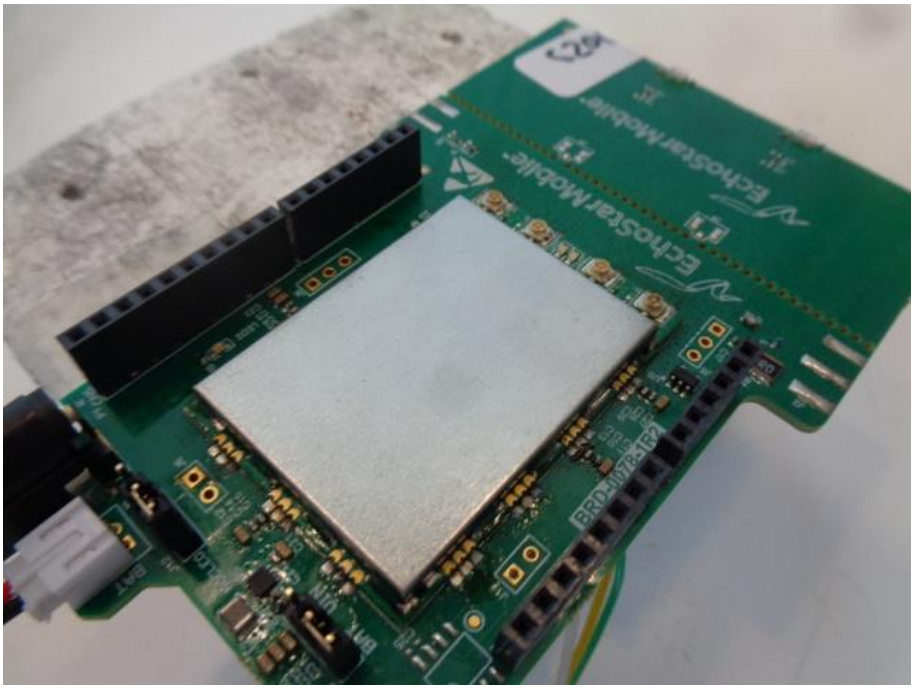
Test set-up for radiated emission test above 1 GHz



Test set-up for conducted emission test

9.2 External photos





End of the test report