Washington Laboratories, Ltd.

FCC PART 15.211 CERTIFICATION TEST REPORT

for the

SubSurface Profiler (SSP)

FCC ID: YSD-5840-SS-1122

REPORT# 15412-01 REV 2

Prepared for:

Reutech Mining

PO Box 686

Stellenbosch, Capetown 7599

Prepared By:

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FCC Part 15.211 Certification Test Report

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FCC ID: YSD-5840-SS-1122

DECEMBER 12, 2018

WLL REPORT# 15412-01 REV 2

Prepared by:

Mike Violette
Test Engineer

Reviewed by:

Steven D. Koster
President

ABSTRACT

This report has been prepared on behalf of Reutech Mining to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.211 (09/2018) of the FCC Rules and Regulations. This Certification Test Report documents the test configuration and test results for the Reutech Mining SubSurface Profiler (SSP) .

Testing was performed in an abandoned turnpike tunnel located near 3300 Pump Station Road, Waterfall, PA. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

The Reutech Mining SubSurface Profiler (SSP) complies with the limits for a Tunnel Radio Station FCC Part 15.211.

Revision History	Description of Change	Date
REV 0	Initial Release	DECEMBER 12, 2018
REV 1	Comments addressed	DECEMBER 18, 2018
REV 2	Comments addressed	May 29, 2018

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1 INTRODUCTION

1.1 COMPLIANCE STATEMENT

The Reutech Mining SubSurface Profiler (SSP) complies with the requirements for a Tunnel Radio Station under FCC Part 15.211.

1.2 TEST SCOPE

Tests for radiated and conducted emissions were performed. All measurements were performed in accordance with the 2014 version of ANSI C63.4. and the 2013 version of ANSI C63.10. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 CONTRACT INFORMATION

Customer:	Reutech Mining
Address	PO Box 686
	Stellenbosch, Capetown 7599
Purchase Order Number:	Invoice request - Refer to PO44384
Quotation Number:	70341

1.4 TEST DATES

Testing was performed on the following date(s): 20 September 2018

1.5 TEST AND SUPPORT PERSONNEL

Washington Laboratories, LTD	Mike Violette
Customer Representative	Jan de Beer

1.6 ABBREVIATIONS

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	Amperes
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**C**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga – prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo – prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega – prefix for 10^6 multiplier
m	**M**eter
μ	**m**icro – prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 EQUIPMENT UNDER TEST

2.1 EUT IDENTIFICATION & DESCRIPTION

Table 1: Device Summary

Item	Radar sensing device for determining subsurface features in mines and tunnels
Manufacturer:	Reutech Mining
FCC ID:	YSD-5840-SS-1122
Model:	SubSurface Profiler (SSP)
Serial Number of Unit Tested:	2017B1/012
Model:	5840-SS-1000V01.00
FCC Rule Parts:	§15.211
Frequency Range:	278.125 MHz to 1.001 GHz
Maximum Output Power:	58.9 mW (17.7 dBm)
Modulation:	Swept Frequency CW
FCC Emission Designator:	N/A
Keying:	Manual
Type of Information:	None
Number of Channels:	N/A
Power Output Level	Fixed
Highest TX Spurious Emission:	<40dBuV/m
Highest RX Spurious Emission:	<40dBuV/m
Antenna Connector	• Antenna boresight gain 4.65 dB • 60° half power beam width
Antenna Type	Integrated
Interface Cables:	None
Maximum Data Rate	N/A
Power Source & Voltage:	15VDC Battery Supply

Table 2: Clocks and Oscillators

Frequency (MHz)	Source
40MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) Used by the DDS and CC3100 Wi-Fi
10MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) via AD9513 800 MHz Clock Distribution IC Used by the STM32F407 Processor
1.25MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) via AD9513 800 MHz Clock Distribution IC Used by the LT8601 DC/DC converter

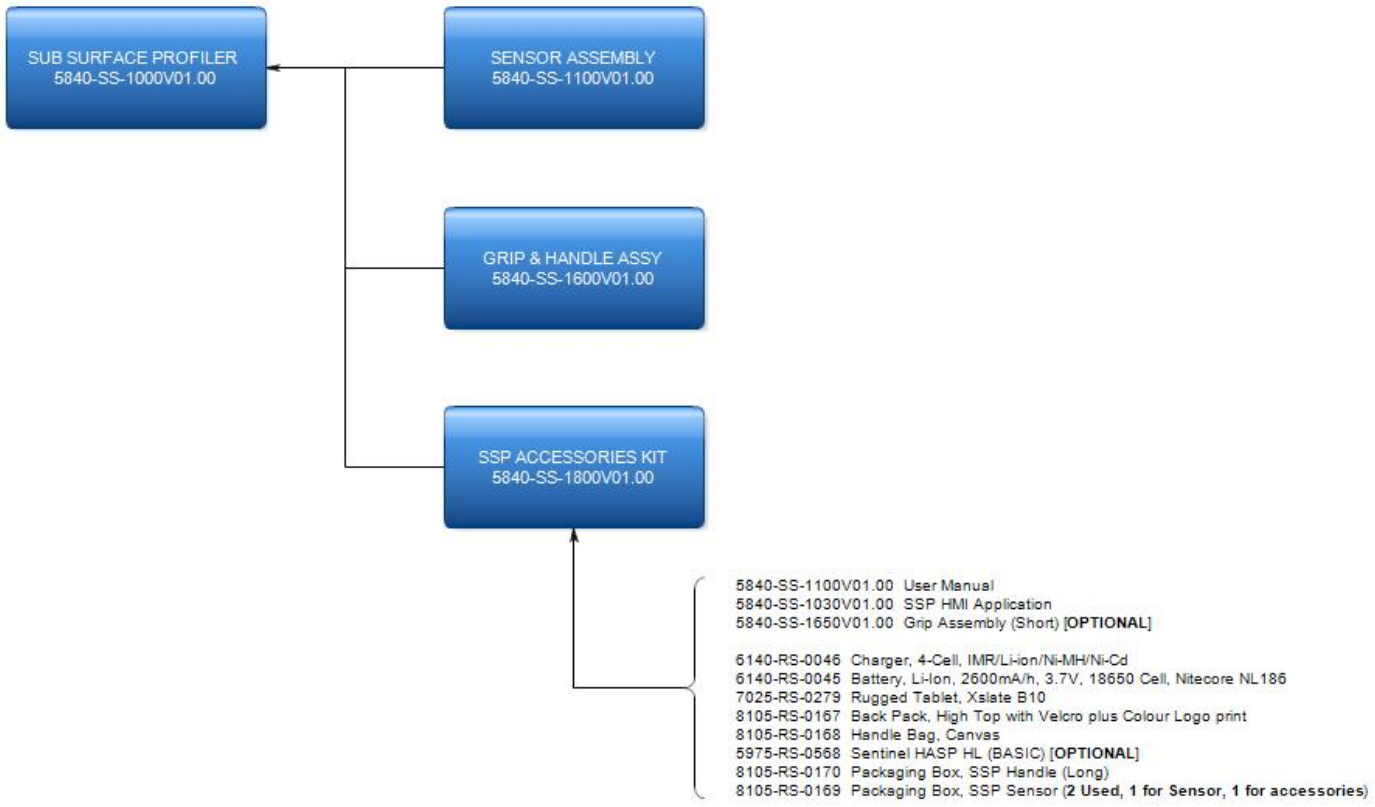

Figure 1. System Diagram

2.2 TEST CONFIGURATION

The SubSurface Profiler (SSP) was set up in an abandoned turnpike tunnel in Waterfall, PA. The unit was set up 363 meters from the opening of the tunnel and arranged for maximum emissions at the tunnel opening. The device was set for continuous transmission and was communicating with a companion tablet that receives the image data from the SSP. The EUT sweep could not be stopped for testing.

Both the swept signal and the WiFi transmitter were operating simultaneously.

2.3 TEST LOCATION

Measurements herein were performed in an abandoned turnpike tunnel in Waterfall, PA. Images of the tunnel entrance are shown in the following figures.

Figure 2. Tunnel Entrance

Figure 3. Tunnel Entrance

Figure 4. Tunnel Entrance

2.4 MEASUREMENTS

2.4.1 References

ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.10 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.5 MEASUREMENT UNCERTAINTY

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a, b, c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where U = expanded uncertainty

k = coverage factor

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 3 below.

Table 3: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, , CISPR32, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, , CISPR32, CISPR14, FCC Part 15	±4.55 dB

3 TEST EQUIPMENT

Table 4 shows a list of the test equipment used for measurements along with the calibration information.

Table 4: Test Equipment List

Test Name:	**Conducted Emissions Voltage**	Test Date:	**09/20/2018**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	4/21/2019
125	SOLAR - 8028-50-TS-24-BNC	LISN	5/23/2019
126	SOLAR - 8028-50-TS-24-BNC	LISN	5/23/2019
53	HP - 11947A	LIMITER TRANSIENT	2/1/2019
Test Name:	**Radiated Emissions**	Test Date:	**09/21/2018**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	4/21/2019
626	ARA - DRG-118/A	ANTENNA HORN	10/7/2018
26	EMCO - 3110B	ANTENNA BICONICAL	1/5/2019
28	EMCO - 3146	ANTENNA LOG PERIODIC	12/13/2018
558	HP - 8447D	AMPLIFIER	2/9/2019
885	UTUTIFLEX Micro Coax	0.5m SMA-SMA RF Coaxial Cable	04/09/2019
892	SMA-SMA RF Coaxial Cable	SMA-SMA RF Coaxial Cable	04/09/2019

4 TEST RESULTS

The plots below show the results of testing for compliance with a Tunnel Radio System in accordance with FCC Part 15.211 (9/2018).

4.1 RADIATED EMISSIONS: (FCC PART §15.211)

Emissions must meet the general radiated emissions of 15.209.

Per guidance received from the FCC, restricted band frequencies do not apply to 15.211

4.1.1 Test Procedure

Pre-scans were performed at a distance of 3m to determine worst-case orientation of the device, which was with the roller long dimension perpendicular to the tunnel opening as shown in the test setup photo.

The procedure was to monitor the emissions at the tunnel entrance until the quasi-peak levels dropped below the 15.209 limit. This distance was found to be 1193 feet or 364 meters. The measurement antenna was set up at the same location during the pre-scan and the final data measurement.

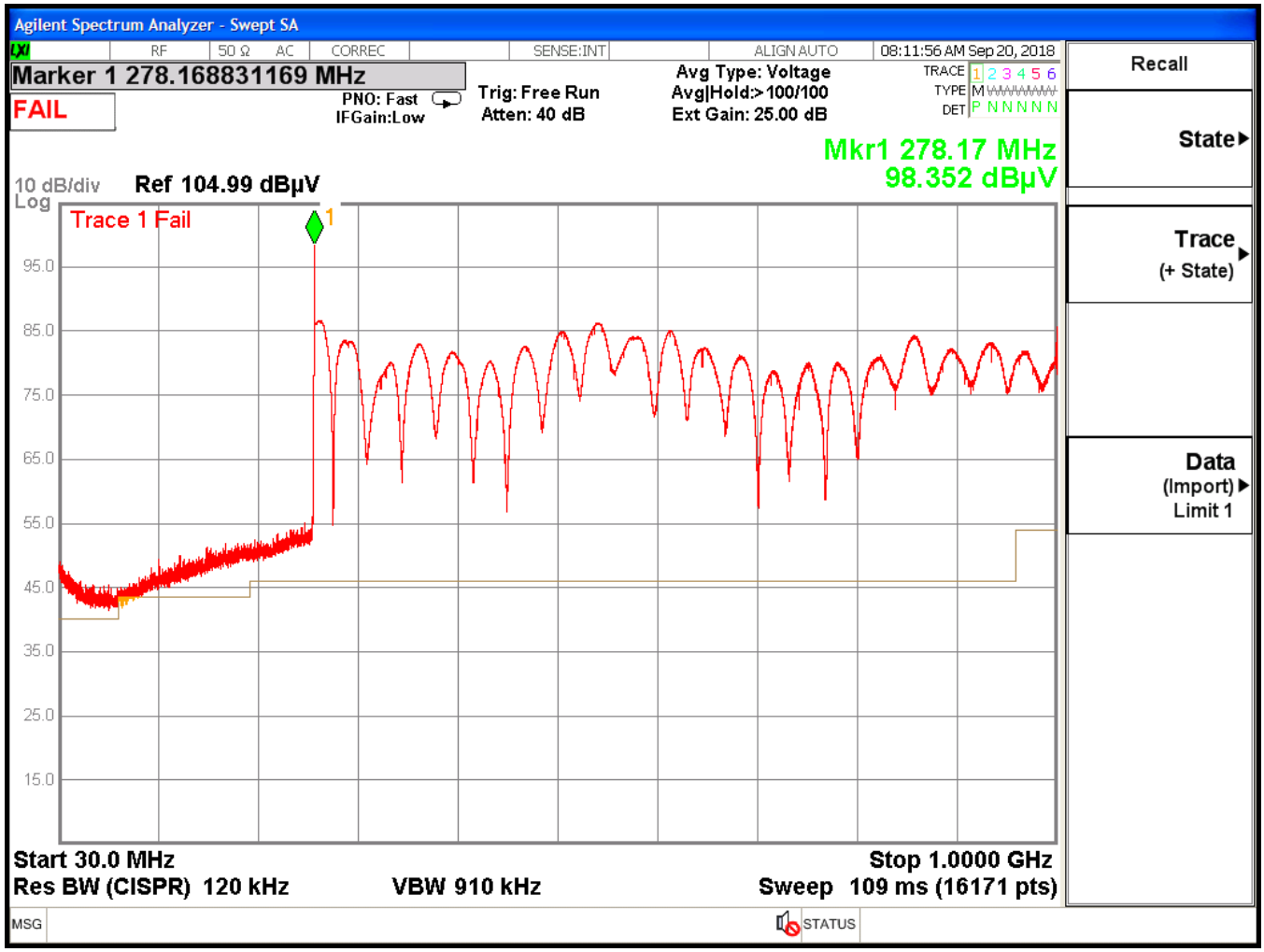

Figure 5. 3m Pre scan Maximum EUT orientation Horizontal (Peak)

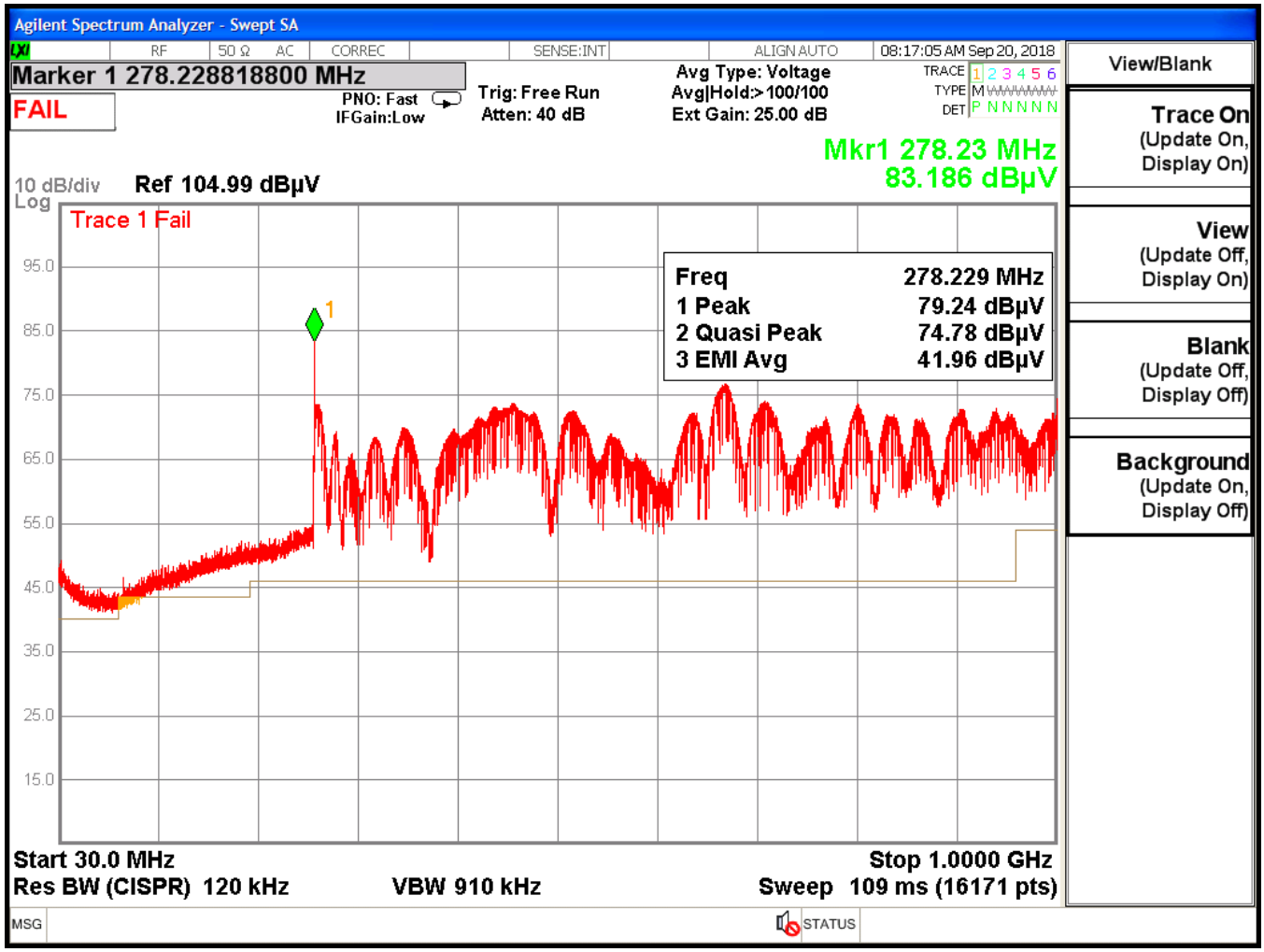

Figure 6. 3m Pre scan Maximum EUT orientation Vertical (Peak)

The EUT was placed 364 meters inside the tunnel and oriented for maximum emissions that were determined at a 3m scanning distance.

Receiving antennas were mounted on a tripod. The height of the antenna was set to 2 meters. The height of the antenna was scanned, but the emissions did not noticeably vary.

Both the horizontal and vertical field components were measured.

The emissions were measured using the following resolution bandwidths:

Table 5: Spectrum Analyzer Settings

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>100 kHz
>1000 MHz	1 MHz	1MHz (Peak)

Cable correction, pre-amplifier and antenna factors were input into the spectrum analyzer. The spectrum analyzer readings in dBuV represent the actual field strength in dBuV/m.

Peak readings are shown in the following figure. The peak-to quasi-peak difference was determined to be approximately 6.2 dB. The maximum level of emissions was found at 293.5 MHz with a quasi-peak value of 41.2 dBuV/m. The remaining marker represent the Peaks in the remainder of the transmit band.

Regrettably the display table was not 'turned off' when the scan was saved, however, the market table shows the peak emissions.

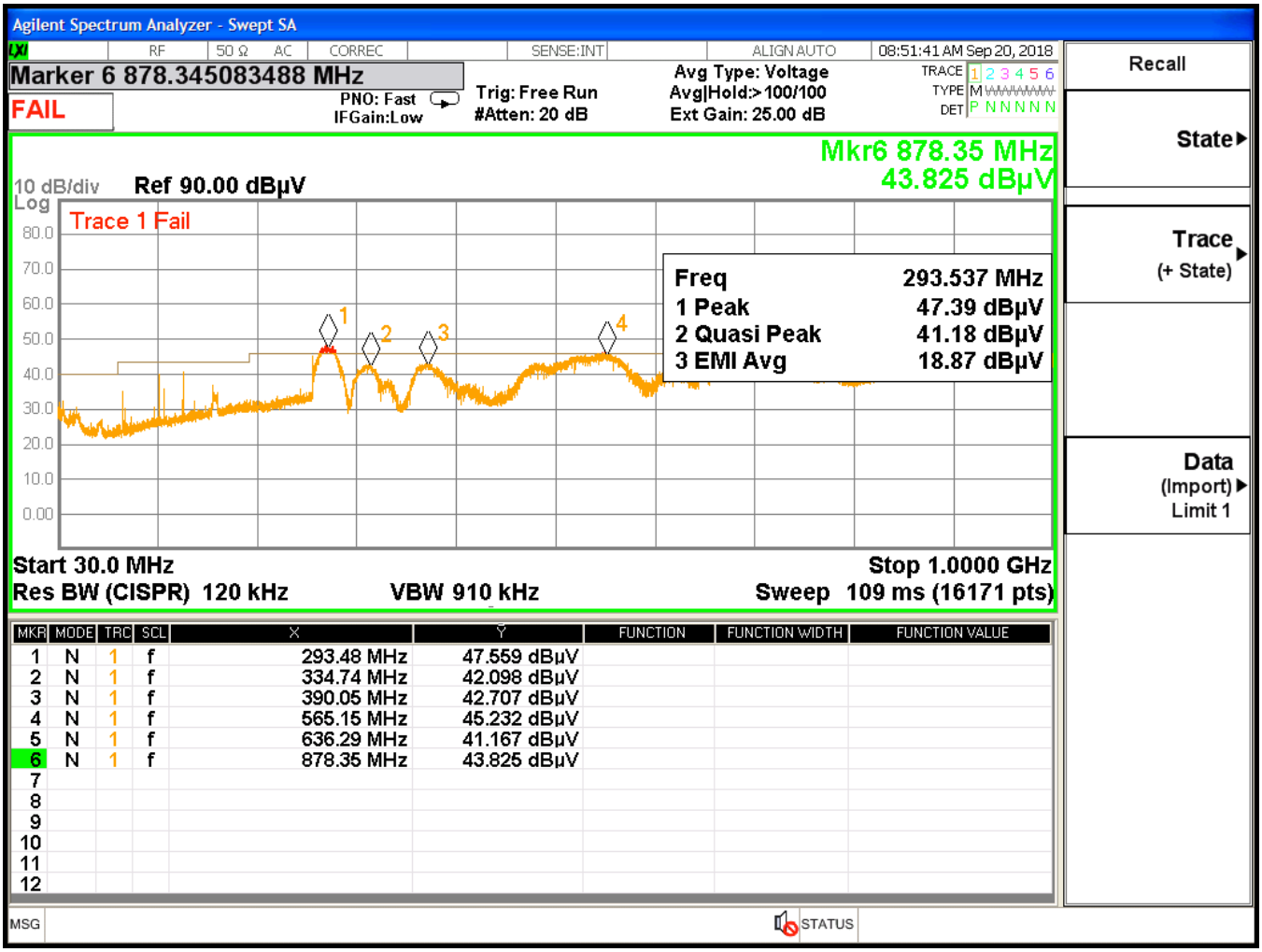

Figure 7. Horizontal Emissions. EUT positioned 364m Inside Tunnel

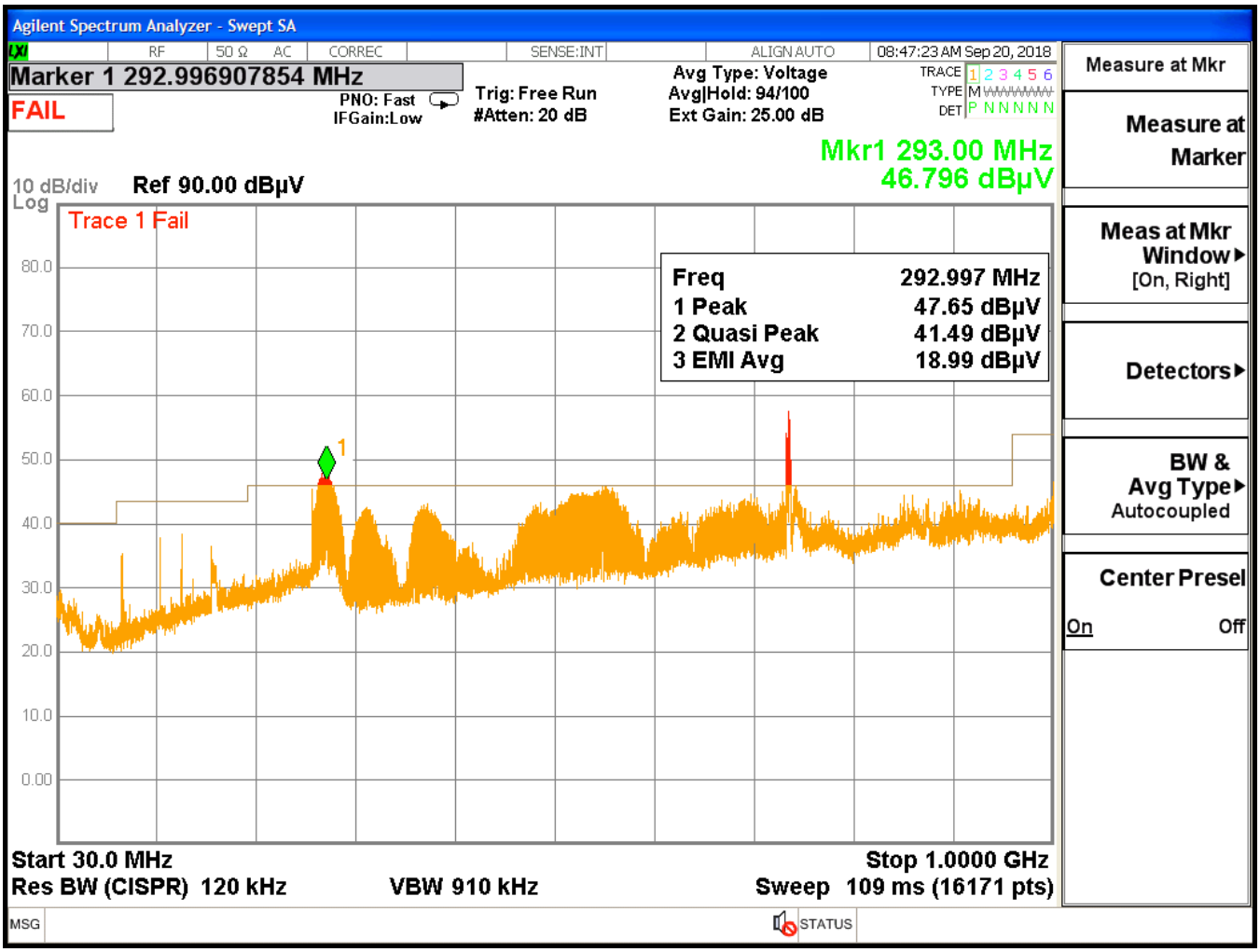

Figure 8. Vertical Emissions. EUT positioned 364m Inside Tunnel

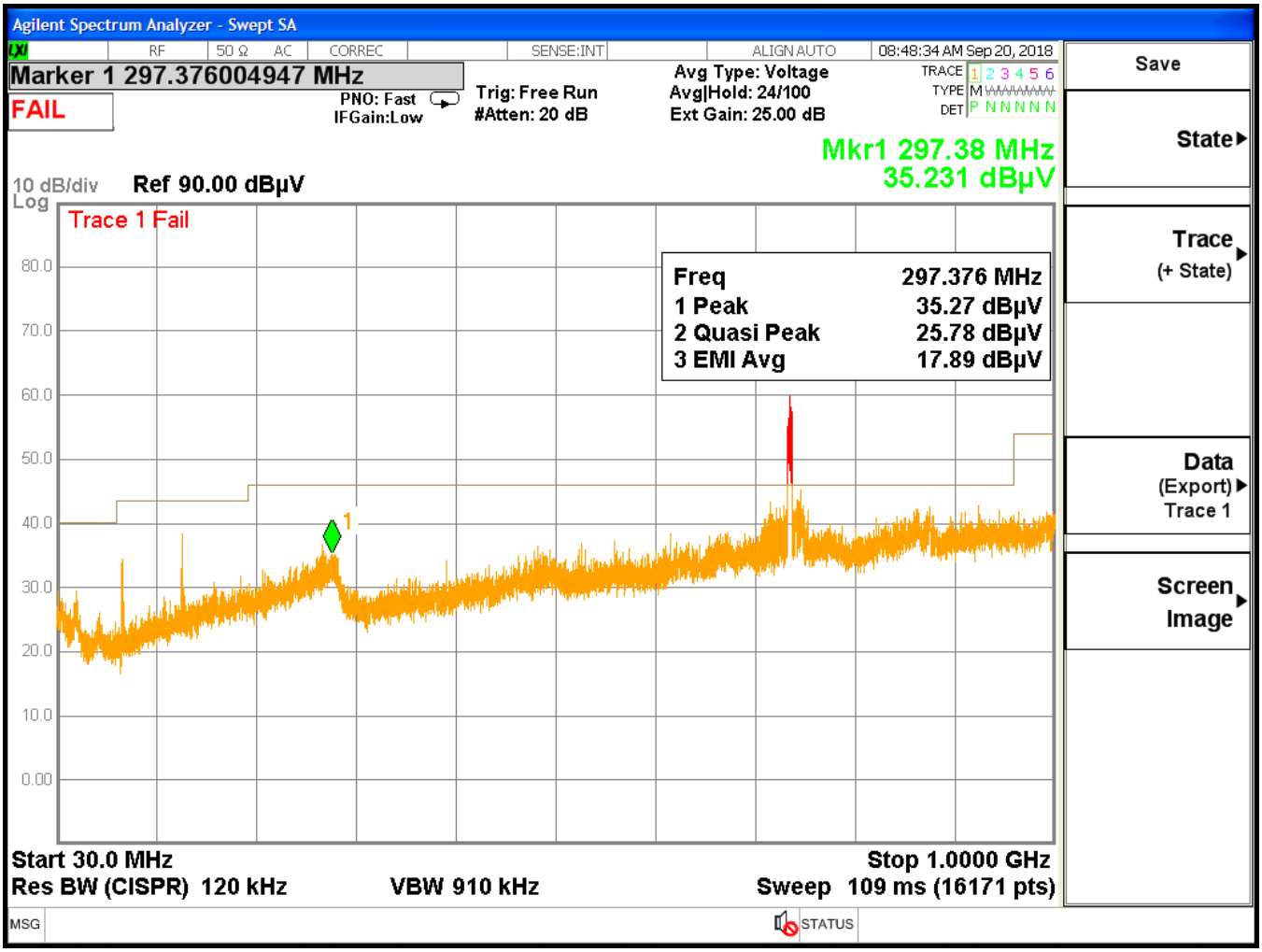

Figure 9. Ambient Vertical

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.

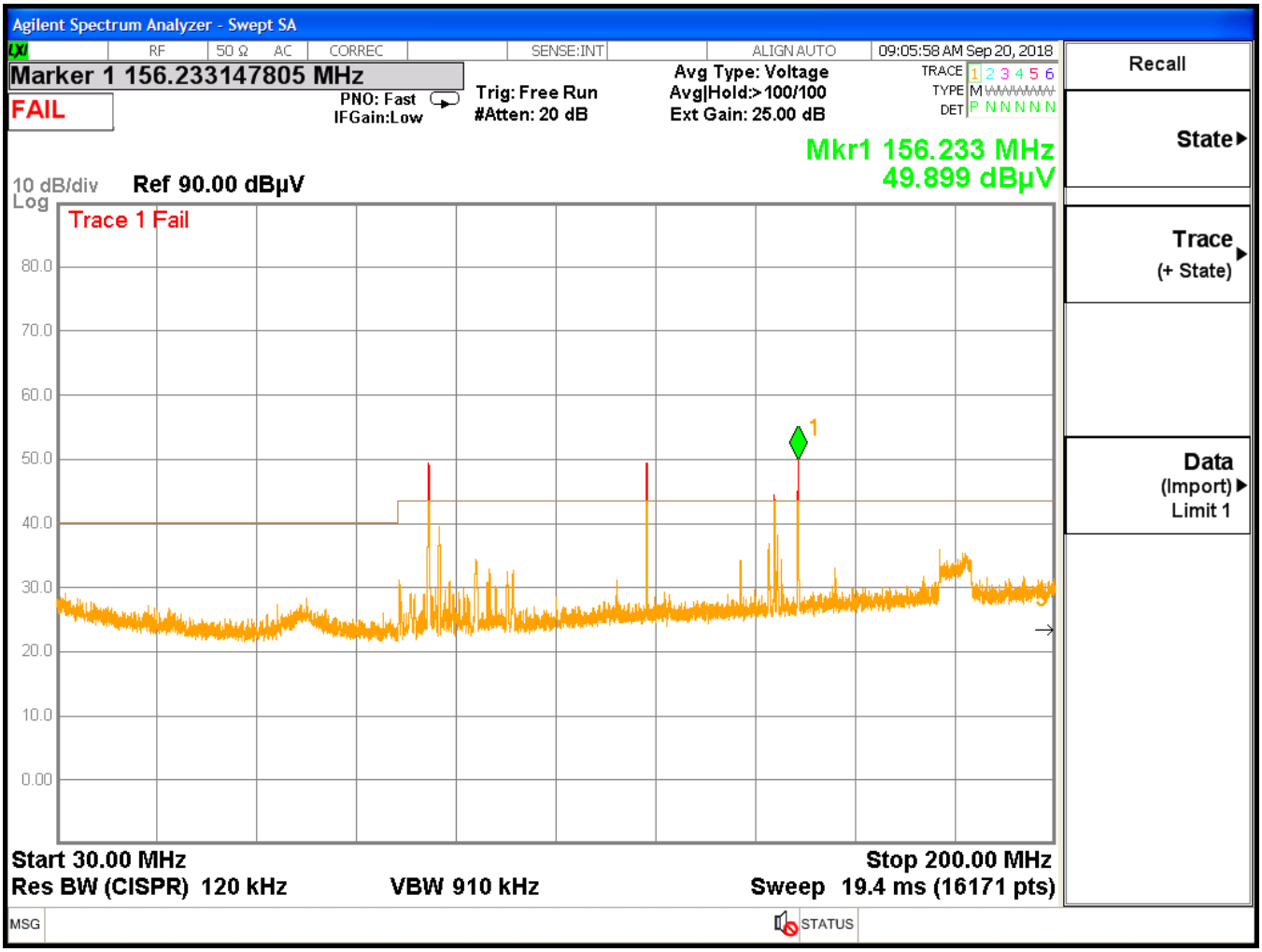

Figure 10. Spurious Horizontal Radiated Field Strength 30-200MHz

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.

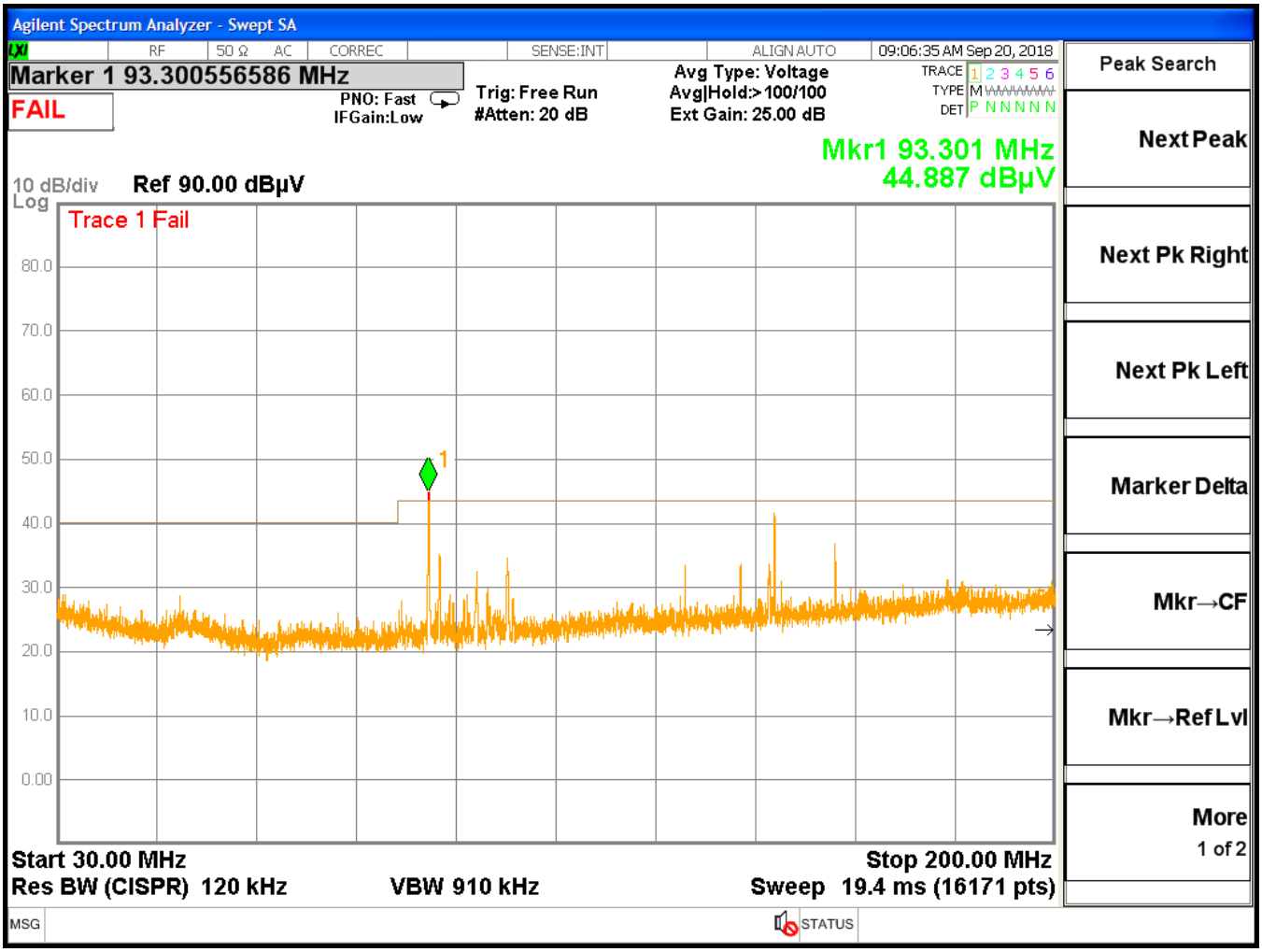

Figure 11. Spurious Vertical Radiated Field Strength 30-200MHz

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.

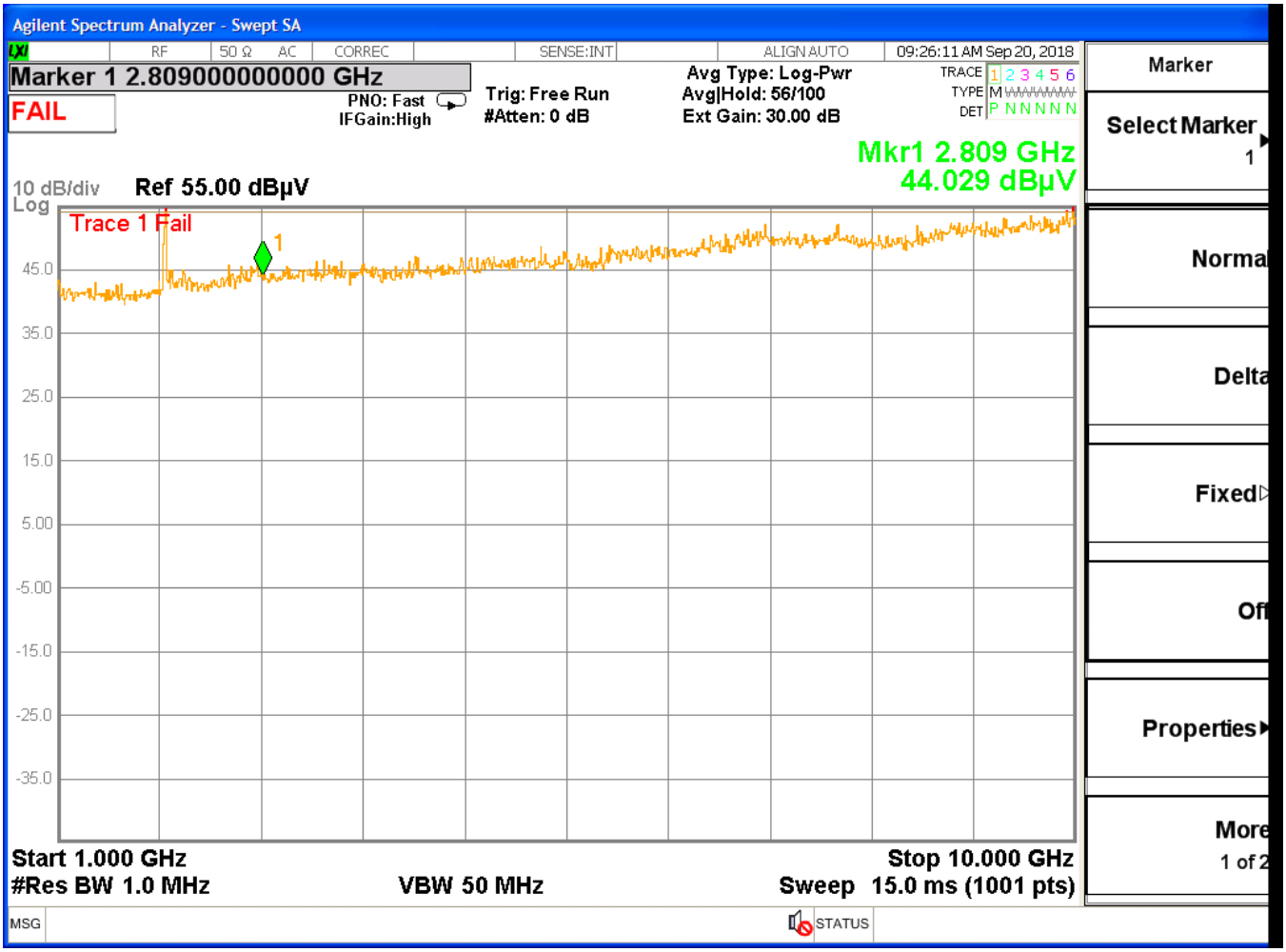

Figure 12. Spurious Horizontal Radiated Field Strength 1-10GHz

Fundamental emission of WiFi device present on the plot at 2.4 GHz.

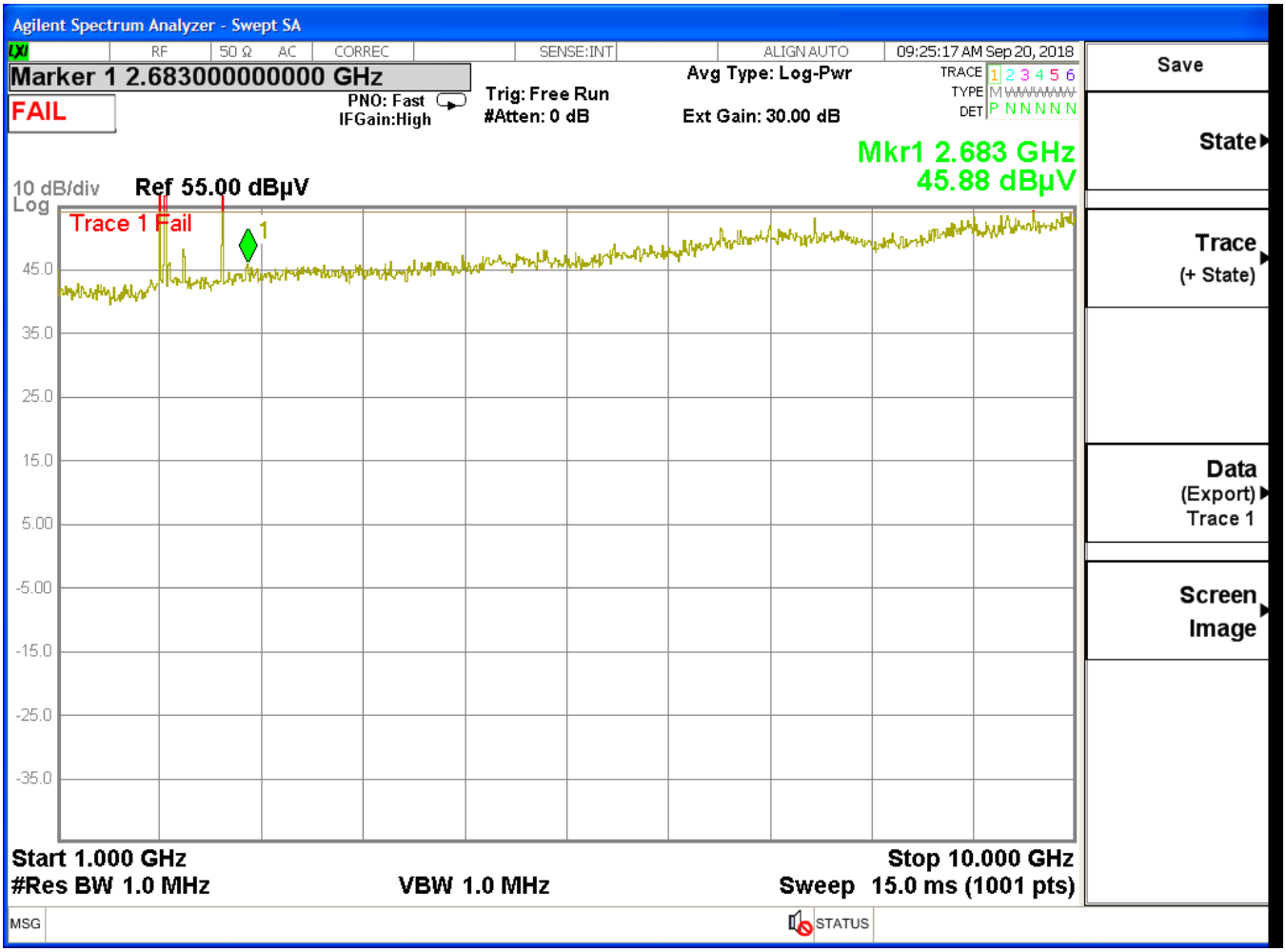

Figure 13. Spurious Vertical Radiated Field Strength 1-10GHz

Fundamental emission of WiFi device present on the plot at 2.4 GHz.

4.2 AC CONDUCTED EMISSIONS

The EUT is powered by rechargeable batteries. The charger was measured for compliance to the conducted emissions requirements of FCC Part 15B. The device does not operate while charging.