



FCC Certification Test Report
For the
Reutech Radar Systems
Esprit RF Beacon

FCC ID: YSD-5840-HG-9120

WLL Report# 15809-01 Rev 0
February 20, 2019

Prepared for:

Reutech Radar Systems
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Stellenbosch, Capetown 7599 South Africa

Prepared By:
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Prepared by:



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Abstract

This report has been prepared on behalf of Reutech Radar Systems to demonstrate Part 90 compliance. The test report was constructed with guidance from Part 90 Subpart I-Private Land Mobile Radio Services general technical requirements section of the FCC Rules and Regulations (10/2015).

Testing was performed at Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

These tests are accredited and meet the requirements of ISO/IEC 17025:2005 as verified by the ANSI-ASQ National Accreditation Board/ANAB. Refer to certificate and scope of accreditation AT-1448.

Revision History	Reason	Date
Rev 0	Initial Release	February 20, 2019
Rev 1	Comments addressed	March 1, 2019
Rev 2	Comments addressed	May 29, 2019

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1 Introduction

1.1 Compliance Statement

The Reutech Radar Systems Esprit RF beacon was tested to the requirements of Part 90 Private Land Mobile Radio Services Subpart I--Private Land Mobile Radio Services general technical requirements section of the FCC Rules and Regulations (10/2015).

1.2 Test Scope Summary

The following tests were performed using the applicable parts of the FCC rules as guidance:

Total Power	FCC Part 90.101
Emission Bandwidth	FCC Part 90.209(b)
Unwanted Radiation	FCC Part 90.210
Frequency Tolerance	FCC Part 90.213(a)
Transient Frequency Behavior	FCC Part 90.214

Additional guidance was obtained from the following references:

- Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook), September 2015 Revision of the May 2013 Edition
- C63.26:2015 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

1.3 Contract Information

Customer:	Reutech Radar Systems PO Box 686, Stellenbosch Capetown, 7599 South Africa
Purchase Order Number:	Deposit
Quotation Number:	70367B

1.4 Test Dates

Testing was performed on the following date(s):	11/26/2018 – 12/3/2018
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1.5 Test and Support Personnel

Washington Laboratories, Ltd.	Nikolas Allen
Customer Representative	Leon Nel

1.6 Abbreviations

A	A mpere
ac	a lternating c urrent
AM	A mplitude M odulation
Amps	A mpere s
b/s	b its per second
BW	B and W idth
CE	C onducted E mission
cm	c entimeter
CW	C ontinuous W ave
dB	d eci B el
dc	d irect c urrent
EMI	E lectromagnetic 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 alyzer
V	V olt

2 Equipment Under Test

2.1 EUT Identification

The results obtained relate only to the item(s) tested.

Table 1: Overview of Equipment Under Test

ITEM	DESCRIPTION
Manufacturer:	Reutech Radar Systems
EUT Name	Esprit RF Beacon
FCC ID:	YSD-5840-HG-9120
Model:	Esprit RF Beacon
FCC Rule Parts:	Part 90
Frequency Range:	9.5 GHz to 9.95 GHz
Output Power Mfg. Stated	0.013 mW (11.25dBm)
Measured Output Power:	28.25dBm EIRP
Modulation:	Frequency Modulated Continuous Wave (FMCW)
Emission Bandwidth:	4.64MHz (6MHz authorized)
Keying:	Automatic
Type of Information:	None
Number of Channels:	NA – device receives and rebroadcasts another signal
Antenna Connector	SMA
Antenna Type	Pyramidal Horn Antenna
Antenna Gain	17 dB
Frequency Tolerance:	0.125%
Emission Designator:	308MF0N
Interface Cables:	Power
Power Source & Voltage:	12 V d.c.

2.2 EUT Description

The Esprit RF Beacon is a stand-alone X-Band transceiver that receives the 9.5GHz to 9.95GHz RF signal broadcast by the Esprit Radar, delays it via a fiber optic delay line, adds RF gain and re-broadcasts the signal back to the Esprit Radar in order to perform calibration of the Esprit Radar.

2.3 Test Configuration

The Reutech Radar System Esprit RF Beacon, Equipment Under Test (EUT), was operated from a DC power supply.

2.4 Equipment Configuration

The EUT was comprised of the following equipment. (All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.)

Table 2: Equipment Configuration

Name / Description	Manufacturer	Part Number	Serial Number
RF Beacon	Reutech	5840-HG-9120V01.00	002

2.5 Support Equipment

No client supplied support equipment was used during testing.

2.6 Interface Cables

Table 3: Interface Cables

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty.	Length (m)	Shielded?
1	DC Input	12 V d.c. power input	1	1	No

2.7 EUT Modifications

There were no modifications necessary for the EUT to comply with requirements.

2.8 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

2.9 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (2002) 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

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

Where u_c = standard uncertainty
 $a, b, c, \dots$ = 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

$$U = k u_c$$

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 4 below.

Table 4: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Radiated Emissions	FCC Part 15	±4.55 dB

3 Test Equipment

Test Name:	Bench/Stability	Test Date:	11/26/2018 -12/3/2018
Asset #	Manufacturer/Model	Description	Cal. Due
776	TENNY - TJR-A-WS4	1.22 CUFT	06/01/2019
75	HP - 8648C	GENERATOR RF SIGNAL	12/23/2019
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	04/21/2019
276	ELECTRO-METRICS - BPA-1000	RF PRE-AMPLIFIER	2/7/2019
29	EMCO - 3146A	ANTENNA LOG PERIODIC	12/13/2018
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	03/21/2020
803	R&S - SMR 40	SIGNAL GENERATOR 1 - 40GHZ	06/05/2019
00597	TENNEY - T10RS1-5	TPS CHAMBER - TEMP AND HUMIDITY	09/19/2019

4 Test Results

4.1 Total Power

4.1.1 Test Method

- a. Connect the 12V DC supply to the RF Beacon
- b. Connect a signal generator to the Horizontal input antenna port and terminate the Vertical input antenna port.
- c. Set the signal generator to sweep from 9.0 GHz to 11 GHz to measure the response to signals outside the normal frequency band that includes the marine radar band.
- d. Set the signal generator power level to -60dBm. **This is the largest input signal level expected in normal operating conditions.**
- e. Connect a spectrum analyser to the output antenna port with the frequency span set to 9 GHz to 11 GHz.
- f. Adjust the analyser offset to compensate for attenuator and cable losses and record the spectrum.
- g. Adjust the input power level to -30dBm and record the spectrum to measure the response to larger signals.
- h. Connect the signal generator to the Vertical input antenna port and terminate the Horizontal input antenna port.
- i. Repeat steps d to g.

4.1.2 Test Limit

Per section 90.205(r), there is no power limit at the fundamental emissions frequencies.

4.1.3 Test Results

The test results are shown in Figure 1 and Figure 2.

4.1.4 Test Summary

The maximum power measured, through the assumption of a worst-case signal, was 11.25 dBm; accounting for 17 dB of gain from the horn antenna the maximum power is 28.25 dBm EIRP.

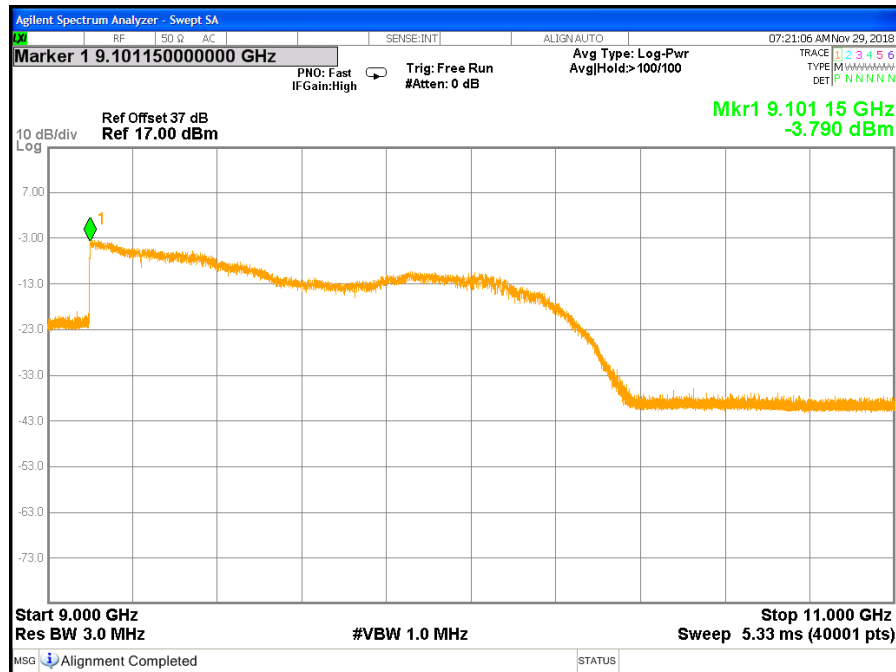


Figure 1: Output Power with -60dBm input (typical) Conducted Measurement Sweep

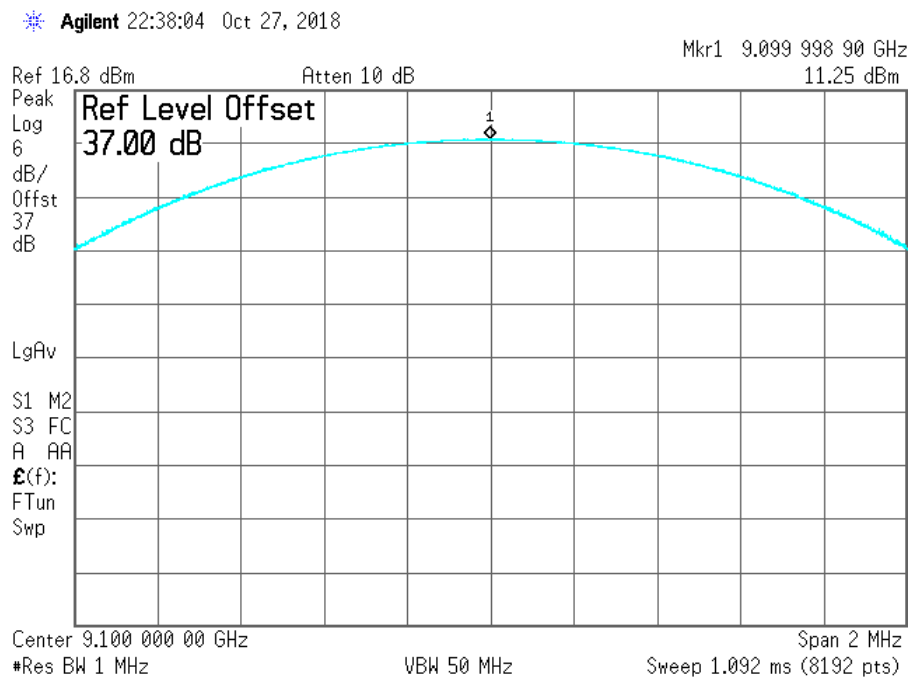


Figure 2: Output Power with -30dBm input [Worst Case]

4.2 Emission Bandwidth

4.2.1 Test Method

The Esprit RF Beacon rebroadcasts whatever signal is passed to it without adding any addition phase or amplitude modulation. Testing was done to make sure no significant change was done to the signal.

- Connect the 12V DC supply to the RF Beacon
- Connect a signal generator to the Horizontal input antenna port and terminate the Vertical input antenna port.
- Set the signal generator to CW at 9.75 GHz.
- Set the signal generator power level to -60dBm. This is the largest input signal level expected in normal operating conditions.
- Connect a spectrum analyser to the output antenna port with the centre frequency set to 9.75 GHz and the span to 10MHz.
- Confirm by examining the output spectrum that the signal bandwidth is not increased by the RF Beacon

4.2.2 Test Results

Figure 3 shows the plot of the occupied bandwidth. The recorded level is 212.43 kHz for supplied and 235.6 kHz for the output. Test Passed.

4.2.3 Test Summary

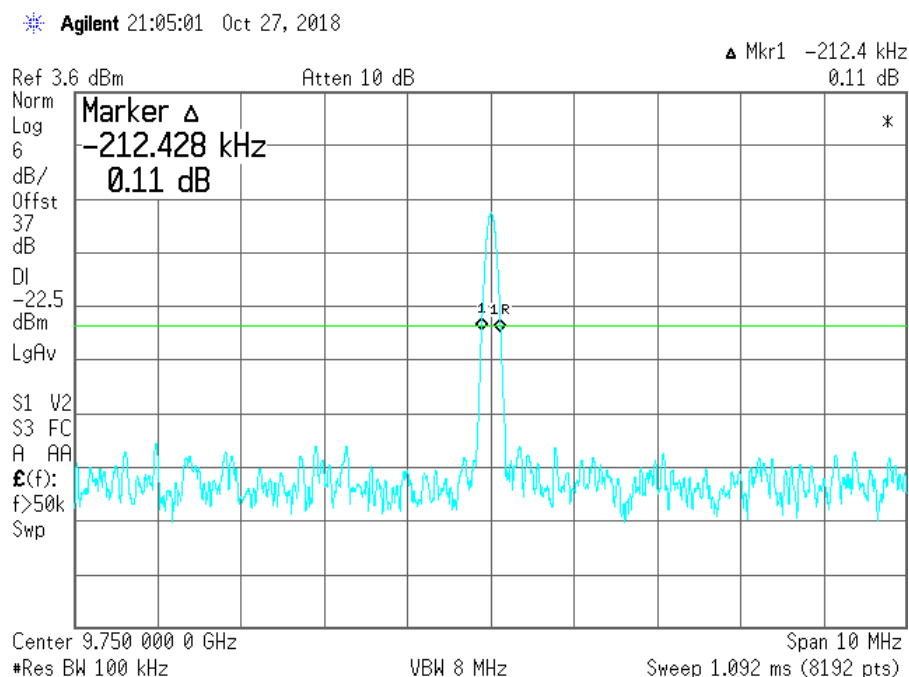


Figure 3: 20dB Occupied bandwidth [supplied signal]

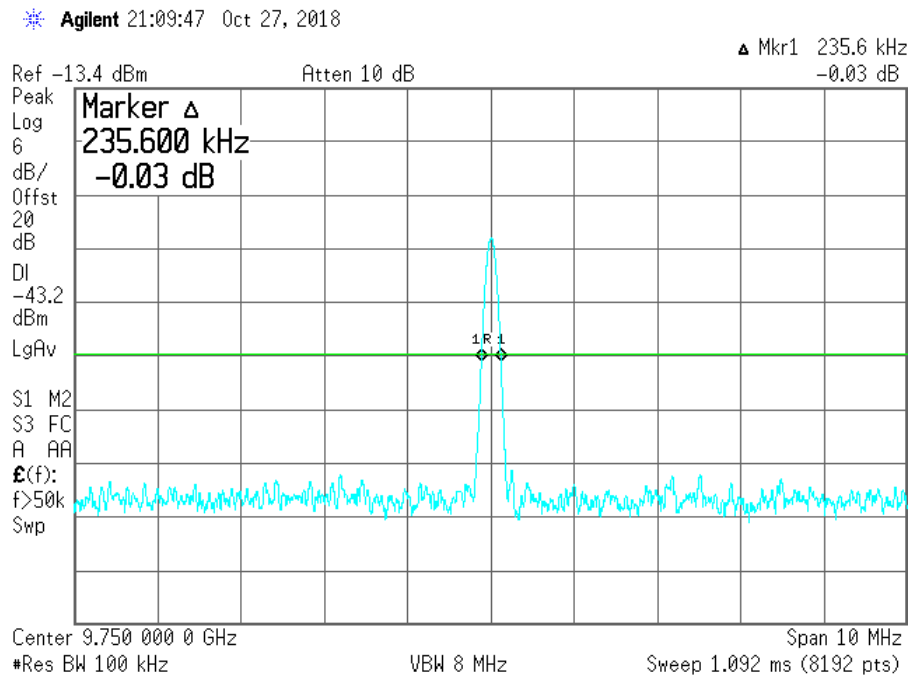


Figure 4: 20 dB Occupied Bandwidth [transmitted signal]

4.2.4 Occupied Bandwidth

Under normal operation, the EUT re-transmits the swept CW signal from the ESPRIT radar from 9.49GHz to 9.802GHz as shown in the following plot.

This plot is representative of the EUT's operation for all ESPRIT MSR emissions that it re-transmits.

The unit continues to comply with the relevant emissions requirements for in all modes of operation, including operating in saturation mode.

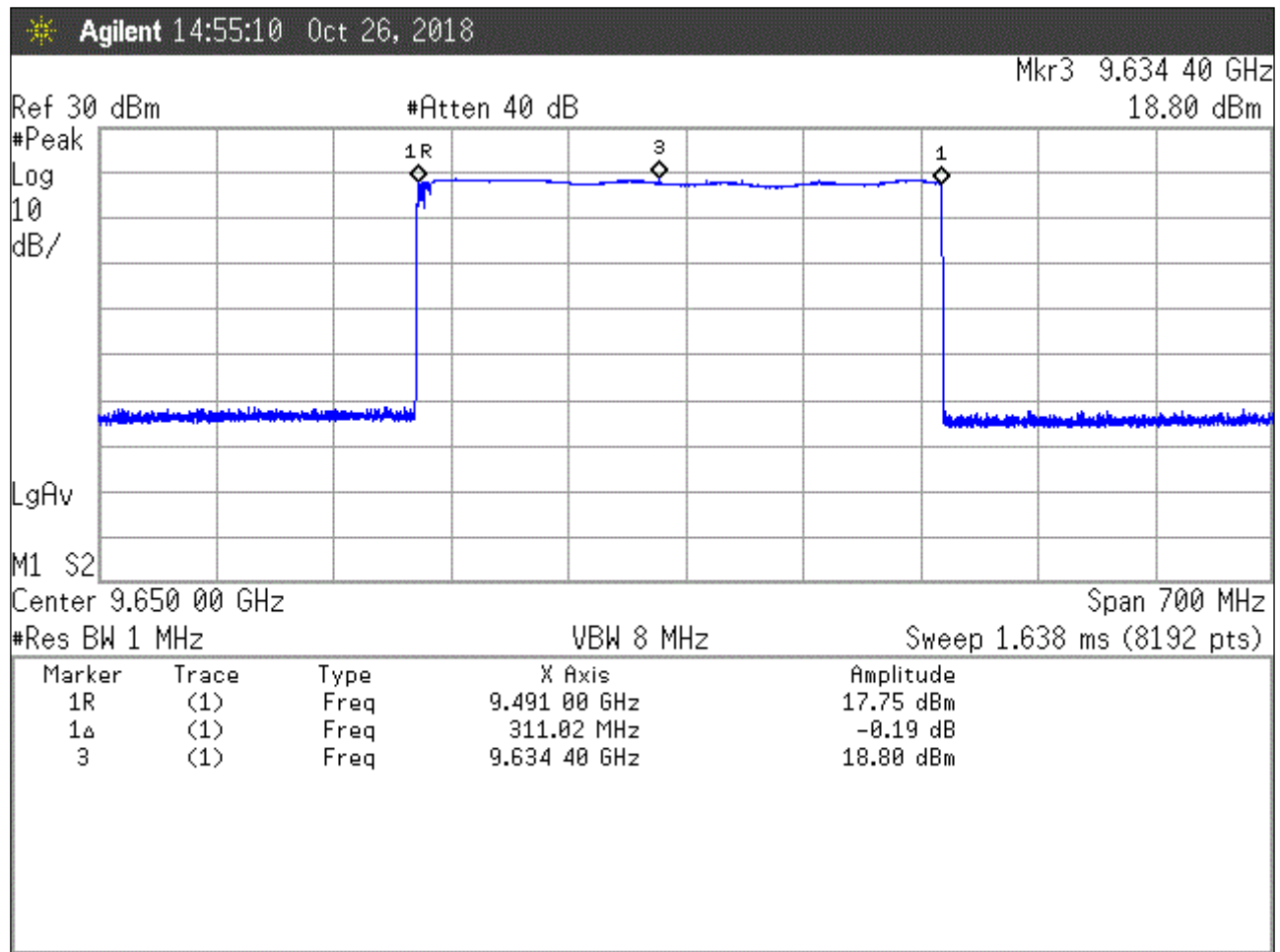


Figure 5: ESPRI Operating Band/Occupied Bandwidth

4.2.5 Emissions Mask

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

Mask C

- (1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least $83 \log(f_d/5)$ dB;
- (2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least $29 \log(f_d/11)$ dB or 50 dB, whichever is the lesser attenuation;
- (3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least $43 + 10 \log(P)$ dB.

The Emissions bandwidth was measured as shown below:

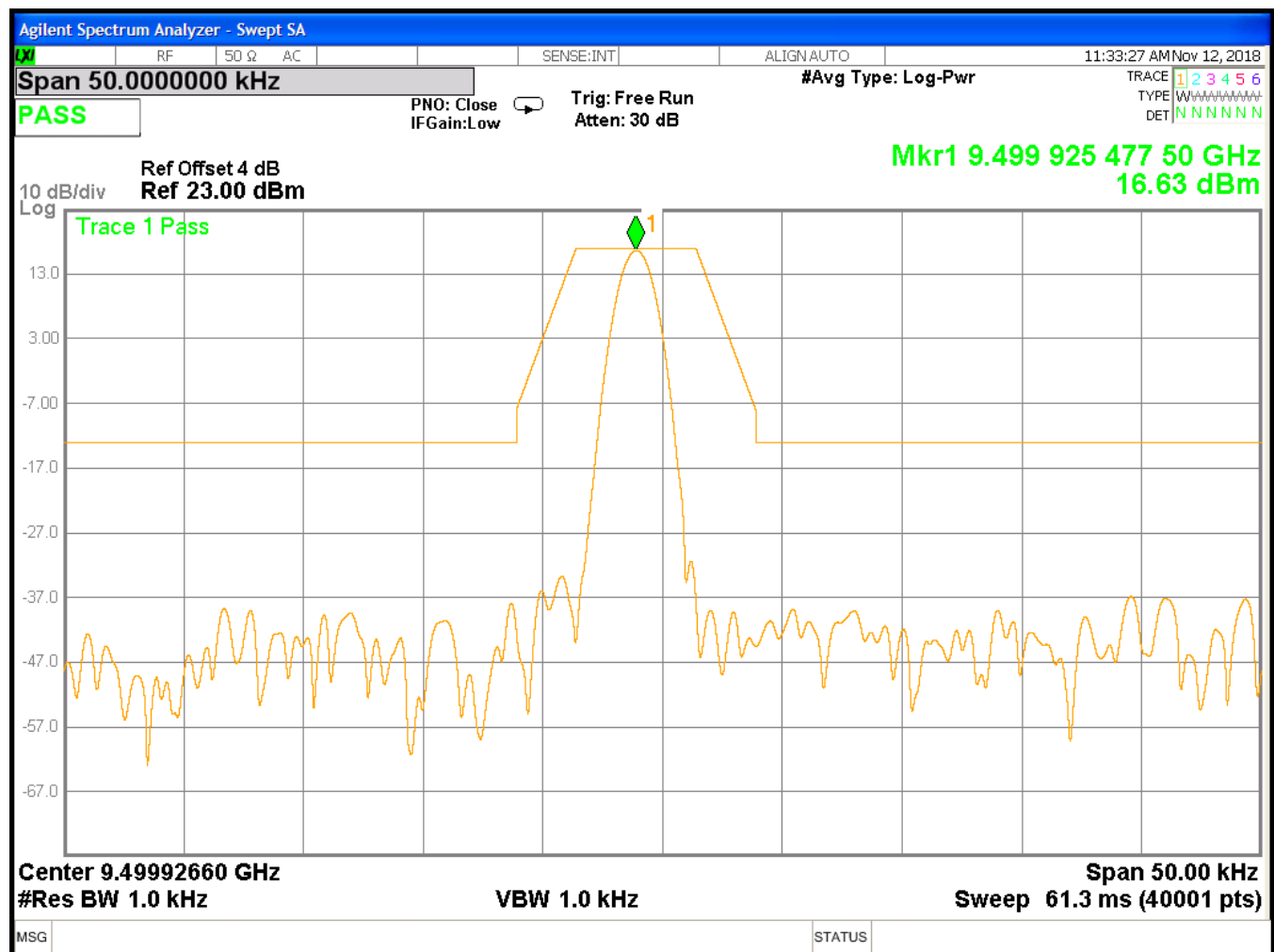


Figure 6: Emissions Bandwidth, Low Channel

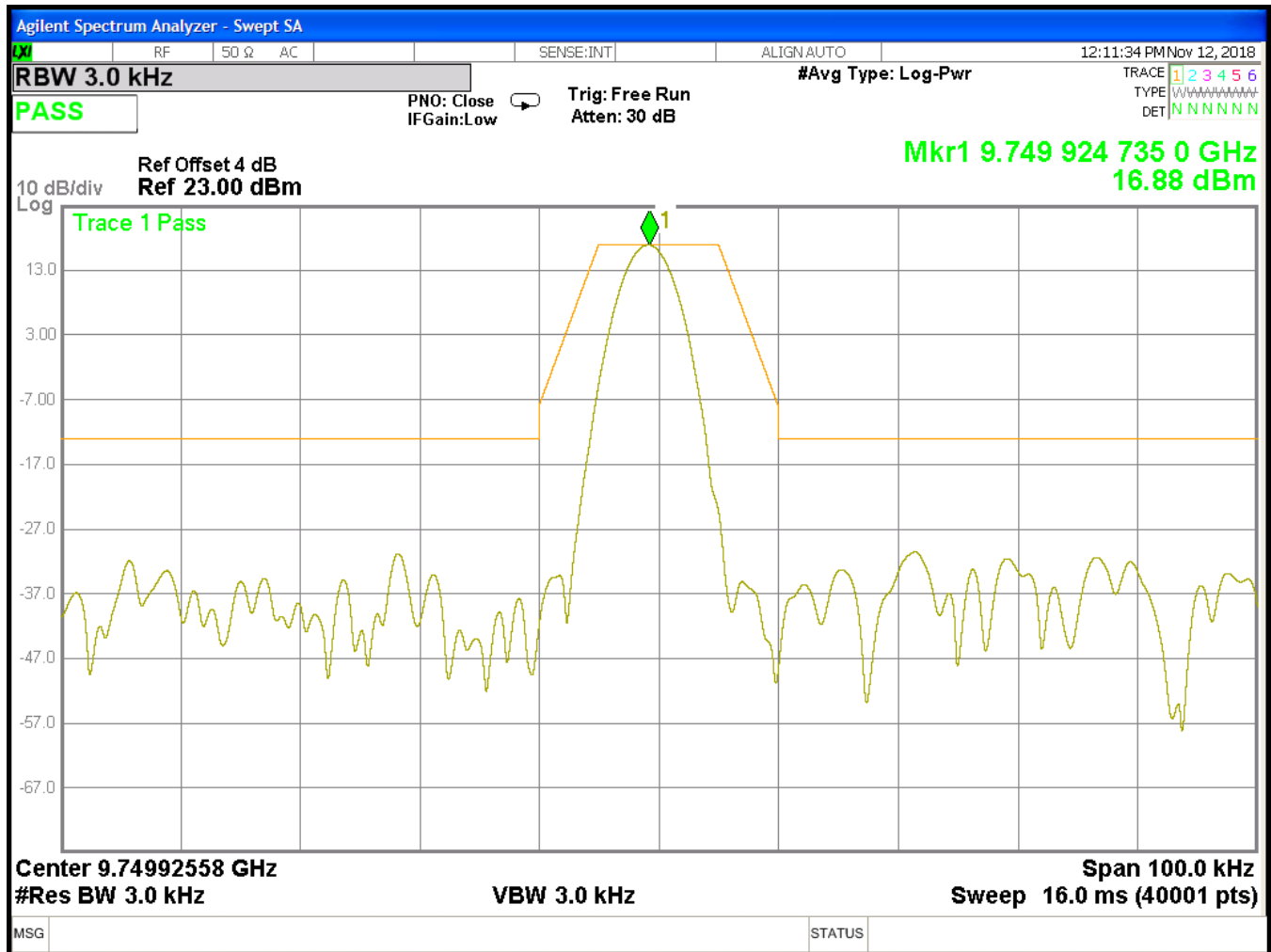


Figure 7: Emissions Bandwidth, Mid Channel

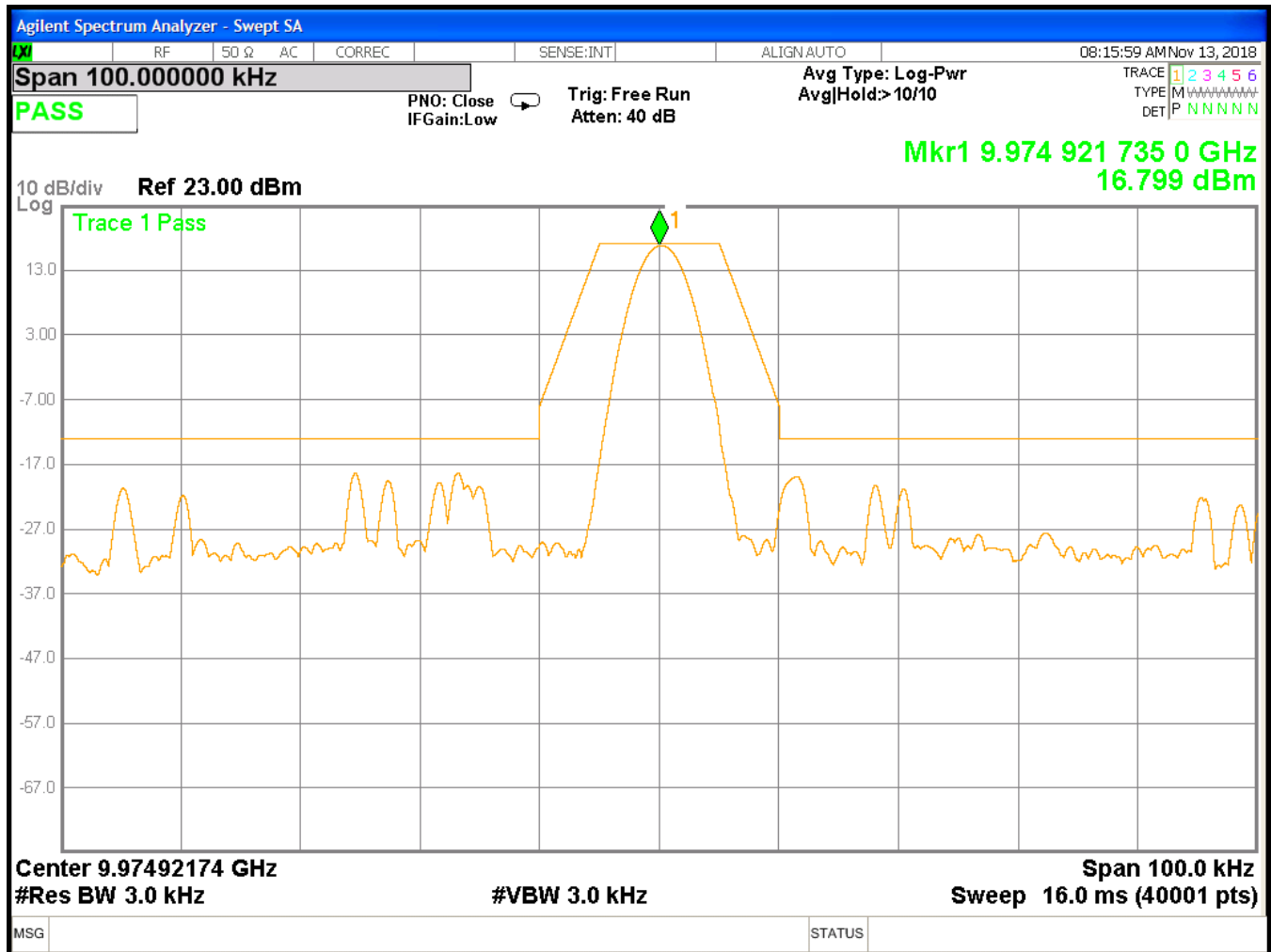


Figure 8: Emissions Bandwidth, High Channel

✱ Agilent 01:51:55 Oct 28, 2018

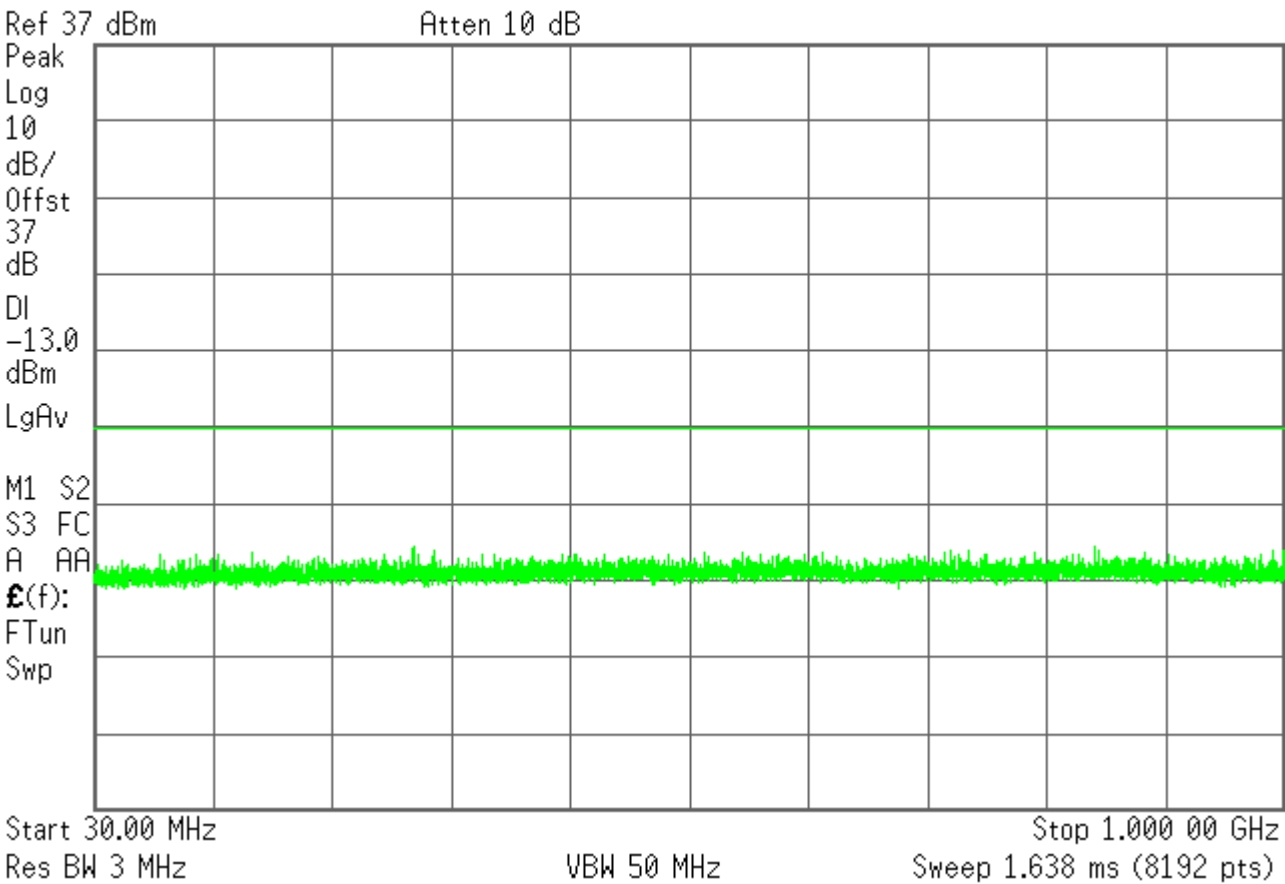


Figure 9: Conducted Emissions 30 MHz to 1 GHz

✱ Agilent 01:53:51 Oct 28, 2018

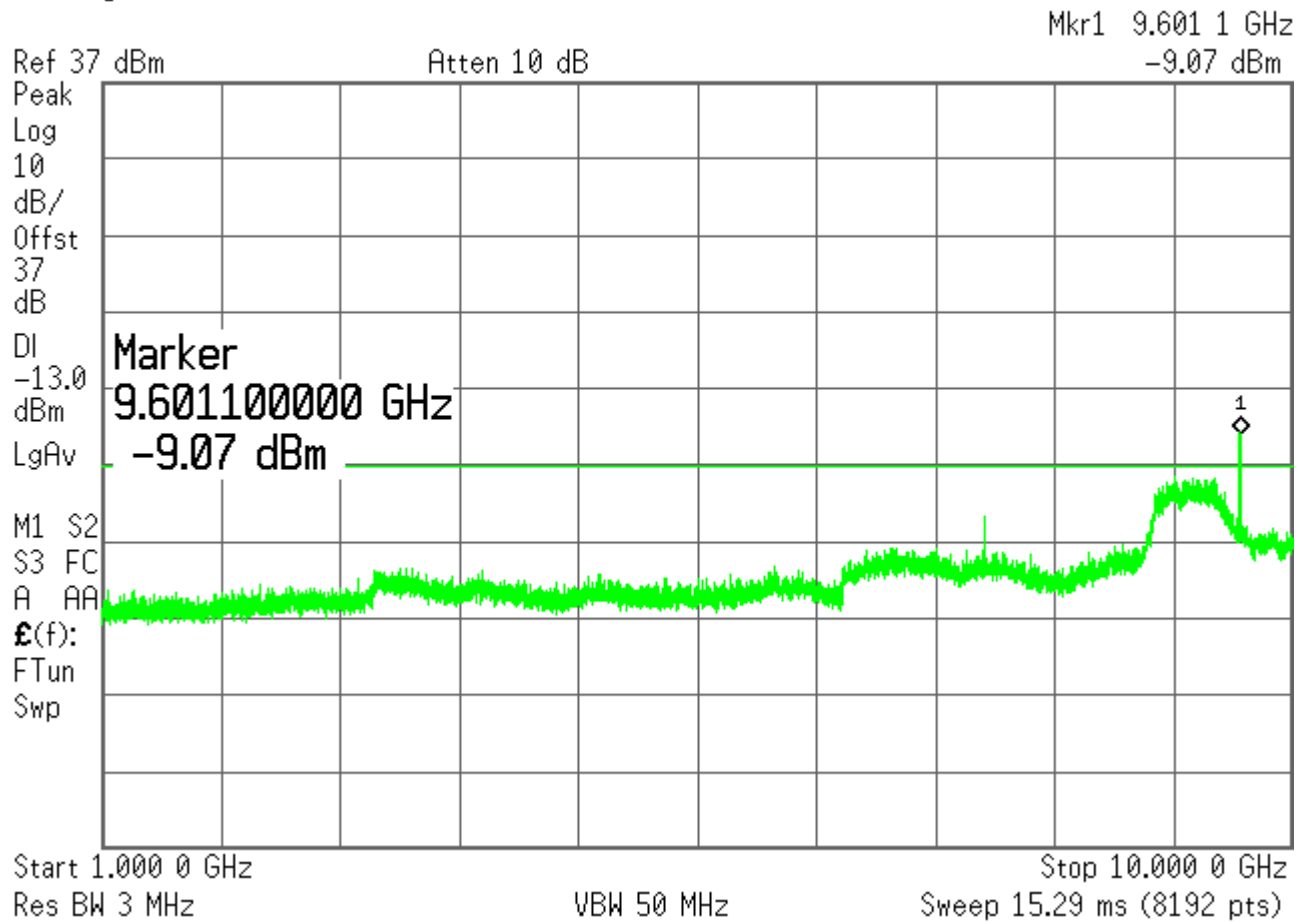


Figure 10: Conducted Emissions 1 GHz to 10 GHz

✱ Agilent 01:57:14 Oct 28, 2018

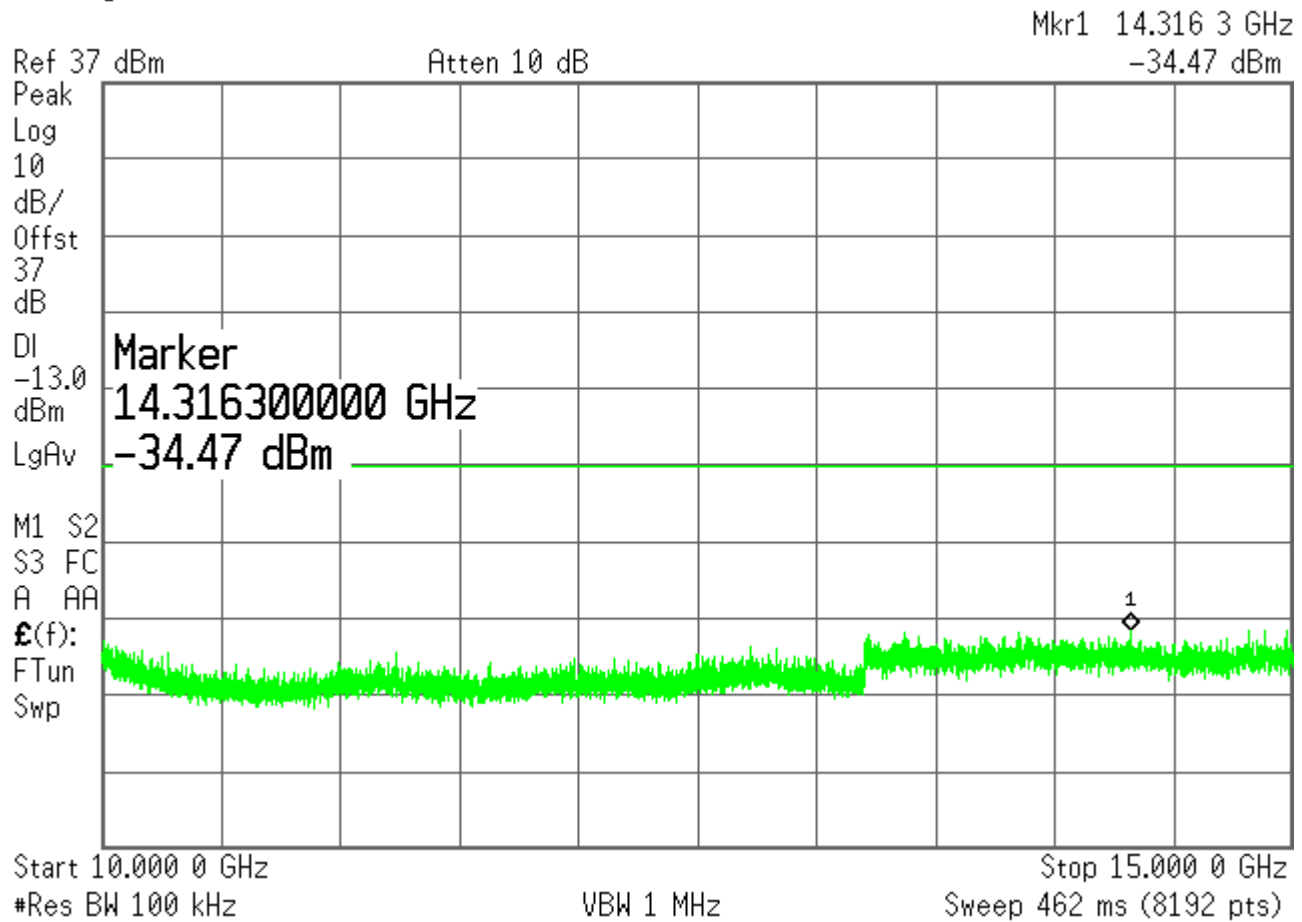


Figure 11: Conducted Emissions 10 GHz to 15 GHz

✱ Agilent 01:57:45 Oct 28, 2018

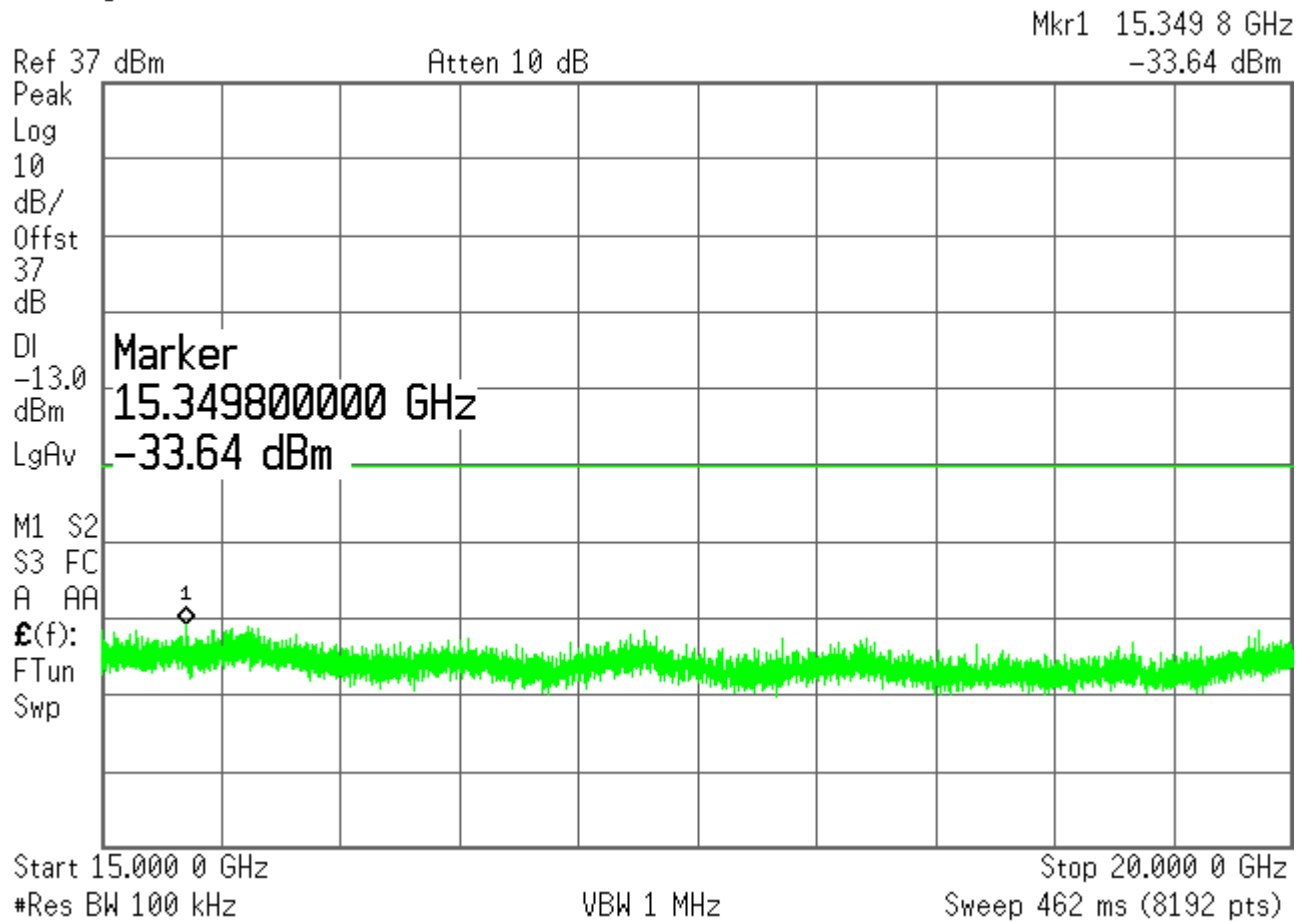


Figure 12: Conducted Emissions 15 GHz to 20 GHz

✱ Agilent 01:58:50 Oct 28, 2018

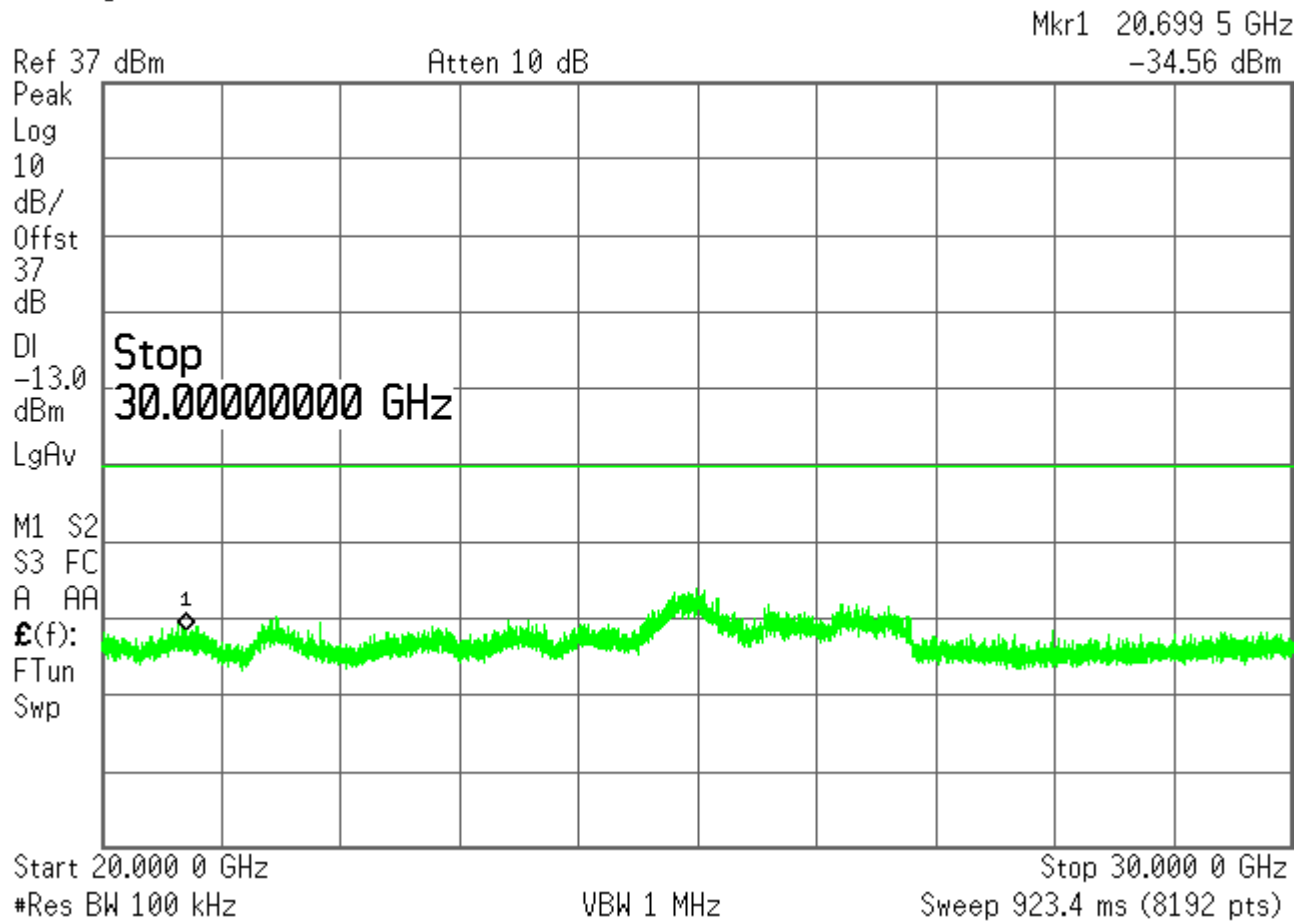


Figure 13: Conducted Emissions 20 GHz to 30 GHz

Agilent 01:59:24 Oct 28, 2018

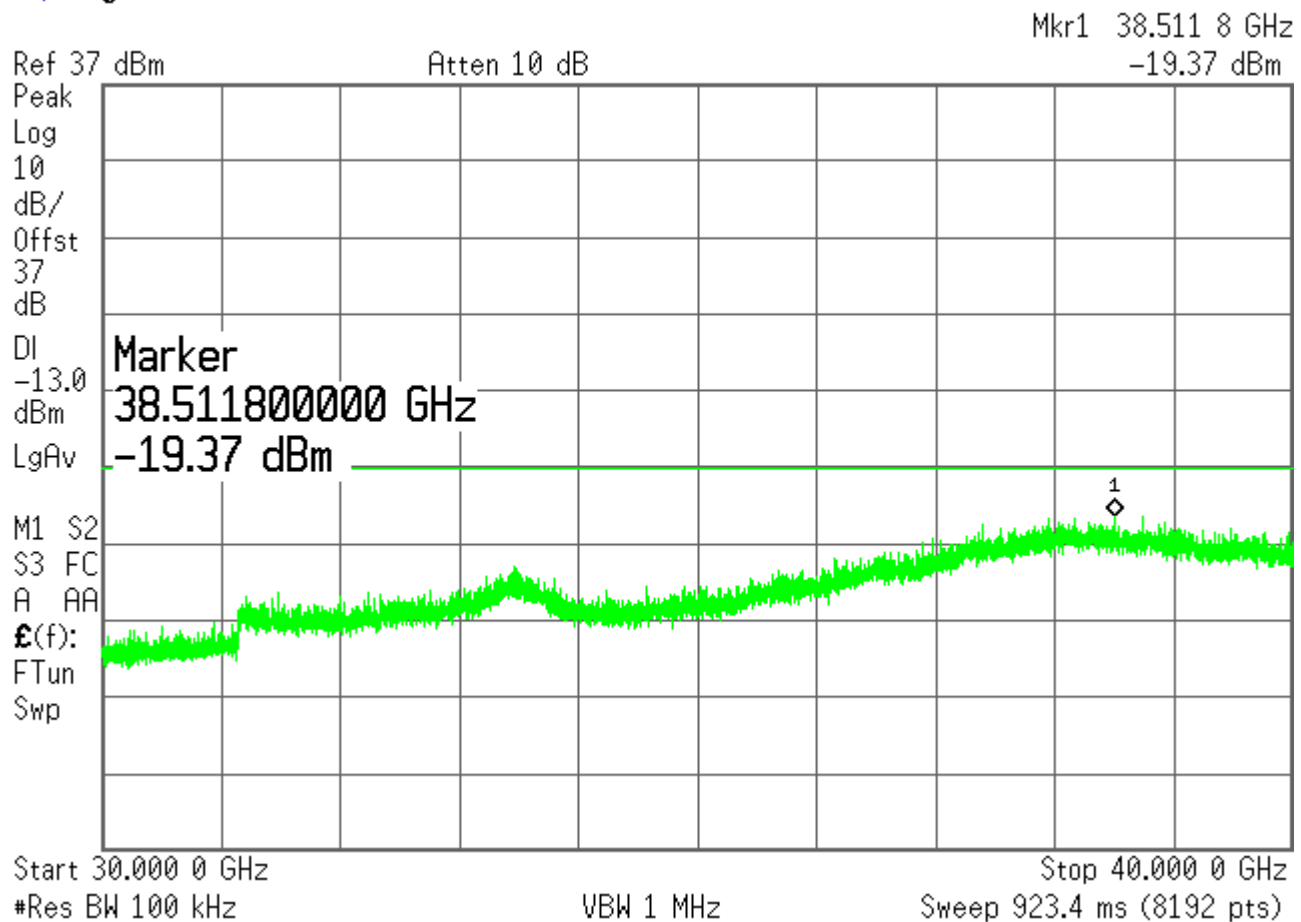


Figure 14: Conducted Emissions 30 GHz to 40 GHz

4.3 Frequency Tolerance [FCC Part 90.213(a)]

4.3.1 Test Method

The EUT was placed in a calibrated temperature chamber. A receive antenna was placed in the temperature chamber with the device connected to a frequency counter outside the chamber. All three units were tested in accordance with Part 90. Discussion below provides an example of one configuration.

4.3.2 Test Limit

According to the Manual of Regulations and Procedures for Federal Radio Frequency Management [Redbook] the limit for frequency tolerance is 0.125%.

4.3.3 Test Results

The test results are stated below in Table 13 and Table 14.

4.3.4 Test Summary

The EUT complied with the requirements of Part 90.213(a).

Table 5: Frequency Tolerance vs. Temperature

Temperature (Centigrade)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
25(ambient)	9600.000739	0	12000001	NA
-30	9600.000891	152	12000001	Pass
-20	9600.000916	177	12000001	Pass
-10	9600.009360	8621	12000001	Pass
0	9600.000950	211	12000001	Pass
10	9600.000965	226	12000001	Pass
20	9600.000976	237	12000001	Pass
30	9600.000997	258	12000001	Pass
40	9600.001008	269	12000001	Pass
50	9600.001024	285	12000001	Pass

Table 6: Frequency Tolerance vs. Battery Voltage

Voltage	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
Nominal Voltage	9600.000739	0	12000001	NA
115% of Nominal Voltage	9600.000752	13	12000001	Pass
85% of Nominal Voltage	9600.000761	22	12000001	Pass

4.4 Radiated Spurious Emissions

4.4.1 Requirements

Test Arrangement: Table Top

Frequency Range Tested: 30MHz to 1000MHz at 10m; 1000MHz to 40GHz at 3m

4.4.2 Test Procedure Summary

The requirements call for the EUT to be configured at the 10m Open Area Test Site (OATS) on an 80cm-high 1m X 1.5m non-conductive table above a ground plane. During test the system under test was rotated 360° while the antenna was varied in height from 1 to 4 meters. The system under test was examined for emissions with both horizontal and vertical antenna polarizations. The EUT was scanned from 30MHz to 1GHz at a distance of 10m and again from 1GHz to 40GHz at a distance of 3m.

4.4.3 Measurement Method

All emission measurements herein were performed according to EN55032:2012/AC:2013. Calibration checks are made periodically to verify proper performance of the measuring instrumentation.

4.4.4 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dB μ V to obtain the Radiated Electric Field in dB μ V/m. This level is then compared to the limit.

Example: Spectrum Analyzer Voltage: VdB μ V
 Antenna Correction Factor: AFdB/m
 Cable Correction Factor: CFdB
Electric Field: EdBV/m = V dB μ V + AFdB/m + CFdB

4.4.5 Results Summary

The EUT complied with the radiated emission requirements throughout the test.

4.4.6 Areas of Concern

None

4.4.7 Test Data

Table 7 provides the test results for radiated emissions with the emission limit normalized to -13dBm EIRP.

Table 7: Radiated Emission Test Data

Freq (MHz)	Pol	Az	Ant. (m)	SA (dBuV)	Corr Factors (dB)	Corr. Level (dBuV/m)	Corr Level dBm	Limit (dBm)	Margin (dB)
33.31	V	0	1	30.4	-7	23.4	-61.4	-13	-48.4
47.03	V	90	1	36.5	-16.9	19.6	-65.2	-13	-52.2
52.03	V	0	1	37.5	-18.6	18.9	-65.9	-13	-52.9
80.82	V	90	1	40.6	-18.1	22.5	-62.3	-13	-49.3
371.84	V	0	1.2	25.6	-8.2	17.4	-67.4	-13	-54.4
395.65	V	0	1.2	32.2	-8.1	24.1	-60.7	-13	-47.7
416.13	V	270	1.2	28.3	-7.9	20.4	-64.4	-13	-51.4
34.12	H	0	2.3	25.3	-7.7	17.6	-67.2	-13	-54.2
48.72	H	180	2.4	27.5	-17.7	9.8	-75	-13	-62
52.85	H	0	2.5	30	-18.8	11.2	-73.6	-13	-60.6
79.78	H	0	2.5	40.6	-18.1	22.6	-62.2	-13	-49.2
371.69	H	0	2.9	27.1	-8.3	18.8	-66	-13	-53
372.91	H	0	2.1	26	-8.2	17.7	-67.1	-13	-54.1
399.59	H	0	2.1	31.4	-8.1	23.3	-61.5	-13	-48.5
408.42	H	0	2	31.5	-8	23.5	-61.3	-13	-48.3