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# 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**
PO Box 686
Stellenbosch, Capetown 7599 South Africa

Prepared By:
Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ilac-MRA

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY AT-1448

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# For the
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Prepared by:

Nikolas Allen
EMC Compliance Engineer

Reviewed by:

Steven D. Koster
President

 

# 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<br>PO Box 686, Stellenbosch<br>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 |

## 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** | Amplitude Modulation |
| **Amps** | **Amp**ere**s** |
| **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

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**

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

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 ≤ 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.

 

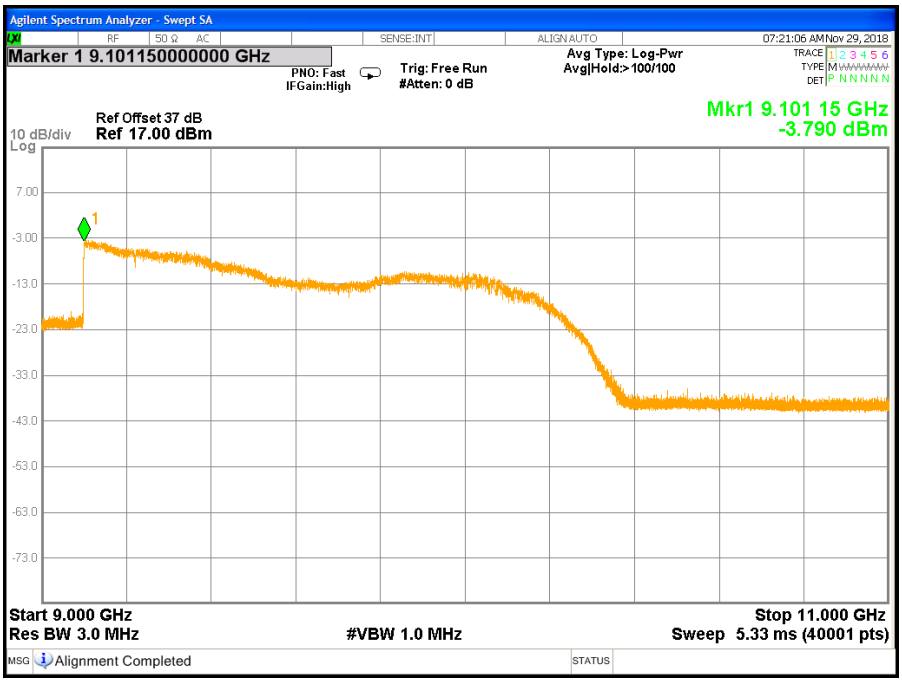


**Figure 1: Output Power with -60dBm input (typical) Conducted Measurement Sweep**

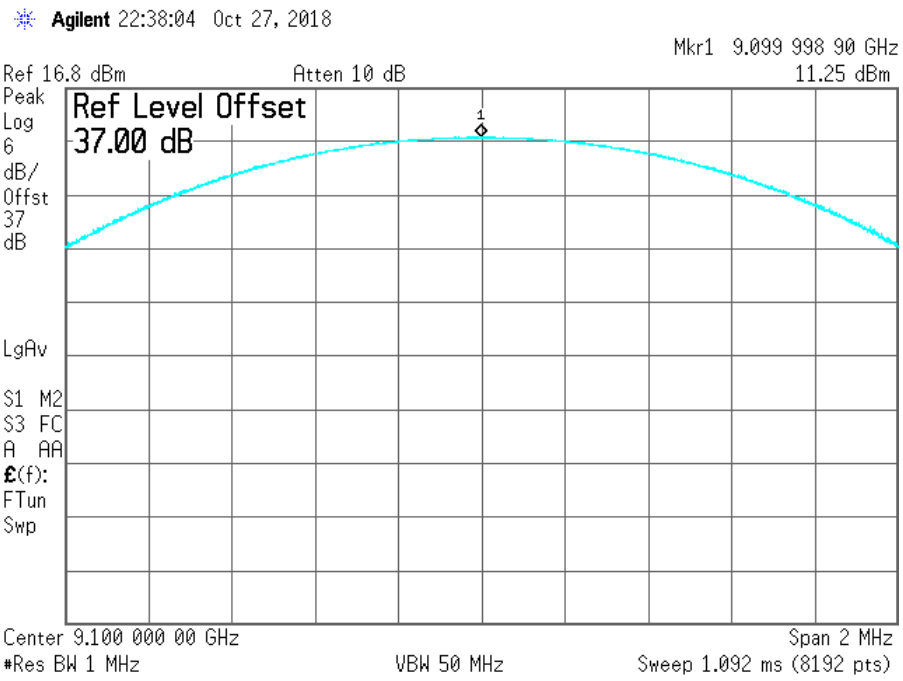


**Figure 2: Output Power with -30dBm input [Worst Case]**

 

## 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.

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 CW at 9.75 GHz.
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 centre frequency set to 9.75 GHz and the span to 10MHz.
f. 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

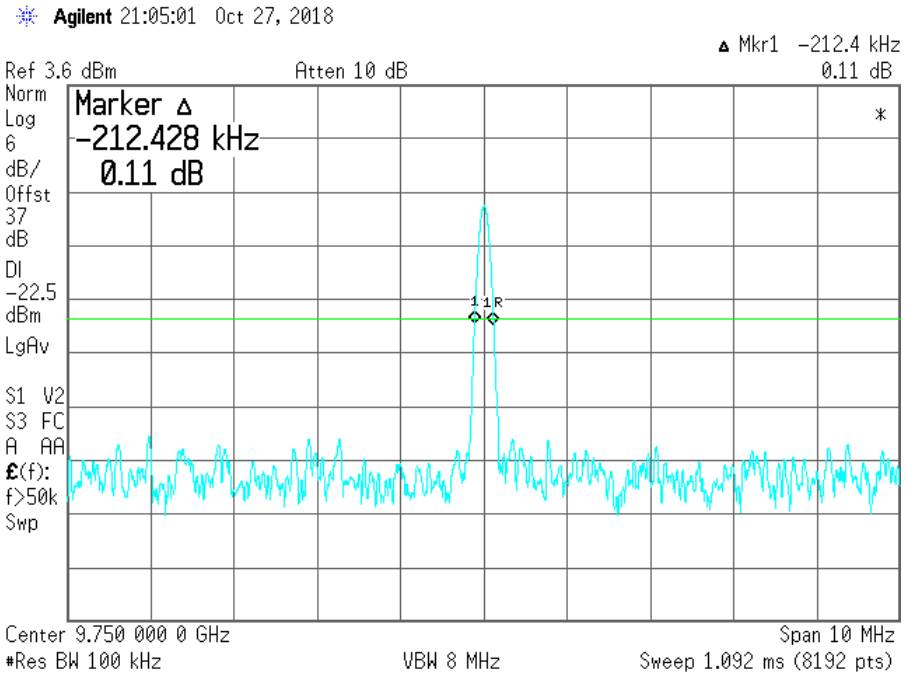


**Figure 3: 20dB Occupied bandwidth [supplied signal]**

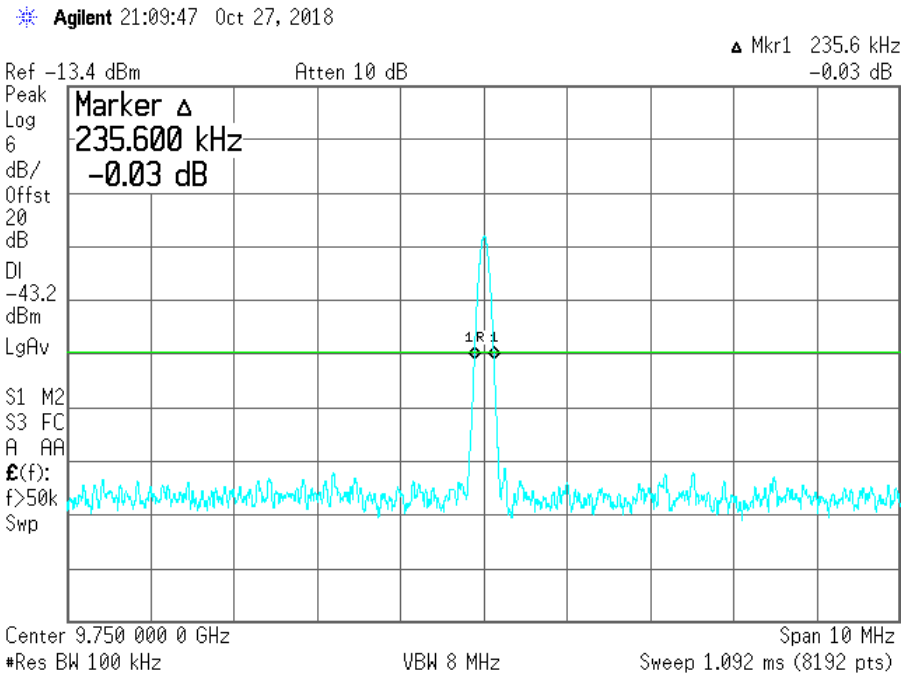


**Figure 4: 20 dB Occupied Bandwidth [transmitted signal]**

### 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.

 

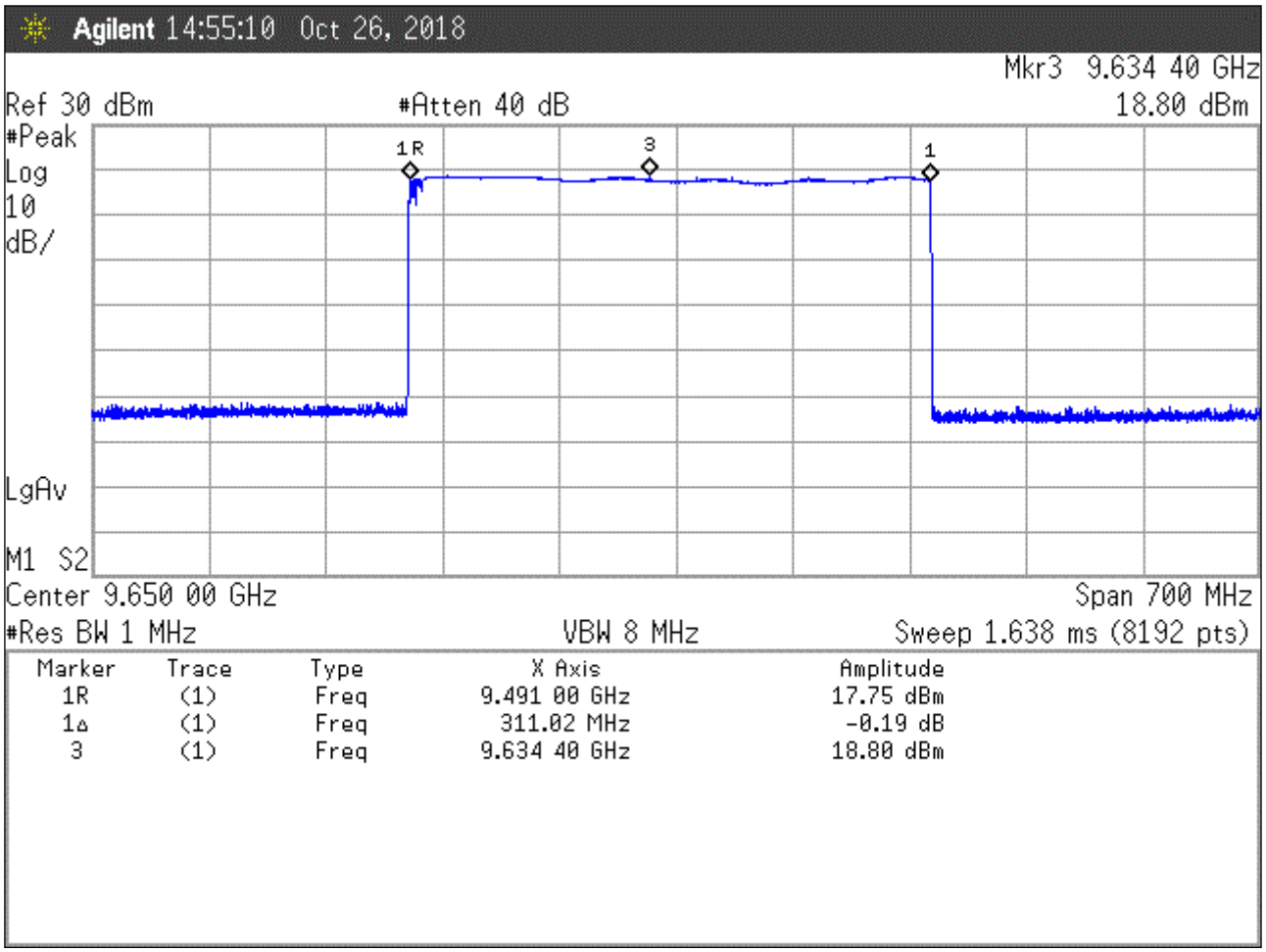


**Figure 5: ESPRI Operating Band/Occupied Bandwidth**

 

### 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 (fd in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (fd/5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (fd 2/11) 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:

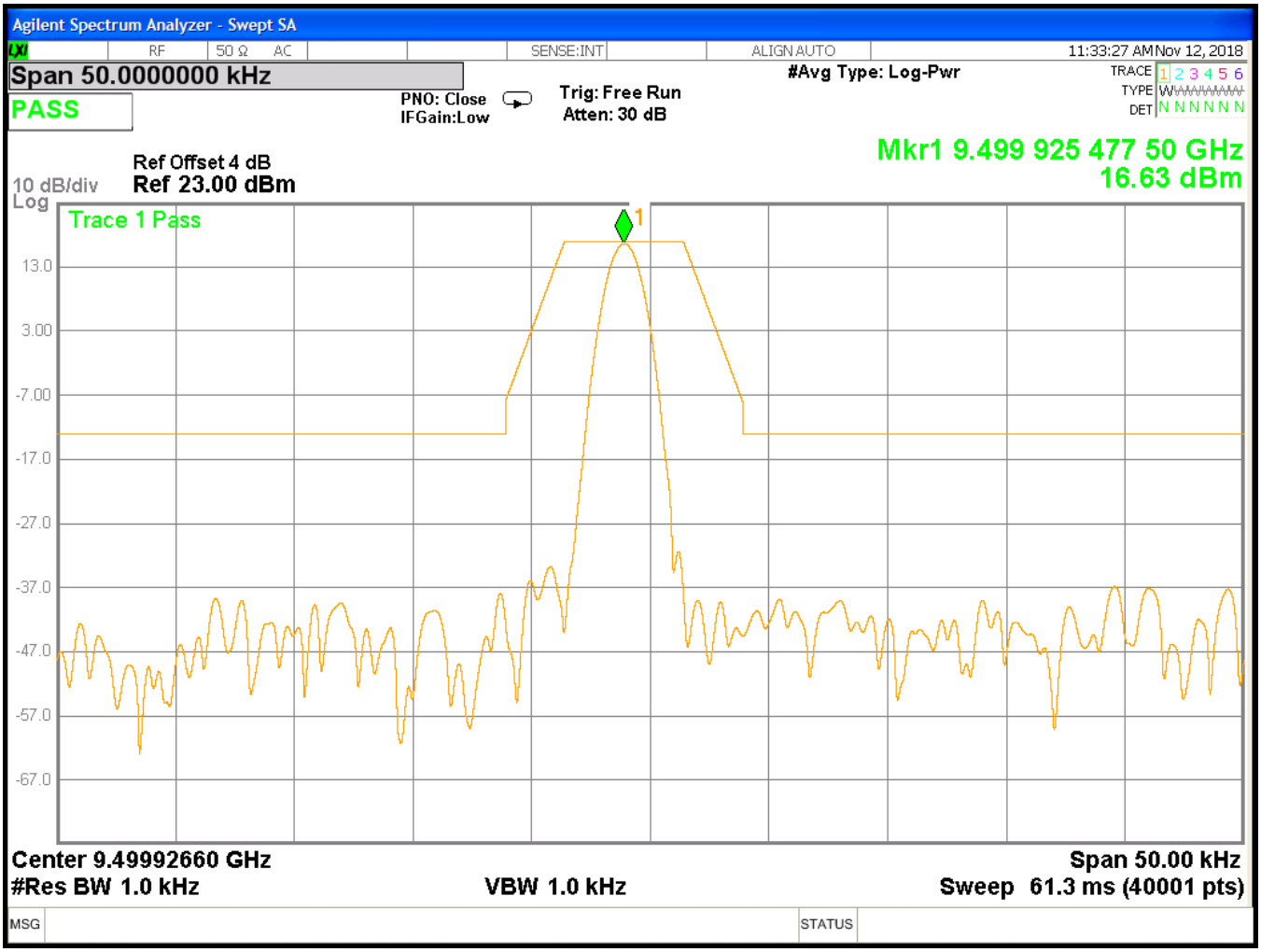


**Figure 6: Emissions Bandwidth, Low Channel**

 

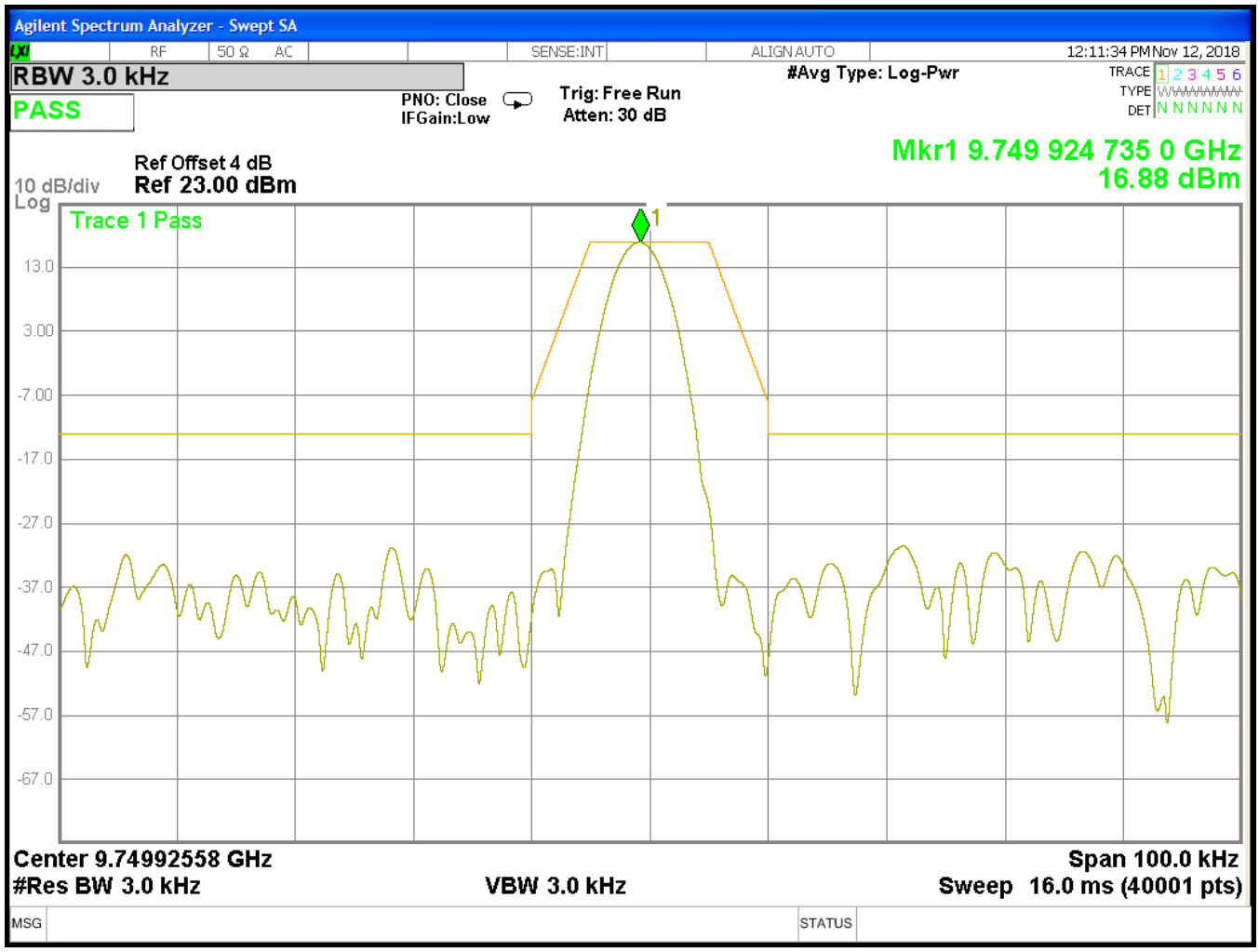


**Figure 7: Emissions Bandwidth, Mid Channel**

 

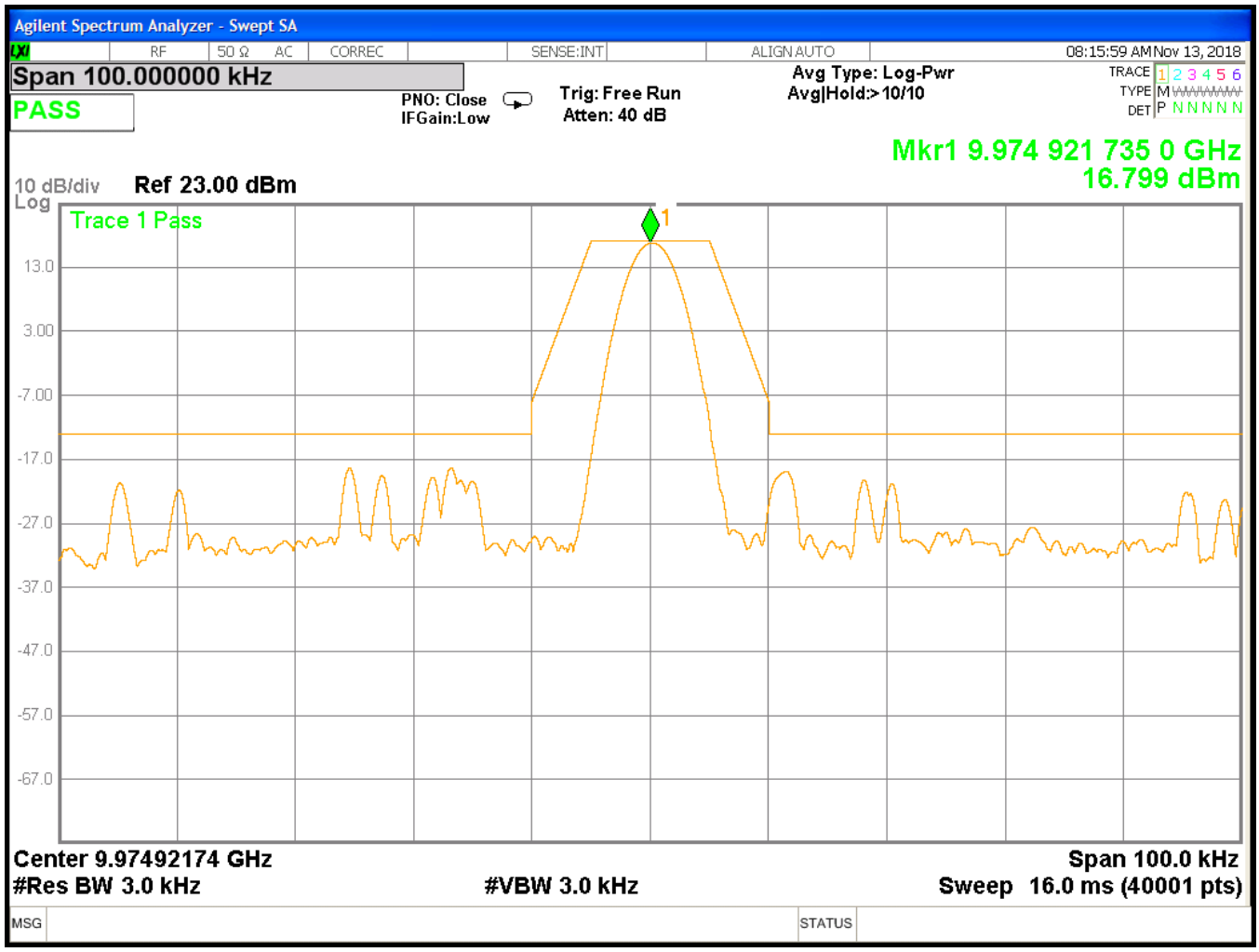


**Figure 8: Emissions Bandwidth, High Channel**

 

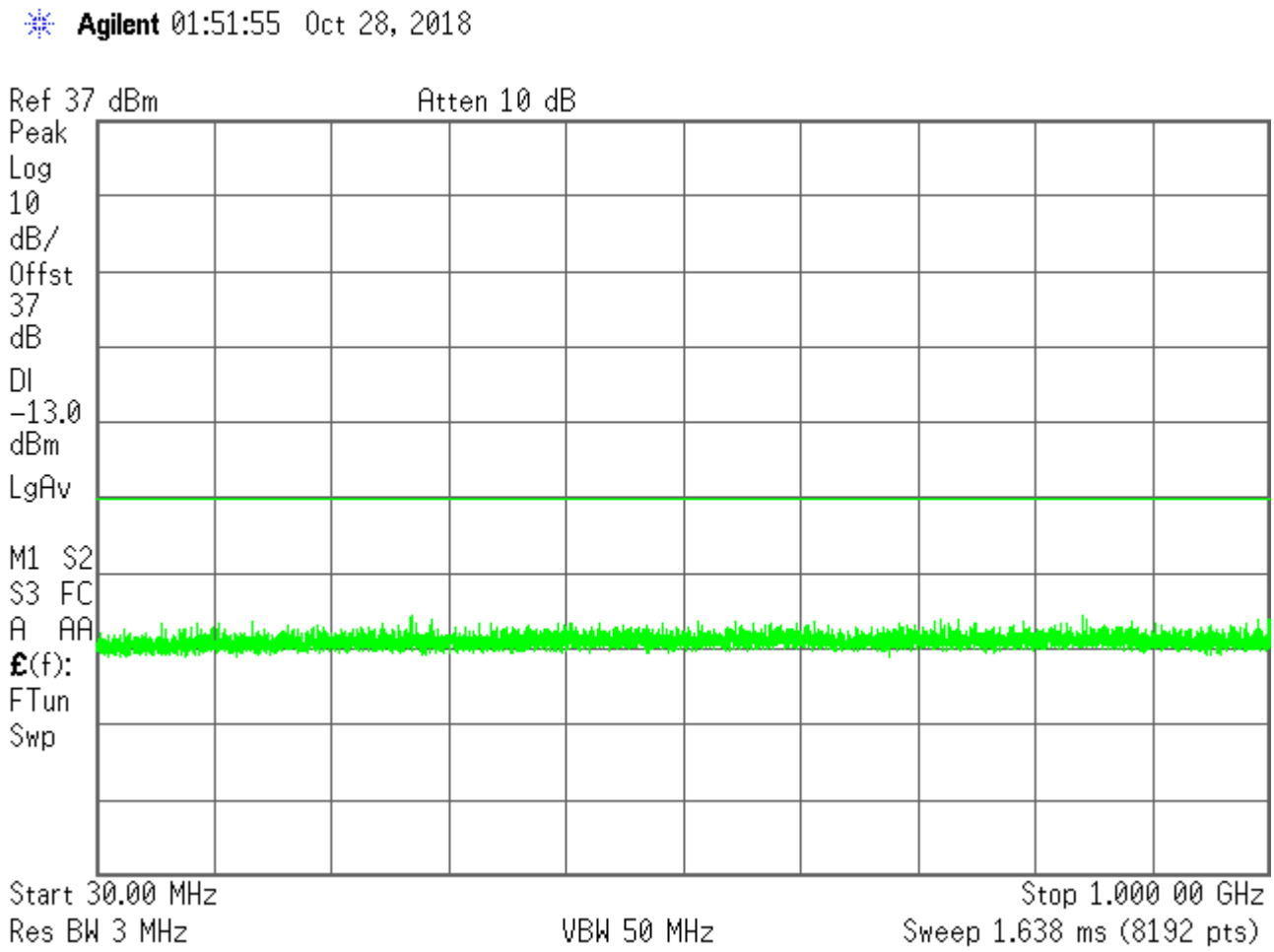


**Figure 9: Conducted Emissions 30 MHz to 1 GHz**

 

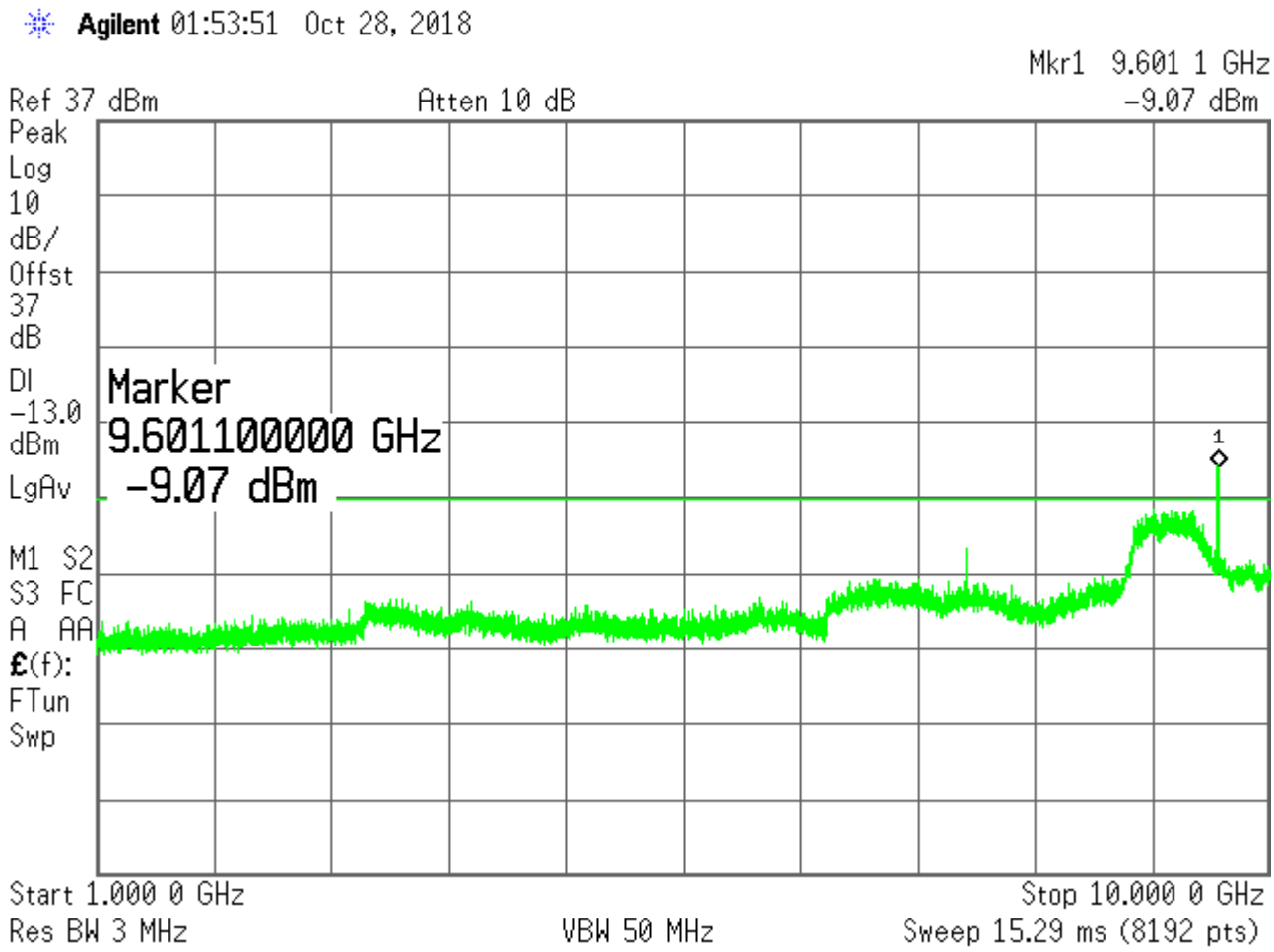


**Figure 10: Conducted Emissions 1 GHz to 10 GHz**

 

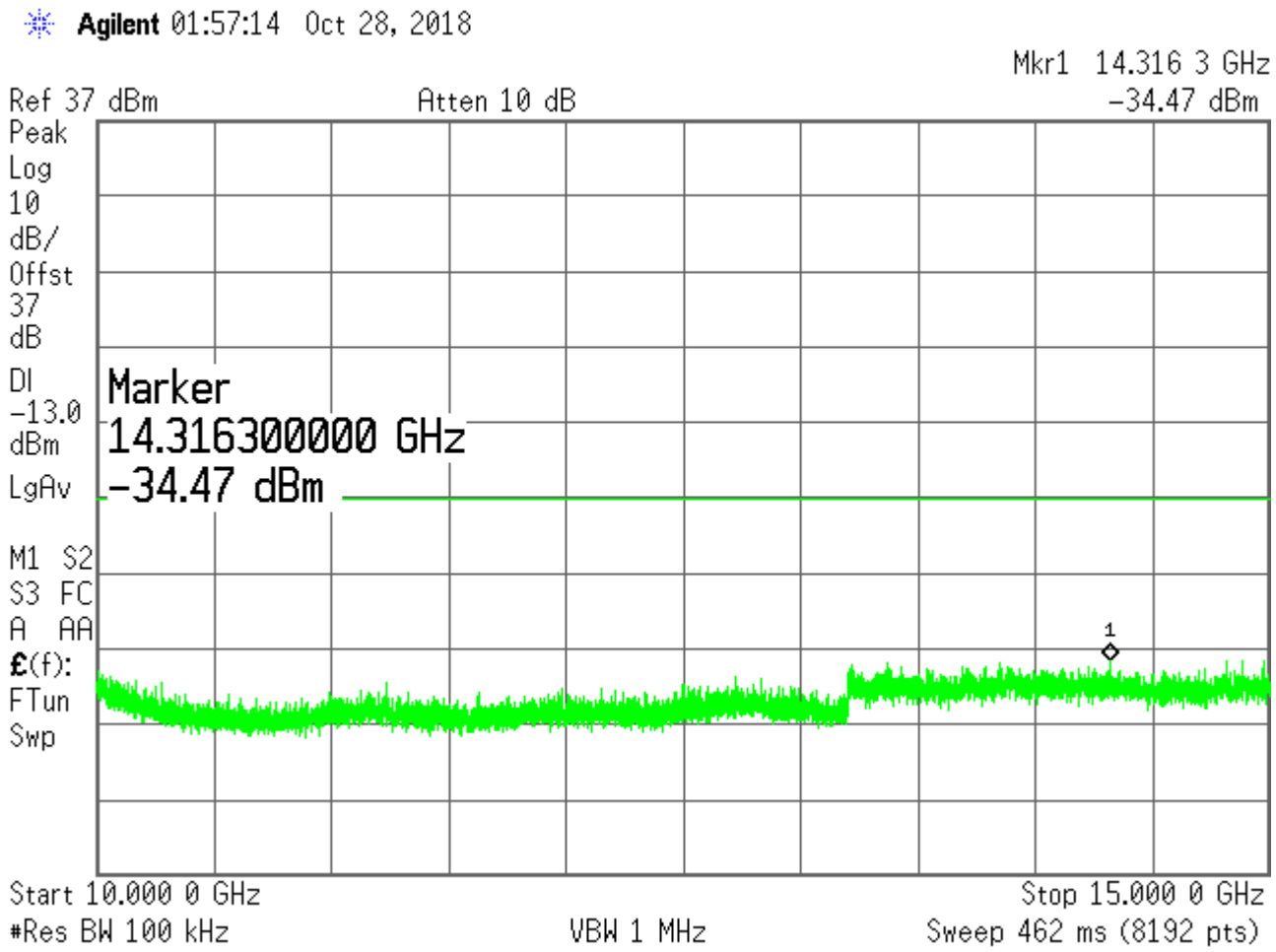


**Figure 11: Conducted Emissions 10 GHz to 15 GHz**

 

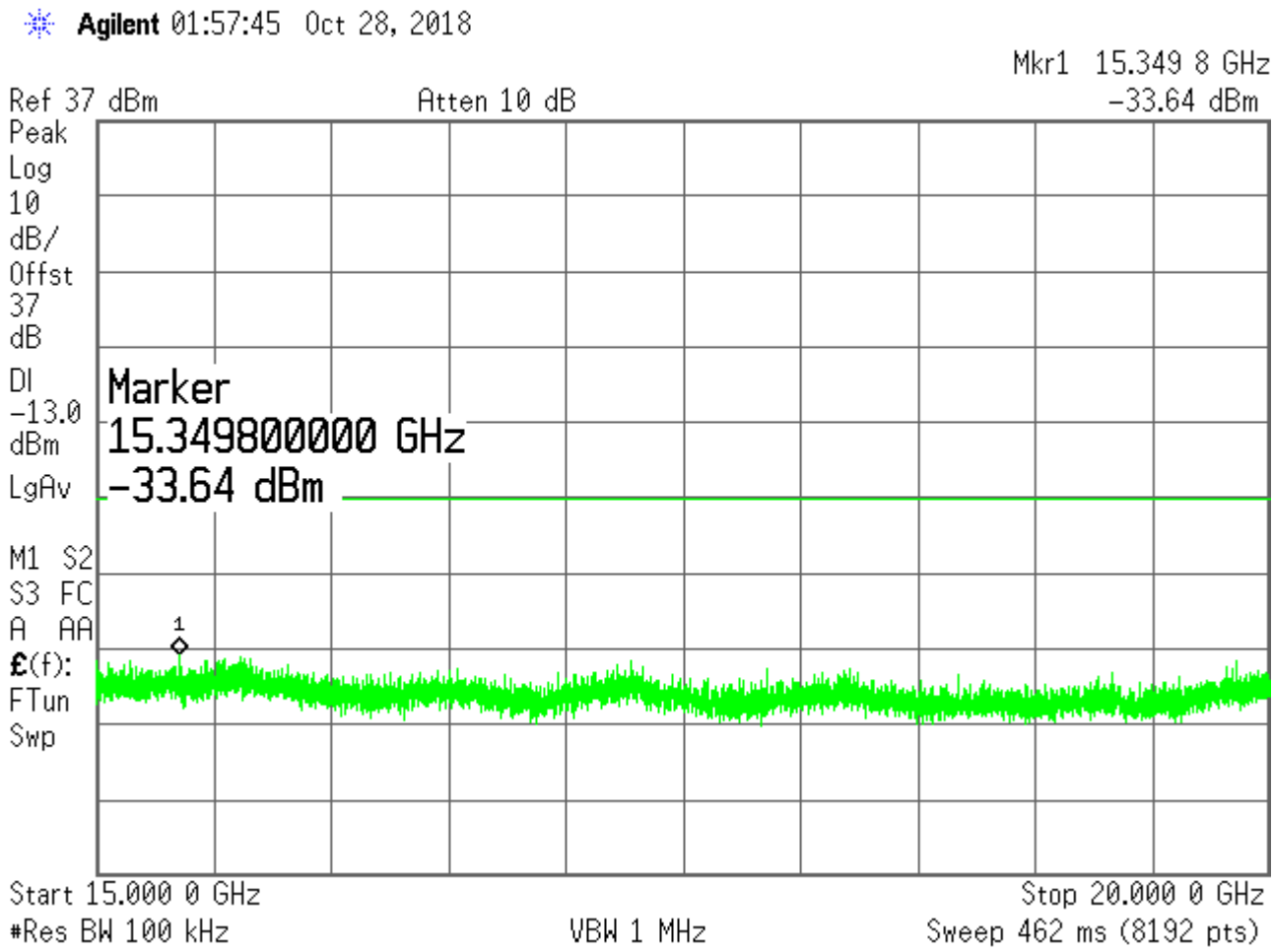


**Figure 12: Conducted Emissions 15 GHz to 20 GHz**

 

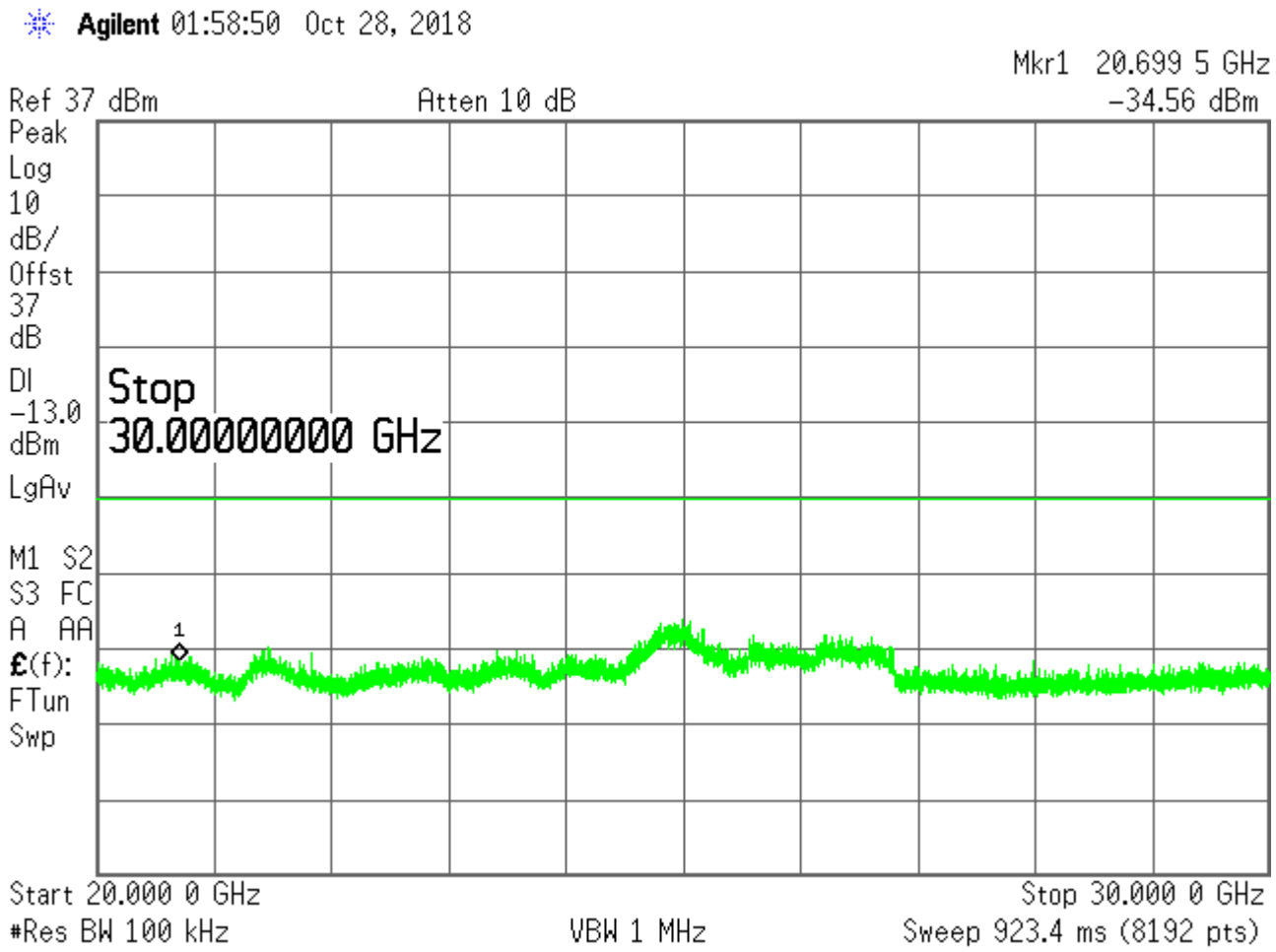


**Figure 13: Conducted Emissions 20 GHz to 30 GHz**

 

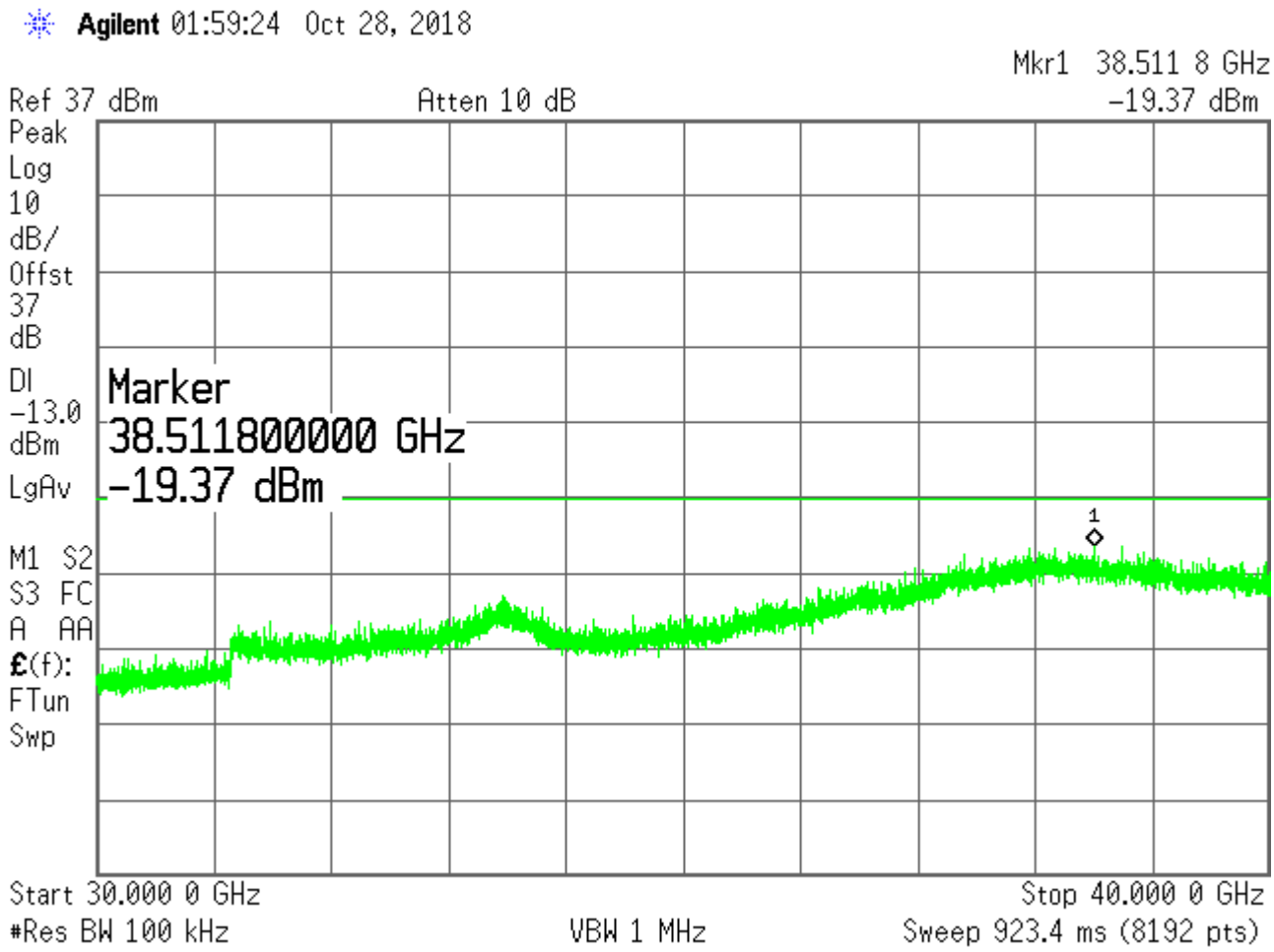


**Figure 14: Conducted Emissions 30 GHz to 40 GHz**

## 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 dBµV to obtain the Radiated Electric Field in dBµV/m. This level is then compared to the limit.

Example: Spectrum Analyzer Voltage: VdBµV
Antenna Correction Factor: AFdB/m
Cable Correction Factor: CFdB
Electric Field: EdBV/m = V dBµV + 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 |