



**FCC CFR47 PART 90  
CERTIFICATION TEST REPORT  
FOR**

**COMPACT SURVEILLANCE RADAR**

**MODEL NUMBER: C40**

**FCC ID: C06-C40-LIC**

**REPORT NUMBER: 12U14653-1, REVISION B**

**ISSUE DATE: FEBRUARY 4, 2013**

*Prepared for*  
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**NVLAP LAB CODE 200065-0**

Revision History

| Rev. | Issue Date | Revisions  | Revised By |
|------|------------|--|------------|
|      | 10/31/12   | Initial  | T. LEE     |
| A    | 11/28/12   | Updated Report: TIA reference, RF Power measurement procedure; photos, deleted AC Conducted; added RF Exposure | T. LEE     |
| B    | 2/4/13     | Updated Frequency units from MHz to GHz  | T. LEE     |

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## 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** SPOTTERRF LLC  
709 E. TECHNOLOGY AVE. BLDG E 3100  
OREM, UTAH 84097 USA

**EUT DESCRIPTION:** COMPACT SURVEILLANCE RADAR

**MODEL:** C40

**SERIAL NUMBER:** PROTO 1496941

**DATE TESTED:** OCTOBER 28 AND 29, 2012

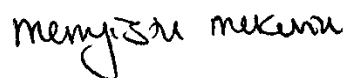
| APPLICABLE STANDARDS |              |
|----------------------|--------------|
| STANDARD             | TEST RESULTS |
| CFR 47 Part 90       | Pass         |

UL CCS tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL CCS based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL CCS will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For UL CCS By:

Tested By:



TIMOTHY K. LEE  
STAFF ENGINEER  
UL CCS

MENGISTU MEKURIA  
EMC TECHNICIAN  
UL CCS

## 2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 90, RSS-GEN Issue 3, and TIA 603.

## 3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

## 4. CALIBRATION AND UNCERTAINTY

### 4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

### 4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamplifier Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

### 4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

| PARAMETER                             | UNCERTAINTY |
|---------------------------------------|-------------|
| Conducted Disturbance, 0.15 to 30 MHz | 3.52 dB     |
| Radiated Disturbance, 30 to 1000 MHz  | 4.94 dB     |

Uncertainty figures are valid to a confidence level of 95%.

## 5. EQUIPMENT UNDER TEST

### 5.1. DESCRIPTION OF EUT

The EUT is 10 GHz medium range Compact Surveillance Radar (CSR). The unit operates only between channel 2 through 9 (10.0670 GHz to 10.4154 GHz)

The radio module is manufactured by SpotterRF LLC.

### 5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

| Frequency (GHz) | Channel | Output Power (dBm) | Output Power (mW) |
|-----------------|---------|--------------------|-------------------|
| 10.0670         | 2       | 26.21              | 417.83            |
| 10.2660         | 5       | 26.02              | 399.94            |
| 10.4154         | 9       | 26.38              | 434.51            |

### 5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a patch antenna, with a maximum gain of 14 dBi.

### 5.4. SOFTWARE AND FIRMWARE

The EUT driver software installed during testing was Spotter RF C40 SP0003 v3.0.0-alpha.00502 (2012-10-16\_12-19).

## **5.5. WORST-CASE CONFIGURATION AND MODE**

Radiated emission was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

All final radiated testing was performed with the EUT in upright orientation as indicated by the installation instructions.

## 5.6. DESCRIPTION OF TEST SETUP

### SUPPORT EQUIPMENT

| Support Equipment List      |              |              |                 |        |
|-----------------------------|--------------|--------------|-----------------|--------|
| Description                 | Manufacturer | Model        | Serial Number   | FCC ID |
| Laptop                      | Toshiba      | PT324U03900R | 2C165037H       | DoC    |
| AC Adapter                  | Toshiba      | PA3714U-1ACA | T0412032003150A | DoC    |
| Power Over Ethernet Adapter | APC          | AP9302-WM    | --              | --     |
| AC Adapter                  | V-infinity   | ETSA200200UD | --              | --     |

### I/O CABLES

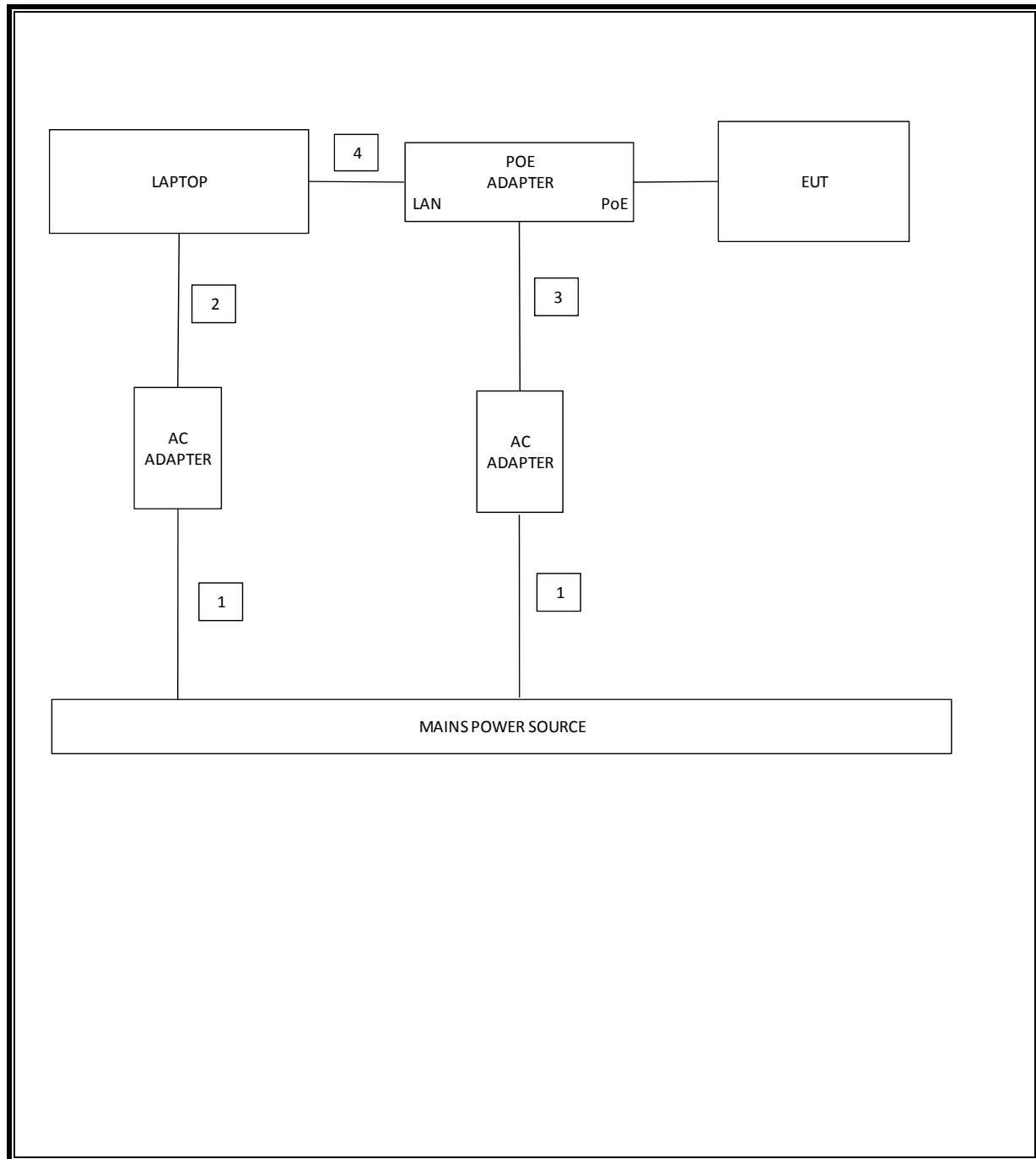
| I/O Cable List |      |                      |                |            |                  |  |
|----------------|------|----------------------|----------------|------------|------------------|--|
| Cable No       | Port | # of identical ports | Connector Type | Cable Type | Cable Length (m) | Remarks                                      |
| 1              | AC   | 2                    | AC 2P          | Unshielded | 1.8m             | None   |
| 2              | DC   | 1                    | DC             | Shielded   | 1.8m             | Ferrite on Laptop end                        |
| 3              | DC   | 1                    | DC             | Unshielded | 1.8m             | Ferrite on Adapter end                       |
| 4              | LAN  | 1                    | CAT5           | Unshielded | 2m               | None   |
| 5              | LAN  | 1                    | CAT5           | Shielded   | 7.5m             | Screw on weatherproof connector for EUT side |

### TEST SETUP

The EUT is powered via the POE adapter. Test software exercised using the Laptop controlled through the Ethernet cables.



**SETUP DIAGRAM FOR TESTS**



## 6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

| Test Equipment List             |                |              |              |            |
|---------------------------------|----------------|--------------|--------------|------------|
| Description                     | Manufacturer   | Model        | Asset        | Cal Due    |
| Spectrum Analyzer, 44 GHz       | Agilent / HP   | E4446A       | C00996       | 5/11/2013  |
| Spectrum Analyzer, 44 GHz       | Agilent / HP   | E4446A       | C00986       | 3/22/2013  |
| Antenna, Bilog, 30MHz-1 GHz     | Sunol Sciences | JB1          | C01011       | 3/23/2013  |
| Antenna, Horn, 18 GHz           | EMCO           | 3115         | C01218/10006 | 11/1/2012  |
| Antenna, Horn, 26.5 GHz         | ARA            | MWH-1826/B   | C00980       | 11/28/2012 |
| Antenna, Horn, 40 GHz           | ARA            | MWH-2640/B   | C00981       | 6/14/2013  |
| Harmonic Mixer, 50 GHz          | Agilent / HP   | 11970Q       | C00769       | 5/11/2013  |
| Harmonic Mixer, 75 GHz          | Agilent / HP   | 11970V       | C00768       | 01/31/14   |
| Preamplifier, 1300 MHz          | Agilent / HP   | 8447D        | C00885       | 11/11/12   |
| Preamplifier, 26.5 GHz          | Agilent / HP   | 8449B        | C01063       | 11/07/12   |
| Preamplifier, 40 GHz            | Miteq          | NSP4000-SP2  | C00990       | 8/2/2013   |
| Temperature / Humidity Chamber  | Thermotron     | SE 600-10-10 | C00930       | 11/1/2013  |
| Down Converter, 67 GHz          | Agilent / HP   | MT-463       | C01188       | CNR        |
| Analog Signal Generator, 40 GHz | Agilent / HP   | E8257D       | C01177       | 9/9/2013   |

## 7. ANTENNA PORT TEST RESULTS

### 7.1. 99% BANDWIDTH

#### LIMITS

FCC § 90.209(b)(5)

None; for reporting purposes only. Bandwidth for radiolocation stations will be reviewed and authorized on a case-by-case basis.

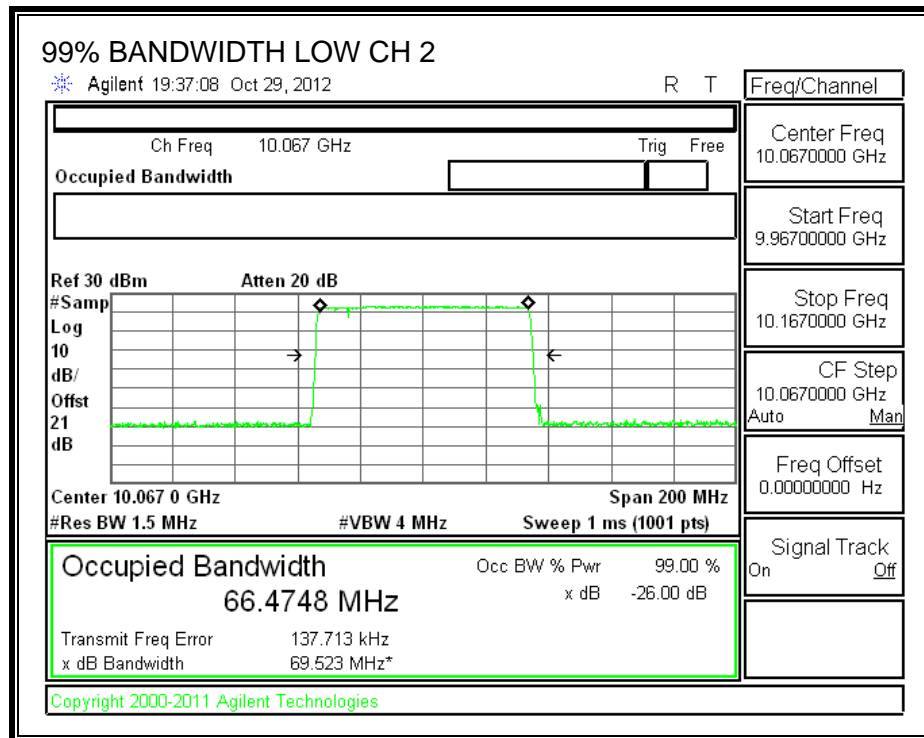
#### TEST PROCEDURE

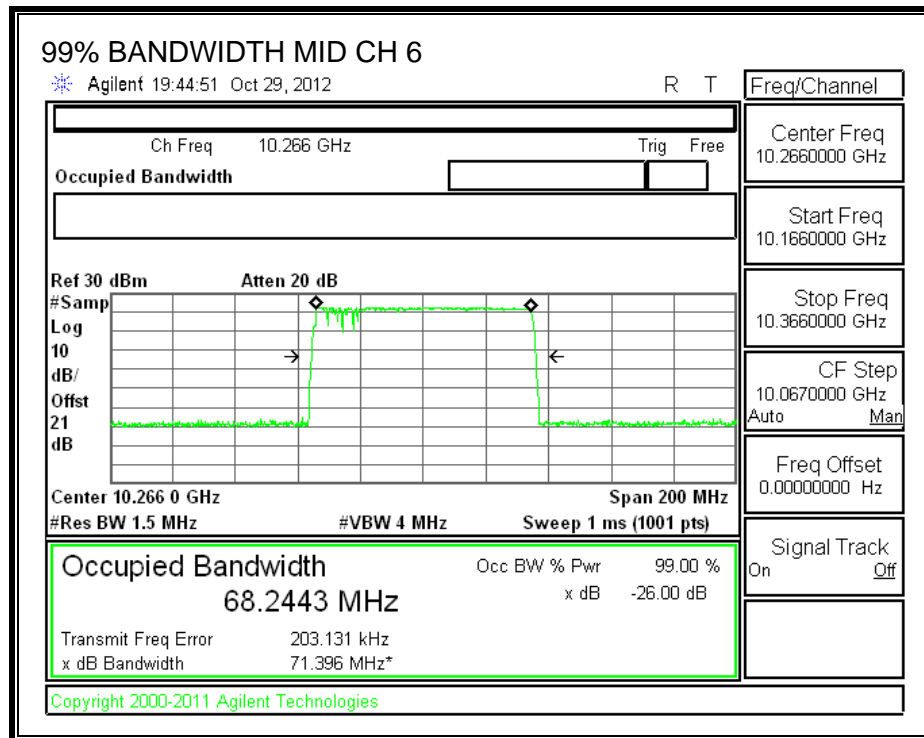
The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

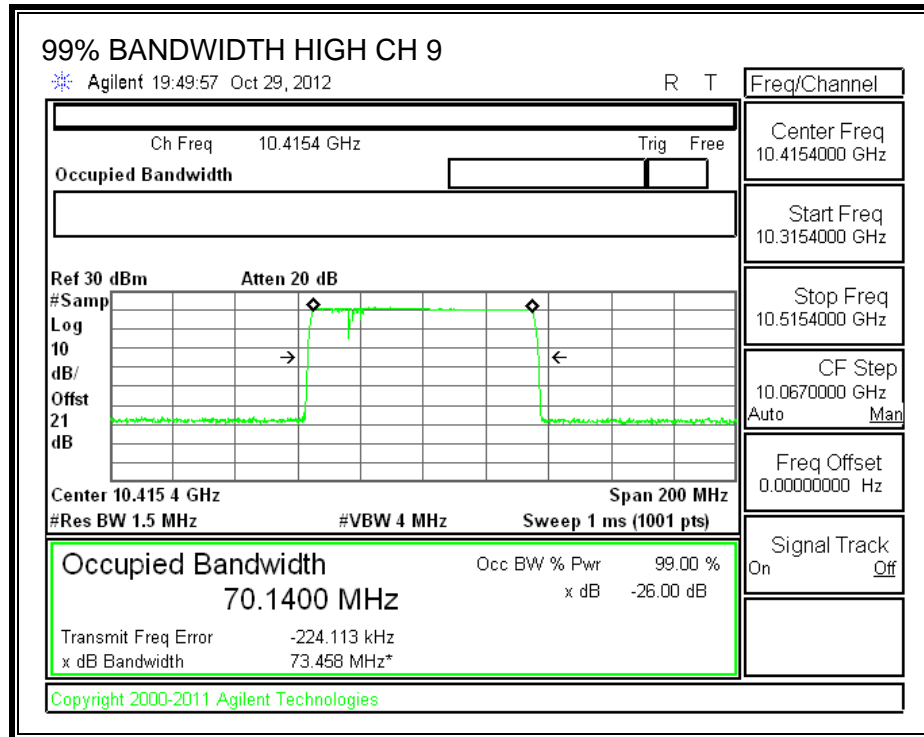
#### RESULTS

| Channel | Frequency (GHz) | 99% Bandwidth (MHz) |
|---------|-----------------|---------------------|
| 2       | 10.0670         | 66.4748             |
| 6       | 10.2660         | 68.2443             |
| 9       | 10.4154         | 70.1400             |

## 99% BANDWIDTH







## 7.2. OUTPUT POWER

### LIMITS

FCC §90.103(c) (13)

The maximum power into the antenna port shall be less than 5 W.

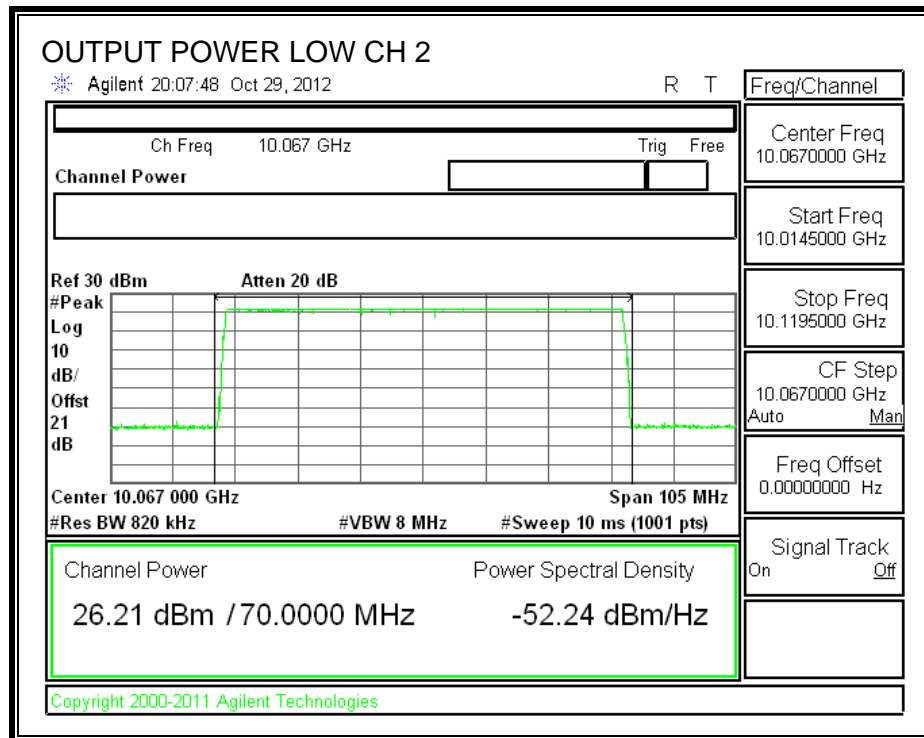
### TEST PROCEDURE

The transmitter output was connected to the input terminal via calibrated coaxial cable. The output power was measured with the spectrum analyzer at the low, middle and high channel in each band.

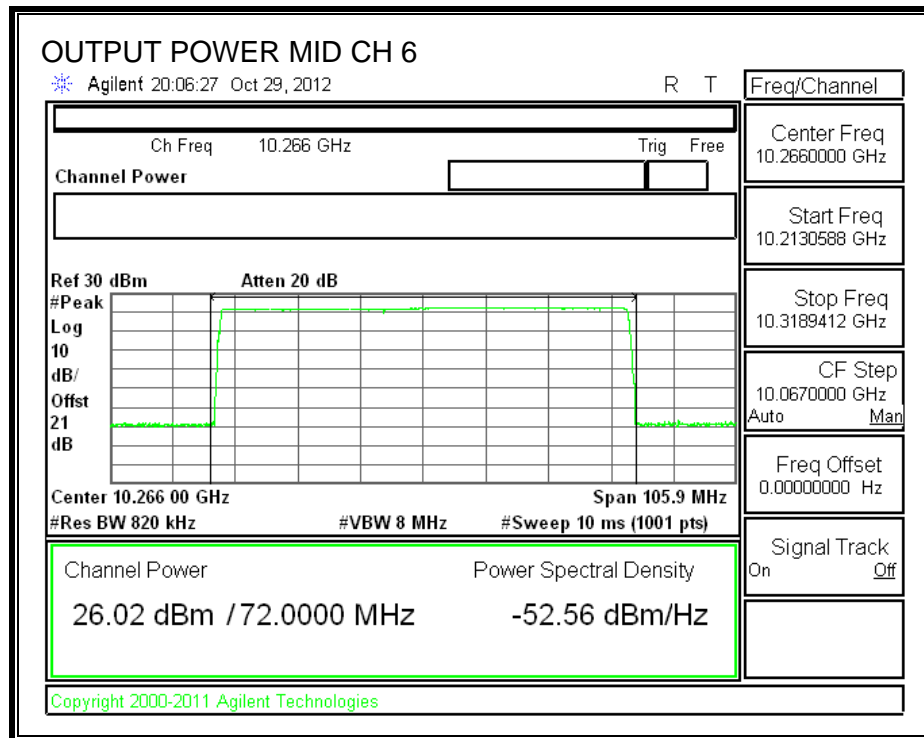
### RESULTS

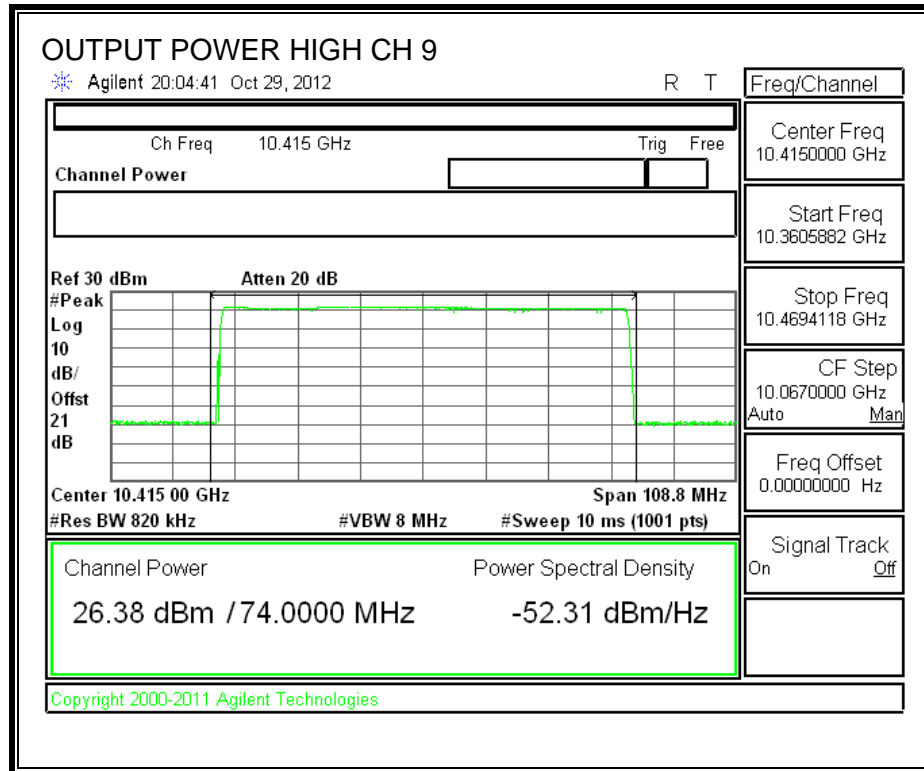
| Channel | Frequency<br>(GHz) | Peak Power<br>Reading<br>(dBm) | Limit<br>(dBm) | Margin<br>(dB) |
|---------|--------------------|--------------------------------|----------------|----------------|
| 2       | 10.0670            | 26.210                         | 37             | -10.790        |
| 6       | 10.2660            | 26.020                         | 37             | -10.980        |
| 9       | 10.4154            | 26.380                         | 37             | -10.620        |

## OUTPUT POWER









### 7.3. AVERAGE POWER

#### LIMITS

None; for reporting purposes only.

#### TEST PROCEDURE

The transmitter output is connected to a power meter.

#### RESULTS

The cable assembly insertion loss of 22 dB (including 20dB pad and 2 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

| Channel | Frequency<br>(GHz) | AV power<br>(dBm) |
|---------|--------------------|-------------------|
| 2       | 10.0670            | 20.63             |
| 6       | 10.2660            | 20.96             |
| 9       | 10.4154            | 20.27             |

## **7.4. CONDUCTED SPURIOUS EMISSIONS**

### **LIMITS**

FCC §90.210

Attenuation below carrier of  $43 + 10 \log (P)$  dB or -13dBm

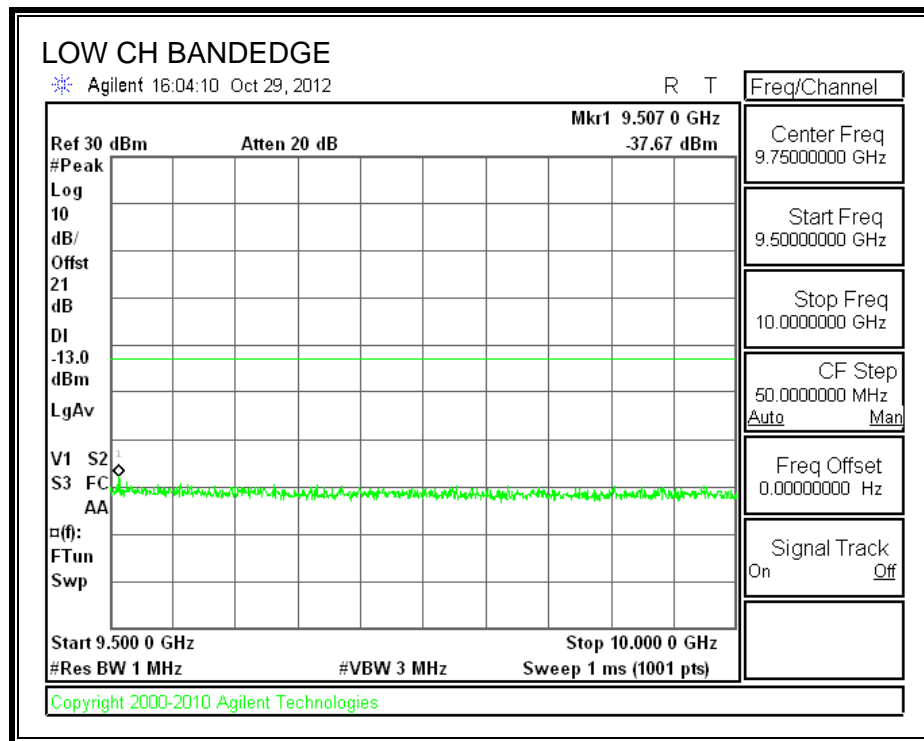
### **TEST PROCEDURE**

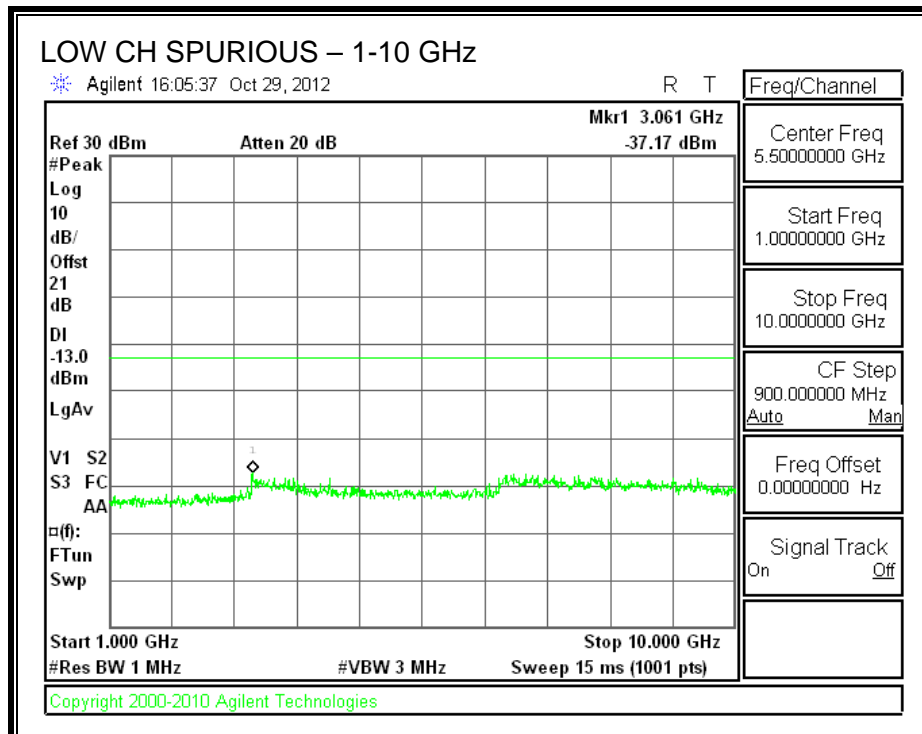
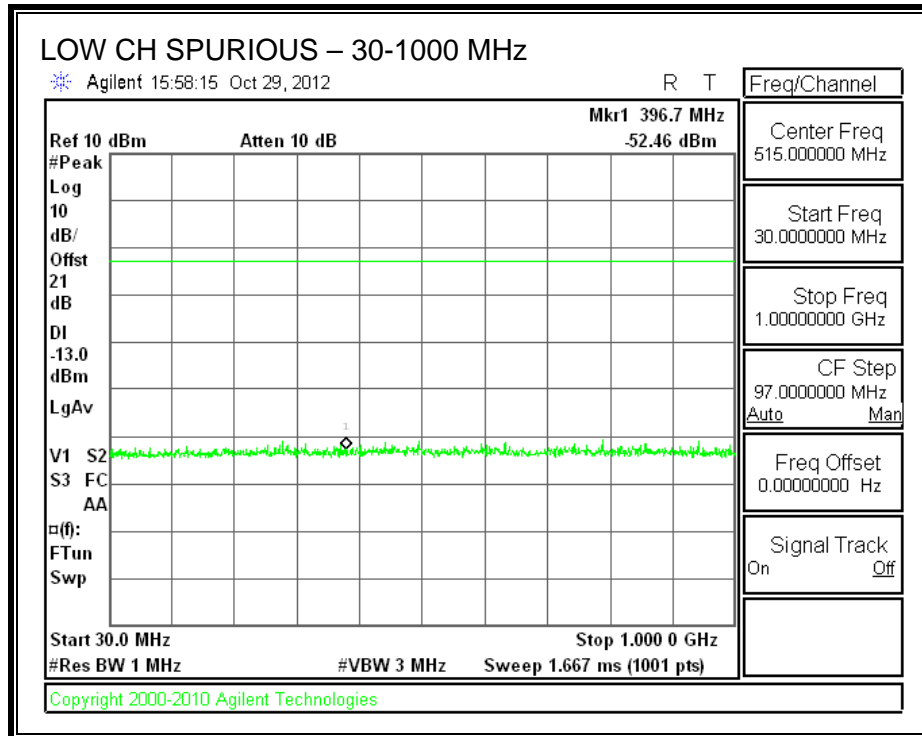
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

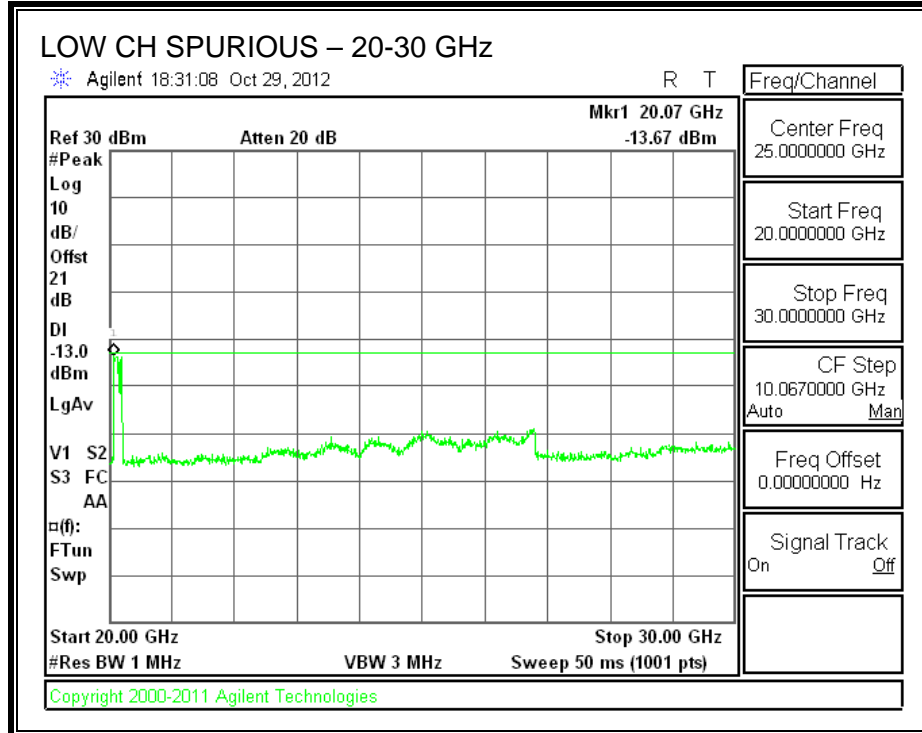
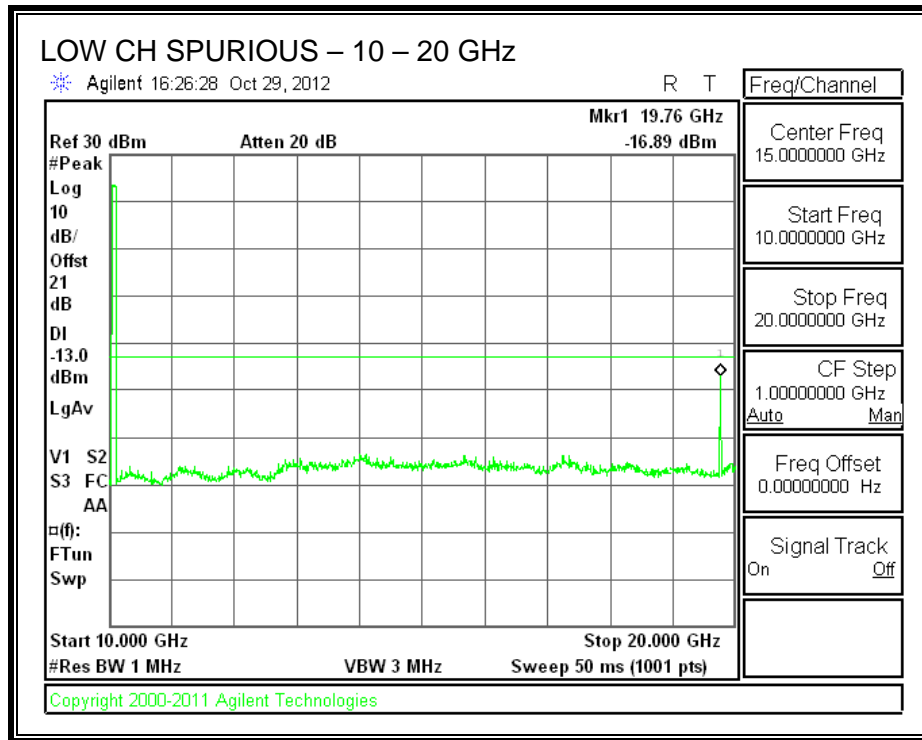
The spectrum from 30 MHz to 40 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

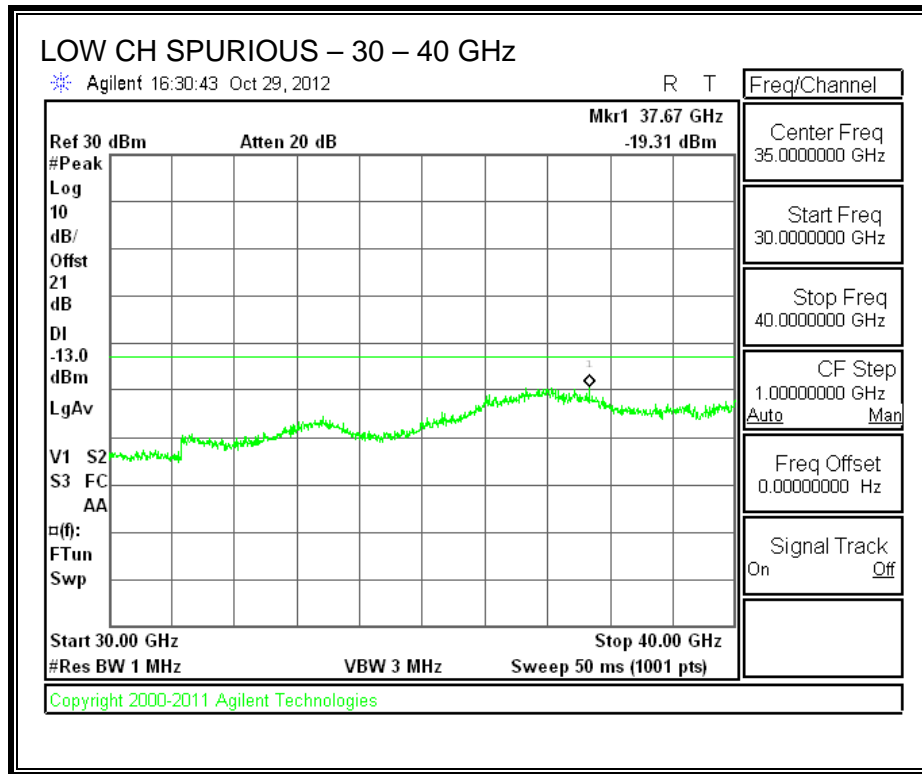
## RESULT

### SPURIOUS EMISSIONS, LOW CHANNEL



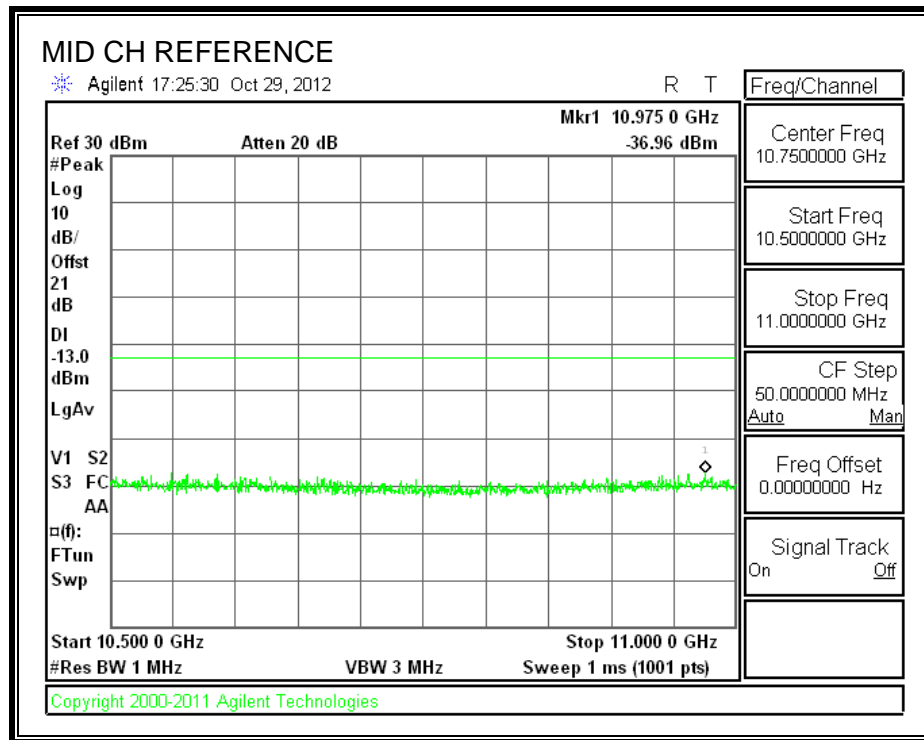


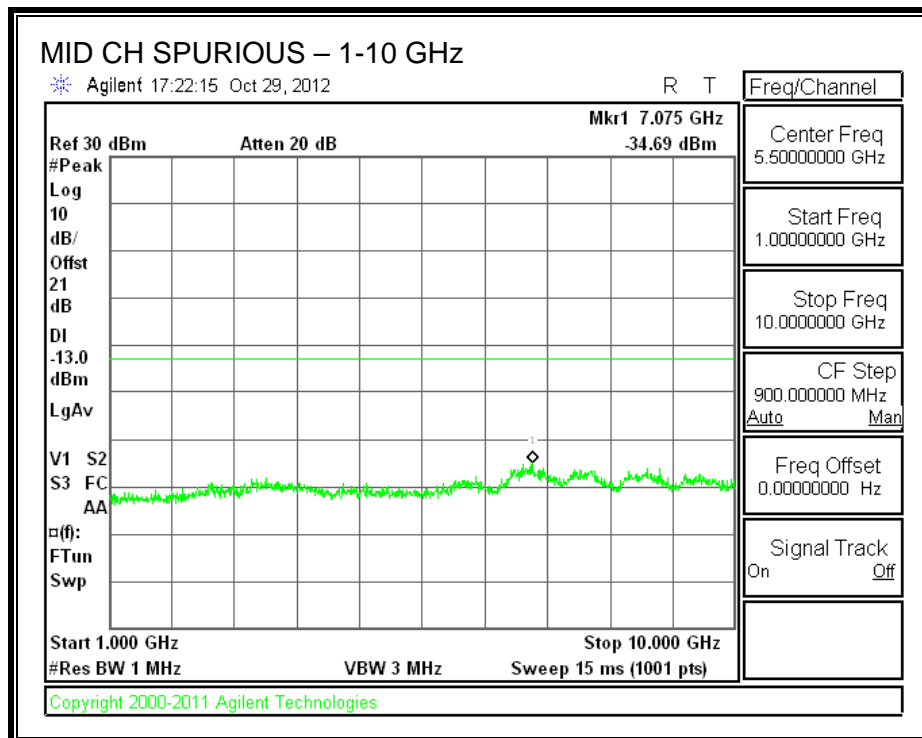
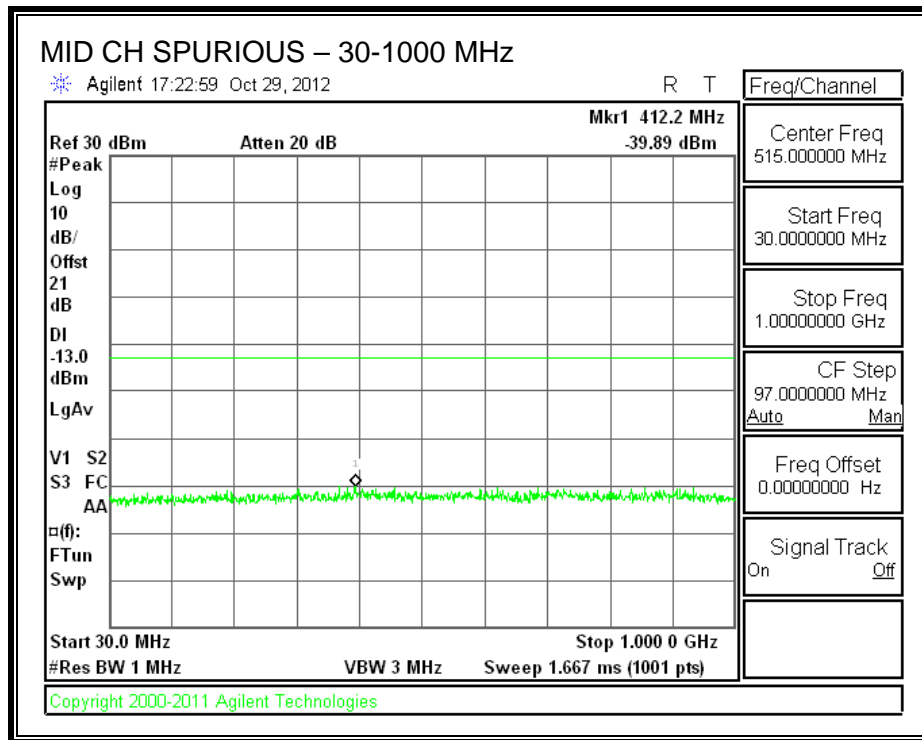


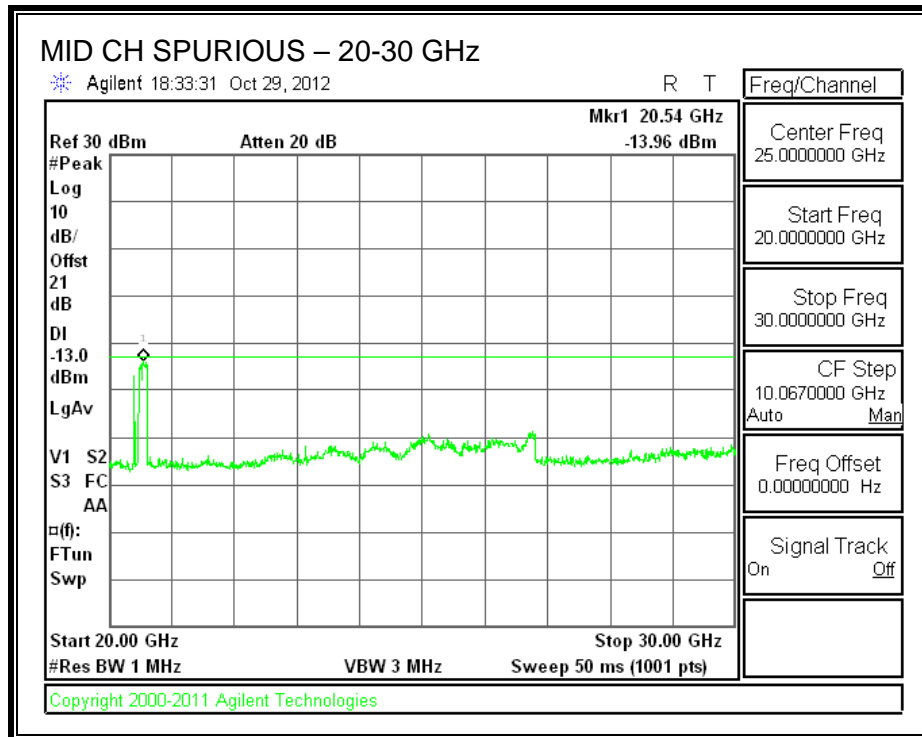
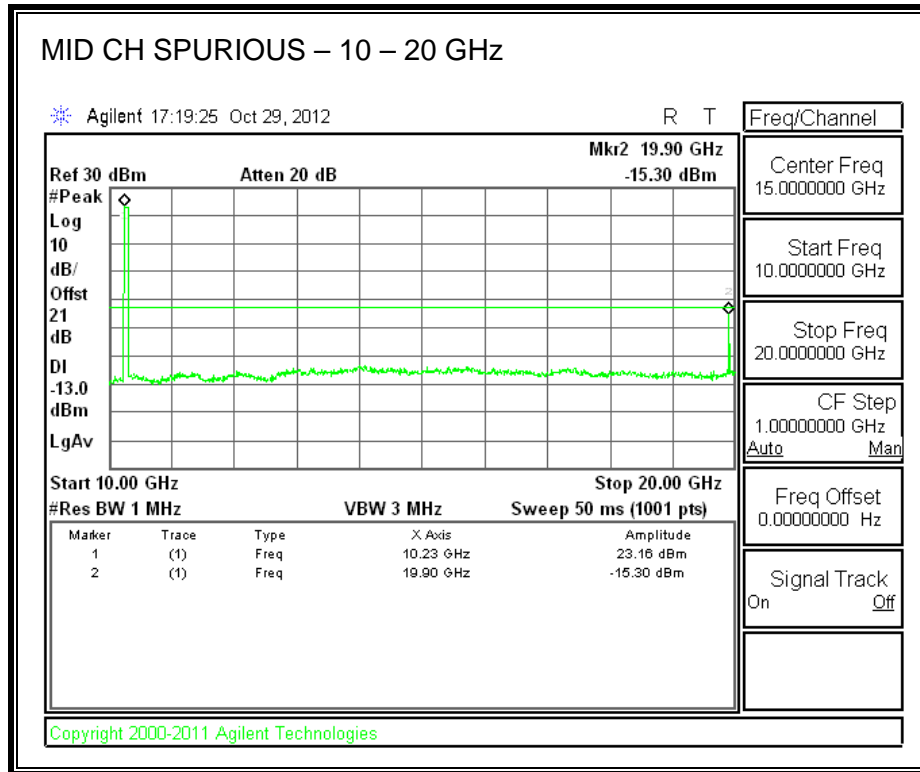


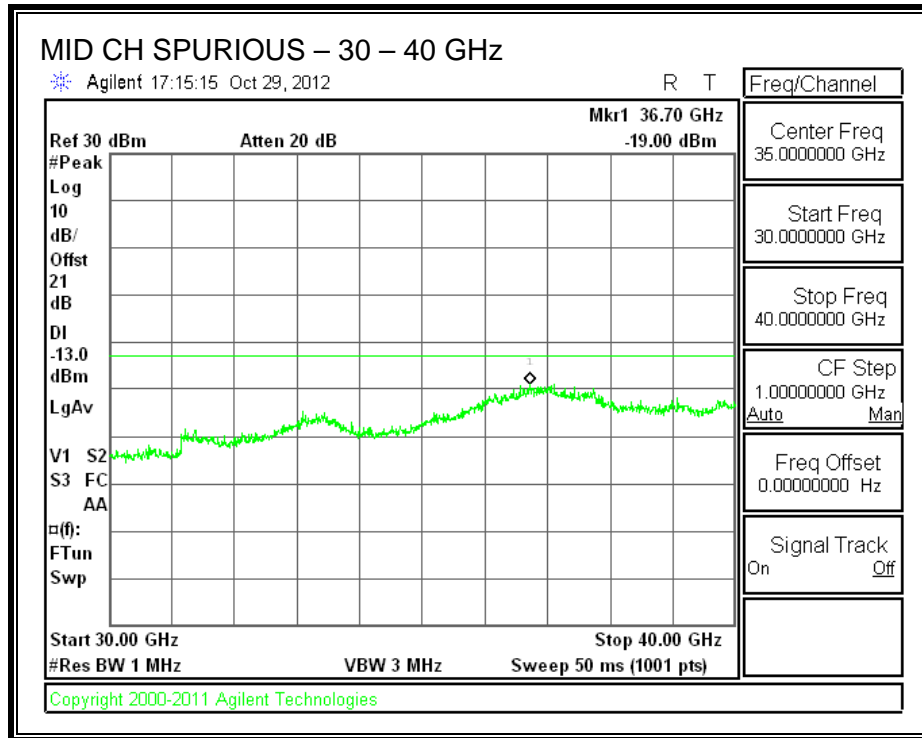


**SPURIOUS EMISSIONS, MID CHANNEL**

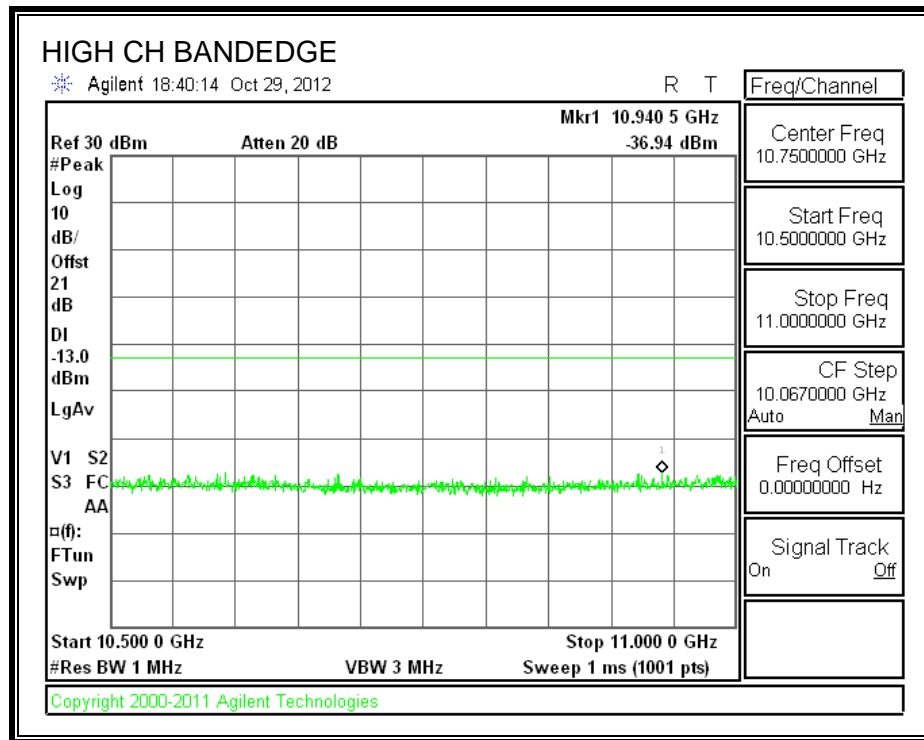


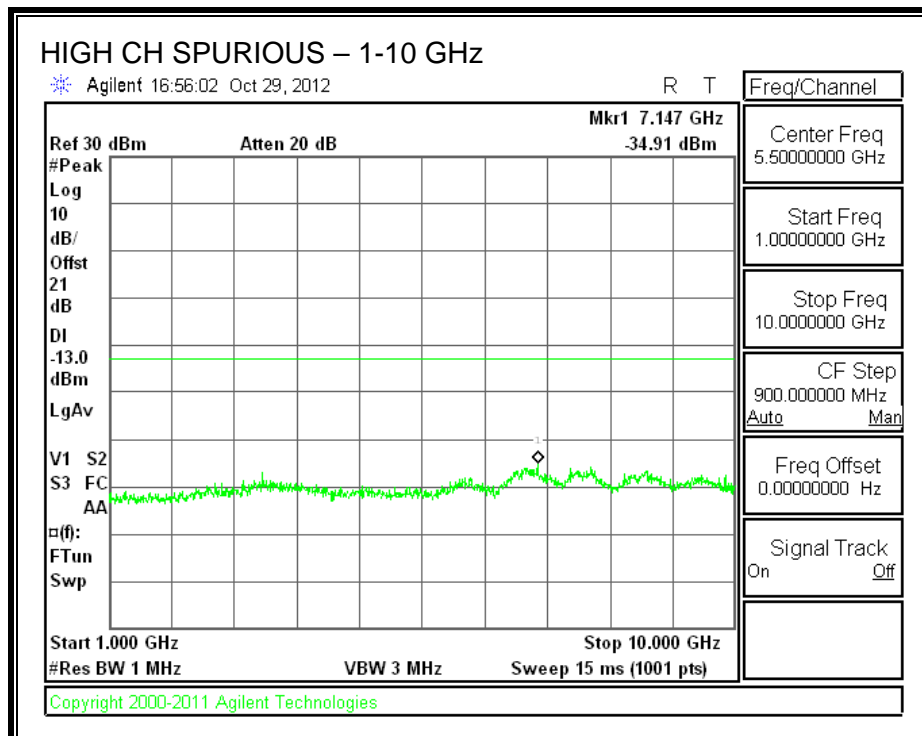
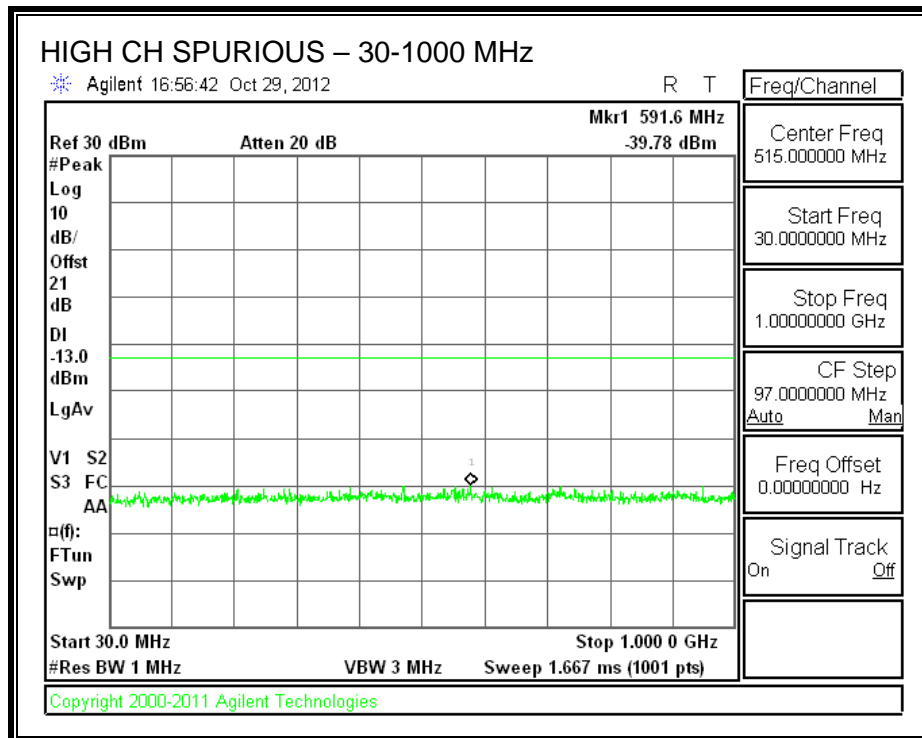


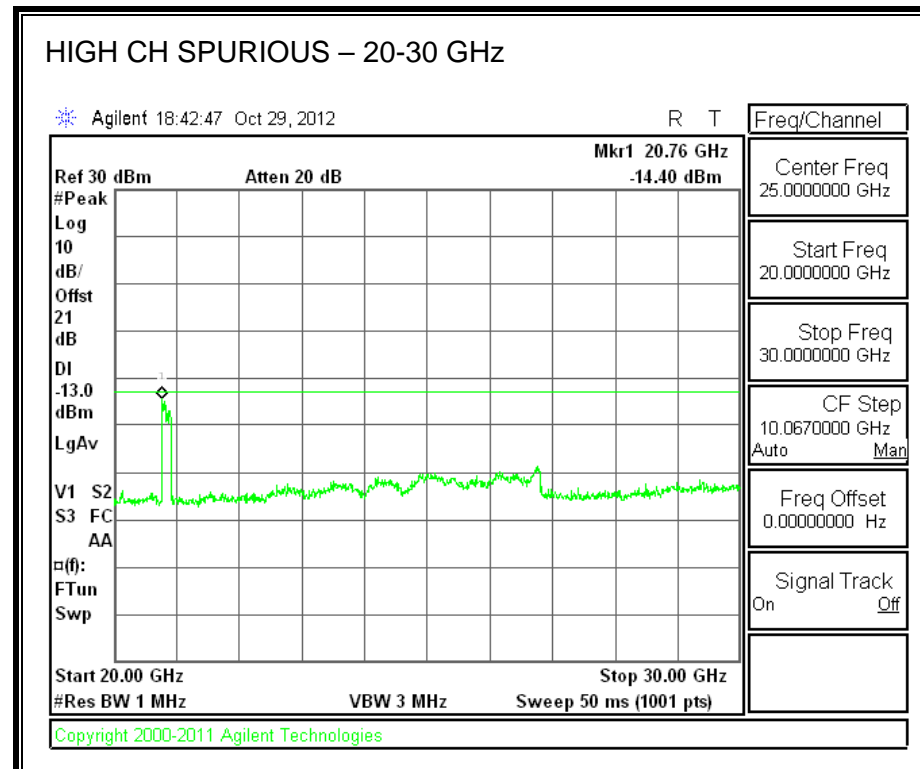
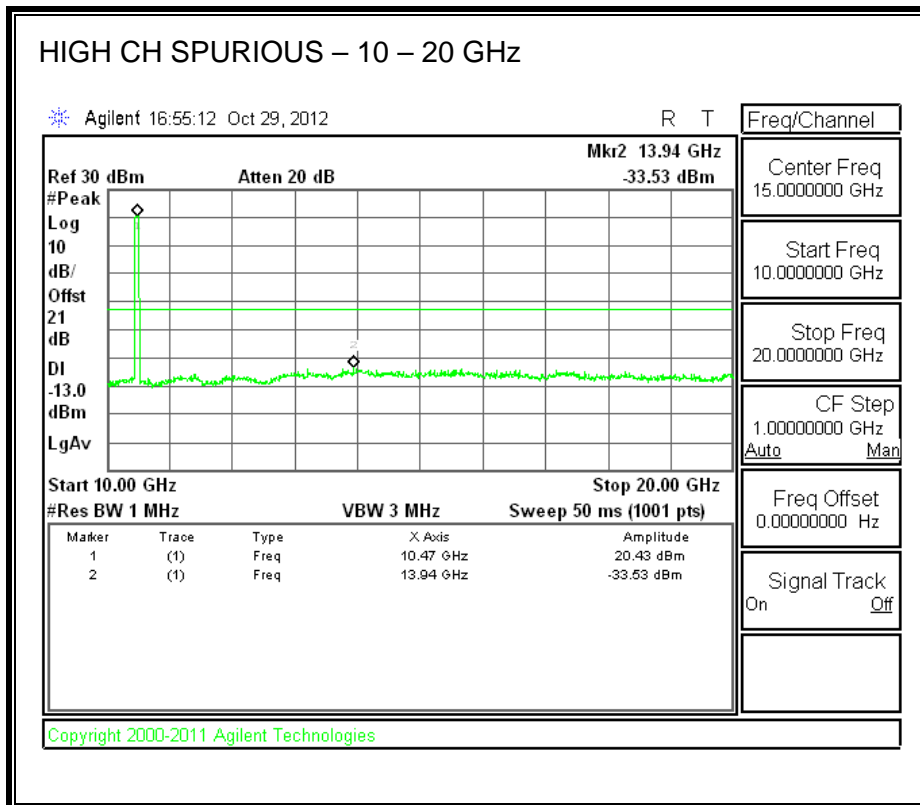


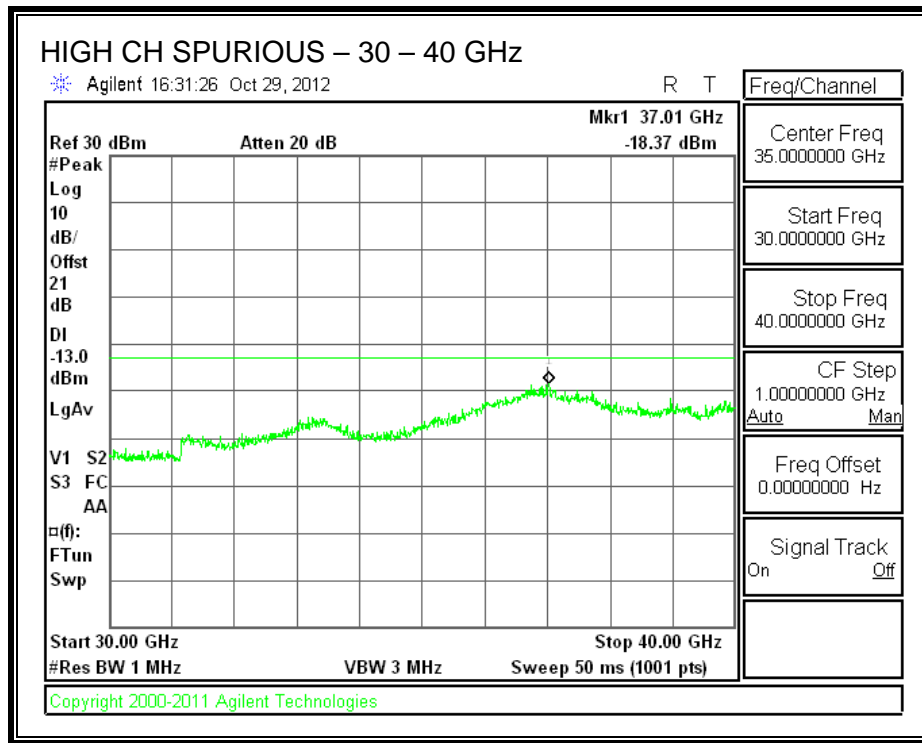


**SPURIOUS EMISSIONS, HIGH CHANNEL**











## 7.5. FREQUENCY STABILITY

### LIMIT

§90.213 (a) The frequency tolerance of the carrier signal shall be maintained within  $\pm 0.01\%$  of the operating frequency, over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

### TEST PROCEDURE

ANSI / TIA / EIA 603 Clause 2.3.1 and 2.3.2

### RESULTS

| Reference Frequency: EUT Mid Channel @ 20°C<br>Limit: $\pm 100$ ppm = 102748.632 kHz |                                 |   |              |                             |
|--|---------------------------------|---|--------------|-----------------------------|
| Power Supply<br>(Vac)  | Environment<br>Temperature (°C) | Frequency Deviation Measured with Time Elapse |              |                             |
|  |                                 | (MHz)   | Delta (ppm)  | Limit (ppm)                 |
| 115.00   | 60                              | 10274.8802923                                 | -0.017       | $\pm 100$                   |
| 115.00   | 50                              | 10274.8627320                                 | 0.000        | $\pm 100$                   |
| 115.00   | 40                              | 10274.8518686                                 | 0.011        | $\pm 100$                   |
| 115.00   | 30                              | 10274.8375478                                 | 0.025        | $\pm 100$                   |
| <b>115.00</b>  | <b>20</b>                       | <b>10274.8632139</b>                          | <b>0.000</b> | <b><math>\pm 100</math></b> |
| 115.00   | 10                              | 10274.8828166                                 | -0.019       | $\pm 100$                   |
| 115.00   | 0                               | 10274.9168166                                 | -0.052       | $\pm 100$                   |
| 115.00   | -10                             | 10274.9548166                                 | -0.089       | $\pm 100$                   |
| 115.00   | -20                             | 10274.9929281                                 | -0.126       | $\pm 100$                   |

## 8. RADIATED TEST RESULTS

### 8.1. LIMITS AND PROCEDURE

#### LIMITS

FCC §90.210

13dBm (~ 82dBuV/m)

#### TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.4. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

The spectrum from 30 MHz to 55 GHz is investigated with the transmitter set at the worst case channel.

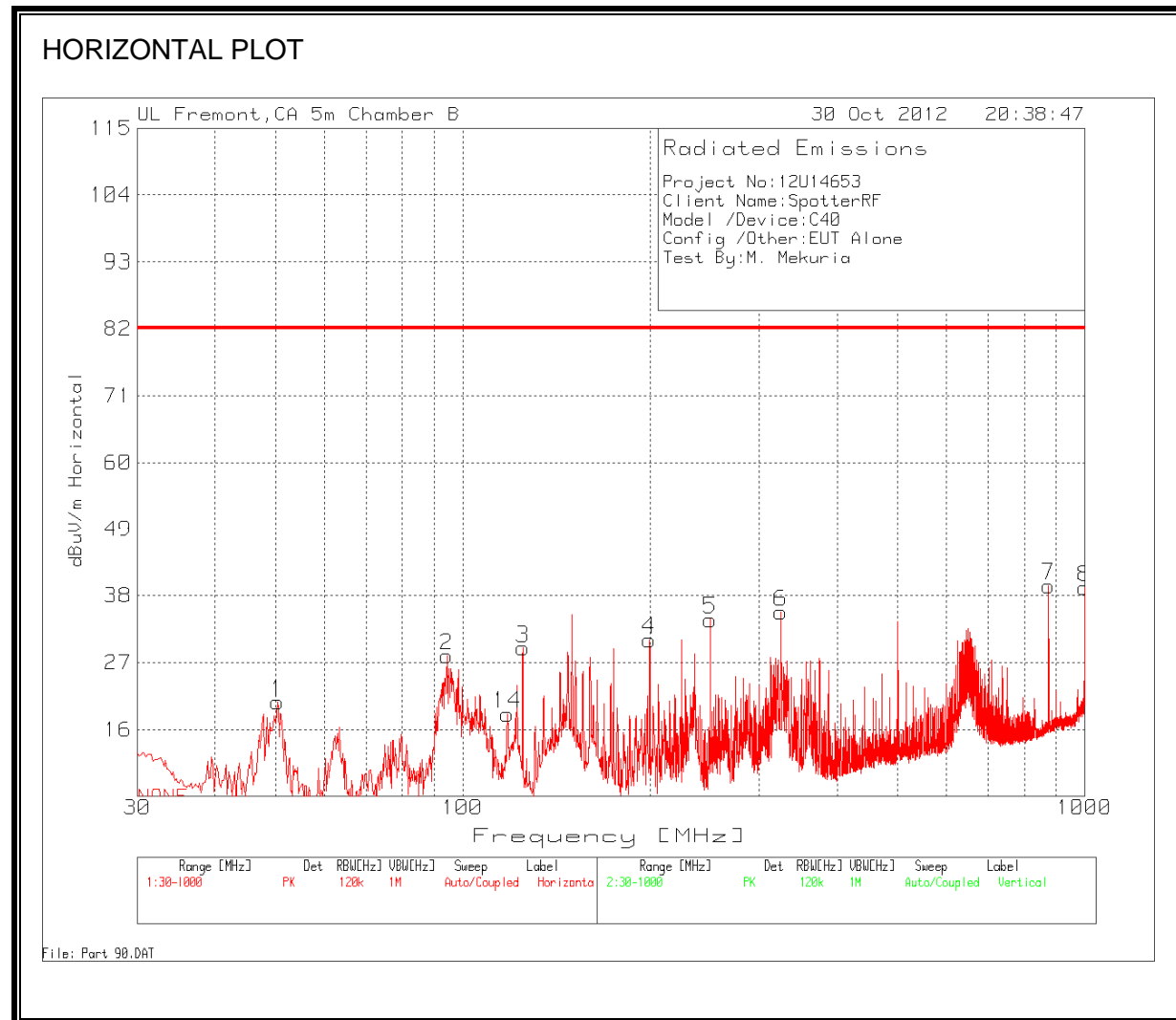
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

## 8.2. TRANSMITTER ABOVE 1 GHz

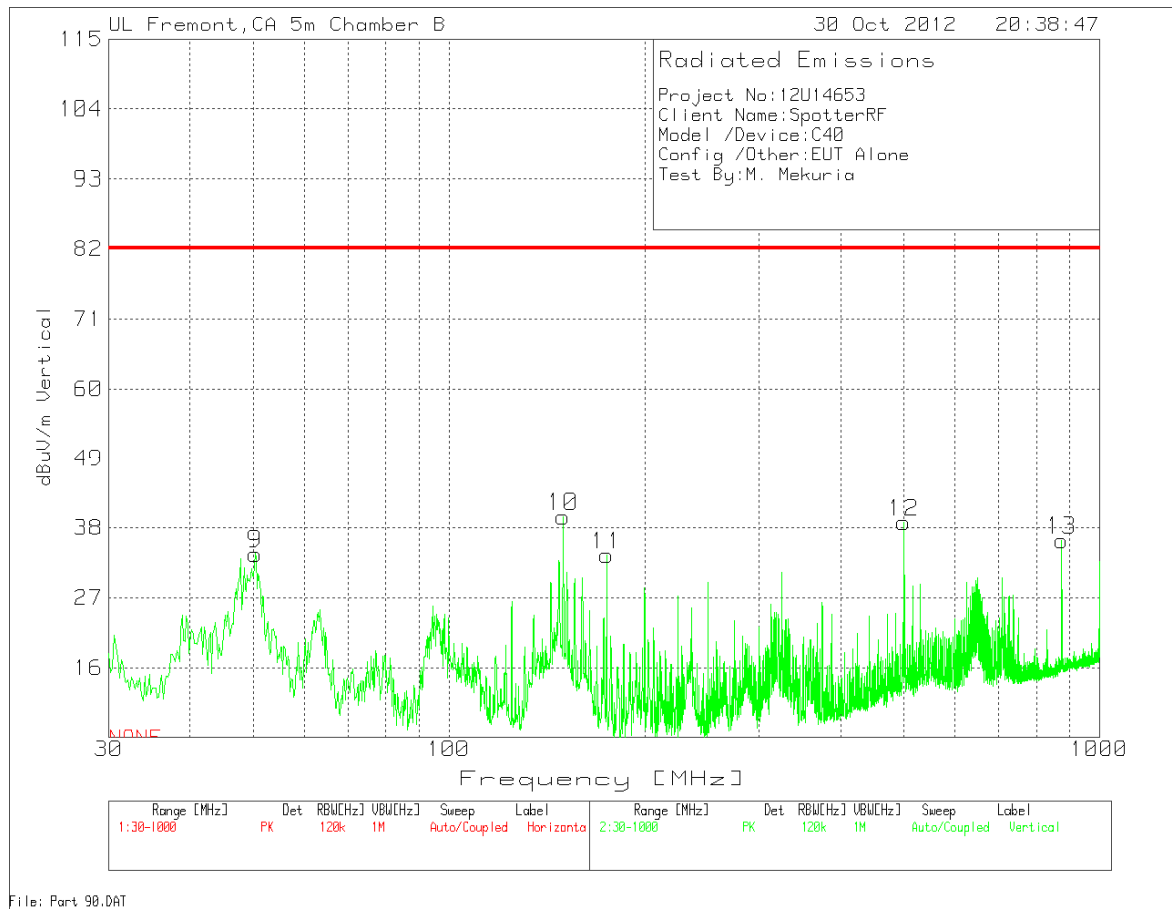
| Compliance Certification Services<br>Above 1GHz High Frequency Substitution Measurement |                     |                                     |                 |                |                |               |                |               |       |
|---|---------------------|-------------------------------------|-----------------|----------------|----------------|---------------|----------------|---------------|-------|
| <b>Company:</b>   |                     | SpotterRF                           |                 |                |                |               |                |               |       |
| <b>Project #:</b>   |                     | 12U14653                            |                 |                |                |               |                |               |       |
| <b>Date:</b>  |                     | 10/29/12                            |                 |                |                |               |                |               |       |
| <b>Test Engineer:</b>   |                     | MENGISTU MEKURIA                    |                 |                |                |               |                |               |       |
| <b>Configuration:</b>   |                     | EUT ALONE (ANTENNA PORT TERMINATED) |                 |                |                |               |                |               |       |
| <b>Mode:</b>  |                     | TX MODE                             |                 |                |                |               |                |               |       |
| <b>Chamber</b>  |                     | <b>Pre-amplifier</b>                |                 | <b>Filter</b>  |                | <b>Limit</b>  |                |               |       |
| 5m Chamber B  |                     | T145 8449B                          |                 |                |                | Part 90       |                |               |       |
| f<br>GHz  | SG reading<br>(dBm) | Ant. Pol.<br>(H/V)                  | Distance<br>(m) | Preamp<br>(dB) | Filter<br>(dB) | EIRP<br>(dBm) | Limit<br>(dBm) | Delta<br>(dB) | Notes |
| <b>Low Channel (Channel 2)</b>  |                     |                                     |                 |                |                |               |                |               |       |
| 1.128   | -22.5               | V                                   | 3.0             | 36.2           |                | -58.6         | -13.0          | -45.6         |       |
| 5.025   | 10.8                | V                                   | 3.0             | 35.3           |                | -24.5         | -13.0          | -11.5         |       |
| 15.132  | -5.1                | V                                   | 3.0             | 33.5           |                | -38.6         | -13.0          | -25.6         |       |
| 20.146  | -3.4                | V                                   | 3.0             | 32.0           |                | -35.5         | -13.0          | -22.5         |       |
| 1.128   | -23.4               | H                                   | 3.0             | 36.2           |                | -59.5         | -13.0          | -46.5         |       |
| 5.025   | 9.1                 | H                                   | 3.0             | 35.3           |                | -26.2         | -13.0          | -13.2         |       |
| 15.132  | -9.1                | H                                   | 3.0             | 33.5           |                | -42.6         | -13.0          | -29.6         |       |
| 20.146  | -1.9                | H                                   | 3.0             | 32.0           |                | -34.0         | -13.0          | -21.0         |       |
| <b>Mid Channel (Channel 6)</b>  |                     |                                     |                 |                |                |               |                |               |       |
| 1.126   | -23.9               | V                                   | 3.0             | 36.2           |                | -60.0         | -13.0          | -47.0         |       |
| 5.113   | 9.4                 | V                                   | 3.0             | 35.3           |                | -26.0         | -13.0          | -13.0         |       |
| 15.380  | 0.6                 | V                                   | 3.0             | 33.4           |                | -32.8         | -13.0          | -19.8         |       |
| 20.500  | -3.1                | V                                   | 3.0             | 32.1           |                | -35.2         | -13.0          | -22.2         |       |
| 1.126   | -24.0               | H                                   | 3.0             | 36.2           |                | -60.1         | -13.0          | -47.1         |       |
| 5.113   | 8.5                 | H                                   | 3.0             | 35.3           |                | -26.8         | -13.0          | -13.8         |       |
| 15.428  | -10.1               | H                                   | 3.0             | 33.3           |                | -43.5         | -13.0          | -30.5         |       |
| 20.050  | -2.6                | H                                   | 3.0             | 32.0           |                | -34.6         | -13.0          | -21.6         |       |
| <b>High Channel (Channel 9)</b>   |                     |                                     |                 |                |                |               |                |               |       |
| 1.126   | -22.7               | V                                   | 3.0             | 36.2           |                | -58.8         | -13.0          | -45.8         |       |
| 5.212   | 7.7                 | V                                   | 3.0             | 35.3           |                | -27.7         | -13.0          | -14.7         |       |
| 15.585  | -1.4                | V                                   | 3.0             | 33.3           |                | -34.7         | -13.0          | -21.7         |       |
| 20.800  | -1.6                | V                                   | 3.0             | 32.1           |                | -33.7         | -13.0          | -20.7         |       |
| 1.126   | -24.0               | H                                   | 3.0             | 36.2           |                | -60.2         | -13.0          | -47.2         |       |
| 5.041   | -3.2                | H                                   | 3.0             | 35.3           |                | -38.5         | -13.0          | -25.5         |       |
| 5.221   | 9.4                 | H                                   | 3.0             | 35.3           |                | -26.0         | -13.0          | -13.0         |       |
| 15.585  | -8.0                | H                                   | 3.0             | 33.3           |                | -41.2         | -13.0          | -28.2         |       |
| 20.800  | -3.1                | H                                   | 3.0             | 32.1           |                | -35.2         | -13.0          | -22.2         |       |
| Rev. 03.03.09   |                     |                                     |                 |                |                |               |                |               |       |
| Note: No other emissions were detected above the system noise floor.                    |                     |                                     |                 |                |                |               |                |               |       |

### 8.3. WORST-CASE BELOW 1 GHz

#### SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION,)



## VERTICAL PLOT



## HORIZONTAL AND VERTICAL DATA

| Project No:12U14653     |               |          |                           |                              |                           |        |      |        |             |          |
|-------------------------|---------------|----------|---------------------------|------------------------------|---------------------------|--------|------|--------|-------------|----------|
| Client Name:SpotterRF   |               |          |                           |                              |                           |        |      |        |             |          |
| Model /Device:C40       |               |          |                           |                              |                           |        |      |        |             |          |
| Config /Other:EUT Alone |               |          |                           |                              |                           |        |      |        |             |          |
| Test By:M. Mekuria      |               |          |                           |                              |                           |        |      |        |             |          |
| Horizontal 30 - 1000MHz |               |          |                           |                              |                           |        |      |        |             |          |
| Test Frequency          | Meter Reading | Detector | T122 Sunol Bilog.TXT (dB) | 5mB Amp Path 30-1000MHz (dB) | to 3m Conversion (dB)     | dBuV/m | NONE | Margin | Height [cm] | Polarity |
| 50.3537                 | 51.98         | PK       | 8                         | -29                          | -10.5                     | 20.48  | 82   | -61.52 | 300         | Horz     |
| 94.3565                 | 58.48         | PK       | 8.7                       | -28.6                        | -10.5                     | 28.08  | 82   | -53.92 | 300         | Horz     |
| 124.984                 | 53.96         | PK       | 14.2                      | -28.3                        | -10.5                     | 29.36  | 82   | -52.64 | 200         | Horz     |
| 199.8082                | 56.03         | PK       | 12.8                      | -27.6                        | -10.5                     | 30.73  | 82   | -51.27 | 100         | Horz     |
| 250.014                 | 60.27         | PK       | 11.5                      | -27.2                        | -10.5                     | 34.07  | 82   | -47.93 | 100         | Horz     |
| 325.032                 | 58.65         | PK       | 13.9                      | -26.8                        | -10.5                     | 35.25  | 82   | -46.75 | 100         | Horz     |
| 875.1639                | 52.96         | PK       | 22.1                      | -25                          | -10.5                     | 39.56  | 82   | -42.44 | 100         | Horz     |
| 1000                    | 50.77         | PK       | 23.2                      | -24.2                        | -10.5                     | 39.27  | 82   | -42.73 | 100         | Horz     |
| 118.1994                | 43.45         | PK       | 13.9                      | -28.3                        | -10.5                     | 18.55  | 82   | -63.45 | 300         | Horz     |
| Vertical 30 - 1000MHz   |               |          |                           |                              |                           |        |      |        |             |          |
| Test Frequency          | Meter Reading | Detector | T122 Sunol Bilog.TXT (dB) | 5mB Amp Path 30-1000MHz (dB) | 10m to 3m Conversion (dB) | dBuV/m | NONE | Margin | Height [cm] | Polarity |
| 50.3537                 | 65.42         | PK       | 8                         | -29                          | -10.5                     | 33.92  | 82   | -48.08 | 100         | Vert     |
| 149.99                  | 65.61         | PK       | 12.6                      | -28                          | -10.5                     | 39.71  | 82   | -42.29 | 100         | Vert     |
| 174.8022                | 60.58         | PK       | 11.4                      | -27.8                        | -10.5                     | 33.68  | 82   | -48.32 | 100         | Vert     |
| 500.0739                | 58.63         | PK       | 17.7                      | -27                          | -10.5                     | 38.83  | 82   | -43.17 | 100         | Vert     |
| 875.1639                | 49.4          | PK       | 22.1                      | -25                          | -10.5                     | 36     | 82   | -46    | 100         | Vert     |

## 9. MAXIMUM PERMISSIBLE RF EXPOSURE

### 9.1. FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

| Frequency range (MHz)                                   | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|---|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| (A) Limits for Occupational/Controlled Exposures        |                               |                               |                                     |                          |
| 0.3–3.0 .....   | 614                           | 1.63                          | *(100)                              | 6                        |
| 3.0–30 .....  | 1842/f                        | 4.89/f                        | *(900/f <sup>2</sup> )              | 6                        |
| 30–300 .....  | 61.4                          | 0.163                         | 1.0                                 | 6                        |
| 300–1500 .....  | .....                         | .....                         | f/300                               | 6                        |
| 1500–100,000 .....                                      | .....                         | .....                         | 5                                   | 6                        |
| (B) Limits for General Population/Uncontrolled Exposure |                               |                               |                                     |                          |
| 0.3–1.34 .....  | 614                           | 1.63                          | *(100)                              | 30                       |
| 1.34–30 .....   | 824/f                         | 2.19/f                        | *(180/f <sup>2</sup> )              | 30                       |

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|-----------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| 30–300 .....          | 27.5                          | 0.073                         | 0.2                                 | 30                       |
| 300–1500 .....        | .....                         | .....                         | f/1500                              | 30                       |
| 1500–100,000 .....    | .....                         | .....                         | 1.0                                 | 30                       |

f = frequency in MHz

\* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

## 9.2. IC RULES

IC Safety Code 6, Section 2.2.1 (a) A person other than an RF and microwave exposed worker shall not be exposed to electromagnetic radiation in a frequency band listed in Column 1 of Table 5, if the field strength exceeds the value given in Column 2 or 3 of Table 5, when averaged spatially and over time, or if the power density exceeds the value given in Column 4 of Table 5, when averaged spatially and over time.

**Table 5**  
**Exposure Limits for Persons Not Classified As RF and Microwave Exposed Workers (Including the General Public)**

| 1<br>Frequency<br>(MHz) | 2<br>Electric Field<br>Strength; rms<br>(V/m) | 3<br>Magnetic Field<br>Strength; rms<br>(A/m) | 4<br>Power<br>Density<br>(W/m <sup>2</sup> ) | 5<br>Averaging<br>Time<br>(min) |
|-------------------------|---|---|--|---------------------------------|
| 0.003–1                 | 280   | 2.19  |  | 6                               |
| 1–10                    | $280/f$                                       | $2.19/f$                                      |  | 6                               |
| 10–30                   | 28  | $2.19/f$                                      |  | 6                               |
| 30–300                  | 28  | 0.073   | 2*   | 6                               |
| 300–1 500               | $1.585f^{0.5}$                                | $0.0042f^{0.5}$                               | $f/150$                                      | 6                               |
| 1 500–15 000            | 61.4  | 0.163   | 10   | 6                               |
| 15 000–150 000          | 61.4  | 0.163   | 10   | $616\,000/f^{1.2}$              |
| 150 000–300 000         | $0.158f^{0.5}$                                | $4.21 \times 10^{-4}f^{0.5}$                  | $6.67 \times 10^{-5}f$                       | $616\,000/f^{1.2}$              |

\* Power density limit is applicable at frequencies greater than 100 MHz.

**Notes:** 1. Frequency,  $f$ , is in MHz.  
2. A power density of 10 W/m<sup>2</sup> is equivalent to 1 mW/cm<sup>2</sup>.  
3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla (μT) or 12.57 milligauss (mG).



### 9.3. EQUATIONS

#### **POWER DENSITY**

Power density is given by:

$$S = \text{EIRP} / (4 * \text{Pi} * D^2)$$

Where

S = Power density in mW/cm<sup>2</sup>

EIRP = Equivalent Isotropic Radiated Power in mW

D = Separation distance in cm

Power density in units of mW/cm<sup>2</sup> is converted to units of W/m<sup>2</sup> by multiplying by 10.

#### **DISTANCE**

Distance is given by:

$$D = \text{SQRT} (\text{EIRP} / (4 * \text{Pi} * S))$$

Where

D = Separation distance in cm

EIRP = Equivalent Isotropic Radiated Power in mW

S = Power density in mW/cm<sup>2</sup>

#### **SOURCE-BASED DUTY CYCLE**

Where applicable (for example, multi-slot cell phone applications) a duty cycle factor may be applied.

$$\text{Source-based time-averaged EIRP} = (\text{DC} / 100) * \text{EIRP}$$

Where

DC = Duty Cycle in %, as applicable

EIRP = Equivalent Isotropic Radiated Power in W

## 10. RF EXPOSURE RESULTS

In the table(s) below, Power and Gain are entered in units of dBm and dBi respectively and conversions to linear forms are used for the calculations.

| Band   | Mode     | Separation Distance (cm) | Output Power (dBm) | Antenna Gain (dBi) | Duty Cycle (%) | EIRP (mW) | FCC Power Density (mW/cm <sup>2</sup> ) | IC Power Density (W/m <sup>2</sup> ) |
|--------|----------|--------------------------|--------------------|--------------------|----------------|-----------|---|--------------------------------------|
| 10 GHz | Transmit | 20                       | 20.96              | 14.00              | 100.0          | 3133.3    | 0.624                                   | 6.24                                 |

FCC Limit = 1 mW/cm<sup>2</sup>  
IC Limit = 10 W/m<sup>2</sup>