America

Choose certainty.
Add value.

Report On

Radio testing of the
Echodyne Corporation
Detect and Avoid Radar
Models: 700-0005-201_DAA_NC
700-0005-202_DAA_LT

FCC CFR 47 Part 2 and Part 87

Report No. BT72129233-0617 **October 2017**

REPORT ON	Radio Testing of the Echodyne Corporation Detect and Avoid Radar
TEST REPORT NUMBER	BT72129233-0617
PREPARED FOR	Echodyne Corporation 2380 116th Ave NE, Bellevue, WA 98004 U.S.A.
CONTACT PERSON	Bill Graves 813-758-6256 bill@echodyne.com
PREPARED BY	Nikolay Shtin **Name** Authorized Signatory Title: EMC/Wireless Test Engineer
APPROVED BY	Ferdie S. Custodio **Name** Authorized Signatory Title: EMC/Senior Wireless Test Engineer
DATED	October 13, 2017

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

Revision History

BT72129233-0617 Echodyne Corporation 700-0005-201_DAA_NC Detect and Avoid Radar					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
10/13/17	Initial Release				Ferdie S. Custodio

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

CONTENTS

Section		Page No
1	**REPORT SUMMARY**	**5**
1.1	Introduction	6
1.2	Brief Summary of Results	7
1.3	Product Information	8
1.4	EUT Test configuration	10
1.5	Deviations from the Standard	11
1.6	Modification Record	11
1.7	Test Methodology	11
1.8	Test Facility	11
1.9	test facility Registration	11
1.10	Sample calculations	13
2	**TEST DETAILS**	**15**
2.1	RF Power Output	16
2.2	Spectral Mask	20
2.3	Frequency Stability	27
2.4	Occupied Bandwidth	38
2.5	Spurious Emissions at Antenna Port	44
2.6	Field Strength Of Spurious Radiation	45
3	**TEST EQUIPMENT USED**	**75**
3.1	Test Equipment Used	76
3.2	Measurement Uncertainty	77
4	**DIAGRAM OF TEST SETUP**	**79**
4.1	Test Setup Diagram	80
5	**ACCREDITATION, DISCLAIMERS AND COPYRIGHT**	**83**
5.1	Accreditation, Disclaimers and Copyright	84

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

SECTION 1

REPORT SUMMARY

Radio Testing of the
Echodyne Corporation
700-0005-201_DAA_NC
Detect and Avoid Radar

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Echodyne Corporation Detect and Avoid Radar to the requirements of the following standards:

- FCC CFR 47 Part 2 and Part 87

Objective	To perform Radio Testing to determine the Equipment Under Test's (EUT's) compliance with the Test Specification, for the series of tests carried out.
Manufacturer	Echodyne Corporation
Model Number(s)	700-0005-201_DAA_NC 700-0005-202_DAA_LT **Note:** The listed models are electrically identical. The 700-0005-201_DAA_NC model uses flight natural convention cooling (no-fans), while the 700-0005-202_DAA_LT uses forced air-cooling (fans or ducting).
Model Tested	700-0005-201_DAA_NC
FCC ID Number(s)	2ANLB-MESADAA00051
Serial Number(s)	00125
Number of Samples Tested	1
Test Specification/Issue/Date	• FCC CFR 47 Part 2 and Part 87 (October 1, 2016) • ANSI/TIA/EIA-603-C 2004, August 17, 2004 • KDB 971168 D01 Power Meas License Digital Systems v02r02
Start of Test	August 21, 2017
Finish of Test	August 25, 2017
Name of Engineer(s)	Nikolay Shtin
Related Document(s)	• MESA-DAA RSEC Mask for FAA 2017 01 19.pdf • Supporting documents for EUT certification are separate exhibits.

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance to FCC CFR 47 Part 2 and Part 87 standards is shown below.

Section	FCC Part Sections(s)	Test Description	Result
2.1	Part 2.1046 (a) and Part 87.131	Transmitter Output Power	As Reported
2.2	Part 87.139 (a) and NTIA RSEC Criteria A*	Spectral Mask	Compliant
2.3	Part 2.1055 and Part 87.133 (a)	Frequency Stability	Compliant
2.4	Part 2.1049 and Part 87.135 (a)	Occupied Bandwidth	Compliant
2.5	Part 87.139 (a)	Spurious Emissions at Antenna Port	N/A**
2.6	Part 2.1053 and Part 87.139 (a)	Field Strength Of Spurious Radiation	Compliant

* NTIA RSEC mask measurement was performed per the manufacturer request.

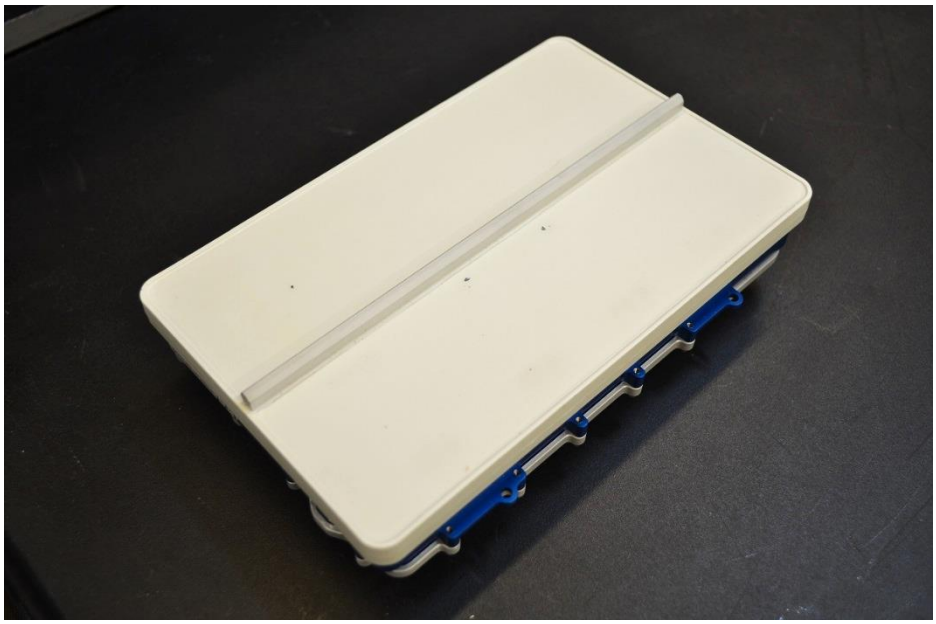
** EUT has no antenna port available. Spurious emissions measurements were performed using radiated method with EUT transmitting from its integral antenna.

Page **7** of **84**

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) was an Echodyne Corporation Detect and Avoid (DAA) Radar as shown in the photographs below. The EUT is a compact high-performance radar that can be mounted on small to medium sized UAVs to safely and reliably Detect and Avoid obstacles for beyond line of sight flight operations. The device utilizes Metamaterial Electronically Scanning Array (MESA) technology operating like a phased array radar with true beam scanning in both azimuth and elevation and with built-in search while track (aka track while scan) capabilities.



Equipment Under Test

1.3.2 EUT General Description

EUT Description	Detect and Avoid Radar
Model Number(s)	700-0005-201_DAA_NC 700-0005-202_DAA_LT
Rated Voltage	+9 to +32 VDC (+24 VDC Nominal)
Power Output	200 W ± 20% EIRP (207.01 Watts measured)
Operating Frequency	24.49 GHz to 24.61 GHz in the 24.45 GHz to 24.65 GHz band
Type of Emissions	FXN
Primary Unit (EUT)	☐ Production
	☒ Pre-Production
Type of Equipment	☐ Fixed
	☒ Mobile
	☐ Portable
Emission Designator/s	50M3FXN
Temperature Range	-45°C to 75°C
Relative Humidity	Up to 95%

1.3.3 Antenna Specification

EUT Model		700-0005-202_DAA_LT	700-0005-201_DAA_NC
Dimensions		18.7cm x 12.1cm x 4.1cm	
Polarization		Linear, Horizontal	
Cross-pol		20 dB (typ.)	
Field of regard		± 60° (AZ plane), ± 40° (EL plane)	
Antenna Directional Characteristics	***Gain (max)***	21 dBi	
	Gain roll-off	2.0 dB (typ. over full field of regard)	
	HP Beam width	4° (AZ plane), 12° (EL plane) one way	
	Side lobe level	14 dB (average) one way	

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	Radiated Test Setup. EUT configured in SEARCH mode transmitting through its integral antenna on Low, Mid and High channels with max. power.

1.4.2 EUT Exercise Software

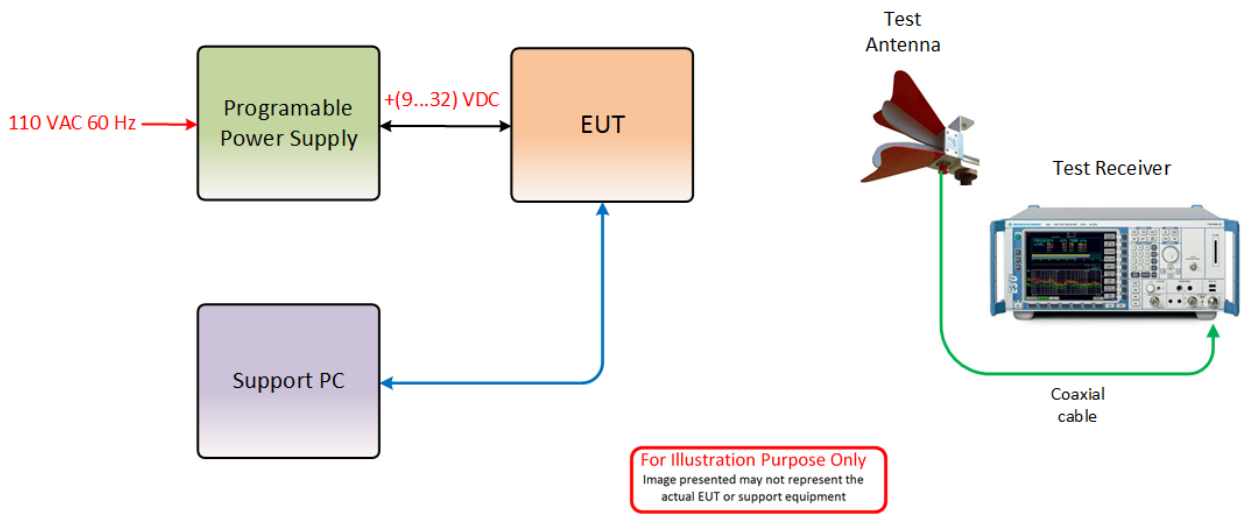
EUT is configured via TCP/IP (Ethernet). EUT IP address is set to 169.254.1.10. This address is used to connect to the EUT via SSH/Telnet client application (PuTTY). Once connected, corresponding programming commands were issued to set the EUT in continues transmission mode at particular channel. Since during its operation the EUT beam direction is constantly changing the minimum/maximum azimuthal and elevation beam positions were set to +/- 2 degres, which is the smallest available value.

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Sony	Laptop (PCG-31311L)	S/N 27545534 3006488
Sony	Laptop AC Adapter (ACDP-120E03)	S/N 592C60AYMSO26N
EchoDyne	Cable Asembly (from EUT to power supply/support Laptop)	

1.4.4 Simplified Test Configuration Diagram

Default test configuration



1.5 DEVIATIONS FROM THE STANDARD

No deviations from the applicable test standards or test plan were made during testing.

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: N/A		
N/A	-	-

The table above details modifications made to the EUT during the test programme. The modifications incorporated during each test (if relevant) are recorded on the appropriate test pages.

1.7 TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.26-2015, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.
For conducted (if applicable) and radiated emissions the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.26-2015. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.8 TEST FACILITY

1.8.1 TÜV SÜD America Inc. (Mira Mesa)

10040 Mesa Rim Road, San Diego, CA 92121-2912 (32.901268,-117.177681). Phone: 858 678 1400 FAX: 858-546 0364

1.8.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: 858 942 5542 Fax: 858 546 0364.

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Registration No.: US1146

TUV SUD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.498 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Registration is US1146.

A2.2 Innovation, Science and Economic Development Canada (IC) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TUV SUD America Inc. (San Diego Rancho Bernardo) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 3067A-1.
The 3m Semi-anechoic chamber of TUV SUD America Inc. (San Diego Mira Mesa) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 22806-1.

A2.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TUV Product Service Inc. (San Diego) is a recognized EMC testing laboratory by the BSMI under the MRA (Mutual Recognition Arrangement) with the United States. Accreditation includes CNS 13438 up to 6GHz.

A2.4 VCCI – Registration No. A-0230

TUV SUD America Inc. (San Diego) is a VCCI registered measurement facility which includes radiated field strength measurement, radiated field strength measurement above 1GHz, mains port interference measurement and telecommunication port interference measurement.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

1.10 SAMPLE CALCULATIONS

1.10.1 EUT Emission Designator

Emission Designator = 50M3FXN
50M3 = 50.3 MHz Bandwidth Designator (based on the measured 26 dB bandwidth)
F = Frequency modulation
X = Cases not otherwise covered (modulating signal does not contain analog or digital information)
N = No information transmitted.

1.10.2 Spurious Radiated Emission (below 1GHz)

Measuring equipment raw measurement (dBµV/m) @ 30 MHz			24.4
Correction Factor (dB)	Asset# 1066 (cable)	0.3	-12.6
	Asset# 1172 (cable)	0.3	
	Asset# 1016 (preamplifier)	-30.7	
	Asset# 1175(cable)	0.3	
	Asset# 1002 (antenna)	17.2	
Reported QuasiPeak Final Measurement (dBµV/m) @ 30MHz			**11.8**

1.10.3 Spurious Radiated Emission (40-60GHz)

Measuring equipment raw measurement (dBµV/m) @ 49.1754GHz			33.3
Correction Factor (dB)	Asset# 7637 (external mixer)	22.2	41.5
	Asset# 9003 (antenna)	23.3	
	Asset# 8932 (2 dB attenuator)	2.0	
	Test distance correction factor*	-6.0	
Reported Final Measurement (dBµV/m) @ 49.1754GHz (2nd harmonic)			**74.8**

* Spurious emissions above 40 GHz were evaluated at 1.5 m to assure that the noise floor is at least 10 dB below the applicable limit. A correction factor of 6.0 dB was used to extrapolate the field strengths measured at 1.5 metres to the 3 meters distance.

1.10.4 Spurious Radiated Emission (60-75GHz)

Measuring equipment raw measurement (dBµV/m) @ 73.4032GHz			56.6
Correction Factor (dB)	Asset# 7636 (external mixer)	30.2	17.8
	Asset# 9004(antenna)	23.4	
	Asset# 8892 (preamplifier)	-31.8	
	Asset# 8932 (2 dB attenuator)	2.0	
	Test distance correction factor*	-6.0	
Reported Final Measurement (dBµV/m) @ 73.4032GHz (3rd harmonic)			**74.4**

* Spurious emissions above 40 GHz were evaluated at 1.5 m to assure that the noise floor is at least 10 dB below the applicable limit. A correction factor of 6.0 dB was used to extrapolate the field strengths measured at 1.5 metres to the 3 meters distance.

1.10.5 Spurious Radiated Emission (75-110GHz)

Measuring equipment raw measurement (dBµV/m) @ 97.8709GHz			36.3
Correction Factor (dB)	Asset# 7636 (external mixer)	25.0	20.0
	Asset# 7628(antenna)	23.1	
	Asset# 8912 (preamplifier)	-24.1	
	Asset# 8932 (2 dB attenuator)	2.0	
	Test distance correction factor*	-6.0	
Reported Final Measurement (dBµV/m) @ 97.8709GHz (4th harmonic)			**56.3**

* Spurious emissions above 40 GHz were evaluated at 1.5 m to assure that the noise floor is at least 10 dB below the applicable limit. A correction factor of 6.0 dB was used to extrapolate the field strengths measured at 1.5 metres to the 3 meters distance.

1.10.6 Spurious Radiated Emission – Substitution Method

Example = 84dBµV/m @ 1413 MHz (numerical sample only)

The field strength reading of 84dBµV/m @ 1413 MHz is the maximized measurement when the EUT is on the turntable measured at 3 meters. The gain of the substituted antenna is 7.8dBi while the transmit cable loss is 1.0 dB (cable between signal generator and the substituted antenna). The signal generator level is adjusted until the 84dBµV/m level at the receiving end is replicated (identical test setup, i.e. same antenna, cable/s and preamp). If the adjusted signal generator level is -18dBm, then we have the following for both EIRP and ERP as required:

P_{EIRP} = -18 dBm + 7.8 dBi – 1dB
= 11.2 dBm
P_{ERP} = P_{EIRP} – 2.15 dB
= 11.2 dBm – 2.15 dB
= 9.05 dBm

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

SECTION 2

TEST DETAILS

Radio Testing of the
Echodyne Corporation
00-0005-201_DAA_NC
Detect and Avoid Radar

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.1 RF POWER OUTPUT

2.1.1 Specification Reference

Part 2.1046 (a), Part 87.131

2.1.2 Standard Applicable

§ 2.1046 Measurements required: RF power output.

(a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in §2.1033(c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

§ 87.131 Power and emissions.

The following table lists authorized emissions and maximum power. Power must be determined by direct measurement.

Class of station	Frequency band/frequency	Authorized emission(s)	Maximum power
(Radionavigation)	Various [7]	Various [7]	Various [7]

[7] Frequency, emission, and maximum power will be determined by appropriate standards during the certification process.

2.1.3 Equipment Under Test and Modification State

Serial No: 00125 / Default Test Configuration

2.1.4 Date of Test/Initial of test personnel who performed the test

August 23, 2017/NS

2.1.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.1.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	26.1 °C
Relative Humidity	50.2 %
ATM Pressure	98.9 kPa

2.1.7 Additional Observations

- This is a radiated test.
- Test distance of 3 m was used for the fundamental emissions measurement.

- The measurement was performed using EMI receiver (Asset# 1049), standard horn antenna (Asset# 9005) and test cable (Asset# 8917) identified in the section 3.1 of this test report.
- A correction factor of 52.4dB was used to account for free-space loss, test antenna gain and test cable loss.
- Sample correction factor calculation @ 24.55 GHz:

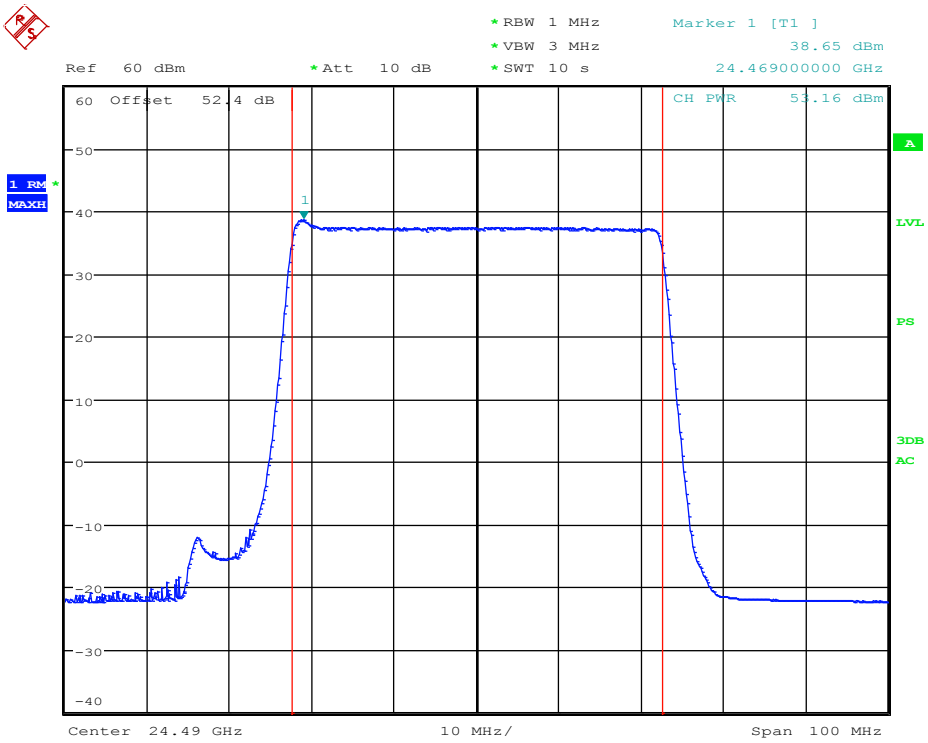
Correction Factor (dB)	Asset# 9005 (antenna)	-22.35	52.4
	Asset# 8917 (cable)	4.97	
	Free space loss @ 3m	69.78	

- Detector is RMS. Trace is Max Hold. RBW is 1MHz while VBW was set to 3x RBW.
- Channel Power measurement mode of the spectrum analyser/receiver was used for this test.
- Maximum input power at the spectrum analyser/receiver input was +0.8 dBm that is well below the equipment nominal 1 dB compression point (+17 dBm), so the receiver overload has been avoided at all times during the test.

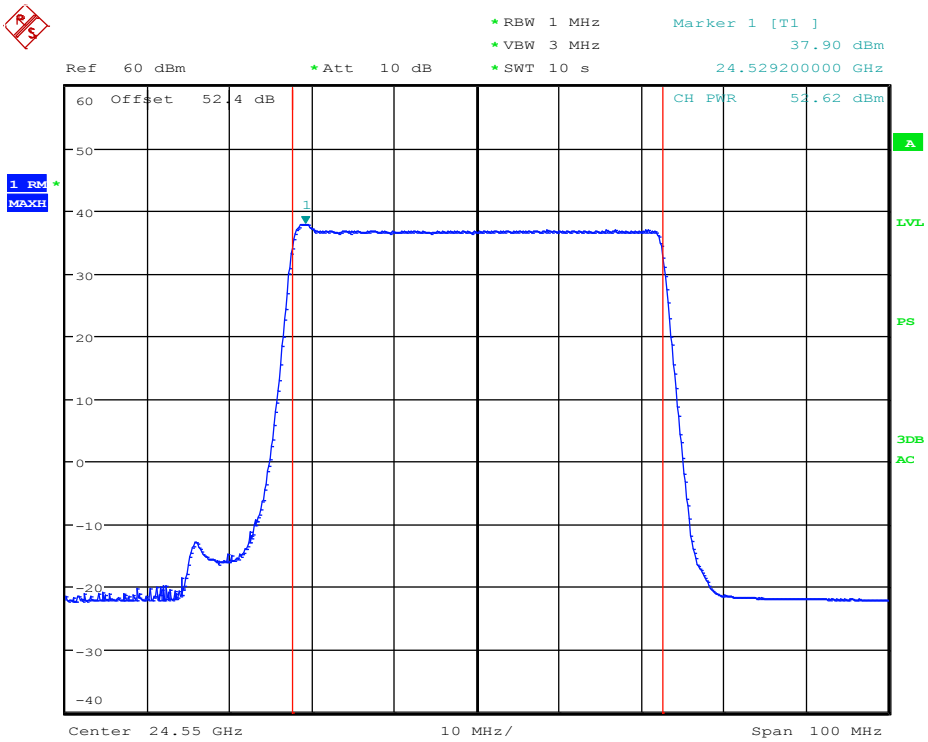
2.1.8 Test Results

Authorized Bandwidth	Channel	EIRP, dBm	EIRP, W
50.3 MHz	Low (24.49 GHz)	***53.16***	***207.01***
	Mid (24.55 GHz)	52.62	182.81
	High (24.61 GHz)	52.67	184.93

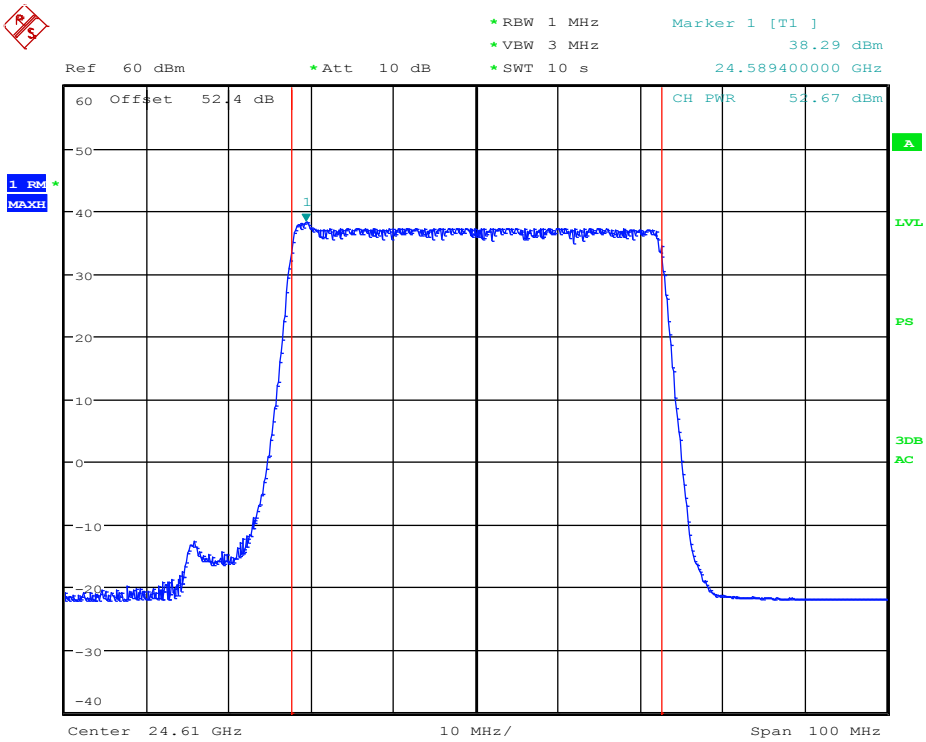
2.1.9 Test Plots



Low channel



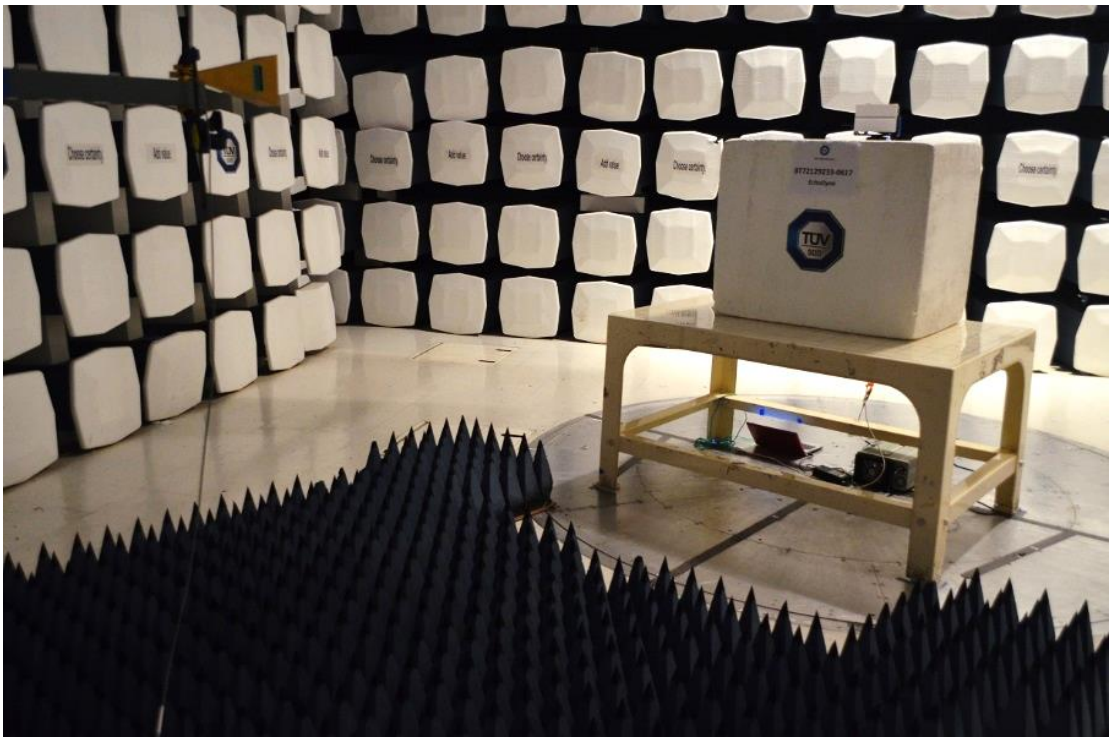
Mid channel



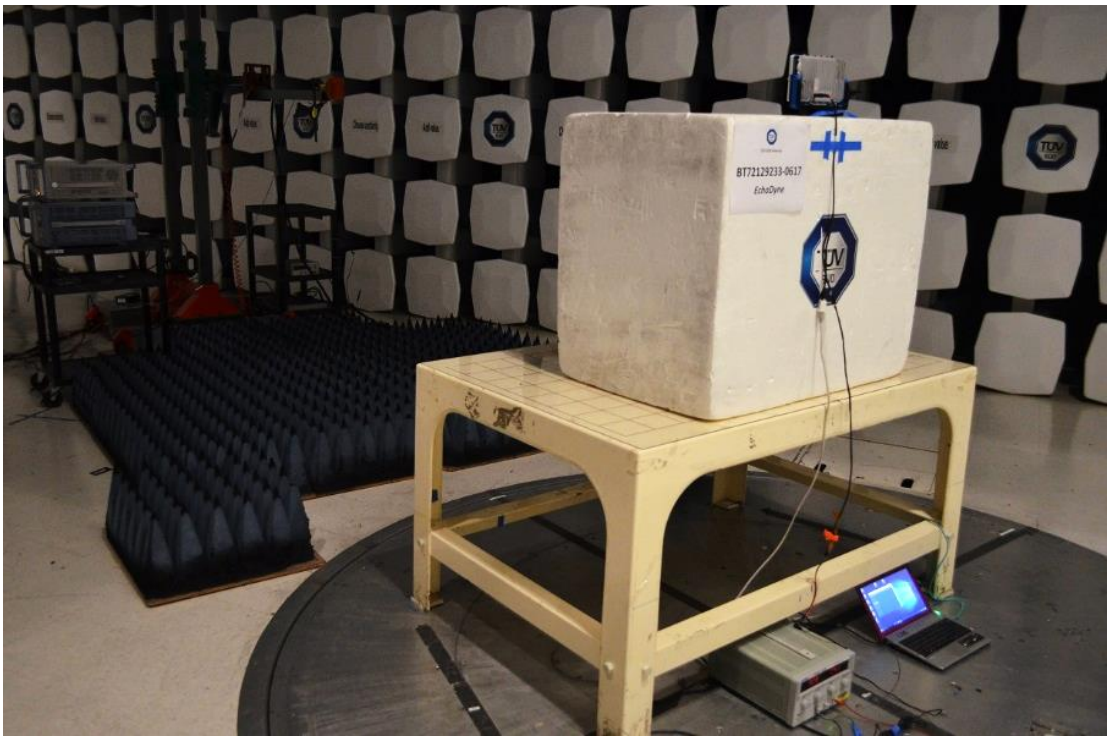
High channel

2.1.10 Test Setup Picture

Front



Back



2.2 SPECTRAL MASK

2.2.1 Specification Reference

Part 87.139 (a), NTIA RSEC Criteria A

2.2.2 Standard Applicable

§ 87.139 Emission limitations.

(a) Except for ELTs and when using single sideband (R3E, H3E, J3E), or frequency modulation (F9) or digital modulation (F9Y) for telemetry or telecommand in the 1435-1525 MHz, 2345-2395 MHz, or 5091-5150 MHz band or digital modulation (G7D) for differential GPS, the mean power of any emissions must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB;

(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 +10 $\log_{10}$ pY dB.

5.5.7.1 RSEC Criteria A
RSEC A radar systems that have been submitted to or certified by NTIA before December 31, 2013, are exempt from meeting new RSEC A requirements and shall be “grandfathered”. Grandfathered systems shall be certified under the NTIA rules applicable prior to 31 December 2013. Systems certified by NTIA at Stage 3 to Section 5.2.2.2 of the NTIA manual before the date shall be certified at Stage 4 using the same criteria until 31 December 2015. On January 1, 2016 all systems seeking Criteria A certification must meet these requirements.

Criteria A Applicability

Radars shall be grouped into Criteria A that have the following system characteristics: Non-pulsed radars of 40 watts or less rated average power; or Pulsed radars of 1 kW or less rated peak power; or Radars with an operating frequency above 40 GHz; or Man-portable10 radars; or Man-transportable11 radars; or as described above; or Expendable, non-recoverable radars on missiles.5.5.7 5-34 May 2013 Edition (Rev. 5/2014)
Previously certified Criteria A systems must adhere to the revised regulations when any of the following system parameters are changed, including power output, pulse width, pulse repetition rate, chirp rate, chirp bandwidth, rise time, and fall time.

Criteria A Emission Mask

For systems operating in the band 2700 – 2900 MHz
Systems operating in this band must adhere to the RSEC Criteria D standard in section 5.5.2.4.

For Systems operating in other frequency bands
For these types of radars, the emission levels at the antenna input or output (radiated) shall be no greater than the values obtainable from the curve in Figure 5-2.

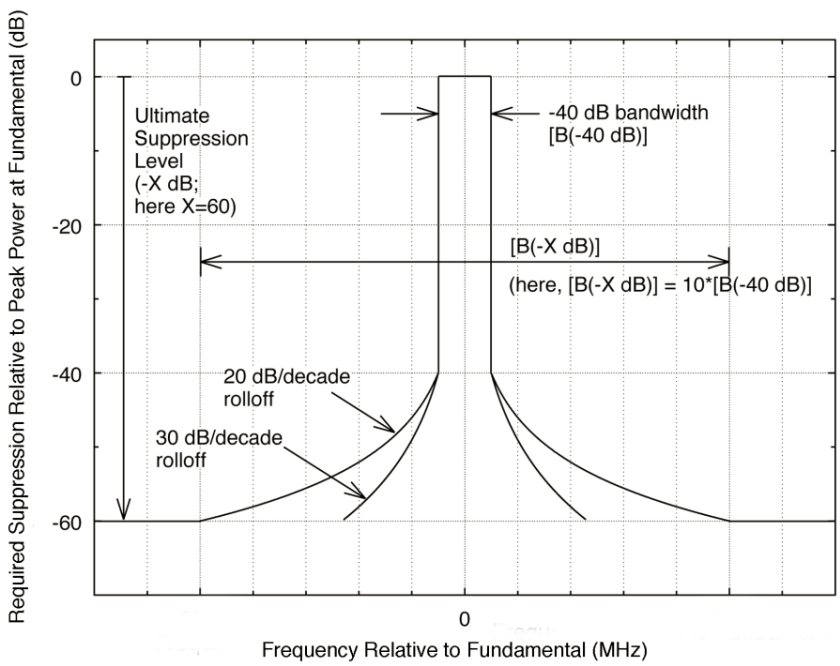


Figure 5-2 The RSEC Emission mask.

-40 dB bandwidth Equations

The -40 dB bandwidth equations are contained in Section 5.5.3.1 for single frequency radars and 5.5.3.2 for frequency hopping radars.

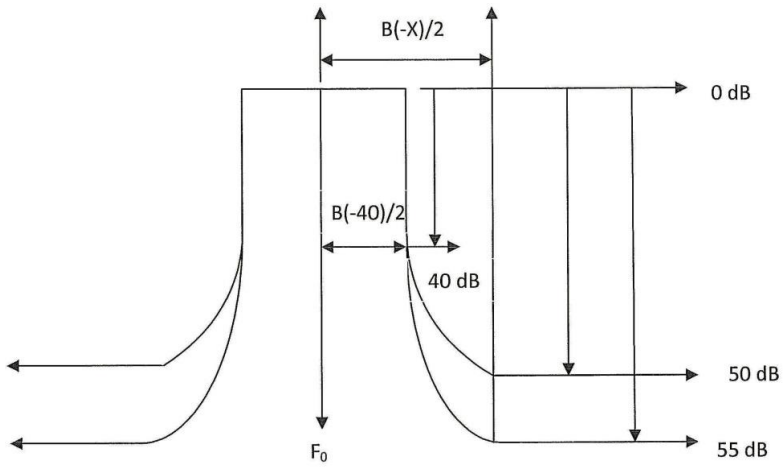
Roll-off in the Out-of–Band (OOB) Domain

At the frequency B(–40dB)/2 displaced from F0, the level shall be at least 40 dB below the maximum value. Between the –40dB and –XdB frequencies the level shall meet a slope (S) of 20 dB per decade (S=20) for all waveforms when the peak power is greater than 1 watt.

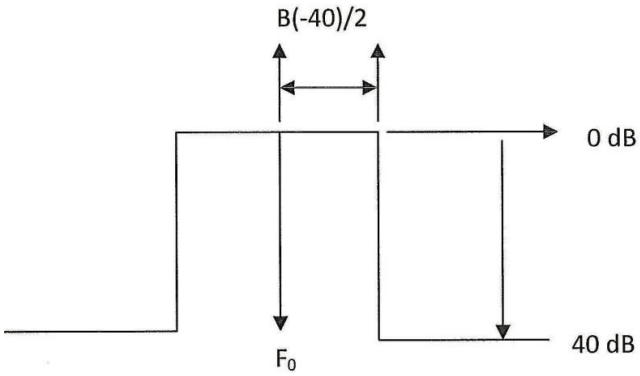
Spurious Domain Limits

At and beyond the frequencies B(–XdB)/2 from F0, the X(dB) level shall be at least the dB value below the maximum spectral power density given by:

For radar systems with peak power above 100 watts: *X(dB)* = 55*dB*
For radar systems with peak power less than 100 watts but more than 1 watt: *X(dB)* = 50*dB*
For radar systems with peak power equal to and less than 1 watt: *X(dB)* = 40*dB*
For radar systems with a duty cycle equal to and greater than 10 percent: *X(dB)* = 55*dB*
All harmonic levels shall be at a level that is at least 55 dB below the maximum power spectral density.
The two figures illustrate the suppression levels and masks for Criteria A systems.



RSEC A Masks for systems with peak power above 1 watt



RSEC A Mask for systems with peak power equal to and below 1 watt

2.2.3 Equipment Under Test and Modification State

Serial No: 00125 / Default Test Configuration

2.2.4 Date of Test/Initial of test personnel who performed the test

August 23 and August 24, 2017/NS

2.2.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.2.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	25.7-26.1 °C
Relative Humidity	50.2-52.3 %
ATM Pressure	98.9-99.1 kPa

2.2.7 Additional Observations

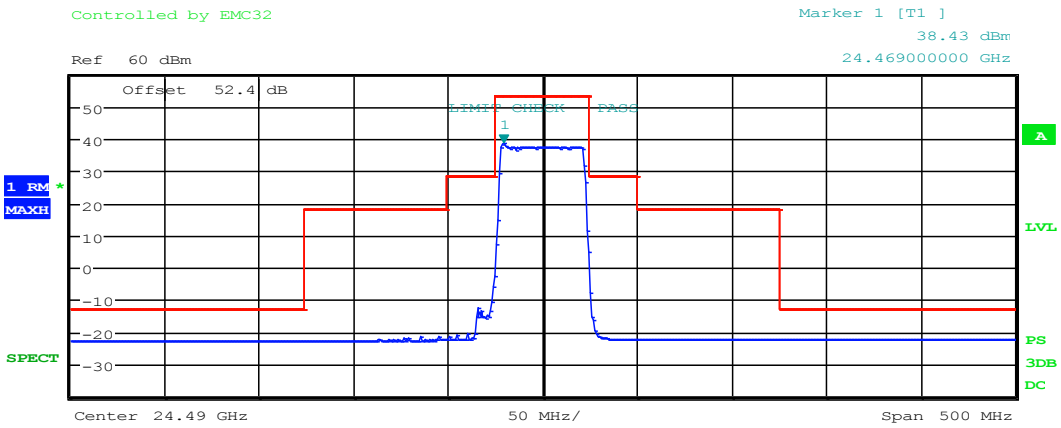
- This is a radiated test.
- Test distance of 3 m was used for this measurement.
- A corr. factor of 52.4 dB was used to account for free-space loss, test antenna gain and cable loss.
- Detector is RMS. Trace is Max Hold. RBW is 1MHz while VBW was set to 3x RBW.
- FCC Emission Mask was drawn for each channel based on the measured 26 dB bandwidth (see section 2.4 of this test report). The mask applied is based on the limit for aeronautical station transmitters considering it the worst-case requirement.
- NTIA RSEC mask is based on the calculations provided by the manufacturer (see related documents). Calculated mask break points are shown in the table below.

Channel	Description	Frequency points	Amplitude	Delta Fc (MHz)
A1-A	Lower -40 dB Edge	24455.1	-40	34.9
	Lower Operating Edge	24467.5	0	22.5
	Center Channel	24490	0	0
	Upper Operating Edge	24512.5	0	22.5
	Upper -40 dB Edge	24524.9	-40	34.9
A1-B	Lower -40 dB Edge	24515.1	-40	34.9
	Lower Operating Edge	24527.5	0	22.5
	Center Channel	24550	0	0
	Upper Operating Edge	24572.5	0	22.5
	Upper -40 dB Edge	24584.9	-40	34.9
A1-C	Lower -40 dB Edge	24575.1	-40	34.9
	Lower Operating Edge	24587.5	0	22.5
	Center Channel	24610	0	0
	Upper Operating Edge	24632.5	0	22.5
	Upper -40 dB Edge	24644.9	-40	34.9

- Emission Mask measurement mode of the spectrum analyzer was used for this test.

2.2.8 Test Plots

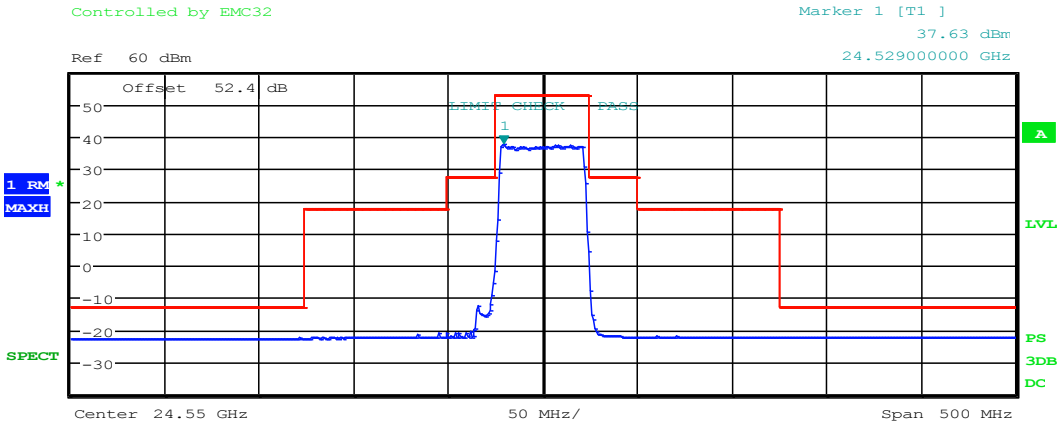
2.2.8.1 FCC Part 87 Emission mask



Tx Channel **Part 87 mask**
Bandwidth 50.3 MHz Power 53.16 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-250.000 M	-125.750 M	1.00 M	24.240000 G	-22.79	-75.95	-9.79
-125.750 M	-50.300 M	1.00 M	24.425500 G	-21.58	-74.74	-39.73
-50.300 M	-25.150 M	1.00 M	24.464500 G	-2.56	-55.72	-30.71
25.150 M	50.300 M	1.00 M	24.515150 G	-1.80	-54.96	-29.95
50.300 M	125.750 M	1.00 M	24.572000 G	-22.32	-75.48	-40.47
125.750 M	250.000 M	1.00 M	24.681500 G	-22.17	-75.32	-9.17

Low channel

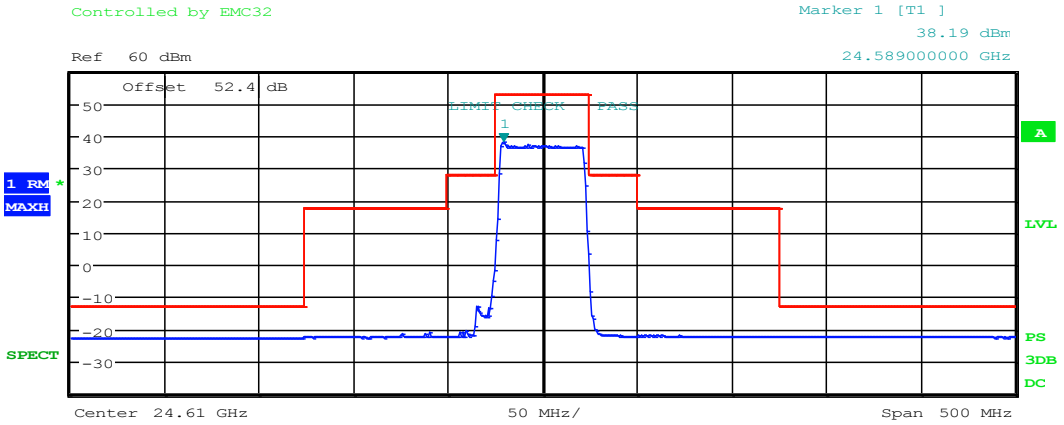


Tx Channel **Part 87 mask**

Bandwidth 50.3 MHz Power 52.60 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-250.000 M	-125.750 M	1.00 M	24.421000 G	-22.61	-75.22	-9.61
-125.750 M	-50.300 M	1.00 M	24.498500 G	-21.01	-73.62	-38.62
-50.300 M	-25.150 M	1.00 M	24.524500 G	-1.90	-54.50	-29.50
25.150 M	50.300 M	1.00 M	24.575150 G	-2.37	-54.97	-29.97
50.300 M	125.750 M	1.00 M	24.610000 G	-21.93	-74.54	-39.54
125.750 M	250.000 M	1.00 M	24.708000 G	-22.13	-74.74	-9.13

Mid channel



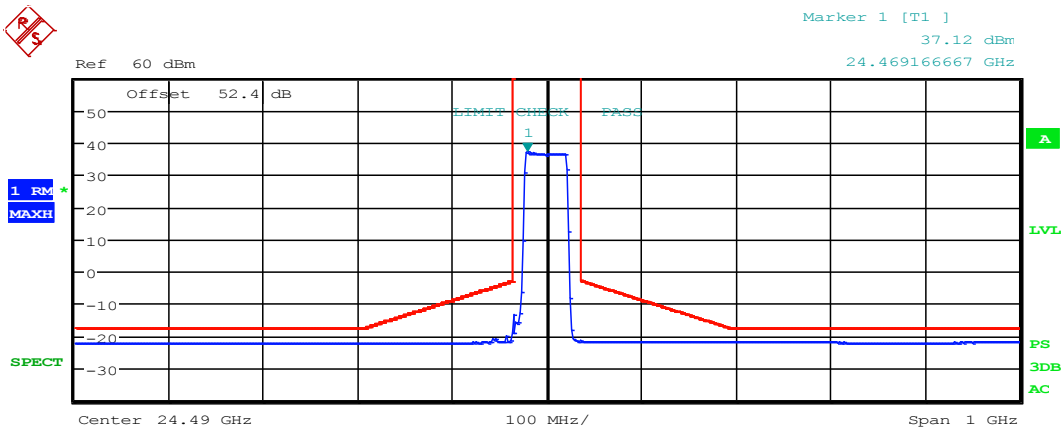
Tx Channel **Part 87 mask**

Bandwidth 50.3 MHz Power 52.67 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-250.000 M	-125.750 M	1.00 M	24.484000 G	-22.62	-75.29	-9.62
-125.750 M	-50.300 M	1.00 M	24.550000 G	-20.99	-73.66	-38.64
-50.300 M	-25.150 M	1.00 M	24.584500 G	-1.79	-54.45	-29.44
25.150 M	50.300 M	1.00 M	24.635150 G	-3.64	-56.31	-31.30
50.300 M	125.750 M	1.00 M	24.672500 G	-21.88	-74.54	-39.53
125.750 M	250.000 M	1.00 M	24.740000 G	-22.25	-74.91	-9.25

High channel

2.2.8.2 NTIA RSEC Criteria A Emission mask

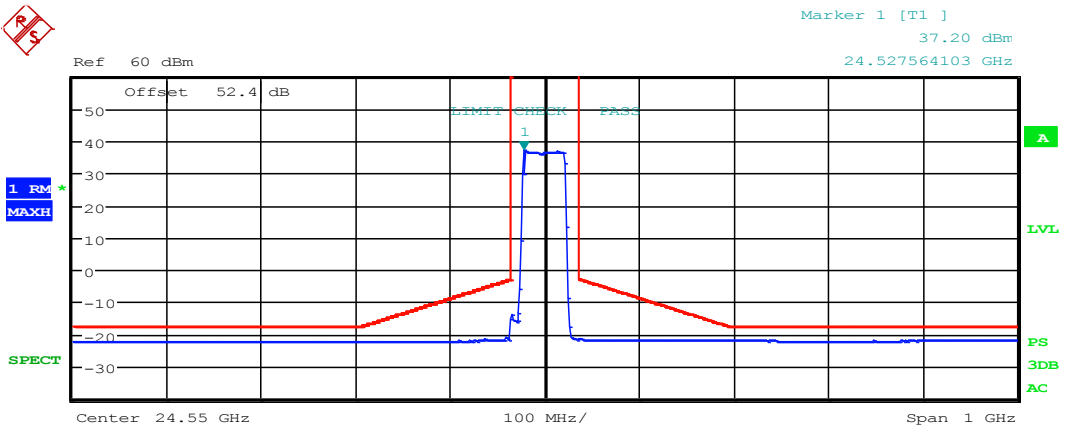


Tx Channel — **RSEC Criteria A**

Bandwidth 1 MHz — Peak Power 37.12 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-500.000 M	-196.270 M	1.00 M	24.185513 G	-22.18	-74.23	-4.29
-196.270 M	-34.900 M	1.00 M	24.294487 G	-22.36	-74.42	-4.48
34.900 M	196.270 M	1.00 M	24.683910 G	-21.87	-73.93	-4.21
196.270 M	500.000 M	1.00 M	24.688718 G	-21.80	-73.86	-3.92

Low channel

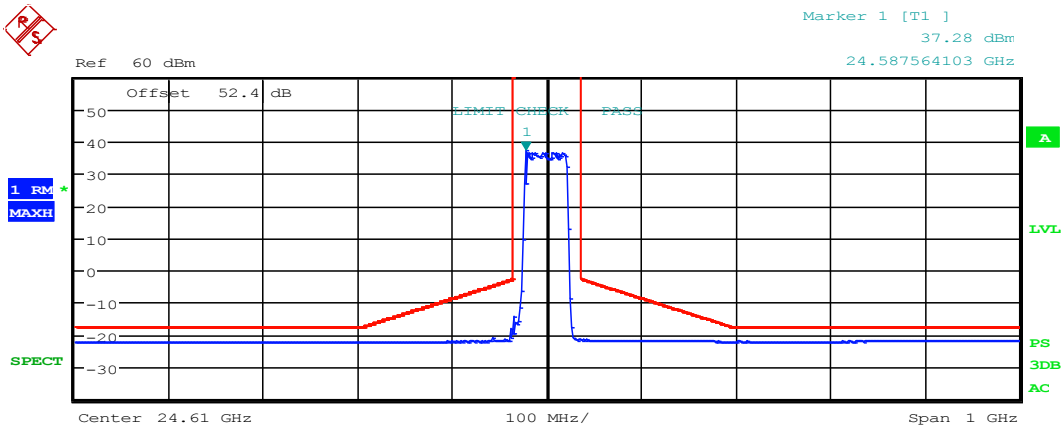


Tx Channel — **RSEC Criteria A**

Bandwidth 1 MHz — Peak Power 37.20 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-500.000 M	-196.270 M	1.00 M	24.195833 G	-22.21	-74.23	-4.40
-196.270 M	-34.900 M	1.00 M	24.354487 G	-22.45	-74.48	-4.65
34.900 M	196.270 M	1.00 M	24.743910 G	-21.94	-73.96	-4.35
196.270 M	500.000 M	1.00 M	24.747115 G	-21.89	-73.91	-4.08

Mid channel



Tx Channel **RSEC Criteria A**

Bandwidth 1 MHz Peak Power 37.28 dBm

Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	PwrRel [dBc]	Δ Limit [dB]
-500.000 M	-196.270 M	1.00 M	24.182115 G	-22.17	-73.59	-4.45
-196.270 M	-34.900 M	1.00 M	24.414487 G	-22.35	-73.77	-4.63
34.900 M	196.270 M	1.00 M	24.803910 G	-22.24	-73.66	-4.74
196.270 M	500.000 M	1.00 M	25.095577 G	-21.91	-73.33	-4.19

High channel

Note: Employed spectal mask is in accordance with RSEC A Mask for systems with peak power above 1 watt, class Hopping Radar, with duty cycle >10%. Therefore X(dB)=55dB for spurious domain and S=20dB/decade.

2.2.9 Test Setup Pictures

Test setup pictures are similar to those from section 2.1.10.

2.3 FREQUENCY STABILITY

2.3.1 Specification Reference

Part 2.1055 and Part 87.133 (a)

2.3.2 Standard Applicable

§ 2.1055 Measurements required: Frequency stability.

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From −30° to 50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

§ 87.133 Frequency stability.

(a) Except as provided in paragraphs (c), (d), (f), and (g) of this section, the carrier frequency of each station must be maintained within these tolerances:

Frequency band (lower limit exclusive, upper limit inclusive), and categories of stations	Tolerance [1]	Tolerance [2]
(9) Band-10.5 GHz to 40 GHz: Radionavigation stations	5000	5000

[1] This tolerance is the maximum permitted until January 1, 1990, for transmitters installed before January 2, 1985, and used at the same installation. Tolerance is indicated in parts in 10^{-6} unless shown as Hertz (Hz).

[2] This tolerance is the maximum permitted after January 1, 1985 for new and replacement transmitters and to all transmitters after January 1, 1990. Tolerance is indicated in parts in 10^{-6} unless shown as Hertz (Hz).

2.3.3 Equipment Under Test and Modification State

Serial No: 00125 / Default Test Configuration

2.3.4 Date of Test/Initial of test personnel who performed the test

August 25, 2017/NS

2.3.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.3.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

Ambient Temperature	25.9 °C
Relative Humidity	47.5 %
ATM Pressure	99.1 kPa

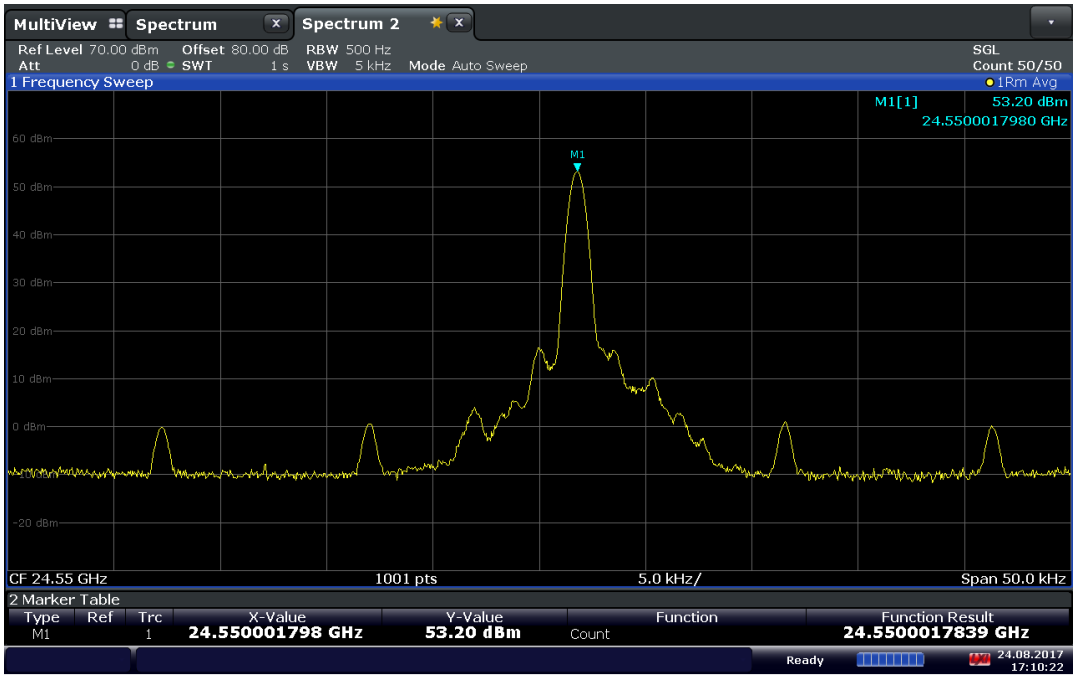
2.3.7 Additional Observations

- This is a radiated test.
- Extreme temperature range used is -45°C to +70°C.
- The temperature was reduced to -45°C and allowed to settle for 1 hour. The EUT is then powered with the operating mode set to Search at mid channel.
- Subsequently the temperature was increased by 10°C steps and allowed to settle before taking the next set of measurements. EUT is "on" only during actual measurement time.
- Extreme test source voltage used is 9.0 VDC and 32.0 VDC. No considerable frequency variations were observed at extreme supply voltages.
- Signal Count function of the spectrum analyzer was used for this test.
- For this test Radar commanded using special engineering sequence to force it to stop sweeping and go into RF CW mode in mid-band of each channel to facilitate power and frequency stability measurements accurately. These commands are not available to users.

2.3.8 Test Results

Voltage (VDC)	Temp (°C)	Frequency (GHz)	Max. Frequency Deviation (ppm)	Limit (ppm)
24.0	-45	24.5500017839	0.072	5000
	-40	24.5500023814	0.097	
	-30	24.5500014673	0.059	
	-20	24.5499982553	-0.071	
	-10	24.5499960972	-0.158	
	0	24.5499986383	-0.055	
	+10	24.5500018265	0.074	
	+20	24.5500015885	0.064	
	+30	24.5500000234	0.001	
	+40	24.5499947753	-0.212	
	+50	24.5499850338	-0.609	
	+60	24.5499866819	-0.542	
	+70	24.5500058687	0.239	
32.0	+20	24.5500032133	0.130	
9.0	+20	24.5500016104	0.065	
EUT **complies**				

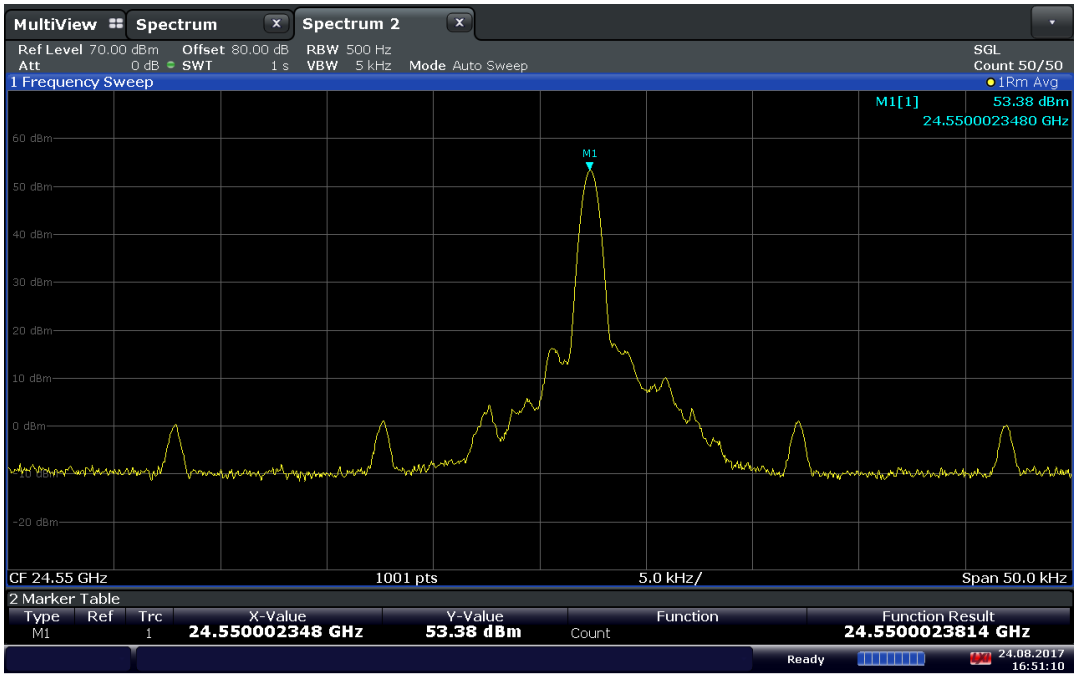
2.3.9 Test Plots



17:10:23 24.08.2017

Mid channel 24.55 GHz @-45°C (Nominal Voltage)

Center Frequency = 24.5500017839 GHz

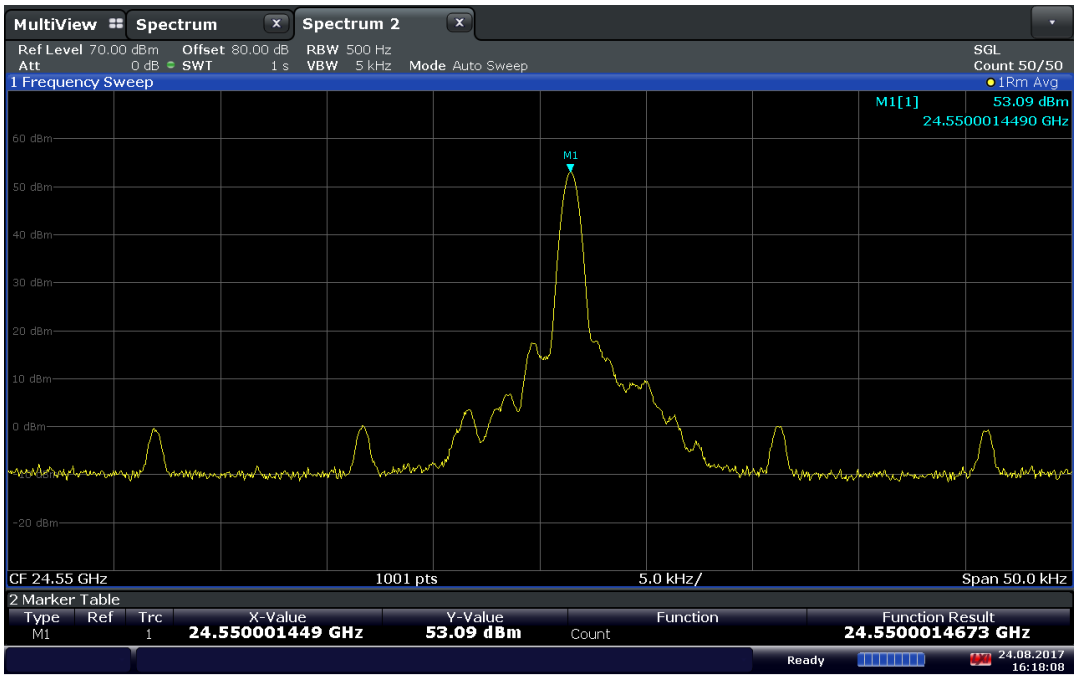


16:51:10 24.08.2017

Mid channel 24.55 GHz @-40°C (Nominal Voltage)

Center Frequency = 24.5500023814 GHz

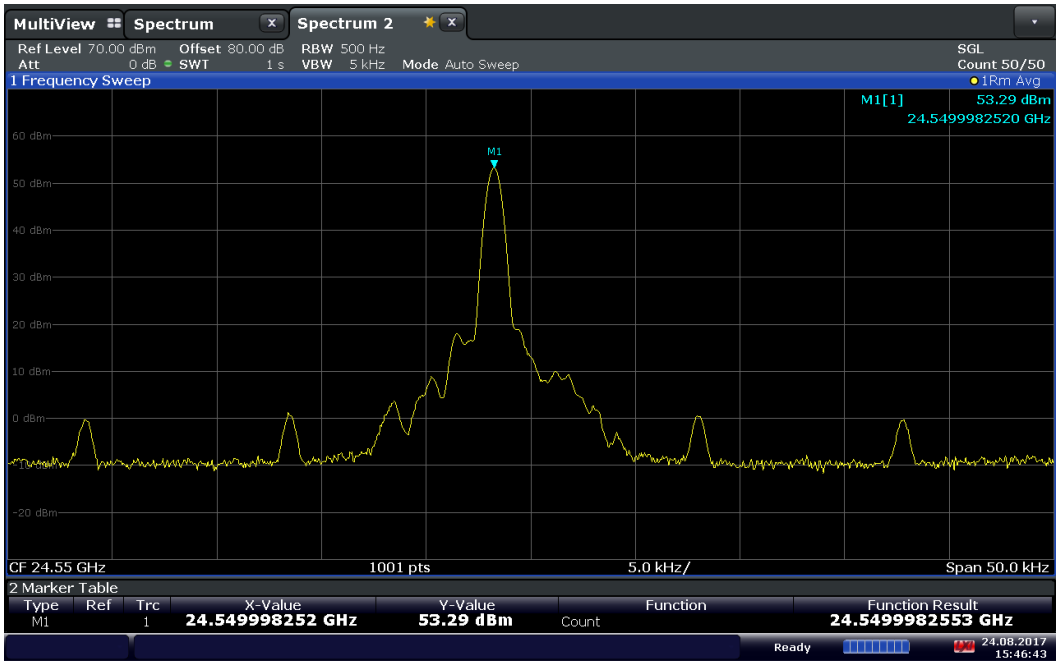
TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364



16:18:10 24.08.2017

Mid channel 24.55 GHz @-30°C (Nominal Voltage)

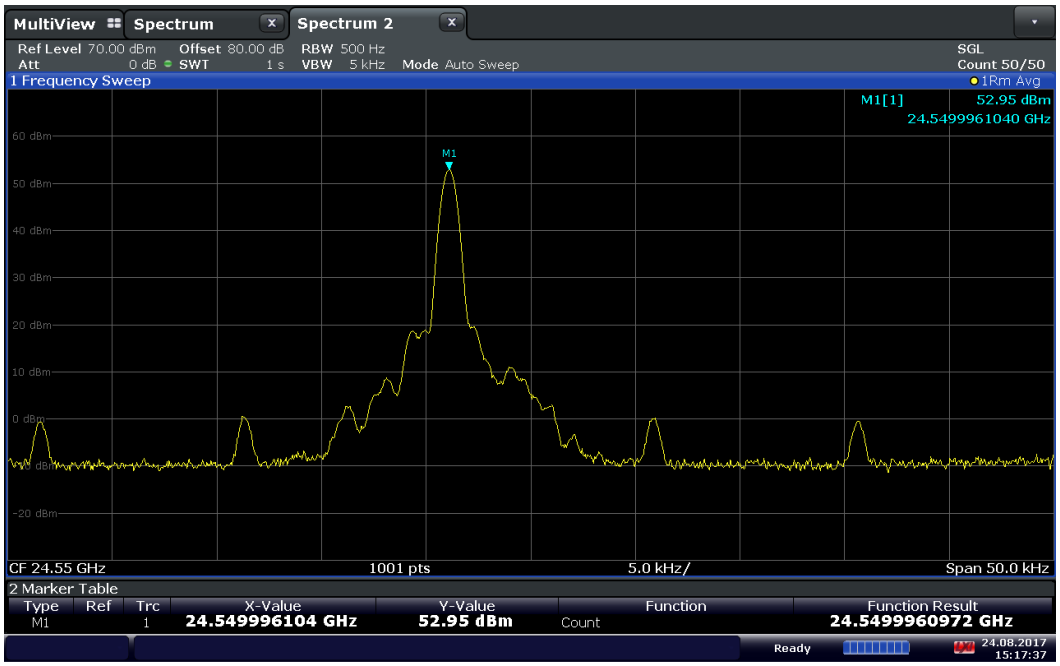
Center Frequency = 24.5500014673 GHz



15:46:44 24.08.2017

Mid channel 24.55 GHz @-20°C (Nominal Voltage)

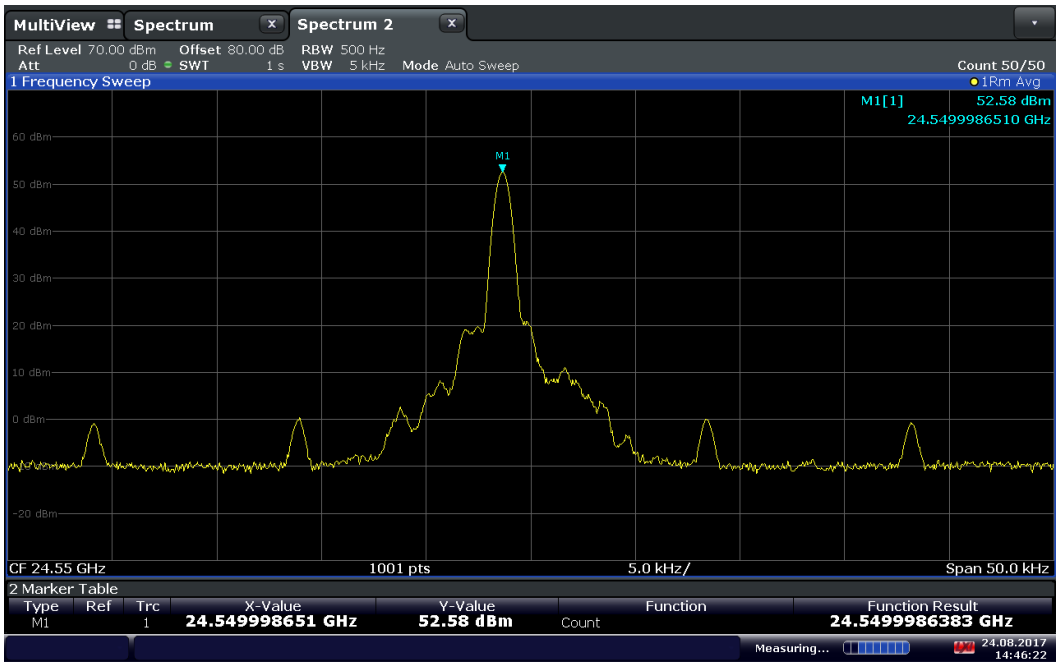
Center Frequency = 24.5499982553 GHz



15:17:38 24.08.2017

Mid channel 24.55 GHz @-10°C (Nominal Voltage)

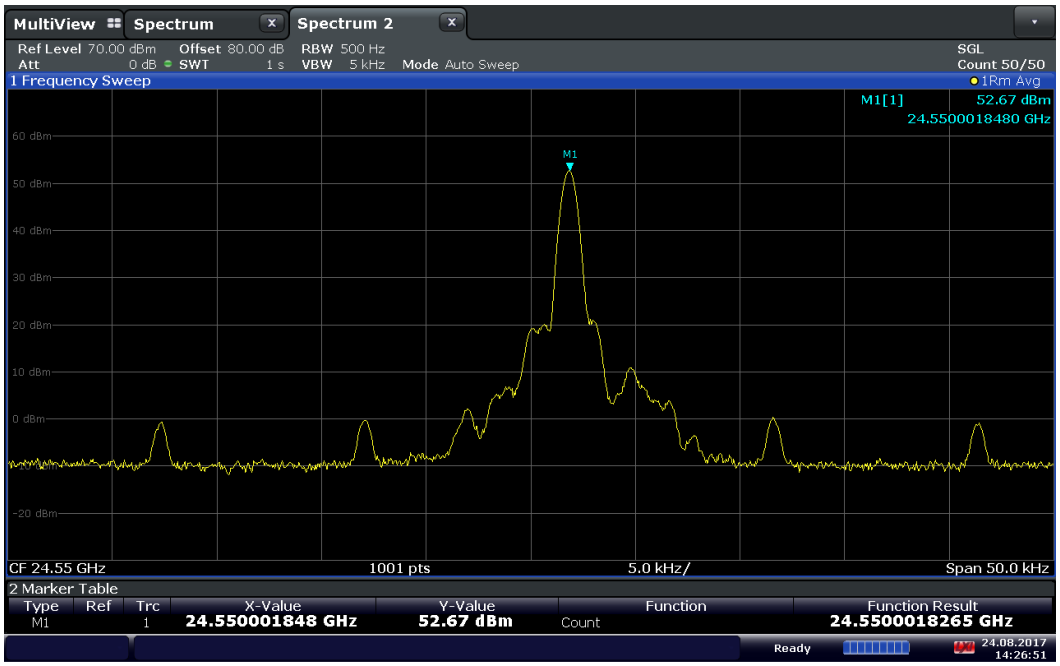
Center Frequency = 24.5499960972 GHz



14:46:23 24.08.2017

Mid channel 24.55 GHz @ 0°C (Nominal Voltage)

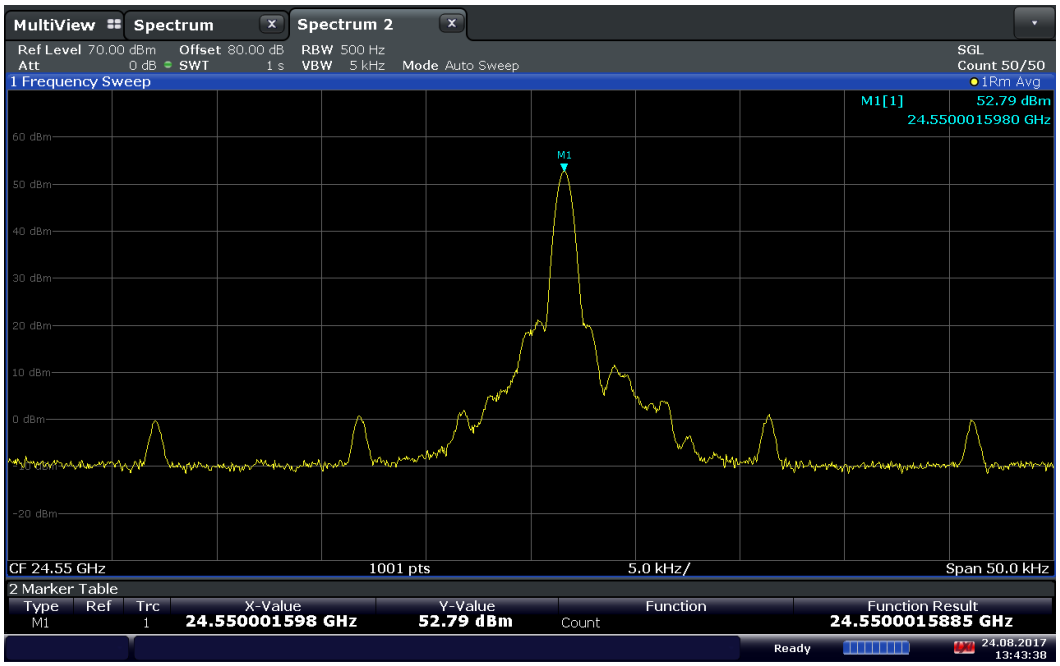
Center Frequency = 24.5499986383 GHz



14:26:52 24.08.2017

Mid channel 24.55 GHz @ 10°C (Nominal Voltage)

Center Frequency = 24.5500018265 GHz

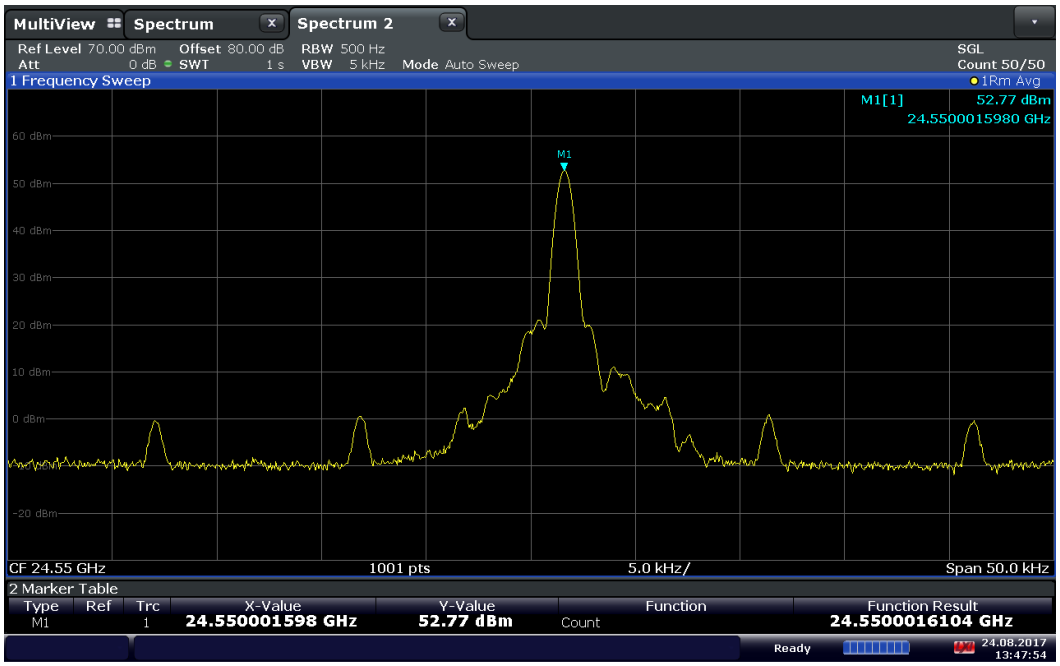


13:43:39 24.08.2017

Mid channel 24.55 GHz @ 20°C (Nominal Voltage)

Center Frequency = 24.5500015885 GHz

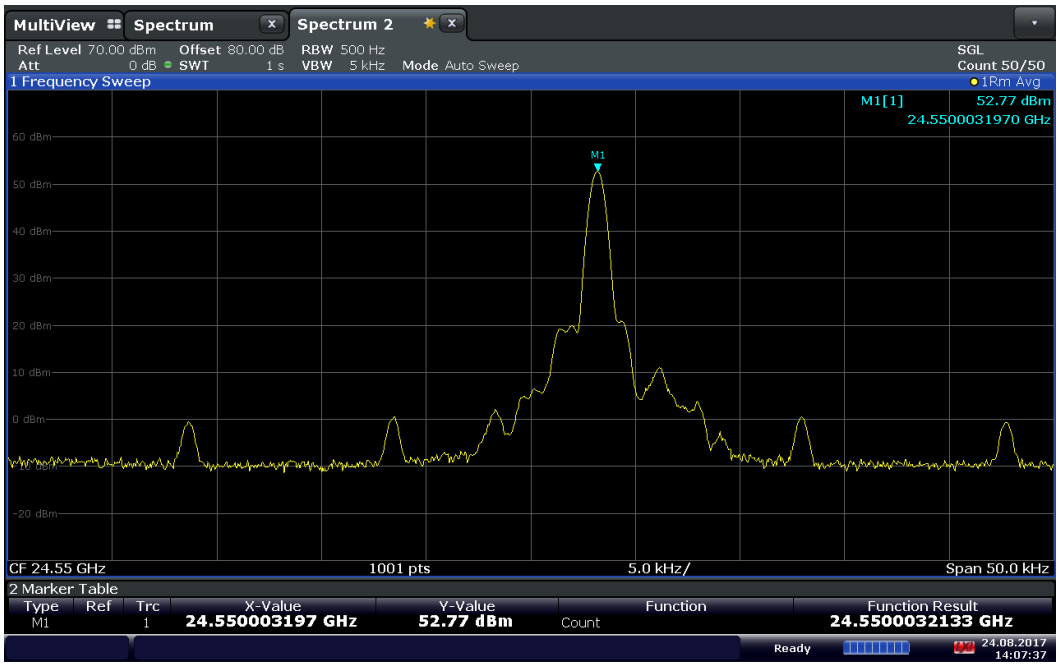
TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364



13:47:54 24.08.2017

Mid channel 24.55 GHz @ 20°C (9 VDC)

Center Frequency = 24.5500016104 GHz

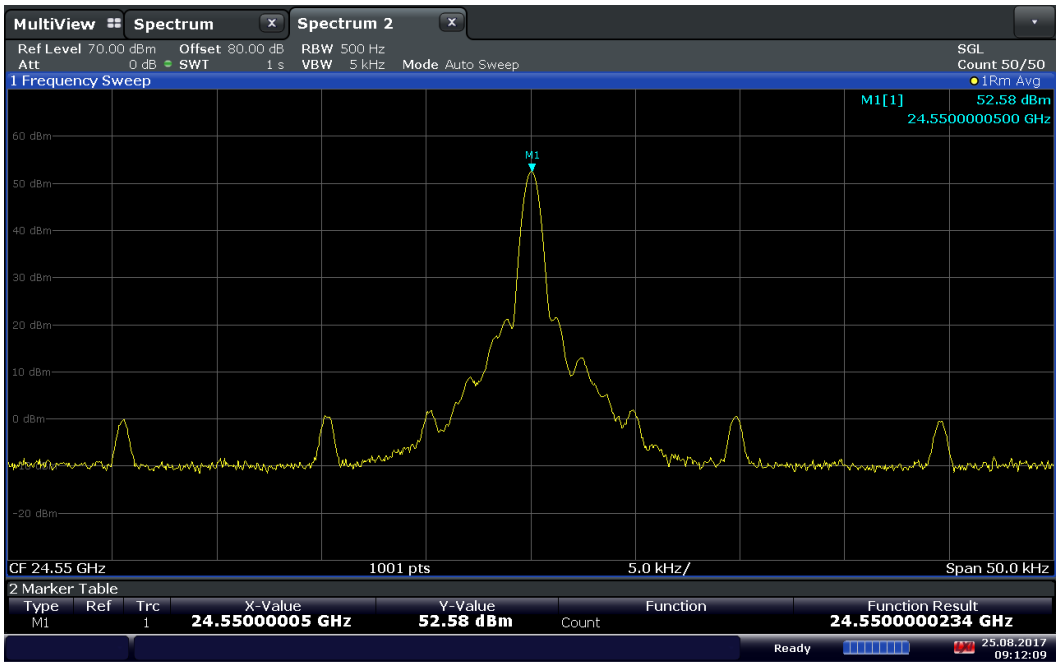


14:07:38 24.08.2017

Mid channel 24.55 GHz @ 20°C (32 VDC)

Center Frequency = 24.5500032133 GHz

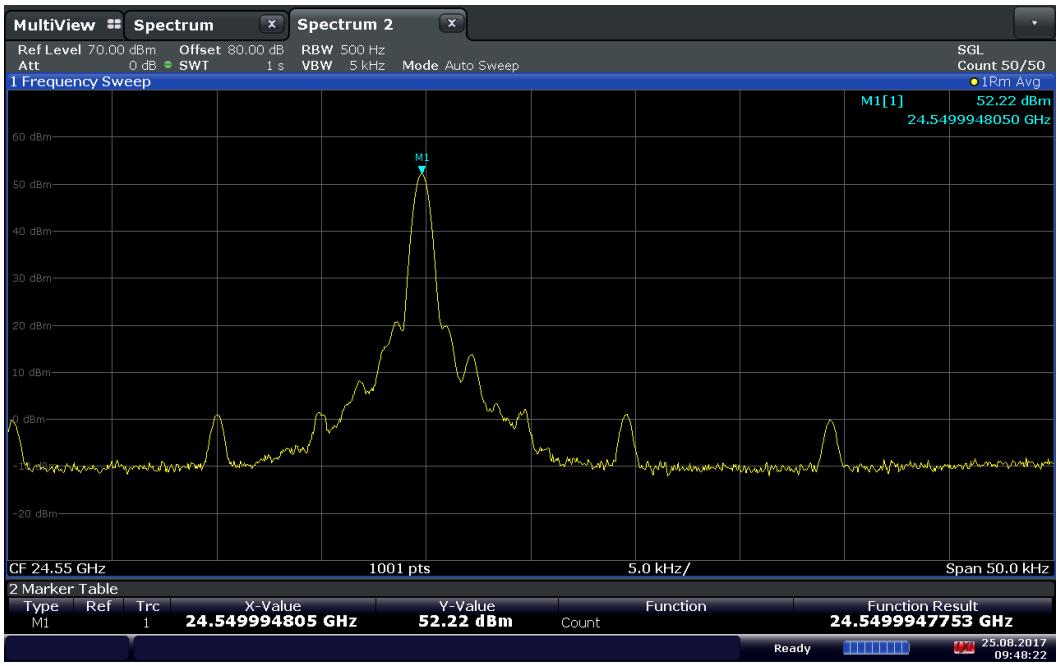
TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364



09:12:10 25.08.2017

Mid channel 24.55 GHz @ 30°C (Nominal voltage)

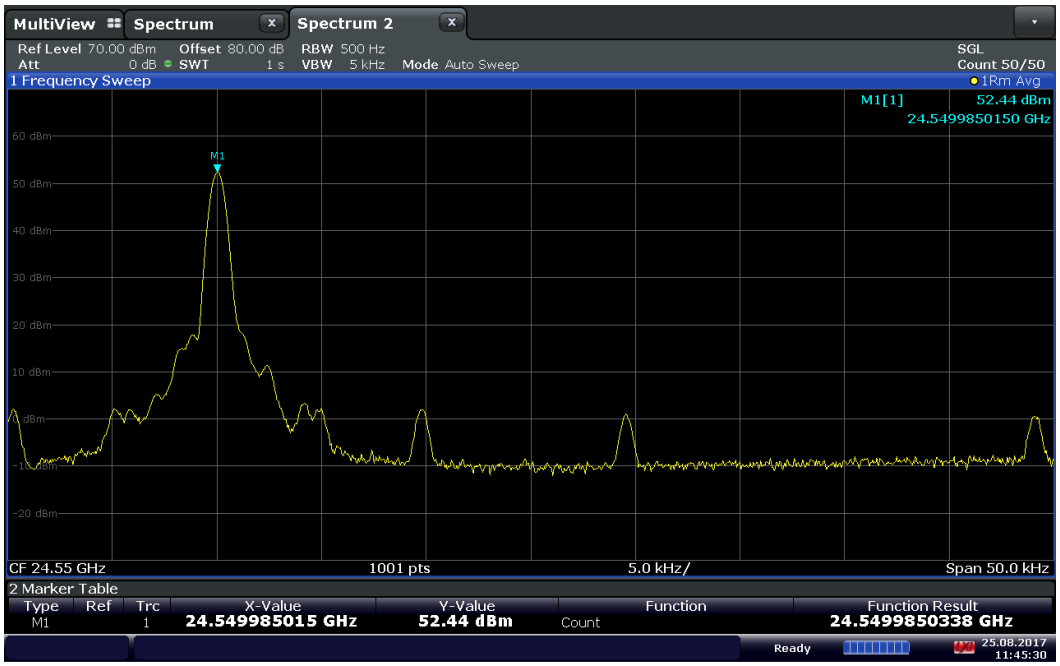
Center Frequency = 24.5500000234 GHz



09:48:22 25.08.2017

Mid channel 24.55 GHz @ 40°C (Nominal voltage)

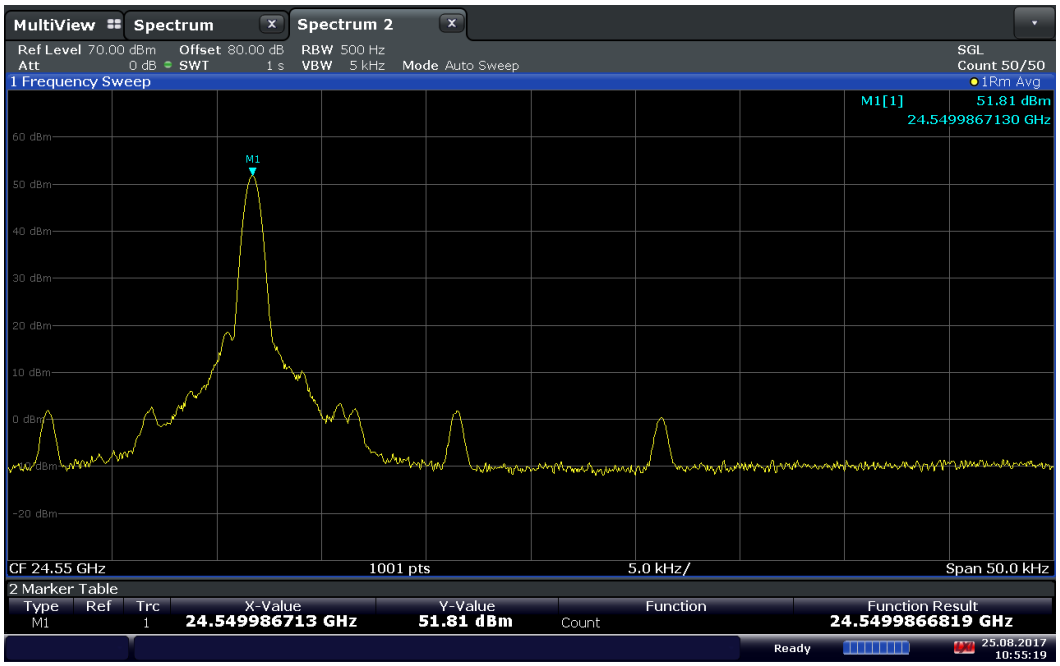
Center Frequency = 24.5499947753 GHz



11:45:30 25.08.2017

Mid channel 24.55 GHz @ 50°C (Nominal voltage)

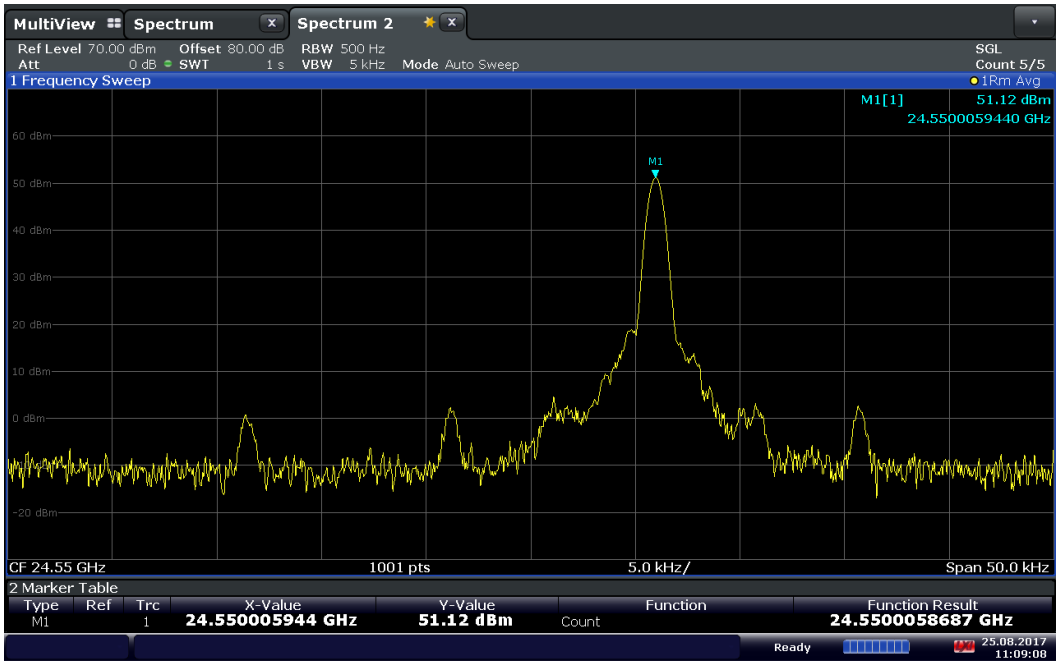
Center Frequency = 24.5499850338 GHz



10:55:20 25.08.2017

Mid channel 24.55 GHz @ 60°C (Nominal voltage)

Center Frequency = 24.5499866819 GHz

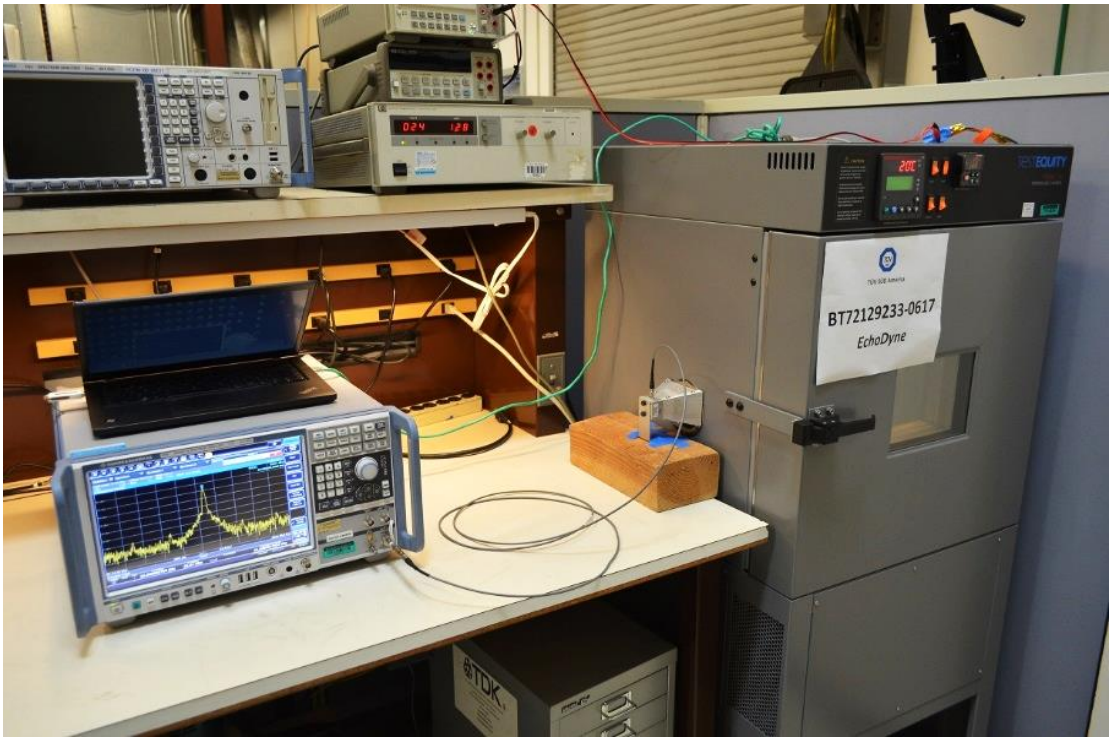


11:09:08 25.08.2017

Mid channel 24.55 GHz @ 70°C (Nominal voltage)

Center Frequency = 24.5500058687 GHz

2.3.10 Test Setup Pictures



2.4 OCCUPIED BANDWIDTH

2.4.1 Specification Reference

Part 2.1049, Part 87.135

2.4.2 Standard Applicable

§ 2.1049 Measurements required: Occupied bandwidth.
The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(h) Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

§ 87.135 Bandwidth.

(a) Occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5 percent of the total mean power of a given emission.

(b) The authorized bandwidth is the maximum occupied bandwidth authorized to be used by a station.

(c) The necessary bandwidth for a given class of emission is the width of the frequency band, which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

2.4.3 Equipment Under Test and Modification State

Serial No: 00125 / Default Test Configuration

2.4.4 Date of Test/Initial of test personnel who performed the test

August 23, 2017 / NS

2.4.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.4.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	26.1 °C
Relative Humidity	50.2 %
ATM Pressure	98.9 kPa

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.4.7 Additional Observations

- This is a conducted test.
- Occupied bandwidth measurement function of the spectrum analyzer was utilized for this test.
- A correction factor of 52.4 dB was used to account for free-space loss, test antenna gain and test cable loss.
- Detector is Peak. Trace is Max Hold.
- RBW is 1MHz while VBW was set to 3x RBW.

2.4.8 Test Results

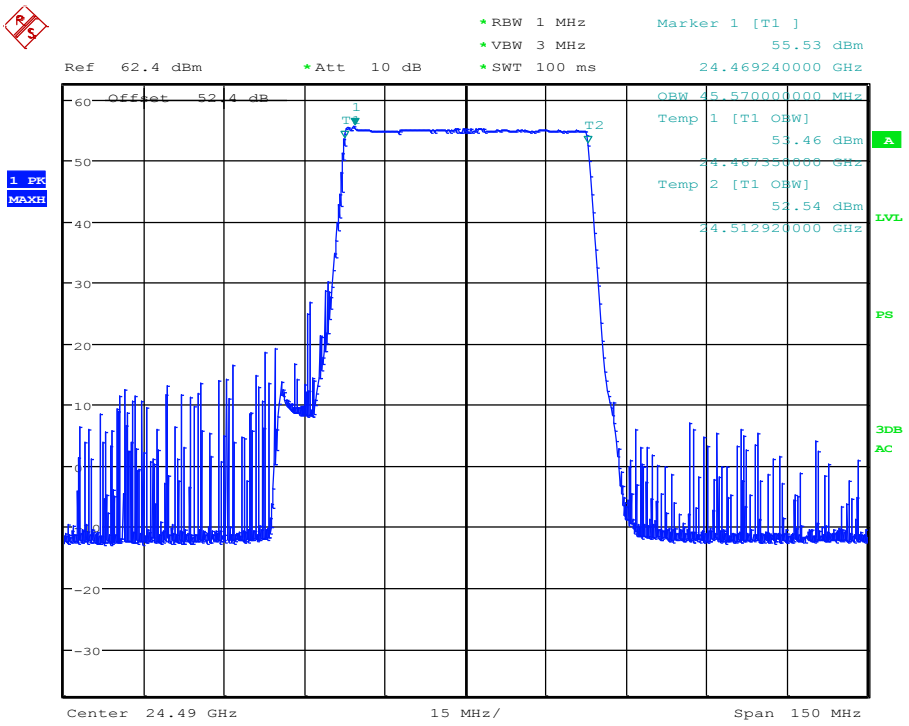
2.4.8.1 Occupied bandwidth table and test plots

Channel	Measured 99% Bandwidth (MHz)	Measured 26 dB Bandwidth (MHz)
Low (24.49 GHz)	45.57	50.3
Mid (24.55 GHz)	45.63	50.3
High (24.61 GHz)	45.51	50.3

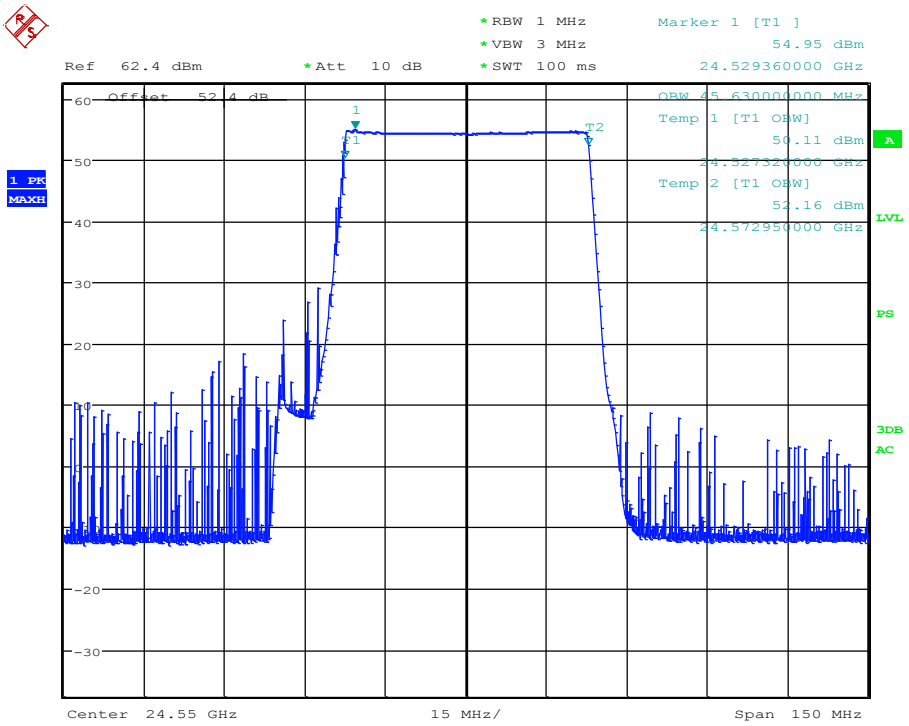
2.4.9 Test Results

See attached plots.

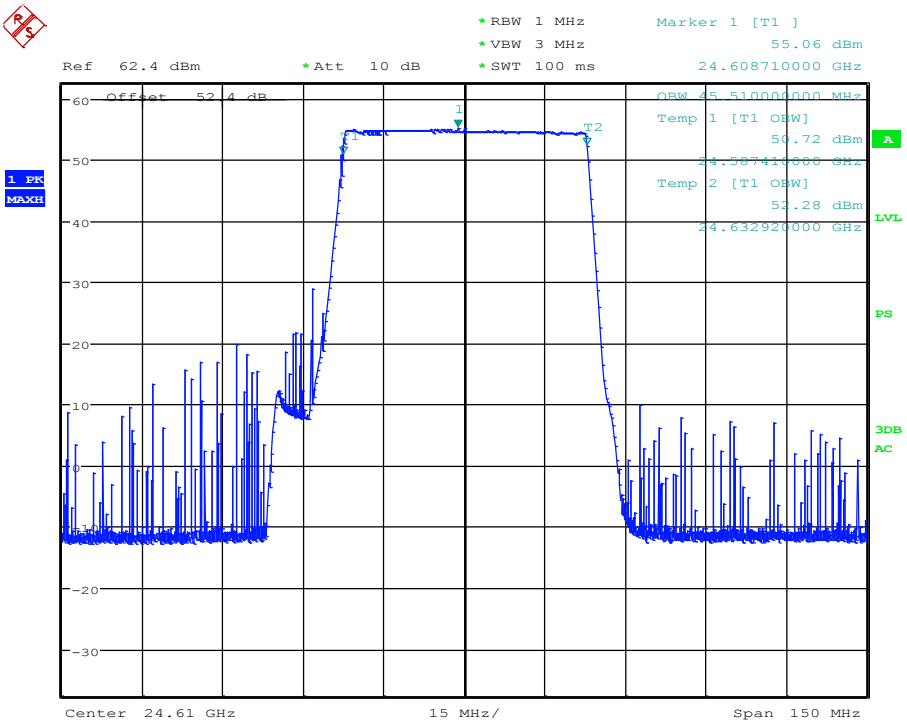
TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364



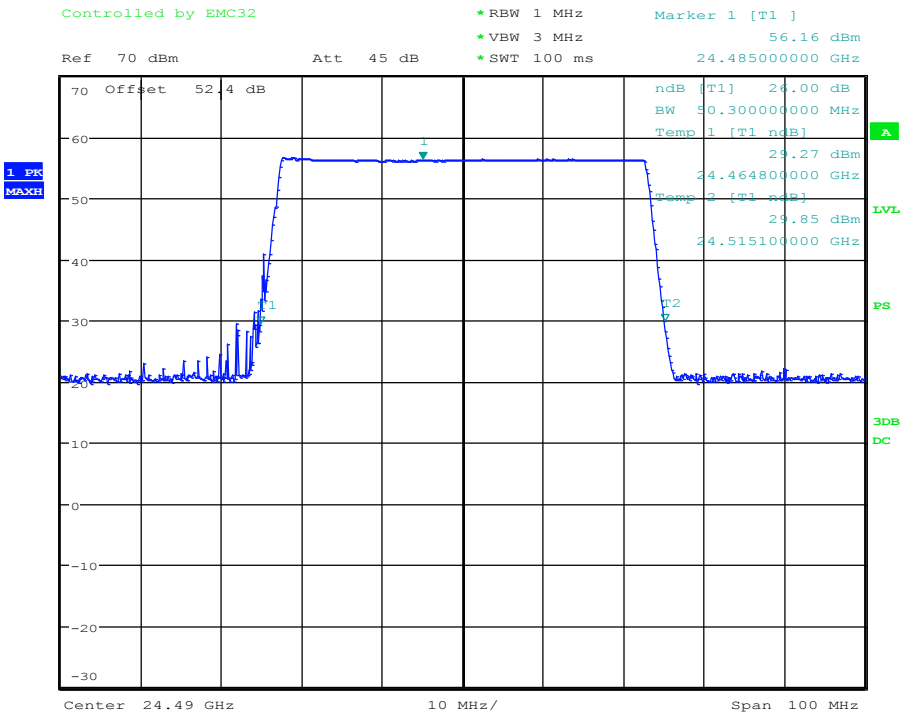
Low channel (99% OBW)



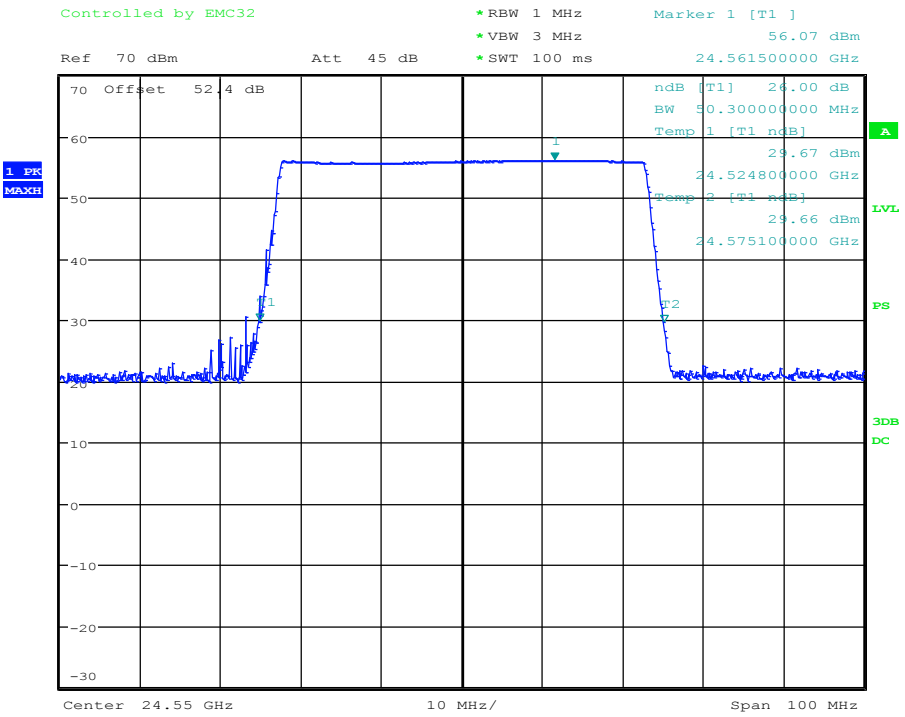
Mid channel (99% OBW)



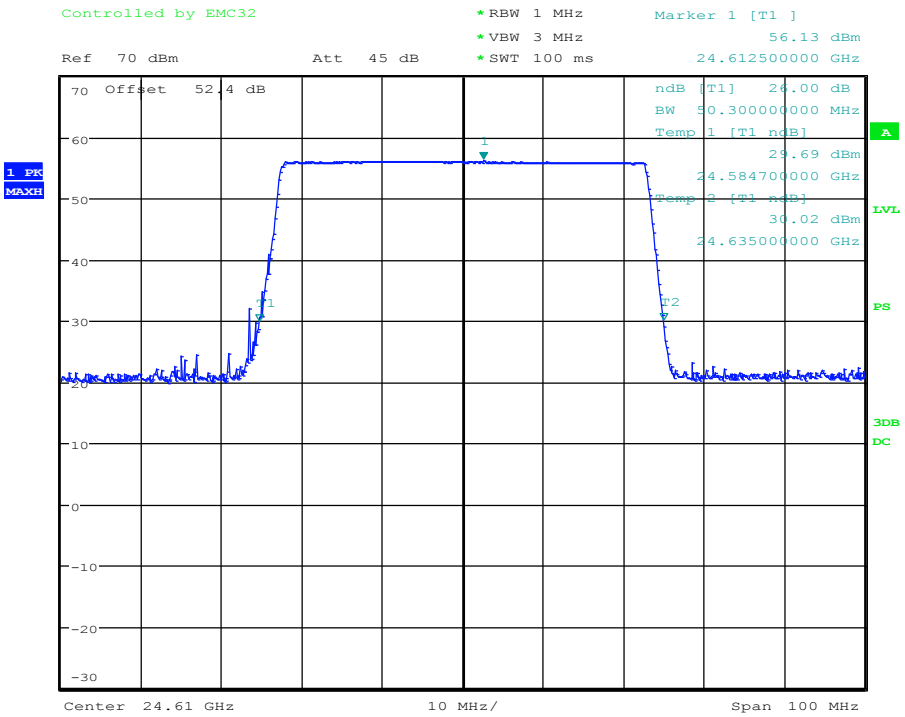
High channel (99% OBW)



Low channel (26 dB Bandwidth)



Mid channel (26 dB Bandwidth)



High channel (26 dB Bandwidth)

2.4.10 Test Setup Pictures

Test setup pictures are similar to those from section 2.1.10.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.5 SPURIOUS EMISSIONS AT ANTENNA PORT

2.5.1 Specification Reference

Part 2.1051 and Part 87.139

2.5.2 Standard Applicable

Part 2.1051 The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in § 2.1049 as appropriate.

§ 87.139 Emission limitations.

(a) Except for ELTs and when using single sideband (R3E, H3E, J3E), or frequency modulation (F9) or digital modulation (F9Y) for telemetry or telecommand in the 1435-1525 MHz, 2345-2395 MHz, or 5091-5150 MHz band or digital modulation (G7D) for differential GPS, the mean power of any emissions must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB;

(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 +10 $\log_{10}$ pY dB.

2.5.3 Equipment Under Test and Modification State

Not performed. EUT has no antenna port available. Spurious emissions were evaluated using radiated method.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.6 FIELD STRENGTH OF SPURIOUS RADIATION

2.6.1 Specification Reference

Part 2.1053, Part 87.139

2.6.2 Standard Applicable

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

§ 87.139 Emission limitations.

(a) Except for ELTs and when using single sideband (R3E, H3E, J3E), or frequency modulation (F9) or digital modulation (F9Y) for telemetry or telecommand in the 1435-1525 MHz, 2345-2395 MHz, or 5091-5150 MHz band or digital modulation (G7D) for differential GPS, the mean power of any emissions must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB;

(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 +10 $\log_{10}$ pY dB.

2.6.3 Equipment Under Test and Modification State

Serial No: 00125 / Default Test Configurations

2.6.4 Date of Test/Initial of test personnel who performed the test

August 21 – August 23, 2017/NS

2.6.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.6.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility.

Ambient Temperature	25.7-26.1 °C
Relative Humidity	50.2-52.3 %
ATM Pressure	98.9-99.1 kPa

2.6.7 Additional Observations

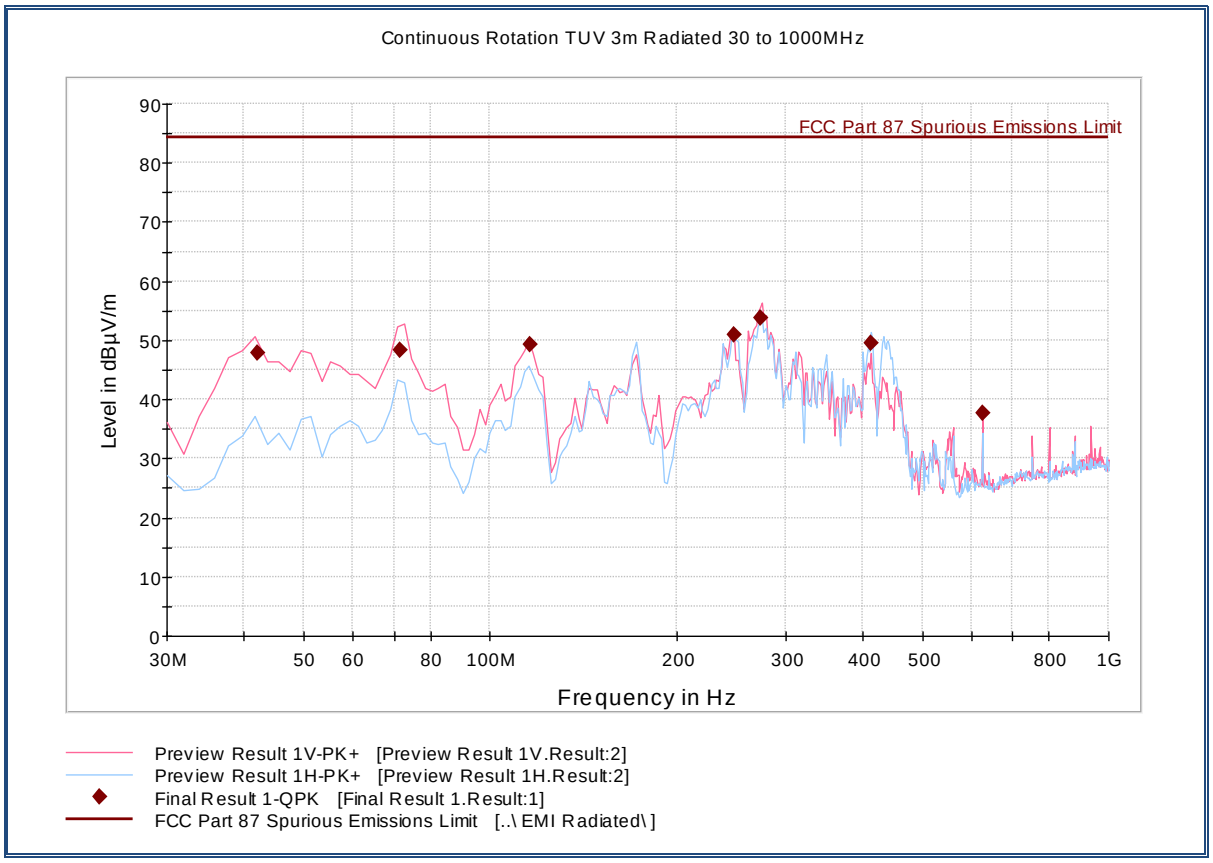
- This is a radiated test using substitution method as per Unwanted Emissions: Radiated Spurious method of measurement of ANSI/TIA/EIA-603-C 2004, August 17, 2004.
- Substitution method verification will be performed for the emissions observed within 60 dB in reference to the rated power output. No such emissions were observed.
- Test distance of 3 m was used for the spurious emissions measurement below 40 GHz. The emissions in the range from 40 GHz to 110 GHz were evaluated at 1.5 m to assure that the noise floor is at least 10 dB below the applicable limit.
- A correction factor of 6.0 dB was used to extrapolate the field strengths measured at 1.5 metres to the 3 meters distance.
- Measurements were done using EMC32 V8.53 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only.

2.6.8 Test Results

See attached plots.

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

2.6.9 Test Results Below 30 MHz (Low Channel)

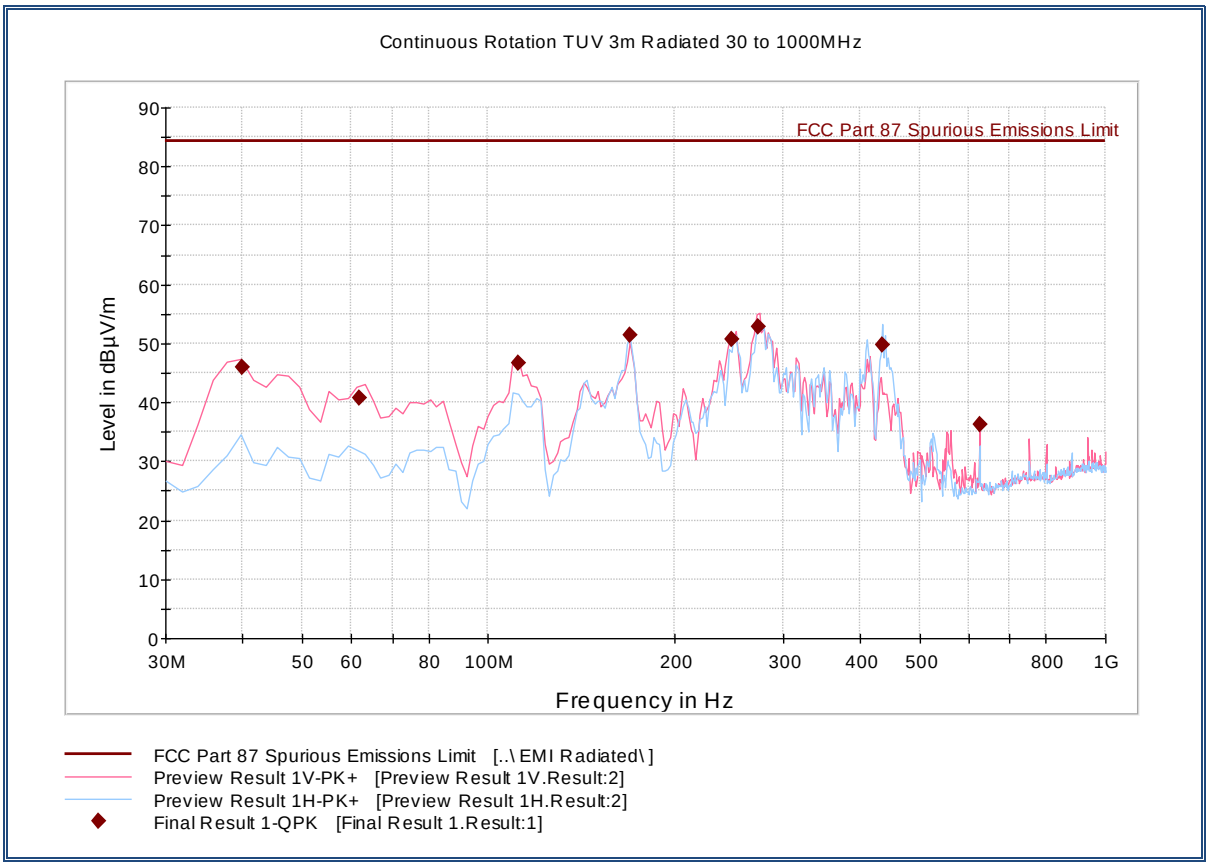


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
41.983327	47.9	1000.0	120.000	100.0	V	-8.0	-13.0	36.5	84.4
71.645531	48.2	1000.0	120.000	100.0	V	225.0	-16.9	36.2	84.4
116.011062	49.2	1000.0	120.000	100.0	V	210.0	-15.7	35.2	84.4
248.011543	50.9	1000.0	120.000	100.0	V	54.0	-9.1	33.5	84.4
273.969860	53.9	1000.0	120.000	100.0	V	54.0	-8.8	30.5	84.4
412.025892	49.5	1000.0	120.000	100.0	H	90.0	-4.5	34.9	84.4
624.989659	37.6	1000.0	120.000	100.0	V	108.0	1.5	46.8	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.10 Test Results Below 30 MHz (Mid Channel)

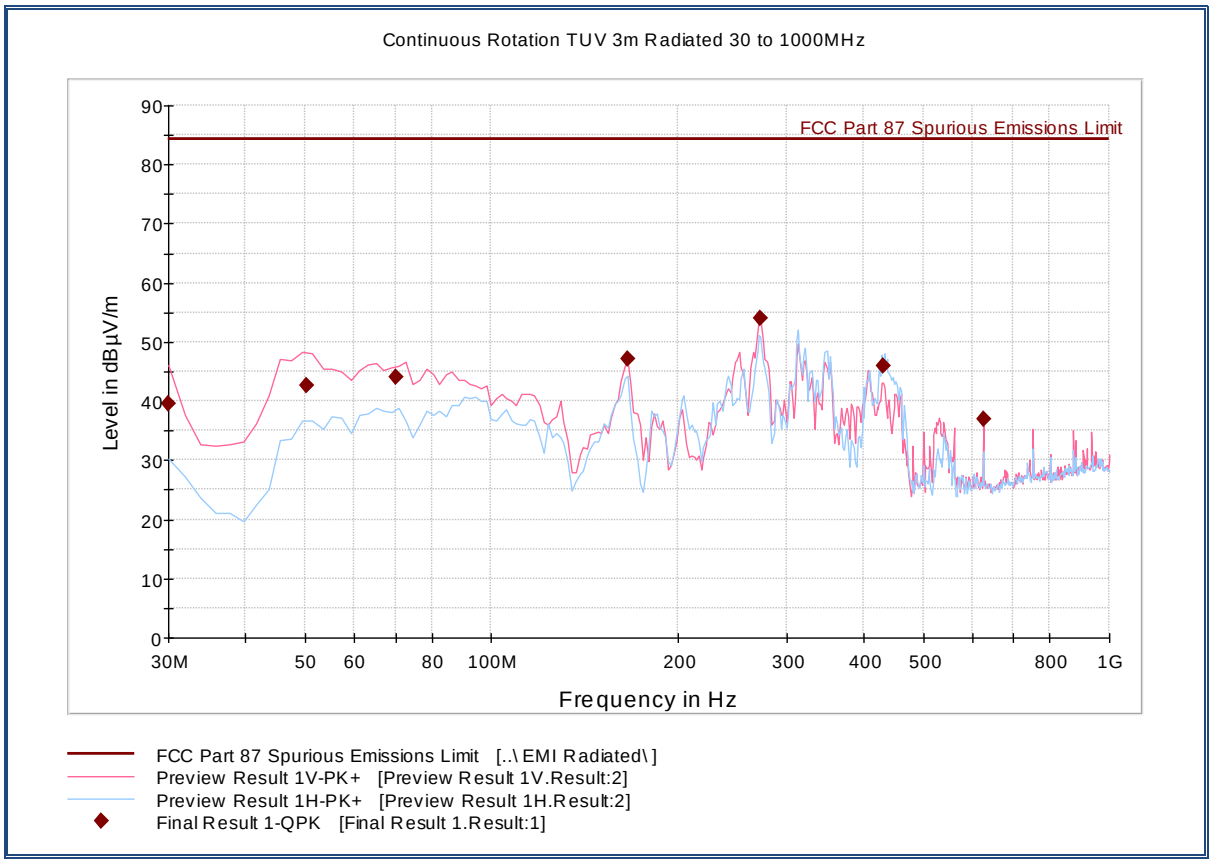


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
39.999439	46.0	1000.0	120.000	100.0	V	183.0	-12.4	38.4	84.4
61.966092	40.7	1000.0	120.000	115.0	V	233.0	-17.0	43.7	84.4
112.003287	46.6	1000.0	120.000	100.0	V	225.0	-15.4	37.8	84.4
169.999920	51.4	1000.0	120.000	109.0	H	257.0	-12.3	33.0	84.4
247.971543	50.7	1000.0	120.000	100.0	V	59.0	-9.1	33.7	84.4
273.969860	52.8	1000.0	120.000	100.0	V	45.0	-8.8	31.6	84.4
434.008657	49.7	1000.0	120.000	100.0	H	80.0	-3.9	34.7	84.4
624.949659	36.3	1000.0	120.000	178.0	V	155.0	1.5	48.1	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.11 Test Results Below 30 MHz (High Channel)

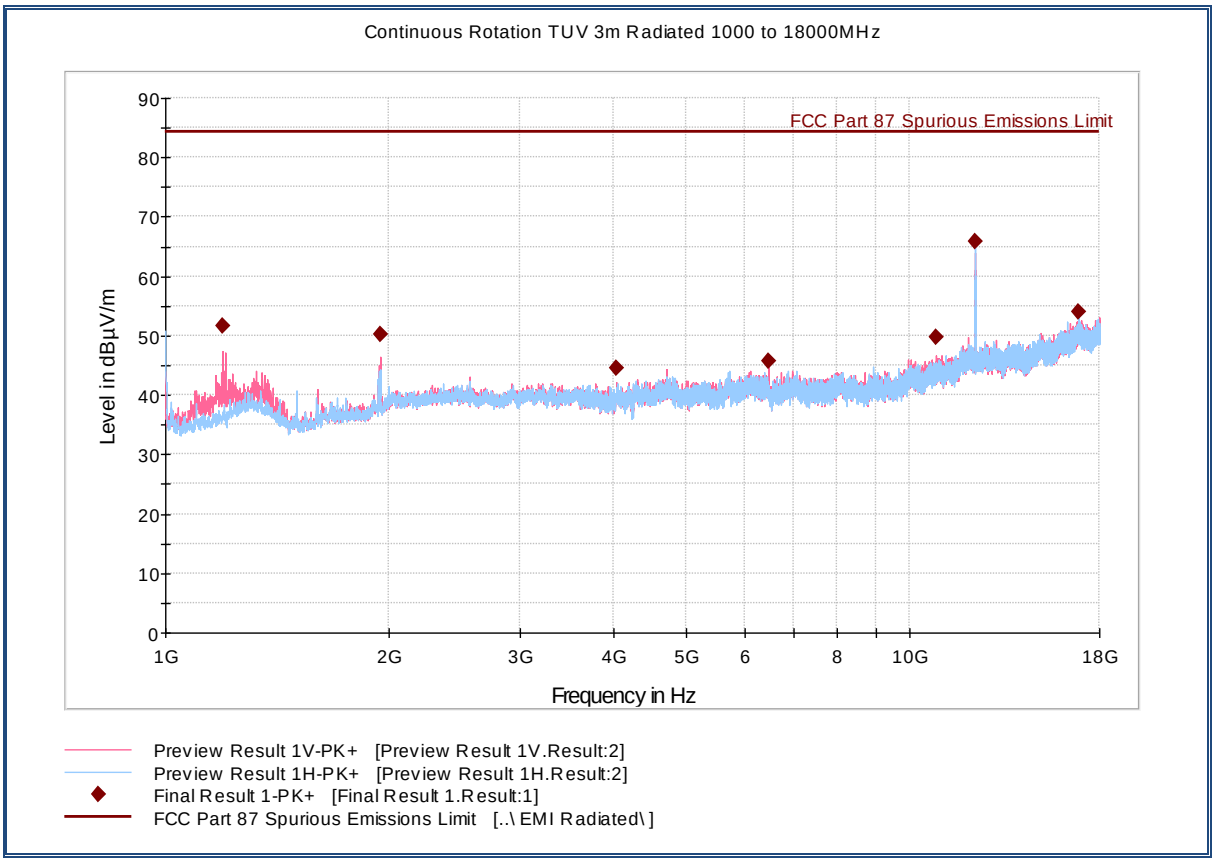


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
30.000000	39.7	1000.0	120.000	100.0	V	343.0	-5.9	44.7	84.4
50.198878	42.7	1000.0	120.000	128.0	V	223.0	-14.4	41.7	84.4
70.205531	44.2	1000.0	120.000	110.0	V	207.0	-17.0	40.2	84.4
165.992144	47.0	1000.0	120.000	100.0	V	19.0	-12.5	37.4	84.4
271.985972	54.1	1000.0	120.000	100.0	V	35.0	-8.7	30.3	84.4
429.984770	46.0	1000.0	120.000	105.0	H	121.0	-4.0	38.4	84.4
624.989659	37.0	1000.0	120.000	100.0	V	124.0	1.5	47.4	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.12 Test Results 1.0 GHz-18.0 GHz (Low Channel)

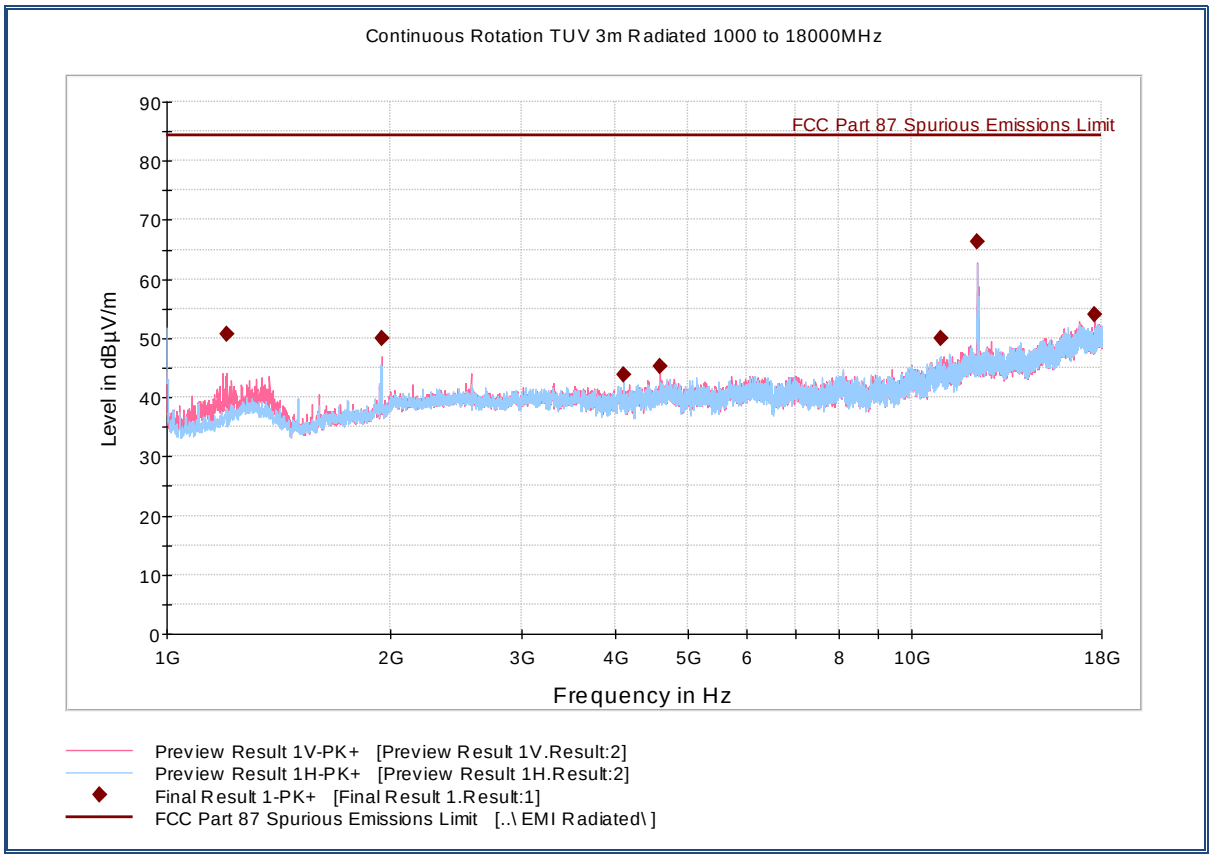


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1193.100000	51.6	1000.0	1000.000	155.4	V	-11.0	-6.4	32.9	84.4
1943.733333	50.2	1000.0	1000.000	391.0	V	241.0	-2.2	34.2	84.4
4032.933333	44.5	1000.0	1000.000	230.2	V	327.0	3.3	39.9	84.4
6452.600000	45.7	1000.0	1000.000	401.8	V	301.0	7.1	38.7	84.4
10846.20000	49.8	1000.0	1000.000	397.0	V	326.0	14.2	34.6	84.4
12234.56666	65.9	1000.0	1000.000	100.4	H	273.0	16.2	18.5	84.4
16888.90000	54.0	1000.0	1000.000	100.4	H	180.0	23.1	30.4	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.13 Test Results 1.0 GHz-18.0 GHz (Mid Channel)

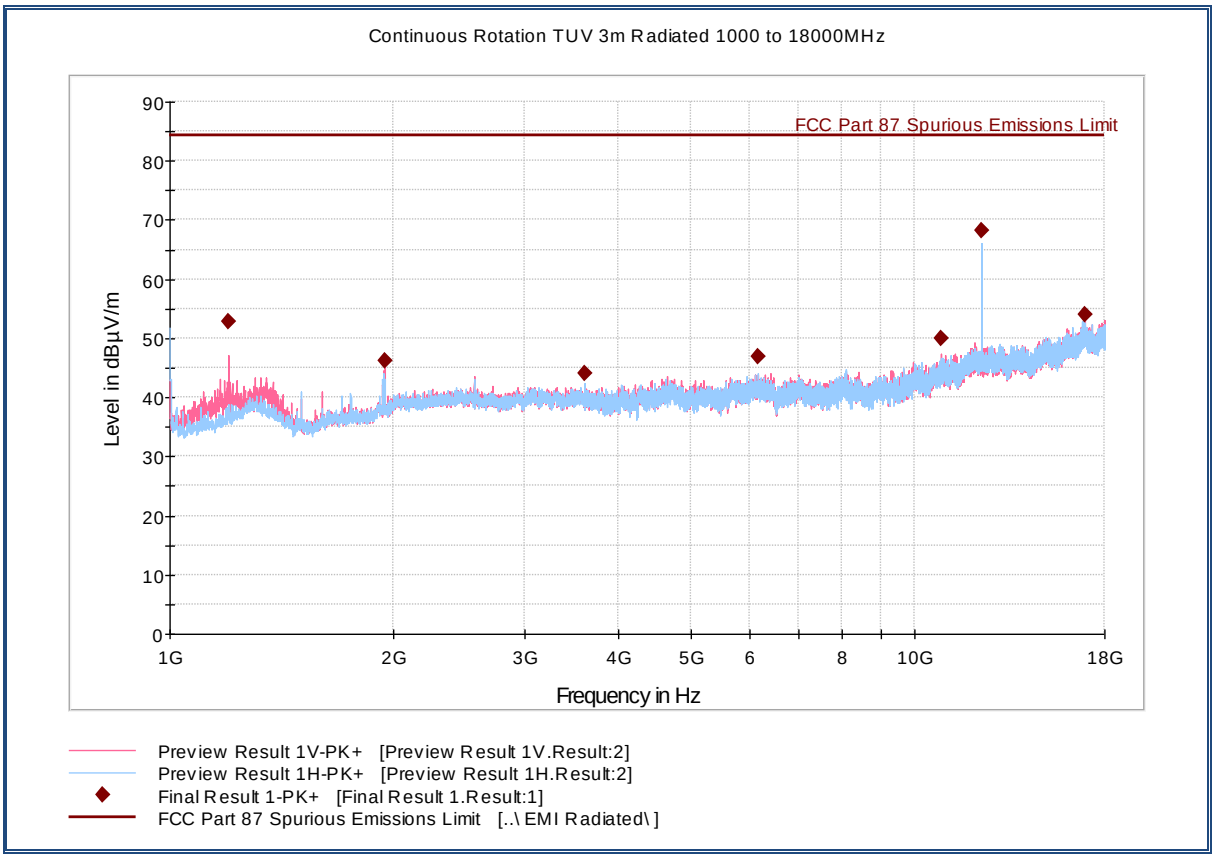


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1202.133333	50.7	1000.0	1000.000	245.2	V	25.0	-6.3	33.7	84.4
1943.700000	50.0	1000.0	1000.000	381.0	V	265.0	-2.2	34.4	84.4
4114.233333	43.9	1000.0	1000.000	322.1	H	183.0	2.7	40.5	84.4
4585.833333	45.3	1000.0	1000.000	142.4	V	85.0	3.6	39.1	84.4
10968.46666	50.1	1000.0	1000.000	322.1	H	103.0	13.9	34.3	84.4
12264.00000	66.4	1000.0	1000.000	292.1	V	312.0	16.4	18.0	84.4
17646.76666	53.9	1000.0	1000.000	372.0	V	240.0	22.9	30.5	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.14 Test Results 1.0 GHz-18.0 GHz (High Channel)

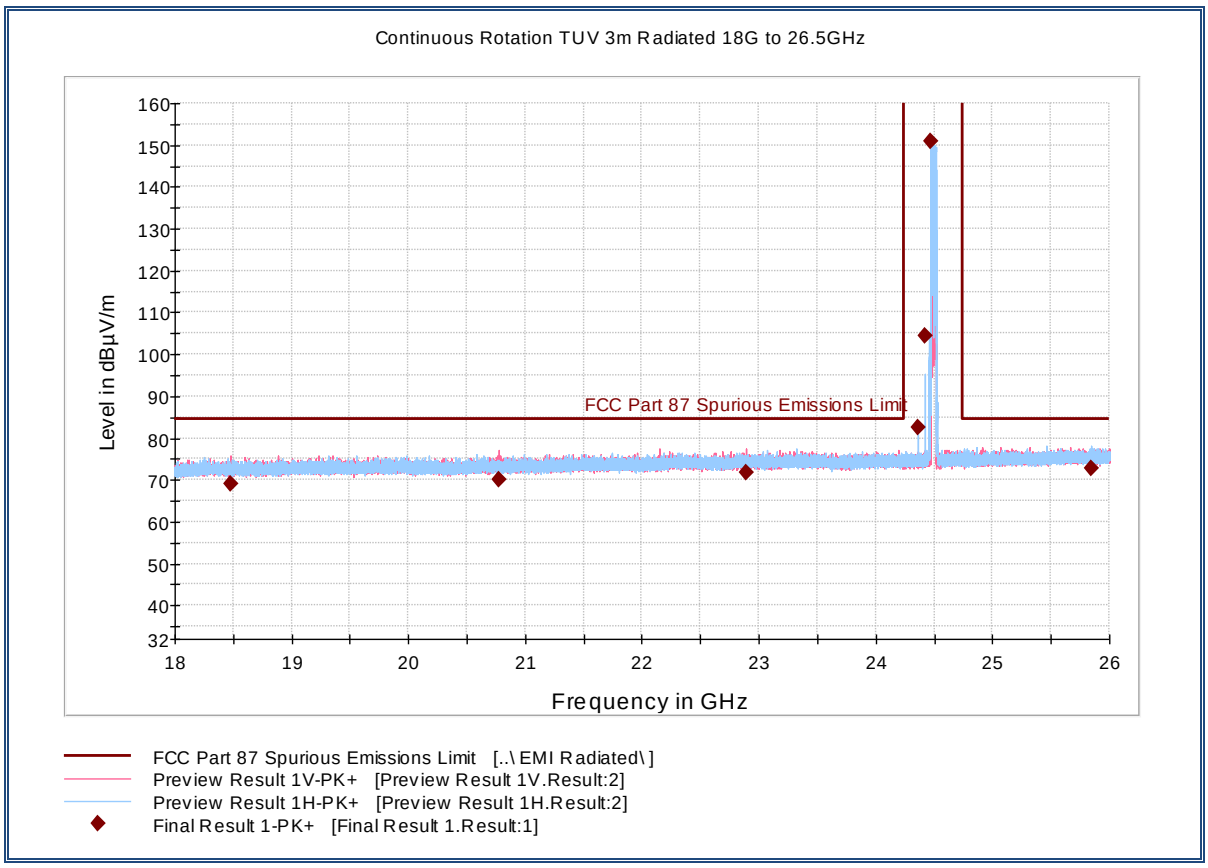


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1199.866667	52.9	1000.0	1000.000	143.4	V	-6.0	-6.4	31.5	84.4
1943.300000	46.2	1000.0	1000.000	406.7	V	157.0	-2.2	38.2	84.4
3608.166667	44.1	1000.0	1000.000	136.4	H	346.0	1.6	40.3	84.4
6175.566667	46.9	1000.0	1000.000	150.4	H	274.0	7.2	37.5	84.4
10870.76666	50.1	1000.0	1000.000	401.8	V	233.0	14.2	34.3	84.4
12294.63333	68.3	1000.0	1000.000	112.4	H	272.0	16.5	16.1	84.4
16939.73333	54.1	1000.0	1000.000	392.0	V	74.0	23.0	30.3	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.15 Test Results 18.0 GHz-26.0 GHz (Low Channel)

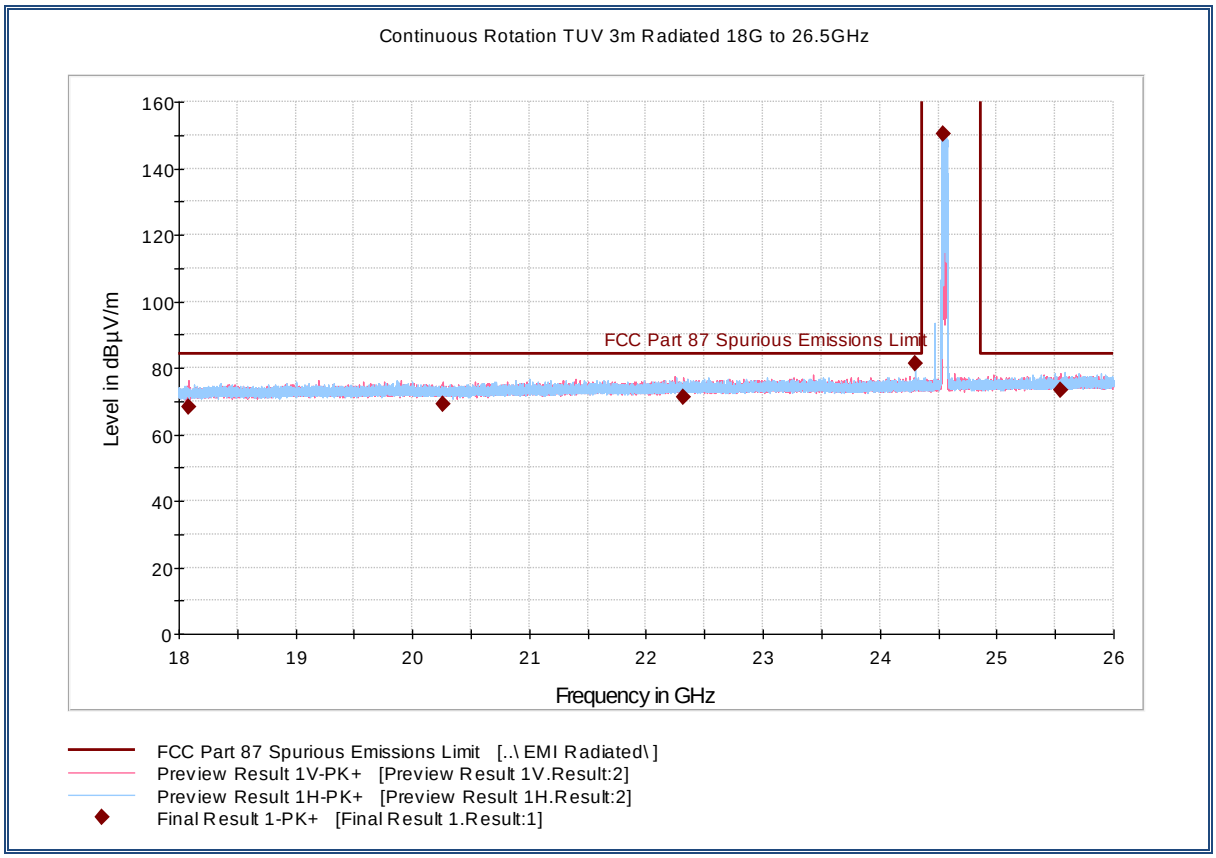


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
18478.18333	69.2	1000.0	1000.000	160.1	V	300.0	38.1	15.2	84.4
20779.45000	69.9	1000.0	1000.000	110.1	V	0.0	39.2	14.5	84.4
22893.53333	71.6	1000.0	1000.000	149.4	V	54.0	39.9	12.8	84.4
24363.10000	82.7	1000.0	1000.000	155.4	H	5.0	40.6	N/A (See test notes)	
24425.58333	104.3	1000.0	1000.000	150.4	H	0.0	40.6	N/A (See test notes)	
24469.48333	150.8	1000.0	1000.000	154.4	H	0.0	40.6	N/A (See test notes)	
25841.08333	72.6	1000.0	1000.000	146.4	H	10.0	41.3	11.8	84.4

Test Notes: EUT transmitting through the integral antenna. Emissions in the range from 24.24 GHz to 24.74 GHz will be ignored in this evaluation. Test results of section 2.5 apply to that frequency range.

2.6.16 Test Results 18.0 GHz-26.0 GHz (Mid Channel)

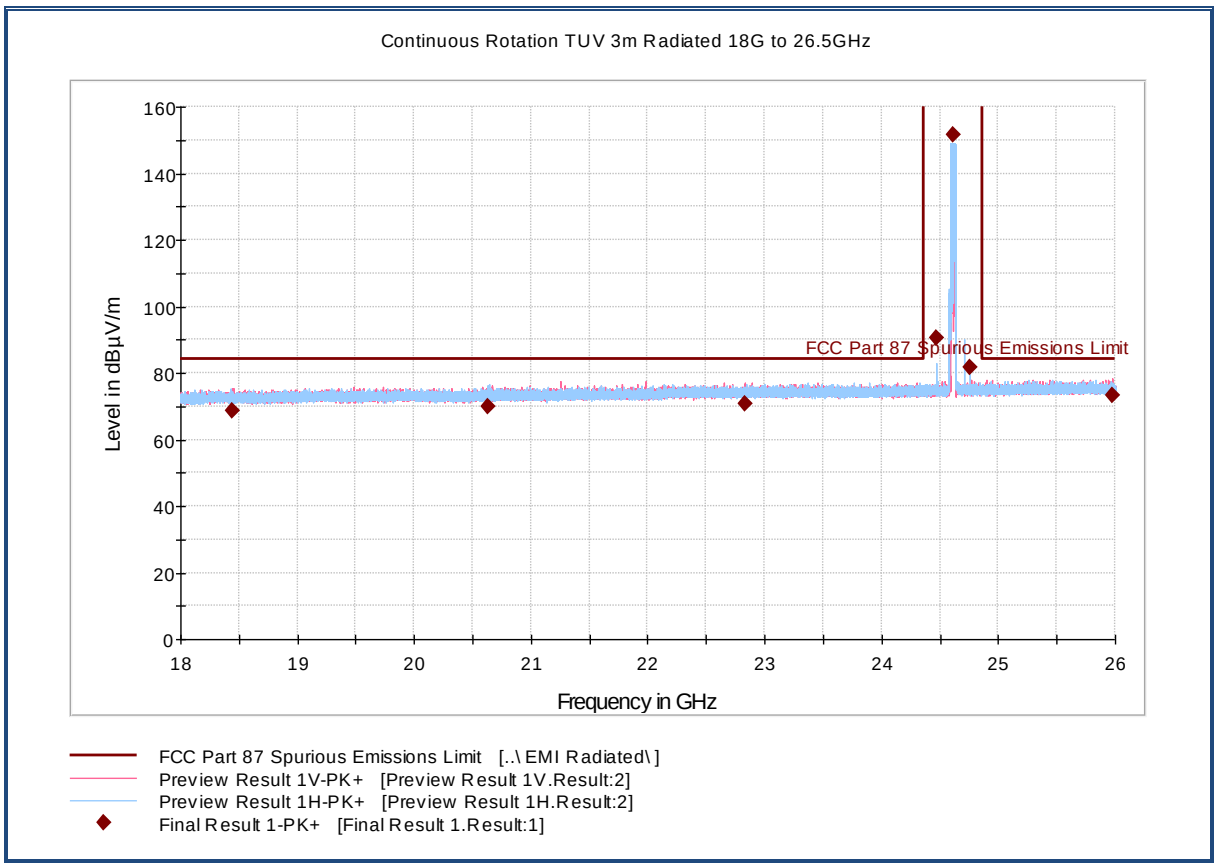


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
18081.00000	68.3	1000.0	1000.000	100.4	V	72.0	37.9	16.1	84.4
20263.55000	69.2	1000.0	1000.000	110.1	V	334.0	38.8	15.2	84.4
22314.11666	71.1	1000.0	1000.000	110.1	V	4.0	39.8	13.3	84.4
24302.31666	81.3	1000.0	1000.000	110.1	H	0.0	40.6	3.1	84.4
24544.95000	150.5	1000.0	1000.000	140.4	H	2.0	40.7	N/A (See test notes)	
25542.98333	73.2	1000.0	1000.000	150.4	V	160.0	41.2	11.2	84.4

Test Notes: EUT transmitting through the integral antenna. Emissions in the range from 24.30 GHz to 24.80 GHz will be ignored in this evaluation. Test results of section 2.5 apply to that frequency range.

2.6.17 Test Results 18.0 GHz-26.0 GHz (High Channel)

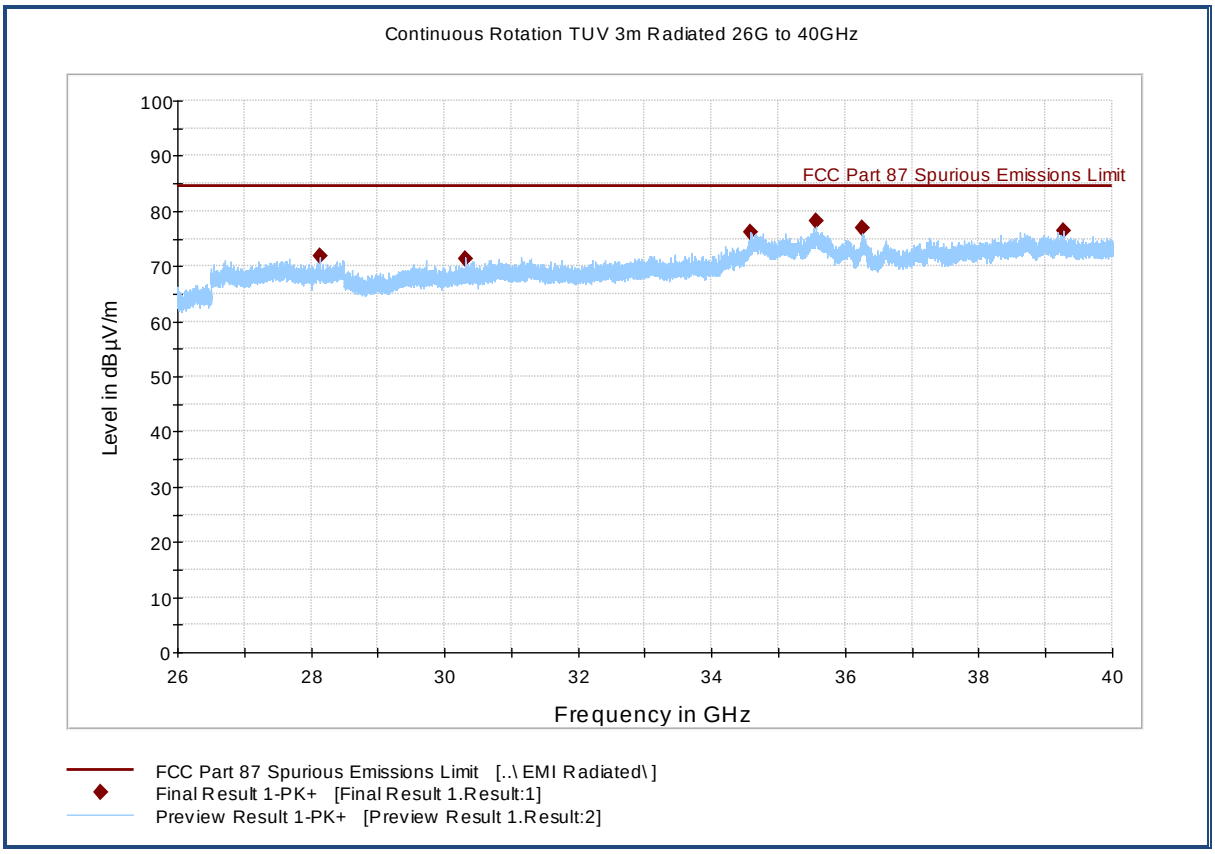


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
18446.16666	68.8	1000.0	1000.000	100.4	V	291.0	38.1	15.6	84.4
20627.35000	70.0	1000.0	1000.000	110.1	H	-10.0	39.0	14.4	84.4
22833.18333	70.6	1000.0	1000.000	110.1	V	263.0	39.9	13.8	84.4
24473.45000	90.4	1000.0	1000.000	148.4	H	0.0	40.6	N/A (See test notes)	
24608.01666	151.5	1000.0	1000.000	155.4	H	-1.0	40.7	N/A (See test notes)	
24755.51666	81.8	1000.0	1000.000	152.4	H	6.0	40.8	N/A (See test notes)	
25977.81666	73.1	1000.0	1000.000	143.4	V	0.0	41.3	11.3	84.4

Test Notes: EUT transmitting through the integral antenna. Emissions in the range from 24.36 GHz to 24.86 GHz will be ignored in this evaluation. Test results of section 2.5 apply to that frequency range.

2.6.18 Test Results 26.0 GHz-40.0 GHz (Low Channel)

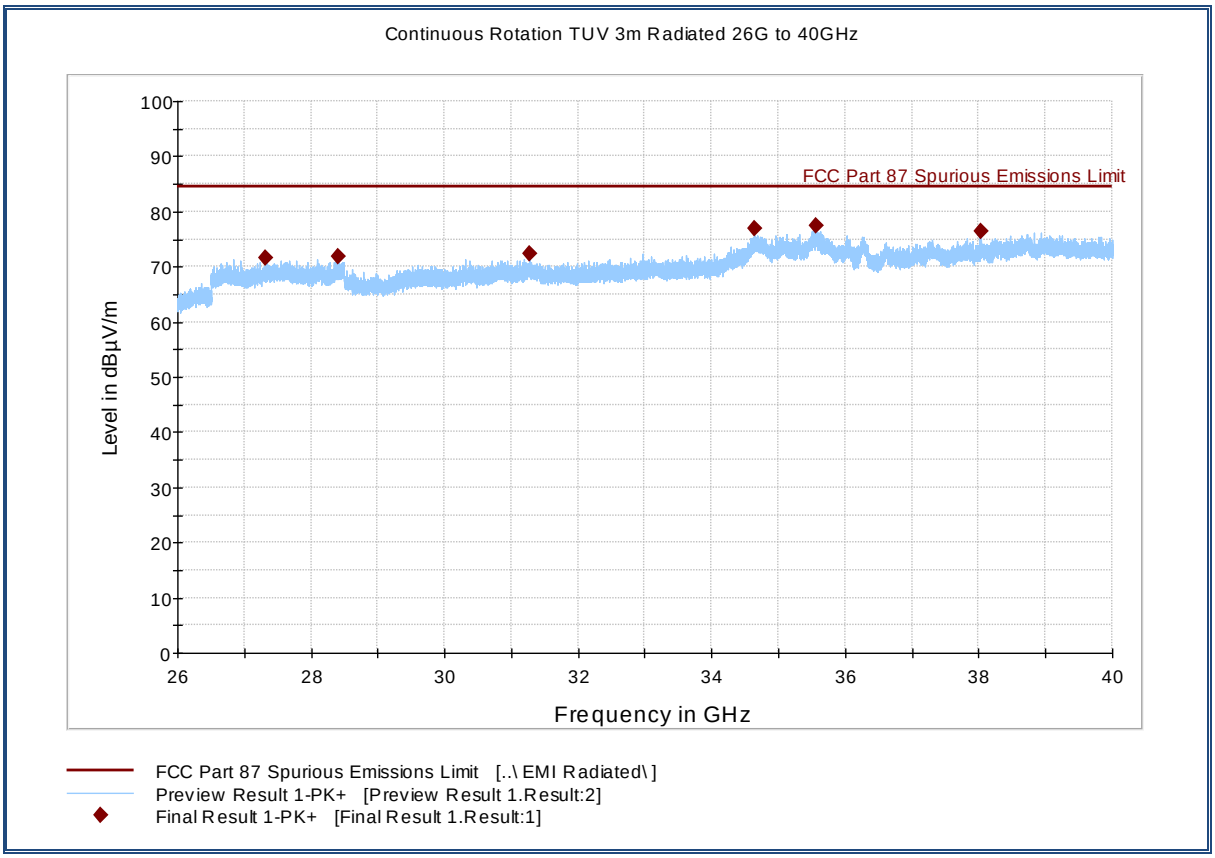


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
28141.73333	71.8	1000.0	1000.000	110.5	V	69.0	36.1	12.6	84.4
30303.40000	71.2	1000.0	1000.000	140.4	V	28.0	36.7	13.2	84.4
34581.00000	76.0	1000.0	1000.000	140.4	V	306.0	38.2	8.4	84.4
35563.33333	78.1	1000.0	1000.000	150.4	H	349.0	38.3	6.3	84.4
36257.66666	76.9	1000.0	1000.000	160.5	H	344.0	38.5	7.5	84.4
39264.26666	76.3	1000.0	1000.000	140.4	V	58.0	39.9	8.1	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.19 Test Results 26.0 GHz-40.0 GHz (Mid Channel)

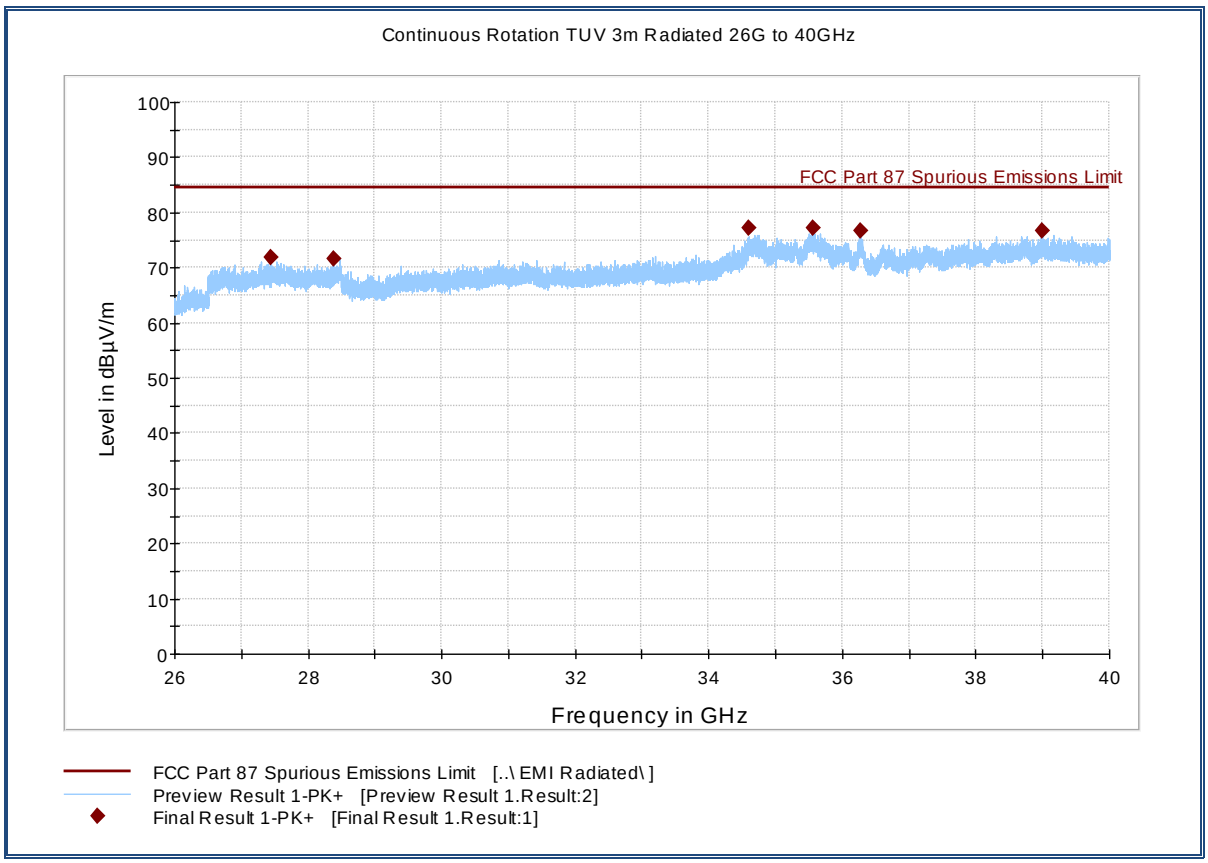


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
27308.53333	71.6	1000.0	1000.000	140.4	V	122.0	35.9	12.8	84.4
28405.46666	71.7	1000.0	1000.000	140.4	H	185.0	36.3	12.7	84.4
31270.13333	72.2	1000.0	1000.000	100.4	H	122.0	37.1	12.2	84.4
34634.60000	76.8	1000.0	1000.000	160.5	V	283.0	38.2	7.6	84.4
35572.13333	77.4	1000.0	1000.000	151.4	H	88.0	38.3	7.0	84.4
38036.26666	76.3	1000.0	1000.000	140.4	H	79.0	39.4	8.1	84.4

Test Notes: EUT transmitting through the integral antenna.

2.6.20 Test Results 26.0 GHz-40.0 GHz (High Channel)

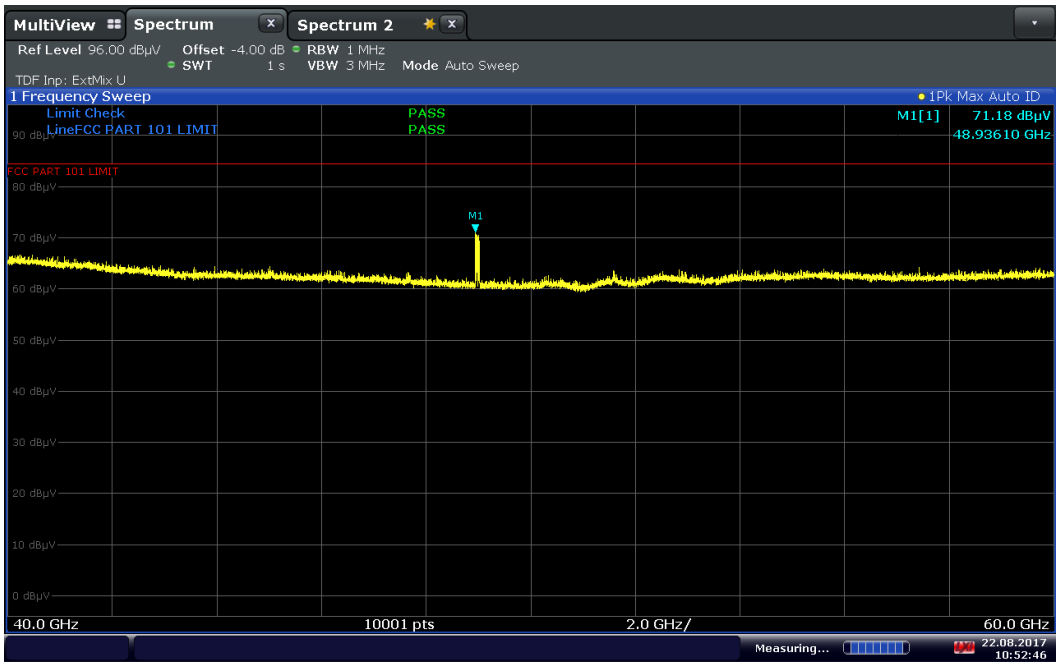


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
27445.33333	71.7	1000.0	1000.000	150.4	H	201.0	36.0	12.7	84.4
28392.13333	71.7	1000.0	1000.000	160.6	H	265.0	36.2	12.7	84.4
34602.00000	77.2	1000.0	1000.000	140.4	H	297.0	38.2	7.2	84.4
35567.06666	77.2	1000.0	1000.000	160.5	V	131.0	38.3	7.2	84.4
36277.20000	76.6	1000.0	1000.000	140.4	V	275.0	38.5	7.8	84.4
38986.66666	76.7	1000.0	1000.000	151.4	V	228.0	39.6	7.7	84.4

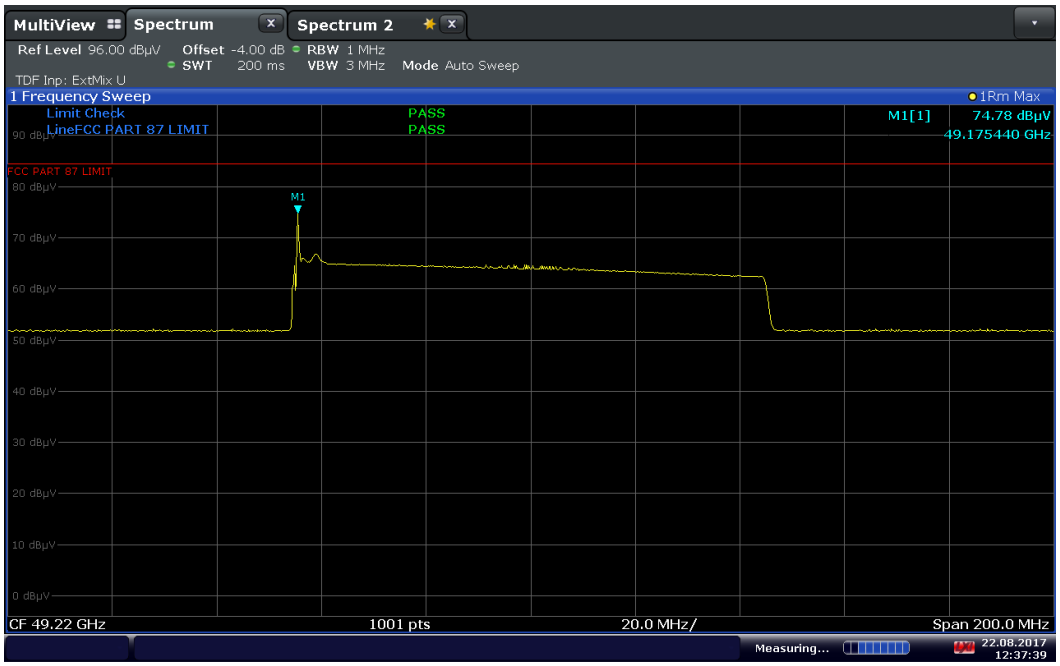
Test Notes: EUT transmitting through the integral antenna.

2.6.21 Test Results 40.0 GHz-110 GHz



10:52:46 22.08.2017

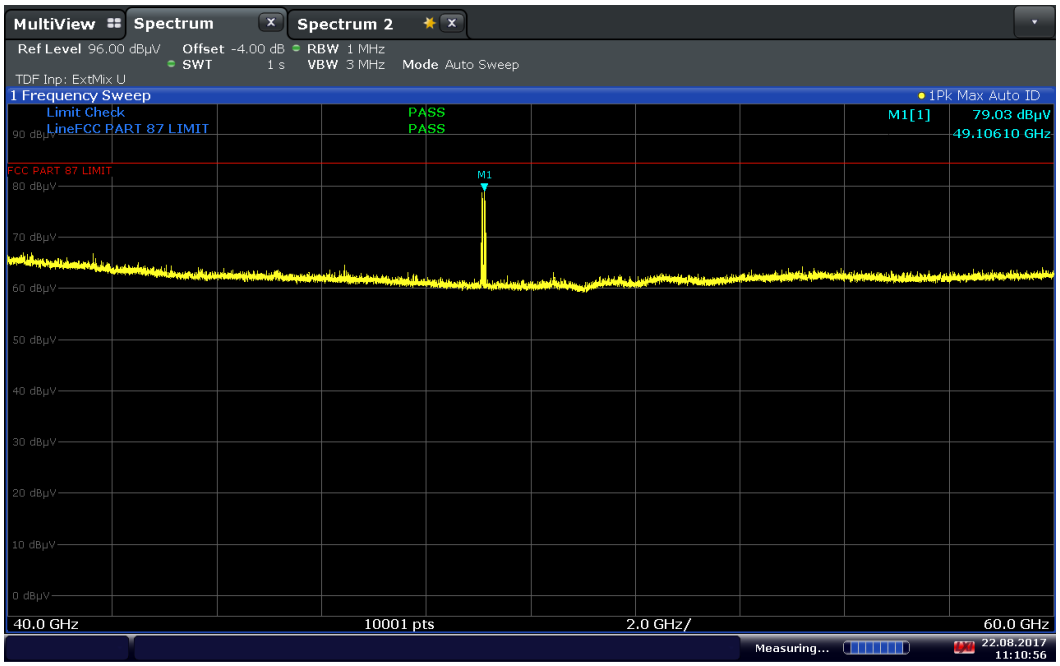
40 GHz to 60 GHz (Low channel)



12:37:39 22.08.2017

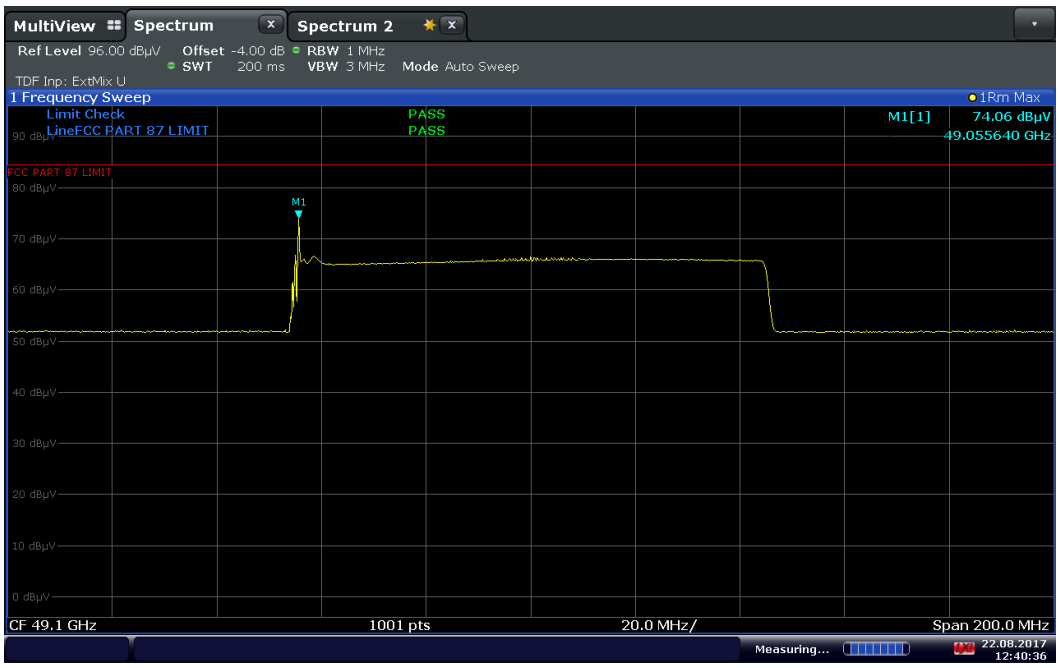
2nd harmonic verification (RMS detector)

Note: No considerable emissions other than the second harmonic were observed.



11:10:56 22.08.2017

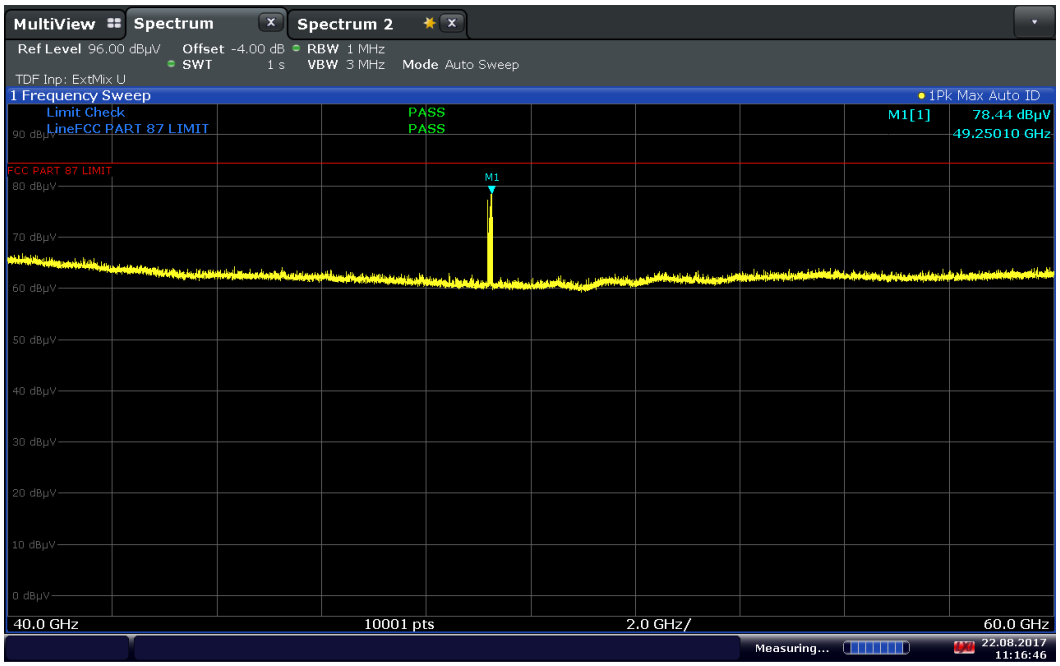
40 GHz to 60 GHz (Mid channel)



12:40:37 22.08.2017

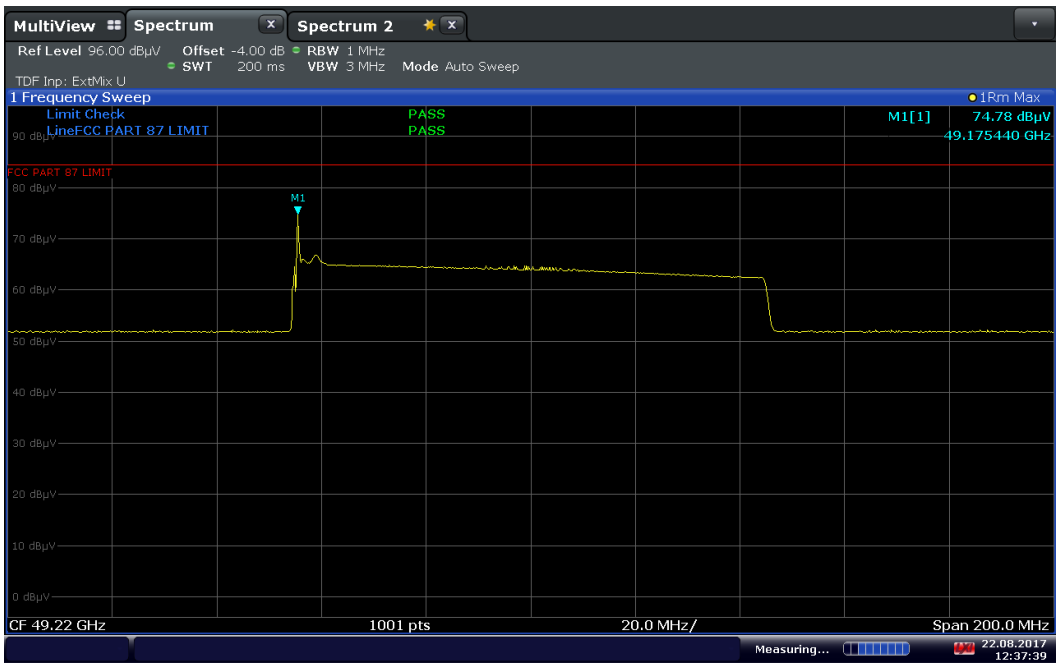
2nd harmonic verification (RMS detector)

Note: No considerable emissions other than the second harmonic were observed.



11:16:46 22.08.2017

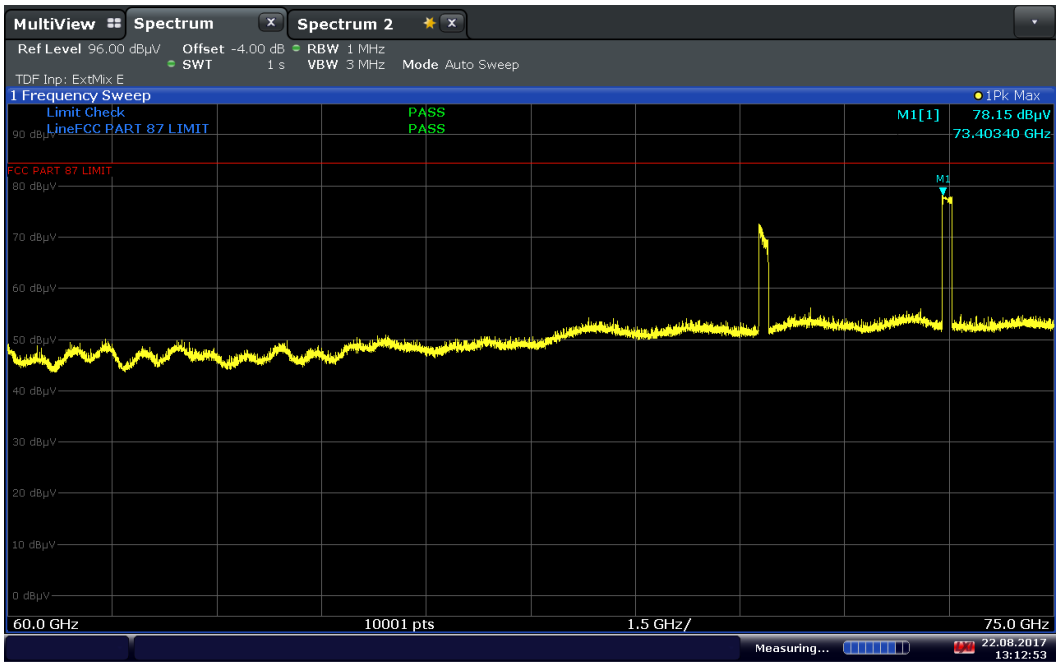
40 GHz to 60 GHz (High channel)



12:37:39 22.08.2017

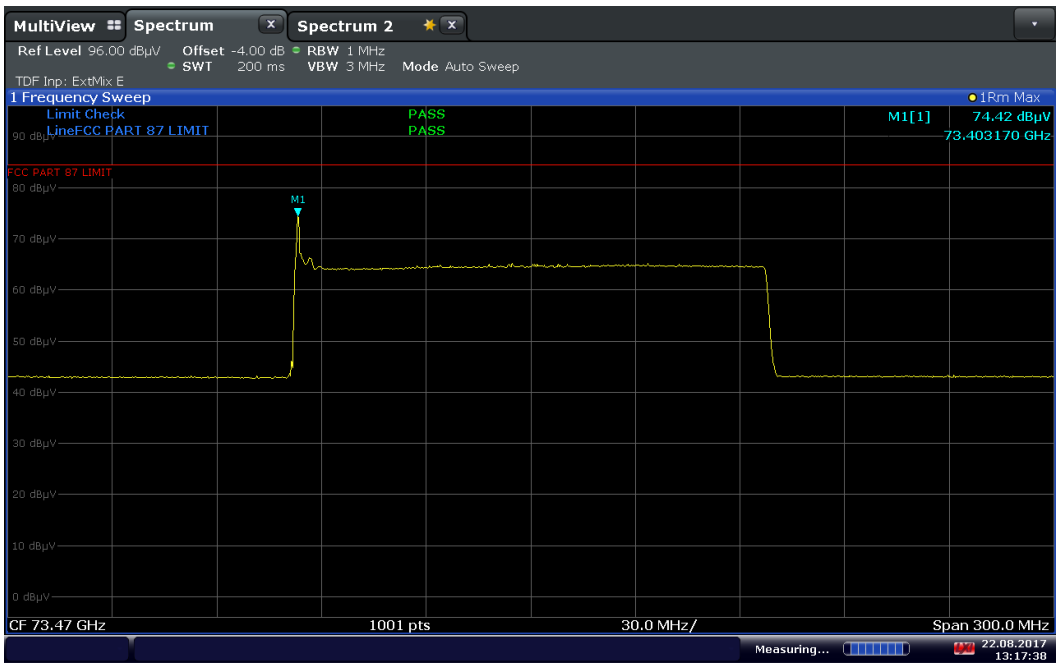
2nd harmonic verification (RMS detector)

Note: No considerable emissions other than the second harmonic were observed.



13:12:53 22.08.2017

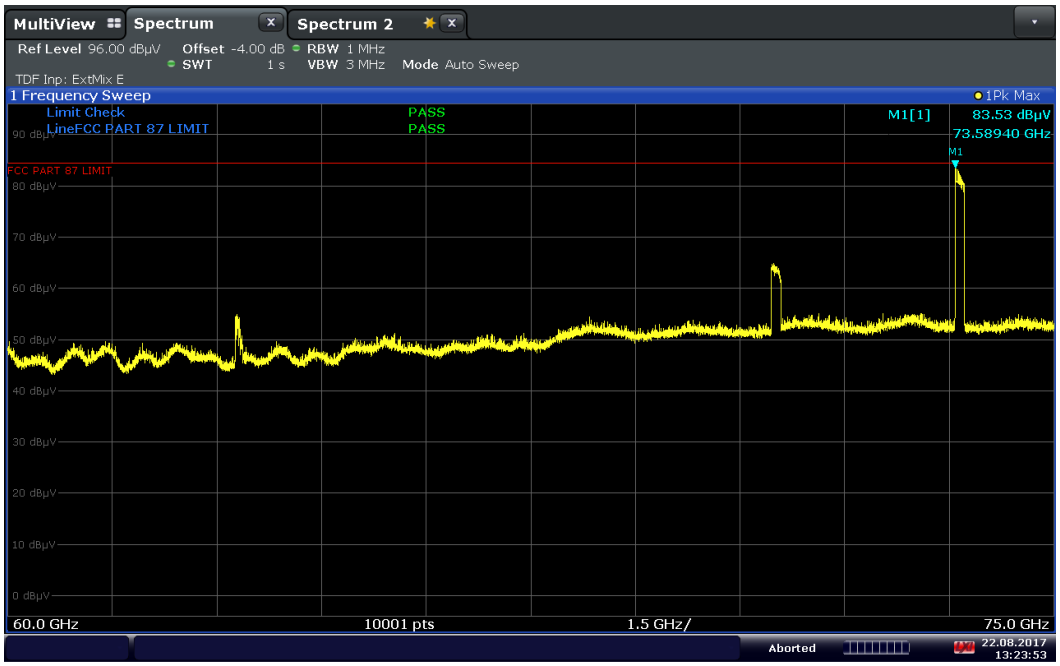
60 GHz to 75 GHz (Low channel)



13:17:39 22.08.2017

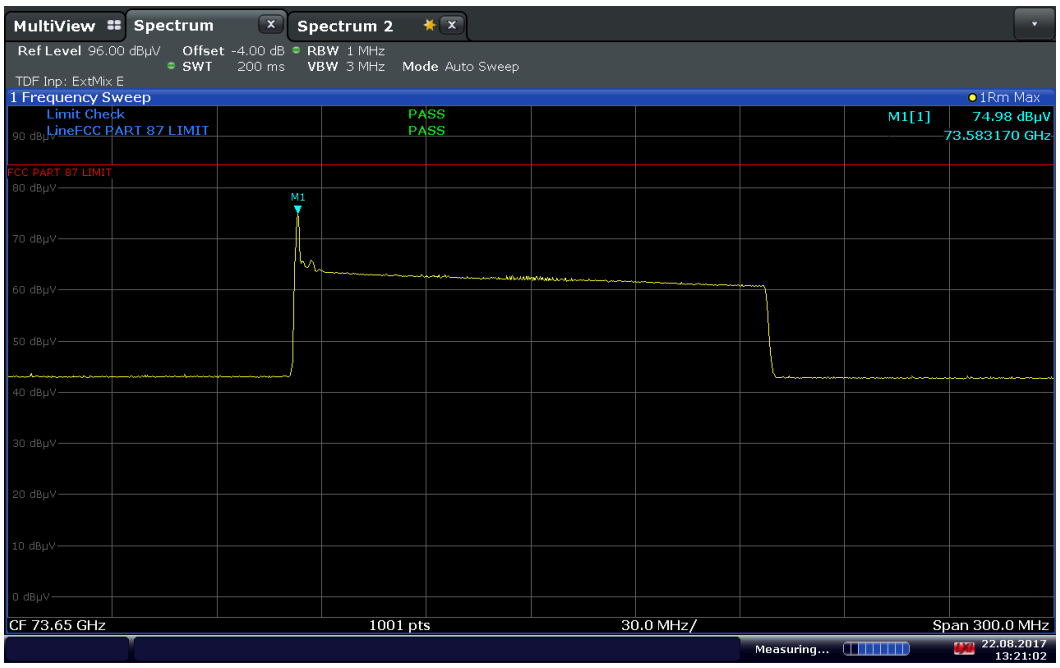
3rd harmonic verification (RMS detector)

Note: No considerable emissions other than the third harmonic were observed.



13:23:54 22.08.2017

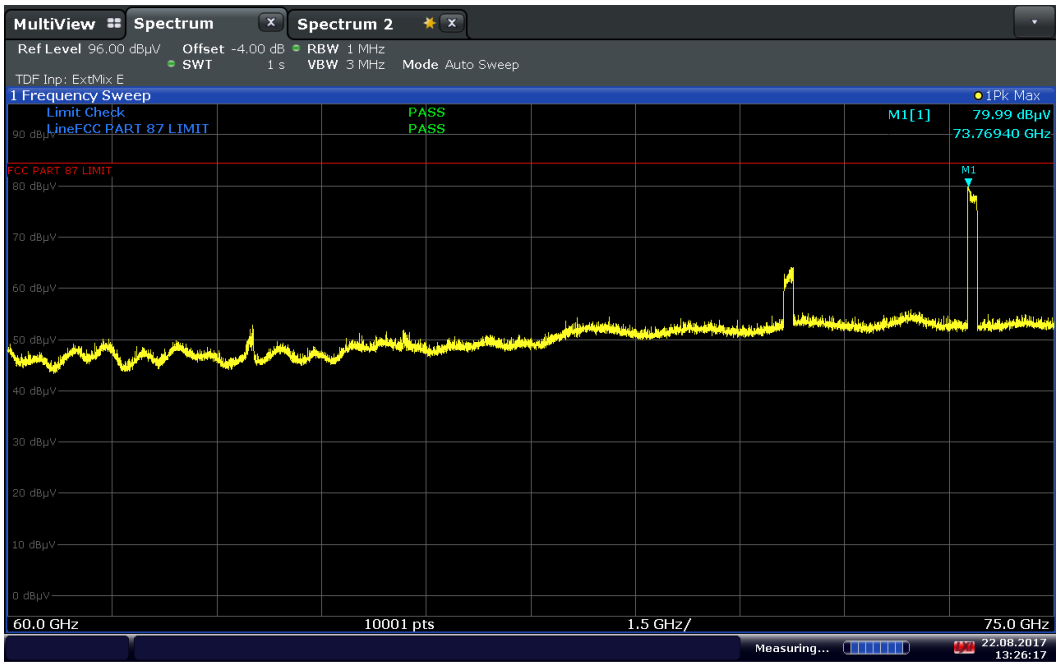
60 GHz to 75 GHz (Mid channel)



13:21:03 22.08.2017

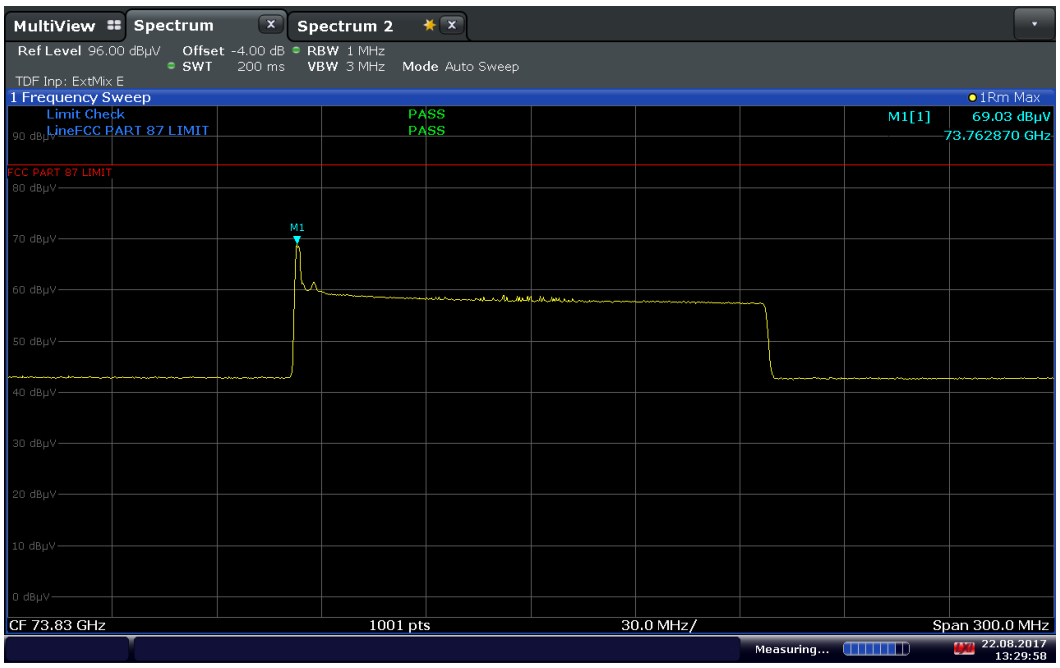
3rd harmonic verification (RMS detector)

Note: No considerable emissions other than the third harmonic were observed.



13:26:17 22.08.2017

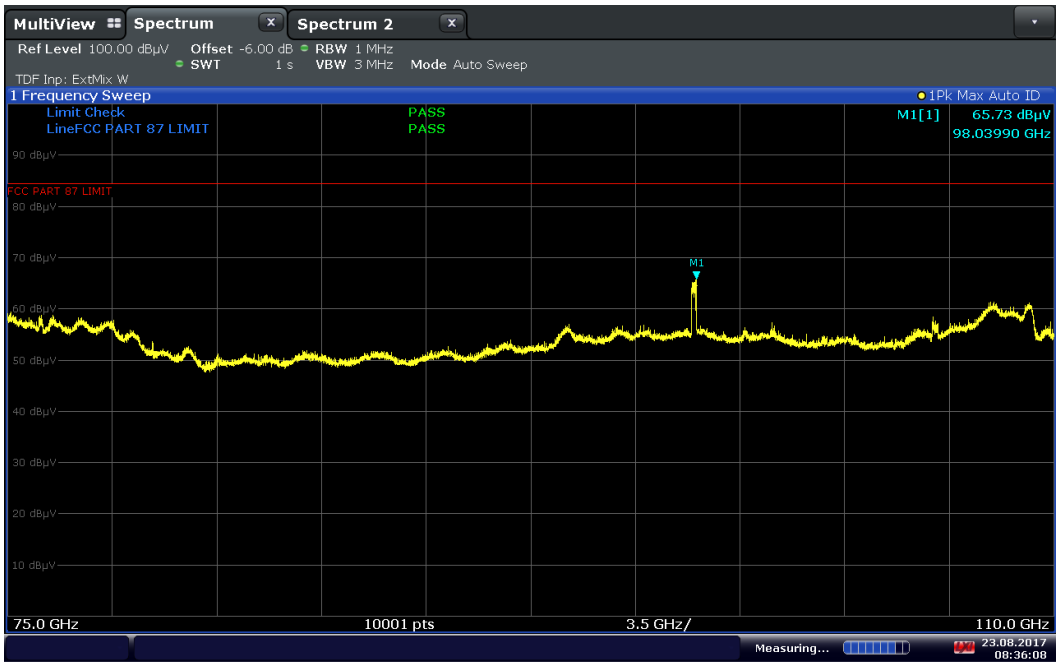
60 GHz to 75 GHz (High channel)



13:29:59 22.08.2017

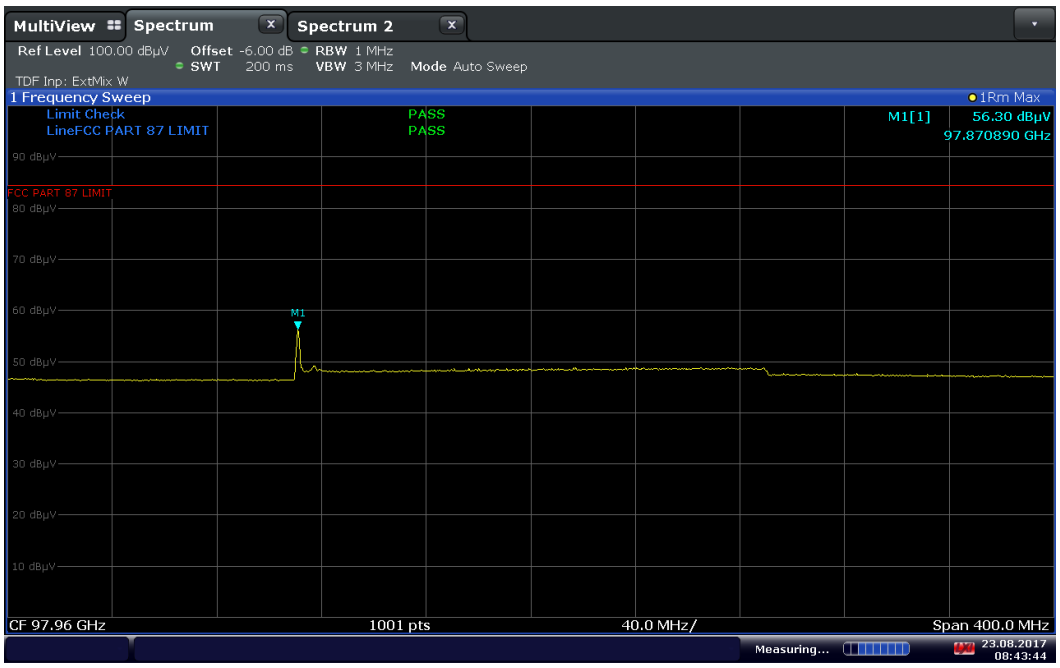
3rd harmonic verification (RMS detector)

Note: No considerable emissions other than the third harmonic were observed.



08:36:09 23.08.2017

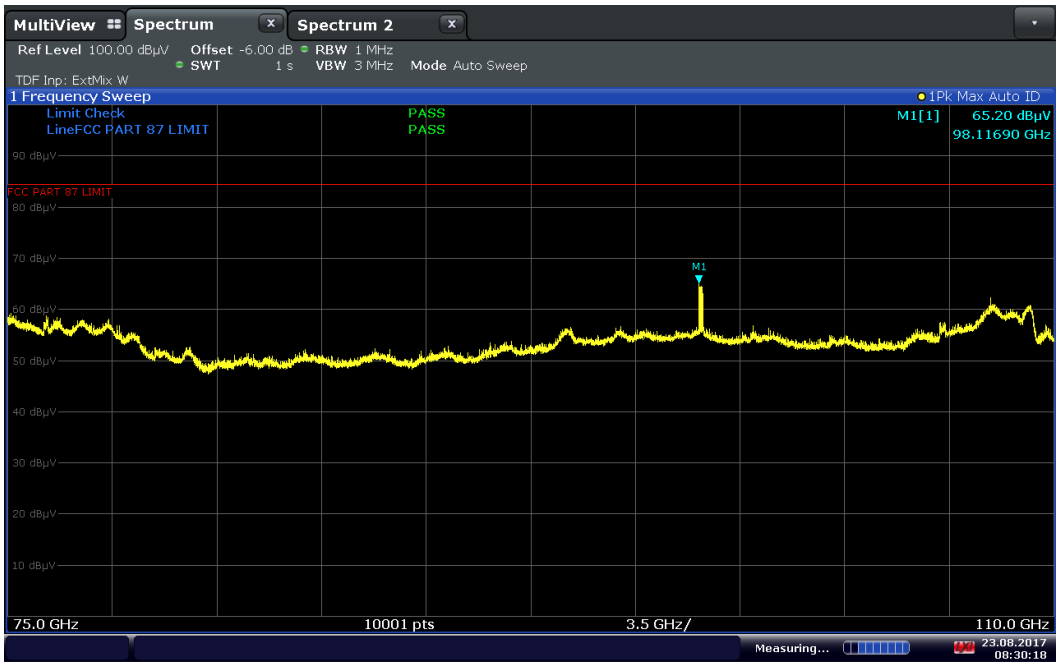
75 GHz to 110 GHz (Low channel)



08:43:45 23.08.2017

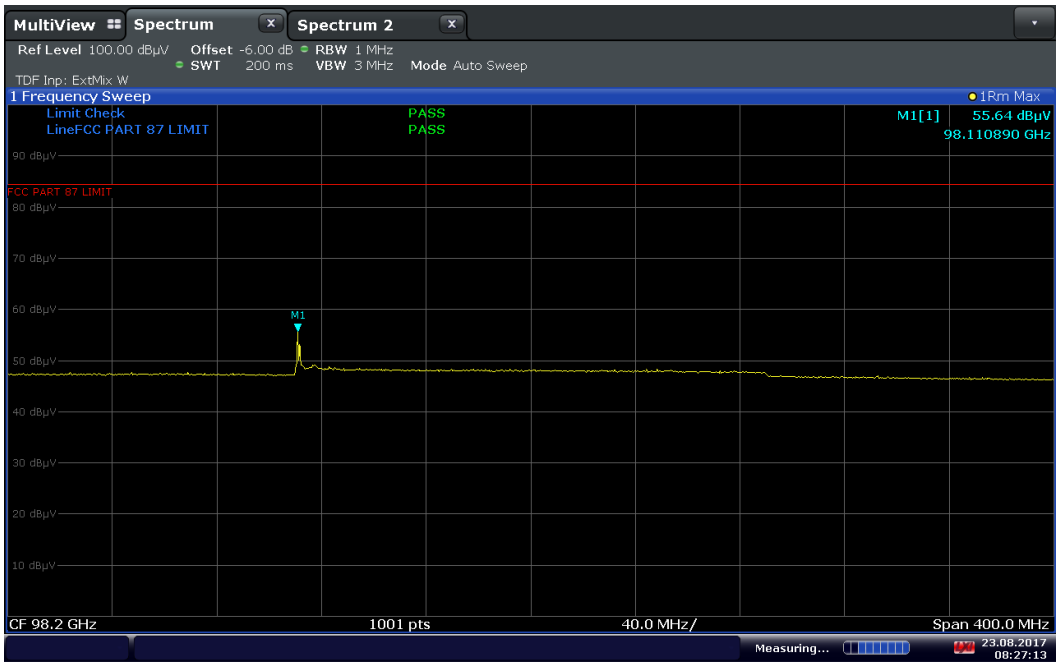
4th harmonic verification (RMS detector)

Note: No considerable emissions other than the forth harmonic were observed.



08:30:19 23.08.2017

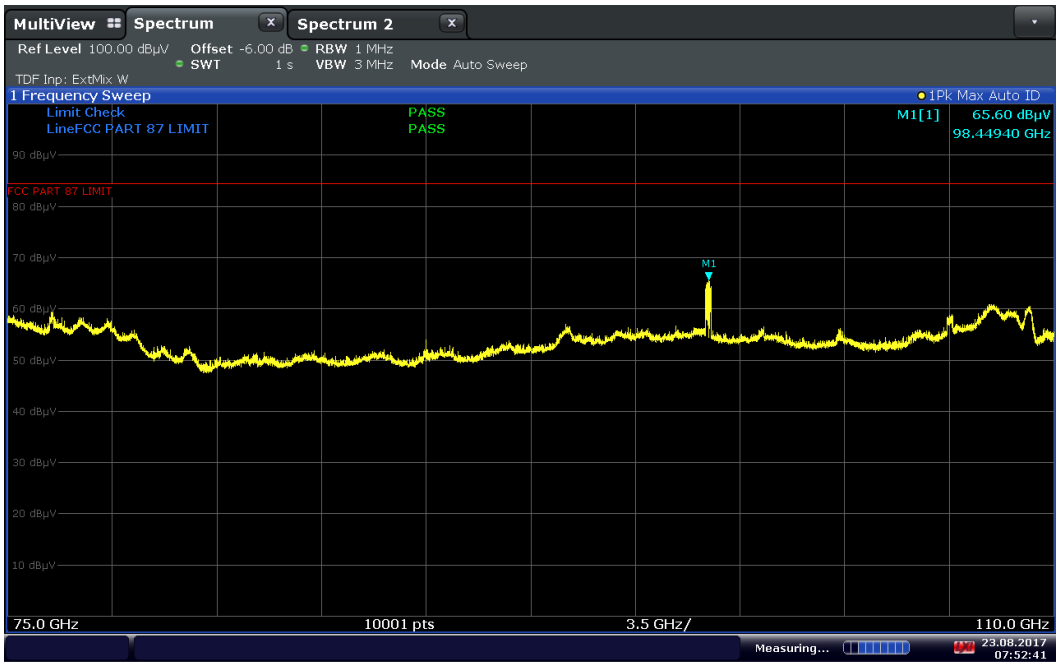
75 GHz to 110 GHz (Mid channel)



08:27:13 23.08.2017

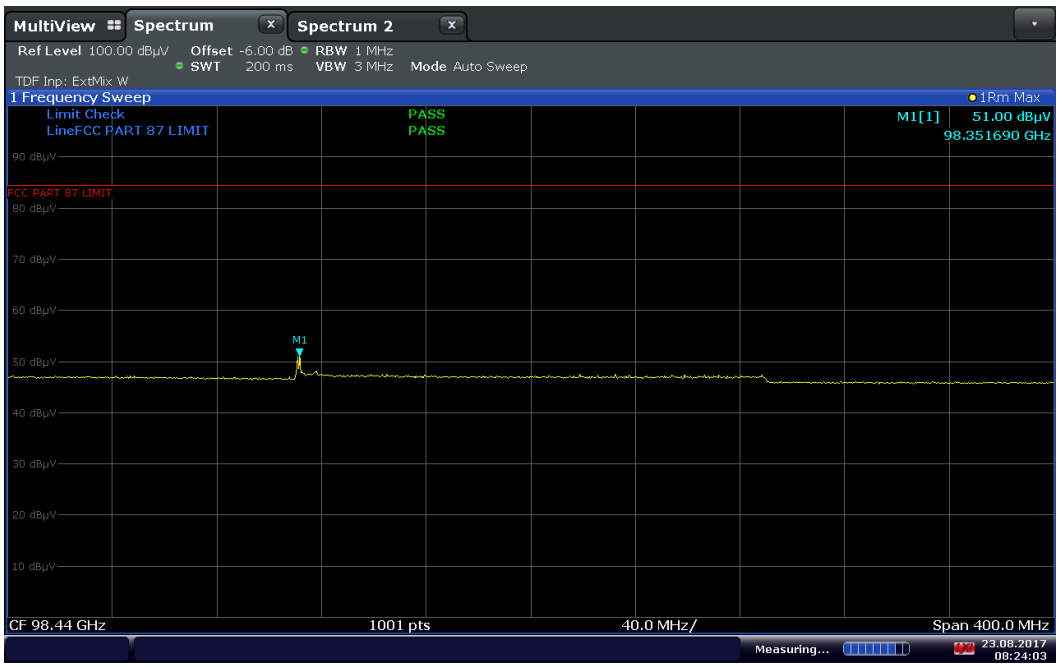
4th harmonic verification (RMS detector)

Note: No considerable emissions other than the forth harmonic were observed.



07:52:41 23.08.2017

75 GHz to 110 GHz (High channel)



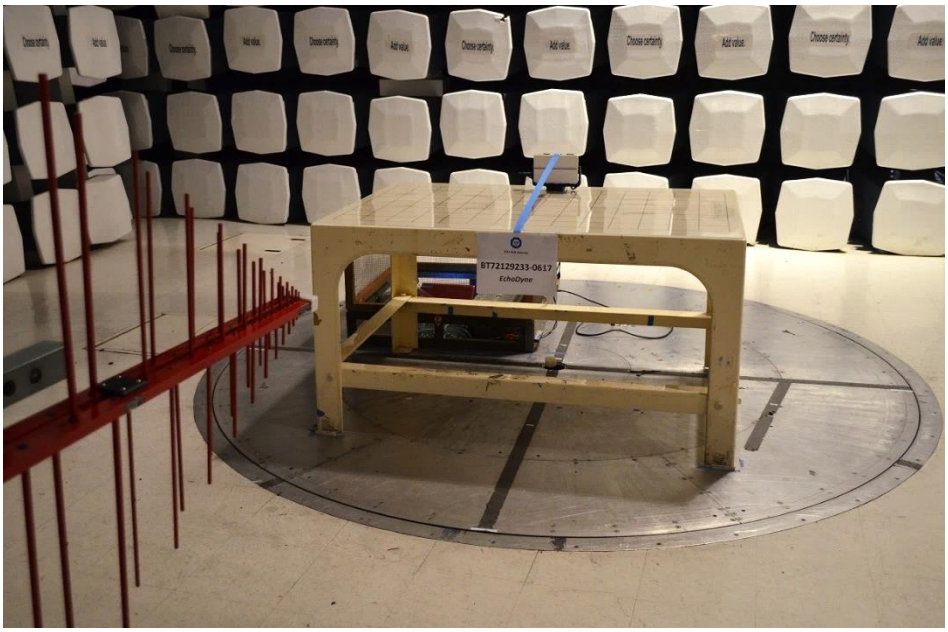
08:24:03 23.08.2017

4th harmonic verification (RMS detector)

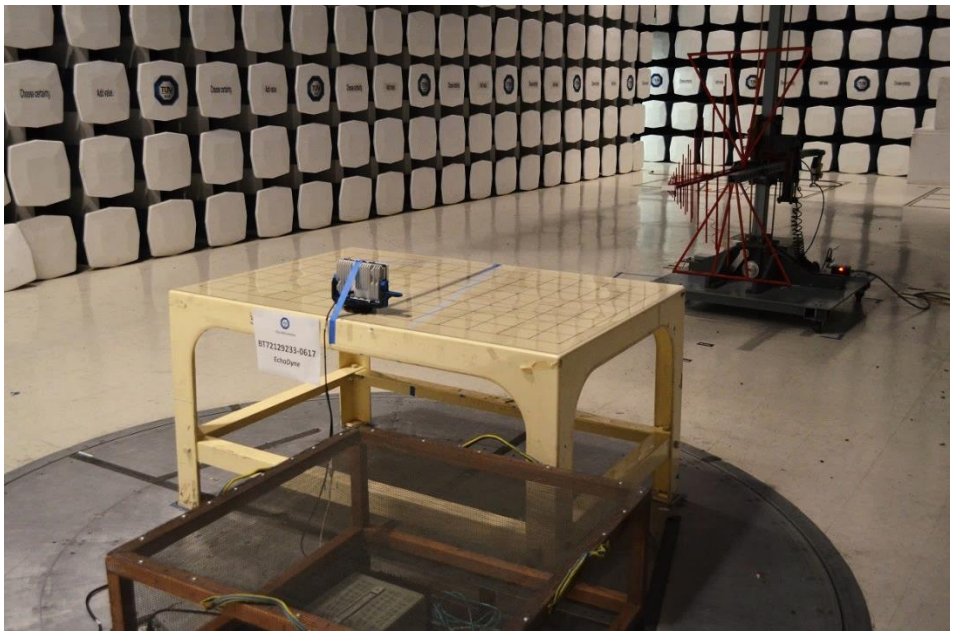
Note: No considerable emissions other than the forth harmonic were observed.

2.6.22 Test Setup Pictures

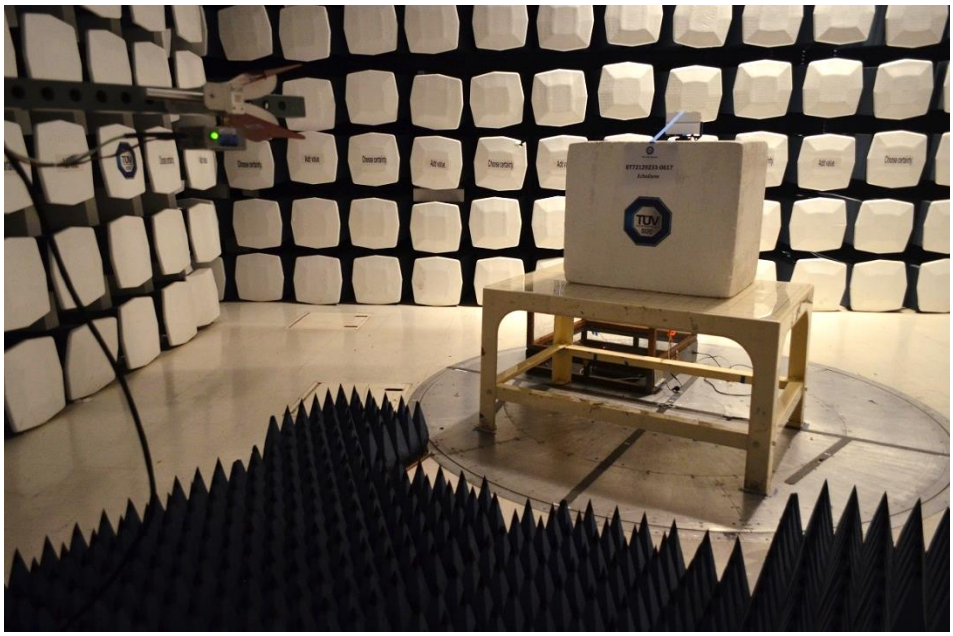
Below 30 MHz (Front)



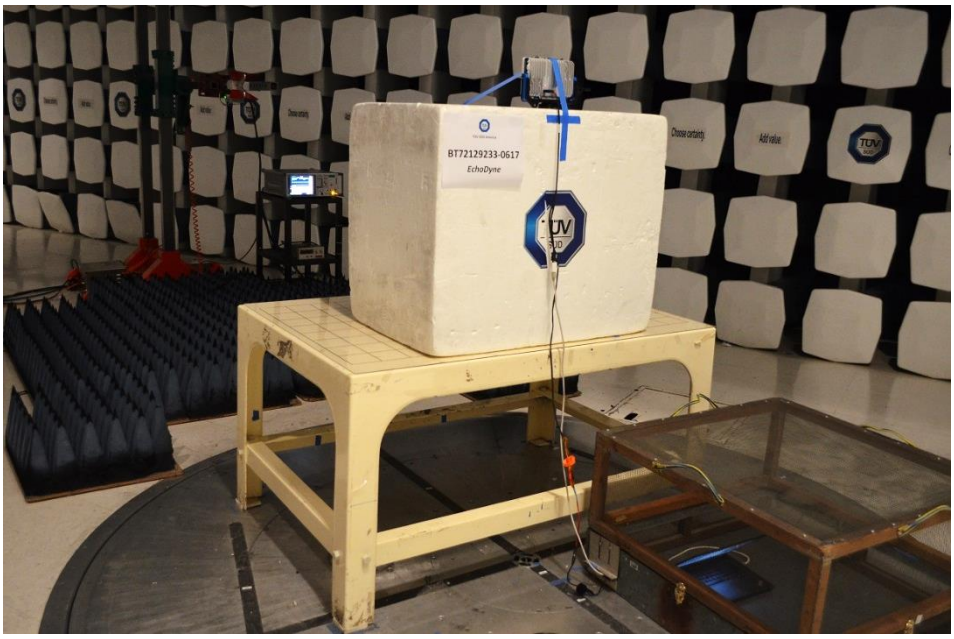
Below 30 MHz (Back)



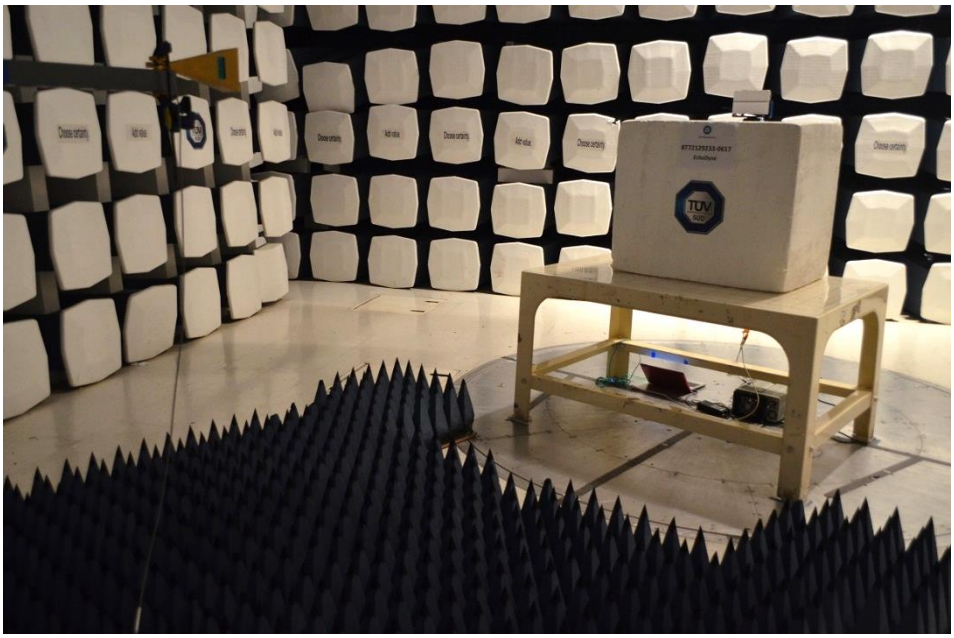
1 GHz to 18 GHz (Front)



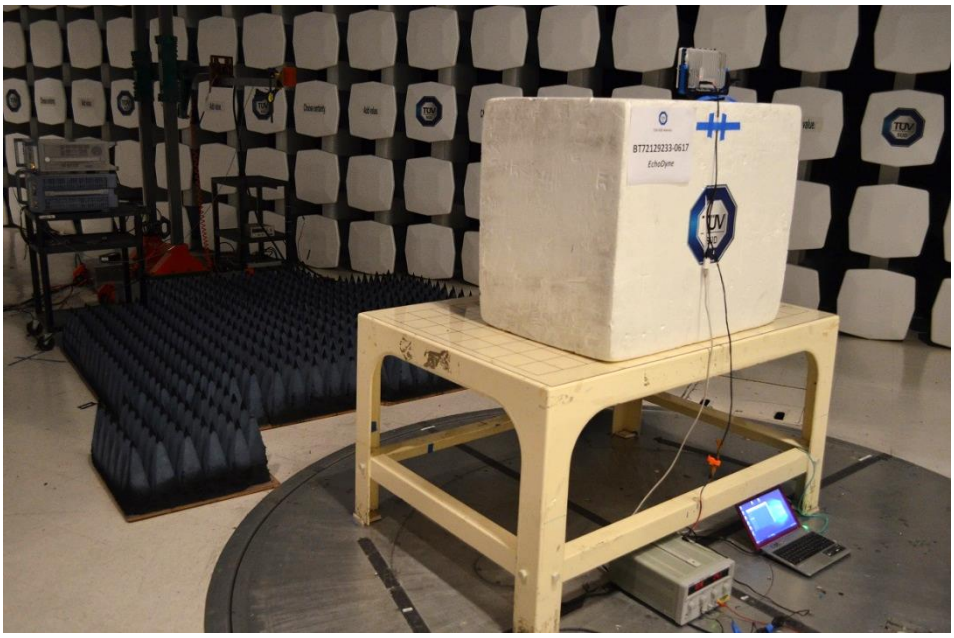
1 GHz to 18 GHz (Back)



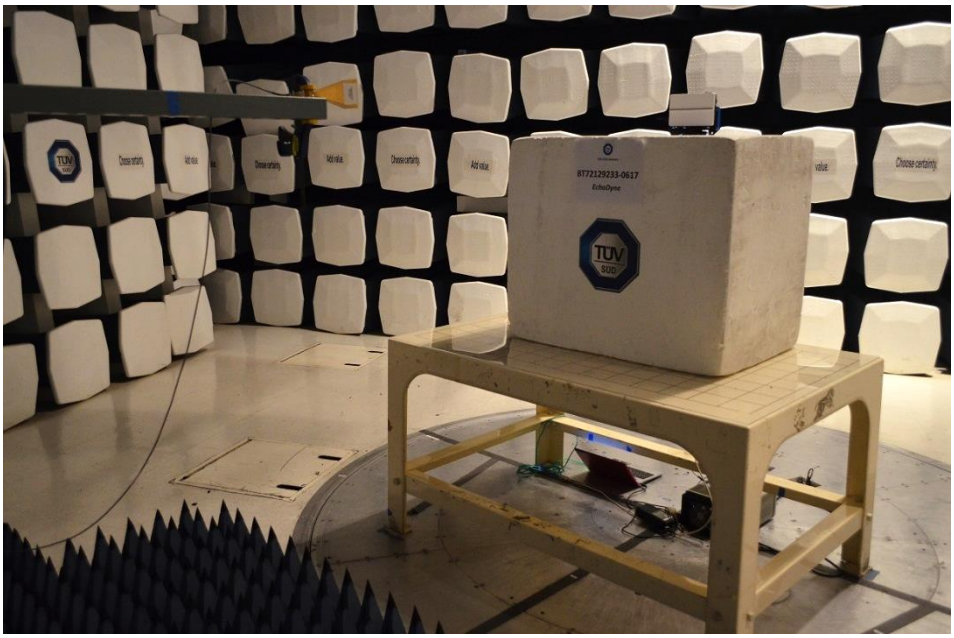
18 GHz to 26 GHz (Front)



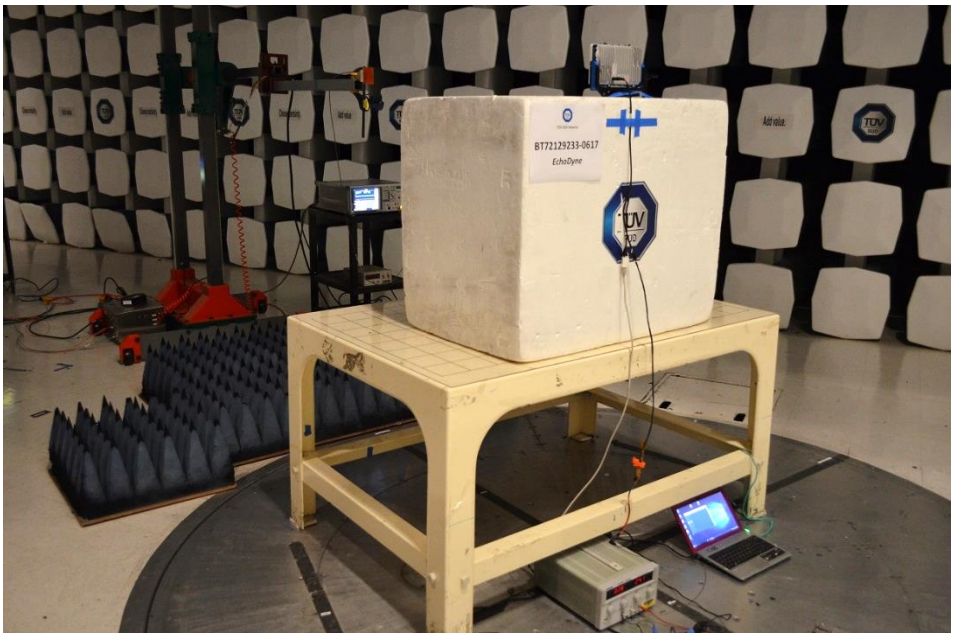
18 GHz to 26 GHz (Back)



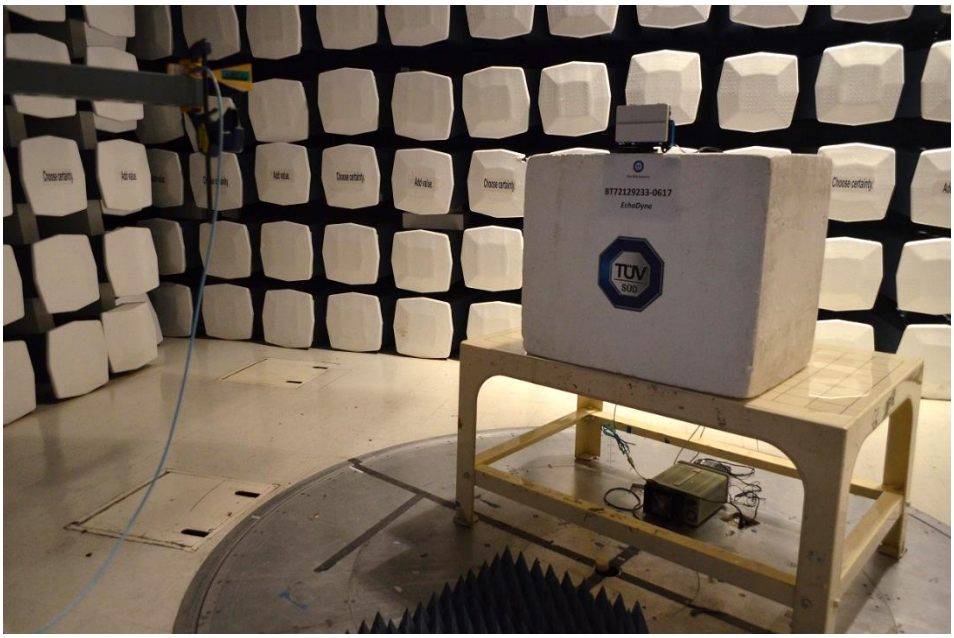
26 GHz to 40 GHz (Front)



26 GHz to 40 GHz (Back)

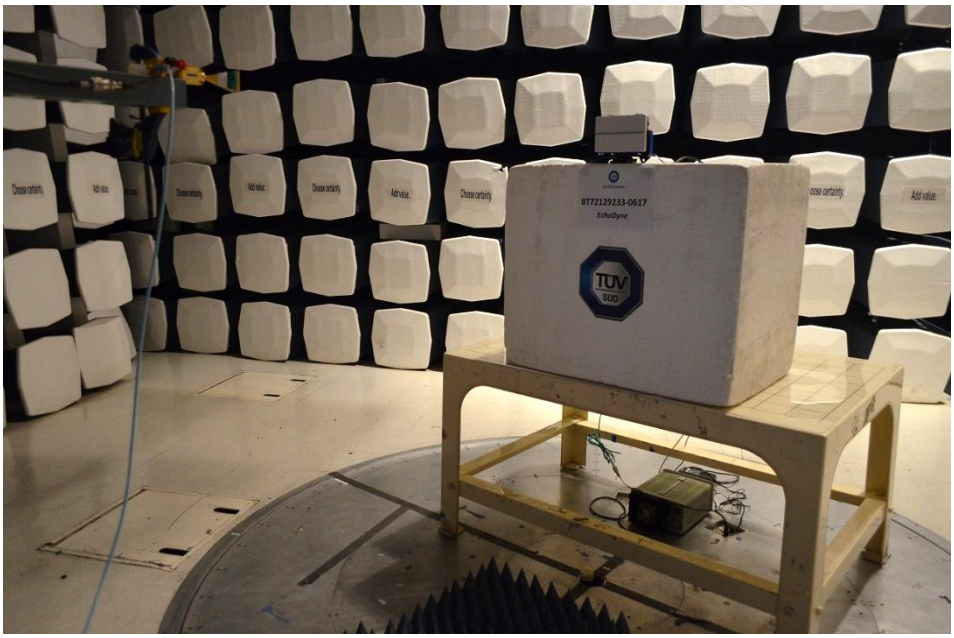


40 GHz to 60 GHz Base Station Unit (Front)

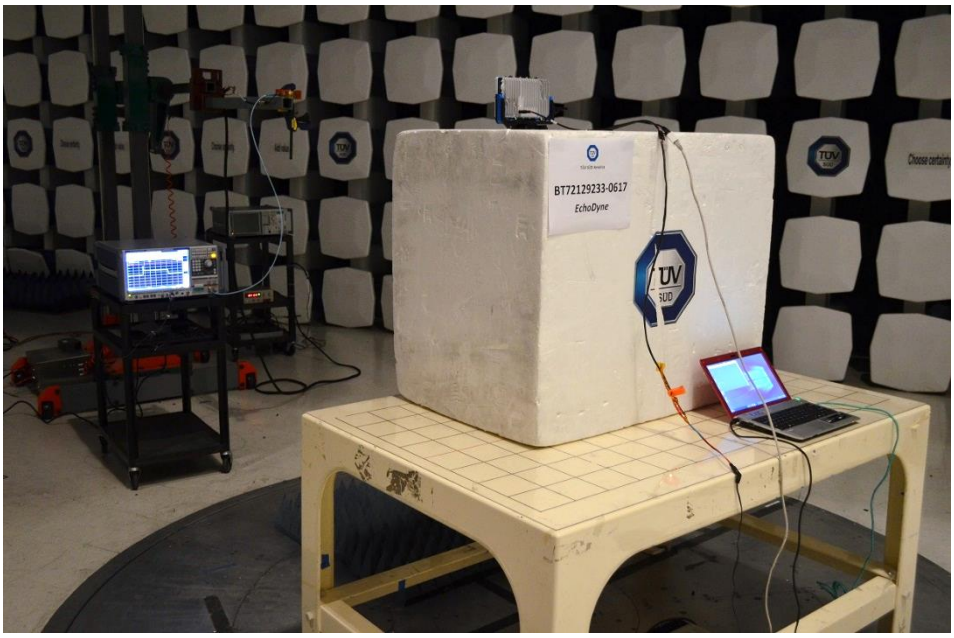


40 GHz to 60 GHz Base Station Unit (Back)

60 GHz to 75 GHz Base Station Unit (Front)

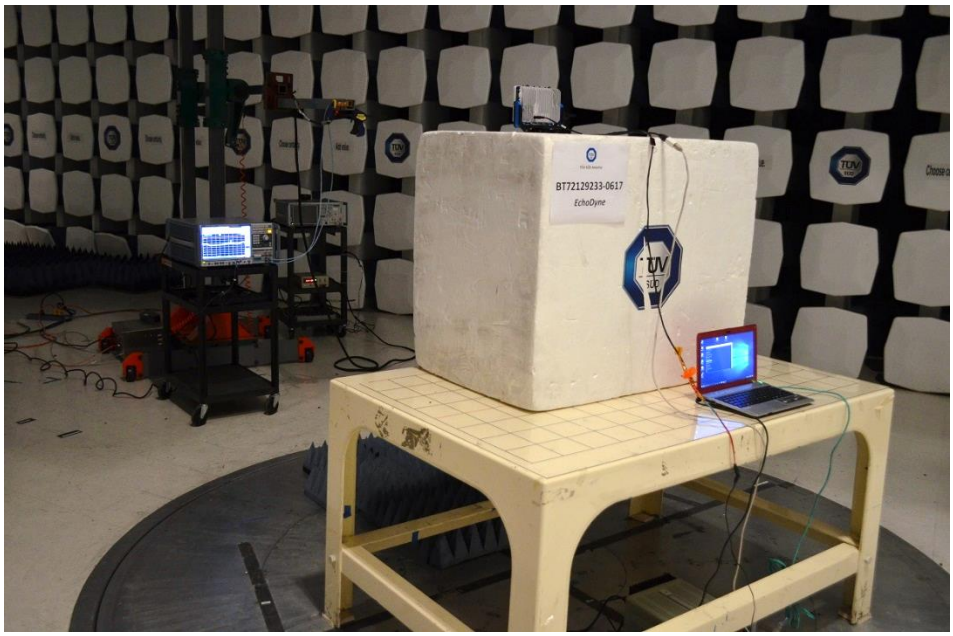


60 GHz to 75 GHz Base Station Unit (Back)



75 GHz to 110 GHz Base Station Unit (Front)

75 GHz to 110 GHz Base Station Unit (Back)



SECTION 3

TEST EQUIPMENT USED

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

3.1 TEST EQUIPMENT USED

List of absolute measuring and other principal items of test equipment.

ID Number (SDGE)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Radiated Test Setup						
1003	Signal Generator	SMR-40	1104.0002.40	Rohde & Schwarz	05/30/17	05/30/18
7611	Signal/Spectrum Analyzer	FSW26	102017	Rohde & Schwarz	04/25/17	04/25/18
1049	EMI Test Receiver	ESU	100133	Rohde & Schwarz	07/13/17	07/13/18
1033	Bilog Antenna	3142C	00044556	EMCO	10/11/16	10/11/18
1016	Pre-amplifier	PAM-0202	187	PAM	10/17/16	10/17/17
7575	Double-ridged waveguide horn antenna	3117	155511	EMCO	06/01/17	06/01/18
1040	EMI Test Receiver	ESIB40	100292	Rohde & Schwarz	10/07/16	10/07/17
8628	Pre-amplifier	QLJ 01182835-JO	8986002	QuinStar Technologies Inc.	02/09/17	02/09/18
8922	High-frequency cable	R90-088-200	N/A	Teledyne	02/10/17	02/10/18
1026	High-frequency cable	3M-7/C2	N/A	MicroCoax	04/26/17	04/26/18
8849	High-frequency cable (1-18 GHz)	SAC-26G-6.1	363	A.H.Systems	04/23/17	04/23/18
8771	6dB attenuator	606-06-1F4/DR	N/A	MECA	10/11/17	10/11/18
9001	Horn antenna (18-26 GHz)	HO42S	101	Custom Microwaves	08/18/17	08/18/19
9002	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	07/14/17	07/14/19
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves	07/19/17	07/19/19
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves	07/19/17	07/19/19
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.	08/16/17	08/16/19
8893	Pre-amplifier (18-40 GHz)	SLKKa-30-6	15G27	Spacek Labs	Verified with 1003 and 1049	
8892	Pre-amplifier (50-75 GHz)	SBL-5037533050-1515-E1	12020-01	Sage Millimeter, Inc.	Verified	
8912	Pre-amplifier (75-110 GHz)	FLNA-10-0005	FTL10839	Farran Technology Ltd.	Verified	
7637	Harmonic mixer (40-60 GHz)	FS-Z60	100009	Rohde & Schwarz	01/26/16	01/26/18
7636	Harmonic mixer (60-90 GHz)	FS-Z90	100092	Rohde & Schwarz	10/26/15	10/26/17
7633	Harmonic mixer (75-110 GHz)	HM-110-7	101000	Radiometer Physics	Verified	
Miscellaneous						
6708	Multimeter	34401A	US36086974	Hewlett Packard	07/05/17	07/05/18
7554	Barometer/Temperature/Humidity Transmitter	iBTHX-W	15250268	Omega	01/17/17	01/17/18
9076	DC Power Supply	18020M	P802039	Protek	Verified by 6708	
7579	Temperature Chamber	115	151617	TestEquity	08/22/17	08/22/18
118208	DC Power Supply	Pad 250-4.5L	29051058	Kikusui Electronics Corp.	Verified by 6708	
	Test Software	EMC32	V8.53	Rohde & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

For a 95% confidence level, the measurement uncertainties for defined systems are:

A2.1 Radiated Emission Measurements (Below 1 GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.45	0.26	0.07
2	Cables	Rectangular	0.50	0.29	0.08
3	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.75	0.43	0.19
5	Site	Rectangular	3.52	1.44	2.07
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.68
				Coverage Factor (k):	2
				Expanded Uncertainty:	3.36

A2.2 Radiated Emission Measurements (1 GHz to 18 GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.57	0.33	0.11
2	Cables	Rectangular	0.70	0.40	0.16
3	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.37	0.21	0.05
5	Site	Rectangular	3.00	1.22	1.50
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.49
				Coverage Factor (k):	2
				Expanded Uncertainty:	2.99

A2.3 Radiated Emission Measurements (Above 18 GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Cables	Rectangular	0.70	0.40	0.16
2	Preamp	Rectangular	0.50	0.29	0.08
3	Spectrum Analyzer/Mixers	Rectangular	3.34	1.93	3.72
4	Antenna	Rectangular	2.70	1.56	2.43
6	EUT Setup	Rectangular	1.50	0.87	0.75
				Combined Uncertainty (u_c):	2.67
				Coverage Factor (k):	2
				Expanded Uncertainty:	5.35

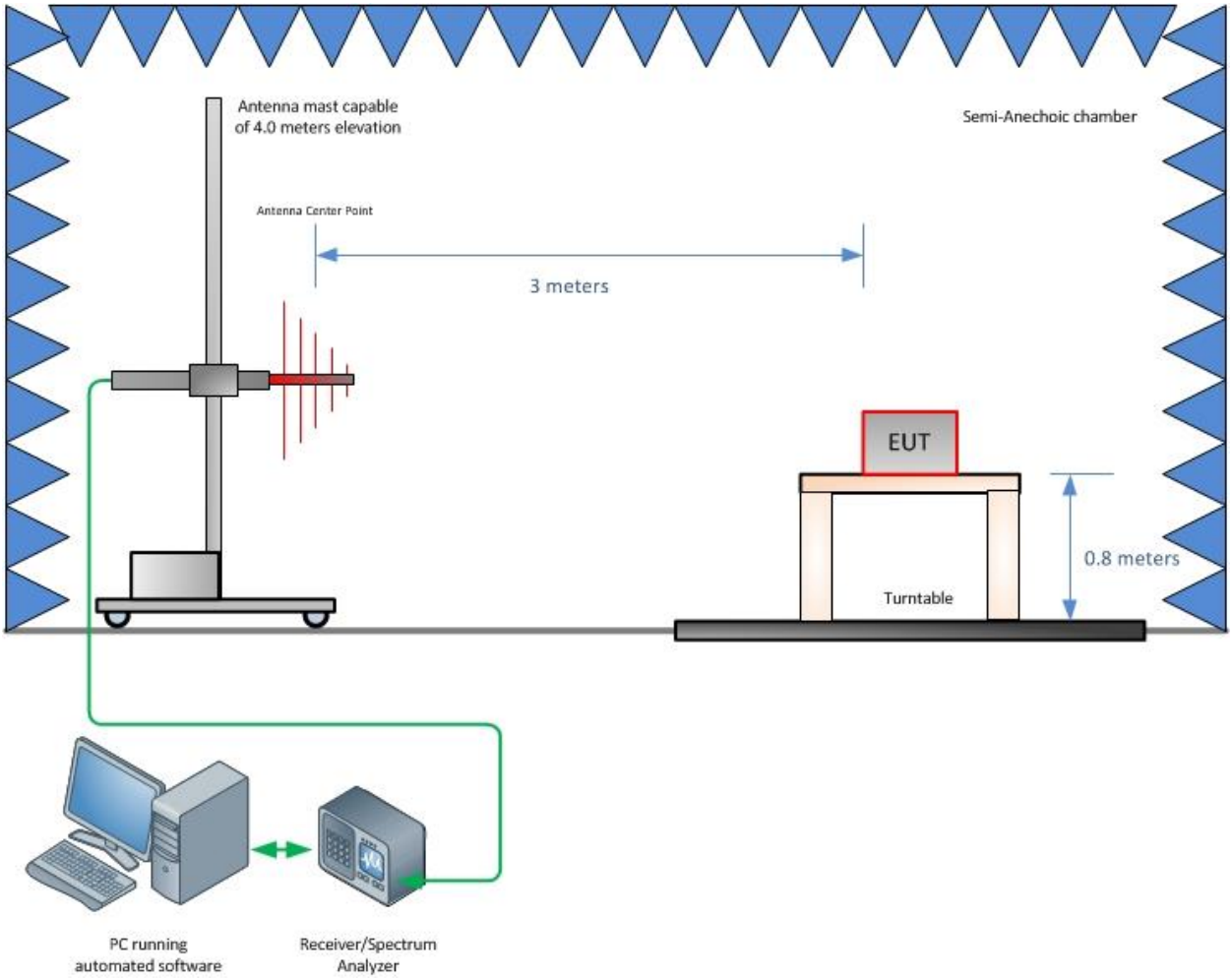
TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

SECTION 4

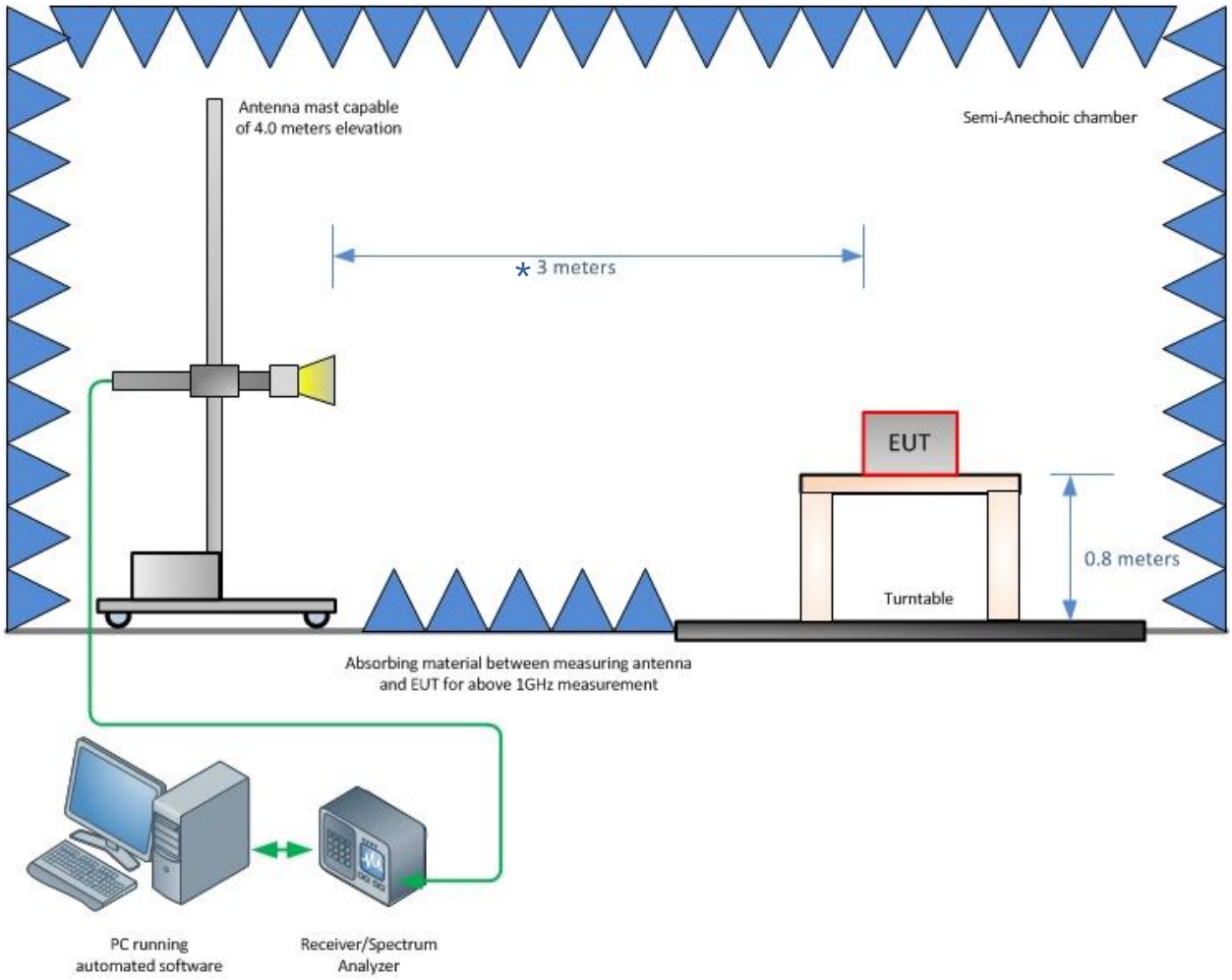
DIAGRAM OF TEST SETUP

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

4.1 TEST SETUP DIAGRAM

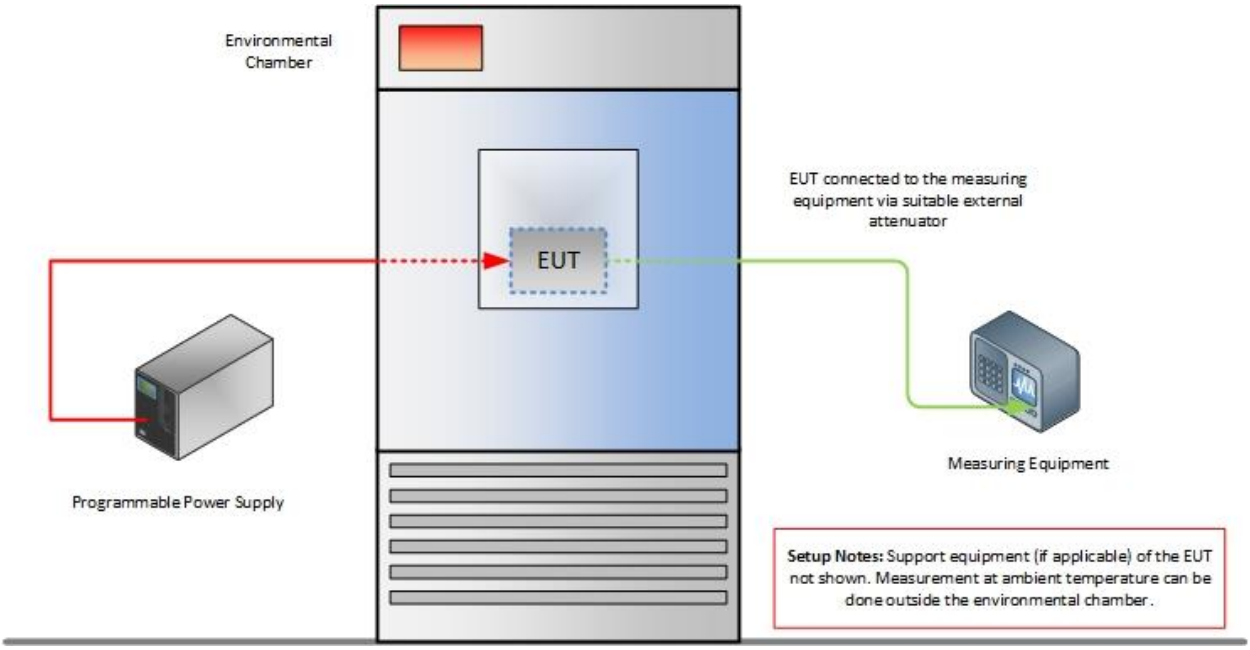


Radiated Emission Test Setup (Below 1GHz)



*A test distance of 3 m was used for the measurements below 40 GHz. The emissions above 40 GHz were evaluated at 1.5 m distance to assure that the noise floor is at least 10 dB below the applicable limit.

Radiated Emission Test Setup (Above 1 GHz)



Frequency Stability Test Configuration

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

TÜV SÜD America Inc.'s reports apply only to the specific sample tested under stated test conditions. It is the manufacturer's responsibility to assure the continued compliance of production units of this model. TÜV SÜD America, Inc. shall have no liability for any deductions, inferences or generalizations drawn by the client or others from TÜV SÜD America, Inc.'s issued reports.

This report is the confidential property of the client. As a mutual protection to our clients, the public and TÜV SÜD America, Inc., extracts from the test report shall not be reproduced, except in full without TÜV SÜD America, Inc.'s written approval.

This report must not be used to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the federal government.

TÜV SÜD America, Inc. and its professional staff hold government
and professional organization certifications for
AAMI, ACIL, AEA, ANSI, IEEE, A2LA, NIST and VCCI.

A2LA Cert. No. 2955.13