

Radio Testing of the

Vayyar Imaging LTD

60GHz short-range radar for in-cabin monitoring

Model: vSILSA

In accordance with FCC Part 15 Subpart C
§15.255

Vayyar Imaging LTD
3 Avramham Giron
Yehud TA 5621717



America

Add value.
Inspire trust.

COMMERCIAL-IN-CONFIDENCE

Date: December 2021

Document Number: 721568510 Issue 01 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Xiaoying Zhang	December 09, 2021	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

EXECUTIVE SUMMARY

A sample of this product was tested and found to be in compliance with FCC Part 15 Subpart C §15.255.



A2LA Cert. No. 2955.13

DISCLAIMER AND COPYRIGHT

This report has been prepared by TÜV SÜD America with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD America. No part of this document may be reproduced without the prior written approval of TÜV SÜD America.

ACCREDITATION

Our A2LA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our A2LA Accreditation.

TÜV SÜD America, Inc.
10040 Mesa Rim Road
San Diego, CA 92121-2912

TÜV SÜD America, Inc.
Rancho Bernardo Facility
16936 Via Del Campo
San Diego, CA 92127

Phone: 858 678 1400
www.tuv-sud-america.com



REPORT ON	Radio Testing of the Vayyar Imaging LTD Model vSILSA 60GHz short-range radar for in-cabin monitoring
TEST REPORT NUMBER	721568510
TEST REPORT DATE	December 2021
PREPARED FOR	Vayyar Imaging LTD 3 Avramham Giron Yehud TA 5621717
CONTACT PERSON	Naftali Chayat Chief Technology Officer naftali.chayat@vayyar.com +972-544-225549
PREPARED BY	 Ferdinand S. Custodio Name Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
APPROVED BY	 Xiaoying Zhang Name Authorized Signatory Title: Senior RF Wireless Test Engineer
DATED	<u>December 09, 2021</u>



Revision History

721568510 Vayyar Imaging LTD Model vSILSA 60GHz short-range radar for in-cabin monitoring					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
12/09/2021	—	Initial Release			Xiaoying Zhang



CONTENTS

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	9
1.5	Deviations from the Standard	10
1.6	Modification Record	10
1.7	Test Methodology	10
1.8	Test Facility Location	10
1.9	Test Facility Registration	11
2	TEST DETAILS	12
2.1	Transmitter Power	13
2.2	Conducted Emissions	16
2.3	Frequency Stability	17
2.4	Occupied Bandwidth	20
2.5	Field Strength of Spurious Radiation	20
3	TEST EQUIPMENT USED	42
3.1	Test Equipment Used	43
3.2	Measurement Uncertainty	45
4	DIAGRAM OF TEST SETUP	47
4.1	Test Setup Diagram	48
5	ACCREDITATION, DISCLAIMERS AND COPYRIGHT	51
5.1	Accreditation, Disclaimers And Copyright	52



SECTION 1

REPORT SUMMARY

Radio Testing of the
Vayyar Imaging LTD
vSILSA_RevC_U 60GHz short-range radar for in-cabin monitoring



1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Vayyar Imaging LTD vSILSA_RevC_U 60GHz short-range radar for in-cabin monitoring to the requirements of FCC Part 15 Subpart C §15.255 per Waiver 21-407.

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	Vayyar Imaging LTD
EUT	60GHz short-range radar for in-cabin monitoring
Model Name	vSILSA_RevC_U
Trade Name	vSILSA
FCC ID	2AHIS-V60GINCAR-SL
IC Number	21498-V60GINCAR-SL
Serial Number(s)	SILC1B1021U0086
Number of Samples Tested	1
Test Specification/Issue/Date	FCC Part 15 Subpart C §15.255 (October 1, 2020).
Start of Test	June 29, 2021
Finish of Test	August 09, 2021
Name of Engineer(s)	Ferdinand Custodio
Related Document(s)	• DA 21-407 Waiver • ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices. • Python MPR for vSILSARevC - Manual_12Apr21.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 with FCC Part 15 Subpart C §15.255 are shown below:

Section	§15.255 Spec Clause	Test Description	Result	Comments/Base Standard
2.1	§15.255(c)(3) and (e) / DA 21-407 Waiver	Transmitter Power	Compliant	
2.2	§15.207(a)	Conducted Emissions	N/A	Vehicle Use Only
2.3	§15.255(f)	Frequency Stability	Compliant	
2.4	§15.255(e)	Occupied Bandwidth	Compliant	
2.5	§15.255(d)(1)(2) and (3)	Field Strength of Spurious Radiation	Compliant	
2.6	DA 21-407 Waiver	Duty Cycle	Compliant	
2.7	DA 21-407 Waiver	Power Spectral Density	Compliant	

1.3 DA 21-407 WAIVER CONDITIONS

- Operate as a radar on new passenger motor vehicles in the 57-64 GHz band at a maximum +13 dBm EIRP, +10 dBm transmitter conducted output power, +13 dBm/MHz power spectral density, and a maximum transmit duty cycle of 10% in any 33 milliseconds (ms) interval.
- Shall be restricted to factory installation in the interior cabin of new passenger motor vehicles as defined by 49 CFR § 571.3 (see the order).
- Limited modular transmitter approval under 47 CFR § 15.212 (see the order)
- Operations under this waiver may not be used to transmit data.
- Users of these radars must be made aware through a disclosure in the vehicle Owner's Manual or an equivalent means that that operation is subject to the conditions that no harmful interference is caused and that any interference must be accepted.
- This waiver and its conditions shall apply only to radars intended for installation in passenger motor vehicles as described herein and are not to be considered to apply generally to any other radars or field disturbance sensors that will operate in different environments where further analysis would be necessary
- to assess the potential for impact to other authorized users.
- The waiver conditions granted are not transferable to any third party via §2.933 or any other means of technology transfer.
- Order is effective upon release



1.4 PRODUCT INFORMATION

1.4.1 Technical Description

The Equipment Under Test (EUT) is a Vayyar Imaging LTD vSILSA_RevC_U 60GHz short-range radar for in-cabin monitoring. The EUT is a 60GHz module which is used as a short-range radar for in-cabin monitoring. The EUT is part of the V60GINCAR-SL family of modules operating at 60GHz – certified under the conditions of the DA-21-407A1 waiver. The models certified under this family are intended to be certified as modules, under modular approval, according to the conditions of the DA-21-407A1 waiver

1.4.2 EUT General Description

EUT Description	60GHz short-range radar for in-cabin monitoring
Trade Name	vSILSA_RevC_U
Model Name	vSILSA
Rated Voltage	USB powered (5VDC)
Mode Verified	60GHz radar
Capability	60GHz radar
Frequency Range	60-64GHz
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering
Transmission Mode	MIMO (16 x 19)
Number of TX Outputs	16 (transmitting each time in parallel with 16 TX-ports each one connected to a separate TX-antennas (MIMO), switching the phase at a high-rate, changing the momentary beam-pattern).
Antenna Type	PCB embedded
Manufacturer	Vayyar Imaging LTD.
Single Antenna Gain	4.5 dBi
Effective Gain	16.5 dBi (4.5 dBi + 10*log10(16)) for 16 TX configuration

1.5 EUT TEST CONFIGURATION

1.5.1 Test Configuration Description

Test Configuration	Description
Default	The EUT was connected to a support laptop via a provided USB cable. Vayyar Multiport Recorder (Python MPR v273) was used to configure the EUT for verifications. The manufacturer provided detailed instructions to exercise the EUT (vSILSA_revC_bpsk16_CHIRP_middle_antennas_2ghz.xml for 2GHz profile and vSILSA_revC_bpsk16_CHIRP_middle_antennas_4ghz.xml for 4GHz profile).

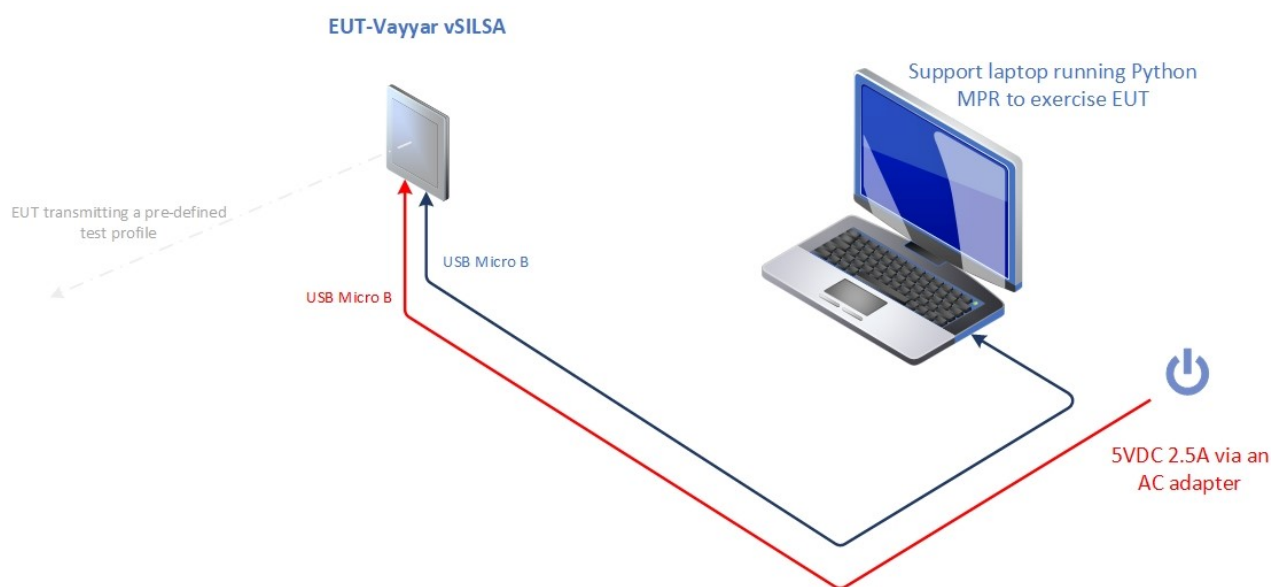
1.5.2 EUT Exercise Software

Vayyar Multiport Recorder (Python MPR v273)

1.5.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Lenovo	Laptop Thinkpad T440S	Type: 20AR-S4250S S/N PC-03BBGR
Lenovo	Laptop Power Supply	Model ADLX45NCC2A S/N 10E75794C1SG7B84A60
CNC Tech	USB 2.0 Cable A Male to Micro B Male	P/N 102-1492-BL-F0200 2-meters, Shielded USB 2.0 cable
TT Electronics	Switching Adapter	Model DSA-13PFC-05 FCA 051250 5.1VDC @ 2.5A

1.5.4 Simplified Test Configuration Diagram



1.6 DEVIATIONS FROM THE STANDARD

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

1.7 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: SILC1B1021U0086		
 A USB 2.0 Cable A Male to Micro B Male 6.56' (2.00m) shielded with Digi-Key Part Number 1175-1810-ND manufactured by CNC Tech (Manufacturer Part Number 102-1492-BL-F0200) is used as the data cable in order to comply with the requirements of §15.209 in the range of 30MHz to 1GHz.	Ferdinand Custodio	June 07, 2021

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.

1.8 TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

For conducted 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 C63.10-2013. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.9 TEST FACILITY LOCATION

1.9.1 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

1.9.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: (858) 678 1400 Fax: (858) 546 0364.



1.10 TEST FACILITY REGISTRATION

1.10.1 FCC – Designation No.: US1146

TÜV SÜD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.948 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Designation is US1146.

1.10.2 Innovation, Science and Economic Development Canada (ISED) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TÜV SÜD 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 TÜV SÜD 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.

1.10.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TÜV 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.

1.10.4 NCC (National Communications Commission - US0102)

TÜV SÜD America Inc. (San Diego) is listed as a Foreign Recognized Telecommunication Equipment Testing Laboratory and is accredited to ISO/IEC 17025 (A2LA Certificate No.2955.13) which under APEC TEL MRA Phase 1 was designated as a Conformity Assessment Body competent to perform testing of equipment subject to the Technical Regulations covered under its scope of accreditation including RTTE01, PLMN01 and PLMN08 for TTE type of testing and LP002 for Low-Power RF Device type of testing.

1.10.5 VCCI – Registration No. A-0280 and A-0281

TÜV SÜD 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.

1.10.6 RRA – Identification No. US0102

TÜV SÜD America Inc. (San Diego) is National Radio Research Agency (RRA) recognized laboratory under Phase I of the APEC Tel MRA.

1.10.7 OFCA – U.S. Identification No. US0102

TÜV SÜD America Inc. (San Diego) is recognized by Office of the Communications Authority (OFCA) under Appendix B, Phase I of the APEC Tel MRA.



SECTION 2

TEST DETAILS

Radio Testing of the
Vayyar Imaging LTD
vSILSA_RevC_U 60GHz short-range radar for in-cabin monitoring



2.1 TRANSMITTER POWER

2.1.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(c)(3) and (e)

2.1.2 Standard Applicable

(c) Within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(3) or fixed field disturbance sensors other than those operating under the provisions of paragraph (c)(2) of this section, and short-range devices for interactive motion sensing, the peak transmitter conducted output power shall not exceed -10 dBm and the peak EIRP level shall not exceed 10 dBm.

(e) Except as specified paragraph (e)(1) of this section, the peak transmitter conducted output power shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (c) of this section.

2.1.3 Waiver Condition

The radar shall be certified for compliance with all the technical specifications applicable to operation under 47 CFR Part 15, with the exception of the following provisions in 47 CFR §§ 15.255(a)(2) and (c)(3), which are waived to allow the device to operate as a radar on new passenger motor vehicles in the 57-64 GHz band at a maximum +13 dBm EIRP, +10 dBm transmitter conducted output power, and +13 dBm/MHz power spectral density.

2.1.4 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

August 09, 2021 / FSC

2.1.6 Test Equipment Used

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

2.1.7 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	28.3 °C
Relative Humidity	45.3 %
ATM Pressure	99.9 kPa



2.1.8 Additional Observations

- This is a radiated test.
- Test methodology is per Section 9.11 of ANSI C63.10-2013.
- The manufacturer provided a test profile with the highest possible duty cycle.
- Test performed using a RF detector, low noise amplifier, active multiplier chain, direct reading attenuator and corresponding horn antenna.
- Initial prescan of the 57 to 64GHz band was used to determine the representative frequency for this test. Based from the profile observed, 62GHz was chosen as worst case for this investigation.
- Once the EUT profile was determined using a RF detector, The EUT was replaced with a known source with a variable attenuator. Starting at the max attenuation, the attenuator was adjusted until identical profile of the EUT was achieved. The EIRP at this point was calculated.

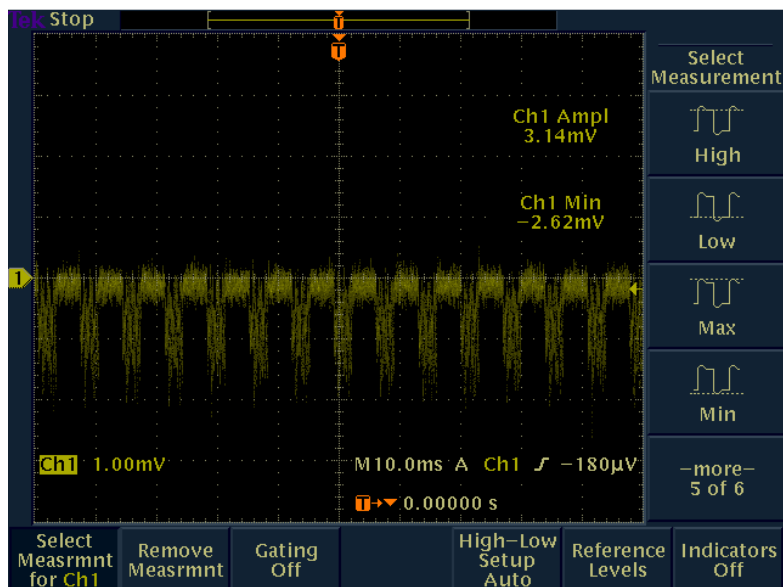
2.1.9 Test Results

Frequency	Peak Power (EIRP)	Conducted Peak Power
62 GHz	12.74 dBm	-3.76 dBm

	EUT Profile	DA-21-811 Waiver Requirements
$P_{\text{Conducted}}$	-3.76 dBm	≤ 10 dBm
$\text{Gain}_{\text{Total}}$	16.5 dBi	
EIRP_{MAX}	12.74 dBm	≤ 13 dBm

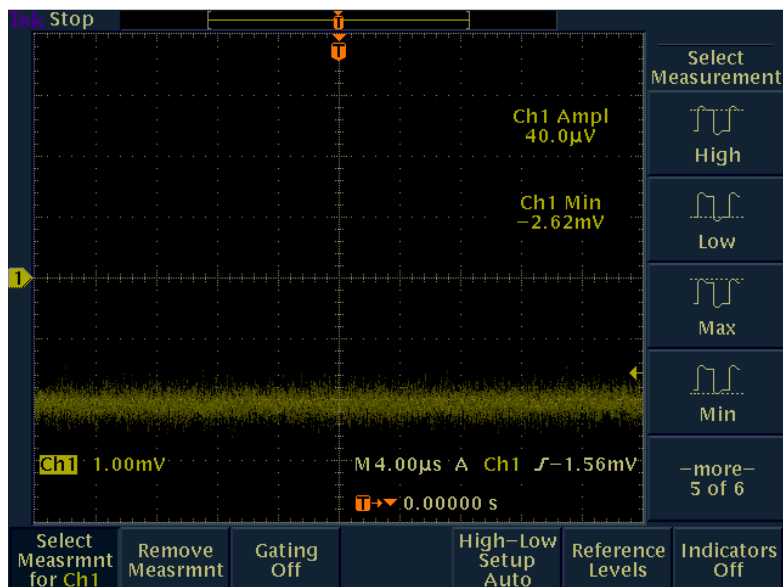
2.1.10 Sample Calculation

Active Multiplier Chain power output @ 62GHz	= 13.50 dBm
Gain Horn -WR15/HO15R (SDGE09004)	= 23.24 dBi
Direct Reading Attenuator setting to replicate EUT profile	= -24.00 dB
Substitution Peak EIRP	= 12.74 dBm



TDS 3054 - 9:54:48 AM 8/9/2021

EUT (12 Transmitter) profile using a RF detector



TDS 3054 - 10:12:38 AM 8/9/2021

Profile using a known source (active multiplier chain with a direct reading attenuator)



2.2 CONDUCTED EMISSIONS

2.2.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.207(a)

2.2.2 Standard Applicable

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

**Decreases with the logarithm of the frequency.*

2.2.3 Equipment Under Test and Modification State

Not performed. The EUT is restricted for vehicular use only, therefore there is no provision for the unit to connect to public AC Mains.



2.3 FREQUENCY STABILITY

2.3.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(f)

2.3.2 Standard Applicable

(f) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range -20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

2.3.3 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

July 04 and 05, 2021 / FSC

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 Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	24.8 °C
Relative Humidity	12.7 %
ATM Pressure	99.5 kPa

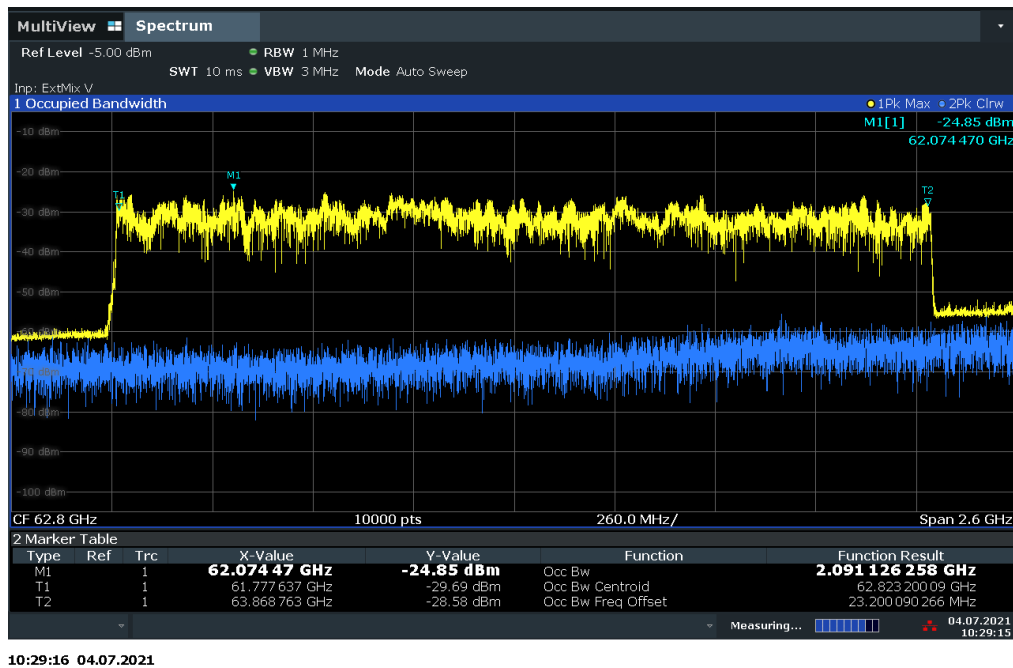
2.3.7 Additional Observations

- The EUT is USB powered (5VDC). Since USB power is regulated, input voltage variation was not performed.
- The temperature chamber has a window, the receive antenna was placed outside the chamber at a distance greater than $2D^2/\lambda$. Where D is the longest single dimension of the receive antenna and λ is the wavelength.
- Test methodology is per Section 9.14 of ANSI C63.10-2013.

2.3.8 Test Results

EUT complies. The spectrum mask of the EUT emissions (max hold) stayed within the frequency band 57GHz to 64GHz on all conditions of operation. Operation of the EUT is >1GHz from the edge of the frequency band (57GHz-71GHz).

2.3.9 Sample Test Plots



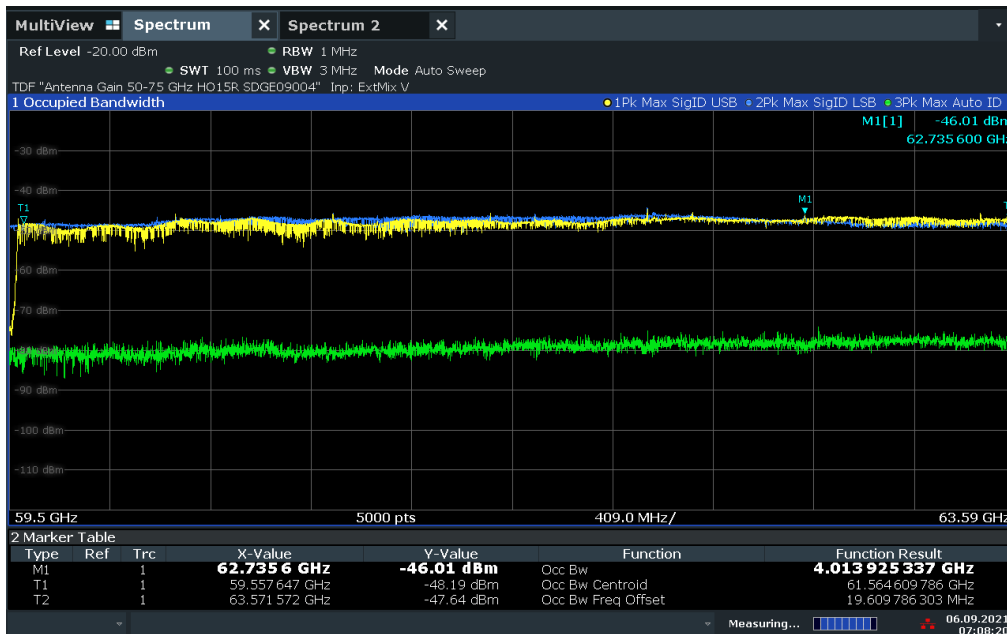
10:29:16 04.07.2021

Spectrum Mask @-20°C (2GHz profile)



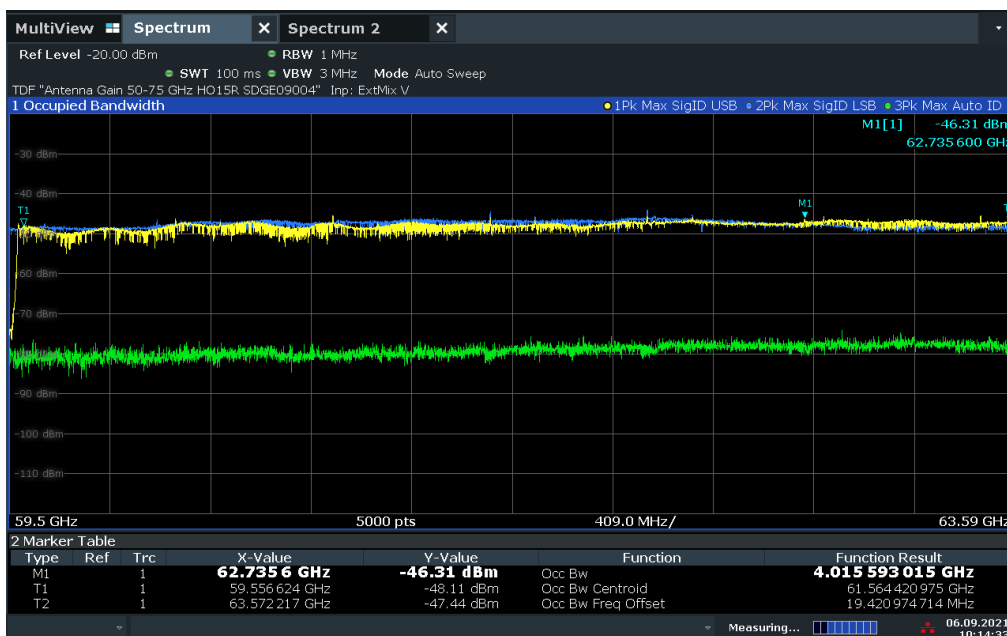
04:31:38 05.07.2021

Spectrum Mask @ 50°C (2GHz profile)



07:08:20 06.09.2021

Spectrum Mask @-20°C (4GHz profile)



10:14:34 06.09.2021

Spectrum Mask @ 50°C (4GHz profile)



2.4 OCCUPIED BANDWIDTH

2.4.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(e)(1)

2.4.2 Standard Applicable

(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

2.4.3 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

July 02, 2021 / FSC

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

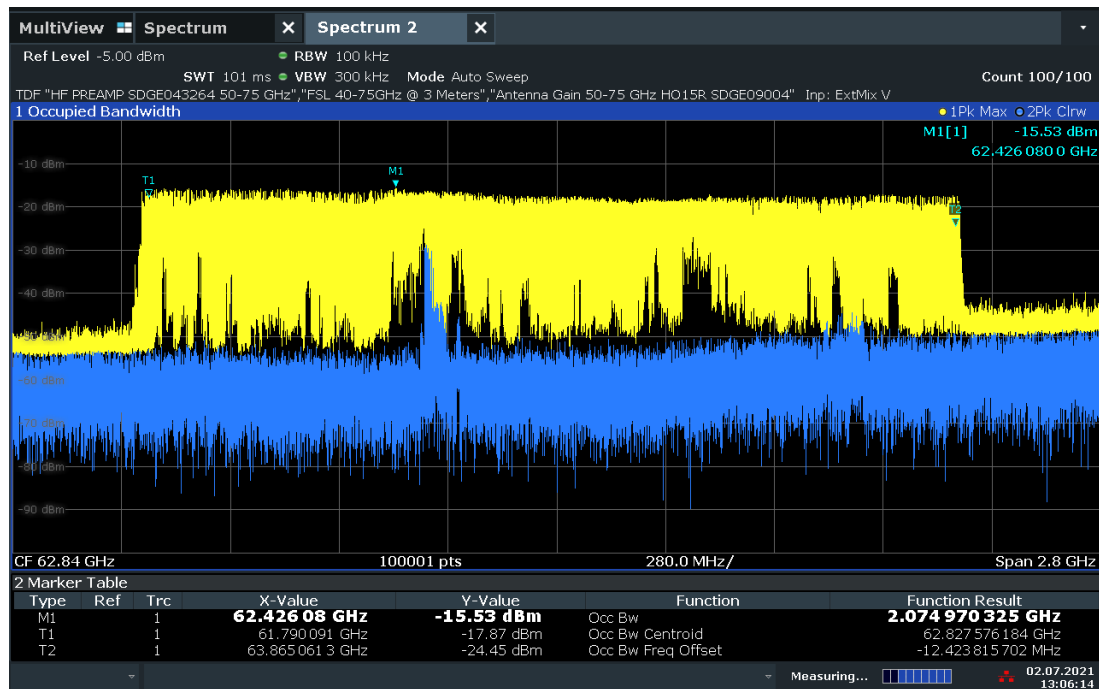
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.8 °C
Relative Humidity	23.9 %
ATM Pressure	99.6 kPa

2.4.7 Additional Observations

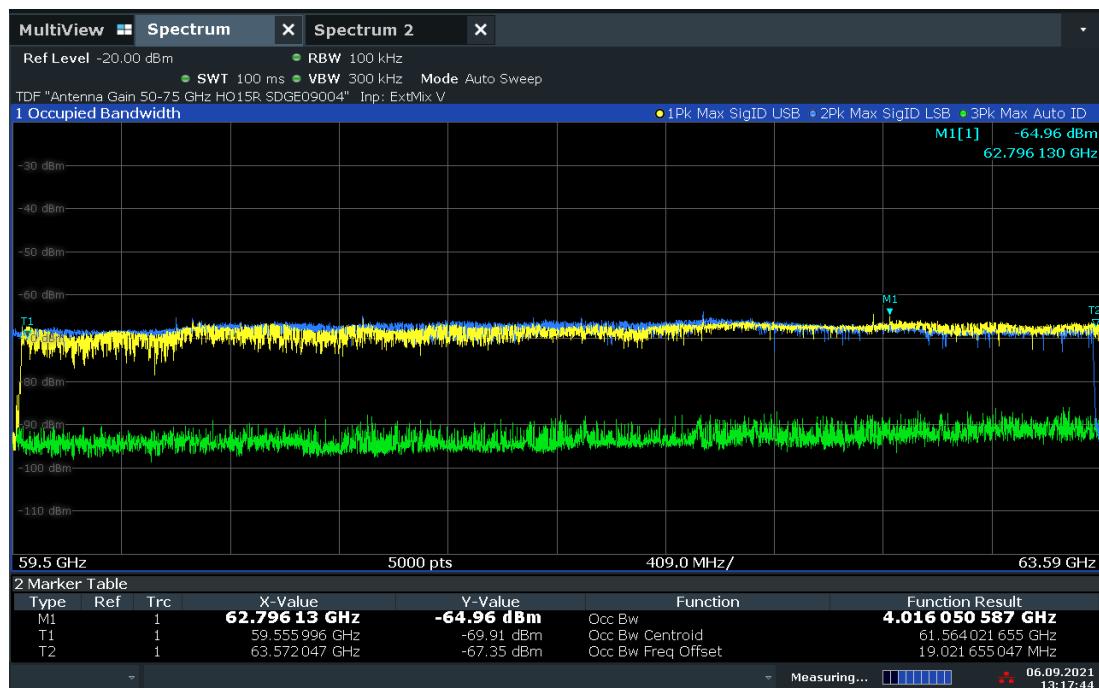
- 6dB BW of the EUT is >100MHz when measured using 100kHz RBW. Therefore, the additional bandwidth requirement per §15.255(e)(1) does not apply.
- Worst case 99% OBW reported as 4.02GHz.
- Plots presented for reference only.

2.4.8 Test Verifications Plots



13:06:15 02.07.2021

99% OBW (2GHz profile)



13:17:45 06.09.2021

99% OBW (4GHz profile)



2.5 FIELD STRENGTH OF SPURIOUS RADIATION

2.5.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.255(d)(1)(2) and (3)

2.5.2 Standard Applicable

(d) Limits on spurious emissions:

(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm² (85.3dBμV/m / -9.93dBm EIRP) at a distance of 3 meters.

2.5.3 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

May 08, 2021 to July 02, 2021 / FSC

2.5.5 Test Equipment Used

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

2.5.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	23.0 °C
Relative Humidity	36.0 %
ATM Pressure	100.6 kPa

2.5.1 Additional Observations

- This is a radiated test. The spectrum was searched from 9kHz to 200GHz.
- Measurements below 40GHz were done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.5.2 for sample computation.
- Measurement above 40GHz were done using harmonic mixers. Corresponding TDF (Transducer Factor) are programmed for each range.

- Tests distances and frequency ranges performed are summarized below:

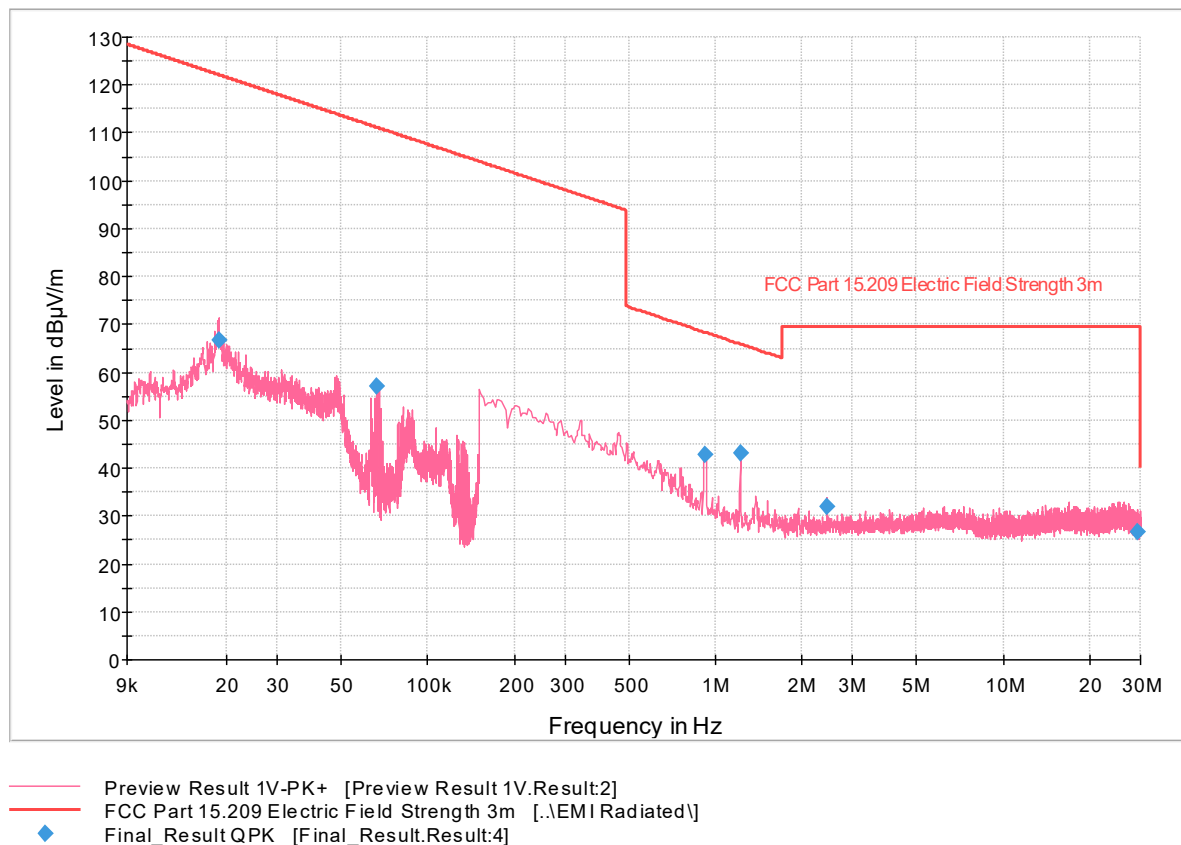
Frequency Range	Test Distance
9 kHz to 30 MHz	3 meters
30 MHz to 1GHz	3 meters
1 GHz to 18 GHz	3 meters
18 GHz to 26.5 GHz	3 meters
26 GHz to 40 GHz	3 meters
40 GHz to 60 GHz	3 meters
50 GHz to 75 GHz	3 meters
75 GHz to 110 GHz	1 meter
110 GHz to 140 GHz	1 meter
140 GHz to 200 GHz	0.5 meter

2.5.2 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dbμV) @ 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

2.5.3 Below 30MHz Radiated Emission Test

Full Spectrum

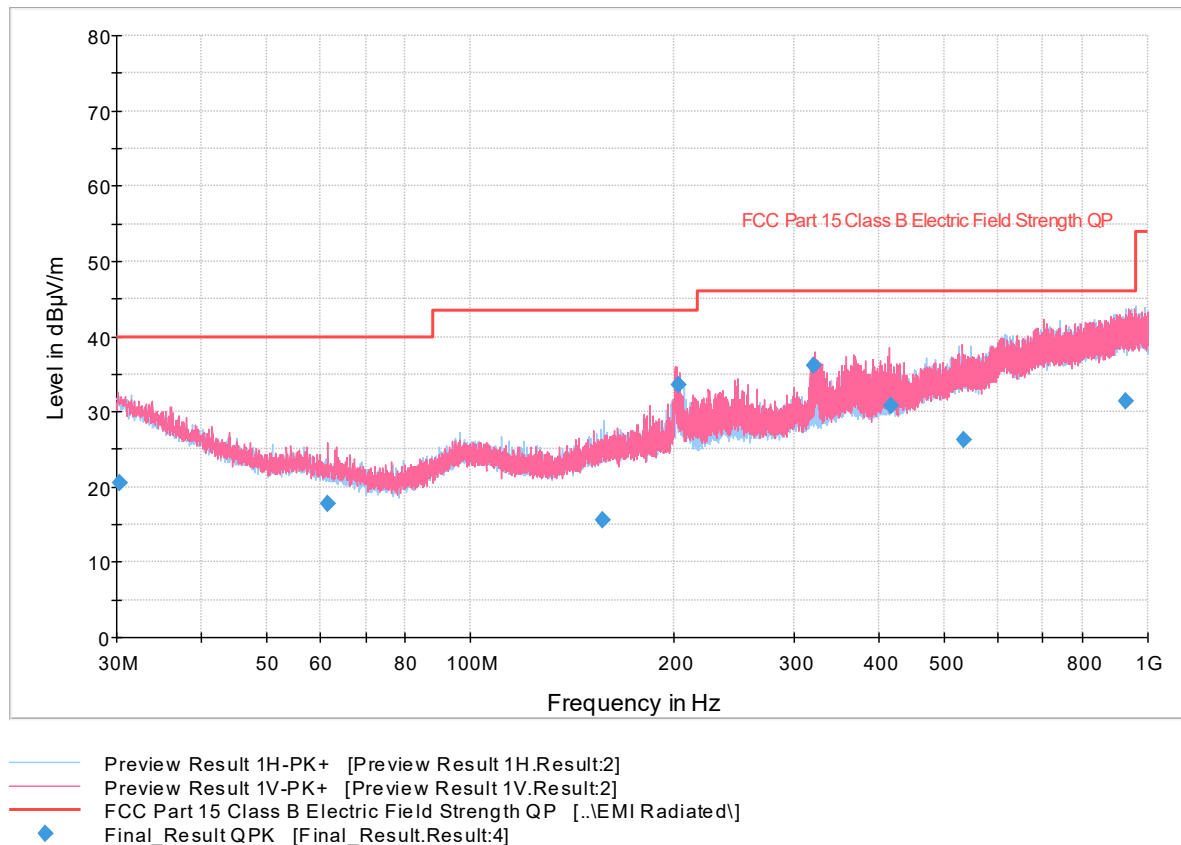


Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
0.018768	66.68	122.13	55.45	1000.0	0.200	100.0	H	42.0	22
0.066543	56.97	111.14	54.17	1000.0	0.200	100.0	H	160.0	20
0.914575	42.90	68.38	25.48	1000.0	9.000	100.0	H	202.0	20
1.223497	43.02	65.85	22.83	1000.0	9.000	100.0	H	209.0	20
2.447223	32.11	69.50	37.39	1000.0	9.000	100.0	H	215.0	20
29.329315	26.82	69.50	42.68	1000.0	9.000	100.0	H	110.0	25

2.5.4 Below 1GHz Radiated Emission Test

Full Spectrum

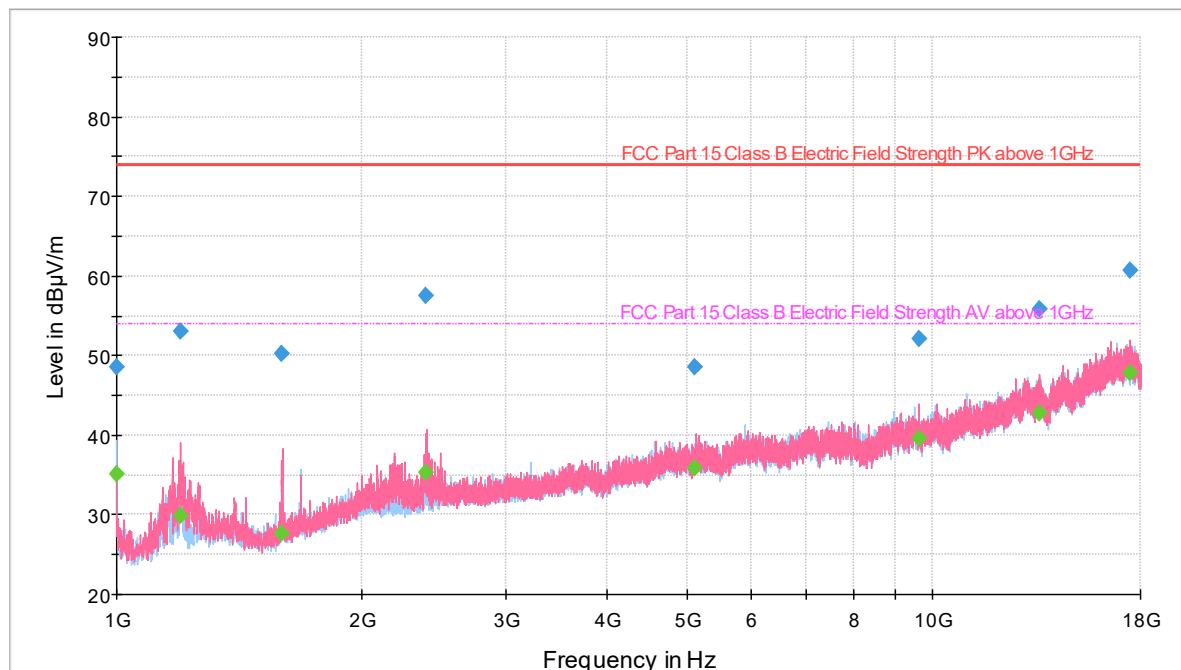


Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.240000	20.52	40.00	19.48	1000.0	120.000	315.0	V	85.0	23
61.532667	17.72	40.00	22.28	1000.0	120.000	175.0	V	319.0	13
156.933000	15.68	43.50	27.82	1000.0	120.000	217.0	H	93.0	17
202.734333	33.63	43.50	9.87	1000.0	120.000	100.0	V	94.0	18
321.319000	36.13	46.00	9.87	1000.0	120.000	100.0	V	127.0	21
417.175000	30.81	46.00	15.19	1000.0	120.000	120.0	V	14.0	23
534.402000	26.21	46.00	19.79	1000.0	120.000	215.0	V	319.0	26
927.194000	31.34	46.00	14.66	1000.0	120.000	287.0	H	132.0	31

2.5.5 Above 1GHz (up to 18GHz) Radiated Emission Test

Full Spectrum



Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1000.000000	48.57	73.90	25.33	1000.0	1000.000	349.0	H	59.0	-6
1199.266667	52.96	73.90	20.94	1000.0	1000.000	175.0	V	158.0	-2
1594.600000	50.32	73.90	23.58	1000.0	1000.000	163.0	V	26.0	-3
2395.300000	57.47	73.90	16.43	1000.0	1000.000	207.0	V	206.0	1
5121.933333	48.64	73.90	25.26	1000.0	1000.000	298.0	V	18.0	6
9643.333333	52.19	73.90	21.71	1000.0	1000.000	365.0	V	153.0	9
13518.200000	55.89	73.90	18.01	1000.0	1000.000	337.0	V	44.0	13
17500.100000	60.60	73.90	13.30	1000.0	1000.000	209.0	V	238.0	19

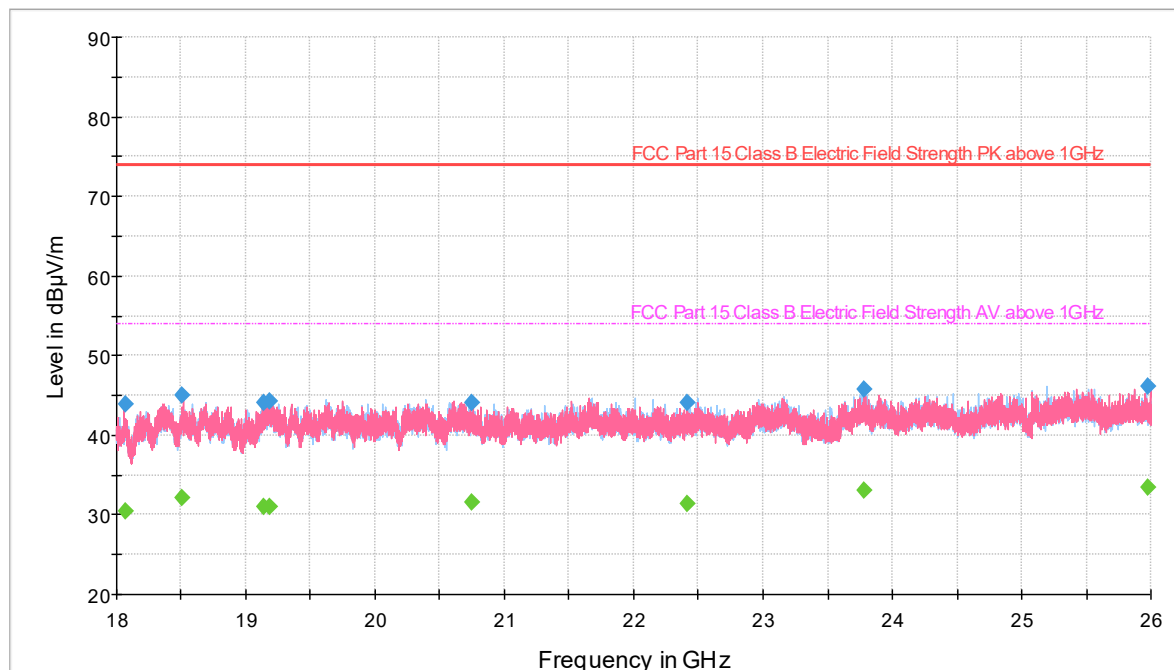


Average Data

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1000.000000	35.03	53.90	18.87	1000.0	1000.000	349.0	H	59.0	-6
1199.266667	29.94	53.90	23.96	1000.0	1000.000	175.0	V	158.0	-2
1594.600000	27.58	53.90	26.32	1000.0	1000.000	163.0	V	26.0	-3
2395.300000	35.25	53.90	18.65	1000.0	1000.000	207.0	V	206.0	1
5121.933333	35.84	53.90	18.06	1000.0	1000.000	298.0	V	18.0	6
9643.333333	39.55	53.90	14.35	1000.0	1000.000	365.0	V	153.0	9
13518.200000	42.85	53.90	11.05	1000.0	1000.000	337.0	V	44.0	13
17500.100000	47.82	53.90	6.08	1000.0	1000.000	209.0	V	238.0	19

2.5.6 18GHz to 26GHz Radiated Emission Test

Full Spectrum



Preview Result 1H-PK+ [Preview Result 1H.Result:2]
Preview Result 1V-PK+ [Preview Result 1V.Result:2]
FCC Part 15 Class B Electric Field Strength PK above 1GHz [.\EMI Radiated\
FCC Part 15 Class B Electric Field Strength AV above 1GHz [.\EMI Radiated\
Final_Result PK+ [Final_Result.Result:4]
Final_Result AVG [Final_Result.Result:5]

Peak Data

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18064.074500	43.89	73.90	30.01	1000.0	1000.000	144.0	V	6.0	-3
18505.014000	45.05	73.90	28.85	1000.0	1000.000	153.0	V	281.0	-3
19139.899500	44.07	73.90	29.83	1000.0	1000.000	213.0	V	98.0	-4
19179.987500	44.19	73.90	29.71	1000.0	1000.000	207.0	H	9.0	-3
20742.270500	44.09	73.90	29.81	1000.0	1000.000	213.0	H	358.0	-3
22409.827000	44.12	73.90	29.78	1000.0	1000.000	163.0	H	75.0	-1
23783.634500	45.81	73.90	28.09	1000.0	1000.000	163.0	V	189.0	0
25977.996500	46.07	73.90	27.83	1000.0	1000.000	187.0	H	122.0	1

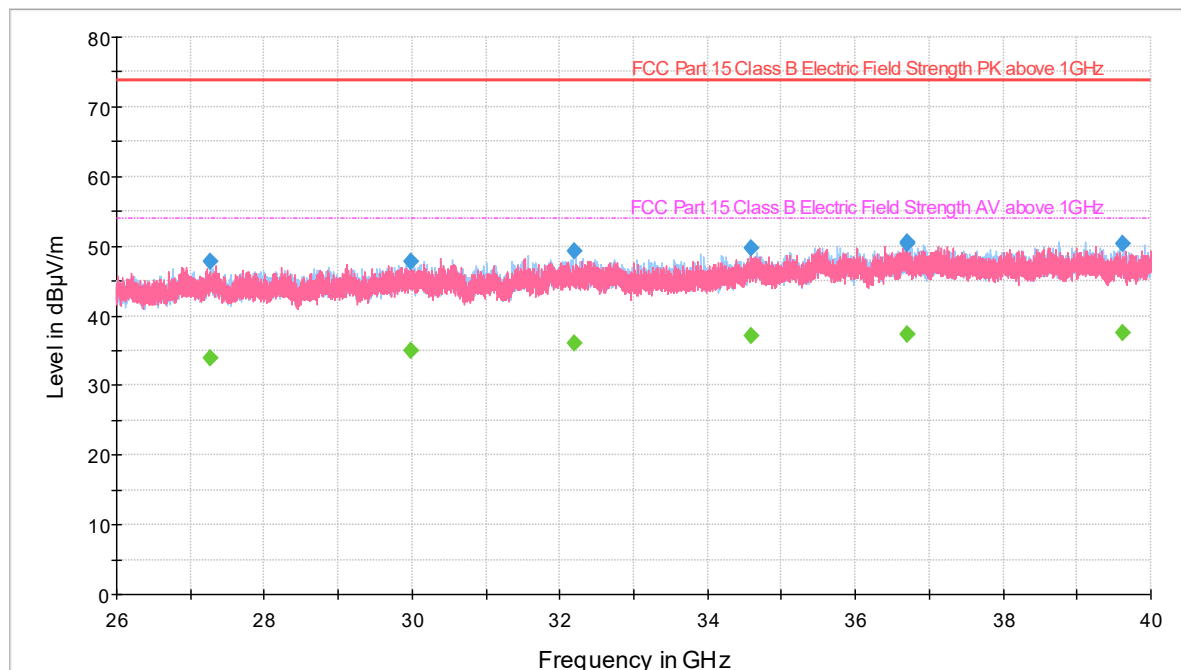


Average Data

Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18064.074500	30.52	53.90	23.38	1000.0	1000.000	144.0	V	6.0	-3
18505.014000	32.20	53.90	21.70	1000.0	1000.000	153.0	V	281.0	-3
19139.899500	31.07	53.90	22.83	1000.0	1000.000	213.0	V	98.0	-4
19179.987500	30.92	53.90	22.98	1000.0	1000.000	207.0	H	9.0	-3
20742.270500	31.49	53.90	22.41	1000.0	1000.000	213.0	H	358.0	-3
22409.827000	31.35	53.90	22.55	1000.0	1000.000	163.0	H	75.0	-1
23783.634500	33.01	53.90	20.89	1000.0	1000.000	163.0	V	189.0	0
25977.996500	33.50	53.90	20.40	1000.0	1000.000	187.0	H	122.0	1

2.5.7 26GHz to 40GHz Radiated Emission Test

Full Spectrum



— Preview Result 1H-PK+ [Preview Result 1H.Result:2]
— Preview Result 1V-PK+ [Preview Result 1V.Result:2]
— FCC Part 15 Class B Electric Field Strength PK above 1GHz [.\EMI Radiated\
— FCC Part 15 Class B Electric Field Strength AV above 1GHz [.\EMI Radiated\
◆ Final_Result PK+ [Final_Result.Result:4]
◆ Final_Result AVG [Final_Result.Result:5]

Peak Data

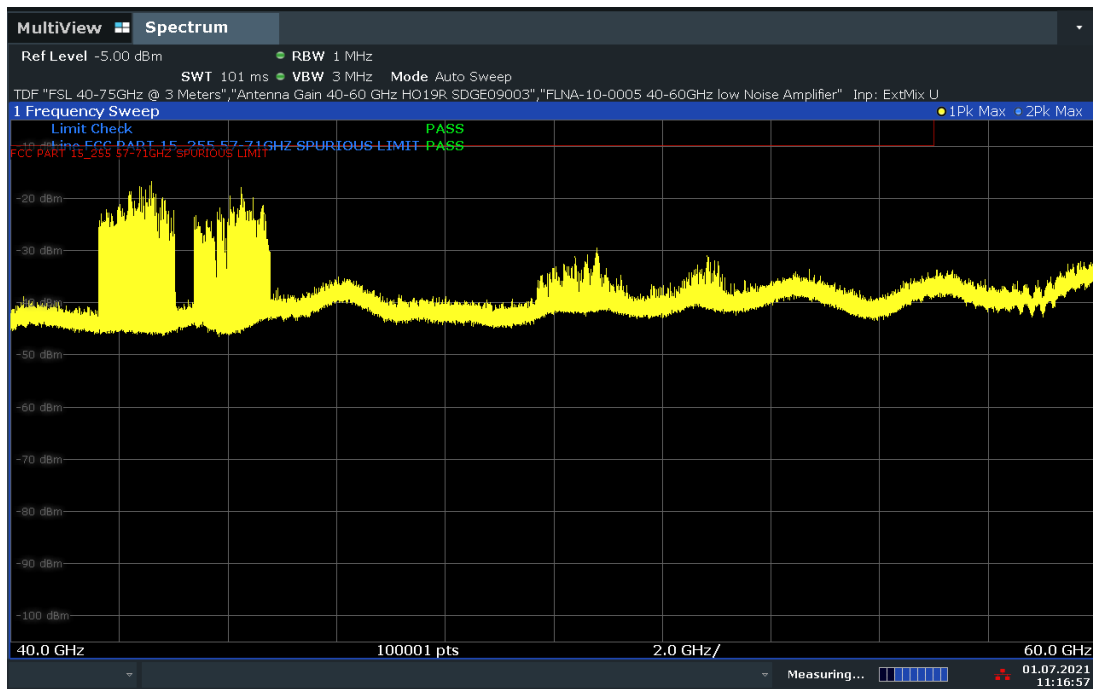
Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
27277.078077	47.73	73.90	26.17	1000.0	1000.000	177.0	H	138.0	2
29981.221538	47.79	73.90	26.11	1000.0	1000.000	161.0	V	71.0	3
32202.289231	49.29	73.90	24.61	1000.0	1000.000	177.0	H	47.0	5
34598.619231	49.79	73.90	24.11	1000.0	1000.000	225.0	H	255.0	6
36691.426154	50.44	73.90	23.46	1000.0	1000.000	212.0	V	41.0	7
36700.840769	50.60	73.90	23.30	1000.0	1000.000	177.0	V	25.0	7
39620.858461	50.42	73.90	23.48	1000.0	1000.000	206.0	H	33.0	7



Average Data

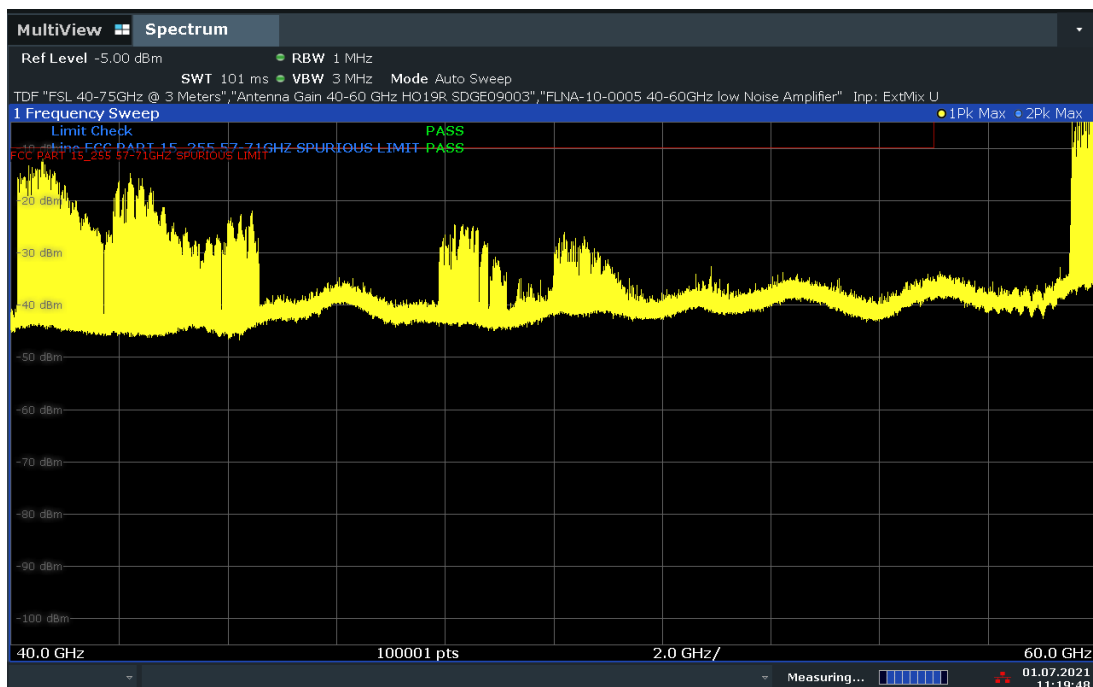
Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
27277.078077	33.91	53.90	19.99	1000.0	1000.000	177.0	H	138.0	2
29981.221538	35.02	53.90	18.88	1000.0	1000.000	161.0	V	71.0	3
32202.289231	35.98	53.90	17.92	1000.0	1000.000	177.0	H	47.0	5
34598.619231	37.04	53.90	16.86	1000.0	1000.000	225.0	H	255.0	6
36691.426154	37.28	53.90	16.62	1000.0	1000.000	212.0	V	41.0	7
36700.840769	37.31	53.90	16.59	1000.0	1000.000	177.0	V	25.0	7
39620.858461	37.61	53.90	16.29	1000.0	1000.000	206.0	H	33.0	7

2.5.8 40GHz to 200GHz Maximized Plots



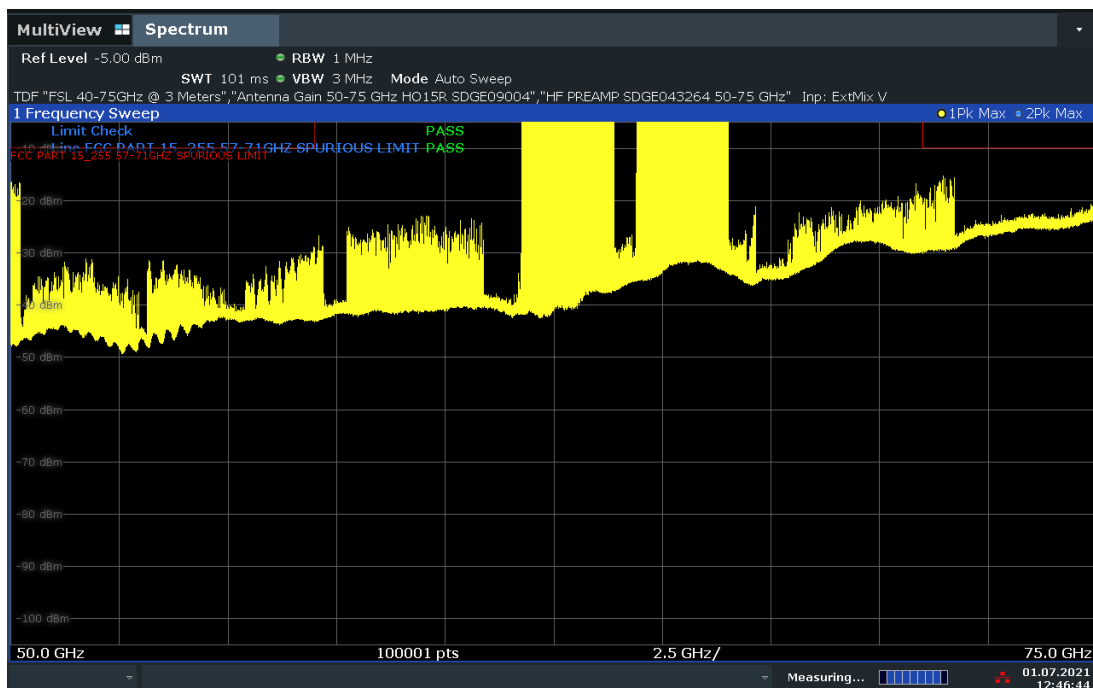
11:16:57 01.07.2021

40GHz to 60GHz Plot (2GHz profile)



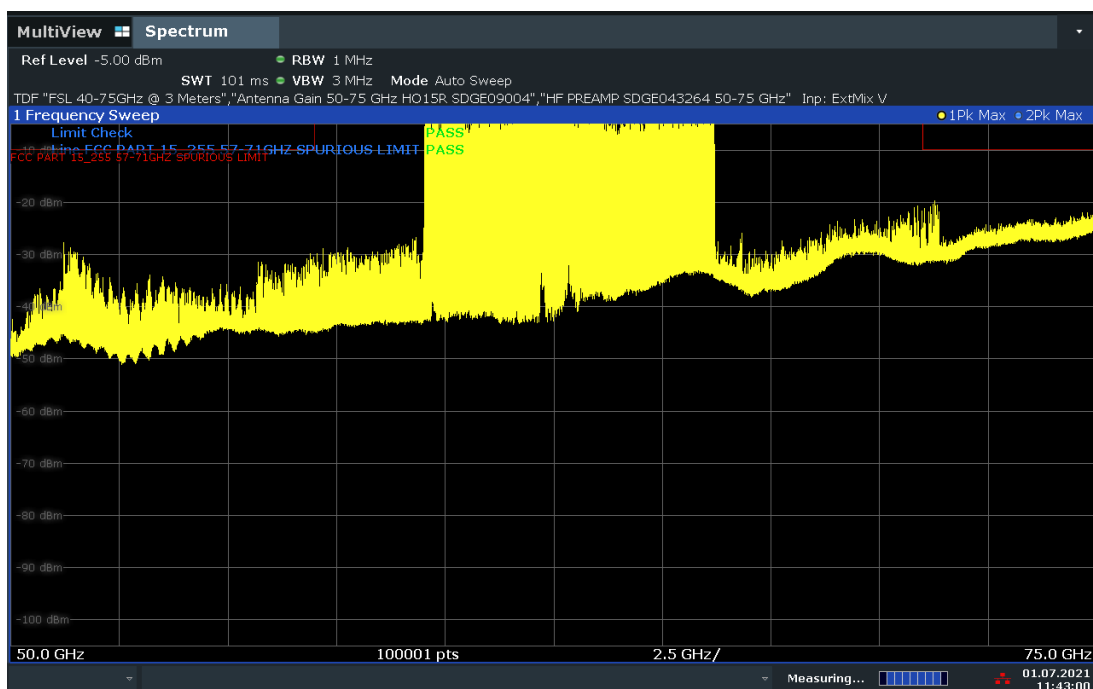
11:19:48 01.07.2021

40GHz to 60GHz Plot (4GHz profile)



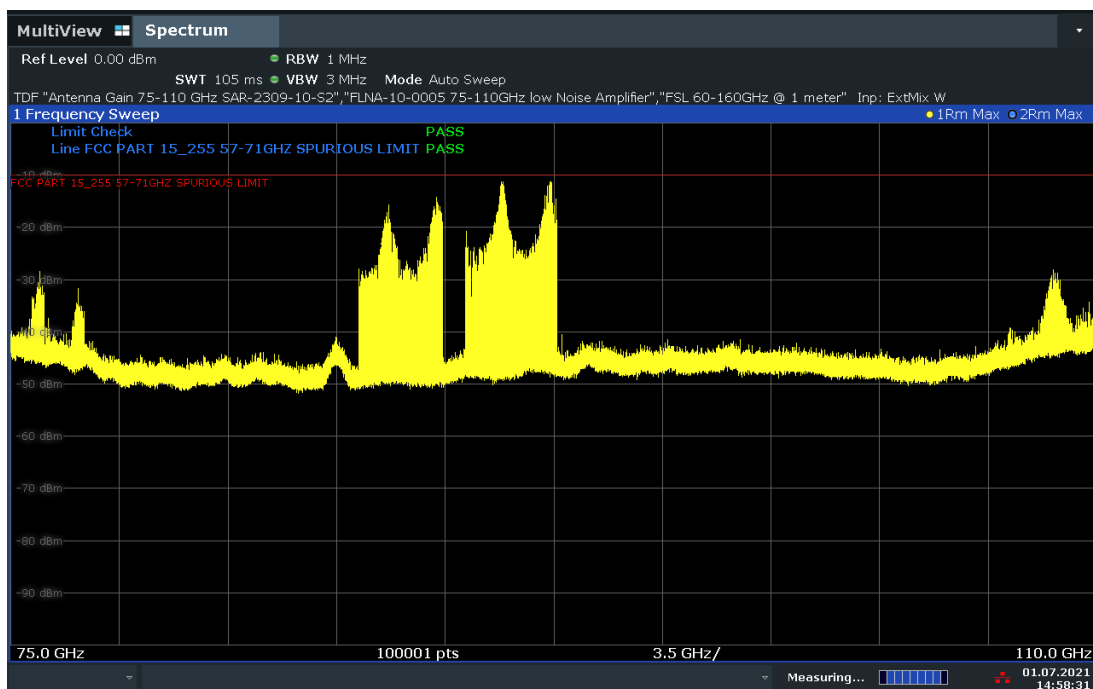
12:46:45 01.07.2021

50GHz to 75GHz Plot (2GHz profile)



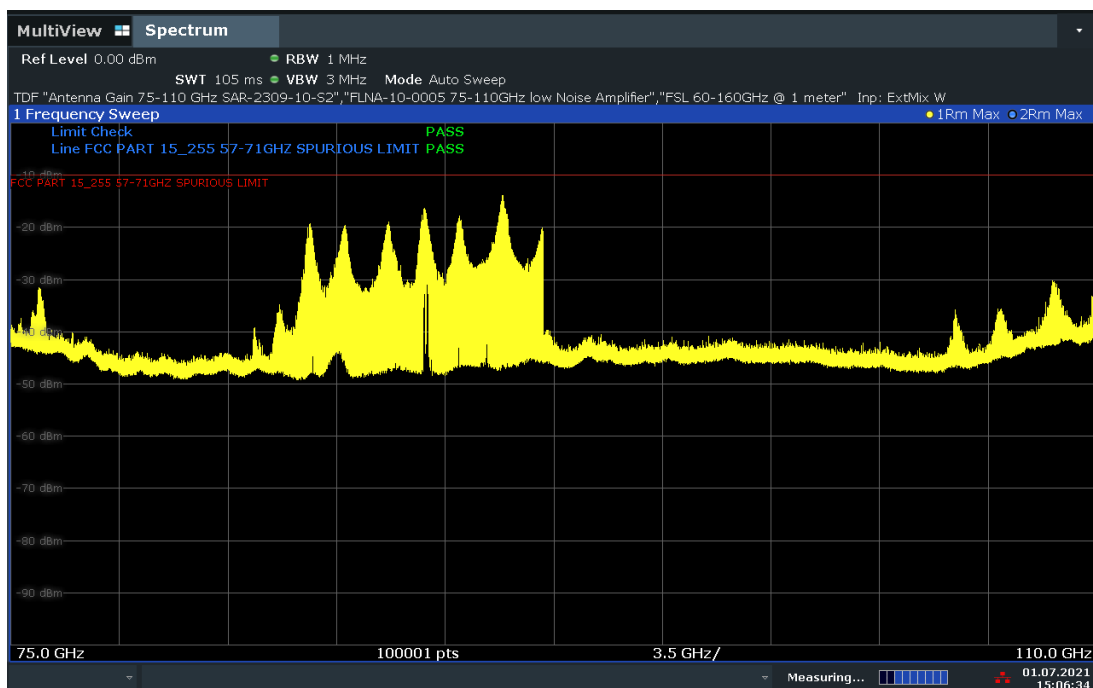
11:43:01 01.07.2021

50GHz to 75GHz Plot (4GHz profile)



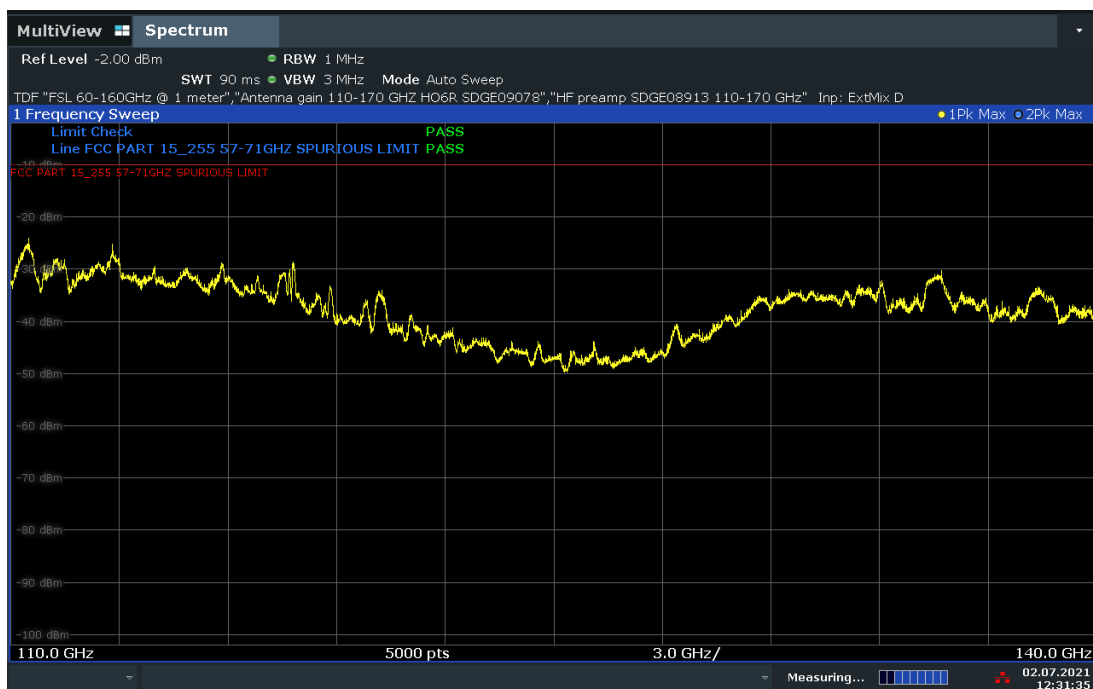
14:58:32 01.07.2021

75GHz to 110GHz Plot (2GHz profile)



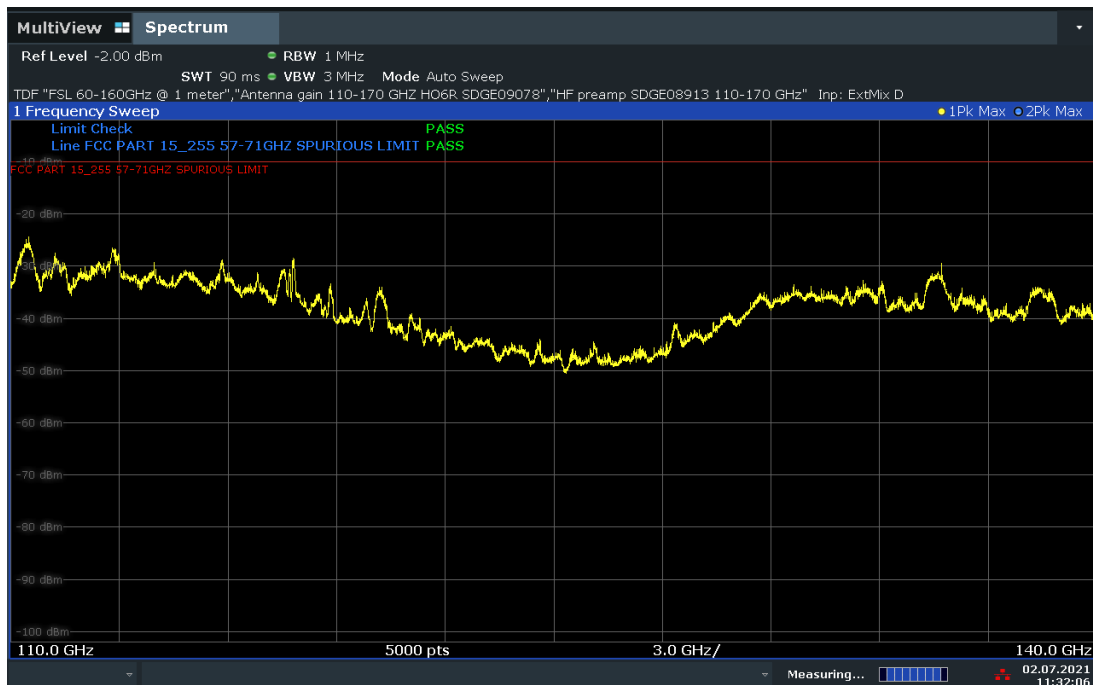
15:06:35 01.07.2021

75GHz to 110GHz Plot (4GHz profile)



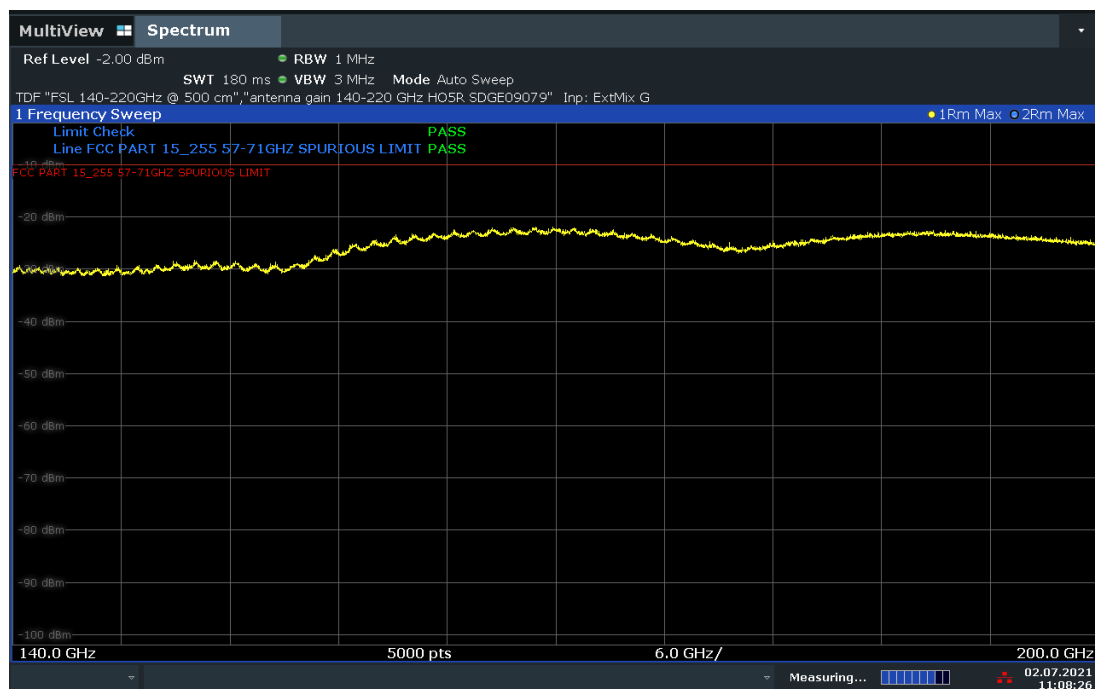
12:31:36 02.07.2021

110GHz to 140GHz Plot (2GHz profile)



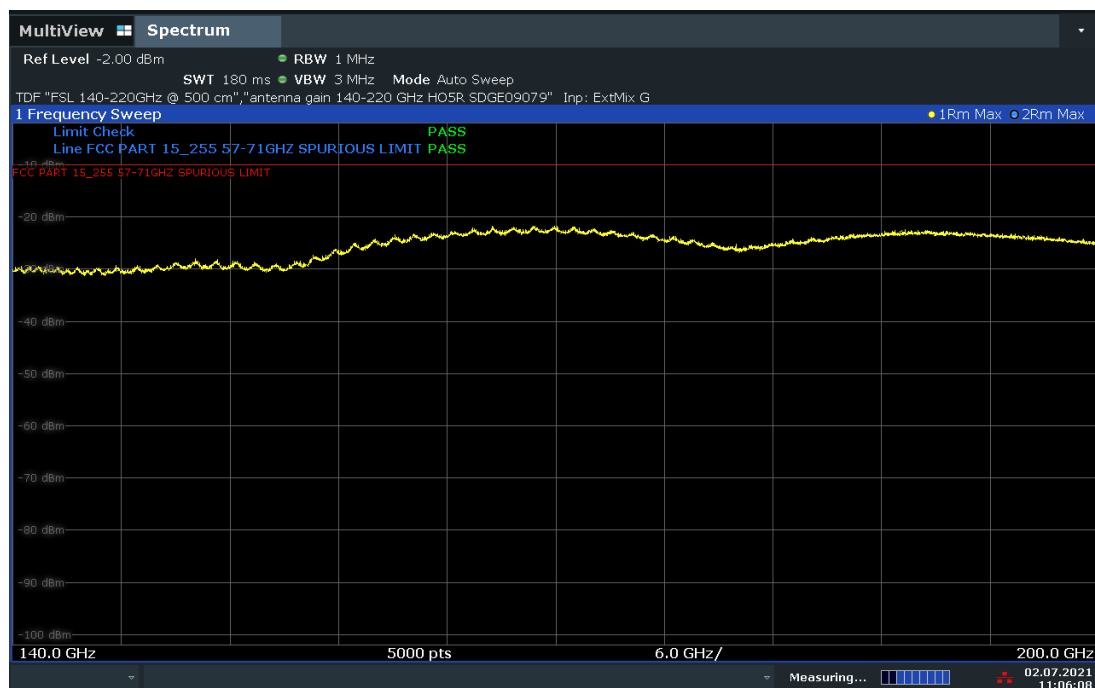
11:32:07 02.07.2021

110GHz to 140GHz Plot (4GHz profile)



11:08:27 02.07.2021

140GHz to 200GHz Plot (2GHz profile)



11:06:08 02.07.2021

140GHz to 200GHz Plot (4GHz profile)



2.6 DUTY CYCLE

2.6.1 Specification Reference

Waiver DA 21-407 (granted April 14, 2021)

2.6.2 Waiver Condition

Maximum transmit duty cycle of 10% in any 33 milliseconds (ms) interval.

2.6.3 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

June 26, 2021 / FSC

2.6.5 Test Equipment Used

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

2.6.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	25.8 °C
Relative Humidity	49.3 %
ATM Pressure	99.8 kPa

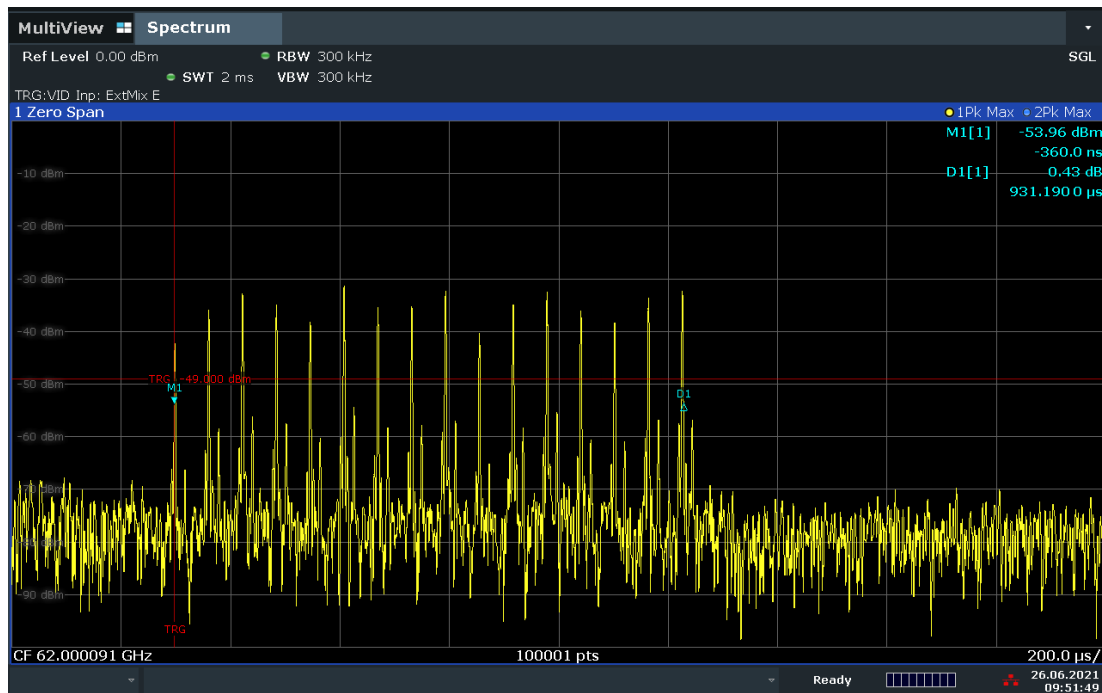
2.6.7 Additional Observations

- This is a radiated test. Only the worst-case profile presented (FMCW sequence over 1.92GHz, the chirp time of the 3.84GHz profile is half of that of the 1.92GHz).
- Duty Cycle calculation is based on the entire chirp (worst case) compared to calculating the total on time per pulse according to the pulse width.

2.6.8 Verification Test Results

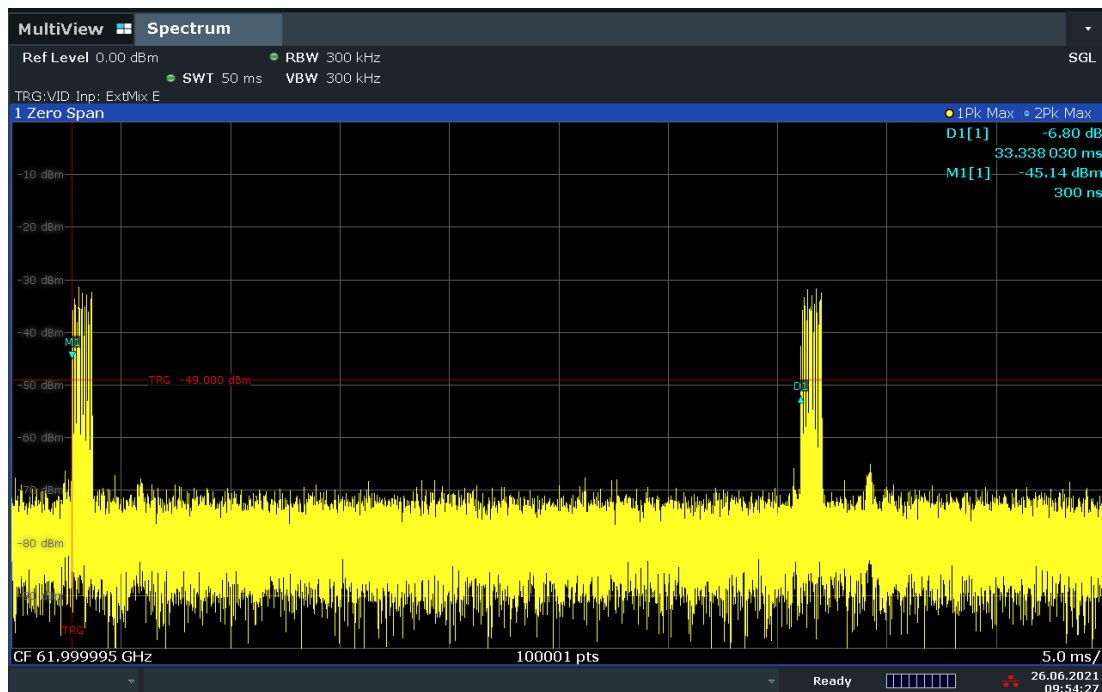
Measured chirp:	= 0.9312 ms
Number of chirp/s per 33ms period	= 1 (one)
Calculated Duty Cycle	= 2.82 % Complies with 10% Waiver condition

2.6.9 Sample Test Plots



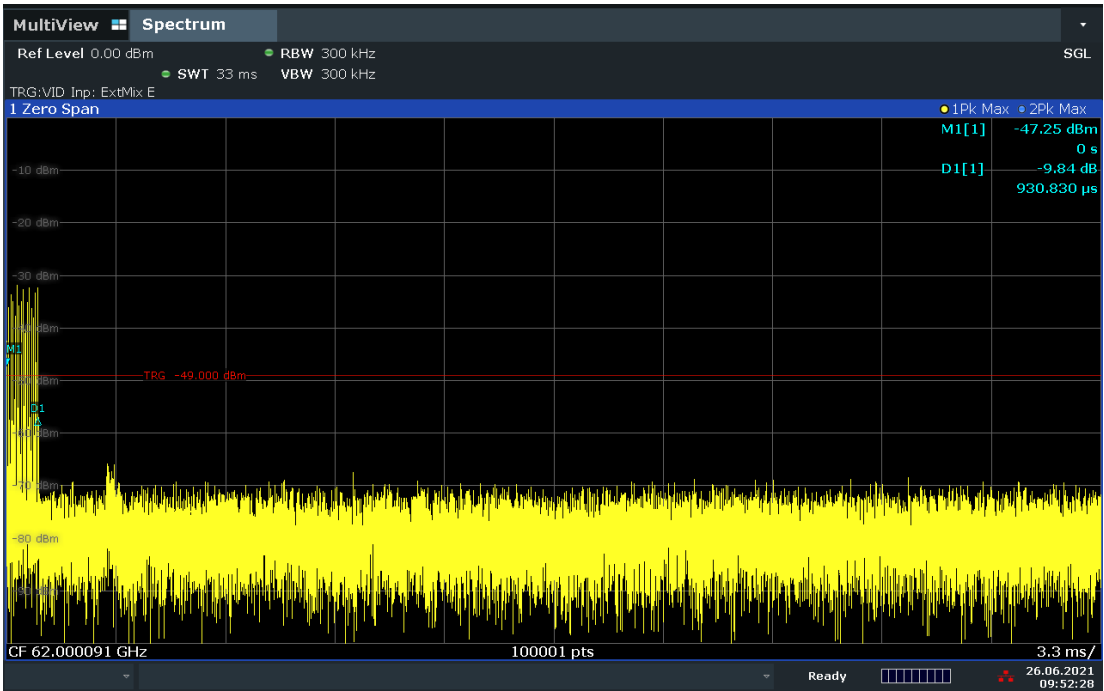
09:51:49 26.06.2021

Worst Case Chirp (1.92GHz Profile)



09:54:27 26.06.2021

Chirp Period



09:52:29 26.06.2021

33ms Observation Period



2.7 POWER SPECTRAL DENSITY

2.7.1 Specification Reference

Waiver DA 21-407 (granted April 14, 2021)

2.7.2 Waiver Condition

Power Spectral Density per the Waiver is +13 dBm/MHz.

2.7.3 Equipment Under Test and Modification State

Serial No: SILC1B1021U0086 / Default Test Configuration

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

July 03, 2021 / FSC

2.7.5 Test Equipment Used

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

2.7.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	25.8 °C
Relative Humidity	49.3 %
ATM Pressure	99.8 kPa

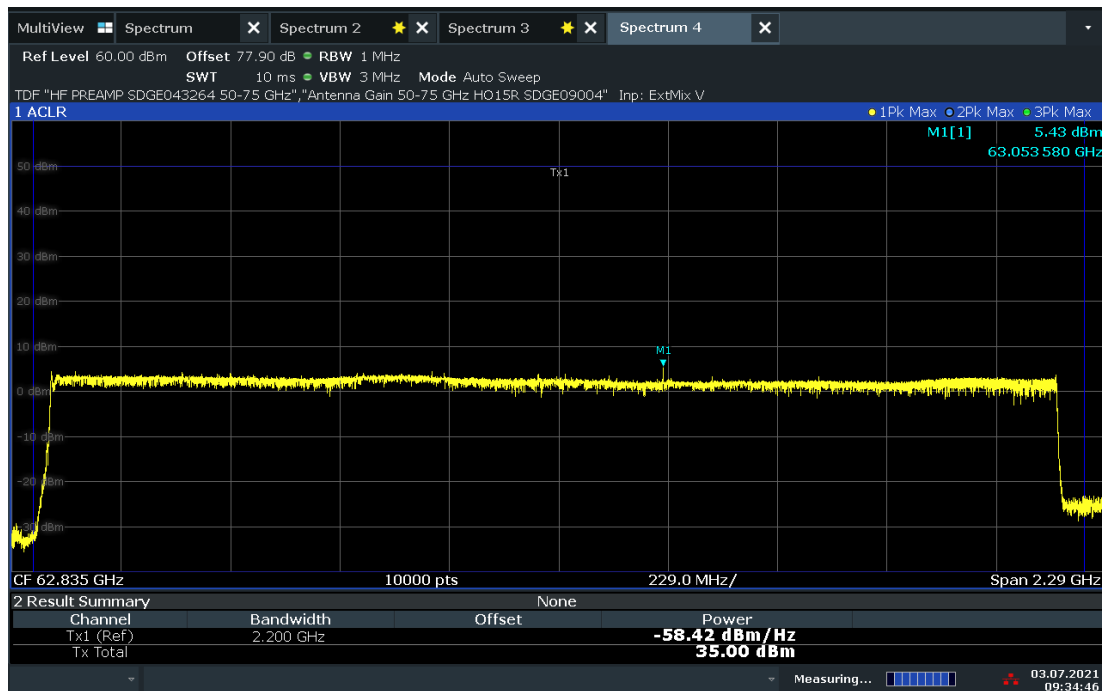
2.7.7 Additional Observations

- This is a radiated test. Test setup is identical to Section 2.5 of this test report covering the frequency range of 60GHz to 64GHz.
- The Power Measurement function of the Spectrum Analyzer is used for this test.

2.7.8 Test Result

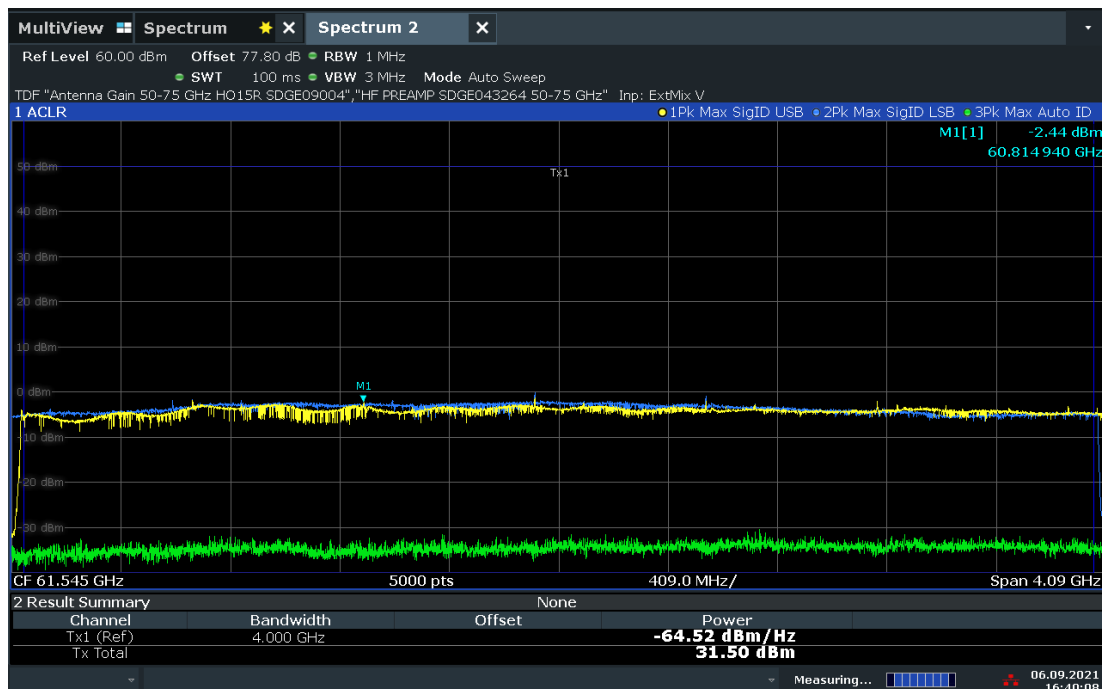
Frequency	Profile	Measured PSD	Calculated PSD
60 to 64 GHz	2GHz	-58.42 dBm/Hz	1.58 dBm/MHz
	4GHz	-64.52 dBm/Hz	-4.52 dBm/MHz

2.7.9 Test Result Plots



09:34:47 03.07.2021

Power Spectral Density (2GHz profile)



16:40:09 06.09.2021

Power Spectral Density (4GHz profile)



SECTION 3

TEST EQUIPMENT USED



3.1 Test Equipment Used

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

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Radiated Emission						
1033	Bilog Antenna	3142C	00044556	EMCO	10/05/21	10/05/23
7631	Double-ridged waveguide horn	3117	00205418	ETS-Lindgren	09/16/20	09/16/22
46797	Preamplifier	PA-122	181925	Com Power	10/11/21	10/11/22
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves	Verified by 7611 and corresponding antenna/Active multiplier combination (Standard Gain Horn Antenna)	
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.		
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves		
9081	Horn antenna (110-170 GHz)	HO6R	N/A	Custom Microwaves		
9082	Horn antenna (140-220 GHz)	HO5R	N/A	Custom Microwaves		
9080	Horn antenna (220-325 GHz)	HO3R	N/A	Custom Microwaves		
7637	Harmonics mixer (40-60 GHz)	FS-Z60	100009	Rhode & Schwarz	07/29/20	07/29/23
7636	Harmonics mixer (60-90 GHz)	FS-Z90	100092	Rhode & Schwarz	07/29/20	07/29/23
7633	Harmonics mixer (75-110 GHz)	HM-110-7	101000	02/22/21	02/22/21	07/29/23
7634	Harmonics mixer (110-170 GHz)	HM-170	0062	Radiometer Physics	02/22/21	07/29/23
7635	Harmonics mixer (170-220 GHz)	HM-220	020022	Radiometer Physics	02/22/21	07/29/23
7632	Harmonics mixer (220-325 GHz)	HM-325	020075	Radiometer Physics	02/22/21	07/29/23
1153	High-frequency cable	SucoFlex 100 SX	N/A	Suhner	Verified by 1003 and 7620	
8543	High-frequency cable	Micropore 19057793	N/A	United Microwave Products	Verified by 1003 and 7620	
40815	Pre-amplifier (18-40 GHz)	19D18	15G27	Spacek Labs	Verified by 1003 and 7620	
44137	V Band waveguide Detector	PE80T3002	V0011860417 20158046	Pasternack	Verified by 1003 and 7611	
8872	Direct Reading Attenuator (40-60 GHz)	STA-60-19-D1	11875-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8860	Direct Reading Attenuator (50-75 GHz)	STA-60-15-D1	11466-01	Sage Millimeter, Inc.		
8861	Direct Reading Attenuator (75-110 GHz)	STA-60-10-D1	11466-01	Sage Millimeter, Inc.		
8919	Direct Reading Attenuator (90-140 GHz)	STA-60-08-D1	12605-01	Sage Millimeter, Inc.		



ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
8909	Direct Reading Attenuator (140-220 GHz)	STA-60-05-D1	12020-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8873	Active Multiplier (40-60 GHz)	AMC-19-RFH00	124	Sage Millimeter, Inc.		
8914	Active Multiplier (50-75 GHz)	AMC-15-RFH00	283	Sage Millimeter, Inc.		
8915	Active Multiplier (75-110 GHz)	AMC-10-RFH00	606	Sage Millimeter, Inc.		
8920	Active Multiplier (90-140 GHz)	AMC-08-RFH00	58	Sage Millimeter, Inc.		
8909	Active Multiplier (140-220 GHz)	MCA-05-150096	13	Sage Millimeter, Inc.		
9001	Horn antenna (18-26.5GHz)	HO42S	101	Custom Microwave	09/23/21	09/21/23
9003	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	10/14/19	07/29/23
7611	Signal/Spectrum Analyzer	FSW26	102017	Rhode & Schwarz	02/02/21	02/02/22
1003	Signal Generator	SMR-40	1104.0002.40	Rhode & Schwarz	06/25/21	06/25/22
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	10/19/21	10/19/22
7620	EMI Test Receiver	ESU40	100399	Rhode & Schwarz	08/02/21	08/02/22
Miscellaneous						
6805	Environmental Chamber	ESL-4CA	18021	Espec	01/13/21	01/13/22
7659	Oscilloscope	TDS7404	B010181	Tectronix	10/29/21	10/29/22
34029	Mini Environmental Quality Meter	Hygrometer	850027	Sper Scientific	07/19/21	07/19/22
-	Test Software	EMC32	V11.20.00	Rhode & Schwarz	N/A	

3.2 Measurement Uncertainty

Calculation of Measurement Uncertainty per CISPR 16-4-2:2011 with Corr. 1

3.2.1 Radiated Measurements (Below 1GHz)

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75 dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	0.45 dB	Normal, k=2	2.000	0.23	0.05
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
13	Cross-polarization	0.90 dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00 dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.76 dB	Triangular	2.449	1.54	2.36
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77 dB	Rectangular	1.732	0.44	0.20
18	Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00 dB				0.00
Combined standard uncertainty			Normal	2.95	dB	
Expanded uncertainty			Normal, k=2	5.90	dB	

3.2.2 Radiated Emission Measurements (Above 1GHz)

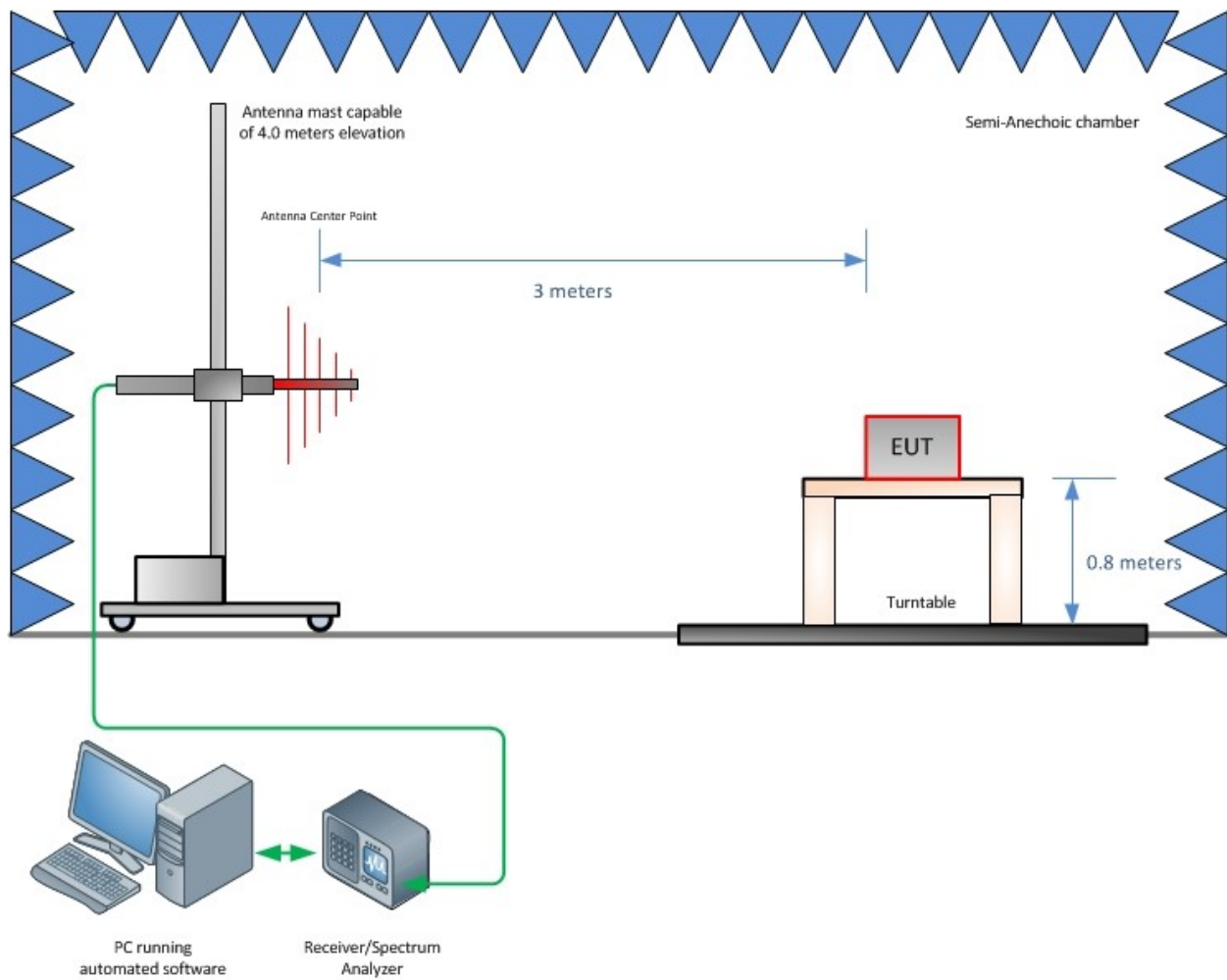
	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75 dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	0.45 dB	Normal, k=2	2.000	0.23	0.05
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
13	Cross-polarization	0.90 dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00 dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.25 dB	Triangular	2.449	1.33	1.76
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77 dB	Rectangular	1.732	0.44	0.20
18	Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00 dB				0.00
Combined standard uncertainty			Normal	2.85 dB		
Expanded uncertainty			Normal, k=2	5.70 dB		



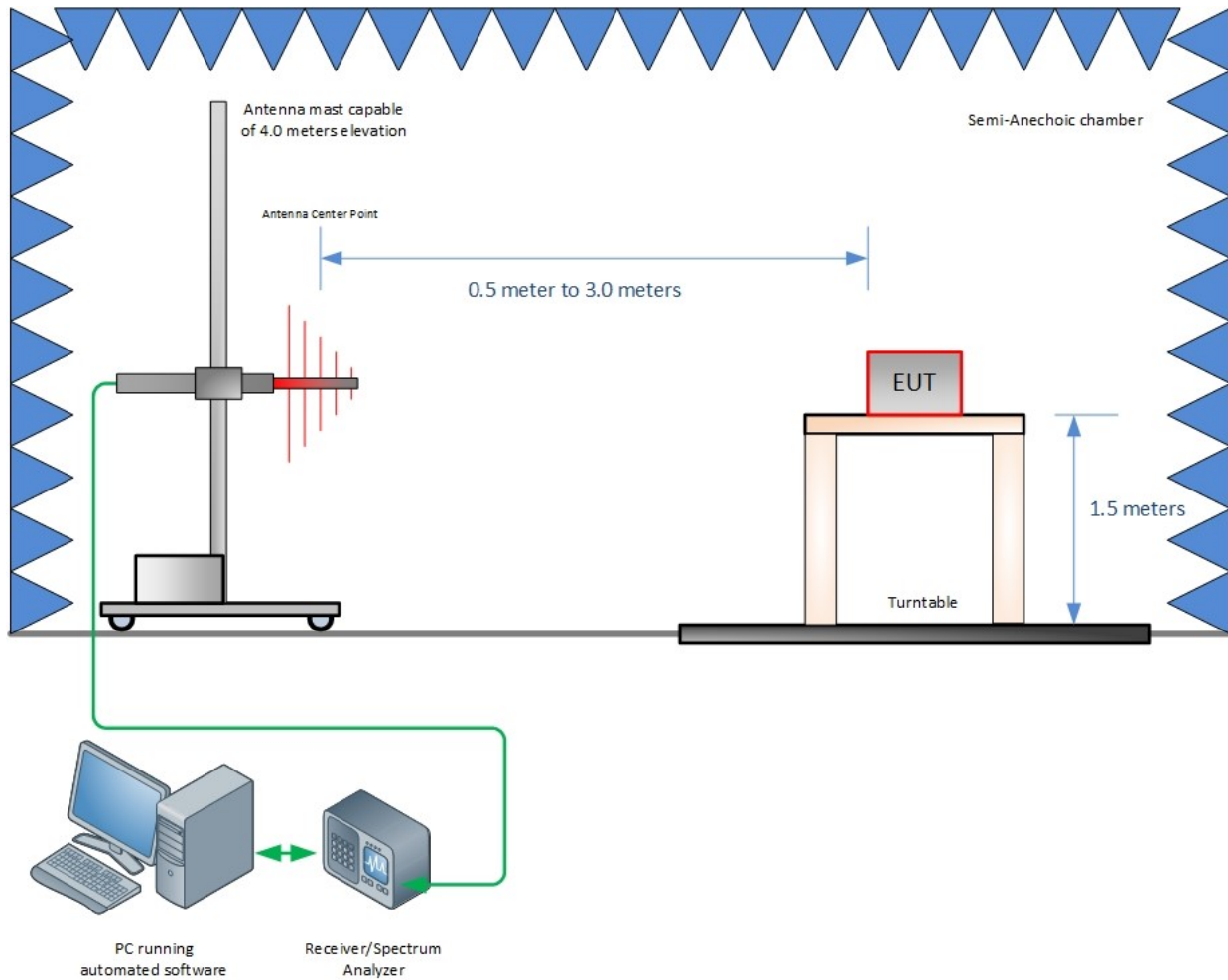
SECTION 4

Diagram of Test Setup

4.1 Test Setup Diagram



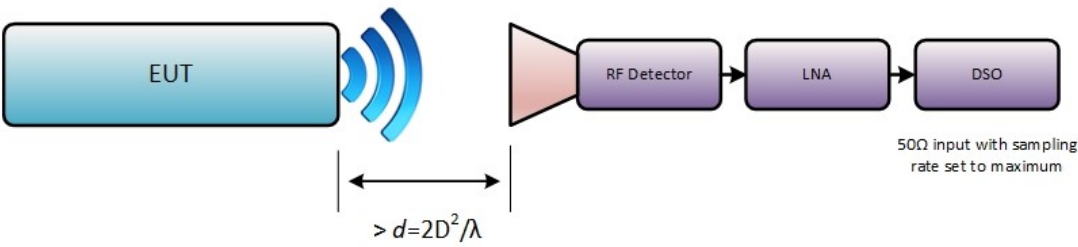
Radiated Emission Test Setup (Below 1GHz)



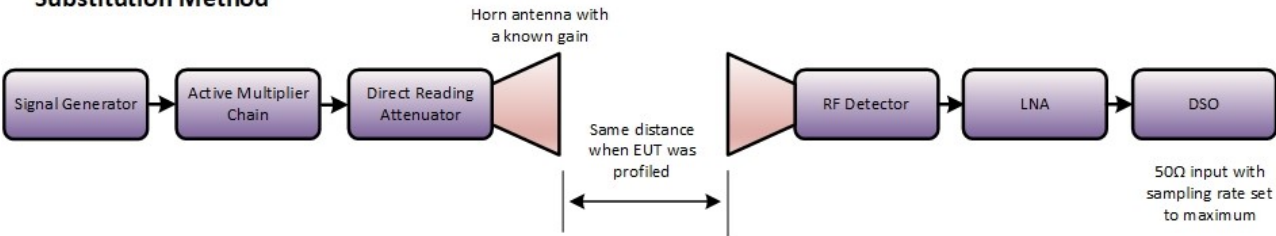
Radiated Emission Test Setup (Above 1GHz)



EUT Power Profile



Substitution Method



Power Measurement Block Diagram



SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT



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

