

Test Report

Prepared for: Wavetronix LLC

Model: Fathom Tank Level Sensor

FCC ID: PCB-FA01

ISED ID: 4513A-FA01

Serial Number: 000126

Project No: p2470002

Test Results: Pass

To

FCC Part 15.255
and
RSS-210: Issue 11 (June25, 2024)

Date of Issue: October 7, 2024

On the behalf of the applicant:

Wavetronix
1827 West 650 North
Springville, Utah

Attention of:

Christopher Uchman
Ph: (801) 655-6561
E-Mail: Chris.Uchman@wavetronix.com

Prepared By:

Compliance Testing, LLC
Mesa, AZ 85204
(480) 926-3100 phone / (480) 926-3598 fax
www.compliancetesting.com
ANAB Cert#: AT-2901
FCC Site Reg. #US2901
ISED Site Reg. #2044A-2

Reviewed / Authorized By:



Greg Corbin,
Project Test Engineer

This report may not be reproduced, except in full, without written permission from Compliance Testing. All results contained herein relate only to the sample tested. All samples were selected by the customer.



Test Results Summary

Specification		Test Name	Pass, Fail, N/A	Comments
FCC	ISED			
15.255 (c)(2)(iii)(B)	RSS-210 Annex J	Output Power	Pass	
15.255 (f)	RSS-GEN 4.6.1	Occupied Bandwidth	Pass	
15.255 (d)	RSS-210 Annex J	Radiated Spurious`	Pass	
15.255 (f)	RSS-210 Annex J	Frequency Stability	Pass	
15.207	RSS-GEN 7.1.4	AC Powerline Conducted Emission	N/A	The EUT is DC powered and installed in on vehicle.

References/Methods	Description
ANSI C63.4-2014	Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz.
ANSI C63.10:2020	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC KDB 364244 D01 v01	Radar Devices Certifying Under the Provisions of 15.255
ISO/IEC 17025:2017	General requirements for the Competence of Testing and Calibrations Laboratories

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	October 7, 2024	Greg Corbin	Original Document
2.0	November 20, 2024	Greg Corbin	In the test summary table on page 18, replaced the raw data with the corrected data for 202.682 MHz from test data table on page 20. Updated HVIN, PMN, UPN on page 8.

Table of Contents

<u>Description</u>	<u>Page</u>
TEST RESULTS SUMMARY	3
EUT DESCRIPTION	8
TEST SETUP AND MODES OF OPERATION	9
TIMING	10
RADIATED OUTPUT POWER	13
OCCUPIED BANDWIDTH.....	15
RADIATED SPURIOUS EMISSIONS	17
FREQUENCY STABILITY.....	25
TEST EQUIPMENT UTILIZED.....	27
MEASUREMENT UNCERTAINTY.....	29

ANAB

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to the joint ISO-ILAC-IAF Communiqué dated January 2009).

The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

Please refer to <http://www.compliancetesting.com/labscope.html> for current scope of accreditation.



FCC Site Reg. #349717

IC Site Reg. #2044A-2

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Authorization Requirements

Intentional Radios may require authorization covered under the following rule parts or standards:

-47 CFR Part 2 Subpart J

-RSS-Gen — General Requirements for Compliance of Radio Apparatus

Standard Engineering Practices

Unless otherwise indicated, the procedures contained in ANSI C63.10 and ANSI C63.4 were observed during testing.

Prior to testing, the EUT was tuned up in accordance with the manufacturer's alignment procedures. All external gain controls were maintained at the position of maximum and/or optimum gain throughout the testing. Measurement results, unless otherwise noted, are worst case measurement.

Standard Test Conditions and Engineering Practices

Unless otherwise indicated in the specific measurement results, the ambient temperature was maintained within the range of 10° to 40°C (50° to 104°F) and the relative humidity levels were in the range of 10% to 90%.

Environmental Conditions		
Temperature (°C)	Humidity (%)	Barometric Pressure (mbar)
25.1 – 30.4	26,8 – 35.2	962.4 – 973.0

EUT Description

Model:	Fathom Tank Level Sensor
Serial:	000126
Firmware:	2.0.3
Software:	N/A
HVIN	FATHOM-FA01
PMN	FATHOM-FA01
UPN	FA01
FVIN	2.0.3
Description:	Tank Level Sensor
Additional Information:	Sensor measures level of grey and black water holding tanks for RV's. Freq Range = 57 – 64 GHz Modulation = FMCW
Receipt of Sample(s):	October 7, 2024
EUT Condition:	Visual Damage No State of Development Production/Production Equivalent

15.203: Antenna Requirement:

- ☒ The antenna is permanently attached to the EUT
- ☐ The antenna uses a unique coupling
- ☐ The EUT must be professionally installed
- ☐ The antenna requirement does not apply

Test Setup and Modes of Operation

For alignment and maximizing signal levels at mm-wave frequencies, the EUT was placed in CW mode of operation.

For final data, the EUT was placed in FMCW mode of operation.

EUT Operation during Tests

The EUT was tested in FMCW mode of operation.

The EUT was powered with a AC to DC power supply with 12 vdc output.

Accessories:				
Qty	Description	Manufacturer	Model	S/N
1	USB2.0 to CANFD converter	Pibiger	PU2CANFD	N/A
1	AC to DC Adaptor	N/A	YCZK-24W1258	N/A

Cables:						
Qty	Description	Length (M)	Ferrites (Y/N)	Shielding Y/N	Shielded Hood Y/N	Termination / Connection
1	Multi-pin	7	N	N	N	AC Adaptor and USB converter

Modifications:	None
----------------	------

Timing

Engineer: Greg Corbin

Test Date: 10/17/2024

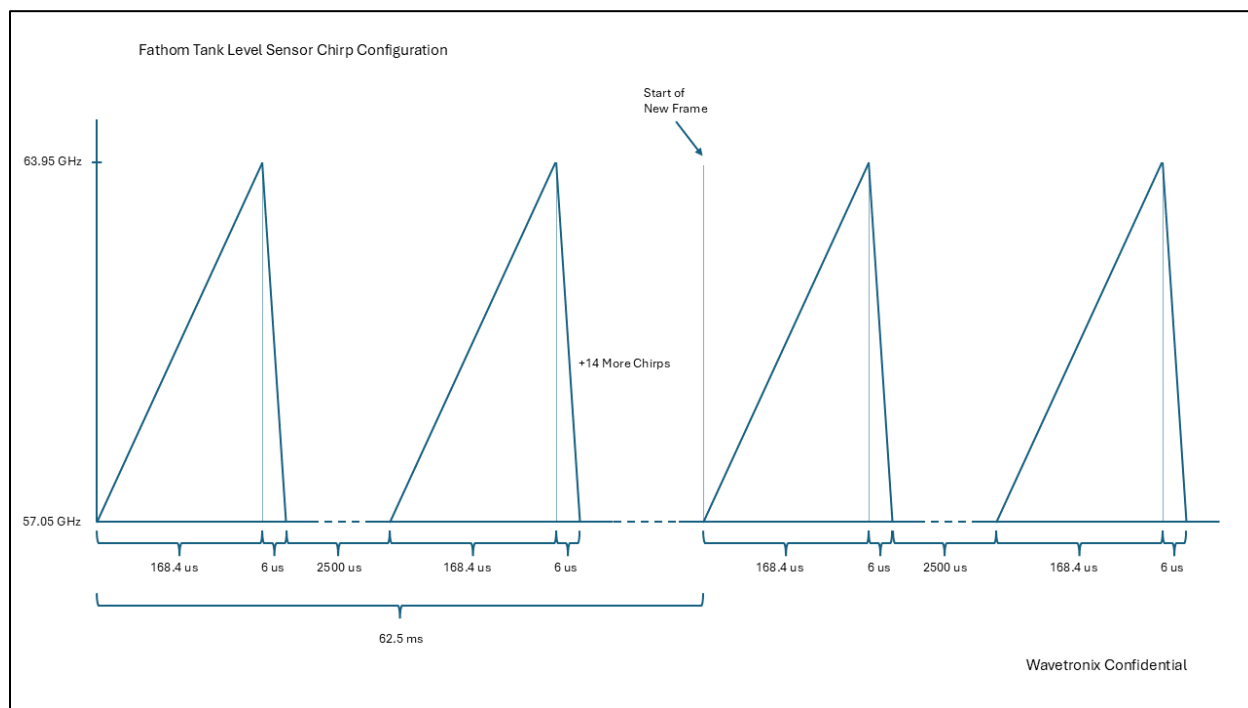
Test Procedure

The EUT timing diagram was provided by the manufacturer and is used to show compliance to the off-time requirement per 15.255 (c)(2)(iii)(B) which state: *the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds when operated outdoors.*

KDB 364244D01 Meas 15.255 Radars v01 contains a note on page 2 that states:

Note: Any discrete off-time periods of less than 2 milliseconds are not considered when determining the total off-time over any 33-millisecond interval.

Manufacturer provided Timing Diagram

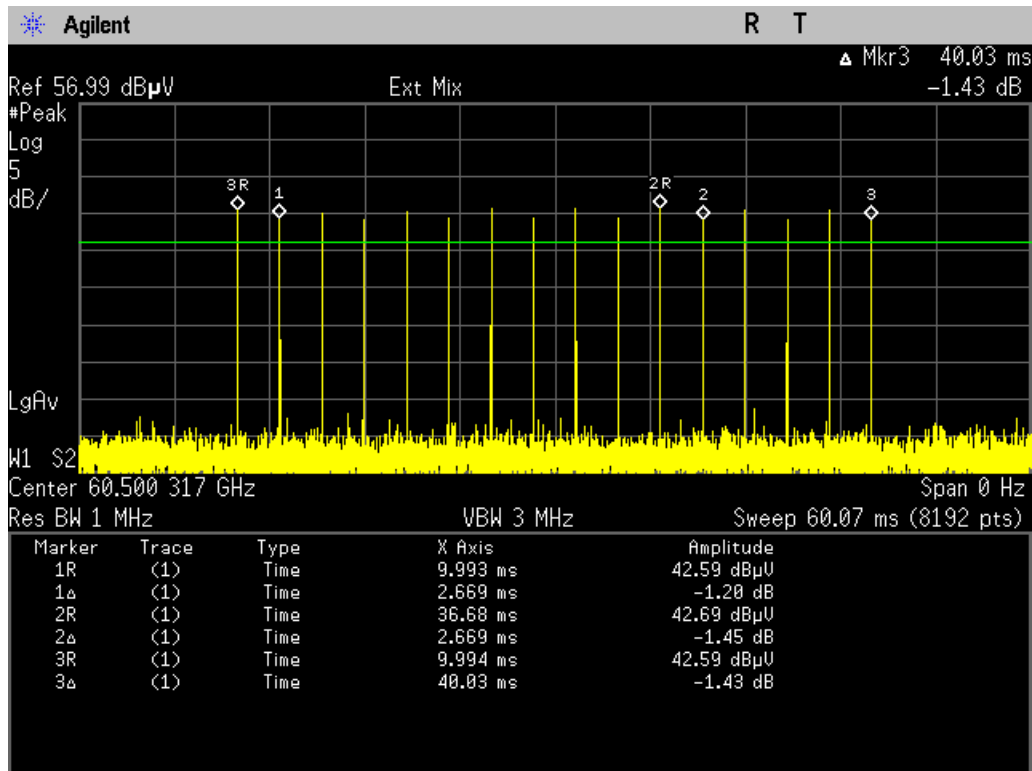


Note:

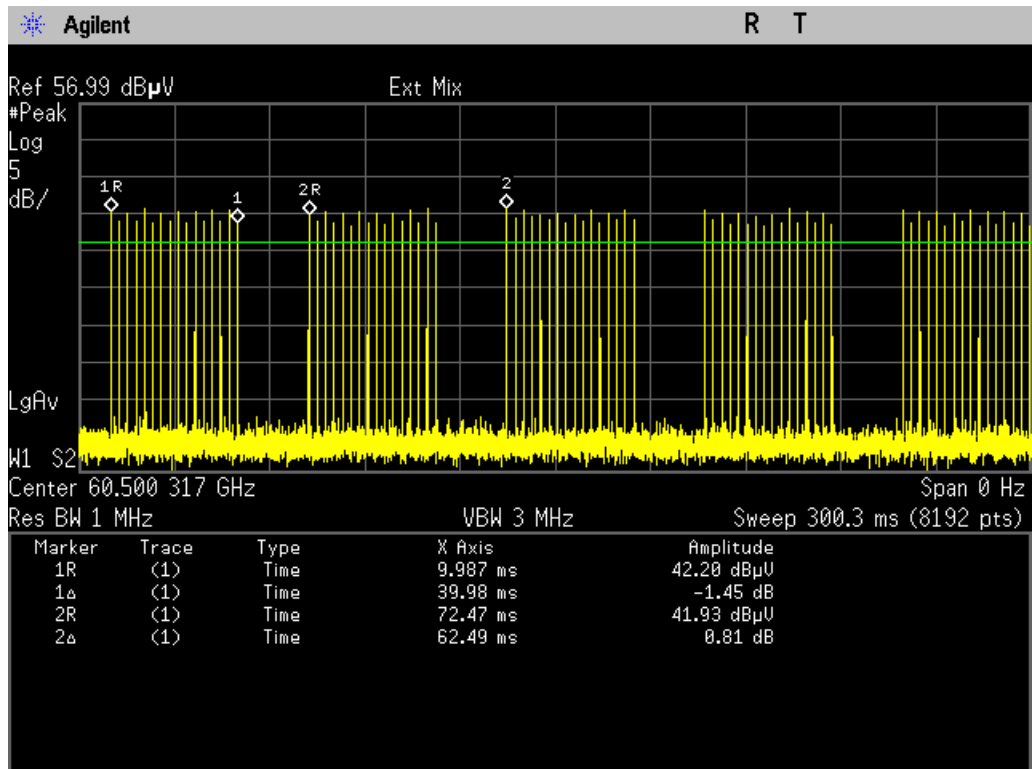
The timing diagram from the manufacturer was confirmed using a spectrum analyzer in zero span mode.

Timing information – Calculated from manufacturer timing diagram			
Description	Time	units	Source or calculation
1 chirp ramp up time	168.4	us	From timing diagram
1 chirp ramp down time	6	us	From timing diagram
1 chirp	174.4	us	= ramp up + ramp down time
1 chirp	0.1744	ms	Convert to ms
Off time between chirps	2.5	ms	From timing diagram
Chirp + off time	2784	us	= 1 chirp + off time
1 chirp + off time	2.784	ms	Convert to ms
# of chirps in 33 ms	12.34	---	= 33 ms / 1 chirp including off time
Total on time in 33 ms	2.09	ms	= 12*1 chirp
Total off time in 33 ms	30	ms	= 12* off time
Measured data			
1 chirp + off time	2.669	ms	Refer to timing plots from spectrum analyzer in zero span mode for measured results
# of chirps in 1 group	16	---	
1 group cycle time	62.49	ms	
Conclusion: The EUT off time of 30 ms for every 33 ms meets the requirements of 16.5 ms off time in 33 ms			

FMCW Chirp rep rate_60 ms span_16 pulses



FMCW Chirp rep rate_300 ms span



Radiated Output Power

Engineer: Greg Corbin

Test Date: 10/17/2024

Test Procedure

The radiated output power was measured using the procedures outlined in ANSI C63.10:2013 section 9.

The radiated output power was measured in normal operation with the FMCW signal sweeping from 57 – 64 GHz.

The EUT FMCW output was recorded from 57 – 64 GHz with the spectrum analyzer trace set to peak detector with max hold.

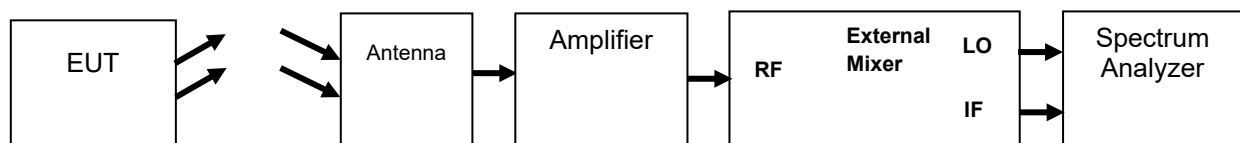
RBW = 1 MHz

Due to the signal BW of 7 GHz being greater than the RBW of 1 MHz a desensitization factor was added to the measurement per C63.10-2020 4.1.5.2.8 and Annex L.

Raw data was recorded with all correction factors added manually in the table below.

A mixer with an internal pre-selector filter was used for the fundamental signal.

Test Setup



Radiated Output Power Test Results

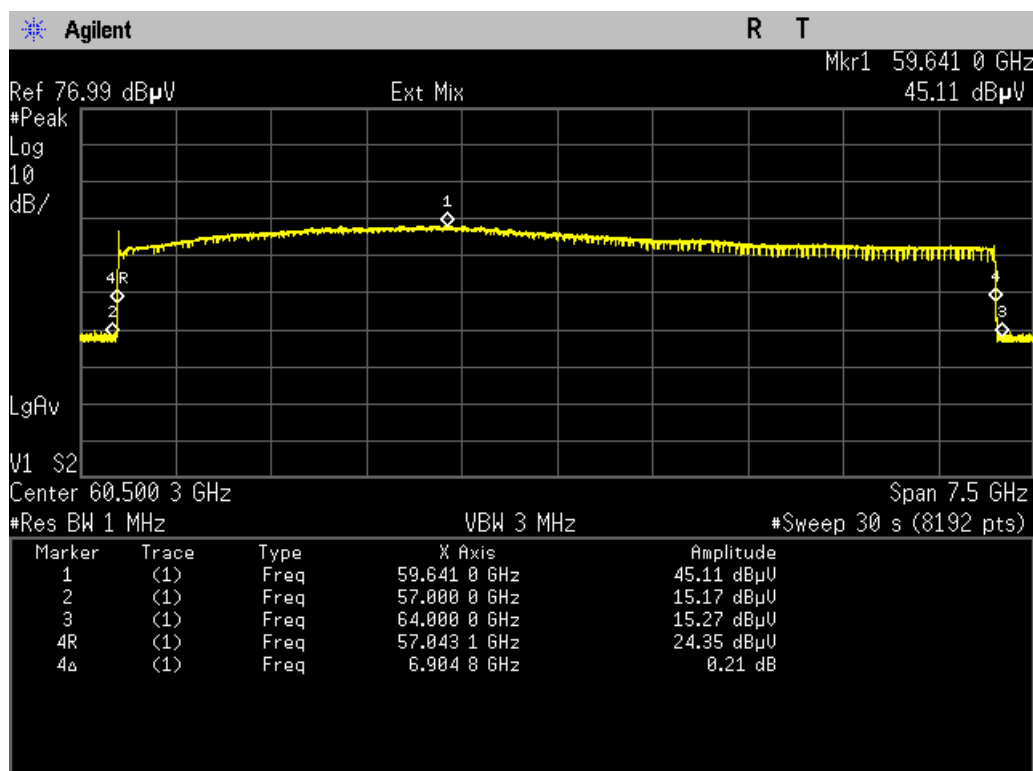
Radiated Spurious (raw data)		FMCW Desense Factor	Cable Insertion Loss	Ext Amp Gain	Receive Mixer C/F	Receive Antenna C/F	Field Strength (calculated)	EIRP (dBuV/m -104.77)	Limit	Margin	Pass / Fail
Freq	Level										
GHz	dBuV	dB	dB	dB	dB	dB	dBuV	dBm	dBm	dB	
59.641	45.11	12.43	0.76	38.9	43.90	42.69	105.99	1.22	20	-18.78	Pass

Field strength = Level + desense factor + cable insertion loss + mixer conversion loss+ antenna factor - amplifier gain

Desense calculation

Unit	Value	Description or Formula
BW _{chirp} (MHz)	6904.8	FMCW Chirp Bandwidth
T _{chirp} (uS)	174.4	FMCW Chirp Time
B (MHz)	1	3 dB IF Bandwidth = RBW
α (linear)	0.057	$\alpha = \frac{1}{\sqrt{1 + \left(\frac{2 \ln(2)}{\pi} \right)^2 \left(\frac{BW_{chirp}}{T_{chirp} B^2} \right)^2}}$
α (dB)	-12.43	=10*LOG(α (linear))

FMCW Chirp_57 - 64 GHz



Occupied Bandwidth

Engineer: Greg Corbin

Test Date: 10/17/2024

Test Procedure

The equipment was set-up as shown in the test set-up below.

The EUT was tested in FMCW mode with the spectrum analyzer set to peak detector, max hold.

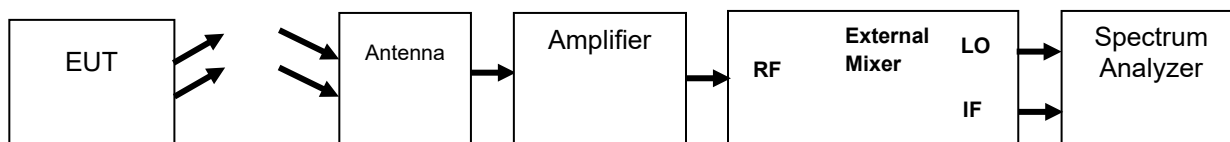
A slow sweep of 100 seconds was used to capture the full emission bandwidth.

A mixer with an internal preselector was used to measure the occupied bandwidth.

RBW = 1 MHz

The 10 dB and 26 dB bandwidths were recorded.

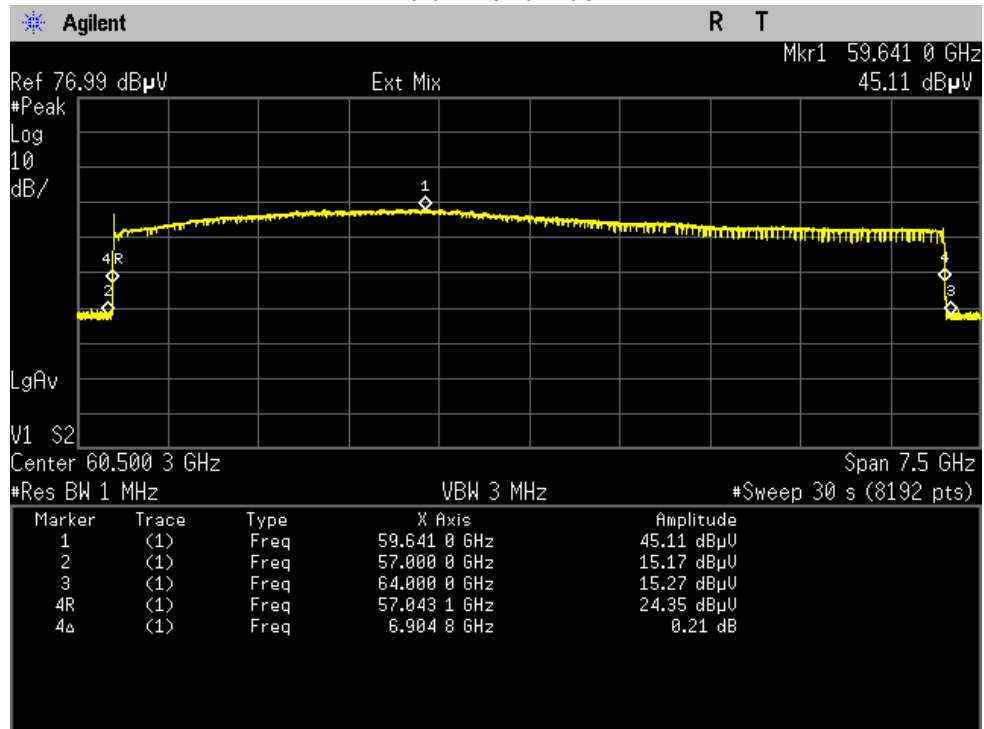
Test Setup



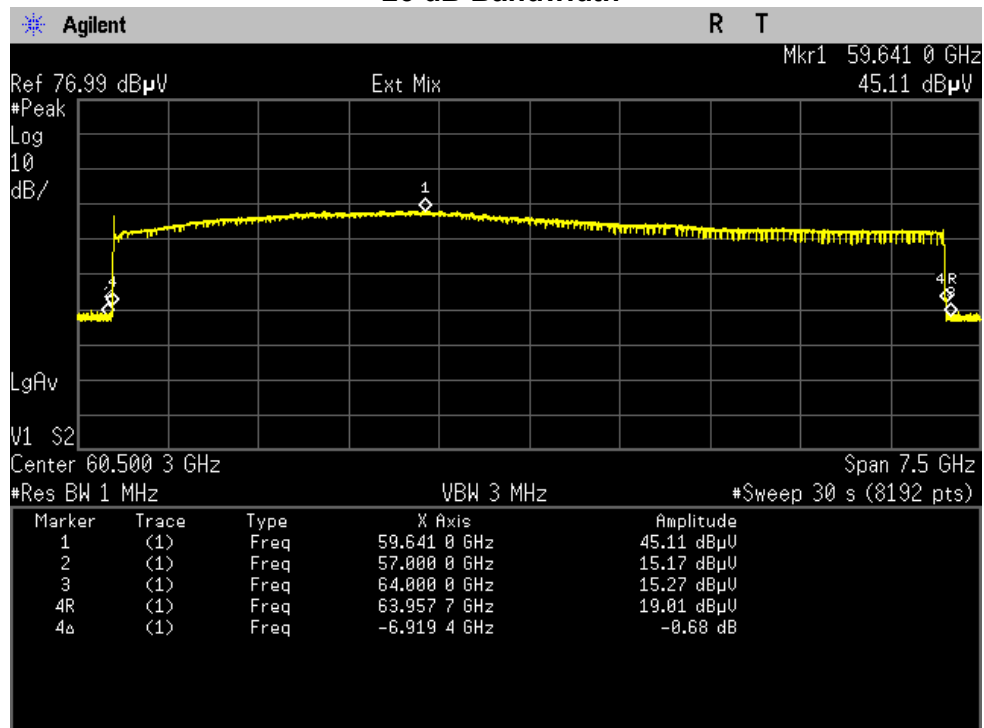
Frequency	Reference BW	Occupied Bandwidth	Limit	Pass / Fail
GHz	dB	GHz	GHz	
57 – 64	10	6.904.8	7.0	Pass
	26	6919.4	7.0	Pass

Occupied Bandwidth Plots

-10 dB Bandwidth



-26 dB Bandwidth



Radiated Spurious Emissions

Engineer: Greg Corbin

Test Date: 10-2-24, 10-4-24

Test Procedure

Radiated spurious emissions were recorded in an anechoic chamber with the EUT at a 3-meter distance for measurements below 40 GHz and 1-meter distance from the receive antenna for measurements above 40 GHz.

The EUT was placed in FMCW Chirp mode for all spurious measurements.

For measurements below 40 GHz, the correction factors were input to the spectrum analyzer before recording the measurement.

For measurements above 40 GHz, raw data was recorded with all correction factors added to the measurement in the table provided.

Cable Correction Factors include WG straight sections + IF cable.

No spurious signals were observed, and all results are spectrum analyzer noise floor measurements. The highest emission was recorded in the table below for each frequency band.

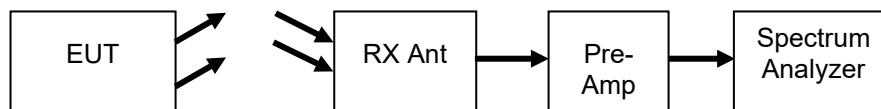
RBW = 100 kHz (30 – 1000 MHz)

RBW = 1 MHz (1 – 200 GHz)

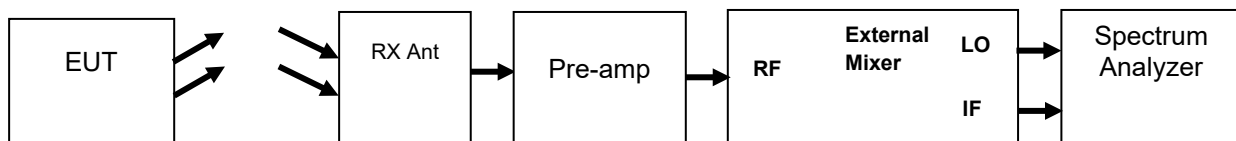
VBW = 3x RBW

Test Set-ups

30 MHz – 50 GHz



50 – 200 GHz



Radiated Spurious Emissions Test Results

30 MHz to 40 GHz Test Summary Table

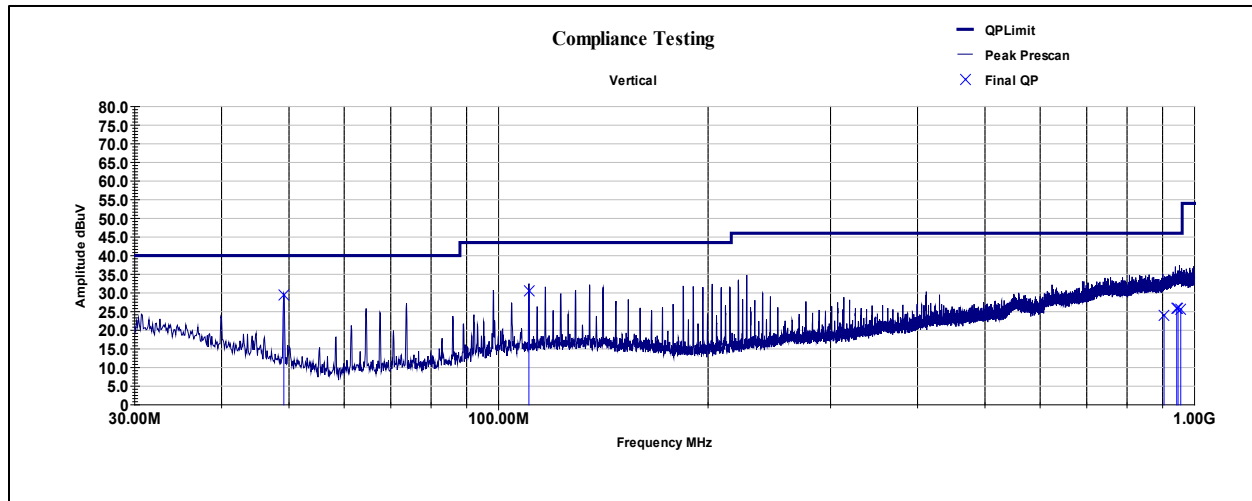
Freq Range	Detector	Measured Data		Limit	Margin	Pass / Fail
		Freq	Level			
		MHz	dBuV/m	dBuV/m	dB	
30 – 1000 MHz	QP	202.682	34.5	43.50	-9.0	Pass
1 – 18 GHz	Avg	17.438	46.8	54	-7.2	Pass
18 – 40 GHz	Avg	34.658	46.11	54	-7.9	Pass

40 – 200 GHz – Test Summary Table

Freq Range	Radiated Spurious (raw data)		Dist per standard	Dist. used	Dist. CF	FMCW Desense Factor	Cable Insertion Loss	Ext Amp Gain	Rcv Mixer C/F	Rcv Ant C/F	Field Strength (calc)	EIRP (dBuV/m -104.77)	Limit	Margin
	Freq	Level												
GHz	GHz	dBuV	m	m	dB	dB	dB	dB	dB	dB	dBuV	dBm	dBm	dB
40 - 50	46.169	55.00	3.00	3.00	0.00	12.43	14.63	47.07	0.00	40.20	75.19	-29.58	85.31	-18.95
50 - 75	53.411	17.25	1.00	1.00	0.00	12.43	0.74	43.08	34.96	42.17	64.47	-40.30	85.31	-18.78
75 - 110	87.380	20.02	3.00	1.00	-9.54	12.43	0.75	44.63	54.56	45.98	79.57	-25.20	85.31	-5.74
110 - 170	130.323	36.08	3.00	1.00	-9.54	12.43	0.96	49.3	12.22	49.59	52.44	-52.33	85.31	-32.87
170 - 200	199.620	22.14	3.00	1.00	-9.54	12.43	5.10	27.33	12.61	53.27	68.68	-36.09	85.31	-16.63

30 – 1000 MHz

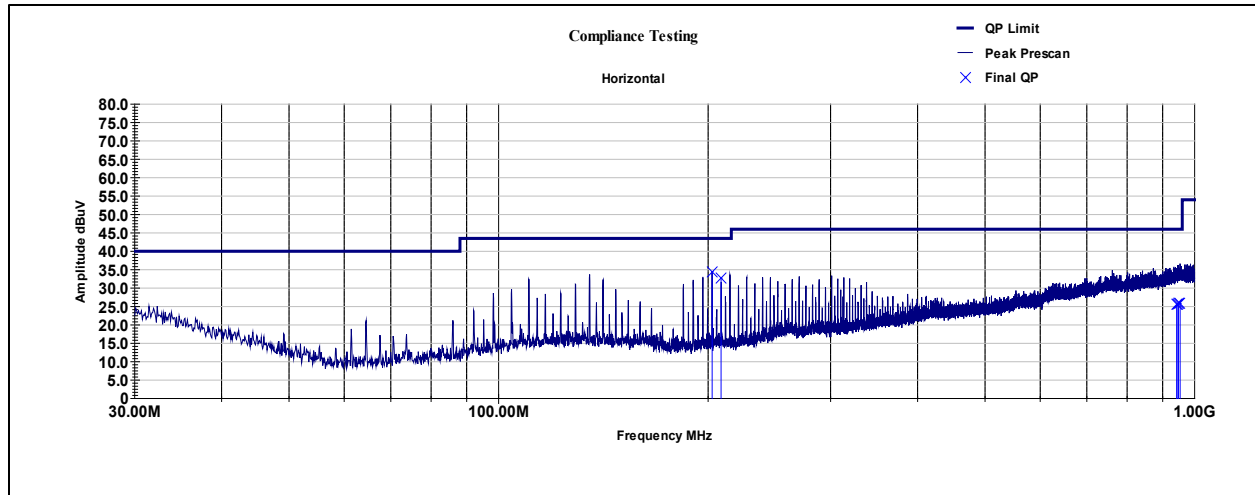
30 – 1000 MHz - Vertical



30 – 1000 MHz - Vertical

Frequency	Azimuth	Height	Raw QP	Correction	Final QP	Limit	QP Margin
MHz	deg	cm	dBuV	dB	dBuV/m	dBuV/m	dB
49.144	333.00	109.00	52.46	-23.06	29.40	40.00	-10.60
110.553	332.00	121.00	49.30	-18.72	30.60	43.50	-12.90
904.111	351.00	226.00	27.03	-2.91	24.10	46.00	-21.90
942.864	209.00	285.00	27.08	-1.21	25.90	46.00	-20.10
947.144	245.00	302.00	26.87	-1.09	25.80	46.00	-20.20
955.615	49.00	148.00	26.83	-1.19	25.60	46.00	-20.40
Final = Raw + Path Loss							
Margin = Final - Limit							

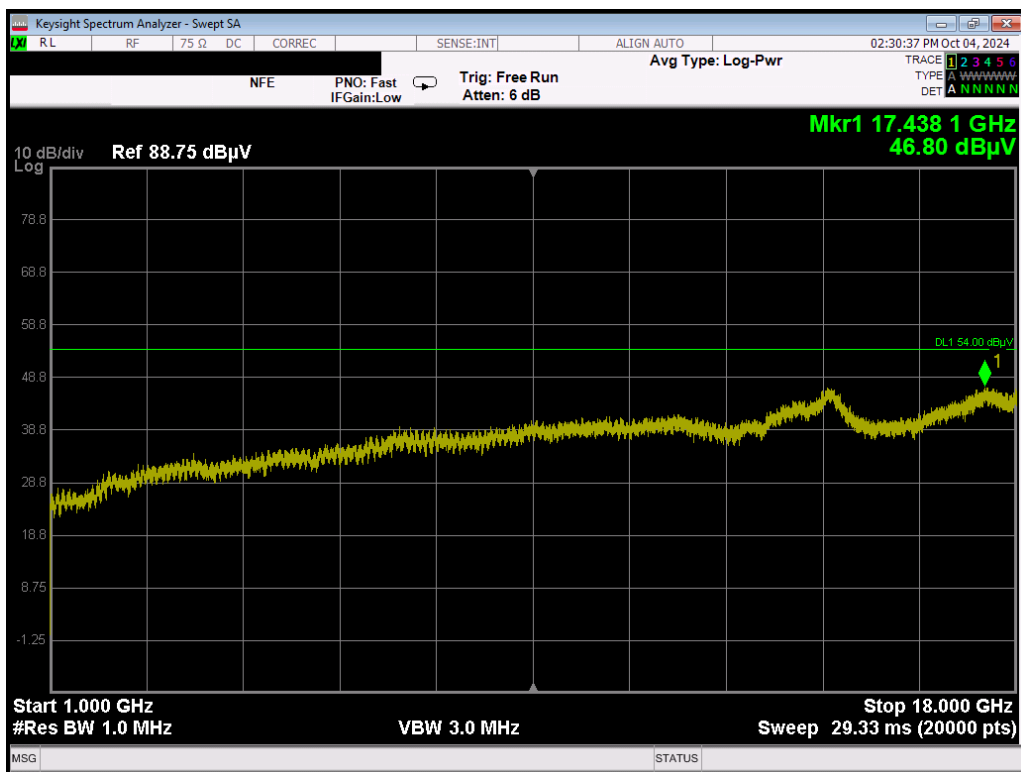
30 – 1000 MHz - Horizontal



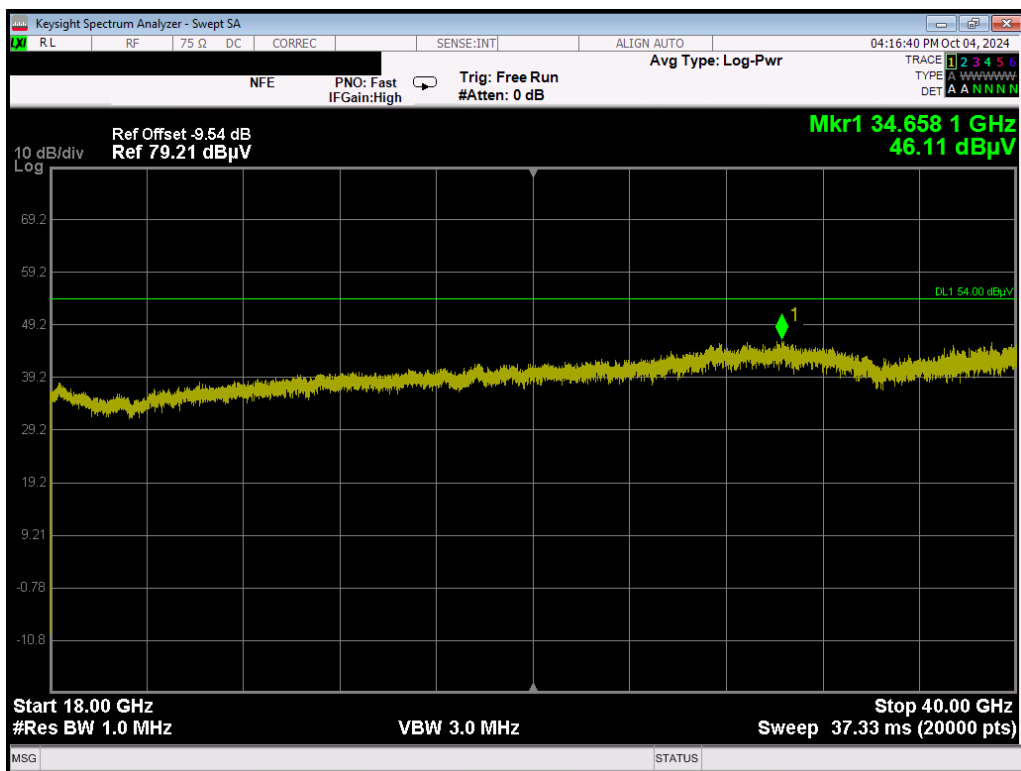
30 – 1000 MHz - Horizontal

Frequency	Azimuth	Height	Raw QP	Correction	Final QP	Limit	QP Margin
MHz	deg	cm	dBuV	dB	dBuV/m	dBuV/m	dB
202.682	98.00	148.00	54.81	-20.33	34.50	43.50	-9.00
208.788	101.00	148.00	52.76	-20.10	32.70	43.50	-10.80
942.097	332.00	331.00	26.93	-1.42	25.50	46.00	-20.50
946.271	284.00	281.00	26.84	-1.29	25.60	46.00	-20.40
948.1	285.00	132.00	26.96	-1.18	25.80	46.00	-20.20
953.294	359.00	356.00	26.95	-1.13	25.80	46.00	-20.20
Final = Raw + Path Loss							
Margin = Final - Limit							

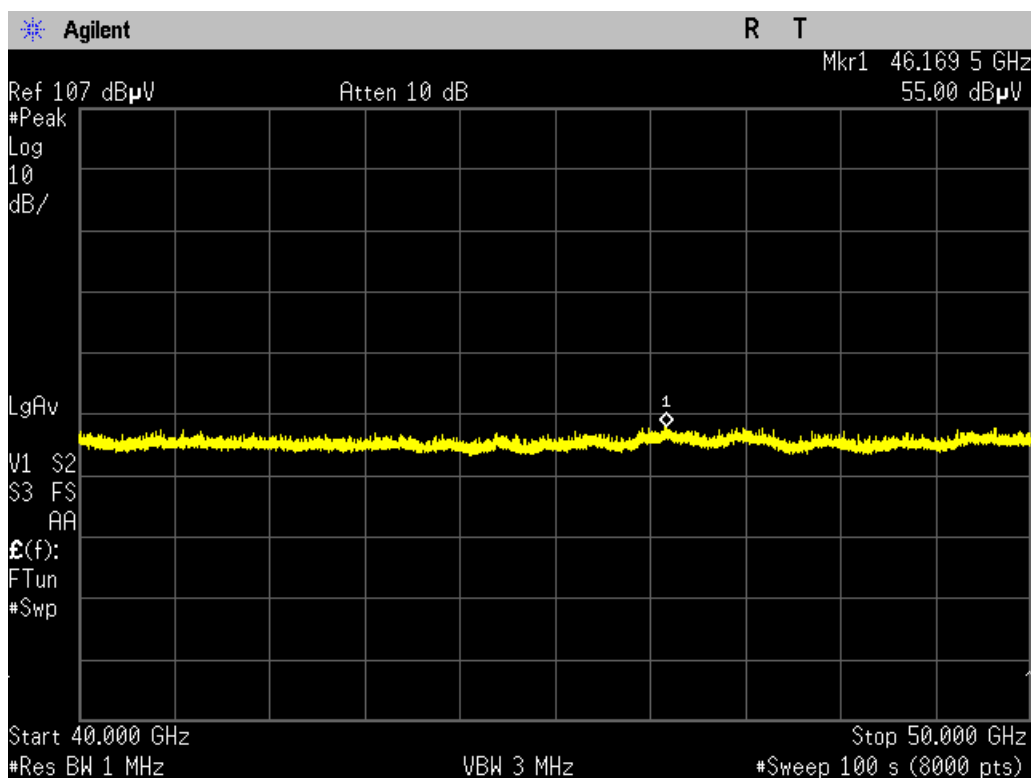
1 - 18 GHz_ correction factors loaded into spectrum analyzer



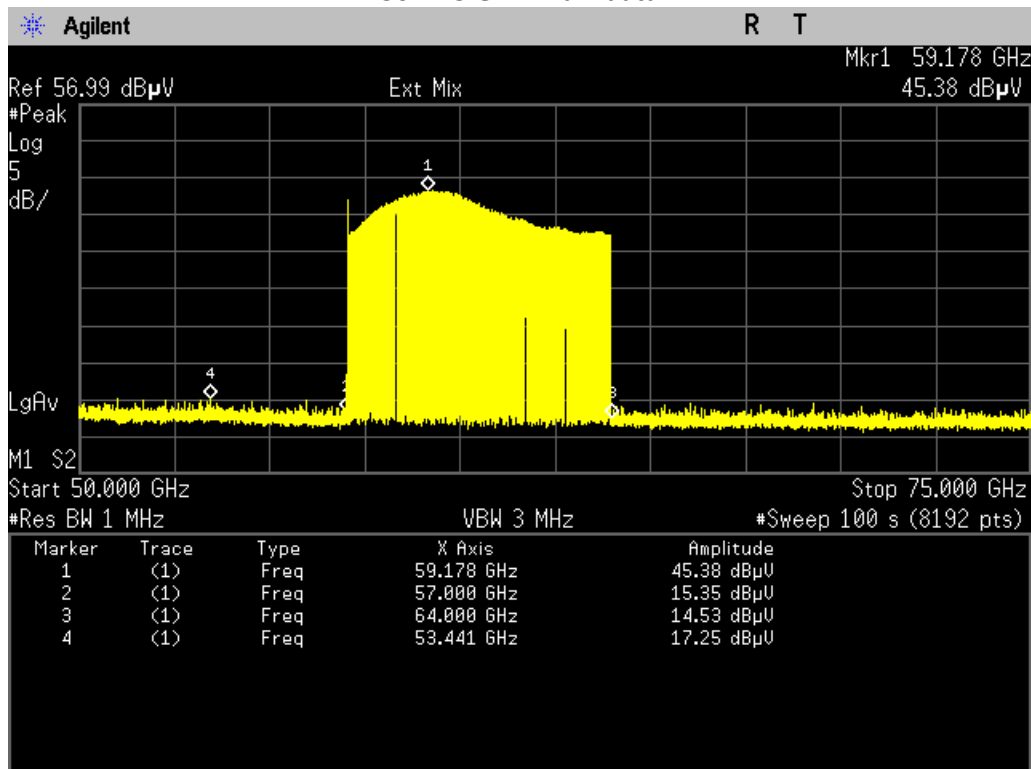
18 – 40 GHz_ correction factors loaded into spectrum analyzer



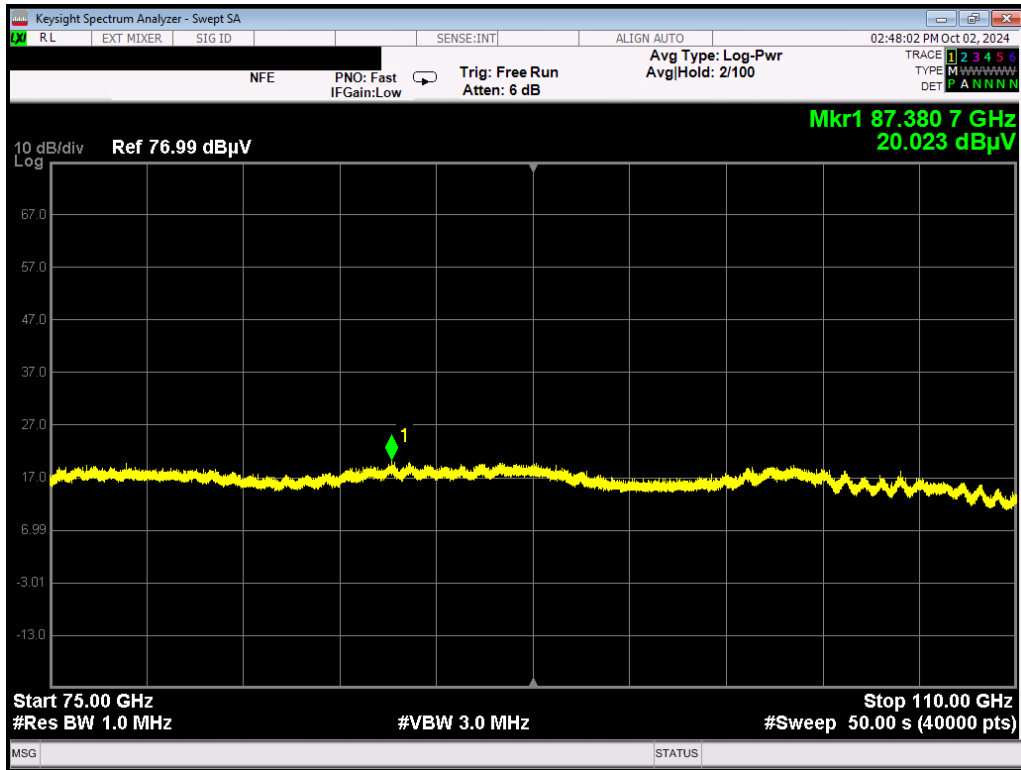
40 – 50 GHz – raw data



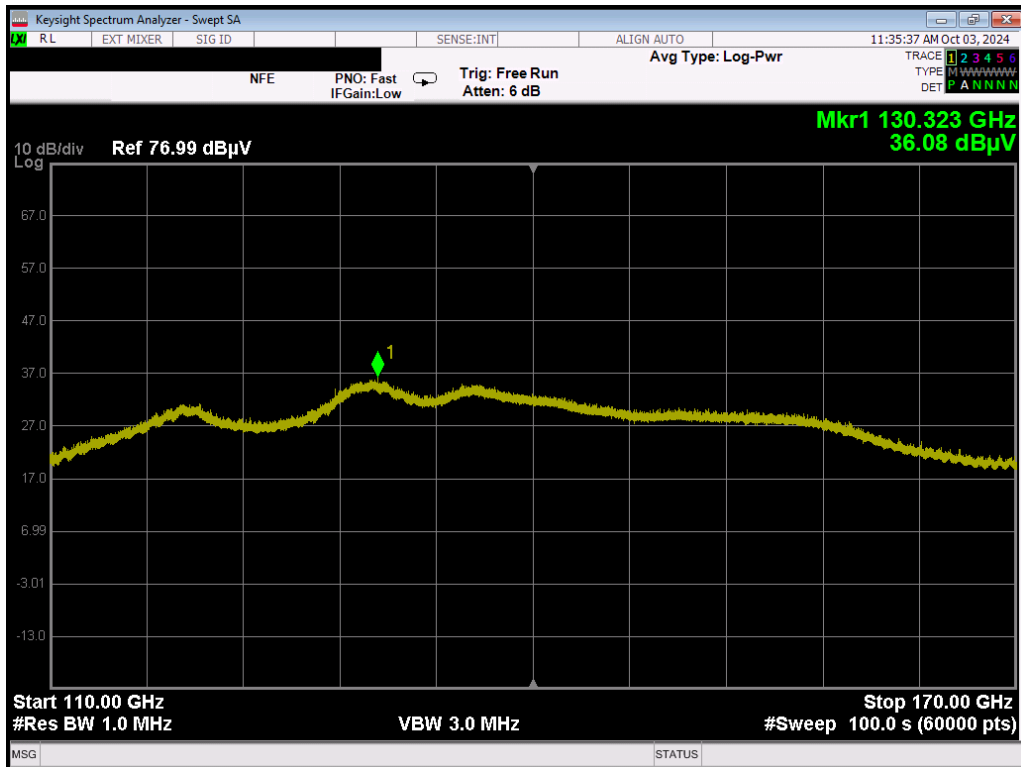
50 – 75 GHz – raw data



75 – 110 GHz – raw data



110 – 170 GHz - raw data



Frequency Stability

Engineer: Greg Corbin

Test Date: 10/7/2024

Test Procedure

The EUT was tested in an environmental chamber with the transmitting antenna pointing directly out of an access port.

15.255(f) states:

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.

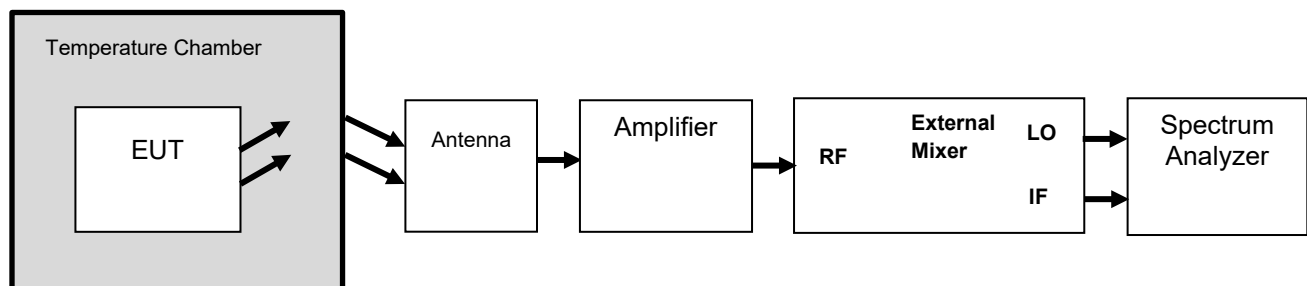
A spectrum analyzer was used to measure the frequency stability.

The EUT lower and upper band edge was recorded every 10 degrees from -20 to $+50$ deg C.

At 20 deg C, the EUT input voltage was varied $\pm 15\%$.

The EUT operated completely within the band of 57 – 64 GHz in all temperature conditions.

Test Setup



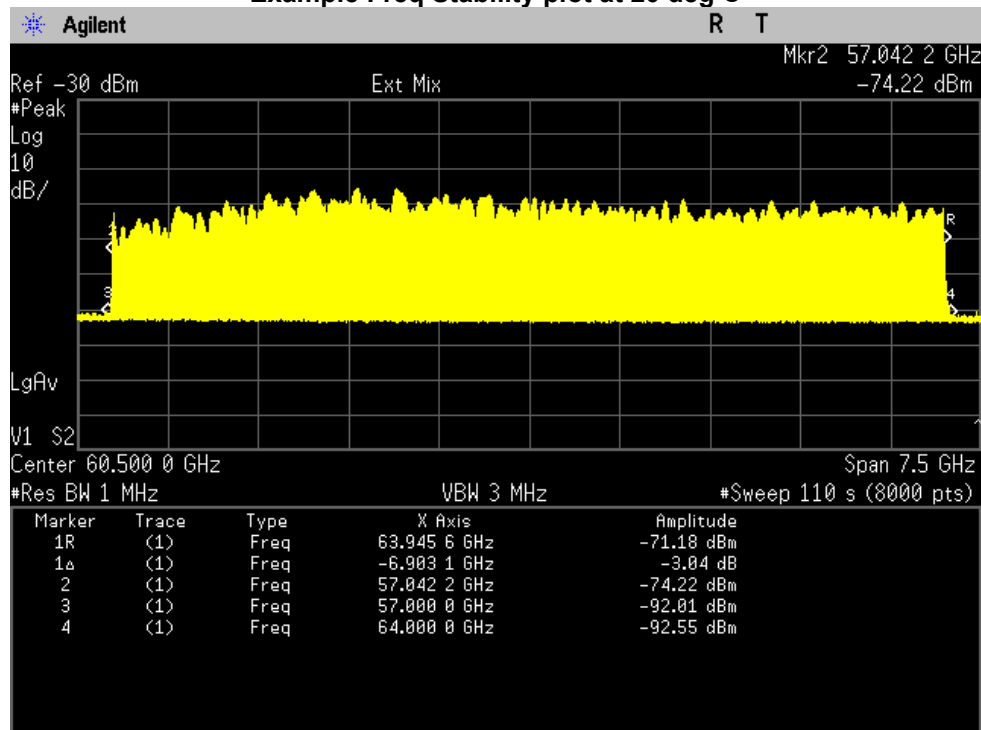
Frequency Stability vs Temperature

Temperature	Band Edge Limit		Band Edge Measured		Margin		Pass / Fail
	Lower	Upper	Lower	Upper	Lower	Upper	
deg C	GHz	GHz	GHz	GHz	GHz	GHz	
-20	57000	64000	57045.7	63942.6	45.7	57.4	Pass
-10	57000	64000	57045.9	63943.7	45.9	56.3	Pass
0	57000	64000	57043.1	63947.5	43.1	52.5	Pass
10	57000	64000	57045.3	63941.9	45.3	58.1	Pass
20	57000	64000	57042.5	63945.6	42.5	54.4	Pass
30	57000	64000	57044.4	63944.7	44.4	55.3	Pass
40	57000	64000	57043.7	63942.8	43.7	57.2	Pass
50	57000	64000	57045.6	63943.7	45.6	56.3	Pass

Frequency Stability vs Voltage

Temperature	Input Voltage	Band Edge Limit		Band Edge Measured		Margin from Band Edge		Pass / Fail
		Lower	Upper	Lower	Upper	Lower	Upper	
deg C	vdc	MHz	MHz	MHz	MHz	MHz	MHz	
20	10.2	57000	64000	57041.6	63949.4	41.6	50.6	Pass
	12	57000	64000	57042.5	63945.6	42.5	54.4	Pass
	13.8	57000	64000	57042.5	63946.6	42.5	53.4	Pass

Example Freq Stability plot at 20 deg C



Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Temperature Chamber	Tenney	Tenney Jr	i00027	NR	
Data Logger	Fluke	Hydra Data Bucket	i00343	6/19/204	6/19/2025
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	7/13/23	7/13/26
Temp./humidity/pressure monitor (Main Lab)	Omega Engineering	iBTHX-W-5	i00686	1/25/204	1/25/2025
Voltmeter	Fluke	79III	i00499	10/15/24	10/15/25
PSA Spectrum Analyzer	Agilent	E4445A	i00471	1/5/24	1/5/25
MXE EMI receiver	Keysight	N9038A	i00552	3/1/24	3/1/25
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	2/7/23	2/7/25
Horn Antenna	ARA	DRG-118/A	i00271	8/9/24	8/9/26
Horn Antenna (18-40GHz)	EMCO	3116	i00085	3/14/23	3/14/25
Horn Antenna, standard gain	CMI	HO22R	i00484	NR	NR
Horn Antenna, standard gain	CMI	HO15R	i00477	NR	NR
Horn Antenna, standard gain	CMI	HO10R	i00476	NR	NR
Horn Antenna, standard gain	CMI	HO6R	i00475	NR	NR
Horn Antenna, standard gain	CMI	HO4R	i00473	NR	NR
Harmonic Mixer	Agilent	11970W	i00464	Verified on: 7/11/24	
Mixer with Preselector	Hewlett Packard	11974	i00726	Verified on: 9/23/24	
Spectrum Analyzer Extension Module	VDI	WR4.3SAX-M	i00740	Verified on: 7/11/24	
Spectrum Analyzer Extension Module	VDI	WR6.5SAX-M	i00741	Verified on: 9/24/24	
LNA	Preamplifier	SBL-1141743065-0606-E 1	i00658	Verified on: 9/30/24	
Preamplifier	Eravant	SBB-0115034019-2F2F-E3	i00588	Verified on: 9/3/24	
LNA	Eravant	SBL-7531143550-1010-E 1	i00589	Verified on: 9/3/24	
Preamplifier	VDI	VDIWR4.3PAMP	i00682	Verified on: 9/24/24	
Preamplifier	Eravant	SBB-0115034019-2F2F-E3	i00722	Verified on: 9/9/24	
Preamplifier	Com Power	PAM-103	i00734	Verified on: 9/9/24	
Power Meter w/859V power sensor (75 – 110 GHz)	VDI	PM5B with 859V sensor	i00736	6-25-24	6-5-25
Waveguide taper WR10 to WR6.5	VDI	WR6.5TA	i00737	N/A	

Waveguide taper WR10 to WR4.3	VDI	WR4.3TA	i00738	N/A
Waveguide Extension, WR-15	Eravant	SWG-15020-FB	i00664	N/A
Waveguide Extension, WR-15	VDI	WR15SWG2R4	i00749	N/A
Waveguide Extension, WR-10	Eravant	SWG-10020-FB	i00665	N/A
Waveguide Extension, WR-06	OML	N/A	i00748	N/A
Waveguide Extension, WR-04	Eravant	STQ-WG-04020-F1-A-R	i00750	N/A

In addition to the equipment listed above, standard RF connectors and cables were utilized in the testing of the equipment described. Prior to testing these components were tested to verify proper operation.

Measurement Uncertainty

Measurement Uncertainty for Compliance Testing is listed in the table below.

Measurement	U_{lab}
Radio Frequency	$\pm 3.3 \times 10^{-8}$
RF Power, conducted	± 1.5 dB
RF Power Density, conducted	± 1.0 dB
Conducted Emissions	± 1.8 dB
Radiated Emissions 30Mhz-1000MHz	± 4.25 dB
Radiated Emissions – 1GHz-18GHz	± 4.5 dB
Temperature	± 1.5 deg C
Humidity	± 4.3 %
DC voltage	± 0.20 VDC
AC Voltage	± 1.2 VAC

The reported expanded uncertainty $\pm U_{lab}$ (dB) has been estimated at a 95% confidence level ($k=2$) U_{lab} is less than or equal to U_{EMC} therefore;

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit.
- Non-Compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

END OF TEST REPORT