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FCC TEST REPORT

Prepared for:	**Garmin International, Inc.**
Address:	**1200 East 151st Street** **Olathe, KS 66062**
Product:	**GMN-02620**
Test Report No:	**R231201-00-E1B**
Approved By:	

Fox Lane,
EMC Test Engineer

DATE:	**August 2, 2024**
Total Pages:	**31**

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ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	28 June 2024	Issued by FLane Reviewed by KVepuri Prepared by FLane
A	9 July 2024	Updated Duty Cycle – FL
B	22 July 2024	Corrected Duty Cycle table – FL
C	2 August 2024	Added Mode Description – FL

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 87.131 FCC Part 2.1051	RF Output Power / Emissions	Complies
FCC Part 87.135 FCC Part 2.1055	Bandwidth of Emissions	Complies
FCC Part 87.139 FCC Part 2.1057	Emission Limitations	Complies
FCC Part 87.141 FCC Part 2.1053	Modulation Requirements	Complies
FCC Part 87.133	Frequency Stability	Complies

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Model	GMN-02620
FCC ID	IPH-04371
EUT Received	16 April 2024
EUT Tested	13 May 2024- 7 June 2024
Serial No.	704000106
Operating Band	1025 MHz – 1150 MHz
Device Type	Licensed Radio
Power Supply	14VDC/28VDC

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Mode	CHANNEL FREQUENCY (MHz)
X	1025
X	1088
X	1150
Y	1025
Y	1088
Y	1150

See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worst-case scenario. The device was investigated on all 3 orthogonal axes, worst case was reported. The manufacturer modified the unit to transmit continuously on 6 different modes. Differences in emissions due to voltage were investigated and worst case was used for testing, 28VDC. Differences between X and Y mode is pulse spacing, Mode X, 12uS spacing. Mode Y, 36uS spacing.

2.3 DESCRIPTION OF SUPPORT UNITS

NA

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

All testing was performed by Fox Lane and Blake Winter of NCEE Labs. The results were reviewed by Karthik Vepuri.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 17, 2023	July 17, 2025
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	July 17, 2023	July 17, 2025
SunAR RF Motion	JB1	A091418	July 27, 2023	July 26, 2024
ETS-Lindgren Red Horn Antenna	3115	218576	July 31, 2023	July 30, 2024
Agilent Preamp*	87405A	3207A01475	May 2, 2024	May 2, 2026
ETS Red Preamplifier (Orange)*	3115-PA	00218576	January 22, 2024	January 22, 2026
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	May 15, 2024	May 15, 2027
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 22, 2024	May 22, 2026
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	June 5, 2023	June 5, 2025
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3874	June 5, 2023	June 5, 2025
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	June 5, 2023	June 5, 2025
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	June 5, 2023	June 5, 2025
N connector bulkhead (control room)*	PE9128	NCEEBH2	June 5, 2023	June 5, 2025
TDK Emissions Lab Software	V11.25	700307	NA	NA

*Internal Characterization

4.0 DETAILED RESULTS

4.1 SPURIOUS EMISSIONS & EMISSION MASKS

Test Method: ANSI C63.26:2015:
Section 5.5, “Radiated Emissions Testing”

Limits for field strength of emissions measurements:
FCC Part 87.139:

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 log10 pY dB.

Test procedures:
The EUT was connected directly to a spectrum analyzer using attenuators to protect the test equipment. Analyzer measurement settings can be found in the plots below along with the corresponding power levels.

Emissions were performed using conducted method for emission mask.
Radiated emissions were investigated at 3m test distance and with 50Ohm load on antenna port.

Deviations from test standard:
No deviation.

Test setup:

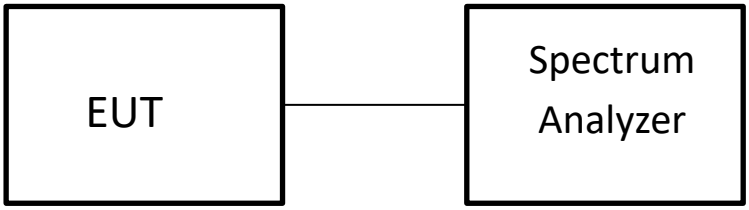

Figure 1 - Conducted Spurious Test Setup

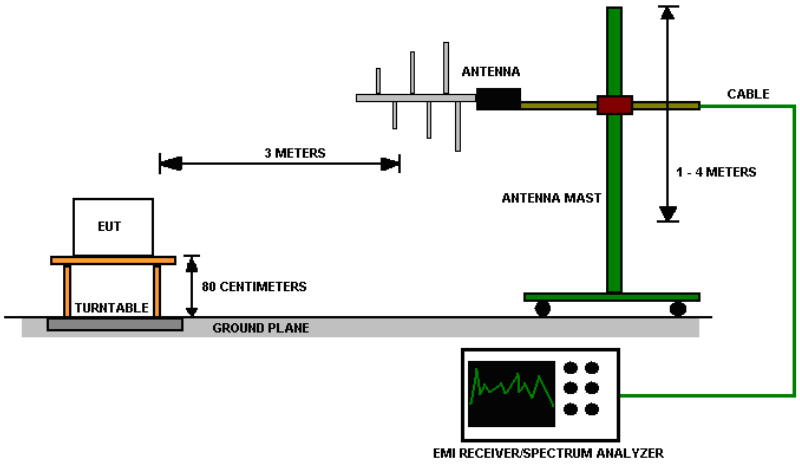

Figure 2 - Radiated Emissions Test Setup

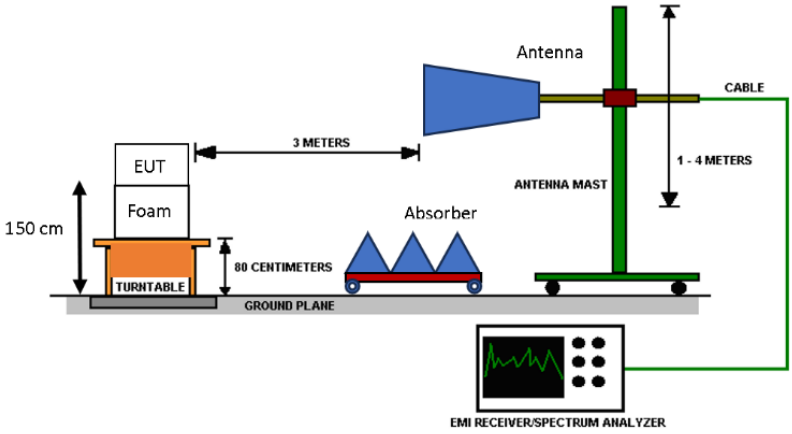

Figure 3 - Radiated Emissions Test Setup, 1GHz – 18GHz

EUT operating conditions
See Section 2.1 & 2.2

Test results:

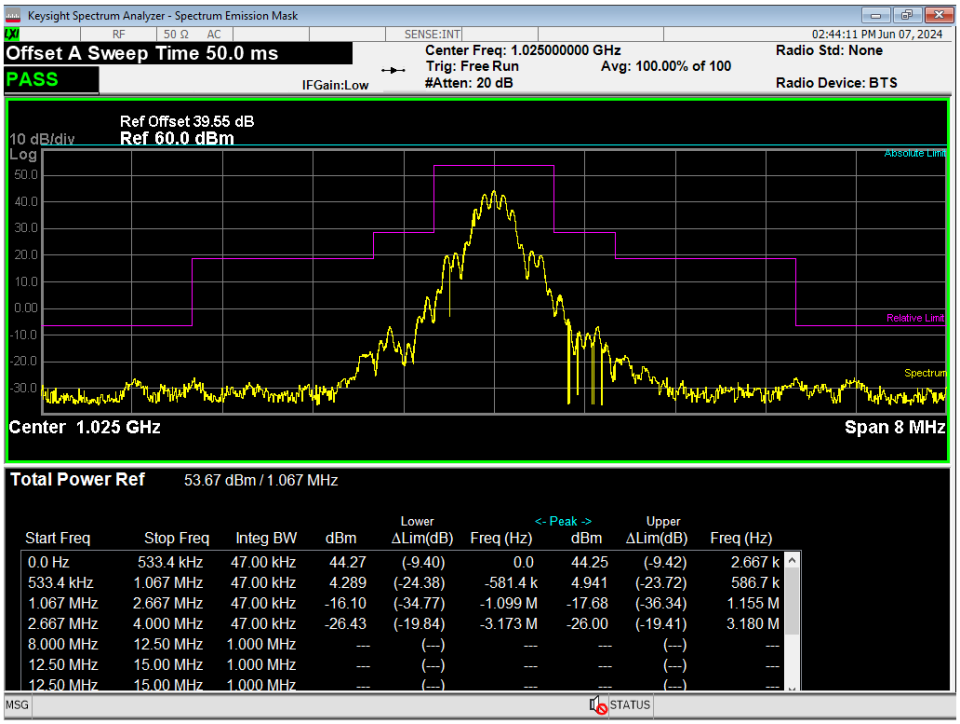

Figure 4 – Emissions Masks Plot, Mode X, 1025MHz

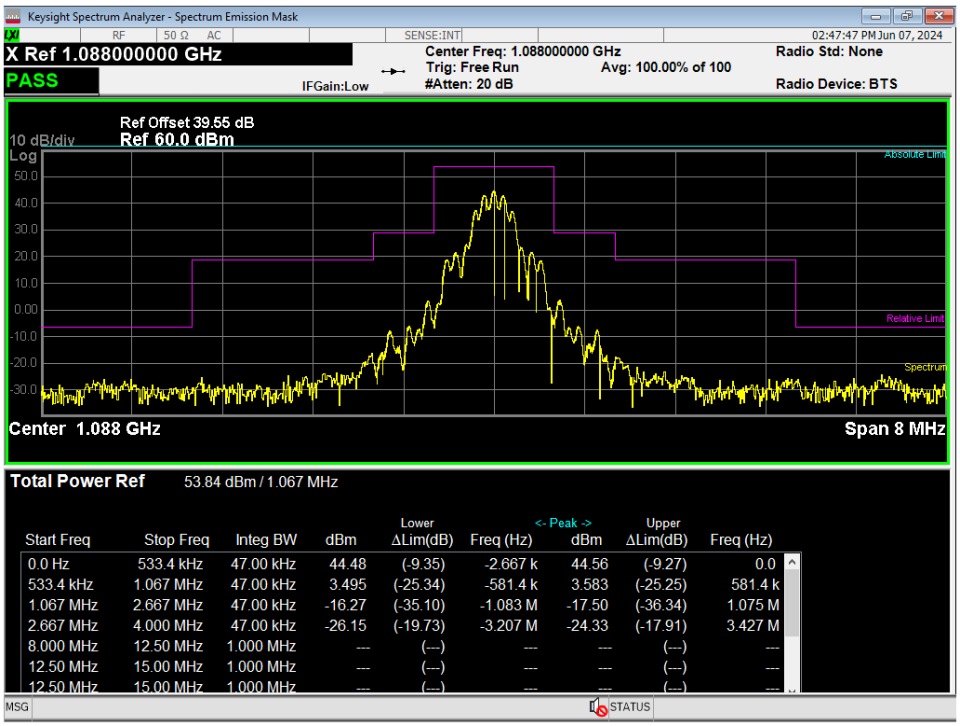

Figure 5 – Emissions Masks Plot, Mode X, 1088MHz

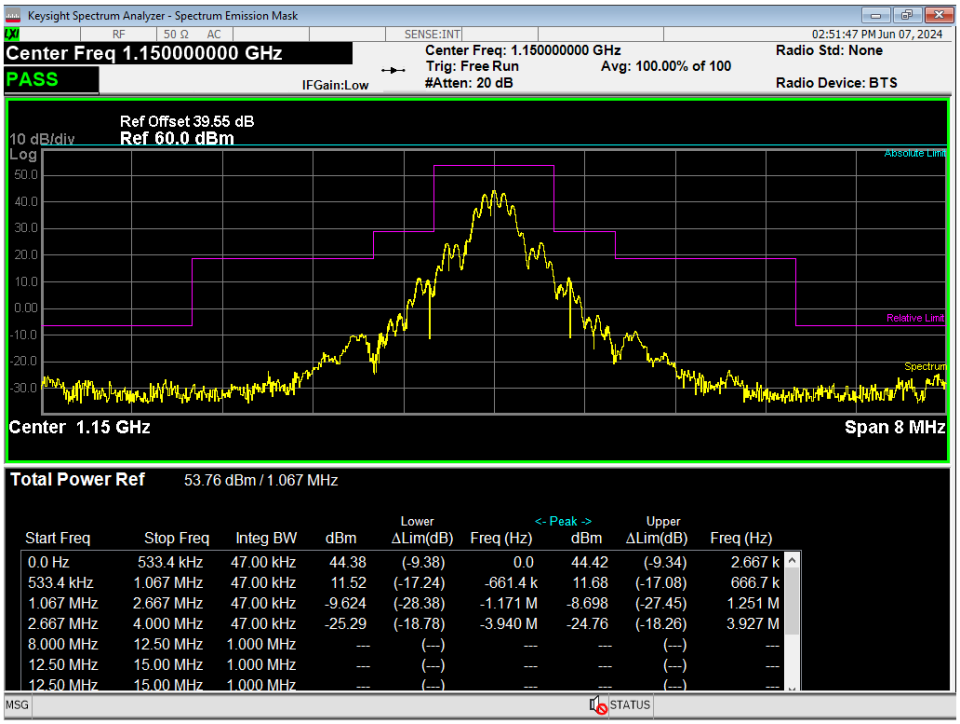

Figure 6 – Emissions Masks Plot, Mode X, 1150MHz

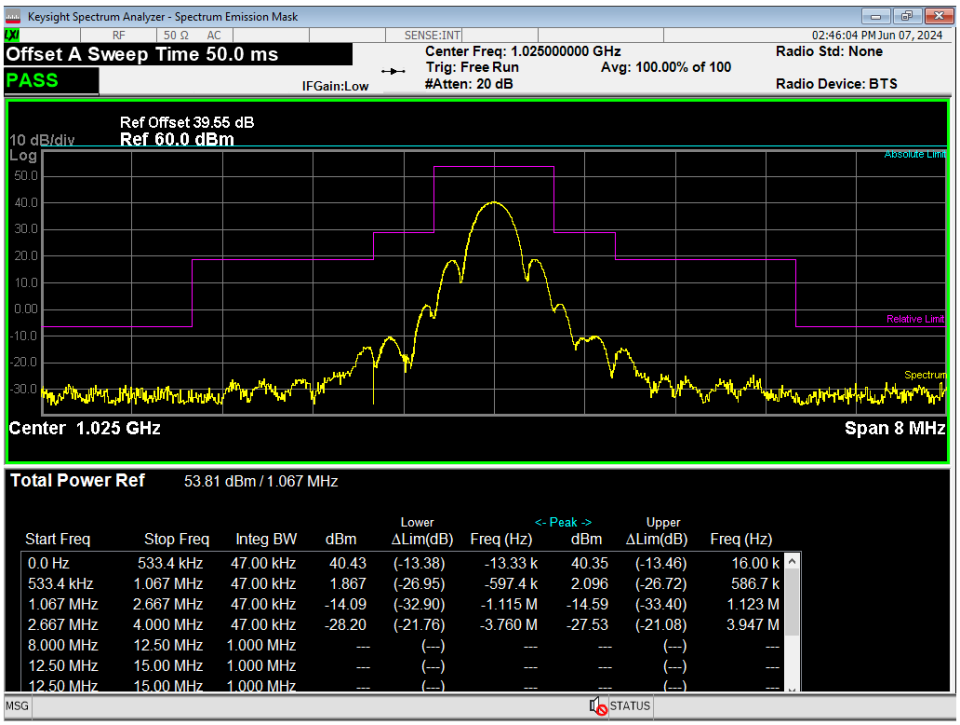

Figure 7 – Emissions Masks Plot, Mode Y, 1025MHz

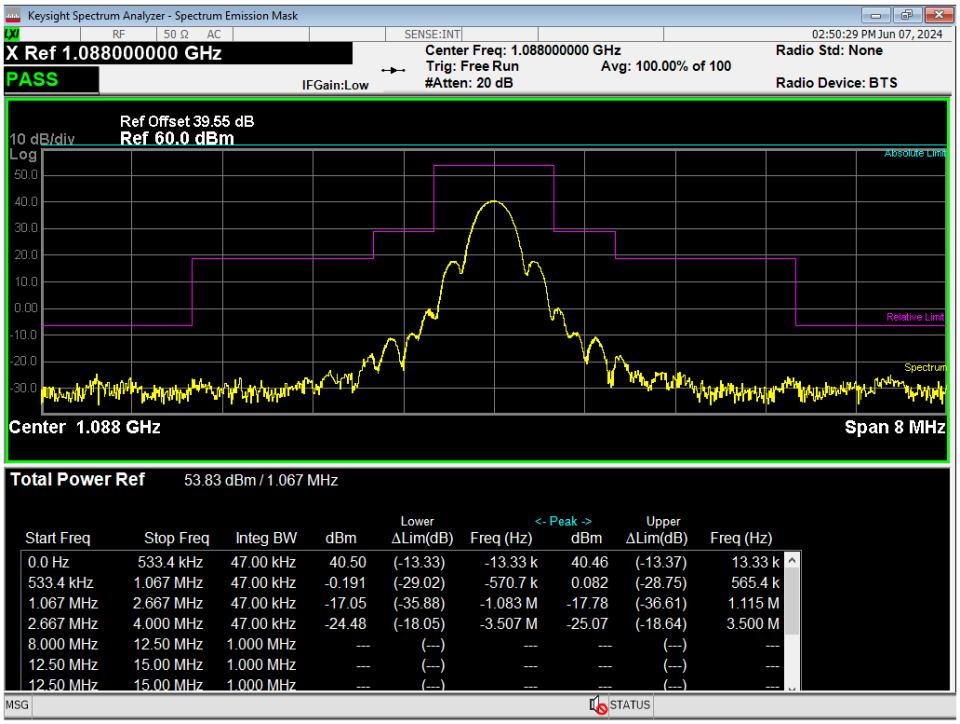

Figure 8 – Emissions Masks Plot, Mode Y, 1088MHz

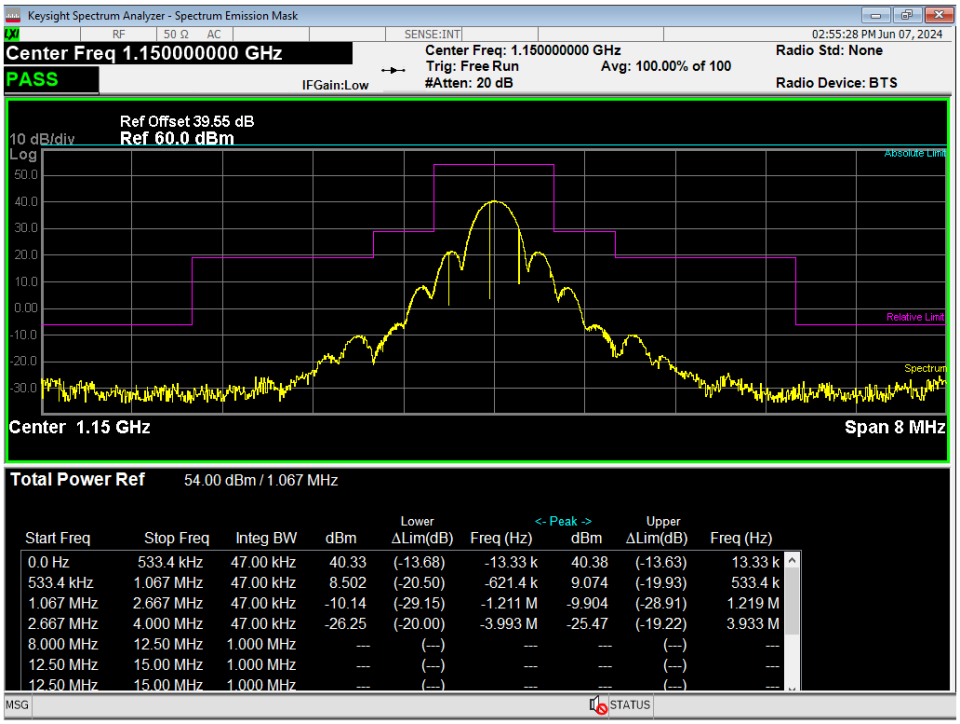

Figure 9 – Emissions Masks Plot, Mode Y, 1150MHz

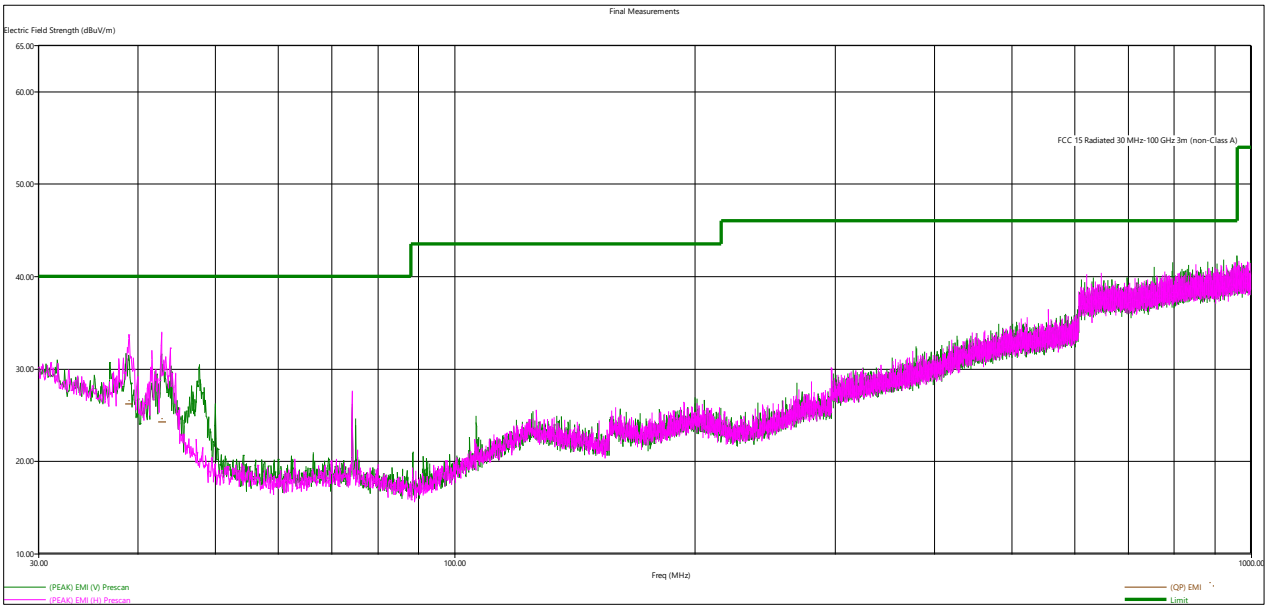

Figure 10 – Radiated Emissions, 30MHz – 1GHz, Mode X

Freq (Max)	(QP) EMI	Limit	(QP) Margin	Twr Ht	Ttbl Ang	Pol
(MHz)	(dBuV/m)	(dBuV/m)	(dB)	(cm)	(deg)	
38.910000	26.10	40.00	13.90	263.73	208.25	H
42.711360	24.17	40.00	15.83	379.13	76.50	H

EUT was investigated on all 3 orthogonal axes, and the worst case was reported.
All other emissions including above 1 GHz were found to be at least 6dB below applicable limit line

4.2 OUTPUT POWER

Test Method: ANSI C63.26-2015
Section(s) 5.2.3.3

Limits of power measurements:
FCC Part 87.131

Test procedures:
All the measurements were done in spectrum analyzer mode with the resolution bandwidth greater than the occupied bandwidth. Peak detector and max hold used.

Deviations from test standard:
No deviation.

Test setup:

Figure 11 – Output Power Measurements Test Setup

EUT operating conditions:
See Section 2.1 & 2.2

Test results:

Output Power

Mode	CHANNEL FREQUENCY (MHz)	Duty Cycle Correction Factor ($DCCF_{Power}$) (dBm)	Peak Output Power (dBm)	Average Output Power (dBm)	Average Output Power (W)	Method	RESULT
X	1025	26.99	55.223	28.233	0.666	Conducted	PASS
X	1088	26.99	55.509	28.519	0.711	Conducted	PASS
X	1150	26.99	55.574	28.584	0.722	Conducted	PASS
Y	1025	26.99	55.388	28.398	0.692	Conducted	PASS
Y	1088	26.99	55.498	28.508	0.709	Conducted	PASS
Y	1150	26.99	55.568	28.578	0.721	Conducted	PASS

Average Power = Peak Power Level – $DCCF_{Power}$

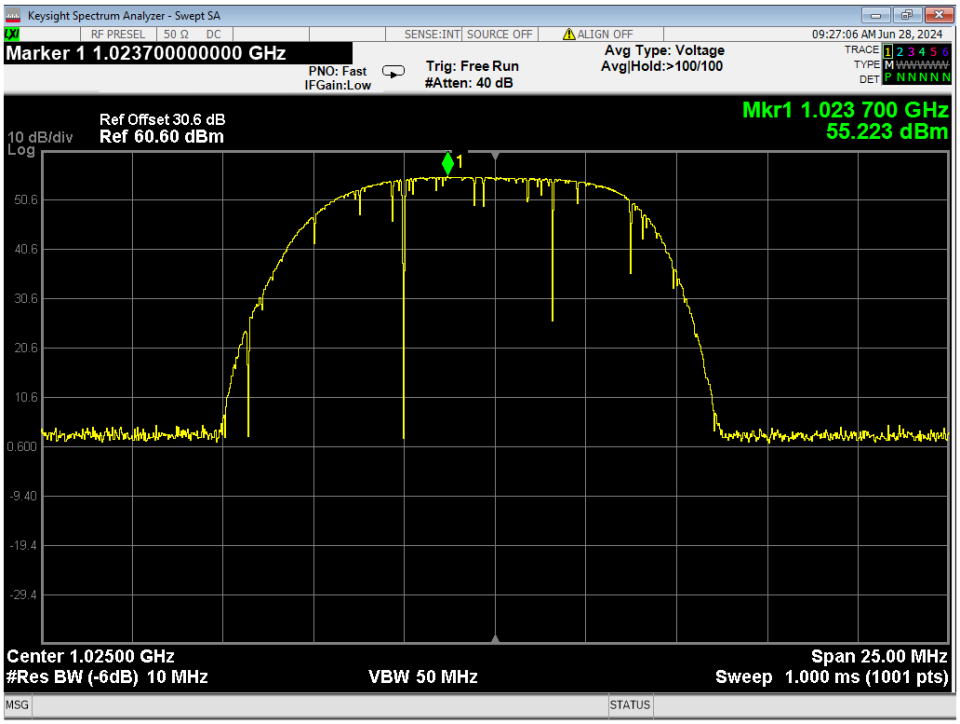

Figure 12 – Peak Power, Mode X, 1025MHz

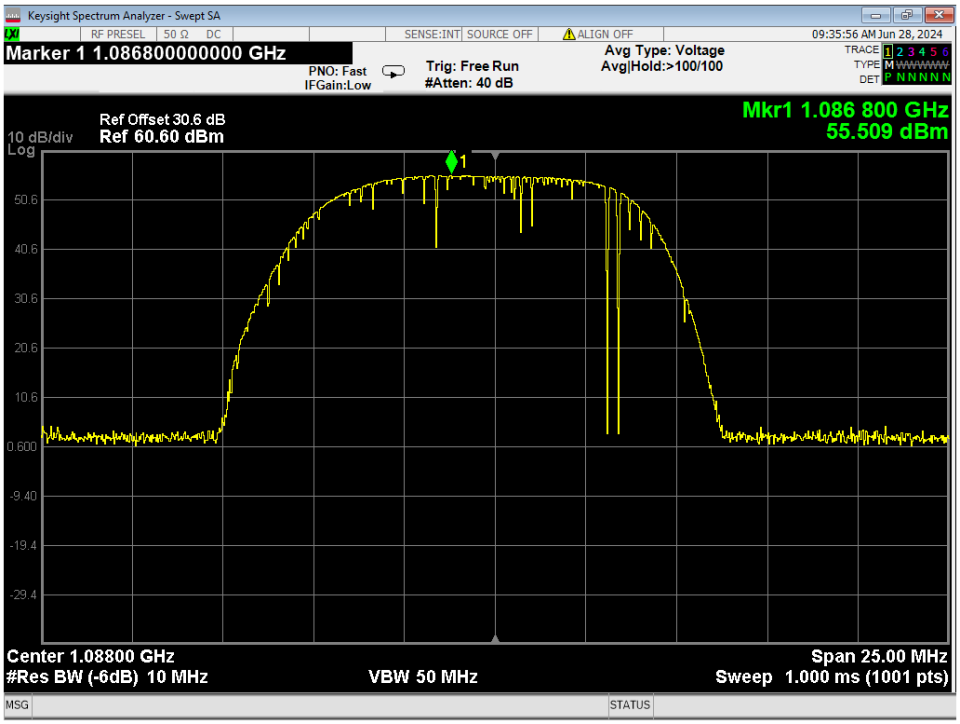

Figure 13 – Peak Power, Mode X, 1088MHz

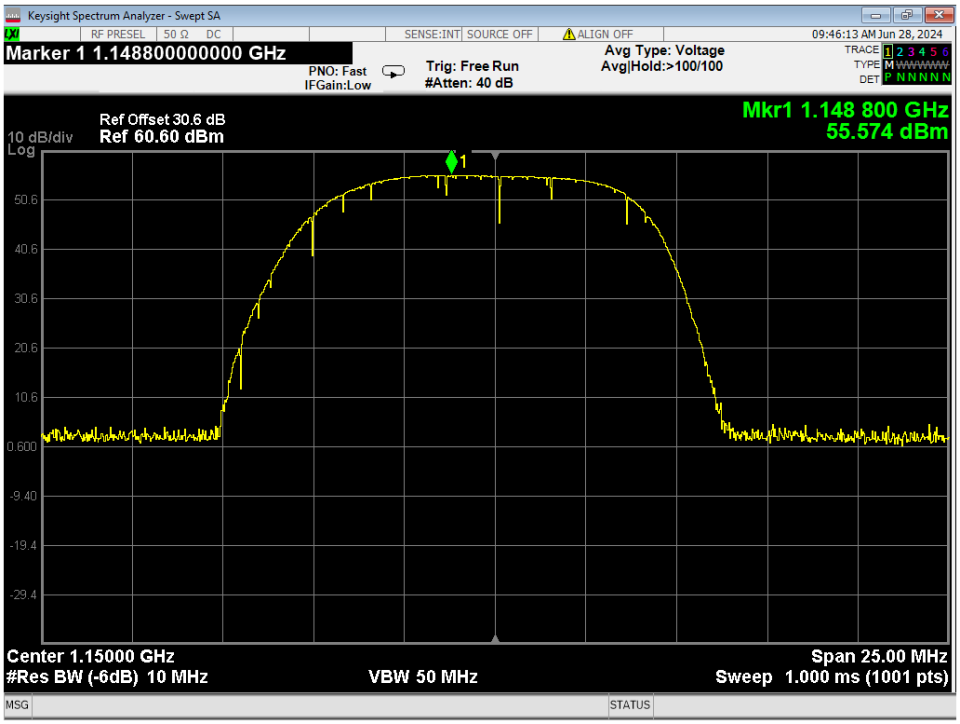

Figure 14 – Peak Power, Mode X, 1150MHz

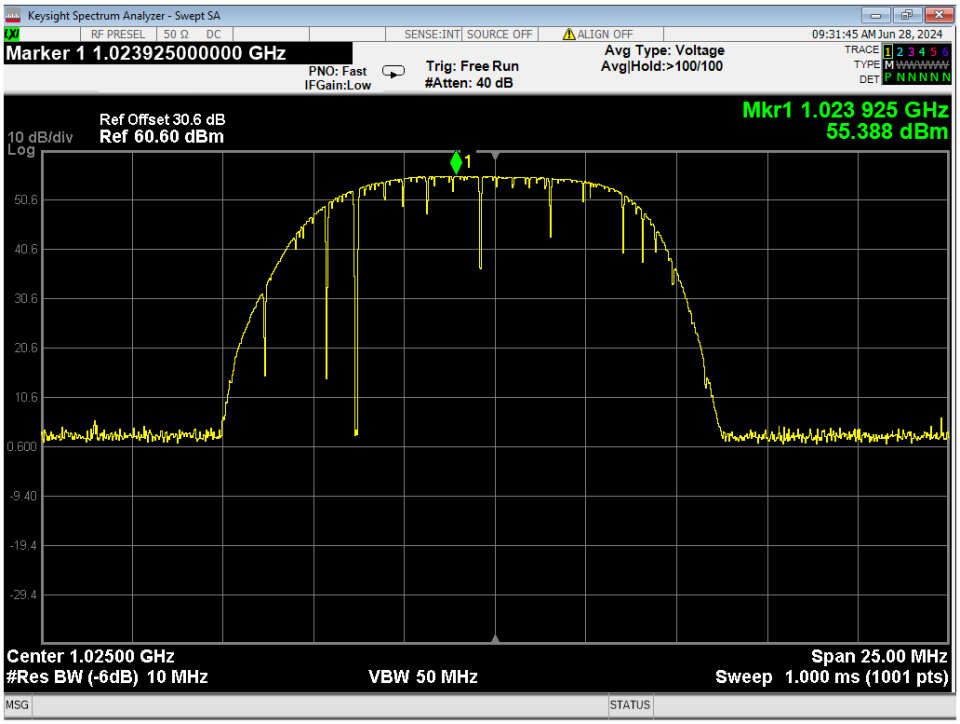

Figure 15 – Peak Power, Mode Y, 1025MHz

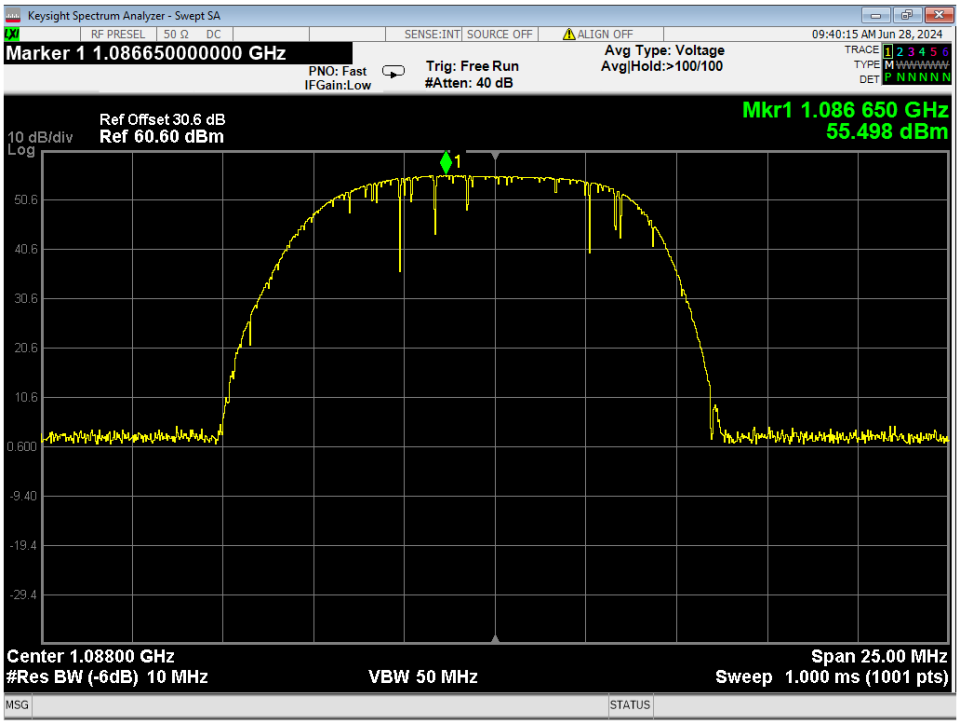

Figure 16 – Peak Power, Mode Y, 1088MHz

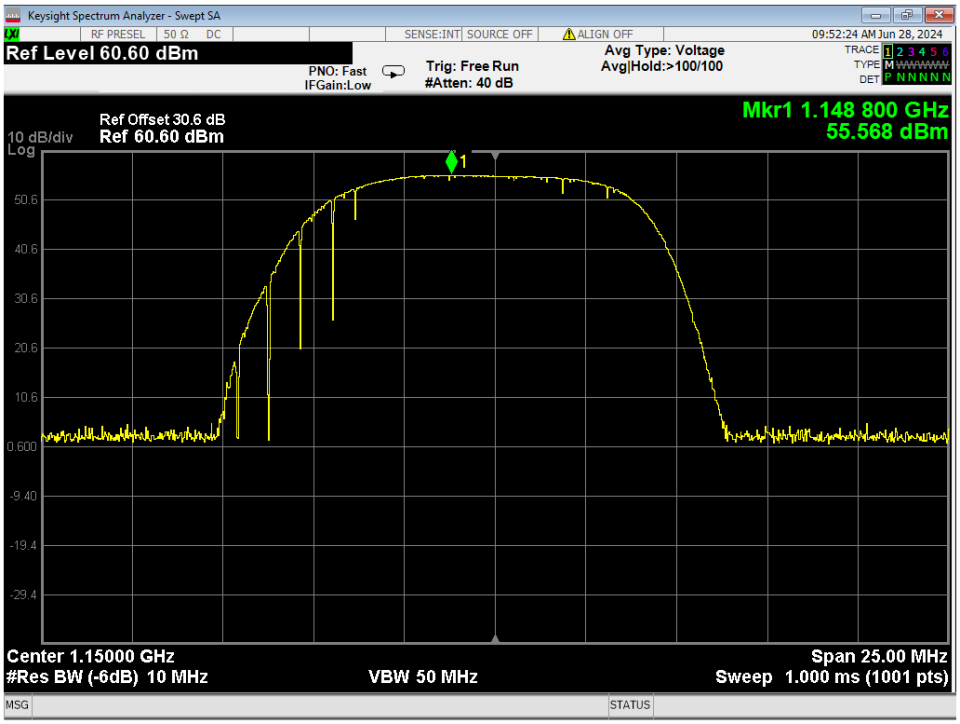

Figure 17 – Peak Power, Mode Y, 1150MHz

4.3 BANDWIDTH AND MODULATION CHARACTERISTICS

Test Method: ANSI C63.26,
Section(s) 5.4.3, 5.4.4

Limits of bandwidth measurements:
Authorized Bandwidth is 1.0667MHz. Operating Range is 1025MHz – 1150MHz.

Limits for Modulation Characteristics:
NA

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable and an attenuator to protect measurement equipment. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 1 MHz RBW and 8 MHz VBW. The bandwidth measurements were done using the automatic bandwidth measurement.

Deviations from test standard:
No deviation

Test setup:

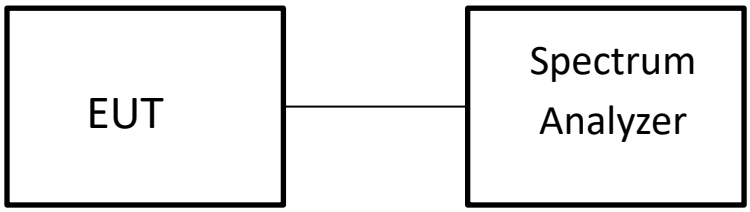

Figure 18 –Measurements Test Setup

EUT operating conditions:
See Section 2.1 & 2.2

Test results:

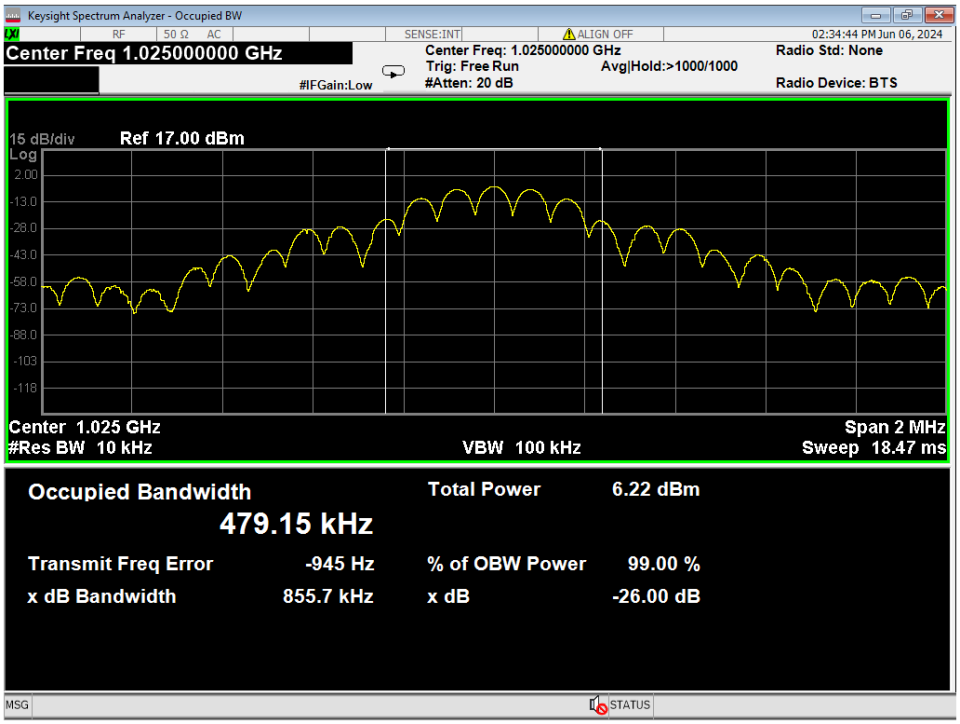

Figure 19 – Occupied Bandwidth, Mode X, 1025MHz

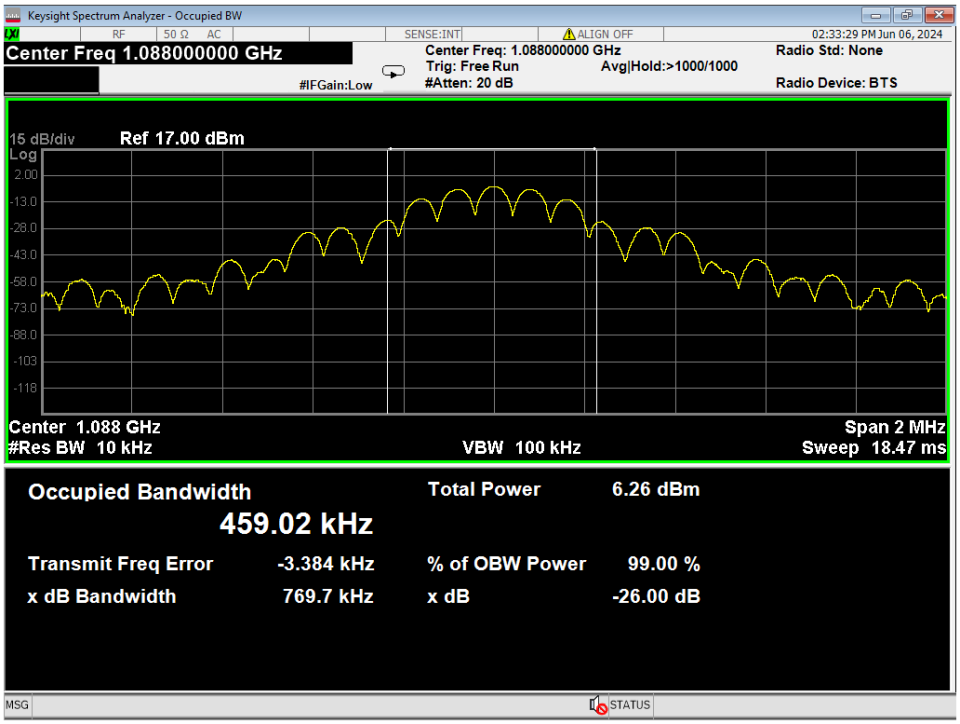

Figure 20 – Occupied Bandwidth, Mode X, 1088MHz

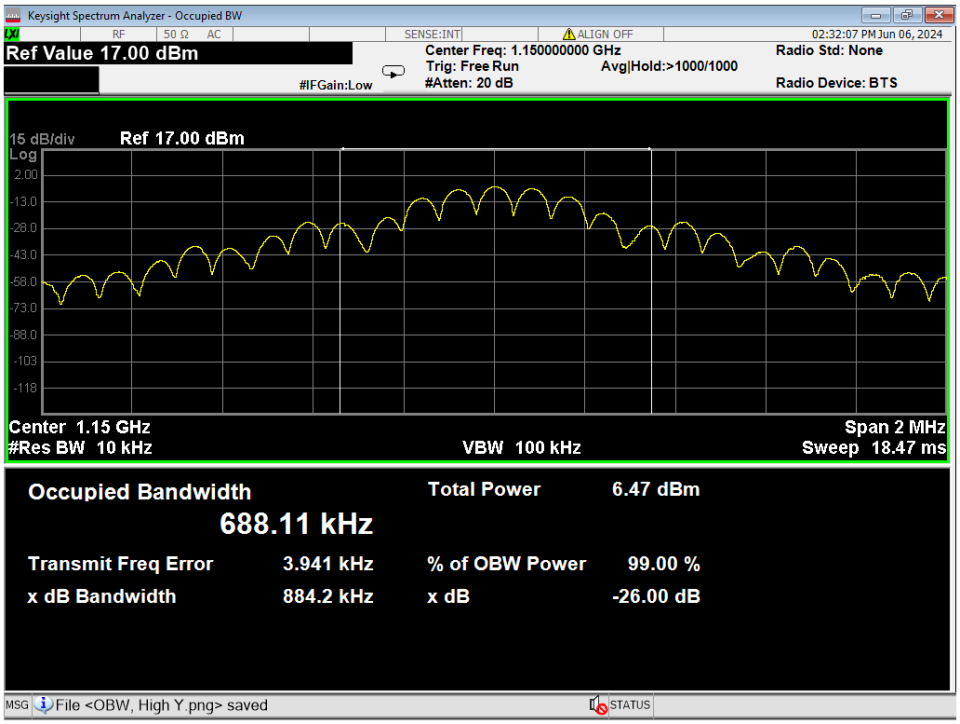

Figure 21 – Occupied Bandwidth, Mode X, 1150MHz

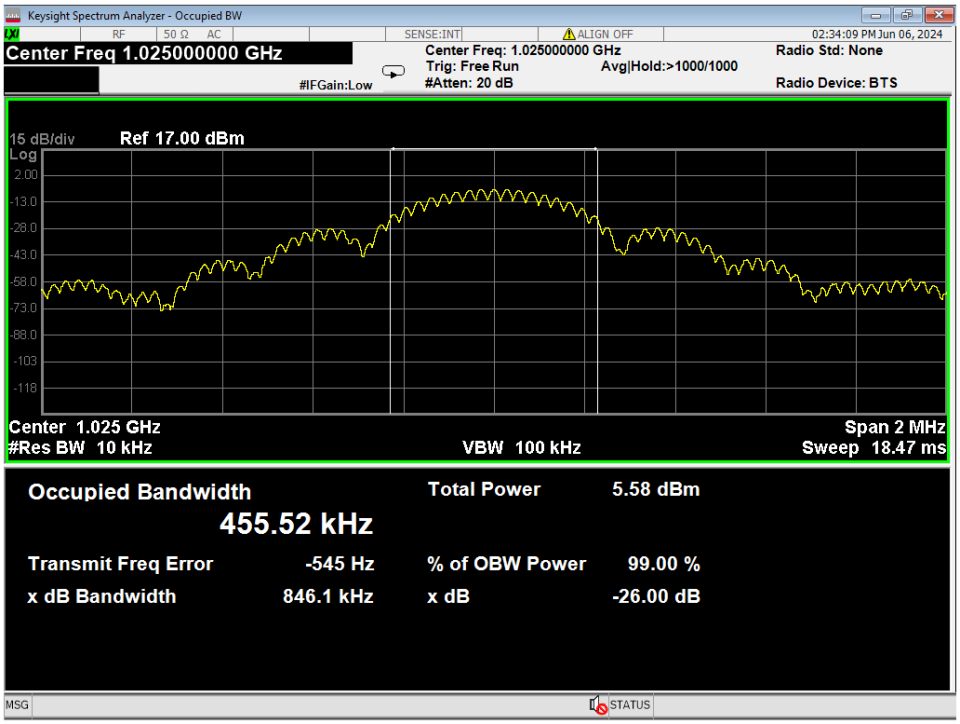

Figure 22 – Occupied Bandwidth, Mode Y, 1025MHz

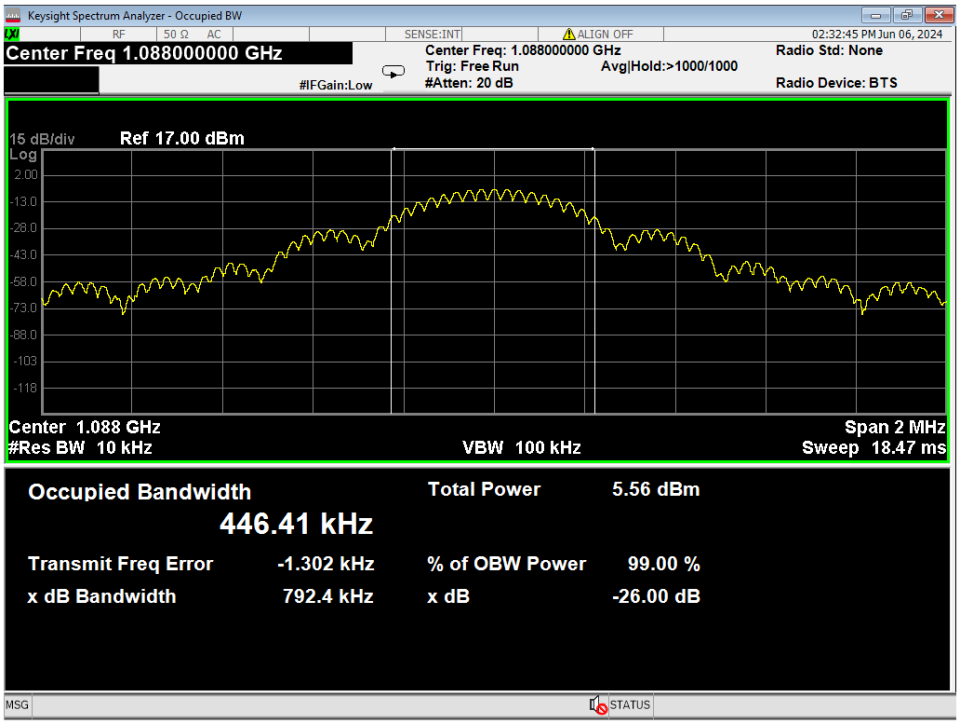

Figure 23 – Occupied Bandwidth, Mode Y, 1088MHz

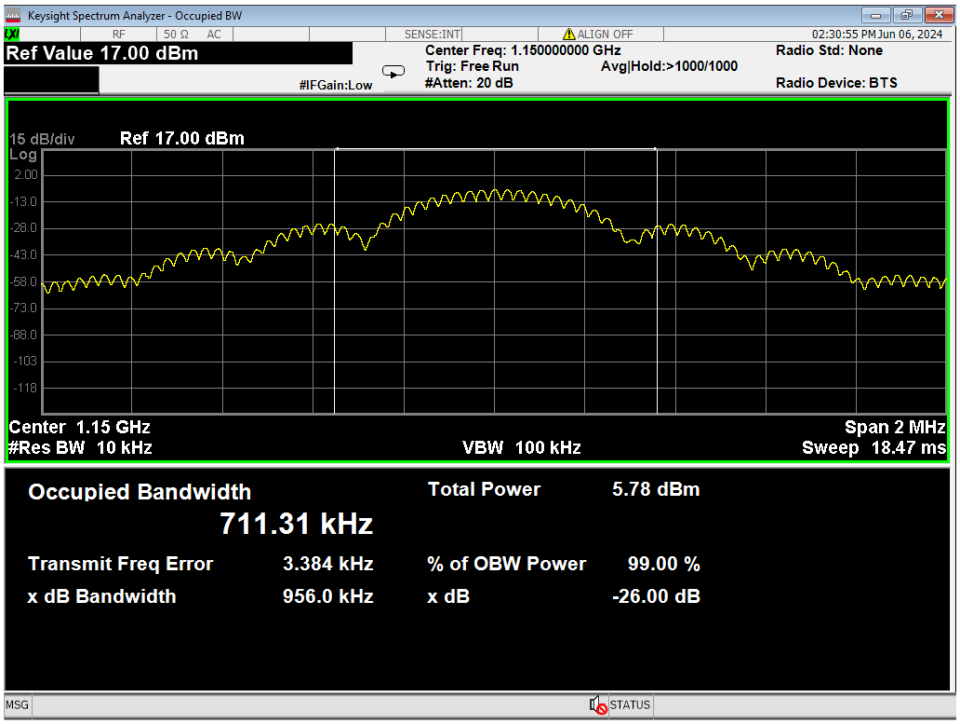

Figure 24 – Occupied Bandwidth, Mode Y, 1150MHz

4.4 FREQUENCY STABILITY MEASUREMENTS

Test Method: ANSI C63.26,
Section(s) 5.6.3 “Procedures for frequency stability testing”

Limits:
47 CFR 87.133(b):
20ppm
1025MHz = 20.50kHz
1088MHz = 21.76kHz
1150MHz = 23.00kHz

Test procedures:
Radiated power was measured on a spectrum analyzer with resolution bandwidth and video bandwidth set to 27kHz and 270kHz respectively. The frequency error functionality on the receiver was used. The temperature was varied from -30°C to +55°C.

Deviations from test standard:
No deviation

Test setup:

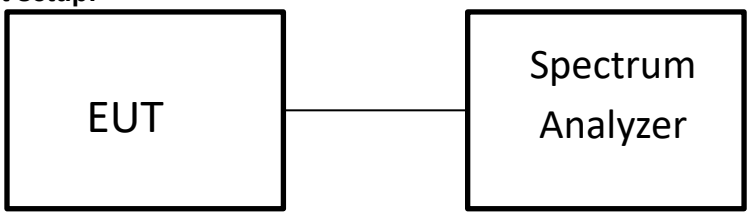

Figure 25 –Measurements Test Setup

EUT operating conditions:
See Section 2.1 & 2.2

Test results: Worst case is reported. Complies

Frequency Deviation (Temperature) (kHz)			
	Nominal Frequency		
Temp [C]	1025MHz	1088MHz	1150MHz
-30	-1.881	-4.412	4.785
-20	-1.224	-4.151	5.02
-10	-0.918	-4.738	3.99
0	-1.464	-4.799	7.162
10	-0.999	-3.659	3.063
20	-1.359	-4.639	3.583
30	2.146	-5.225	1.224
40	1.657	-4.397	1.836
55	1.587	3.226	5.923

Frequency Stability (Voltage) (kHz)			
	Nominal Frequency		
Voltage	1025MHz	1088MHz	1150MHz
23.8	-2.12	-5.189	3.643
28.0	-1.921	-5.09	3.633
32.2	-2.369	-4.901	3.788

4.5 DUTY CYCLE

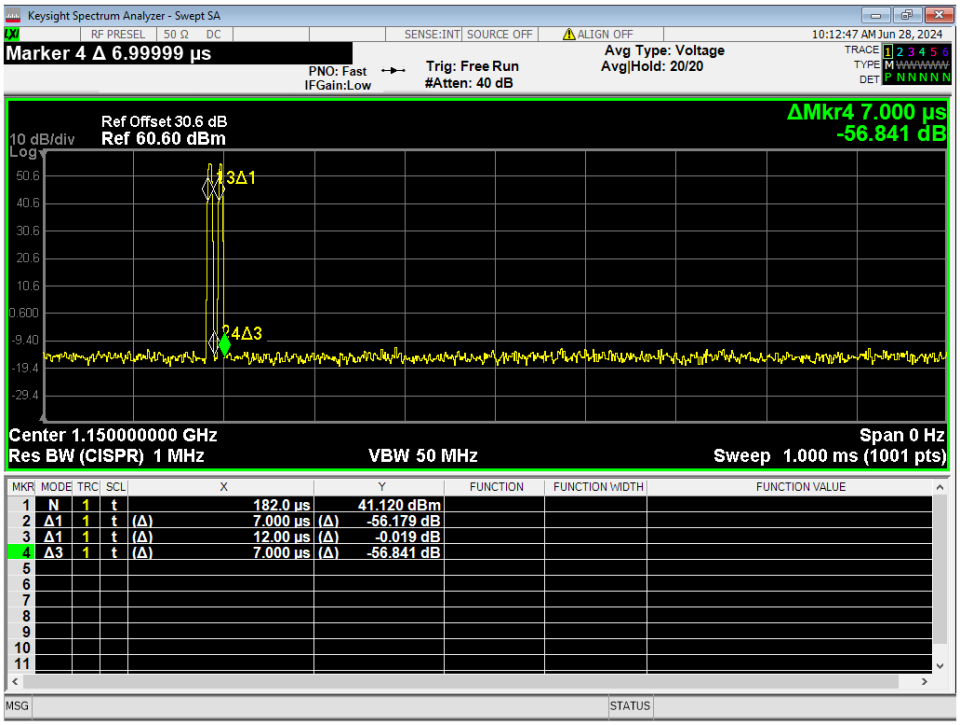

Figure 26 – Duty Cycle, Mode X

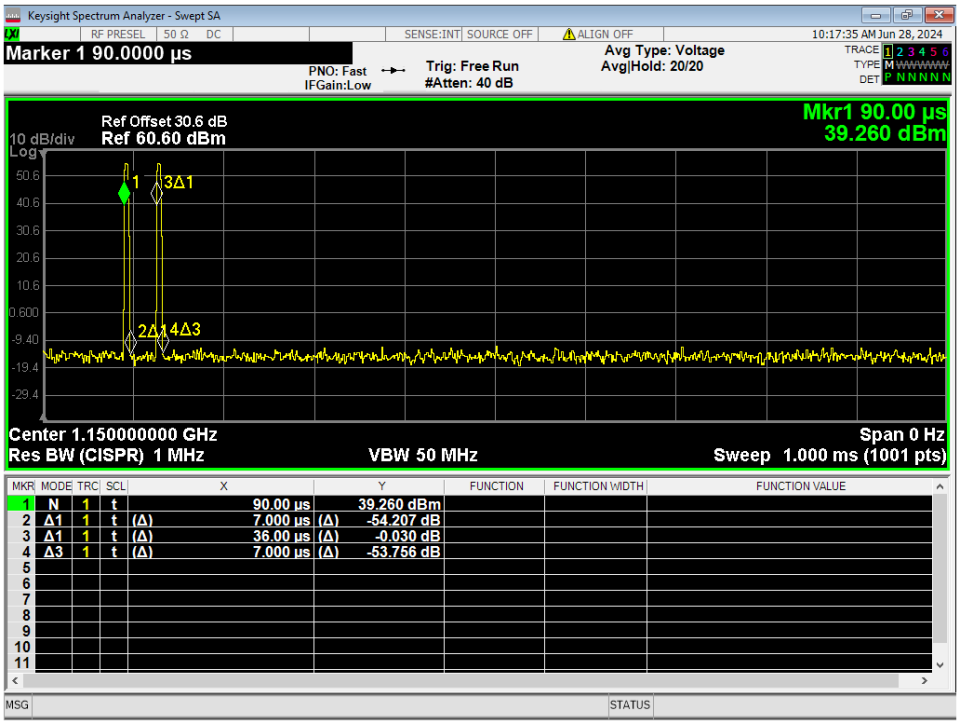

Figure 27 – Duty Cycle, Mode Y

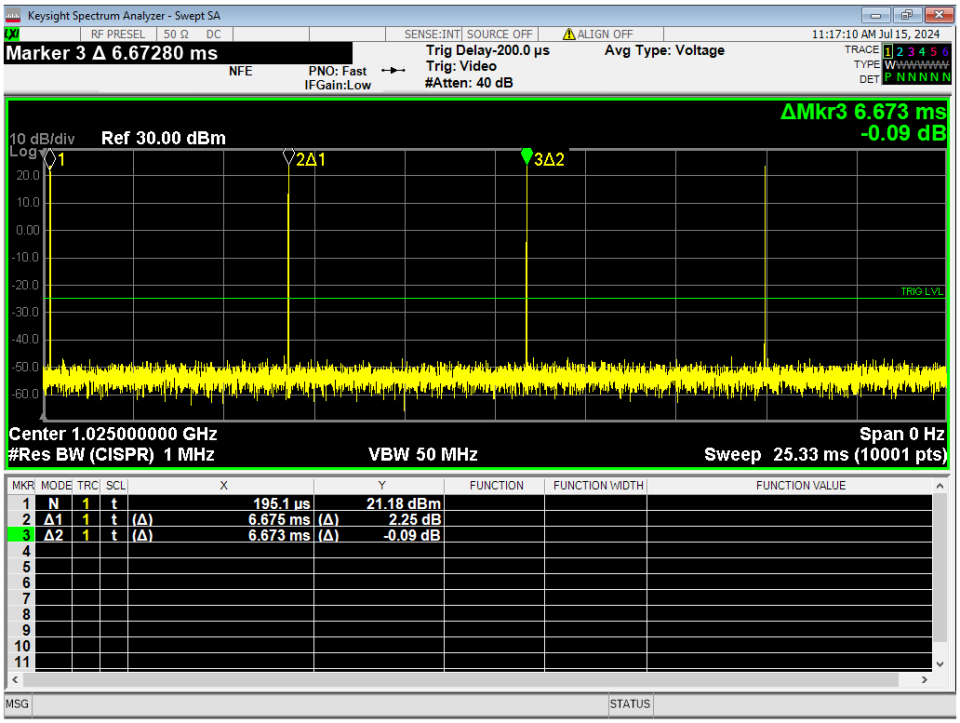

Figure 28 – Period, Mode X

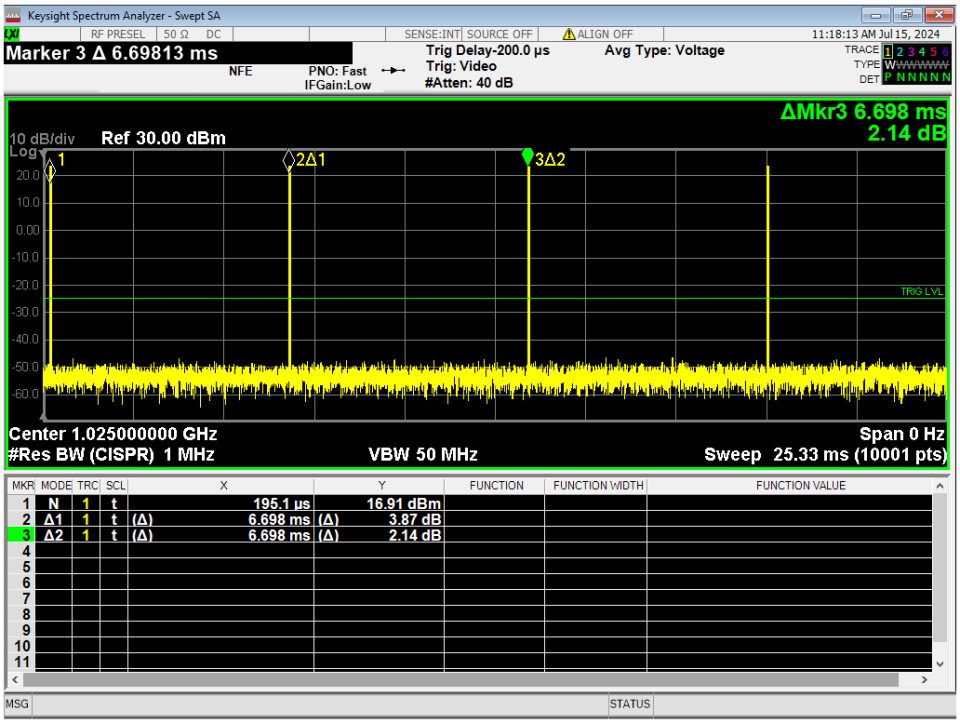

Figure 29 – Period, Mode Y

Modulation	ON Time (uS)	Period (uS)	DCCF For Emissions	DCCF For Power
Mode X	14	6673	53.98	26.99
Mode Y	14	6698	53.98	26.99

DC = ON Time / Period
DCCF For Emissions = 20*log(1/DC)
DCCF For Power = 10*log(1/DC)

Mode X:
DC = 14/6673 = 0.002
DCCF For Emissions = 20*log(1/0.002) = 53.98
DCCF For Power = 10*log(1/0.002) = 26.99

Mode Y:
DC = 14/6698 = 0.002
DCCF For Emissions = 20*log(1/0.002) = 53.98
DCCF For Power = 10*log(1/0.002) = 26.99

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation
The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Attenuation Factor
AG = Amplifier Gain
AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.
Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m
AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30
Power (watts) = 10^[Power (dBm)/10] / 1000
Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)
Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6
Gain = 1 (numeric gain for isotropic radiator)
Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3
EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23
10log(10^9) is the conversion from micro to milli

APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08

Expanded uncertainty values are calculated to a confidence level of 95%.

REPORT END