

*FCC PART 15, SUBPART B and C; and FCC SECTION 15.247
TEST REPORT*

for

HOPPER CONTROLLER

Model: FTW000223

Prepared for

FTW LLC
7016 MOTZ STREET
PARAMOUNT, CALIFORNIA 90723

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	REPORT BODY	APPENDICES					TOTAL
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GENERAL REPORT SUMMARY

This electromagnetic emission test report is generated by Compatible Electronics Inc., which is an independent testing and consulting firm. The test report is based on testing performed by Compatible Electronics personnel according to the measurement procedures described in the test specifications given below and in the "Test Procedures" section of this report.

The measurement data and conclusions appearing herein relate only to the sample tested and this report may not be reproduced without the written permission of Compatible Electronics, unless done so in full.

This report must not be used by the client to claim product certification, approval or endorsement by NVLAP, NIST or any agency of the U.S. Government.

Device Tested: Hopper Controller
Model: FTW000223
S/N: N/A

Product Description: The equipment under test is a Hopper Controller with BLE connectivity that is used in controlling a wireless controlled drone. Crystal oscillator frequency: 32 MHz. Highest frequency generated: 2480 MHz. Dimensions (LxWxH): 150 mm. x 90 mm x 35 mm. Weight: 8 oz. Internal Batteries: 2 AAA Alkaline.

Modifications: The EUT was not modified in order to meet the specifications.

Customer: FTW LLC
7016 Motz Street
Paramount, California 90723

Test Dates: July 26 and 29; and August 2 and 3, 2023

Test Specification covered by accreditation:



Test Specifications: Emissions requirements
CFR Title 47, Part 15, Subpart B; and Subpart C, sections 15.205, 15.209, and 15.247

Test Procedures: ANSI C63.4 and ANSI C63.10

Test Deviations: The test procedure was not deviated from during the testing.

SUMMARY OF TEST RESULTS

TEST	DESCRIPTION	RESULTS
1	Conducted RF Emissions, 150 kHz - 30 MHz	This test was not performed because the EUT is an internal battery powered device only and does not connect to the public AC mains.
2	Radiated RF Emissions, 9 kHz – 25000 MHz	Complies with the Class B limits of CFR Title 47, Part 15, Subpart B; and the limits of CFR Title 47, Part 15 Subpart C, 15.205, 15.209 and 15.247 (d) See section 6.3 for Measurement Uncertainty
3	DTS Bandwidth	Complies with the relevant requirements of CFR Title 47, Part 15, Subpart C, section 15.247 (a)(2)
4	Peak Output Power	Complies with the relevant requirements of FCC Title 47, Part 15, Subpart C, section 15.247 (b)(3)
5	RF Band Edges	Complies with the relevant requirements of FCC Title 47, Part 15, Subpart C, section 15.247 (d)
6	Spectral Density	Complies with the relevant requirements of FCC Title 47, Part 15, Subpart C, section 15.247 (e)

1. PURPOSE

This document is a qualification test report based on the emissions tests performed on the Hopper Controller, Model: FTW000223 (EUT). The emissions measurements were performed according to the measurement procedure described in ANSI C 63.4 and ANSI C 63.10. The tests were performed in order to determine whether the electromagnetic emissions from the equipment under test, referred to as EUT hereafter, are within the Class B specification limits defined by CFR Title 47, Part 15, Subpart B; and Subpart C, sections 15.205, 15.209, and 15.247.

1.1 DECISION RULE & RISK

If a measured value exceeds a specification limit it implies non-compliance. If the value is below a specification limit it implies compliance. Measurement uncertainty of the laboratory is reported with all measurement results but generally not taken into consideration unless a standard, rule or law requires it to be considered.

Qualification test reports are only produced for products that are in compliance with the test requirements, therefore results are always in conformity. Otherwise, an engineering report or just the data is provided to the customer.

When performing a measurement and making a statement of conformity, in or out-of-specification to manufacturer's specifications or Pass/Fail against a requirement, there are two possible outcomes:

- The result is reported as conforming with the specification
- The result is reported as not conforming with the specification

The decision rule is defined below.

When the test result is found to be below the limit but within our measurement uncertainty of the limit, it is our policy that the final acceptance decision is left to the customer, after discussing the implications and potential risks of the decision.

When the test result is found to be exactly on the specification, it is our policy, in the case of unwanted emissions measurements to consider the result non-compliant; however, the final decision is left to the customer, after discussing the implications and potential risks of the decision.

When the test result is found to be over the specification limit under any condition, it is our policy to consider the result non-compliant.

In terms of uncertainty of measurement, the laboratory is a calibrated and tightly controlled environment and generally exceptionally stable, the measurement uncertainties are evaluated without the consideration of the test sample. When it comes to the test sample however, as most testing is performed on a single sample rather than a sample population, and that sample is often a pre-production representation of the final product that test sample represents a significantly higher source of measurement uncertainty. We advise our customers of this and that when in doubt (small test to limit margins), they may wish to perform statistical sampling on a population to gain a higher confidence in the results. All lab reported results are that of a single sample in any event.

2. ADMINISTRATIVE DATA

2.1 Location of Testing

The emissions tests described herein were performed at the test facility of Compatible Electronics, 114 Olinda Drive, Brea, California 92823.

2.2 Traceability Statement

The calibration certificates of all test equipment used during the test are on file at the location of the test. The calibration is traceable to the National Institute of Standards and Technology (NIST).

2.3 Cognizant Personnel

FTW LLC

Rob Harvey, Executive Chairman + Cofounder
Robert Ganton

Compatible Electronics Inc.

Kyle Fujimoto	Sr. Test Engineer
James Ross	Sr. Test Engineer

2.4 Date Test Sample was Received

The test sample was received prior to initial date of testing. Received as defined in product description.

2.5 Disposition of the Test Sample

The test sample has been returned to FTW LLC prior to the date of this test report.

2.6 Abbreviations and Acronyms

The following abbreviations and acronyms may be used in this document.

EMI	Electromagnetic Interference
EUT	Equipment Under Test
P/N	Part Number
S/N	Serial Number
ITE	Information Technology Equipment
DoC	Declaration of Conformity
FCC	Federal Communications Commission
ID	Identification
N/A	Not Applicable
Tx	Transmit
Rx	Receive
Inc.	Incorporated
RF	Radio Frequency
GND	Ground
BLE	Bluetooth Low Energy

3. APPLICABLE DOCUMENTS

The following documents are referenced or used in the preparation of this emissions Test Report.

SPEC	TITLE
FCC Title 47, Part 15 Subpart C	FCC Rules – Radio frequency devices (including digital devices) – Intentional Radiators
FCC Title 47, Part 15 Subpart B	FCC Rules – Radio frequency devices (including digital devices) – Unintentional Radiators
558074 D01 DTS Meas Guidance v05r02	Guidance for Performing Compliance Measurements on Digital Transmissions Systems (DTS) Operating Under Section 15.247
EN 50147-2: 1997	Anechoic chambers. Alternative test site suitability with respect to site attenuation
ANSI C63.4: 2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10: 2013	American National Standard for Testing Unlicensed Wireless Devices

4. DESCRIPTION OF TEST CONFIGURATION

The Hopper Controller, Model: FTW000223 (EUT) was tested as a stand-alone device and was powered by two AAA Alkaline batteries.

The EUT was continuously transmitting at 2402 MHz during spurious emissions testing (worst case).

The EUT was tested for emissions while in the X, Y, and Z axis. The X orientation is when the EUT is parallel to the ground mounted horizontally. The Y orientation is when the EUT is perpendicular to the ground mounted vertically. The Z orientation is when the EUT is perpendicular to the ground mounted horizontally.

The firmware inside the EUT to continuously transmit at the low, middle, and high during the intentional radiator tests.

The firmware is stored on the company's servers.

The radiated data was taken in the continuously exercising mode of operation. All initial investigations were performed with the EMI Receiver in manual mode scanning the frequency range continuously. The cables were bundled and routed as shown in the photographs in Appendix D.

4.1.1 Cable Construction and Termination

The EUT contained no externally connected cables.



5. LISTS OF EUT, ACCESSORIES AND TEST EQUIPMENT

5.1 EUT and Accessory List

EQUIPMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID
HOPPER CONTROLLER (EUT)	FTW LLC	FTW000223	N/A	2BB9E-0223A
FIRMWARE*	FTW LLC	EspRFTestTool	N/A	N/A

*Only used to program the EUT to continuously transmit at the low, middle, and high channels (not used during testing)



5.2 Emissions Test Equipment

EQUIPMENT TYPE	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CAL. DATE	CAL. DUE DATE
RF RADIATED EMISSIONS TEST EQUIPMENT					
TDK TestLab	TDK RF Solutions, Inc.	9.22	700145	N/A	N/A
EMI Receiver, 3 Hz – 44 GHz	Keysight Technologies, Inc.	N9038A	MY59050117	July 14, 2023	July 14, 2024
Loop Antenna	Com-Power	AL-130R	121090	February 10, 2022	February 10, 2025
CombiLog Antenna	Com-Power	AC-220	61093	December 14, 2021	December 14, 2023
Horn Antenna	Com-Power	AH-118	10050113	December 16, 2021	December 16, 2023
Horn Antenna	Com-Power	AH-826	0071957	NCR	NCR
Preamplifier	Com-Power	PA-118	181653	March 7, 2022	March 7, 2024
Preamplifier	Com-Power	PA-840	711013	April 8, 2022	April 8, 2024
System Controller	Sunol Sciences Corporation	SC110V	112213-1	N/A	N/A
Turntable	Sunol Sciences Corporation	2011VS	N/A	N/A	N/A
Antenna-Mast	Sunol Sciences Corporation	TWR95-4	112213-3	N/A	N/A
Computer	Hewlett Packard	p6716f	MXX1030PX0	N/A	N/A

6. TEST SITE DESCRIPTION

6.1 Test Facility Description

Please refer to section 2.1 of this report for emissions test location.

6.2 EUT Mounting, Bonding and Grounding

For frequencies 1 GHz and below: The EUT was mounted on a 0.6 by 1.2 meter non-conductive table 0.8 meters above the ground plane.

For frequencies above 1 GHz: The EUT was mounted on a 0.6 by 1.2 meter non-conductive table 1.5 meters above the ground plane.

The EUT was not grounded.

6.3 Measurement Uncertainty

“Compatible Electronics” U_{lab} value is less than U_{cisprr} , thus based on this – compliance is deemed to occur if no measured disturbance exceeds the disturbance limit.

The uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level, using a coverage factor of $k=2$

$$u_c(y) = \sqrt{\sum_i c_i^2 u^2(x_i)}$$

Measurement		U_{cisprr}	$U_{lab} = 2u_c(y)$
Conducted disturbance (mains port)	(150 kHz – 30 MHz)	3.4 dB	2.72 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(30 MHz – 1,000 MHz)	6.3 dB	3.32 dB (Vertical) 3.30 dB (Horizontal)
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(1 GHz – 6 GHz)	5.2 dB	4.06 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(6 GHz – 18 GHz)	5.5 dB	4.06 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(18 GHz – 26 GHz)	N/A	4.43 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site)	(26.5 GHz – 40 GHz)	N/A	4.57 dB



7. CHARACTERISTICS OF THE TRANSMITTER

The following sections describe the test methods and the specifications for the tests. Test results are also included in this section.

7.1 Channel Number and Frequencies

The EUT uses a total of 40 channels.

The low channel is 2402 MHz

The middle channel is 2440 MHz

The high channel is 2480 MHz

7.2 Antenna

The EUT utilized the following antenna:

A printed antenna – Peak Gain is < 2.1 dBi



8. TEST PROCEDURES

The following sections describe the test methods and the specifications for the tests. Test results are also included in this section.

8.1 RF Emissions

8.1.1 Conducted Emissions Test

The EMI Receiver was used as a measuring meter. A quasi-peak and/or average reading was taken only where indicated in the data sheets. A 10 dB attenuator used for the protection of the EMI Receiver input stage, and the offset was adjusted accordingly to read the actual data measured. The LISN output was measured using the EMI Receiver. The output of the second LISN was terminated by a 50-ohm termination. The effective measurement bandwidth used for this test was 9 kHz.

Please see section 6.2 of this report for mounting, bonding, and grounding of the EUT. The EUT was powered through the LISN, which was bonded to the ground plane. The LISN power was filtered and the filter was bonded to the ground plane. The EUT was set up with the minimum distances from any conductive surfaces as specified in ANSI 63:4. The excess power cord was wrapped in a figure eight pattern to form a bundle not exceeding 0.4 meters in length.

The conducted emissions from the EUT were maximized for operating mode as well as cable placement. The final data was collected under program control by computer software.

Test Results:

This test was not performed because the EUT is an internal battery powered device only and does not connect to the public AC mains.

8.1.2 Radiated Emissions Test

The EMI Receiver was used as the measuring meter. Above 1000 MHz, preamplifiers were used to increase the sensitivity of the instrument. The EMI Receiver was initially used with the Analyzer mode feature activated. In this mode, the EMI receiver can then record the actual frequency to be measured. This final reading is then taken accurately in the EMI Receiver mode, which takes into account the cable loss, amplifier gain and antenna factors, so that a true reading is compared to the true limit. The effective measurement bandwidth used for the radiated emissions test was according to the frequency measured.

The frequencies below 1 GHz were quasi-peaked using the quasi-peak detector of the EMI Receiver.

The frequencies above 1 GHz were averaged using the RMS average function of the EMI Receiver.

The EMI test chamber of Compatible Electronics, Inc. was used for radiated emissions testing. This test site is in full compliance with ANSI C63.4 and ANSI C63.10. Please see section 6.2 of this report for mounting, bonding and grounding of the EUT. The turntable supporting the EUT is remote controlled using a motor. The turntable permits EUT rotation of 360 degrees in order to maximize emissions. Also, the antenna mast allows height variation of the antenna from 1 meter to 4 meters. Data was collected in the worst case (highest emission) configuration of the EUT. At each reading, the EUT was rotated 360 degrees and the antenna height was varied from 1 to 4 meters (for E field radiated field strength). The gunsight method was used when measuring with the horn antenna in order to ensure accurate results.

The EUT was tested at a 3-meter test distance. The six highest emissions are listed in Table 1.

The measurement bandwidths and transducers used for the radiated emissions test were:

FREQUENCY RANGE	EFFECTIVE MEASUREMENT BANDWIDTH	TRANSDUCER
9 kHz to 150 kHz	200 Hz	Loop Antenna
150 kHz to 30 MHz	9 kHz	Loop Antenna
30 MHz to 1 GHz	120 kHz	CombiLog Antenna
1 GHz to 25 GHz	1 MHz	Horn Antenna

Test Results:

The EUT complies with the **Class B** limits of CFR Title 47, Part 15, Subpart B; the limits of CFR Title 47, Part 15, Subpart C, sections 15.205, 15.209 and 15.247 for radiated emissions.



8.1.3 RF Emissions Test Results

Table 1 RADIATED EMISSION RESULTS
Hopper Controller
Model: FTW000223

Frequency (MHz)	EMI Reading (dB μ V/m)	Specification Limit (dB μ V/m)	Delta (EMI Reading – Spec. Limit) (dB)
12200 (H) (Middle Channel) (Y-Axis)	40.67	53.97	-13.30
12200 (V) (Middle Channel) (X-Axis)	40.05	53.97	-13.92
12010 (V) (Low Channel) (Y-Axis)	39.79	53.97	-14.18
12200 (H) (Middle Channel) (X-Axis)	39.66	53.97	-14.31
12200 (V) (Middle Channel) (Z-Axis)	39.33	53.97	-14.64
12200 (V) (Middle Channel) (Y-Axis)	39.27	53.97	-14.70

Notes:

- * The complete emissions data is given in Appendix E of this report.
- (V) Vertical
- (H) Horizontal

8.1.4 Sample Calculations

A correction factor for the antenna, cable and a distance factor (if any) must be applied to the meter reading before a true field strength reading can be obtained. This Corrected Meter Reading is then compared to the specification limit in order to determine compliance with the limits.

Conversion to logarithmic terms: Specification limit ($\mu\text{V/m}$) $\log \times 20$ = Specification Limit in dBuV/m

To correct for distance when measuring at a distance other than the specification

For measurements below 30 MHz: (Specification distance / test distance) $\log \times 40$ = distance factor

For measurements above 30 MHz: (Specification distance / test distance) $\log \times 20$ = distance factor

Note: When using an Active Antenna, the Antenna factor shall be subtracted due to the combination of the internal amplification and antenna loss.

Corrected Meter Reading = meter reading + F – A + C

where: F = antenna factor

A = amplifier gain

C = cable loss

The correction factors for the antenna and the amplifier gain are attached in Appendix D of this report. The data sheets are attached in Appendix E.

The distance factor D is 0 when the test is performed at the required specification distance.

8.2 DTS Bandwidth

The DTS Bandwidth was measured using the EMI Receiver. The following steps were performed for measuring the DTS Bandwidth.

1. Set RBW = 100 kHz
2. Set the video bandwidth (VBW) to equal or greater than 3 times the RBW
3. Detector = Peak
4. Trace Mode = Max Hold
5. Sweep = Auto Couple
6. Allow the trace to stabilize
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Test Results:

The EUT complies with the relevant requirements of FCC Title 47, Part 15, Subpart C section 15.247 (a)(2).

8.3 Maximum Peak Conducted Output Power

The Maximum Peak Conducted Output Power was measured using the EMI Receiver. The Maximum Peak Conducted Output Power was measured using the procedure described in section 11.9.1.1 of ANSI C63.10. The Maximum Peak Conducted Output Power was then taken. The following steps were performed for measuring the Maximum Peak Conducted Output Power.

1. Set the RBW $\geq$ DTS bandwidth
2. Set VBW $\geq$ [3 x RBW]
3. Set span $\geq$ [3 x RBW]
4. Sweep time = auto couple
5. Detector = peak
6. Trace mode = max hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level

Test Results:

The EUT complies with the relevant requirements of FCC Title 47, Part 15, Subpart C section 15.247 (b)(3)



8.4 Emissions in Non-restricted Frequency Bands

The emissions in the non-restricted frequency bands measurements were performed using the EMI receiver directly connected to the EUT. The reference level was established by setting the instrument center frequency to the DTS channel center frequency. The span was set to ≥ 1.5 times the DTS bandwidth. The RBW was set to 100 kHz and the VBW was set to 300 kHz. A peak detector was used with sweep set to auto. A max hold trace was used and allowed to fully stabilize. The peak marker function was used to determine the reference level. For emission level measurement, the center frequency and span were set to encompass the frequency range to be measured. The RBW was set to 100 kHz and the VBW was set to 300 kHz. A peak detector was used with a sweep time set to auto. The number of measurement points were greater than the span/RBW. A max hold trace was used and allowed to fully stabilize. The peak marker function was used to determine the maximum amplitude level. The final qualification data sheets are located in Appendix E.

Test Results:

The EUT complies with the relevant requirements of FCC Title 47, Part 15, Subpart C section 15.247 (d).

8.5 RF Band Edges

The RF band edges were taken at 2390 MHz when the EUT was on the low channel and 2483.5 MHz when the EUT was on the high channel using the EMI Receiver. A preamplifier was used to boost the signal level, with the plots being taken at a 3 meter test distance. The radiated emissions test procedure as describe in section 8.1.2 of this test report was used to maximize the emission.

Test Results:

The EUT complies with the relevant requirements of FCC Title 47, Part 15, Subpart C section 15.247 (d). The RF power at the restricted bands closest to the band edges at 2390 MHz and 2483.5 MHz also meet the limits of section 15.209. Please see the data sheets located in Appendix E.

8.6 Spectral Density Test

The spectrum density output was measured using the EMI Receiver. The spectral density output was measured using a direct connection from the RF out on the EUT into the input of the EMI Receiver. The following steps were performed for measuring the spectral density.

1. Set analyzer center frequency to DTS channel center frequency
2. Set the span to 1.5 times the OBW.
3. Set the RBW to $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
4. Set the VBW $\geq [3 \times \text{RBW}]$
5. Detector = peak
6. Sweep time = auto couple
7. Trace mode = max hold
8. Allow the trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

Test Results:

The EUT complies with the relevant requirements of FCC Title 47, Part 15, Subpart C section 15.247 (e).

8.7 Variation of the Input Power

The variation of the input power test was performed using the EMI Receiver. The EUT input power was varied between 85 % and 115 % of the nominal rated supply voltage. The carrier frequency was monitored for any change in amplitude.

Test Results:

This test was not performed because the EUT is an internal battery powered device only and does not connect to the public AC mains.

9. CONCLUSIONS

The Hopper Controller, Model: FTW000223 (EUT), as tested, meets all of the specification limits defined in CFR Title 47, Part 15, Subpart B; and Subpart C, sections 15.205, 15.209, and 15.247.

APPENDIX A

LABORATORY ACCREDITATIONS AND RECOGNITIONS

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

LABORATORY ACCREDITATIONS AND RECOGNITIONS



For US, Canada, Australia/New Zealand, Japan, Taiwan, Korea, and the European Union, Compatible Electronics is currently accredited by NVLAP to ISO/IEC 17025.

For the most up-to-date version of our scopes and certificates please visit

<http://celectronics.com/quality/scope/>

Quote from ISO-ILAC-IAF Communiqué on the Management Systems Requirements of ISO/IEC 17025, General Requirements for the competence of testing and calibration laboratories:

"A laboratory's fulfilment of the requirements of ISO/IEC 17025 means the laboratory meets both the technical competence requirements and management system requirements that are necessary for it to consistently deliver technically valid test results and calibrations. The management system requirements in ISO/IEC 17025 are written in language relevant to laboratory operations and operate generally in accordance with the principles of ISO 9001"

ISED Test Site Registration Number: 2154A

APPENDIX B

MODIFICATIONS TO THE EUT

MODIFICATIONS TO THE EUT

The modifications listed below were made to the EUT to pass FCC Subpart B and FCC 15.247 specifications.

All the rework described below was implemented during the test in a method that could be reproduced in all the units by the manufacturer.

No modifications were made to the EUT during the testing.



APPENDIX C

***MODELS COVERED
UNDER THIS REPORT***

MODELS COVERED UNDER THIS REPORT

USED FOR THE PRIMARY TEST

Hopper Controller
Model: FTW000223
S/N: N/A

There are no additional models covered under this report.



APPENDIX D

DIAGRAMS AND CHARTS



FIGURE 1: CONDUCTED EMISSIONS TEST SETUP

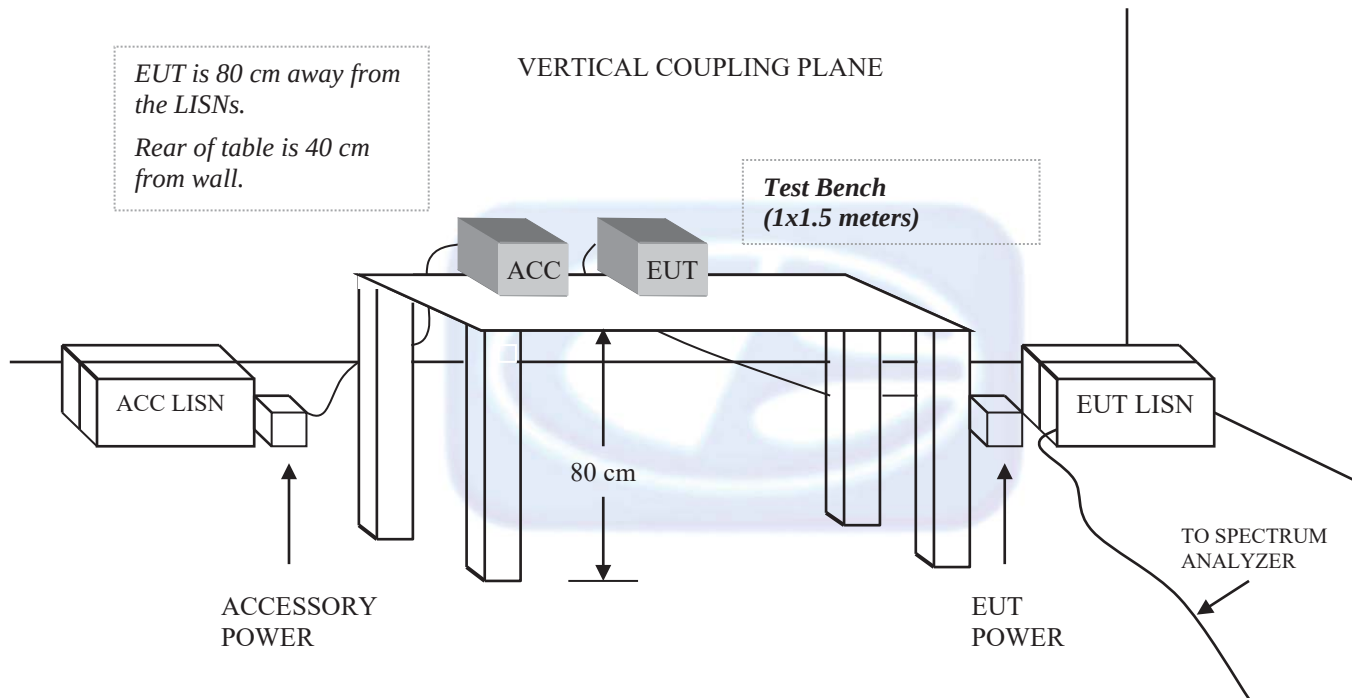
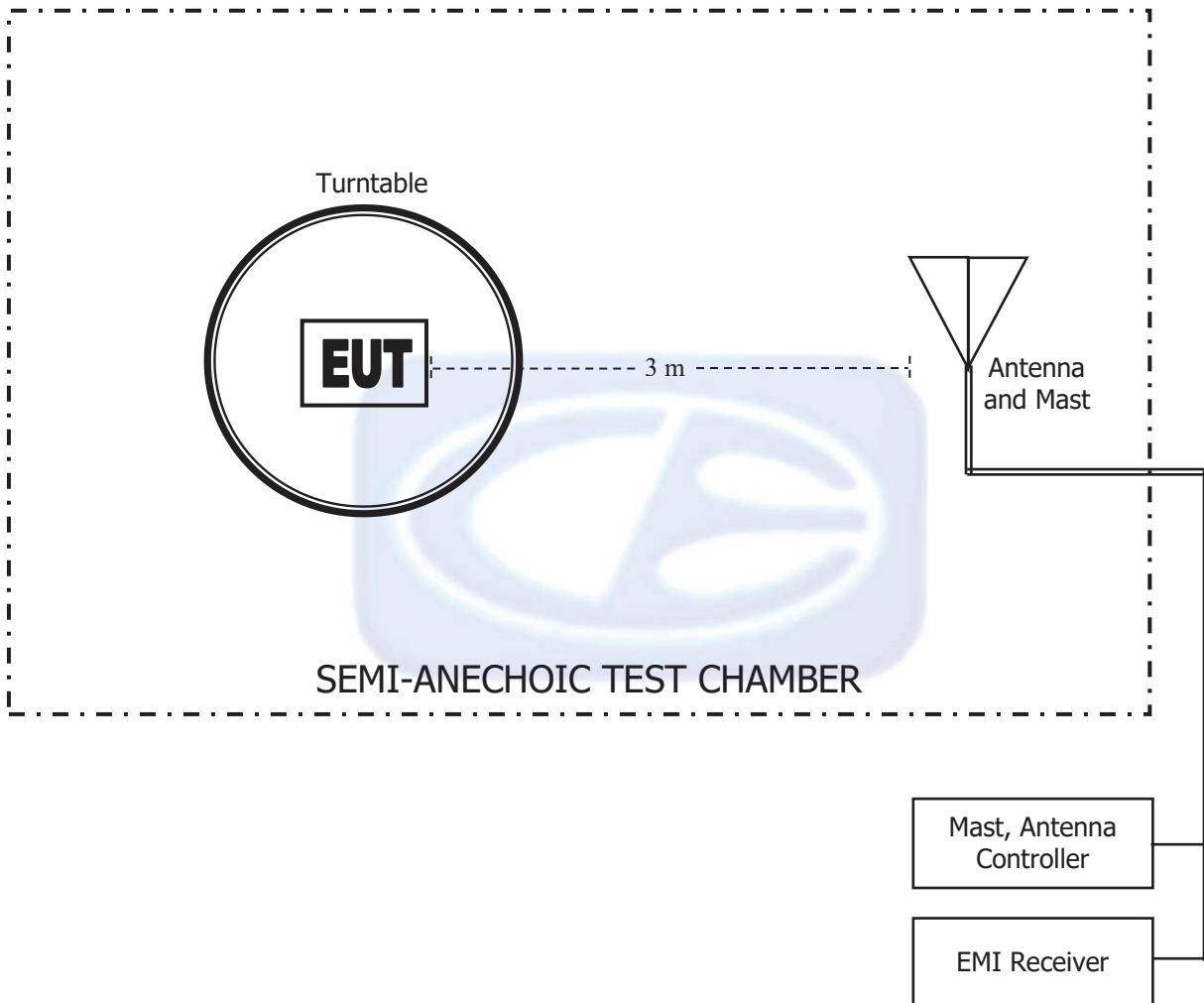


FIGURE 2: LAYOUT OF THE SEMI-ANECHOIC TEST CHAMBER



COM-POWER AL-130R

LOOP ANTENNA

S/N: 121090

CALIBRATION DATE: FEBRUARY 10, 2022

FREQUENCY (MHz)	MAGNETIC (dB/m)	ELECTRIC (dB/m)
0.009	15.6	-35.8
0.01	15.8	-35.6
0.02	14.8	-36.6
0.03	15.6	-35.9
0.04	15.0	-36.5
0.05	14.4	-37.1
0.06	14.6	-36.9
0.07	14.3	-37.2
0.08	14.3	-37.2
0.09	14.4	-37.0
0.10	14.1	-37.4
0.20	14.1	-37.4
0.30	14.0	-37.5
0.40	13.9	-37.6
0.50	14.1	-37.3
0.60	14.1	-37.3
0.70	14.2	-37.3
0.80	14.2	-37.3
0.90	14.2	-37.2
1.00	14.4	-37.0
2.00	14.6	-36.9
3.00	14.6	-36.8
4.00	14.9	-36.6
5.00	14.9	-36.7
6.00	14.8	-36.7
7.00	14.6	-36.8
8.00	14.5	-37.0
9.00	14.3	-37.2
10.00	14.5	-37.0
11.00	14.6	-36.9
12.00	14.7	-36.7
13.00	14.9	-36.6
14.00	15.0	-36.5
15.00	14.9	-36.6
16.00	14.9	-36.6
17.00	14.6	-36.8
18.00	14.4	-37.1
19.00	14.5	-37.0
20.00	14.5	-37.0
21.00	14.2	-37.3
22.00	13.9	-37.5
23.00	13.9	-37.5
24.00	13.8	-37.7
25.00	13.4	-38.0
26.00	13.2	-38.2
27.00	13.2	-38.3
28.00	12.7	-38.7
29.00	12.7	-38.8
30.00	12.4	-39.0

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

COM-POWER AC-220

COMBILOG ANTENNA

S/N: 61093

CALIBRATION DATE: DECEMBER 14, 2021

FREQUENCY (MHz)	FACTOR (dB)	FREQUENCY (MHz)	FACTOR (dB)
30	22.50	200	16.00
35	21.40	250	17.40
40	21.00	300	19.70
45	20.60	350	20.00
50	19.70	400	22.20
60	16.10	450	22.40
70	12.80	500	23.10
80	12.50	550	23.40
90	14.20	600	24.90
100	15.40	650	25.30
120	16.50	700	25.40
125	16.80	750	26.40
140	15.90	800	26.70
150	16.60	850	27.10
160	18.50	900	27.90
175	15.90	950	28.00
180	15.50	1000	28.00

COM POWER AH-118**HORN ANTENNA****S/N: 10050113****CALIBRATION DATE: DECEMBER 16, 2021**

FREQUENCY (GHz)	FACTOR (dB)	FREQUENCY (GHz)	FACTOR (dB)
1.0	23.86	10.0	38.91
1.5	25.67	10.5	39.94
2.0	28.25	11.0	39.10
2.5	29.17	11.5	39.70
3.0	29.78	12.0	40.29
3.5	30.88	12.5	41.93
4.0	31.21	13.0	41.34
4.5	32.96	13.5	40.57
5.0	33.30	14.0	40.23
5.5	34.24	14.5	42.25
6.0	34.57	15.0	43.63
6.5	35.61	15.5	39.96
7.0	36.60	16.0	40.38
7.5	37.49	16.5	40.56
8.0	37.44	17.0	40.93
8.5	37.98	17.5	42.27
9.0	38.01	18.0	43.77
9.5	38.53		

COM-POWER AH-826**HORN ANTENNA**

S/N: 71957

FREQUENCY (GHz)	FACTOR (dB)	FREQUENCY (GHz)	FACTOR (dB)
18.0	33.5	22.5	35.5
18.5	33.5	23.0	35.9
19.0	34.0	23.5	35.7
19.5	34.0	24.0	35.6
20.0	34.3	24.5	36.0
20.5	34.9	25.0	36.2
21.0	34.7	25.5	36.1
21.5	35.0	26.0	36.2
22.0	35.0	26.5	35.7

COM-POWER PA-118**PREAMPLIFIER**

S/N: 181653

CALIBRATION DATE: MARCH 7, 2022

FREQUENCY (GHz)	FACTOR (dB)	FREQUENCY (GHz)	FACTOR (dB)
1.0	40.02	6.0	38.84
1.1	39.72	6.5	39.20
1.2	39.93	7.0	39.46
1.3	39.98	7.5	39.67
1.4	39.99	8.0	39.28
1.5	40.20	8.5	38.63
1.6	40.05	9.0	38.96
1.7	40.15	9.5	39.33
1.8	40.20	10.0	39.58
1.9	40.33	11.0	38.25
2.0	40.33	12.0	40.03
2.5	40.60	13.0	40.55
3.0	40.76	14.0	40.36
3.5	40.87	15.0	39.34
4.0	40.39	16.0	37.34
4.5	39.55	17.0	42.14
5.0	40.34	18.0	42.54
5.5	39.45		

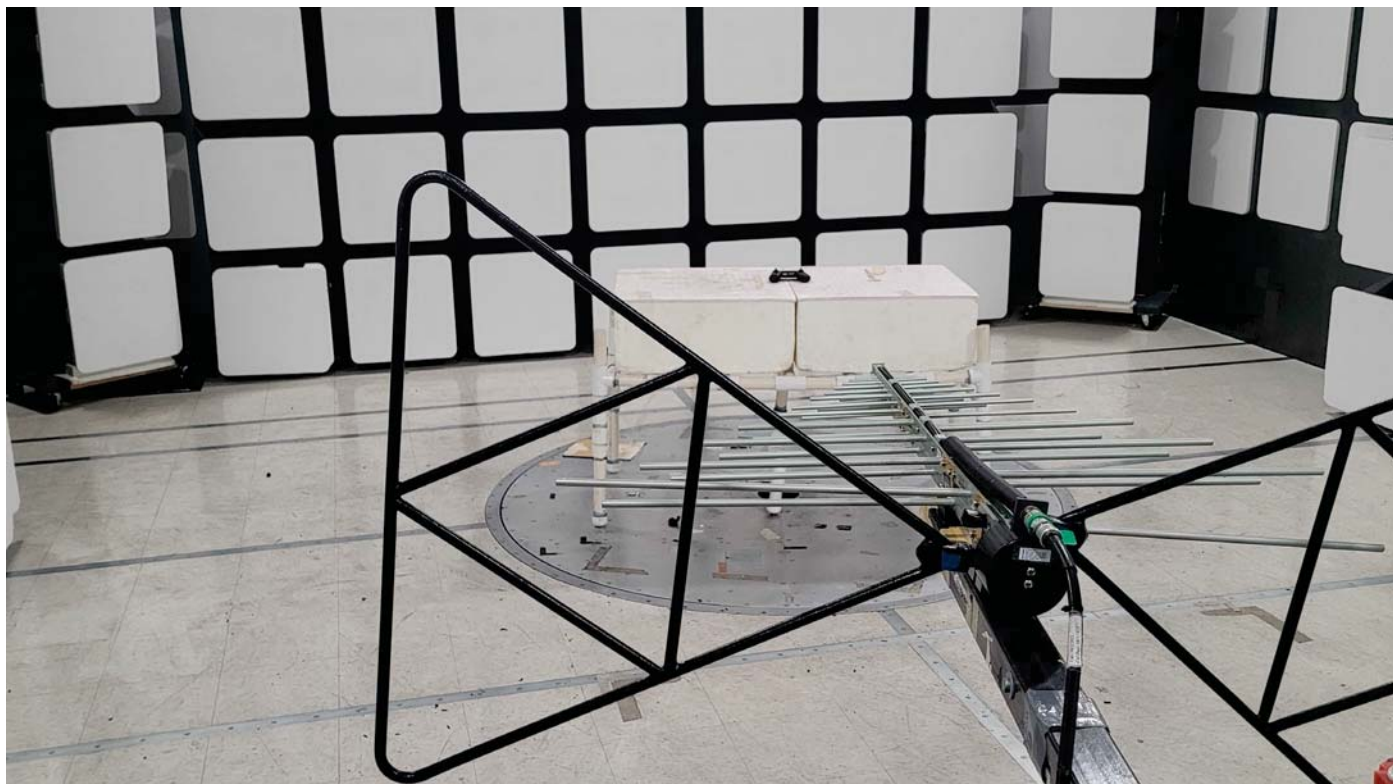
COM-POWER PA-840

MICROWAVE PREAMPLIFIER

S/N: 711013

CALIBRATION DATE: APRIL 8, 2022

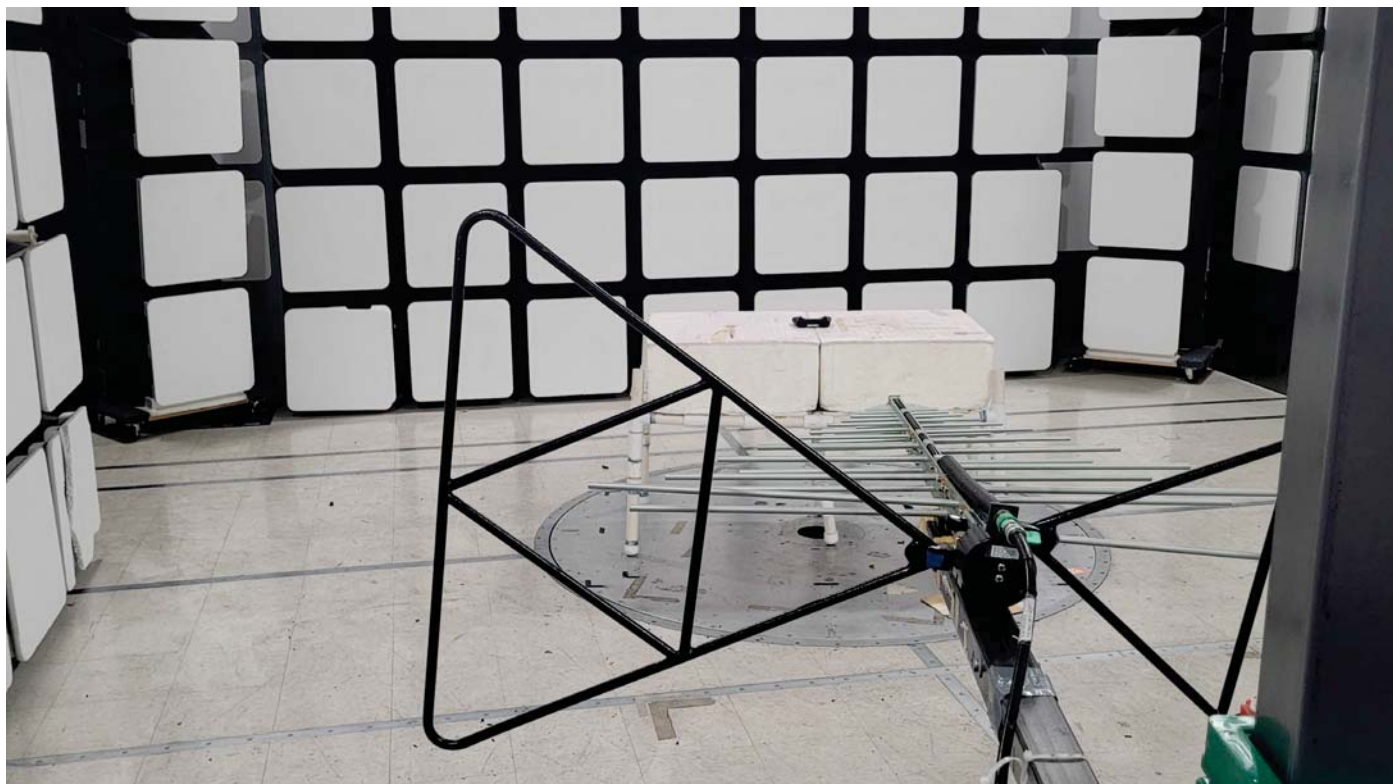
FREQUENCY (GHz)	FACTOR (dB)
18.0	24.85
19.0	24.25
20.0	22.69
21.0	22.17
22.0	22.78
23.0	23.23
24.0	23.72
25.0	24.13
26.0	24.28
26.5	25.06



FRONT VIEW

FTW LLC
HOPPER CONTROLLER
MODEL: FTW000223
FCC SUBPART B AND C – RADIATED EMISSIONS – BELOW 1 GHz

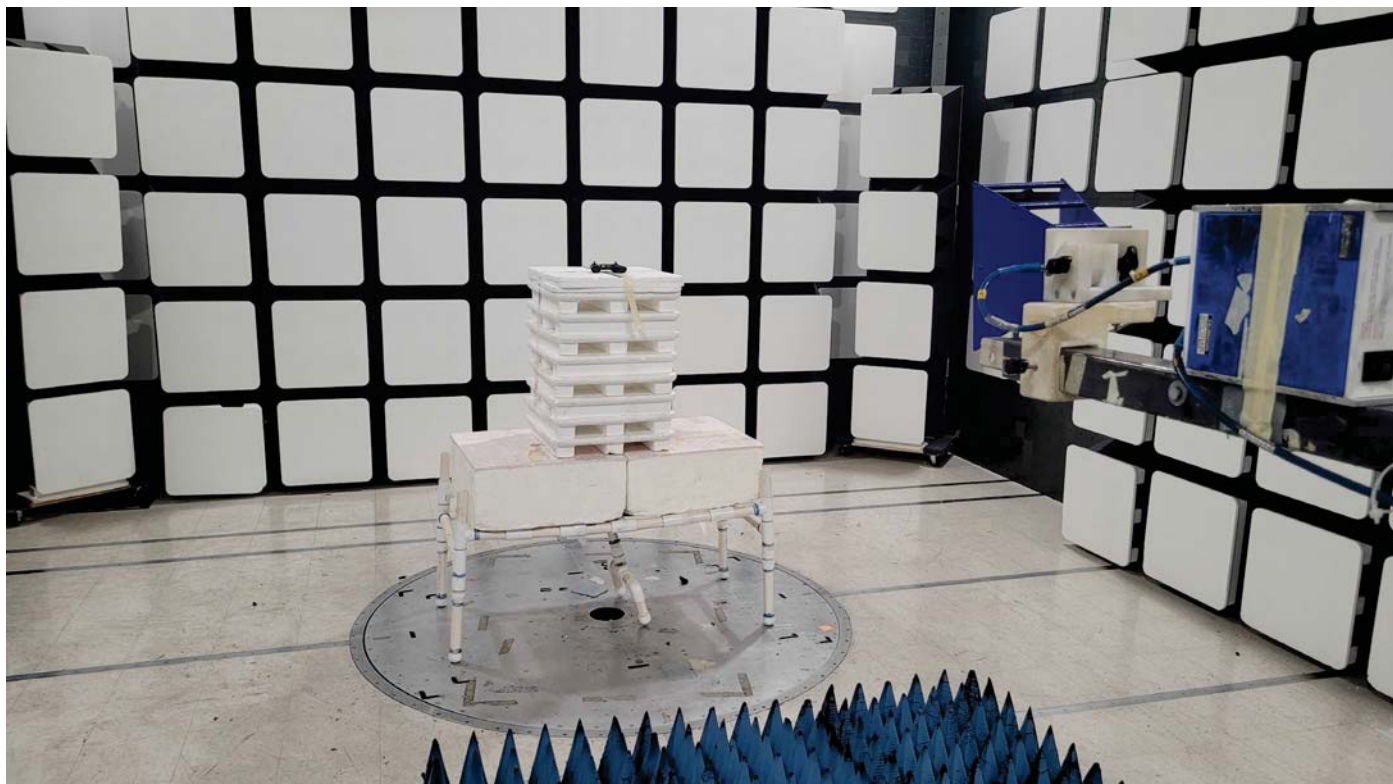
**PHOTOGRAPH SHOWING THE EUT CONFIGURATION
FOR MAXIMUM EMISSIONS**



REAR VIEW

FTW LLC
HOPPER CONTROLLER
MODEL: FTW000223
FCC SUBPART B AND C – RADIATED EMISSIONS – BELOW 1 GHz

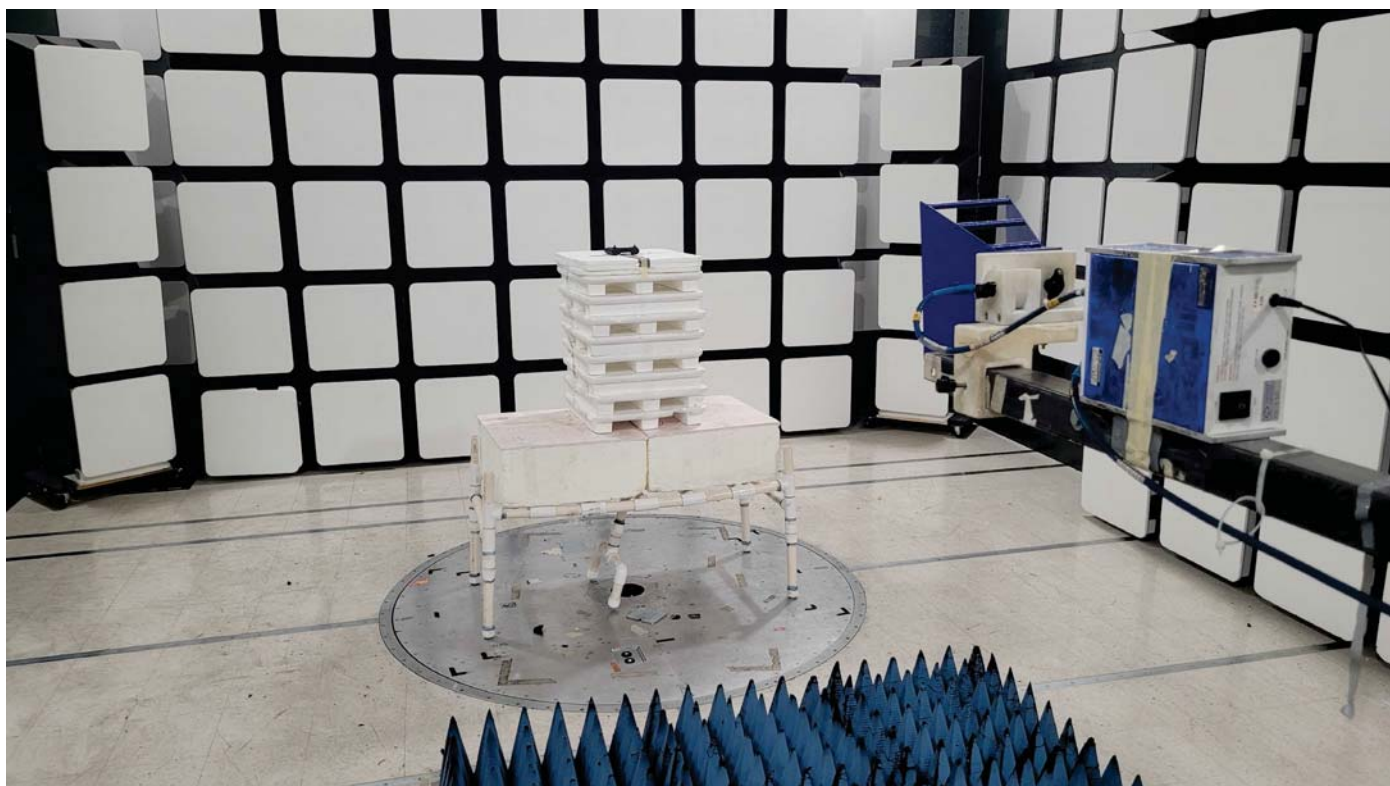
**PHOTOGRAPH SHOWING THE EUT CONFIGURATION
FOR MAXIMUM EMISSIONS**



FRONT VIEW

FTW LLC
HOPPER CONTROLLER
MODEL: FTW000223
FCC SUBPART B AND C – RADIATED EMISSIONS – ABOVE 1 GHz

**PHOTOGRAPH SHOWING THE EUT CONFIGURATION
FOR MAXIMUM EMISSIONS**



REAR VIEW

FTW LLC
HOPPER CONTROLLER
MODEL: FTW000223
FCC SUBPART B AND C – RADIATED EMISSIONS – ABOVE 1 GHz

**PHOTOGRAPH SHOWING THE EUT CONFIGURATION
FOR MAXIMUM EMISSIONS**

APPENDIX E

DATA SHEETS

***SPURIOUS EMISSIONS – 30 MHz TO 1000 MHz
DATA SHEETS***

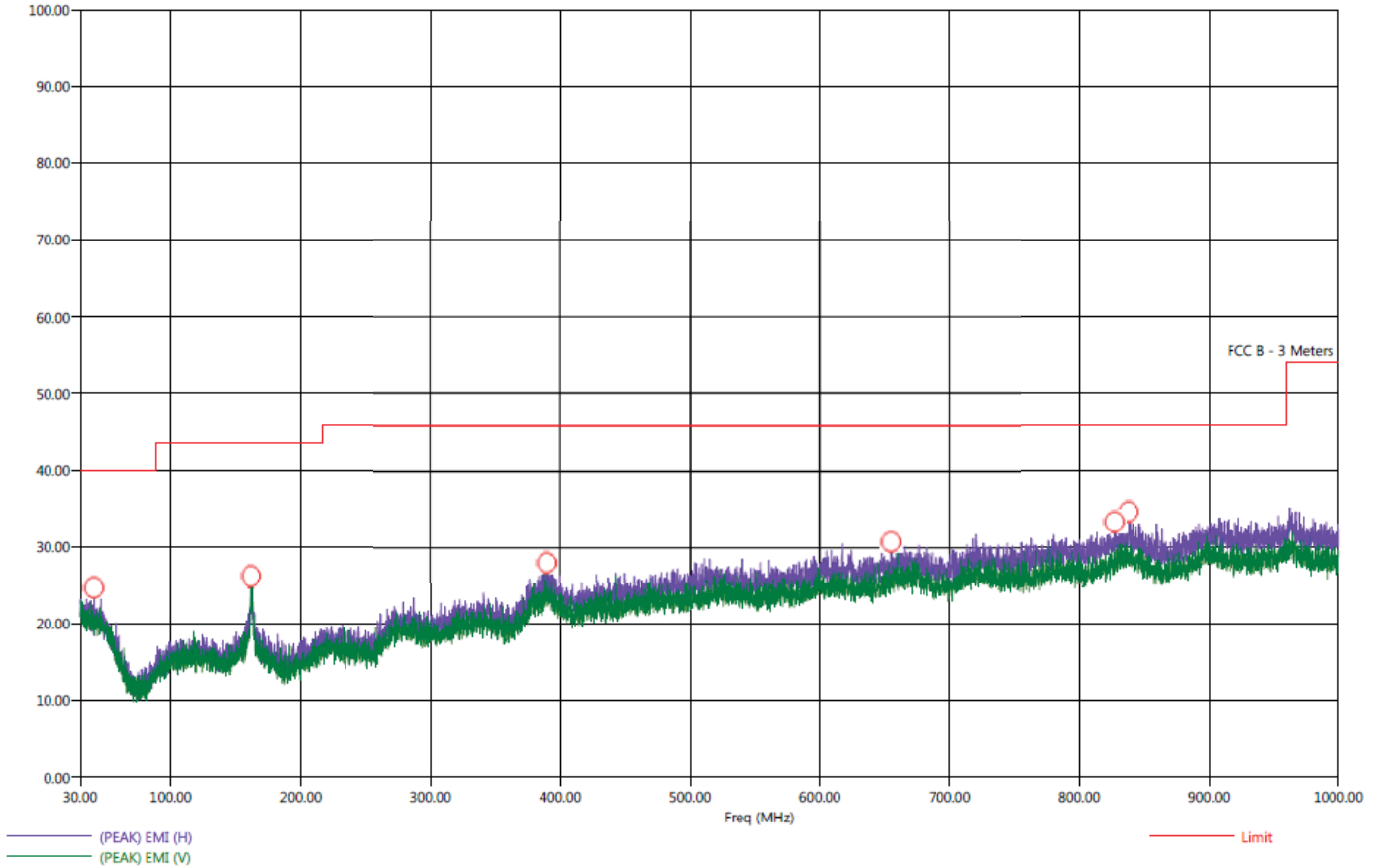


Title: Pre-Scan – FCC Class B
File: 1 – Pre-Scan – X-Axis – 2402 MHz – 08-02-2023.set
Operator: Kyle Fujimoto
EUT Type: Hopper Controller
EUT Condition: The EUT is continuously transmitting at 2402 MHz
Company: FTW LLC
Model: FTW000223
S/N: N/A
X-Axis (Worst Case)

8/2/2023 11:48:36 AM
Sequence: Preliminary Scan

FCC Class B

Electric Field Strength (dBμV/m)



Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



Title: Radiated Final – FCC Class B
 File: 1 – Final-Scan – X-Axis – 2402 MHz – 08-02-2023.set
 Operator: Kyle Fujimoto
 EUT Type: Hopper Controller
 EUT Condition: The EUT is continuously transmitting at 2402 MHz
 Company: FTW LLC
 Model: FTW000223
 S/N: N/A
 X-Axis (Worst Case)

8/2/2023 3:22:38 PM
 Sequence: Final Measurements

FCC Class B

Freq (MHz)	Pol	(PEAK) EMI (dBμV/m)	(QP) EMI (dBμV/m)	Freq (Max) (MHz)	Limit (dBμV/m)	(PEAK) Margin (dB)	(QP) Margin (dB)	(PEAK) Trace (dBμV)	(QP) Trace (dBμV)
40.80	H	13.54	8.29	40.76	40.00	-26.46	-31.71	-7.81	-13.06
161.90	H	16.41	11.38	161.96	43.50	-27.09	-32.12	-7.43	-12.46
390.30	H	17.44	12.65	390.41	46.00	-28.56	-33.35	-7.55	-12.34
655.00	H	19.53	14.38	654.81	46.00	-26.47	-31.62	-8.03	-13.18
827.20	H	21.75	16.51	827.19	46.00	-24.25	-29.49	-8.37	-13.61
838.20	H	22.15	16.95	838.04	46.00	-23.85	-29.05	-7.96	-13.16



***TRANSMIT HARMONICS
DATA SHEETS***

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - X-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	40.15	V	73.97	-33.82	Peak	327.25	207.50	
4804.00	27.55	V	53.97	-26.42	Avg	327.25	207.50	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	40.15	V	73.97	-33.82	Peak	327.25	175.02	
12010.00	27.55	V	53.97	-26.42	Avg	327.25	175.02	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	38.91	V	73.97	-35.06	Peak	343.75	127.50	
4804.00	27.00	V	53.97	-26.97	Avg	343.75	127.50	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	51.74	V	73.97	-22.23	Peak	21.00	143.32	
12010.00	39.79	V	53.97	-14.18	Avg	21.00	143.32	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	42.74	V	73.97	-31.23	Peak	315.50	223.20	
4804.00	26.73	V	53.97	-27.24	Avg	315.50	223.20	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	49.67	V	73.97	-24.30	Peak	213.25	111.32	
12010.00	38.43	V	53.97	-15.54	Avg	213.25	111.32	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - X-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	42.25	H	73.97	-31.72	Peak	142.97	125.25	
4804.00	26.87	H	53.97	-27.10	Avg	142.97	125.25	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	48.12	H	73.97	-25.85	Peak	177.75	142.79	
12010.00	36.10	H	53.97	-17.87	Avg	177.75	142.79	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	40.58	H	73.97	-33.39	Peak	127.00	111.38	
4804.00	29.83	H	53.97	-24.14	Avg	127.00	111.38	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	49.26	H	73.97	-24.71	Peak	246.00	143.32	
12010.00	37.80	H	53.97	-16.17	Avg	246.00	143.32	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Low Channel**Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4804.00	40.77	H	73.97	-33.20	Peak	125.00	175.14	
4804.00	30.12	H	53.97	-23.85	Avg	125.00	175.14	
7206.00								Not in Restricted Band
7206.00								Done Via Conducted
9608.00								Not in Restricted Band
9608.00								Done Via Conducted
12010.00	49.83	H	73.97	-24.14	Peak	328.00	191.32	
12010.00	38.94	H	53.97	-15.03	Avg	328.00	191.32	
14412.00								No Emission
14412.00								Detected
16814.00								No Emission
16814.00								Detected
19216.00								No Emission
19216.00								Detected
21618.00								No Emission
21618.00								Detected
24020.00								No Emission
24020.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Middle Channel**Transmit Mode - X-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	41.66	V	73.97	-32.31	Peak	143.25	127.44	
4880.00	32.09	V	53.97	-21.88	Avg	143.25	127.44	
7320.00	44.06	V	73.97	-29.91	Peak	172.00	249.01	
7320.00	32.84	V	53.97	-21.13	Avg	172.00	249.01	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	50.85	V	73.97	-23.12	Peak	266.50	111.14	
12200.00	40.05	V	53.97	-13.92	Avg	266.50	111.14	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Middle Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	41.51	V	73.97	-32.46	Peak	200.50	127.38	
4880.00	32.00	V	53.97	-21.97	Avg	200.50	127.38	
7320.00	46.18	V	73.97	-27.79	Peak	177.50	239.38	
7320.00	34.63	V	53.97	-19.34	Avg	177.50	239.38	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	50.14	V	73.97	-23.83	Peak	88.75	191.08	
12200.00	39.27	V	53.97	-14.70	Avg	88.75	191.08	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

FCC 15.247

FTW LLC
Hopper Controller
Model: FTW000223

Date: 07/29/2023
Lab: D
Tested By: Kyle Fujimoto

**Harmonics - Middle Channel
Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	41.62	V	73.97	-32.35	Peak	200.25	127.38	
4880.00	29.00	V	53.97	-24.97	Avg	200.25	127.38	
7320.00	45.67	V	73.97	-28.30	Peak	155.50	249.95	
7320.00	34.05	V	53.97	-19.92	Avg	155.50	249.95	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	50.21	V	73.97	-23.76	Peak	313.75	127.14	
12200.00	39.33	V	53.97	-14.64	Avg	313.75	127.14	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Middle Channel**Transmit Mode - X-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	42.10	H	73.97	-31.87	Peak	305.50	158.97	
4880.00	32.99	H	53.97	-20.98	Avg	305.50	158.97	
7320.00	45.25	H	73.97	-28.72	Peak	64.75	175.20	
7320.00	33.88	H	53.97	-20.09	Avg	64.75	175.20	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	50.45	H	73.97	-23.52	Peak	312.25	126.24	
12200.00	39.66	H	53.97	-14.31	Avg	312.25	126.24	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Middle Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	42.56	H	73.97	-31.41	Peak	212.00	191.02	
4880.00	32.06	H	53.97	-21.91	Avg	212.00	191.02	
7320.00	45.80	H	73.97	-28.17	Peak	154.75	110.13	
7320.00	34.27	H	53.97	-19.70	Avg	154.75	110.13	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	51.38	H	73.97	-22.59	Peak	105.25	143.32	
12200.00	40.67	H	53.97	-13.30	Avg	105.25	143.32	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - Middle Channel**Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4880.00	39.45	H	73.97	-34.52	Peak	350.00	159.32	
4880.00	26.15	H	53.97	-27.82	Avg	350.00	159.32	
7320.00	43.89	H	73.97	-30.08	Peak	234.00	249.01	
7320.00	32.29	H	53.97	-21.68	Avg	234.00	249.01	
9760.00								Not in Restricted Band
9760.00								Done Via Conducted
12200.00	50.02	H	73.97	-23.95	Peak	3.25	111.14	
12200.00	38.58	H	53.97	-15.39	Avg	3.25	111.14	
14640.00								No Emission
14640.00								Detected
17080.00								No Emission
17080.00								Detected
19520.00								No Emission
19520.00								Detected
21960.00								No Emission
21960.00								Detected
24400.00								No Emission
24400.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - High Channel**Transmit Mode - X-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	40.31	V	73.97	-33.66	Peak	306.50	238.97	
4960.00	29.99	V	53.97	-23.98	Avg	306.50	238.97	
7440.00	44.97	V	73.97	-29.00	Peak	112.00	175.14	
7440.00	32.56	V	53.97	-21.41	Avg	112.00	175.14	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	48.68	V	73.97	-25.29	Peak	42.75	159.38	
12400.00	37.16	V	53.97	-16.81	Avg	42.75	159.38	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - High Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	40.06	V	73.97	-33.91	Peak	41.25	127.92	
4960.00	28.82	V	53.97	-25.15	Avg	41.25	127.92	
7440.00	46.29	V	73.97	-27.68	Peak	21.00	191.50	
7440.00	35.65	V	53.97	-18.32	Avg	21.00	191.50	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	49.52	V	73.97	-24.45	Peak	173.25	111.32	
12400.00	38.05	V	53.97	-15.92	Avg	173.25	111.32	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - High Channel**Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	41.03	V	73.97	-32.94	Peak	285.75	159.44	
4960.00	25.68	V	53.97	-28.29	Avg	285.75	159.44	
7440.00	44.01	V	73.97	-29.96	Peak	0.00	159.26	
7440.00	32.42	V	53.97	-21.55	Avg	0.00	159.26	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	47.98	V	73.97	-25.99	Peak	217.25	175.32	
12400.00	36.31	V	53.97	-17.66	Avg	217.25	175.32	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

**FCC 15.247**

FTW LLC
Hopper Controller
Model: FTW000223

Date: 07/29/2023
Lab: D
Tested By: Kyle Fujimoto

Harmonics - High Channel
Transmit Mode - X-Axis

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	42.19	H	73.97	-31.78	Peak	112.00	143.32	
4960.00	28.91	H	53.97	-25.06	Avg	112.00	143.32	
7440.00	44.77	H	73.97	-29.20	Peak	93.75	159.50	
7440.00	33.40	H	53.97	-20.57	Avg	93.75	159.50	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	48.07	H	73.97	-25.90	Peak	247.75	207.26	
12400.00	36.54	H	53.97	-17.43	Avg	247.75	207.26	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Harmonics - High Channel**Transmit Mode - Y-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	40.59	H	73.97	-33.38	Peak	317.00	159.14	
4960.00	26.50	H	53.97	-27.47	Avg	317.00	159.14	
7440.00	44.81	H	73.97	-29.16	Peak	183.25	111.02	
7440.00	33.01	H	53.97	-20.96	Avg	183.25	111.02	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	50.93	H	73.97	-23.04	Peak	293.25	127.08	
12400.00	38.41	H	53.97	-15.56	Avg	293.25	127.08	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

FCC 15.247

FTW LLC
Hopper Controller
Model: FTW000223

Date: 07/29/2023
Lab: D
Tested By: Kyle Fujimoto

**Harmonics - High Channel
Transmit Mode - Z-Axis**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
4960.00	40.38	H	73.97	-33.59	Peak	75.75	127.02	
4960.00	30.27	H	53.97	-23.70	Avg	75.75	127.02	
7440.00	47.19	H	73.97	-26.78	Peak	351.50	206.67	
7440.00	35.29	H	53.97	-18.68	Avg	351.50	206.67	
9920.00								Not in Restricted Band
9920.00								Done Via Conducted
12400.00	49.11	H	73.97	-24.86	Peak	94.50	126.37	
12400.00	36.85	H	53.97	-17.12	Avg	94.50	126.37	
14880.00								No Emission
14880.00								Detected
17360.00								No Emission
17360.00								Detected
19840.00								No Emission
19840.00								Detected
22320.00								No Emission
22320.00								Detected
24800.00								No Emission
24800.00								Detected

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Non Harmonic Emissions from the Tx and Digital Portion - 9 kHz to 30 MHz**Non Harmonic Emissions from the Tx and Digital Portion - 1 GHz to 25 GHz**

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
								No Emissions Detected
								from 9 kHz to 30 MHz
								for the digital portion
								of the EUT
								No Emissions Detected
								from 9 kHz to 30 MHz
								for the Non-Harmonic Emissions
								of the Transmitter for the EUT
								No Emissions Detected
								from 1 GHz to 25 GHz
								for the digital portion
								of the EUT
								No Emissions Detected
								from 1 GHz to 25 GHz
								for the Non-Harmonic Emissions
								of the Transmitter for the EUT
								Investigated in the X-Axis,
								Y-Axis, and Z-Axis

***BAND EDGES
DATA SHEETS***

**FCC 15.247**

FTW LLC

Hopper Controller

Model: FTW000223

Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Band Edges

Freq. (MHz)	Level (dBuV/m)	Pol (v/h)	Limit	Margin	Peak / QP / Avg	Table Angle (deg)	Ant. Height (cm)	Comments
2402.00	86.13	H	--	--	Peak	325.00	170.13	Fundamental - Low Ch.
2402.00	84.85	H	--	--	Avg	325.00	170.13	X-Axis - Worst Case
2390.00	35.07	H	73.97	-38.90	Peak	325.00	170.13	Band Edge
2390.00	23.58	H	53.97	-30.39	Avg	325.00	170.13	X-Axis - Worst Case
2402.00	85.55	V	--	--	Peak	90.50	159.80	Fundamental - Low Ch.
2402.00	84.30	V	--	--	Avg	90.50	159.80	Z-Axis - Worst Case
2390.00	34.87	V	73.97	-39.10	Peak	90.50	159.80	Band Edge
2390.00	23.56	V	53.97	-30.41	Avg	90.50	159.80	Z-Axis - Worst Case



FCC 15.247

FTW LLC

Hopper Controller

Model: FTW000223

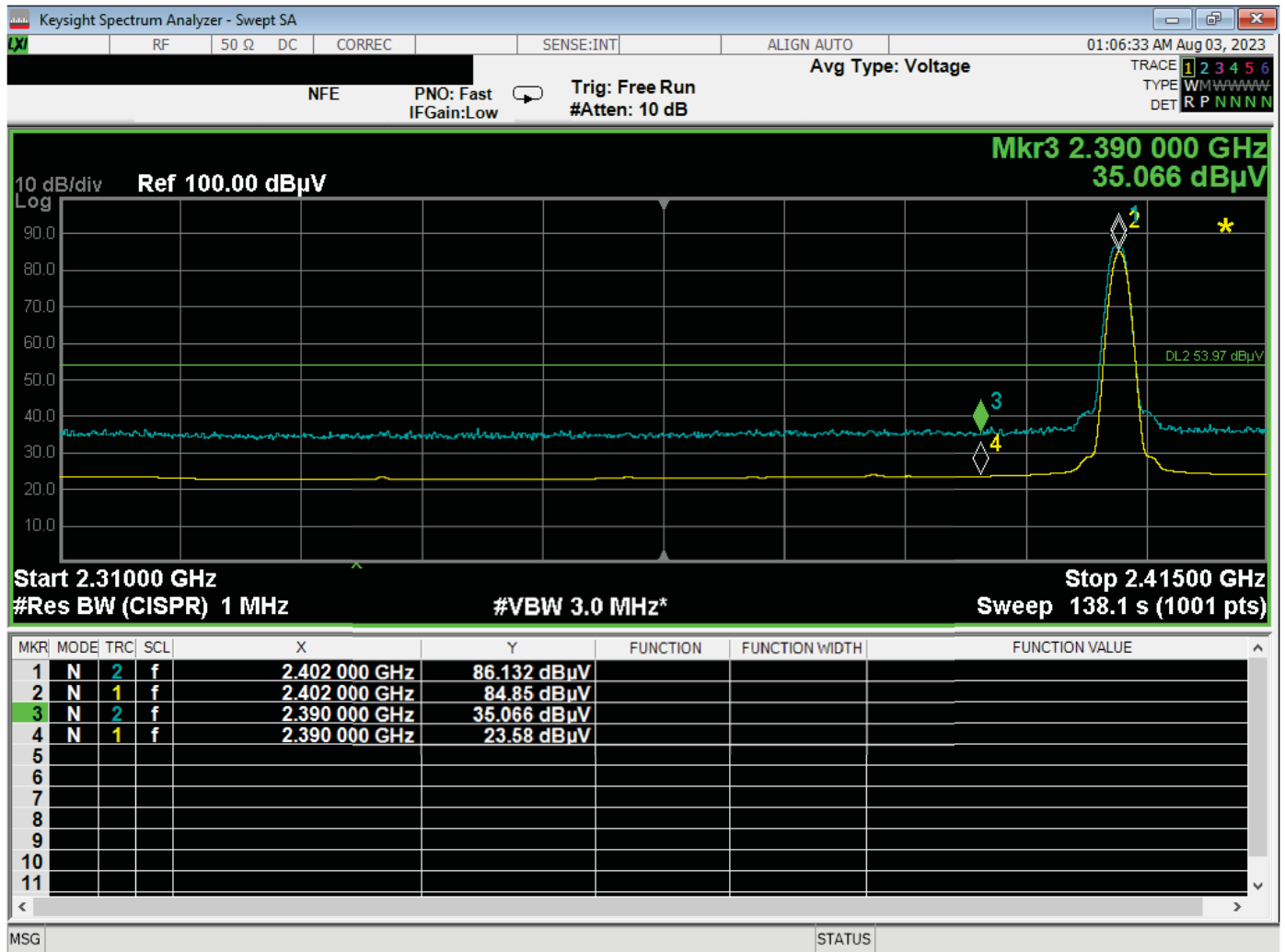
Date: 07/29/2023

Lab: D

Tested By: Kyle Fujimoto

Band Edges

[illegible]

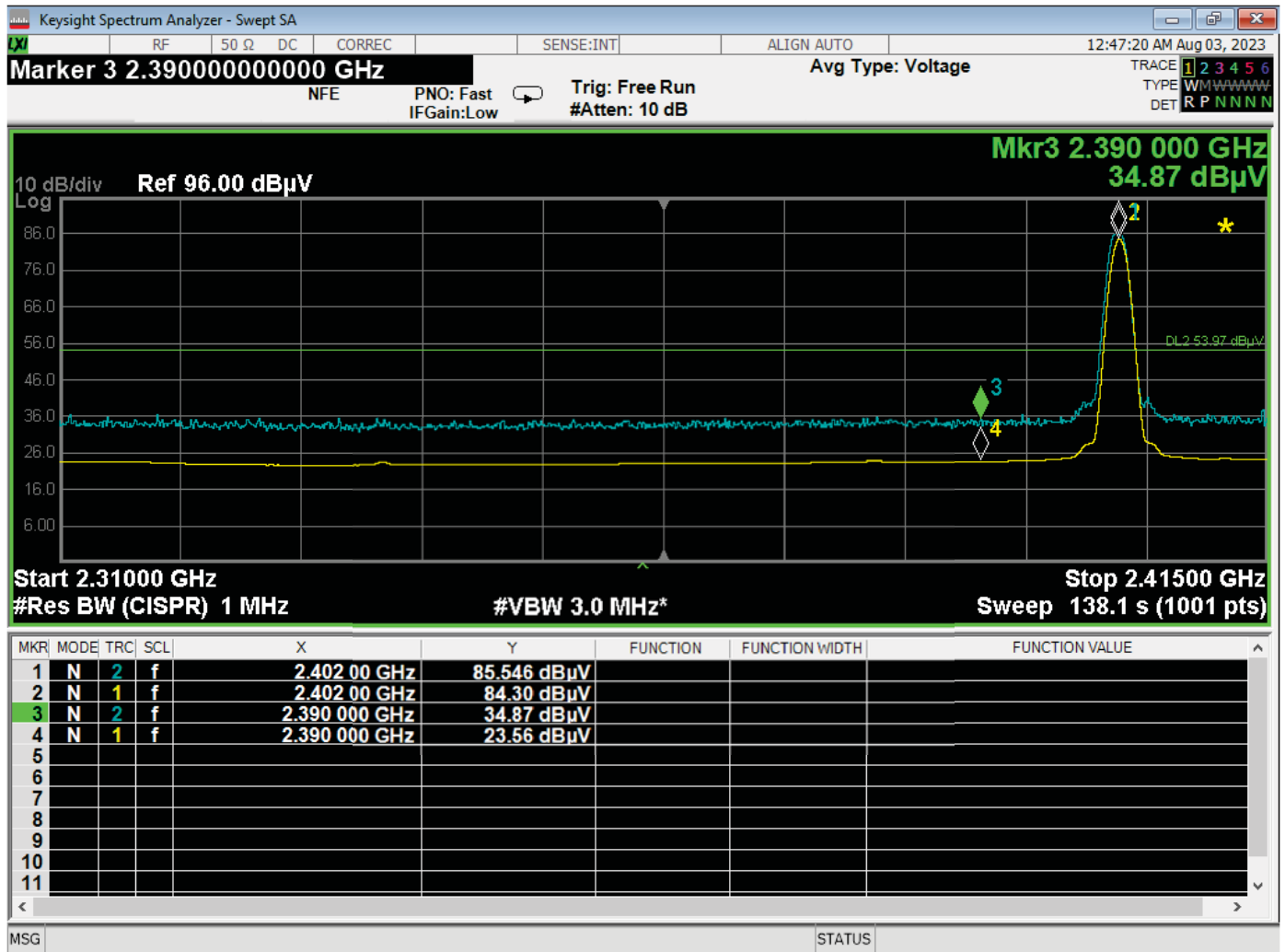


Band Edge - 2402 MHz - BLE - Controller - Horizontal - X-Axis

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

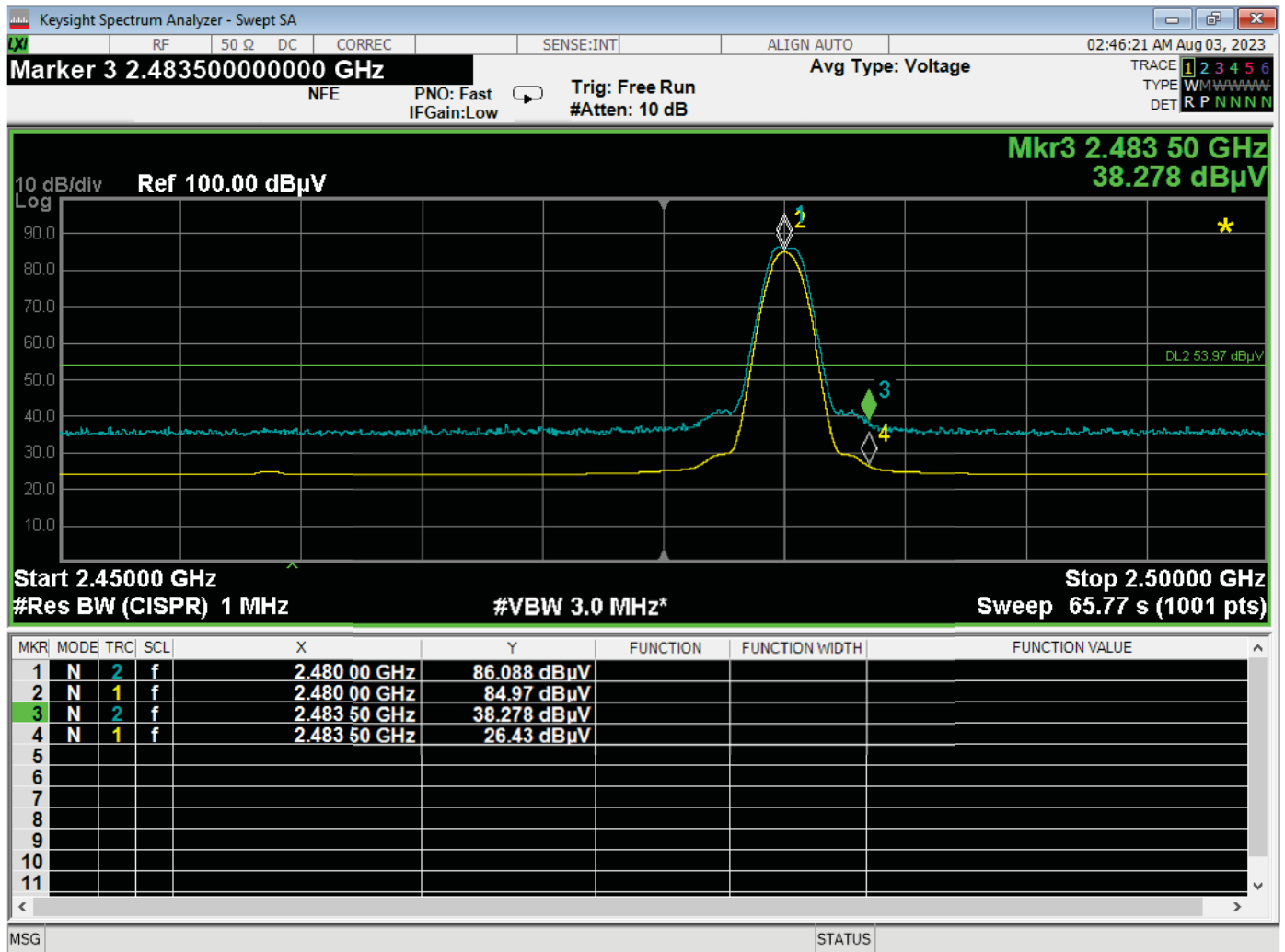


Band Edge - 2402 MHz - BLE - Controller - Vertical - Z-Axis

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

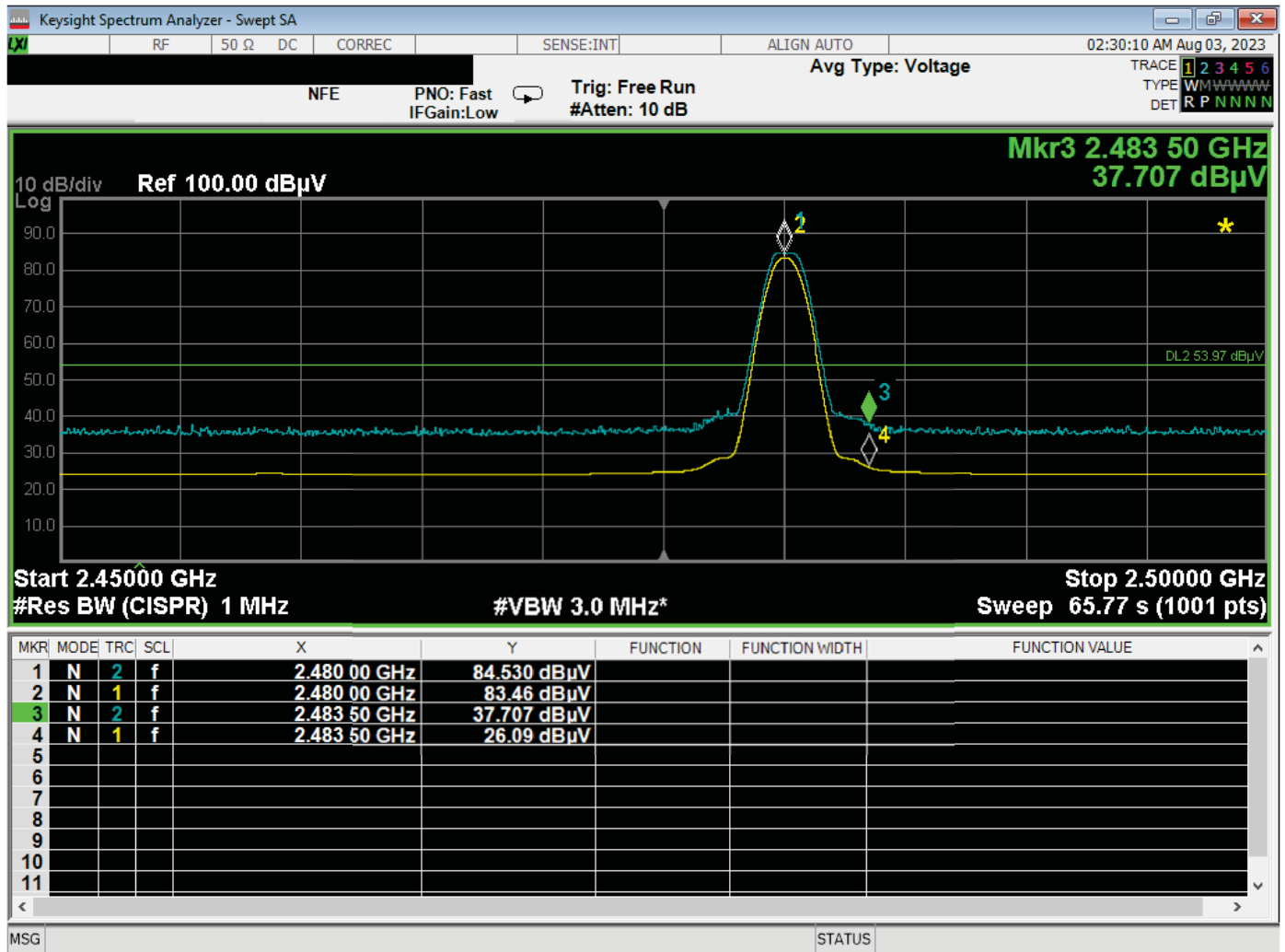


Band Edge - 2480 MHz - BLE - Controller - Horizontal - X-Axis

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



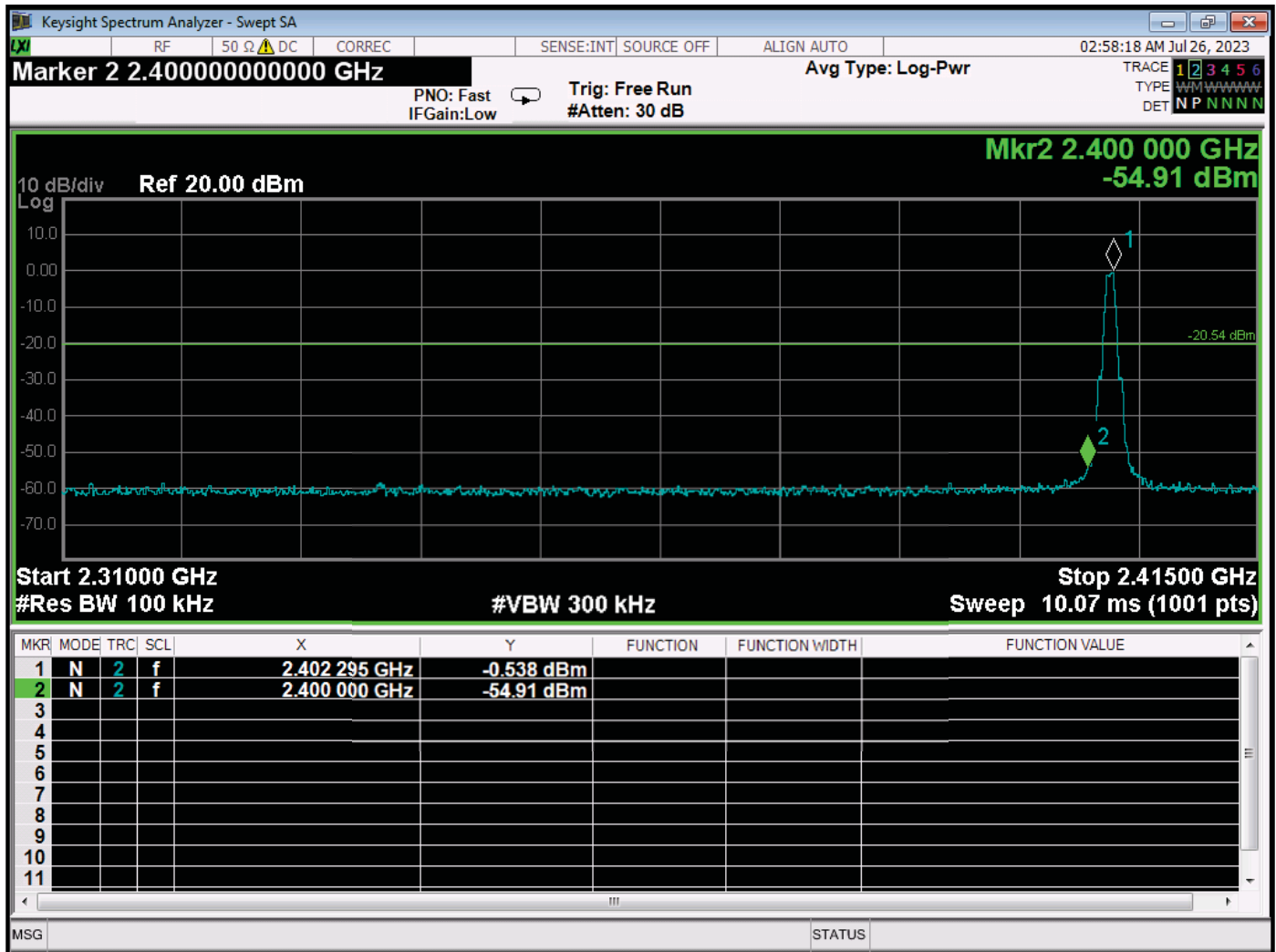
Band Edge - 2480 MHz - BLE - Controller - Vertical - Z-Axis

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

***BAND EDGES
CONDUCTED
2402 MHz at 2400 MHz
DATA SHEETS***



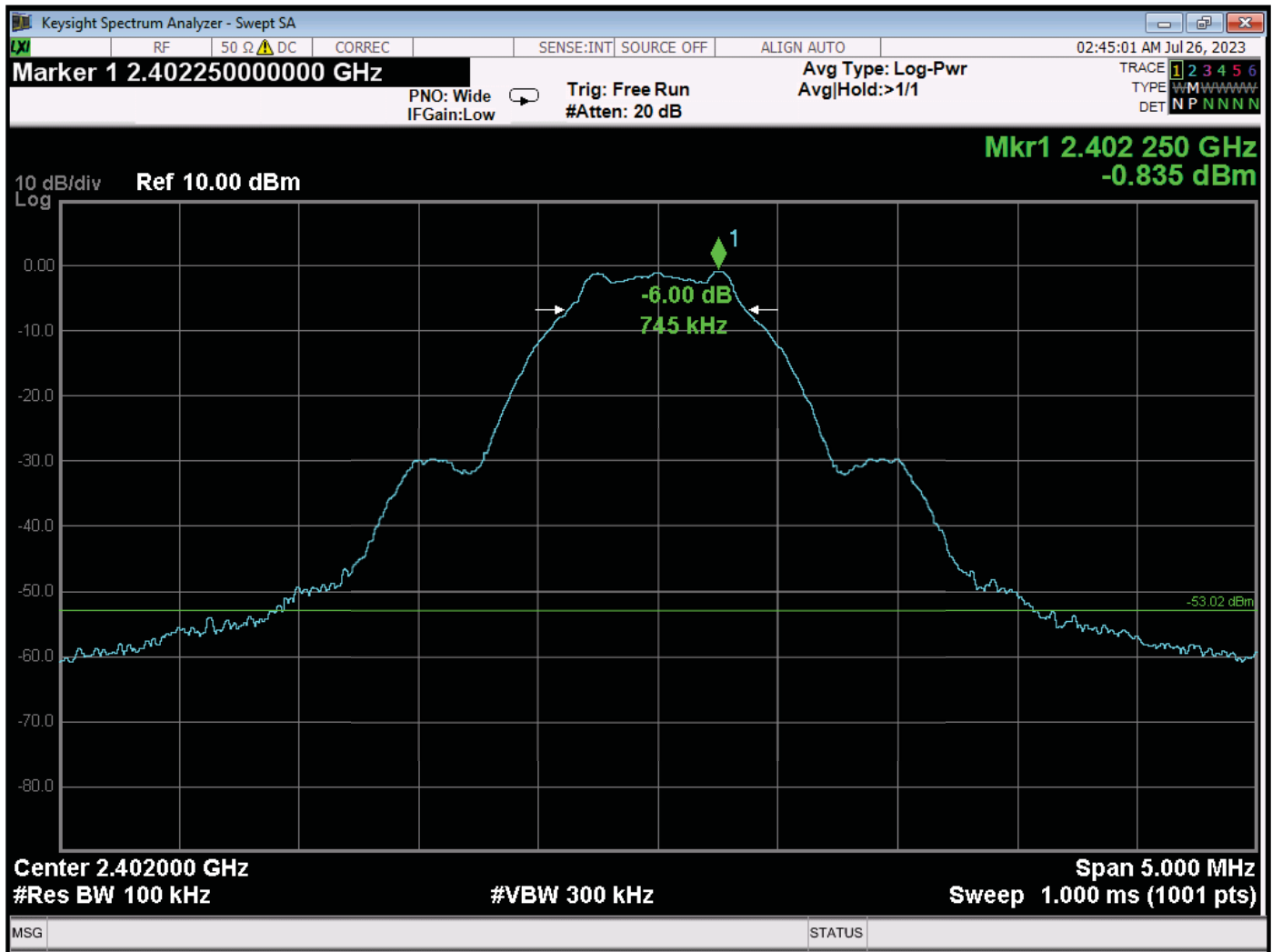
Band Edge at 2400 MHz - 2402 MHz - BLE - Controller - Conducted

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

***DTS BANDWIDTH
DATA SHEETS***

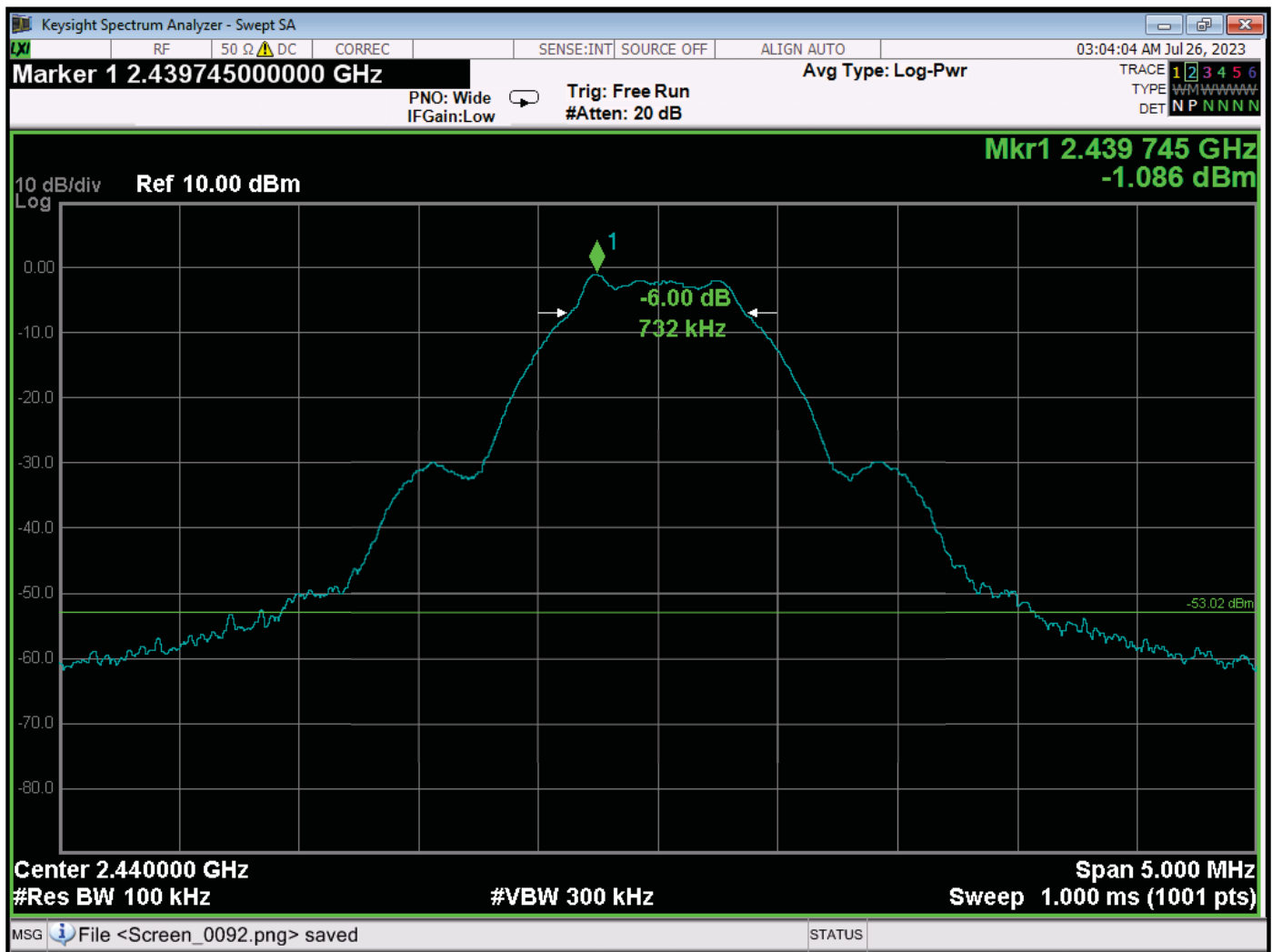


Bandwidth 6 dB – 2402 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

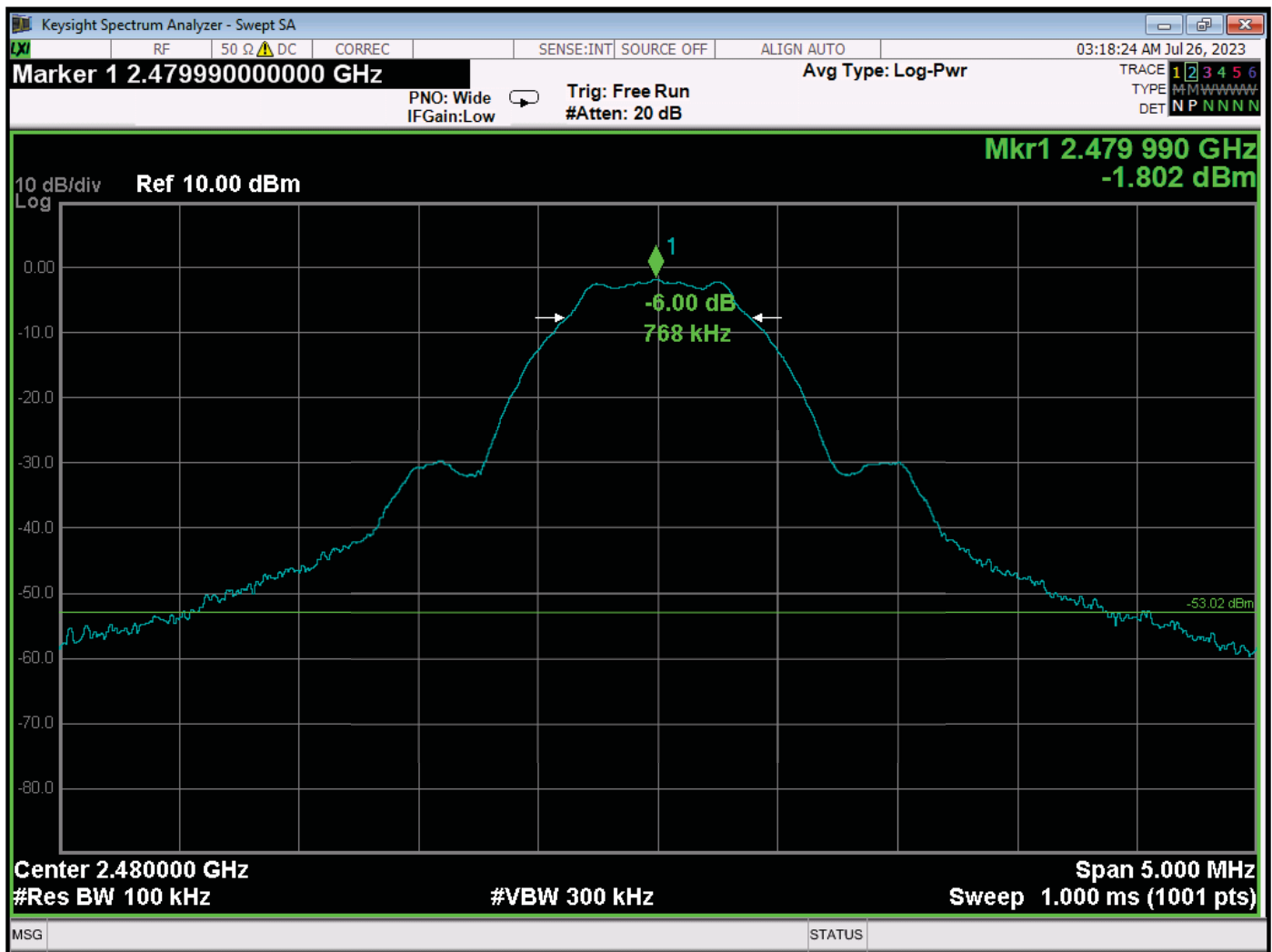


Bandwidth 6 dB – 2440 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



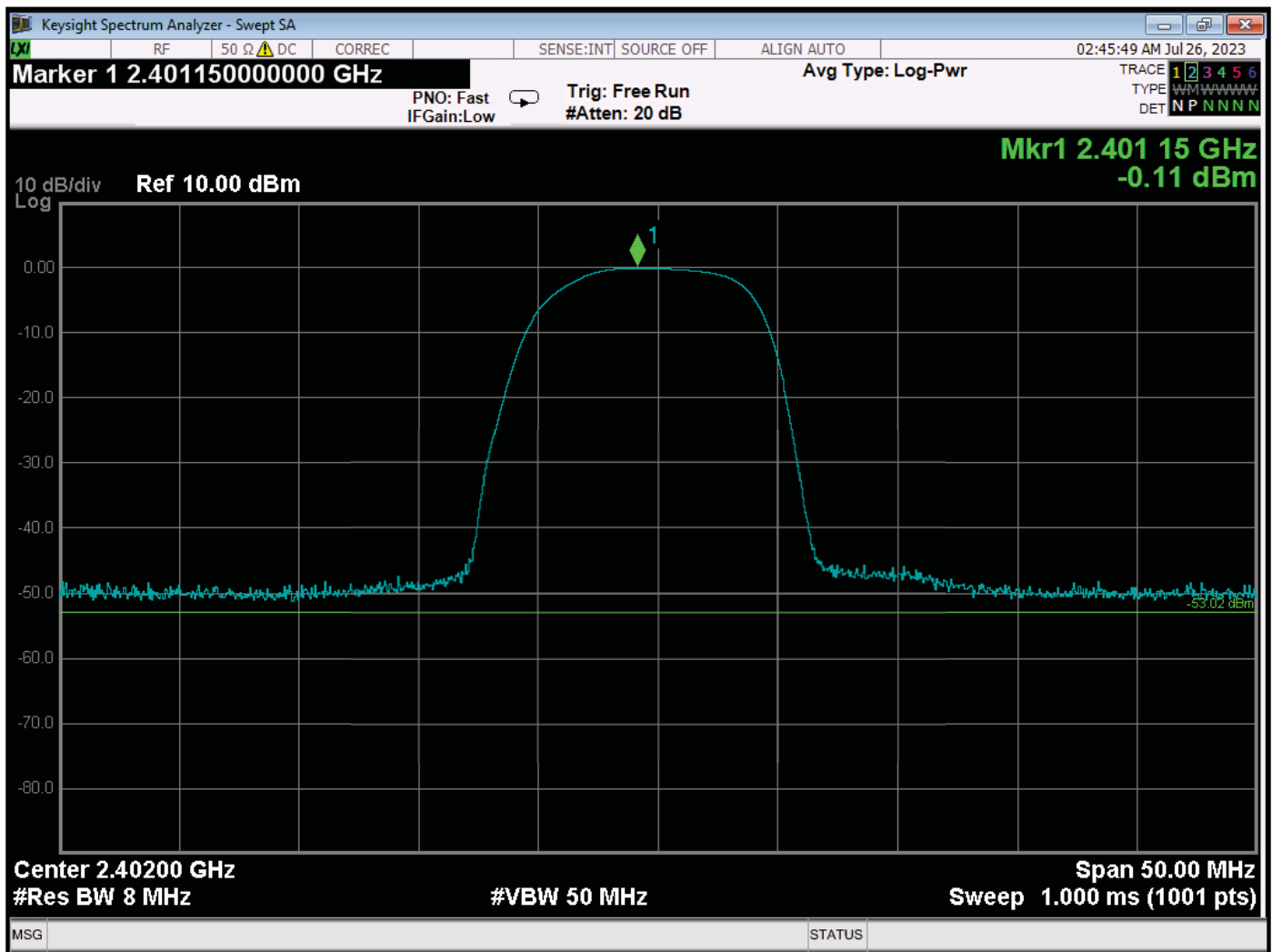
Bandwidth 6 dB – 2480 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

***PEAK OUTPUT POWER
DATA SHEETS***

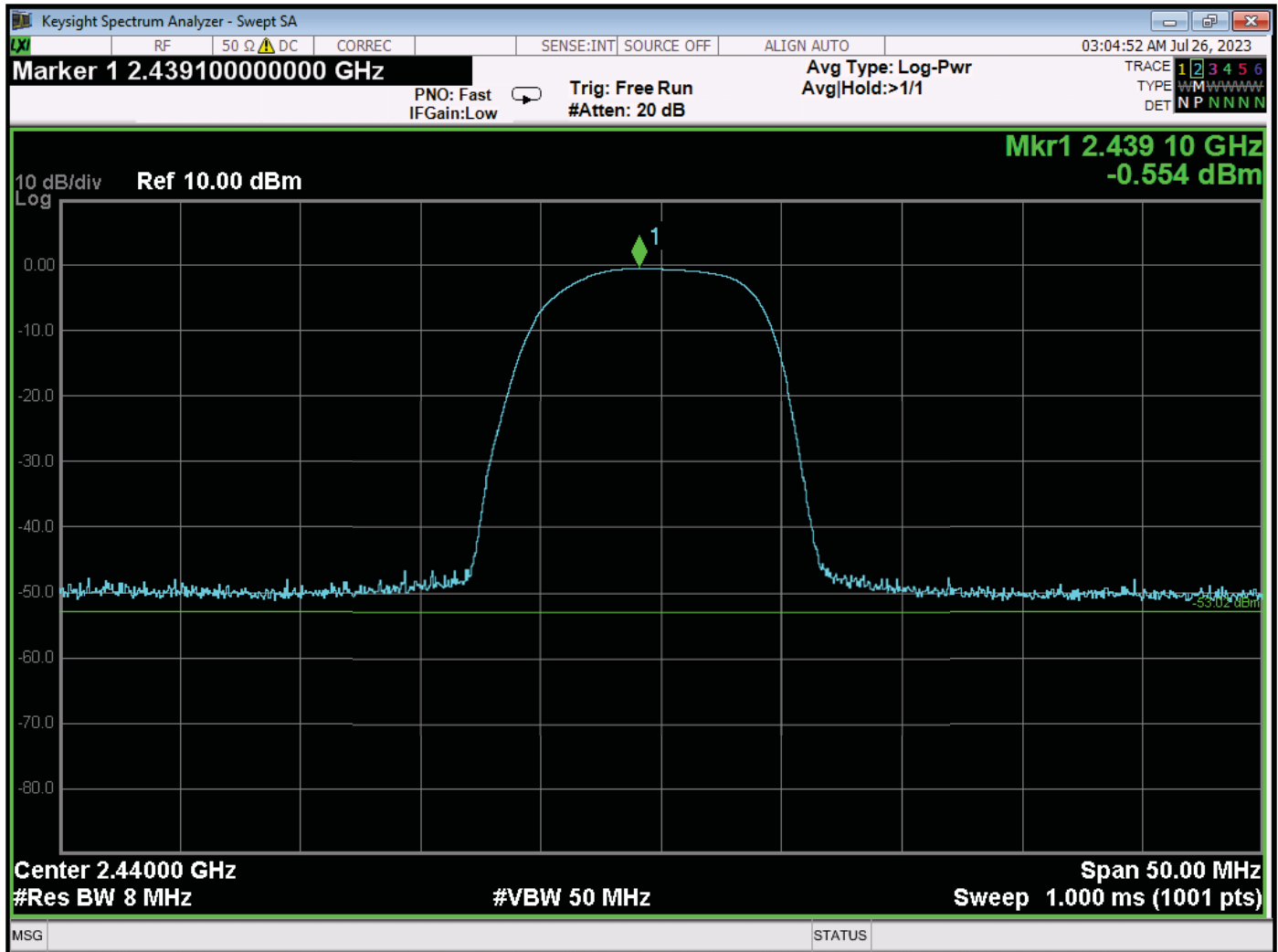


Peak Power Output – 2402 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

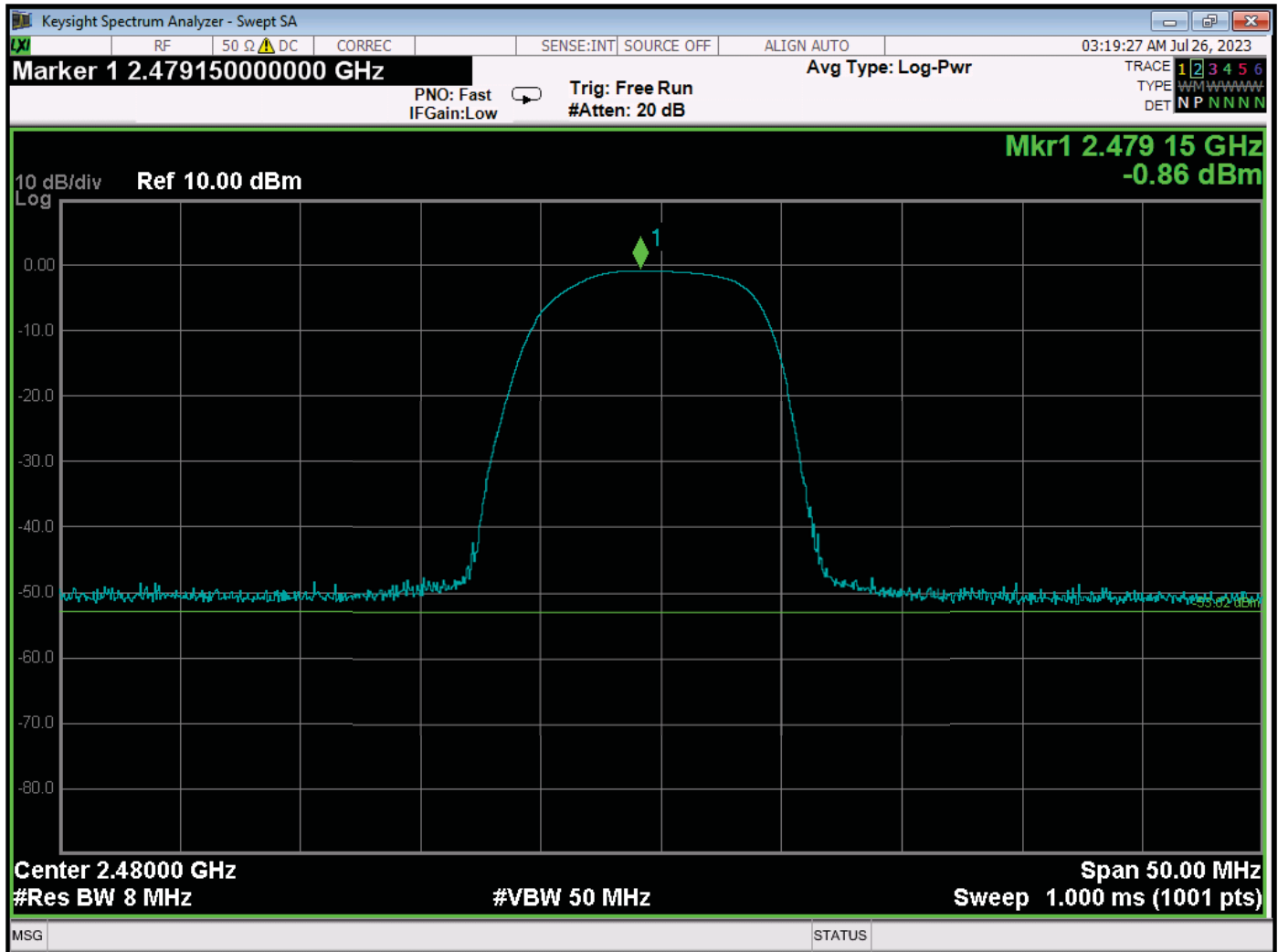


Peak Power Output – 2440 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



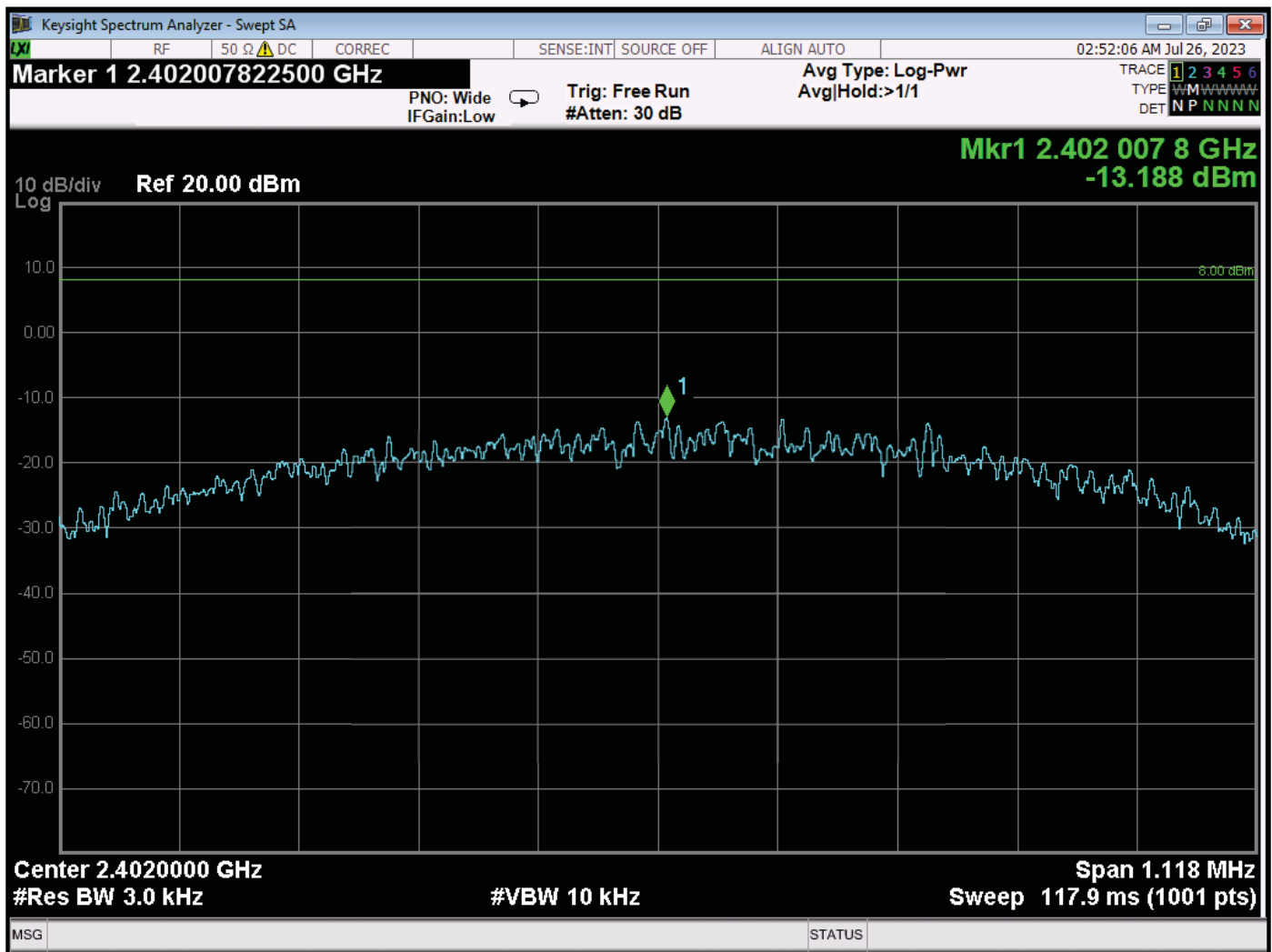
Peak Power Output – 2480 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

***SPECTRAL DENSITY OUTPUT
DATA SHEETS***

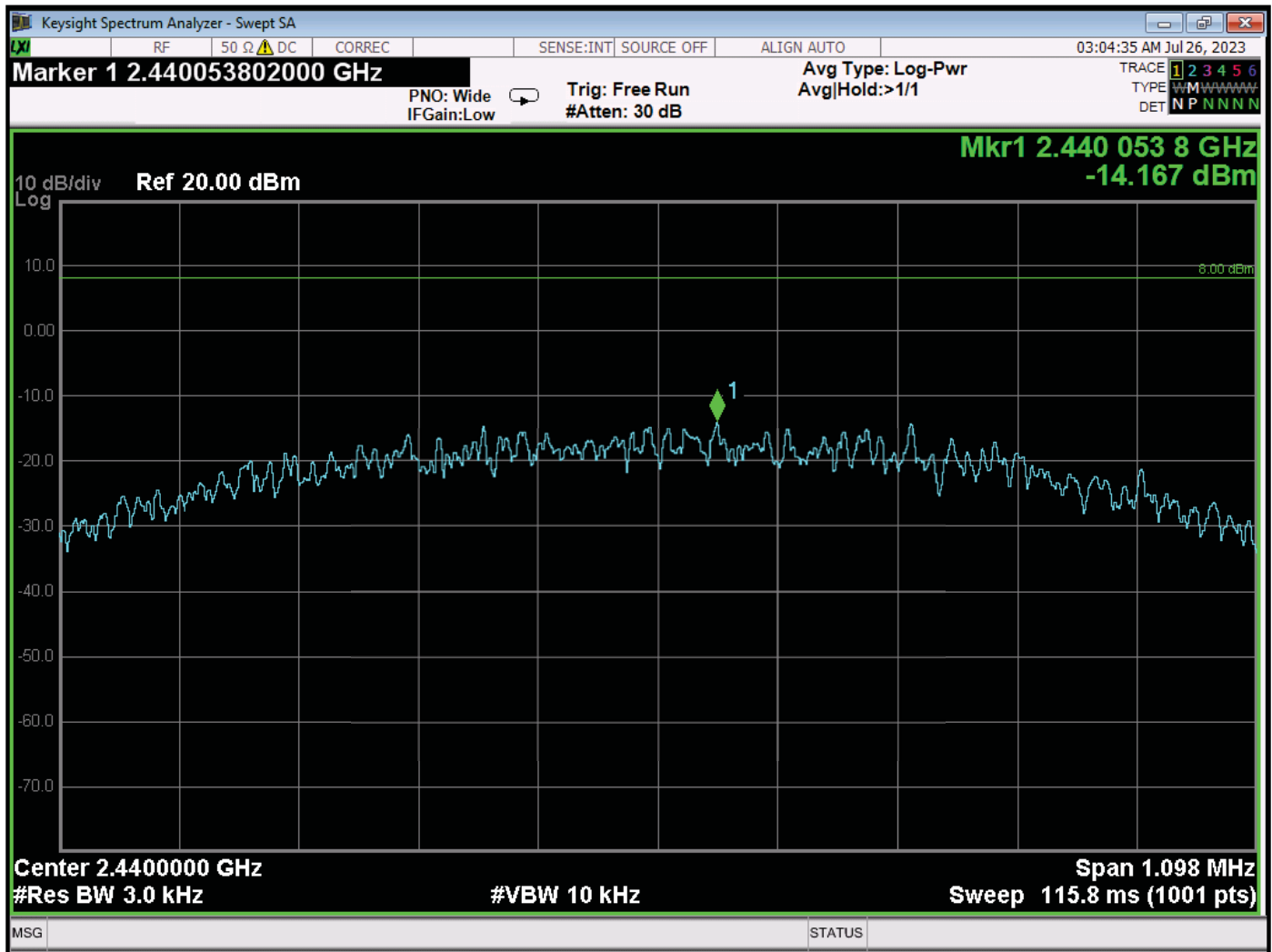


Special Density Output – 2402 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

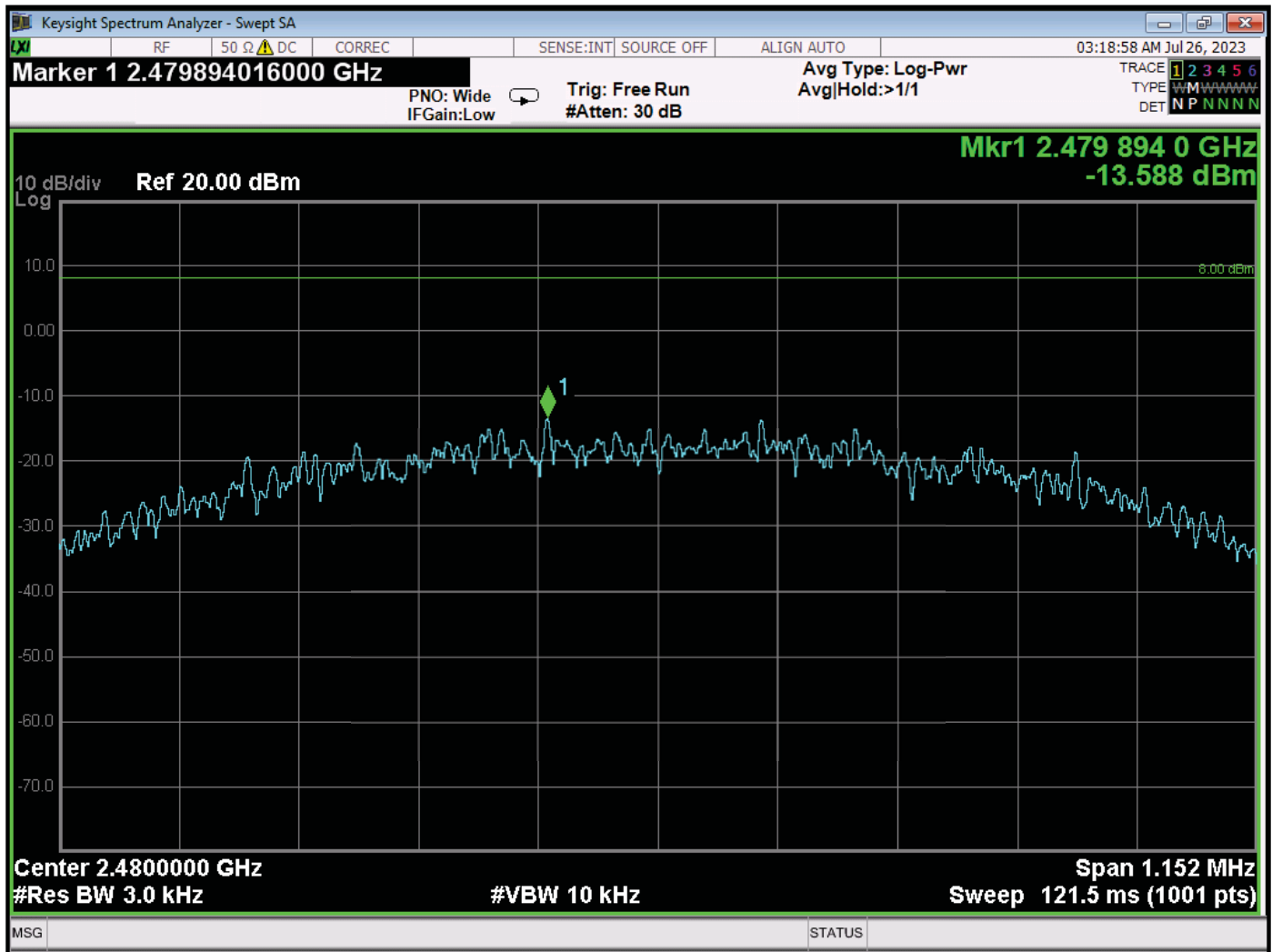


Special Density Output – 2440 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



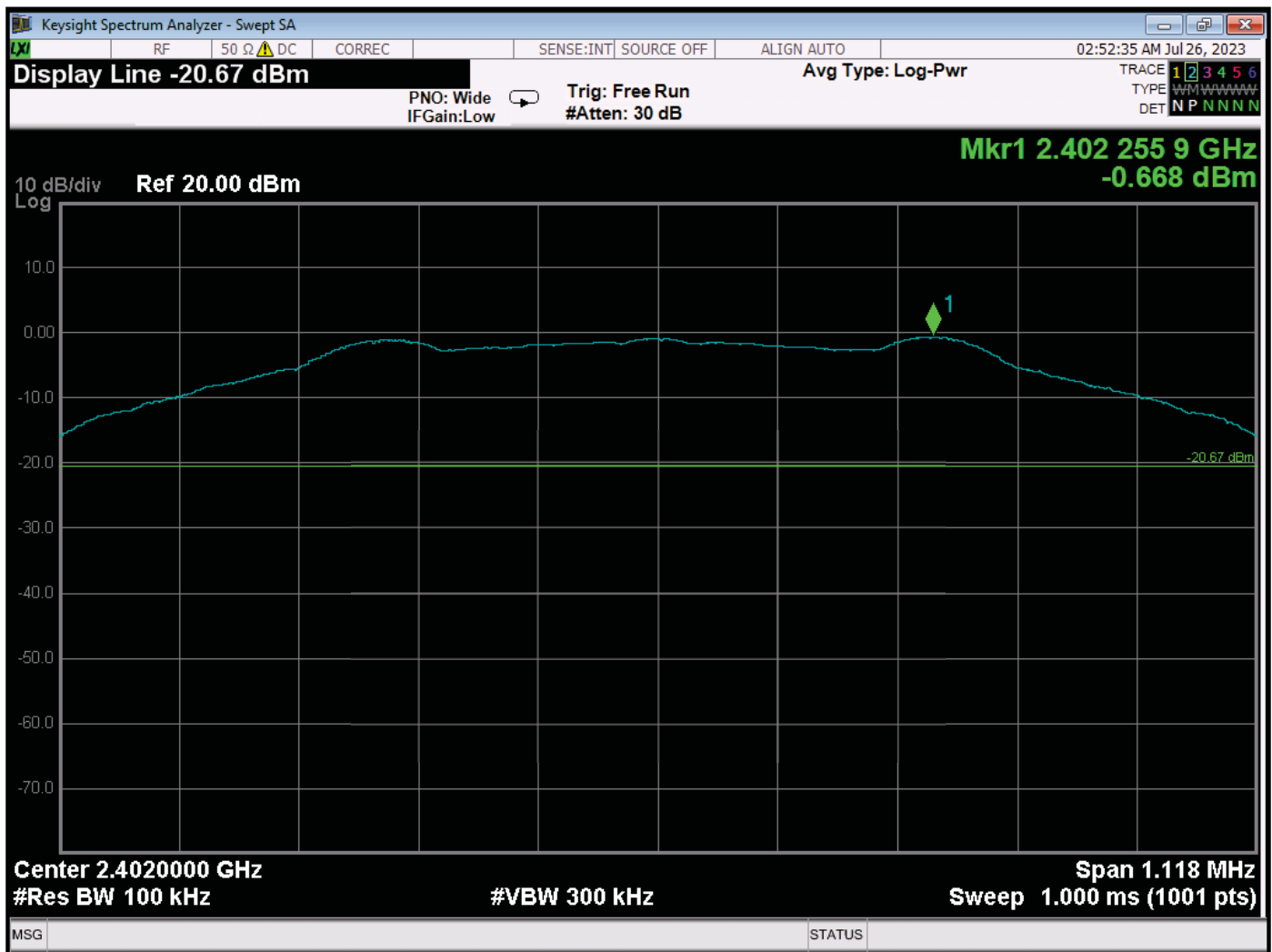
Special Density Output – 2480 MHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

***RF ANTENNA CONDUCTED
DATA SHEETS***

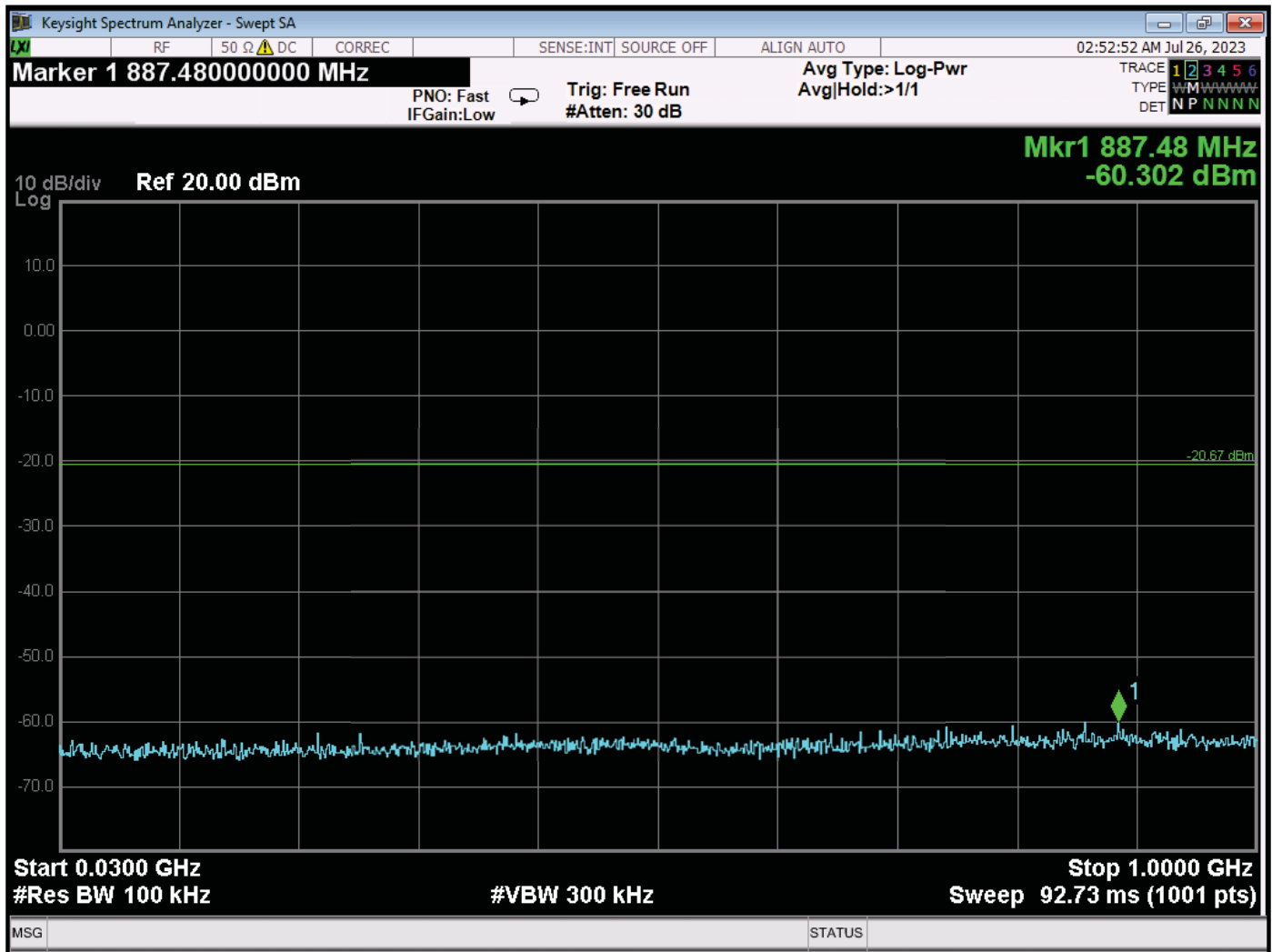


RF Antenna Conducted Test – Low Channel – Reference Level

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

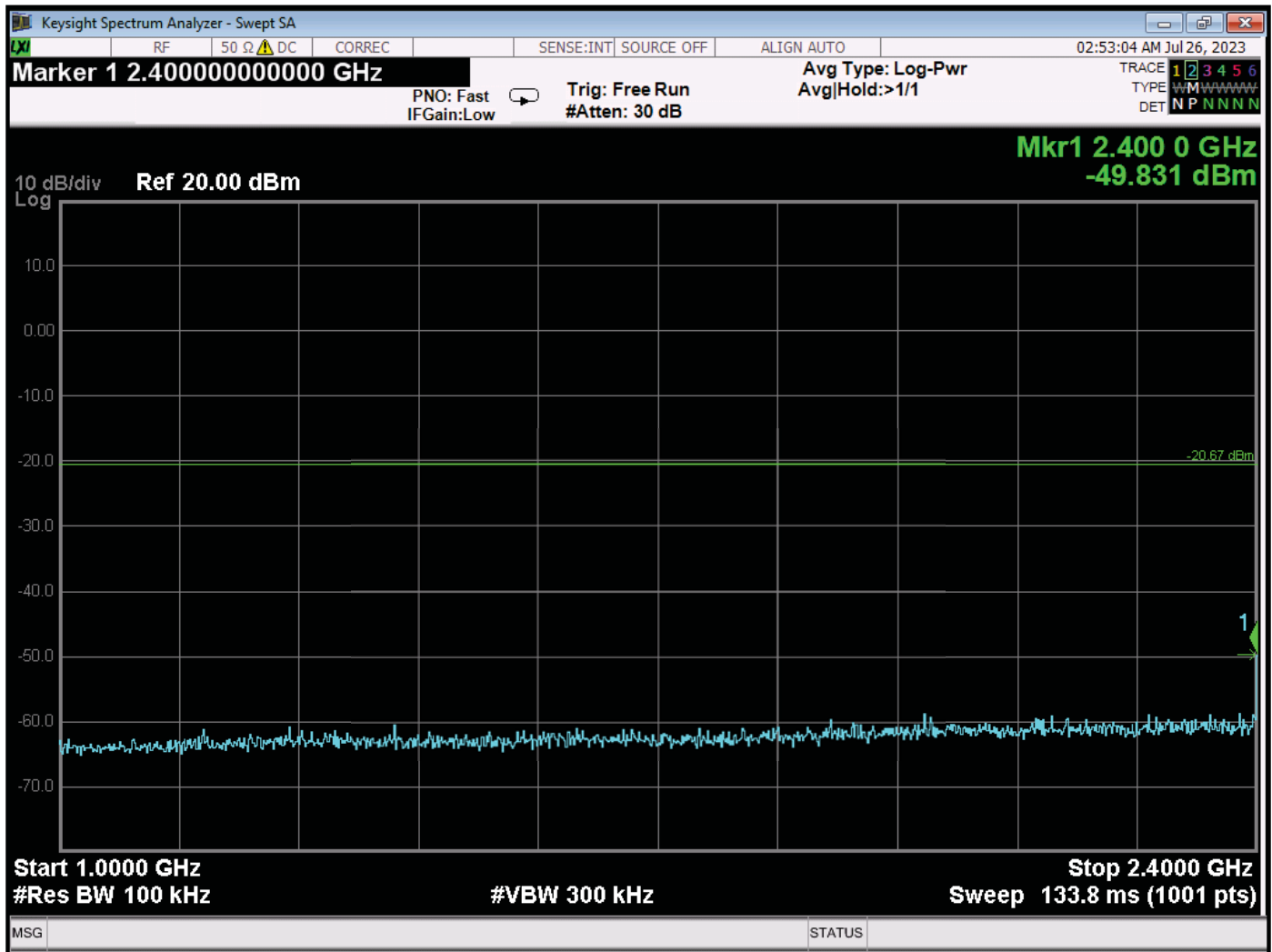


RF Antenna Conducted Test – Low Channel – 30 MHz to 1 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

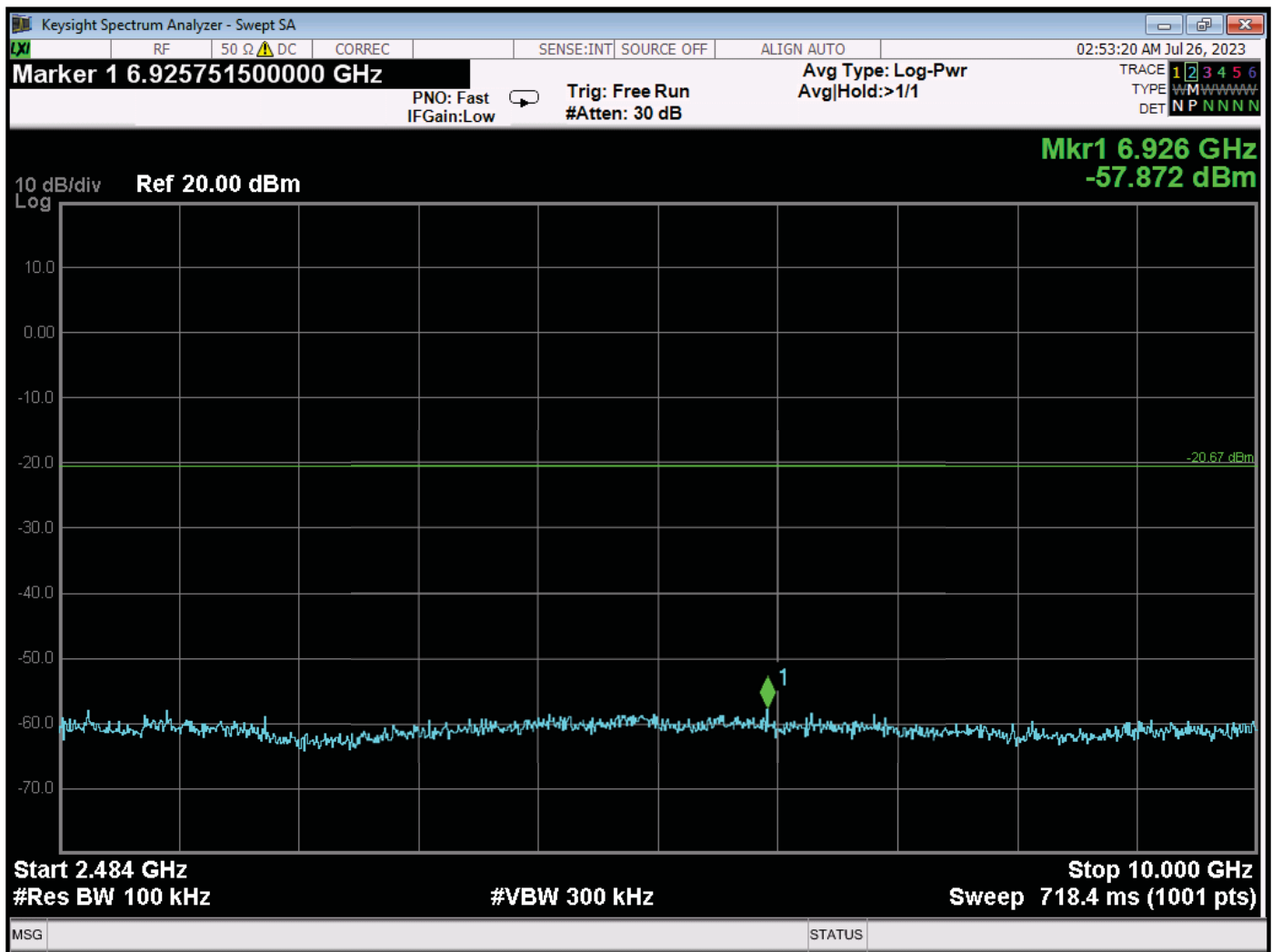


RF Antenna Conducted Test – Low Channel – 1 GHz to 2.4 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



RF Antenna Conducted Test – Low Channel – 2483.5 MHz to 10 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

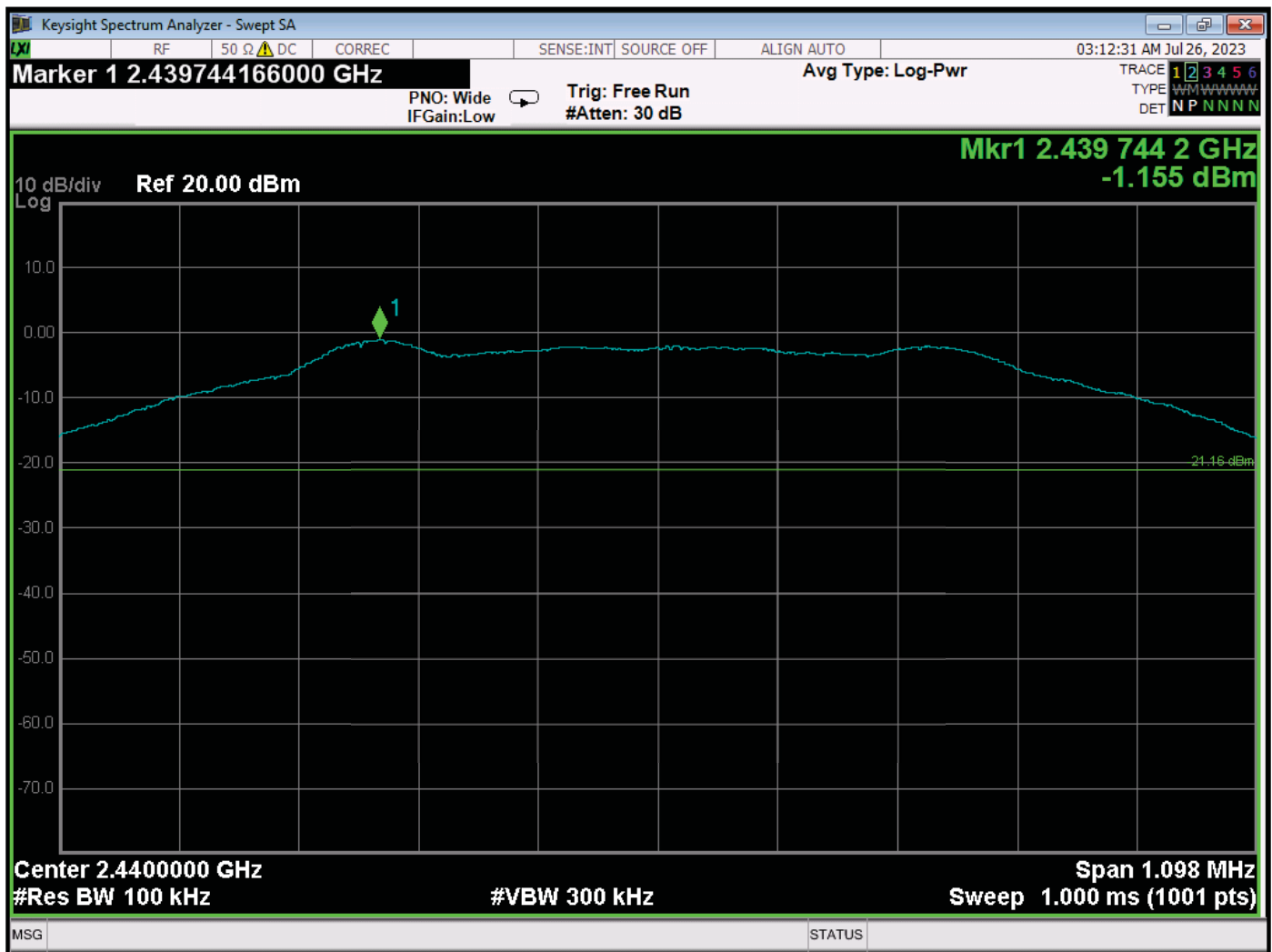


RF Antenna Conducted Test – Low Channel – 10 GHz to 25 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

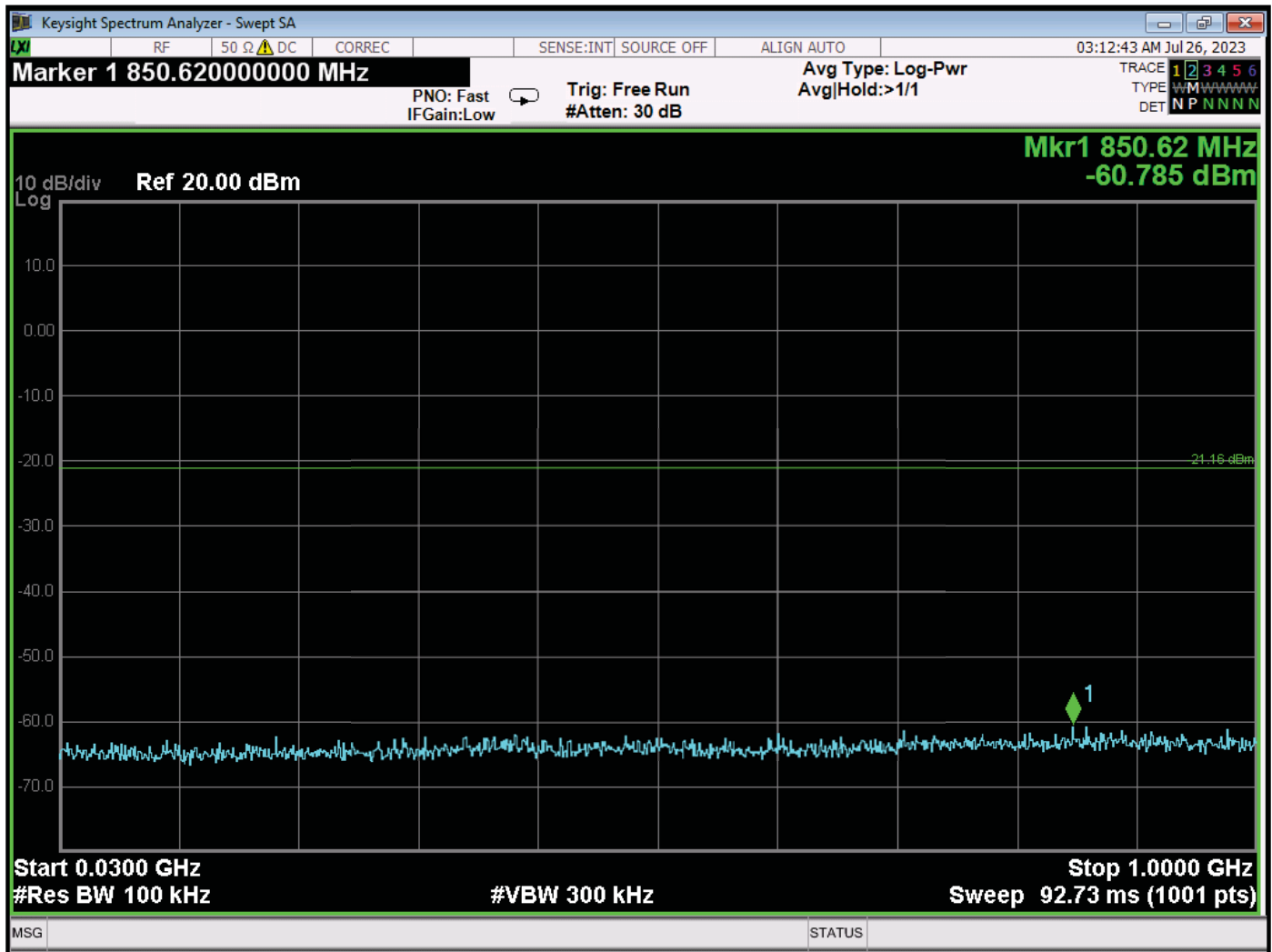


RF Antenna Conducted Test – Mid Channel – Reference Level

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

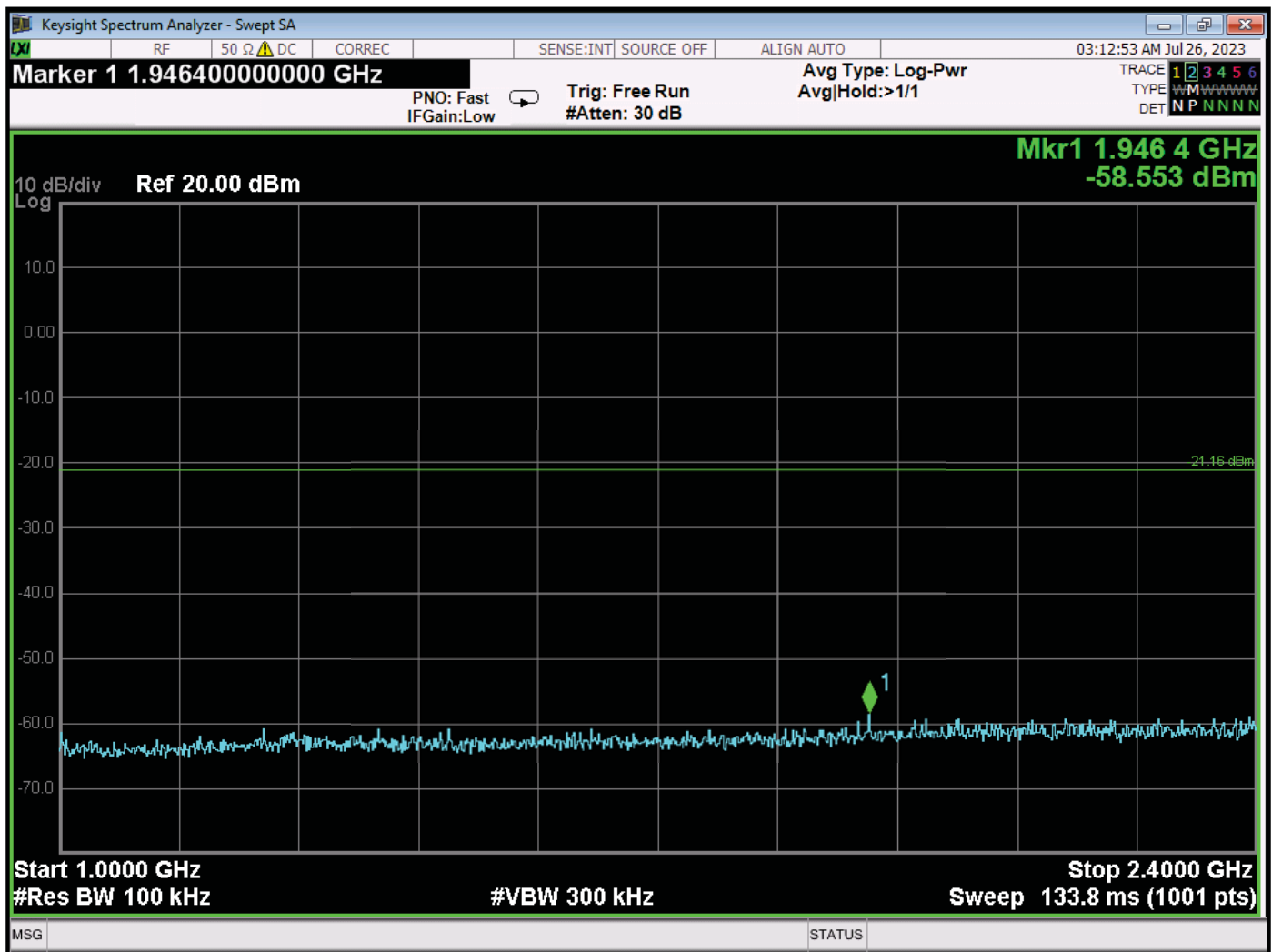


RF Antenna Conducted Test – Mid Channel – 30 MHz to 1 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

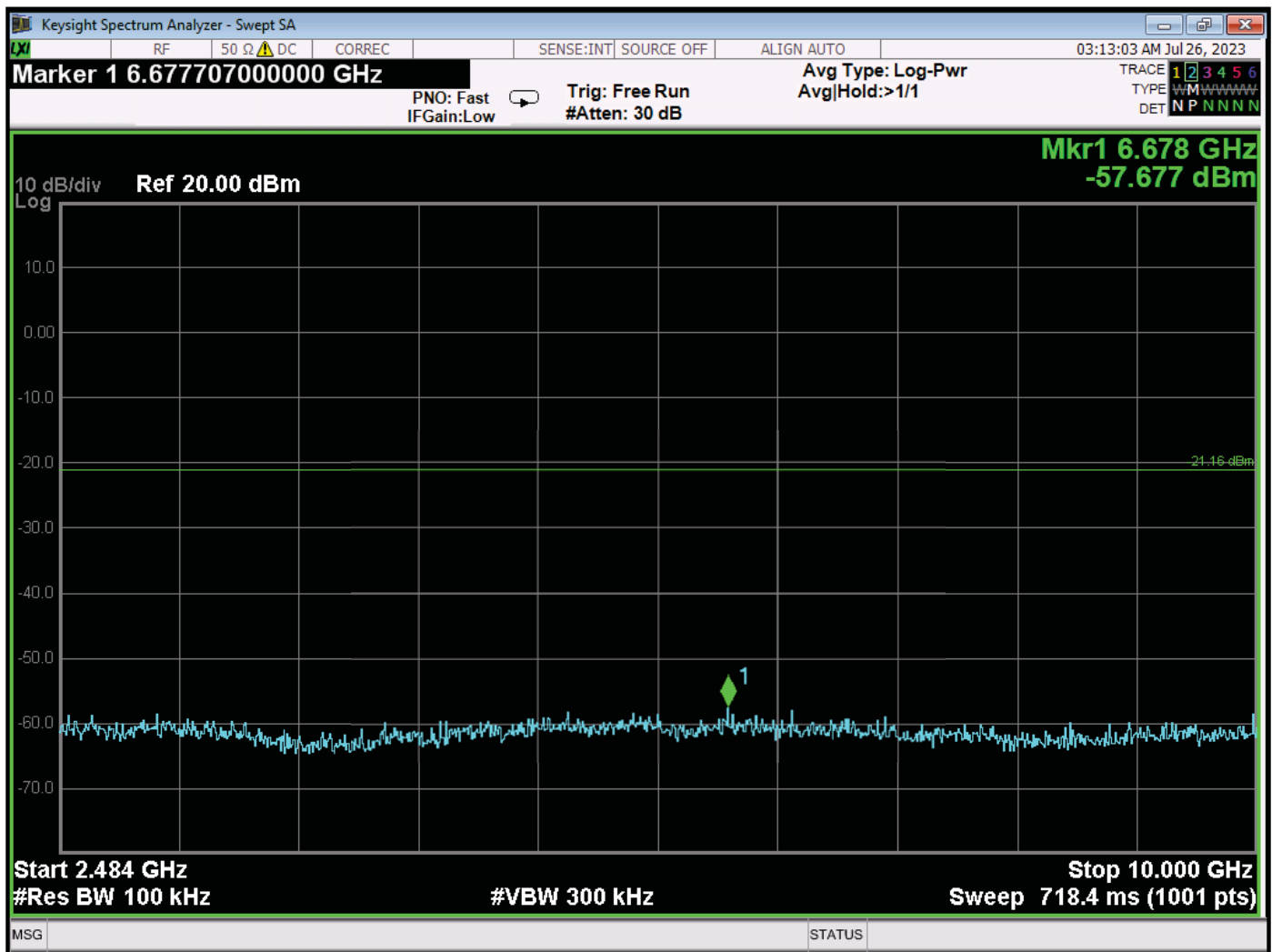


RF Antenna Conducted Test – Mid Channel – 1 GHz to 2.4 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

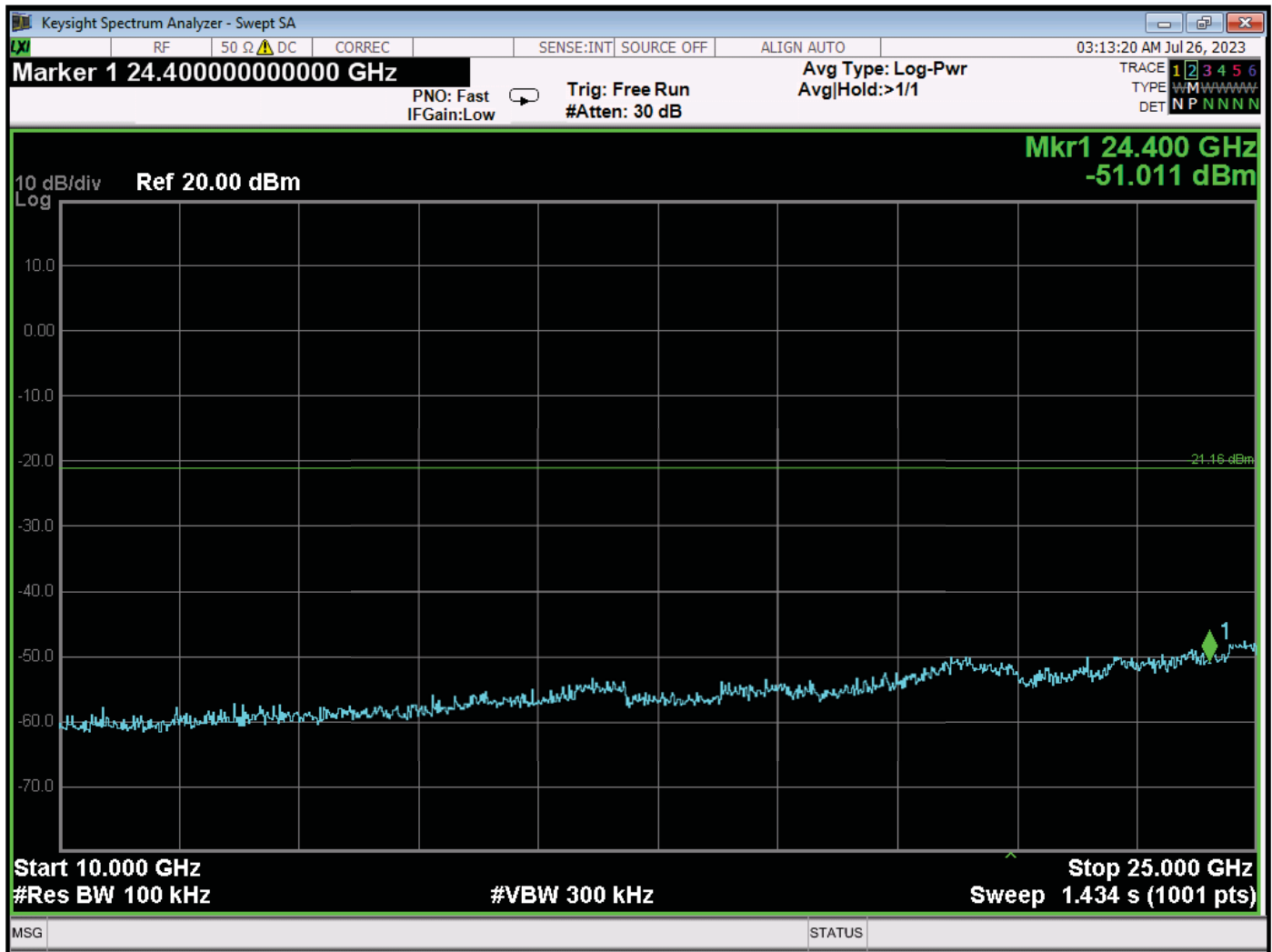


RF Antenna Conducted Test – Mid Channel – 2483.5 MHz to 10 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

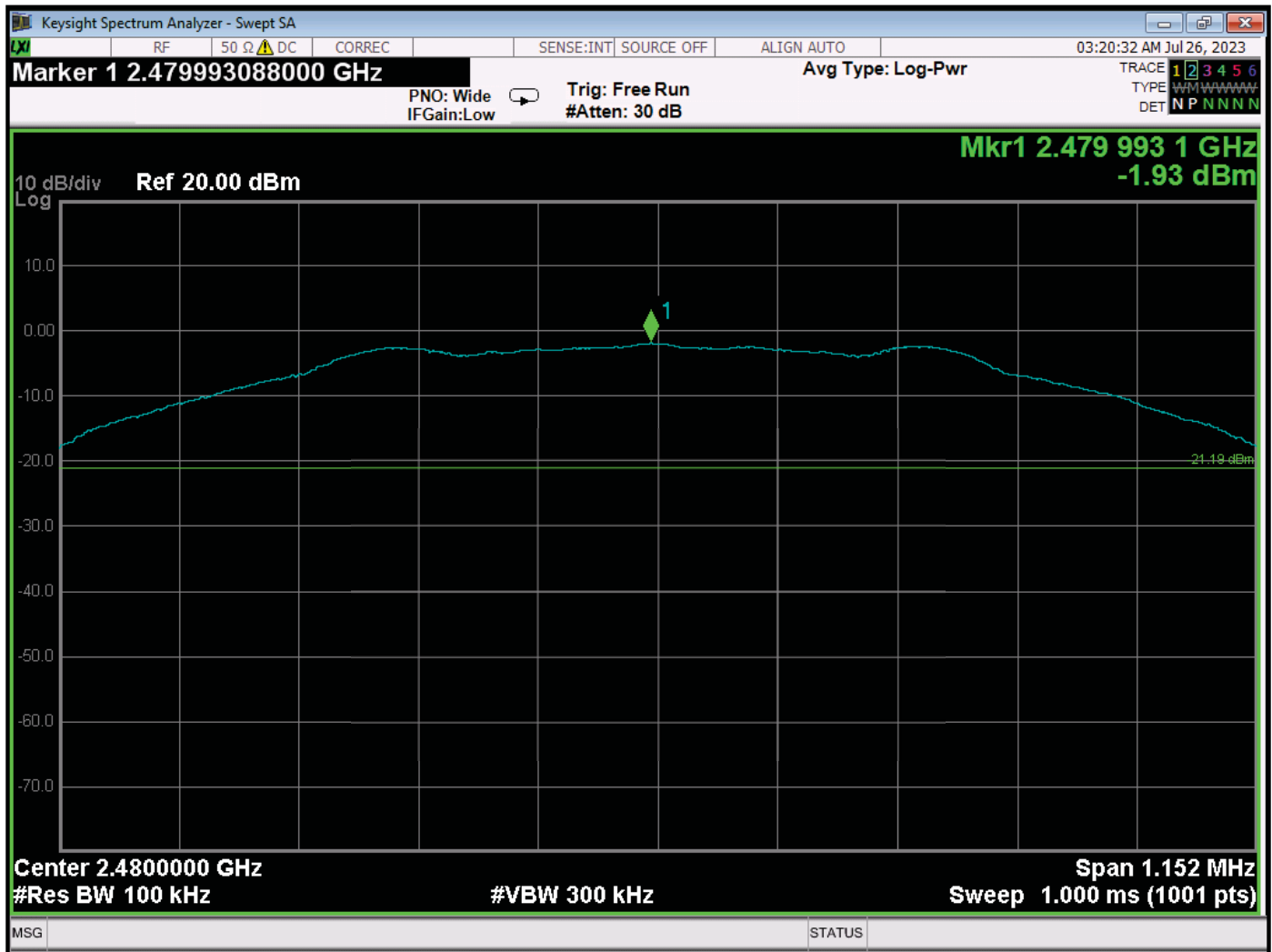


RF Antenna Conducted Test – Mid Channel – 10 GHz to 25 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

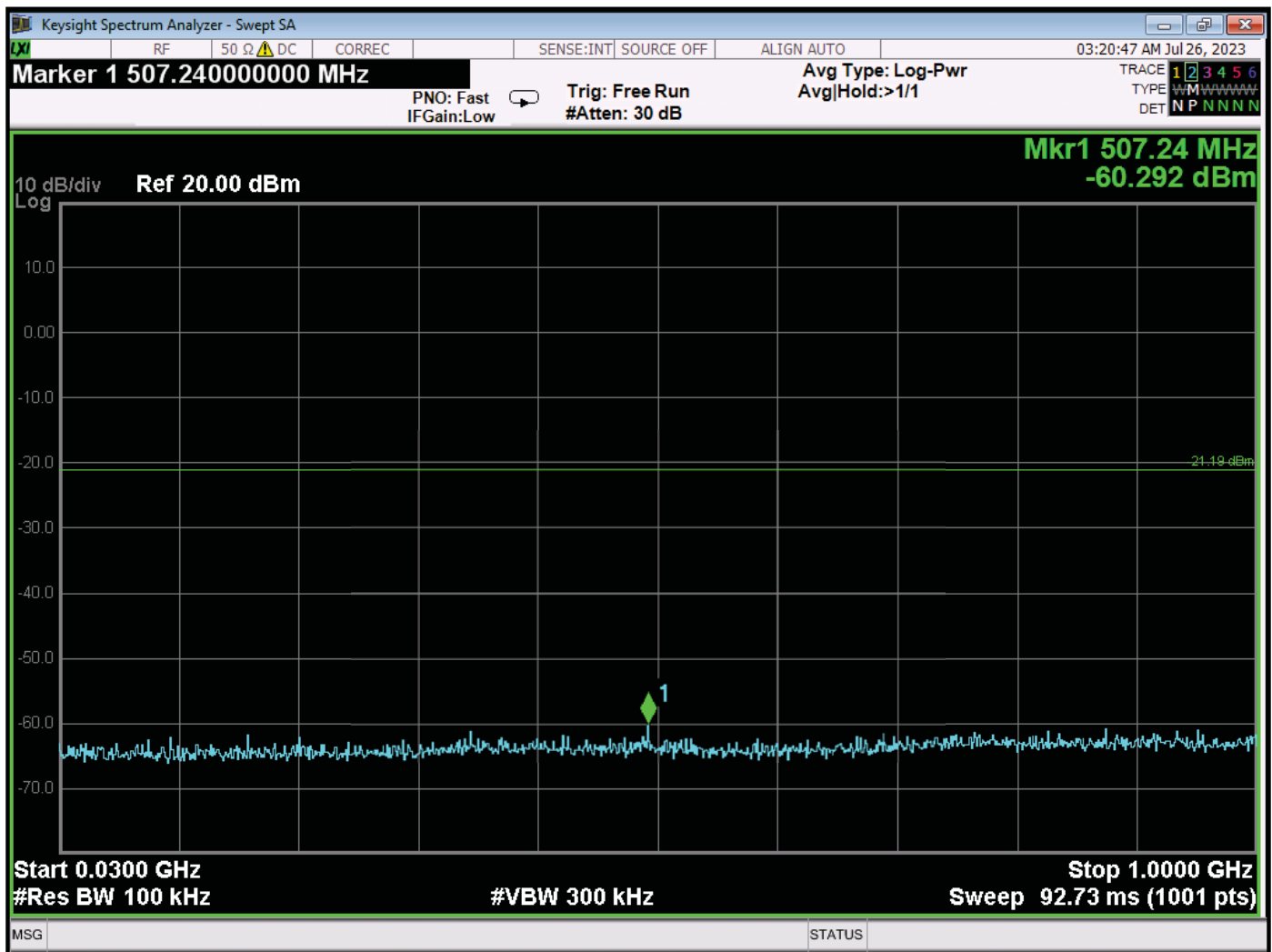


RF Antenna Conducted Test – High Channel – Reference Level

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

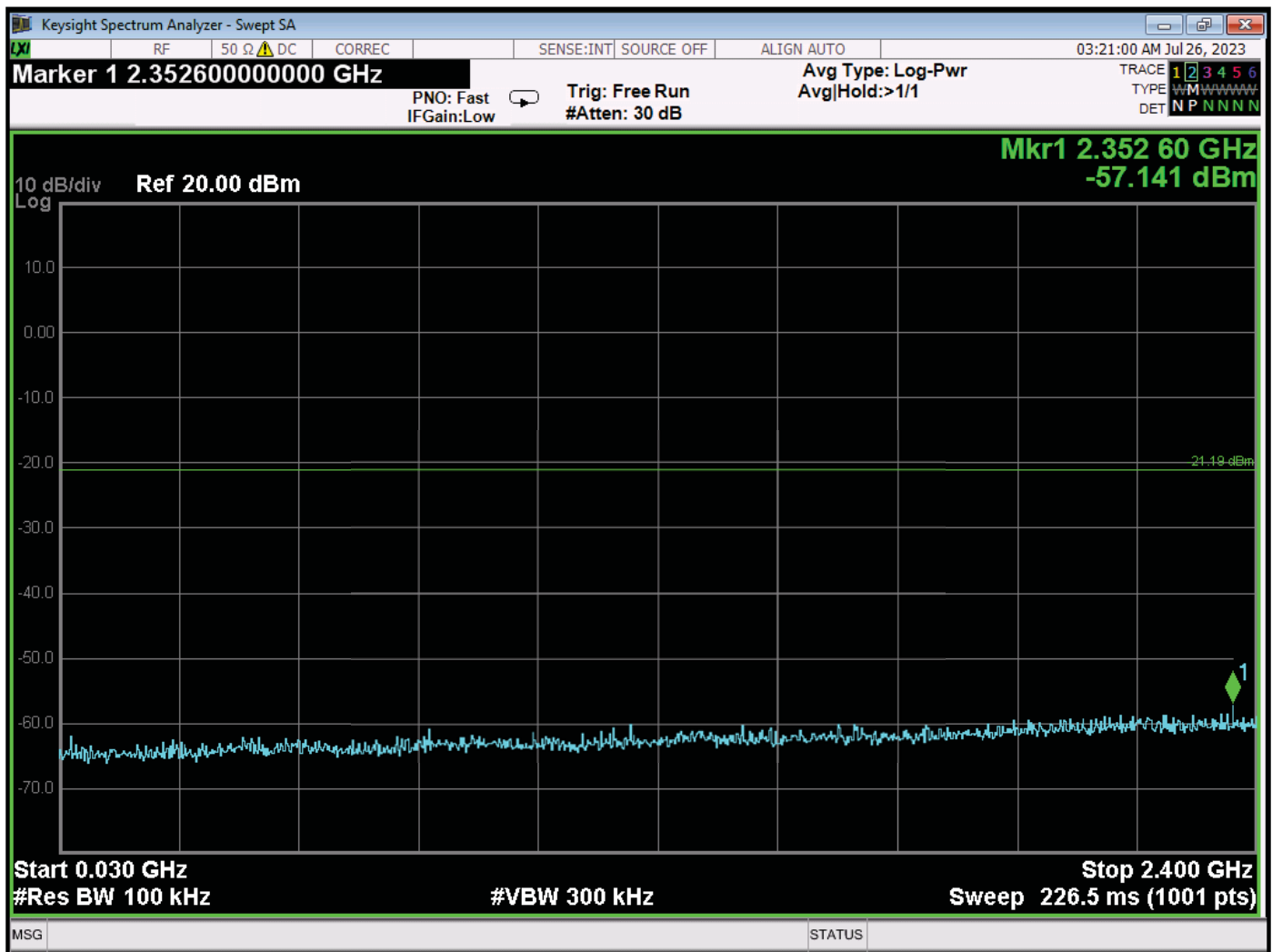


RF Antenna Conducted Test – High Channel – 30 MHz to 1 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

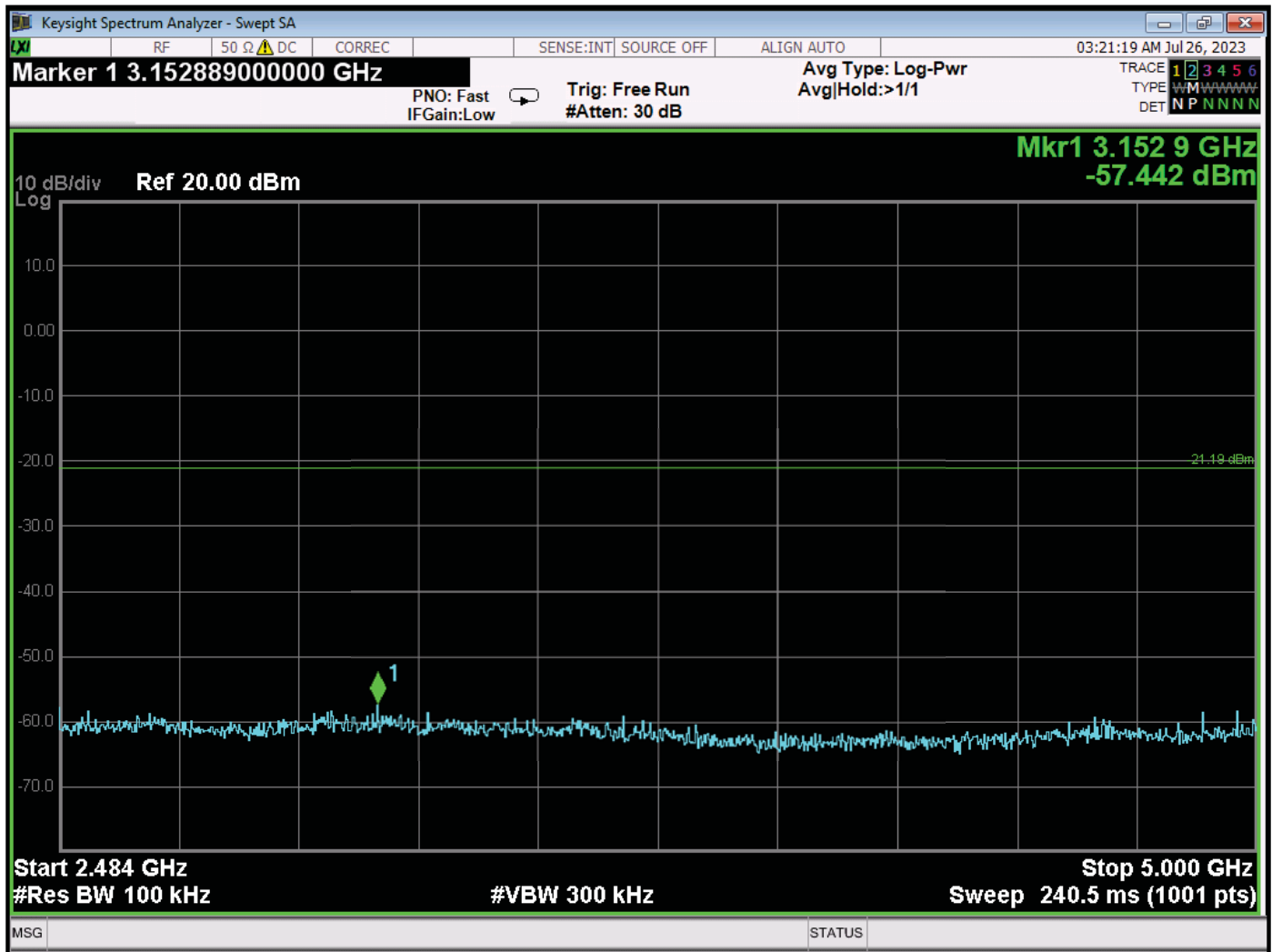


RF Antenna Conducted Test – High Channel – 30 MHz to 2.4 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

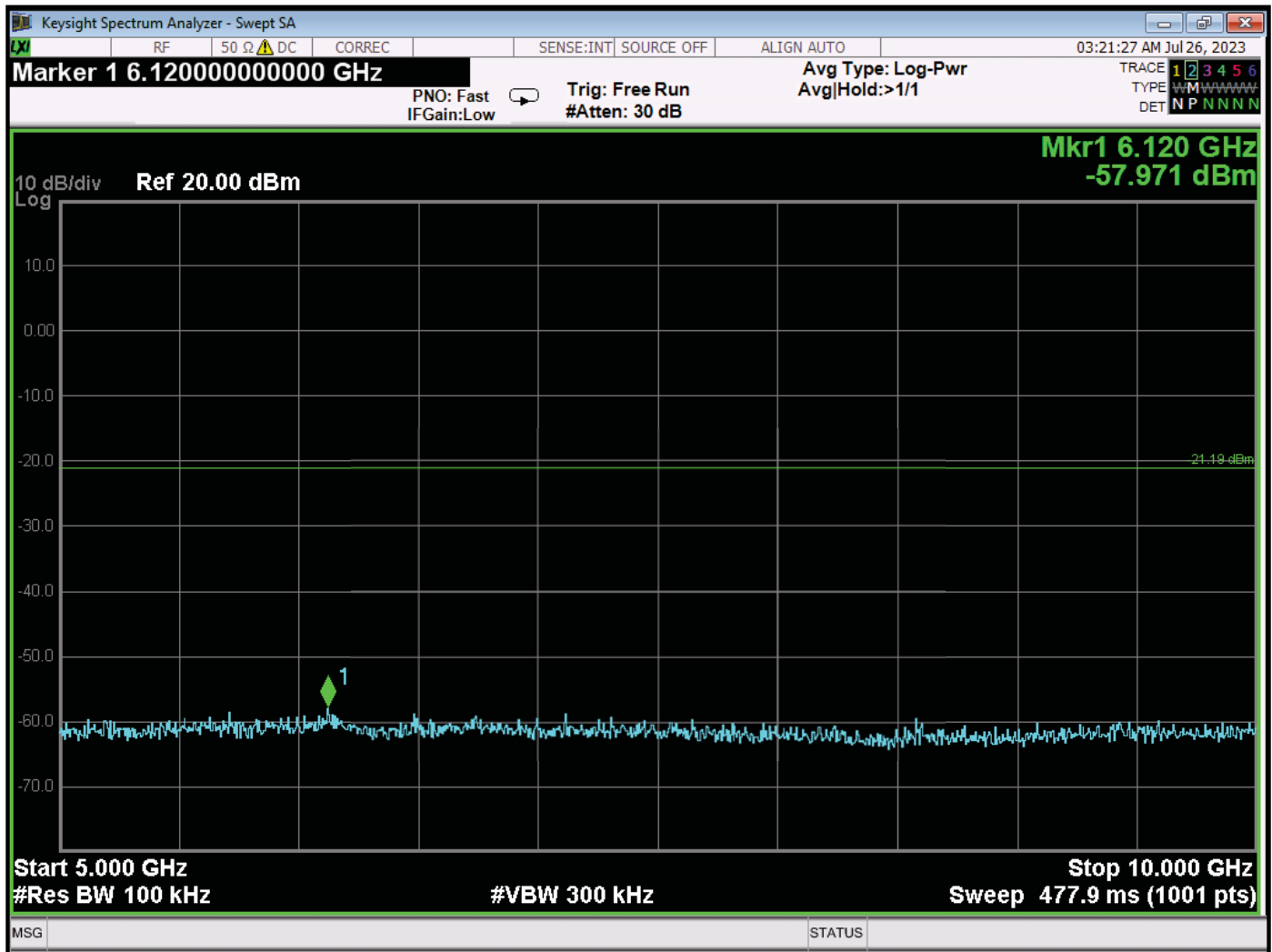


RF Antenna Conducted Test – High Channel – 2483.5 MHz to 5 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

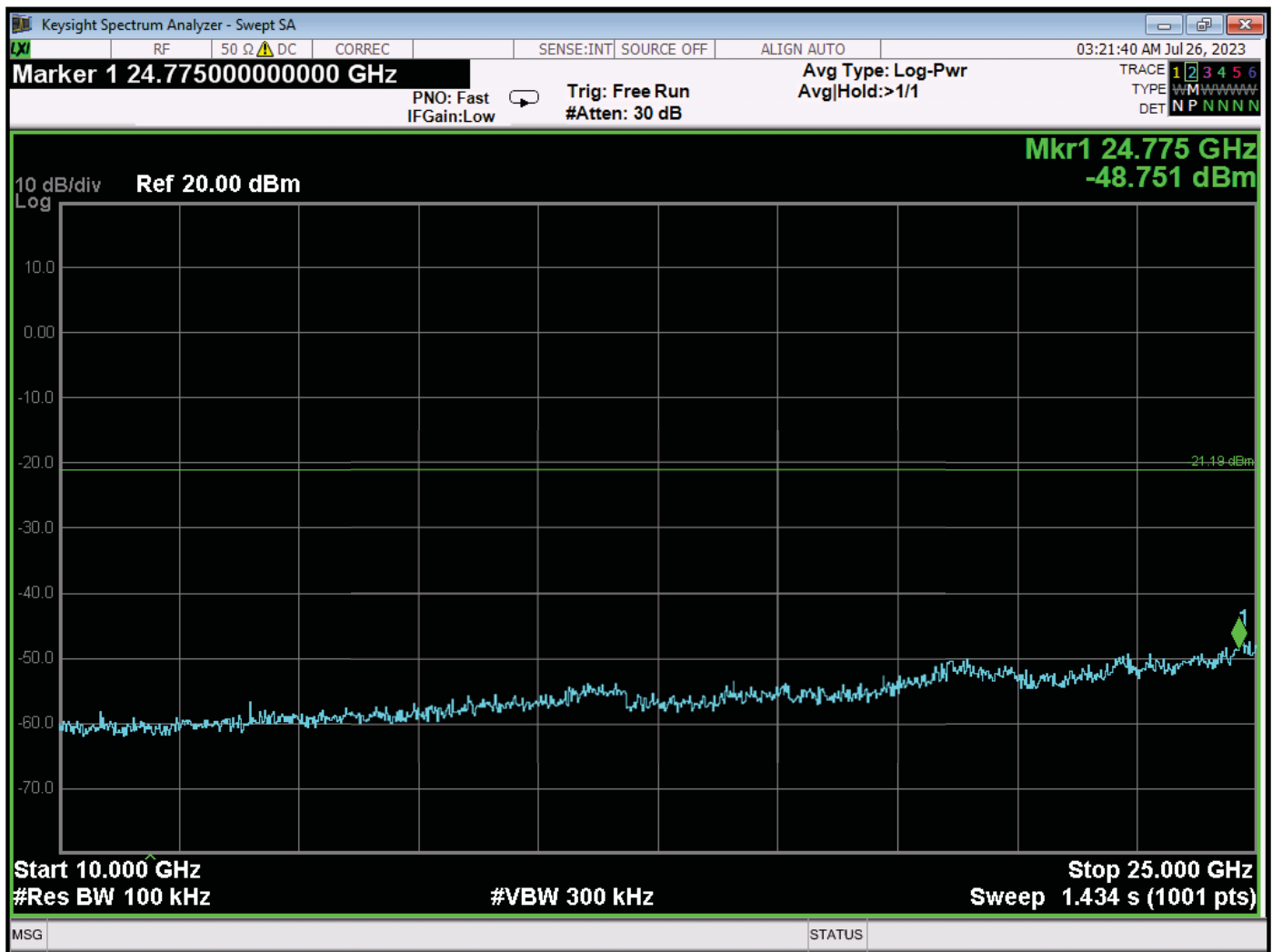


RF Antenna Conducted Test – High Channel – 5 GHz to 10 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044



RF Antenna Conducted Test – High Channel – 10 GHz to 25 GHz

Brea Division
114 Olinda Drive
Brea, CA 92823
(714) 579-0500

Lake Forest Division
20621 Pascal Way
Lake Forest, CA 92630
(949) 587-0400

Newbury Park Division
1050 Lawrence Drive
Newbury Park, CA 91320
(805) 480-4044

FTW LLC

HOPPER CONTROLLER

MODEL: FTW000223

EMISSIONS IN NON-RESTRICTED BANDS

FREQUENCY (MHz)	LEVEL (dBm)	Limit* (dBm)	Margin (dB)
24775.00	-48.751	-21.93	-26.821
24805.00	-47.599	-20.67	-26.929
2400.00	-49.831	-20.67	-29.161

Note: The three highest non-restricted emissions are reported.

*The Limit is based on 20 dB below the highest reference level obtained on the previous pages.