





Engineering Test Report No. 2202153-01 Rev A

| | | |
|---------------------------------|---|--|
| Report Date | August 10, 2023 | |
| Manufacturer Name | Appareo Systems | |
| Manufacturer Address | 1810 NDSU Research Circle North Fargo, ND 58102 | |
| Product Name Brand/Model No. | TCU-NA,V1 | |
| Date Received | August 7, 2023 | |
| Test Dates | August 7, 2023 through August 9, 2023 | |
| Specifications | FCC "Code of Federal Regulations" Title 47 Part 15, Subpart B FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C FCC "Code of Federal Regulations" Title 47 Part 27, Subpart C Innovation, Science, and Economic Development Canada, ICES-003 Innovation, Science, and Economic Development Canada, RSS-130 Innovation, Science, and Economic Development Canada, RSS-139 | |
| Test Facility | Elite Electronic Engineering, Inc. 1516 Centre Circle, Downers Grove, IL 60515 | FCC Reg. Number: 269750 IC Reg. Number: 2987A CAB Identifier: US0107 |
| Signature |  | |
| Tested by | Javier Cardenas | |
| Signature |  | |
| Approved by | Raymond J. Klouda, Registered Professional Engineer of Illinois – 44894 | |
| PO Number | 46741 | |

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1. Report Revision History

| Revision | Date | Description |
|----------|-----------------------------------|--|
| – | 11 AUG 2023 | Initial Release of Engineering Test Report No. 2202153-01A |
| A | 29 AUG 2023 By Javier Cardenas | Throughout the report: <ul style="list-style-type: none">- The serial number was updated from “Sample 1” to “531.”- The Model No. was updated from “TCU-NA, V1” to “TCU-NA,V1” Section 17: <ul style="list-style-type: none">- A note about the ribbon cables and Comprion connectors on the EUT was added. |

2. Introduction

This document presents the results of a series of electromagnetic compatibility (EMC) tests that were performed on one (1) Telematic Control Unit (hereinafter referred to as the Equipment Under Test (EUT)).

Additionally, this document presents the results of limited spurious emissions measurements performed on the EUT. The EUT is equipped with the following pre-certified radio modules:

- LTE CAT4 EG95-NAXD Modem, FCC ID XMR202008EG95NAXD.
- LTE CAT M1 BG772AGLAA-N06-SGNSA Modem, FCC ID XMR2022BG772AGL, IC ID 10224A-2022BG772A
- WiFi and BT FC20 Module, FCC ID XMR201703FC20, IC ID 10224A-201703FC20

The nature of these measurements is to ensure that the radio module and host remain in compliance with the emissions requirements of the FCC and Innovation, Science, and Economic Development Canada after the integration process.

The EUT was identified as follows:

| EUT Identification | |
|---------------------------------------|-------------------------|
| Description | Telematics control unit |
| Model/Part No. | TCU-NA,V1 |
| Serial No. | 531 |
| Number of Interconnection Wires | 2 |
| Type of Interconnection Wires | USB, D-sub9 |
| Highest Internal Frequency of the EUT | 5GHz |

The EUT listed above was used throughout the test series.

3. Power Input

The EUT was powered by 12VDC from a twisted pair, 1 meter, cable harness.

4. Grounding

The EUT was not connected to ground.

5. Support Equipment

The EUT was submitted for testing along with the following support equipment:

| Description | Model # | S/N |
|-------------------------------|-----------------------|-----|
| Comprion UT3 2FF Adapter | 1110 0007 | NA |
| Lenovo Laptop | ThinkPad | NA |
| GridConnect CAN-USB Converter | GC-CAN-USB-COM-FD-ISO | NA |

6. Interconnect Leads

The following interconnect cables were submitted with the test item:

| Item | Description |
|--------|------------------------------------|
| USB | Connects laptop to EUT |
| D-sub9 | Connects EUT to CAN-USB converter. |

7. Modifications Made to the EUT

No modifications were made to the EUT during the testing.

8. Modes of Operation

The EMC tests were performed with the EUT operating in the test modes described below. See the specific test section for the applicable test modes.

8.1. Test Operations

This mode was achieved by applying 12VDC to the EUT with the support equipment attached. The support equipment software was used to enable CAN communications between the EUT and the test laptop.

8.2. Tx

This mode was achieved by applying 12VDC to the EUT with the support equipment attached. The support equipment software was used to configure the EUT's onboard radios into the proper operating mode.

- LTE CAT4 B4, 1732.5MHz
- LTE CAT4 B12, 707.5MHz
- LTE CAT M1 B4, 1732.5MHz
- LTE CAT M1 B12, 707.5MHz
- 802.11n20, 2412MHz
- 802.11ac VHT20, 5180MHz
- BLE, 2402MHz

8.3. Simultaneous Tx

This mode was achieved by applying 12VDC to the EUT with the support equipment attached. The support equipment software was used to configure the EUT's onboard radios into the proper operating mode.

Combination 1

- LTE CAT4 B4, 1732.5MHz
- 802.11n20, 2412MHz
- BLE, 2440MHz

Combination 2

- LTE CAT M1, 1732.5MHz
- 802.11n20, 2412MHz
- BLE, 2440MHz

9. Test Specifications

The tests were performed to selected portions of, and in accordance with the following test specifications:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter A, Part 15, Subpart B
- Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter A, Part 15, Subpart C
- Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter B, Part 27, Subpart C
- ICES-003, Issue 7, October 15, 2020, "Information Technology Equipment (including Digital Apparatus)"
- RSS-Gen, Issue 5, February 2021, Amendment 2, "General Requirements for Compliance of Radio Apparatus"
- RSS-139, Issue 4, September 2022, Advanced Wireless Services Equipment Operating in the Bands 1710-1780 MHz, and 2110-2200 MHz
- RSS-130, Issue 2, February 2019, Equipment Operating in the Frequency Bands 617-652 MHz, 663-698 MHz, 698-756 MHz, and 777-787 MHz
- 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 of Procedures for Compliance Testing of Unlicensed Wireless Devices"
- ANSI C63.26-2015, "American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services"
- 996369 D04 Module Integration Guide v02, October 13, 2020

10. Test Plan

No test plan was provided. Instructions were provided by personnel from Appareo Systems and used in conjunction with the FCC "Code of Federal Regulations" Title 47 Part 15, Subpart B and Innovation, Science, and Economic Development Canada, ICES-003, and ANSI C63.4-2014 specifications.

11. Deviation, Additions to, or Exclusions from Test Specifications

There were no deviations, additions to, or exclusions from the test specifications during this test series.

12. Laboratory Conditions

The following were the laboratory conditions while the EMC tests were performed:

| Ambient Parameters | Value |
|----------------------|----------|
| Temperature | 23°C |
| Relative Humidity | 38% |
| Atmospheric Pressure | 1007.9mb |

13. Summary

The following EMC tests were performed, and the results are shown below:

| Test Description | Test Requirements | Test Methods | Equipment Class | EUT S/N | Results |
|--------------------------------|--|---------------------------------|-----------------|---------|----------|
| RF Radiated Emissions | FCC 15B 15.109 ISED ICES-003, Section 3.2.2 | ANSI C63.4:2014 | A | 531 | Conforms |
| Module Integration – Emissions | FCC Part 15, FCC Part 27, RSS-130, RSS-139 | ANSI C63.10:2013 ANSI C63.26 | NA | 531 | Conforms |

14. Sample Calculations

For Powerline Conducted Emissions:

The resultant voltage level (VL) is a summation in decibels (dB) of the receiver meter reading (MTR) and the cable loss factor (CF).

$$\text{Formula 1: VL (dB}\mu\text{V)} = \text{MTR (dB}\mu\text{V)} + \text{CF (dB)}.$$

For Radiated Emissions:

The resultant field strength (FS) is a summation in decibels (dB) of the receiver meter reading (MTR), the antenna correction factor (AF), and the cable loss factor (CF). If an external preamplifier is used, the total is reduced by its gain (-PA). If a distance correction (DC) is required, it is added to the total.

$$\text{Formula 1: FS (dB}\mu\text{V/m)} = \text{MTR (dB}\mu\text{V)} + \text{AF (dB/m)} + \text{CF (dB)} + (-\text{PA (dB)}) + \text{DC (dB)}$$

To convert the Field Strength dB μ V/m term to μ V/m, the dB μ V/m is first divided by 20. The Base 10 AntiLog is taken of this quotient. The result is the Field Strength value in μ V/m terms.

$$\text{Formula 2: FS (}\mu\text{V/m)} = \text{AntiLog}[(\text{FS (dB}\mu\text{V/m)})/20]$$

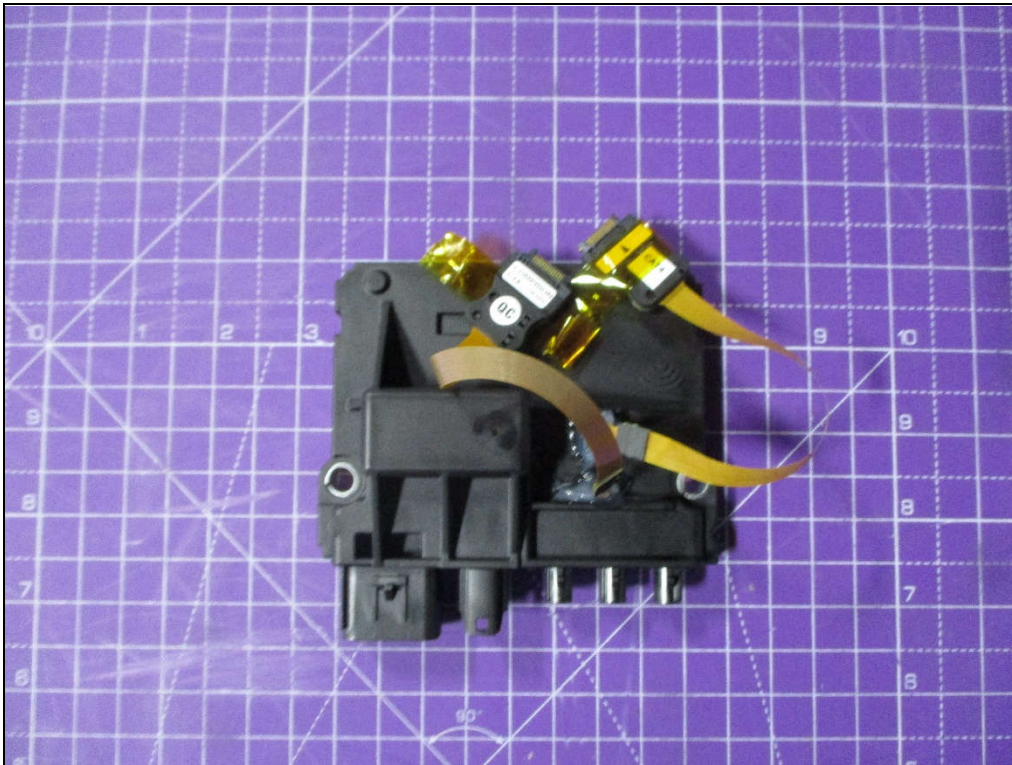
15. Statement of Conformity

The Appareo Systems Telematic Control Unit, Model No. TCU-NA,V1, Serial No. 531, did fully conform to the selected requirements of FCC "Code of Federal Regulations" Title 47 Part 15, Subpart B, Innovation, Science, and Economic Development Canada, ICES-003, Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter A, Part 15, Subpart C, Federal Communications Commission "Code of Federal Regulations", Title 47, Chapter I, Subchapter B, Part 27, Subpart C, Innovation, Science, and Economic Development Canada RSS-130 and Innovation, Science, and Economic Development Canada RSS-139

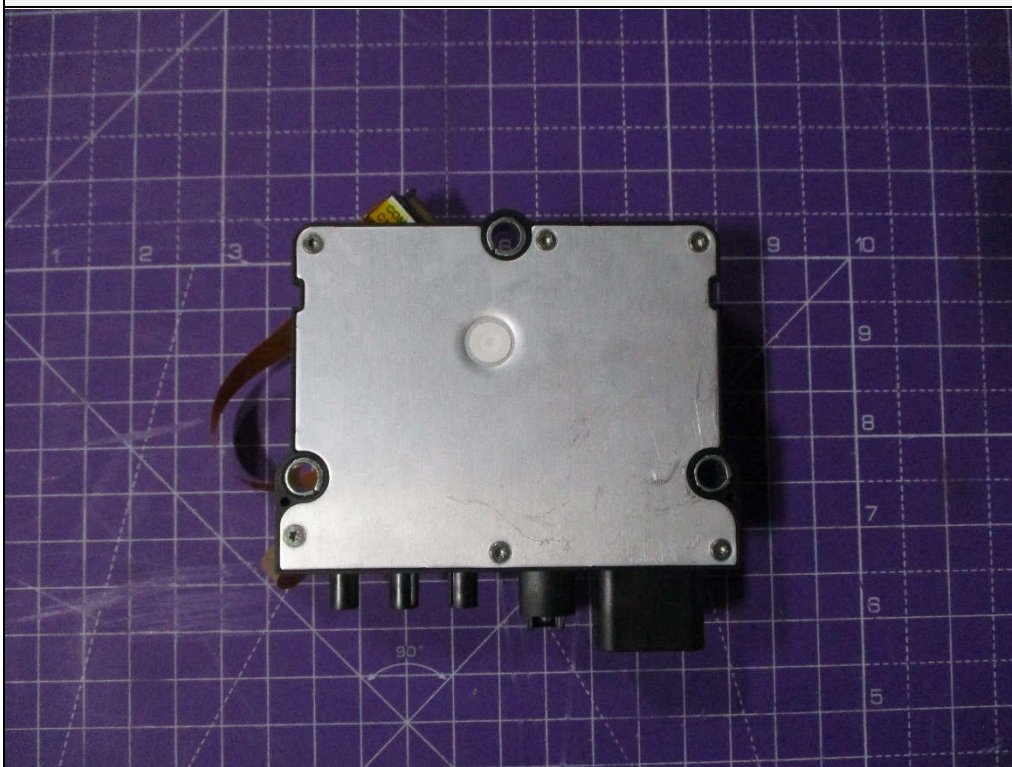
16. Certification

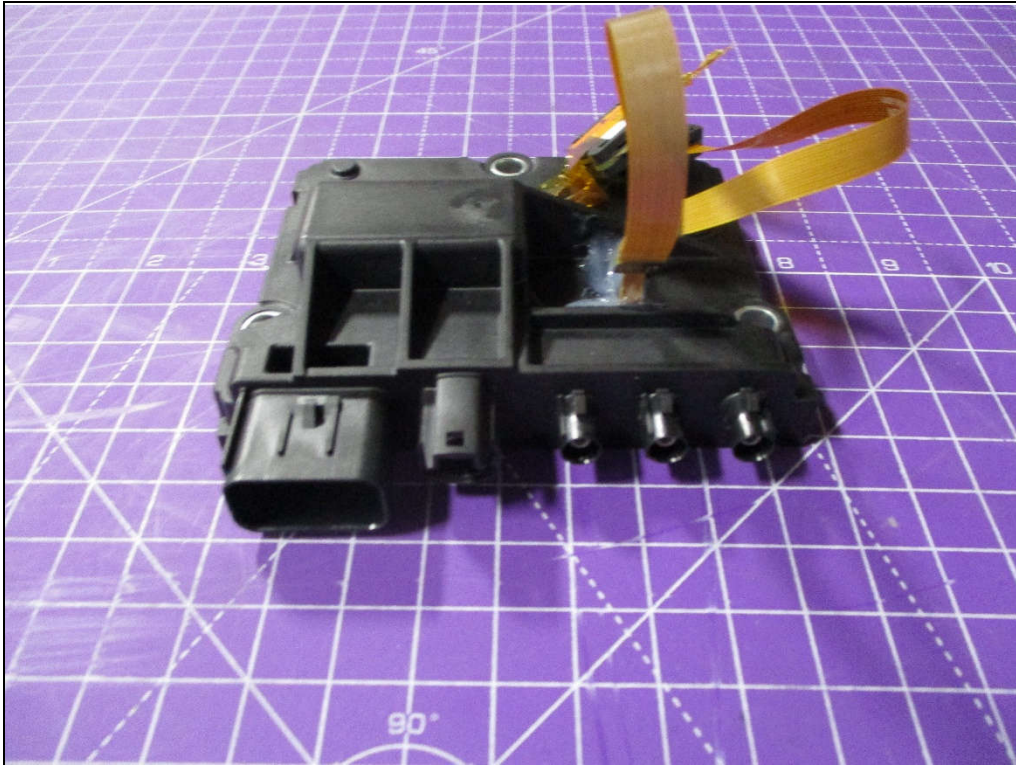
Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the FCC "Code of Federal Regulations" Title 47 Part 15, Subpart B and Innovation, Science, and Economic Development Canada, ICES-003 test specifications. The data presented in this test report pertains to the EUT as received by the customer on the test date specified. Any electrical or mechanical modifications made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

17. Photographs of EUT

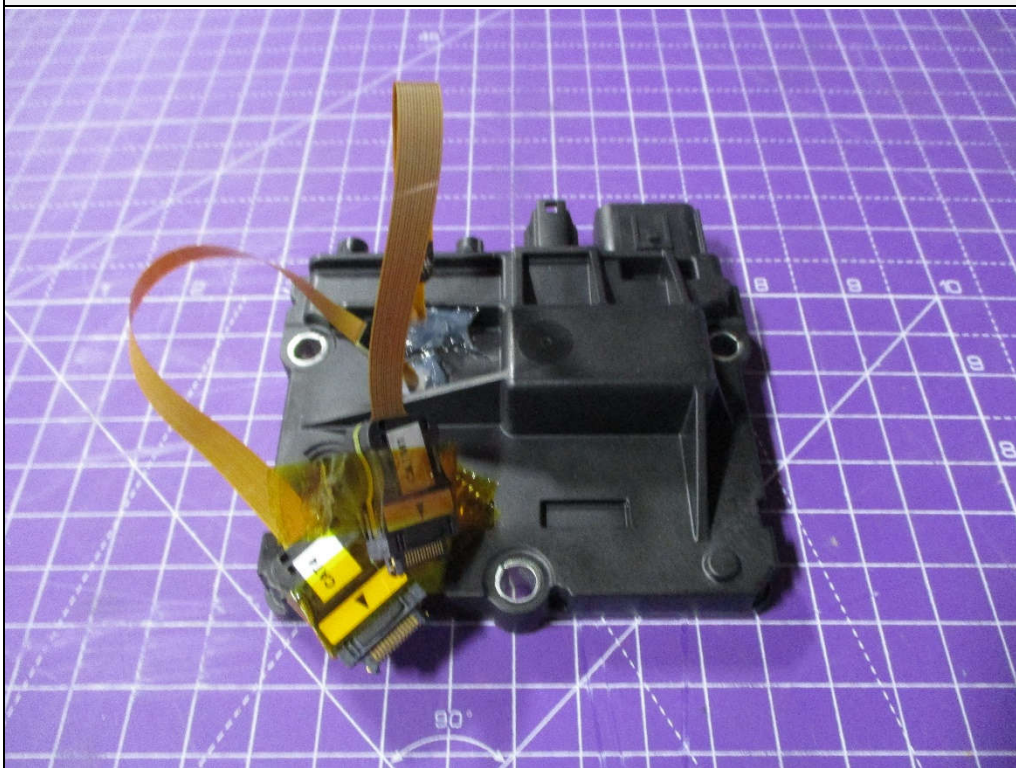


The ribbon cables and Compron connectors were only on the test item for testing purposes.





The ribbon cables and Comprion connectors were only on the test item for testing purposes.



18. Equipment List

| Eq ID | Equipment Description | Manufacturer | Model No. | Serial No. | Frequency Range | Cal Date | Due Date |
|-------|---------------------------------|-----------------|--------------------------|------------|-----------------|------------|------------|
| CDZ3 | LAB WORKSTATION | ELITE | LWS-10 | | WINDOWS 10 | CNR | |
| NTA3 | BILOG ANTENNA | TESEQ | 6112D | 32853 | 25-1000MHz | 11/17/2022 | 11/17/2024 |
| NWQ1 | DOUBLE RIDGED WAVEGUIDE ANTENNA | ETS-LINDGREN | 3117 | 66655 | 1GHZ-18GHZ | 5/26/2022 | 5/26/2024 |
| NWQ2 | DOUBLE RIDGED WAVEGUIDE ANTENNA | ETS LINDGREN | 3117 | 66659 | 1GHZ-18GHZ | 4/27/2022 | 4/27/2024 |
| RBF2 | WIDEBAND RADIO COMM. TESTER | ROHDE & SCHWARZ | CMW500 | 121396 | --- | 2/28/2023 | 2/28/2024 |
| RBG2 | EMI ANALYZER | ROHDE & SCHWARZ | ESW44 | 101591 | 2HZ-44GHZ | 4/10/2023 | 4/10/2024 |
| SES0 | 24VDC POWER SUPPLY | P-TRANS | FS-32024-1M | 001 | 18-27VDC | NOTE 1 | |
| VBV2 | CISPR EN FCC ICES RE.EXE | ELITE | CISPR EN FCC ICES RE.EXE | --- | --- | N/A | |
| WKA1 | SOFTWARE, UNIVERSAL RCV EMI | ELITE | UNIV_RCV_EMI | 1 | --- | I/O | |
| XPQ4 | HIGH PASS FILTER | K&L MICROWAVE | 11SH10-4800/X20000-O/O | 1 | 4.8-20GHZ | 9/7/2021 | 9/7/2023 |
| XPQ5 | FILTER | K&L MICROWAVE | 11SH10-9000/U2000-O/O | 1 | 5000-5800 MHZ | 9/7/2021 | 9/7/2023 |
| XPQ7 | HIGH PASS FILTER | K&L MICROWAVE | 4IH30-1804/T10000-0 | 5 | 1.8-10GHZ | 2/2/2023 | 2/2/2025 |

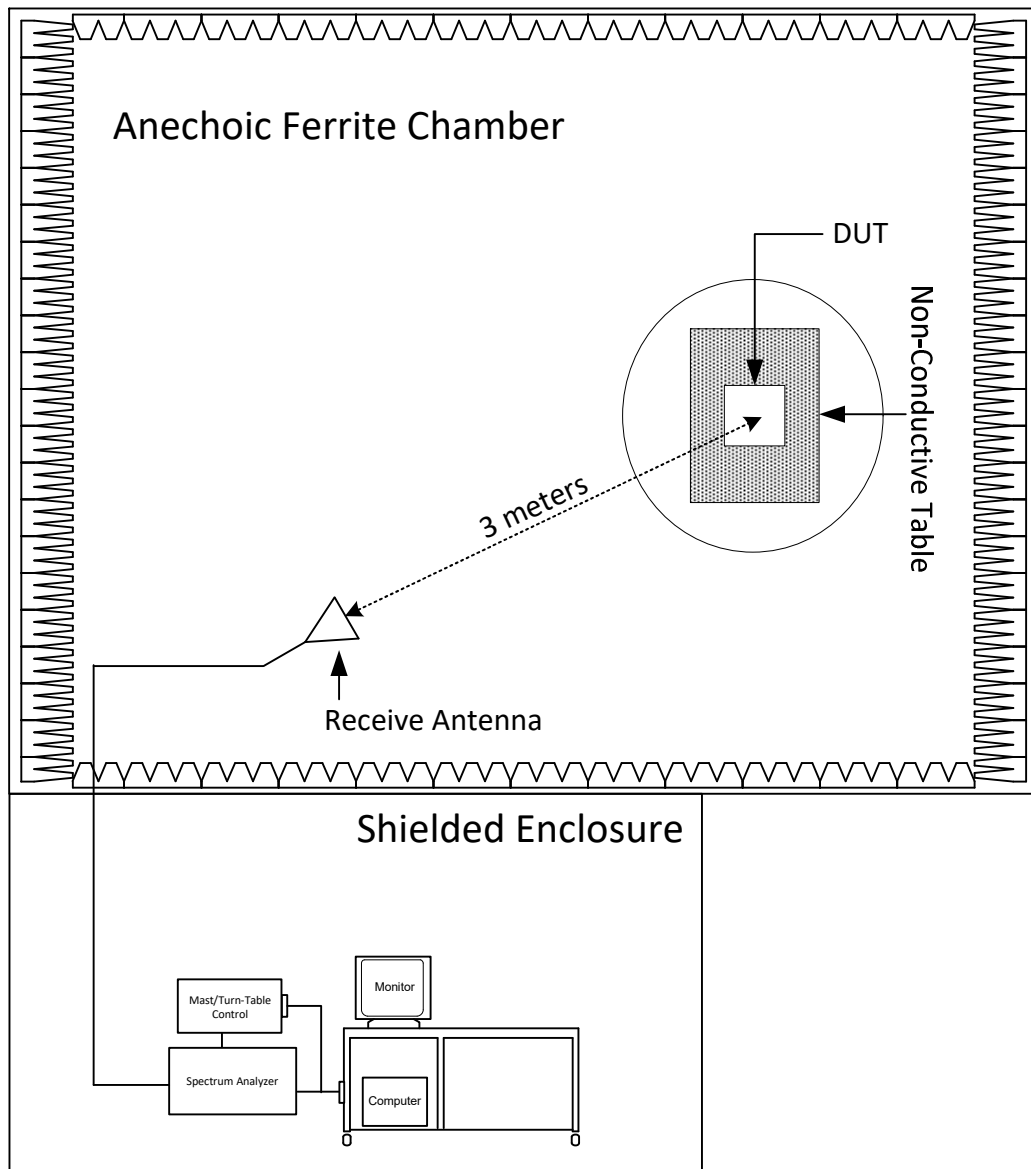
N/A: Not Applicable

I/O: Initial Only

CNR: Calibration Not Required

NOTE 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

19. Block Diagram of Test Setup



Radiated Measurements Test Setup

20. RF Radiated Emissions

| EUT Information | |
|-----------------|------------------------|
| Manufacturer | Appareo Systems |
| Product | Telematic Control Unit |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Mode | Test Operations |

| Test Site Information | |
|-------------------------------|--|
| Setup Format | Tabletop |
| Height of Support | NA |
| Type of Test Site | Semi-Anechoic Chamber |
| Test Site Used | Room 29 |
| Type of Antennas Used | Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-ridged waveguide (or equivalent) |
| Highest Internal Frequency | 5GHz |
| Highest Measurement Frequency | 29GHz |
| Notes | The cables were manually maximized during the preliminary emissions sweeps. The cable arrangement which resulted in the worst-case emissions was utilized. |

| Measurement Uncertainty | |
|---|----------------------------------|
| Measurement Type | Expanded Measurement Uncertainty |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz) | 4.3 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz) | 3.1 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (6 GHz – 18 GHz) | 3.2 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (18 GHz – 26.5 GHz) | 3.3 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (26.5 GHz – 40 GHz) | 3.4 |

| Requirements |
|---|
| The field strength of radiated emissions from unintentional radiators at a distance of 10 meters shall not exceed the values in the following tables. |

| FCC Part 15 Class A Radiated Emissions Limits (30MHz to 1GHz) | | |
|---|---|---|
| Frequency of Emission (MHz) | Field Strength ($\mu\text{V/m}$) | Field Strength ($\text{dB}\mu\text{V/m}$) |
| 30 – 88 | 90 | 39 |
| 88 – 216 | 150 | 43.5 |
| 216 – 960 | 210 | 46.5 |
| Above 960 | 300 | 49.5 |
| FCC Part 15 Class A Radiated Emissions Limits (Above 1GHz) | | |
| Frequency of Emission (MHz) | Peak Limit ($\text{dB}\mu\text{V/m}$) | Average Limit ($\text{dB}\mu\text{V/m}$) |
| Above 1000 | 69.5 | 49.5 |

| ICES-003 Class A Radiated Emissions Limits (30MHz to 1GHz) | | |
|--|---|--|
| Frequency Range (MHz) | Field Strength at 3 meters ($\text{dB}\mu\text{V/m}$) | Field Strength at 10 meters ($\text{dB}\mu\text{V/m}$) |
| 30 – 88 | 50 | 40 |
| 88 – 216 | 54 | 43.5 |
| 216 – 230 | 56.9 | 46.4 |
| 230 – 960 | 57 | 47 |
| 960 – 1000 | 60 | 49.5 |
| ICES-003 Class A Radiated Emissions Limits (At and Above 1GHz) | | |
| Frequency Range (GHz) | Average ($\text{dB}\mu\text{V/m}$) | Peak ($\text{dB}\mu\text{V/m}$) |
| 1 – F_M | 60 | 80 |
| F_M = highest measurement frequency | | |

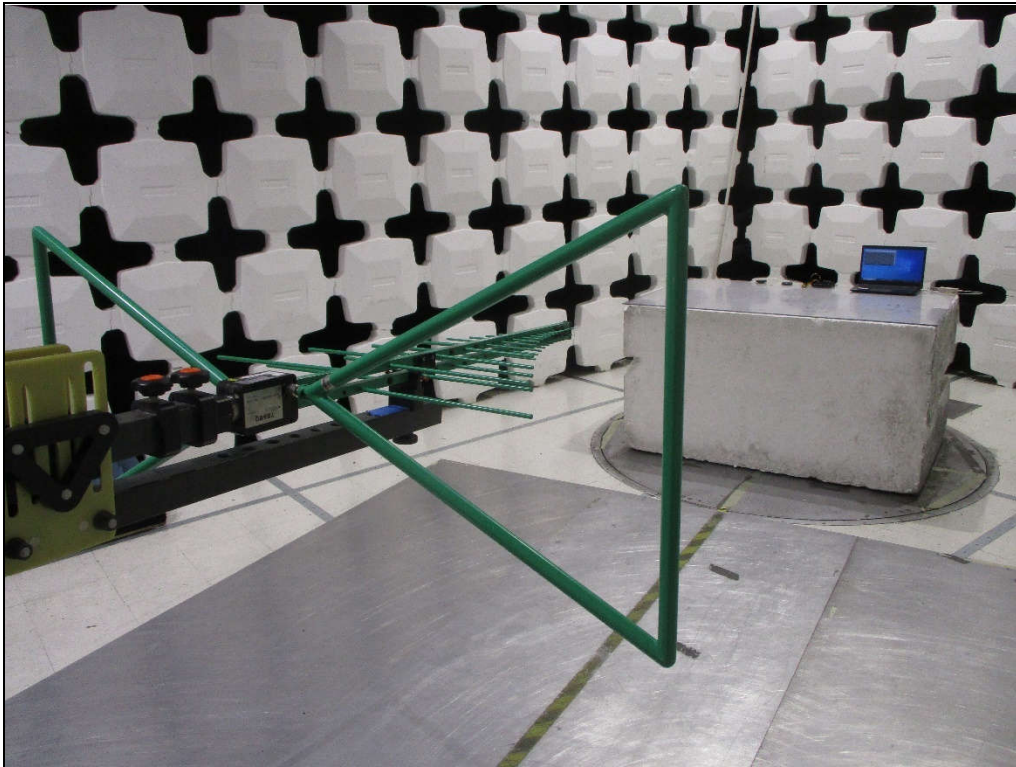
Procedure

Since a quasi-peak detector and an average detector requires long integration times, it is not practical to automatically sweep through the quasi-peak and average levels. Therefore, radiated emissions from the EUT were first scanned using a peak detector and automatically plotted. The frequencies where significant emission levels were noted were then remeasured using the quasi-peak detector or average detector.

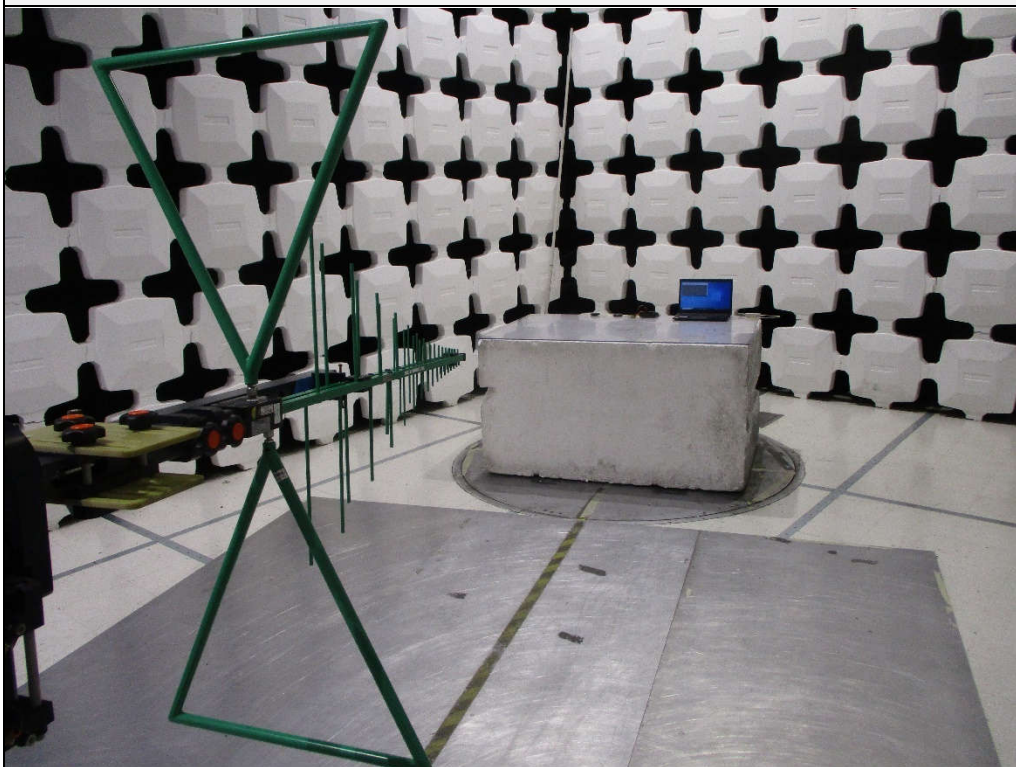
The EUT and all peripheral equipment were placed on an 80cm high non-conductive stand. The broadband measuring antenna was positioned at a 3-meter distance from the EUT. The frequency range from 30MHz to 1GHz was investigated using a peak detector function with the bilog antenna at several heights, horizontal and vertical polarization, and with several different orientations of the EUT with respect to the antenna. The frequency range from 1GHz to 29GHz was investigated using a peak detector function with the double ridged waveguide antenna at several heights, horizontal and vertical polarization, and with several different orientations of the EUT with respect to the antenna. The maximum levels for each antenna polarization were plotted. The data was then processed by the computer to equivalent field intensity at 10 meters using linear extrapolation. A -10.5dB ($-10.5\text{dB} = 20 * \text{Log} (3\text{m}/10\text{m})$) distance correction factor has automatically been applied to the plotted emissions data.

Final radiated emissions were performed on all significant broadband and narrowband emissions found in the exploratory sweeps using the following methods:

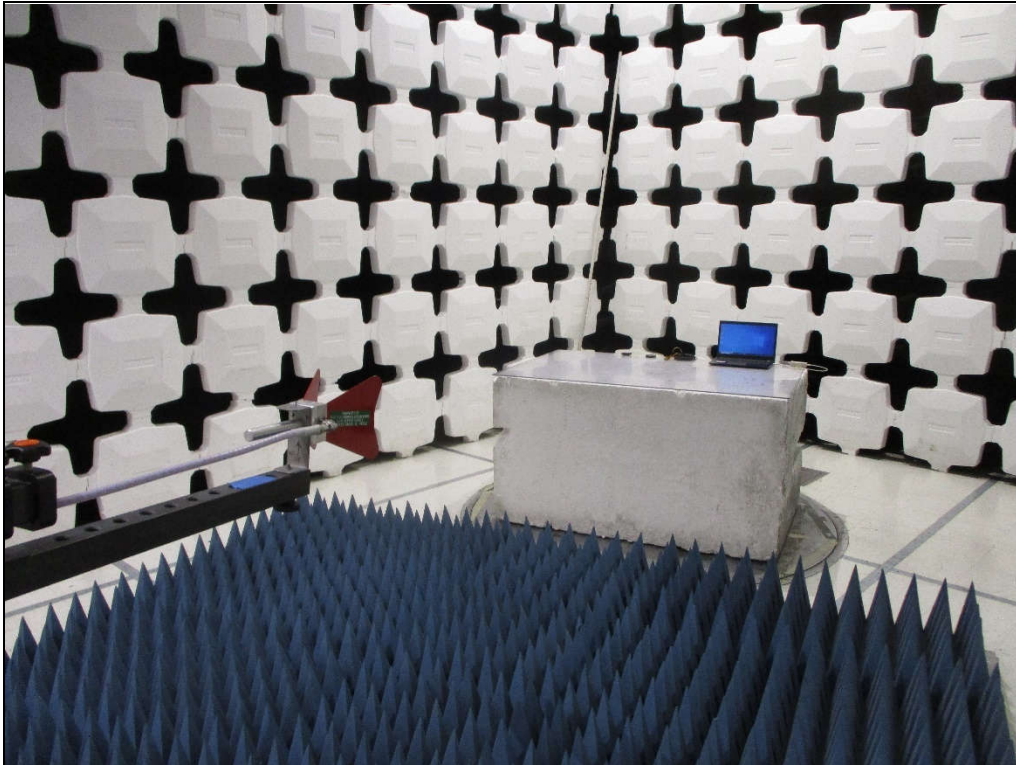
- 1) Measurements from 30MHz to 1GHz were made using a quasi-peak detector and a broadband bilog antenna. Measurements above 1GHz were made using an average detector and a broadband double ridged waveguide antenna.
- 2) To ensure that maximum or worst case, emission levels were measured, the following steps were taken:
 - a) The EUT was rotated so that all sides were exposed to the receiving antenna.
 - b) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - c) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
 - d) For hand-held or body-worn devices, the EUT was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.



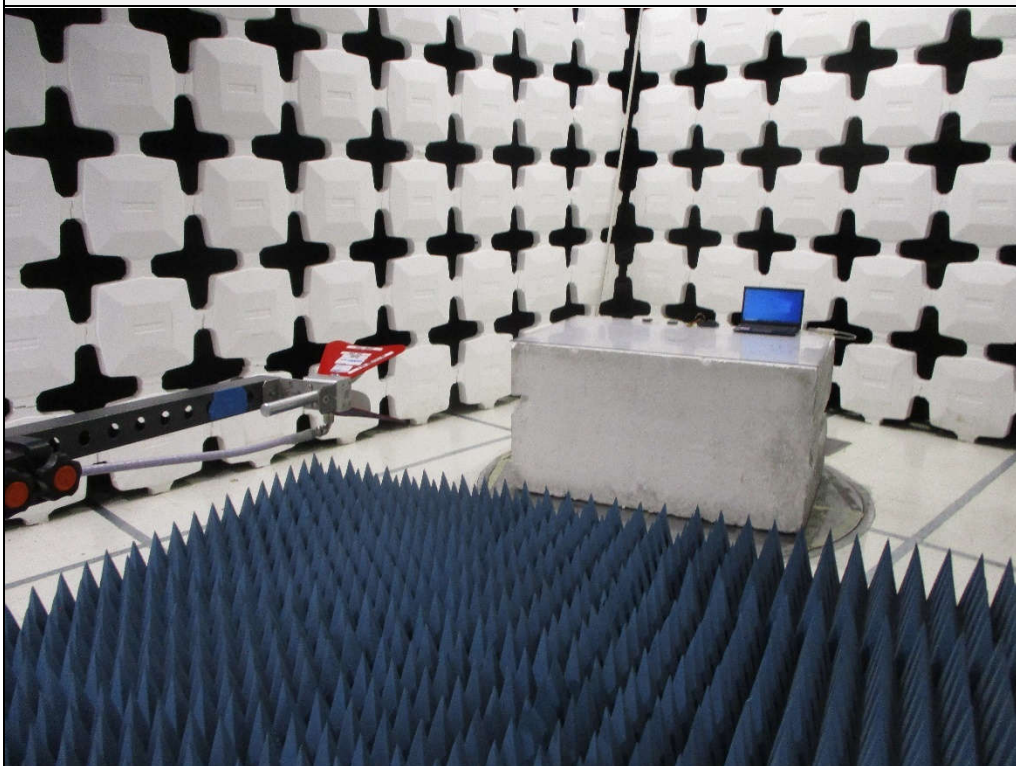
Test Setup for Radiated Emissions: 30MHz to 1GHz, Horizontal Polarization



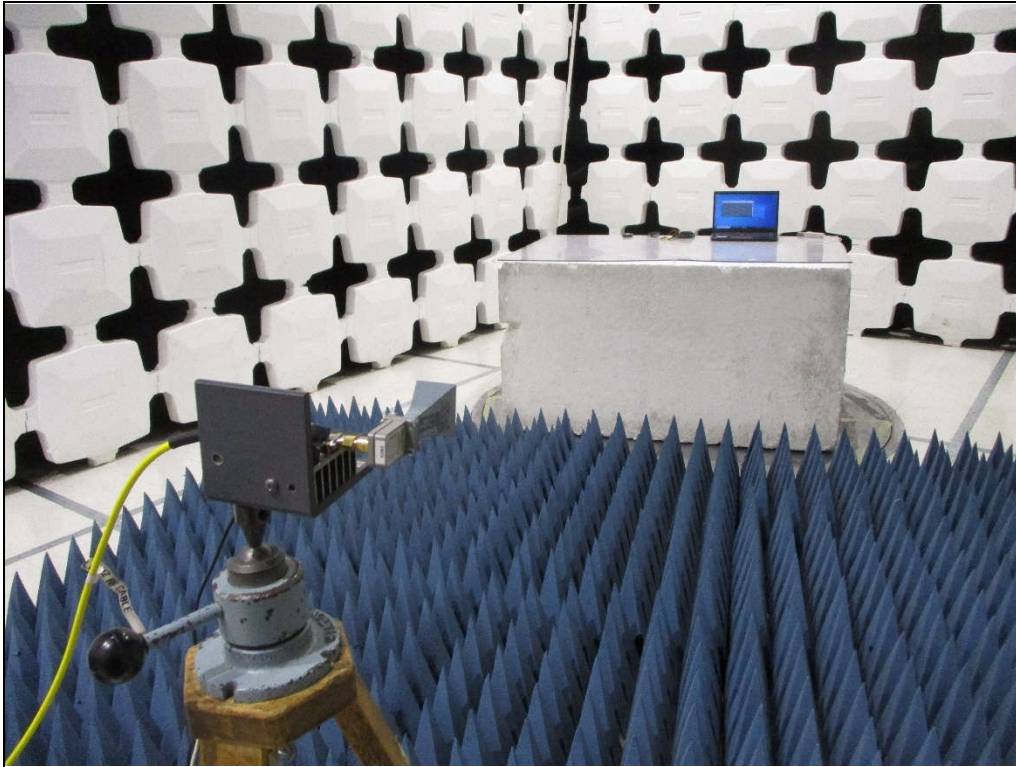
Test Setup for Radiated Emissions: 30MHz to 1GHz, Vertical Polarization



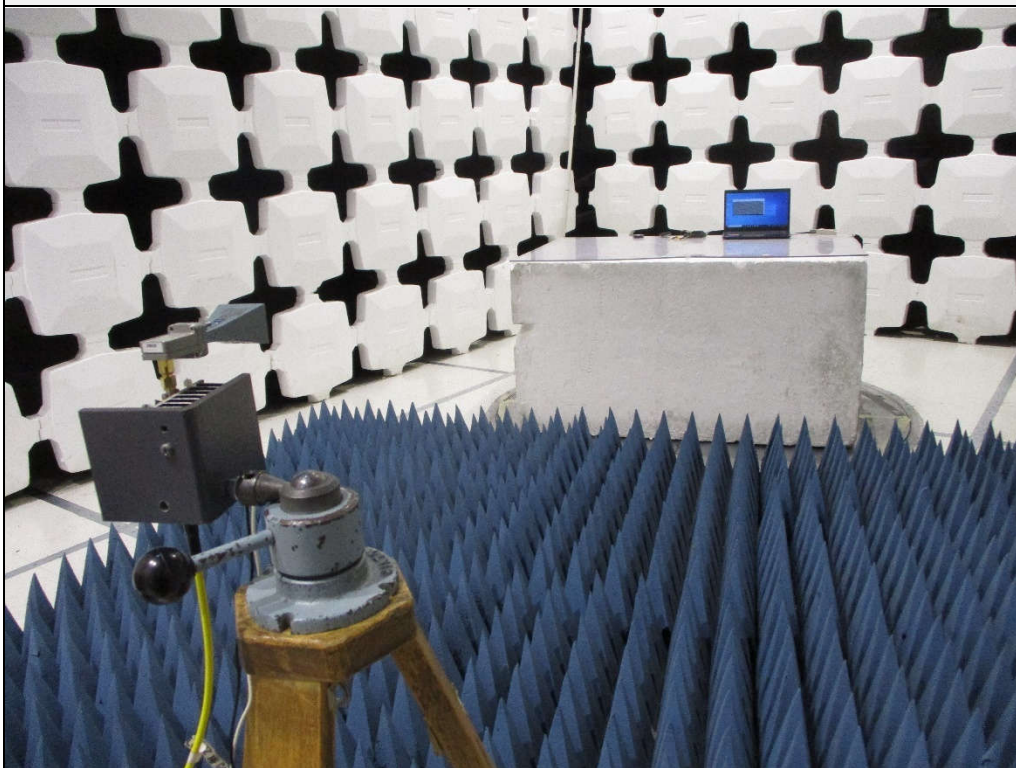
Test Setup for Radiated Emissions: 1GHz to 18GHz, Horizontal Polarization



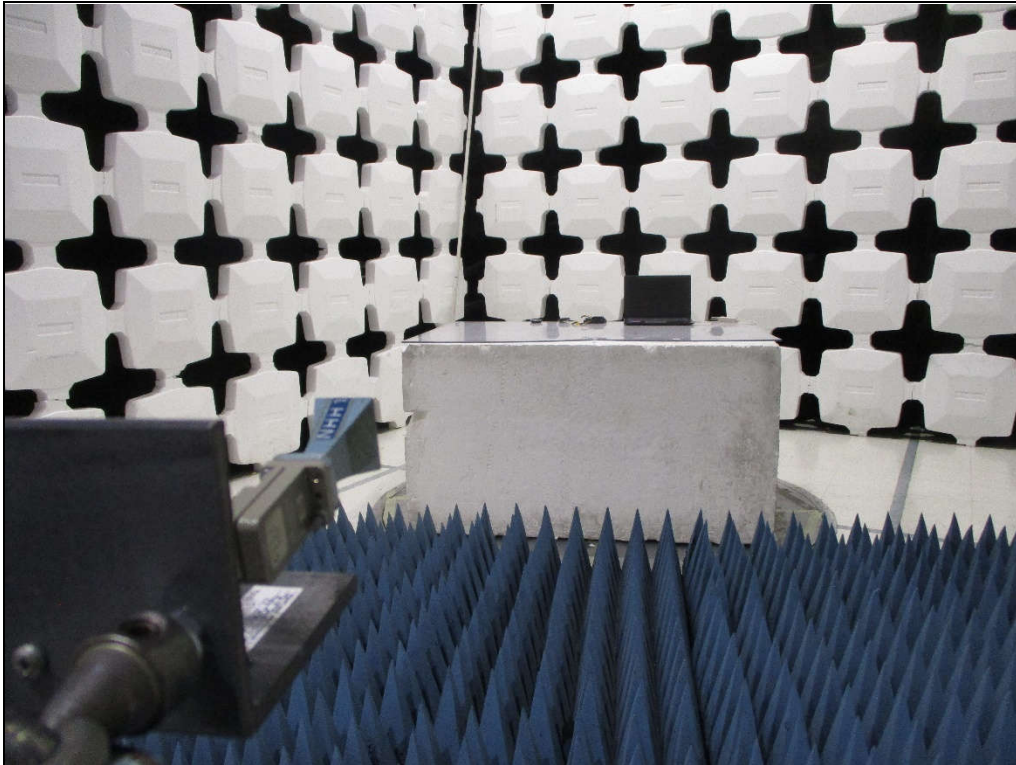
Test Setup for Radiated Emissions: 1GHz to 18GHz, Vertical Polarization



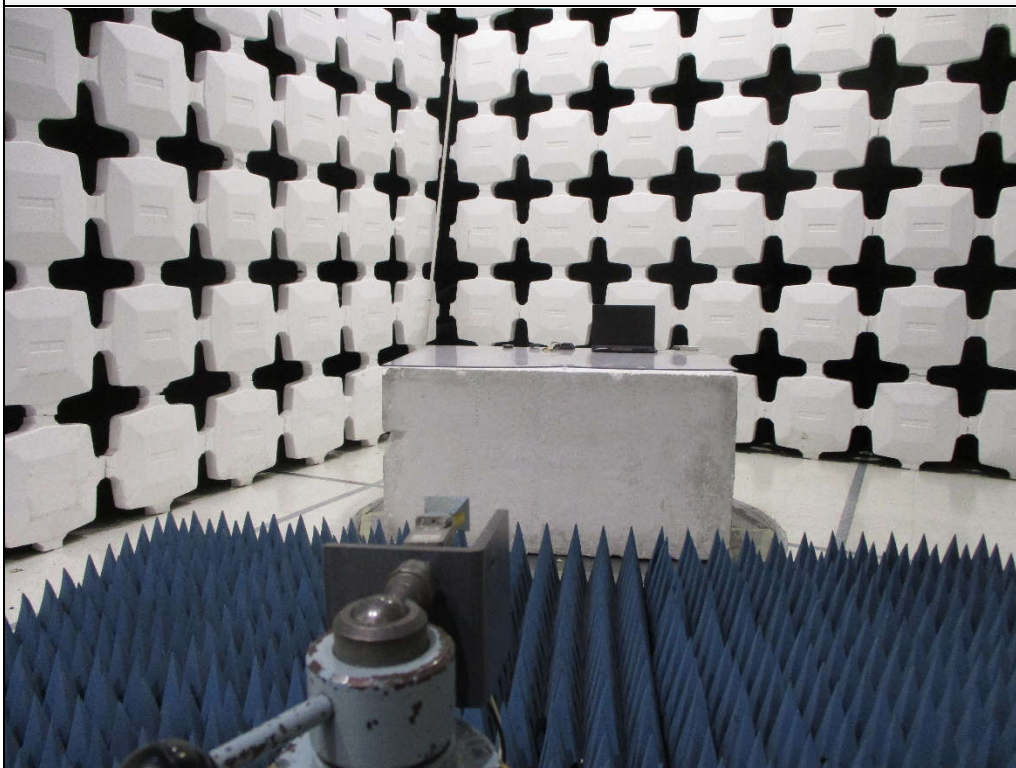
Test Setup for Radiated Emissions: 18GHz to 26.5GHz, Horizontal Polarization



Test Setup for Radiated Emissions: 18GHz to 26.5GHz, Vertical Polarization



Test Setup for Radiated Emissions: 26.5GHz to 29GHz, Horizontal Polarization



Test Setup for Radiated Emissions: 26.5GHz to 29GHz, Vertical Polarization

FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

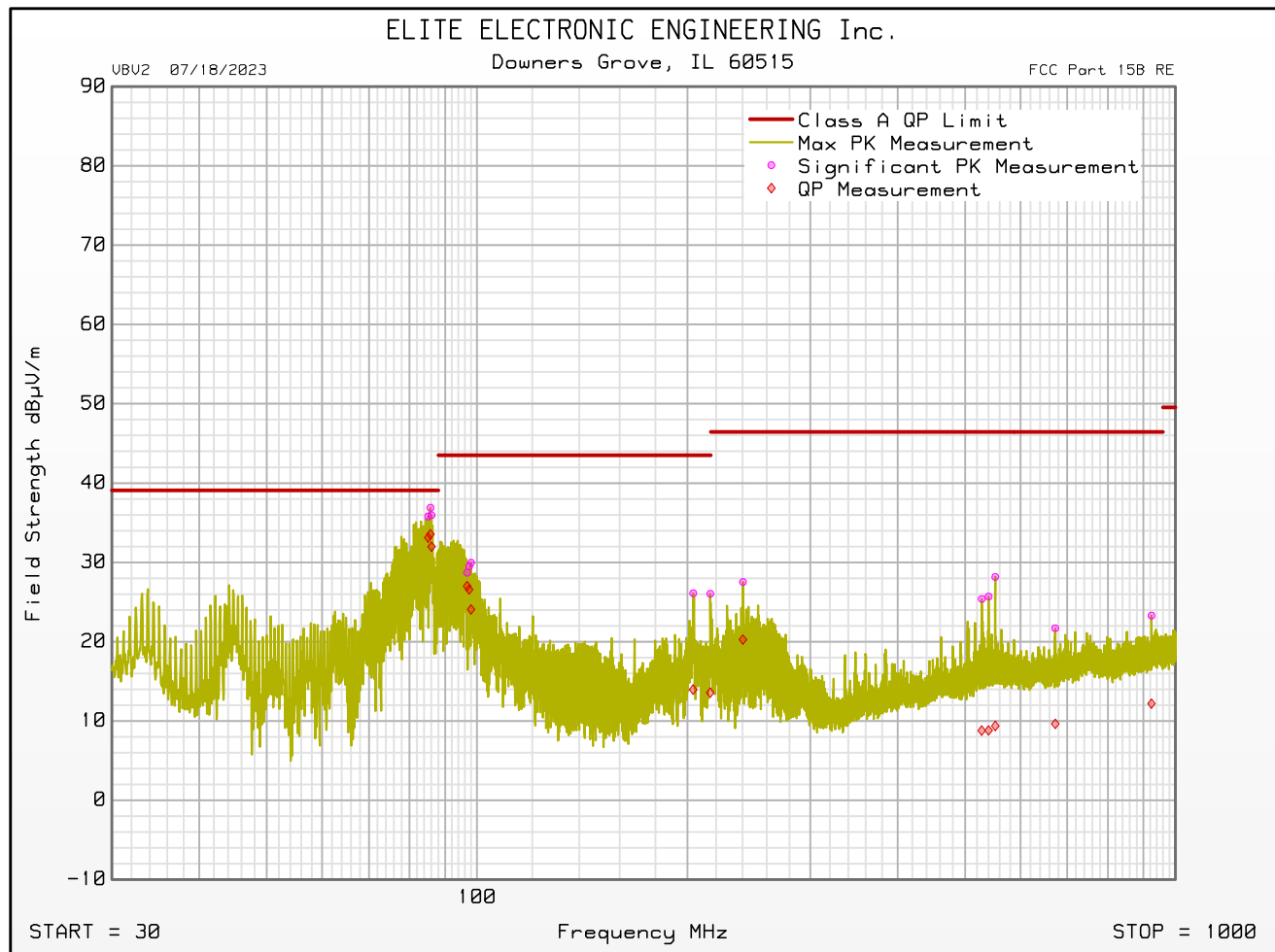
Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Scan Type : Stepped Scan
 Test RBW : 120 kHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 10:09:50 AM

| Freq MHz | Peak Mtr Rdg dBuV | QP Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Peak Total dBuV/m | QP Total dBuV/m | QP Limit dBuV/m | QP Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive QP Level |
|-------------|----------------------------|--------------------------|--------------------|------------------|------------------|--------------------|-------------------------|-----------------------|-----------------------|------------------------|------------|------------------|-----------|--------------------------|
| 33.120 | 25.7 | 4.2 | 22.6 | 0.0 | 0.4 | -10.5 | 38.2 | 16.7 | 39.1 | -22.4 | Vertical | 120 | 0 | |
| 33.720 | 25.3 | 3.0 | 22.3 | 0.0 | 0.4 | -10.5 | 37.4 | 15.2 | 39.1 | -23.9 | Vertical | 120 | 0 | |
| 34.440 | 23.6 | 6.1 | 21.9 | 0.0 | 0.4 | -10.5 | 35.4 | 17.9 | 39.1 | -21.2 | Vertical | 120 | 0 | |
| 85.080 | 32.1 | 29.4 | 13.8 | 0.0 | 0.4 | -10.5 | 35.8 | 33.1 | 39.1 | -6.0 | Horizontal | 200 | 180 | |
| 85.740 | 33.0 | 29.7 | 13.9 | 0.0 | 0.4 | -10.5 | 36.9 | 33.5 | 39.1 | -5.5 | Horizontal | 200 | 180 | |
| 86.040 | 32.1 | 28.1 | 14.0 | 0.0 | 0.4 | -10.5 | 36.0 | 32.0 | 39.1 | -7.1 | Horizontal | 200 | 180 | |
| 96.760 | 22.5 | 20.8 | 16.3 | 0.0 | 0.4 | -10.5 | 28.7 | 27.0 | 43.5 | -16.5 | Horizontal | 200 | 180 | |
| 97.420 | 23.1 | 20.2 | 16.4 | 0.0 | 0.4 | -10.5 | 29.5 | 26.6 | 43.5 | -16.9 | Horizontal | 200 | 180 | |
| 98.020 | 23.5 | 17.6 | 16.5 | 0.0 | 0.4 | -10.5 | 30.0 | 24.1 | 43.5 | -19.5 | Horizontal | 200 | 0 | |
| 203.920 | 20.3 | 8.1 | 15.5 | 0.0 | 0.8 | -10.5 | 26.1 | 14.0 | 43.5 | -29.6 | Horizontal | 200 | 180 | |
| 215.680 | 20.7 | 8.3 | 15.0 | 0.0 | 0.8 | -10.5 | 26.0 | 13.6 | 43.5 | -29.9 | Horizontal | 120 | 135 | |
| 240.240 | 19.8 | 12.5 | 17.4 | 0.0 | 0.8 | -10.5 | 27.5 | 20.3 | 46.4 | -26.2 | Horizontal | 120 | 180 | |
| 527.940 | 11.0 | -5.6 | 23.7 | 0.0 | 1.1 | -10.5 | 25.4 | 8.8 | 46.4 | -37.7 | Horizontal | 120 | 135 | |
| 540.000 | 10.9 | -6.0 | 24.1 | 0.0 | 1.1 | -10.5 | 25.7 | 8.8 | 46.4 | -37.6 | Horizontal | 120 | 135 | |
| 552.120 | 12.8 | -6.0 | 24.7 | 0.0 | 1.1 | -10.5 | 28.2 | 9.4 | 46.4 | -37.1 | Horizontal | 120 | 135 | |
| 672.720 | 5.8 | -6.2 | 25.0 | 0.0 | 1.3 | -10.5 | 21.7 | 9.6 | 46.4 | -36.8 | Horizontal | 200 | 135 | |
| 718.680 | 6.4 | -5.5 | 25.0 | 0.0 | 1.4 | -10.5 | 22.3 | 10.4 | 46.4 | -36.0 | Vertical | 200 | 90 | |
| 924.000 | 5.7 | -5.4 | 26.5 | 0.0 | 1.5 | -10.5 | 23.3 | 12.2 | 46.4 | -34.3 | Horizontal | 120 | 180 | |

FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

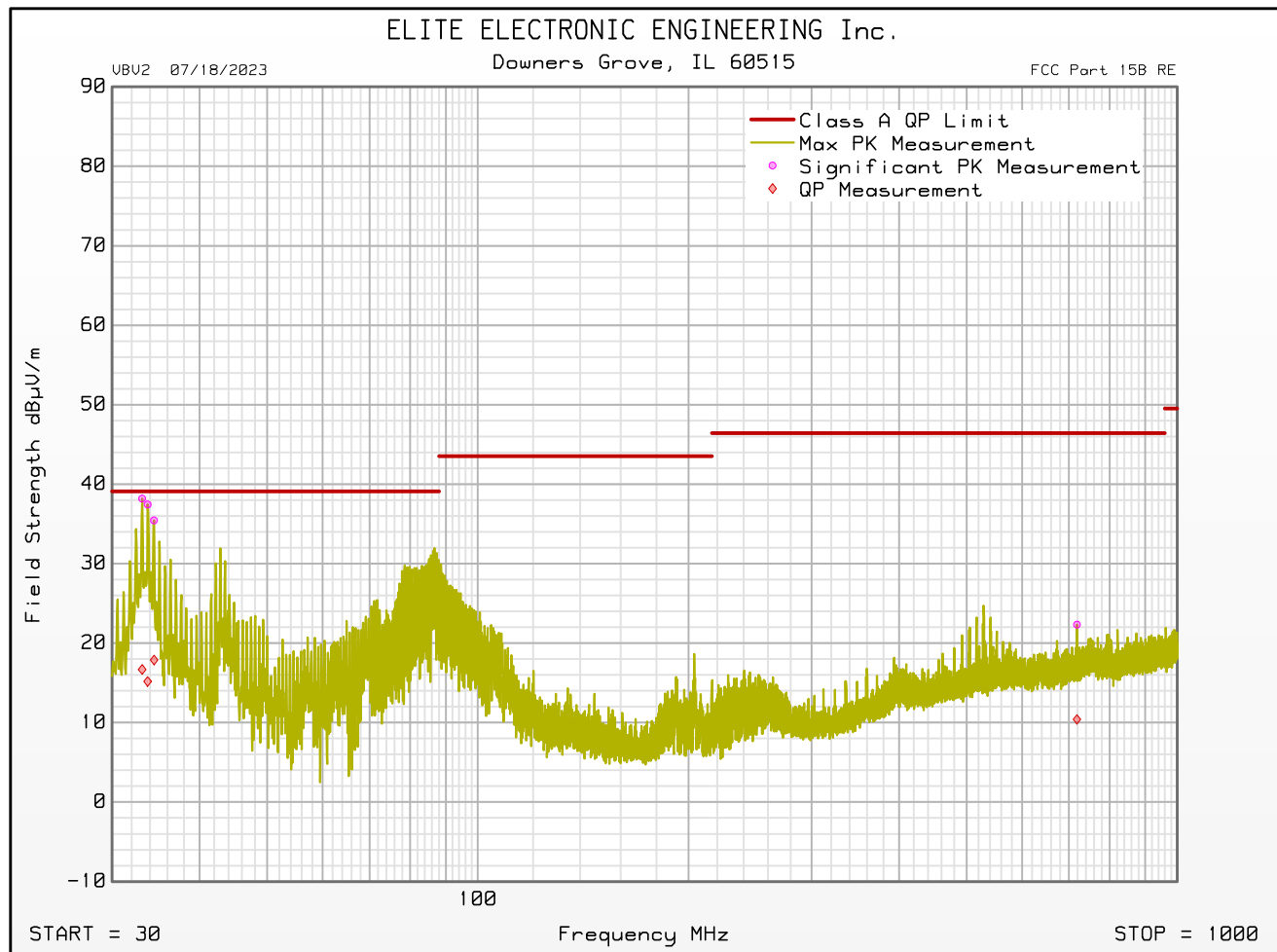
Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Horizontal
 Scan Type : Stepped Scan
 Test RBW : 120 kHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 10:09:50 AM



FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Vertical
 Scan Type : Stepped Scan
 Test RBW : 120 kHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 10:09:50 AM



FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°) : 45
 Mast Positions (cm) : 120, 200, 340
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 12:01:40 PM

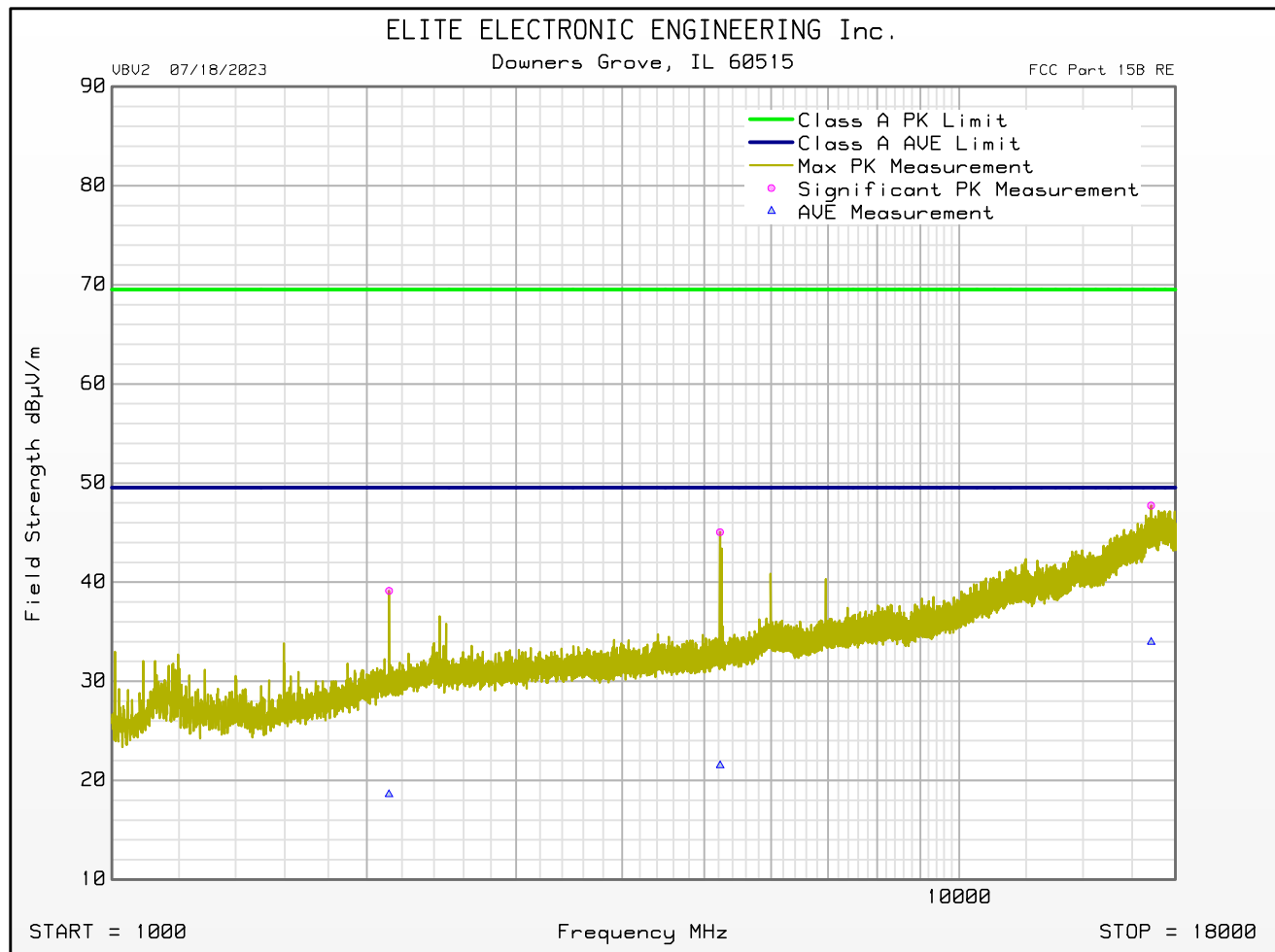
| Freq MHz | Peak Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Peak Total dBuV/m | Peak Limit dBuV/m | Peak Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Peak Level |
|-----------|-------------------|--------------|------------|------------|--------------|-------------------|-------------------|-----------------|------------|------------|--------|----------------------|
| 1593.000 | 63.2 | 28.8 | -41.1 | 2.0 | -10.5 | 42.5 | 69.5 | -27.1 | Vertical | 200 | 0 | |
| 1594.500 | 63.3 | 28.8 | -41.1 | 2.0 | -10.5 | 42.6 | 69.5 | -27.0 | Vertical | 120 | 180 | |
| 1596.500 | 63.4 | 28.8 | -41.1 | 2.0 | -10.5 | 42.7 | 69.5 | -26.8 | Vertical | 200 | 0 | |
| 2123.500 | 56.1 | 31.8 | -40.7 | 2.4 | -10.5 | 39.1 | 69.5 | -30.4 | Horizontal | 340 | 0 | |
| 2124.500 | 62.2 | 31.8 | -40.7 | 2.4 | -10.5 | 45.2 | 69.5 | -24.4 | Vertical | 200 | 90 | |
| 2483.000 | 52.8 | 32.7 | -40.5 | 2.6 | -10.5 | 37.2 | 69.5 | -32.4 | Vertical | 120 | 90 | |
| 2660.000 | 53.8 | 32.6 | -40.6 | 2.8 | -10.5 | 38.2 | 69.5 | -31.4 | Vertical | 200 | 270 | |
| 3191.000 | 53.8 | 33.1 | -40.5 | 3.1 | -10.5 | 39.0 | 69.5 | -30.6 | Vertical | 200 | 225 | |
| 3199.000 | 51.9 | 33.1 | -40.5 | 3.1 | -10.5 | 37.1 | 69.5 | -32.4 | Vertical | 200 | 45 | |
| 5221.500 | 57.4 | 34.5 | -40.3 | 3.9 | -10.5 | 45.0 | 69.5 | -24.5 | Horizontal | 120 | 315 | |
| 5977.000 | 58.3 | 36.3 | -40.4 | 4.2 | -10.5 | 47.8 | 69.5 | -21.7 | Vertical | 340 | 270 | |
| 5997.000 | 59.8 | 36.3 | -40.4 | 4.2 | -10.5 | 49.4 | 69.5 | -20.1 | Vertical | 120 | 90 | |
| 6960.000 | 53.4 | 36.4 | -40.5 | 4.5 | -10.5 | 43.5 | 69.5 | -26.1 | Vertical | 340 | 0 | |
| 16845.000 | 47.1 | 42.3 | -38.3 | 7.2 | -10.5 | 47.7 | 69.5 | -21.8 | Horizontal | 120 | 135 | |

| Freq MHz | Average Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Average Total dBuV/m | Average Limit dBuV/m | Average Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Average Level |
|-----------|----------------------|--------------|------------|------------|--------------|----------------------|----------------------|--------------------|------------|------------|--------|-------------------------|
| 1593.000 | 36.5 | 28.8 | -41.1 | 2.0 | -10.5 | 15.8 | 49.5 | -33.7 | Vertical | 200 | 0 | |
| 1594.500 | 36.5 | 28.8 | -41.1 | 2.0 | -10.5 | 15.7 | 49.5 | -33.8 | Vertical | 120 | 180 | |
| 1596.500 | 36.7 | 28.8 | -41.1 | 2.0 | -10.5 | 16.0 | 49.5 | -33.6 | Vertical | 200 | 0 | |
| 2123.500 | 35.6 | 31.8 | -40.7 | 2.4 | -10.5 | 18.6 | 49.5 | -31.0 | Horizontal | 340 | 0 | |
| 2124.500 | 35.8 | 31.8 | -40.7 | 2.4 | -10.5 | 18.8 | 49.5 | -30.7 | Vertical | 200 | 90 | |
| 2483.000 | 35.9 | 32.7 | -40.5 | 2.6 | -10.5 | 20.2 | 49.5 | -29.3 | Vertical | 120 | 90 | |
| 2660.000 | 35.3 | 32.6 | -40.6 | 2.8 | -10.5 | 19.6 | 49.5 | -29.9 | Vertical | 200 | 270 | |
| 3191.000 | 35.1 | 33.1 | -40.5 | 3.1 | -10.5 | 20.3 | 49.5 | -29.3 | Vertical | 200 | 225 | |
| 3199.000 | 35.0 | 33.1 | -40.5 | 3.1 | -10.5 | 20.2 | 49.5 | -29.3 | Vertical | 200 | 45 | |
| 5221.500 | 33.8 | 34.5 | -40.3 | 3.9 | -10.5 | 21.5 | 49.5 | -28.0 | Horizontal | 120 | 315 | |
| 5977.000 | 33.9 | 36.3 | -40.4 | 4.2 | -10.5 | 23.4 | 49.5 | -26.1 | Vertical | 340 | 270 | |
| 5997.000 | 33.8 | 36.3 | -40.4 | 4.2 | -10.5 | 23.4 | 49.5 | -26.2 | Vertical | 120 | 90 | |
| 6960.000 | 48.5 | 36.4 | -40.5 | 4.5 | -10.5 | 38.6 | 49.5 | -11.0 | Vertical | 340 | 0 | |
| 16845.000 | 33.3 | 42.3 | -38.3 | 7.2 | -10.5 | 33.9 | 49.5 | -15.6 | Horizontal | 120 | 135 | |

FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

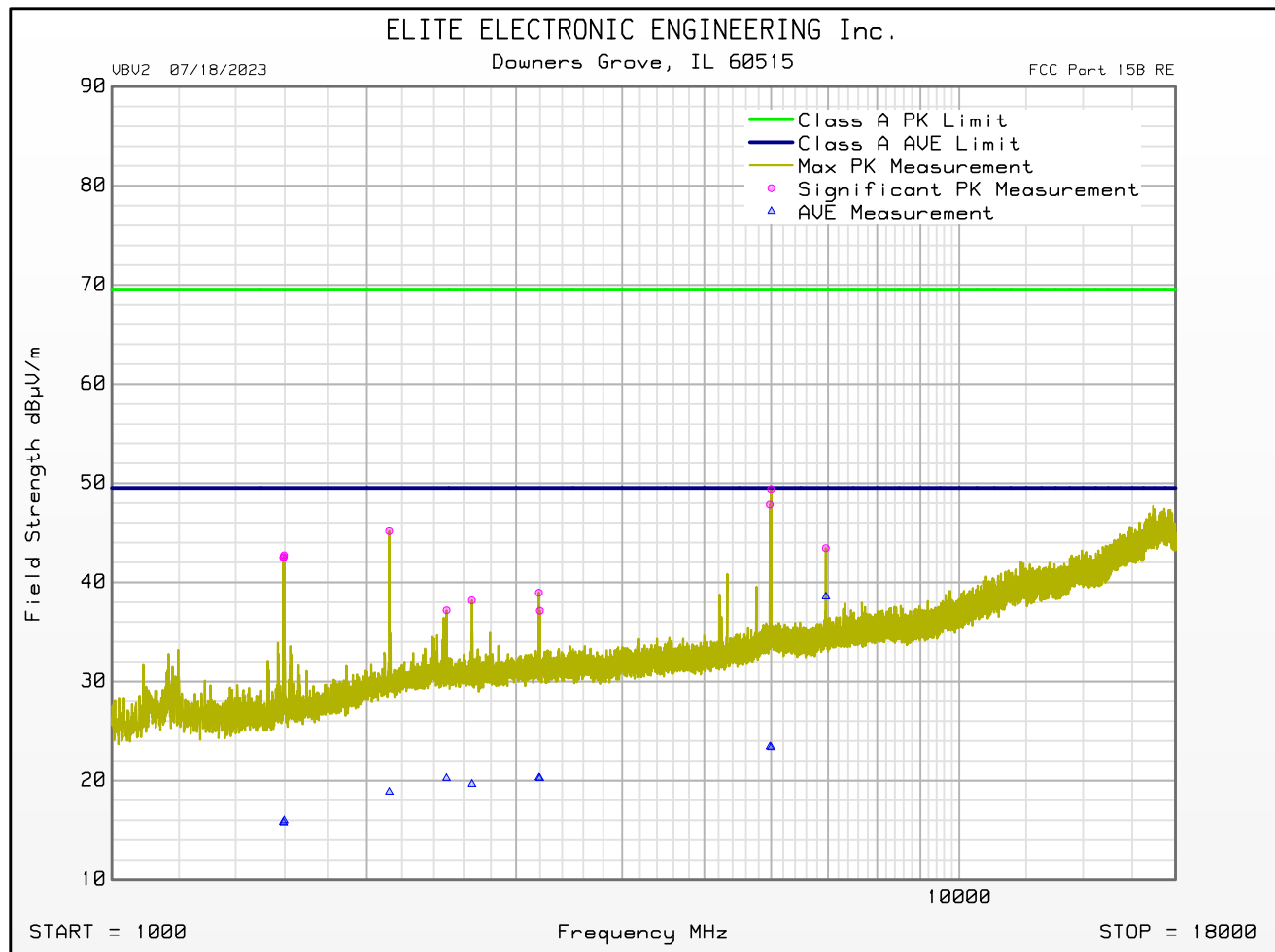
Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Horizontal
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 12:01:40 PM



FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Vertical
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 07, 2023 12:01:40 PM





FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
Model : TCU-NA,V1
Serial Number : 531
DUT Mode : Test Operations
Turntable Step Angle (°) : 45
Mast Positions (cm) : 120, 200, 340
Scan Type : Stepped Scan
Test RBW : 1 MHz
Prelim Dwell Time (s) : 0.0001
Notes : CAN Transmission
Test Engineer : J. Cardenas
Test Date : Aug 09, 2023 10:28:58 AM

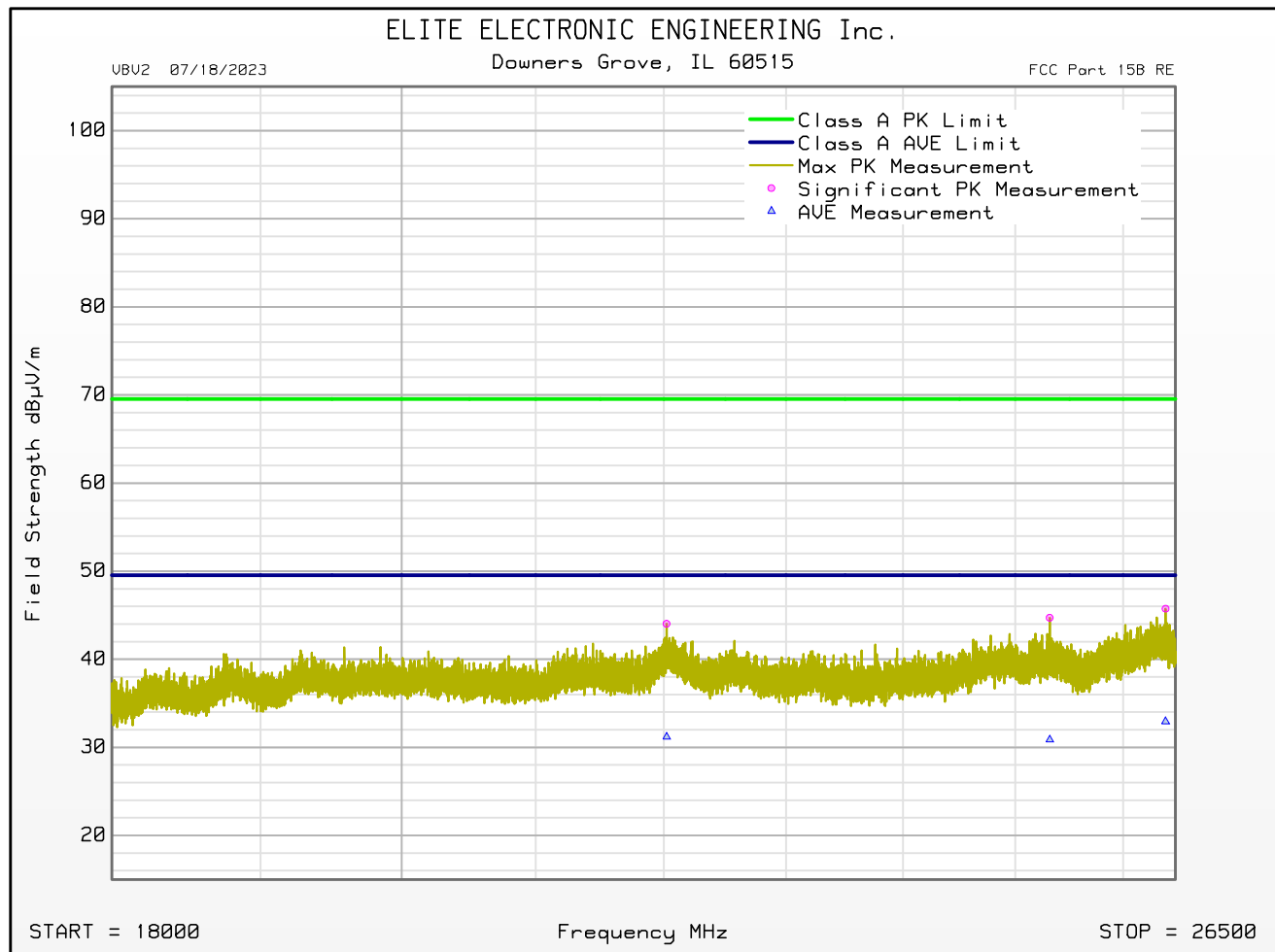
| Freq MHz | Peak Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Peak Total dBuV/m | Peak Limit dBuV/m | Peak Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Peak Level |
|-----------|-------------------|--------------|------------|------------|--------------|-------------------|-------------------|-----------------|------------|------------|--------|----------------------|
| 22023.000 | 40.5 | 40.6 | -28.8 | 2.2 | -10.5 | 44.0 | 69.5 | -25.5 | Horizontal | 120 | 0 | |
| 25315.000 | 41.4 | 40.7 | -29.1 | 2.2 | -10.5 | 44.7 | 69.5 | -24.6 | Horizontal | 120 | 0 | |
| 26405.000 | 42.3 | 40.7 | -29.1 | 2.3 | -10.5 | 45.7 | 69.5 | -23.8 | Horizontal | 120 | 0 | |
| 22051.500 | 40.5 | 40.6 | -28.8 | 2.2 | -10.5 | 44.0 | 69.5 | -25.5 | Vertical | 120 | 0 | |
| 25350.000 | 41.0 | 40.7 | -29.3 | 2.2 | -10.5 | 44.2 | 69.5 | -25.4 | Vertical | 120 | 0 | |
| 26432.500 | 42.2 | 40.7 | -29.1 | 2.3 | -10.5 | 45.5 | 69.5 | -24.0 | Vertical | 120 | 0 | |

| Freq MHz | Average Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Average Total dBuV/m | Average Limit dBuV/m | Average Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Average Level |
|-----------|----------------------|--------------|------------|------------|--------------|----------------------|----------------------|--------------------|------------|------------|--------|-------------------------|
| 22023.000 | 27.7 | 40.6 | -28.8 | 2.2 | -10.5 | 31.2 | 49.5 | -18.4 | Horizontal | 120 | 0 | |
| 25315.000 | 27.6 | 40.7 | -29.1 | 2.2 | -10.5 | 30.9 | 49.5 | -18.7 | Horizontal | 120 | 0 | |
| 26405.000 | 29.5 | 40.7 | -29.1 | 2.3 | -10.5 | 32.9 | 49.5 | -16.6 | Horizontal | 120 | 0 | |
| 22051.500 | 27.8 | 40.6 | -28.8 | 2.2 | -10.5 | 31.3 | 49.5 | -18.3 | Vertical | 120 | 0 | |
| 25350.000 | 27.8 | 40.7 | -29.3 | 2.2 | -10.5 | 31.0 | 49.5 | -18.6 | Vertical | 120 | 0 | |
| 26432.500 | 29.4 | 40.7 | -29.1 | 2.3 | -10.5 | 32.7 | 49.5 | -16.8 | Vertical | 120 | 0 | |

FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

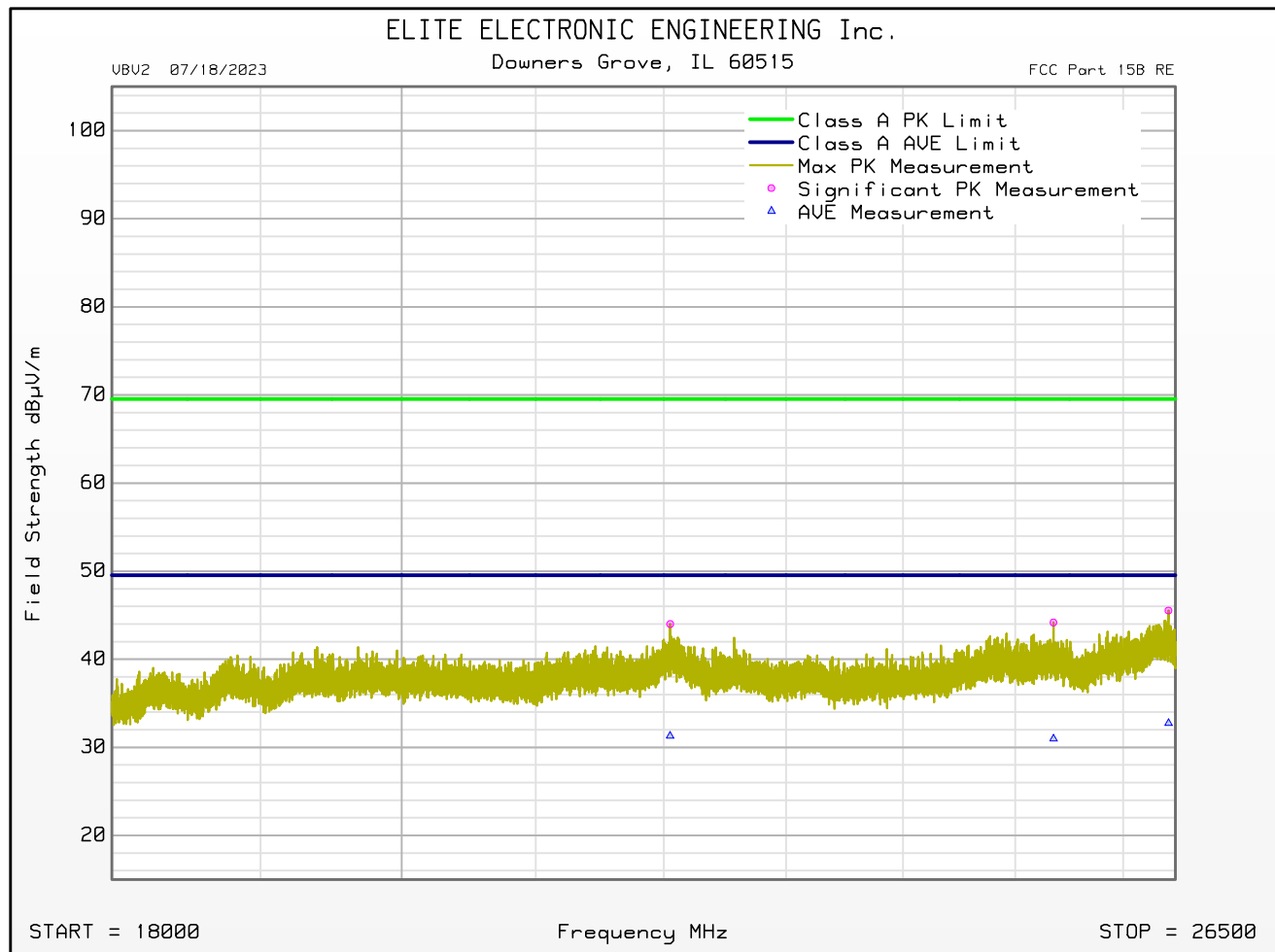
Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Horizontal
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 09, 2023 10:28:58 AM



FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Vertical
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 09, 2023 10:26:26 AM





FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
Model : TCU-NA,V1
Serial Number : 531
DUT Mode : Test Operations
DUT Mode : >26GHz
Turntable Step Angle (°): 45
Mast Positions (cm) : 120, 200, 340
Scan Type : Stepped Scan
Test RBW : 1 MHz
Prelim Dwell Time (s) : 0.0001
Notes : CAN Transmission
Test Engineer : J. Cardenas
Test Date : Aug 09, 2023 10:40:27 AM

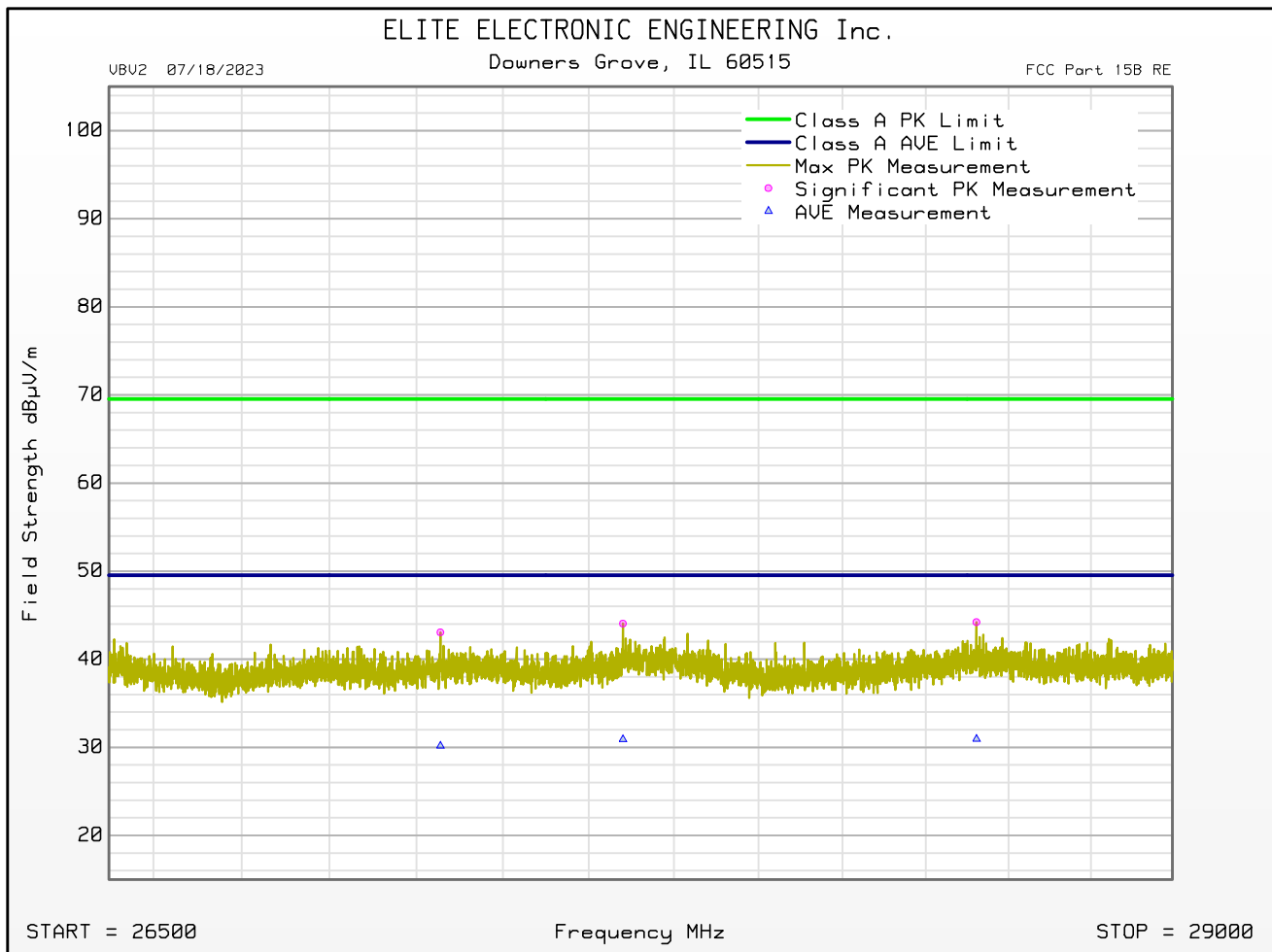
| Freq MHz | Peak Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Peak Total dBuV/m | Peak Limit dBuV/m | Peak Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Peak Level |
|-----------|-------------------|--------------|------------|------------|--------------|-------------------|-------------------|-----------------|------------|------------|--------|----------------------|
| 27255.000 | 42.9 | 43.7 | -35.0 | 1.9 | -10.5 | 43.1 | 69.5 | -26.5 | Horizontal | 120 | 0 | |
| 27680.000 | 43.1 | 43.8 | -34.3 | 1.9 | -10.5 | 44.1 | 69.5 | -25.5 | Horizontal | 120 | 0 | |
| 28522.000 | 42.8 | 43.8 | -33.9 | 2.0 | -10.5 | 44.2 | 69.5 | -25.3 | Horizontal | 120 | 0 | |
| 27255.000 | 30.0 | 43.7 | -35.0 | 1.9 | -10.5 | 30.2 | 49.5 | -19.4 | Horizontal | 120 | 0 | |
| 27680.000 | 30.0 | 43.8 | -34.3 | 1.9 | -10.5 | 30.9 | 49.5 | -18.6 | Horizontal | 120 | 0 | |
| 28522.000 | 29.5 | 43.8 | -33.9 | 2.0 | -10.5 | 30.9 | 49.5 | -18.6 | Horizontal | 120 | 0 | |

| Freq MHz | Peak Mtr Rdg dBuV | Ant Fac dB/m | Amp Fac dB | Cbl Fac dB | Dist Corr dB | Peak Total dBuV/m | Peak Limit dBuV/m | Peak Lim Mrg dB | Ant Pol | Mast Ht cm | Azim ° | Excessive Peak Level |
|-----------|-------------------|--------------|------------|------------|--------------|-------------------|-------------------|-----------------|----------|------------|--------|----------------------|
| 26518.500 | 43.3 | 43.7 | -35.3 | 1.9 | -10.5 | 43.2 | 69.5 | -26.3 | Vertical | 120 | 0 | |
| 27760.000 | 42.5 | 43.8 | -34.1 | 1.9 | -10.5 | 43.7 | 69.5 | -25.8 | Vertical | 120 | 0 | |
| 28520.500 | 42.3 | 43.8 | -33.9 | 2.0 | -10.5 | 43.8 | 69.5 | -25.8 | Vertical | 120 | 0 | |
| 26518.500 | 30.5 | 43.7 | -35.3 | 1.9 | -10.5 | 30.4 | 49.5 | -19.2 | Vertical | 120 | 0 | |
| 27760.000 | 29.8 | 43.8 | -34.1 | 1.9 | -10.5 | 31.0 | 49.5 | -18.5 | Vertical | 120 | 0 | |
| 28520.500 | 29.5 | 43.8 | -33.9 | 2.0 | -10.5 | 31.0 | 49.5 | -18.6 | Vertical | 120 | 0 | |

FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

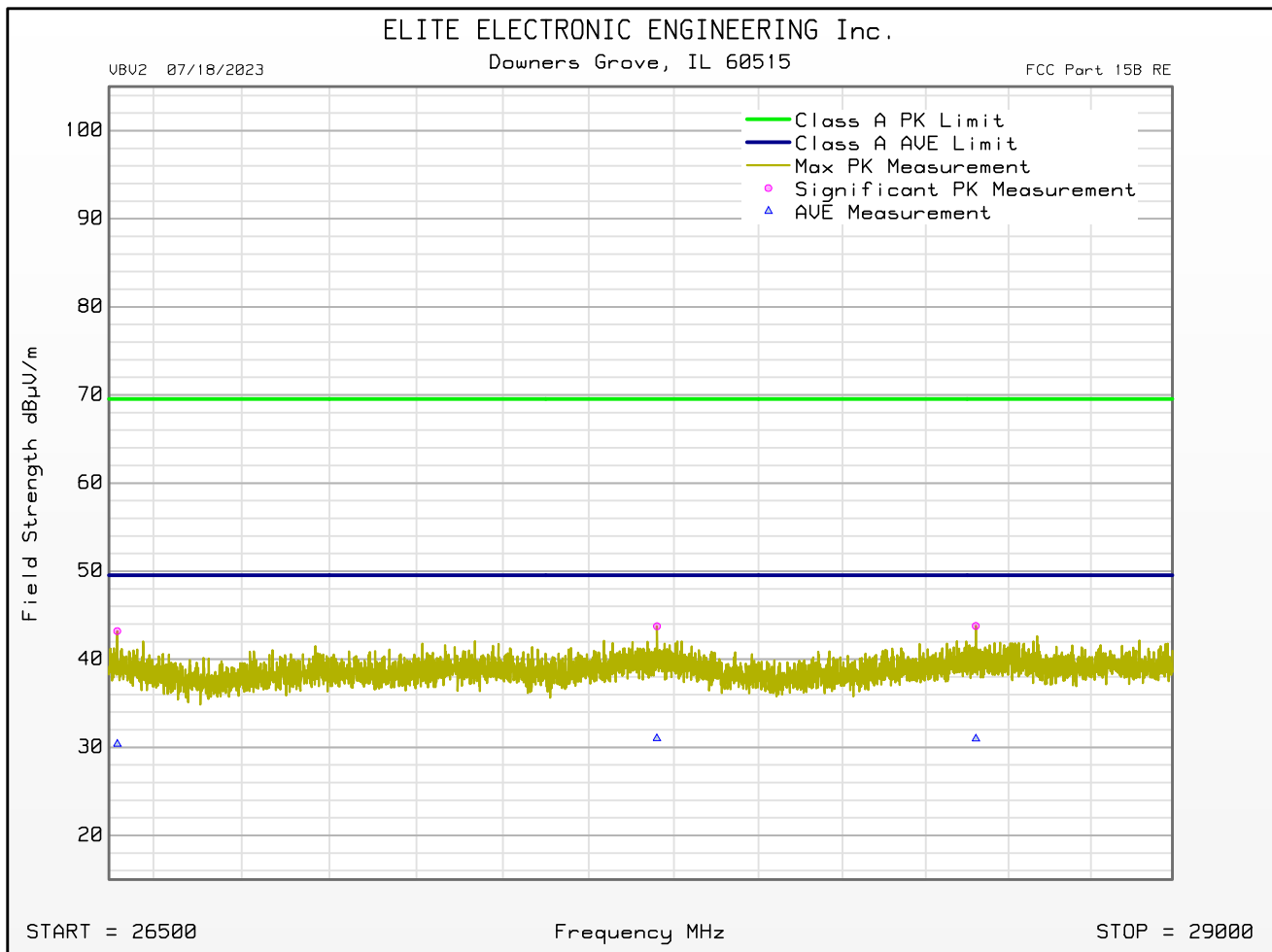
Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Horizontal
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 09, 2023 10:40:27 AM



FCC Part 15B Class A Radiated RF Emissions Test

SW ID/Rev: VBV2 07/18/2023

Manufacturer : Appareo Systems
 Model : TCU-NA,V1
 Serial Number : 531
 DUT Mode : Test Operations
 Turntable Step Angle (°): 45
 Mast Positions (cm) : 120, 200, 340
 Antenna Polarization : Vertical
 Scan Type : Stepped Scan
 Test RBW : 1 MHz
 Prelim Dwell Time (s) : 0.0001
 Notes : CAN Transmission
 Test Engineer : J. Cardenas
 Test Date : Aug 09, 2023 10:42:11 AM



21. Module Integration – Emissions Test

| EUT Information | |
|-----------------|------------------------|
| Manufacturer | Appareo Systems |
| Product | Telematic Control Unit |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Mode | Test Operations |

| Test Site Information | |
|-----------------------|--|
| Setup Format | Tabletop |
| Height of Support | NA |
| Type of Test Site | Semi-Anechoic Chamber |
| Test Site Used | R29F |
| Type of Antennas Used | Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-ridged waveguide (or equivalent) |
| Notes | The cables were manually maximized during the preliminary emissions sweeps. The cable arrangement which resulted in the worst-case emissions was utilized. |

| Measurement Uncertainty | |
|---|----------------------------------|
| Measurement Type | Expanded Measurement Uncertainty |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz) | 4.3 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz) | 3.1 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (6 GHz – 18 GHz) | 3.2 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (18 GHz – 26.5 GHz) | 3.3 |
| Radiated disturbance (electric field strength on an open area test site or alternative test site) (26.5 GHz – 40 GHz) | 3.4 |

Requirements

Per 996369 D04 Module Integration Guide v01:

Testing of the host product with all the transmitters installed is recommended, to verify that the host product meets all the applicable FCC rules. The radio spectrum is to be investigated with all the transmitters in the final host product functioning to determine that no emissions exceed the highest limit permitted for any one individual transmitter as required by Section 2.947(f).

The testing shall also check for emissions that may occur due to the intermixing of emissions with the other transmitters, digital circuitry, or due to physical properties of the host product (enclosure). This investigation is especially important when integrating multiple modular transmitters where the certification is based on testing each of them in a stand-alone configuration. No emissions exceed the highest limit permitted for any one individual transmitter as required by Section 2.947(f).

FCC 15.247:

In any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

FCC 27.53(g)/(h):

For operations in the 600MHz band and the 698 – 746MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P)$ dB.

Procedures

Radiated measurements were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles and anechoic absorber material is installed over the ferrite tiles. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2014 for site attenuation.

The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads.

For FCC Part 15:

Preliminary radiated emissions tests were performed to determine the emission characteristics of the EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3-meter distance from the EUT. The entire frequency range from 30MHz to 18GHz was investigated using a peak detector function.

The final open field emission tests were then manually performed over the frequency range of 30MHz to 18GHz.

1) For all harmonics not in the restricted bands, the following procedure was used:

- a) The field strength of the fundamental was measured using a double ridged waveguide antenna. The waveguide antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on a 1.5-meter-high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.
- b) The field strengths of all of the harmonics not in the restricted band were then measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on a non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.
- c) To ensure that maximum or worst-case emission levels at the fundamental and harmonics were measured, the following steps were taken when measuring the fundamental emissions and the spurious emissions:
 - i. The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - ii. Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - iii. The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.
 - iv. In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer, the measuring antenna was not raised or lowered to ensure maximized readings. Instead, the EUT was rotated through all axis to ensure the maximum readings were recorded for the EUT.
- d) All harmonics not in the restricted bands must be at least 20dB below levels measured at the fundamental. However, attenuation below the general limits specified in §15.209(a) is not required.

2) For all emissions in the restricted bands, the following procedure was used:

- a) The field strengths of all emissions below 1GHz were measured using a bi-log antenna. The bilog antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on an 80cm high non-conductive stand. A peak detector with a resolution bandwidth of 100kHz was used on the spectrum analyzer.
- b) The field strengths of all emissions above 1GHz were measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3-meter distance from the EUT. The EUT was placed on a 1.5-meter-high non-conductive stand. A peak

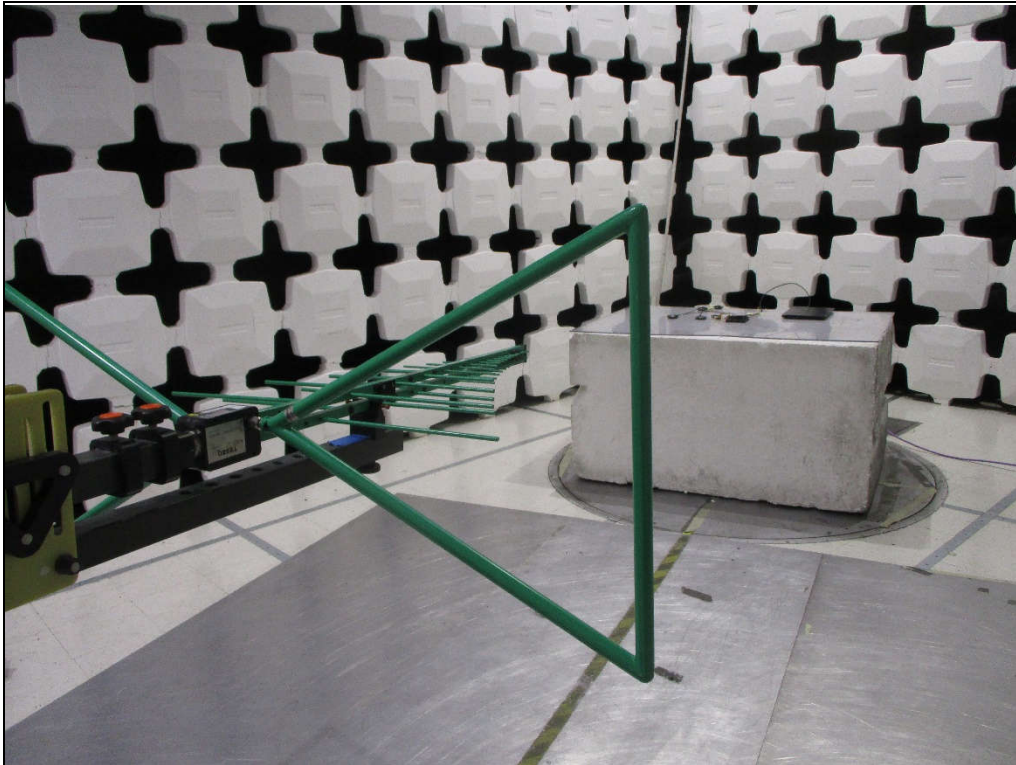
detector with a resolution bandwidth of 1MHz was used on the spectrum analyzer.

- c) To ensure that maximum (or worst case) emission levels were measured, the following steps were taken when taking all measurements:
 - i. The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - ii. Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - iii. The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.
 - iv. In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer, the measuring antenna was not raised or lowered to ensure maximized readings. Instead, the EUT was rotated through all axis to ensure the maximum readings were recorded.
- d) For all radiated emissions measurements below 1GHz, if the peak reading is below the limits listed in §15.209(a), no further measurements are required. If, however, the peak readings exceed the limits listed in 15.209(a), then the emissions are remeasured using a quasi-peak detector.
- e) For all radiated emissions measurements above 1GHz, the peak readings must comply with the §15.35(b) limits. §15.35(b) states that when average radiated emissions measurements are specified, there also is a limit on the peak level of the radiated emissions. The limit on the peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. Therefore, all peak readings above 1GHz must be no greater than 20dB above the limits specified in §15.209(a).
- f) Next, for all radiated emissions measurements above 1GHz, the resolution bandwidth was set to 1MHz. The analyzer was set to linear mode with a 10Hz video bandwidth in order to simulate an average detector and an average reading was taken.

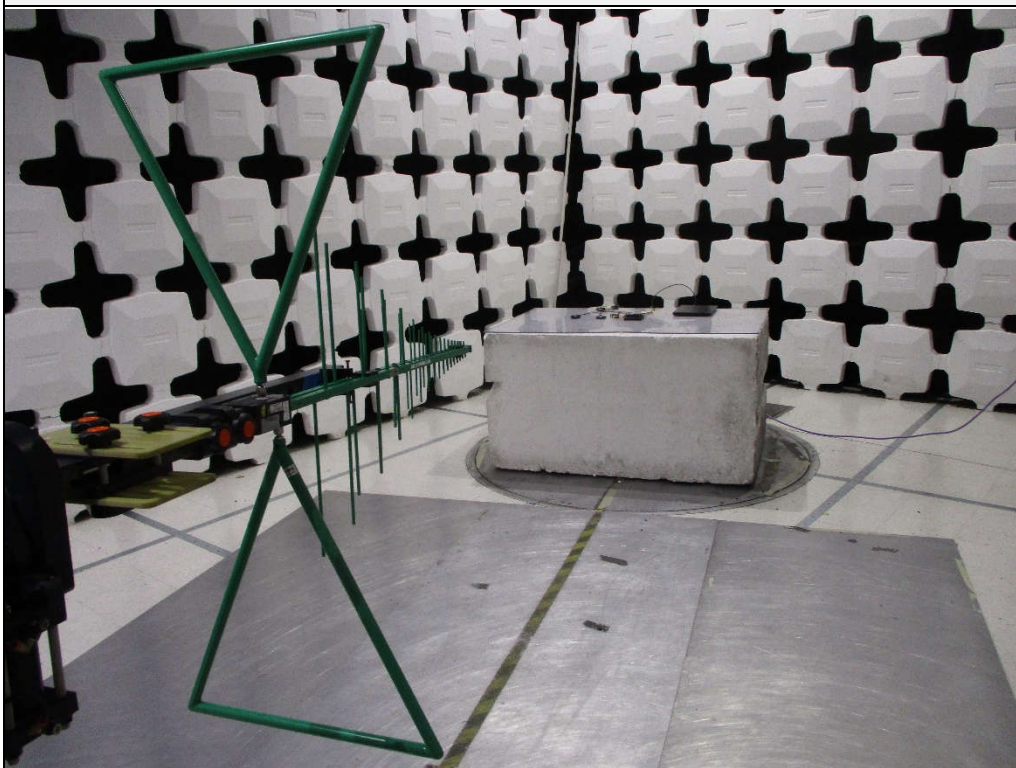
For FCC Part 27:

The EUT was placed on the non-conductive stand and set to transmit. A bilog antenna (double ridged waveguide antenna for all measurements above 1GHz) was placed at a test distance of 3 meters from the EUT. The EUT was maximized for worst case emissions (or maximum output power) at the measuring antenna. The maximum meter reading was recorded. The peak power output was measured for the low, middle, and high channels.

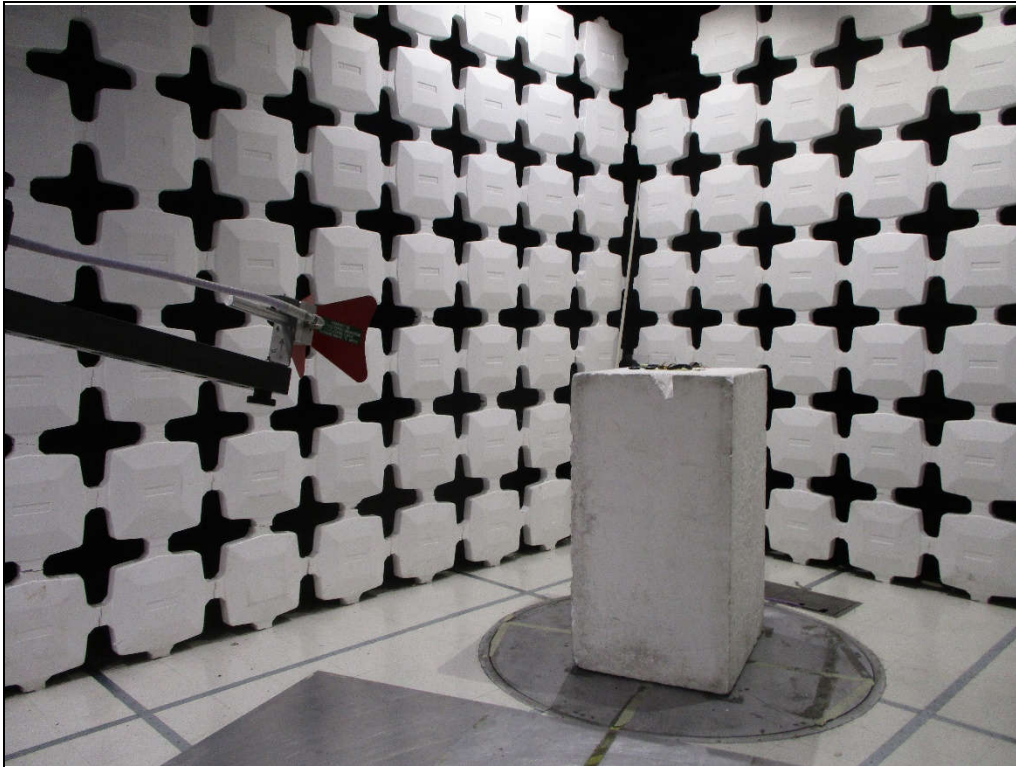
The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power, a dipole antenna (double ridged waveguide antenna for all measurements above 1GHz) was then set in place of the EUT and connected to a calibrated signal generator. The output of the signal generator was adjusted to match the received level at the spectrum analyzer. The signal level was recorded. The reading was then corrected to compensate for cable loss (and antenna gain for all measurements above 1GHz), as required. The peak power output was calculated for low, middle, and high hopping frequencies.



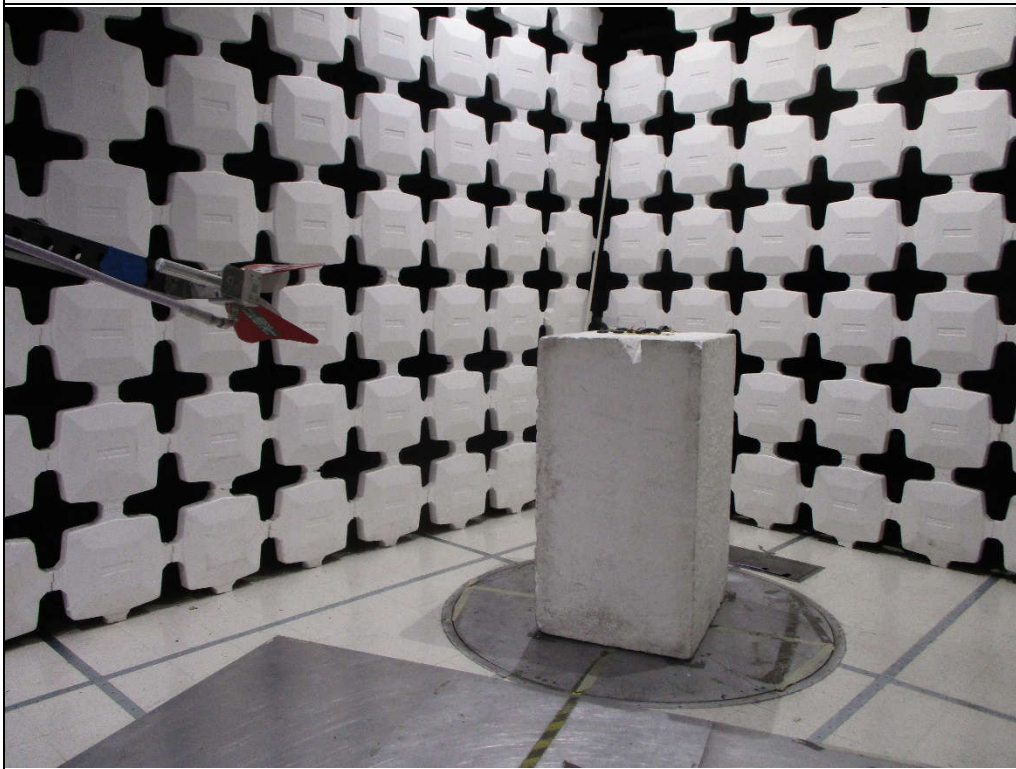
Test Setup for Spurious Emissions: 30MHz to 1GHz, Horizontal Polarization



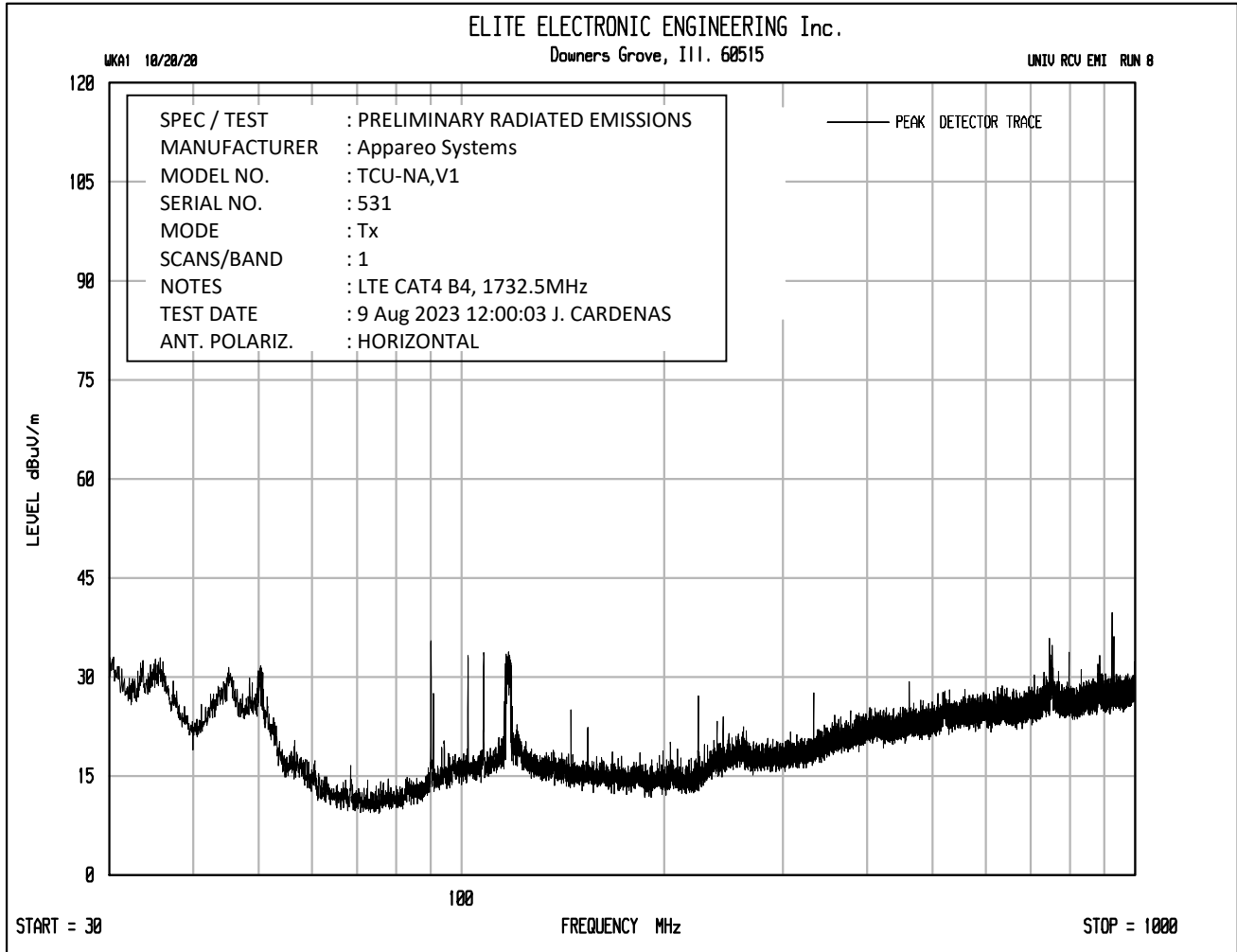
Test Setup for Spurious Emissions: 30MHz to 1GHz, Vertical Polarization

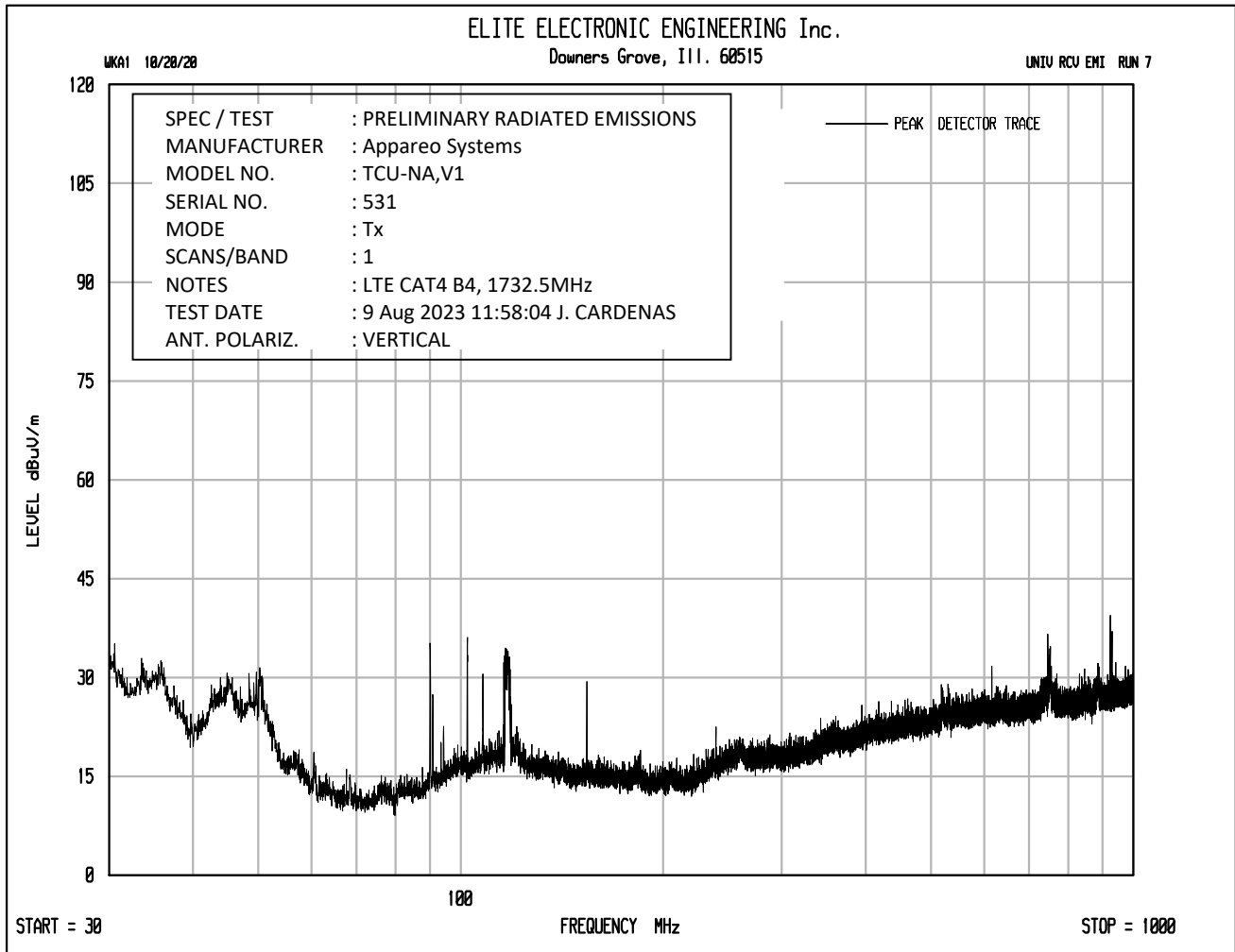


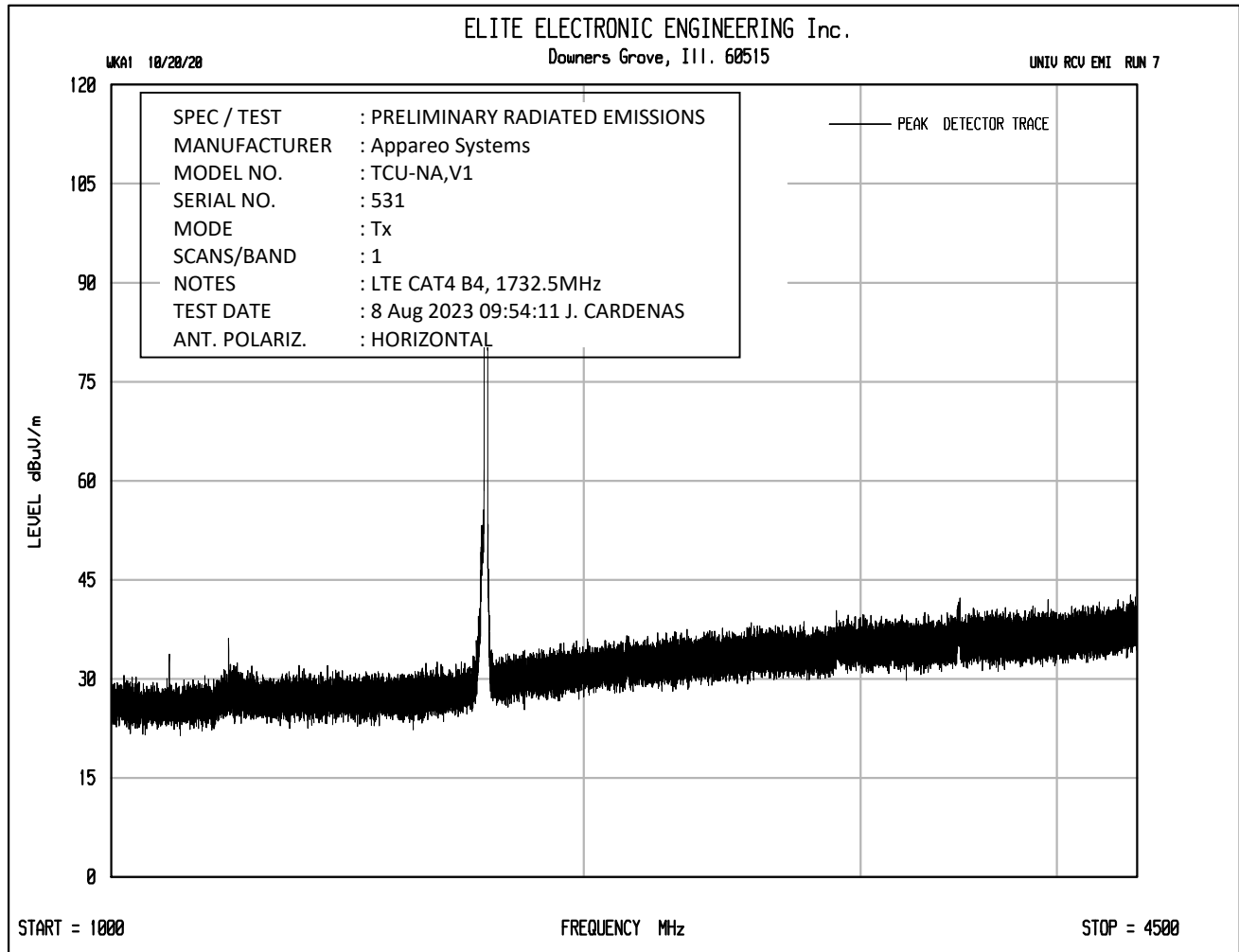
Test Setup for Spurious Emissions: Above 1GHz, Horizontal Polarization

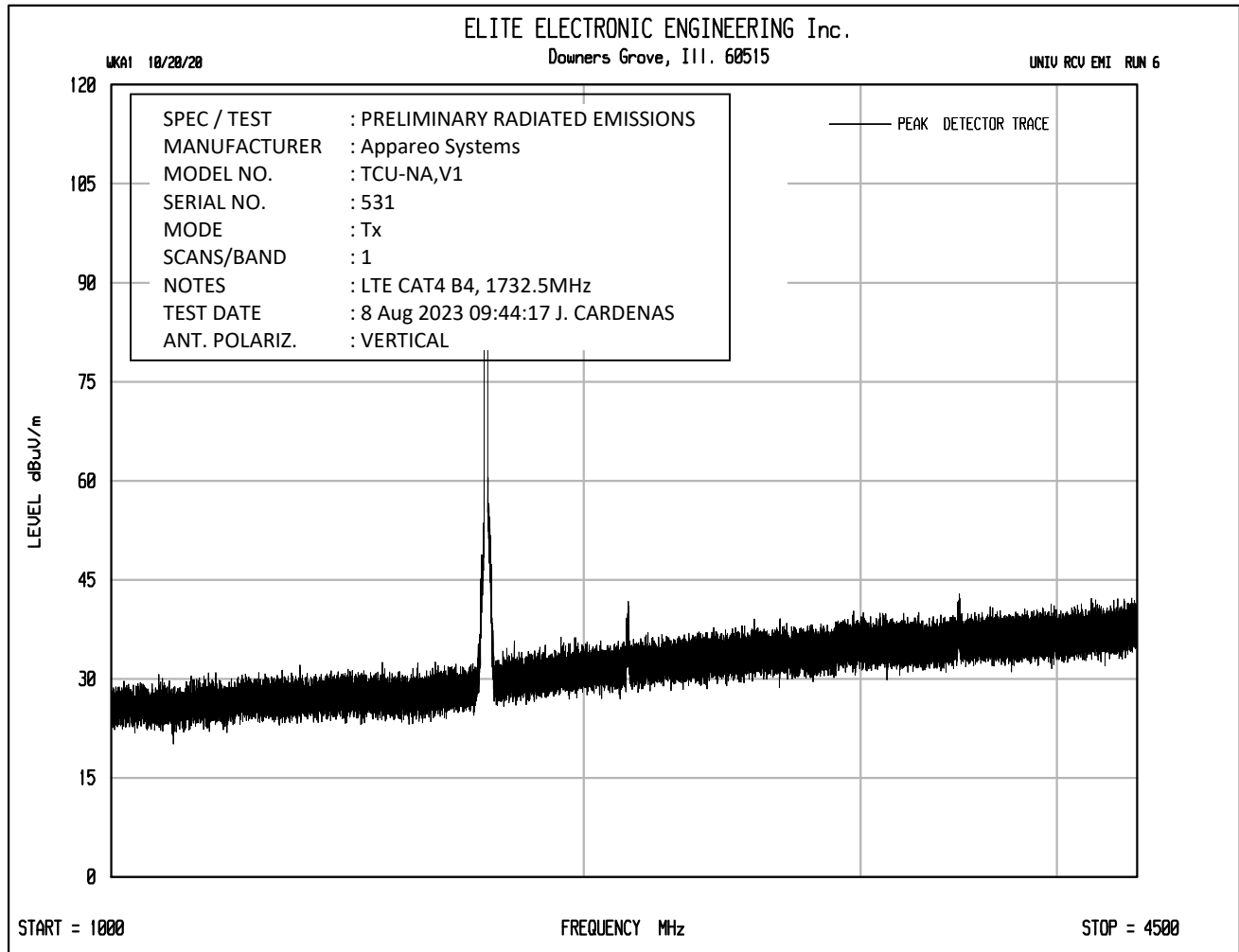


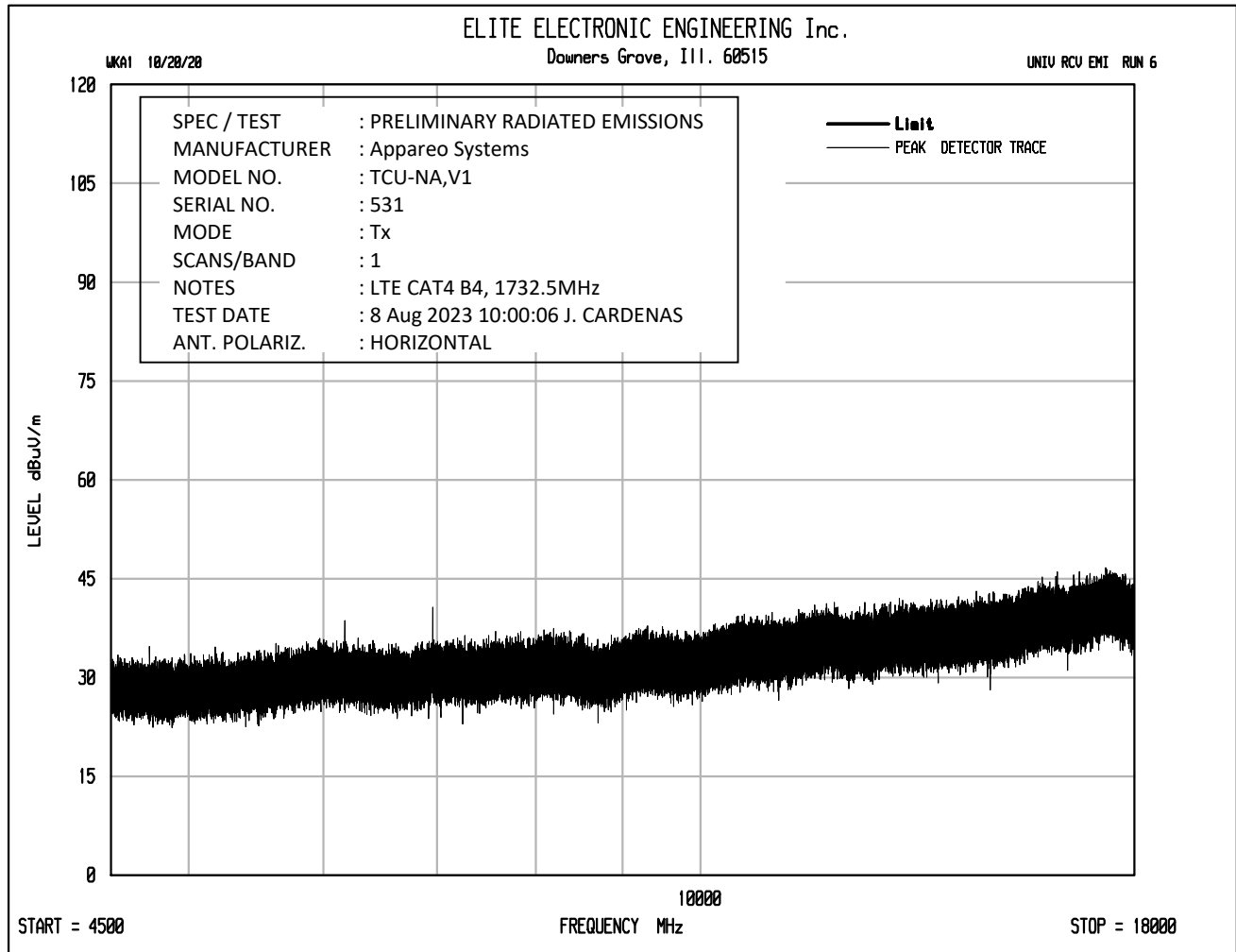
Test Setup for Spurious Emissions: Above 1GHz, Vertical Polarization

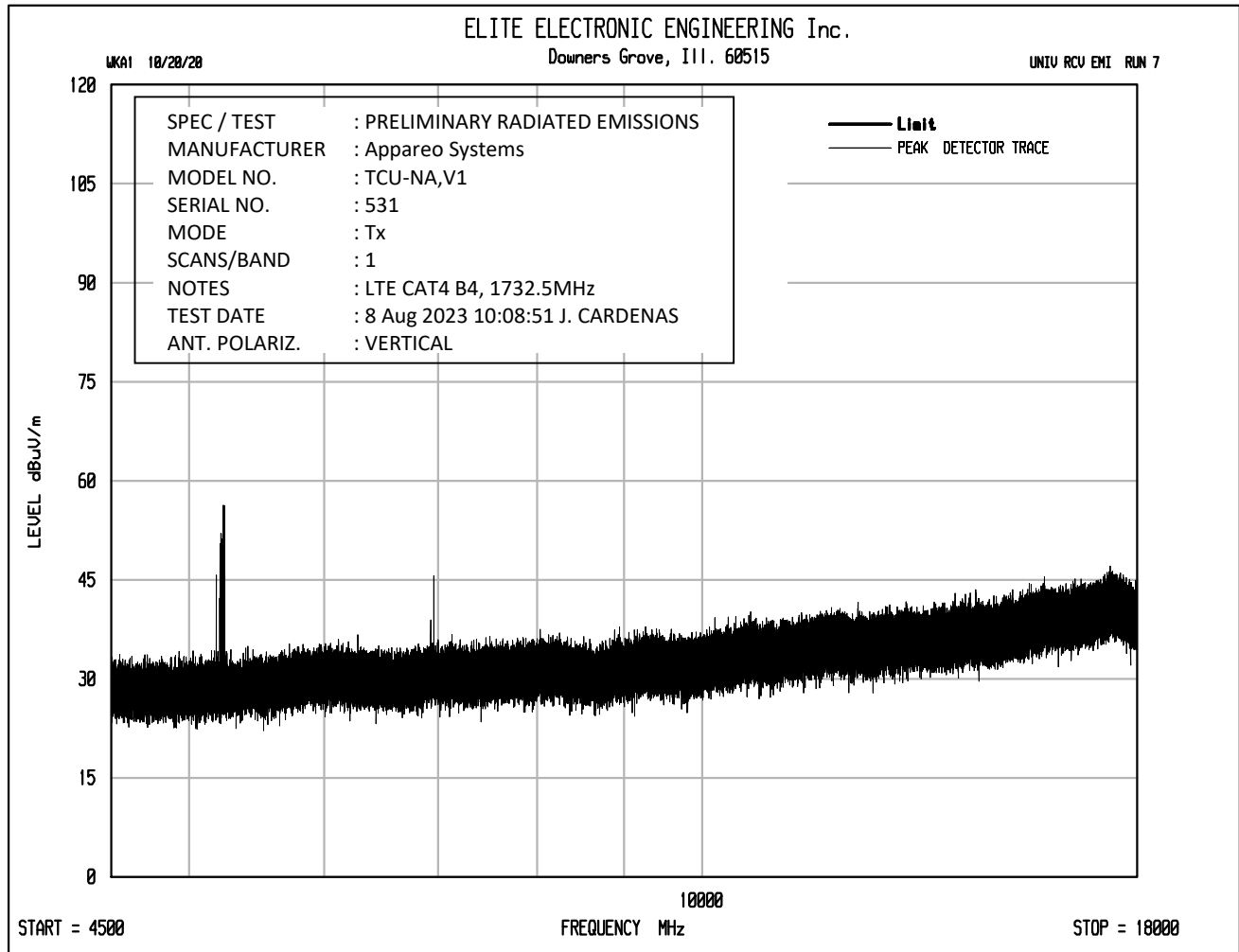






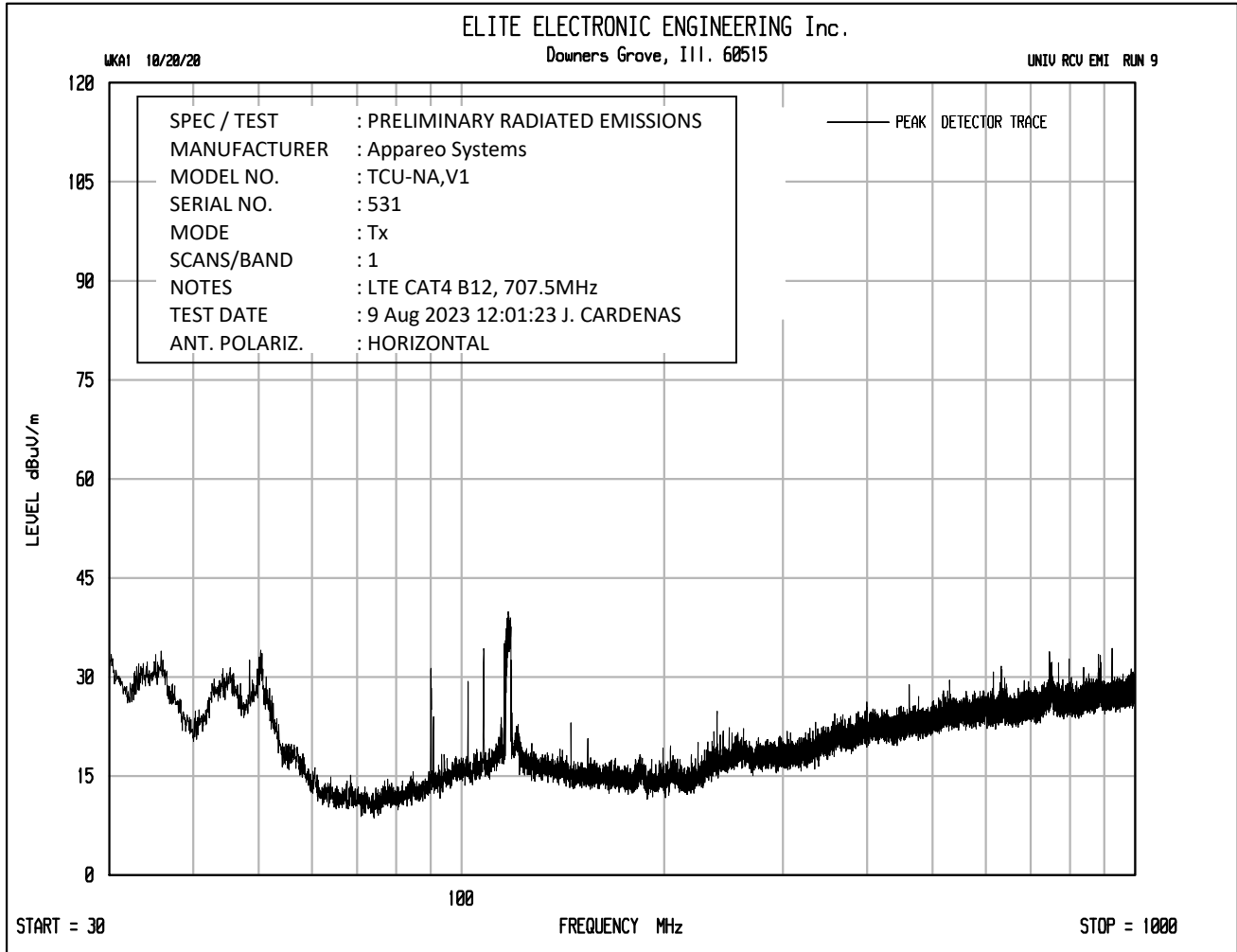


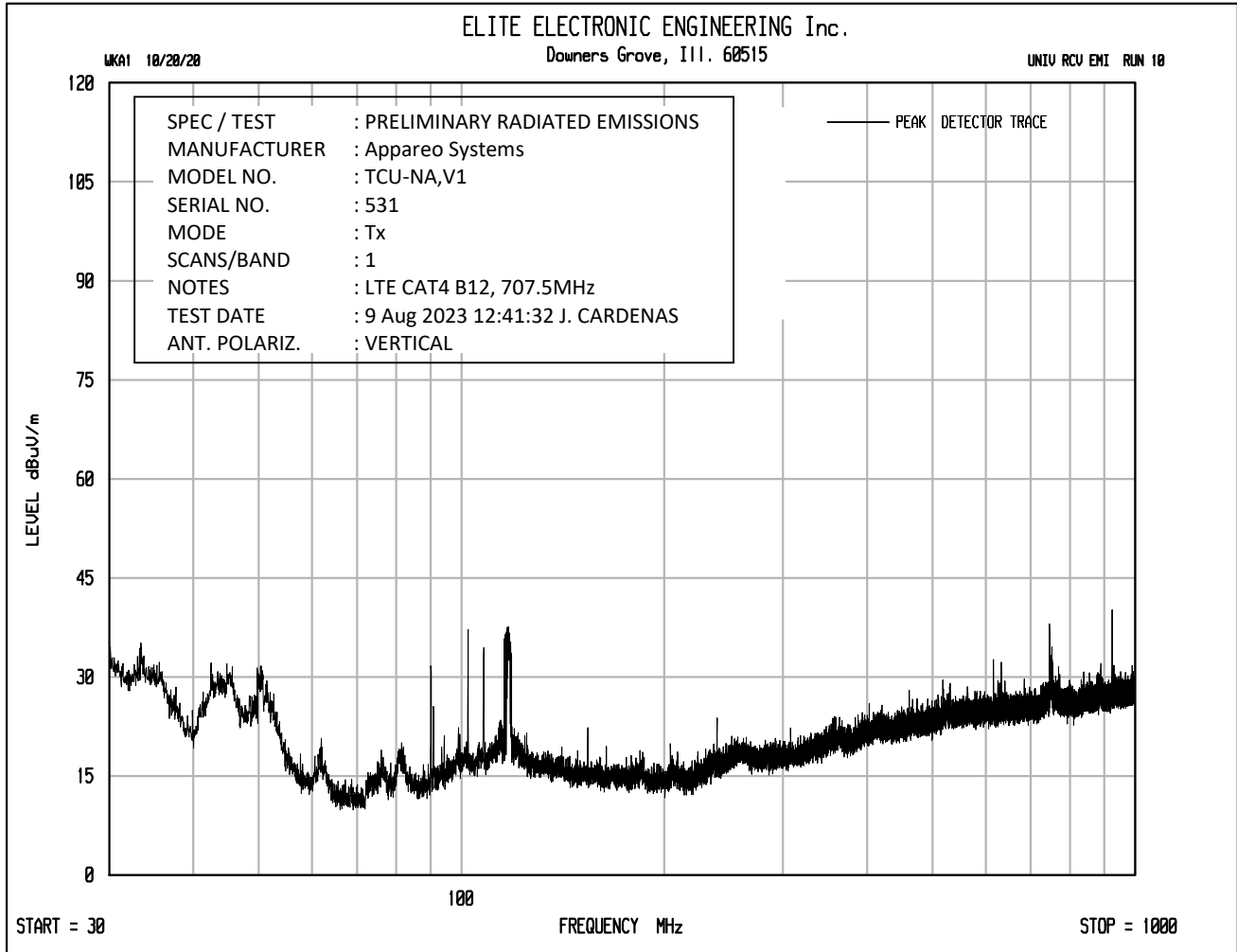


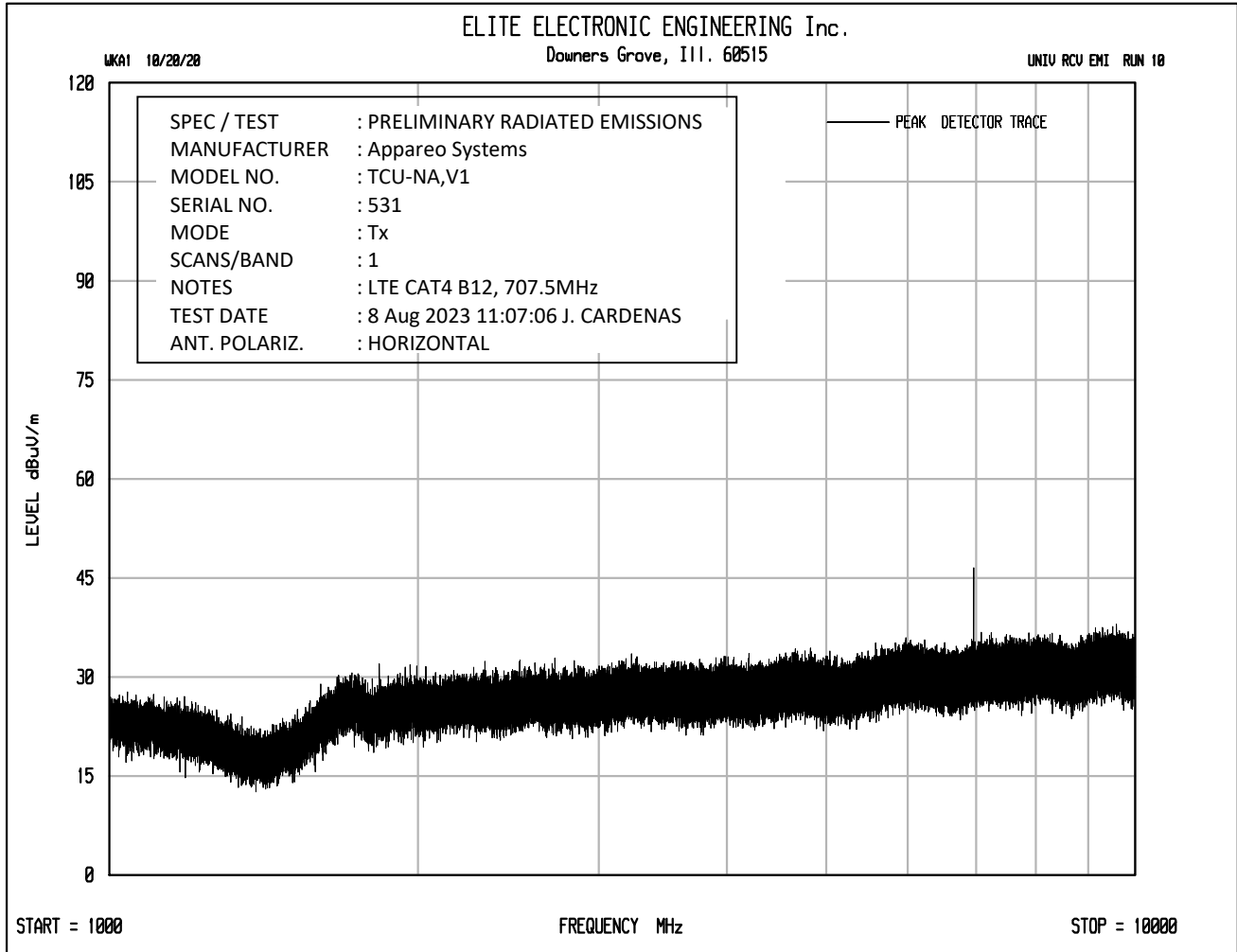


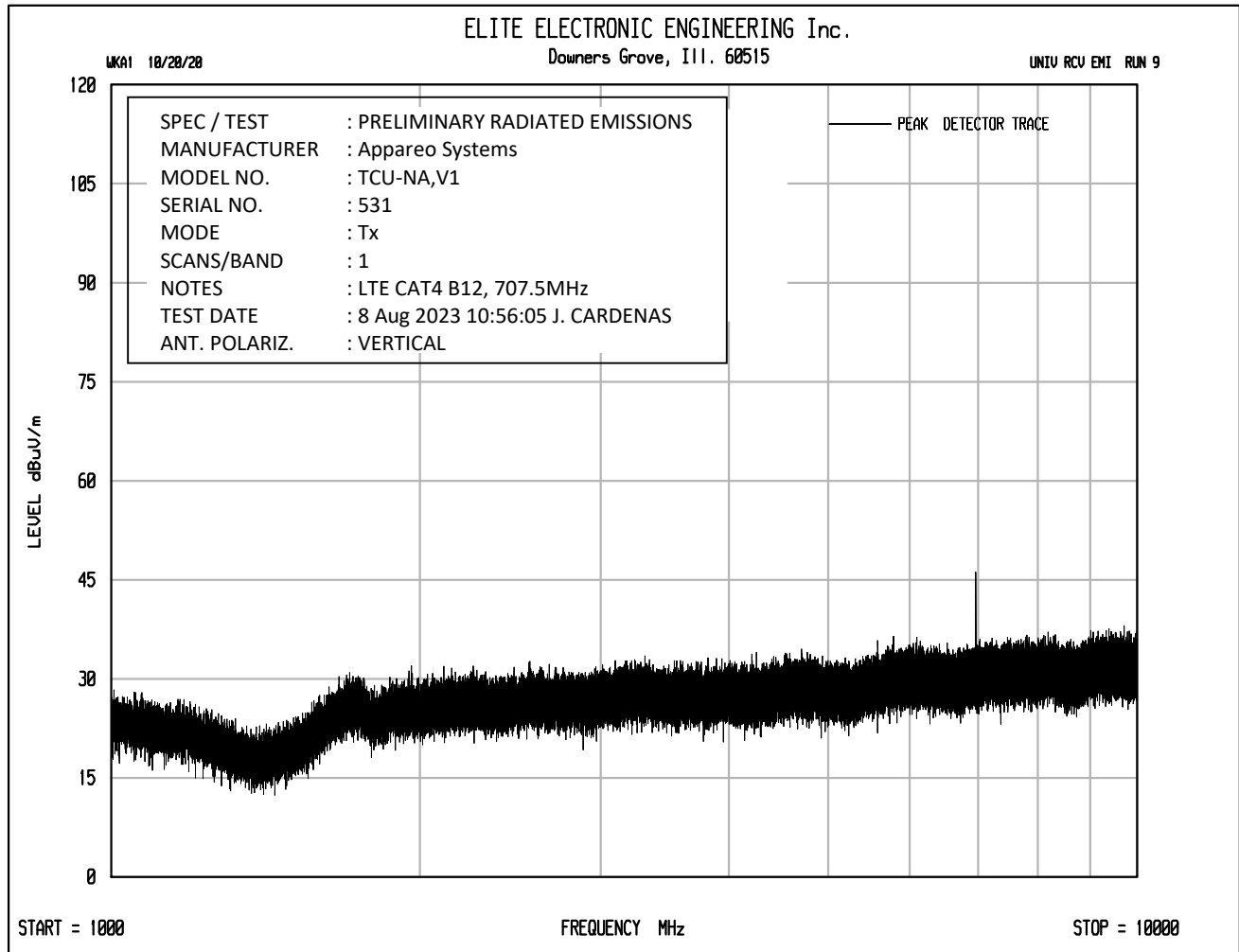
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Tx |
| Frequency Tested | LTE CAT4 B4, 1732.5MHz |
| Notes | None |

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | Calculated Sig. Gen. Reading (dBm) | Equivalent Antenna Gain (dB) | Cable Loss (dB) | ERP (dBm) | Attenuation Below Output Power (dB) | Minimum Attenuation (dB) |
|--------------|------------|----------------------------|---------|---|---------------------------------------|-----------------------|--------------|--|--------------------------------|
| 3465.00 | H | 41.8 | | -23.0 | 4.8 | 4.2 | -22.3 | 46.3 | 37.0 |
| 3465.00 | V | 39.4 | | -23.7 | 4.8 | 4.2 | -23.0 | 47.1 | 37.0 |
| 5197.50 | H | 48.9 | | -49.6 | 5.0 | 5.0 | -49.7 | 73.7 | 37.0 |
| 5197.50 | V | 52.3 | | -46.3 | 5.0 | 5.0 | -46.4 | 70.4 | 37.0 |
| 6930.00 | H | 50.0 | | -46.3 | 6.8 | 6.0 | -45.4 | 69.4 | 37.0 |
| 6930.00 | V | 51.2 | | -46.0 | 6.8 | 6.0 | -45.1 | 69.2 | 37.0 |
| 8662.50 | H | 48.6 | * | -48.0 | 8.1 | 6.5 | -46.5 | 70.5 | 37.0 |
| 8662.50 | V | 48.5 | * | -48.6 | 8.1 | 6.5 | -47.0 | 71.0 | 37.0 |
| 10395.00 | H | 49.5 | * | -43.8 | 8.2 | 7.2 | -42.8 | 66.8 | 37.0 |
| 10395.00 | V | 49.6 | * | -44.6 | 8.2 | 7.2 | -43.7 | 67.7 | 37.0 |



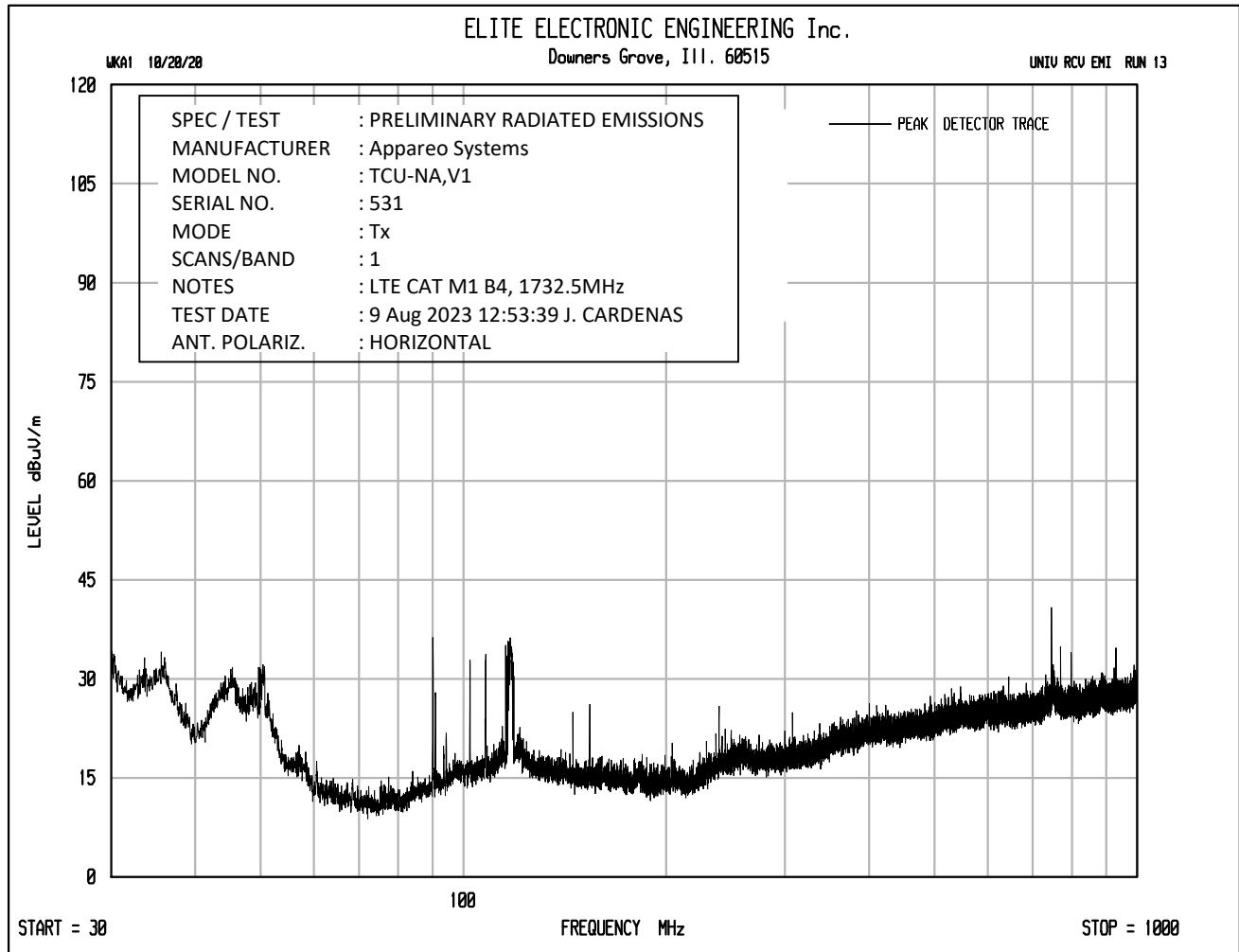


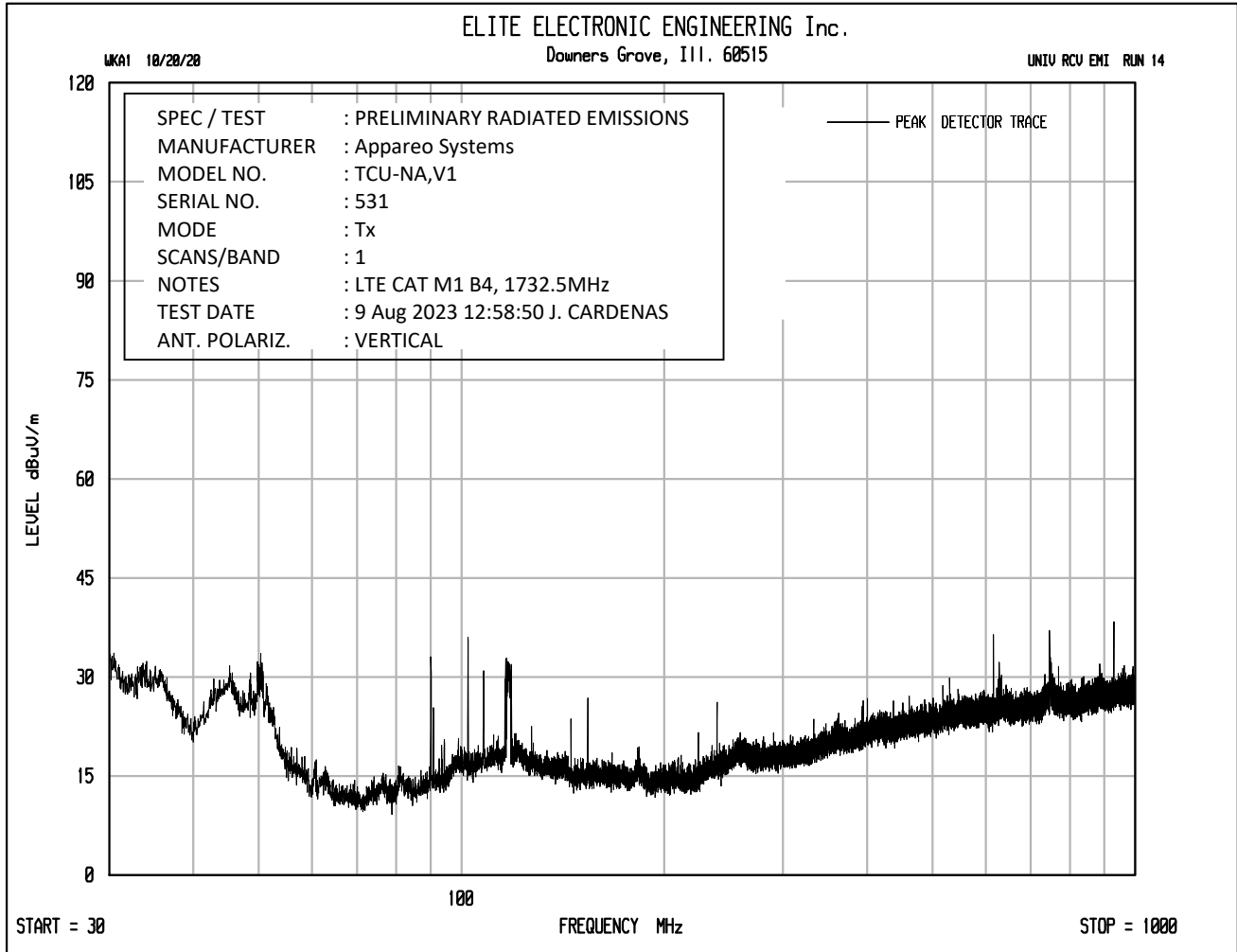


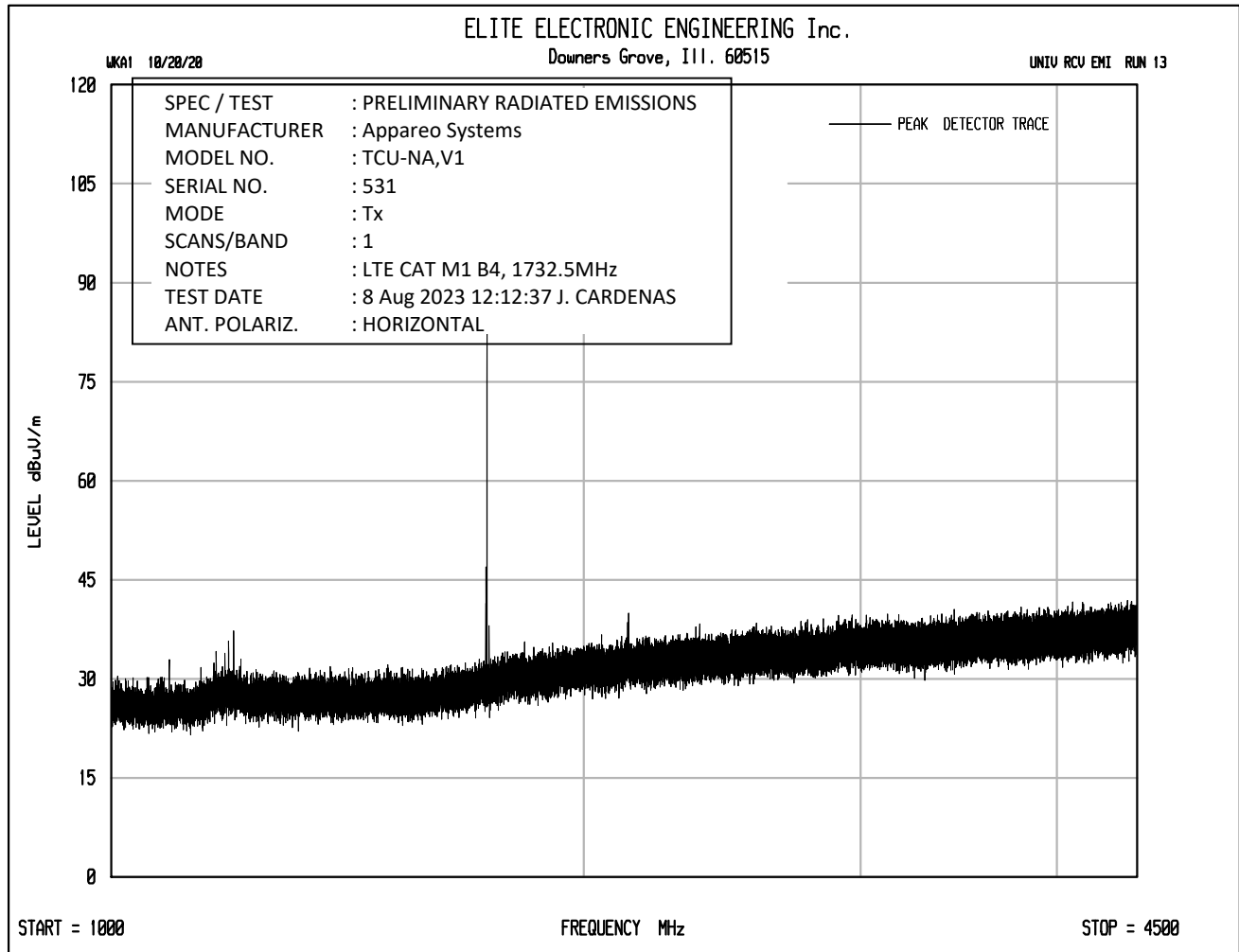


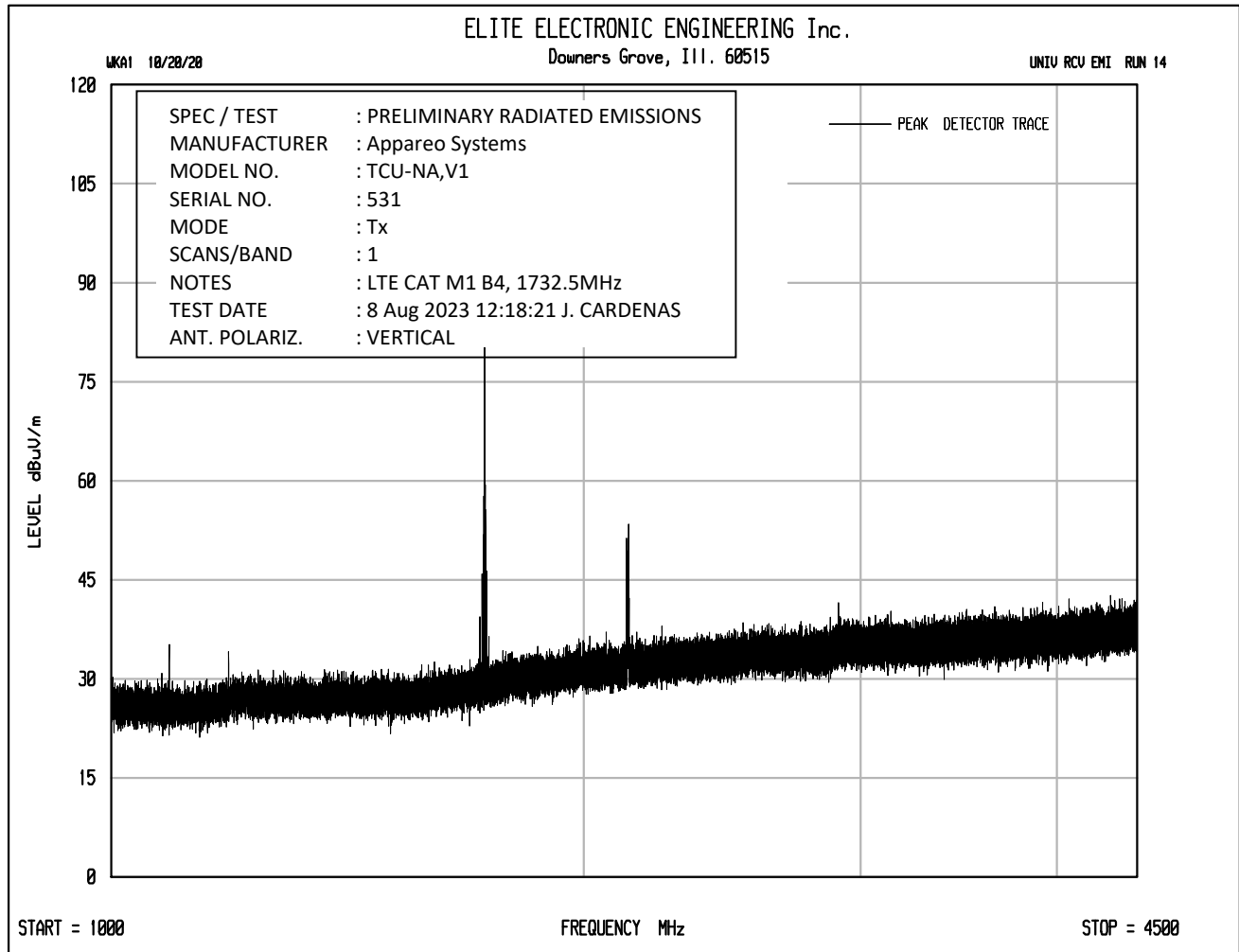
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Test Operations |
| Frequency Tested | LTE CAT4 B12, 707.5MHz |
| Notes | None |

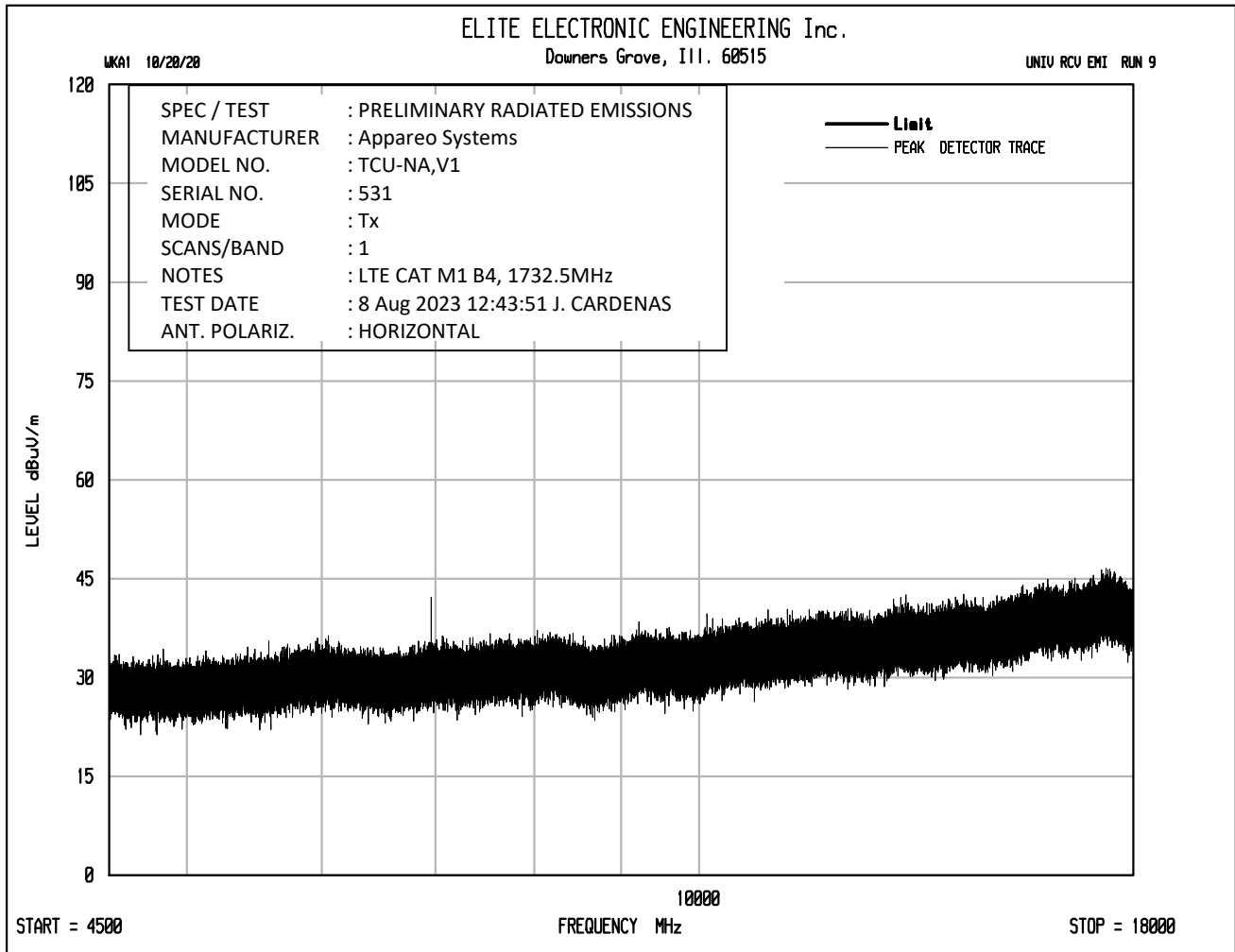
| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | Calculated Sig. Gen. Reading (dBm) | Equivalent Antenna Gain (dB) | Cable Loss (dB) | ERP (dBm) | Attenuation Below Output Power (dB) | Minimum Attenuation (dB) |
|--------------|------------|----------------------------|---------|---|---------------------------------------|-----------------------|--------------|--|--------------------------------|
| 1415.00 | H | 47.6 | * | -62.6 | 1.6 | 2.6 | -63.6 | 87.5 | 36.9 |
| 1415.00 | V | 47.0 | * | -61.1 | 1.6 | 2.6 | -62.1 | 86.0 | 36.9 |
| 2122.50 | H | 50.8 | * | -53.7 | 1.7 | 3.2 | -55.2 | 79.1 | 36.9 |
| 2122.50 | V | 52.8 | * | -50.9 | 1.7 | 3.2 | -52.3 | 76.2 | 36.9 |
| 6959.90 | H | 49.6 | | -46.7 | 7.0 | 6.0 | -45.7 | 69.6 | 36.9 |
| 6959.90 | V | 52.6 | | -44.7 | 7.0 | 6.0 | -43.7 | 67.6 | 36.9 |

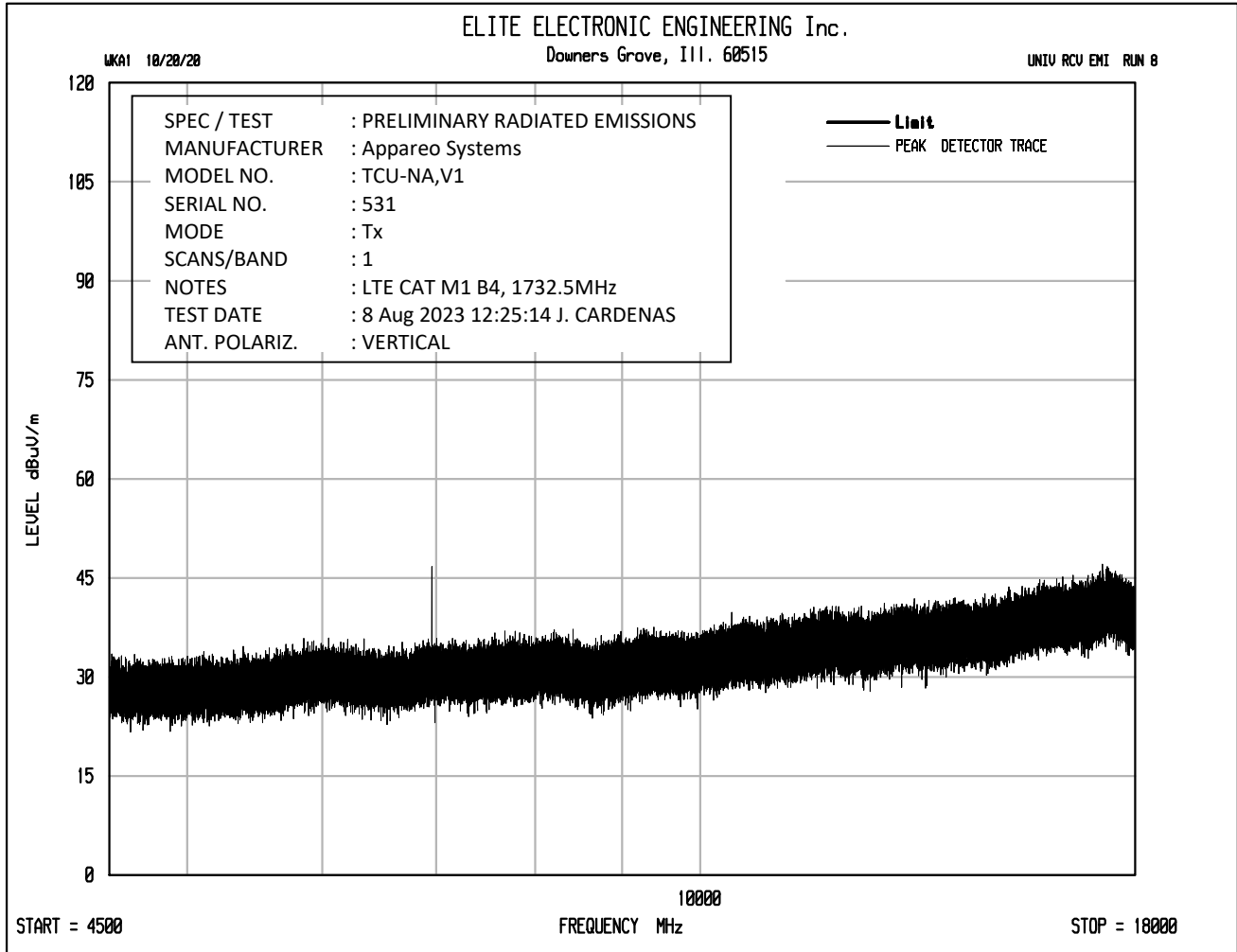






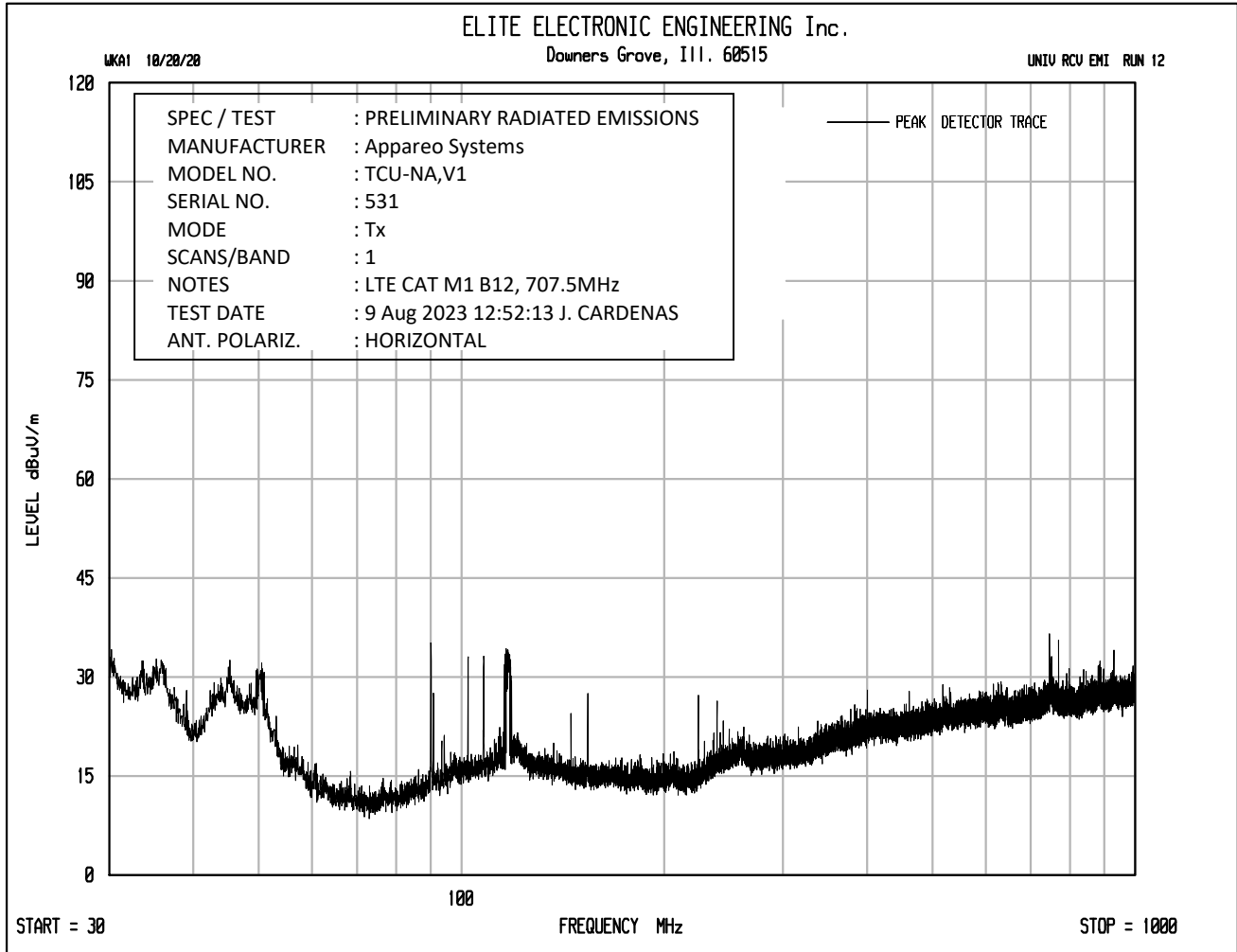


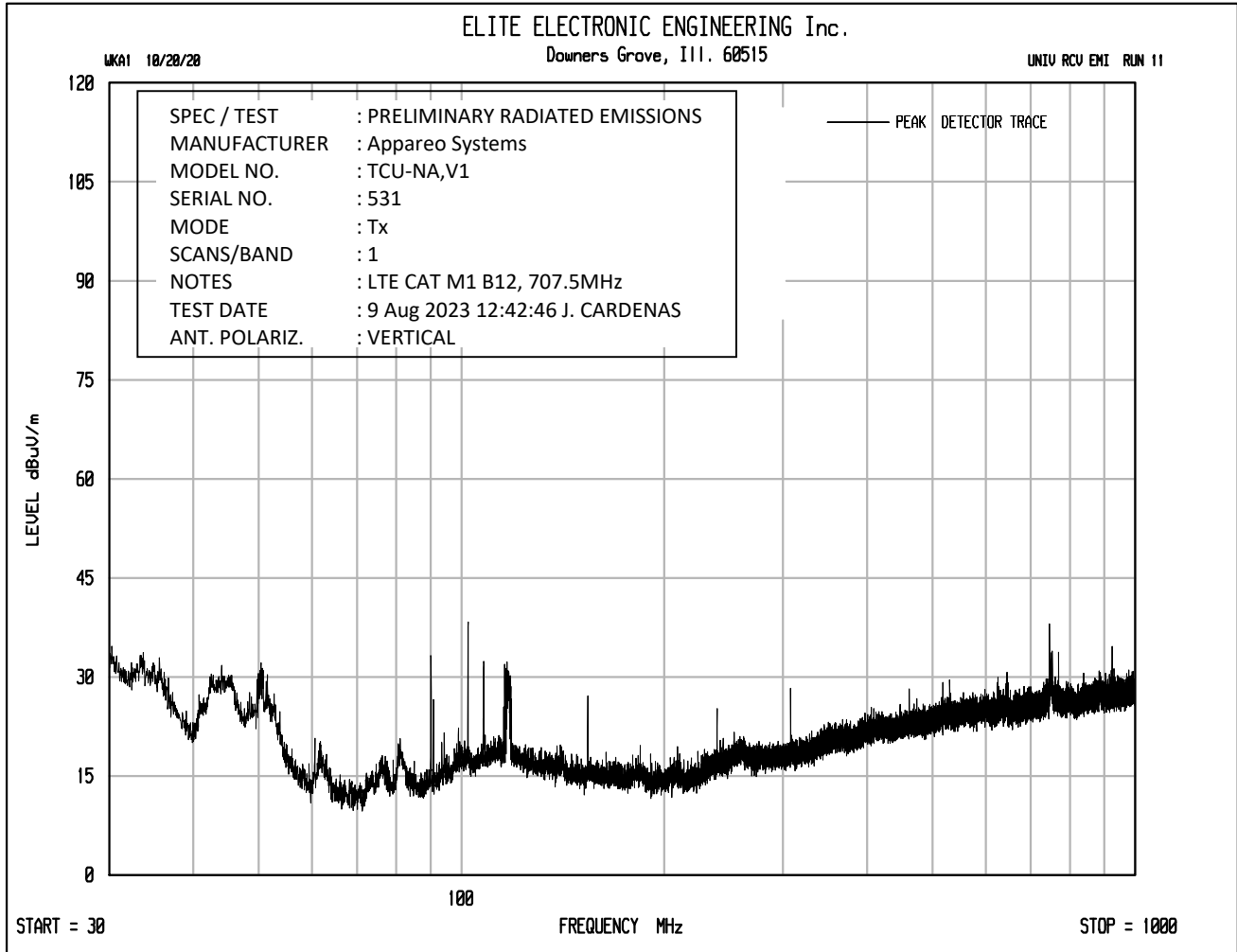


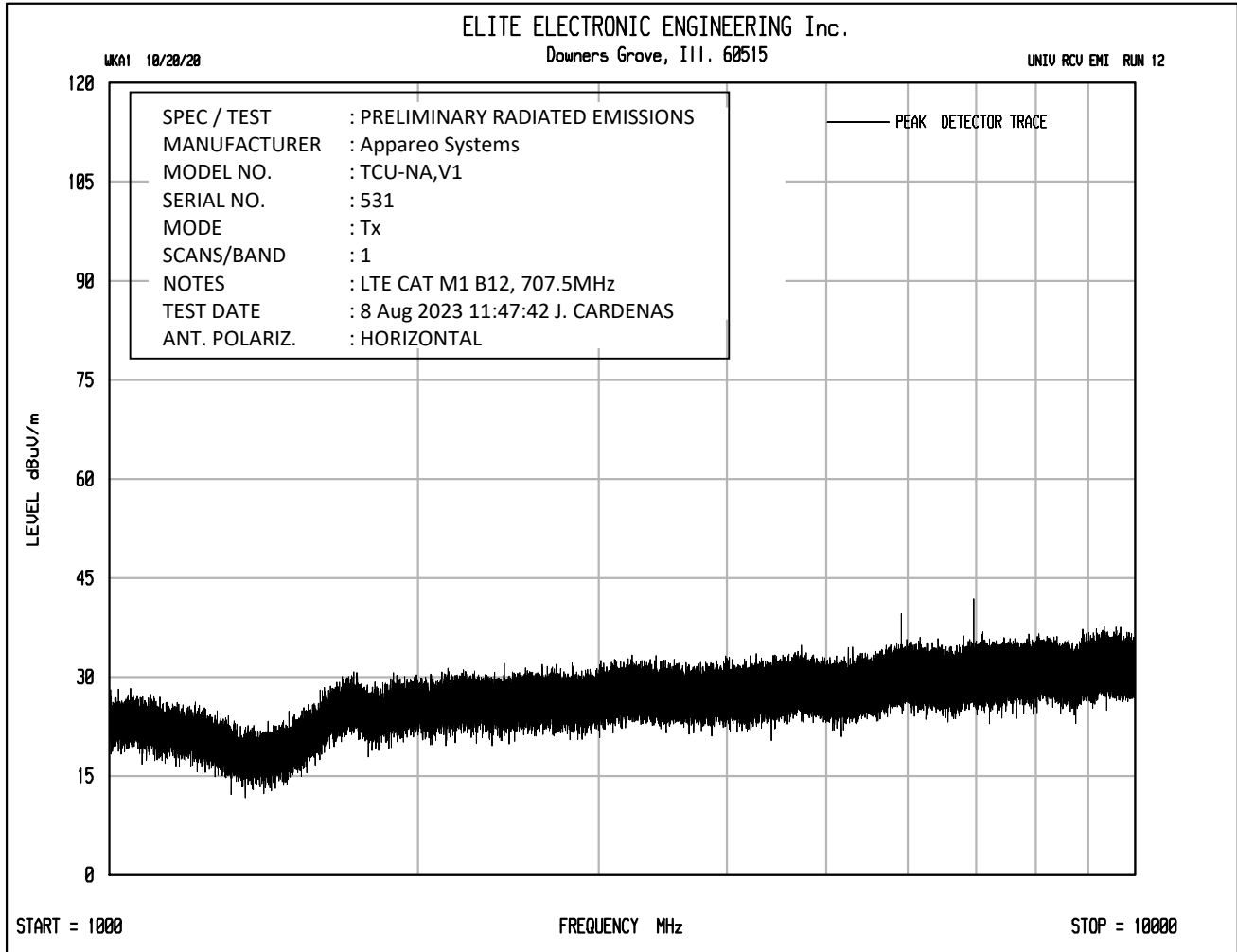


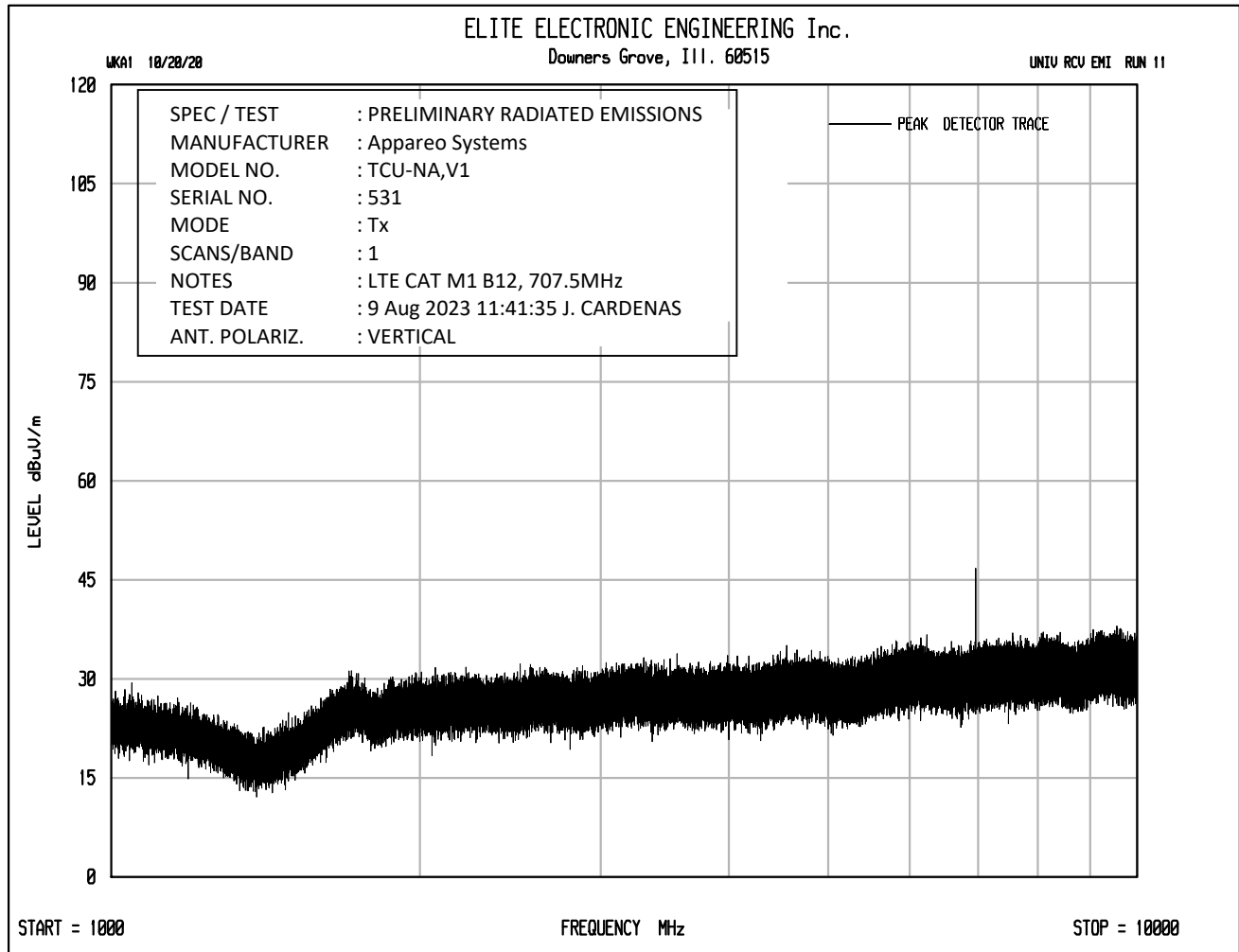
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Test Operations |
| Frequency Tested | LTE CAT M1 B4, 1732.5MHz |
| Notes | None |

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | Calculated Sig. Gen. Reading (dBm) | Equivalent Antenna Gain (dB) | Cable Loss (dB) | ERP (dBm) | Attenuation Below Output Power (dB) | Minimum Attenuation (dB) |
|--------------|------------|----------------------------|---------|---|---------------------------------------|-----------------------|--------------|--|--------------------------------|
| 3465.00 | H | 32.8 | * | -72.1 | 4.8 | 4.2 | -71.5 | 97.2 | 38.7 |
| 3465.00 | V | 33.3 | * | -69.9 | 4.8 | 4.2 | -69.2 | 94.9 | 38.7 |
| 5197.50 | H | 48.5 | * | -50.0 | 5.0 | 5.0 | -50.1 | 75.8 | 38.7 |
| 5197.50 | V | 48.1 | * | -50.5 | 5.0 | 5.0 | -50.6 | 76.3 | 38.7 |



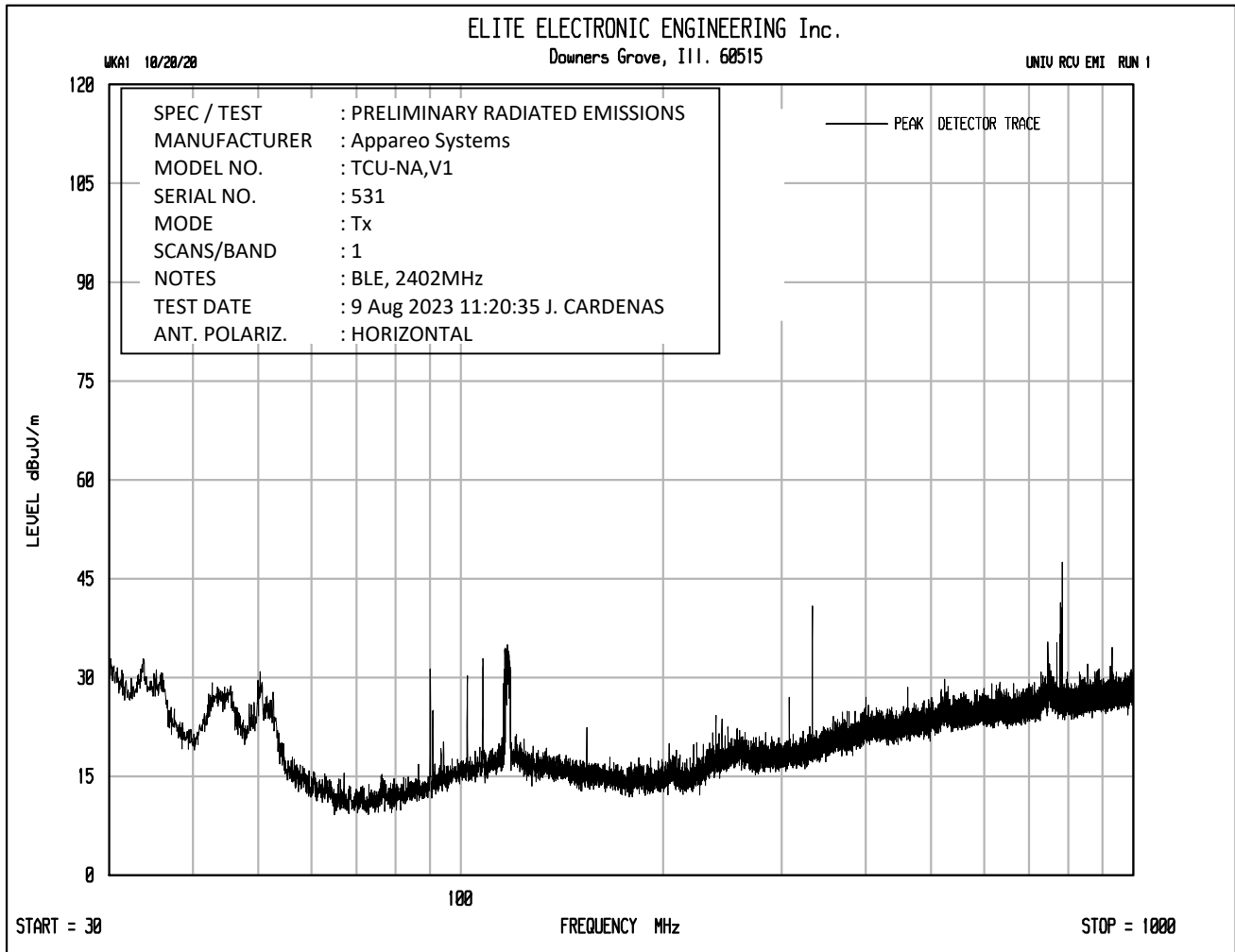


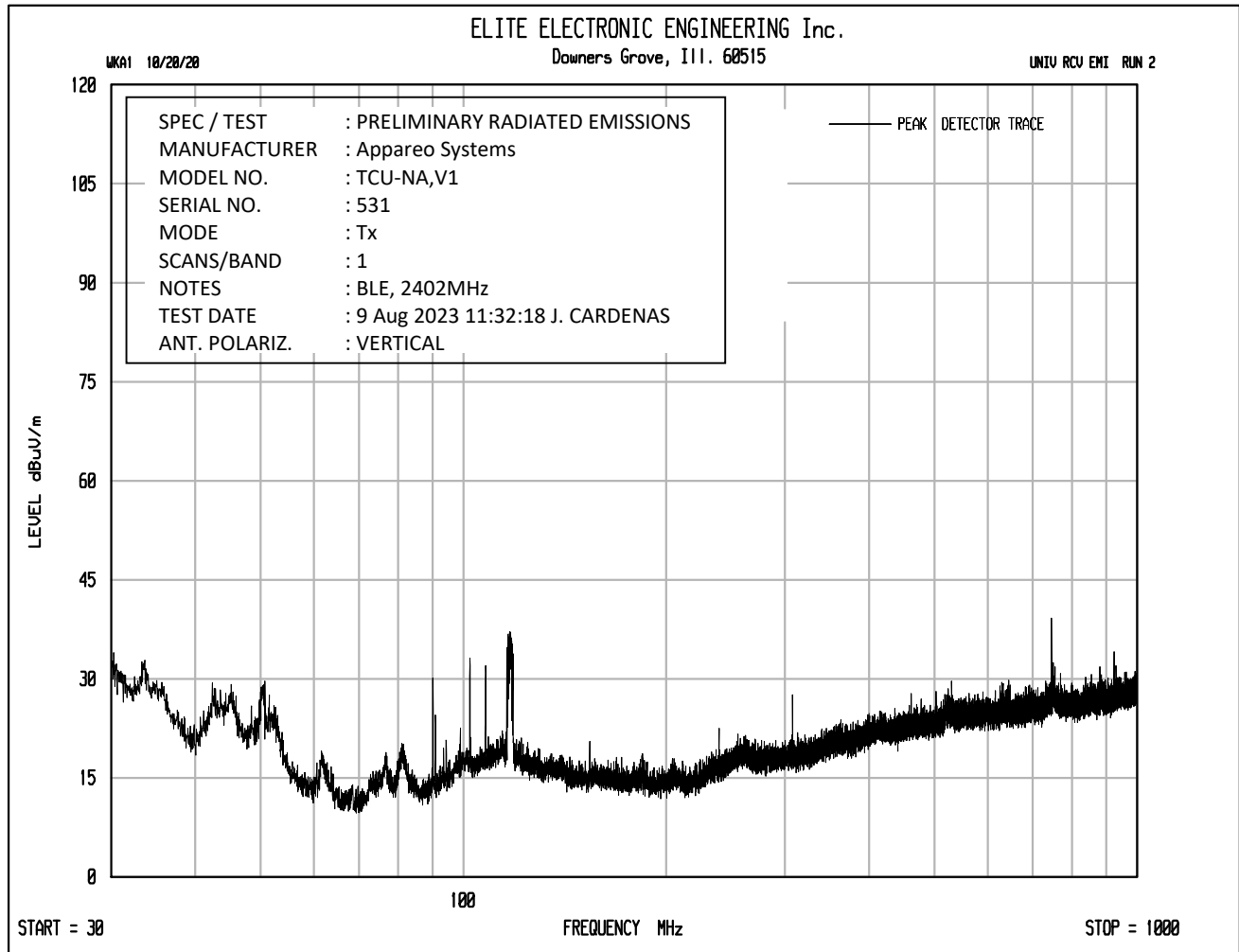


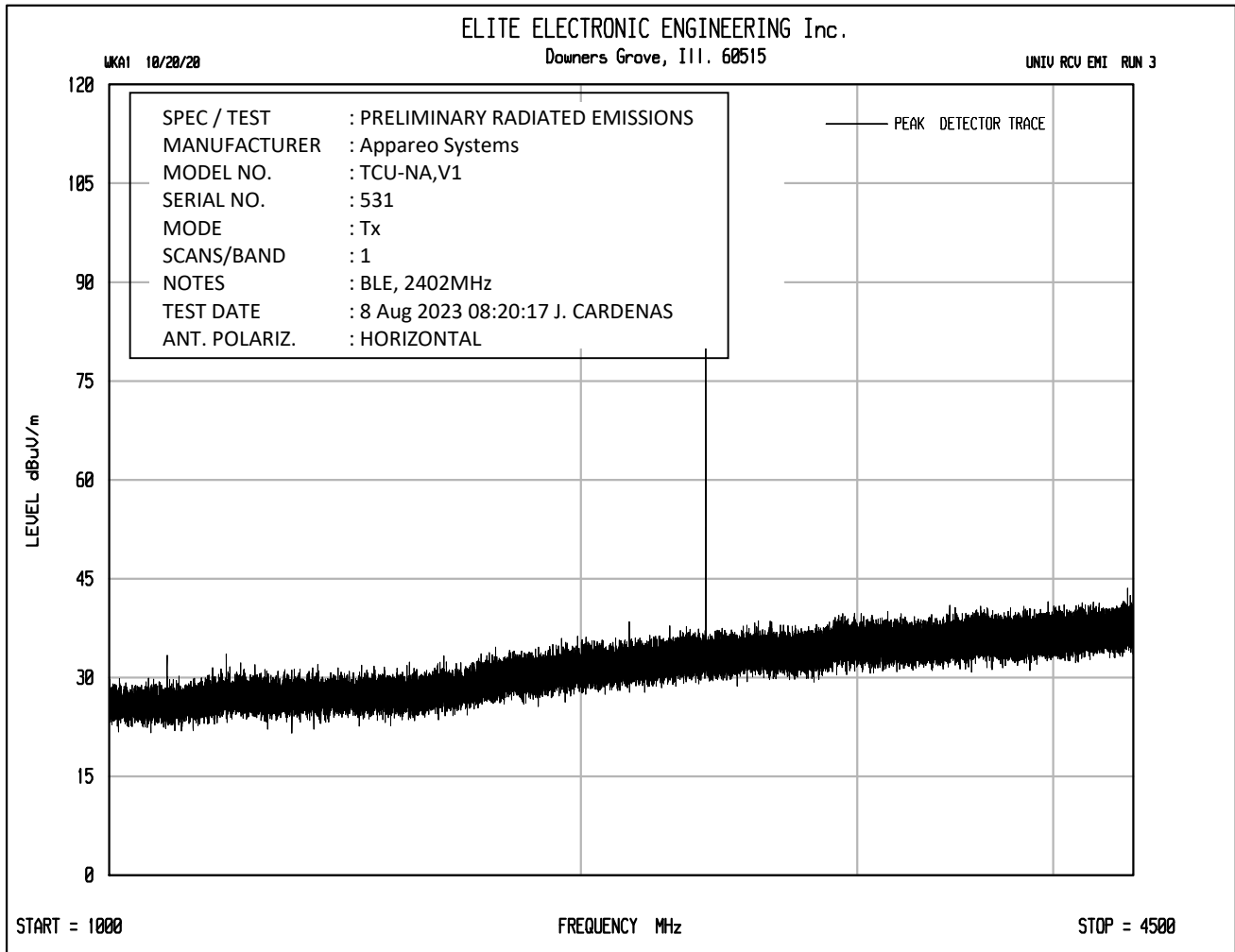


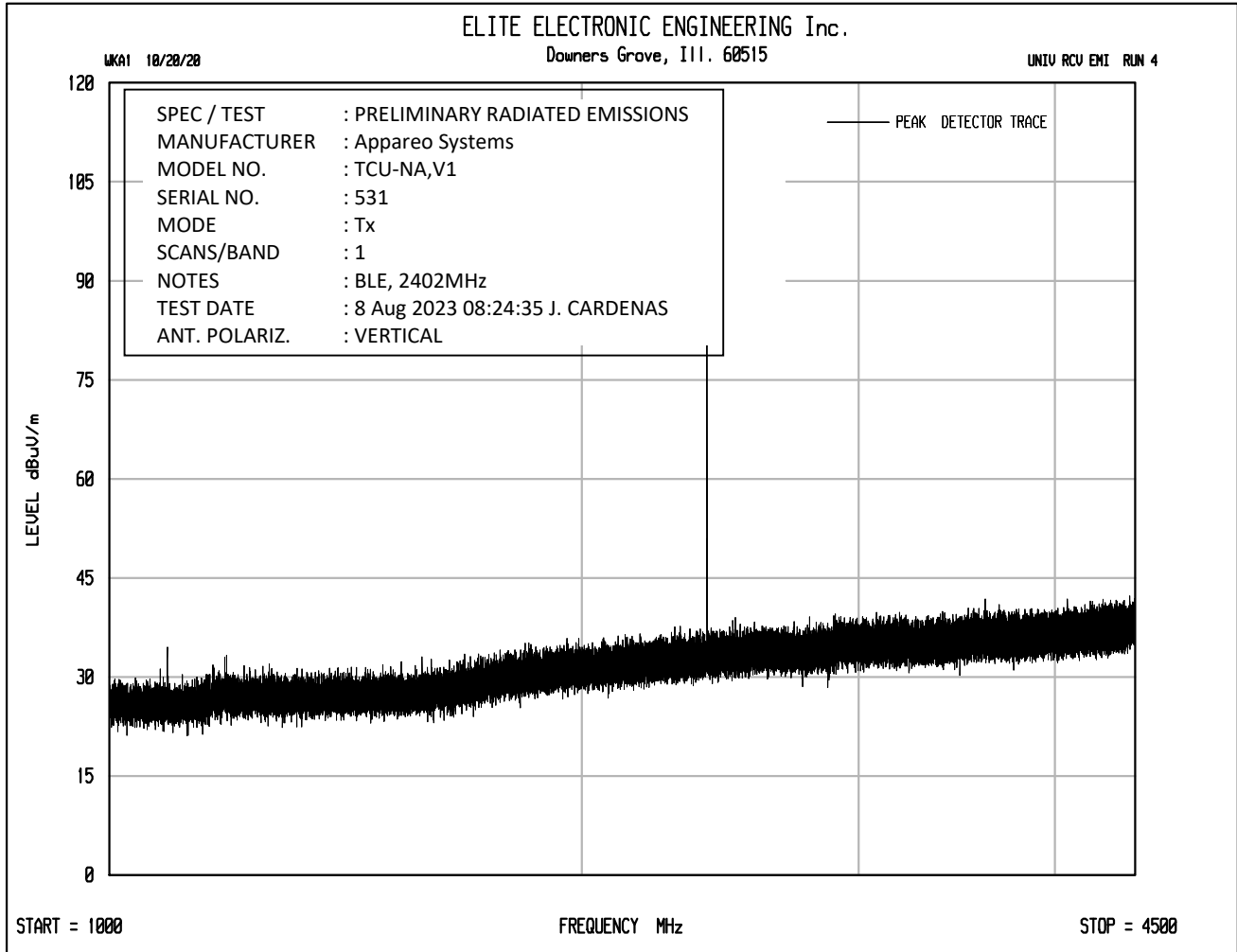
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Test Operations |
| Frequency Tested | LTE CAT M1 B12, 707.5MHz |
| Notes | None |

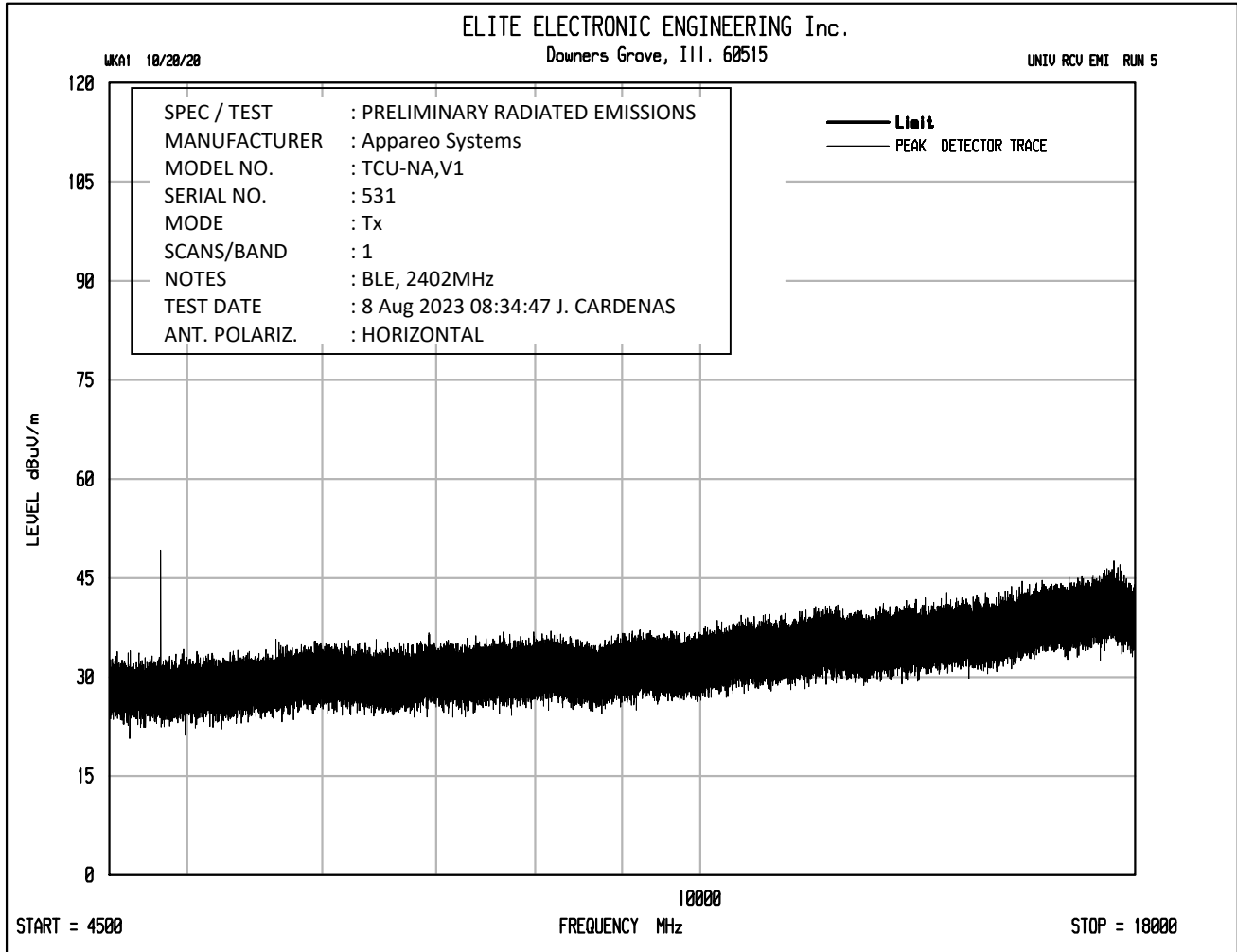
| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | Calculated Sig. Gen. Reading (dBm) | Equivalent Antenna Gain (dB) | Cable Loss (dB) | ERP (dBm) | Attenuation Below Output Power (dB) | Minimum Attenuation (dB) |
|--------------|------------|----------------------------|---------|---|---------------------------------------|-----------------------|--------------|--|--------------------------------|
| 1415.00 | H | 46.4 | * | -63.8 | 1.6 | 2.6 | -64.8 | 90.5 | 38.7 |
| 1415.00 | V | 47.7 | * | -60.4 | 1.6 | 2.6 | -61.4 | 87.1 | 38.7 |
| 2122.50 | H | 49.2 | * | -55.3 | 1.7 | 3.2 | -56.8 | 82.5 | 38.7 |
| 2122.50 | V | 50.3 | * | -53.3 | 1.7 | 3.2 | -54.8 | 80.5 | 38.7 |

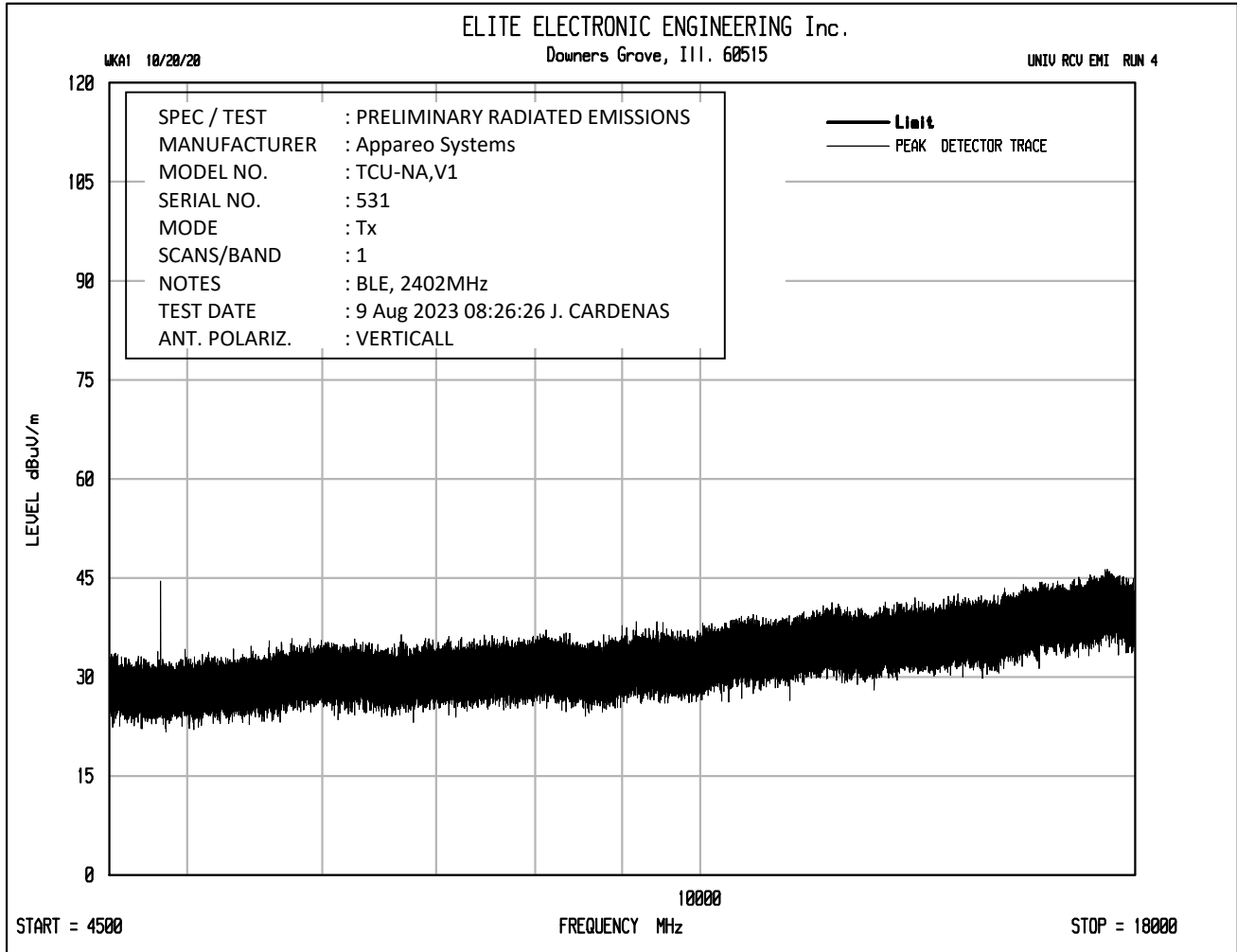










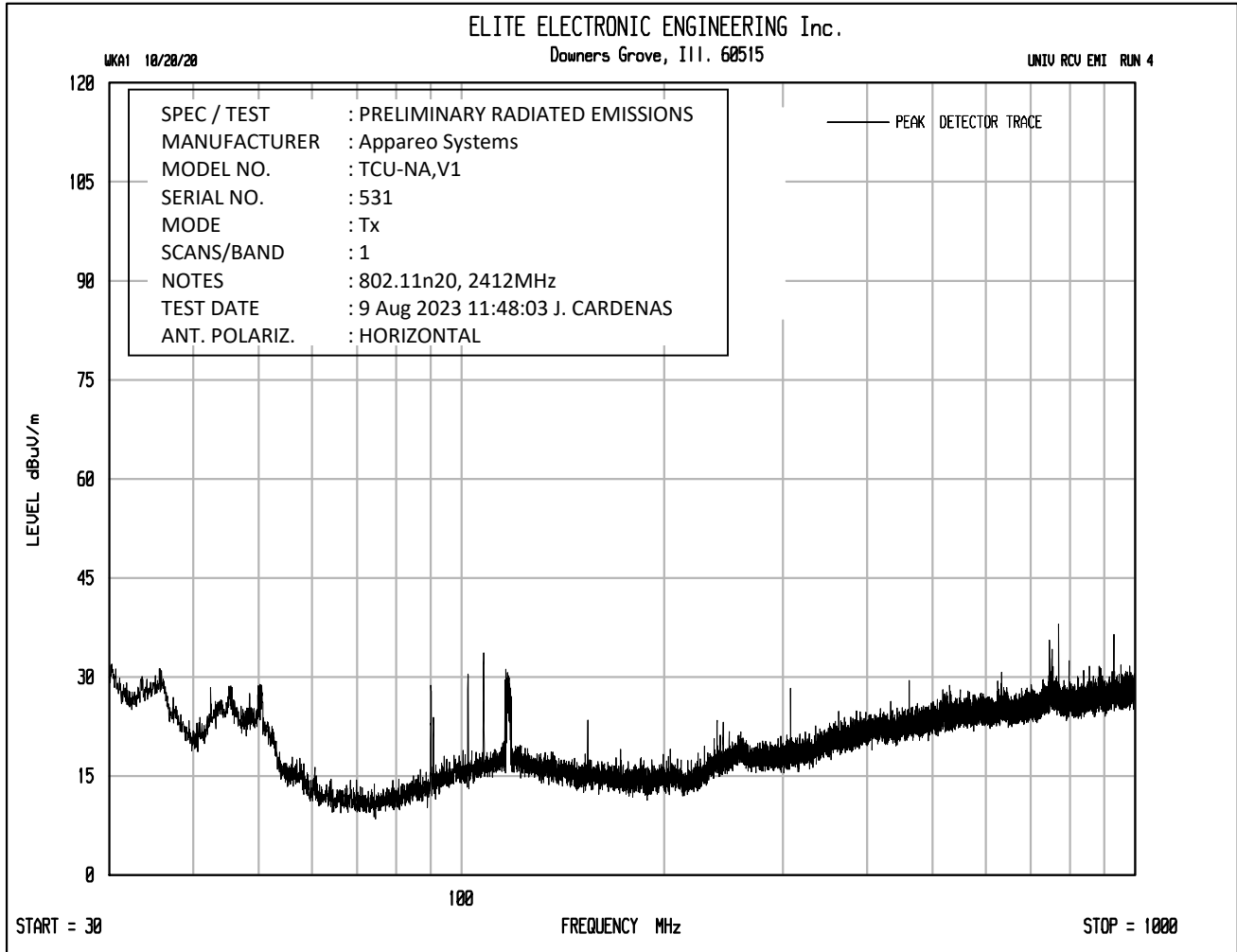


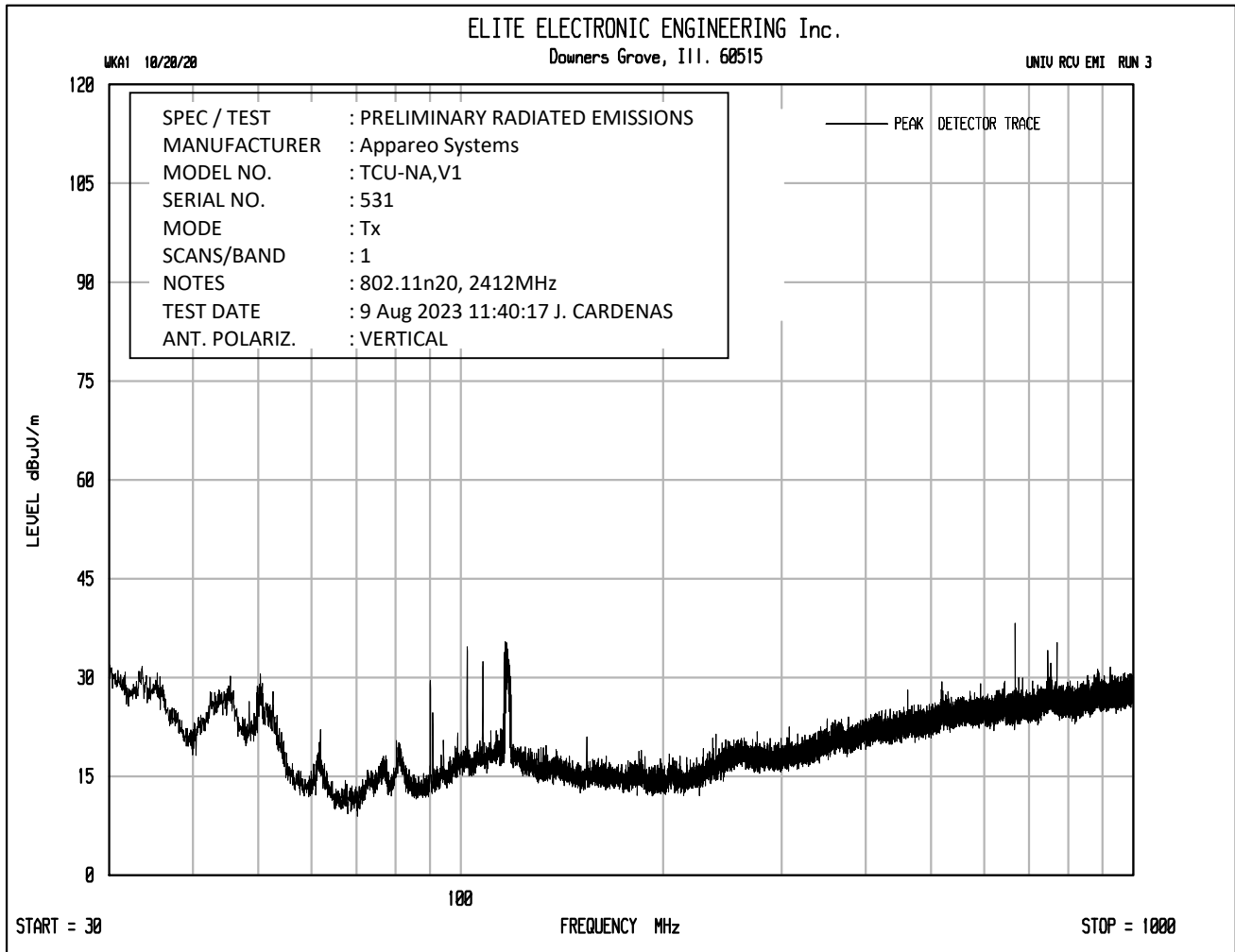
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Test Operations |
| Frequency Tested | BLE, 2402MHz |
| Notes | None |

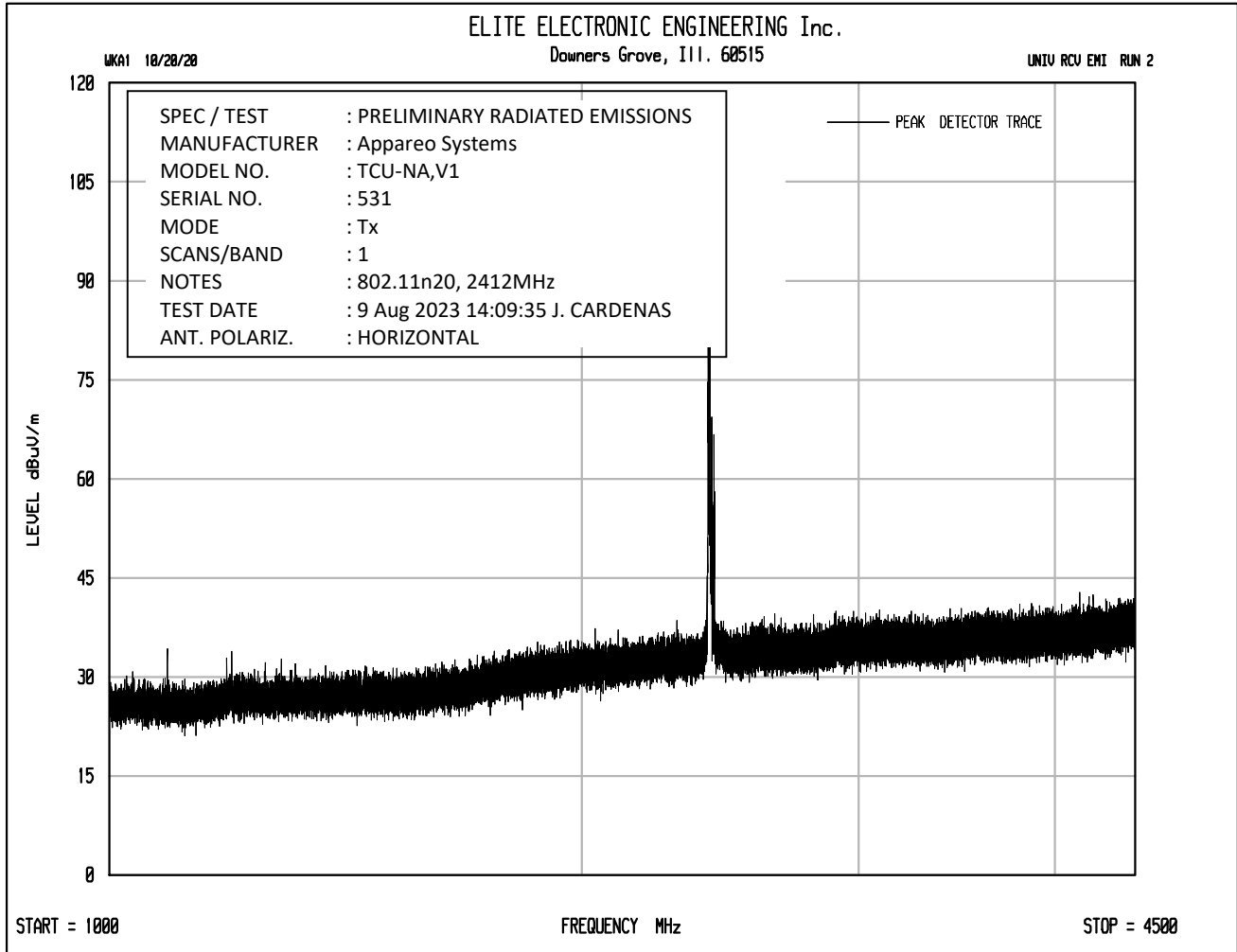
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | Cable Factor (dB) | Antenna Factor (dB/m) | Pre Amp (dB) | Peak Total at 3m (dBμV/m) | Peak Total at 3m (μV/m) | Peak Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|-------------------|-----------------------|--------------|---------------------------|-------------------------|-------------------------|-------------|
| 4804.00 | H | 50.9 | | 3.7 | 34.3 | -39.3 | 49.5 | 299.7 | 5000.0 | -24.4 |
| | V | 49.9 | | 3.7 | 34.3 | -39.3 | 48.5 | 267.1 | 5000.0 | -25.4 |
| 12010.00 | H | 49.9 | * | 6.1 | 38.8 | -39.2 | 55.7 | 607.7 | 5000.0 | -18.3 |
| | V | 48.8 | * | 6.1 | 38.8 | -39.2 | 54.6 | 536.0 | 5000.0 | -19.4 |

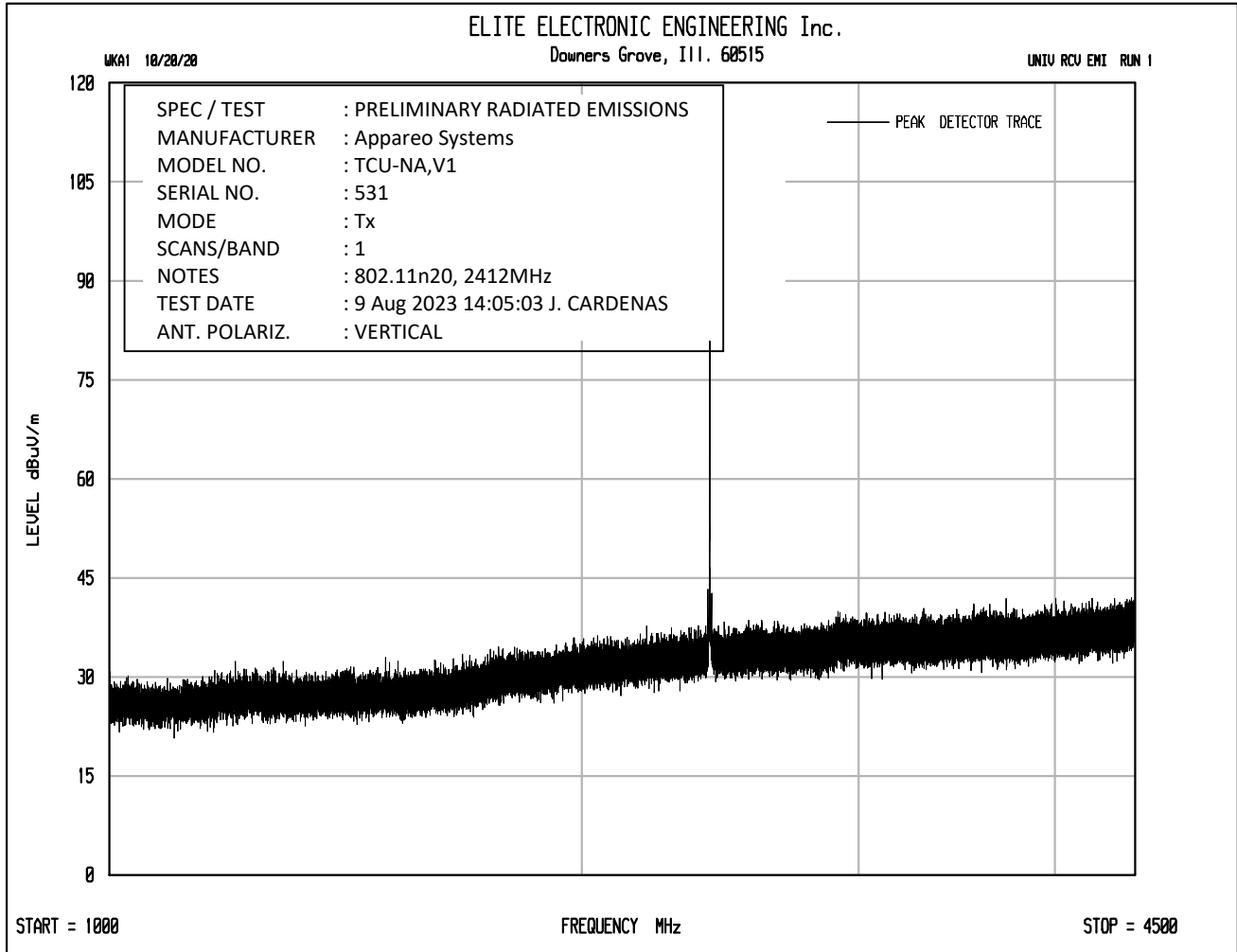
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | CBL Fac (dB) | Ant Fac (dB/m) | Pre Amp (dB) | Duty Cycle Factor (dB) | Average Total at 3m (dBμV/m) | Average Total at 3m (μV/m) | Average Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|--------------|----------------|--------------|------------------------|------------------------------|----------------------------|----------------------------|-------------|
| 4804.00 | H | 37.63 | | 3.7 | 34.3 | -39.3 | 0.0 | 36.3 | 65.4 | 500.0 | -17.7 |
| | V | 35.80 | | 3.7 | 34.3 | -39.3 | 0.0 | 34.5 | 53.0 | 500.0 | -19.5 |
| 12010.00 | H | 35.77 | * | 6.1 | 38.8 | -39.2 | 0.0 | 41.5 | 119.2 | 500.0 | -12.5 |
| | V | 35.67 | * | 6.1 | 38.8 | -39.2 | 0.0 | 41.4 | 117.8 | 500.0 | -12.6 |

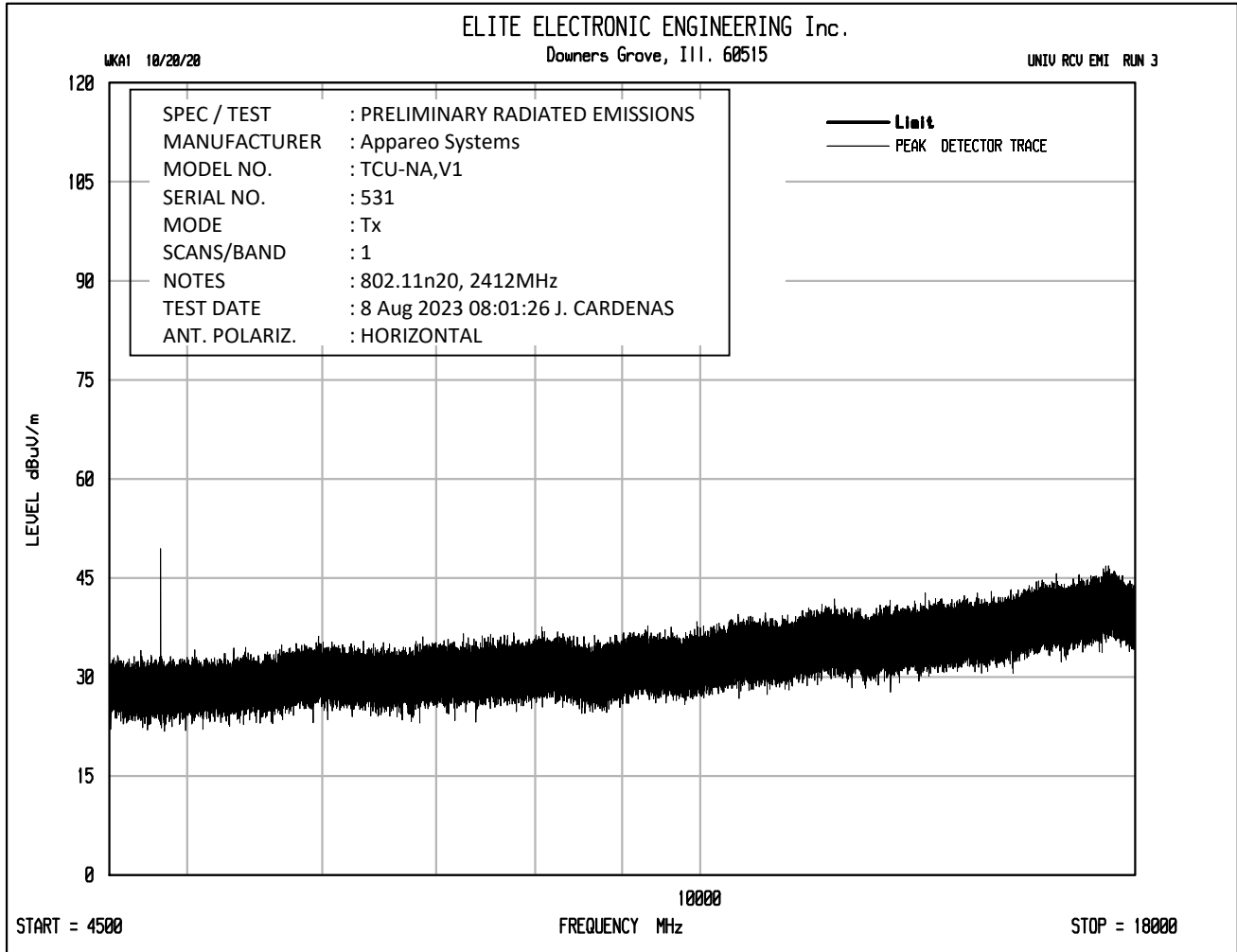
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | Cable Factor (dB) | Antenna Factor (dB/m) | Pre Amp (dB) | Peak Total at 3m (dBμV/m) | Peak Total at 3m (μV/m) | Peak Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|-------------------|-----------------------|--------------|---------------------------|-------------------------|-------------------------|-------------|
| 2402.00 | H | 51.23 | | 2.6 | 32.6 | 0.0 | 86.4 | 20931.7 | NA | NA |
| | V | 51.31 | | 2.6 | 32.6 | 0.0 | 86.5 | 21125.3 | NA | NA |
| 7206.00 | H | 37.58 | * | 4.6 | 36.3 | -39.4 | 39.1 | 90.0 | 2112.5 | -27.4 |
| | V | 39.17 | * | 4.6 | 36.3 | -39.4 | 40.7 | 108.1 | 2112.5 | -25.8 |
| 9608.00 | H | 37.82 | * | 5.2 | 37.1 | -39.3 | 40.9 | 110.5 | 2112.5 | -25.6 |
| | V | 37.86 | * | 5.2 | 37.1 | -39.3 | 40.9 | 111.0 | 2112.5 | -25.6 |

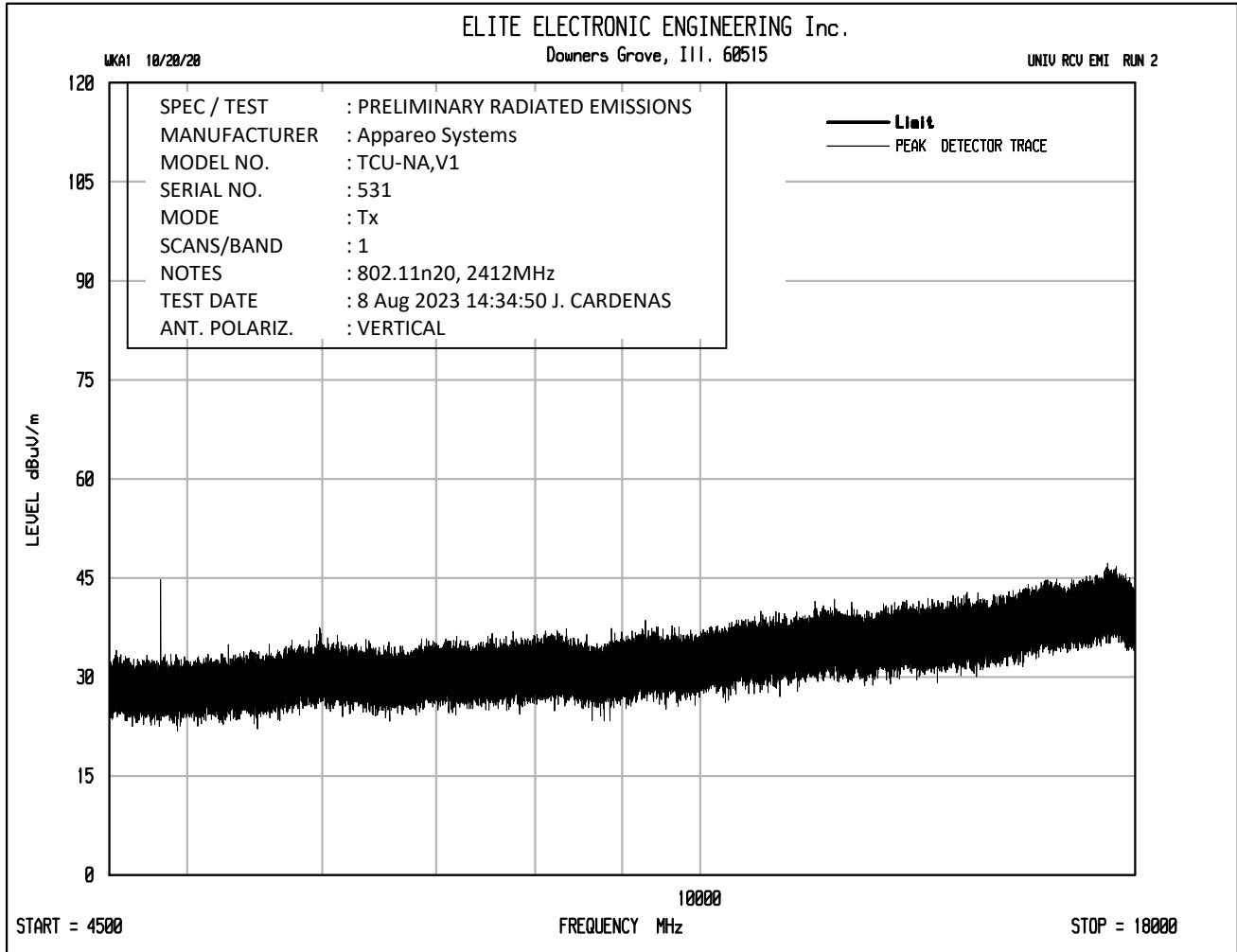










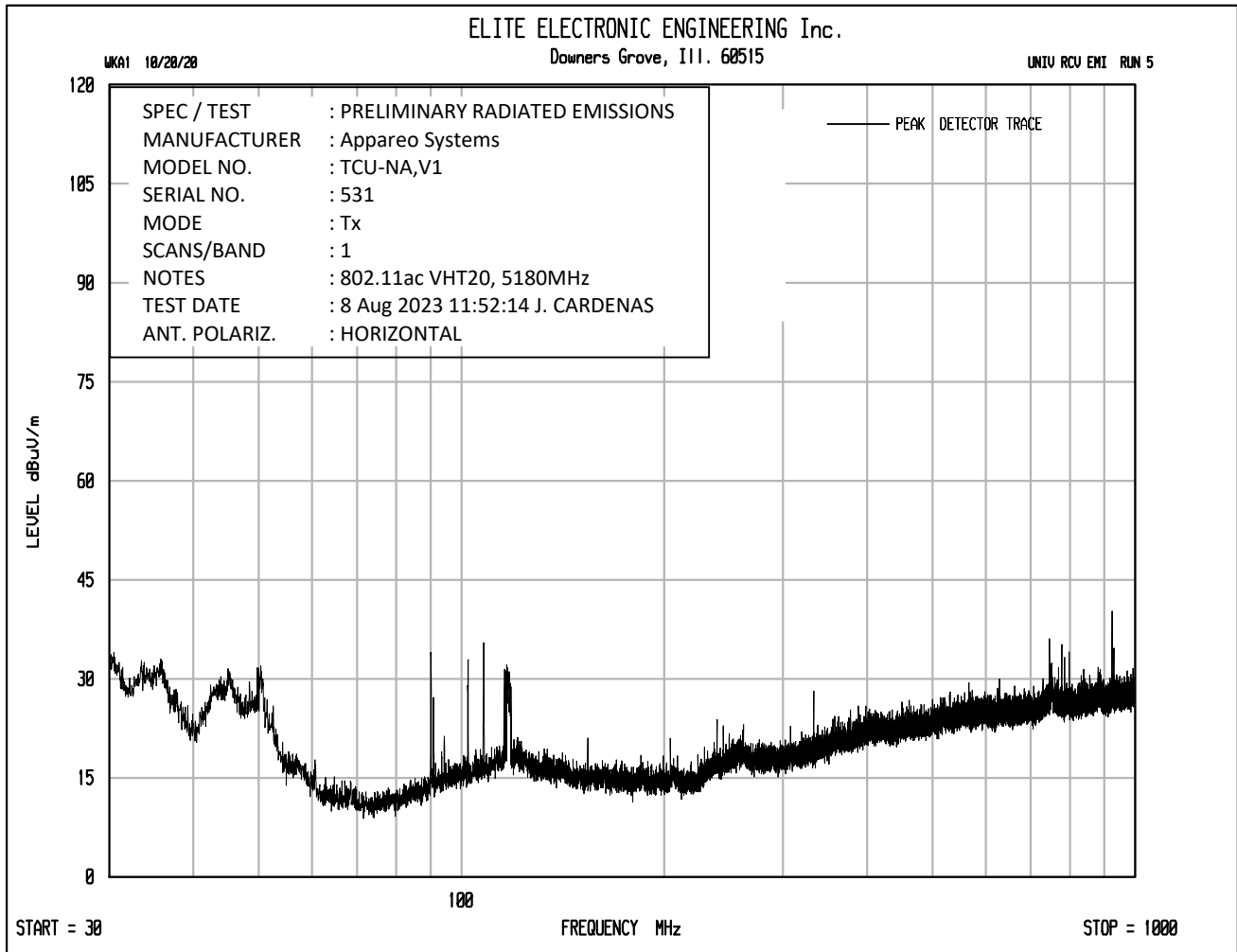


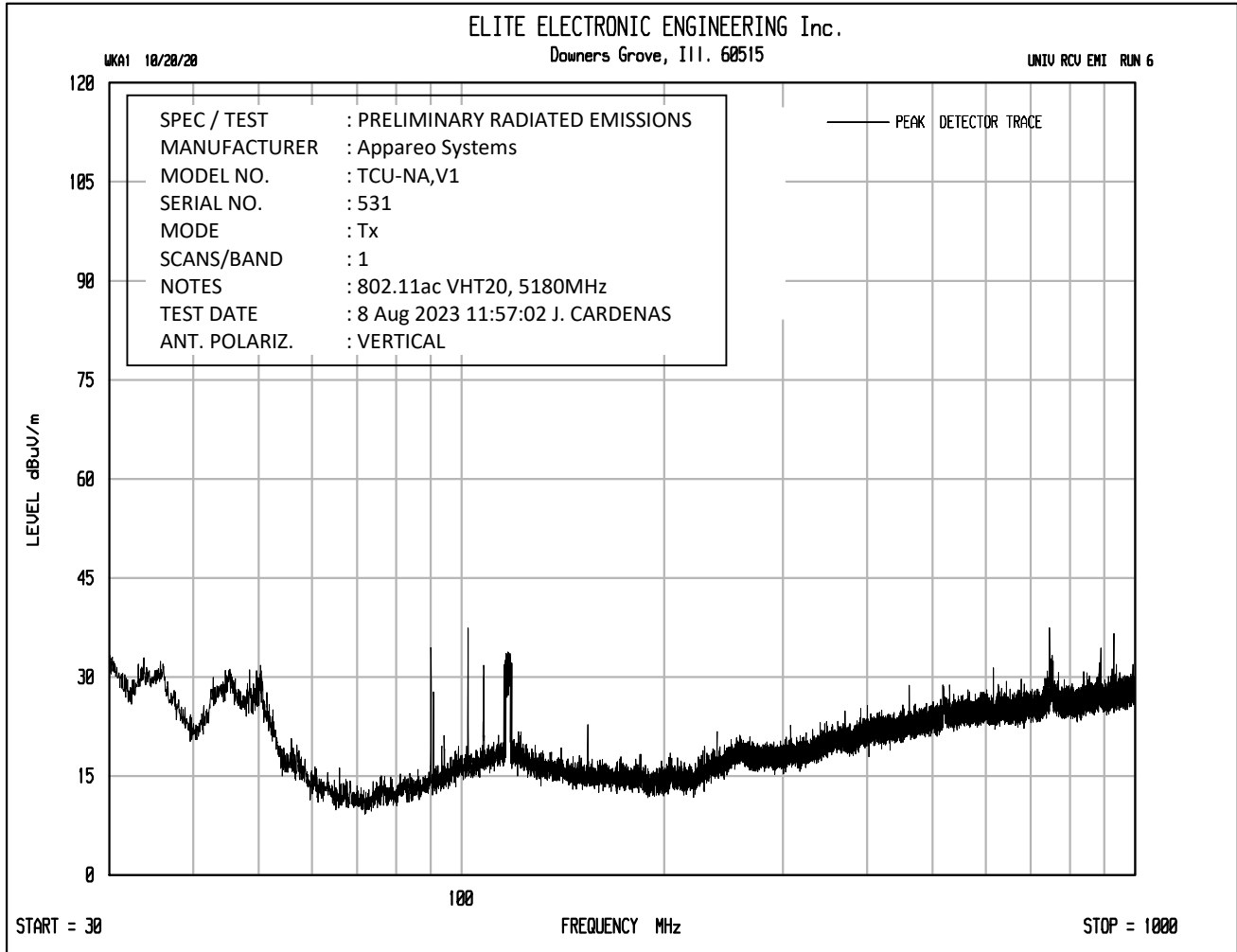
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Tx |
| Frequency Tested | 802.11n20, 2412MHz |
| Notes | None |

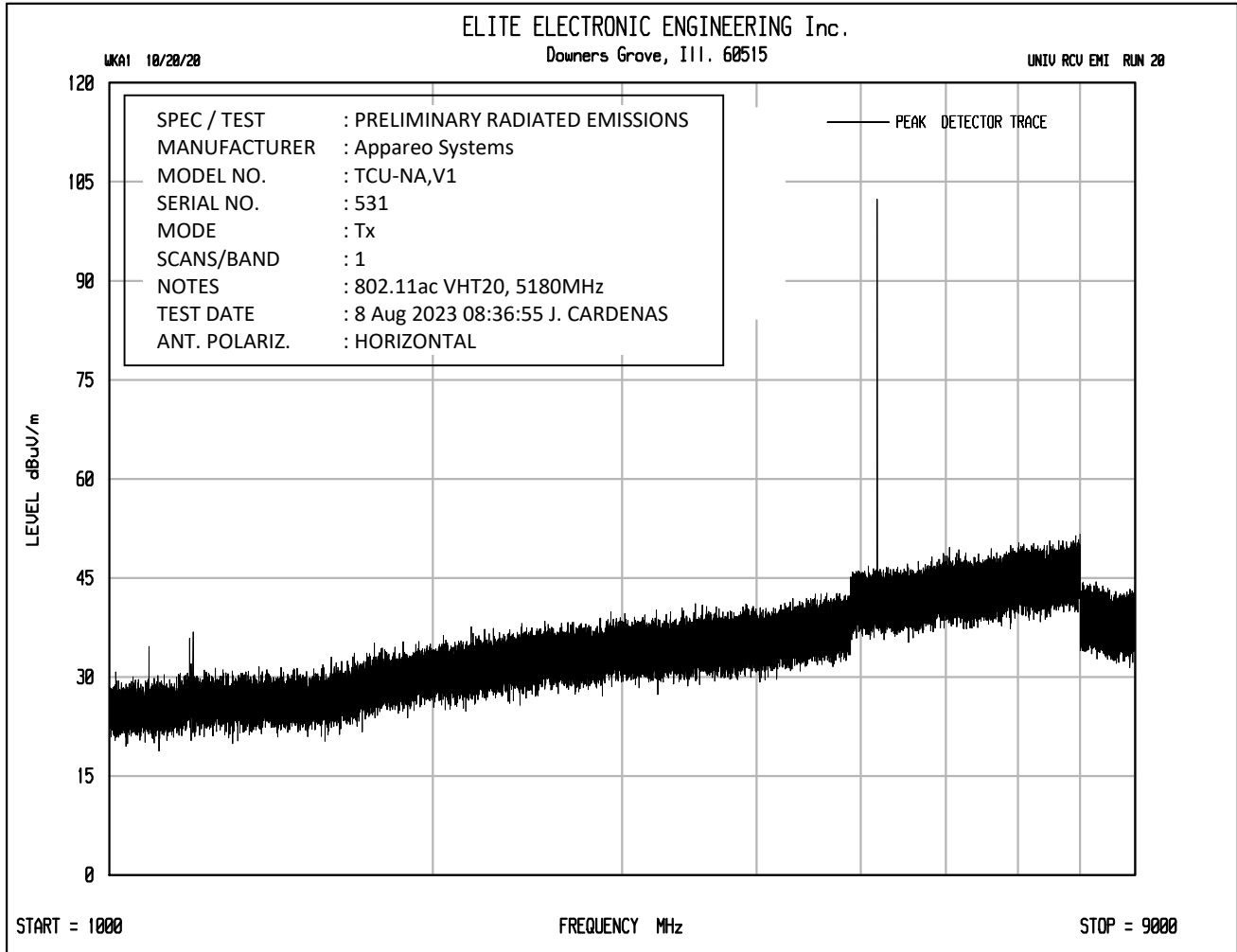
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | Cable Factor (dB) | Antenna Factor (dB/m) | Pre Amp (dB) | Peak Total at 3m (dBμV/m) | Peak Total at 3m (μV/m) | Peak Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|-------------------|-----------------------|--------------|---------------------------|-------------------------|-------------------------|-------------|
| 4824.00 | H | 55.1 | | 3.7 | 34.3 | -39.3 | 53.7 | 485.0 | 5000.0 | -20.3 |
| | V | 54.8 | | 3.7 | 34.3 | -39.3 | 53.4 | 468.5 | 5000.0 | -20.6 |
| 12060.00 | H | 49.5 | * | 6.1 | 38.8 | -39.1 | 55.2 | 578.1 | 5000.0 | -18.7 |
| | V | 49.3 | * | 6.1 | 38.8 | -39.1 | 55.1 | 567.5 | 5000.0 | -18.9 |

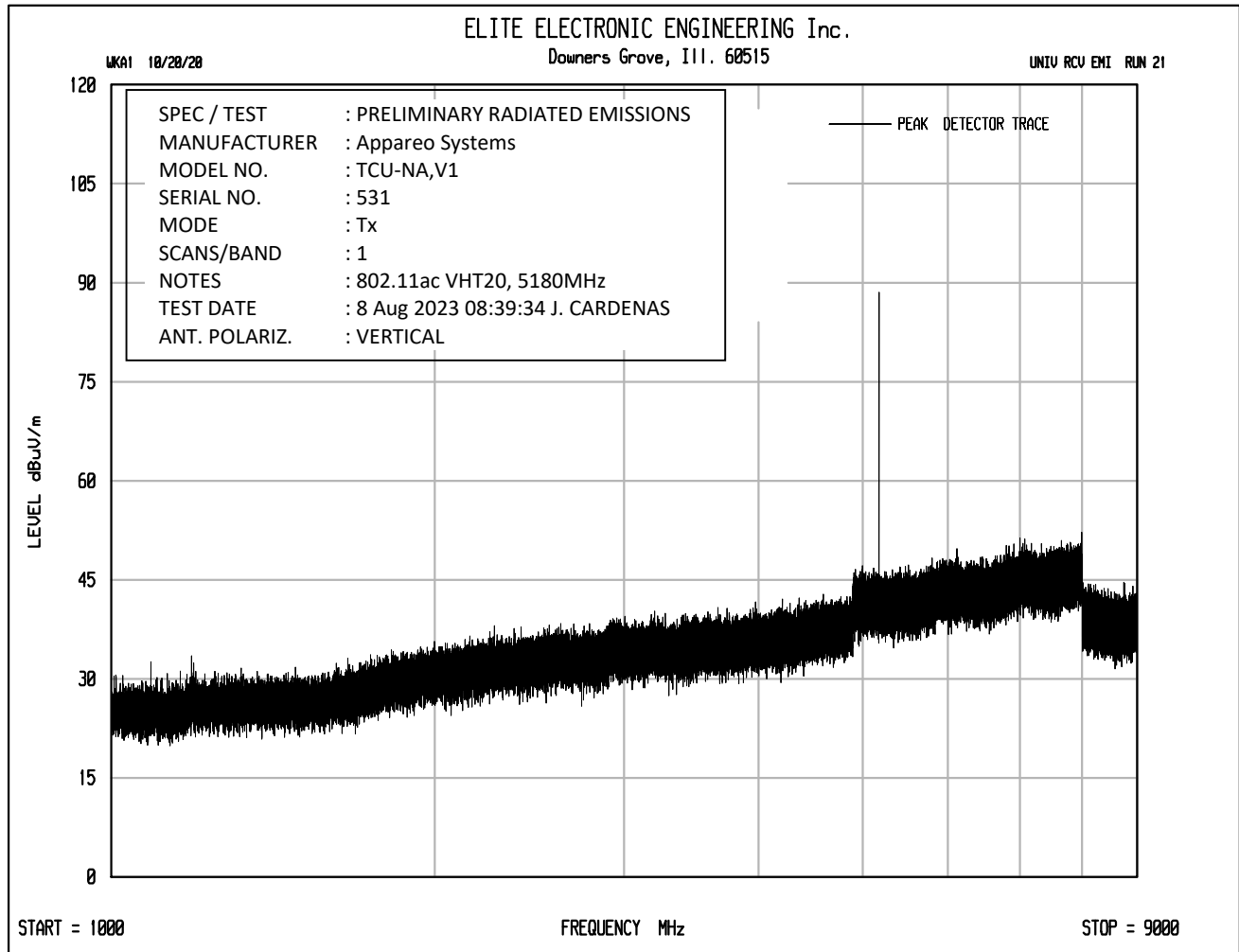
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | CBL Fac (dB) | Ant Fac (dB/m) | Pre Amp (dB) | Duty Cycle Factor (dB) | Average Total at 3m (dBμV/m) | Average Total at 3m (μV/m) | Average Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|--------------|----------------|--------------|------------------------|------------------------------|----------------------------|----------------------------|-------------|
| 4824.00 | H | 52.47 | | 3.7 | 34.3 | -39.3 | 0.0 | 51.1 | 359.9 | 500.0 | -2.9 |
| | V | 53.17 | | 3.7 | 34.3 | -39.3 | 0.0 | 51.8 | 390.1 | 500.0 | -2.2 |
| 12060.00 | H | 36.96 | * | 6.1 | 38.8 | -39.1 | 0.0 | 42.7 | 136.9 | 500.0 | -11.2 |
| | V | 37.06 | * | 6.1 | 38.8 | -39.1 | 0.0 | 42.8 | 138.5 | 500.0 | -11.1 |

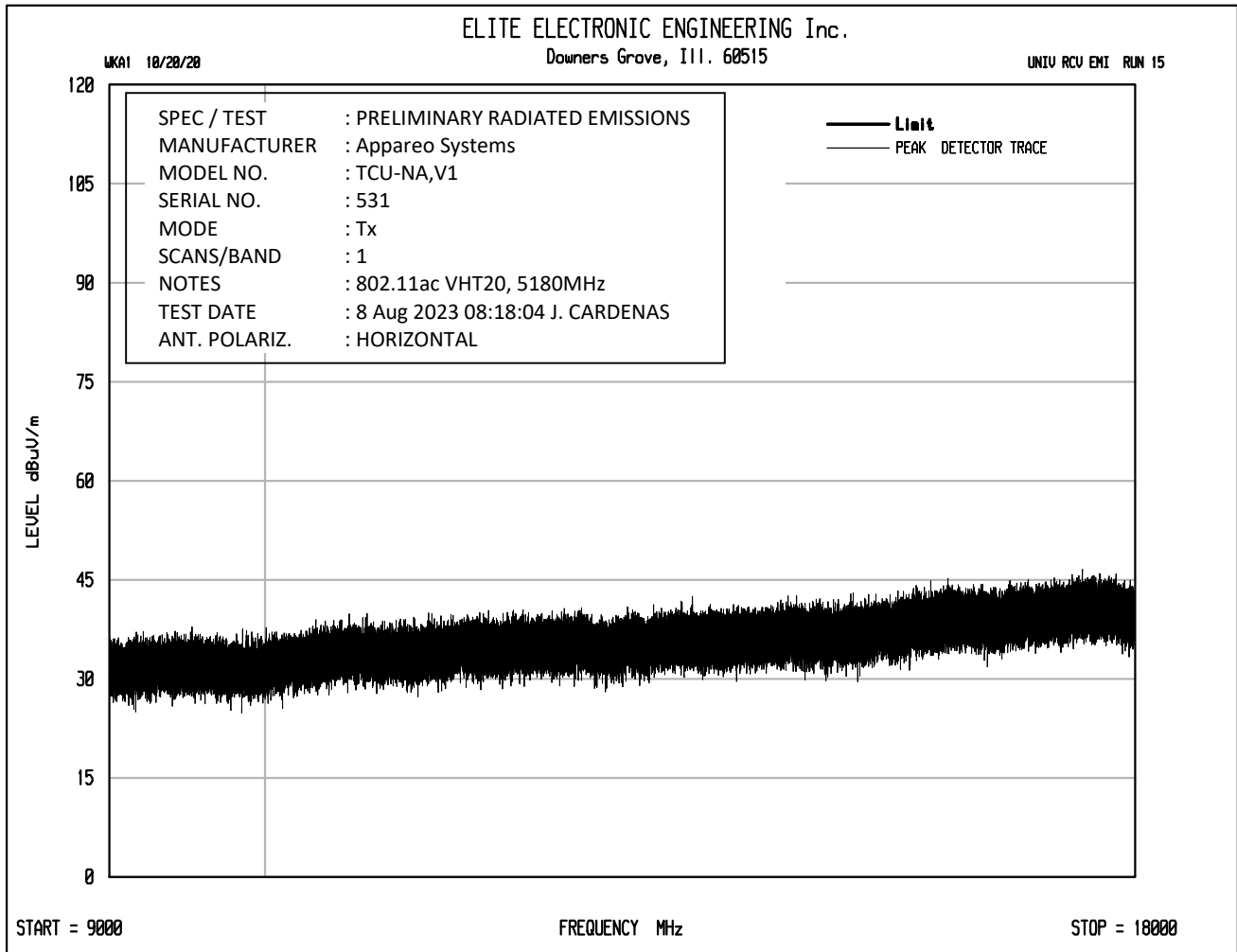
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | Cable Factor (dB) | Antenna Factor (dB/m) | Pre Amp (dB) | Peak Total at 3m (dBμV/m) | Peak Total at 3m (μV/m) | Peak Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|-------------------|-----------------------|--------------|---------------------------|-------------------------|-------------------------|-------------|
| 2412.00 | H | 76.80 | | 2.6 | 32.6 | 0.0 | 112.0 | 398426.7 | NA | NA |
| | V | 74.15 | | 2.6 | 32.6 | 0.0 | 109.4 | 293662.5 | NA | NA |
| 7236.00 | H | 39.14 | * | 4.7 | 36.3 | -39.4 | 40.6 | 107.6 | 39842.7 | -51.4 |
| | V | 38.30 | * | 4.7 | 36.3 | -39.4 | 39.8 | 97.7 | 39842.7 | -52.2 |
| 9648.00 | H | 38.71 | * | 5.2 | 37.2 | -39.3 | 41.8 | 123.2 | 39842.7 | -50.2 |
| | V | 37.92 | * | 5.2 | 37.2 | -39.3 | 41.0 | 112.5 | 39842.7 | -51.0 |

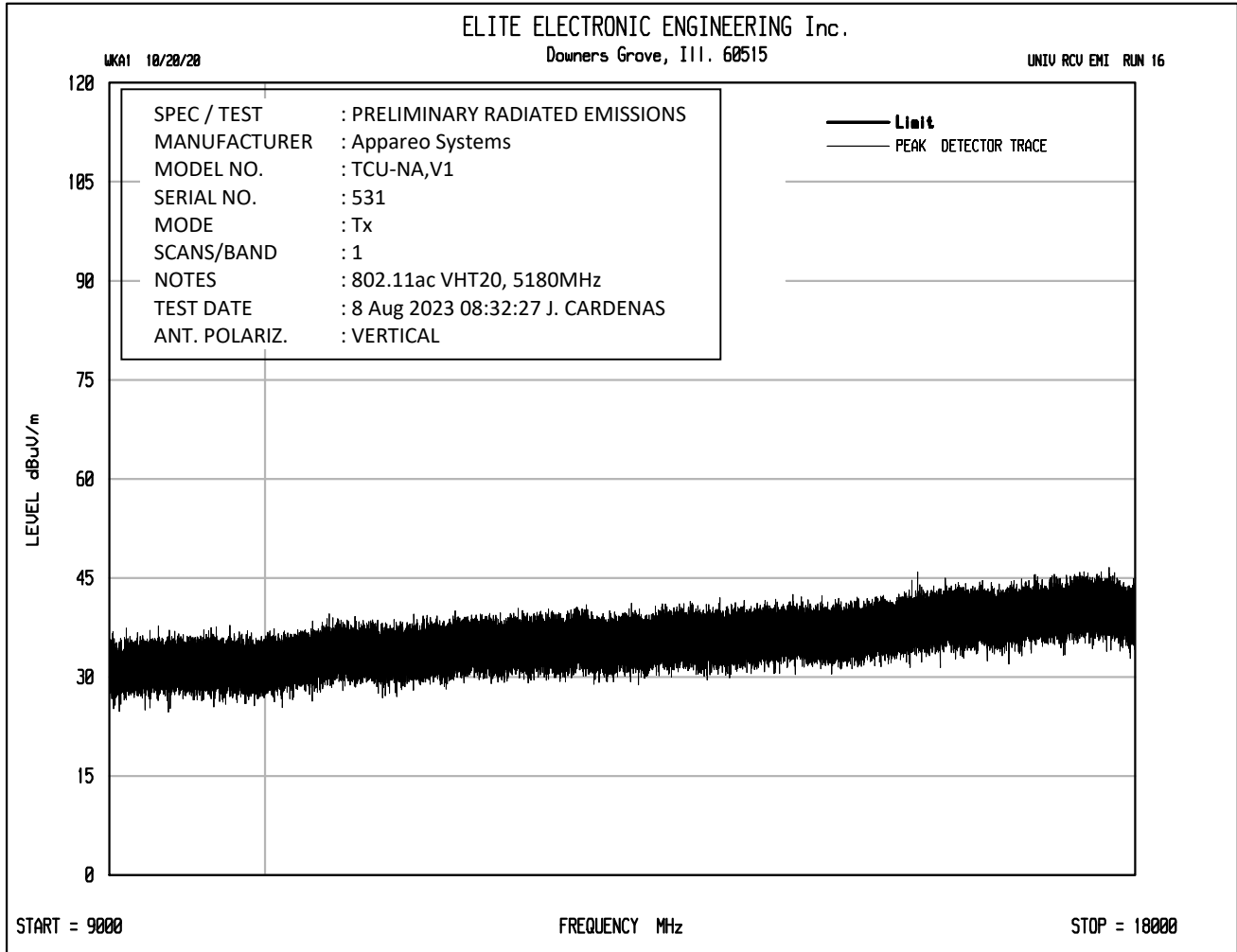








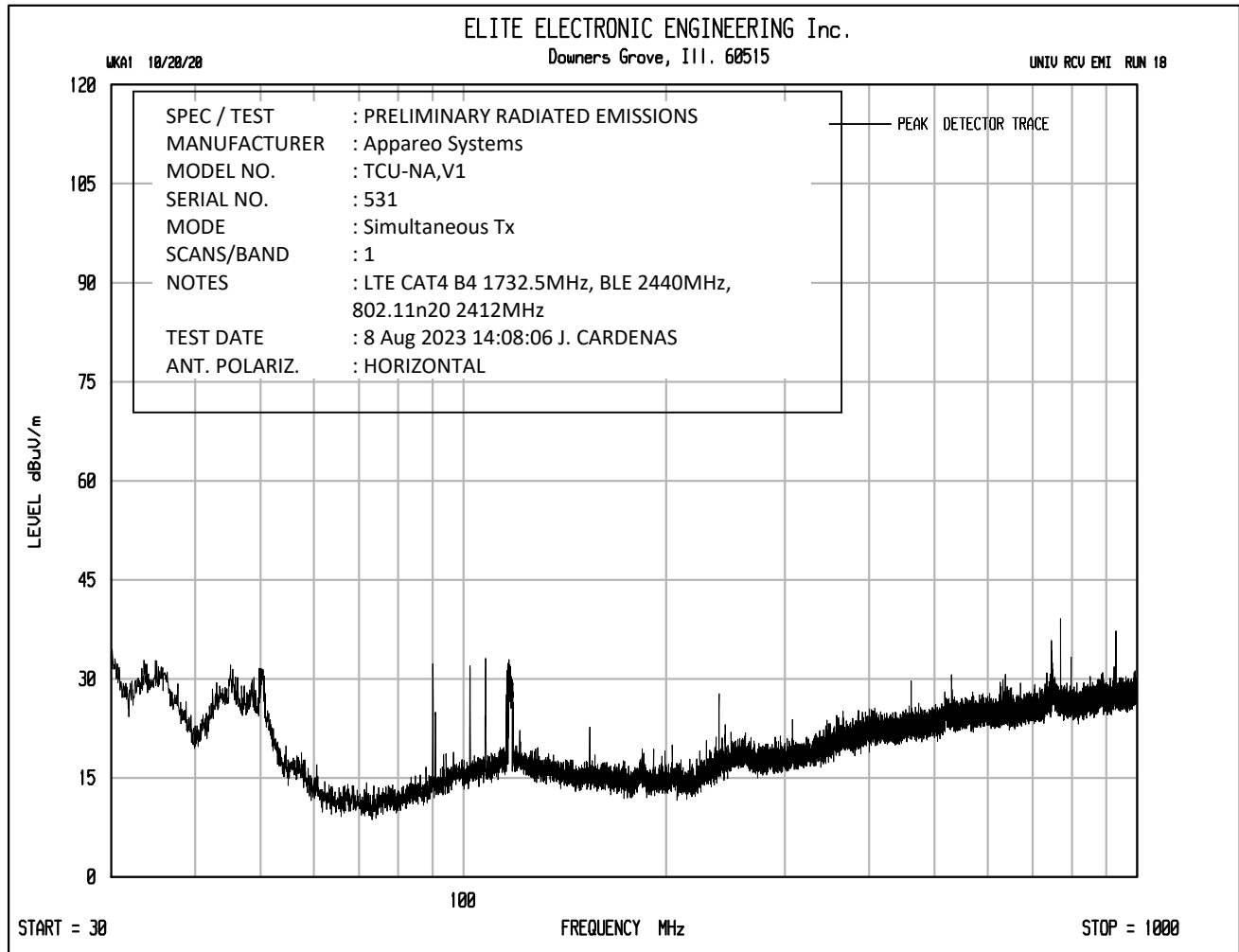


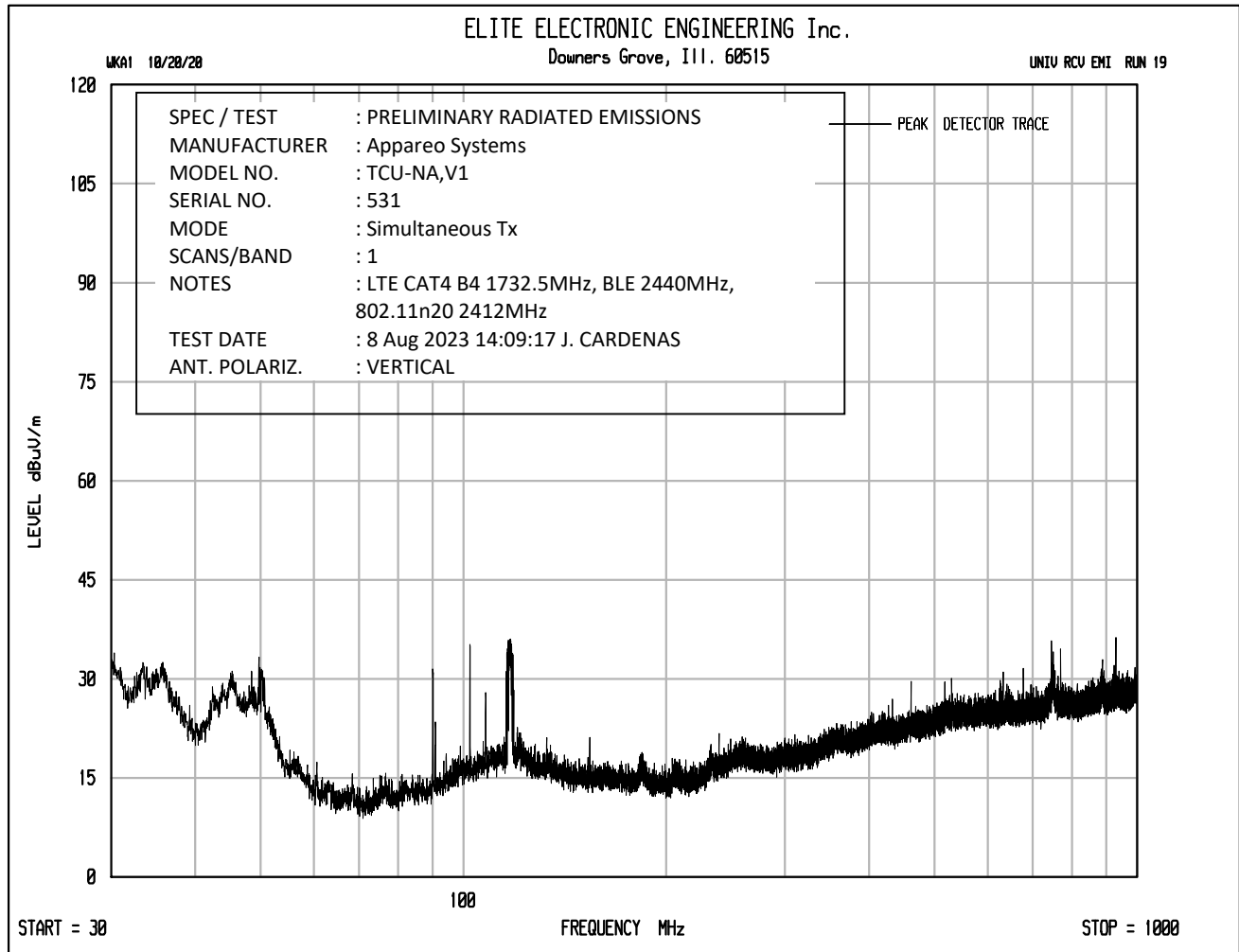


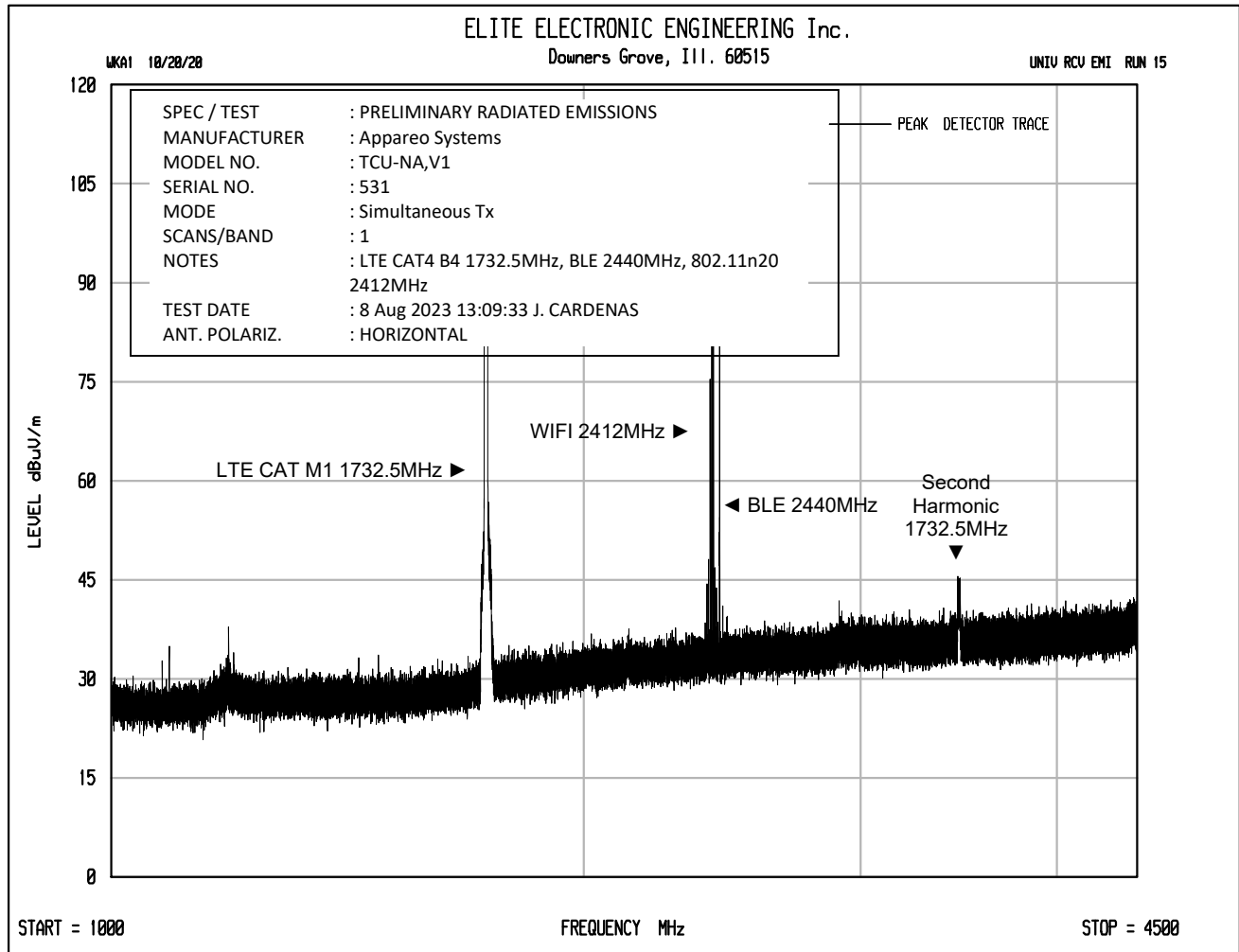
| Test Details | |
|------------------|--|
| Manufacturer | Appareo Systems |
| Model No. | TCU-NA,V1 |
| Serial No. | 531 |
| Test | Host Product Testing – Case Spurious Emissions |
| Mode | Test Operations |
| Frequency Tested | 802.11ac VHT20, 5180MHz |
| Notes | None |

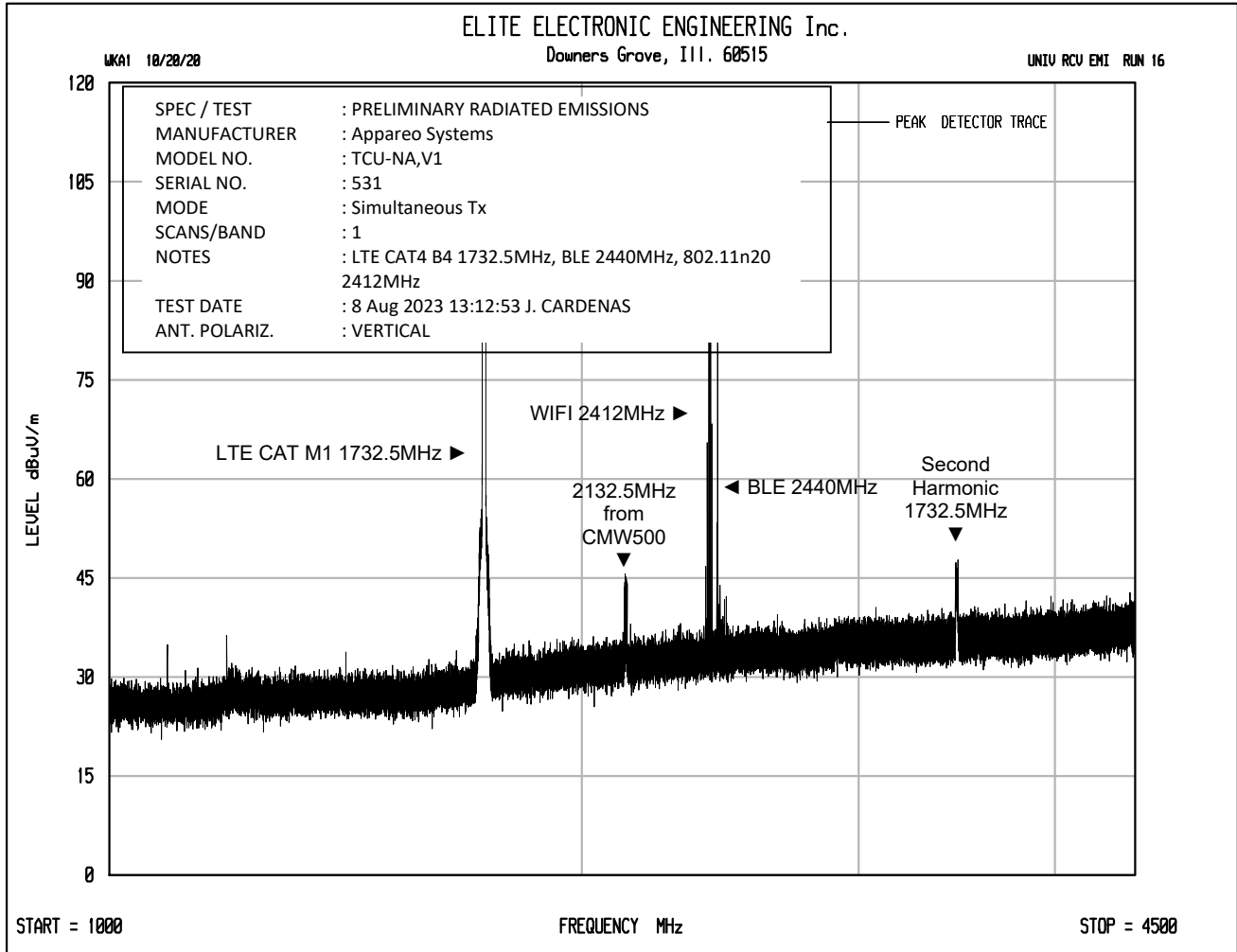
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | Cable Factor (dB) | Antenna Factor (dB/m) | Pre Amp (dB) | Peak Total at 3m (dBμV/m) | Peak Total at 3m (μV/m) | Peak Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|-------------------|-----------------------|--------------|---------------------------|-------------------------|-------------------------|-------------|
| 15540.00 | H | 48.5 | | 6.8 | 40.4 | -37.7 | 58.1 | 800.9 | 5000.0 | -15.9 |
| | V | 48.2 | | 6.8 | 40.4 | -37.7 | 57.7 | 767.5 | 5000.0 | -16.3 |
| 20720.00 | H | 0.0 | | 2.3 | 40.1 | 0.0 | 42.4 | 132.0 | 5000.0 | -31.6 |
| | V | 0.0 | | 2.3 | 40.1 | 0.0 | 42.4 | 132.0 | 5000.0 | -31.6 |

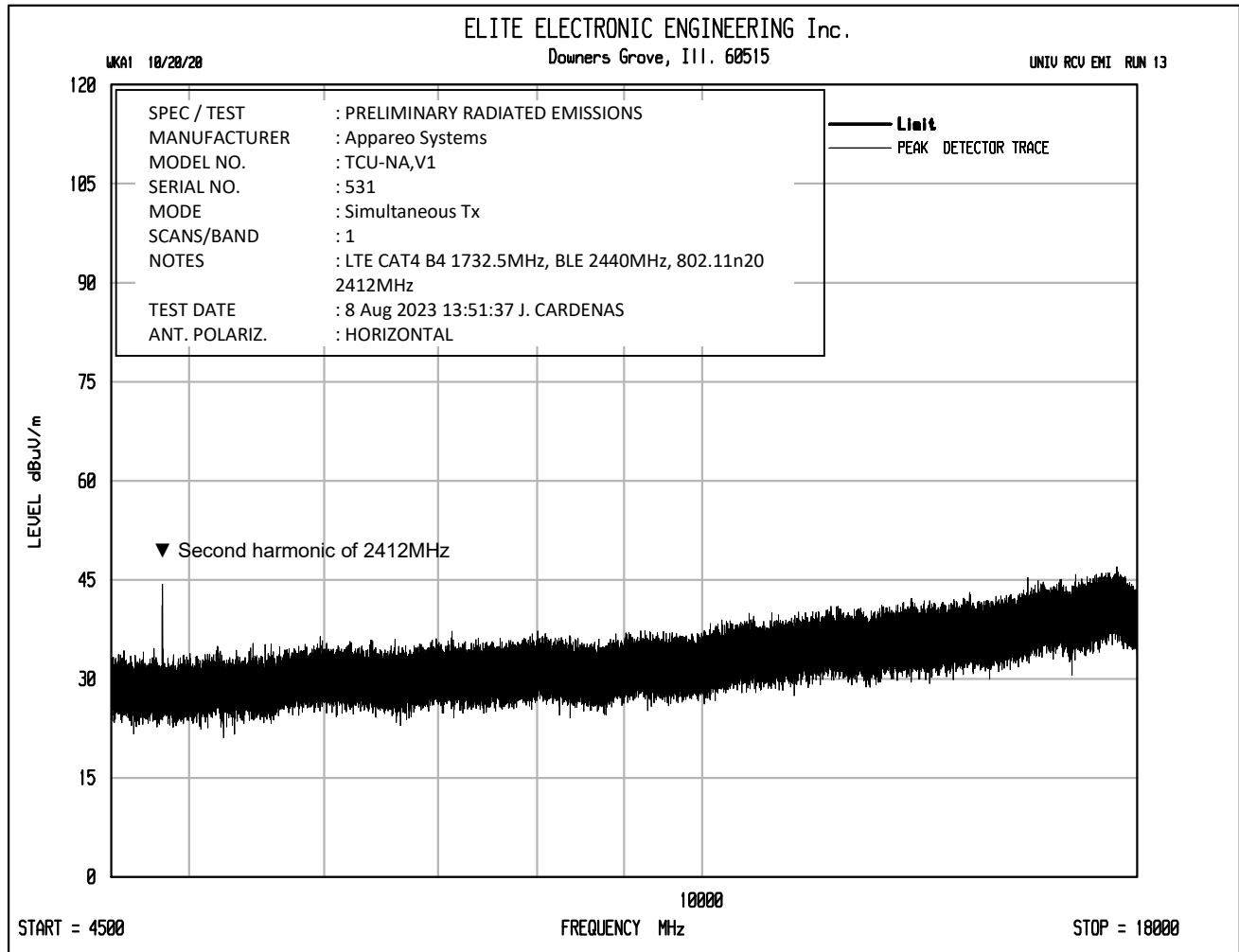
| Freq (MHz) | Ant Pol | Meter Reading (dBμV) | Ambient | CBL Fac (dB) | Ant Fac (dB/m) | Pre Amp (dB) | Duty Cycle Factor (dB) | Average Total at 3m (dBμV/m) | Average Total at 3m (μV/m) | Average Limit at 3m (μV/m) | Margin (dB) |
|------------|---------|----------------------|---------|--------------|----------------|--------------|------------------------|------------------------------|----------------------------|----------------------------|-------------|
| 15540.00 | H | 41.55 | | 6.8 | 40.4 | -37.7 | 0.0 | 51.1 | 358.2 | 500.0 | -2.9 |
| | V | 44.16 | | 6.8 | 40.4 | -37.7 | 0.0 | 53.7 | 483.7 | 500.0 | -0.3 |

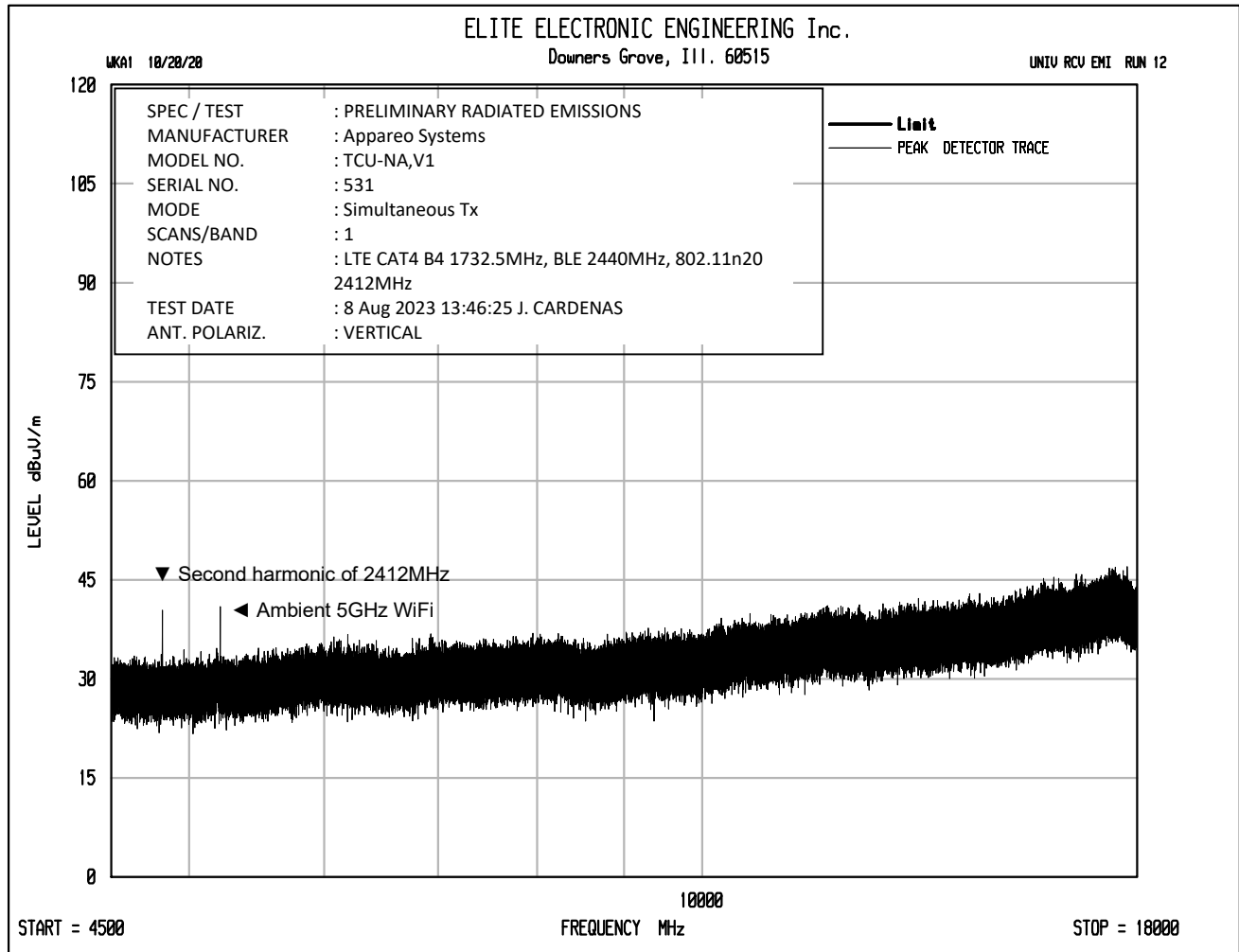




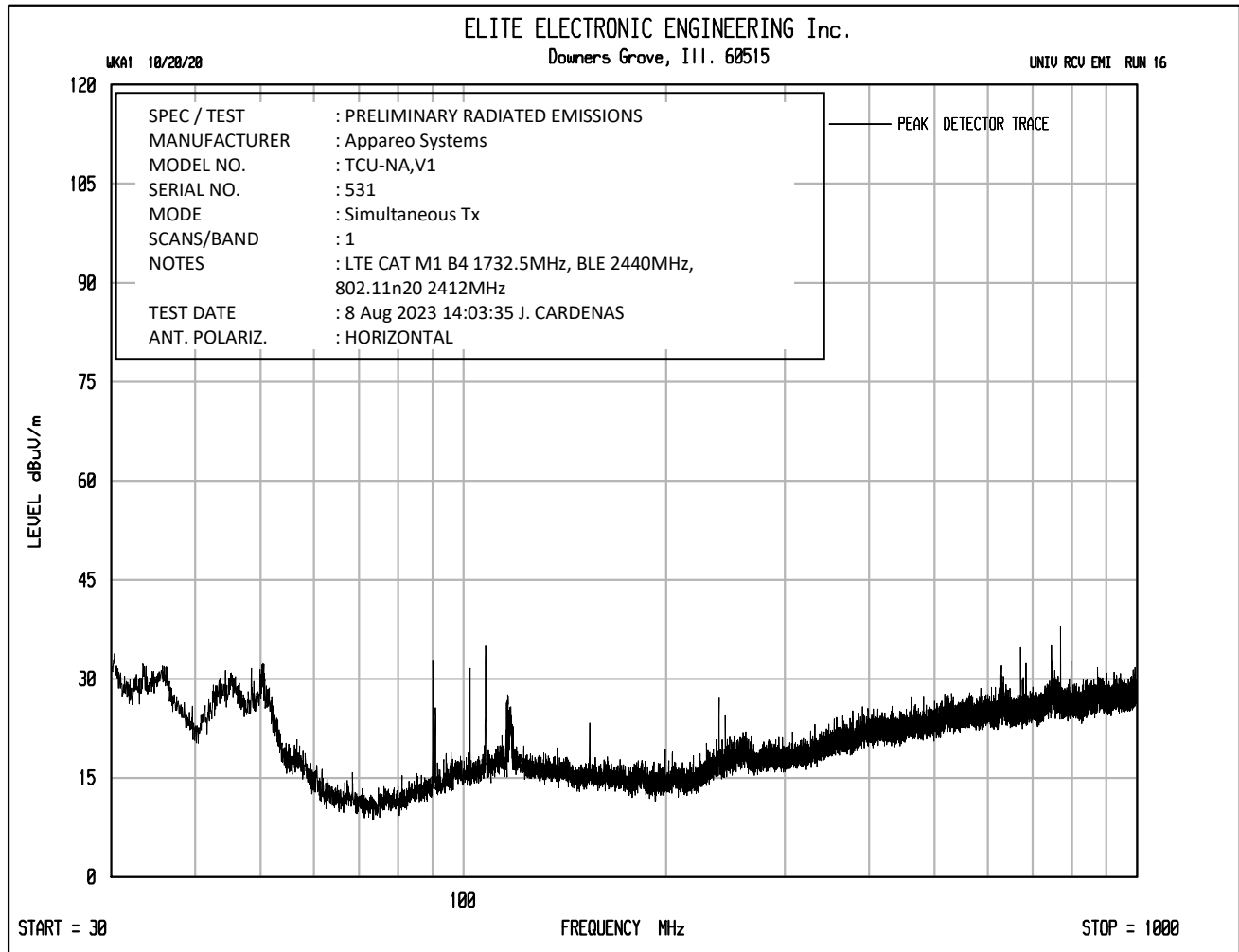


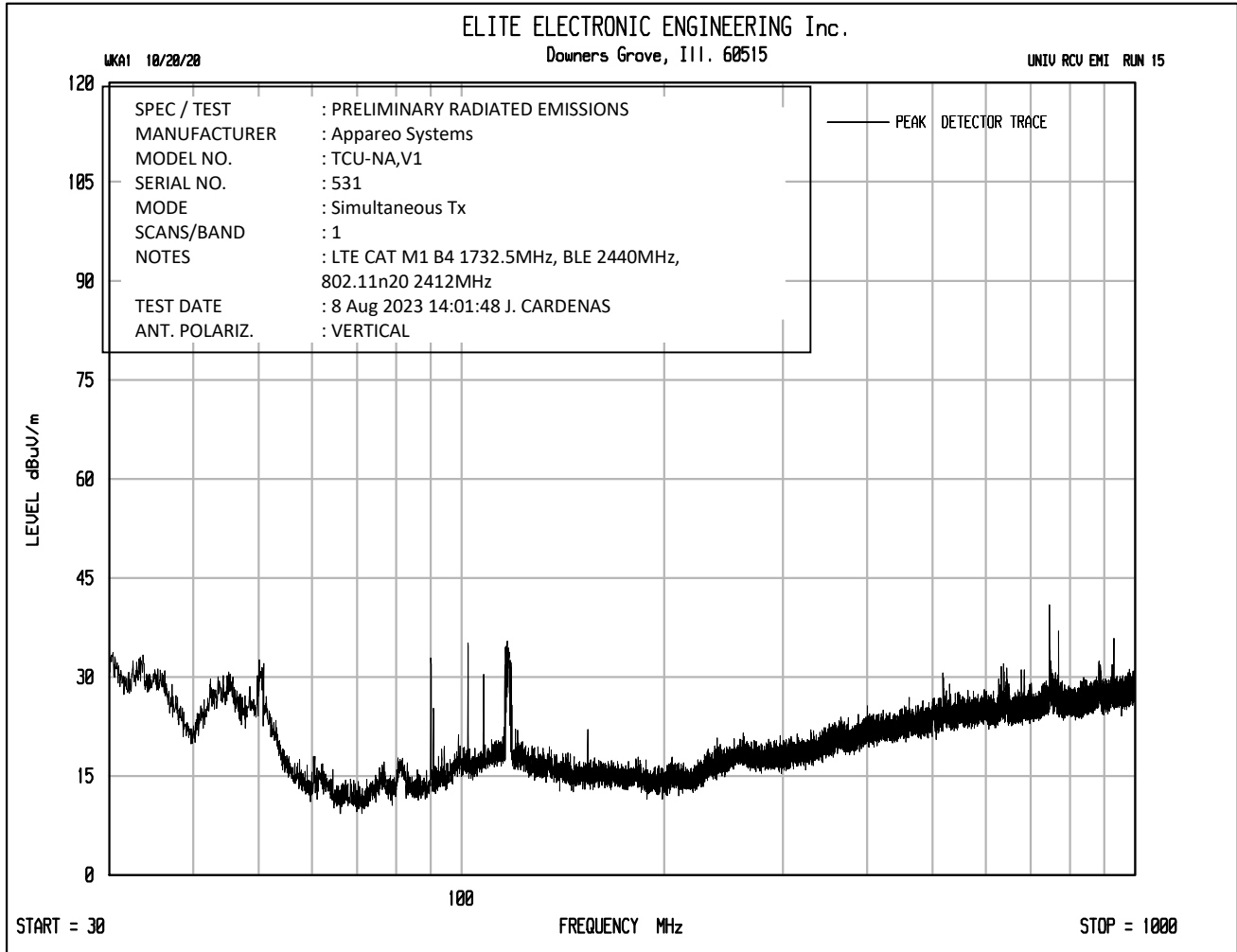


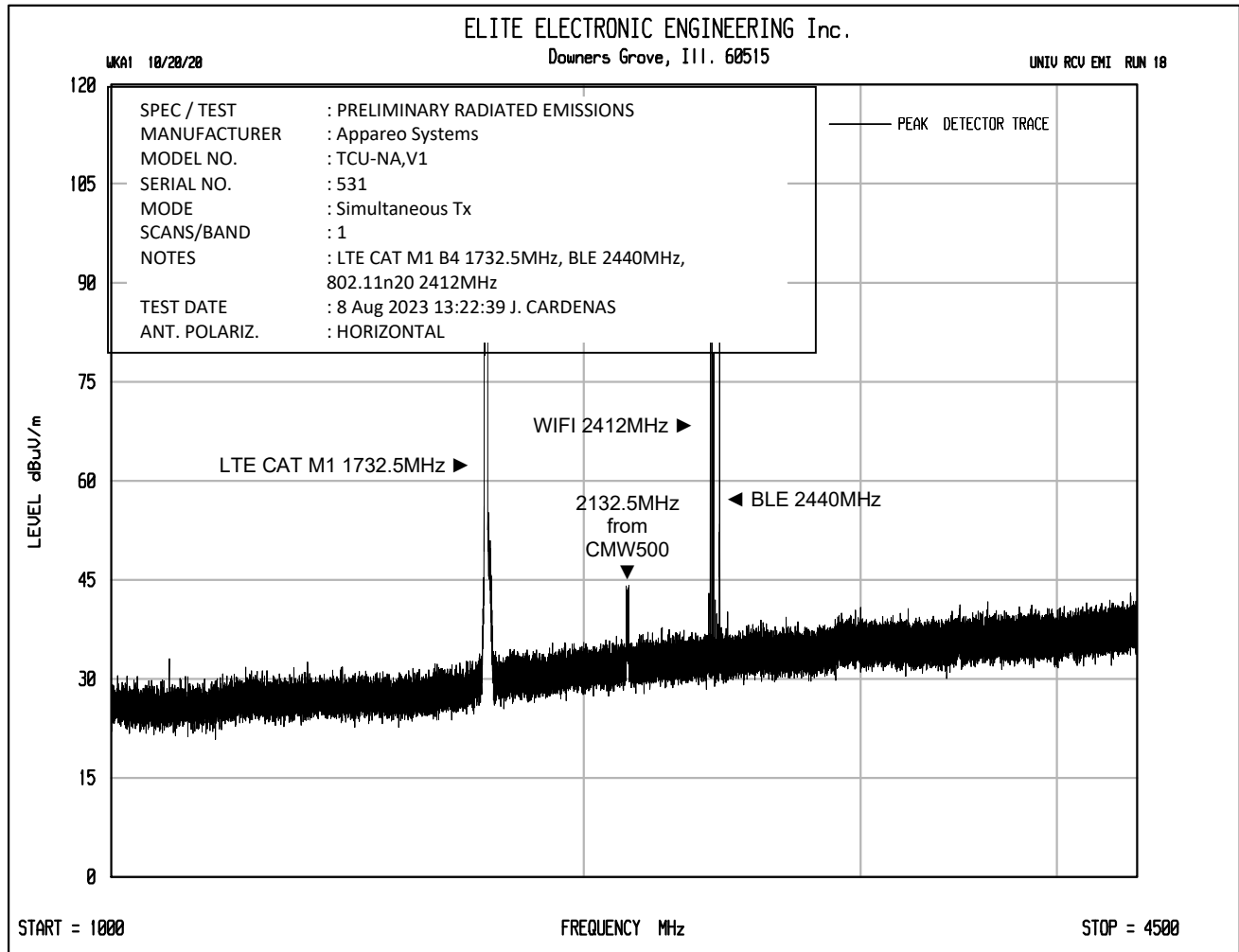


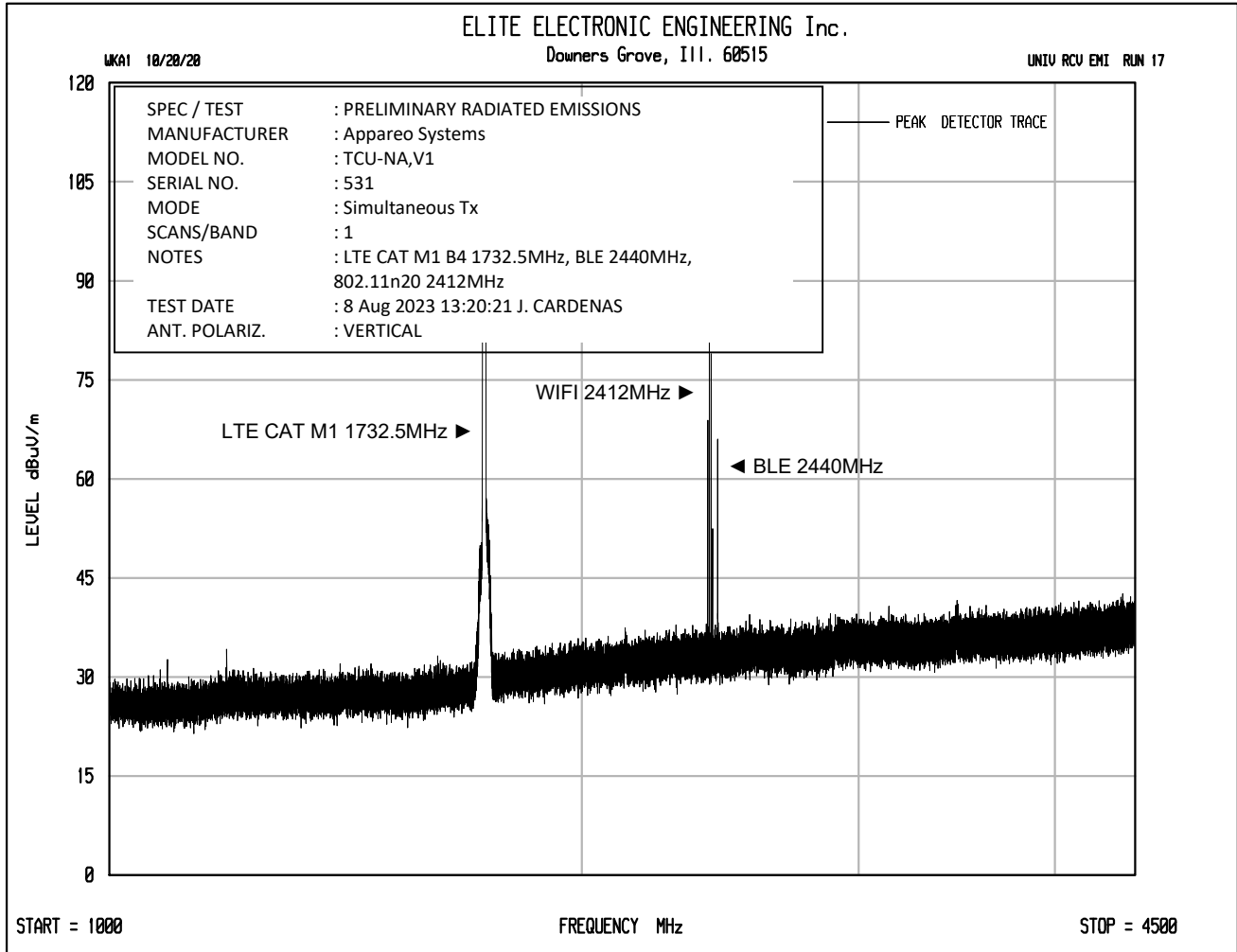


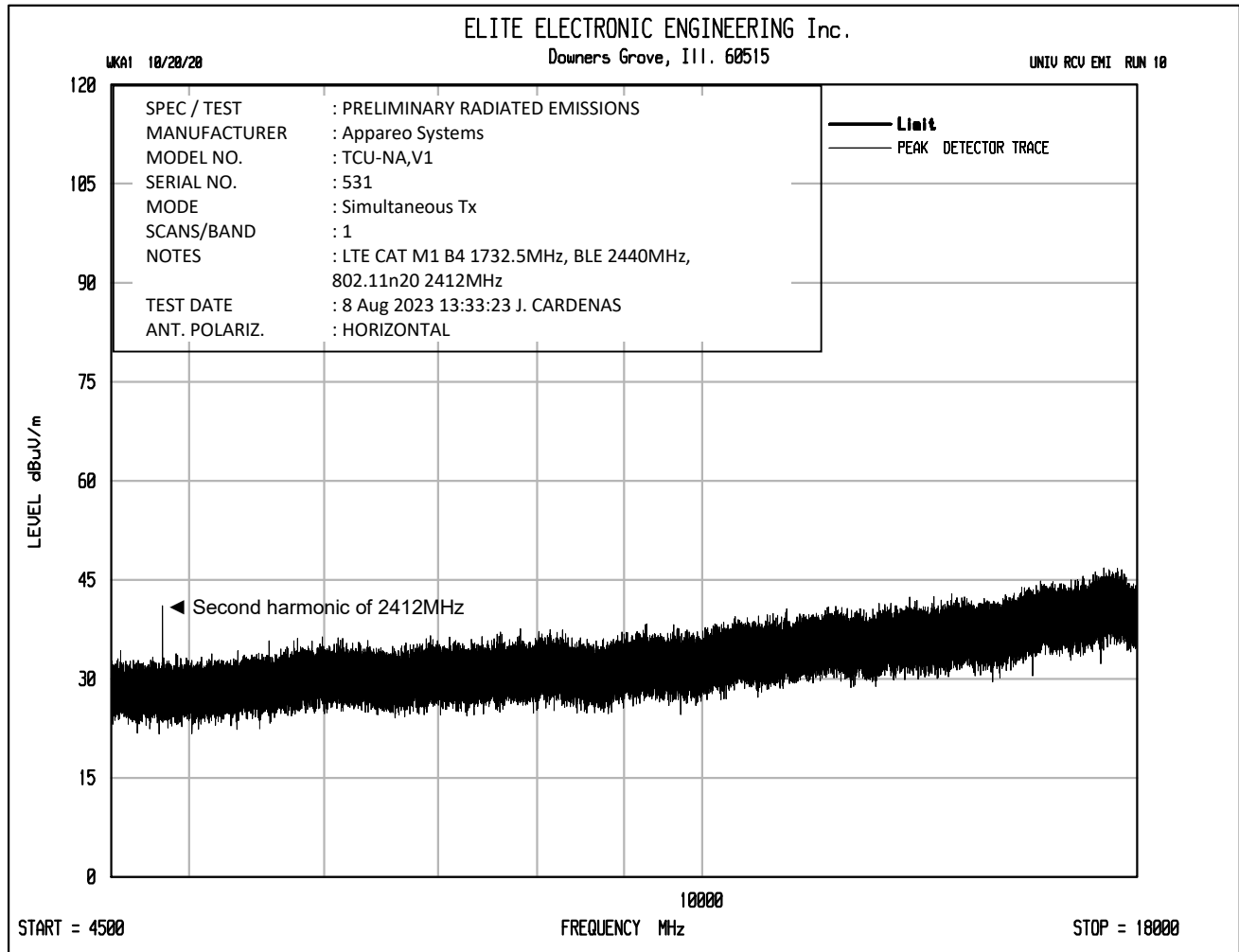
No intermodulation products were observed.

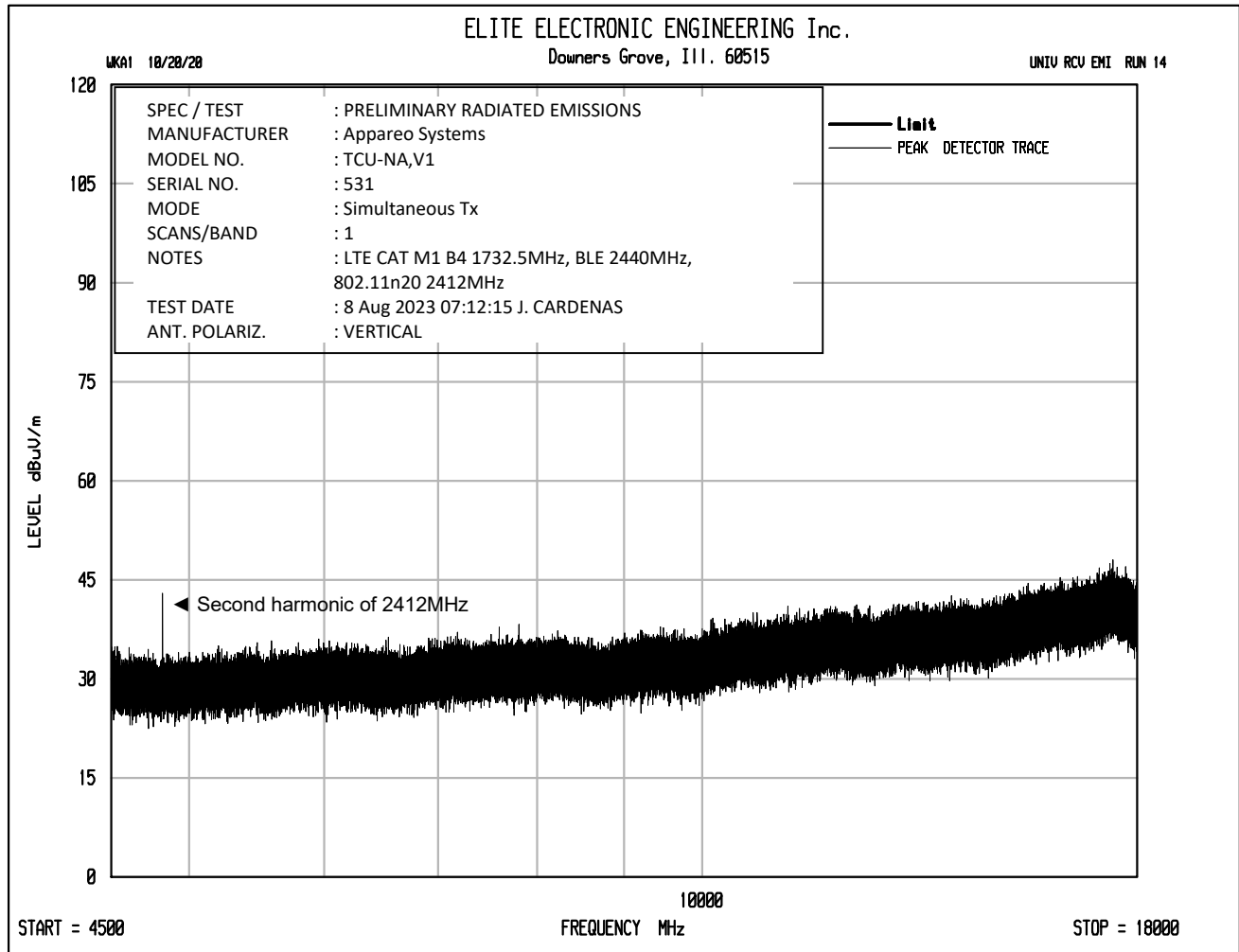












No intermodulation products were observed.

22. Scope of Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

ELITE ELECTRONIC ENGINEERING, INC.
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Downers Grove, IL 60515
Robert Bugielski (QA Manager) Phone: 630 495 9770 ext. 168
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Email: reking@elitetest.com
Website: www.elitetest.com

ELECTRICAL

Valid To: June 30, 2025

Certificate Number: 1786.01

In recognition of the successful completion of the A2LA Accreditation Program evaluation process, accreditation is granted to this laboratory to perform the following automotive electromagnetic compatibility and other electrical tests:

Test Technology:Test Method(s)¹:

Transient Immunity
(Max Voltage 60V/Max current 100A)

ISO 7637-2 (including emissions); ISO 7637-3;
ISO 16750-2:2012, Sections 4.6.3 and 4.6.4;
CS-11979, Section 6.4; CS.00054, Section 5.9;
EMC-CS-2009.1 (CI220); FMC1278 (CI220, CI221, CI222);
GMW 3097, Section 3.5; SAE J1113-11; SAE J1113-12;
ECE Regulation 10.06 Annex 10

Electrostatic Discharge (ESD)
(Up to +/-25kV)

ISO 10605 (2001, 2008);
CS-11979 Section 7.0; CS.00054, Section 5.10;
EMC-CS-2009.1 (CI 280); FMC1278 (CI280); SAE J1113-13;
GMW 3097 Section 3.6

Conducted Emissions

CISPR 25 (2002, 2008), Sections 6.2 and 6.3;
CISPR 25 (2016), Sections 6.3 and 6.4;
CS-11979, Section 5.1; CS.00054, Sections 5.6.1 and 5.6.2;
GMW 3097, Section 3.3.2;
EMC-CS-2009.1 (CE 420); FMC1278 (CE420, CE421,
CE 430, CE440)

(A2LA Cert. No. 1786.01) 08/15/2023



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5202 Presidents Court, Suite 220 | Frederick, MD 21703-8515 | Phone: 301 644 3248 | Fax: 240 454 9449 | www.A2LA.org

Test Technology:
Test Method(s)¹:

Radiated Emissions Anechoic
(Up to 6GHz)

CISPR 25 (2002, 2008), Section 6.4;
CISPR 25 (2016), Section 6.5;
CS-11979, Section 5.3; CS.00054, Section 5.6.3;
GMW 3097, Section 3.3.1;
EMC-CS-2009.1 (RE 310); FMC1278 (RE310, RE320);

Vehicle Radiated Emissions

CISPR 12; CISPR 36; ICES-002;
ECE Regulation 10.06 Annex 5

Bulk Current Injection (BCI)
(1 to 400MHz 500mA)

ISO 11452-4; CS-11979, Section 6.1; CS.00054, Section 5.8.1;
GMW 3097, Section 3.4.1; SAE J1113-4;
EMC-CS-2009.1 (RI112); FMC1278 (RI112);
ECE Regulation 10.06 Annex 9

Radiated Immunity Anechoic
(Up to 6GHz and 200V/m)
(Including Radar Pulse 600V/m)

ISO 11452-2;
CS-11979, Section 6.2; CS.00054, Section 5.8.2;
GMW 3097, Section 3.4.2;
EMC-CS-2009.1 (RI114); FMC1278 (RI114); SAE J1113-21;
ECE Regulation 10.06 Annex 9

Radiated Immunity Magnetic Field

ISO 11452-8; FMC 1278 (RI140)

Radiated Immunity Reverb
(360MHz to 6GHz and 100V/m)

ISO/IEC 61000-4-21; GMW 3097, Section 3.4.3;
EMC-CS-2009.1 (RI114); FMC1278 (RI114);
ISO 11452-11

Radiated Immunity
(Portable Transmitters)
(Up to 6GHz and 20W)

ISO 11452-9;
EMC-CS-2009.1 (RI115); FMC1278 (RI115);
GMW 3097, Sec 3.4.4

Vehicle Radiated Immunity (ALSE)

ISO 11451-2; ECE Regulation 10.06 Annex 6

Vehicle Product Specific EMC Standards

EN 14982; EN ISO 13309; ISO 13766; EN 50498;
EC Regulation No. 2015/208; EN 55012

Electrical Loads

ISO 16750-2

Stripline

ISO 11452-5

Transverse Electromagnetic (TEM) Cell

ISO 11452-3

Test Technology:
Test Method(s)¹:
Emissions

Radiated and Conducted
(3m Semi-anechoic chamber,
up to 40 GHz)

47 CFR, FCC Part 15 B (using ANSI C63.4:2014);
47 CFR, FCC Part 18 (using FCC MP-5:1986);
ICES-001; ICES-003; ICES-005;
IEC/CISPR 11, Ed. 4.1 (2004-06); AS/NZS CISPR 11 (2004);
IEC/CISPR 11 Ed 5 (2009-05) + A1 (2010);
KN 11 (2008-5) with RRL Notice No. 2008-3 (May 20, 2008);
CISPR 11; EN 55011; KS C 9811; CNS 13803 (1997, 2003);
CISPR 14-1; EN 55014-1; AS/NZS CISPR 14.1;
CISPR 16-2-1 (2008); CISPR 16-2-1; KS C 9814-1; KN 14-1;
IEC/CISPR 22 (1997);
EN 55022 (1998) + A1(2000);
EN 55022 (1998) + A1(2000) + A2(2003); EN 55022 (2006);
IEC/CISPR 22 (2008-09); AS/NZS CISPR 22 (2004);
AS/NZS CISPR 22, 3rd Edition (2006); KN 22 (up to 6 GHz);
CNS 13438 (up to 6 GHz); VCCI V-3 (up to 6 GHz);
CISPR 32; EN 55032; KS C 9832; KN 32;
ECE Regulation 10.06 Annex 7 (Broadband);
ECE Regulation 10.06 Annex 8 (Narrowband);
ECE Regulation 10.06 Annex 14 (Conducted)

Cellular Radiated Spurious Emissions

ETSI TS 151 010-1 GSM; 3GPP TS 51.010-1, Sec 12;
ETSI TS 134 124 UMTS; 3GPP TS 34.124;
ETSI TS 136 124 LTE; E-UTRA; 3GPP TS 36.124

Current Harmonics

IEC 61000-3-2; IEC 61000-3-12;
EN 61000-3-2; KN 61000-3-2;
KS C 9610-3-2; ECE Regulation 10.06 Annex 11

Flicker and Fluctuations

IEC 61000-3-3; IEC 61000-3-11;
EN 61000-3-3; KN 61000-3-3;
KS C 9610-3-3; ECE Regulation 10.06 Annex 12

Immunity

Electrostatic Discharge

IEC 61000-4-2, Ed. 1.2 (2001);
IEC 61000-4-2 (1995) + A1(1998) + A2(2000);
EN 61000-4-2 (1995); EN 61000-4-2 (2009-05);
KN 61000-4-2 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
IEC 61000-4-2; EN 61000-4-2; KN 61000-4-2;
KS C 9610-4-2; IEEE C37.90.3 2001

Radiated Immunity

IEC 61000-4-3 (1995) + A1(1998) + A2(2000);
IEC 61000-4-3, Ed. 3.0 (2006-02);
IEC 61000-4-3, Ed. 3.2 (2010);
KN 61000-4-3 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
IEC 61000-4-3; EN 61000-4-3; KN 61000-4-3;
KS C 9610-4-3; IEEE C37.90.2 2004

Test Technology:
Test Method(s)¹:
Immunity (cont'd)

Electrical Fast Transient/Burst

IEC 61000-4-4, Ed. 2.0 (2004-07);
IEC 61000-4-4, Ed. 2.1 (2011);
IEC 61000-4-4 (1995) + A1(2000) + A2(2001);
KN 61000-4-4 (2008-5);
RRL Notice No. 2008-5 (May 20, 2008);
IEC 61000-4-4; EN 61000-4-4; KN 61000-4-4;
KS C 9610-4-4; ECE Regulation 10.06 Annex 15

Surge

IEC 61000-4-5 (1995) + A1(2000);
IEC 61000-4-5, Ed 1.1 (2005-11);
EN 61000-4-5 (1995) + A1(2001);
KN 61000-4-5 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
IEC 61000-4-5; EN 61000-4-5; KN 61000-4-5;
KS C 9610-4-5;
IEEE C37.90.1 2012; IEEE STD C62.41.2 2002;
ECE Regulation 10.06 Annex 16

Conducted Immunity

IEC 61000-4-6 (1996) + A1(2000);
IEC 61000-4-6, Ed 2.0 (2006-05);
IEC 61000-4-6 Ed. 3.0 (2008);
KN 61000-4-6 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
EN 61000-4-6 (1996) + A1(2001); IEC 61000-4-6;
EN 61000-4-6; KN 61000-4-6; KS C 9610-4-6

Power Frequency Magnetic Field
Immunity (*Down to 3 A/m*)

IEC 61000-4-8 (1993) + A1(2000); IEC 61000-4-8 (2009);
EN 61000-4-8 (1994) + A1(2000);
KN 61000-4-8 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
IEC 61000-4-8; EN 61000-4-8; KN 61000-4-8; KS C 9610-4-8

Voltage Dips, Short Interrupts, and Line
Voltage Variations

IEC 61000-4-11, Ed. 2 (2004-03);
KN 61000-4-11 (2008-5);
RRL Notice No. 2008-4 (May 20, 2008);
IEC 61000-4-11; EN 61000-4-11; KN 61000-4-11;
KS C 9610-4-11

Ring Wave

IEC 61000-4-12, Ed. 2 (2006-09);
EN 61000-4-12:2006;
IEC 61000-4-12; EN 61000-4-12; KN 61000-4-12;
IEEE STD C62.41.2 2002

Test Technology:

Generic and Product Specific EMC Standards

Test Method(s):

IEC/EN 61000-6-1; AS/NZS 61000-6-1; KN 61000-6-1;
KS C 9610-6-1; IEC/EN 61000-6-2; AS/NZS 61000-6-2;
KN 61000-6-2; KS C 9610-6-2; IEC/EN 61000-6-3;
AS/NZS 61000-6-3; KN 61000-6-3; KS C 9610-6-3;
IEC/EN 61000-6-4; AS/NZS 61000-6-4; KN 61000-6-4;
KS C 9610-6-4; EN 50130-4; EN 61326-1; EN 50121-3-2;
EN 12895; EN 50270; EN 50491-1; EN 50491-2; EN 50491-3;
EN 55015; EN 60730-1; EN 60945; IEC 60533;
EN 61326-2-6; EN 61800-3; IEC/CISPR 14-2; EN 55014-2;
AS/NZS CISPR 14-2; KN 14-2; KS C 9814-2;
IEC/CISPR 24; AS/NZS CISPR 24; EN 55024; KN 24;
IEC/CISPR 35; AS/NZS CISPR 35; EN 55035; KN 35;
KS C 9835; IEC 60601-1-2; JIS T0601-1-2

TxRx EMC Requirements

EN 301 489-1; EN 301 489-3; EN 301 489-9;
EN 301 489-17; EN 301 489-19; EN 301 489-20

European Radio Test Standards

ETSI EN 300 086-1; ETSI EN 300 086-2;
ETSI EN 300 113-1; ETSI EN 300 113-2;
ETSI EN 300 220-1; ETSI EN 300 220-2;
ETSI EN 300 220-3-1; ETSI EN 300 220-3-2;
ETSI EN 300 330-1; ETSI EN 300 330-2;
ETSI EN 300 440-1; ETSI EN 300 440-2;
ETSI EN 300 422-1; ETSI EN 300 422-2;
ETSI EN 300 328; ETSI EN 301 893;
ETSI EN 301 511; ETSI EN 301 908-1;
ETSI EN 908-2; ETSI EN 908-13;
ETSI EN 303 413; ETSI EN 302 502;
EN 303 340; EN 303 345-2; EN 303 345-3; EN 303 345-4

Canadian Radio Tests

RSS-102 measurement (RF Exposure Evaluation);
RSS-102 measurement (Nerve Stimulation);
SPR-002; RSS-111; RSS-112; RSS-117; RSS-119; RSS-123;
RSS-125; RSS-127; RSS-130; RSS-131; RSS-132; RSS-133;
RSS-134; RSS-135; RSS-137; RSS-139; RSS-140; RSS-141;
RSS-142; RSS-170; RSS-181; RSS-182; RSS-191; RSS-192;
RSS-194; RSS-195; RSS-196; RSS-197; RSS-199; RSS-210;
RSS-211; RSS-213; RSS-215; RSS-216; RSS-220; RSS-222;
RSS-236; RSS-238; RSS-243; RSS-244; RSS-247; RSS-248;
RSS-251; RSS-252; RSS-287; RSS-288; RSS-310; RSS-GEN

Mexico Radio Tests

IFT-008-2015; NOM-208-SCFI-2016

Japan Radio Tests

Radio Law No. 131, Ordinance of MPT No. 37, 1981,
MIC Notification No. 88:2004, Table No. 22-11;
ARIB STD-T66, Regulation 18

Taiwan Radio Tests

LP-0002 (July 15, 2020)

Test Technology:
Test Method(s):
Australia/New Zealand Radio Tests

AS/NZS 4268; Radiocommunications (Short Range Devices) Standard (2014)

Hong Kong Radio Tests

HKCA 1039 Issue 6;
HKCA 1042;
HKCA 1033 Issue 7;
HKCA 1061;
HKCA 1008;
HKCA 1043;
HKCA 1057;
HKCA 1073

Korean Radio Test Standards

KN 301 489-1; KN 301 489-3; KN 301 489-9;
KN 301 489-17; KN 301 489-52; KS X 3124; KS X 3125;
KS X 3130; KS X 3126; KS X 3129

Vietnam Radio Test Standards

QCVN 47:2015/BTTTT; QCVN 54:2020/BTTTT;
QCVN 55:2011/BTTTT; QCVN 65:2013/BTTTT;
QCVN 73:2013/BTTTT; QCVN 74:2020/BTTTT;
QCVN 112:2017/BTTTT; QCVN 117:2020/BTTTT

Vietnam EMC Test Standards

QCVN 18:2014/BTTTT; QCVN 86:2019/BTTTT;
QCVN 96:2015/BTTTT; QCVN 118:2018/BTTTT

*Unlicensed Radio Frequency Devices
(3 Meter Semi-Anechoic Room)*

47 CFR FCC Part 15C, 15D, 15E, 15F, 15G, 15H
(using ANSI C63.10:2013, ANSI C63.17:2013 and
FCC KDB 905462 D02 (v02))

Licensed Radio Service Equipment

47 CFR FCC Parts 20, 22, 24, 25, 27, 30, 73, 74, 80, 87,
90, 95, 96, 97, 101 (using ANSI/TIA-603-E,
TIA-102.CAAA-E, ANSI C63.26:2015)

OIA (Over the Air) Performance

GSM, GPRS, EGPRS
UMTS (W-CDMA)
LTE including CAT M1
A-GPS for UMTS/GSM
LTS A-GPS, A-GLONASS,
SIB8/SIB16
Large Device/Laptop/Tablet Testing
Integrated Device Testing
WiFi 802.11 a/b/g/n/a

CTIA Test Plan for Wireless Device Over-the-Air
Performance (Method for Measurement for Radiated Power
and Receiver Performance) V3.8.2;
CTIA Test Plan for RF Performance Evaluation of WiFi
Mobile Converged Devices V2.1.0

Test Technology:
Test Method(s)¹:
Electrical Measurements and Simulation
AC Voltage / Current

(1mV to 5kV) 60 Hz
(0.1V to 250V) up to 500 MHz
(1μA to 150A) 60 Hz

FAA AC 150/5345-10H;
FAA AC 150/5345-43J;
FAA AC 150/5345-44K;
FAA AC 150/5345-46E;
FAA AC 150/5345-47C;
FAA EB 67D

DC Voltage / Current

(1mV to 15 kV) / (1μA to 10A)

Power Factor / Efficiency / Crest Factor

(Power to 30kW)

Resistance

(1mΩ to 4000MΩ)

Surge

(Up to 10 kV / 5 kA) (Combination
Wave and Ring Wave)

On the following products and materials:

Telecommunications Terminal Equipment (TTE), Radio Equipment, Network Equipment, Information Technology Equipment (ITE), Automotive Electronic Equipment, Automotive Hybrid Electronic Devices, Maritime Navigation and Radio Communication Equipment and Systems, Vehicles, Boats and Internal Combustion Engine Driven Devices, Automotive, Aviation, and General Lighting Products, Medical Electrical Equipment, Motors, Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment, Household Appliances, Electric Tools, Low-voltage Switchgear and Control gear, Programmable Controllers, Electrical Equipment for Measurement, Control and Laboratory Use, Base Materials, Power and Data Transmission Cables and Connectors

¹ When the date, edition, version, etc. is not identified in the scope of accreditation, laboratories may use the version that immediately precedes the current version for a period of one year from the date of publication of the standard measurement method, per part C., Section 1 of A2LA R101 - General Requirements - Accreditation of ISO-IEC 17025 Laboratories.

Testing Activities Performed in Support of FCC Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1²

| Rule Subpart/Technology | Test Method | Maximum Frequency (MHz) |
|---|--------------------------|-------------------------|
| <u>Unintentional Radiators</u> | | |
| Part 15B | ANSI C63.4:2014 | 40000 |
| <u>Industrial, Scientific, and Medical Equipment</u> | | |
| Part 18 | FCC MP-5 (February 1986) | 40000 |
| <u>Intentional Radiators</u> | | |
| Part 15C | ANSI C63.10:2013 | 40000 |

Testing Activities Performed in Support of FCC Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1²

| Rule Subpart/Technology | Test Method | Maximum Frequency (MHz) |
|---|--|-------------------------|
| <u>Unlicensed Personal Communication Systems Devices</u> Part 15D | ANSI C63.17:2013 | 40000 |
| <u>U-NII without DFS Intentional Radiators</u> Part 15E | ANSI C63.10:2013 | 40000 |
| <u>U-NII with DFS Intentional Radiators</u> Part 15E | FCC KDB 905462 D02 (v02) | 40000 |
| <u>UWB Intentional Radiators</u> Part 15F | ANSI C63.10:2013 | 40000 |
| <u>BPL Intentional Radiators</u> Part 15G | ANSI C63.10:2013 | 40000 |
| <u>White Space Device Intentional Radiators</u> Part 15H | ANSI C63.10:2013 | 40000 |
| <u>Commercial Mobile Services (FCC Licensed Radio Service Equipment)</u> Parts 22 (cellular), 24, 25 (below 3 GHz), and 27 | ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015 | 40000 |
| <u>General Mobile Radio Services (FCC Licensed Radio Service Equipment)</u> Parts 22 (non-cellular), 90 (below 3 GHz), 95, 97, and 101 (below 3 GHz) | ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015 | 40000 |
| <u>Citizens Broadband Radio Services (FCC Licensed Radio Service Equipment)</u> Part 96 | ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015 | 40000 |
| <u>Maritime and Aviation Radio Services</u> Parts 80 and 87 | ANSI/TIA-603-E; ANSI C63.26:2015 | 40000 |
| <u>Microwave and Millimeter Bands Radio Services</u> Parts 25, 30, 74, 90 (above 3 GHz), 97 (above 3 GHz), and 101 | ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015 | 40000 |

Testing Activities Performed in Support of FCC Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1²

| Rule Subpart/Technology | Test Method | Maximum Frequency (MHz) |
|--|--|-------------------------|
| <u>Broadcast Radio Services</u> Parts 73 and 74 (below 3 GHz) | ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015 | 40000 |
| <u>Signal Boosters</u> Part 20 (Wideband Consumer Signal Boosters, Provider-specific signal boosters, and Industrial Signal Boosters) Section 90.219 | ANSI C63.26:2015 | 40000 |

² Accreditation does not imply acceptance to the FCC equipment authorization program. Please see the FCC website (<https://apps.fcc.gov/oetcf/eas/>) for a listing of FCC approved laboratories.



Accredited Laboratory

A2LA has accredited

ELITE ELECTRONIC ENGINEERING INC.

Downers Grove, IL

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 15th day of August 2023.



Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1786.01
Valid to June 30, 2025

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.