Engineering Test Report No. 2100734-01 Rev. B		
Report Date	April 13-14, 2021	
Manufacturer Name	Badger Meter	
Manufacturer Address	4545 W. Brown Deer Road Milwaukee, WI 53223	
Model No.	Orion Cellular Endpoint LTE-M	
Date Received	April 13, 2021	
Test Dates	April 13-14, 2021	
Specifications	FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247 FCC “Code of Federal Regulations” Title 47, Part15, Subpart 15B Innovation, Science, and Economic Development Canada, RSS-247 Innovation, Science, and Economic Development Canada, RSS-GEN	
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	MARK E. LONGINOTTI	
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Signature	RICHARD E. KING	
Approved by	For Raymond J. Klouda, Registered Professional Engineer of Illinois – 44894	
PO Number	405610	

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1. Report Revision History

Revision	Date	Description
–	June 8, 2021	Initial Release of Engineering Test Report No. 2100734-01
A	July 1, 2021	- Updated Engineering Test Report N0. 2100734-01 to 2100734-01 Rev. A throughout report. - Corrected the test dates on the cover page from October 20-21, 2020 to April 13-14, 2021.
B	July 21, 2021 By Rick King	- Updated the Test Report No. 2100734-01 Rev. A to 2100734-01 Rev. B throughout report. Corrected the output power reading to the remeasured value throughout report. - Section 8: Removed the power setting to 16 dBm from table.

2. Introduction

2.1. Scope of Tests

This document presents the results of a series of RF emissions tests that were performed on the Badger Meter Water Meter Transceiver (hereinafter referred to as the Equipment Under Test (EUT)). The EUTs were manufactured and submitted for testing by Badger Meter located in Milwaukee, WI.

2.2. Purpose

The test series was performed to determine if the EUTs meet the RF emission requirements for a class II permissive change to FCC “Code of Federal Regulations” Title 47, Part15, Subpart C, Sections 15.247 for a Frequency Hopping Spread Spectrum intentional radiator operating within the 902-928MHz band.

The test series was also performed to determine if the EUTs meet the RF emission requirements for a class II permissive change to Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-Gen and Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-247 for a Frequency Hopping Spread Spectrum intentional radiator operating within the 902-928MHz band.

Testing was performed in accordance with ANSI C63.10-2013 and ANSI C63-4-2014.

2.3. Identification of the EUT

The EUTs are identified as follows:

EUT Identification	
Product Description	Water Meter
Model/Part No.	Orion Cellular Endpoint LTE-M
S/N	120002016
Device Type	Frequency Hopping Transmission Device
Band of Operation	902-928MHz
Modulation Type	FHSS
Software/Firmware Version	0.2.94
Radiated EIRP Output Power	10mW (10dBm)
Rated Output Power	N/A
Antenna Type	SMD, Lucida Part No. SR4L002
Manufacturer Supplied* Antenna Gain (dBi)	-2
20dB Bandwidth	319.7kHz
Occupied Bandwidth (99% CBW)	268.73kHz
Size of EUT	12.5cm x 5cm x 4.5cm
Product Description	Water Meter
Model/Part No.	Orion Cellular Endpoint LTE-M
S/N	130000005
Device Type	Frequency Hopping Transmission Device
Band of Operation	902-928MHz
Modulation Type	FHSS
Software/Firmware Version	0.2.94
Conducted Output Power	N/A
Antenna Type	SMD, Lucida Part No. SR4L002
Antenna Gain (dBi)	-2
Rated Output Power	26.3mW (14.2dBm)
Size of EUT	12.5cm x 5cm x 4.5cm

Serial No. 130000005 was used for duty cycle measurements for the spurious radiated emissions tests. Serial No. 120002016 was used for all other tests.

3. Power Input

The EUTs normally obtain 3.6VDC from an internal Tadiran Lithium Inorganic Battery. For testing purposes, the EUTs were powered with 3.65VDC from an external power supply via 2 wires.

4. Grounding

The EUTs were not connected to ground.

5. Support Equipment

The EUTs were submitted for testing along with the following support equipment:

Description	Model #
Dell Laptop Computer	Latitude E5540
USB to IR Dongle	ACT-IR224UN-L+

The laptop computer and the USB to IR dongle were used to program the device. For all radiated emissions tests, they were removed from the test chamber prior to test.

6. Interconnect Leads

No interconnect leads were used during the tests.

7. Modifications Made to the EUT

No modifications were made to the EUTs during the testing.

8. Modes of Operation

The EUTs and all peripheral equipment were energized. The units were programmed to transmit in one of the following modes:

Mode	Description
904.94MHz	
914.1MHz	
923.79MHz	
Hopping Enabled	

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, Part 15, Subpart C
- Federal Communications Commission “Code of Federal Regulations”, Title 47, Part 15, Subpart B
- 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 9kHz to 40 GHz”
- ANSI C63.10-2013, “American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices”
- Federal Communications Commission Office of Engineering and Technology Laboratory Division,

Guidance For Compliance Measurements On Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 April 2, 2019 KDB 558074 D01v05r02

- RSS-247 Issue 2, February 2017, “Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices”
- RSS-Gen Issue 5, March 2019, Amendment 1, Innovation, Science, and Economic Development Canada, “Spectrum Management and Telecommunications, Radio Standards Specification, General Requirements for Compliance of Radio Apparatus”
- Federal Communications Commission “Code of Federal Regulations”, Title 47, Part 2, Subpart J
- ANSI C63.26-2015, “American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services”
- 96369 D04 Module Integration Guide v02, October 13, 2020

10. Test Plan

No test plan was provided. Instructions were provided by personnel from Badger Meter and used in conjunction with the FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247, Innovation, Science, and Economic Development Canada, RSS-247, and ANSI C63.10-2014 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

Ambient Parameters	Value
Temperature	22°C
Relative Humidity	22%
Atmospheric Pressure	1014mb

13. Summary

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

Test Description	Requirements	Test Methods	S/N	Results
Effective Isotropic Radiated Power (EIRP)	FCC 15C 15.247 ISED RSS-247	ANSI C63.10: 2013	120002016	Conforms
Duty Cycle Factor Measurements	FCC 15C 15.247 ISED RSS-247	ANSI C63.10: 2013	130000005	—
Case Spurious Radiated Emissions	FCC 15C 15.247 ISED RSS-247	ANSI C63.10: 2013	120002016	Conforms
Module Integration spot frequency case spurious	FCC 24	ANSI C63.26: 2015	120002016	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).

Formula 1: VL (dBuV) = MTR (dBuV) + 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.

Formula 1: FS (dBuV/m) = MTR (dBuV) + AF (dB/m) + CF (dB) + (- PA (dB)) + DC (dB)

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

Formula 2: FS (uV/m) = AntiLog [(FS (dBuV/m))/20]

15. Statement of Conformity

The Badger Meter Water Meter Transceiver, Model No. Orion Cellular Endpoint LTE-M, did fully conform to the selected requirements of FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.247, Innovation, Science, and Economic Development Canada, RSS-247, and FCC “Code of Federal Regulations” Title 47 Part 15, Subpart B, Section 15.109.

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 C, Section 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 test specifications. The data presented in this test report pertains to the EUTs on the test date specified. Any electrical or mechanical modifications made to the EUTs subsequent to the specified test date will serve to invalidate the data and void this certification.

17. Photographs of EUT

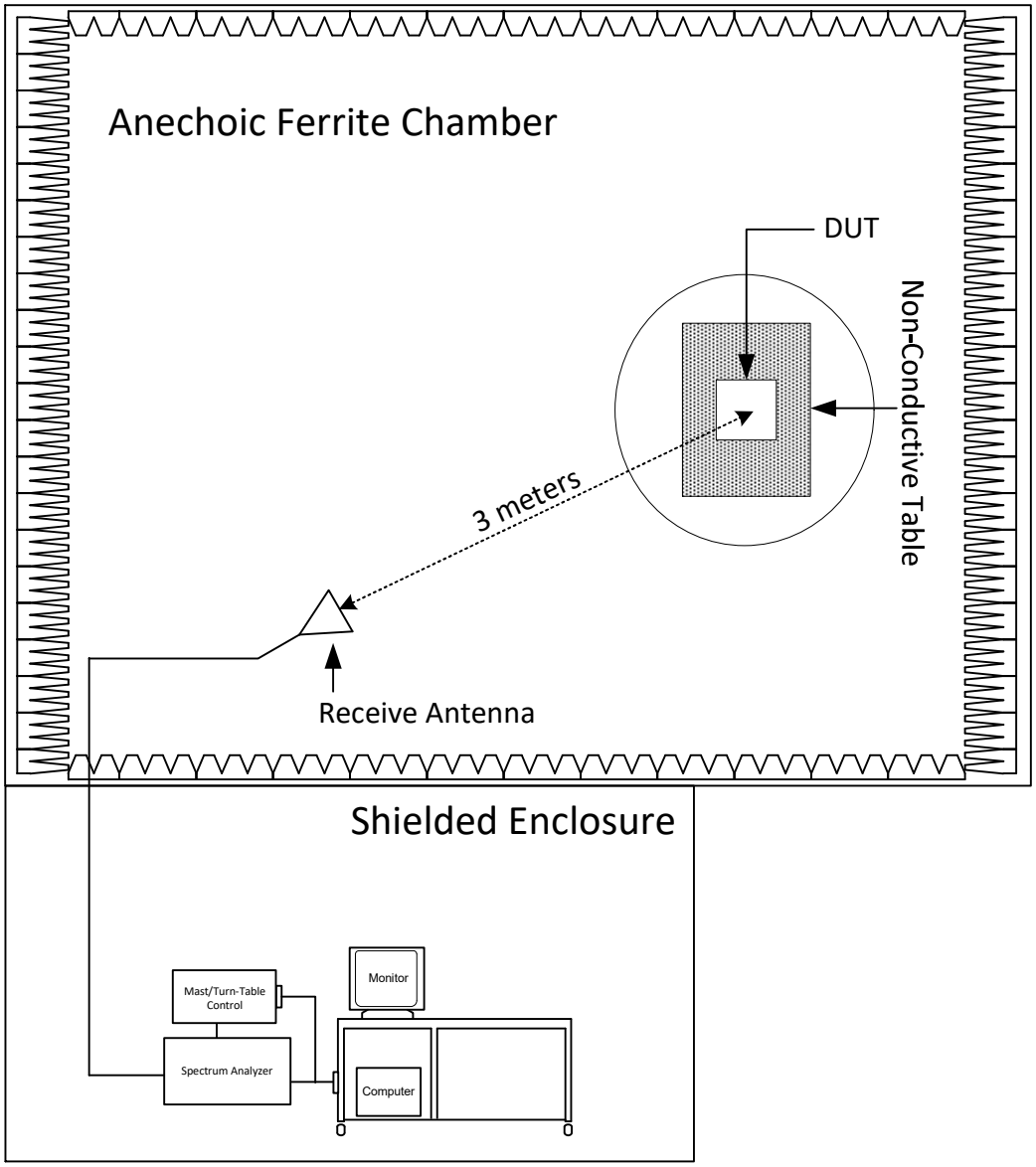
18. Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW3	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10-12	PL2924	1GHZ-20GHZ	3/11/2021	3/11/2022
CDZ4	LAB WORKSTATION	ELITE	LWS-10		WINDOWS 10	CNR	
NTA3	BILOG ANTENNA	TESEQ	6112D	32853	25-1000MHz	10/20/2020	10/20/2021
NWQ2	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS LINDGREN	3117	66659	1GHZ-18GHZ	4/7/2020	4/7/2022
R21F	3M ANECHOIC CHAMBER NSA	EMC TEST SYSTEMS	3M ANECHOIC		30MHZ-18GHZ	3/14/2021	3/14/2022
RBG2	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101591	2HZ-44GHZ	3/11/2021	3/11/2022
XPQ7	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T10000-0	5	1.8-10GHZ	2/3/2021	2/3/2023
XPR0	HIGH PASS FILTER	K&L MICROWAVE	11SH10-4800/X20000	001	4.8-20GHZ	9/6/2019	9/6/2021

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. Effective Isotropic Radiated Power (EIRP)

Test Information	
Manufacturer	Badger Meter
Product	Water Meter Transceiver
Model	Orion Cellular Endpoint LTE-M
Serial No	120002016
Mode	Transmit at 904.94MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support	N/A
Measurement Method	Radiated
Type of Test Site	Semi-Anechoic Chamber
Type of Antennas Used	Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-ridged waveguide (or equivalent) NA
Notes	None

Requirements
<u>FOR FREQUENCY HOPPING SYSTEMS IN THE 902-928 MHz, CHANNELS < 50</u> The output power shall not exceed 1W (30dBm).

Procedures
The EUT was placed on an 80cm high, non-conductive stand and set to transmit. A bilog antenna was placed at a test distance of 3 meters from the EUT. The resolution bandwidth (RBW) of the spectrum analyzer was set to greater than the 20dB bandwidth. The span was set to approximately 5 times the 20 dB bandwidth. 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 hopping frequencies. 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 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, as required. The peak power output was calculated for low, middle, and high hopping frequencies.

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

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 904.94MHz
Parameters	EIRP = 7.58mW (8.8dBm)
Notes	None

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
904.94	H	73.8	2.7	2.2	1.6	3.2	30.0	-26.8
904.94	V	76.8	8.3	2.2	1.6	8.8	30.0	-21.2

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 914.1MHz
Parameters	EIRP = 10.0mW (10dBm)
Notes	None

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
914.10	H	70.9	0.9	2.2	1.6	1.4	30.0	-28.6
914.10	V	77.2	9.5	2.2	1.6	10.0	30.0	-20.0

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 923.79MHz
Parameters	EIRP = 9.9mW (9.9dBm)
Notes	None

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
923.79	H	74.5	5.5	2.2	1.7	6.0	30.0	-24.0
923.79	V	77.9	9.4	2.2	1.7	9.9	30.0	-20.1

21. Duty Cycle Factor Measurements

Test Information	
Manufacturer	Badger Meter
Product	Water Meter Transceiver
Model	Orion Cellular Endpoint LTE-M
Serial No	130000005
Mode	Transmit at 904.94MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support	N/A
Measurement Method	Antenna Conducted
Notes	None

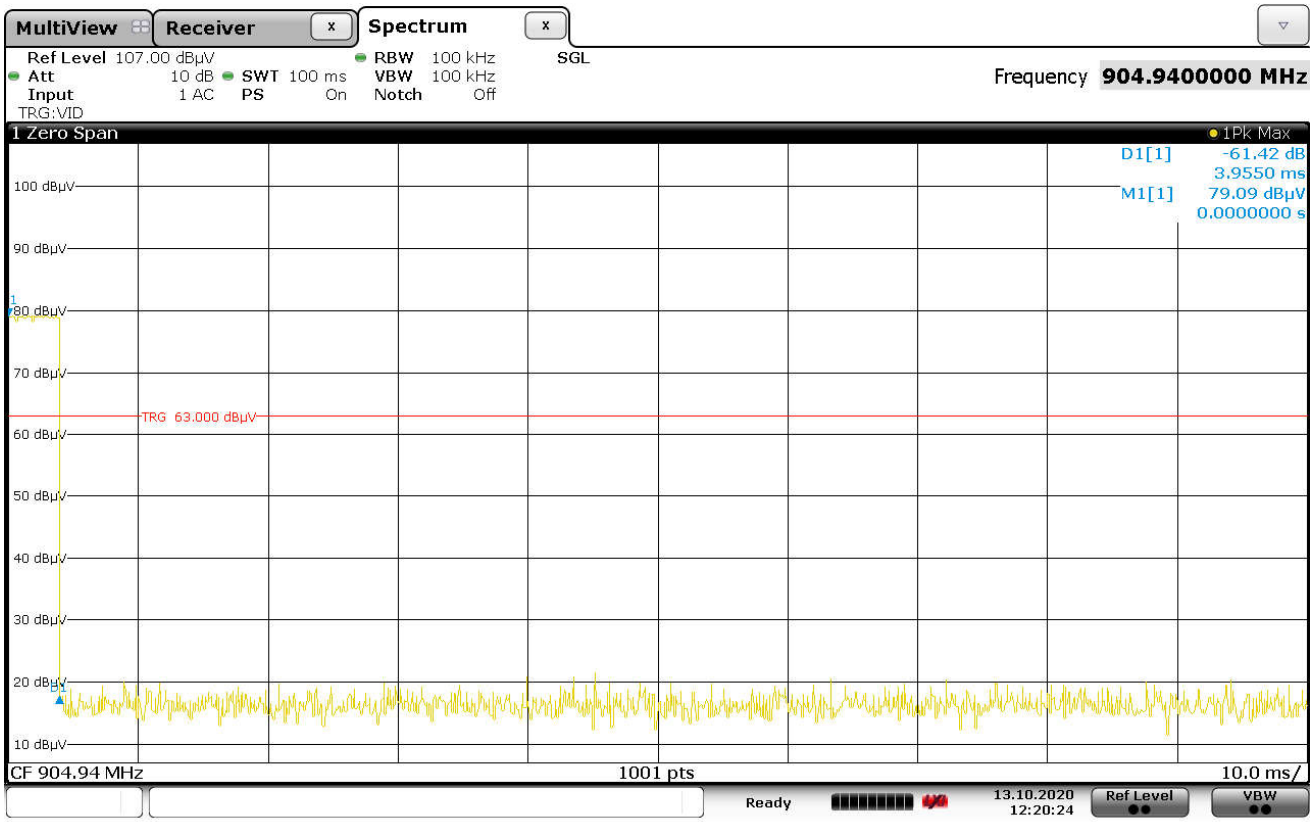
Procedures
The duty cycle factor is used to convert peak detected readings to average readings when pulsed modulation is employed. This factor is computed from the time domain trace of the pulse modulation signal. With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 0.5 msec/div. The amplitude settings are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at the beginning and end of the “on-time”. The trace is recorded. Next the spectrum analyzer center frequency is set to the transmitter frequency with a zero span width and 10msec/div. This shows if the word is longer than 100msec or shorter than 100msec. If the word period is less than 100msec, the display is set to show at least one word. The on-time and off-time are then measured. The on-time is total time signal level exceeds the 4th division. Off-time is time under for the word period. The duty cycle is then computed as the (On-time/ word period) where the word period = (On-time + Off-time).

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

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	130000005
Mode	Transmit at 904.94MHz
Parameters	On-time per pulse = 3.955msec
Notes	None

Date: 13.OCT.2020 12:19:28

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	130000005
Mode	Transmit at 904.94MHz
Parameters	On-time per pulse = 3.955msec; 1 pulse in a 100msec period; Total on time in a 100msec period = 3.995msec
Notes	None



Date: 13.OCT.2020 12:20:25

$$\text{Duty Cycle Factor} = 20\log\left(\frac{On-Time}{100\text{msec}}\right) = -28.06\text{dB}$$

22. Case Spurious Radiated Emissions

Test Information	
Manufacturer	Badger Meter
Product	Water Meter Transceiver
Model	Orion Cellular Endpoint LTE-M
Serial No	120002016
Mode	Transmit at 904.94MHz, Transmit at 914.1MHz, Transmit at 923.79MHz

Test Setup Details	
Setup Format	Tabletop
Height of Support	N/A
Measurement Method	Radiated
Type of Test Site	Semi-Anechoic Chamber
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

Procedures

Radiated measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. 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.

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 10.0GHz was investigated using a peak detector function.

The final open field emission tests were then manually performed over the frequency range of 30MHz to 10.0GHz.

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 bilog 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 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 1.5m high 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 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 20 dB 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 1 GHz were measured using a bi-log antenna. The bi-log 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 100 kHz was used on the spectrum analyzer.

b) The field strengths of all emissions above 1 GHz 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 1.5m high non-conductive stand. A peak detector with a resolution bandwidth of 1 MHz 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 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.

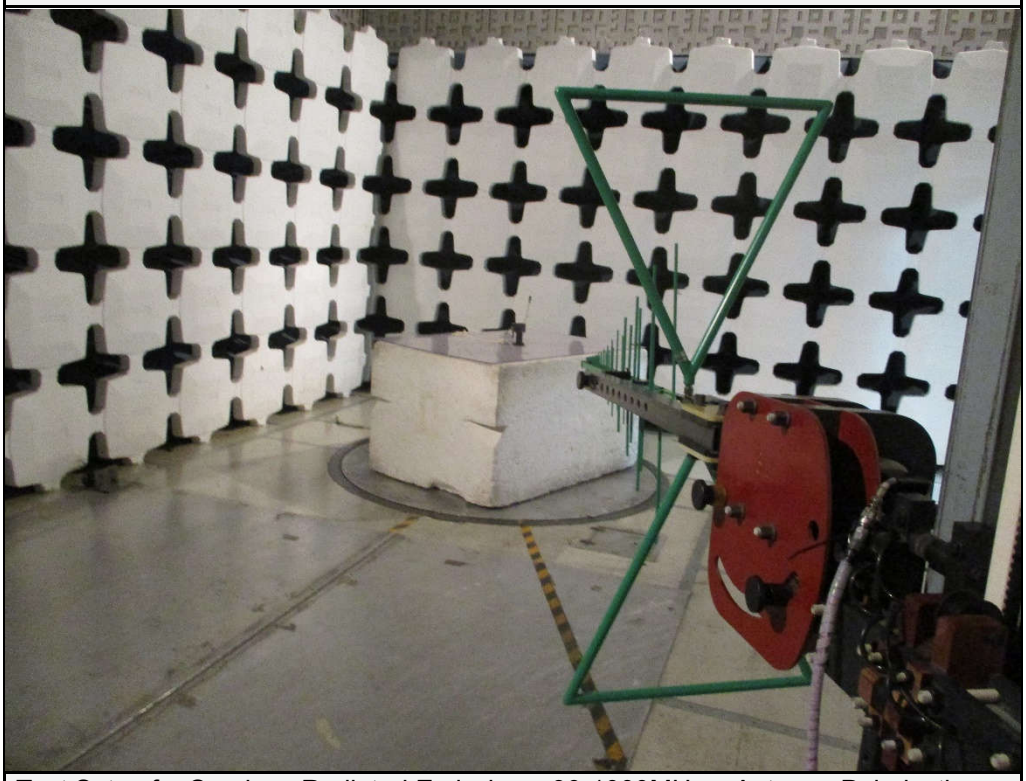
d) For all radiated emissions measurements below 1 GHz, if the peak reading is below the limits listed in 15.209(a), no further measurements are required. If however, the peak readings exceed the limits listed in 15.209(a), then the emissions are remeasured using a quasi-peak detector.

e) For all radiated emissions measurements above 1 GHz, 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 20 dB above the maximum permitted average emission limit applicable to the equipment

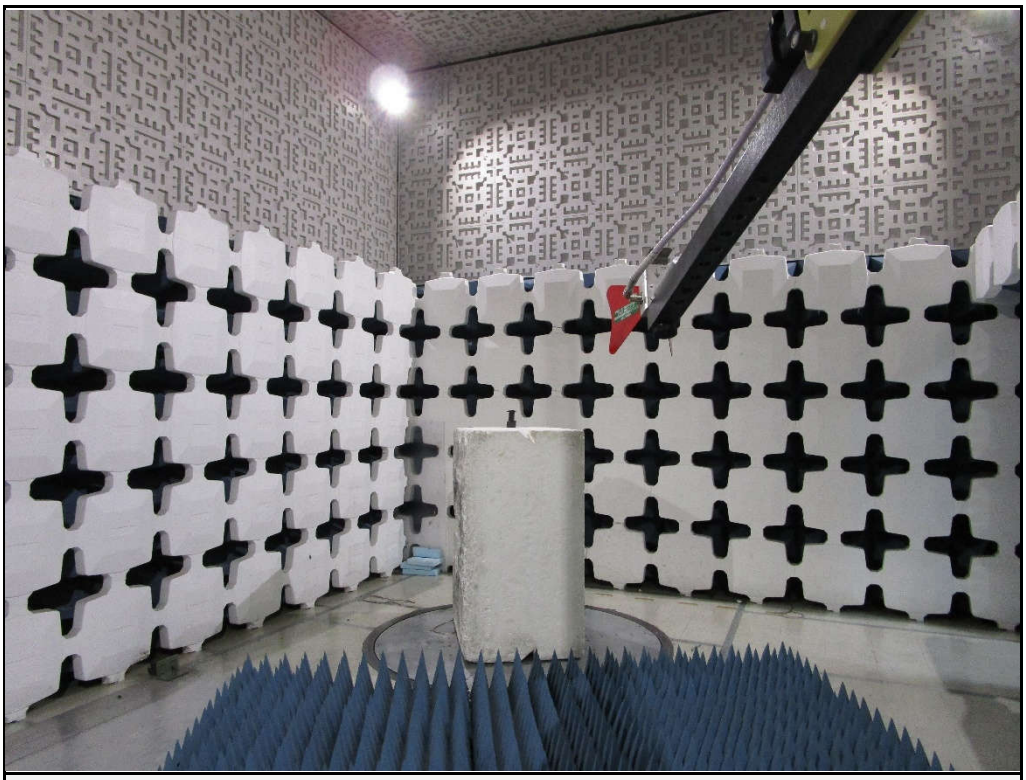
under test. Therefore, all peak readings above 1 GHz must be no greater than 20 dB above the limits specified in 15.209(a).

If the dwell time per channel of the hopping signal is less than 100msec, then the reading obtained with the 10 Hz video bandwidth may be further adjusted by a “duty cycle correction factor”, derived from 20*log(dwell time/100msec). These readings must be no greater than the limits specified in 15.209(a).

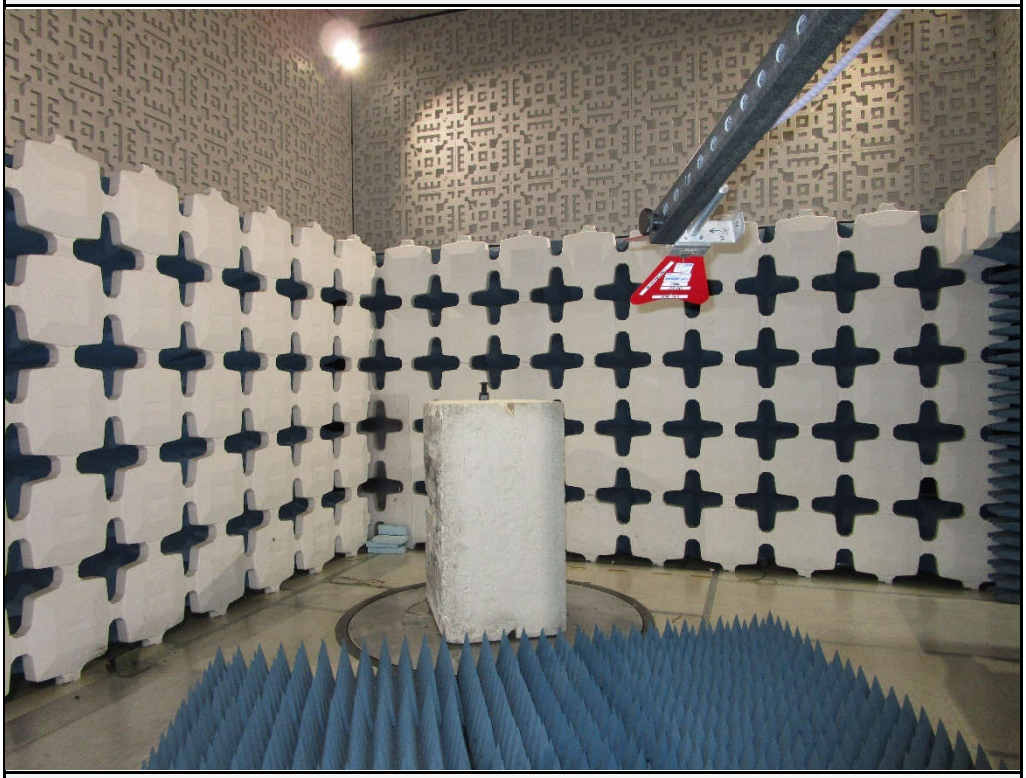
Test Setup for Spurious Radiated Emissions, 30-1000MHz – Antenna Polarization Horizontal



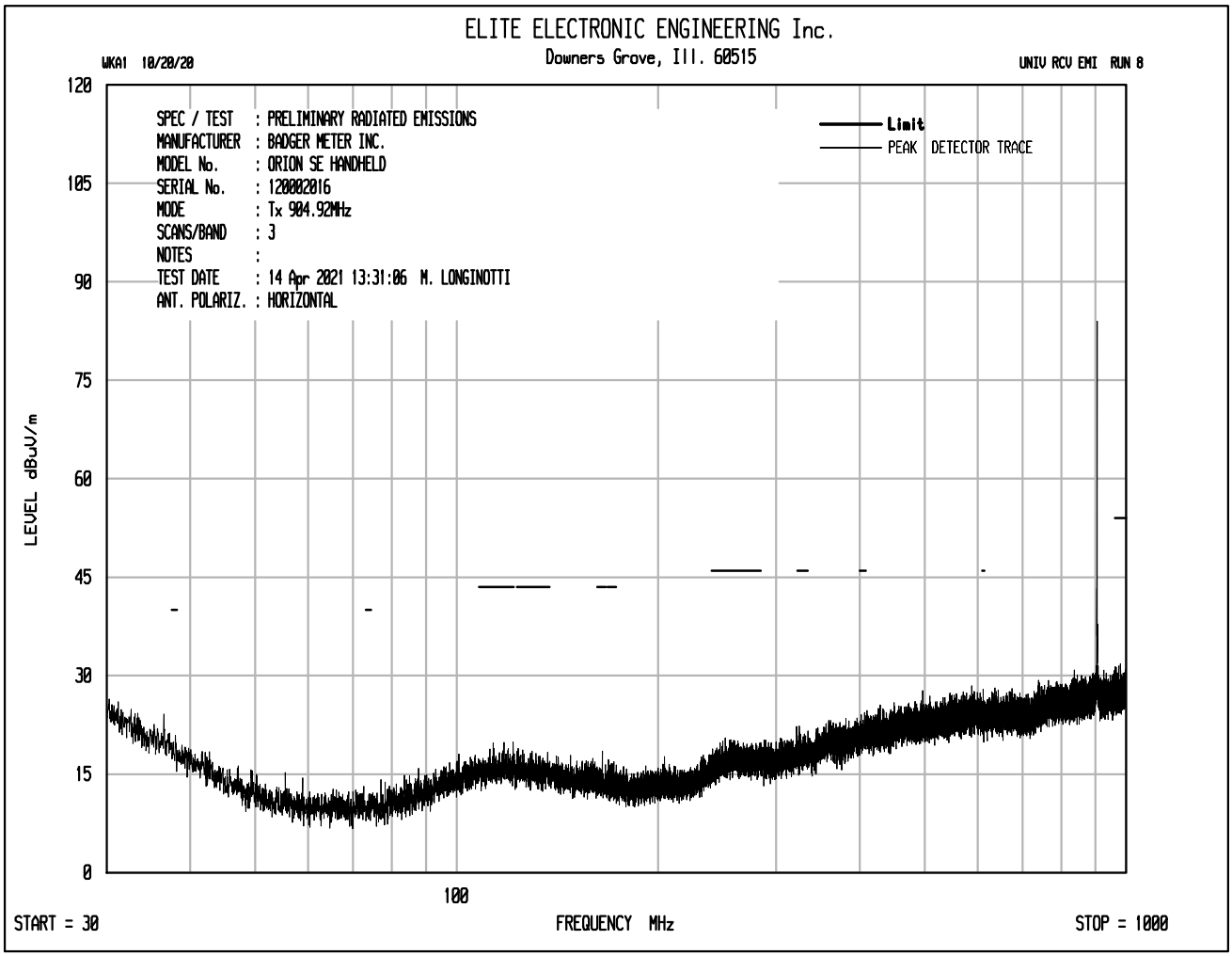
Test Setup for Spurious Radiated Emissions, 30-1000MHz – Antenna Polarization Vertical

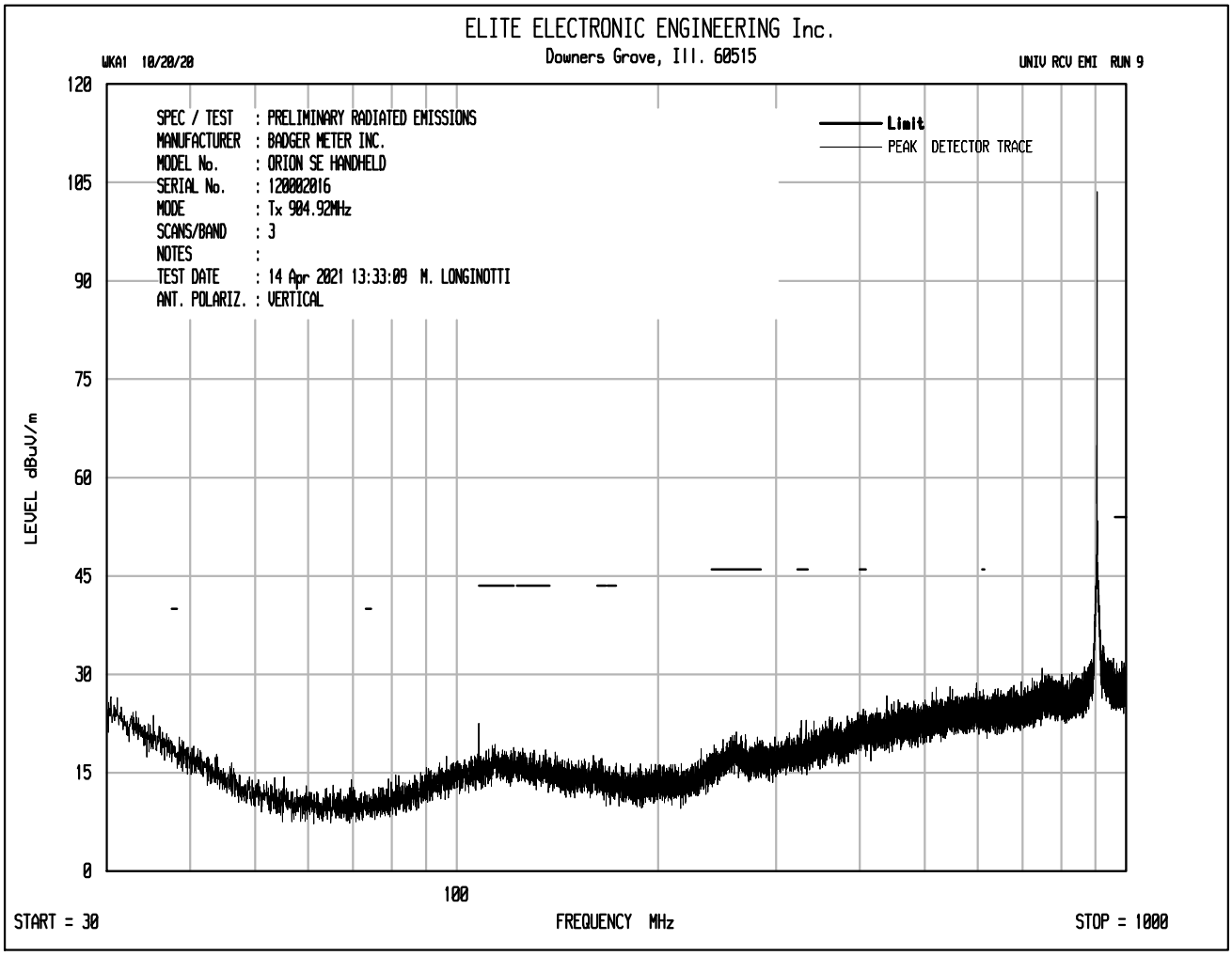


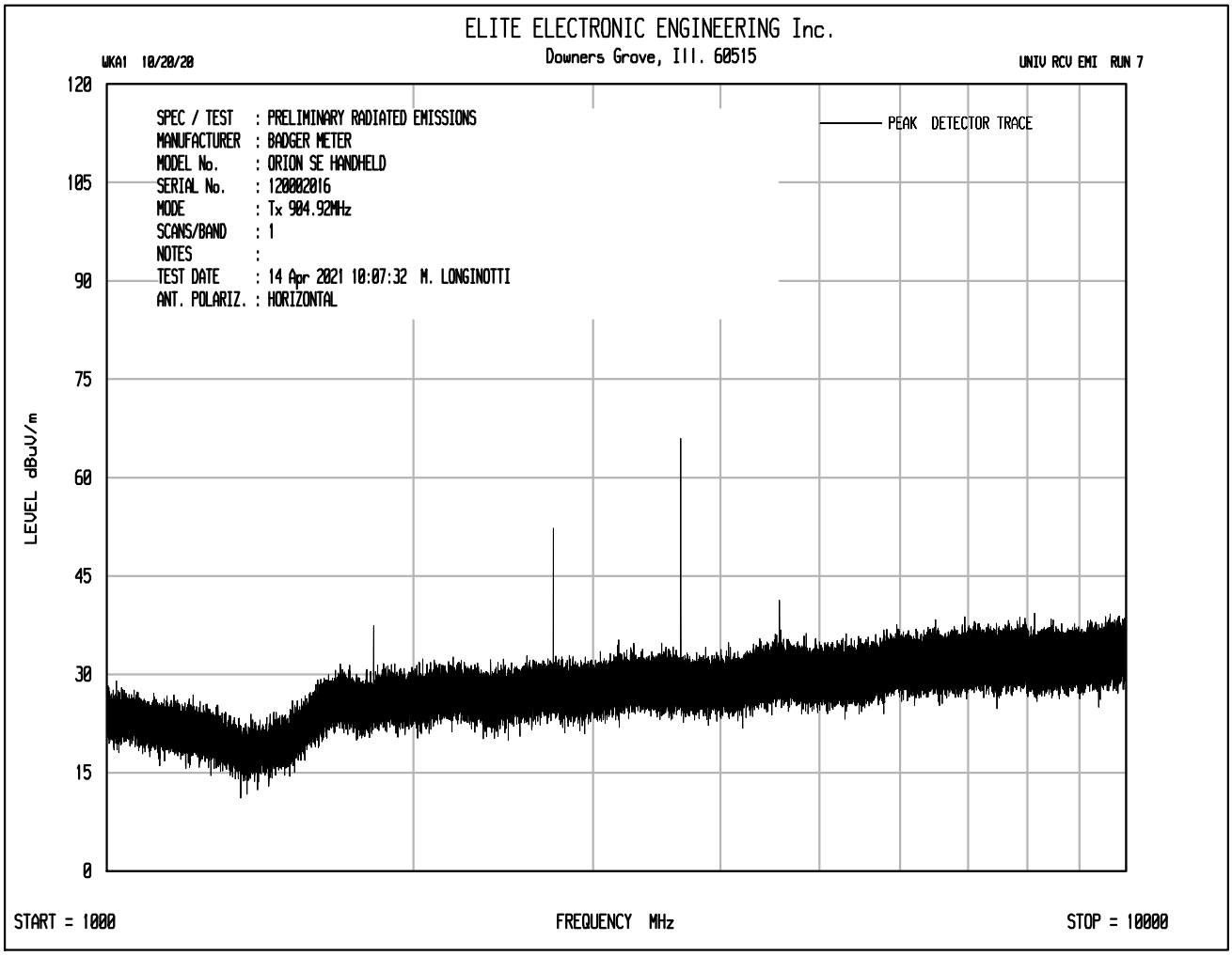
Test Setup for Spurious Radiated Emissions, Above 1GHz – Antenna Polarization Horizontal

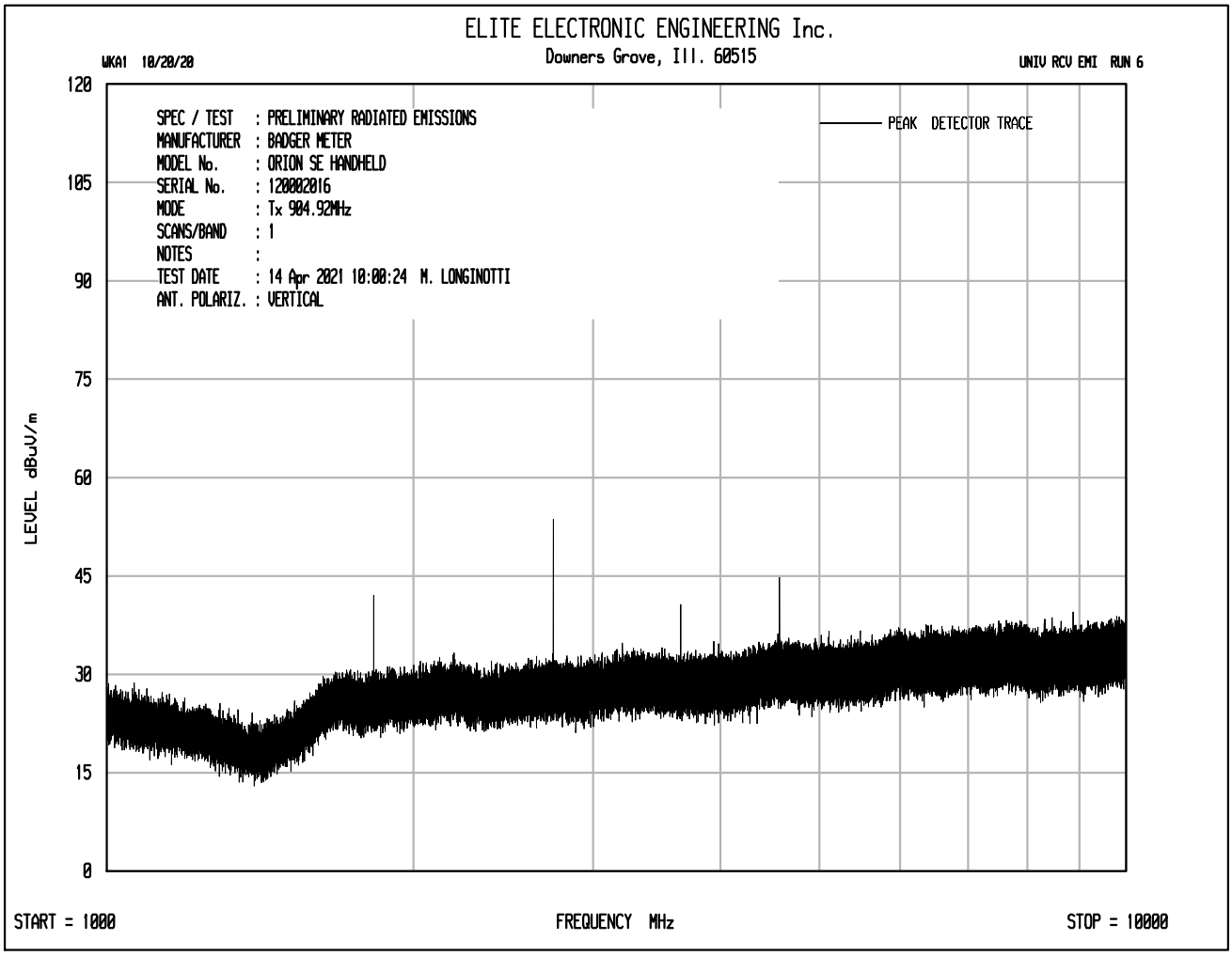


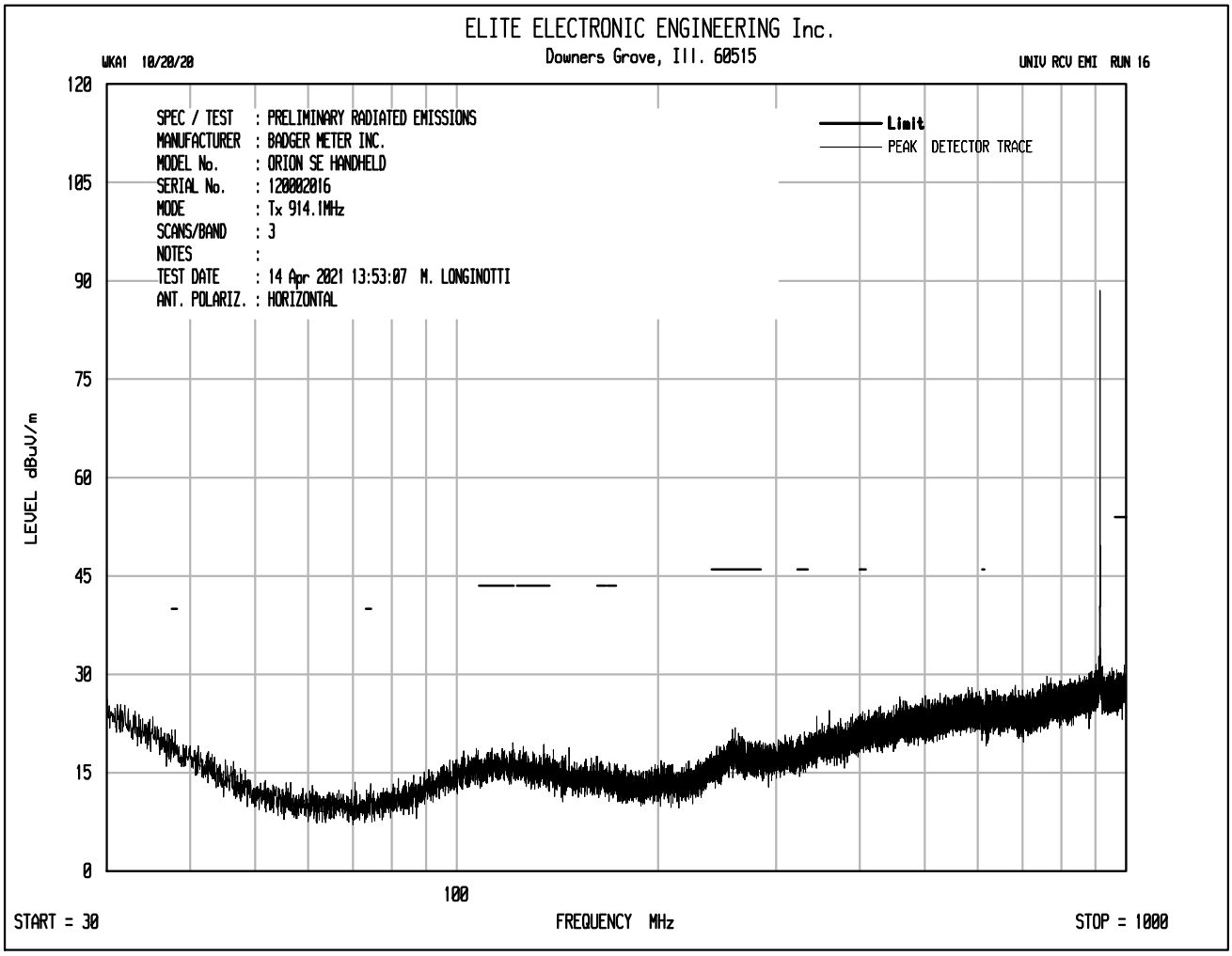
Test Setup for Spurious Radiated Emissions, Above 1GHz – Antenna Polarization Vertical

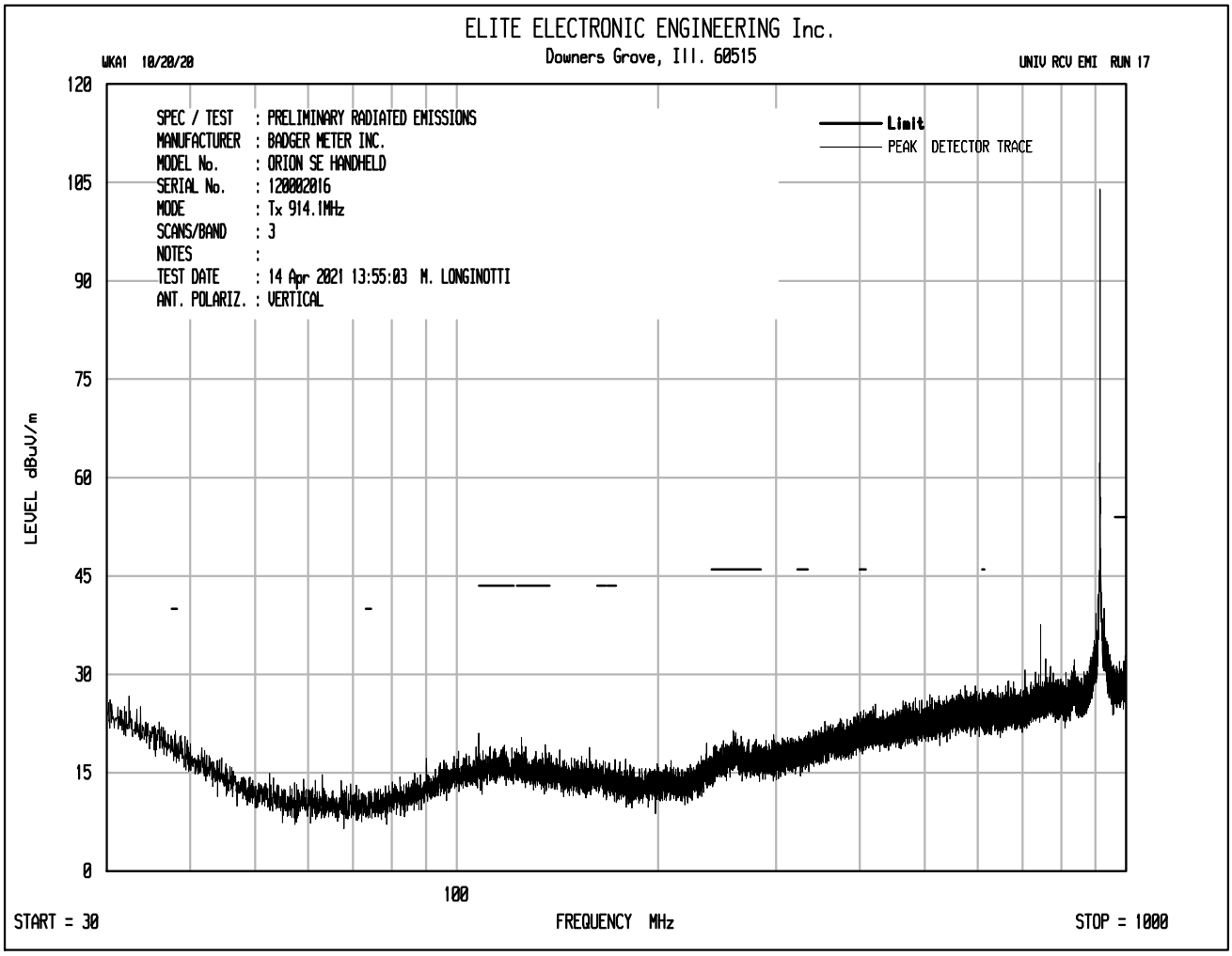

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 8
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 904.92MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 13:31:06 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000

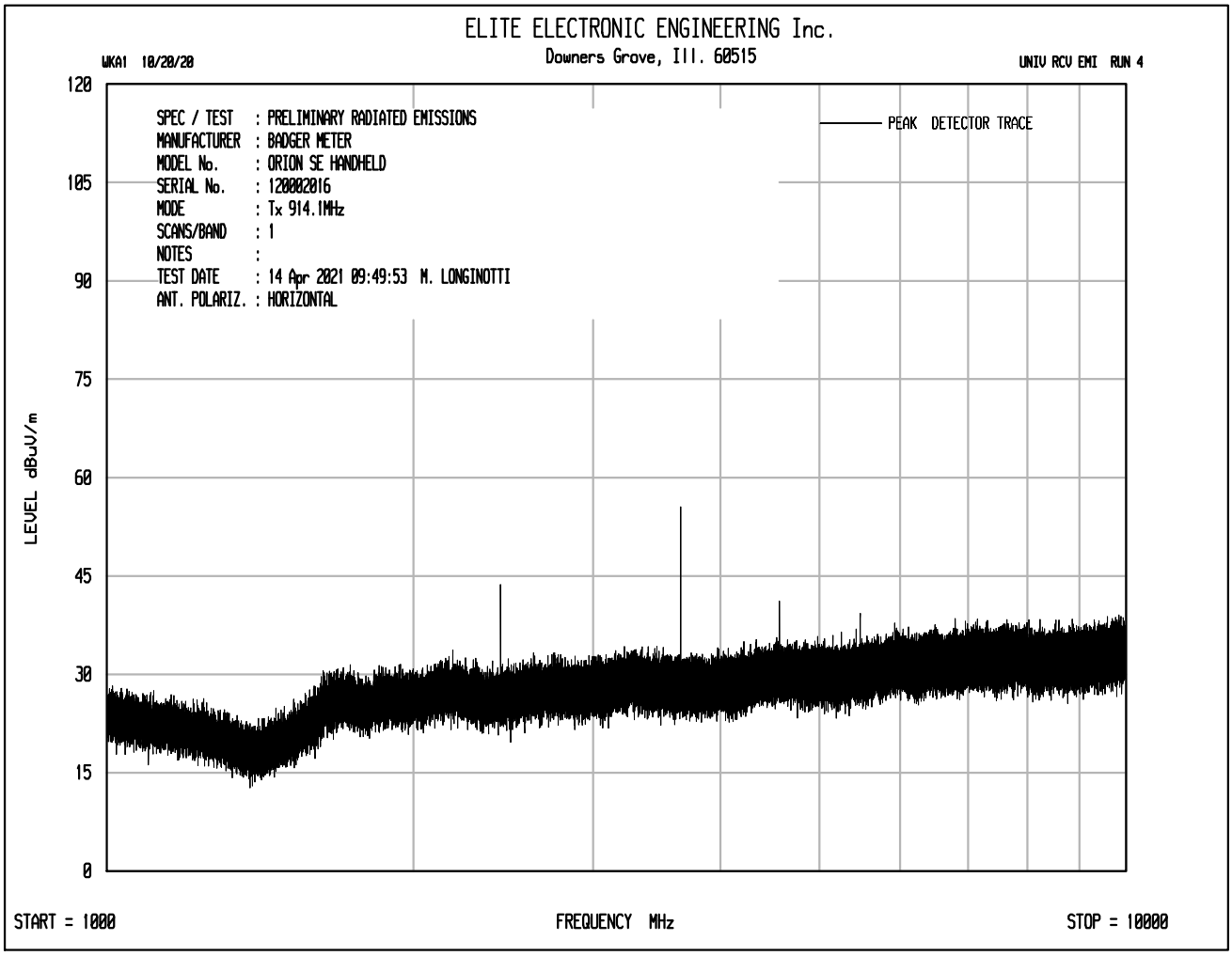

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 9
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 904.92MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 13:33:09 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000

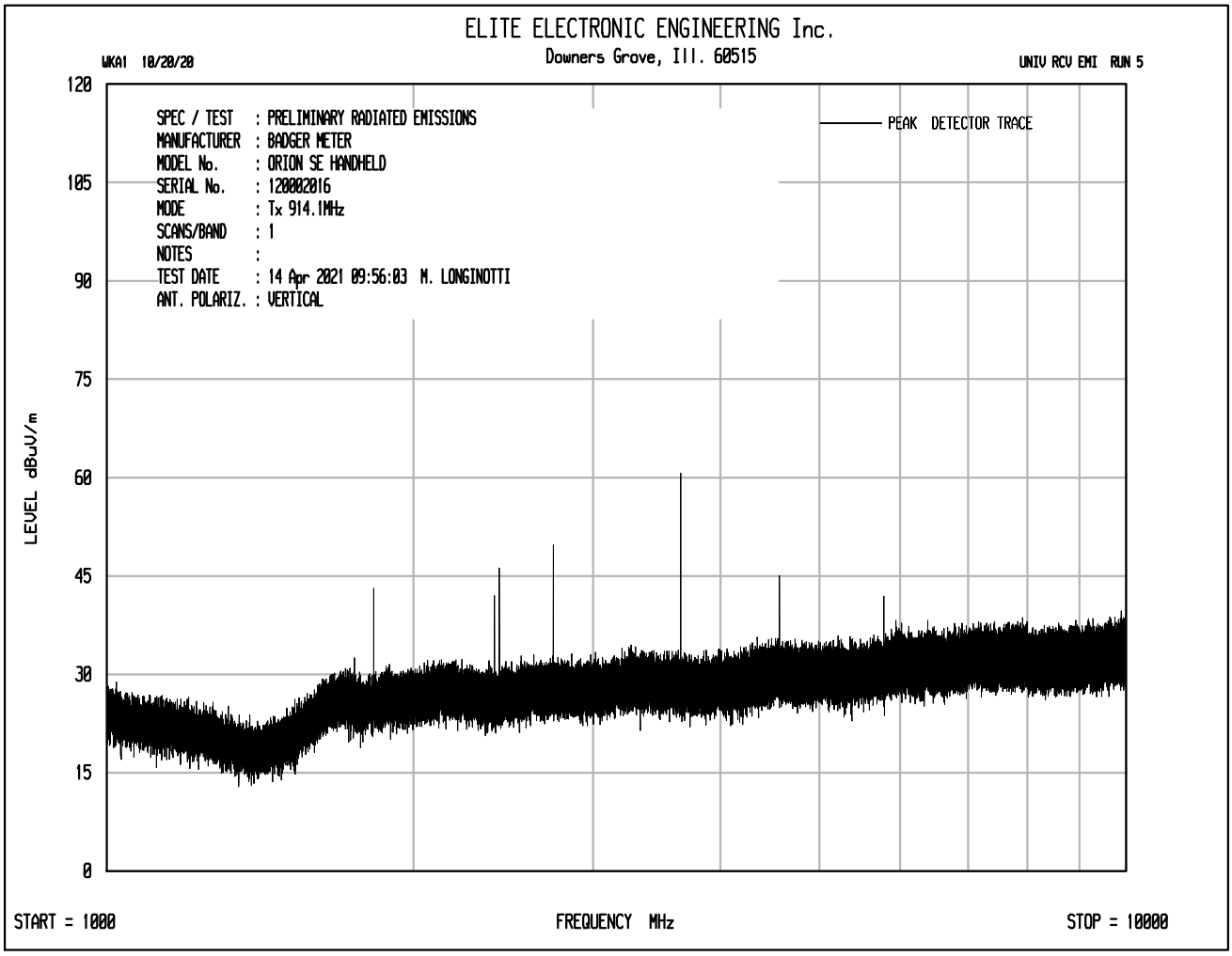

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 7
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 904.92MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 10:07:32 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000

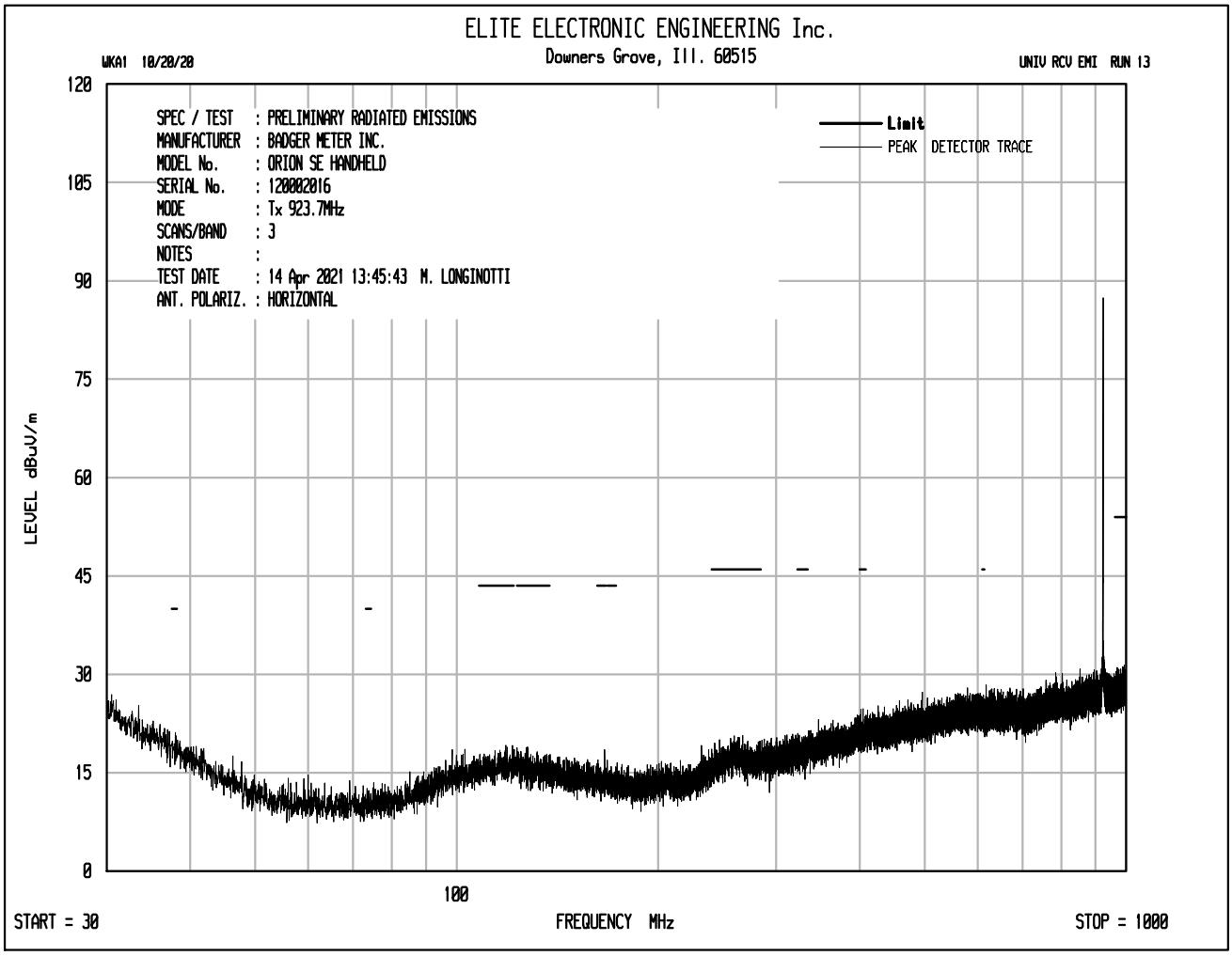

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 6
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 904.92MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 10:00:24 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000

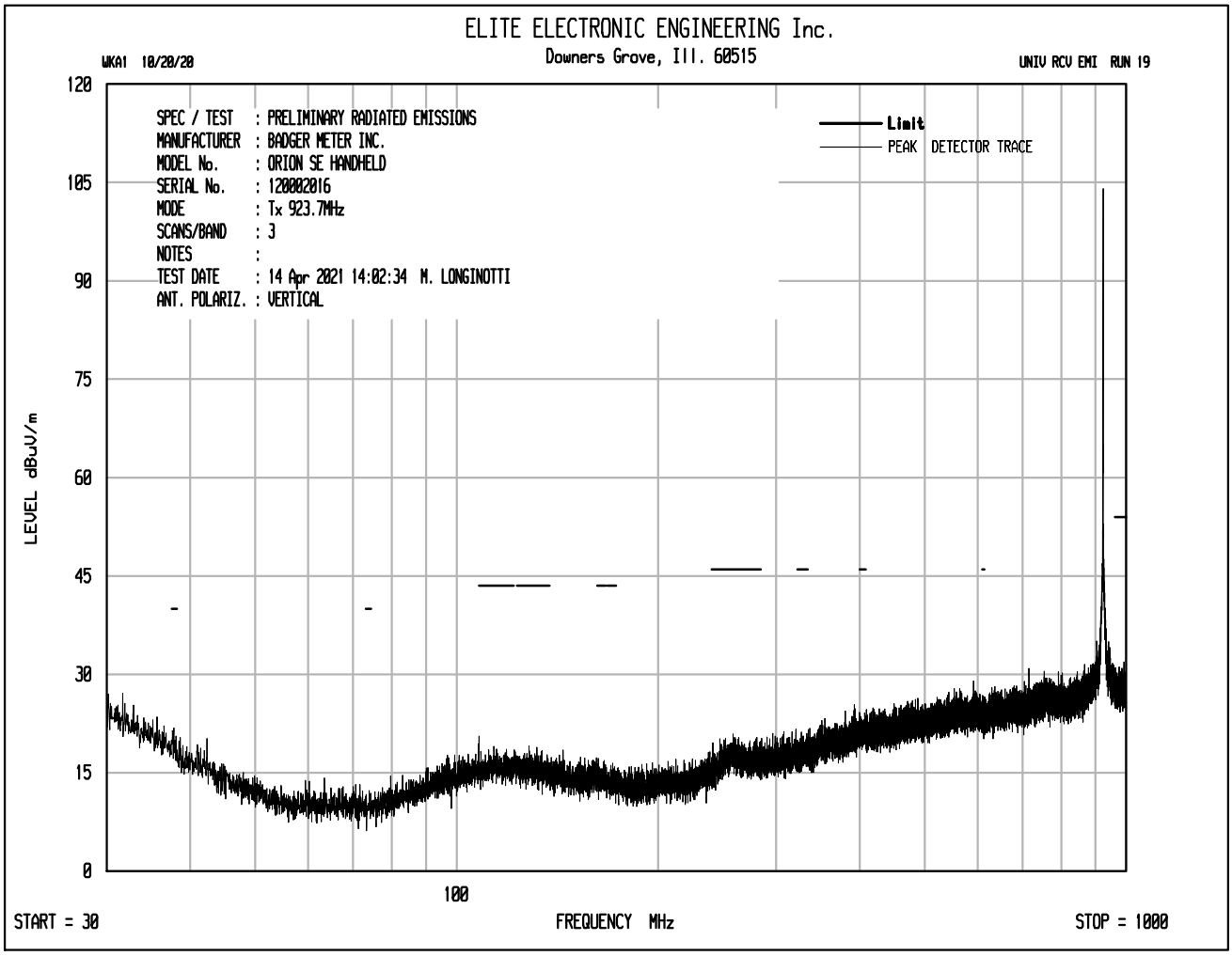

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 16
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 914.1MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 13:53:07 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000

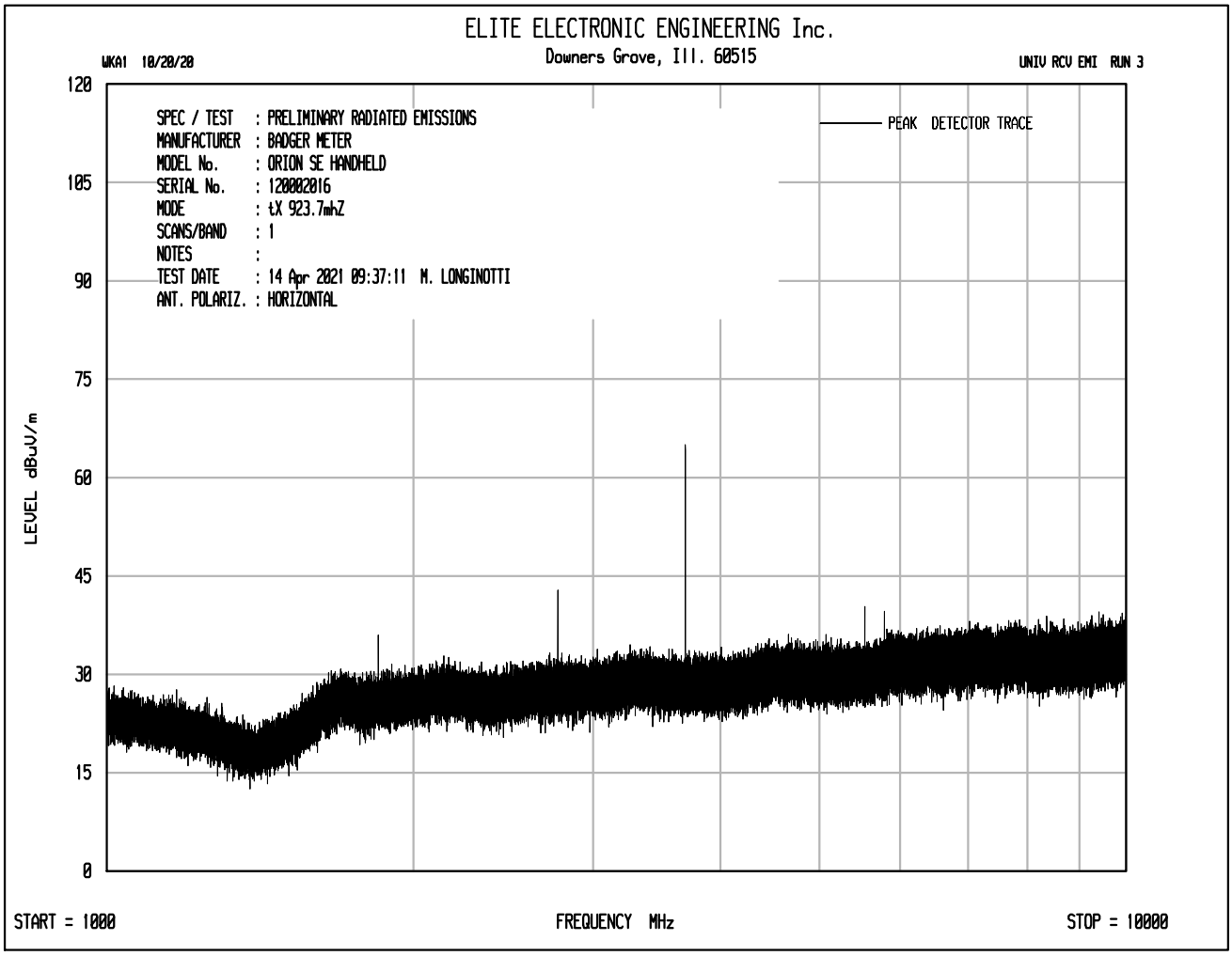

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 17
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 914.1MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 13:55:03 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000

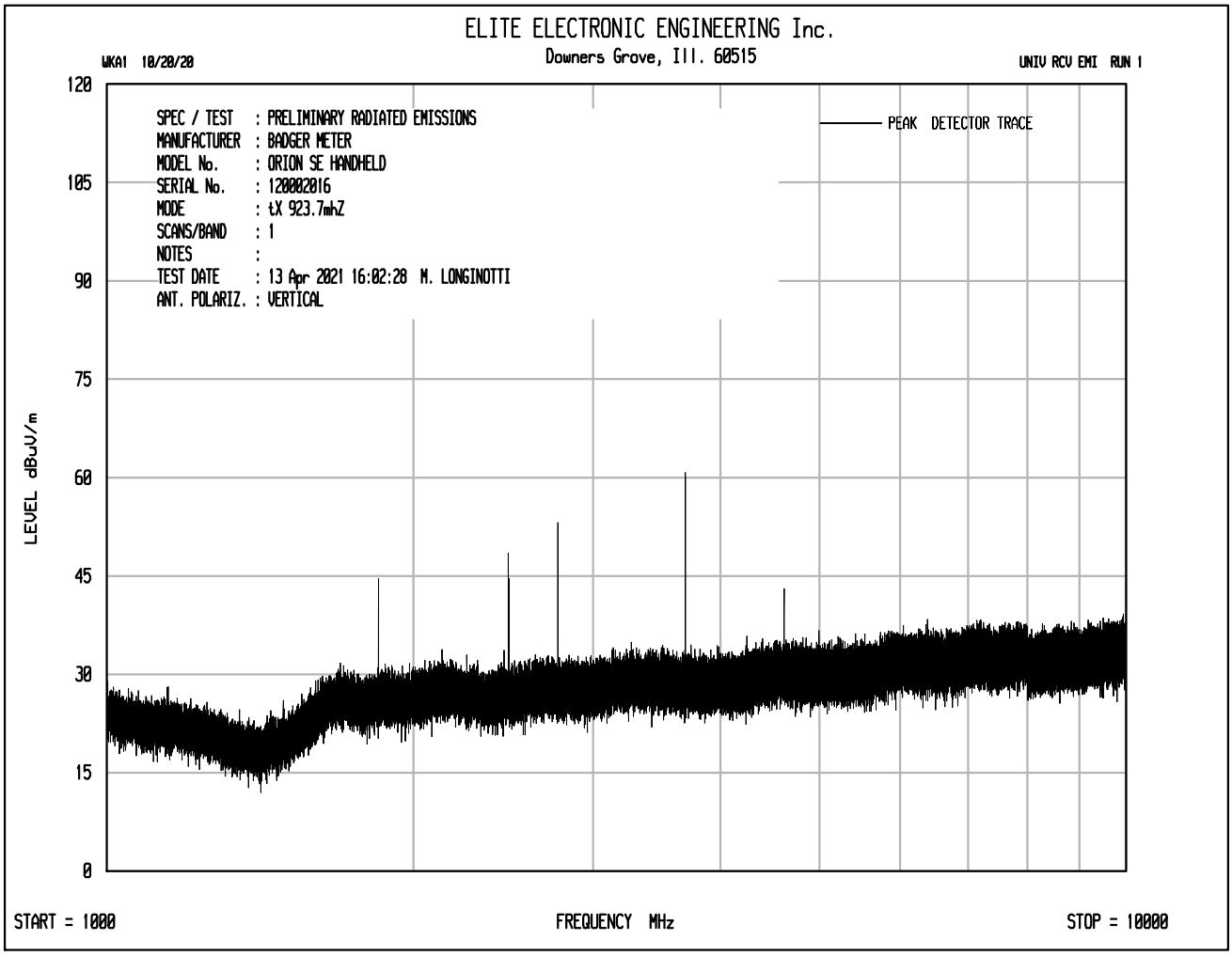

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 4
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 914.1MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 09:49:53 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 5
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 914.1MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 09:56:03 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 13
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 923.7MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 13:45:43 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 19
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : Tx 923.7MHz
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 14:02:34 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 3
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : tX 923.7mhZ
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 09:37:11 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 1
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : tX 923.7mhZ
SCANS/BAND : 1
NOTES :
TEST DATE : 13 Apr 2021 16:02:28 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 904.94MHz
Parameters	Peak Measurements in the Restricted Bands
Notes	None

Frequency (MHz)	Ant Pol	Meter Reading (dBµV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBµV/m at 3m	Peak Total µV/m at 3 m	Peak Limit µV/m at 3 m	Margin (dB)
2714.82	H	53.1		3.7	32.6	-40.2	49.2	286.8	5000.0	-24.8
2714.82	V	51.4		3.7	32.6	-40.2	47.5	235.9	5000.0	-26.5
3619.76	H	57.9		4.3	33.2	-39.5	55.8	619.5	5000.0	-18.1
3619.76	V	56.4		4.3	33.2	-39.5	54.3	521.3	5000.0	-19.6
4524.70	H	64.6		4.7	34.2	-39.6	63.9	1575.6	5000.0	-10.0
4524.70	V	61.2		4.7	34.2	-39.6	60.5	1065.2	5000.0	-13.4
5429.64	H	73.0		5.2	35.0	-39.4	73.7	4844.8	5000.0	-0.3
5429.64	V	65.7		5.2	35.0	-39.4	66.4	2090.6	5000.0	-7.6
8144.46	H	52.8		6.5	35.8	-39.6	55.5	598.7	5000.0	-18.4
8144.46	V	54.8		6.5	35.8	-39.6	57.5	753.7	5000.0	-16.4
9049.40	H	53.3		6.5	36.3	-39.4	56.7	685.1	5000.0	-17.3
9049.40	V	53.1		6.5	36.3	-39.4	56.5	669.5	5000.0	-17.5

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 904.94MHz
Parameters	Average Measurements in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
2714.82	H	52.60		3.7	32.6	-40.2	-28.1	20.6	10.7	500.0	-33.4
2714.82	V	51.4		3.7	32.6	-40.2	-28.1	19.4	9.3	500.0	-34.6
3619.76	H	57.9		4.3	33.2	-39.5	-28.1	27.8	24.5	500.0	-26.2
3619.76	V	56.4		4.3	33.2	-39.5	-28.1	26.3	20.6	500.0	-27.7
4524.70	H	64.6		4.7	34.2	-39.6	-28.1	35.9	62.3	500.0	-18.1
4524.70	V	61.2		4.7	34.2	-39.6	-28.1	32.5	42.1	500.0	-21.5
5429.64	H	73.0		5.2	35.0	-39.4	-28.1	45.6	191.5	500.0	-8.3
5429.64	V	65.7		5.2	35.0	-39.4	-28.1	38.3	82.7	500.0	-15.6
8144.46	H	52.8		6.5	35.8	-39.6	-28.1	27.5	23.7	500.0	-26.5
8144.46	V	54.8		6.5	35.8	-39.6	-28.1	29.5	29.8	500.0	-24.5
9049.40	H	53.3		6.5	36.3	-39.4	-28.1	28.7	27.1	500.0	-25.3
9049.40	V	53.1		6.5	36.3	-39.4	-28.1	28.5	26.5	500.0	-25.5

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 904.94MHz
Parameters	Peak Measurements not in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
904.94	H	73.8		2.0	26.4	0.0	102.2	129353.9		
904.94	V	76.8		2.0	26.4	0.0	105.2	182717.3		
1809.88	H	56.7		2.9	31.5	-40.9	50.3	328.2	18271.7	-34.9
1809.88	V	56.7		2.9	31.5	-40.9	50.3	327.0	18271.7	-34.9
6334.58	H	45.6		5.6	38.1	-40.1	49.2	287.4	18271.7	-36.1
6334.58	V	42.4		5.6	38.1	-40.1	45.9	197.7	18271.7	-39.3
7239.52	H	43.9		6.1	38.3	-40.1	48.3	261.1	18271.7	-36.9
7239.52	V	39.2		6.1	38.3	-40.1	43.6	151.8	18271.7	-41.6

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 914.1MHz
Parameters	Peak Measurements in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2742.30	H	55.7		3.7	32.6	-40.2	51.8	390.1	5000.0	-22.2
2742.30	V	52.4		3.7	32.6	-40.2	48.5	266.8	5000.0	-25.5
3656.40	H	58.5		4.3	33.2	-39.6	56.4	662.8	5000.0	-17.6
3656.40	V	56.3		4.3	33.2	-39.6	54.2	514.5	5000.0	-19.8
4570.50	H	65.5		4.7	34.3	-39.7	64.8	1746.9	5000.0	-9.1
4570.50	V	63.5		4.7	34.3	-39.7	62.8	1387.6	5000.0	-11.1
7312.80	H	58.9		6.2	35.7	-39.6	61.1	1138.7	5000.0	-12.9
7312.80	V	59.2		6.2	35.7	-39.6	61.4	1178.7	5000.0	-12.6
8226.90	H	53.5		6.5	35.9	-39.5	56.4	657.1	5000.0	-17.6
8226.90	V	54.3		6.5	35.9	-39.5	57.2	720.5	5000.0	-16.8
9141.00	H	51.1		6.6	36.3	-39.4	54.6	537.3	5000.0	-19.4
9141.00	V	51.3		6.6	36.3	-39.4	54.8	549.8	5000.0	-19.2

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 914.1MHz
Parameters	Average Measurements in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
2742.30	H	55.70		3.7	32.6	-40.2	-28.1	23.8	15.4	500.0	-30.2
2742.30	V	52.4		3.7	32.6	-40.2	-28.1	20.5	10.5	500.0	-33.5
3656.40	H	58.5		4.3	33.2	-39.6	-28.1	28.4	26.2	500.0	-25.6
3656.40	V	56.3		4.3	33.2	-39.6	-28.1	26.2	20.3	500.0	-27.8
4570.50	H	65.5		4.7	34.3	-39.7	-28.1	36.8	69.1	500.0	-17.2
4570.50	V	63.5		4.7	34.3	-39.7	-28.1	34.8	54.9	500.0	-19.2
7312.80	H	58.9		6.2	35.7	-39.6	-28.1	33.1	45.0	500.0	-20.9
7312.80	V	59.2		6.2	35.7	-39.6	-28.1	33.4	46.6	500.0	-20.6
8226.90	H	53.5		6.5	35.9	-39.5	-28.1	28.3	26.0	500.0	-25.7
8226.90	V	54.3		6.5	35.9	-39.5	-28.1	29.1	28.5	500.0	-24.9
9141.00	H	51.1		6.6	36.3	-39.4	-28.1	26.5	21.2	500.0	-27.4
9141.00	V	51.3		6.6	36.3	-39.4	-28.1	26.7	21.7	500.0	-27.2

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 914.1MHz
Parameters	Peak Measurements not in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
914.10	H	70.9		2.1	26.3	0.0	99.3	91882.8		
914.10	V	77.2		2.1	26.3	0.0	105.6	189772.8		
1828.20	H	53.5		2.9	31.7	-40.8	47.2	229.6	18977.3	-38.3
1828.20	V	56.6		2.9	31.7	-40.8	50.4	330.4	18977.3	-35.2
5484.60	H	50.0		5.2	36.7	-40.2	51.6	381.1	18977.3	-33.9
5484.60	V	50.6		5.2	36.7	-40.2	52.3	410.7	18977.3	-33.3
6398.70	H	46.6		5.7	38.0	-40.1	50.1	319.7	18977.3	-35.5
6398.70	V	47.0		5.7	38.0	-40.1	50.5	336.3	18977.3	-35.0

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 923.79MHz
Parameters	Peak Measurements in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2771.37	H	56.9		3.7	32.5	-40.1	53.0	448.1	5000.0	-21.0
2771.37	V	57.0		3.7	32.5	-40.1	53.1	453.3	5000.0	-20.9
3695.16	H	58.8		4.3	33.2	-39.5	56.8	693.8	5000.0	-17.2
3695.16	V	60.3		4.3	33.2	-39.5	58.3	824.6	5000.0	-15.7
4618.95	H	64.9		4.8	34.4	-39.7	64.4	1662.5	5000.0	-9.6
4618.95	V	62.8		4.8	34.4	-39.7	62.3	1305.5	5000.0	-11.7
7390.32	H	59.5		6.2	35.7	-39.6	61.8	1227.0	5000.0	-12.2
7390.32	V	57.8		6.2	35.7	-39.6	60.1	1008.9	5000.0	-13.9
8314.11	H	54.6		6.5	35.9	-39.5	57.5	753.1	5000.0	-16.4
8314.11	V	54.7		6.5	35.9	-39.5	57.6	761.8	5000.0	-16.3

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 923.79MHz
Parameters	Average Measurements in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
2771.37	H	56.90		3.7	32.5	-40.1	-28.1	25.0	17.7	500.0	-29.0
2771.37	V	57.0		3.7	32.5	-40.1	-28.1	25.1	17.9	500.0	-28.9
3695.16	H	58.8		4.3	33.2	-39.5	-28.1	28.8	27.4	500.0	-25.2
3695.16	V	60.3		4.3	33.2	-39.5	-28.1	30.3	32.6	500.0	-23.7
4618.95	H	64.9		4.8	34.4	-39.7	-28.1	36.4	65.7	500.0	-17.6
4618.95	V	62.8		4.8	34.4	-39.7	-28.1	34.3	51.6	500.0	-19.7
7390.32	H	59.5		6.2	35.7	-39.6	-28.1	33.7	48.5	500.0	-20.3
7390.32	V	57.8		6.2	35.7	-39.6	-28.1	32.0	39.9	500.0	-22.0
8314.11	H	54.6		6.5	35.9	-39.5	-28.1	29.5	29.8	500.0	-24.5
8314.11	V	54.7		6.5	35.9	-39.5	-28.1	29.6	30.1	500.0	-24.4

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Transmit at 923.79MHz
Parameters	Peak Measurements not in the Restricted Bands
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
923.79	H	73.7		2.1	26.4	0.0	102.2	128960.3		
923.79	V	81.1		2.1	26.4	0.0	109.6	302312.5		
1847.58	H	60.6		3.0	31.0	-40.1	54.4	525.7	30231.2	-35.2
1847.58	V	63.1		3.0	31.0	-40.1	56.9	701.1	30231.2	-32.7
5542.74	H	73.2		5.2	35.0	-39.4	73.9	4971.2	30231.2	-15.7
5542.74	V	67.9		5.2	35.0	-39.4	68.6	2700.6	30231.2	-21.0
6466.53	H	62.8		5.7	35.6	-39.5	64.5	1687.0	30231.2	-25.1
6466.53	V	56.8		5.7	35.6	-39.5	58.5	845.5	30231.2	-31.1
9237.90	H	45.0		6.6	36.3	-39.4	48.6	268.7	30231.2	-41.0
9237.90	V	45.6		6.6	36.3	-39.4	49.2	287.9	30231.2	-40.4

23. Module Integration Spot Frequency Emissions

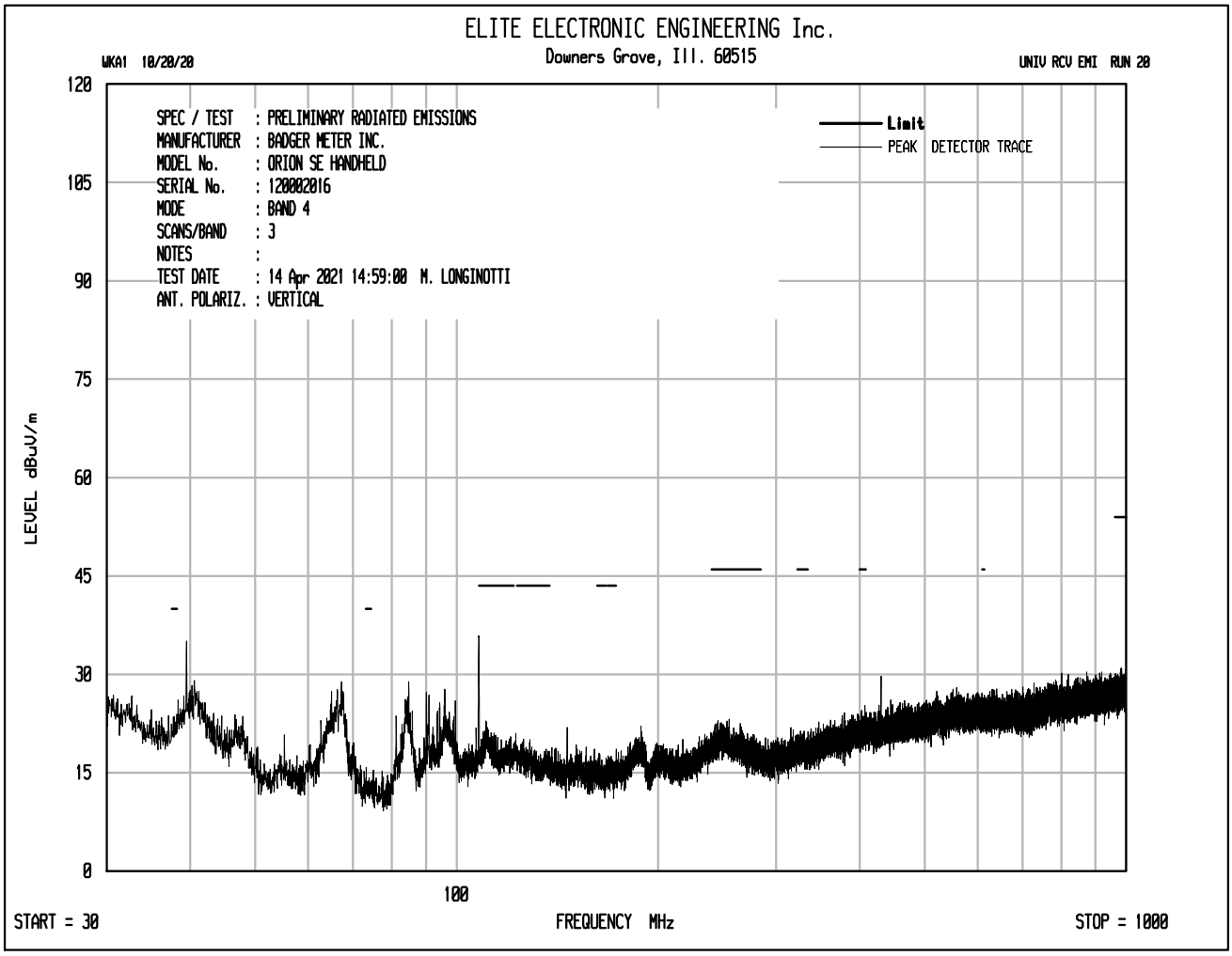
Manufacturer	Badger Meter
Product	Water Meter Transceiver
Model	Orion Cellular Endpoint LTE-M
Serial No	120002016
Mode	Band 4

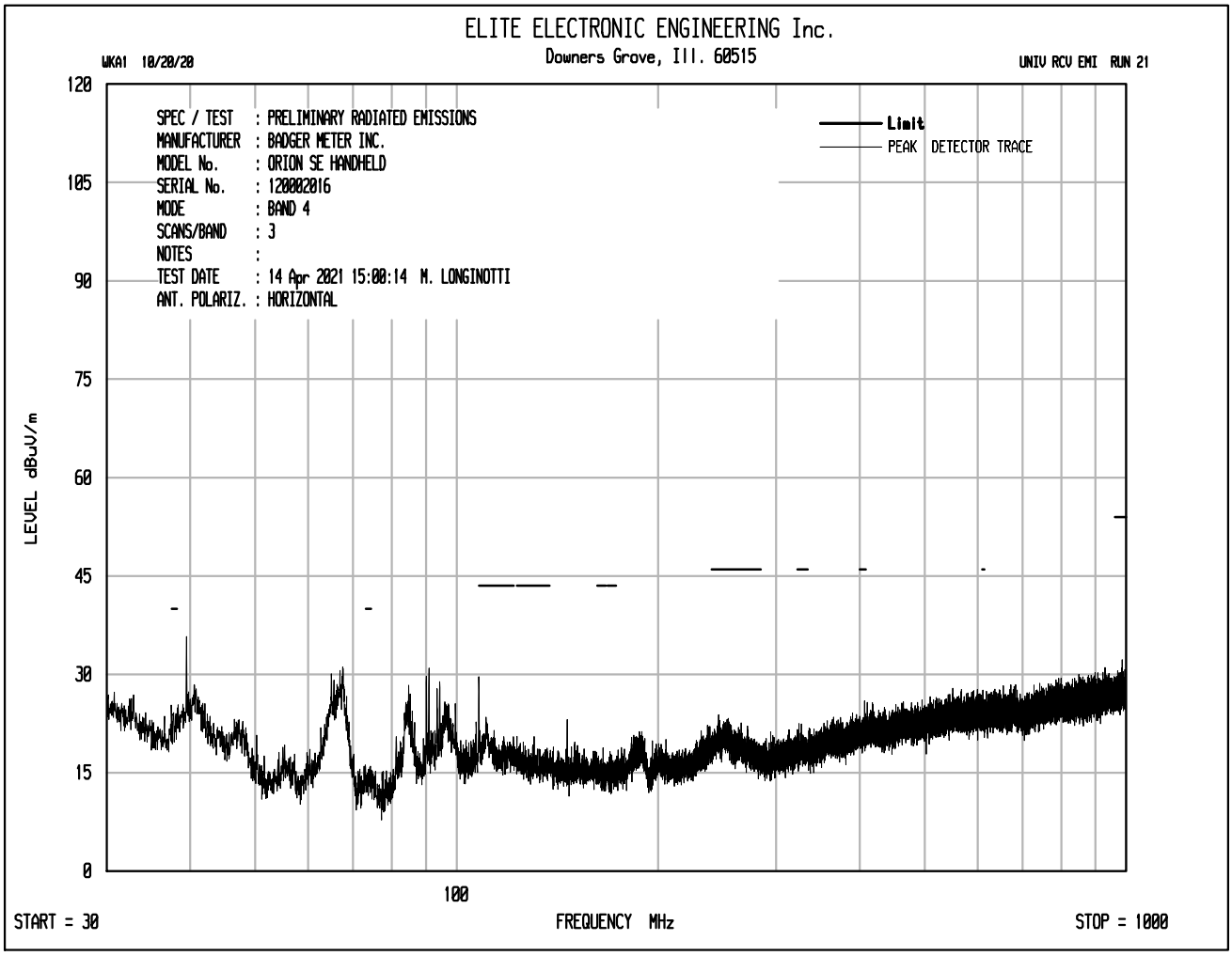
Information	
Setup Format	Tabletop
Height of Support	1.5 Meters
Type of Test Site	Semi-Anechoic Chamber
Type of Antennas Used	Below 1GHz: Bilog (or equivalent) Above 1GHz: Double-ridged waveguide (or equivalent)
Notes	The cables were manually maximized during the preliminary emissions sweeps. The cable arrangement which resulted in the worst-case emissions was utilized.

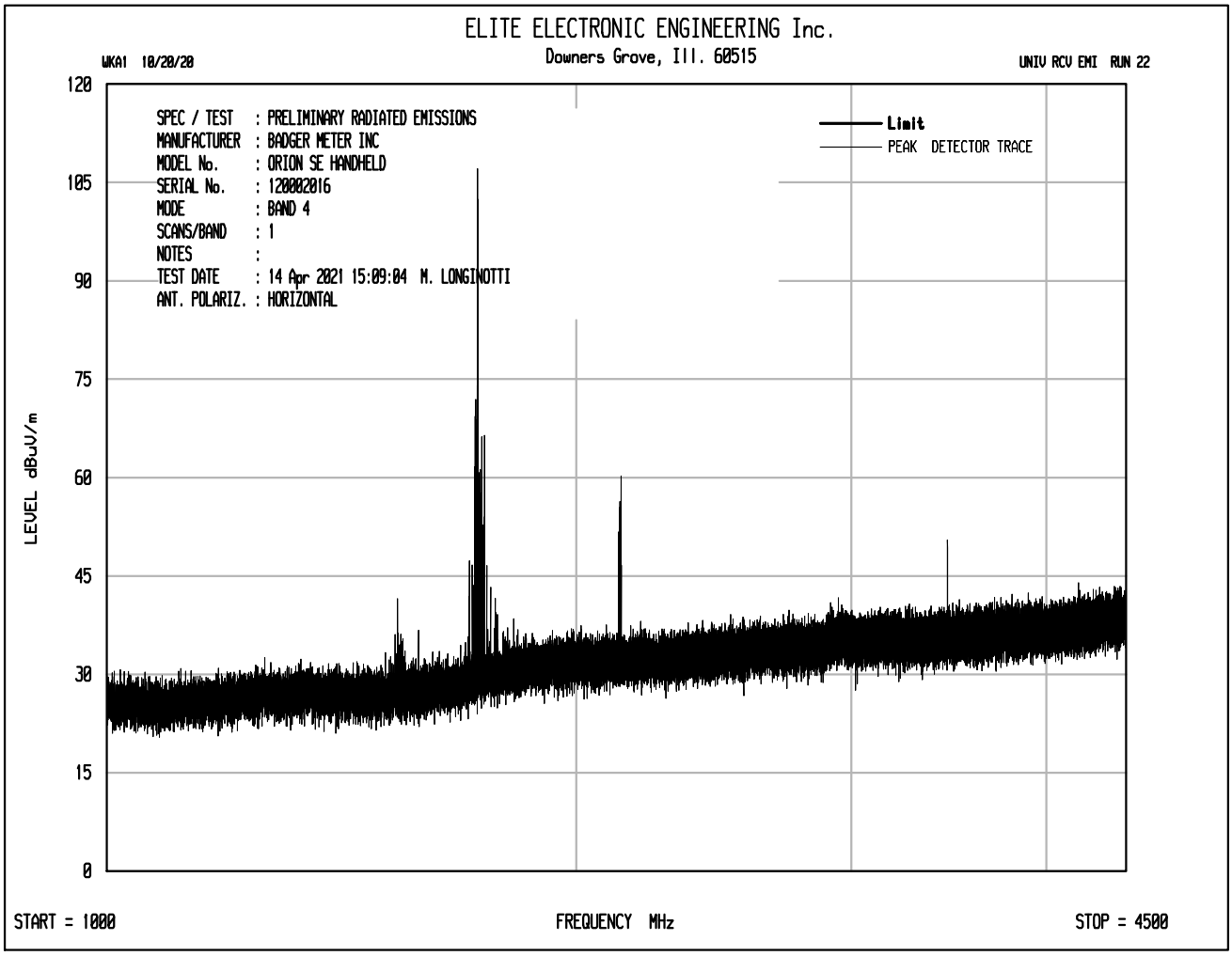
Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 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

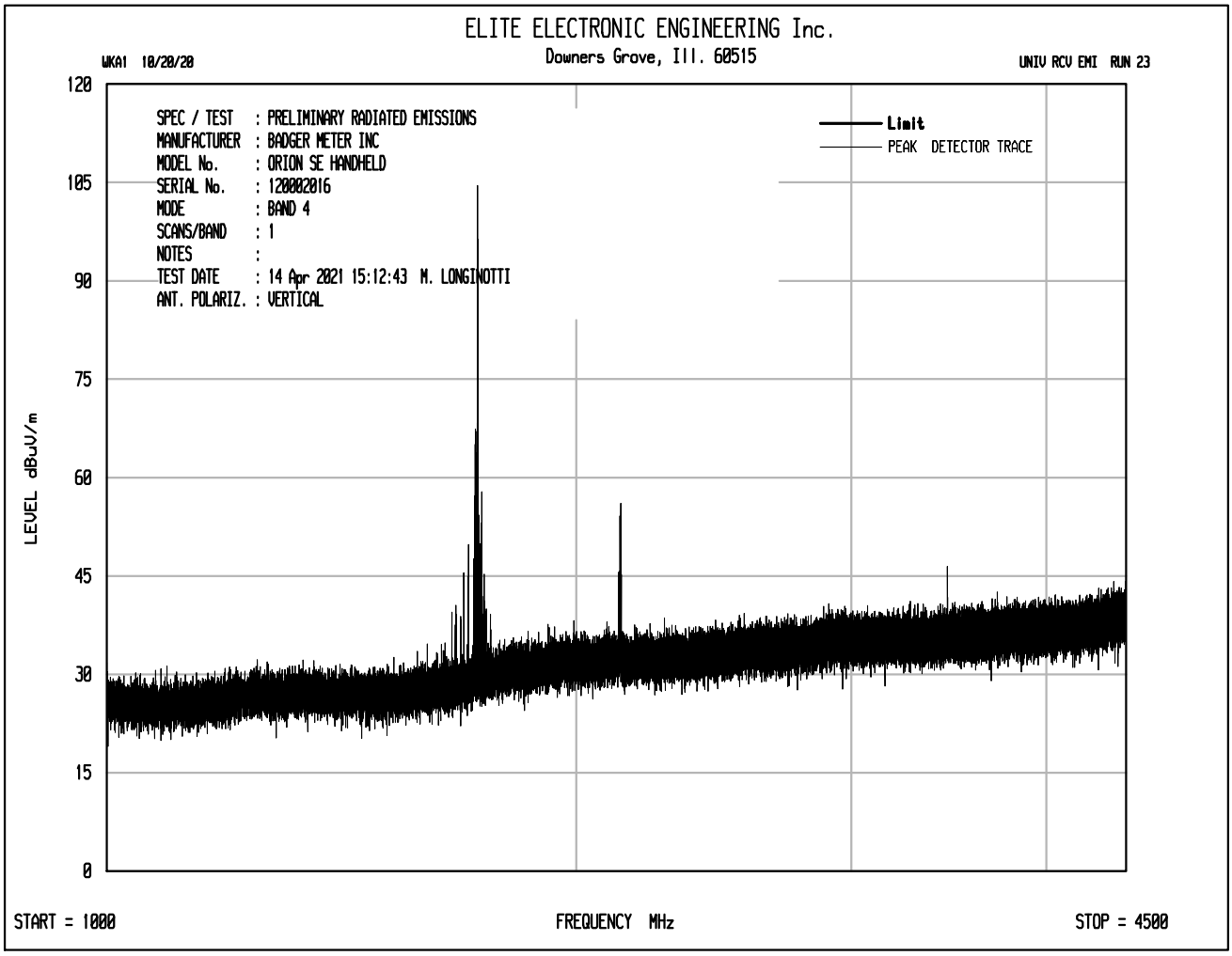
Requirements
AWS emission limits—(1) *General protection levels.* Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 $\log_{10}$ (P) dB.

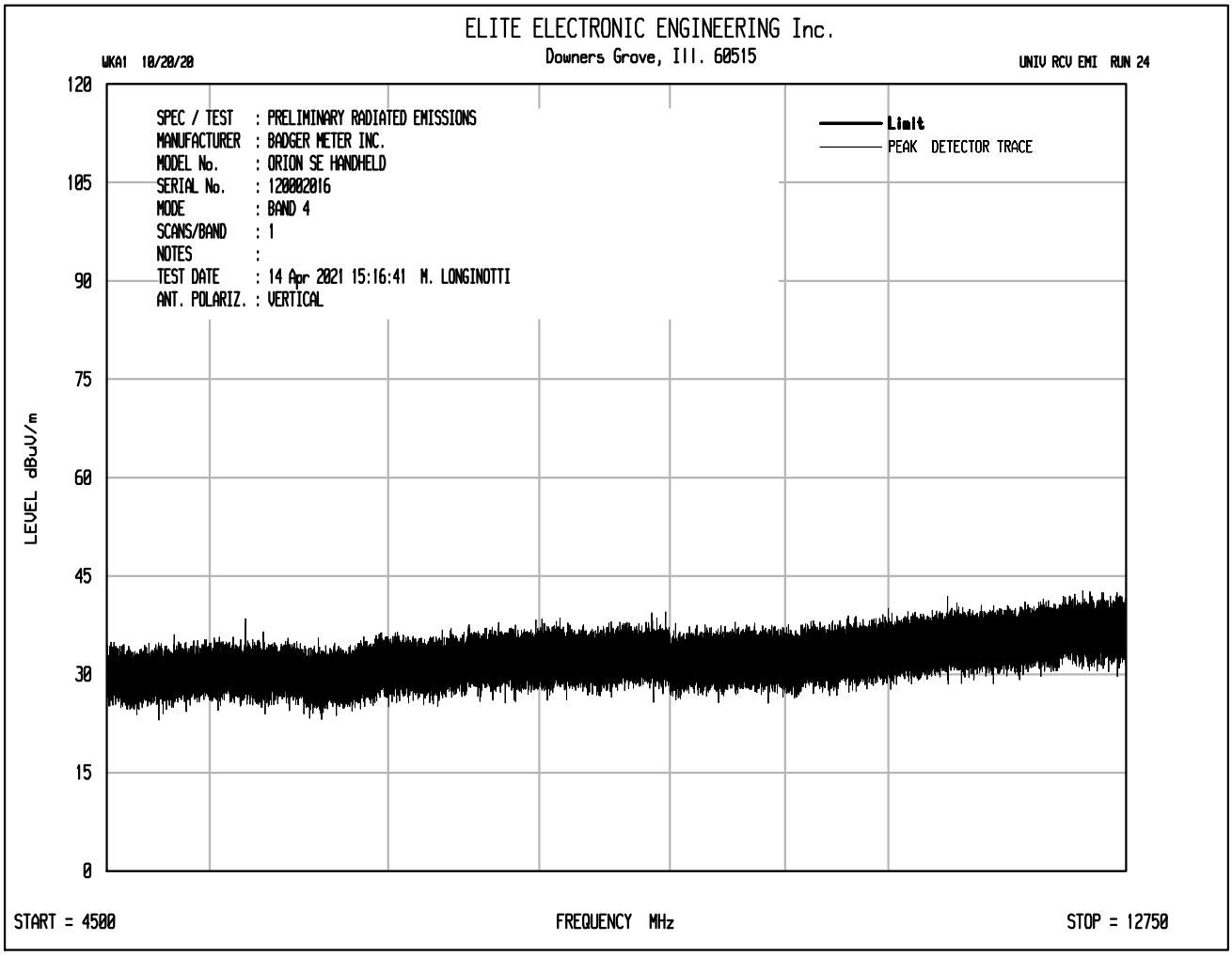
Procedures
All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground 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. A preliminary radiated emissions test was 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 12.75GHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity. The final emission tests were then manually performed over the frequency range of 30MHz to 12.75GHz. Between 30MHz and 1000MHz, a Bi-Log antenna was used as the pick-up device. A broadband double ridged waveguide antenna was used as the pick-up device for all frequencies above 1GHz. All significant broadband and narrowband signals were measured and recorded. The peak detected levels were converted to average levels using a duty cycle factor which was computed from the pulse train. To ensure that maximum or worst case, emission levels were measured, the following steps were taken: 1) The EUT was rotated so that all of its sides were exposed to the receiving antenna. 2) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured. 3) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings. 4) 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. The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power, another antenna was set in place of the EUT and connected to a calibrated signal generator. (A tuned dipole was used for all measurements below 1GHz and a double ridged waveguide antenna was used for all measurements above 1GHz.) 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 corrected to compensate for cable loss, as required, and for frequencies above 1GHz, increased by the gain of the waveguide.

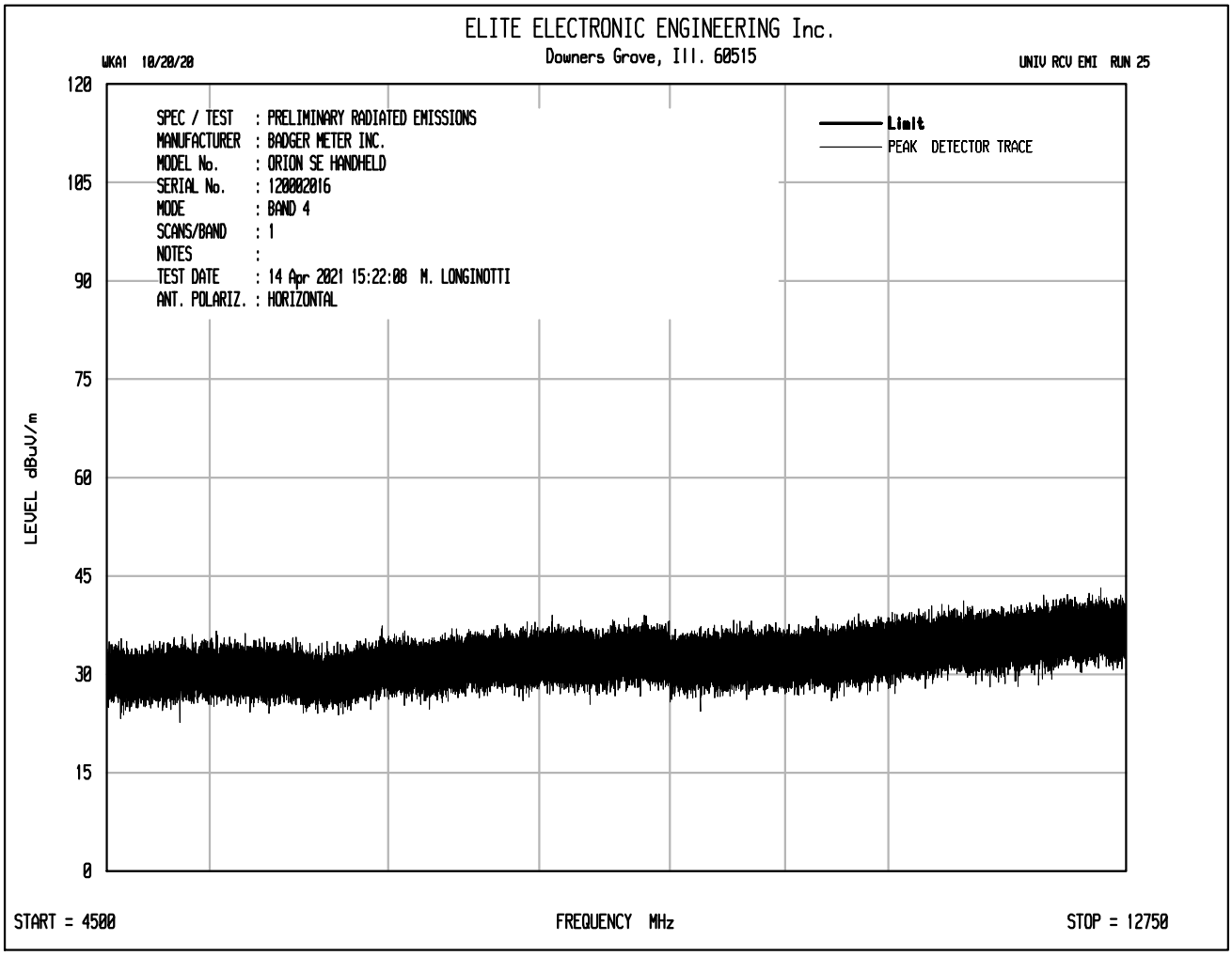

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 20
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 14:59:00 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 21
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 3
NOTES :
TEST DATE : 14 Apr 2021 15:00:14 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
100
START = 30
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 22
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 15:09:04 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 23
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 15:12:43 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 24
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 15:16:41 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 4500
FREQUENCY MHz
STOP = 12750


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 10/20/20
UNIV RCV EMI RUN 25
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : ORION SE HANDHELD
SERIAL No. : 120002016
MODE : BAND 4
SCANS/BAND : 1
NOTES :
TEST DATE : 14 Apr 2021 15:22:08 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 4500
FREQUENCY MHz
STOP = 12750

Test Details	
Manufacturer	Badger Meter
Model	Orion Cellular Endpoint LTE-M
S/N	120002016
Mode	Band 4
Parameters	Peak detector
Notes	None

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	ERP (dBm)	Attenuation Below Output Power (dB)	Minimum Attenuation (dB)
3465.00	H	46.5		-61.5	5.7	3.3	-59.1	92.4	46.3
3465.00	V	42.2		-65.8	5.7	3.3	-63.4	96.7	46.3
5197.50	H	37.3		-64.4	7.7	4.0	-60.7	94.0	46.3
5197.50	V	35.6		-66.1	7.7	4.0	-62.4	95.7	46.3
6930.00	H	33.3	*	-64.8	9.3	4.8	-60.3	93.5	46.3
6930.00	V	34.1	*	-64.0	9.3	4.8	-59.5	92.7	46.3
8662.50	H	35.6	*	-62.1	10.9	5.2	-56.4	89.7	46.3
8662.50	V	36.5	*	-61.2	10.9	5.2	-55.5	88.8	46.3

ERP(dBm) = Matched Sig. Gen. Reading (dBm) + Equivalent Antenna Gain (dB) – Cable Loss (dB)
Minimum Attenuation = 43+10*log(P in watts) = 43+10*log(0.2128) = 46.3dB

24. Scope of Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

ELITE ELECTRONIC ENGINEERING, INC.
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Email: blugo@elitetest.com
Richard King (FCC/Commercial Team Leader) Phone: 630 495 9770 ext. 123
Email: reking@elitetest.com
Website: www.elitetest.com

ELECTRICAL

Valid to: June 30, 2021 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	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)	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)

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	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); ECE Regulation 10.06 Annex 7 (Broadband) ECE Regulation 10.06 Annex 8 (Narrowband)
Vehicle Radiated Emissions	CISPR 12; ICES-002; ECE Regulation 10.06 Annex 5
Bulk Current Injection (BCI)	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
Bulk Current Injections (BCI) *(Closed Loop Method)*	ISO 11452-4; SAE J1113-4
Radiated Immunity Anechoic *(Including Radar Pulse)*	ISO 11452-2; ISO 11452-5; 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
Radiated Immunity Reverb	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)*	ISO 11452-9; EMC-CS-2009.1 (RI115); FMC1278 (RI115)
Vehicle Radiated Immunity (ALSE)	ISO 11451-2; ECE Regulation 10.06 Annex 6
Electrical Loads	ISO 16750-2, Sections 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.11, and 4.12
Dielectric Withstand Voltage	MIL-STD-202, Method 301; EIA-364-20D
Insulation Resistance	MIL-STD-202, Method 302; SAE/USCAR-2, Revision 6, Section 5.5.1; EIA-364-21D
Contact Resistance	MIL-STD-202, Method 307; SAE/USCAR-2, Revision 6, Section 5.3.1; EIA-364-23C; USCAR21-3 Section 4.5.3

Test Technology:	**Test Method(s) [1]:**
DC Resistance	MIL-STD-202, Method 303
Contact Chatter	MIL-STD-202, Method 310; SAE/USCAR-2, Revision 6, Section 5.1.9
Voltage Drop	SAE/USCAR-2, Revision 6, Section 5.3.2; USCAR21-3 Section 4.5.6
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; KN 11; CNS 13803 (1997, 2003); CISPR 14-1; EN 55014-1; AS/NZS CISPR 14.1; 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; KN 32; ECE Regulation 10.06 Annex 14
Current Harmonics	IEC 61000-3-2; EN 61000-3-2; KN 61000-3-2; ECE Regulation 10.06 Annex 11
Flicker and Fluctuations	IEC 61000-3-3; EN 61000-3-3; KN 61000-3-3; 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; 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; IEEE C37.90.2 2004
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; ECE Regulation 10.06 Annex 15

Test Technology:	**Test Method(s)[1]:**
European Radio Test Standards (cont'd)	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
Canadian Radio Tests	RSS-102 (RF Exposure Evaluation only); 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-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
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
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; ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015;
OTA (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	FAA AC 150/5345-10H
(1mV to 5kV) 60 Hz	FAA AC 150/5345-43J
(0.1V to 250V) up to 500 MHz	FAA AC 150/5345-44K
(1µA to 150A) 60 Hz	FAA AC 150/5345-46E
DC Voltage / Current	FAA AC 150/5345-47C
(1mV to 15kV) / (1µA to 10A)	FAA EB 67D
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, revision or edition of a test method standard is not identified on the scope of accreditation, the laboratory is expected to be using the current version within one year of the date of publication, 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.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
Unintentional Radiators Part 15B	ANSI C63.4:2014	40000
Industrial, Scientific, and Medical Equipment Part 18	FCC MP-5 (February 1986)	40000
Intentional Radiators Part 15C	ANSI C63.10:2013	40000
Unlicensed Personal Communication Systems Devices Part 15D	ANSI C63.17:2013	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.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
U-NII without DFS Intentional Radiators Part 15E	ANSI C63.10:2013	40000
U-NII with DFS Intentional Radiators Part 15E	FCC KDB 905462 D02 (v02)	40000
UWB Intentional Radiators Part 15F	ANSI C63.10:2013	40000
BPL Intentional Radiators Part 15G	ANSI C63.10:2013	40000
White Space Device Intentional Radiators Part 15H	ANSI C63.10:2013	40000
Commercial Mobile Services (FCC Licensed Radio Service Equipment) Parts 22 (cellular), 24, 25 (below 3 GHz), and 27	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
General Mobile Radio Services (FCC Licensed Radio Service Equipment) 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
Citizens Broadband Radio Services (FCC Licensed Radio Service Equipment) Part 96	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
Maritime and Aviation Radio Services Parts 80 and 87	ANSI/TIA-603-E; ANSI C63.26:2015	40000
Microwave and Millimeter Bands Radio Services 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
Broadcast Radio Services Parts 73 and 74 (below 3 GHz)	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.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
Signal Boosters 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 8th day of August 2019.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1786.01
Valid to June 30, 2021

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