Measurement of RF Emissions from a Bluetooth Low Energy Transmitter Model No. PL161 SC

For	CATERPILLAR Mossville AC 100 NE Adams Peoria, IL 61629
P.O. Number	JBJ 62846
Date Tested	May 16-23, 2019
Test Personnel	Richard King
Test Specification	FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.247 for Digital Modulation Intentional Radiators Operating within The bands 2400-2483.5MHz Innovation, Science, and Economic Development Canada RSS-247 Innovation, Science, and Economic Development Canada RSS-GEN

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REVISION HISTORY

Revision	Date	Description
—	14 June 2019	Initial release

Measurement of RF Emissions from a Bluetooth Low Energy Transmitter,
Model No. PL161 SC

1. INTRODUCTION

1.1. Scope of Tests

This document represents the results of the series of radio interference measurements performed on a CATERPILLAR Mossville AC Bluetooth Low Energy Transmitter, Model No. PL161 SC (hereinafter referred to as the EUT).

The EUT is a digital modulation transmitter. The transmitter was designed to transmit in the 2400-2483.5 MHz band using a Taoglas Antenna Solutions SWLP.2450.12.4.B.02 Patch Antenna with 2.0dBi gain.

The EUT was manufactured and submitted for testing by CATERPILLAR Mossville AC located in Peoria, IL.

1.2. Purpose

The test series was performed to determine if the EUT meets the conducted RF emission requirements, radiated RF emissions requirements, and additional provisions of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.247 for Intentional Radiators Operating within the 2400-2483.5 MHz band.

The test series was also performed to determine if the EUT meets the conducted RF emission requirements, radiated RF emissions requirements, and additional provisions of the Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-Gen Section 8.8 and Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-Gen Section 8.8 and Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-247 for Transmitters.

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

1.3. Deviations, Additions and Exclusions

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

1.4. EMC Laboratory Identification

This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by The American Association for Laboratory Accreditation (A2LA). A2LA Certificate Number: 1786.01.

1.5. Laboratory Conditions

The temperature at the time of the test was 23.3^{o}C and the relative humidity was 43%.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2019
- ANSI C63.4-2004, "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"
- FCC Public Notice, DA 00-705, "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems", Released March 30, 2000

- Federal Communications Commission Office of Engineering and Technology Laboratory Division Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247, April 2, 2019

- Industry Canada Radio Standards Specification, RSS-Gen, “General Requirements and Information for the Certification of Radiocommunication Equipment”, Issue 1, March 2019

- Industry Canada Radio Standards Specification, RSS-247, “ Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices”, Issue 2, February 2019

3. EUT SETUP AND OPERATION

3.1. General Description

The EUT is a CATERPILLAR Mossville AC, Bluetooth Low Energy Transmitter, Model No. PL161 SC. A block diagram of the EUT setup is shown as Figure 1.

3.1.1.Power Input

The EUT normally obtains 3.6VDC from an internal TL-2450 tadiran battery. For testing purposes, the battery was removed and short wires were soldered onto the battery leads and a power supply was used to provide 3.6VDC to the EUT.

3.1.2.Peripheral Equipment

The following peripheral equipment was submitted with the EUT:

Item	Description
Laptop computer	HP ProBook Laptop Computer: Running HP SmartRF Studio 7.
Debugger	TI CC Debugger

3.1.3.Signal Input/Output Leads

The following interconnect cables were submitted with the EUT:

Item	Description
USB Cable	Used to connect the HP laptop computer to the TI CC Debugger
Ribbon Cable	Used to connect the TI CC Debugger to the EUT

3.1.4.Grounding

The EUT was not grounded during testing.

3.1.5.Software

For all tests, the EUT had software loaded from the HP SmartRF Studio 7 program prior to each test.

3.2. Operational Mode

The EUT and all peripheral equipment were energized. The EUT was connected to the TI CC Debugger and laptop computer. The TI SmartRF Studio 7 software was used to program the EUT as follows.

For the PL161 SC the following transmit frequencies and power levels were used:

- Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm

- Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
- Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm

The TI CC Debugger was disconnected from the EUT during testing.

3.3. EUT Modifications

No modifications were required for compliance to the specifications listed in paragraph 1.2.

4. TEST FACILITY AND TEST INSTRUMENTATION

4.1. Shielded Enclosure

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. With the exception of the floor, the reflective surfaces of the shielded chamber are lined with ferrite tiles on the walls and ceiling. 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 C63.4-2004 for site attenuation.

4.2. Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

Conducted and radiated emission measurements were performed with a spectrum analyzer. This receiver allows measurements with the bandwidths and detector functions specified by the FCC. The receiver bandwidth was 120kHz for the 30MHz to 1000MHz radiated emissions data and 1MHz for the 1000MHz to 5000MHz radiated emissions data.

4.3. Calibration Traceability

Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

4.4. Measurement Uncertainty

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

Values of Expanded Measurement Uncertainty (95% Confidence)are presented below:

Measurement Type	Expanded Measurement Uncertainty
Conducted disturbance (mains port) (150 kHz – 30 MHz)	2.7
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

5. TEST PROCEDURES

5.1. Powerline Conducted Emissions

5.1.1.Requirements

Since the EUT was powered by internal batteries, no conducted emissions tests were performed.

5.2. 6dB Bandwidth

5.2.1. Requirements

Per 15.247(a)(2),the minimum 6dB bandwidth shall be at least 500kHz for all systems using digital modulation techniques.

5.2.2.Procedures

The antenna port of the EUT was connected to the Rohde & Schwarz Wireless Test Set.

The EUT was allowed to transmit continuously. The transmit channel was set separately to low, middle, and high channels. The resolution bandwidth (RBW) was set to 100kHz, the video bandwidth (VBW) was set to the same as or 3 times greater than the RBW, and the span was set to 3 times the RBW.

5.2.3.Results

The plots on pages 20 through 22 show that the minimum 6 dB bandwidth was 871.288kHz which is greater than minimum allowable 6dB bandwidth requirement of 500kHz for systems using digital modulation techniques. The 99% bandwidth was measured to be 1.080MHz.

5.3. Peak Conducted Output Power

5.3.1.Requirements

Per section 15.247(b)(3), for systems using digital modulation the maximum peak output conducted power shall not be greater than 1.0W (30dBm).

5.3.2.Procedures

The antenna port of the EUT was connected to the Rohde & Schwarz Wireless Test Set. The EUT was set to transmit separately at the low, middle, and high channels. The resolution bandwidth (RBW) was set to greater than the 6dB bandwidth. The testing was in accordance to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance and ANSI C63.10.

5.3.3.Results

The results are presented on pages 23 through 25. The maximum peak conducted output power from the transmitter was .0005W (-2.7 dBm) which is below the 1 Watt limit.

5.4. PEAK EIRP

5.4.1.Requirements

Per section 15.247(b)(3), for systems using digital modulation the maximum peak output conducted power shall not be greater than 1.0W (30dBm). Per section 15.247(b)(4), this limit is based on the use of antennas with directional gains that do not exceed 6dBi. Since the limit allows for a 6dBi antenna gain, the maximum EIRP can be increased by 6dB to 4 Watt (36dBm).

5.4.2.Procedures

The EUT was placed on the non-conductive stand and set to transmit. A double ridged waveguide 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 6dB 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 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 double ridged waveguide 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 (and antenna gain for all measurements above 1GHz), as required. The peak power output was calculated for low, middle, and high hopping frequencies. The testing was in accordance to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance and ANSI C63.10.

5.4.3.Results

The results are presented on pages 26 through 28. The maximum EIRP measured from the transmitter was -18dBm or 0.0000158 W which is below the 4 Watt limit.

5.5. Radiated Spurious Emissions Measurements

5.5.1.Requirements

Per section 15.247(d), 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 20 dB 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 emissions measurement. 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 comply with the radiated emission limits specified in §15.209(a).

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must comply with the radiated emission limits specified in §15.209(a).

Paragraph 15.209(a) has the following radiated emission limits:

Frequency MHz	Field Strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30.0-88.0	100	3
88.0-216.0	150	3
216.0-960.0	200	3
Above 960	500	3

5.5.2.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 25GHz was investigated using a peak detector function.

The final emission tests were then manually performed over the frequency range of 30MHz to 25GHz.

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 1.5 meter 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 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 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 1.5 meter 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 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) 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).

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. An average reading was taken

5.5.3.Results

Preliminary radiated emissions plots with the EUT transmitting at Low Frequency, Middle Frequency, and High Frequency are shown on pages 29 through 52. Final radiated emissions data are presented on data pages 53 through 61. As can be seen from the data, all emissions measured from the EUT were within the specification limits.

Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown in Figures 3 through 6.

5.6. Band Edge Compliance

5.6.1.Requirement

Per section 15.247(d), the emissions at the band edges must be at least 20dB below the highest level measured within the band but attenuation below the general limits listed in 15.209(a) is not required. In addition, the radiated emissions which fall in the restricted band beginning at 2483.5 MHz must meet the general limits of 15.209(a).

5.6.2.Procedures

5.6.2.1 Low Band Edge

1) The output of the EUT was connected to the Rohde & Schwarz Wireless Test Set.
2) The EUT was set to transmit continuously at the channel closest to the low band-edge
3) To determine the band edge compliance, the following spectrum analyzer settings were used:

    a. Center frequency = low band-edge frequency.
    b. Span = Wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, as well as any modulation products which fall outside of the authorized band of operation.
    c. Resolution bandwidth (RBW) ≥ 1% of the span.
    d. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined.

4) The marker was set on the peak of the in-band emissions. A display line was placed 20dB down from the peak of the in-band emissions. All emissions which fall outside of the authorized band of operation must be below the 20dB down display line. (All emissions to the left of the center frequency (band edge) must be below the display line.)

5.6.2.2 High Band Edge

1) The EUT was set to transmit continuously at the channel closest to the high band-edge
2) A double ridged waveguide was placed 3 meters away from the EUT. The antenna was connected to the input of a spectrum analyzer.
3) The center frequency of the analyzer was set to the high band edge (2483.5MHz)

4) The resolution bandwidth was set to 1MHz.
5) To ensure that the maximum or worst case emission level was measured, the following steps were taken:

    a. The EUT was rotated so that all of its 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.

6) The highest measured peak reading was recorded.
7) The highest measured average reading was recorded.

5.6.3.Results

Pages 62 through 64 show the band edge compliance results. As can be seen from these plots, the conducted emissions at the low end band edge are within the 20 dB down limits. The radiated emissions at the high end band edge are within the general limits.

5.7. Power Spectral Density

5.7.1.Requirements

Per section 15.247(d), the peak power spectral density from the intentional radiator shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.7.2.Procedures

1) The output of the EUT was connected to the Rohde & Schwarz Wireless Test Set.
2) The EUT was set to transmit separately at the low, middle, and high channels.
3) To determine the power spectral density, the following spectrum analyzer settings were used:

    a. Center frequency = transmit frequency
    b. Resolution bandwidth (RBW) greater than the 20dB bandwidth.
    c. Sweep time = auto
    d. The peak detector and 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined.
    e. The analyzer's display was plotted using a 'screen dump' utility.

4) The testing was in accordance to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Measurement Guidance and ANSI C63.10.
5) To determine the power spectral density, the following spectrum analyzer settings were used:
    a. Center frequency = transmit frequency
    b. Span =1.5times the channel bandwidth
    c. Resolution bandwidth (RBW) ≥3kHz
    d. Video bandwidth (VBW) ≥ 3 x RBW
    e. Sweep time = auto couple
    f. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The peak detector and 'Max-Hold' function was engaged.
    g. The analyzer's display was plotted using a 'screen dump' utility.
    h. If the measured value exceeds the +8dBm limit, reduce the RBW (no less than 3kHz) and repeat step 7.

5.7.3.Results

Pages 65 and 67 show the power spectral density results. As can be seen from the plots, the peak power density is less than 8dBm in a 3kHz band during any time interval of continuous transmission.

6. OTHER TEST CONDITIONS

6.1. Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated. The test series was witnessed by CATERPILLAR Mossville AC personnel.

6.2. Disposition of the EUT

The EUT and all associated equipment were returned to CATERPILLAR Mossville AC upon completion of the tests.

7. CONCLUSIONS

It was determined that the CATERPILLAR Mossville AC Bluetooth Low Energy Transmitter, Part No. PL161 SC and PL161 SC did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and Subpart C, Sections 15.207 and 15.247 for Intentional Radiators Operating within the 2400-2483.5 MHz band, when tested per ANSI C63.4-2004 and ANSI C63.10-2013.

It was also determined that the CATERPILLAR Mossville AC Bluetooth Low Energy Transmitter, Part No. PL161 SC and PL161 SC, did fully meet the conducted and radiated RF emission requirements of the Innovation, Science, and Economic Development Canada Radio Standards Specification, RSS-Gen, Section 8.8 and the Innovation, Science, and Economic Development Canada Radio Standards Specification RSS-Gen Section 8.8 and Radio Standards Specification RSS-247 for transmitters, when tested per ANSI C63.4-2004 and ANSI C63.10-2013.

8. 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 test specifications.

The data presented in this test report pertains to the EUT at the test date CATERPILLAR Mossville AC personnel. Any electrical or mechanical modification made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

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

9. EQUIPMENT LIST

Table 9-1 Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW0	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-30-20G20R6G	PL2926/0646	20GHZ-26.5GHZ	4/8/2019	4/8/2020
APW11	PREAMPLIFIER	PMI	PE2-35-120-5R0-10-12-SFF	PL11685/1241	1GHZ-20GHZ	4/8/2019	4/8/2020
CDX8	COMPUTER	ELITE	WORKSTATION			N/A	
GRE2	SIGNAL GENERATOR	AGILENT	E4438C	MY42081749	250KHZ-6GHZ	2/28/2019	2/28/2020
GSFA	OSP-B157 OSP MODULE	ROHDE & SCHWARZ	OSP-B157	100867		10/23/2018	10/23/2019
GSFB	OSP120 BASE UNIT	ROHDE & SCHWARZ	OSP120	101246	---	10/23/2018	10/23/2019
GSG0	PSG ANALOG SIGNAL GENERATOR	AGILENT	E8257D	US46461202	250KHZ-50GHZ	8/31/2018	8/31/2019
NHG1	STANDARD GAIN HORN ANTENNA	NARDA	638	---	18-26.5GHZ	NOTE 1	
NTA4	BILOG ANTENNA	TESEQ	6112D	46660	20-2000GHZ	9/5/2018	9/5/2019
NWQ0	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS LINDGREN	3117	66657	1GHZ-18GHZ	5/31/2018	5/31/2020
NWQ2	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS LINDGREN	3117	66659	1GHZ-18GHZ	3/22/2018	3/22/2020
RBG0	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101533	10HZ-44GHZ	12/5/2018	12/5/2019
RBG2	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101591	2HZ-44GHZ	2/21/2019	2/21/2020
SES0	24VDC POWER SUPPLY	P-TRANS	FS-32024-1M	001	18-27VDC	NOTE 1	
XOB2	ADAPTER	HEWLETT PACKARD	K281C,012	09407	18-26.5GHZ	NOTE 1	
XPR0	HIGH PASS FILTER	K&L MICROWAVE	11SH10-4800/X20000	001	4.8-20GHZ	9/12/2017	9/12/2019

I/O: Initial Only
N/A: Not Applicable
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.

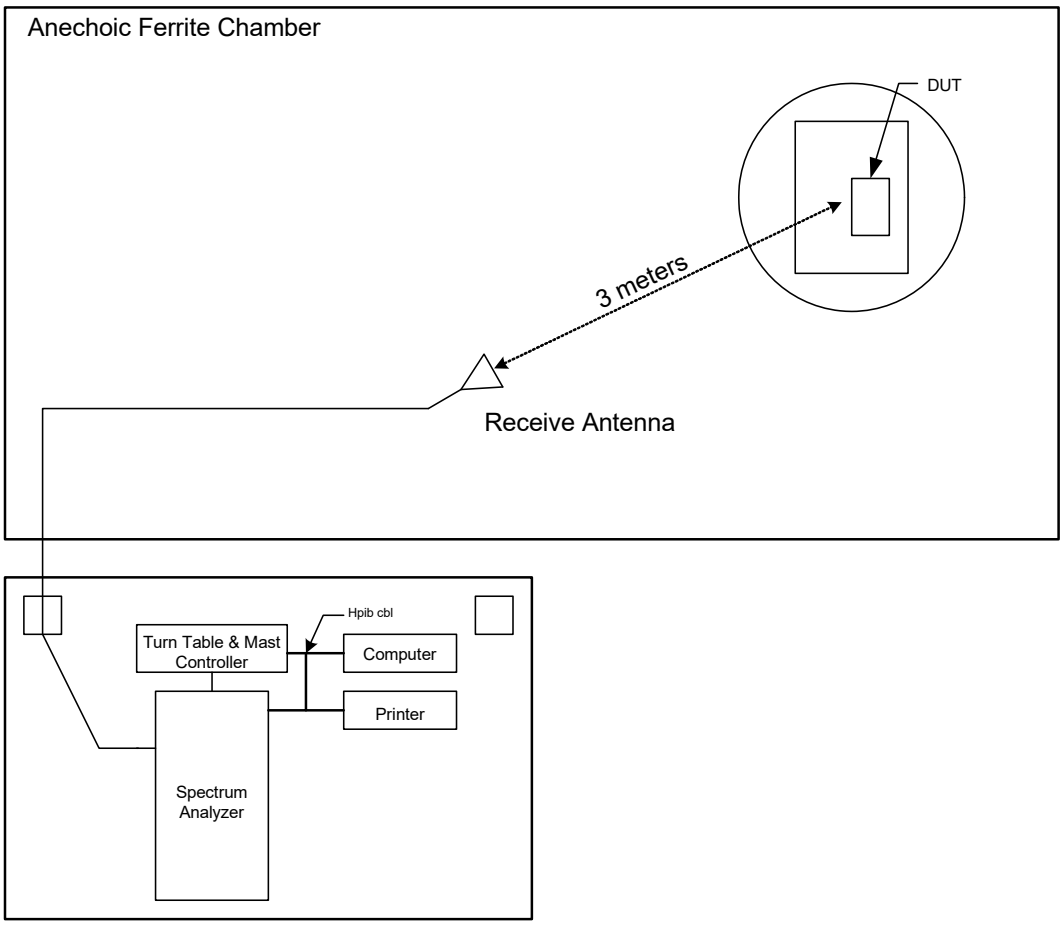


FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

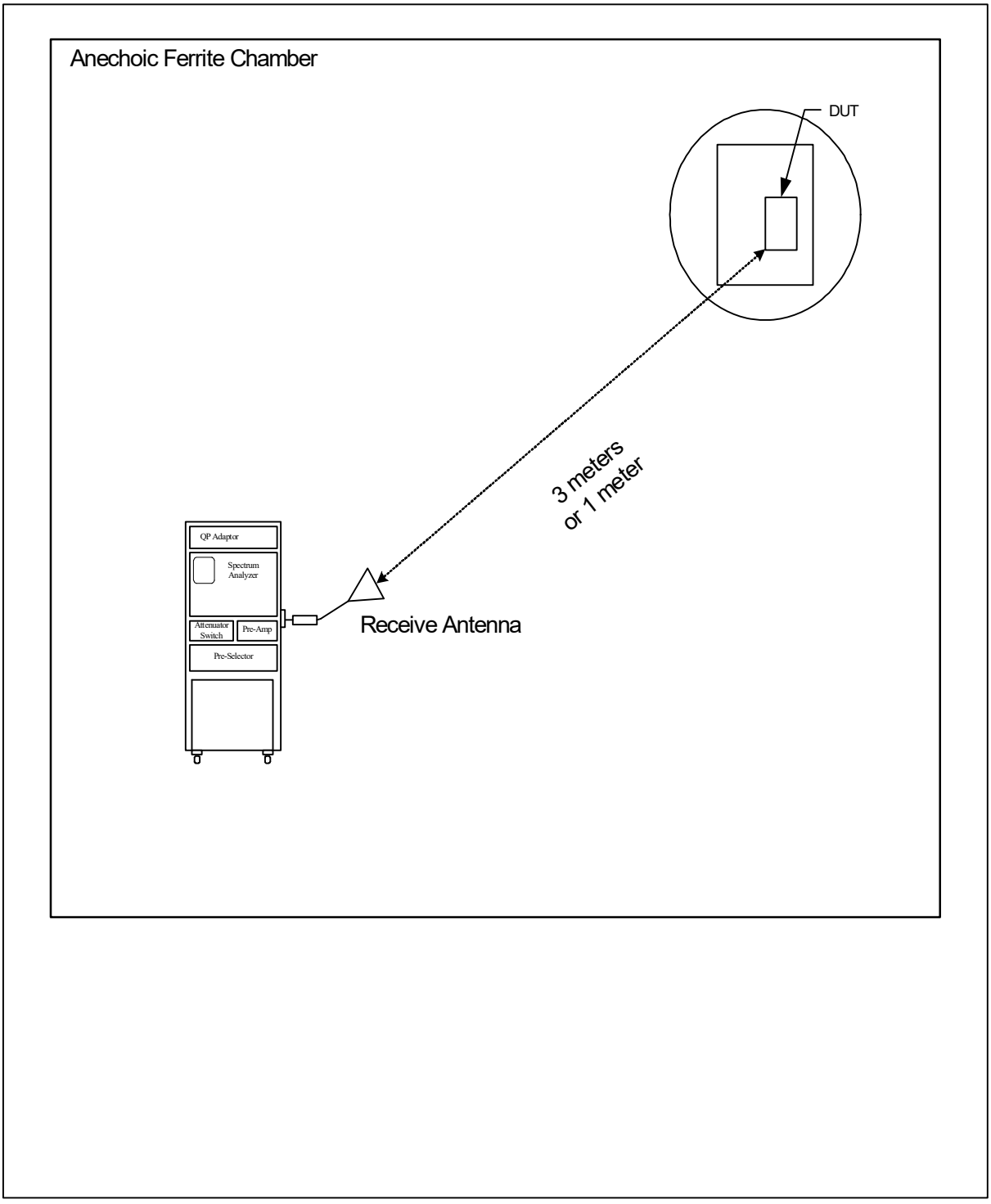
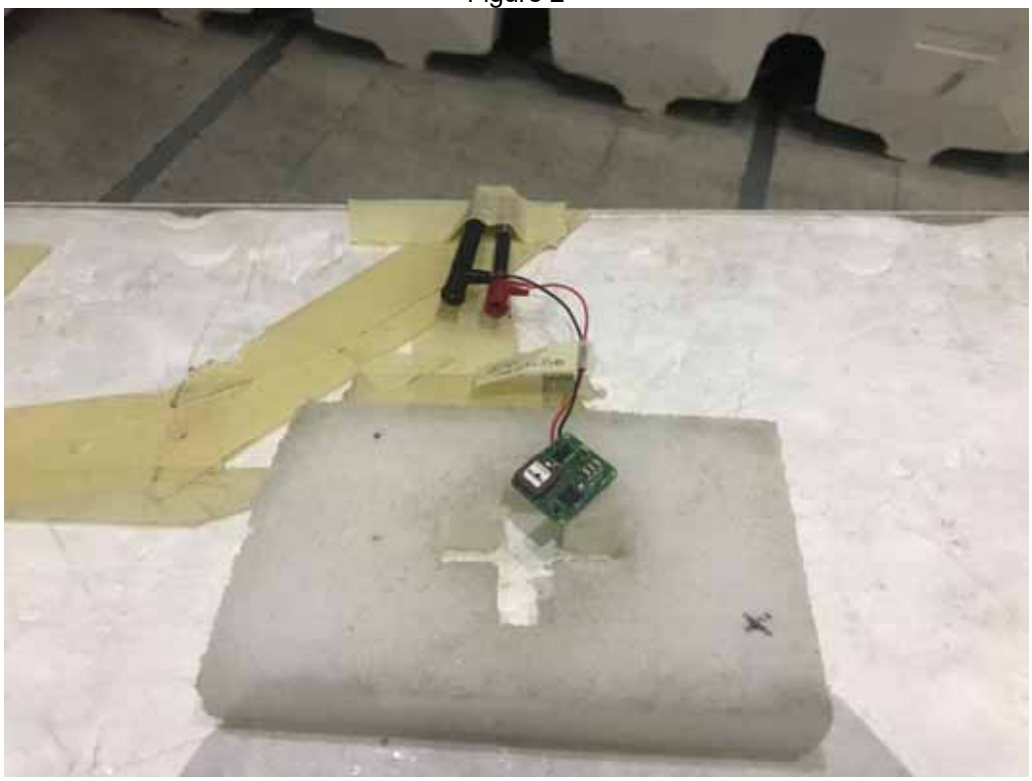
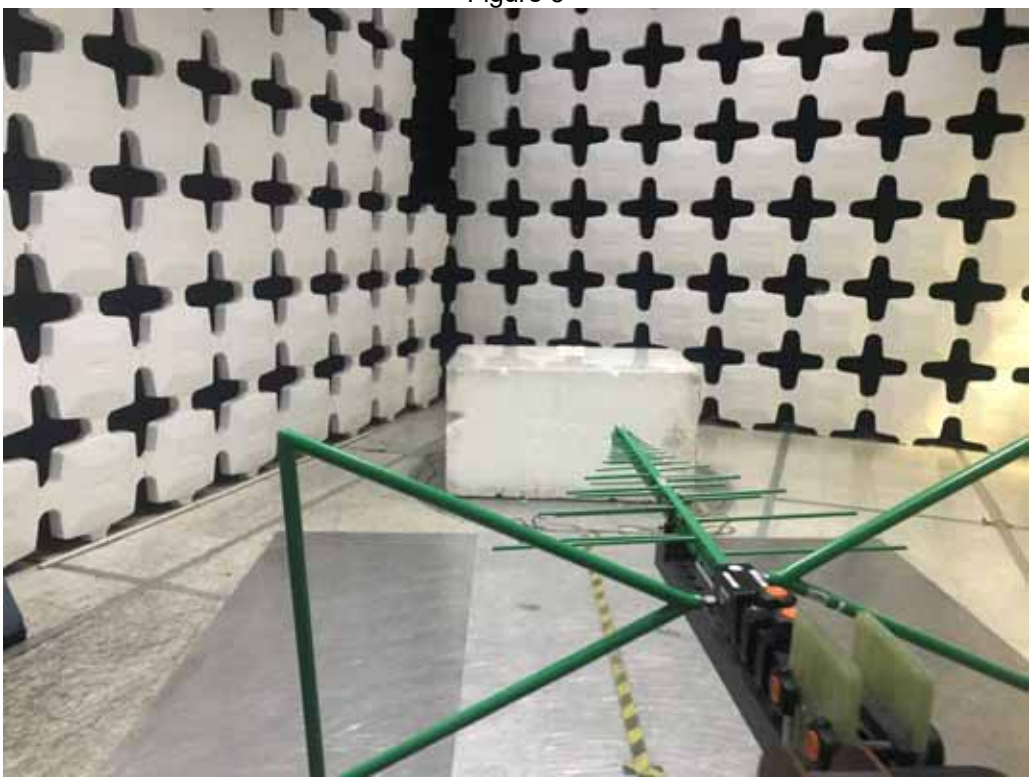

Anechoic Ferrite Chamber
DUT
3 meters
or 1 meter
QP Adaptor
Spectrum
Analyzer
Attenuator
Switch
Pre-Amp
Pre-Selector
Receive Antenna

Figure 2



EUT

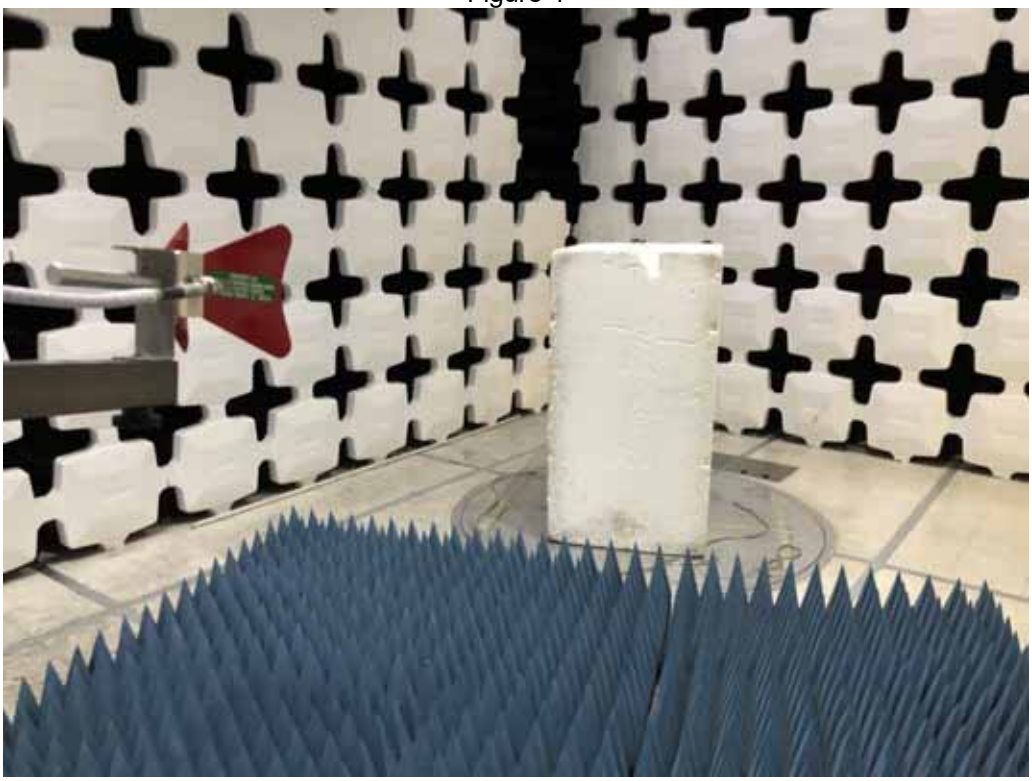
Figure 3



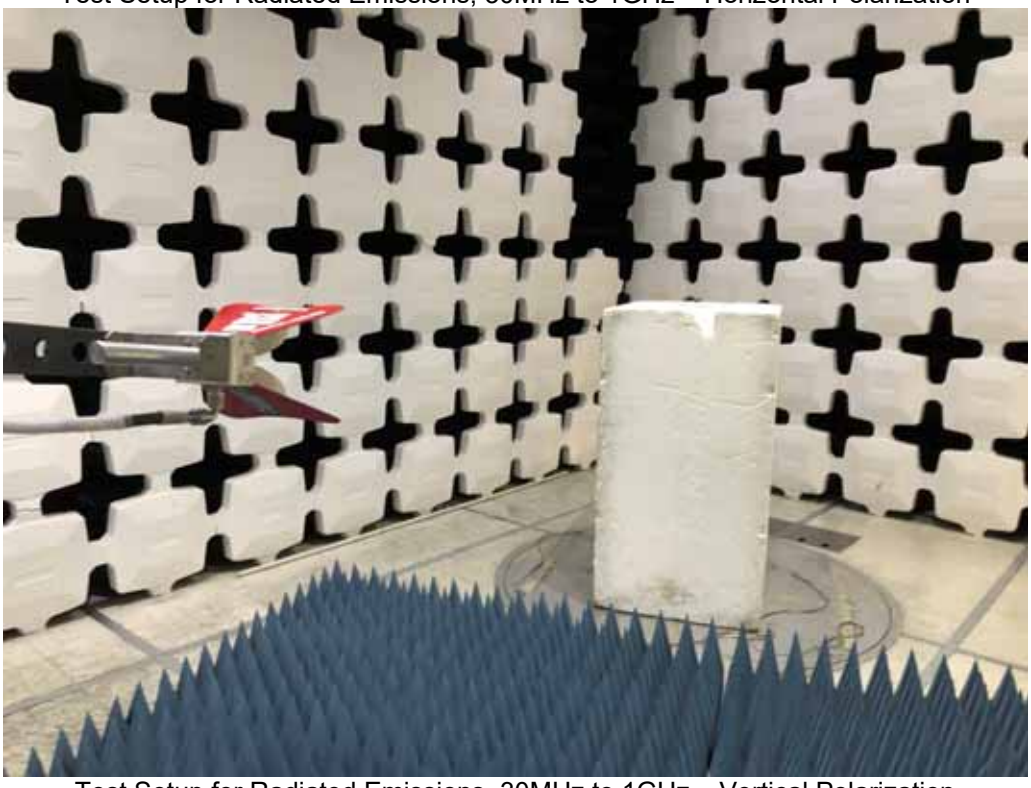
Test Setup for Radiated Emissions, 30MHz to 1GHz – Horizontal Polarization

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

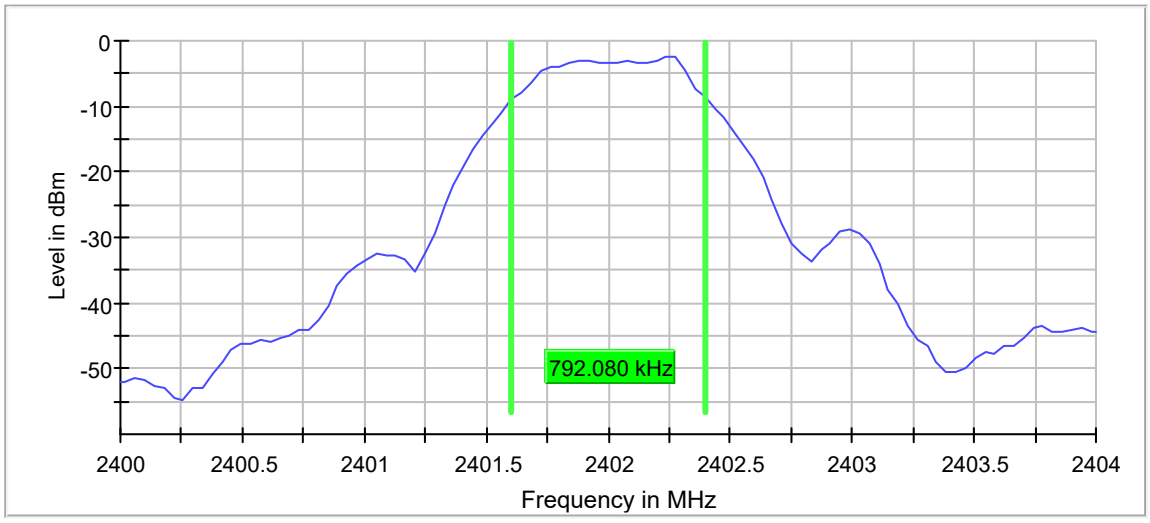
Figure 4



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

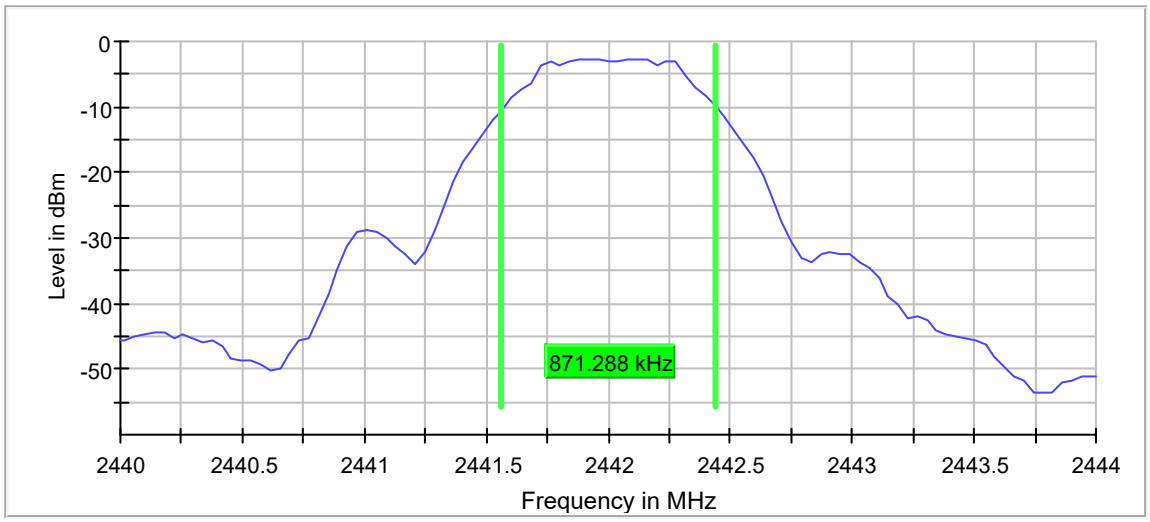


Test Setup for Radiated Emissions, 30MHz to 1GHz – Vertical Polarization



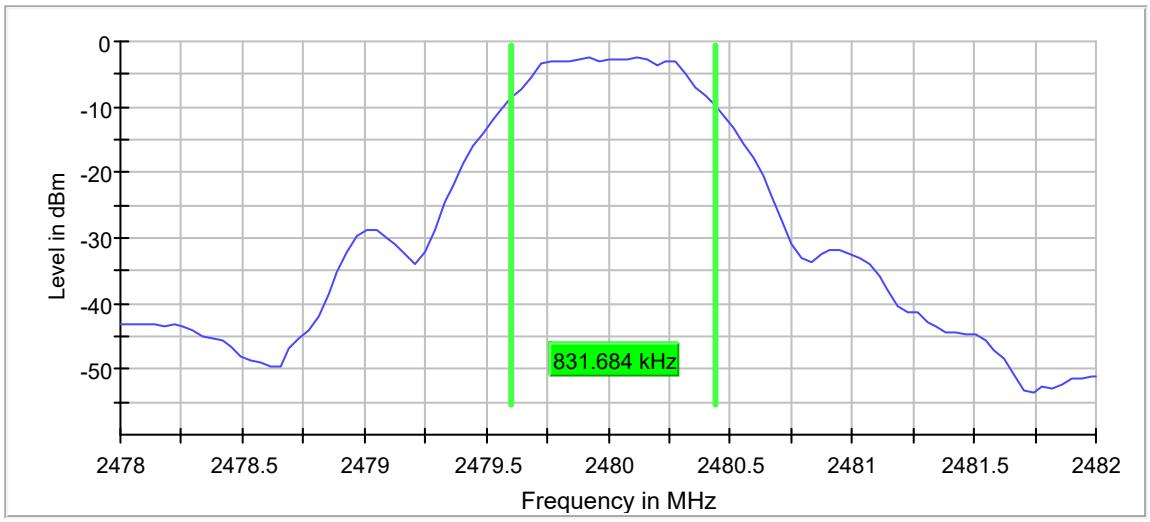
FCC 15.247 6dB Bandwidth

MANUFACTURER	:	CATERPILLAR Mossville AC
MODEL NUMBER	:	PL161 SC
TEST MODE	:	Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
NOTES	:	6dB bandwidth = 792.080kHz
EQUIPMENT USED	:	Wireless Test Set



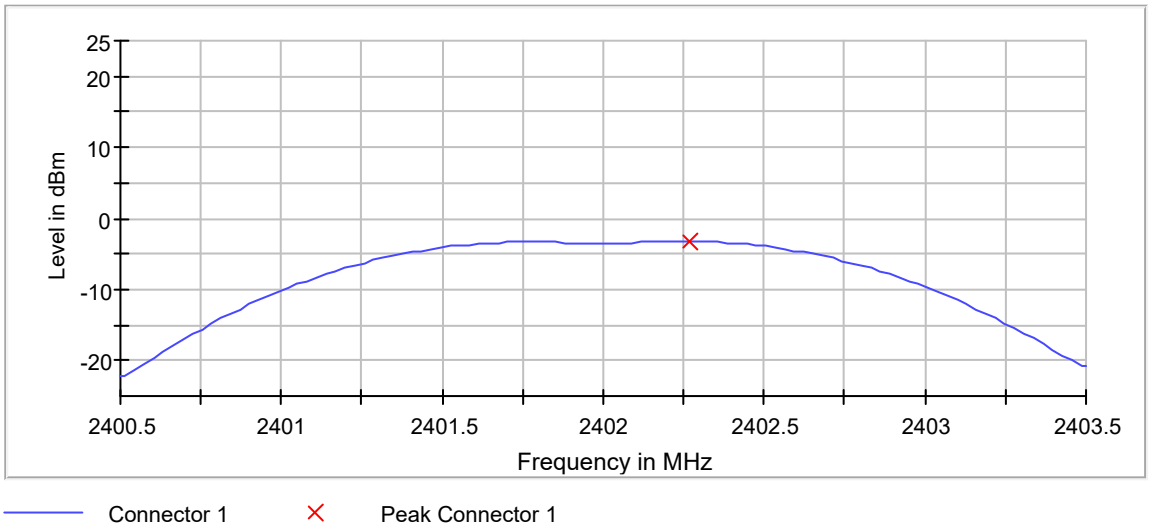
FCC 15.247 6dB Bandwidth

MANUFACTURER	:	CATERPILLAR Mossville AC
MODEL NUMBER	:	PL161 SC
TEST MODE	:	Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
NOTES	:	6dB bandwidth = 871.288kHz
EQUIPMENT USED	:	Wireless Test Set



FCC 15.247 6dB Bandwidth

MANUFACTURER	:	CATERPILLAR Mossville AC
MODEL NUMBER	:	PL161 SC
SERIAL NUMBER	:	
TEST MODE	:	Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
NOTES	:	6dB bandwidth = 831.684kHz
EQUIPMENT USED	:	Wireless Test Set

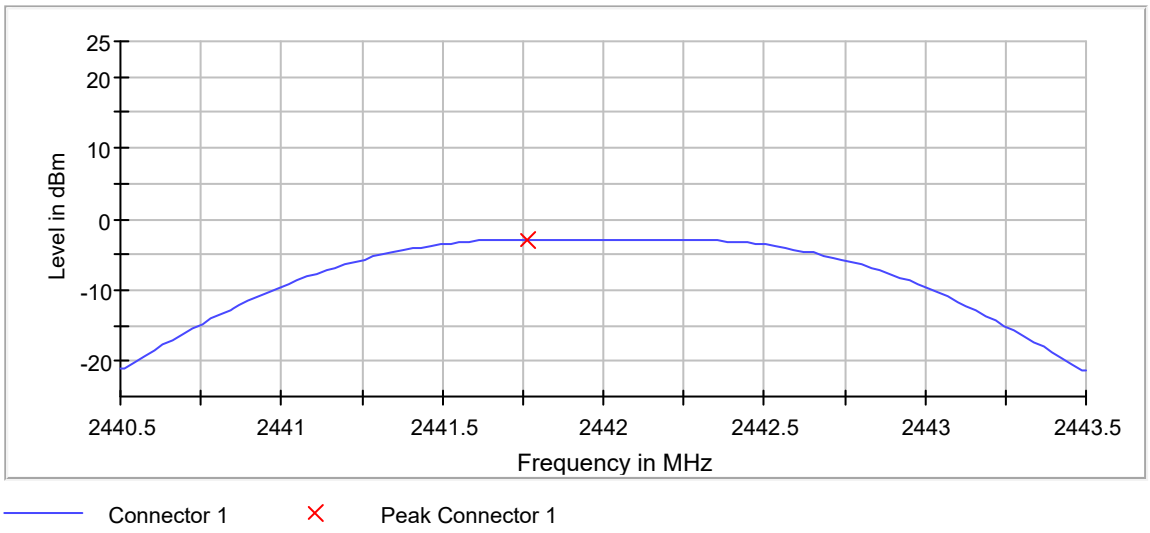


Result

DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2402.000000	-3.3	30.0	PASS

FCC 15.247 Peak Conducted Power

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
NOTES : Power = -3.3 dBm
EQUIPMENT USED : Wireless Test Set

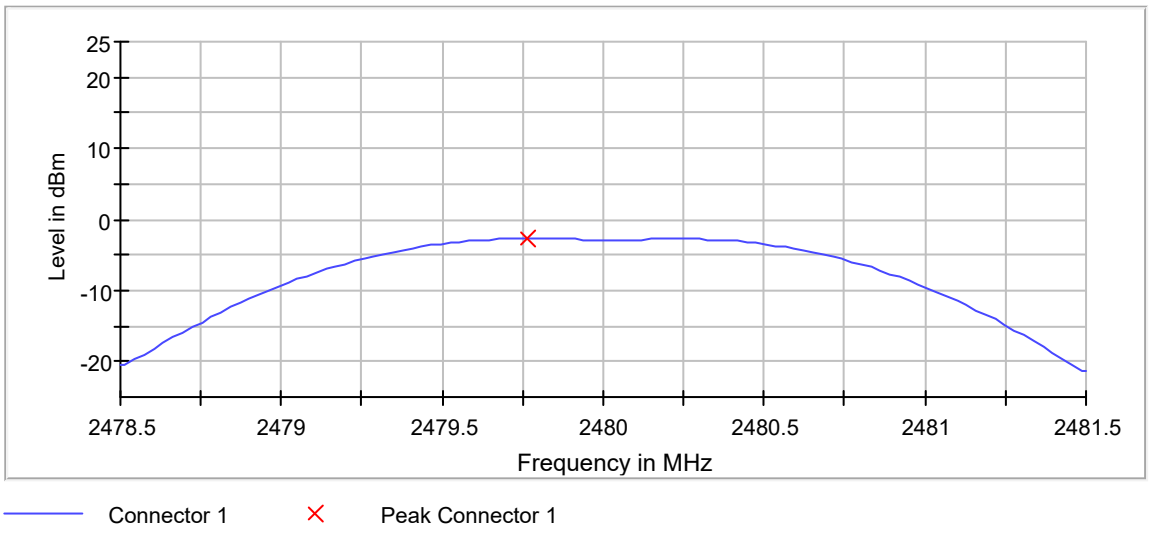


Result

DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2442.000000	-2.8	30.0	PASS

FCC 15.247 Peak Conducted Power

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
NOTES : Power = -2.8 dBm
EQUIPMENT USED : Wireless Test Set



Result

DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2480.000000	-2.7	30.0	PASS

FCC 15.247 Peak Conducted Power

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
NOTES : Power = -2.7 dBm
EQUIPMENT USED : Wireless Test Set

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 18), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 EIRP Output Power
Date : May 16-24, 2019
Test Distance :3 meters
Notes :

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)
2402.00	H	39.0	-26.6	4.2	2.7	-25.1	36.0	-61.1
2402.00	V	38.0	-24.8	4.2	2.7	-23.3	36.0	-59.3

EIRP = Sig. Gen. Reading (dBm) + Antenna Gain (dB) – Cable Loss (dB)

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 EIRP Output Power
Date : May 16-24, 2019
Test Distance : 3 meters
Notes :

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)
2442.00	H	41.6	-24.8	4.4	2.8	-23.2	36.0	-59.2
2442.00	V	44.3	-19.6	4.4	2.8	-18.0	36.0	-54.0

EIRP = Sig. Gen. Reading (dBm) + Antenna Gain (dB) – Cable Loss (dB)

Checked BY Richard E. King :

Richard E. King

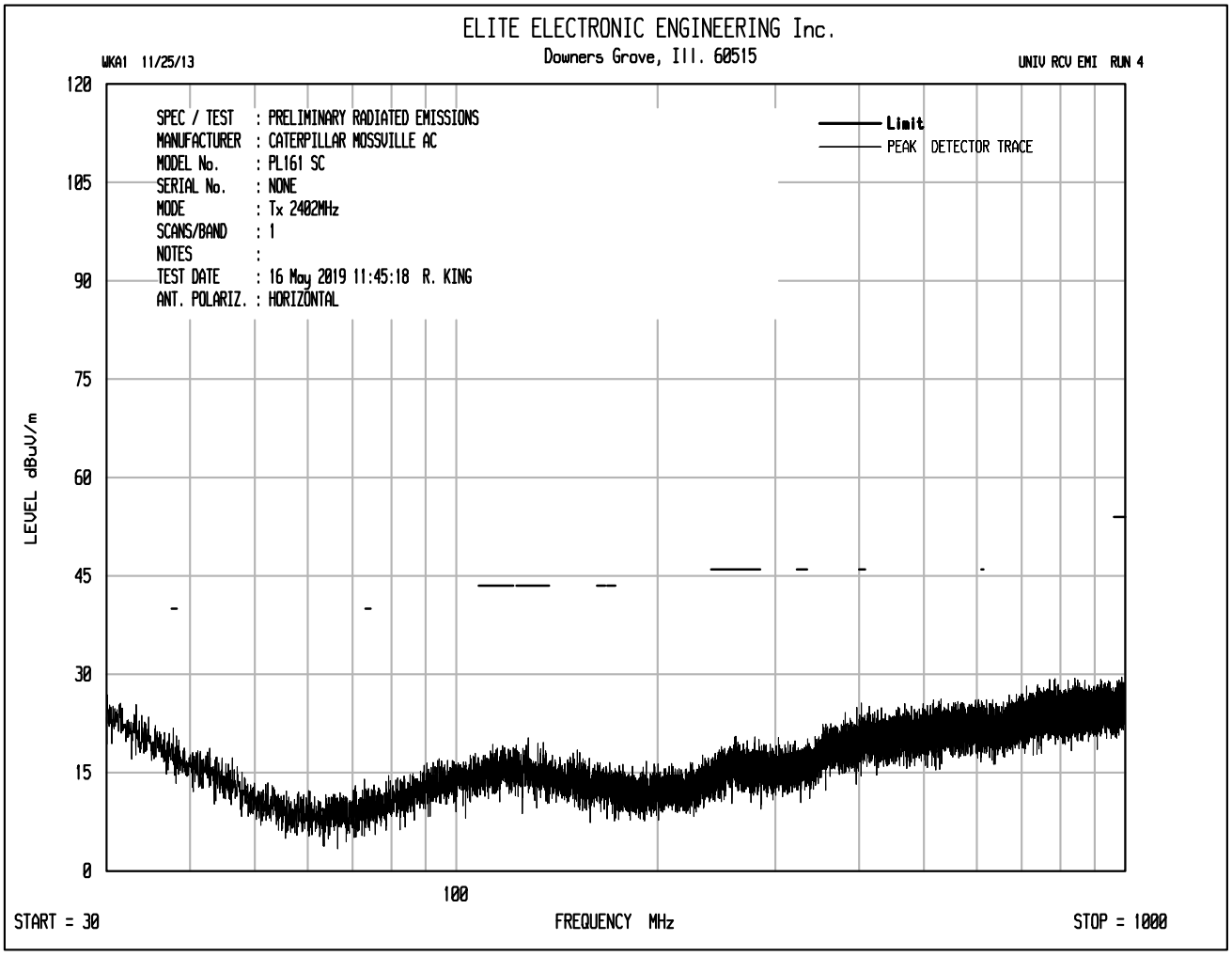
Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 EIRP Output Power
Date : May 16-24, 2019
Test Distance : 3 meters
Notes :

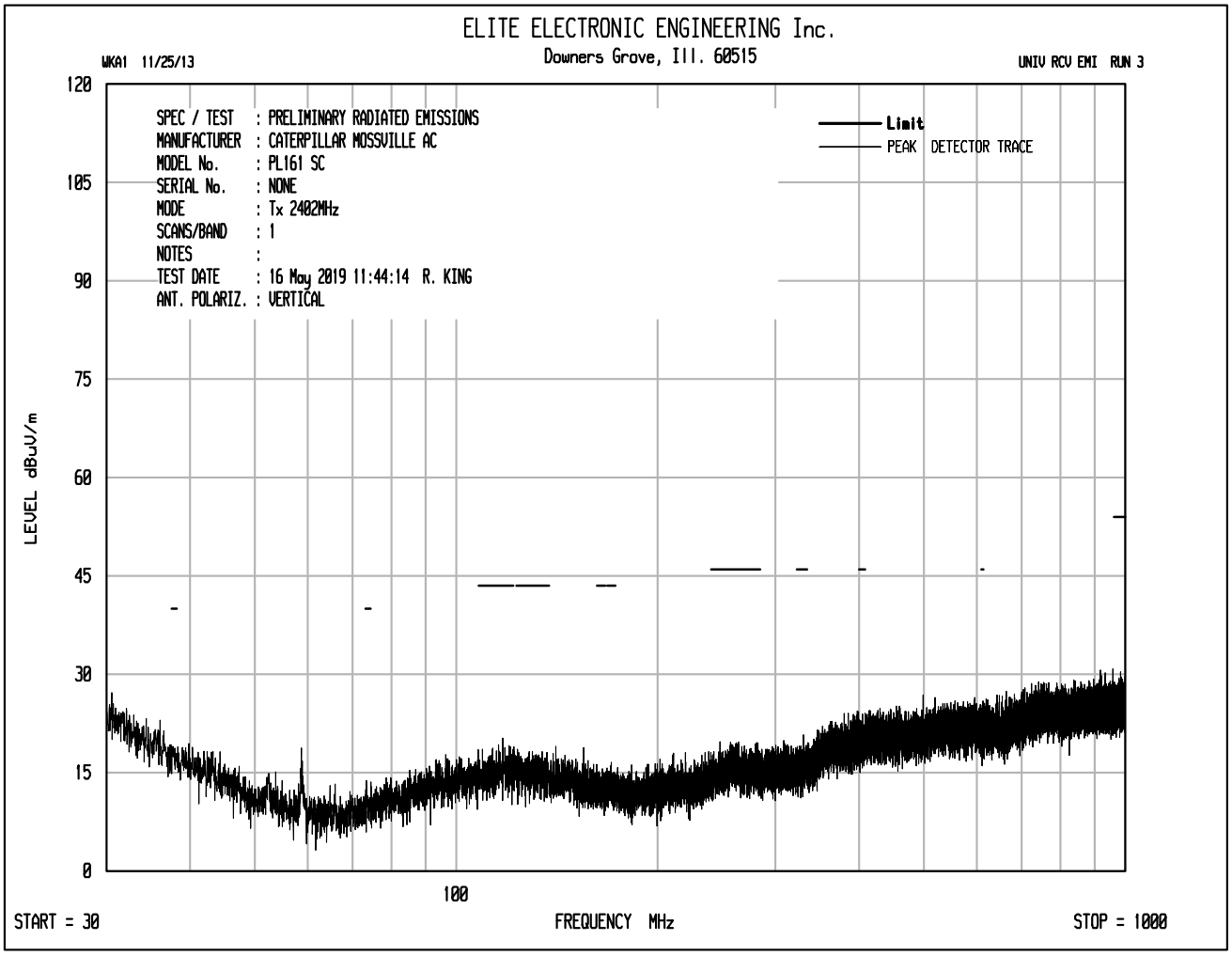
Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2480.00	H	35.6	-30.6	4.5	2.8	-28.9	36.0	-64.9
2480.00	V	37.6	-25.6	4.5	2.8	-23.9	36.0	-59.9

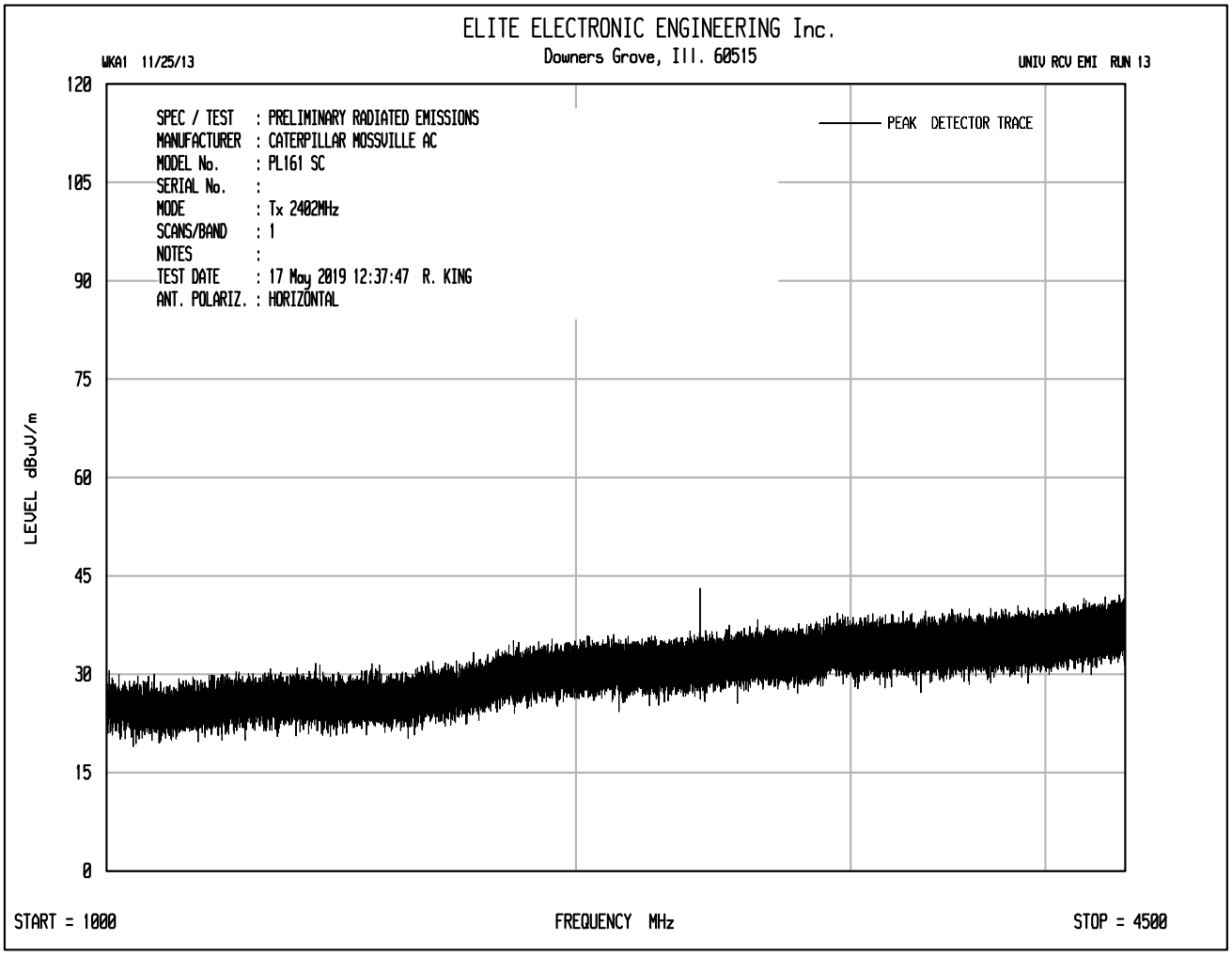
EIRP = Sig. Gen. Reading (dBm) + Antenna Gain (dB) – Cable Loss (dB)

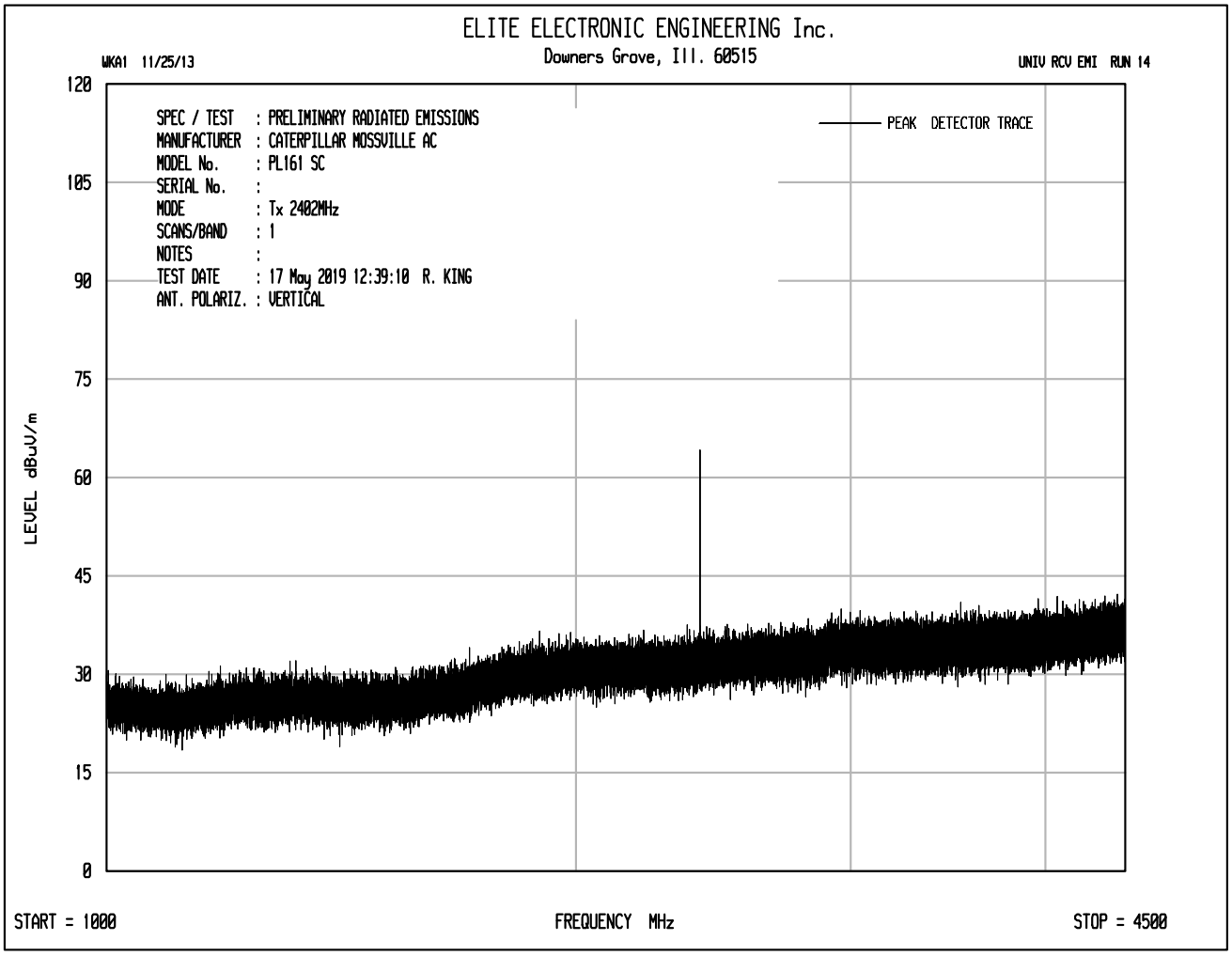
Checked BY Richard E. King :

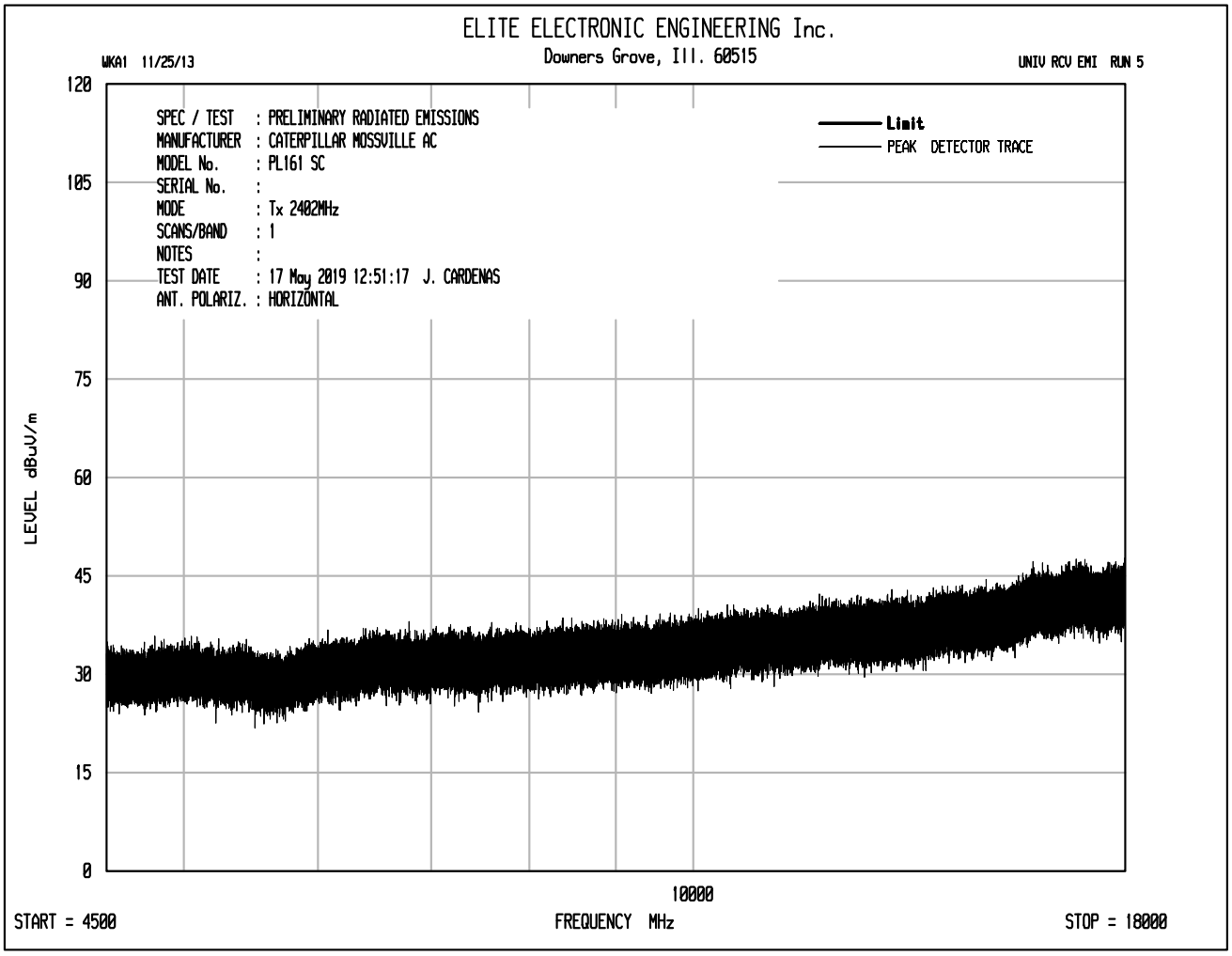
Richard E. King

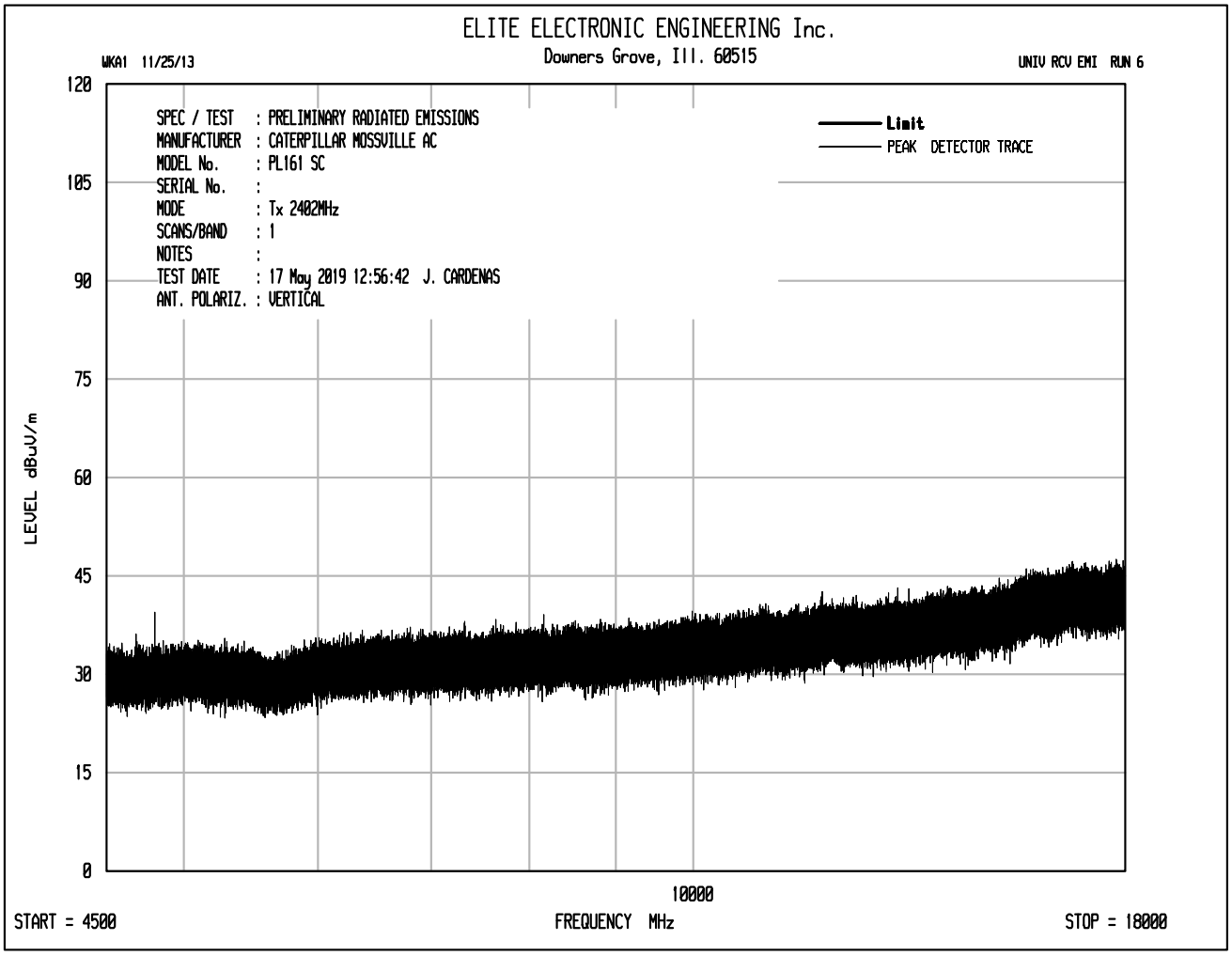

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 4
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 11:45:18 R. KING
ANT. 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

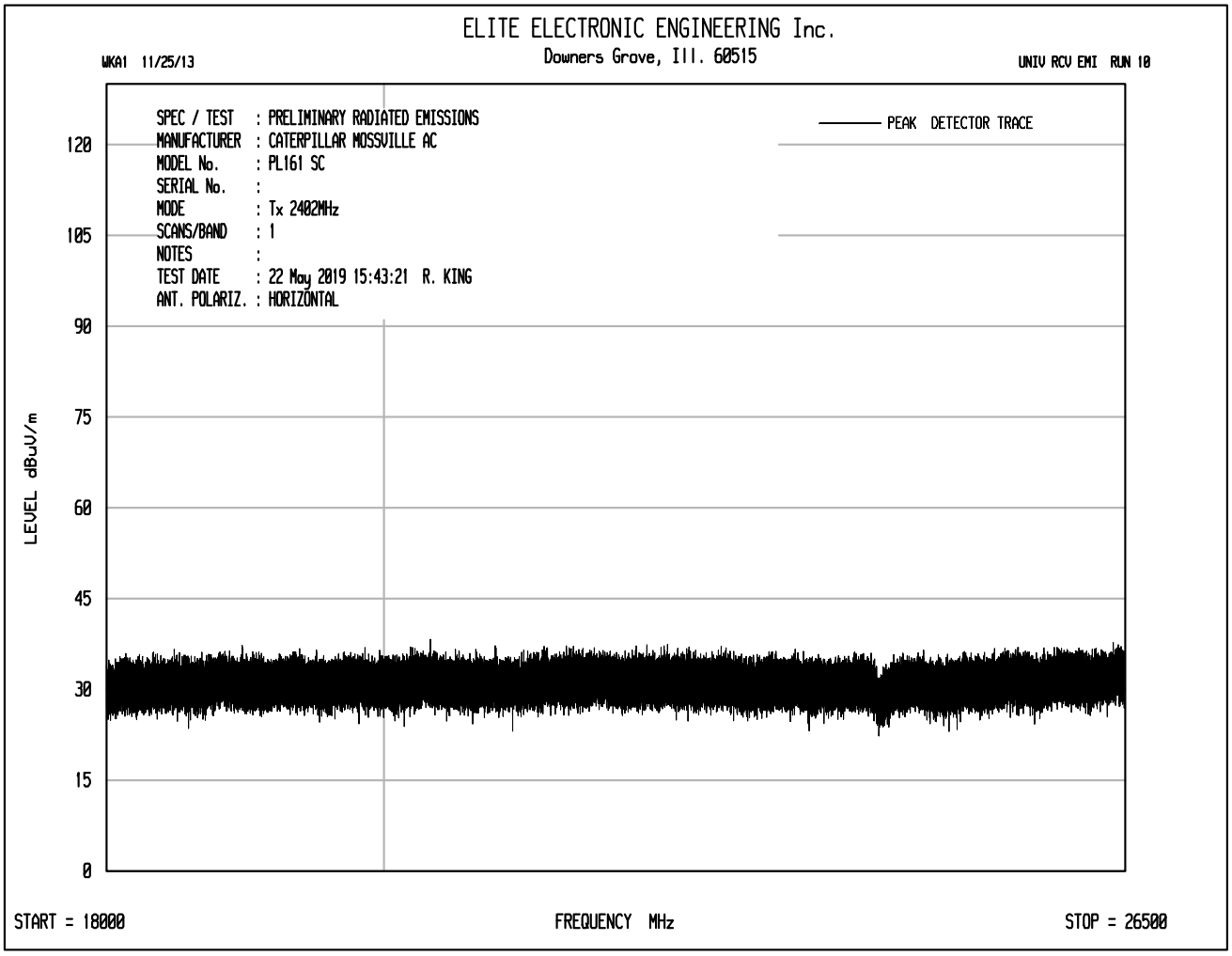

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 3
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 11:44:14 R. KING
ANT. 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

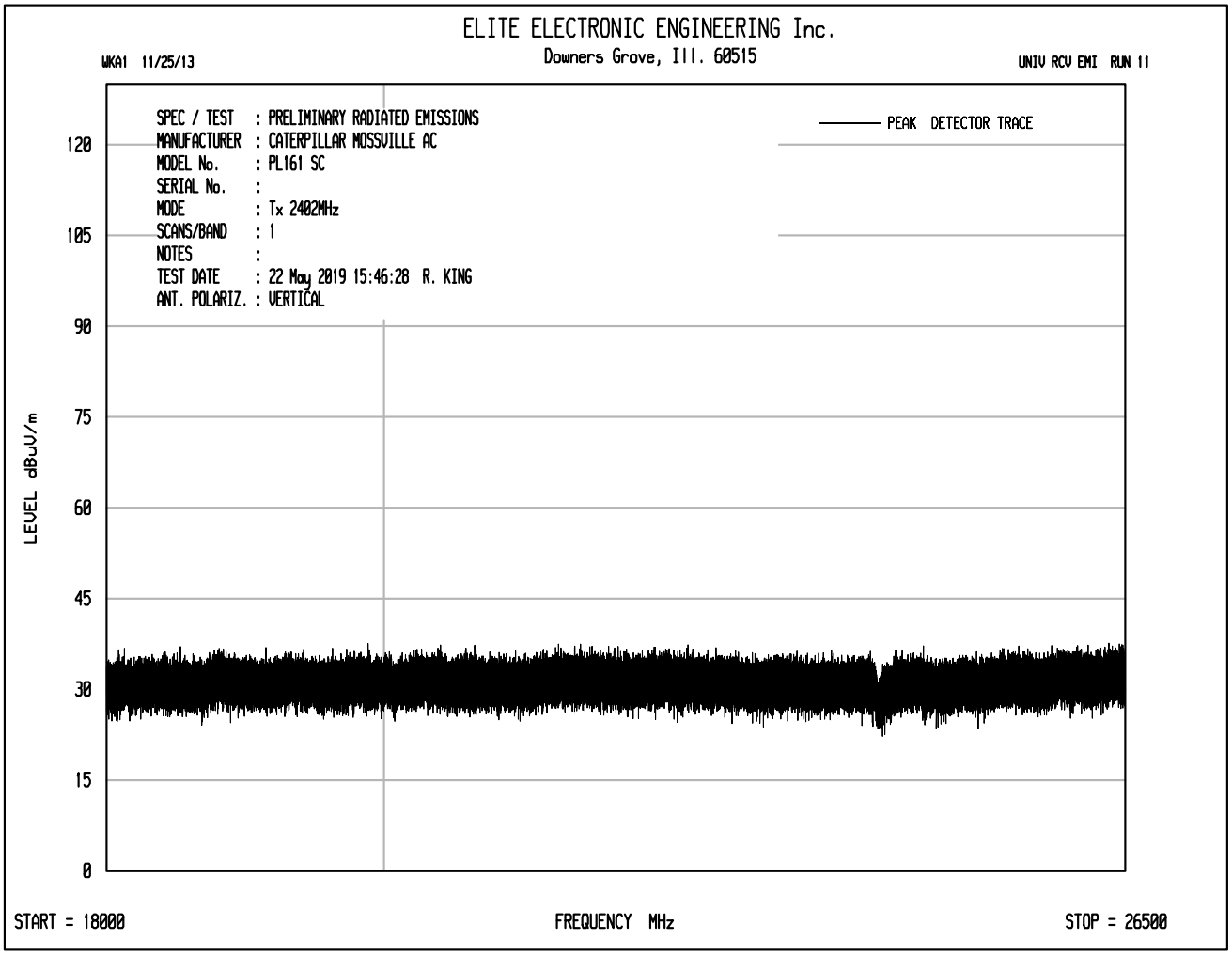

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 13
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:37:47 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500

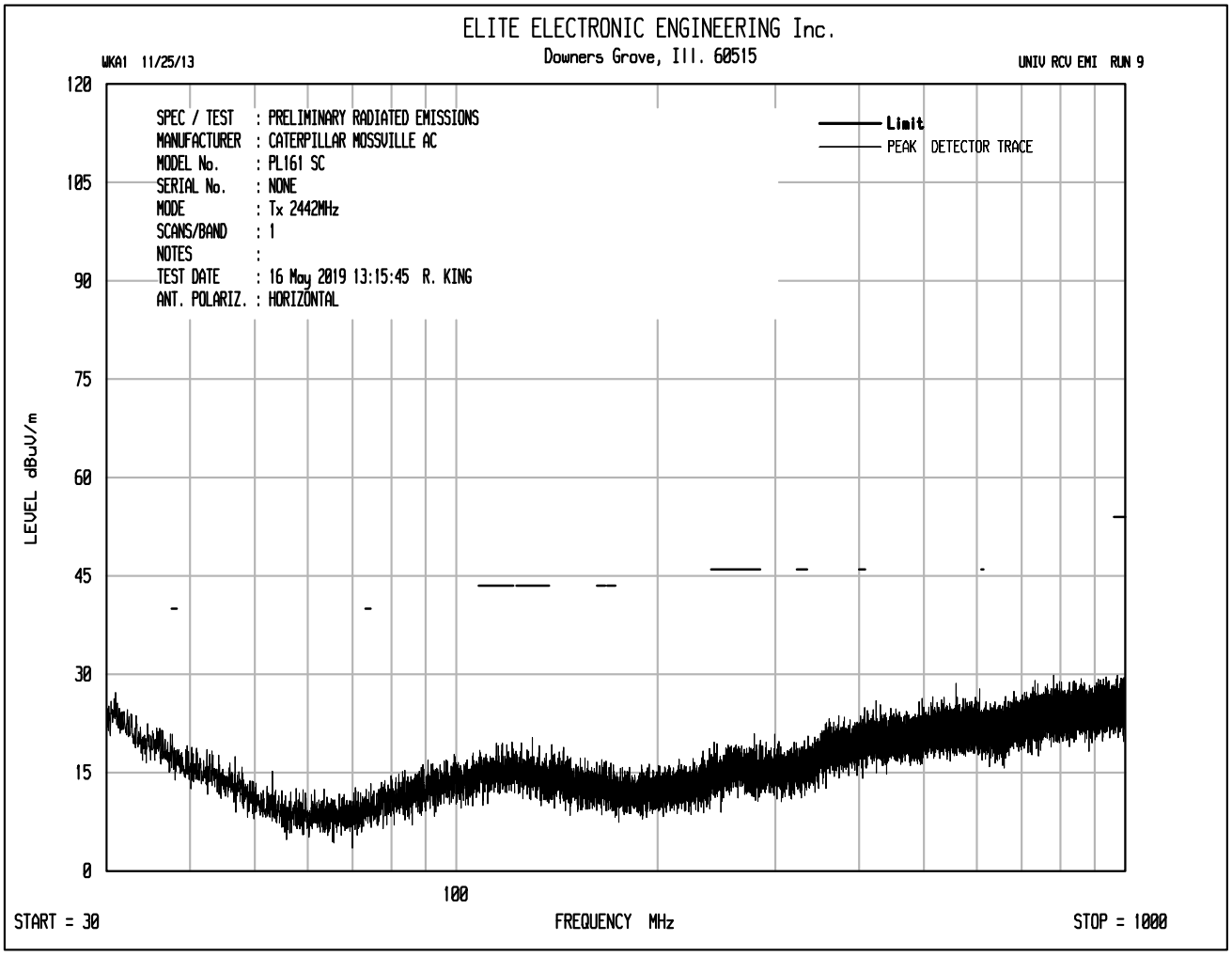

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 14
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:39:10 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500

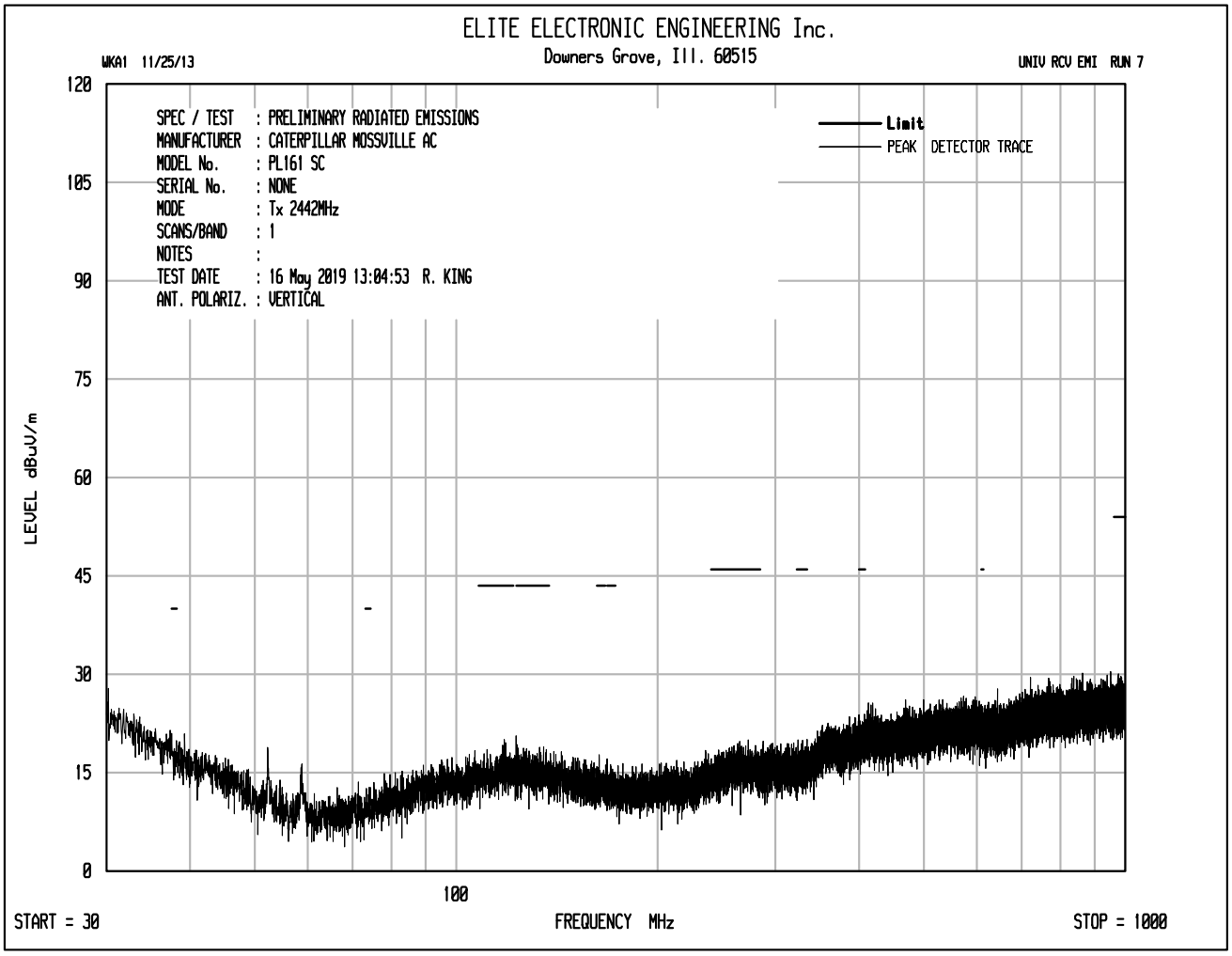

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 5
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:51:17 J. CARDENAS
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000

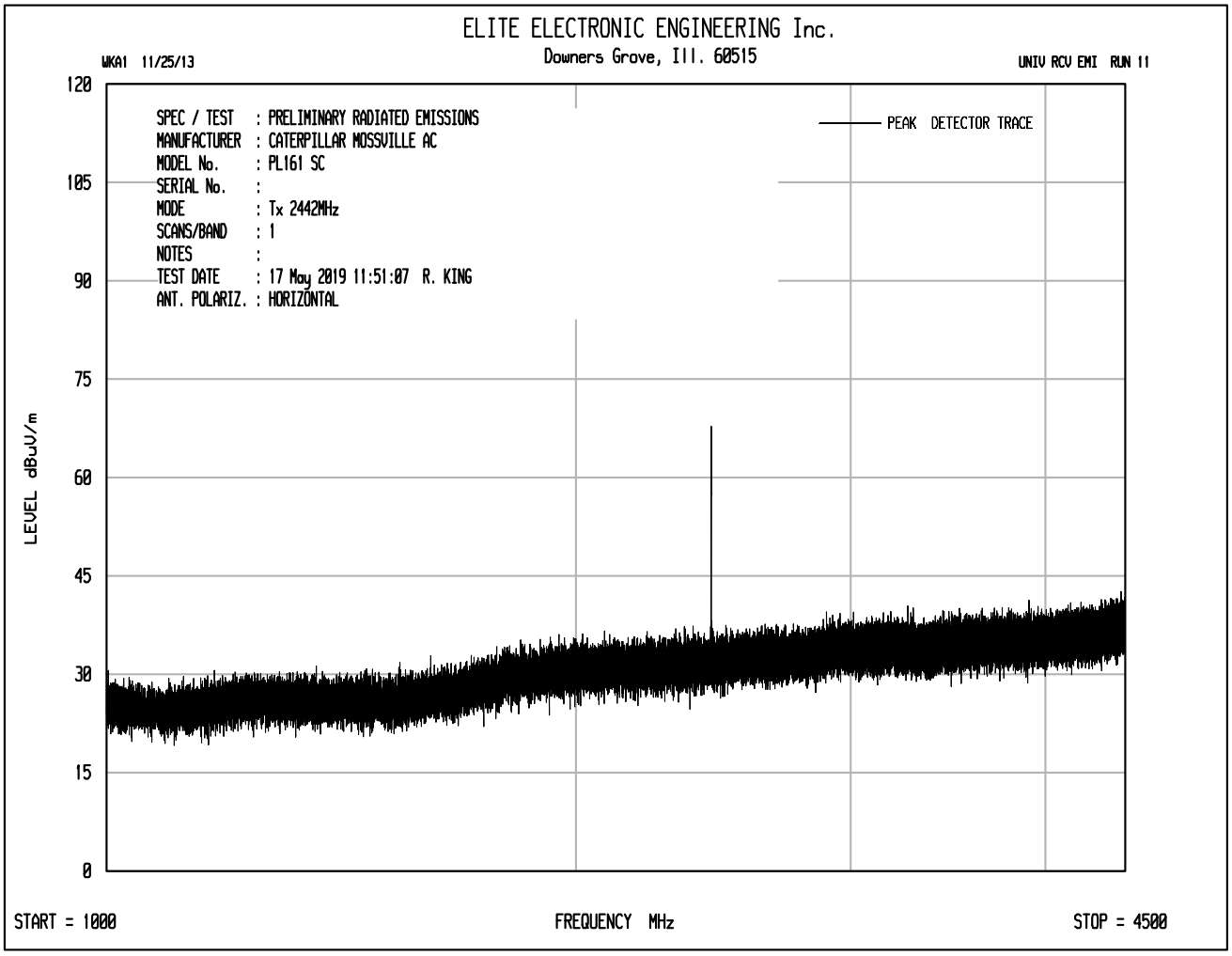

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 6
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:56:42 J. CARDENAS
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000

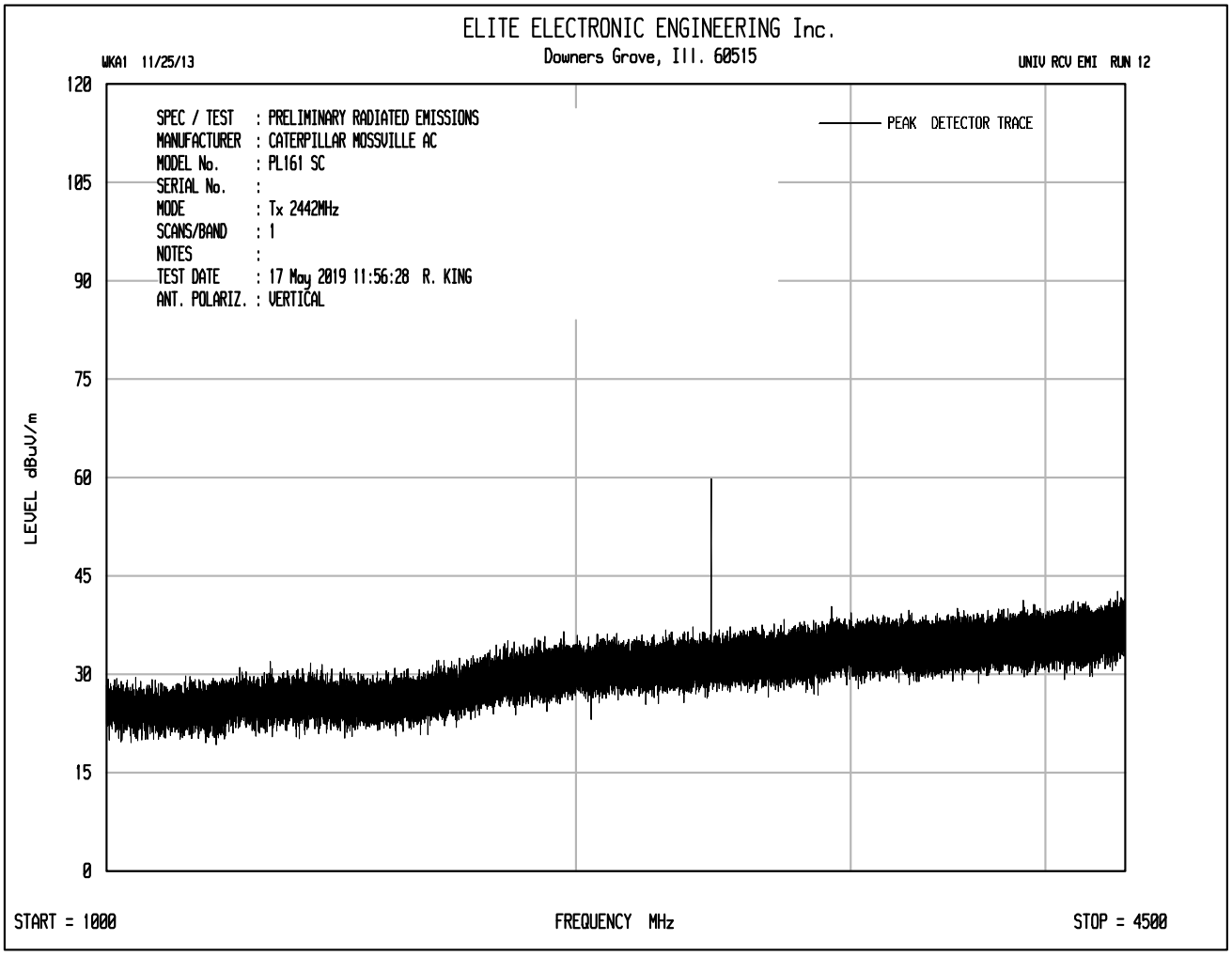

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:43:21 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500

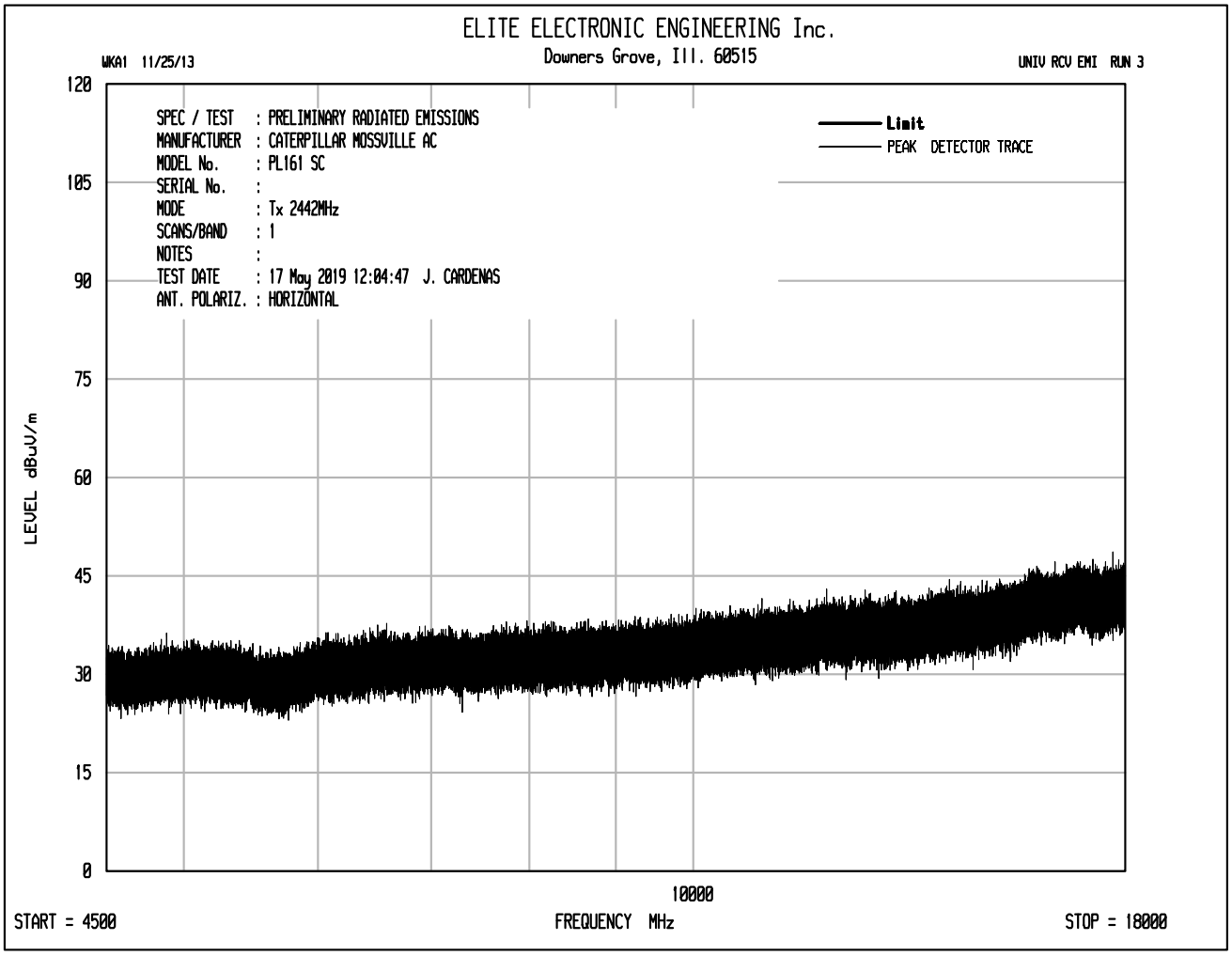

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 11
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2402MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:46:28 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500

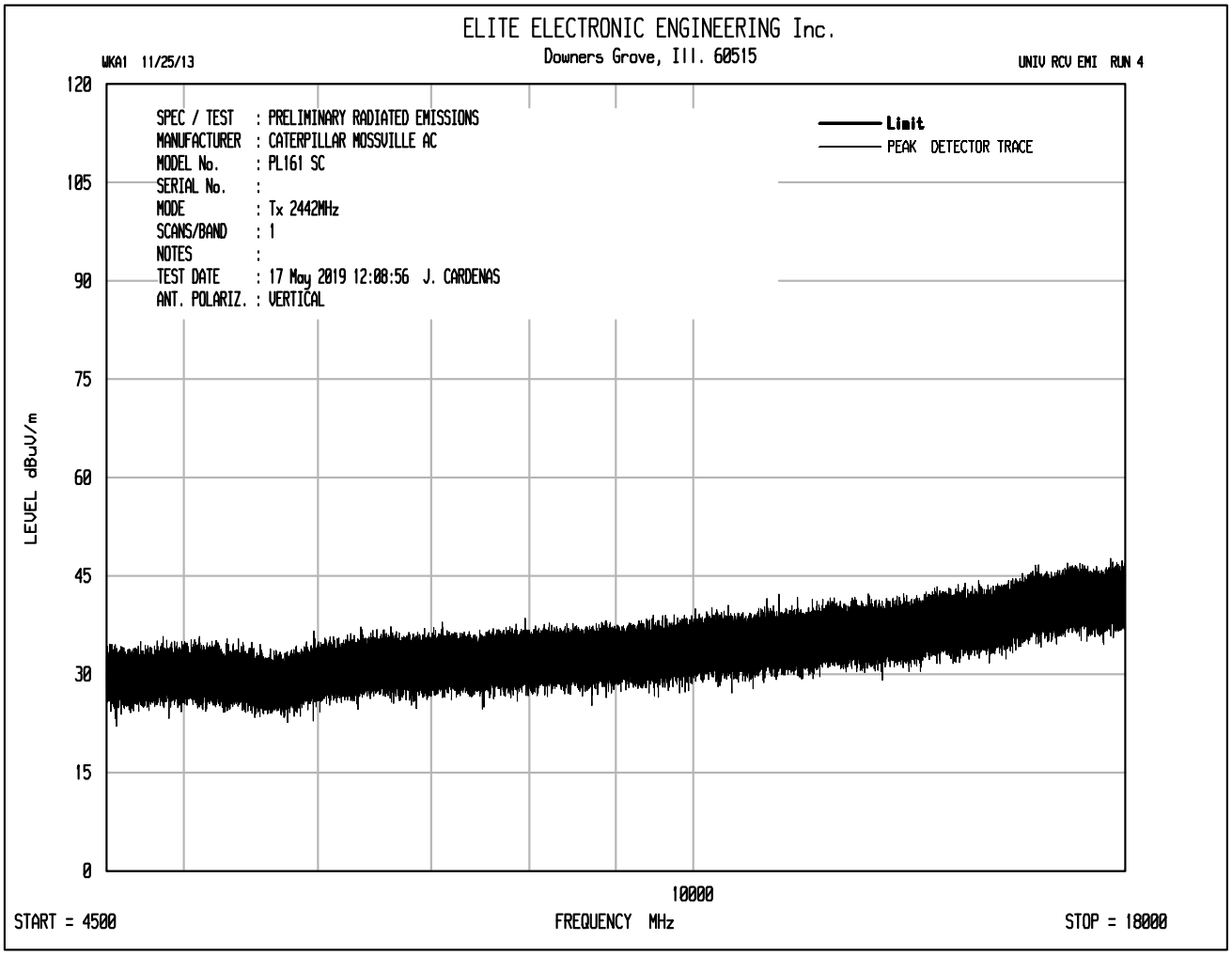

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 9
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 13:15:45 R. KING
ANT. 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

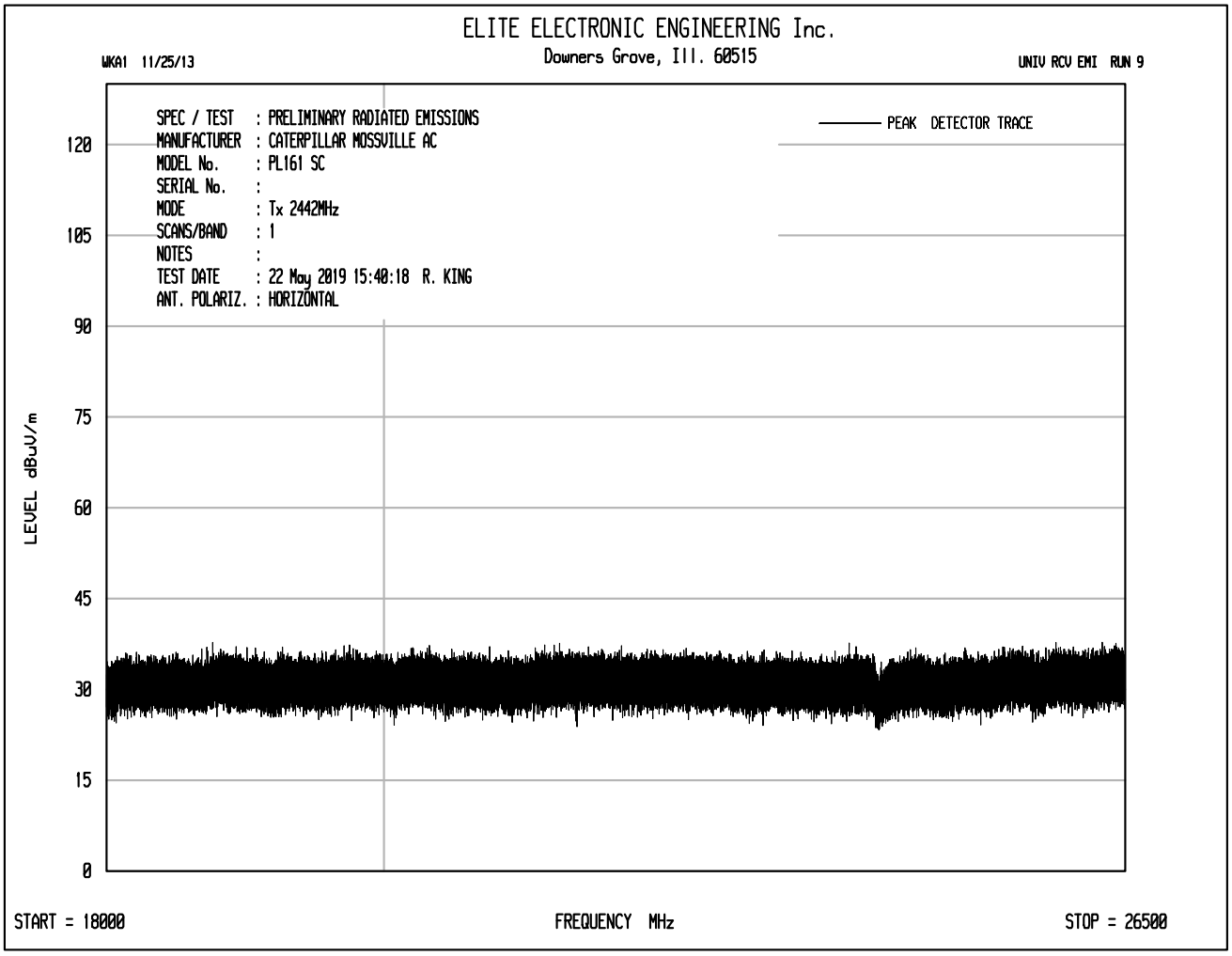

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 7
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 13:04:53 R. KING
ANT. 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

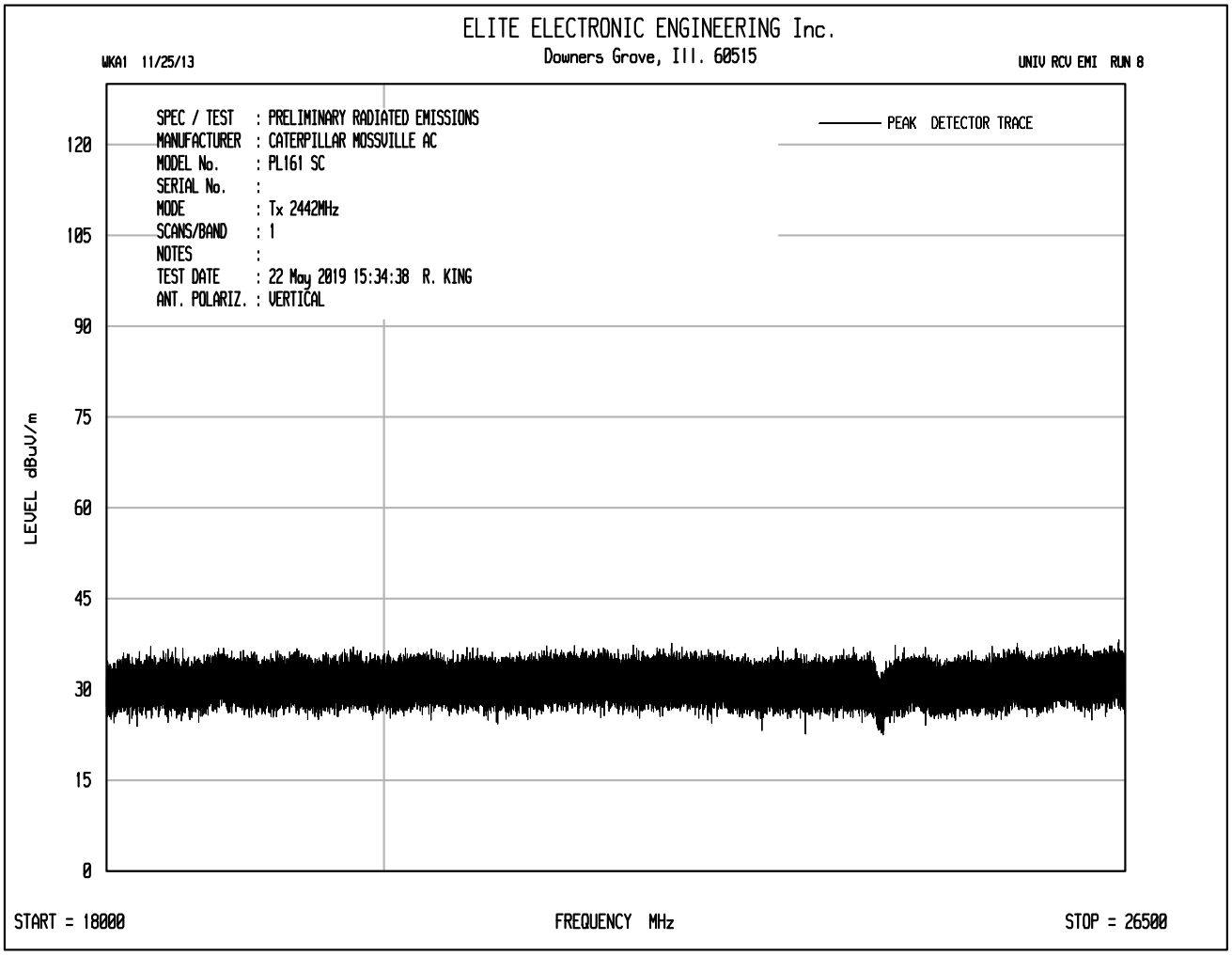

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 11
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 11:51:07 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500

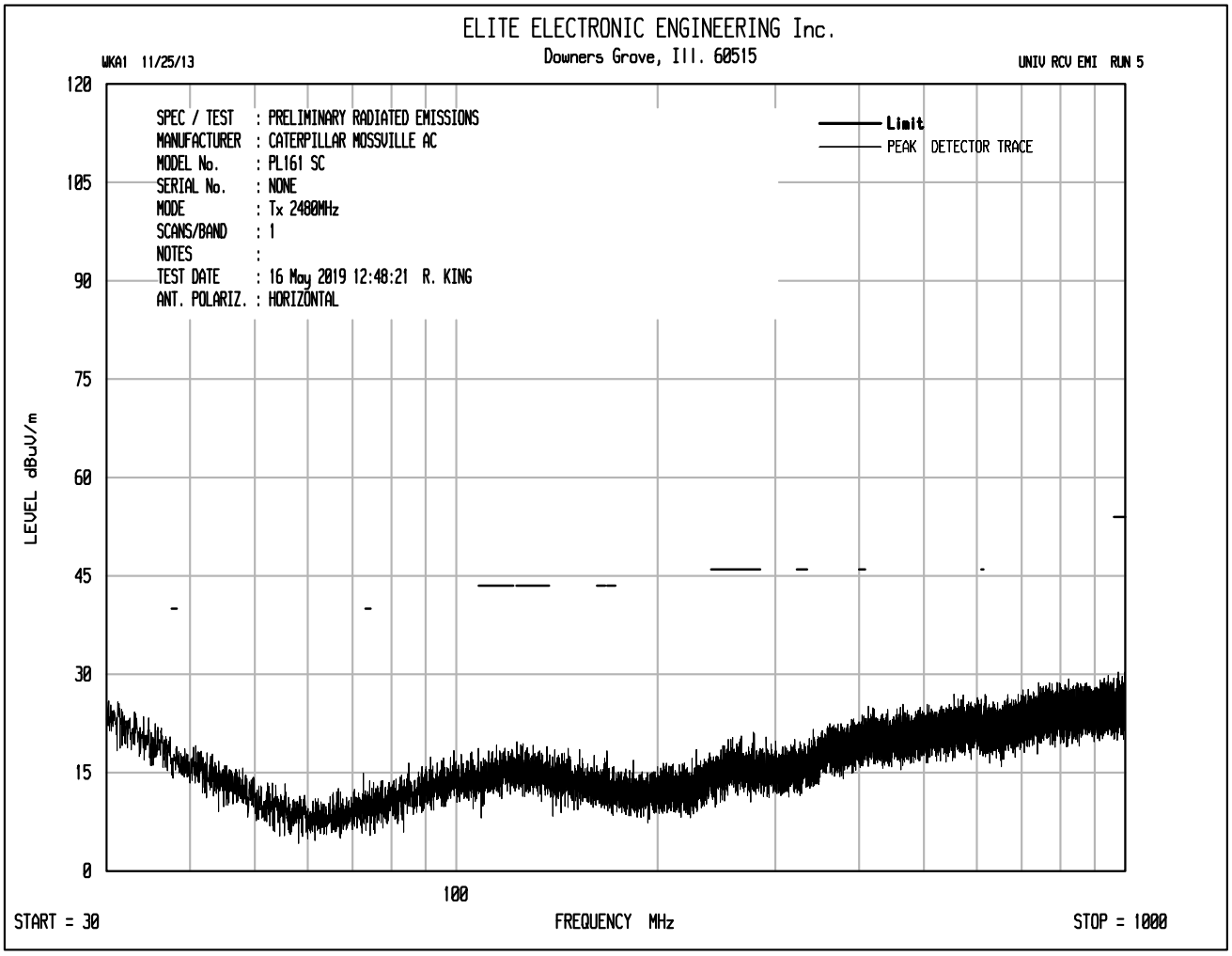

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 12
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 11:56:28 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 4500

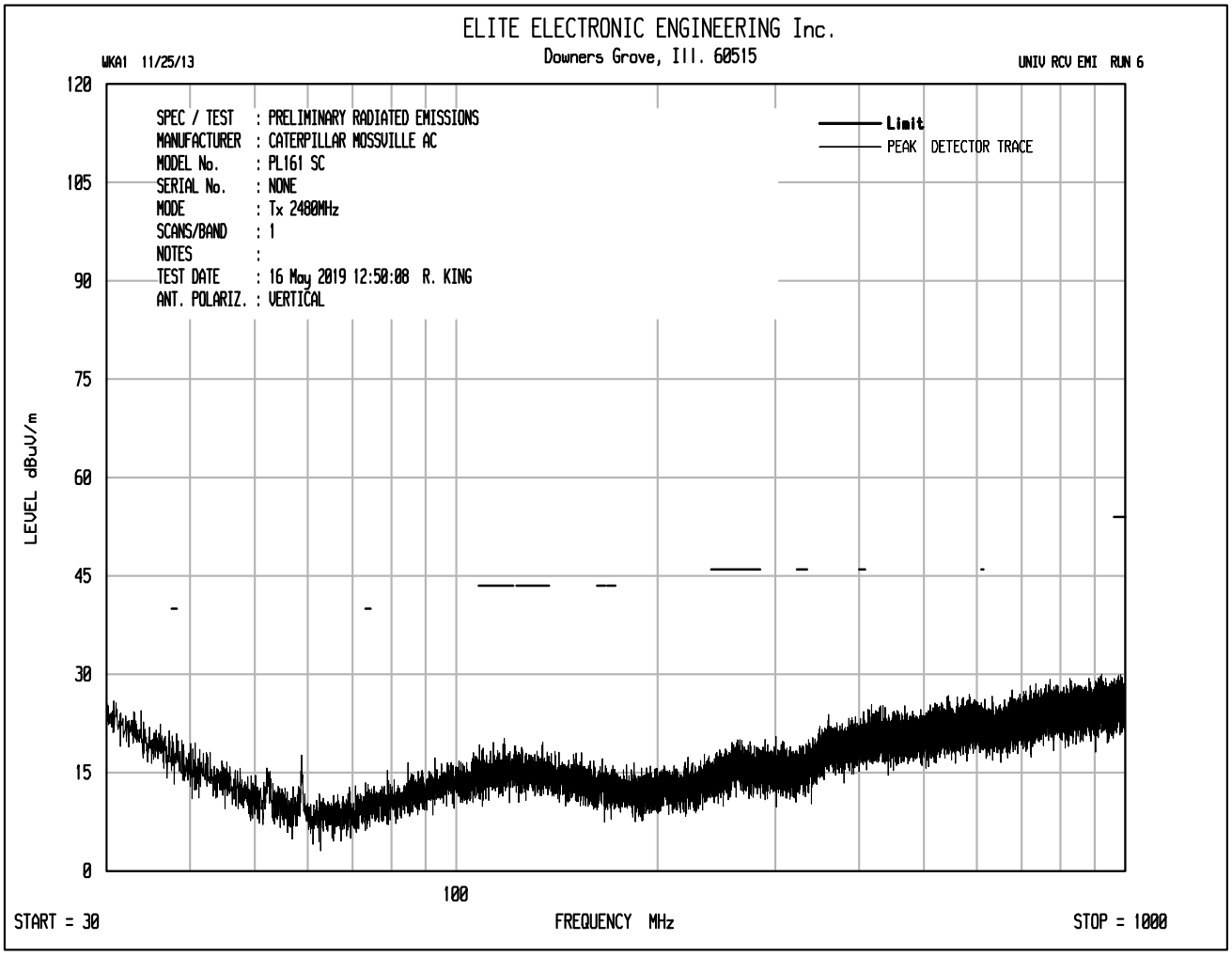

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 3
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:04:47 J. CARDENAS
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000

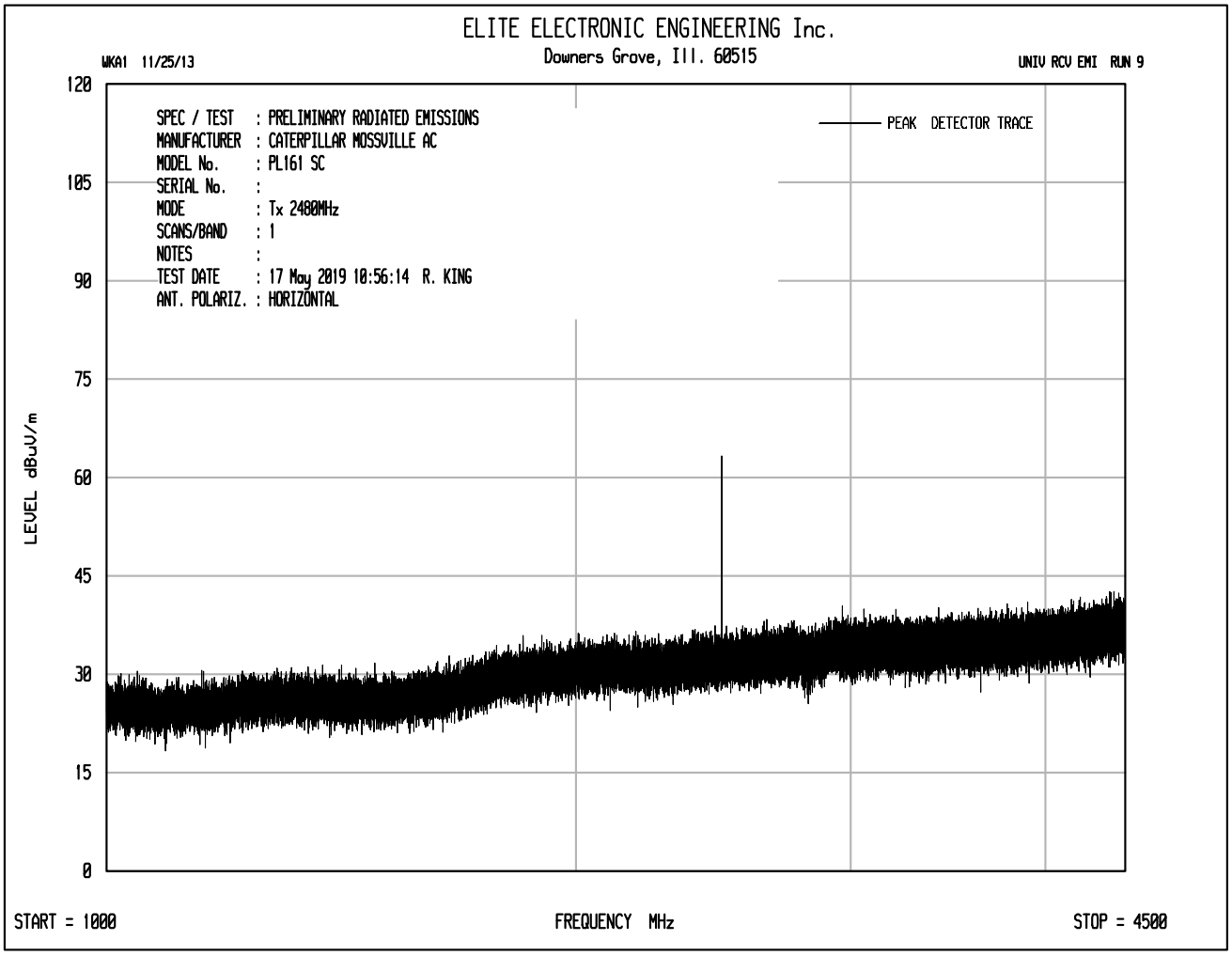

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 4
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 12:08:56 J. CARDENAS
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000

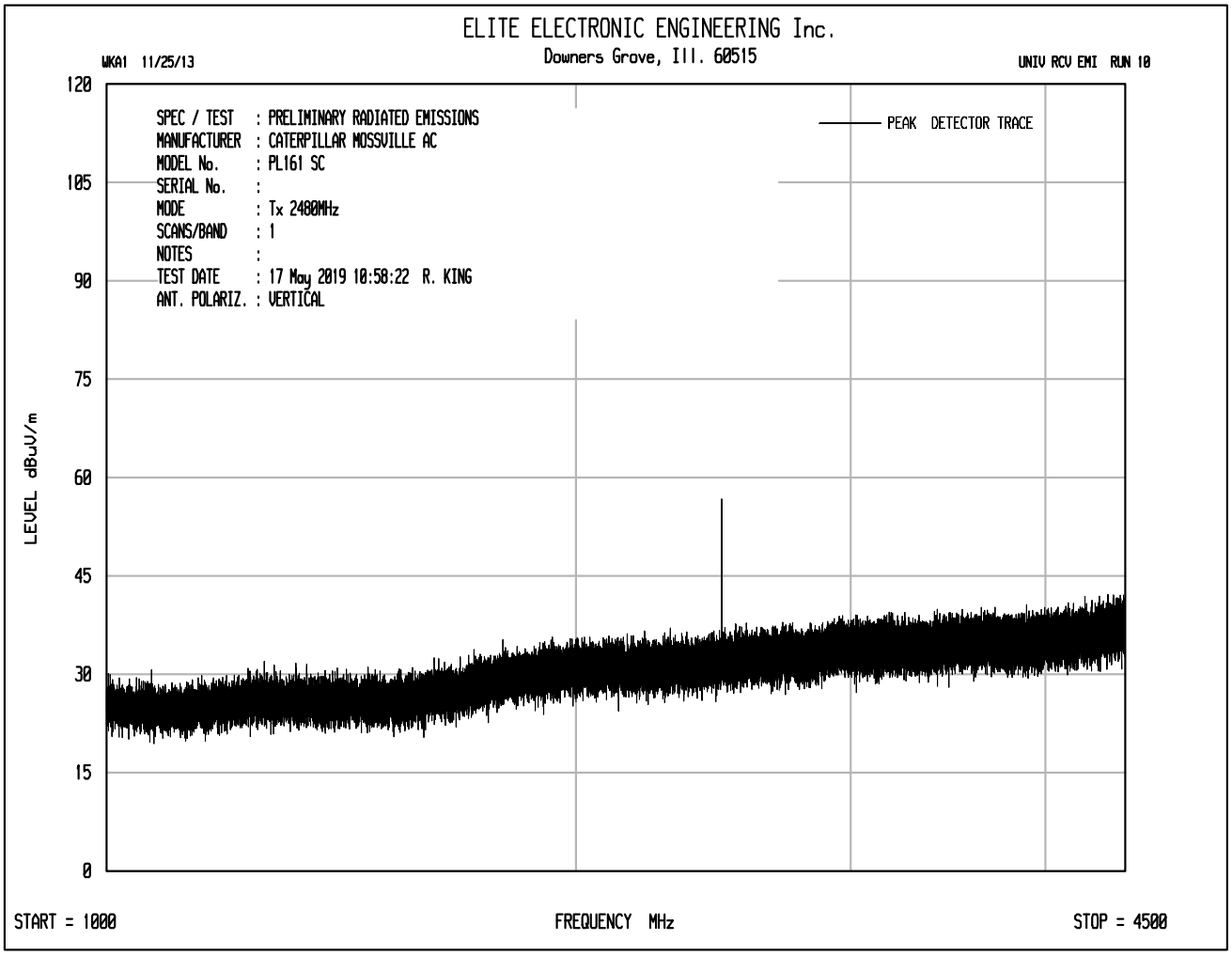

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 9
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:40:18 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500

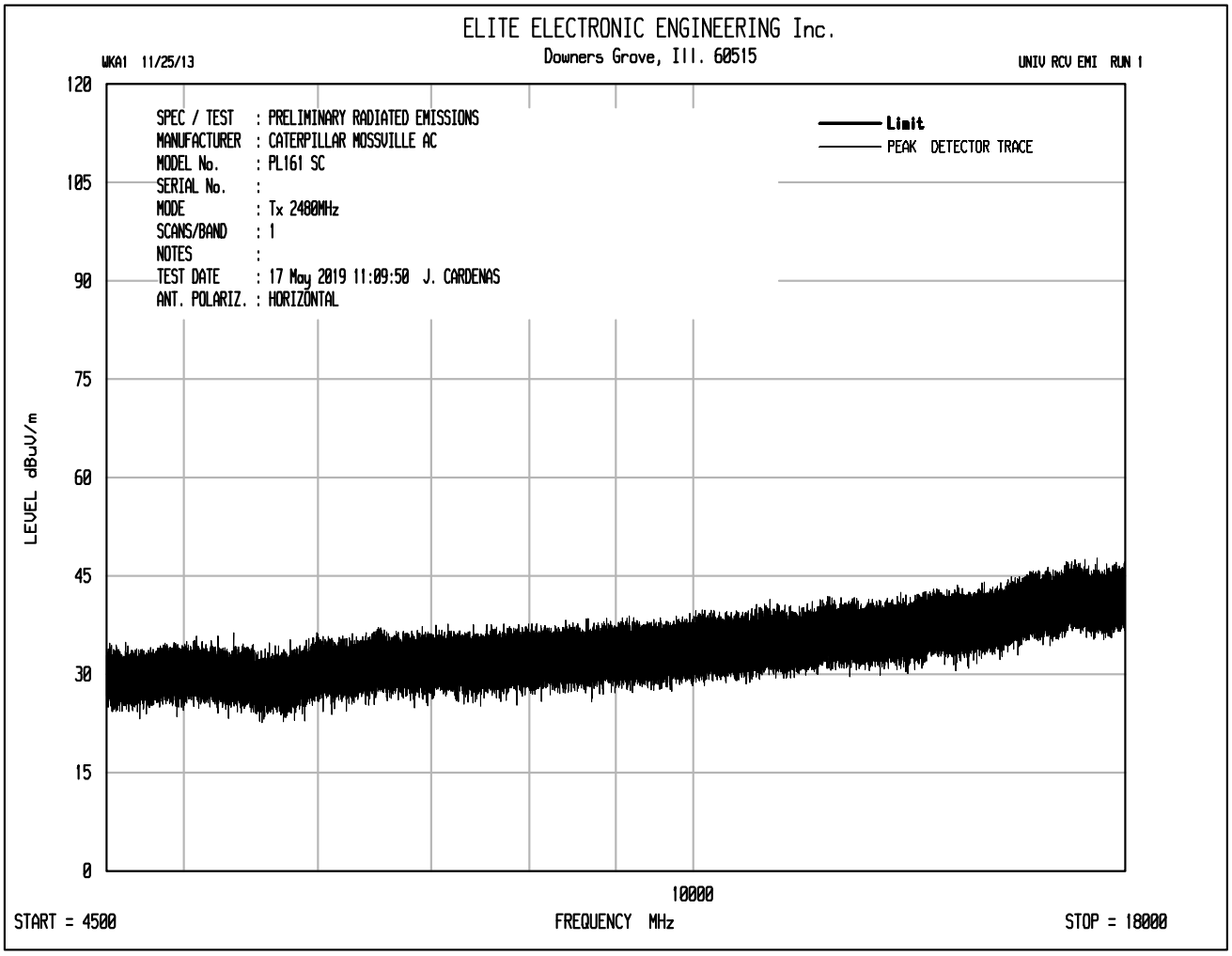

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 8
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2442MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:34:38 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500

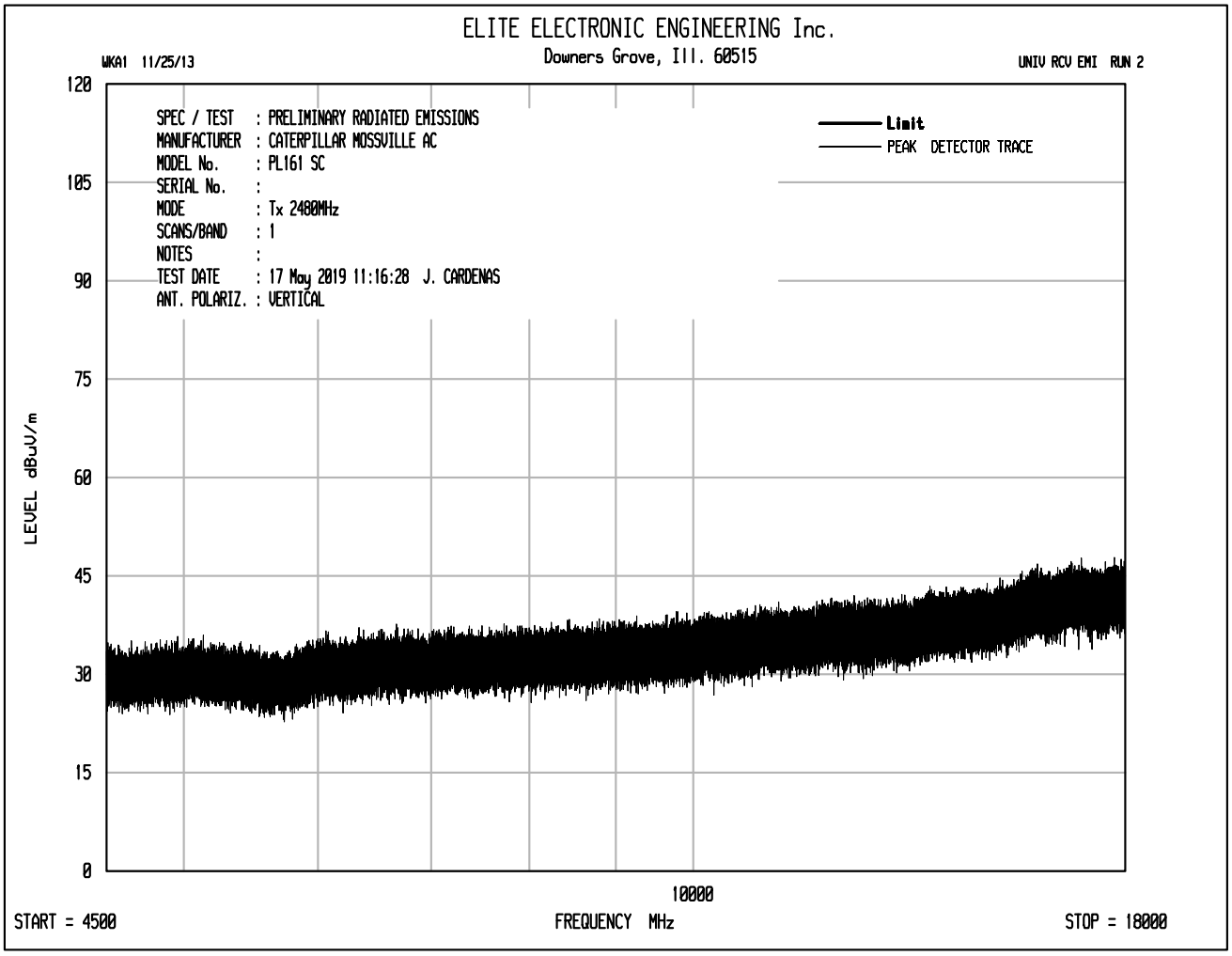

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 5
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 12:48:21 R. KING
ANT. 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

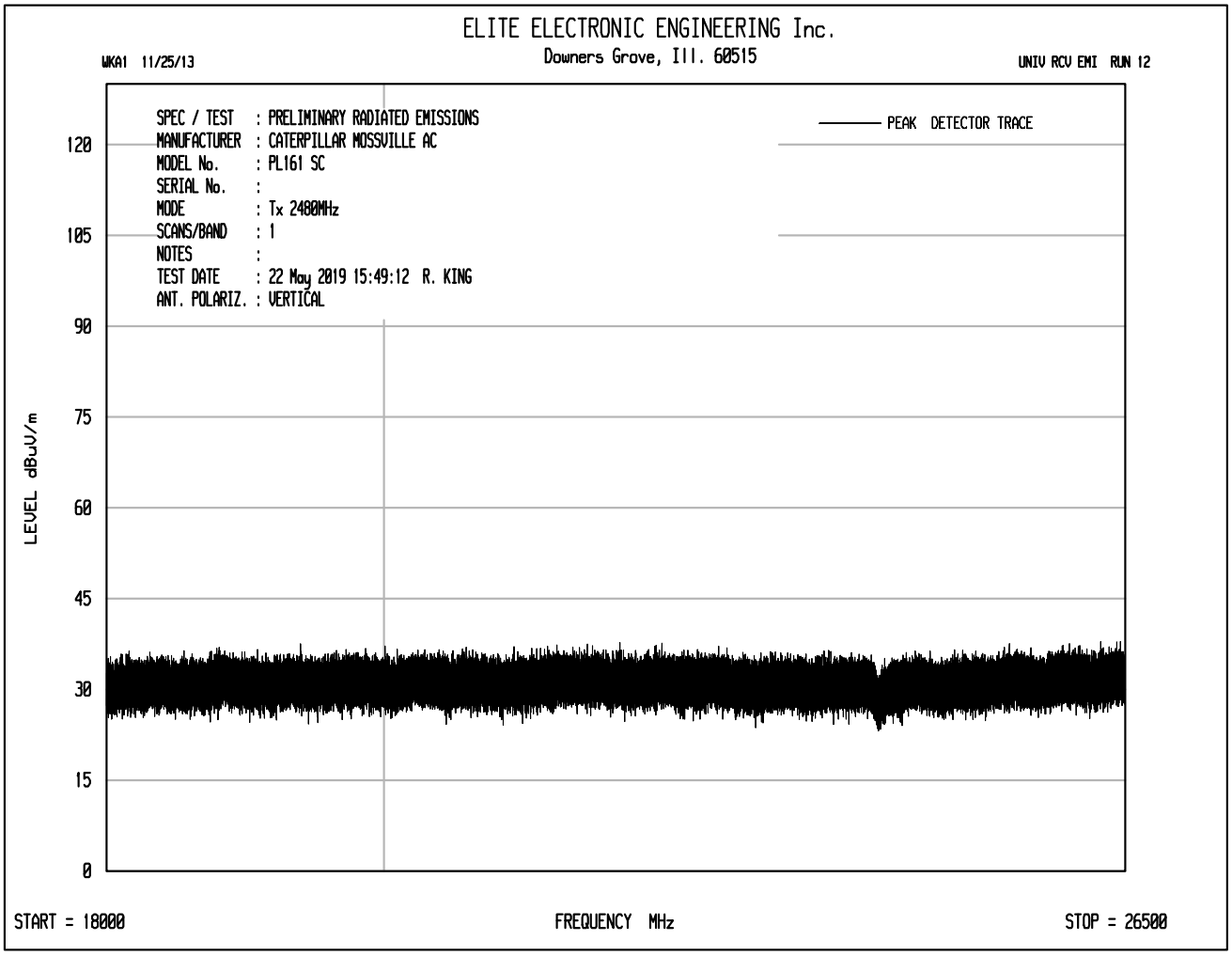

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 6
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. : NONE
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 16 May 2019 12:50:08 R. KING
ANT. 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

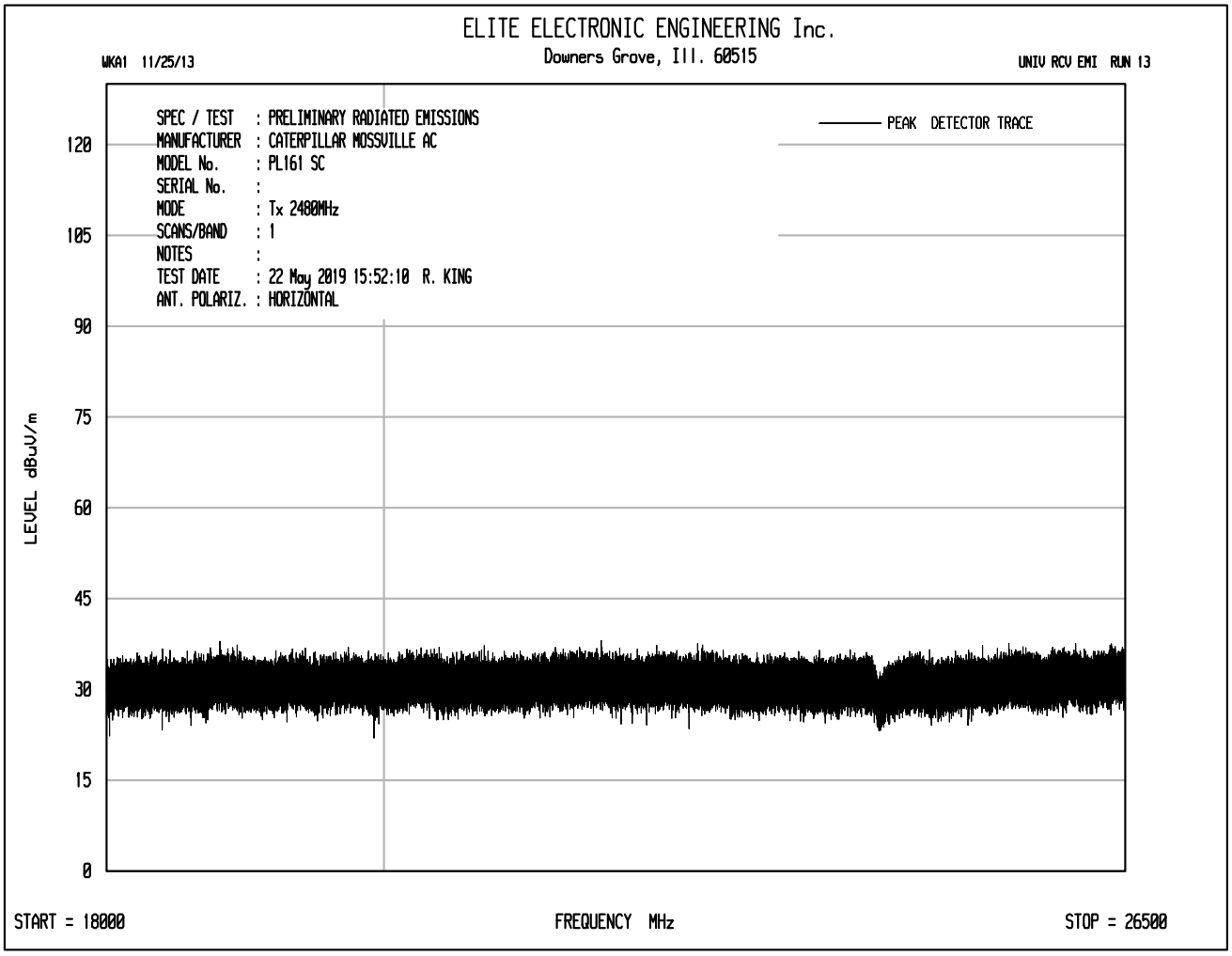

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 9
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 10:56:14 R. KING
ANT. POLARIZ. : HORIZONTAL
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 11/25/13
UNIV RCV EMI RUN 10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 10:58:22 R. KING
ANT. POLARIZ. : VERTICAL
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 11/25/13
UNIV RCV EMI RUN 1
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 11:09:50 J. CARDENAS
ANT. POLARIZ. : HORIZONTAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 2
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 17 May 2019 11:16:28 J. CARDENAS
ANT. POLARIZ. : VERTICAL
Limit
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
10000
START = 4500
FREQUENCY MHz
STOP = 18000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 12
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:49:12 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 13
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : CATERPILLAR MOSSVILLE AC
MODEL No. : PL161 SC
SERIAL No. :
MODE : Tx 2480MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 22 May 2019 15:52:10 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 18000
FREQUENCY MHz
STOP = 26500

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4804.00	H	51.0		3.7	34.2	-40.2	48.6	270.1	5000.0	-25.3
4804.00	V	50.3		3.7	34.2	-40.2	47.9	248.6	5000.0	-26.1
12010.00	H	49.6	*	6.1	38.7	-39.9	54.5	529.6	5000.0	-19.5
12010.00	V	50.2	*	6.1	38.7	-39.9	55.1	566.8	5000.0	-18.9
19216.00	H	36.6	*	2.2	40.4	-28.2	51.0	352.9	5000.0	-23.0
19216.00	V	36.6	*	2.2	40.4	-28.2	51.0	353.3	5000.0	-23.0

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Average Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4804.00	H	42.3		3.7	34.2	-40.2	0.0	39.9	98.5	500.0	-14.1
4804.00	V	38.3		3.7	34.2	-40.2	0.0	36.0	62.8	500.0	-18.0
12010.00	H	34.0	*	6.1	38.7	-39.9	0.0	38.8	87.3	500.0	-15.2
12010.00	V	34.0	*	6.1	38.7	-39.9	0.0	38.9	87.7	500.0	-15.1
19216.00	H	20.7	*	2.2	40.4	-28.2	0.0	35.0	56.3	500.0	-19.0
19216.00	V	20.7	*	2.2	40.4	-28.2	0.0	35.0	56.3	500.0	-19.0

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 37), Power Setting = 4dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions not in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 100kHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
2402.00	H	31.6		2.6	32.2	0.0	66.4	2092.7		
2402.00	V	35.3		2.6	32.2	0.0	70.1	3193.1		
7206.00	H	39.1	*	4.6	35.9	-40.3	39.3	92.3	500.0	-14.7
7206.00	V	38.8	*	4.6	35.9	-40.3	39.1	89.9	500.0	-14.9
9608.00	H	39.2	*	5.2	36.8	-40.3	41.0	111.7	500.0	-13.0
9608.00	V	39.1	*	5.2	36.8	-40.3	40.9	110.4	500.0	-13.1
14412.00	H	37.7	*	6.6	39.6	-39.6	44.3	163.5	500.0	-9.7
14412.00	V	37.2	*	6.6	39.6	-39.6	43.9	156.0	500.0	-10.1
16814.00	H	37.6	*	7.2	42.0	-39.2	47.5	237.9	500.0	-6.5
16814.00	V	37.7	*	7.2	42.0	-39.2	47.6	240.1	500.0	-6.4
21618.00	H	25.6	*	2.2	40.6	-28.6	39.8	97.7	500.0	-14.2
21618.00	V	25.6	*	2.2	40.6	-28.6	39.8	97.7	500.0	-14.2
24020.00	H	26.3	*	2.2	40.6	-28.8	40.3	104.0	500.0	-13.6
24020.00	V	26.3	*	2.2	40.6	-28.8	40.3	104.0	500.0	-13.6

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4884.00	H	50.5		3.7	34.1	-40.1	48.2	258.3	5000.0	-25.7
4884.00	V	50.9		3.7	34.1	-40.1	48.6	268.9	5000.0	-25.4
7326.00	H	48.7	*	4.7	35.9	-40.3	48.9	279.4	5000.0	-25.1
7326.00	V	48.9	*	4.7	35.9	-40.3	49.1	286.2	5000.0	-24.8
12210.00	H	48.2	*	6.1	38.7	-39.9	53.0	448.2	5000.0	-20.9
12210.00	V	48.7	*	6.1	38.7	-39.9	53.6	476.4	5000.0	-20.4
19536.00	H	36.1	*	2.2	40.4	-28.1	50.5	336.7	5000.0	-23.4
19536.00	V	36.1	*	2.2	40.4	-28.1	50.5	336.7	5000.0	-23.4

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Average Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4884.00	H	40.1		3.7	34.1	-40.1	0.0	37.8	77.4	500.0	-16.2
4884.00	V	42.2		3.7	34.1	-40.1	0.0	39.9	98.9	500.0	-14.1
7326.00	H	34.47	*	4.7	35.9	-40.3	0.0	34.7	54.5	500.0	-19.3
7326.00	V	34.5	*	4.7	35.9	-40.3	0.0	34.8	54.7	500.0	-19.2
12210.00	H	33.6	*	6.1	38.7	-39.9	0.0	38.4	83.4	500.0	-15.6
12210.00	V	33.6	*	6.1	38.7	-39.9	0.0	38.5	83.8	500.0	-15.5
19536.00	H	20.3	*	2.2	40.4	-28.1	0.0	34.7	54.5	500.0	-19.2
19536.00	V	20.3	*	2.2	40.4	-28.1	0.0	34.7	54.5	500.0	-19.2

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions not in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 100kHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
2442.00	H	39.1		2.6	32.3	0.0	74.0	4987.7		
2442.00	V	40.1		2.6	32.3	0.0	74.9	5589.9		
9768.00	H	38.3	*	5.2	37.0	-40.3	40.2	102.7	559.0	-14.7
9768.00	V	38.4	*	5.2	37.0	-40.3	40.4	104.8	559.0	-14.5
14652.00	H	36.8	*	6.7	39.7	-39.6	43.7	152.8	559.0	-11.3
14652.00	V	37.7	*	6.7	39.7	-39.6	44.5	168.5	559.0	-10.4
17094.00	H	37.8	*	7.3	41.8	-39.3	47.6	238.6	559.0	-7.4
17094.00	V	37.5	*	7.3	41.8	-39.3	47.2	230.2	559.0	-7.7
21978.00	H	25.9	*	2.2	40.6	-29.0	39.7	96.2	559.0	-15.3
21978.00	V	25.9	*	2.2	40.6	-29.0	39.7	96.2	559.0	-15.3
24420.00	H	26.5	*	2.2	40.6	-29.1	40.2	102.7	559.0	-14.7
24420.00	V	26.5	*	2.2	40.6	-29.1	40.2	102.7	559.0	-14.7

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4960.00	H	51.6		3.7	34.1	-40.0	49.5	297.2	5000.0	-24.5
4960.00	V	51.1		3.7	34.1	-40.0	48.9	278.3	5000.0	-25.1
7440.00	H	48.9		4.7	35.8	-40.3	49.1	285.6	5000.0	-24.9
7440.00	V	48.6		4.7	35.8	-40.3	48.8	276.6	5000.0	-25.1
12400.00	H	38.7	*	6.1	38.6	-40.0	43.4	148.2	5000.0	-30.6
12400.00	V	37.9	*	6.1	38.6	-40.0	42.6	135.3	5000.0	-31.4
19840.00	H	37.1	*	2.2	40.4	-28.4	51.4	370.7	5000.0	-22.6
19840.00	V	37.1	*	2.2	40.4	-28.4	51.4	370.7	5000.0	-22.6
22320.00	H	38.0	*	2.2	40.6	-29.0	51.9	391.4	5000.0	-22.1
22320.00	V	38.0	*	2.2	40.6	-29.0	51.9	391.4	5000.0	-22.1

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Average Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
4960.00	H	39.6		3.7	34.1	-40.0	0.0	37.4	74.2	500.0	-16.6
4960.00	V	39.5		3.7	34.1	-40.0	0.0	37.3	73.6	500.0	-16.6
7440.00	H	33.90		4.7	35.8	-40.3	0.0	34.1	50.7	500.0	-19.9
7440.00	V	34.0		4.7	35.8	-40.3	0.0	34.2	51.4	500.0	-19.8
12400.00	H	33.7		6.1	38.6	-40.0	0.0	38.4	83.4	500.0	-15.6
12400.00	V	33.6		6.1	38.6	-40.0	0.0	38.4	82.9	500.0	-15.6
19840.00	H	21.9	*	2.2	40.4	-28.4	0.0	36.2	64.5	500.0	-17.8
19840.00	V	21.9	*	2.2	40.4	-28.4	0.0	36.1	64.2	500.0	-17.8
22320.00	H	21.9	*	2.2	40.6	-29.0	0.0	35.7	61.2	500.0	-18.2
22320.00	V	21.9	*	2.2	40.6	-29.0	0.0	35.7	61.2	500.0	-18.2

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King

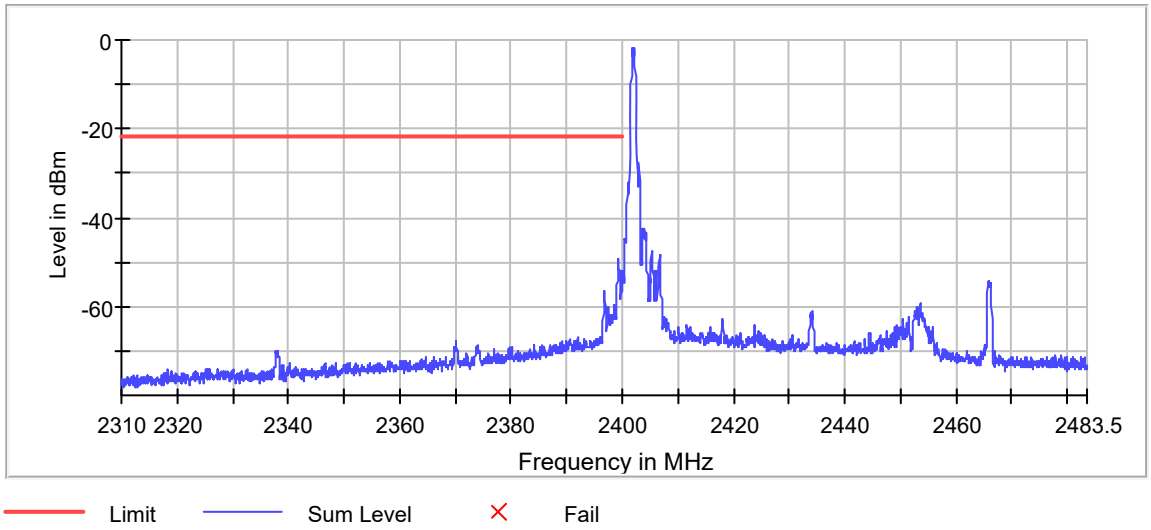
Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions not in Restricted Bands
Date : May 17-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 100kHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
2480.00	H	31.7		2.7	32.3	0.0	66.7	2159.2		
2480.00	V	30.6		2.7	32.3	0.0	65.6	1904.5		
9920.00	H	38.3	*	5.3	37.1	-40.3	40.5	106.0	500.0	-13.5
9920.00	V	39.4	*	5.3	37.1	-40.3	41.5	119.2	500.0	-12.5
14880.00	H	37.8	*	6.8	39.8	-39.6	44.7	172.5	500.0	-9.2
14880.00	V	37.9	*	6.8	39.8	-39.6	44.9	174.9	500.0	-9.1
17360.00	H	37.9	*	7.4	41.7	-39.4	47.5	238.0	500.0	-6.4
17360.00	V	37.7	*	7.4	41.7	-39.4	47.3	232.5	500.0	-6.6
24800.00	H	26.4	*	2.2	40.6	-29.2	40.1	100.6	500.0	-13.9
24800.00	V	26.4	*	2.2	40.6	-29.2	40.1	100.6	500.0	-13.9

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Checked BY Richard E. King :

Richard E. King



FCC 15.247 Low Frequency Band Edge Compliance

MANUFACTURER	:	CATERPILLAR Mossville AC
MODEL NUMBER	:	PL161 SC
TEST MODE	:	Transmit at 2402MHz (Ch. 37), Power Setting = 0dBm
NOTES	:	The trace represents the highest power measured inside the band with a 100kHz
	:	bandwidth. The red lines represents the 20dB down level from the peak in a
	:	100kHz bandwidth and the low frequency band edge.
EQUIPMENT USED	:	Rohde & Schwarz Wireless Test Set

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions at High Band Edge
Date : May 16-24, 2019
Test Distance : 3 meters
Notes : Peak Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
2483.50	H	22.9		2.7	32.3	0.0	57.9	783.7	5000.0	-16.1
2483.50	V	23.9		2.7	32.3	0.0	58.9	876.3	5000.0	-15.1

Checked BY Richard E. King :

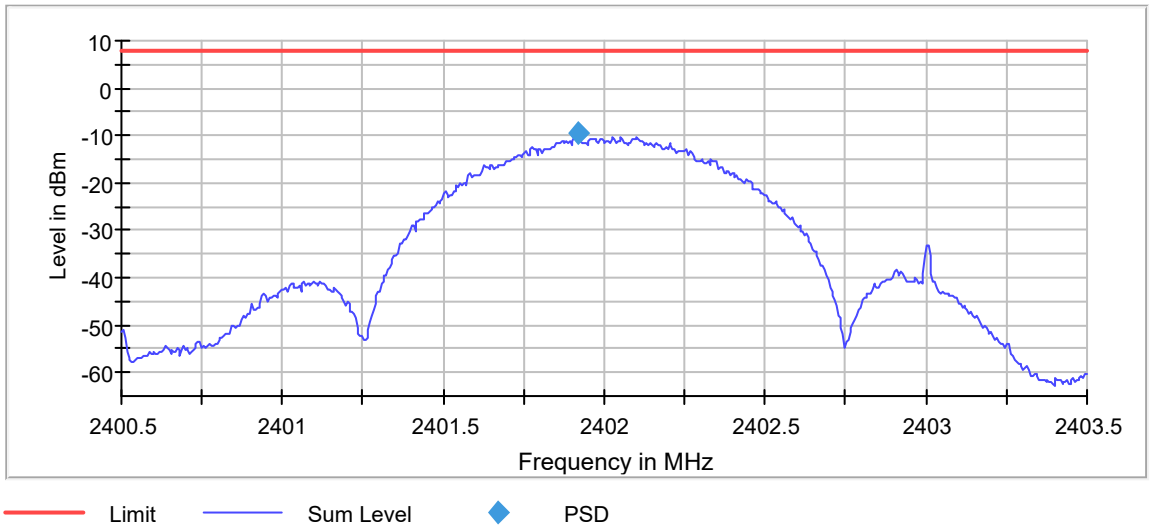
Richard E. King

Manufacturer : CATERPILLAR Mossville AC
Test Item : Bluetooth Low Energy Transmitter
Model No. : PL161 SC
Mode : Transmit at 2480MHz (Ch. 39), Power Setting = 4dBm
Test Specification : FCC-15.247, RSS-247 Average Radiated Emissions at High Band Edge
Date : May 16-24, 2019
Test Distance : 3 meters
Notes : Average Detector with 1MHz Resolution Bandwidth

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	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)
2483.50	H	6.9		2.7	32.3	0.0	0.0	41.9	124.8	500.0	-12.1
2483.50	V	6.8		2.7	32.3	0.0	0.0	41.8	122.4	500.0	-12.2

Checked BY Richard E. King :

Richard E. King

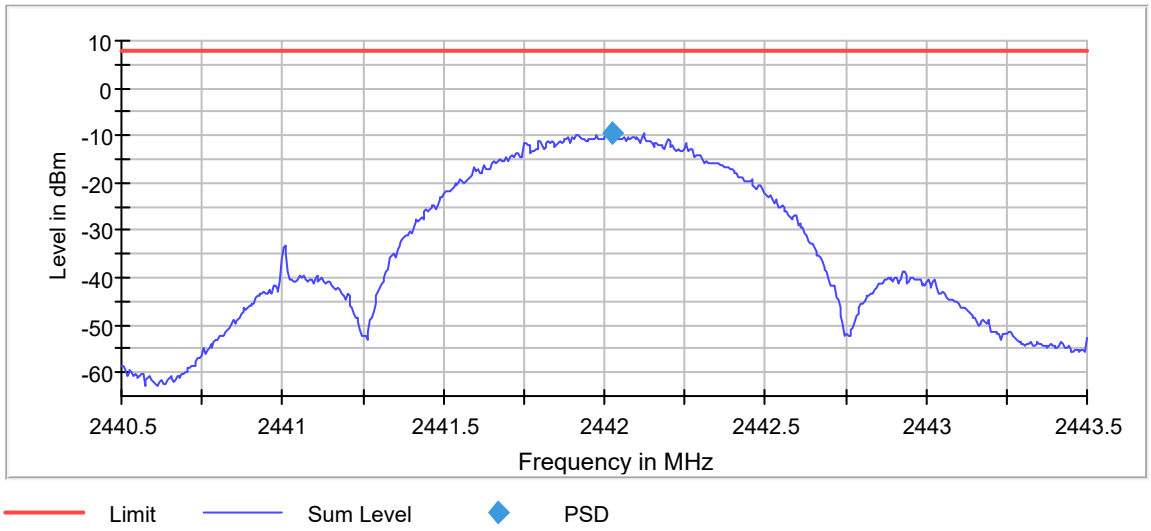


Result

DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2402.000000	2401.917500	-9.693	8.0	PASS

FCC 15.247 Power Spectral Density

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
NOTES : Power Spectral Density = -9.693dBm
EQUIPMENT USED : Rohde & Schwarz Wireless Test Set

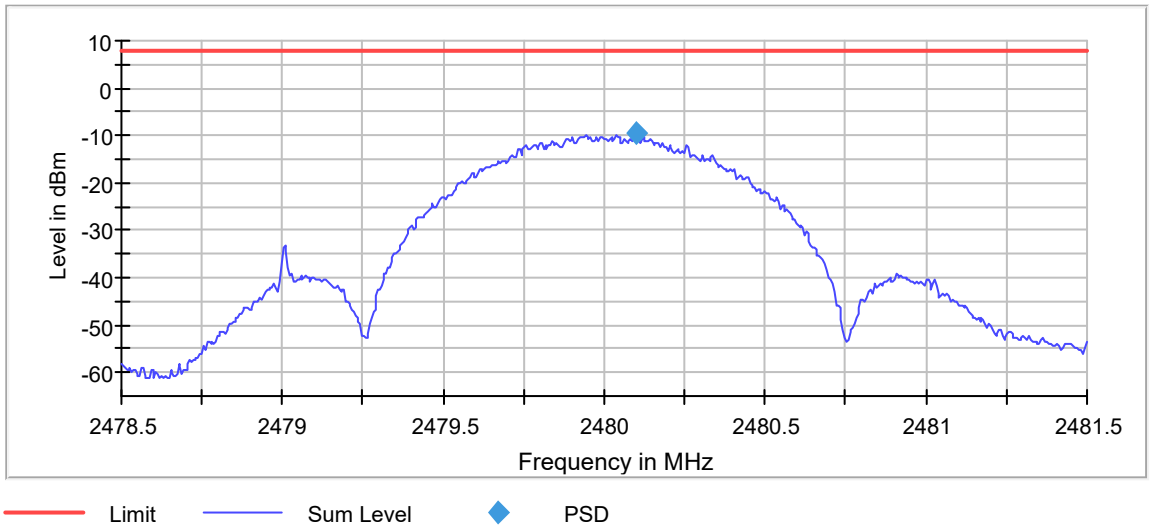


Result

DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2442.000000	2442.022500	-9.552	8.0	PASS

FCC 15.247 Power Spectral Density

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2442MHz (Ch. 18), Power Setting = 0dBm
NOTES : Power Spectral Density = -9.552dBm
EQUIPMENT USED : Rohde & Schwarz Wireless Test Set



Result

DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2480.000000	2480.102500	-9.414	8.0	PASS

FCC 15.247 Power Spectral Density

MANUFACTURER : CATERPILLAR Mossville AC
MODEL NUMBER : PL161 SC
TEST MODE : Transmit at 2480MHz (Ch. 39), Power Setting = 0dBm
NOTES : Power Spectral Density = -9.414dBm
EQUIPMENT USED : Rohde & Schwarz Wireless Test Set

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

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ELECTRICAL

Valid to: June 30, 2019 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; 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
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)
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)
Vehicle Radiated Emissions	CISPR 12

Test Technology:	Test Method(s) [1]:
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)
Bulk Current Injections (BCI) *(Closed Loop Method)*	ISO 11452-4; SAE J1113-4
Radiated Immunity Anechoic	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
Radiated Immunity Anechoic *(Radar Pulse Only)*	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)
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
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/ECA-364-23C; USCAR21-3 Section 4.5.3
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

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-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
Current Harmonics	IEC 61000-3-2; EN 61000-3-2; KN 61000-3-2
Flicker and Fluctuations	IEC 61000-3-3; EN 61000-3-3; KN 61000-3-3
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
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
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
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
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

Test Technology:	Test Method(s) [1]:
Power Frequency Magnetic Field Immunity	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
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
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
Generic and Product Specific EMC Standards	IEC 61000-6-1; AS/NZS 61000-6-1; IEC 61000-6-2; AS/NZS 61000-6-2; EN 61000-6-3; AS/NZS 61000-6-3; IEC 61000-6-4; AS/NZS 61000-6-4; EN 50130-4; IEC 61326-1; IEC/CISPR 14-2; EN 55014-2; AS/NZS CISPR 14.2; KN 14-2; IEC/CISPR 24; AS/NZS CISPR 24; EN 55024; KN 24; IEC 60601-1-2; JIS T0601-1-2
Telecommunications Test Methods	Industry Canada CS-03, Part 1, Issue 9, Amendment 4 (2010): Analogue Terminal Equipment (TE); Industry Canada CS-03, Part II, Issue 9, Amendment 1 (2012): Digital TE Intended for Connection to 1.544 Mbps (DS-1) Digital Facilities; Industry Canada CS-03, Part III, Issue 9, August 2013: Acceptable Methods of Connection for Single Line and Multi-Line Terminal Equipment; Industry Canada CS-03, Part V, Issue 9, Amendment 1 (2009): Requirements and Test Methods for Magnetic Output from Handset Telephones for Hearing Aid Coupling and for Receive Volume Control; Industry Canada CS-03, Part VI, Issue 9, Amendment 1 (2012): ISDN TE; Industry Canada CS-03, Part VII, Issue 9, Amendment 4 (2012): Limited Distance Modem and Digital Subrate TE; Industry Canada CS-03, Part VIII, Issue 9, Amendment 4 (2009): Requirements and Test Methods for Digital Subscriber Line (xDSL) TE;

Test Technology:	Test Method(s) [1]:
Telecommunications Test Methods (Cont'd)	Terminal Equipment Network Protection Standards, FCC/ACTA Method - 47 CFR Part 68 - Analog and Digital: 68.302 (Parts C, D, E, F) Environmental simulation; 68.304 Leakage Current Limit; 68.306 Hazardous Voltage Limit; 68.308 Signal Power Limit; 68.310 Longitudinal Balance Limit; 68.312 On-hook Impedance Limit; 68.314 Billing Protection; 68.316 and 68.317 Hearing Aid Compatibility: Technical Standards; 68.302 Environmental Simulation (Parts A, B); T1.TRQ.6 (2001): Technical Requirements for SHDSL, HDSL2, HDSL4, Digital Subscriber Line Terminal Equipment to Prevent Harm to the Telephone Network; TIA/EIA TSB-31-D (2015): Part 68 Rational and Measurement Guidelines; ANSI/TIA-968-A (2003): Telephone Terminal Equipment, Technical Requirements for Connection of Terminal Equipment to the Telephone Network; ANSI/TIA-968-A-1 (2003): Telephone Terminal Equipment, Technical Requirements for Connection of Terminal Equipment to the Telephone Network - Addendum 1; ANSI/TIA-968-A-2 (2004): Telephone Terminal Equipment, Technical Requirements for Connection of Terminal Equipment to the Telephone Network - Addendum 2; ANSI/TIA-968-A-3 (2005): Telephone Terminal Equipment, Technical Requirements for Connection of Terminal Equipment to the Telephone Network - Addendum 3; TIA-968-B (2009): Telecommunication - Telephone Terminal Equipment - Technical Requirements for Connection of Terminal Equipment to the Telephone Network
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 300 330-1; 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
Canadian Radio Tests	RSS-102; 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-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-287; RSS-288; RSS-310; RSS-GEN

Test Technology:	Test Method(s) [1]:
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
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, 73, 74, 80, 87, 90, 95, 96, 97, 101; ANSI/TIA-603-D; TIA-102.CAAA-D; ANSI C63.26:2015; FCC KDB 935210 D03 (v04); FCC KDB 935210 D04 (v02); FCC KDB 935210 D05 (v01r01)
Electrical Measurements and Simulation	FAA AC 150/5345-10H
AC Voltage / Current	FAA AC 150/5345-43G
(1mV to 5KV) 60 Hz	FAA AC 150/5345-44J
(0.1V to 250V) up to 500 MHz	FAA AC 150/5345-46D
(1µA to 150A) 60 Hz	FAA AC 150/5345-47C
DC Voltage / Current	FAA EB 67D
(1mV to 15KV) / (1µA to 10A)	
Power Factor / Efficiency / Crest Factor	
(Power to 30KW)	
Resistance	
(1mΩ to 4000MΩ)	
Surge	
(Up to 10KV / 5000A) (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 required 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 Declaration of Conformity and 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
U-NIII without DFS Intentional Radiators Part 15E	ANSI C63.10:2013	40000
U-NIII with DFS Intentional Radiators Part 15E	FCC KDB 905462 D02 (v01)	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 (non-microwave), and 27	ANSI/TIA-603-D; TIA-102.CAAA-D	40000
General Mobile Radio Services (FCC Licensed Radio Service Equipment) Parts 22 (non-cellular), 90 (non-microwave), 95, 97, and 101 (non-microwave)	ANSI/TIA-603-D; TIA-102.CAAA-D	40000
Citizens Broadband Radio Services (FCC Licensed Radio Service Equipment) Part 96	ANSI/TIA-603-D; TIA-102.CAAA-D	40000
Maritime and Aviation Radio Services Parts 80 and 87	ANSI/TIA-603-D	40000

Testing Activities Performed in Support of FCC Declaration of Conformity and 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)
Microwave and Millimeter Bands Radio Services		
Parts 25, 74, 90 (90Y, 90Z, DSRC), and 101	ANSI/TIA-603-D; TIA-102.CAAA-D	40000
Broadcast Radio Services		
Parts 73 and 74 (non-microwave)	ANSI/TIA-603-D; TIA-102.CAAA-D	40000
Signal Boosters		
Part 20 (Wideband Consumer Signal Boosters, Provider-specific signal boosters, and Industrial Signal Boosters)	FCC KDB 935210 D03 (v04); FCC KDB 935210 D04 (v02); FCC KDB 935210 D05 (v01r01)	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 17025:2005 *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 8 January 2009*).

Presented this 23rd day of October 2017.

President and CEO
For the Accreditation Council
Certificate Number 1786.01
Valid to June 30, 2019

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