Measurement of RF Emissions from a Caterpillar Inc. MSS3i RF ID Key Fob

For	Caterpillar Inc. 330 S.W. Adams Street Peoria, IL 61630
P.O. Number	JBJ 76282 and D001234715
Date Tested	July 13, 2015
Test Personnel	Mark Longinotti
Test Specification	FCC "Code of Federal Regulations" Title 47 Part15, Subpart C, §15.209 Industry Canada RSS-Gen

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REVISION HISTORY

Revision	Date	Description
—	3 Aug 2015	Initial release

Measurement of RF Emissions from a Caterpillar Inc. RF ID Key Fob, Model No.: MSS3i

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of the RF emissions measurements performed on a Caterpillar Inc. RF ID Key Fob, M/N: MSS3i, Serial Number: 115486-0055, hereinafter referred to as the Equipment Under Test (EUT). The EUT was designed to transmit at approximately 133.8kHz. The EUT was manufactured and submitted for testing by Caterpillar Inc. located in Peoria, IL.

1.2. Purpose

The test series was performed to determine if the EUT meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 207 and 209 for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2014.

The test series was also performed to determine if the EUT meets the conducted and radiated RF emission requirements of the Industry Canada Radio Standards Specification RSS-Gen Section 8.8 and Section 8.9 for transmitters. Testing was performed in accordance with ANSI C63.4-2014.

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^{o}C and the relative humidity was 45%.

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 2014
- ANSI C63.4-2014, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
- Industry Canada Radio Standards Specification, RSS-Gen, “General Requirements for Compliance of Radio Apparatus”, Issue 4, November 2014

3. EUT SETUP AND OPERATION

3.1. General Description

The EUT is a Caterpillar Inc. RF ID Key Fob, Model No. MSS3i. A block diagram of the EUT setup is shown as Figure 1. A photograph of the EUT is shown as Figure 2.

The MSS3i consists of the following components:

- Key Switch
- Caterpillar Electronic Key
- Exciter Coil
- Electronic Key Ready Module

3.1.1. Power Input

The EUT obtained 27VDC through 2, 70cm long power leads.

3.1.2. Peripheral Equipment

No peripheral equipment was submitted with the EUT.

3.1.3. Signal Input/Output Leads

A 60cm long, 6 wire harness was used to connect the Electronic Key Reader Module to the Key Switch/Exciter Coil/Electronic Key.

3.1.4. Grounding

The battery return wire of the EUT was connected to ground.

3.2. Software

For all tests, the EUT had low-level firmware Version 4466711-00.s19 loaded onto the device. The application that it runs (that makes it transmit for 50 ms every 500 ms) for certification tests is: mss_a5s1_app.fls.

3.3. Operational Mode

For all tests, the EUT was placed on an 80cm high non-conductive stand. The EUT was energized. The EUT was programmed so that upon power up, it would begin transmitting a 50msec pulse ever 500msec at 133.8kHz.

3.4. EUT Modifications

No modifications were required for compliance.

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 C63.4-2014 for site attenuation.

4.2. Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1.

Conducted and radiated emission measurements were performed with an EMI receiver. This receiver allows measurements with the bandwidths and detector functions specified in the requirements.

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.

The measurement uncertainty for these tests is presented below:

Conducted Emissions Measurements		
Combined Standard Uncertainty	1.06	-1.06
Expanded Uncertainty (95% confidence)	2.12	-2.12

Radiated Emissions Measurements		
Combined Standard Uncertainty	2.09	-2.09
Expanded Uncertainty (95% confidence)	4.19	-4.19

5. TEST PROCEDURES

5.1. Powerline Conducted Emissions

5.1.1. Requirements

In normal operation, the EUT is powered by 24 VDC from the vehicle battery in which it is installed. Since the EUT does not connect to AC power, no conducted emission measurements are required.

5.2. Radiated Measurements

5.2.1. Requirements

The EUT must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.209.

Section 15.209 states that the emissions from an intentional radiator shall not exceed the field strength limits specified below:

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 -216	150	3
216 -960	200	3
Above 960	500	3

In the emission table above, the tighter limit applies at the band edge.

The emissions limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90kHz, 110-490kHz, and above 1000MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

5.2.2. 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, an active loop measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 150kHz to 30MHz was investigated using a peak detector function.

The final open field emission tests were then manually performed over the frequency range of 150kHz to 30MHz using an active loop antenna. The field strength of the fundamental of the transmitter was measured using an average detector with a 200Hz resolution bandwidth. All spurious emissions were measured and recorded using a quasi-peak detector with a 9kHz bandwidth.

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) The active loop antenna was placed at a height of 1 meter.
3) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
4) With the loop antenna in the vertical polarization, the loop antenna was rotated through 360 degrees.

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 pre-amplifier is used, the total is reduced by its gain (-PA). If a distance correction (DC) is required, it is added to the total. (Per 15.231(f)(2), at frequencies below 30MHz, measurements may be made at a distance closer than that specified. When performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by using the square of an inverse linear distance extrapolation factor (40 dB/decade).

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]

5.2.3.Results

The preliminary plots, with the EUT transmitting at 133.8kHz, are presented on data pages 13 and 14. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the EUT transmitting at 133.8kHz, are presented on data page 15. As can be seen from the data, all emissions measured from the EUT were within the specification limits. The emissions level closet to the limit (worst case) occurred at 133.8kHz. The emissions level at this frequency was 11.6dB within the limit. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figure 3.

6. OTHER TEST CONDITIONS

6.1. Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated.

6.2. Disposition of the EUT

The EUT and all associated equipment were returned to Caterpillar Inc. upon completion of the tests.

7. CONCLUSIONS

It was determined that the Caterpillar Inc. RF ID Key Fob, Model No. MSS3i, Serial No. 115486-0055, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 205 and 209 for Intentional Radiators, when tested per ANSI C63.4-2014.

It was also determined that the Caterpillar Inc. RF ID Key Fob, Model No. MSS3i, Serial No. 115486-0055, did fully meet the conducted and radiated emission requirements of the Industry Canada RSS-Gen, Sections 8.8 and 8.9 for transmitters, when tested per ANSI C63.4-2014.

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. 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
CDY0	WORKSTATION	ELITE	WORKSTATION		WINDOWS 7	N/A	
CMA1	Controllers	EMCO	2090	9701-1213	---	N/A	
NLS0	24" ACTIVE LOOP ANTENNA	EMCO	6502	89979	10KHZ-30MHZ	7/7/2014	8/7/2015
RBB0	EMI TEST RECEIVER 20HZ TO 40 GHZ.	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	2/13/2015	2/13/2016

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.

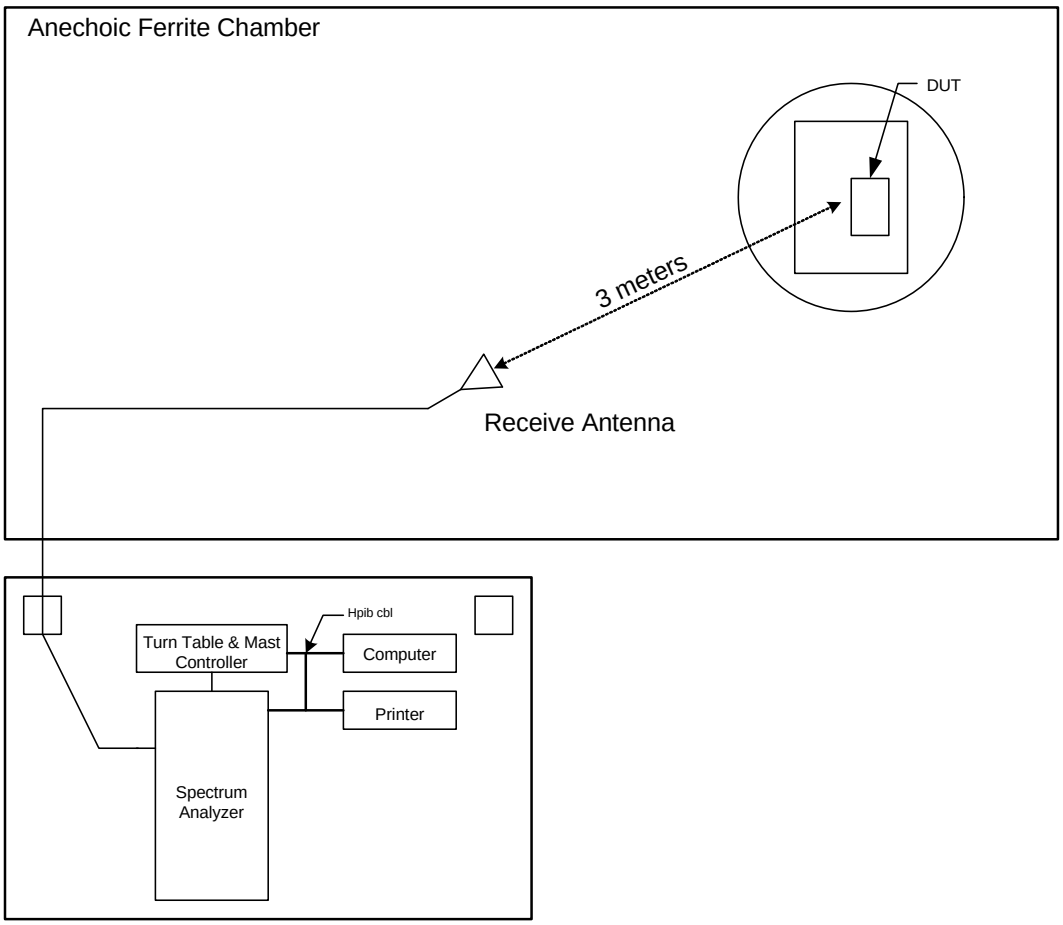
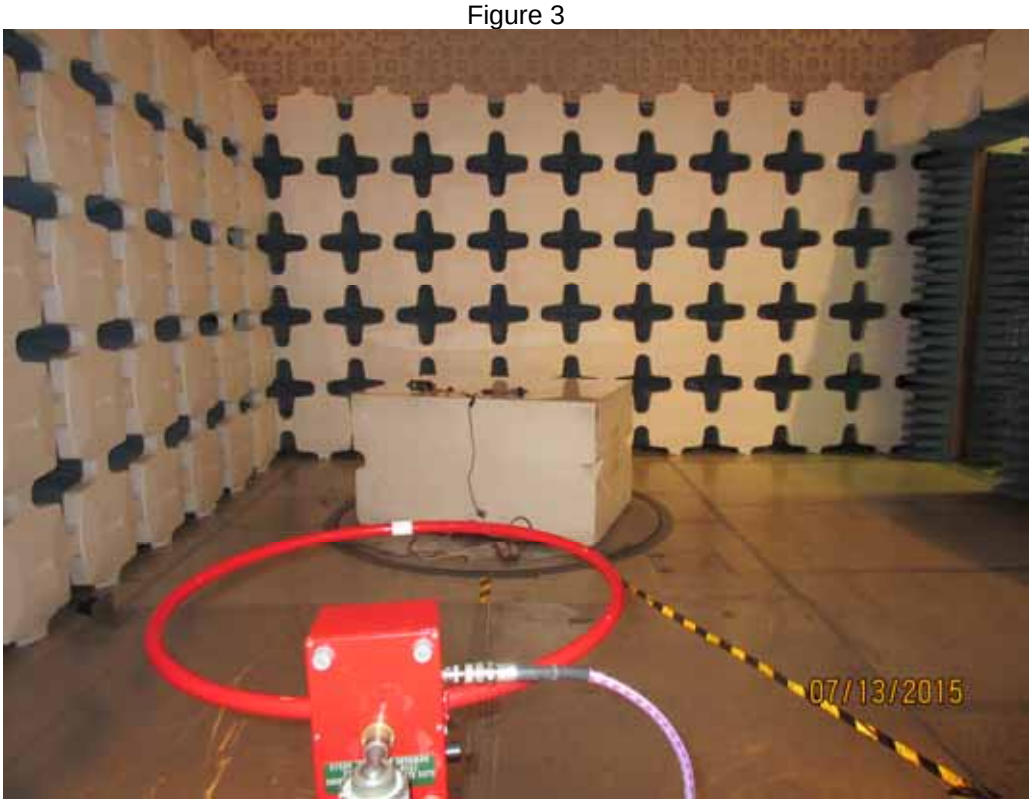


FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

Figure 2

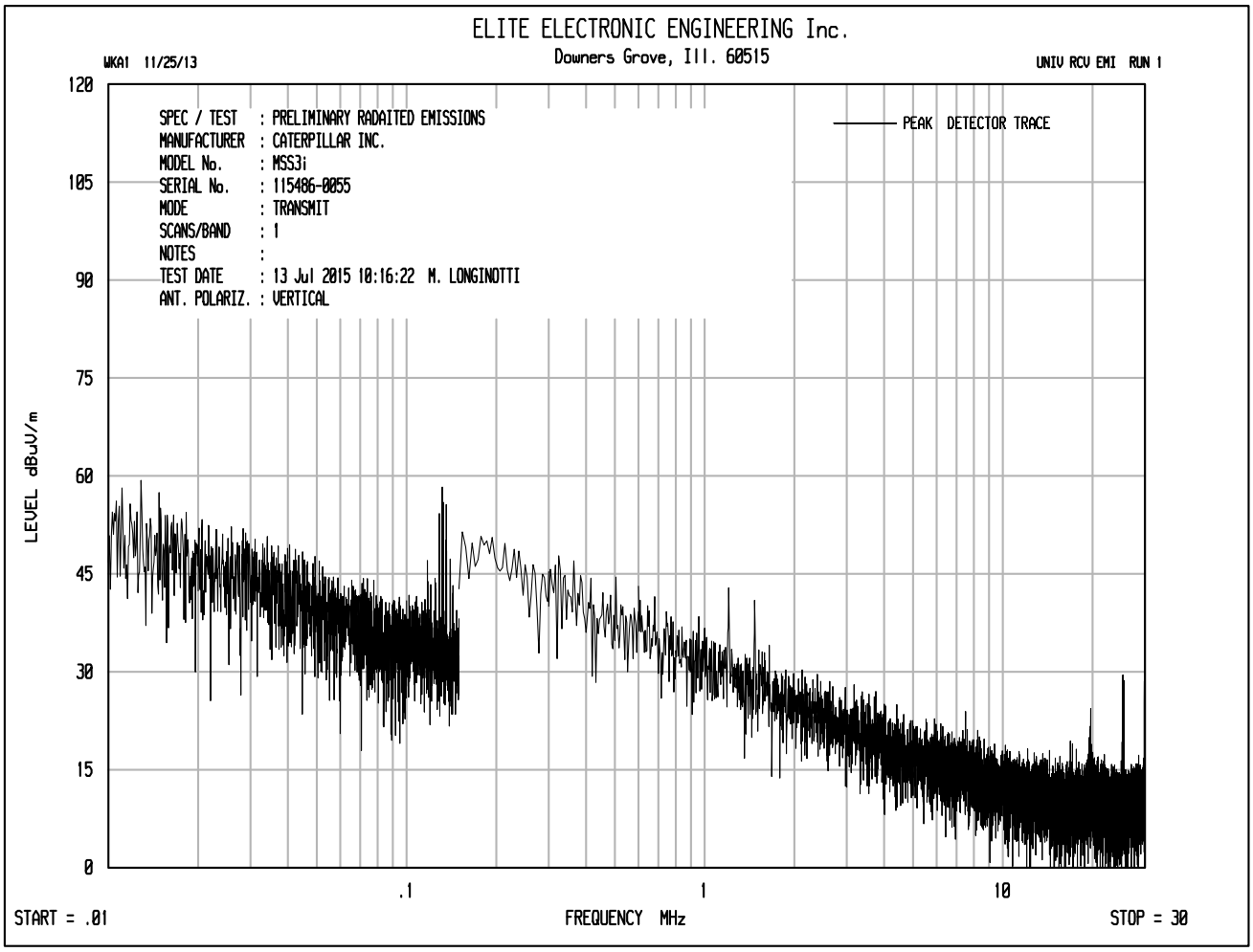
Photograph of the EUT

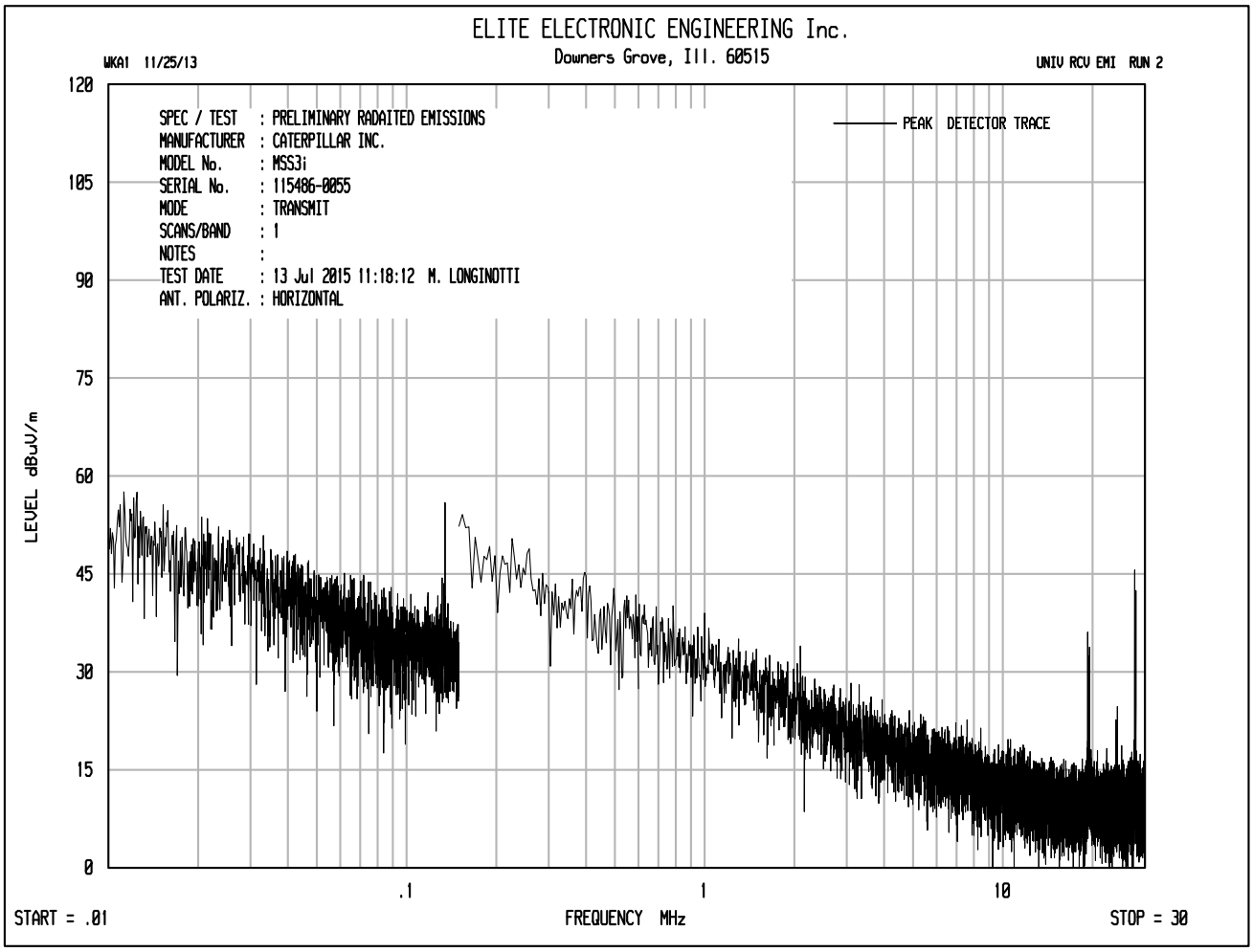
Figure 3



Test Setup for Radiated Emissions, 150kHz to 30MHz – Horizontal Polarization

Test Setup for Radiated Emissions, 150kHz to 30MHz – Vertical Polarization


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 1
SPEC / TEST : PRELIMINARY RADAITED EMISSIONS
MANUFACTURER : CATERPILLAR INC.
MODEL No. : MSS3i
SERIAL No. : 115486-0055
MODE : TRANSMIT
SCANS/BAND : 1
NOTES :
TEST DATE : 13 Jul 2015 10:16:22 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
.1
1
10
START = .01
FREQUENCY MHz
STOP = 30


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 2
SPEC / TEST : PRELIMINARY RADAITED EMISSIONS
MANUFACTURER : CATERPILLAR INC.
MODEL No. : MSS3i
SERIAL No. : 115486-0055
MODE : TRANSMIT
SCANS/BAND : 1
NOTES :
TEST DATE : 13 Jul 2015 11:18:12 M. LONGINOTTI
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
.1
1
10
START = .01
FREQUENCY MHz
STOP = 30

Manufacturer : Caterpillar Inc.
EUT : RF ID Key Fob
Model No. : MSS3i
Serial No. : 115486-0055
Test Specification : FCC 15.209
Test Mode : Transmitting at 133.8kHz
Test Date : July 13, 2015
Test Distance : 3 meters

Freq. (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	Pre Amp (dB)	Dist. Corr. (dB)	Total (dBuV/m)	Total (uV/m)	Limit (uV/m)	Specified Test Distance (meters)	Margin (dB)
0.134	H	71.8		0.0	11.1	0.0	-80.0	2.9	1.38963	17.9	300.0	-22.2
0.134	V	82.4		0.0	11.1	0.0	-80.0	13.5	4.70868	17.9	300.0	-11.6
0.268	H	37.8	Ambient	0.0	10.9	0.0	-80.0	-31.3	0.02732	9.0	300.0	-50.3
0.268	V	38.2	Ambient	0.0	10.9	0.0	-80.0	-30.9	0.02860	9.0	300.0	-49.9
0.401	H	40.8		0.0	10.8	0.0	-80.0	-28.4	0.03803	6.0	300.0	-43.9
0.401	V	49.6		0.0	10.8	0.0	-80.0	-19.6	0.10475	6.0	300.0	-35.1
0.535	H	31.6	Ambient	0.0	11.0	0.0	-40.0	2.6	1.34896	44.8	30.0	-30.4
0.535	V	31.6	Ambient	0.0	11.0	0.0	-40.0	2.6	1.34896	44.8	30.0	-30.4
0.669	H	34.0		0.0	11.0	0.0	-40.0	5.0	1.77828	35.9	30.0	-26.1
0.669	V	42.3		0.0	11.0	0.0	-40.0	13.3	4.62381	35.9	30.0	-17.8
0.803	H	27.3	Ambient	0.0	11.0	0.0	-40.0	-1.7	0.82252	29.9	30.0	-31.2
0.803	V	27.7	Ambient	0.0	11.0	0.0	-40.0	-1.3	0.86129	29.9	30.0	-30.8
0.937	H	27.1	Ambient	0.0	11.1	0.0	-40.0	-1.8	0.81638	25.6	30.0	-29.9
0.937	V	32.7		0.0	11.1	0.0	-40.0	3.8	1.55558	25.6	30.0	-24.3
1.070	H	24.6	Ambient	0.0	11.2	0.0	-40.0	-4.2	0.61775	22.4	30.0	-31.2
1.070	V	24.8	Ambient	0.0	11.2	0.0	-40.0	-4.0	0.63214	22.4	30.0	-31.0
1.204	H	24.6	Ambient	0.0	11.2	0.0	-40.0	-4.2	0.61977	19.9	30.0	-30.1
1.204	V	30.9		0.0	11.2	0.0	-40.0	2.1	1.28005	19.9	30.0	-23.8
1.338	H	22.2	Ambient	0.0	11.2	0.0	-40.0	-6.5	0.47151	17.9	30.0	-31.6
1.338	V	26.6	Ambient	0.0	11.2	0.0	-40.0	-2.1	0.78251	17.9	30.0	-27.2
27.16	H	38.6		0.4	9.0	0.0	-40.0	7.9	2.49631	30.0	30.0	-21.6