FCC 47 CFR PART 15 SUBPART F
ISED CANADA RSS-220 ISSUE 1

CERTIFICATION TEST REPORT

FOR

WALL IMAGING RADAR

MODEL NUMBER: FTS200

FCC ID: 2AK3W-FTS200
IC: 22510-FTS200

REPORT NUMBER: 11628470-E2V3

ISSUE DATE: 2017-05-18

Prepared for
PANERA TECH, INC.
4125 LAFAYETTE CENTER DRIVE, SUITE 200
CHANTILLY, VA 20151 USA

Prepared by
UL LLC
12 LABORATORY DR.
RESEARCH TRIANGLE PARK, NC 27709 USA
TEL: (919) 549-1400

NVLAP TESTING

NVLAP LAB CODE 200246-0

Revision History

Ver.	Issue Date	Revisions	Revised By
1	2017-04-10	Initial Issue	Jeff Moser
2	2017-04-20	Revised worst-case mode in Section 5.6. Added details about the dry sand box configuration and occupied bandwidth test setup in Section 7. Added statement on below 30 MHz testing, added additional test setup photos.	Jeff Moser
3	2017-05-18	Revised Section 8.1 Occupied Bandwidth and Section 8.3 Peak Power data presentation.	Jeff Moser

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS 4

2. TEST METHODOLOGY 5

3. FACILITIES AND ACCREDITATION 5

4. CALIBRATION AND UNCERTAINTY 5

4.1. MEASURING INSTRUMENT CALIBRATION 5

4.2. SAMPLE CALCULATION 5

4.3. MEASUREMENT UNCERTAINTY 6

5. EQUIPMENT UNDER TEST 7

5.1. DESCRIPTION OF EUT 7

5.2. OPERATING FREQUENCY RANGE 7

5.3. MAXIMUM OUTPUT POWER 7

5.4. DESCRIPTION OF AVAILABLE ANTENNAS 7

5.5. SOFTWARE AND FIRMWARE 7

5.6. WORST-CASE CONFIGURATION 8

5.7. DESCRIPTION OF TEST SETUP 8

6. TEST AND MEASUREMENT EQUIPMENT 11

7. UWB TEST PROCEDURES 13

8. LIMITS AND RESULTS 14

8.1. UWB BANDWIDTH, CENTER FREQUENCY, AND FRACTIONAL BW 14

8.1.1. UWB BANDWIDTH 15

8.2. TRANSMISSION TIME 19

8.3. PEAK POWER 21

8.4. RADIATED EMISSIONS ABOVE 960 MHz 24

8.4.1. RADIATED EMISSIONS ABOVE 960 MHz 26

8.5. RADIATED EMISSIONS AT OR BELOW 960 MHz 30

8.5.1. RADIATED EMISSIONS AT OR BELOW 960 MHz 31

9. AC POWER LINE CONDUCTED EMISSIONS 33

10. SETUP PHOTOS 36

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: PANERA TECH, INC.
4125 LAFAYETTE CENTER DRIVE, SUITE 200
CHANTILLY, VA 20151 USA

EUT DESCRIPTION: WALL IMAGING RADAR

MODEL: FTS200

SERIAL NUMBER: Non Serialized

DATE TESTED: 2017-01-31 to 2017-02-02, 2017-05-18

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart F	Pass
ISED CANADA RSS-220 Issue 1	Pass
ISED CANADA RSS-GEN Issue 4	Pass

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL LLC based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

Approved & Released
For UL LLC By:

Jeff Moser
EMC Program Manager
UL – Consumer Technology Division

Prepared By:

Gerard Paul
EMC Staff Engineer
UL – Consumer Technology Division

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC KDB 393764, ANSI C63.10-2013, RSS-GEN Issue 4, and RSS-220 Issue 1.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 12 Laboratory Dr., Research Triangle Park, NC 27709, USA and 2800 Suite B, Perimeter Park Drive, Morrisville, NC 27560.

12 Laboratory Dr., RTP, NC 27709
☐ Chamber A
☐ Chamber C

2800 Suite B Perimeter Park Dr., Morrisville, NC 27560
☒ Chamber NORTH
☐ Chamber SOUTH

The onsite chambers are covered under Industry (ISED) Canada company address code 2180C with site numbers 2180C -1 through 2180C-4, respectively.

UL LLC (RTP) is accredited by NVLAP, Laboratory Code 200246-0. The full scope of accreditation can be viewed at http://www.nist.gov/nvlap/.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Total RF power, conducted	± 0.45
RF power density, conducted	± 1.50
Spurious emissions, conducted	± 2.94
All emissions, radiated up to 26 GHz	± 5.36
Temperature	± 0.07
Humidity	± 2.26
DC and low frequency voltages	± 1.27
Conducted Emissions (0.150-30MHz)	± 3.65
Frequency Stability	± 141 Hz

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an UWB wall imaging radar that is used in glass manufacturing industry to monitor structural health of the walls of high temperature melters made out of specialty refractory bricks. The sensor has two dual polarized TEM horn antennas that are designed to couple energy into highly microwave lossy refractories used in the melter walls.

5.2. OPERATING FREQUENCY RANGE

The UWB radio operates over a nominal frequency range of BANDWIDTH. The measured UWB bandwidths of all channels lie within this range.

FTS200 and FTS400 BANDWIDTH: 1000 to 8,000 MHz

5.3. MAXIMUM OUTPUT POWER

The UWB transmitter has a maximum radiated output power as follows:

Max PK E-Field Strength (dBuV/m)	PK Output Power (dBm/MHz EIRP)	PK Output Power (nW/MHz EIRP)
43.58	-51.62	6.887

The Peak Power was derived from a maximum field strength measurement of 43.58 dBuV/m – 95.2 (3m) = -51.62 dBm/MHz.

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes two custom TEM horn antennas, with a maximum gain of MAX GAIN.

FTS200 MAX GAIN: 5 dBi

5.5. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was v2.0, rev. A
The EUT driver software installed during testing was WinUSB Embedded Handheld 8.1
The test utility software used during testing was v2.0, rev. A

5.6. WORST-CASE CONFIGURATION

Preliminary investigations were performed at all coding, modulation rates and channels as defined in the Theory of Operation. The worst-case mode was determined to be turning on the transmitter (Port 1 and Port 2) and switching through each transmitting port, with a 2mS dwell time.

Note – The EUT required 10 dB internal attenuation to meet the requirements.

5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Handheld computer	Panasonic	FZ-E1	4KKSA01612	ACJFZE1B

I/O CABLES

I/O CABLE LIST						
Cable No.	**Port**	**# of Identica Ports**	**Connector Type**	**Cable Type**	**Cable Length**	**Remarks**
W1	FZ-E1	1	LEMO-PHG	USB, custom	6 in.	
W2	Upstream	1	LEMO-FGG	USB, custom	50 in.	
W3	Downstrea m	1	LEMO-PHG	USB, custom	46 in.	
W4	Probe	1	LEMO-FGG	USB, custom	6 in.	

TEST SETUP

The EUT is connected to the Handheld computer through a custom USB controller cable. The Handheld computer commands the EUT through USB to acquire radar frames, sensor and diagnostic data throughout the test. All antennas were active during testing.

For Radiated Emissions testing, the EUT was configured so that the transmit antenna was facing down in a bed of dry sand as described in ANSI C63.10: 2013 Section 10.2.2. The dry sand had a depth of 50 cm and the surface of the sand that the EUT was placed on was 80 cm above the ground reference plane.

Note – The EUT required 10 dB internal attenuation to meet the requirements.

SETUP DIAGRAM FOR TESTS

6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - North Chamber)

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	0.009-30MHz	**(Loop Ant.)**			
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2016-12-28	2017-12-31
	30-1000 MHz				
AT0073	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2016-06-27	2017-06-30
	1-18 GHz				
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2016-03-07, 2017-04-05	2017-03-31, 2018-04-30
	18-40 GHz				
AT0076	Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	2016-09-06	2017-09-06
AT0077	Horn Antenna, 26-40GHz	ARA	MWH-2640/B	2016-09-06	2017-09-06
	Gain-Loss Chains				
N-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2016-10-04	2017-10-04
N-SAC02	Gain-loss string: 30-1000MHz	Various	Various	2016-06-26	2017-06-30
N-SAC03	Gain-loss string: 1-18GHz	Various	Various	2016-08-28	2017-08-28
N-SAC04	Gain-loss string: 18-40GHz	Various	Various	2016-04-27, 2017-03-03	2017-04-30, 2018-03-03
	Receiver & Software				
SA0027	Spectrum Analyzer	Agilent	N9030A	2016-02-08, 2017-03-16	2017-02-08, 2018-03-16
SA0026 (18-40GHz RSE)	Spectrum Analyzer	Agilent	N9030A	2016-02-24, 2017-02-17	2017-02-28, 2018-02-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
	Additional Equipment used				
139844	Temp/Humid/Pressure Meter	Control Co./Fisher	14-650-118	2016-02-19	2017-02-19
s/n 161024690	Environmental Meter	Fisher Scientific	15-077-963	2016-12-21	2018-12-21

Test Equipment Used - Line-Conducted Emissions – Voltage (Morrisville – Conducted 1)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL077	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3476-240	2016-06-15	2017-06-30
139843	Temp/Humid/Pressure Meter	Control Co./Fisher	14-650-118	2016-02-19	2017-02-19
LISN003	LISN, 50-ohm/50-uH, 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50-25-2-01-550V	2016-08-24	2017-08-24
PRE0101521 (75141)	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2016-08-23	2017-08-23
TL001	Transient Limiter, 0.009-30MHz	Com-Power	LIT-930A	2016-06-09	2017-06-30
PS215	AC Power Source	Elgar	CW2501M (s/n 1523A02397)	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
	Miscellaneous (if needed)				
MM0170	Multi-meter	Fluke	83V	2016-03-15	2017-03-31

7. UWB TEST PROCEDURES

TEST PROCEDURES

All RF characteristics of the EUT are made using radiated measurements.

For Occupied Bandwidth, in order to capture the waveform, the EUT was placed on a non-reflective surface and pointed directly toward the Receive antenna. Due to the low amplitude of the transmit signal, the Receive Antenna was moved as close as necessary to obtain a measurable signal.

For Radiated Emissions testing, the EUT was configured so that the transmit antenna was facing down in a bed of dry sand as described in ANSI C63.10: 2013 Section 10.2.2. The dry sand had a depth of 50 cm and the surface of the sand that the EUT was placed on was 80 cm above the ground reference plane. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the antenna is located 3 meters from the EUT. The resolution bandwidth is set to 1 MHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For 1 MHz RBW final measurements above 960 MHz the antenna is located no more than 3 meter from the EUT. The RBW and VBW are both set to 1 MHz. An Agilent PXA series spectrum analyzer with a true RMS detector is utilized. The number of points is equal to (Frequency Span in MHz) and the sweep time is set to no more than (Frequency Span in MHz) milliseconds so as not to exceed the maximum 1 ms averaging time.

For 1 kHz (30 kHz) RBW final measurements above 960 MHz the antenna is located no more than 3 meter from the EUT. The RBW and VBW are both set to 1 kHz (30 kHz). An Agilent PSA series spectrum analyzer with a true RMS detector is utilized. The number of points is equal to (Frequency Span in MHz) and the sweep time is set to no more than (Frequency Span in MHz) milliseconds so as not to exceed the maximum 1 ms averaging time.

The resulting 3 meter field strength is converted to EIRP using the equation P (dBm EIRP) = E (dBuV/m) – 95.2.

Measurements used for calculating bandwidth, peak power, and the peak level of digital device emissions are made using peak detection.

8. LIMITS AND RESULTS

8.1. UWB BANDWIDTH, CENTER FREQUENCY, AND FRACTIONAL BW

DEFINITIONS AND LIMITS

§15.503 Definitions.
(a) UWB Bandwidth. For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated fH and the lower boundary is designated fL. The frequency at which the highest radiated emission occurs is designated fM.
(b) Center frequency. The center frequency, fC, equals (fH + fL)/2.
(c) Fractional bandwidth. The fractional bandwidth equals 2(fH - fL)/ (fH + fL).
(d) Ultra-wideband (UWB) transmitter. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

§15.509 (a) The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz..

RSS-220 6.2.1 (a) - The -10 dB UWB bandwidth for GPR or an in-wall radar imaging device shall be entirely below 10.6 GHz.

TEST PROCEDURE

Radiated measurements are made using the procedures described above. The detection mode is set to peak detection, RBW/VBW = 1MHz/3MHz, the sweep time is AUTO, and the Max Hold trace function is utilized. The frequency range from 30 MHz to 10.6 GHz is measured, and corrected from raw values to Peak EIRP.

The frequency at which the maximum EIRP is measured is designated as fM. A major graticule line of the plot is adjusted to exactly equal the peak EIRP at fM. The spectral envelope at the major graticule line that is 10 dB below the reference graticule is examined to determine the frequency band bounded by the points that are 10 dB below the highest radiated emission. The upper boundary is designated fH and the lower boundary is designated fL.

The center frequency, fC, is calculated as (fH + fL)/2.

The antenna polarization that yields the highest EIRP at fM is used to calculate the above parameters.

8.1.1. UWB BANDWIDTH

FTS200 RESULTS

VERTICAL

f Max (MHz)	Reference EIRP at f Max (dBuV/m)	10 dB down from Reference EIRP (dBm)
4347.376	69.4	59.4

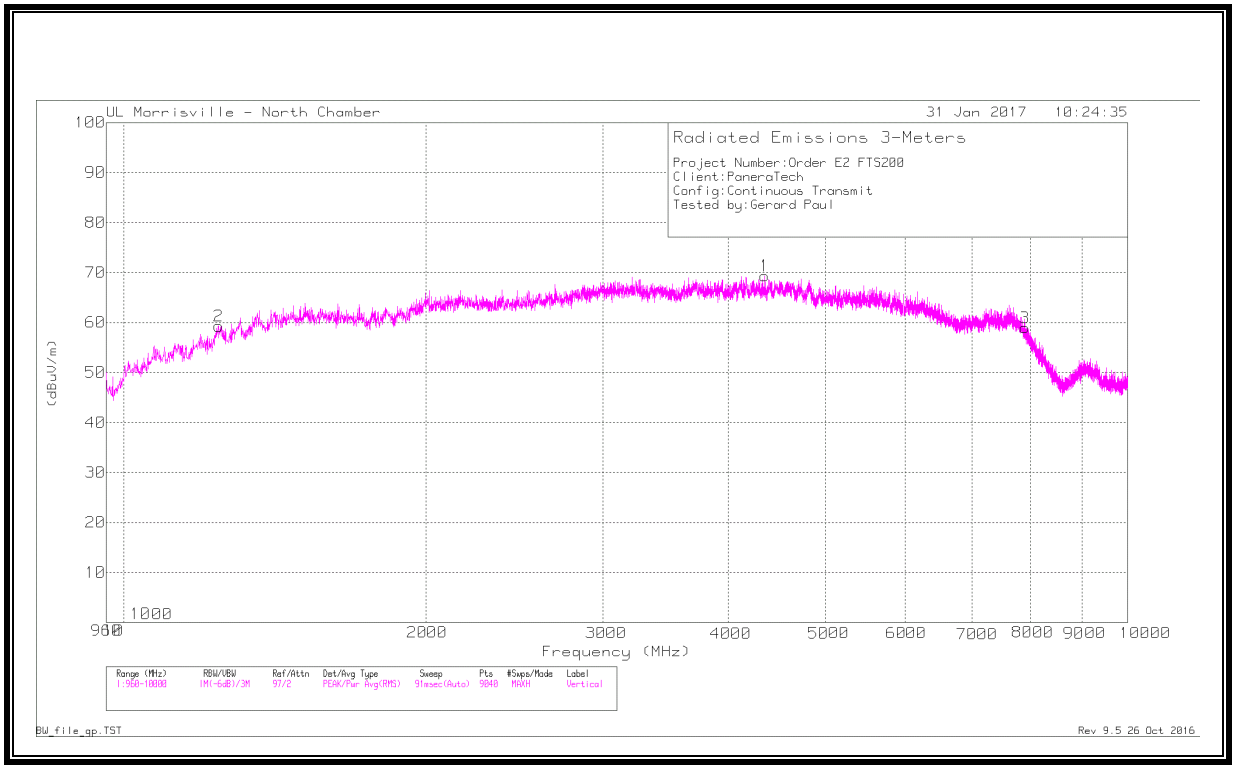
f Low (MHz)	Minimum f Low (GHz)
1242.031	None

f High (MHz)	Maximum f High (GHz)
7900.770	10.6

f Center (MHz)
4571.401

UWB BW (MHz)	Minimum UWB BW (MHz)
6659	500

PLOT FTS200 VERTICAL



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	Azimuth (Degs)	Height (cm)	Polarity
2	1242.031	68.6	Pk	29	-38.3	59.3	0	101	V
1	4347.376	71.15	Pk	33.7	-35.5	69.35	0	101	V
3	7900.77	56.46	Pk	35.8	-33.3	58.96	0	101	V

Pk - Peak detector
BW_file_gp.TST
Rev 9.5 26 Oct 2016

Marker 1 – fMax
Marker 2 – fLow
Marker 3 - fHigh

Note – Start frequency is 960 MHz.

HORIZONTAL

f Max (MHz)	Reference EIRP at f Max (dBuV/m)	10 dB down from Reference EIRP (dBm)
4831.107	69.8	59.8

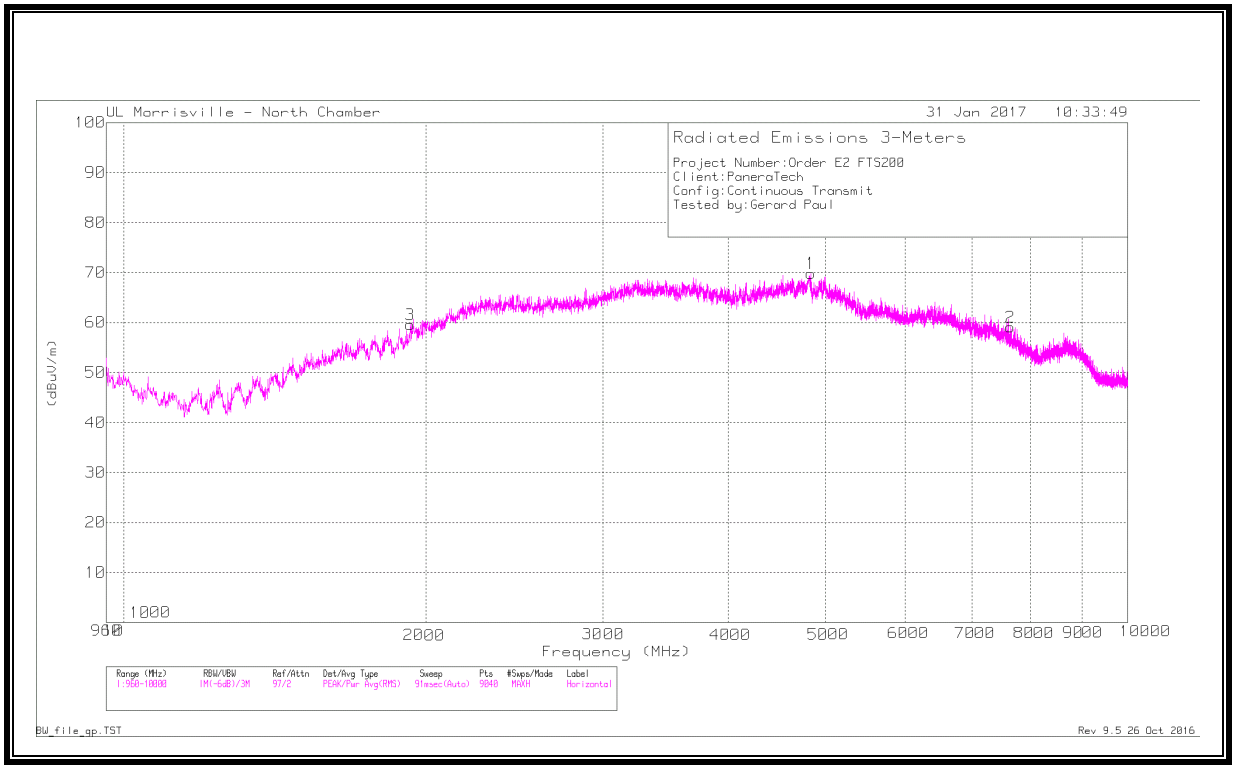
f Low (MHz)	Minimum f Low (GHz)
1928.107	None

f High (MHz)	Maximum f High (GHz)
7642.742	10.6

f Center (MHz)
4785.425

UWB BW (MHz)	Minimum UWB BW (MHz)
5715	500

PLOT FTS200 HORIZONTAL



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	Azimuth (Degs)	Height (cm)	Polarity
3	1928.107	65.4	Pk	31.4	-37.2	59.6	0	101	H
1	4831.43	71.14	Pk	34.1	-35.4	69.84	0	101	H
2	7642.742	57	Pk	35.6	-33.5	59.1	0	101	H

Pk - Peak detector
BW_file_gp.TST
Rev 9.5 26 Oct 2016

Marker 1 – fMax
Marker 3 – fLow
Marker 2 - fHigh

Note – Start frequency is 960 MHz.
.

8.2. TRANSMISSION TIME

LIMITS

FCC §15.509 (c)

A GPR that is designed to be operated while being hand held and a wall imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

ISED RSS-220 6.2.1 (b)

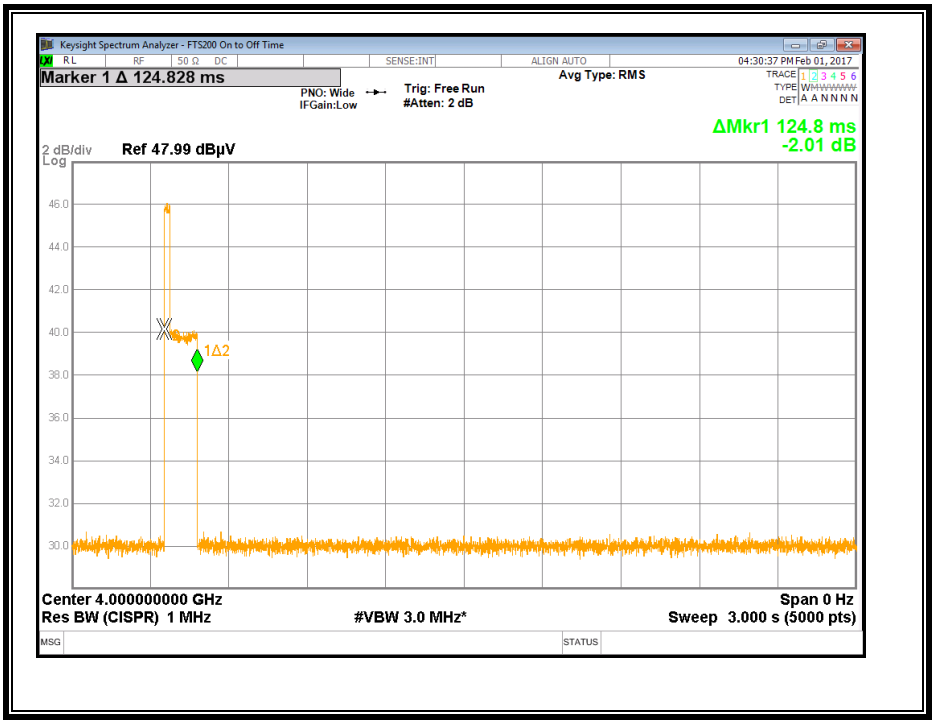
A device operating under the provisions of this section shall contain a mechanism that deactivates the equipment when normal use is interrupted. For manually operated hand-held devices, this mechanism shall contain a manual switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of remotely/computer controlled equipment with a switch located on the radar imaging device, it is permissible to operate the device by a remote control unit provided that deactivation takes place within 10 seconds of the remote switch being released by the operator.

TEST PROCEDURE

The transmitter output is coupled to a spectrum analyzer via an antenna connected to the input of the spectrum analyzer. The RBW is set to 1MHz and the VBW is set to 3MHz. The sweep time is set to roughly 20 seconds and the span is set to 0 Hz.

RESULTS

Time indicated is time from radar turn on to radar turn off.



Time denotes total time from button press commanding radar on to button release and radar off. The measured time was 124.8 ms.

8.3. PEAK POWER

LIMIT

§15.509 (f) For UWB devices where the frequency at which the highest radiated emission occurs, fM, is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521.

§15.521 (g) When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, f_M. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

§15.521 (e) The frequency at which the highest radiated emission occurs, f_M, must be contained within the UWB bandwidth.

RSS-220 6.2.1 (g) - The peak level of the transmissions shall not exceed the peak equivalent of the average limit contained within any 50 MHz bandwidth, as defined in section 4 of the Annex.

TEST PROCEDURE

Radiated measurements are made using the procedures described above.

The spectrum analyzer center frequency is set to f_M. The frequency span is set to 50 MHz. The RBW and VBW are both set to 1 MHz. The detector function is set to peak.

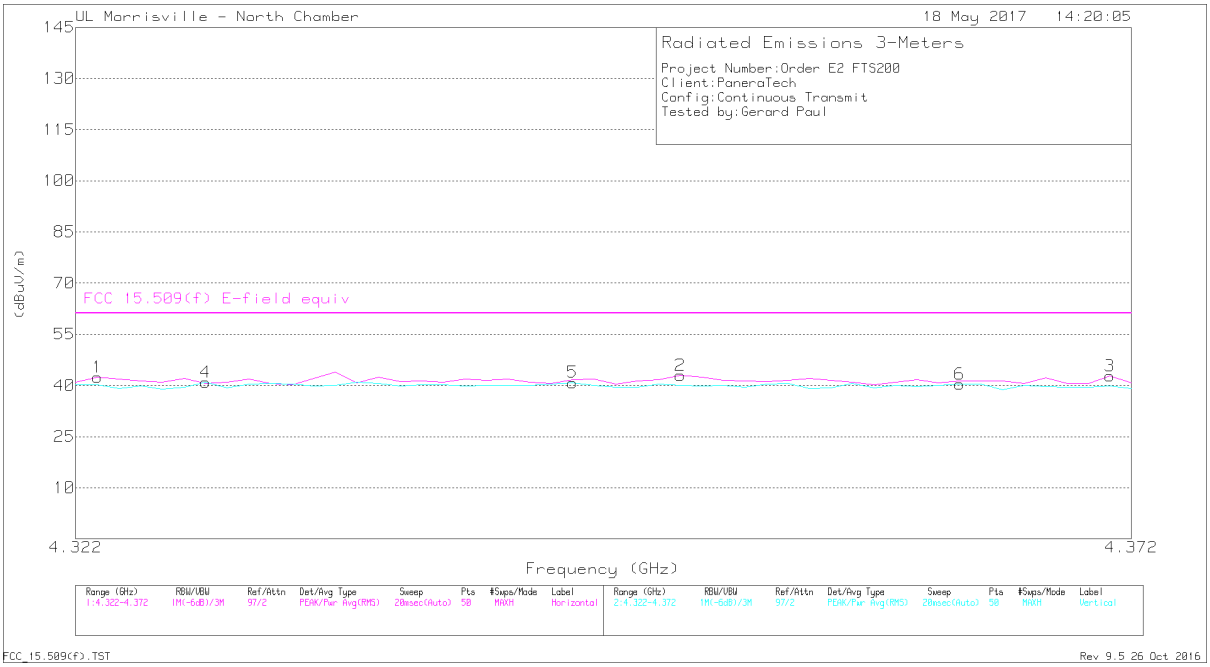
The test procedure and the calibration of the test setup are both identical to that for which a 1 or 3 MHz RBW is specified. The instrumentation is an Agilent PXA series spectrum analyzer, which includes a standard maximum RBW of 8 MHz.

Limit calculated as follows (RBW = 1MHz)

20 log (RBW/50) dBm = 20 log (1/50) dBm = -33.98 dBm
Peak E-field (3m) E(dBuV/m) = P(dBm EIRP) + 95.2 = -33.98 + 95.2 = 61.2 dBuV/m

RESULTS

FTS200, VERTICAL



Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	FCC 15.509(f) E-field equiv	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	4.323	44.26	Pk	33.6	-35.5	42.36	61.2	-18.84	0-360	299	H
4	4.328	42.78	Pk	33.6	-35.4	40.98	61.2	-20.22	0-360	299	V
5	4.345	42.65	Pk	33.7	-35.5	40.85	61.2	-20.35	0-360	299	V
2	4.351	44.76	Pk	33.7	-35.5	42.96	61.2	-18.24	0-360	299	H
6	4.364	42.02	Pk	33.7	-35.3	40.42	61.2	-20.78	0-360	299	V
3	4.371	44.26	Pk	33.8	-35.3	42.76	61.2	-18.44	0-360	299	H

Pk - Peak detector
FCC_15.509(f).TST
Rev 9.5 26 Oct 2016

FTS200 HORIZONTAL

Trace Markers

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	FCC 15.509(f) E-field equiv	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	4.812	44.76	Pk	34	-35.5	43.26	61.2	-17.94	0-360	299	H
4	4.815	43.66	Pk	34.1	-35.5	42.26	61.2	-18.94	0-360	299	V
5	4.825	43.58	Pk	34.1	-35.4	42.28	61.2	-18.92	0-360	299	V
2	4.827	44.88	Pk	34.1	-35.4	43.58	61.2	-17.62	0-360	299	H
3	4.848	42.68	Pk	34.2	-35.3	41.58	61.2	-19.62	0-360	299	H
6	4.853	42.54	Pk	34.2	-35.3	41.44	61.2	-19.76	0-360	299	V

Pk - Peak detector
FTS400 15.509(f).TST
Rev 9.5 26 Oct 2016

8.4. RADIATED EMISSIONS ABOVE 960 MHz

LIMITS

§15.509 (d) The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

RSS-220 6.2.1 (d) - Radiated emissions above 960 MHz from a device shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz.

Frequency in MHz	EIRP in dBm
960-1610	-65.3
1610-1990	-53.3
1990-3100	-51.3
3100-10600	-41.3
Above 10600	-51.3

15.509 (e) In addition to the radiated emission limits specified in the table in paragraph (d) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

RSS-220 6.2.1 (e) - In addition to the limits specified in paragraph (d) of this section, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

Frequency in MHz	EIRP in dBm
1164-1240	-75.3
1559-1610	-75.3

§15.521 (d) Within the tables in §§15.509, 15.511, 15.513, 15.515, 15.517, and 15.519, the tighter emission limit applies at the band edges. Radiated emission levels above 960 MHz are based on RMS average measurements over a 1 MHz resolution bandwidth. The RMS average measurement is based on the use of a spectrum analyzer with a resolution bandwidth of 1 MHz, an RMS detector, and a 1 millisecond or less averaging time.

§15.521 (e) The frequency at which the highest radiated emission occurs, f_M, must be contained within the UWB bandwidth.

TEST PROCEDURE

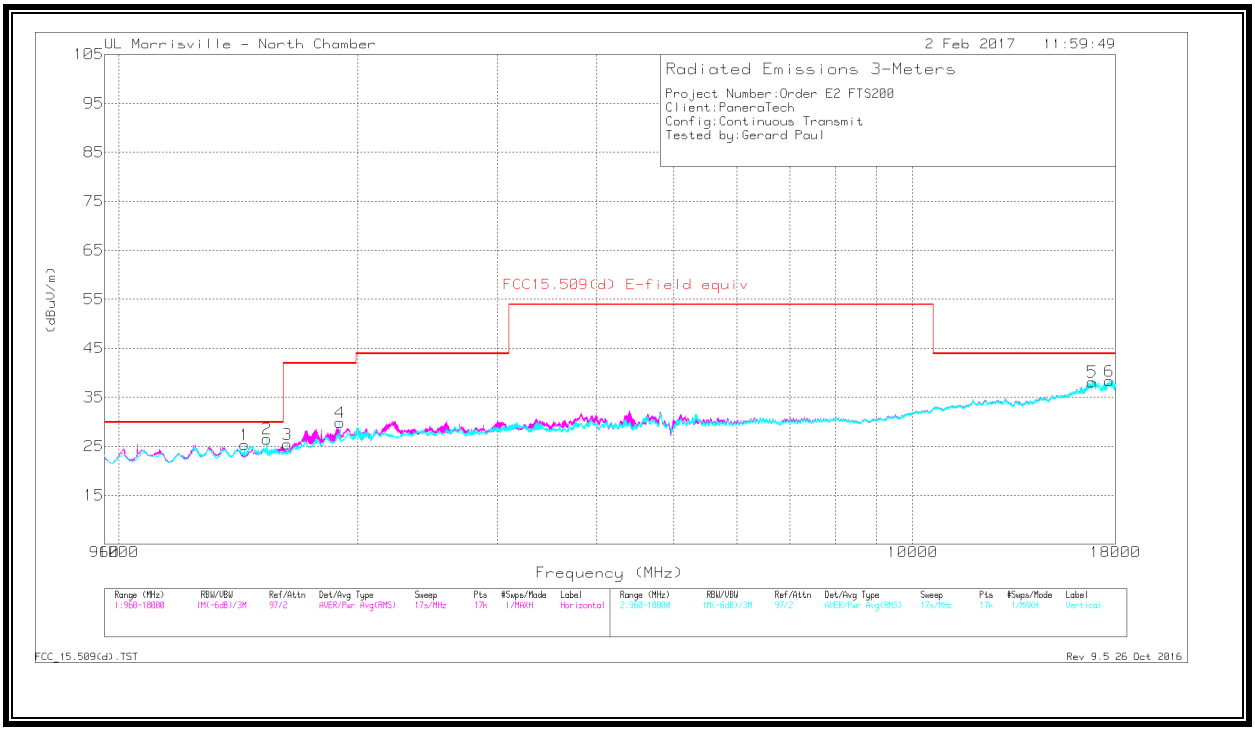
Radiated measurements are made using the procedures described in ANSI C63.10: 2013 Section 10.3.5. The RBW/VBW = 1MHz/3MHz, the sweep time is set to 1mS/MHz, and the detector function is set to RMS average.

For the requirements of §15.509 (e), an RBW of 30 kHz is utilized, except that an RBW of 1 kHz is utilized the 1164 to 1240 MHz and 1.559-1610 MHz frequency range.

RESULTS

8.4.1. RADIATED EMISSIONS ABOVE 960 MHz

EIRP 0.960 TO 18 GHz, 1 MHz BW



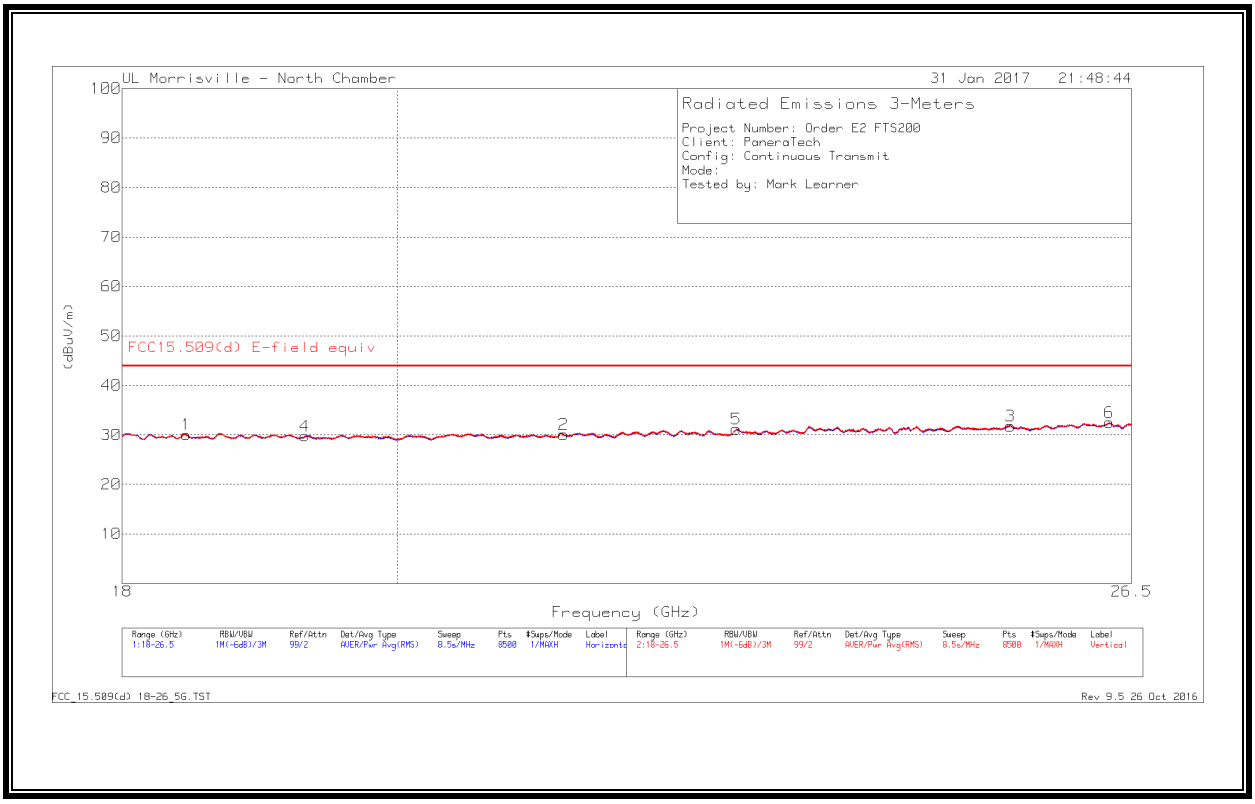
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	FCC15.509(d) E-field equiv	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1440.028	34.8	RMS	28.4	-37.9	25.3	29.9	-4.6	144	299	V
2	1536.034	36.49	RMS	27.9	-37.9	26.49	29.9	-3.41	312	299	V
3	1632.04	34.7	RMS	28.4	-37.7	25.4	41.9	-16.5	106	101	V
4	1900.055	36.01	RMS	31.1	-37.3	29.81	41.9	-12.09	62	101	V
5	16824.936	26.74	RMS	42.1	-30.7	38.14	43.9	-5.76	62	101	V
6	17686.987	26.23	RMS	41.4	-29.3	38.33	43.9	-5.57	106	101	V

EIRP 1164-1240 and 1559-1610 GHz, 30 kHz BW

Marker	Freq. (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Gain/Loss	Corrected Reading (dBuV/m)	FCC15.509(e) E-field equiv	Margin (dB)	FCC15.509(e) E-field equiv	PK Margin (dB)	Height (cm)	Polarity
1	1.189	21.72	RMS	28.4	-38.4	11.72	19.9	-8.18	-	-	299	V
2	1.585	22.4	RMS	28.1	-37.8	12.7	19.9	-7.2	-	-	101	V

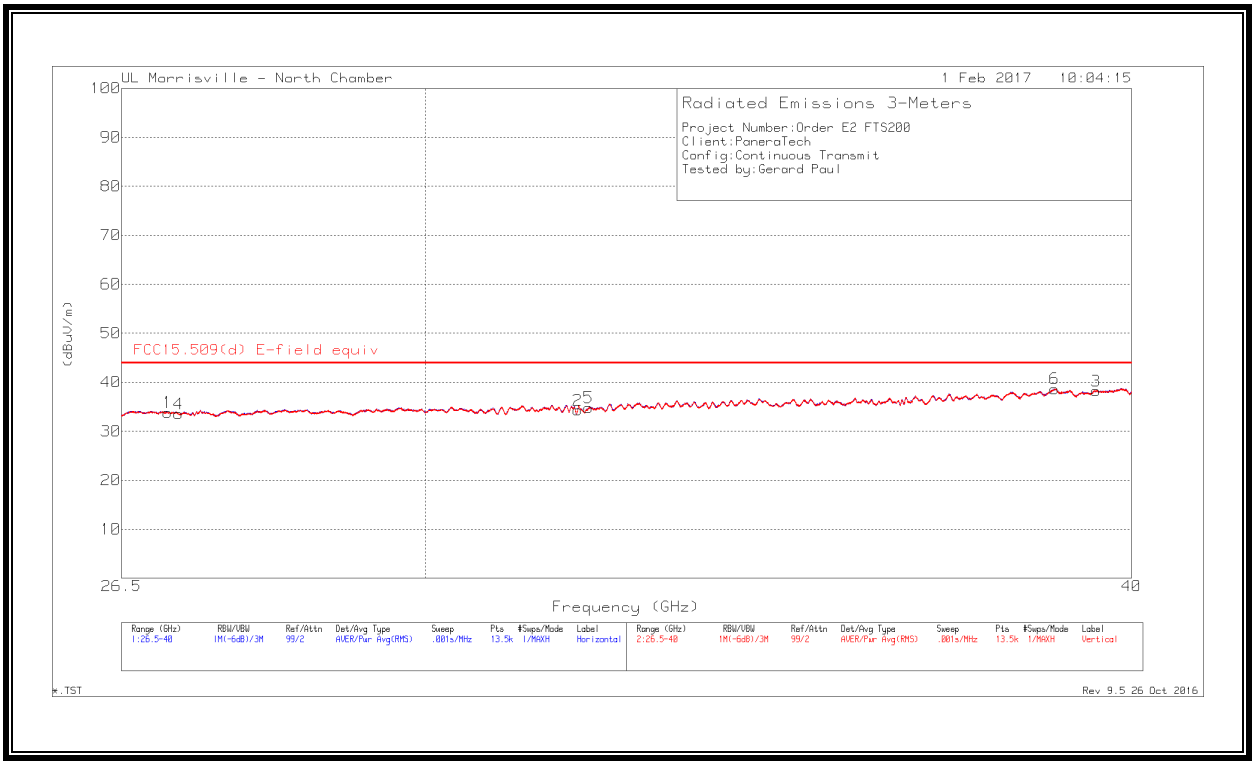
RMS - RMS detection

EIRP 18 TO 26.5 GHz, 1 MHz BW



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0076 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	FCC15.509(d) E-field equiv	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	18.449	37.57	RMS	32.7	-40.2	30.07	43.9	-13.83	182	300	H
4	19.304	37.66	RMS	32.7	-40.6	29.76	43.9	-14.14	246	299	V
2	21.317	37.5	RMS	33.2	-40.6	30.1	43.9	-13.8	223	300	H
5	22.775	37.5	RMS	33.7	-40	31.2	43.9	-12.7	156	102	V
3	25.298	36.29	RMS	34.5	-39	31.79	43.9	-12.11	223	300	H
6	26.273	36.14	RMS	34.8	-38.4	32.54	43.9	-11.36	200	102	V

EIRP 26.5 TO 40 GHz, 1 MHz BW



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0077 (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	FCC15.509(d) E-field equiv	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	27.005	35.77	RMS	36.1	-38	33.87	43.9	-10.03	70	299	H
4	27.123	35.78	RMS	36	-38.2	33.58	43.9	-10.32	238	300	V
2	31.913	34.69	RMS	36.7	-37.1	34.29	43.9	-9.61	202	299	H
5	32.06	34.85	RMS	36.8	-36.8	34.85	43.9	-9.05	154	300	V
6	38.765	33.88	RMS	38.9	-34.1	38.68	43.9	-5.22	114	300	V
3	39.423	32.95	RMS	38.8	-33.5	38.25	43.9	-5.65	132	299	H

8.5. RADIATED EMISSIONS AT OR BELOW 960 MHz

LIMITS

§15.509 (d) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209 of this chapter.

RSS-220 6.2.1 (c) - Radiated emissions at or below 960 MHz from a device shall not exceed the limits in section 3.4.

§15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

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	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

§15.209 (b) In the emission table above, the tighter limit applies at the band edges.

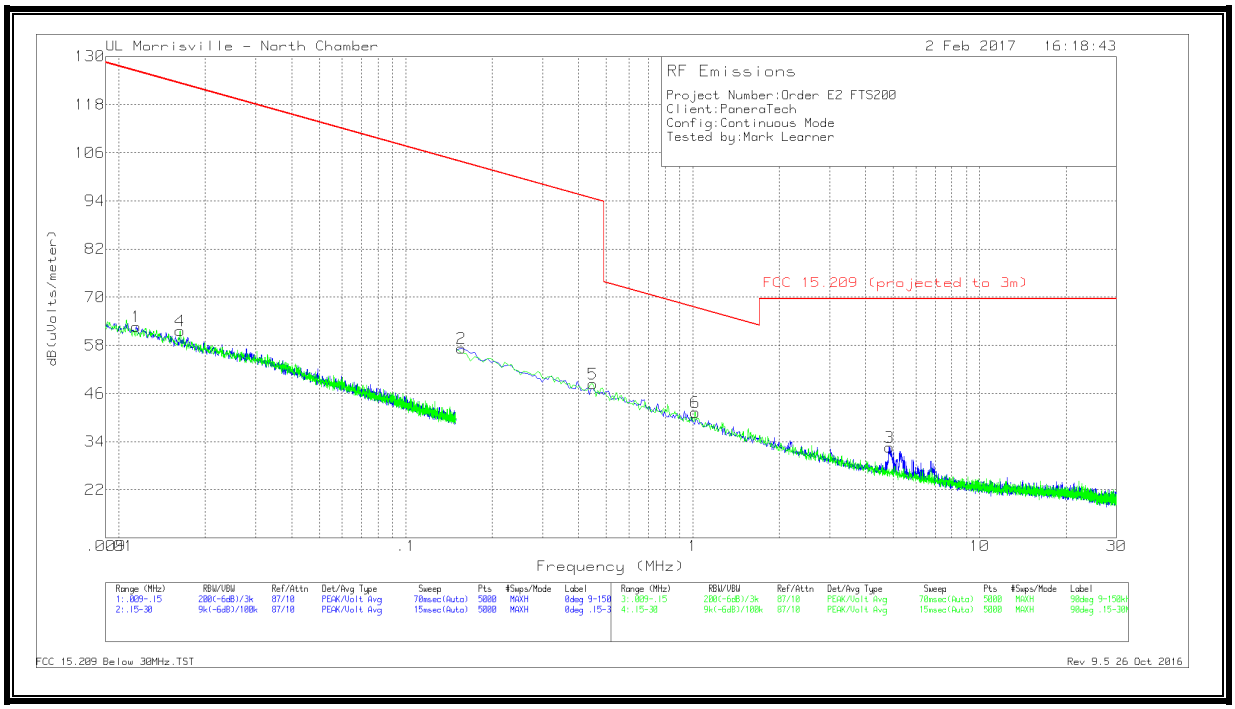
RESULTS

8.5.1. RADIATED EMISSIONS AT OR BELOW 960 MHz

SPURIOUS EMISSIONS 0.009 TO 30 MHz

Note: All measurements were made at a test distance of 3 m. The limits in the plots and tabular data are the FCC/IC limits extrapolated from the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to the measurement distance to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (specification distance / test distance).

Although these tests were performed at a test site other than an open area test site, adequate comparison measurements were confirmed against an open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 937606.

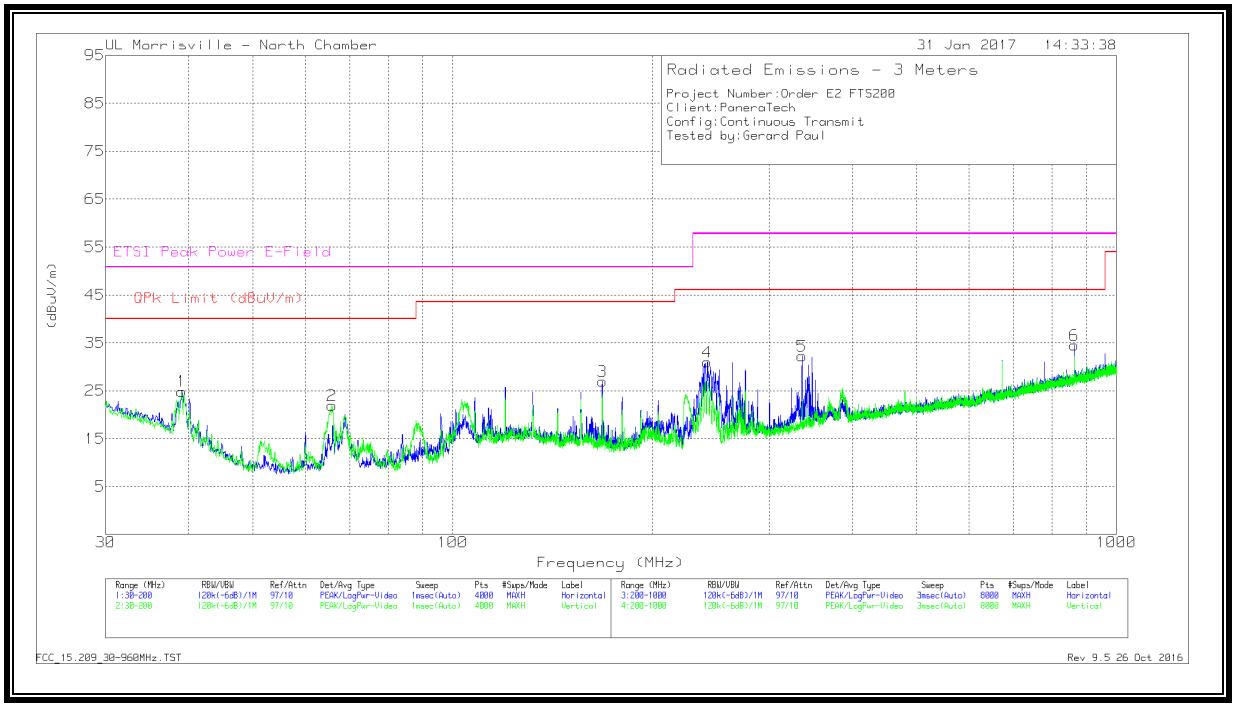


Note – Start freq is 0.009 MHz.

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0079 AF (dB/m)	Cbl (dB)	Corrected Reading dB(uVolts/meter)	FCC 15.209 (projected to 3m)	Margin (dB)	Azimuth (Degs)	Polaritty
1	.01149	44.87	Pk	17.7	.1	62.67	126.4	-63.73	0-360	Face ON
2	.15597	46.45	Pk	10.7	.1	57.25	103.74	-46.49	0-360	Face ON
3	4.86112	21.18	Pk	11	.4	32.58	69.54	-36.96	0-360	Face ON
4	.01634	45.92	Pk	15.6	.1	61.62	123.34	-61.72	0-360	Face Off
5	.44855	37.57	Pk	10.7	.1	48.37	94.57	-46.2	0-360	Face Off
6	1.02177	30.06	Pk	11	.2	41.26	67.42	-26.16	0-360	Face Off

Pk - Peak detector

SPURIOUS EMISSIONS 30 TO 1000 MHz



Marker	Freq. (MHz)	Meter Reading (dBuV)	Det	AT0073 AF (dB/m)	Amp/Cbl (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	ETSI Peak Power E-Field (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	39.0548	37.29	Pk	19.2	-31.6	24.89	40	-15.11	50.8	-25.91	0-360	299	H
2	65.7943	41.04	Pk	12.2	-31.3	21.94	40	-18.06	50.8	-28.86	0-360	102	V
3	168.0332	40.79	Pk	16.5	-30.3	26.99	43.52	-16.53	50.8	-23.81	0-360	199	H
4	242.0055	44.6	Pk	16.2	-29.8	31	46.02	-15.02	57.8	-26.8	0-360	102	H
5	335.9177	42.61	Pk	18.8	-29.2	32.21	46.02	-13.81	57.8	-25.59	0-360	102	H
6	863.9863	34.69	Pk	26.5	-26.7	34.49	46.02	-11.53	57.8	-23.31	0-360	102	H

9. AC POWER LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

RSS-Gen 7.2.2

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency.

TEST PROCEDURE

The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.10.

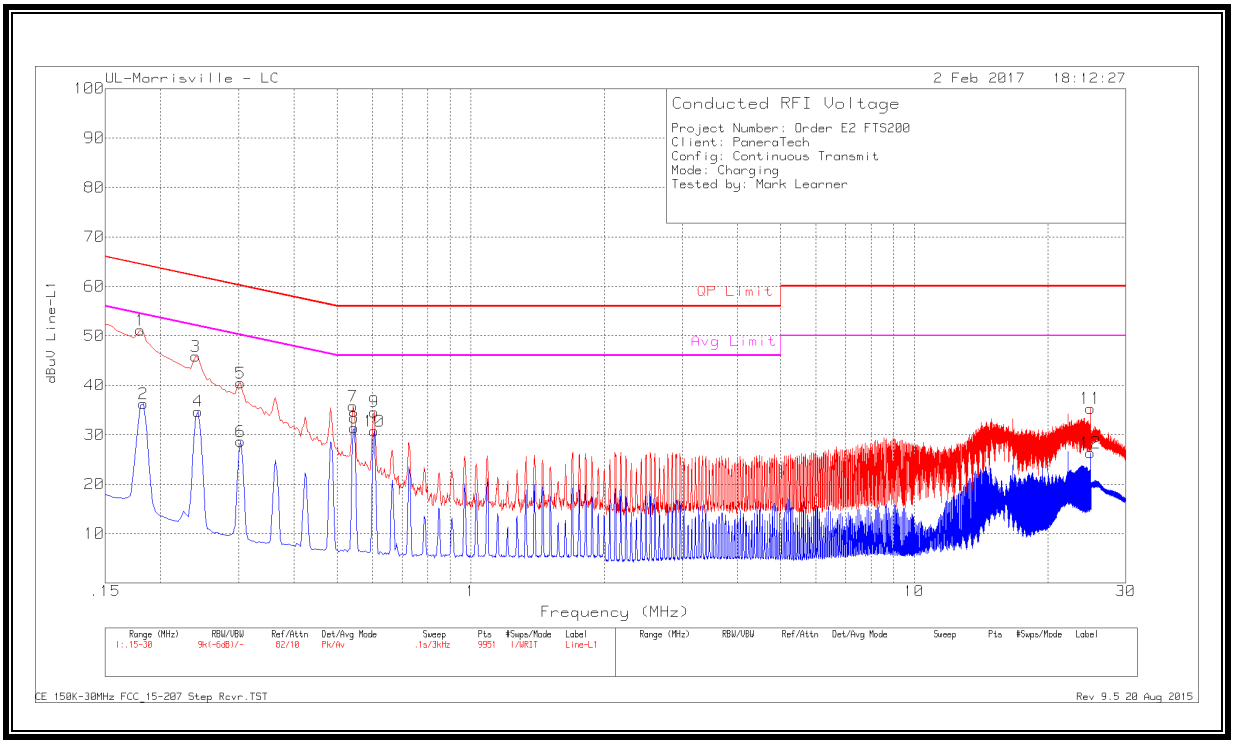
The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

Line conducted data is recorded for both NEUTRAL and HOT lines.

RESULTS

6 WORST EMISSIONS

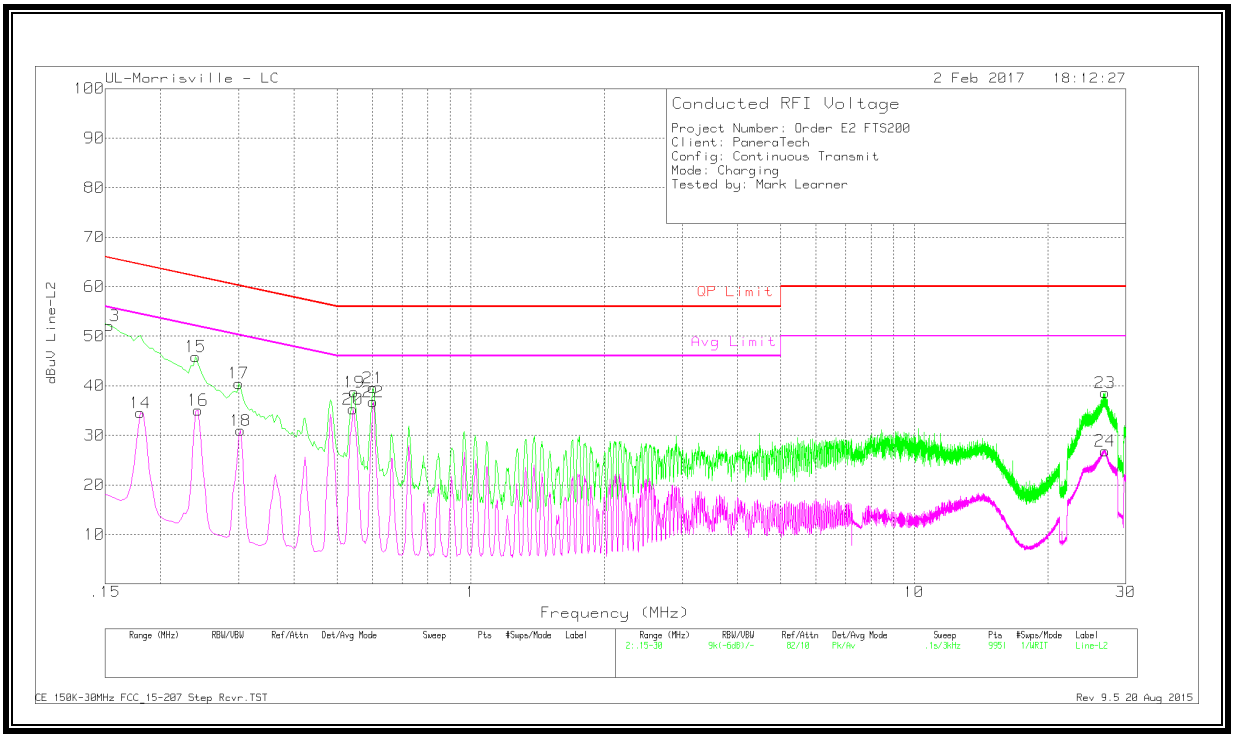
LINE 1 RESULTS



Range 1: Line-L1 .15 - 30MHz										
Marker	**Frequency (MHz)**	**Meter Reading (dBuV)**	**Det**	**LISN VCF (dB)**	**Cbl/Limiter (dB)**	**Corrected Reading dBuV**	**QP Limit**	**Margin (dB)**	**Avg Limit**	**Margin (dB)**
1	.18	40.97	Pk	.2	10	51.17	64.49	-13.32	-	-
2	.183	26.11	Av	.2	10	36.31	-	-	54.35	-18.04
3	.24	35.76	Pk	.1	10	45.86	62.1	-16.24	-	-
4	.243	24.65	Av	.1	10	34.75	-	-	51.99	-17.24
5	.303	30.39	Pk	.1	10	40.49	60.16	-19.67	-	-
6	.303	18.52	Av	.1	10	28.62	-	-	50.16	-21.54
7	.543	25.82	Pk	0	10	35.82	56	-20.18	-	-
8	.546	21.42	Av	0	10	31.42	-	-	46	-14.58
9	.606	24.62	Pk	0	10	34.62	56	-21.38	-	-
10	.606	20.75	Av	0	10	30.75	-	-	46	-15.25
11	24.984	24.45	Pk	.3	10.6	35.35	60	-24.65	-	-
12	24.987	15.48	Av	.3	10.6	26.38	-	-	50	-23.62

Pk - Peak detector
Av - Average detection

LINE 2 RESULTS



Range 2: Line-L2 .15 - 30MHz										
Marker	**Frequency (MHz)**	**Meter Reading (dBuV)**	**Det**	**LISN VCF (dB)**	**Cbl/Limiter (dB)**	**Corrected Reading dBuV**	**QP Limit**	**Margin (dB)**	**Avg Limit**	**Margin (dB)**
13	.153	41.9	Pk	.2	10	52.1	65.84	-13.74	-	-
14	.18	24.37	Av	.2	10	34.57	-	-	54.49	-19.92
15	.24	35.81	Pk	.1	10	45.91	62.1	-16.19	-	-
16	.243	24.99	Av	.1	10	35.09	-	-	51.99	-16.9
17	.3	30.42	Pk	.1	10	40.52	60.24	-19.72	-	-
18	.303	20.92	Av	.1	10	31.02	-	-	50.16	-19.14
19	.546	28.71	Pk	0	10	38.71	56	-17.29	-	-
20	.543	25.3	Av	0	10	35.3	-	-	46	-10.7
21	.603	29.58	Pk	0	10	39.58	56	-16.42	-	-
22	.603	26.8	Av	0	10	36.8	-	-	46	-9.2
23	26.922	27.64	Pk	.3	10.7	38.64	60	-21.36	-	-
24	26.931	15.87	Av	.3	10.7	26.87	-	-	50	-23.13

Pk - Peak detector
Av - Average detection