FCC 47 CFR PART 15 SUBPART C
INDUSTRY CANADA RSS-247 ISSUE 2

CERTIFICATION TEST C2PC REPORT

FOR

RF ID Reader

MODEL NUMBER: HD5000

FCC ID: YGP5000-01
IC: 9016A-HD5000A

REPORT NUMBER: 1160223-E4

ISSUE DATE: 2017-04-19

Prepared for
CROWN EQUIPMENT CORP
44 SOUTH WASHINGTON STREET
NEW BREMEN, OH 45869 USA

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NVLAP TESTING

NVLAP LAB CODE 200246-0

Revision History

Ver.	Issue Date	Revisions	Revised By
1	2017-03-31	Initial Issue	Richard Jankovics
2	2017-04-19	Updated IC company number. Updated Class II Permissive Change section. Updated company address. Added exerpt for below 30 MHz measurements.	Richard Jankovics
3	2017-05-11	Updated KDB referenced for below 30 MHz to 414788.	Richard Jankovics

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1. CLASS II PERMISSIVE CHANGE

1.1. INTRODUCTION

The following changes have been made to the HD5000 under FCC ID: YGP5000-01. Based on the changes made by the manufacturer, only radiated spurious emissions was performed under this evaluation. The 15.215 antenna port conducted data for FCC ID: YGP5000-01 is represented by the results of the original grant, test report 10766018B.

Crown Equipment Corp takes full responsibility that the data as referenced in FCC ID: YGP5000-01, test report 10766018B represent compliance for this model.

1.2. DIFFERENCES

According to manufacturer, changes to FCC ID: YGP5000-01 include:

RFID board

- The transmit section has not changed since last certification.
- The receive side has changed some resistor values to help with Reverse power detection.

Control board

- Board has power supply pads that were not populated and removed to allow room.
- Jumper wire for input power was removed and input protection circuitry was added to allow for protection against voltage spikes and mis-wiring
- CAN circuity was changed to allow less loading on the CAN communication lines.
- Circuity added to be able to drive confidence tags separately of either antenna. Currently not being used.
- Connection to frame capacitor was removed to help reduce truck noise effecting diagnostics.

Antenna

- Antenna material was changed to a Rodgers 4835 from a Rodgers 3035 to allow for easier manufacturing.
- Patch size was changed slightly to allow for the difference in dielectric constant of the new material.
- Additional resistor was added to help with impedance matching to RFID radio board with the new material.
- Two capacitors were added to help with antenna tuning with the new material.
- Two sides of the antenna were changed to allow for better communication with the passive RFID tags internal to the antenna

Confidence tag

- Confidence tag ground plane was connected to truck frame to allow for more consistent reading of the confidence tag in presence of truck electrical noise generated by the electrical system.

No changes to the power output level of the system was done.

1.3. TESTING PERFORMED

Testing performed under this report for FCC ID: YGP5000-01 contains radiated spurious emissions.

2. ATTESTATION OF TEST RESULTS

COMPANY NAME: CROWN EQUIPMENT CORP
44 SOUTH WASHINGTON STREET
NEW BREMEN, OH 45869 USA

EUT DESCRIPTION: RF ID Reader

MODEL: HD5000

SERIAL NUMBER: 20170109-001

DATE TESTED: 2017-03-09 - 2017-03-10

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Pass
INDUSTRY CANADA RSS-247 Issue 2	Pass
INDUSTRY 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:

Richard Jankovics
WiSE Engineer
UL – Consumer Technology Division

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 15, ANSI C63.10-2013, RSS-GEN Issue 4, RSS-247 Issue 2.

4. 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

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/.

5. CALIBRATION AND UNCERTAINTY

5.1. 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.

5.2. 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

5.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	UNCERTAINTY
All emissions, radiated up to 10 GHz	± 5.36 dB

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

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is an RF ID reader with two radios and two antennas. Simultaneous operation is possible when both radios happen to hop to the same channels. It is used to read tags built into warehouse aisles to allow for automation in steering warehouse forklift trucks.

The radio module is manufactured by Crown Equipment.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power * (dBm)	Output Power (mW)
902 - 928 Ant1	DSB	26.16	413.05
902 - 928 Ant2	DSB	27.50	562.34

* Per report 10766018A

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes two patch antennas. Each antenna has maximum gain of 5.0 dBi.

6.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was 156190-900-03.

The EUT driver software installed in the host support equipment during testing was Indy_Mac_Firmware_2.6.0.

The test utility software used during testing was RFID_PC_4.3.0.0.

The software power setting was at 251.

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT in normal use will be installed in single orientation with antennas pointing down. Radiated emissions measurements were conducted in simulated setup – see photos.

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List			
Description	**Manufacturer**	**Model**	**Serial Number**
PCAN USB Adapter	PEAK-System Technik	IPEH-002022	79233
DC Regulated Power Supply	Circuit Specialists	CSI3005X5	NA
Laptop	Dell	E5430	211641
Power Adapter	Dell	LA90PS1-00	CN-0DF315-71615-95G-0DD1

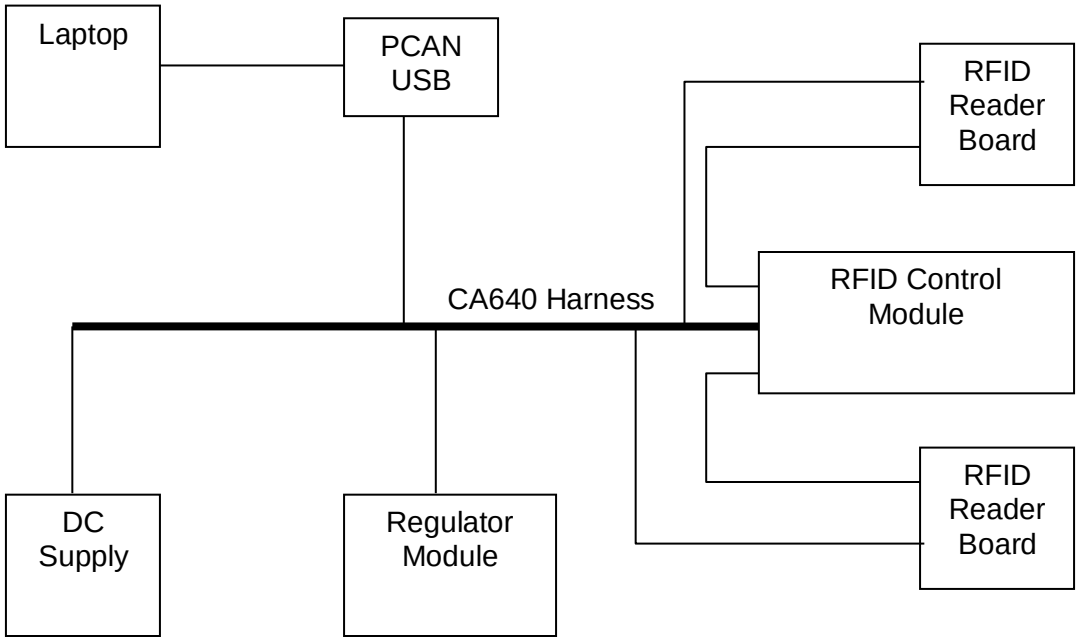
I/O CABLES

I/O Cable List						
Cable No	**Port**	**# of identical ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	CA640 port	1	custom	stranded	4.6	Wiring Harness to power supply, RFID Reader Boards, Regulator Module, CAN bus
2	CA641/CA642	2	custom	stranded	0.2	To Antenna Interface of RFID Reader Board
4	Antenna Interface	2	SMA	50 Ω coax	0.6	To CA641 or CA642 of RFID Control Module
5	JC611/JC616	2	custom	stranded	0.3 / 0.6	To CA640 port of RFID Control Module

TEST SETUP

The EUT connected to a computer via the CAN to USB to a laptop computer. The laptop computer is running software exercising the radio.

SETUP DIAGRAM FOR TESTS



7. 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.
	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	2017-03-31
	Tuned Dipole Set				
AT0013-AT0016	Four Dipole Antenna Set, 30 to 1000 MHz	EMCO	3121C-DB-1, -2, -3, -4	2016-06-14	2017-06-30
	Gain-Loss Chains				
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
	Receiver & Software				
SA0026	Spectrum Analyzer	Agilent	N9030A	2017-02-17	2018-07-28
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA

8. RADIATED TEST RESULTS

8.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209

IC RSS-GEN Clause 8.9 (Transmitter)

IC RSS-GEN Clause 7.1.2 (Receiver)

§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:

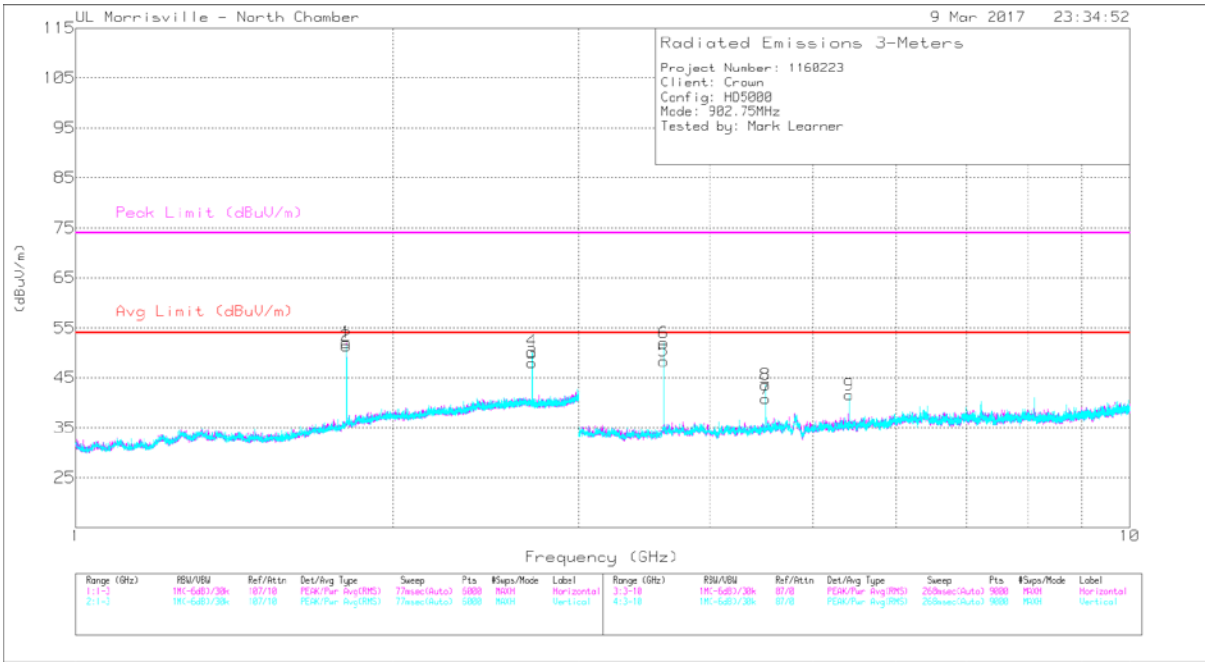
Limits for radiated disturbance of an intentional radiator		
Frequency range (MHz)	Limits (µV/m)	Measurement Distance (m)
0.009 – 0.490	2400 / F (kHz)	300
0.490 – 1.705	24000 / F (kHz)	30
1.705 – 30.0	30	30
30 – 88	100**	3
88 - 216	150**	3
216 – 960	200**	3
Above 960	500	3

** 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. §§ 15.231 and 15.241.
§15.209 (b) In the emission table above, the tighter limit applies at the band edges.

Formula for converting the filed strength from uV/m to dBuV/m is:
Limit (dBuV/m) = 20 log limit (uV/m)

8.2. RADIATED EMISSIONS ABOVE 1 GHz

Low Channel



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	HPF (dB)	DCCF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	* 2.708	42.9	Pk	32.3	-24	0.5	0	51.7	-	-	74	-22.3	262	107	H
	* 2.708	42.9	Av	32.3	-24	0.5	-8.4	43.3	54	-10.7	-	-	262	107	H
4	* 2.708	47.72	Pk	32.3	-24	0.5	0	56.52	-	-	74	-17.48	149	238	V
	* 2.708	47.72	Av	32.3	-24	0.5	-8.4	48.12	54	-5.88	-	-	149	238	V
5	* 3.611	51.86	Pk	32.9	-31.7	0.3	0	53.36	-	-	74	-20.64	126	113	H
	* 3.611	51.86	Av	32.9	-31.7	0.3	-8.4	44.96	54	-9.04	-	-	126	113	H
7	* 4.514	47.54	Pk	33.9	-32.1	0.4	0	49.74	-	-	74	-24.26	171	254	H
	* 4.514	47.54	Av	33.9	-32.1	0.4	-8.4	41.34	54	-12.66	-	-	171	254	H
6	* 3.611	54.84	Pk	32.9	-31.7	0.3	0	56.34	-	-	74	-17.66	279	259	V
	* 3.611	54.84	Av	32.9	-31.7	0.3	-8.4	47.94	54	-6.06	-	-	279	259	V
8	* 4.514	46.69	Pk	33.9	-32.1	0.4	0	48.89	-	-	74	-25.11	178	102	V
	* 4.514	46.69	Av	33.9	-32.1	0.4	-8.4	40.49	54	-13.51	-	-	178	102	V
9	* 5.416	42.41	Pk	34.5	-31.2	0.4	0	46.11	-	-	74	-27.89	181	135	V
	* 5.416	42.41	Av	34.5	-31.2	0.4	-8.4	37.71	54	-16.29	-	-	181	135	V
1	1.805	45.64	Pk	30.3	-24.4	0.5	0	52.04	-	-	-	-	0-360	102	H
2	1.805	44.94	Pk	30.3	-24.4	0.5	0	51.34	-	-	-	-	0-360	199	V

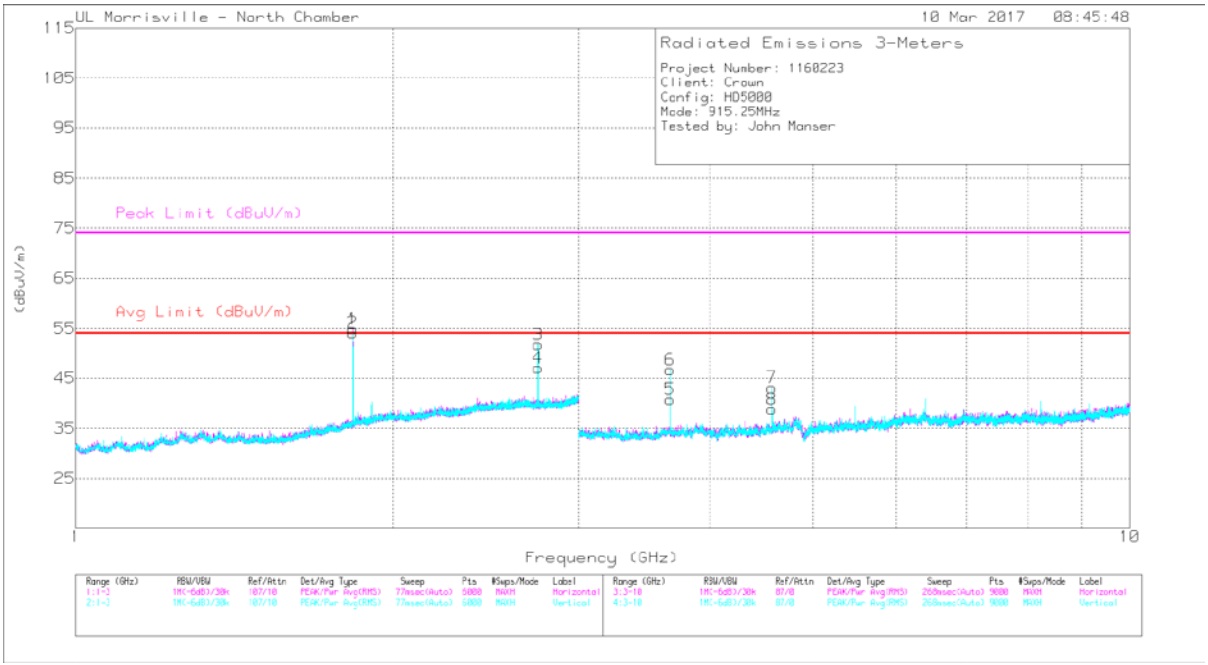
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

Av – Average value computed per FCC 15.35(c) based on dwell time measured in section 7.5 of UL report 10766018A, dated 10/09/2015. The average value is computed as follows:

Av = Pk + 20*log(dwell-time/100ms) = Pk + 20*log(37.98ms/100ms) = Pk - 8.4dB

Middle Channel



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	HPF (dB)	DCCF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	* 2.746	41.8	Pk	32.1	-23.9	0.6	0	50.6	-	-	74	-23.4	256	113	H
	* 2.746	41.8	Av	32.1	-23.9	0.6	-8.4	42.2	54	-11.8	-	-	256	113	H
3	* 2.746	46.26	Pk	32.1	-23.9	0.6	0	55.06	-	-	74	-18.94	134	148	V
	* 2.746	46.26	Av	32.1	-23.9	0.6	-8.4	46.66	54	-7.34	-	-	134	148	V
5	* 3.661	45.14	Pk	33.1	-31.7	0.4	0	46.94	-	-	74	-27.06	205	115	H
	* 3.661	45.14	Av	33.1	-31.7	0.4	-8.4	38.54	54	-15.46	-	-	205	115	H
8	* 4.576	44.66	Pk	34	-32.4	0.4	0	46.66	-	-	74	-27.34	160	312	H
	* 4.576	44.66	Av	34	-32.4	0.4	-8.4	38.26	54	-15.74	-	-	160	312	H
6	* 3.661	49.07	Pk	33.1	-31.7	0.4	0	50.87	-	-	74	-23.13	154	235	V
	* 3.661	49.07	Av	33.1	-31.7	0.4	-8.4	42.47	54	-11.53	-	-	154	235	V
7	* 4.576	45.71	Pk	34	-32.4	0.4	0	47.71	-	-	74	-26.29	176	106	V
	* 4.576	45.71	Av	34	-32.4	0.4	-8.4	39.31	54	-14.69	-	-	176	106	V
1	1.83	48.25	Pk	30.6	-24.5	0.5		54.85	-	-	-	-	0-360	102	H
2	1.83	47.46	Pk	30.6	-24.5	0.5		54.06	-	-	-	-	0-360	199	V

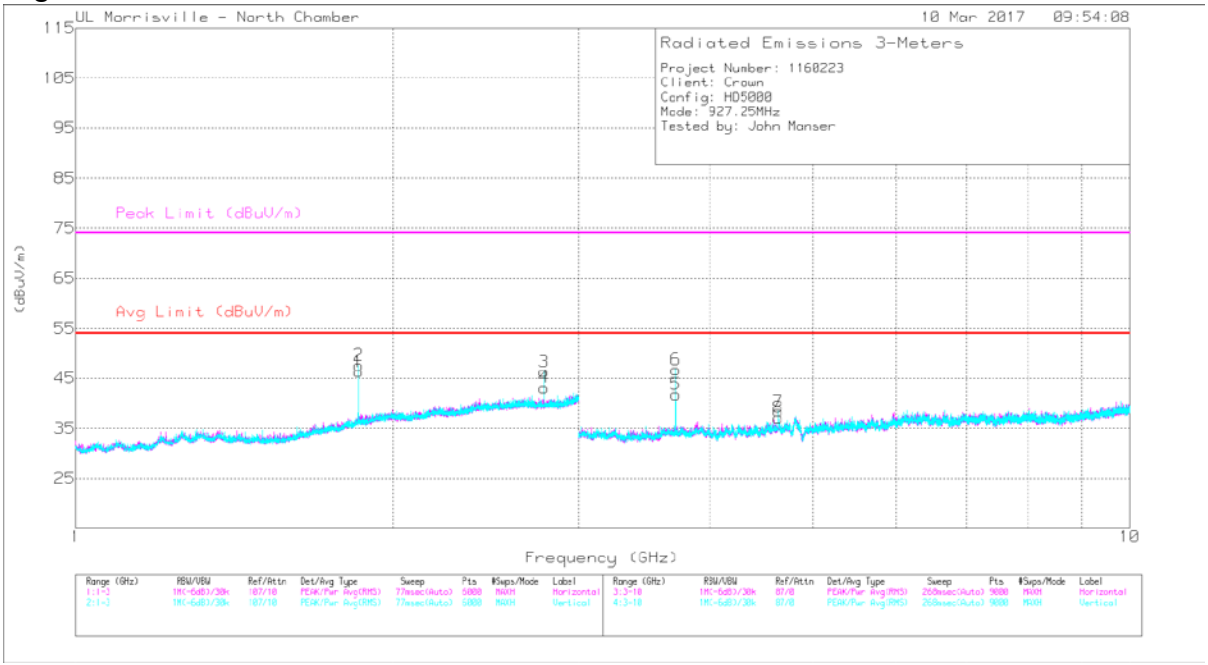
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

Av – Average value computed per FCC 15.35(c) based on dwell time measured in section 7.5 of UL report 10766018A, dated 10/09/2015. The average value is computed as follows:

Av = Pk + 20*log(dwell-time/100ms) = Pk + 20*log(37.98ms/100ms) = Pk - 8.4dB

High Channel



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF AT0072 (dB/m)	Amp/Cbl/ Fltr/Pad (dB)	HPF (dB)	DCCF (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	* 2.782	39.31	Pk	32.1	-23.9	0.6	0	48.11	-	-	74	-25.89	262	104	H
	* 2.782	39.31	Av	32.1	-23.9	0.6	-8.4	39.71	54	-14.29	-	-	262	104	H
3	* 2.782	42.54	Pk	32.1	-23.9	0.6	0	51.34	-	-	74	-22.66	127	110	V
	* 2.782	42.54	Av	32.1	-23.9	0.6	-8.4	42.94	54	-11.06	-	-	127	110	V
5	* 3.709	45.52	Pk	33.3	-32.4	0.4	0	46.82	-	-	74	-27.18	199	398	H
	* 3.709	45.52	Av	33.3	-32.4	0.4	-8.4	38.42	54	-15.58	-	-	199	398	H
8	* 4.636	42.88	Pk	34.1	-32.8	0.4	0	44.58	-	-	74	-29.42	175	258	H
	* 4.636	42.88	Av	34.1	-32.8	0.4	-8.4	36.18	54	-17.82	-	-	175	258	H
6	* 3.709	48.16	Pk	33.3	-32.4	0.4	0	49.46	-	-	74	-24.54	153	262	V
	* 3.709	48.16	Av	33.3	-32.4	0.4	-8.4	41.06	54	-12.94	-	-	153	262	V
7	* 4.636	42.25	Pk	34.1	-32.8	0.4	0	43.95	-	-	74	-30.05	171	106	V
	* 4.636	42.25	Av	34.1	-32.8	0.4	-8.4	35.55	54	-18.45	-	-	171	106	V
1	1.854	39.31	Pk	30.9	-24.4	0.5		46.31	-	-	-	-	0-360	199	H
2	1.854	40.63	Pk	30.9	-24.4	0.5		47.63	-	-	-	-	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

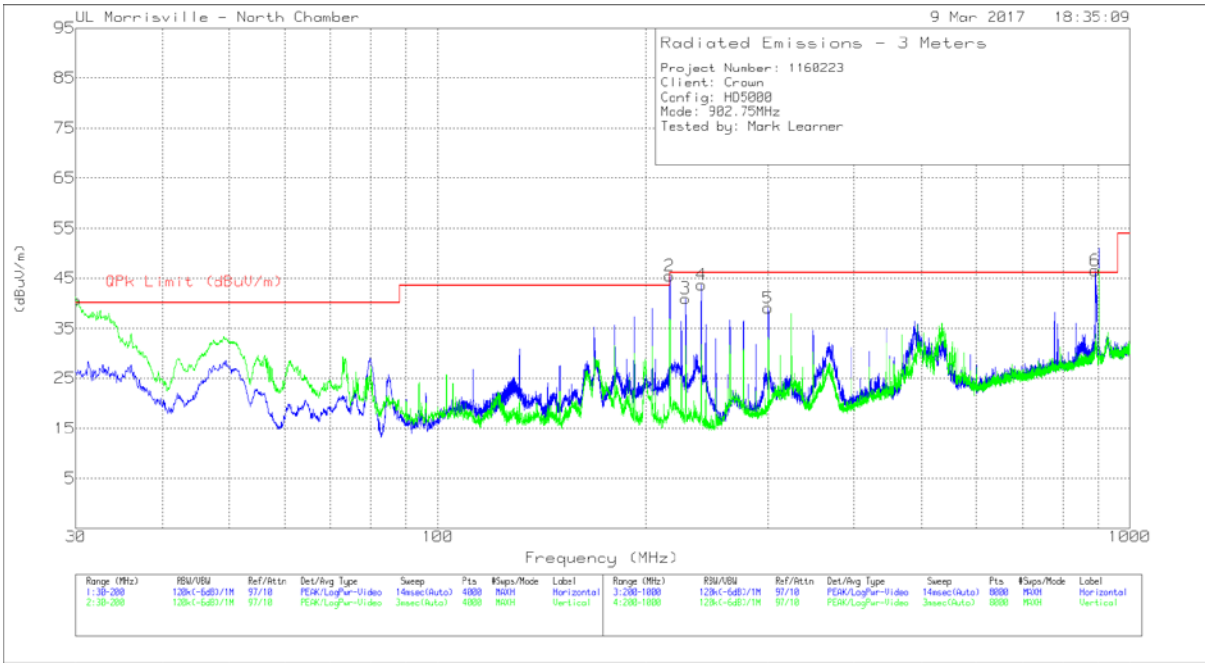
Pk - Peak detector

Av – Average value computed per FCC 15.35(c) based on dwell time measured in section 7.5 of UL report 10766018A, dated 10/09/2015. The average value is computed as follows:

Av = Pk + 20*log(dwell-time/100ms) = Pk + 20*log(37.98ms/100ms) = Pk - 8.4dB

8.3. RADIATED EMISSIONS BELOW 1 GHz

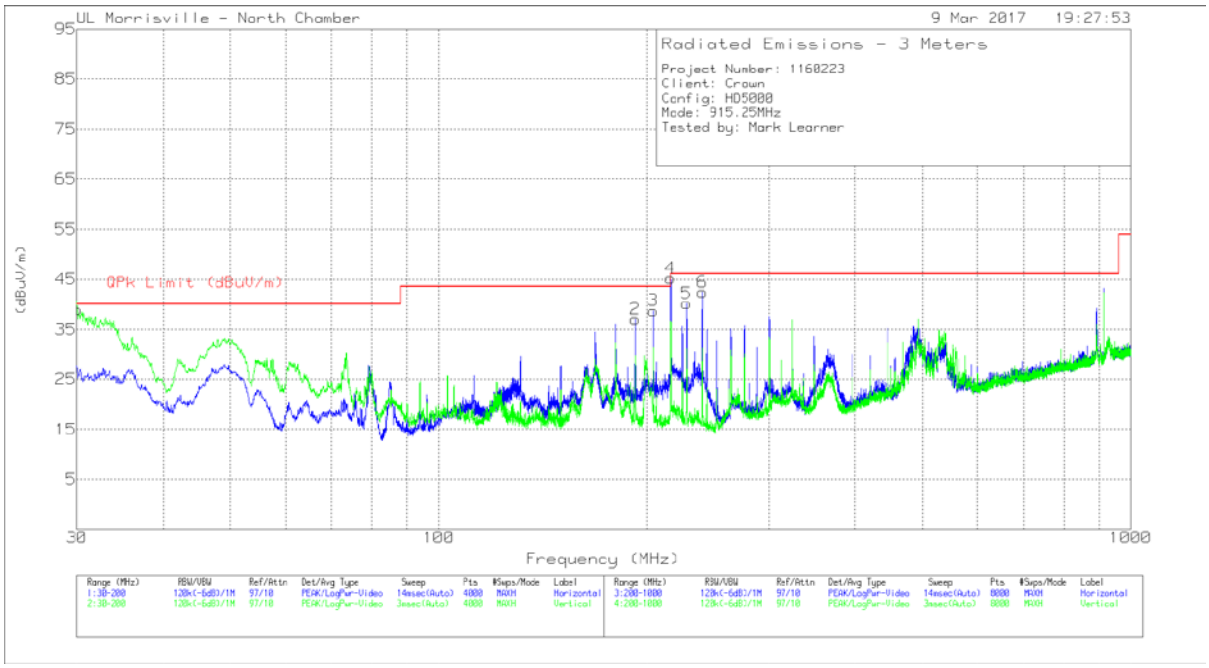
SPURIOUS EMISSIONS 30 TO 1000 MHz Low Channel



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 AF (dB/m)	Amp/Cbl (dB)	BRF902-928MHz	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	* 240.2641	55.93	Qp	16.2	-29.8	.3	42.63	46.02	-3.39	153	115	H
1	33.4063	43.37	Qp	23.5	-31.7	.1	35.27	40	-4.73	41	103	V
2	216.2338	60.1	Qp	15.3	-30	.3	45.7	46.02	-.32	271	157	H
3	228.2521	53.82	Qp	15.7	-29.9	.3	39.92	46.02	-6.1	81	160	H
5	300.313	50.16	Pk	18	-29.4	.3	39.06	46.02	-6.96	0-360	102	H
6	891.7741	32.22	Qp	26.6	-26.5	2.5	34.82	46.02	-11.2	255	102	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Pk - Peak detector
Qp - Quasi-Peak detector

SPURIOUS EMISSIONS 30 TO 1000 MHz Middle Channel



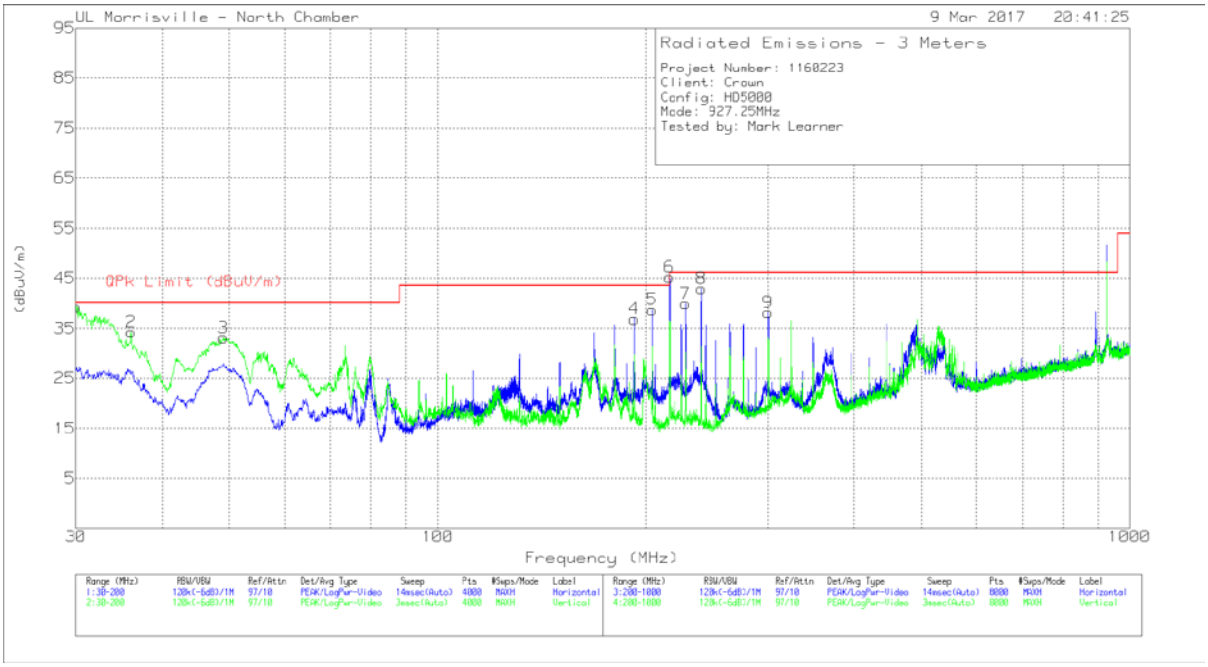
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 AF (dB/m)	Amp/Cbl (dB)	BRF902-928MHz	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
6	* 240.2568	55.75	Qp	16.2	-29.8	.3	42.45	46.02	-3.57	159	127	H
1	32.6726	42.19	Qp	24	-31.7	.1	34.59	40	-5.41	18	103	V
2	192.222	50.54	Pk	16.3	-30.1	.3	37.04	43.52	-6.48	0-360	102	H
3	204.2283	52.25	Qp	16	-30.1	.3	38.45	43.52	-5.07	280	128	H
4	216.2367	59.73	Qp	15.3	-30	.3	45.33	46.02	-.69	283	132	H
5	228.2567	53.5	Qp	15.7	-29.9	.3	39.6	46.02	-6.42	88	153	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detector

Qp - Quasi-Peak detector

SPURIOUS EMISSIONS 30 TO 1000 MHz High Channel

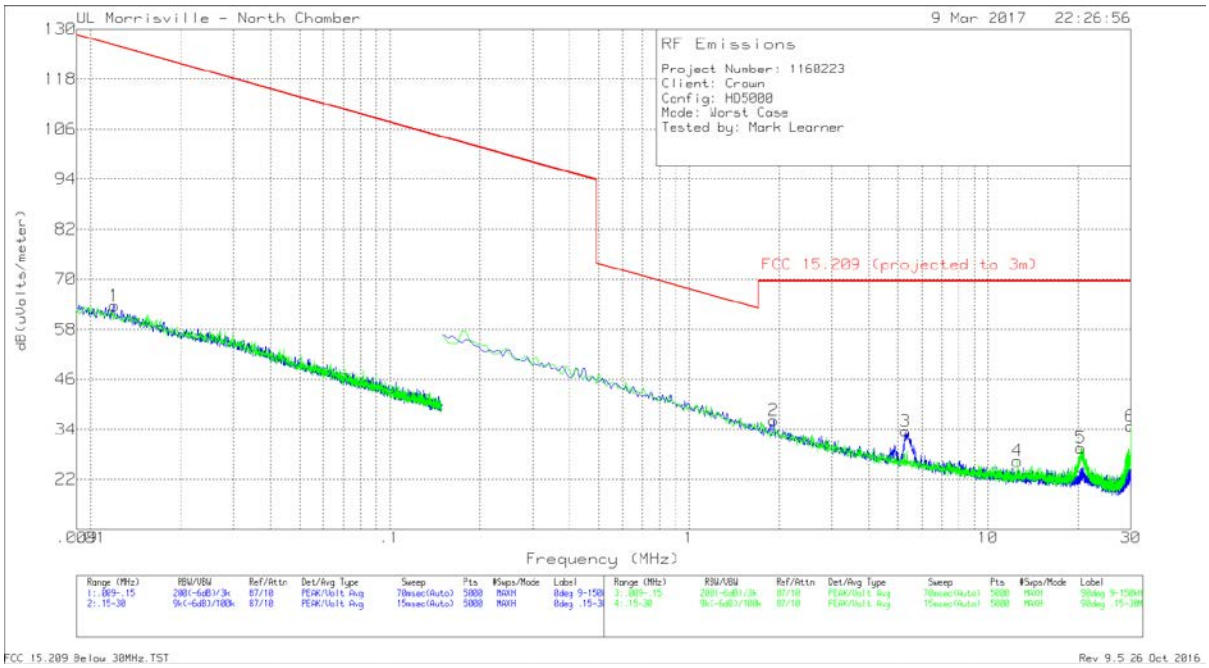


Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0073 AF (dB/m)	Amp/Cbl (dB)	BRF902-928MHz	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
8	* 240.2666	56.17	Qp	16.2	-29.8	.3	42.87	46.02	-3.15	147	130	H
1	33.145	42.33	Qp	23.7	-31.7	.1	34.43	40	-5.57	68	104	V
2	36.0406	40.11	Qp	21.5	-31.7	.1	30.01	40	-9.99	96	106	V
3	49.0024	51.48	Pk	13	-31.5	.1	33.08	40	-6.92	0-360	102	V
4	192.1795	50.34	Pk	16.3	-30.1	.3	36.84	43.52	-6.68	0-360	102	H
5	204.2283	52.3	Qp	16	-30.1	.3	38.5	43.52	-5.02	277	140	H
6	216.2422	59.87	Qp	15.3	-30	.3	45.47	46.02	-.55	280	137	H
7	228.2037	53.77	Pk	15.7	-29.9	.3	39.87	46.02	-6.15	0-360	102	H
9	300.313	49.26	Pk	18	-29.4	.3	38.16	46.02	-7.86	0-360	102	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

Pk - Peak detectorQp - Quasi-Peak detector

SPURIOUS EMISSIONS 0.009 to 30 MHz Worst-Case



Trace Markers

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)	Polarity
1	.012	46.14	Pk	17.4	.1	63.64	126.02	-62.38	0-360	Face On
2	1.9204	24.91	Pk	11	.2	36.11	69.54	-33.43	0-360	Face On
3	5.28805	22.18	Pk	11	.4	33.58	69.54	-35.96	0-360	Face On
4	12.53385	15.43	Pk	10.4	.6	26.43	69.54	-43.11	0-360	Face Off
5	20.42155	18.87	Pk	9.9	.8	29.57	69.54	-39.97	0-360	Face Off
6	30	25.86	Pk	8	.9	34.76	69.54	-34.78	0-360	Face Off

Pk - Peak detector

NOTE: Although these tests were performed at a test site other than an open area test site, adequate comparison measurements were confirmed against 30 m 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 414788.