

TEST REPORT

Report Number: 102448906LEX-001.1

Project Number: G102448906

Report Issue Date: 1/16/2016

Product Name: On-Board Validator

Model Number: 50T0177

Standards: Title 47 CFR Part 15 Subpart C

Radios Under Test: Near Field Communication (NFC)

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Drive
Lexington, KY 40510

Client:
Trapeze Software Group, Inc
5265 Rockwell Dr NE
Cedar Rapids, IA 52402-2014

Report prepared by



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1 Introduction and Conclusion

The tests indicated in section 2 were performed on the product constructed as described in section 3. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test method, a list of the actual test equipment used, documentation photos, results and raw data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested complied with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

The INTERTEK-Lexington is located at 731 Enterprise Drive, Lexington Kentucky, 40510. The radiated emission test site is a 10-meter semi-anechoic chamber. The chamber meets the characteristics of CISPR 16-1 and ANSI C63.4. For measurements, a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters. The test site is listed with the FCC under registration number 485103. The test site is listed with Industry Canada under site number IC 2042M-1.

2 Test Summary

Page	Test Name	FCC Reference	IC Reference	Result
6	20dB Bandwidth	§ 2.1049	RSS-GEN (4.6.1)	Pass
7	In-Band Radiated Spurious Emissions (Transmitter)	§ 15.225(a)(b)(c)	RSS-210 (A2.6)	Pass
9	Out of Band Radiated Spurious Emissions (Transmitter)	§ 15.225(d), § 15.209	RSS-210 (A2.6)	Pass
10	AC Powerline Conducted Emissions	§ 15.107, § 15.207	RSS-Gen (7.2.4)	N/A ¹
11	This test is not applicable since the EUT will be installed in a vehicle. Frequency Stability	§ 15.225(e)	RSS-210 (A2.6)	Pass
13	Antenna Requirement per FCC Part 15.203	§ 15.203	RSS-Gen (7.1.2)	Pass

¹ This test is not applicable since the EUT will be installed in a vehicle

3 Description of Equipment Under Test

Equipment Under Test	
Manufacturer	Trapeze Software Group, Inc
Model Number	50T0177
Serial Number	Sample 1
Receive Date	1/25/2016
Test Start Date	1/26/2016
Test End Date	2/3/2016
Device Received Condition	Good
Test Sample Type	Production
Frequency Band	13.56MHz
Mode(s) of Operation	NFC
Transmission Control	Normal Operation
Antenna Type (15.203)	Internal
Power Supply	115VAC/60Hz (Via AC / DC Power Adapter)

Description of Equipment Under Test

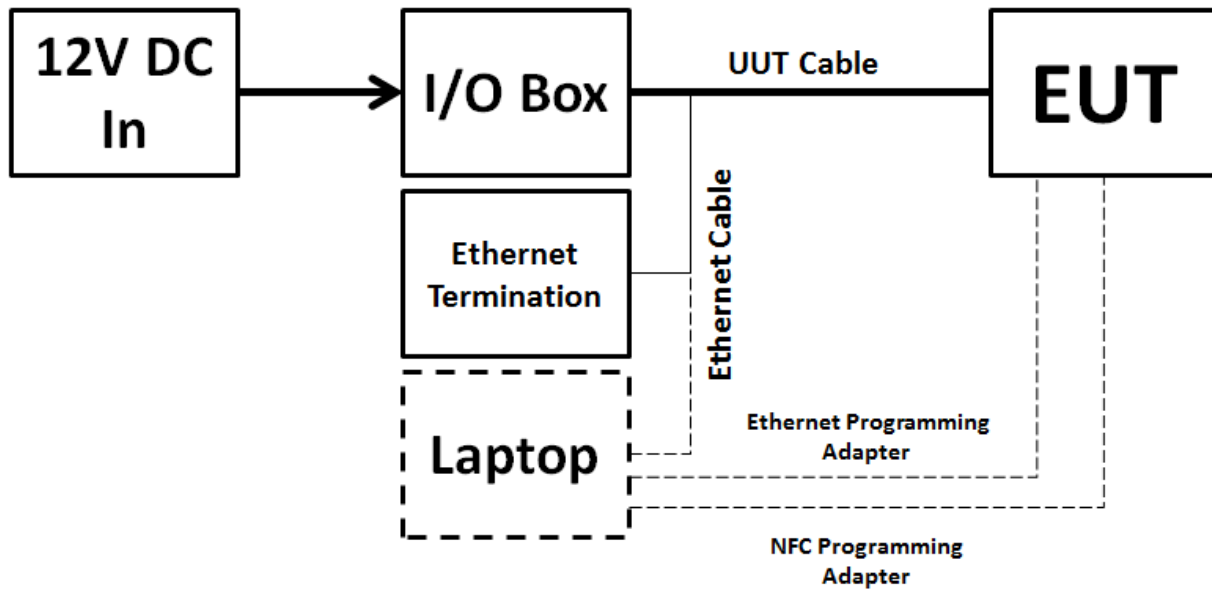
The On-Board Validator is used a mass transit vehicles to collect fares either by scanning 1-D or 2-D barcodes, or reading Smartcards.

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Transmitting NFC signal at 13.56MHz
2	Receive / idle mode

3.1 System setup including cable interconnection details, support equipment and simplified block diagram

3.2 EUT Block Diagram:



3.3 Cables:

Cables					
Description	Length	Shielding	Ferrites	Connection	
				From	To
UUT Cable	4ft	No	No	EUT (UUT Cable Port)	I/O Box (Multiple)
Ethernet Programming Adapter	8ft	No	No	EUT (Exposed Header)	Laptop (USB)
Ethernet Cable	8ft	No	No	EUT (UUT Cable Port)	Laptop (Ethernet) / Ethernet Termination
NFC Programming Adapter	4ft	No	No	EUT (NFC Module)	Laptop (USB)

3.4 Support Equipment:

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
I/O Box	Trapeze Group	N/A	N/A
Ethernet Termination	Trapeze Group	N/A	N/A
Laptop	HP	EliteBook 8440p	CND046136B

4 20dB Bandwidth

4.1 Test Limits

None

4.2 Test Procedure

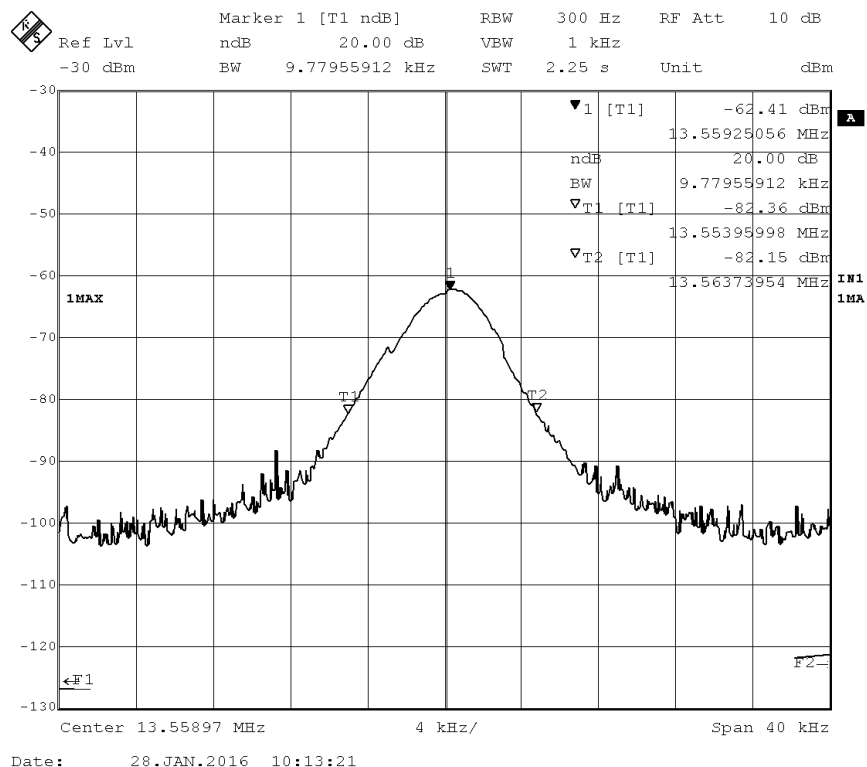
The 20dB bandwidth was measured by a spectrum analyzer connected to a receive antenna placed near the test sample while it is transmitting. The "N dB Down" function of the analyzer was used to mark the bandwidth.

4.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	9/20/2015	9/20/2016

4.4 Results:

The 20dB bandwidth was measured to be 9.780MHz as shown in the plot below.



5 In-Band Radiated Spurious Emissions (Transmitter)

5.1 Test Limits

§ 15.225 Operation within the band 13.110-14.010 MHz.

- (a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.
- (b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.
- (c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

5.2 Test Procedure

ANSI C63.10: 2014

5.3 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:

$$FS = RA + AF + CF$$

FS = Field Strength in dB μ V/m

RA = Receiver Amplitude in dB μ V

AF = Antenna Factor in dB

CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

RA = 19.48 dB μ V

AF = 18.52 dB

CF = 0.78 dB

$$FS = 19.48 + 18.52 + 0.78 = 38.78 \text{ dB}\mu\text{V/m}$$

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(38.78 \text{ dB}\mu\text{V/m})/20] = 86.89 \mu\text{V/m}$$

5.4 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	1302.6005.40	Rohde & Schwarz	ESU40	9/19/2015	9/19/2016
Active Loop Antenna	3416	ETS	6502	4/28/2015	4/28/2016
System Controller	121701-1	Sunol Sciences	SC99V	Calibration Not Required	Calibration Not Required

5.5 Results:

The spurious emissions listed in the following tables are the worst case emissions. Emissions not reported were at or below the measurement noise floor.

Worst Case Spurious Emissions (NFC Radio Transmitting)

Frequency (MHz)	QP @ 3m (dBμV/m)	Limit @ 3m (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
13.558888	21.77	124.0	102.23	9	96	-28.3
13.558929	6.05	124.0	117.95	9	0	-28.3
13.558942	5.96	124.0	118.04	9	0	-28.3
13.758976	-25.24	80.5	105.74	9	0	-28.3

Notes:

- (1) The test sample was evaluated on three orthogonal axes since the device could be used in any orientation.
- (2) All measurements were performed with a loop antenna positioned in three orthogonal axis with the level at the highest position being recorded.
- (3) Measurements were performed at 3m distance and the level extrapolated to the specified measurement distance of 30m. An inverse linear distance extrapolation factor of 40dB/decade (from part 15.31(f)) was used to facilitate this. Extrapolation Factor = $20\log(30/3)^2 = 40\text{dB}$.

6 Out of Band Radiated Spurious Emissions (Transmitter)

6.1 Test Limits

6.2 § 15.225 Operation within the band 13.110-14.010 MHz.

- (d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

Part 15.209(a): Field General Strength Limits for Restricted Bands of Operation

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / 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

6.3 Test Procedure

ANSI C63.4: 2014

6.4 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:

$$FS = RA + AF + CF$$

FS = Field Strength in dB μ V/m

RA = Receiver Amplitude in dB μ V

AF = Antenna Factor in dB

CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

$$RA = 19.48 \text{ dB}\mu\text{V}$$

$$AF = 18.52 \text{ dB}$$

$$CF = 0.78 \text{ dB}$$

$$FS = 19.48 + 18.52 + 0.78 = 38.78 \text{ dB}\mu\text{V/m}$$

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(38.78 \text{ dB}\mu\text{V/m})/20] = 86.89 \mu\text{V/m}$$

6.5 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	9/20/2015	9/20/2016
Preamplifier	SF456200904	Mini-Circuits	ZX60-3018G-S+	11/19/2015	11/19/2016
Bilog Antenna	145	AH Systems	SAS-521-4	3/4/2015	3/4/2017
Active Loop Antenna	3416	ETS	6502	4/28/2015	4/28/2016
System Controller	121701-1	Sunol Sciences	SC99V	Time of Use	Time of Use

6.6 Results:

All out of band emissions were below the general limits from Part 15.209. The sample was tested from 9kHz – 1GHz excluding the in band 13.110 – 14.010 MHz range. The spurious emissions listed in the following tables are the worst case emissions.

Worst Case Out of Band Spurious Emissions (NFC Radio Transmitting)

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
55.814000	32.55	49.5	16.95	120.000	109.4	V	27.0	8.8
62.782000	37.94	49.5	11.56	120.000	111.9	V	292.0	8.3
62.946000	36.58	49.5	12.92	120.000	114.9	V	285.0	8.3
74.576000	42.53	49.5	6.97	120.000	100.4	V	283.0	9.3
98.491000	36.44	54.0	17.56	120.000	110.0	V	283.0	15.0
108.500000	32.80	54.0	21.20	120.000	100.3	V	155.0	16.5
122.020000	34.37	54.0	19.63	120.000	109.3	V	72.0	18.6
135.580000	40.49	54.0	13.51	120.000	100.5	V	135.0	19.4

Notes:

- (1) The test sample was evaluated on three orthogonal axes since it was a hand held device and could be used in any orientation.
- (2) All measurements below 30MHz were performed with a loop antenna positioned in three orthogonal axis with the level at the highest position being recorded.
- (3) All measurements above 30MHz were performed with a bilog antenna maximized from 1-4m in height and in vertical and horizontal polarities.
- (4) Measurements were performed at 3m distance.

7 AC Powerline Conducted Emissions

7.1 Test Limits

§ 15.107(e): Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	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.

7.2 Test Procedure

ANSI C63.4: 2009

7.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESi26	9/20/2015	9/20/2016
LISN	110WT50202	PMM	L3-100	12/18/2015	12/18/2016

7.4 Results:

This test is not applicable since the EUT will be installed in a vehicle.

8 Frequency Stability

8.1 Test Limits

8.2 § 15.225 Operation within the band 13.110-14.010 MHz.

- (e) The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to $+50$ degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.3 Results:

The data below shows that the test sample meets the frequency stability requirements from Part 15.225.

Frequency Stability Test Data

Operating Frequency:		13,560,000 Hz			
Channel:		NFC Radio (Single Channel)			
Reference Voltage:		115 VAC			
Deviation Limit (+/-):		0.01 % =		1356 Hz	
Notes:					
Voltage (%)	Voltage (VAC)	Temp (°C)	Frequency (Hz)	Deviation (Hz)	Deviation (%)
100%	115	-30	13558964	-1036	-0.007640
100%	115	-20	13559007	-993	-0.007323
100%	115	-10	13559022	-978	-0.007212
100%	115	0	13559017	-983	-0.007249
100%	115	10	13559001	-999	-0.007367
100%	115	20	13558984	-1016	-0.007493
100%	115	30	13558956	-1044	-0.007699
100%	115	40	13558954	-1046	-0.007714
100%	115	50	13558959	-1041	-0.007677
100%	115	60	13558955	-1045	-0.007706
115%	132.25	20	13558964	-1036	-0.007640
85%	97.75	20	13558963	-1037	-0.007647

9 Antenna Requirement per FCC Part 15.203

9.1 Test Limits

§ 15.203: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

9.2 Results:

The sample tested met the antenna requirement. The antenna utilized a U.fl connector for connection to the PCB antenna.

10 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements.

The measurement uncertainty figures were calculated and correspond to a coverage factor of $k = 2$, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Measurement uncertainty Table

Parameter	Uncertainty	Notes
Radiated emissions, 30 to 1000 MHz	+3.9dB	
Radiated emissions, 1 to 18 GHz	+4.2dB	
Radiated emissions, 18 to 40 GHz	+4.3dB	
Power Port Conducted emissions, 150kHz to 30 MHz	±2.8dB	

11 Revision History

Revision Level	Date	Report Number	Notes
0	2/4/2016	102448906LEX-001	Original Issue
1	1/16/2016	102448906LEX-001.1	Fixed in-band spurious emission limit and margin calculation