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Cubic Transportation Systems Ltd.
TEST REPORT

SCOPE OF WORK
EMC TESTING – VALIDATOR 2

REPORT NUMBER
103679095LEX-003.1

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2/8/2019	9/8/2019

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DOCUMENT CONTROL NUMBER
Non-Specific EMC Report Shell Rev. December 2017

EMC TEST REPORT

(FULL COMPLIANCE)

Report Number: 103679095LEX-003.1
Project Number: G103679095

Report Issue Date: 9/8/2019

Model(s) Tested: 5300-08066

FCC Standards: Title 47 CFR Part 22, 24, and 27

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

Client:
Cubic Transportation Systems Ltd.
AFC House,
Honeycrock Lane,
Salfords,
Redhill,
RH1 6LA, UK

Report prepared by

Brian Lackey, Project Engineer

Report reviewed by

Bryan Taylor, Team Leader

Table of Contents

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. 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 **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
6	Radiated Spurious Emissions (ANSI C63.26: 2014)	Compliant

Results for the remainder of the tests can be found in the module certification reports for the SARA-R410M.

3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	Cubic Transportation Systems Ltd.
Address:	AFC House, Honeycrock Lane, Salfords, Redhill, RH1 6LA, UK
Contact:	Robert Johnson
Telephone:	+44 1737 786556
Email:	Robert.johnson@cubic.com
Manufacturer Information	
Manufacturer Name:	Cubic Transportation Systems Inc.
Manufacturer Address:	1308 South Washington Street, Tullahoma, TN 37388 USA

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	Validator 2
Model Number	5300-08066
Serial Number	PROT2040
Receive Date	12/4/2018
Test Start Date	12/6/2018
Test End Date	12/20/2018
Device Received Condition	Good
Test Sample Type	Production
Input Rating	24Vdc via AC-DC adapter, 100V-240V, 0.8A, 50/60Hz
Number of Phases	1
Software Used By EUT	V1.12.1
Frequency Band(s)	LTE bands 2, 4, 5, 13, 17
Description of Equipment Under Test (provided by client)	
The Validator 2 is intended to be used as a revenue collection device for transit operators. It is typically installed on buses or transit stations and used to “tag on” and “tag off” Contactless Smart Cards or Barcodes carried by passengers intending to pay for their journey.	

4.1 Variant Models:

The original samples tested were updated by Cubic Transportation Systems Ltd. The changes to the unit were as follows:

- *The Validator 2 will not have the 4G antenna board (5300-57014) fitted anymore, so cables 5300-06049-3 and 5300-06049-4 will also be omitted*
- *5300-57012 Rev. C [Barcode Illumination and Proximity PCB ASSEMBLY] – Copper on both layers was pulled back from the stud holes to give greater electrical clearance. Parts that were no-fit parts in previous revision were completely removed in copper in this revision.*
- *5300-57015 Rev. E [NFC and User LED PCB Assembly] – Minor capacitor and resistor changes for EMV CO. compliance testing. (180pF ->160pF | 2x0.05 Ohm -> 1x 0.75Ohm and 1x 0.1 Ohm)*
- *53000-57011 Rev. E [PZ Personality Module PCB Assembly]*
    - *2 copper layers / planes added to the board stack to give better GND return paths to traces/signals on the board.*
    - *Additional ground stitching added throughout the board (particularly all around the outer edges) to improve ground return paths of signals (attempt to reduce on board noise).*
    - *Silkscreen and ResDef changes around the WiFi module (previously a low pass filter was created (and tested) to remove the 5GHz spur by fitting components to no-fit resistors pads, now LPF is placed properly in designated footprints)*
    - *4G modem (U5) removed as 4G connectivity not required*
    - *WiFi and 4G modem modules are now on islands i.e. moats created around the modules on the PCB with narrow bridges allowing the comms signals to modules to reduce noise interacting with the modules*
    - *Battery Fuel Gauge (U54 - BQ27Z561YPHR) added to monitor the battery voltage*
    - *Switcher components around U33 - TPS61088RHLR switcher adjusted for more efficient operation. Switching coil reduced from 4.8uH to 1.5uH*
    - *Series resistance (6.8k) added to GPS UART line to reduce conducted noise from the board to the off-board GPS module, common mode choke added to the GND connected to the GPS module connector*
    - *Current inrush limiting circuitry added (N-MOSFET limiter) to POE voltage input*
    - *Battery switchover circuitry modified to allow the device to operate/switchover at lower voltages, approx. 8V. Leaky ORing IC replaced with MOSFET switches which have much lower leakage*
    - *Second speaker connection added (only one speaker is still fitted to the Validator 2)*
    - *PCB clearances of power traces increased to meet Low Voltage Directive requirements*

These modified units are considered to also be covered by the test results presented in this report.

4.2 EUT Photo (Front):

4.3 EUT Photo (Back):

5 Radiated Spurious Emissions

5.1 Method

Tests are performed in accordance with ANSI C63.26: 2015

TEST SITE: 10m ALSE

Site Designation: 10m Chamber

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	3.9dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.0dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.7dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required.

5.2 Limit Line Calculation

As described in FCC parts 22.359, 24.238, and 27.53, the power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log (P) dB.

Since the FCC defines P as the total power in watts, the limit can be defined by the following

Unwanted Emissions Power (dBW) < 10 log(P) – [43 + 10 log(P)]

The first 10 log(P) expression is the fundamental power in dBW, and the second is from the FCC reference. The limit then simplifies to the following

Unwanted Emissions Power (dBW) < 10 log(P) – 43 – 10 log(P)

After cancelling the 10 log(P) factors, the limit is just -43dBW, or -13dBm.

From there, ANSI C63.26 Clause 5 describes a method for converting field strength to field power based on the test distance. The formula they use is to add 20 log(D) – 104.8, where D is the distance between the device and the measurement antenna. So, converting the -13dBm limit to dBμV/m for a 3 meter test distance is as follows

-13 – [20 log(3) – 104.8] = 82.25 dBμV/m

5.3 Sample Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

5.4 Test Equipment Used:

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	9/18/2018	9/18/2019
Bilog Antenna	7088	SunAR	JB6	7/24/2018	7/24/2019
Horn Antenna	3780	ETS Lindgren	3117	6/11/2018	6/11/2019
System Controller	4096	ETS Lindgren	2090	Verify at Time of Use	Verify at Time of Use
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
3m Cable Antenna→Preamp	3074			11/26/2018	11/26/2019
3m Cable Preamplifier	3918	Rohde & Schwarz	TS-PR18	11/26/2018	11/26/2019
3m Cable Preamp→Chamber	2588			11/26/2018	11/26/2019
3m Cable Chamber→Control Room	2593			11/26/2018	11/26/2019
3m Cable Control Room→Receiver	2592			11/26/2018	11/26/2019

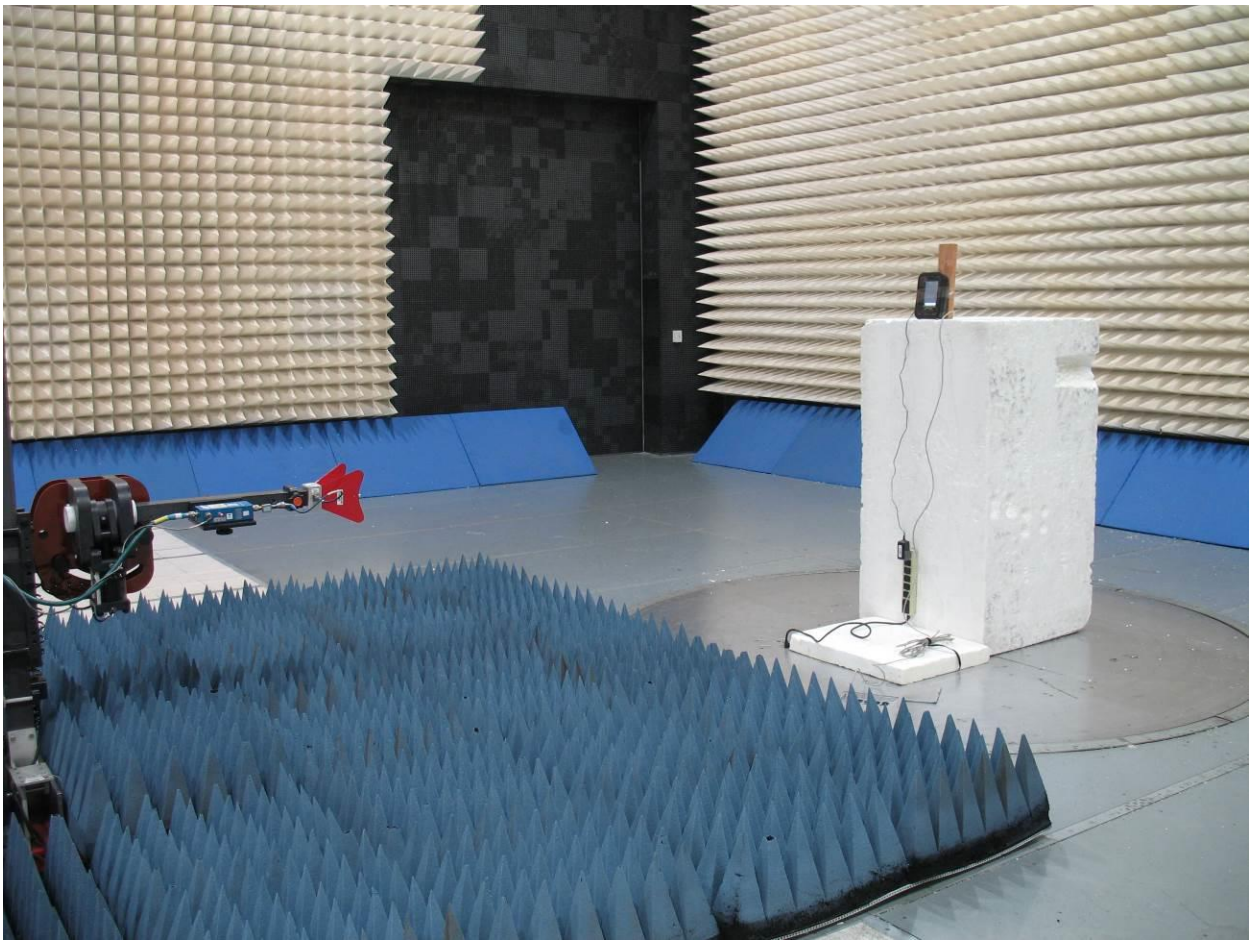
5.5 Software Utilized:

Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.04

5.6 Results:

The sample tested was found to Comply.

5.7 Test Setup Photograph:



5.8 Data: Radiated Spurious Emissions

LTE Band 2

Channel Frequency (MHz)	Spurious Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
1852	3717.5	48.22	82.25	34.03
	5565.0	43.13	82.25	39.12
	7420.0	44.44	82.25	37.81
	9275.0	46.97	82.25	35.28
1880	3755.5	43.29	82.25	38.96
	4874.0	56.23	82.25	26.02
	6000.5	45.08	82.25	37.17
	6988.5	46.74	82.25	35.51
	13222.5	52.33	82.25	29.92
	17688.0	57.48	82.25	24.77
1908	3810.0	43.56	82.25	38.69
	5715.0	43.01	82.25	39.24
	7620.0	45.49	82.25	36.76
	9525.0	47.33	82.25	34.92
	11430.0	49.17	82.25	33.08

Spurious Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
177.328222	49.98	82.25	32.27
430.669778	53.39	82.25	28.86
481.336333	54.80	82.25	27.45
532.001889	56.60	82.25	25.65
582.684444	57.05	82.25	25.20
593.392333	47.57	82.25	34.68
633.349889	54.02	82.25	28.23
741.757333	47.05	82.25	35.20
785.354556	40.25	82.25	42.00
890.110444	49.84	82.25	32.41

Note: Spurious emissions below 1GHz represent the worst case of all channels

LTE Band 4

Channel Frequency (MHz)	Spurious Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
1711.5	3430.0	43.63	82.25	38.62
	5145.0	42.35	82.25	39.90
	6860.0	45.76	82.25	36.49
	8575.0	45.27	82.25	36.98
	10290.0	47.62	82.25	34.63
	17692.0	57.93	82.25	24.32
1732.5	2463.5	39.87	82.25	42.38
	2903.5	39.00	82.25	43.25
	4874.0	58.11	82.25	24.14
	7941.5	46.41	82.25	35.84
	16077.0	55.61	82.25	26.64
	17720.5	58.37	82.25	23.88
1753.5	3500.0	46.59	82.25	35.66
	5250.0	43.11	82.25	39.14
	7000.0	47.57	82.25	34.68
	8750.0	45.69	82.25	36.56
	10500.0	47.59	82.25	34.66

Spurious Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
177.340222	50.28	82.25	31.97
430.681889	53.16	82.25	29.09
481.350333	55.13	82.25	27.12
532.009889	57.12	82.25	25.13
582.675444	57.37	82.25	24.88
593.400333	47.05	82.25	35.20
633.327889	55.57	82.25	26.68
741.759333	52.92	82.25	29.33
791.199444	44.19	82.25	38.06
890.112444	51.11	82.25	31.14

Note: Spurious emissions below 1GHz represent the worst case of all channels

LTE Band 5

Channel Frequency (MHz)	Spurious Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
825.3	1599.0	39.67	82.25	42.58
	1648.0	42.94	82.25	39.31
	2479.5	39.47	82.25	42.78
	2665.0	44.01	82.25	38.24
	12332.0	51.79	82.25	30.46
	17752.5	57.62	82.25	24.63
836.5	1089.5	44.19	82.25	38.06
	1140.0	44.24	82.25	38.01
	1665.0	55.40	82.25	26.85
	1681.0	54.70	82.25	27.55
	2142.0	37.35	82.25	44.90
	2466.0	40.39	82.25	41.86
	3329.5	47.01	82.25	35.24
	4874.0	58.45	82.25	23.80
847.7	1599.0	40.20	82.25	42.05
	1697.5	41.91	82.25	40.34
	2665.0	42.85	82.25	39.40
	3395.5	44.07	82.25	38.18
	3731.0	43.44	82.25	38.81
	17811.0	57.51	82.25	24.74

Spurious Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
75.997000	44.08	82.25	38.17
126.680000	46.98	82.25	35.27
177.340000	50.20	82.25	32.05
278.700000	45.65	82.25	36.60
430.660000	52.93	82.25	29.32
481.360000	54.61	82.25	27.64
582.680000	56.11	82.25	26.14
633.350000	54.22	82.25	28.03
841.340000	77.28	82.25	4.97
890.120000	49.65	82.25	32.60

Note: Spurious emissions below 1GHz represent the worst case of all channels

LTE Band 13

Channel Frequency (MHz)	Spurious Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
777	1335.5	34.23	82.25	48.02
	1567.0	40.55	82.25	41.70
	1599.0	39.49	82.25	42.76
	2456.0	39.04	82.25	43.21
	2664.5	41.43	82.25	40.82
	17367.5	57.55	82.25	24.70
782	1089.5	43.55	82.25	38.70
	1139.5	42.25	82.25	40.00
	1568.5	54.36	82.25	27.89
	2352.5	46.90	82.25	35.35
	2463.5	40.05	82.25	42.20
	3128.0	39.34	82.25	42.91
	4874.0	58.52	82.25	23.73
787	1567.5	41.51	82.25	40.74
	1598.5	37.40	82.25	44.85
	2665.0	42.80	82.25	39.45
	3198.5	42.76	82.25	39.49
	12533.0	51.81	82.25	30.44
	17757.0	57.40	82.25	24.85

Spurious Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
75.997000	44.09	82.25	38.16
126.660000	47.08	82.25	35.17
148.360000	41.12	82.25	41.13
177.340000	50.28	82.25	31.97
228.020000	44.52	82.25	37.73
430.680000	53.33	82.25	28.92
481.360000	54.85	82.25	27.40
582.680000	57.23	82.25	25.02
741.800000	49.28	82.25	32.97
890.120000	49.74	82.25	32.51

Note: Spurious emissions below 1GHz represent the worst case of all channels

LTE Band 17

Channel Frequency (MHz)	Spurious Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
704	1410.5	55.29	82.25	26.96
	1419.0	50.94	82.25	31.31
	1599.0	39.36	82.25	42.89
	2665.0	43.37	82.25	38.88
	3198.0	42.94	82.25	39.31
	16079.0	56.48	82.25	25.77
710	1089.0	43.61	82.25	38.64
	1139.5	42.68	82.25	39.57
	1292.0	43.4	82.25	38.85
	1415.0	49.77	82.25	32.48
	1606.5	33.61	82.25	48.64
	2465.0	44.65	82.25	37.60
	4874.0	59.08	82.25	23.17
716	1412.5	56.41	82.25	25.84
	1429.0	53.71	82.25	28.54
	1598.5	37.7	82.25	44.55
	2664.5	41.59	82.25	40.66
	3197.5	41.39	82.25	40.86
	17667.0	57.86	82.25	24.39

Spurious Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)
177.340000	50.30	82.25	31.95
430.680000	53.34	82.25	28.91
481.360000	54.97	82.25	27.28
532.010000	57.16	82.25	25.09
582.680000	57.42	82.25	24.83
698.600000	59.78	82.25	22.47
741.800000	49.09	82.25	33.16

Note: Spurious emissions below 1GHz represent the worst case of all channels

Test Personnel:	Michael Carlson Ben Coolbear	Test Date:	12/6/2018-2/7/2019
Supervising/Reviewing Engineer: (Where Applicable)	N/A	Limit Applied:	See Tables Above
		Ambient Temperature:	25.7 °C
Input Voltage:	24VDC via 120V/60Hz AC/DC adapter	Relative Humidity:	41.1 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	982.0 mbar

Deviations, Additions, or Exclusions: The device was tested in three orthogonal positions, with the worst case results reported in the data above

6 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	2/8/2019	103679095LEX-003	BL	BCT	Original Issue
1	9/8/2019	103679095LEX-003.1	BL	BCT	Included a description of updates performed to the product under variant models