Test Report No. 7191184231-EEC18/02
dated 04 Jun 2018

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FORMAL REPORT ON TESTING IN ACCORDANCE WITH
47 CFR FCC Parts 15B & C
OF A
RFID Module [Model : 03153721-01]
[FCC ID : 2AK8D03153721]

TEST FACILITY	TÜV SÜD PSB Pte Ltd Electrical & Electronics Centre (EEC), Product Services, No. 1 Science Park Drive, Singapore 118221
FCC REG. NO.	994109 (Test Firm Registration Number) SG0002 (Designation Number)
IND. CANADA REG. NO.	2932I-1 (3m and 10m Semi-Anechoic Chamber, Science Park)
PREPARED FOR	ASM Assembly Systems Singapore Pte. Ltd. 535 Yishun Industrial Park A ASM TECH-PARK Building 2 (5th Floor) Singapore 768775
QUOTATION NUMBER	2191069439
JOB NUMBER	7191184231
TEST PERIOD	19 Apr 2018 – 25 May 2018

PREPARED BY

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APPROVED BY

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TÜV SÜD PSB

ilac-MRA

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LA-2007-0381-F
LA-2007-0382-B
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LA-2007-0384-G
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LA-2007-0386-C
LA-2010-0464-D

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council. Inspections/Calibrations/Tests marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our inspection body/laboratory.

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TEST SUMMARY

The product was tested in accordance with the customer's specifications.

Test Results Summary

Test Standard	Description	Pass / Fail
47 CFR FCC Part 15		
15.107(a), 15.207	Conducted Emissions	Not Applicable *See Note 5
15.109(a), 15.205, 15.209, 15.225(d)	Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement)	Pass
15.225(a)	Radiated Emissions (Fundamental)	Pass
15.225(e)	Frequency Stability Versus Temperature	Pass
15.225(e)	Frequency Stability Versus Input Voltage	Pass

Notes

1. The Equipment Under Test (EUT) was configured to operate in the test mode at 13.56MHz
2. The measurements in section 15.225(e) were done based on conducted measurements.
3. The EUT is a Class B device when in non-transmitting state and meets the 47 CFR FCC Part15B Class B requirements.
4. All test measurement procedures are according to ANSI C63.4: 2014 and ANSI C63.10: 2013.
5. The Equipment Under Test (EUT) is a DC operated device and contains no provision for public utility connections.
6. The EUT was tested using fully charged batteries with DC voltage of 24.0V.

Modifications

No modifications were made.

PRODUCT DESCRIPTION

Description	:	The Equipment Under Test (EUT) is **RFID Read Module.**
Manufacturer	:	ASM Assembly Systems Singapore Pte. Ltd 535 Yishun Industrial Park A ASM Tech-Park Building 2 Singapore 768775
Model Number	:	03153721-01
FCC ID	:	2AK8D03153721
Serial Number	:	Pre-series#1
Microprocessor	:	RFID transceiver: CR95HF (ST Microelectronics) RFID Tag: ZC-2016-530
Operating / Transmitting Frequency	:	13.56MHz
Clock / Oscillator Frequency	:	27.12MHz
Modulation	:	100% Amplitude-Shift Keying (ASK) according to ISO 15693
IF Filter Bandwidth	:	18MHz
Port / Connectors	:	Refer to manufacturer's user manual / operating manual
Rated Input Power	:	5Vdc, 75mA max
Accessories	:	Nil

SUPPORTING EQUIPMENT DESCRIPTION

Equipment Description (Including Brand Name)	Model, Serial & FCC ID Number	Cable Description (List Length, Type & Purpose)
ASM Control Board	P/N: 03125534-02 S/N: KL-47-0004 FCC ID: Nil	Nil
GW Power Supply	M/N: GPR-3030 S/N: 1720389 FCC ID: DoC	2.00m unshielded power cable
Kvaser CAN Communication	M/N: USB CANIII S/N: 18786 FCC ID: DoC	2.00m USB cable
Fujitsu Laptop	M/N: Celsius #710 S/N: DSCF018897 FCC ID: DoC	Nil
Fujitsu Adapter	P/N: CP500601-01 FPCAC113 S/N: 1230107901 FCC ID: Nil	2.00m unshielded power cable

EUT OPERATING CONDITIONS

47 CFR FCC Part 15
1. Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement) **2. Radiated Emissions (Fundamental)** **3. Frequency Stability Versus Temperature** **4. Frequency Stability Versus Input Voltage**
The EUT was exercised by operating in maximum continuous transmission in test mode, i.e transmitting at 13.56MHz continuously.

47 CFR FCC Part 15.205 Restricted Bands

MHz			MHz			MHz			GHz		
0.090	-	0.110	16.42	-	16.423	399.9	-	410	4.5	-	5.15
0.495	-	0.505	16.69475	-	16.69525	608	-	614	5.35	-	5.46
2.1735	-	2.1905	16.80425	-	16.80475	960	-	1240	7.25	-	7.75
4.125	-	4.128	25.5	-	25.67	1300	-	1427	8.025	-	8.5
4.17725	-	4.17775	37.5	-	38.25	1435	-	1626.5	9.0	-	9.2
4.20725	-	4.20775	73	-	74.6	1645.5	-	1646.5	9.3	-	9.5
6.215	-	6.218	74.8	-	75.2	1660	-	1710	10.6	-	12.7
6.26775	-	6.26825	108	-	121.94	1718.8	-	1722.2	13.25	-	13.4
6.31175	-	6.31225	123	-	138	2200	-	2300	14.47	-	14.5
8.291	-	8.294	149.9	-	150.05	2310	-	2390	15.35	-	16.2
8.362	-	8.366	156.52475	-	156.52525	2483.5	-	2500	17.7	-	21.4
8.37625	-	8.38675	156.7	-	156.9	2690	-	2900	22.01	-	23.12
8.41425	-	8.41475	162.0125	-	167.17	3260	-	3267	23.6	-	24.0
12.29	-	12.293	167.72	-	173.2	3332	-	3339	31.2	-	31.8
12.51975	-	12.52025	240	-	285	3345.8	-	3358	36.43	-	36.5
12.57675	-	12.57725	322	-	335.4	3600	-	4400	Above 38.6		
13.36	-	13.41									

47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Limits

Frequency Range (MHz)	Quasi-Peak Limit Values (dBµV/m)
0.009 - 0.490	20 log [2400 / F (kHz)] @ 300m
0.490 - 1.705	20 log [24000 / F (kHz)] @ 30m
1.705 - 30.0	30.0 @ 30m
30 - 88	40.0 @ 3m
88 - 216	43.5 @ 3m
216 - 960	46.0 @ 3m
Above 960	54.0* @ 3m
* For frequency bands 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, average detector was used. A peak limit of 20dB above the average limit does apply.	

47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Test Instrumentation

Instrument	Model	S/No	Cal Due Date
R&S Test Receiver – ESI1	ESI40	100010	25 Oct 2018
Com-Power Preamplifier (1MHz-1GHz)	PAM-103	441056	04 Jul 2018
Schaffner Bilog Antenna (30MHz-2GHz)	CBL6112B	2597	20 Feb 2019
EMCO Loop Antenna	6502	134413	28 Oct 2018

47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Test Setup

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m X 1.0m X 0.8m high, non-metallic table for measurement up to 1GHz. For measurement above 1GHz, 1.5m height table was used.
2. The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
3. The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

47 CFR FCC Parts 15.109(a), 15.209 and 5.225(d) Radiated Emission Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A prescan was carried out to pick the worst emission frequencies from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.
3. The test was carried out at the selected frequency points obtained from the prescan in step 2. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
4. A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point in the range of 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, both Peak and Average measurements were carried out.
5. Steps 3 and 4 were repeated for the next frequency point, until all selected frequency points were measured.
6. The frequency range covered was from the lowest radio frequency signal generated from the EUT, without going below 9kHz to 10th harmonics of the EUT fundamental frequency, using the loop antenna for frequency below 30MHz, Bi-log antenna for frequencies from 30MHz up to 1GHz, and the Horn antenna above 1GHz.

Sample Calculation Example

At 300 MHz	Q-P limit = 46.0 dBμV/m
Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB	
Q-P reading obtained directly from EMI Receiver = 40.0 dBμV/m (Calibrated level including antenna factors & cable losses)	
Therefore, Q-P margin = 46.0 - 40.0 = 6.0	i.e. 6.0 dB below Q-P limit

47 CFR FCC Parts 15.109(a), 15.205, 15.209 and 15.225(d) Radiated Emission Results

Test Input Power	5 Vdc	Temperature	23ºC
Test Distance	10m (<30MHz) 3m (≥30MHz – 1GHz)	Relative Humidity	54%
		Atmospheric Pressure	1030mbar
		Tested By	Dylan Lin

Spurious Emissions ranging from 9kHz – 30MHz (for 9kHz – 90kHz, 110kHz – 490kHz) *See Note 3

Freq (MHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)
0.0100	10.9	48.5	37.6	1.0	48.5	47.5	150	330
0.0120	10.2	48.3	38.1	0.0	48.3	48.3	150	167
0.0140	8.8	48.1	39.3	-1.1	48.1	49.2	150	167
0.0160	7.0	48.0	41.0	-2.3	48.0	50.3	150	167
0.0190	6.6	47.8	41.2	-3.9	47.8	51.7	150	334
0.0210	6.4	47.7	41.3	-4.4	47.7	52.1	150	86

Spurious Emissions ranging from 9kHz – 30MHz *See Note 3

Frequency (MHz)	Peak Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)
0.1500	3.7	38.3	34.6	150	85
0.3310	-1.0	25.3	26.3	150	313
0.6330	-8.1	33.7	41.8	150	204
1.4190	-14.2	33.5	47.7	150	11
27.1570	-21.2	24.0	45.2	150	245
29.1510	-34.9	23.3	58.2	150	75

Spurious Emissions ranging from 30MHz – 1GHz

Frequency (MHz)	Q-P Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)
36.8090	19.6	40.0	20.4	100	58	V
200.0030	30.9	43.5	12.6	100	216	V
249.9700	19.6	46.0	26.4	100	51	V
275.0020	29.3	46.0	16.7	100	258	V
375.0050	32.6	46.0	13.4	100	140	V
401.0690	14.0	46.0	32.0	100	51	V

Notes

1. All possible modes of operation were investigated. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2. A closer test distance of 10m was used for the measurement instead of 30m as the fundamental (carrier) electric field strength of the EUT at the 10m distance shows compliance to the limit of 30m test distance.
3. The measurement was done at 10m. The measured results were extrapolated to the specified test limits as specified in § 15.209 (a) based on 40dB/decade.
4. Quasi-peak measurement was used for frequency measurement up to 1GHz. Average and peak measurements were used for emissions above 1GHz. The average measurement was done by averaging over a complete cycle of the pulse train, including the blanking interval as the pulse train duration does not exceed 0.1 second.
5. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
6. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   9kHz - 150kHz
   RBW: 100Hz VBW: 300Hz
   150kHz - 30MHz
   RBW: 10kHz VBW: 30kHz
   30MHz - 1GHz
   RBW: 120kHz VBW: 1MHz
   >1GHz
   RBW: 1MHz VBW: 3MHz
7. The upper frequency of radiated emission investigations was according to requirements stated in Section 15.33(a) for intentional radiators & Section 15.33(b) for unintentional radiators.
8. Radiated Emissions Measurement Uncertainty
   All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2, in the range 30MHz – 1GHz is ±3.8dB and >1GHz – 40GHz is ±4.5dB.

47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Limits

Fundamental Frequency (MHz)	Field Strength of Fundamental Limit Values @ 30m (dBµV/m)
13.553 - 13.567	84.0
13.410 -13.553	50.5
13.567 -13.710	50.5
13.110 -13.410	40.5
13.710 -14.010	40.5

47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Instrumentation

Instrument	Model	S/No	Cal Due Date
R&S Test Receiver – ESI1	ESI40	100010	25 Oct 2018
EMCO Loop Antenna	6502	134413	28 Oct 2018

RADIATED EMISSION (FUNDAMENTAL) TEST

47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Setup

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m X 1.0m X 0.8m high, non-metallic table for measurement up to 1GHz. For measurement above 1GHz, 1.5m height table was used.
2. The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
3. The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A prescan was carried out to pick the fundamental frequency from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.
3. The test was carried out at the selected frequency points obtained from the prescan in step 2. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
4. A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point that above 1GHz, both Peak and Average measurements were carried out.
5. Steps 3 and 4 were repeated for the next frequency point, until all selected frequency points were measured.

Sample Calculation Example

At 300 MHz Q-P limit = 46.0 dBμV/m
Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB
Q-P reading obtained directly from EMI Receiver = 40.0 dBμV/m (Calibrated level including antenna factors & cable losses)
Therefore, Q-P margin = 46.0 - 40.0 = 6.0 i.e. 6.0 dB below Q-P limit

47 CFR FCC Part 15.225(a) Radiated Emission (Fundamental) Results

Test Input Power	5 Vdc	Temperature	23°C
Test Distance	10m (<30MHz)	Relative Humidity	54%
		Atmospheric Pressure	1030mbar
		Tested By	Dylan Lin

Frequency (MHz)	Q-P Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)
13.5650	-18.8	84.0	102.8	150	177

Notes

1. All possible modes of operation were investigated. Only the worst case emissions measured, using the average and peak detectors, are reported. All other emissions were relatively insignificant.
2. A closer test distance of 10m was used for the measurement instead of 30m as the fundamental (carrier) electric field strength of the EUT at the 10m distance shows compliance to the limit of 30m test distance.
3. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
4. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   150kHz - 30MHz
   RBW: 10kHz VBW: 30kHz
   30MHz - 1GHz
   RBW: 120kHz VBW: 1MHz
   >1GHz
   RBW: 1MHz VBW: 3MHz
5. Radiated Emissions (Fundamental) Measurement Uncertainty
   All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2, in the range 30MHz – 25GHz is ±4.0dB.

FREQUENCY STABILITY VERSUS TEMPERATURE TEST

47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Limits

The EUT shows compliance to the requirements of this section, which states that the frequency tolerance of the carrier frequency shall be ± 0.01% for a temperature variation of -20ºC to +50ºC at normal supply voltage.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Instrumentation

Instrument	Model	S/No	Cal Due Date
HP Universal Counter	53132A	3736A06236	05 Oct 2018
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
Cincinnati Sub-Zero Products, INC. Temperature & Humidity Chamber	ZH-8-1-1-H/AC	ZF9722653	29 Nov 2018

47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo. The EUT was placed in an environmental temperature chamber with a nominal supply voltage. For the battery operated EUT, a new battery was used.
2. The RF antenna connector of the EUT was connected to the frequency counter via a low-loss coaxial cable.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Method

1. The EUT was switched off and the environmental temperature was set to the highest temperature, i.e, +50ºC.
2. Upon reaching the highest set temperature with 30 minutes of stabilisation period, the EUT was switched on and configured to operate in the test mode with transmitting frequency at 13.56MHz.
3. The EUT's transmitting frequency was then measured at start up, and two, five and ten minutes after start up with the spectrum analyser was set to max hold to capture the transmitting frequency. For each measurement, the signal capturing was continuous until no further changes were observed. Four measurements were made in total.
4. The EUT was switched off. The environmental chamber temperature was lowered by 10 °C and was allowed the temperature inside the chamber to stabilize.
5. The EUT was turned on and the step 3 was repeated.
6. The steps 3 and 4 were repeated until the lowest temperature was reached, i.e, -20 ºC.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Results

Test Input Power	5 Vdc	Temperature	See table below
		Relative Humidity	55%
		Atmospheric Pressure	1030mbar
		Tested By	Win Min Htwe

Channel Frequency (MHz)	Temperature (°C)	± 0.01% Carrier Tolerance (Hz)	Measured Tolerance (Hz)	Measurement with respects to Start Up Time (Mins)
13.56	50.0	1356	272.1	0
		1356	271.7	2
		1356	271.4	5
		1356	270.5	10
	40.0	1356	283.6	0
		1356	283.6	2
		1356	283.5	5
		1356	283.4	10
	30.0	1356	281.3	0
		1356	281.5	2
		1356	281.7	5
		1356	281.8	10
	20.0	1356	274.6	0
		1356	275.9	2
		1356	276.3	5
		1356	276.4	10
	10.0	1356	267.8	0
		1356	268.2	2
		1356	268.4	5
		1356	268.4	10
	0.0	1356	263.6	0
		1356	263.8	2
		1356	263.9	5
		1356	264	10
	-10.0	1356	263.8	0
		1356	264.2	2
		1356	264.8	5
		1356	266.7	10
	-20.0	1356	296.9	0
		1356	297.6	2
		1356	297.2	5
		1356	298.0	10

FREQUENCY STABILITY VERSUS INPUT VOLTAGE TEST

47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Limits

The EUT shows compliance to the requirements of this section, which states that the frequency tolerance of the carrier frequency shall be ± 0.01% for variation of a primary voltage from 85% to 115% of the rated supply voltage at a temperature of 20ºC. For a battery operated equipment, the equipment tests shall be performed using a new battery.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Instrumentation

Instrument	Model	S/No	Cal Due Date
HP Universal Counter	53132A	3736A06236	05 Oct 2018
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
Cincinnati Sub-Zero Products, INC. Temperature & Humidity Chamber	ZH-8-1-1-H/AC	ZF9722653	29 Nov 2018

47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo. The EUT was placed in an environmental temperature chamber with a nominal supply voltage. For the battery operated EUT, the EUT was supplied using a variable power supply.
2. The RF antenna connector of the EUT was connected to the frequency counter via a low-loss coaxial cable.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Method

1. The EUT was switched off and the environmental temperature was set to 20ºC.
2. Upon reaching the set temperature with 30 minutes of stabilisation period, the EUT was switched on and configured to operate in the test mode with transmitting frequency at 13.56MHz
3. The EUT's transmitting frequency was then measured with the spectrum analyser which was set to max hold. The signal capturing was continuous until no further changes were observed. Four measurements were made in total.
4. Repeat steps 2 to 3 with the supply voltage set to 85% and 115% of the nominal voltage supply respectively.

47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Results

Test Input Power	See table below	Temperature	20ºC
		Relative Humidity	55%
		Atmospheric Pressure	1030mbar
		Tested By	Win Min Htwe

Channel Frequency (MHz)	Test Input Power (Vdc)	± 0.01% Carrier Tolerance (Hz)	Measured Tolerance (Hz)
13.56	5.75	1356	281.6
	5.00	1356	280.6
	4.25	1356	282.5

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5. Unless otherwise stated, the tests were carried out in TÜV SÜD PSB Pte Ltd, No.1 Science Park Drive Singapore 118221.

July 2011