



RF EXPOSURE TEST REPORT



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Laboratory Accreditations (per ISO/IEC 17025:2017)



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Manufacturer: Bitstrata Systems Inc.
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Equipment Tested: Libra Module
Model Number(s): M1000
FCC ID: 2BAFL-GC848354
ISED ID: 30137-GC848354



REVISION HISTORY

Date	Report Number	Details	Author's Initials
August 18, 2023	E10959-2301_Bitstrata_Libra_RF Exposure_Rev0.0	Initial draft	AH
August 25, 2023	E10959-2301_Bitstrata_Libra_RF Exposure_Rev1.0	Final	AH
All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.			

REPORT AUTHORIZATION

The data documented in this report is for the test equipment provided by the manufacturer. The tests were conducted on the sample equipment as requested by the manufacturer for the purpose of demonstrating compliance with the standards outlined in Section I of this report as agreed upon by the Manufacturer under the quote 23RH02073R2.

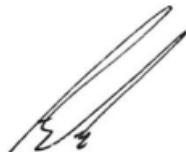
The Manufacturer is responsible for the tested product configurations, continued product compliance, and for the appropriate auditing of subsequent products as required.

This report may comprise a partial list of tests that are required for FCC, ISED, CE, RCM and UKCA conformity. A Declaration of Conformity can only be produced by the manufacturer. This is to certify that the following report is true and correct to the best of our knowledge.

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QAI EMC ACCREDITATION

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1 EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to demonstrate and document the compliance of the Bitstrata Libra Module as per Sections 1.2 and 1.3.

1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 23RH02073R2:

- **FCC KDB 447498 D04: v01** – General RF Exposure Guidance
- **RSS-102 Issue 5** – Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
- **EN 62479:2010** – Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields

1.3 Summary of Results

No.	Test	Applicable Standard	Description	Result
1	RF Exposure Evaluation	FCC 47 CFR 2.1093 FCC 47 CFR 1.1310 RSS-102 Issue 2 (2.5.1) EN 62479	RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm	Complies

Table 1: Applicable Test Standards and Descriptions

Note: The gain of the antenna(s) is provided by the client to measure or calculate test results and is not independently measured by QAI.

2 GENERAL INFORMATION

2.1 Product Description

The information provided in this section is for the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment needed to perform the tests as a complete system.



Figure 1: EUT

Equipment Under Test (EUT) – General Information

Equipment	Libra Module
Description	2.4 GHz Bluetooth Low Energy (BLE) Module
Manufacturer	Bitstrata Systems Inc.
Model No.	M1000
Serial No.	Sample 1
Tested as	Table-top
Dimensions	3.3 x 2.5 x 0.9 cm
Input power	3.3V / 25 mA, 83 mW
Clock frequencies tuned upon within the EUT:	32.768 kHz, 24 MHz
Highest frequency generated within the EUT:	2483.5 MHz

2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	Indoors
Temperature	20.1 °C
Relative Humidity	43.5%
Atmospheric Pressure	101.2 kPa

2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1.5 x 10 ⁻⁵ MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1°C
Humidity	±5 %
DC and low frequency voltages	±3 %

3 DATA & TEST RESULTS

3.1 RF Exposure Evaluation – Federal Communications Commission (FCC)

Date Performed:	23-Aug-18
Test Standard:	FCC 47 CFR 1.1307 FCC 47 CFR 1.1310 FCC 47 CFR 2.1091
Test Method:	FCC OET Bulletin 65 Ed 97-01 FCC KDB 477498 D01: v06
Modifications:	None
Final Result:	Complies

3.1.1 Applicable Regulations

3.1.1.1 FCC – KDB 447498: General RF Exposure Guidance

7. RF EXPOSURE EVALUATION GUIDANCE FOR MOBILE CONDITIONS

7.1 Transmitters used in mobile device exposure conditions for standalone operations.

A minimum test separation distance ≥ 20 cm is required between the antenna and radiating structures of the device and nearby persons to apply mobile device exposure limits. The minimum test separation distance required for a device to comply with mobile device exposure conditions must be clearly identified in the installation and operating instructions, for all installation and exposure conditions, to enable users and installers to comply with RF exposure requirements.

When a device qualifies for the categorical exclusion provision of 2.1091 (c), the minimum test separation distance may be estimated, when applicable, by simple calculations according to plane-wave equivalent conditions, to ensure the transmitter and its antenna(s) can operate in manners that meet or exceed the estimated distance.

When a device does not qualify for the categorical exclusion provision of 2.1091 (c), routine evaluation using MPE measurement or computational modeling is required to determine compliance. For mobile devices operating in mostly stationary configurations MPE estimated instead of measurements or numerical simulation may be acceptable.

7.2 Transmitters used in mobile device exposure conditions for simultaneous transmission operations.

For mobile exposure host platform devices to qualify for simultaneous transmission MPE test exclusion, all transmitters and antennas in the host must either be evaluated for MPE compliance, by measurement or computational modeling, or qualify for the standalone MPE test exclusion in 7.1. When modular transmitters are used, the minimum test separation distance required for each simultaneously transmitting antenna installed in the host device must satisfy MPE compliance for both standalone and simultaneous transmission operations. When simultaneous transmission MPE test exclusion applies, transmitter modules may be incorporated in host devices according to Class I permissive change requirements to document the test exclusion conditions.

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0 , according to calculated/estimated, numerically modeled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency. Either the maximum peak or spatially averaged results from measurements or numerical simulations may be used to determine the MPE ratios. Spatial averaging should not be applied when MPE is estimated using simple calculations based on far-field plane-wave equivalent conditions. The antenna installation and operating

requirements for the host device must meet the minimum test separation distances required for all antennas, in both standalone and simultaneous transmission operations, to satisfy compliance.

3.1.1.2 FCC 47 CFR 1.1307: Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.

(b)(3)(i)(B) A single RF source is exempt if the available maximum time-averaged power or effective radiated power (ERP), whichever is greater is less than or equal to the threshold P_{th} (mW) described in the following formula:

$$P_{th}(mW) = \begin{cases} ERP_{20cm}(d/20cm)^x & d \leq 20cm \\ ERP_{20cm} & 20cm \leq d \leq 40cm \end{cases}$$

Where

$$x = -\log_{10} \left(\frac{60}{ERP_{20cm}\sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$$

And

$$ERP_{20cm} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f \leq 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$$

(b)(3)(i)(C) Table 1 – Single RF Sources Subject to Routine Environmental Evaluation:

RF Source Frequency (MHz)	Threshold ERP (W)
0.3 – 1.34	1,920 R ²
1.34 – 30	3,450 R ² /f ²
30 – 300	3.83 R ²
300 – 1,500	0.0128 R ² f
1,500 – 100,000	19.2 R ²

R is the separation distance in meters

Table 2: Single RF Sources Subject to Routine Evaluation

(b)(3)(ii)(B) in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation:

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$$

Where:

a = number of fixed, mobile, or portable RF sources claiming exemption using (b)(3)(i)(B) for P_{th}

b = number of fixed, mobile, or portable RF sources claiming exemption using (b)(3)(i)(C) for ERP_{th}

c = number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance.

P_i = the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source i at a distance between 0.5 cm and 40 cm

$P_{th,i}$ = the exemption threshold power (P_{th}) according to (b)(3)(i)(B) for fixed, mobile, or portable RF source i

ERP_j = the ERP of fixed, mobile, or portable RF source j .

$ERP_{th,j}$ = exemption threshold ERP for fixed, mobile, or portable RF source j , at a distance of at least $\lambda/2\pi$ according to the applicable formula of (b)(3)(i)(C)

$Evaluated_k$ = the maximum reported SAR or MPE of fixed, mobile, or portable RF source k either in the device or at the transmitter site from an existing evaluation at the location of exposure.

$Exposure Limit_k$ = either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable RF source k , as applicable from 1.1310

3.1.1.3 FCC 47 CFR 1.1310: Radiofrequency radiation exposure limits

(e)(1) Table 1 – Limits for Maximum Permissible Exposure (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	*(100)	≤ 6
3.0 – 30	1842/f	4.89/f	*(900/f ²)	< 6
30 – 300	61.4	0.163	1.0	< 6
300 – 1,500			f/300	< 6
1,500 – 100,000			5	< 6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3 – 3.0	614	1.63	*(100)	< 30
3.0 – 30	824/f	2.19/f	*(180/f ²)	< 30
30 – 300	27.5	0.073	0.2	< 30
300 – 1,500			f/1500	< 30
1,500 – 100,000			1.0	< 30

f = frequency in MHz

* = Plane-wave equivalent power density

Table 3: Limits for Maximum Permissible Exposure (MPE)

(e)(2) Occupational/controlled exposure limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure.

3.1.1.4 FCC 47 CFR 2.1091: Radiofrequency radiation exposure evaluation: mobile devices

(c) (1): Evaluation of compliance with the exposure limits in 1.1310 of this chapter, and preparation of an EA if the limits are exceeded, is necessary for mobile devices with single RF sources having either more than an available maximum time averaged power of 1 mW or more than the ERP listed in table 1 of 1.1307(b)(3)(i)(C), whichever is greater.

3.1.2 FCC Measurement Data and Results:

Peak Output Power: 4.66 dBm, 2.90 mW
Antenna Gain: 0.5 dBi
Antenna Type: Chip Antenna, Soldered
Frequency Range: 2.4 – 2.5 GHz
Exposure Distance: > 0.2 m

Maximum Permissible Exposure (MPE) threshold, Per FCC 47 CFR 1.1310 (e)(1):

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	*(100)	≤ 6
3.0 – 30	1842/f	4.89/f	*(900/f ²)	< 6
30 – 300	61.4	0.163	1.0	< 6
300 – 1,500			f/300	< 6
1,500 – 100,000			5	< 6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3 – 3.0	614	1.63	*(100)	< 30
3.0 – 30	824/f	2.19/f	*(180/f ²)	< 30
30 – 300	27.5	0.073	0.2	< 30
300 – 1,500			f/1500	< 30
1,500 – 100,000			1.0	< 30

f = frequency in MHz

* = Plane-wave equivalent power density

Using the Maximum Permissible Exposure (MPE) threshold table above, taken from FCC 47 CFR 1.1310(e)(1), the limit for occupational/controlled exposure at 2400 MHz is:

$$MPE_{2400MHz} = 1 \text{ mW/cm}^2$$

The plane-wave power density calculation for the transmitter is:

$$S = \frac{P_{mW} * G_{ant}}{4\pi * R_{cm}^2} \text{ mW/cm}^2$$

Where,

S = power density

P_{mW} = conducted output power in mW

G_{ant} = linear antenna gain

R_{cm} = the separation distance in cm

$$S_{Tx1_BLE} = \frac{2.90 \text{ mW} * \left(10^{0.5 \text{ dBi}/10}\right)}{4\pi * 20^2} = 0.00064 \text{ mW/cm}^2$$

Transmitter	Detail	Power Density (mW/cm ²)	Power Density Limit (mW/cm ²)	Result
Tx ₁	2.4 GHz BLE	0.00064	1	Complies

Table 4: FCC RF Exposure Evaluation Results

3.2 RF Exposure Evaluation – Innovation, Science and Economic Development Canada (ISED)

Date Performed:	23-Aug-18
Test Standard:	RSS-102 Issue 5
Test Method:	KDB 447498 D01
Modifications:	None
Final Result:	Complies

3.2.1 Applicable Regulations

3.2.1.1 ISED – RSS-102

Section 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation:

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- Below 20 MHz and the source-based, time-averaged maximum E.I.R.P. of the device is equal to or less than 1 W.
- At or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum E.I.R.P. of the device is equal to or less than $4.49/f^{0.5}$ W, where f is in MHz.
- At or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum E.I.R.P. of the device is equal to or less than 0.6 W.
- At or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum E.I.R.P. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W, where f is in MHz.

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the E.I.R.P. was derived.

Section 3.2 RF Exposure Evaluation of Devices:

A device requiring an RF exposure evaluation shall be made in accordance with the latest version of IEEE C95.3.

If the device is designed such that more than one antenna can functionally transmit at the same time, the RF exposure evaluation shall be conducted while all antennas are transmitting. The individual exposure level ratios shall be totalled and used for compliance purposes.

If the device has more than one antenna but is not designed to have more than one antenna functionally transmit at the same time, the RF exposure evaluation of the device shall be performed for each of the individually transmitting antennas. The maximum RF field strength value shall be recorded and used for compliance purposes.

If the device combines groups of simultaneous and non-simultaneous transmitting antennas, the worst-case of the above scenarios applies.

Section 4 Exposure Limits:

RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (Minutes)
0.003 – 10	83	90	-	Instantaneous*
0.1 – 10	-	0.73 / f	-	6**
1.1 – 10	87 / f ^{0.5}	-	-	6**
10 – 20	27.46	0.0728	2	6
20 – 48	58.07 / f ^{0.25}	0.1540 / f ^{0.25}	8.944 / f ^{0.5}	6
48 – 300	22.06	0.05852	1.291	6
300 – 6000	3.142 f ^{0.25}	0.008335 f ^{0.25}	0.02619 f ^{0.5}	6
6000 – 15000	61.4	0.163	10	6
15000 – 150000	61.4	0.163	10	616000 / f ^{1.2}
150000 – 300000	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000 / f ^{1.2}

Note: f is frequency in MHz.

* Based on nerve stimulation (NS).

** Based on specific absorption rate (SAR).

Table 5: ISED Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

RF Field Strength Limits for Controlled Use Devices (Controlled Environment)				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (Minutes)
0.003 – 10	170	180	-	Instantaneous*
0.1 – 10	-	1.6 / f	-	6**
1.1 – 10	193 / f ^{0.5}	-	-	6**
10 – 20	61.4	0.163	10	6
20 – 48	129.8 / f ^{0.25}	0.3444 / f ^{0.25}	44.72 / f ^{0.5}	6
48 – 300	49.33	0.1309	6.455	6
300 – 6000	15.60 f ^{0.25}	0.04138 f ^{0.25}	0.6455 f ^{0.5}	6
6000 – 15000	137	0.364	50	6
15000 – 150000	137	0.364	50	616000 / f ^{1.2}
150000 – 300000	0.354 f ^{0.5}	9.4 x 10 ⁻⁴ f ^{0.5}	3.33 x 10 ⁻⁴ f	616000 / f ^{1.2}

Note: f is frequency in MHz.

* Based on nerve stimulation (NS).

** Based on specific absorption rate (SAR).

Table 6: ISED Field Strength Limits for Controlled Use Devices (Controlled Environments)

3.2.2 ISED Measurement Data and Results:

From the RSS-102 limits for RF field strength limits in uncontrolled environments, the maximum power density at 2400 MHz is 1.283 W/m².

Transmitter	Detail	Power Density (mW/cm ²) ^{Note 1}	Power Density Limit (mW/cm ²) ^{Note 2}	Result
Tx ₁	2.4 GHz BLE	0.00064	0.1283	Complies

Note 1: See section 3.1.1 for calculation of transmitter power density

Note 2: Power density limit converted from W/m² to mW/cm²

Table 7: RSS-102 Exposure Evaluation

3.3 RF Exposure Evaluation – European Standard EN 62479:2010

Date Performed:	23-Aug-18
Test Standard:	EN 62479:2010 IEEE C95.1
Test Method:	IEEE C95.1 KDB 447498 D01
Modifications:	None
Final Result:	Complies

3.3.1 Applicable Regulations

3.3.1.1 EN 62479:2010

4.1 General Considerations:

Compliance of electromagnetic emissions from electronic and electrical equipment with the basic restrictions usually is determined by measurements and, in some cases, calculation of the exposure level. If the electrical power used by or radiated by the equipment is sufficiently low, the electromagnetic fields emitted will be incapable of producing exposures that exceed the basic restrictions. This standard provides simple EMF assessment procedures for this low power equipment.

Any relevant compliance assessment procedure which is consistent with the state of the art, reproducible and gives valid results can be used.

For transmitters intended for use with more than one antenna configuration option, the combination of transmitter and antenna(s) which generates the highest available antenna power and/or average total radiated power shall be assessed.

4.2 Low Power Exclusion Level (P_{\max})

Low-power electronic and electrical equipment is deemed to comply with the provisions of this standard if it can be demonstrated that the average total radiated power is less than or equal to the applicable low-power exclusion level P_{\max} .

4.3 Exposure to Multiple Transmitting Sources

If an equipment under test (EUT) is equipped with multiple intentional radiators, the overall conformity assessment might require more than just the assessment of conformity of each one of the radiators separately. The effect of multiple intentional radiators should be considered in the conformity assessment process.

3.3.1.2 IEEE C95.1-2019

4.3.2 Whole-body exposure ERLs (100 kHz to 300 GHz)

The ERLs are provided in the subclause for convenience in exposure assessments. For human exposure to electromagnetic energy at radio frequencies from 100 kHz to 300 GHz, the ERLs, in terms of rms electric (E) and magnetic (H) field strengths, the power density (S) and plane wave-equivalent power densities (S_E , S_H) are presented as a function of frequency in the following table. For uncorrelated (in time) fields, such as multiple field

exposure situations (e.g., different frequency field sources), compliance is determined by summing the percentages of the applicable ERLs in terms of E^2 , H^2 , or power density that each frequency field represents and ensuring that this sum does not exceed 100 %

ERLs for whole-body exposure of persons permitted in unrestricted environments				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	
			S _E	S _H
0.1 – 1	614	16.3 / f	1000	100 000 / f ²
1 – 30	823.8 / f	16.3 / f ^{1.668}	1800 / f ²	100 000 / f ²
30 – 100	27.5	158.3 / f	2	9 400 000 / f ^{3.336}
100 – 400	27.5	0.0729	2	
400 - 2000	-	-	f / 200	
2000 – 300 000	-	-	10	

Note: f is frequency in MHz.

Table 8: IEEE ERLs for whole-body exposure of persons permitted in unrestricted environments

ERLs for whole-body exposure of persons permitted in restricted environments (Controlled Environment)				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	
			S _E	S _H
0.1 – 1	1842	16.3 / f	9000	100 000 / f ²
1 – 30	1842 / f	16.3 / f	9000 / f ²	100 000 / f ²
30 – 100	61.4	16.3 / f	10	100 000 / f ²
100 – 400	61.4	0.163	10	
400 - 2000	-	-	f / 40	
2000 – 300 000	-	-	50	

Note: f is frequency in MHz.

Table 9: IEEE ERLs for whole-body exposure of persons permitted in restricted environments

3.3.2 EN 62479 RF Exposure Evaluation

From the IEEE C95.1 table of ERLs for whole-body exposure in uncontrolled environments, the maximum power density in the 2000 – 300 000 MHz range is 10 W/m².

Transmitter	Detail	Power Density (mW/cm ²) ^{Note 1}	Power Density Limit (mW/cm ²) ^{Note 2}	Result
Tx ₁	2.4 GHz BLE	0.00064	1	Complies

Note 1: See section 3.1.1 for calculation of transmitter power density

Note 2: Power density limit converted from W/m² to mW/cm²

Table 10: EN 62479 RF Exposure Evaluation



Appendix A: ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
AM	Amplitude Modulation
CE	European Conformity
CISPR	Comité International Spécial des Perturbations Radioélectriques (International Special Committee on Radio Interference)
DC	Direct Current
EFT	Electrical Fast Transient
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electrostatic Discharge
EUT	Equipment Under Test
FCC	Federal Communications Commission
FVIN	Firmware Version Identification Number FVIN
ICES	Interference Causing Equipment Standard
IEC	International Electrotechnical Commission
ISED	Innovation, Science and Economic Development (Canada)
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RCM	Regulatory Compliance Mark
RF	Radio Frequency
RMS	Root-Mean-Square
SAC	Semi-Anechoic Chamber
UKCA	UK Conformity Assessed



END OF REPORT