Report Date	January 7, 2020
Manufacturer Name	Astronics CSC
Manufacturer Address	804 S Northpoint Blvd Waukegan, IL 60087
Product Name Brand/Model No.	E71-319-01 Rev B
Assessment Dates	January 7, 2020
Specifications	FCC 47 CFR Part 2.1093 KDB, 447498 D01 OET Bulletin 65:1997 EN 62311:2008 EN 62479:2010 Industry Canada RSS-102 AS/NZ 2772.2 RSP 3
Test Facility	Elite Electronic Engineering, Inc. 1516 Centre Circle, Downers Grove, IL 60515
Signature	
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Signature	
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1. Report Revision History

Revision	Date	Description
–	06 FEB 2020	Initial Release of Engineering Test Report No. 1903461-03

2. Introduction

The FCC, EU, ISED and AS/NZ publish standards regarding the evaluation of the RF Exposure hazard of radio communications devices. An evaluation has been performed on the Astronics CSC Sierra™ Portable IFE, Model No. E71-319-01 Rev B pursuant to the relevant requirements.

3. Subject of Investigation

This document presents the demonstration of RF Exposure compliance on a Sierra™ Portable IFE, (hereinafter referred to as the Equipment under Test (EUT)). The Sierra™ Portable IFE utilizes the following radio access technology(s):

- Hewlett Packard Aruba Access Point, Model No. APINP303,
  - WiFi 802.11b/g/n 2.4GHz
  - WiFi 802.11n/a/ac U-NII-1, U-NII-2A, U-NII-2C, U-NII-3
  - Bluetooth 2.4GHz

- Sierra Wireless, Model No. EM7565-9,
  - E-UTRA B2
  - E-UTRA B3*
  - E-UTRA B4
  - E-UTRA B5
  - E-UTRA B7
  - E-UTRA B12
  - E-UTRA B13
  - E-UTRA B26
  - E-UTRA B30
  - E-UTRA B41**
  - E-UTRA B66**

- Intel® Dual Band Wireless-AC 8265: Model No. 8265NGW, FCC ID 1000M-8265NG
  - WiFi 802.11 a/b/g/n/ac 2.4GHz, 5GHz U-NII-1, U-NII-2A, U-NII-2C, U-NII-3,
  - Bluetooth 2.4GHz

* Not used in North America
** Downlink Only

4. Standards and Requirements

The tests were performed to selected portions of, and in accordance with the following specification(s).

47 CFR Parts 1.1310, 2.1091 and 2.1093 Code of Federal Regulations, Title 47, Telecommunications

KDB 447498 D01 – "RF Exposure Procedures and Equipment Authorization Polices for Mobile and Portable Devices, General RF Exposure Guidance v06"

OET Bulletin 65 Edition 97-01:1997 – "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields"

ANSI/IEEE C95.1:1992 – "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz,"
EN 62311:2008   Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

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 (10MHz-300GHz)

1999/519/EC   Council Recommendation on the Limitation of Exposure of The General Public to

Electromagnetic fields (0Hz-300GHz)

RSS-102, Issue 5   Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands

AS/NZS 2772.2: 2016   Principles and methods of measurement and computation-3 kHz to 300 GHz

RSP 3   Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz

5. Sample Calculations

The far field power density can be calculated using the following formula:

$$S = \frac{PG}{4\pi R^2} \tag{1}$$

where P is the transmit output power (mW), G is the maximum antenna gain relative to an isotropic antenna (linear) and R is the evaluation distance (cm).

In cases where multiple antennas are utilized for a single signal, the following formula is applied to calculate the maximum antenna gain:

$$Gain\ (dBi) = G + 10\log N \tag{2}$$

where N is the number of antennas, G is the gain of a single antenna.

A minimum separation distance can be calculated using the following formulas

$$Minimum\ Seperation\ Distance = \sqrt{\frac{PG}{4\pi(Power\ Density\ Limit)}} \tag{3}$$

where P is the transmit output power (mW) and G is the maximum antenna gain relative to an isotropic antenna (linear).

For sources with frequencies <30MHz

$$Minimum\ Seperation\ Distance = R\left(10^{\frac{(FS_{Limit}-FS_R)}{40}}\right)^{-1} \tag{4}$$

For sources with frequencies >30MHz

$$Minimum\ Seperation\ Distance = R\left(10^{\frac{(FS_{Limit}-FS_R)}{20}}\right)^{-1} \tag{5}$$

where R is the measurement distance, FS_{Limit} is the field strength limit and FS_R is the measured field strength at distance R.

6. Photographs of EUT

7. Limits and Requirements

7.1. As mandated by the FCC:

The first step is to determine if the product is categorically exempt from RF exposure evaluation based on the criteria listed in 1.1307(b)(1)

The next step is to evaluate RF exposure either by measurement or by calculating the power density at an evaluation distance of 0.2m, as specified by ANSI/IEEE C95.1-1992. If it is determined that the calculated power density does not meet the basic restrictions, a minimum separation distance must be measured or calculated such that the basic restrictions are met. The assessment is based on transmitter power levels, transmit frequency(s) and antenna parameters.

In environments where the possibility of simultaneous exposure to fields on different frequencies exists, the exposure shall be considered to be additive. The fraction of the recommended limit incurred within each frequency should be determined, and the sum of all fractional contributions should not exceed 1.0.

The following formula(s) shall apply:

$$\sum_{i=1}^{n} \frac{S_1}{S_{L,1}} + \frac{S_2}{S_{L,2}} + \frac{S_3}{S_{L,3}} + \cdots \frac{S_n}{S_{L,n}} \leq 1 \qquad (6)$$

where:
S is the measured/calculated power density;
S_L is the MPE limit.

Per 1.1310(e), the power density shall not exceed the levels below:

Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)
0.3 - 3.0	614	1.63	*100
3.0 – 30	1842/f	4.89/f	*900/f^2
30 – 300	61.4	0.163	1.0
300 – 1,500	-	-	f/300
1,500 – 100,000	-	-	5
Limits for General/Uncontrolled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)
0.3 – 1.34	614	1.63	*100
1.34 – 30	842/f	2.19/f	*180/f^2
30 – 300	27.5	0.073	0.2
300 – 1,500	-	-	f/1500
1,500 – 100,000	-	-	1.0

f – Frequency in MHz
* – Plane wave Equivalent Power Density

7.2. As mandated by the European Union and outlined in EN 62311,

The first step is to evaluate RF exposure either by measurement or by calculating the power density at an evaluation distance of 0.2m, as specified by ANSI/IEEE C95.1-1992. If it is determined that the measured or calculated power density does not meet the basic restrictions, a minimum separation distance must be measured or calculated such that the basic restrictions are met. The assessment is based on transmitter power levels, transmit frequency(s), and antenna parameters.

In environments where the possibility of simultaneous exposure to fields on different frequencies exists, the exposure shall be considered to be additive. The fraction of the recommended limit incurred within each frequency should be determined and the sum of all fractional contributions should not exceed 1.0.

The following formula shall apply:

$$\sum_{i=1}^{n} \frac{S_1}{S_{L,1}} + \frac{S_2}{S_{L,2}} + \frac{S_3}{S_{L,3}} + \cdots \frac{S_n}{S_{L,n}} \leq 1 \tag{7}$$

where:
S is the measured/calculated power density;
S_L is the power density limit.

Per the 1999/519/EC Council Recommendation, the measured field strength shall not exceed the levels below:

Reference Levels for Maximum Exposure			
Frequency Range	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
0 – 1 Hz	—	3.2×10^4	—
1 – 8 Hz	10000	$3.2 \times 10^4 / f^2$	—
8 – 25 Hz	10000	$4000 / f$	—
0.025 – 0.8 kHz	$250 / f$	$4 / f$	—
0.8 – 3 kHz	$250 / f$	5	—
3 – 150 kHz	87	5	—
0.15 – 1 MHz	87	$0.73 / f$	—
1 – 10 MHz	$87 / f^{1/2}$	$0.73 / f$	—
10 – 400 MHz	28	0.073	2
400 – 2000 MHz	$1.375\, f^{0.5}$	$0.0037 / f^{0.5}$	$f/200$
2 – 300 GHz	61	0.16	10
f as indicated in the frequency range column			

7.3. As mandated by the Innovation, Science and Economic Development Canada,

The next step is to evaluate RF exposure either by measurement or by calculating the power density at an evaluation distance of 0.2m, as specified by ANSI/IEEE C95.1-1992. If it is determined that the measured or calculated power density does not meet the basic restrictions, a minimum separation distance must be measured or calculated such that the basic restrictions are met. The assessment is based on transmitter power levels, transmit frequency(s), and antenna parameters.

In environments where the possibility of simultaneous exposure to fields on different frequencies exists, the exposure shall be considered to be additive. The fraction of the recommended limit incurred within each frequency should be determined, and the sum of all fractional contributions should not exceed 1.0.

The following formula(s) shall apply:

$$\sum_{i=1}^{n} \frac{S_{C,1}}{S_{L,1}} + \frac{S_{C,2}}{S_{L,2}} + \frac{S_{C,3}}{S_{L,3}} + \cdots \frac{S_{C,n}}{S_{L,n}} \leq 1 \tag{8}$$

where:
S_C is the measured/calculated power density;
S_L is the MPE limit.

Per RSS 102 Section 4, the power density shall not exceed the levels below:

Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
1 – 10	-	1.6 / f	-
1.29 – 10	193 / f$^{0.5}$	-	-
10 – 20	61.4	0.163	10
20 – 48	129.8 / f$^{0.5}$	0.3444 / f$^{0.5}$	44.72 / f^2
48 – 100	49.33	0.1309	6.455
100 – 6000	15.60 f$^{0.25}$	0.04138 f$^{0.25}$	0.6455 f$^{0.5}$
6000 – 15000	137	0.364	50
15000 – 150000	137	0.364	50
150000 – 300000	0.354 f$^{0.5}$	9.40x10^{-4} f$^{0.5}$	3.33x10^{-4} f
Limits for General/Uncontrolled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
0.1 – 10	-	0.73 / f	-
1.1 – 10	87 / f$^{0.5}$	-	-
10 – 20	27.46	0.0728	2
20 – 48	58.07 / f$^{0.25}$	0.1540 / f$^{0.25}$	8.944 / f$^{.05}$
48 – 300	22.06	0.05852	1.291
300 – 6000	3.142 f$^{0.3417}$	0.008335 f$^{0.3417}$	0.02619 f$^{0.6834}$
6000 – 15000	61.4	0.163	10
15000 – 150000	61.4	0.163	10
150000 – 300000	0.158 f$^{0.5}$	4.21x10^{-4} f$^{0.5}$	6.67x10^{-5} f
f – Frequency in MHz			

7.1. As mandated by Australia/New Zealand and outlined in AS/NZS 2772.2

The first step is to evaluate RF exposure either by measurement or by calculating the power density at an evaluation distance of 0.2m, as specified by ANSI/IEEE C95.1-1992. If it is determined that the measured or calculated power density does not meet the basic restrictions, a minimum separation distance must be measured or calculated such that the basic restrictions are met. The assessment is based on transmitter power levels, transmit frequency(s) and antenna parameters.

In environments where the possibility of simultaneous exposure to fields on different frequencies exists, the exposure shall be considered to be additive. The fraction of the recommended limit incurred within each frequency should be determined, and the sum of all fractional contributions should not exceed 1.0.

The following formula(s) shall apply:

$$\sum_{i=1}^{n} \frac{S_1}{S_{L,1}} + \frac{S_2}{S_{L,2}} + \frac{S_3}{S_{L,3}} + \cdots \frac{S_n}{S_{L,n}} \leq 1 \tag{9}$$

where:
S is the measured/calculated power density;
S_L is the MPE limit.

Per RPS 3, the calculated power density shall not exceed the levels below:

Limits for Occupational/Controlled Exposure			
Frequency Range	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
100kHz – 1MHz	614	1.63 / f	-
1MHz – 10MHz	614 / f	1.63 / f	1000 / f^2
10MHz – 400MHz	61.4	0.163	10
400MHz – 2GHz	3.07 x f$^{0.5}$	0.00814 / f$^{0.5}$	f / 40
2GHz – 300GHz	137	0.364	50
Limits for General/Uncontrolled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
100kHz – 150kHz	86.8	4.86	-
150Khz – 1MHz	86.8	0.729 / f	-
1MHz – 10MHz	86.8 / f$^{0.5}$	0.729 / f	-
10MHz – 400MHz	27.4	0.0729	2
400MHz – 2GHz	1.37 x f$^{0.5}$	0.00364 x f$^{0.5}$	f / 200
2GHz – 300GHz	61.4	0.163	10
f – Frequency in MHz			

8. Assessment Results

8.1. Evaluation Relevant to the Requirements of the FCC

The power density will be calculated for the worst case with a 100% transmitter duty cycle.

Radio Access Technology	f Mid-Band of Transmit Frequency (MHz)	Antenna Gain (dB)	Number of Antennas	G Maximum Antenna Gain (Linear)	P Output Power (mW)
WiFi U-NII-3	5785	5.9	2.00	7.78	148
Bluetooth	2426	4.5	1	2.82	6.4
WiFi 2.4GHz	2412	4.0	1	2.52	1000
Bluetooth	2426	4.2	1	2.64	8
E-UTRA B12	707.5	6	1.00	3.98	189

Assessment Results for Power Density Relative to Occupational/Controlled Exposure Limit					
Radio Access Technology	f Mid-Band of Transmit Frequency (MHz)	S Calculated Power Density (mW/cm^2)	MPE Limit (mW/cm^2)	S:MPE Ratio	Sum of S:MPE Ratios
WiFi U-NII-3	5785	0.22910	5.00	0.04582	
Bluetooth	2426	0.00359	5.00	0.00072	
WiFi 2.4GHz	2412	0.50088	5.00	0.10018	0.21
Bluetooth	2426	0.00421	5.00	0.00084	
E-UTRA B12	707.5	0.14969	2.36	0.06347	

8.2. Evaluation Relevant to the Requirements of the EU

The power density will be calculated for the worst case with a 100% transmitter duty cycle.

Radio Type	f Mid-Band of Transmit Frequency (MHz)	Antenna Gain (dB)	Number of Antennas	G Maximum Antenna Gain (Linear)	P Output Power (W)
WiFi U-NII-3	5785	5.9	2.00	7.78	0.148
Bluetooth	2426	4.5	1.00	2.82	0.0064
WiFi 2.4GHz	2412	4.01	1.00	2.52	1.000
Bluetooth	2426	4.22	1.00	2.64	0.008
E-UTRA B7	2500	9	1.00	7.94	0.240

Assessment Results for Power Density Relative to Exposure Limit					
Radio Type	f Mid-Band of Transmit Frequency (MHz)	S_C Calculated Power Density (W/m^2)	S_L Power Density Limit (W/m^2)	S_C:S_L Ratio	Sum of S_C:S_L Ratios
WiFi U-NII-3	5785	2.29098	10.00	0.22910	
Bluetooth	2426	0.03588	10.00	0.00359	
WiFi 2.4GHz	2412	5.00876	10.00	0.50088	1.12
Bluetooth	2426	0.04206	10.00	0.00421	
E-UTRA B7	2500	3.79264	10.00	0.37926	

Based on the initial assessment above, a minimum separation distance of 0.22m from the EUT is required to be compliant with the RF exposure limits of the EN 62311 specification. The details of the final assessment can be seen below:

Final Assessment Results for Power Density Relative to Exposure Limit					
Radio Type	f Mid-Band of Transmit Frequency (MHz)	Separation Distance (m)	S_C Calculated Power Density (W/m^2)	S_C:S_L Ratio	Sum of S_C:S_L Ratios
WiFi U-NII-3	5785		1.89337	0.18934	
Bluetooth	2426		0.02966	0.00297	
WiFi 2.4GHz	2412	0.22	4.13947	0.41395	0.92
Bluetooth	2426		0.03476	0.00348	
E-UTRA B7	2500		3.13441	0.31344	

8.3. Evaluation Relevant to the Requirements of ISED

The power density will be calculated for the worst case with a 100% transmitter duty cycle.

Radio Type	f Mid-Band of Transmit Frequency (MHz)	Antenna Gain (dB)	Number of Antennas	G Maximum Antenna Gain (Linear)	P Output Power (W)
WiFi U-NII-3	5785	5.9	2.00	7.78	0.148
Bluetooth	2426	4.5	1.00	2.82	0.0064
WiFi 2.4GHz	2412	4.01	1.00	2.52	1.000
Bluetooth	2426	4.22	1.00	2.64	0.008
E-UTRA B12	707.5	6	1.00	3.98	0.189

Assessment Results for Power Density Relative to Occupational/Controlled Exposure Limit					
Radio Type	f Mid-Band of Transmit Frequency (MHz)	S_C Calculated Power Density (W/m^2)	S_L Power Density Limit (W/m^2)	S_C:S_L Ratio	Sum of S_C:S_L Ratios
WiFi U-NII-3	5785	2.29098	49.10	0.04666	
Bluetooth	2426	0.03588	31.79	0.00113	
WiFi 2.4GHz	2412	5.00876	31.70	0.15800	0.29
Bluetooth	2426	0.04206	31.79	0.00132	
E-UTRA B12	707.5	1.49690	17.17	0.08718	

8.4. Evaluation Relevant to the Requirements of the AS/NZ

The power density will be calculated for the worst case with a 100% transmitter duty cycle.

Radio Type	f Mid-Band of Transmit Frequency (MHz)	Antenna Gain (dB)	Number of Antennas	G Maximum Antenna Gain (Linear)	P Output Power (W)
WiFi U-NII-3	5785	5.90	2	7.78	0.148
Bluetooth	2426	4.50	1	2.82	0.006
WiFi 2.4GHz	2412	4.01	1	2.52	1.000
Bluetooth	2426	4.22	1	2.64	0.008
E-UTRA B7	2500	9.00	1	7.94	0.240

Assessment Results for Power Density Relative to Occupational/Controlled Exposure Limit					
Radio Type	f Mid-Band of Transmit Frequency (MHz)	S_C Calculated Power Density (W/m^2)	S_L Power Density Limit (W/m^2)	S_C:S_L Ratio	Sum of S_C:S_L Ratios
WiFi U-NII-3	5785	2.29098	50.00	0.04582	
Bluetooth	2426	0.03364	50.00	0.00067	
WiFi 2.4GHz	2412	5.00876	50.00	0.10018	0.22
Bluetooth	2426	0.04206	50.00	0.00084	
E-UTRA B7	2500	3.79264	50.00	0.07585	

9. Statement of Compliance

The Astronics CSC Sierra™ Portable IFE, Model E71-319-01 Rev B is in compliance with the FCC, EU, ISED and AS/NZ requirements for RF Exposure at a minimum separation distance of 22m.