



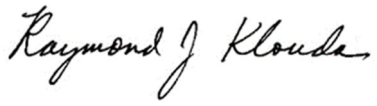
Engineering Test Report No. 2402851-03	
Report Date	January 27, 2025
Manufacturer Name	Badger Meter, Incorporated
Manufacturer Address	4545 W. Brown Deer Road Milwaukee, WI 53223
Product Name Brand/Model No.	ORION® Cellular HLEX
Date Received	December 12, 2024
Assessment Date	January 27, 2025
Specifications	FCC 47 CFR Part 2.1093 KDB, 447498 D01 OET Bulletin 65:1997 RSS-102 Issue 6
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1. Report Revision History

Revision	Date	Description
–	03 FEB 2025	Initial Release of Engineering Test Report No. 2402851-03

2. Introduction

The FCC, Innovation, Science and Economic Development Canada, European Union and Australia/New Zealand publish standards regarding the evaluation of the RF Exposure hazard of radio communications devices. An evaluation has been performed on the Badger Meter, Incorporated ORION® Cellular HLEX, Model No. HLEX pursuant to the relevant requirements.

3. Subject of Investigation

This document presents the demonstration of RF Exposure compliance on a ORION® Cellular HLEX, (hereinafter referred to as the Equipment under Test (EUT)). The EUT was identified as follows:

EUT Identification	
Description	ORION® Cellular HLEX
Model/Part No.	HLEX
S/N	170000119 (Standard Antenna)
Radio Access Technology	FHSS, LTE
Bands of Operation	CAT M1 LTE Band 2 902-928MHz FHSS
EIRP	23.6dBm (LTE Band 2) 21.9dBm (900MHz FHSS)

4. Standards and Requirements

The tests were performed to selected portions of, and in accordance with the following specifications.

- 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 Policies 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,"
- RSS-102, Issue 6 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

5. Sample Calculations

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

$$S = \frac{PG}{4\pi R^2} \quad (1)$$

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:

$$Gain (dBi) = G + 10 \log N \quad (2)$$

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

$$\text{Minimum Separation Distance} = \sqrt{\frac{PG}{4\pi(\text{Power Density Limit})}} \quad (3)$$

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

$$\text{Separation Distance} = R \left(10^{\frac{(FS_{Limit} - FS_R)}{40}} \right)^{-1} \quad (4)$$

For sources with frequencies >30MHz

$$\text{Separation Distance} = R \left(10^{\frac{(FS_{Limit} - FS_R)}{20}} \right)^{-1} \quad (5)$$

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. Requirements mandated by the FCC

Equipment pursuing compliance to the requirements with respect to the limits of human exposure to RF provided in FCC 1.1310, need follow the criteria in FCC 1.1307(b)(1).

Equipment exemption qualification must be demonstrated pursuant to FCC 1.1307(b)(3).

For single RF sources (i.e., any single portable device, mobile device or fixed RF source), the EUT is exempt if:

- FCC 1.1307(b)(3)(i)(A) - The available maximum time-averaged power is no more than 1 mW, regardless of separation distance.
- FCC 1.1307(b)(3)(i)(B) - 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). This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive).
- FCC 1.1307(b)(3)(i)(C) – The available maximum ERP (watts) shall not exceed the calculated ERP_{th} (watts) in this section. For the exemption to apply, the separation distance, R (meters), must be at least $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

For multiple RF sources (i.e., any single portable device, mobile device or fixed RF source), the EUT is exempt if:

- FCC 1.1307(b)(3)(ii)(A) The available maximum time-averaged power of each source is no more than 1 mW and there is a separation distance of two centimeters between any portion of a radiating structure operating and the nearest portion of any other radiating structure in the same device, except if the sum of multiple sources is less than 1 mW during the time-averaging period, in which case they may be treated as a single source (separation is not required).
- FCC 1.1307(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.

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

If it is determined that the equipment under investigation is not exempt from routine evaluation an assessment must be performed to determine compliance in regard to the RF exposure limits by means of measurement or calculation of the electric field, magnetic field, power density or SAR.

It may be the case that a minimum separation distance will need to be calculated or measured and maintained from the source of RF to meet radiofrequency radiation exposure restrictions.

Per 1.1310(e)(1), the power density shall not exceed the levels below:

Specific Absorption Rate (SAR) - SAR Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	Whole Body SAR Limit (W/kg)	Peak Spatial AVG SAR Limit (W/kg)	Peak Spatial Extremities SAR Limit 10g (W/kg)
0.1 - 6000	0.4	8	20
Specific Absorption Rate (SAR) - SAR Limits for General/Uncontrolled Exposure			
Frequency Range (MHz)	Whole Body SAR Limit (W/kg)	Peak Spatial AVG SAR Limit 1g (W/kg)	Peak Spatial Extremities SAR Limit 10g (W/kg)
0.1 - 6000	0.08	1.6	4

Limits for Maximum Permissible Exposure (MPE) - 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 Maximum Permissible Exposure (MPE) - 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. Requirements mandated by Innovation, Science and Economic Development Canada

Equipment exemption qualification must be demonstrated pursuant to RSS-102 Issue 6 section 6. If it is determined that the equipment under investigation is not exempt, it must be demonstrated that the equipment does not exceed the exposure limits in section 5 of RSS-102 Issue 6 or a minimum separation distance must be calculated to ensure that the exposure limits are met.

Per RSS 102 Section 5, the equipment shall not exceed the levels below:

Specific Absorption Rate (SAR) - SAR Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	Whole Body SAR Limit (W/kg)	Peak Spatial AVG SAR Limit (W/kg)	Peak Spatial Extremities SAR Limit 10g (W/kg)
0.1 - 6000	0.4	8	20
Specific Absorption Rate (SAR) - SAR Limits for General/Uncontrolled Exposure			
Frequency Range (MHz)	Whole Body SAR Limit (W/kg)	Peak Spatial AVG SAR Limit 1g (W/kg)	Peak Spatial Extremities SAR Limit 10g (W/kg)
0.1 - 6000	0.08	1.6	4

Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m ²)
0.003 – 10*	170	180	—
0.1 – 10*	—	1.6 / f	—
1.29 – 10*	193 / f ^{0.5}	—	—
10 – 20	61.4	0.163	10
20 – 48	129.8 / f ^{0.25}	0.3444 / f ^{0.25}	44.72 / f ^{0.5}
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)
0.003 – 10*	83	90	—
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 ^{0.5}
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			
*Limits only apply to Specific Absorption Rate and Nerve Stimulation requirements.			

8. Assessment Results

The following evaluation(s) was performed at a separation distance of 20cm. The separation distance was measured based on the minimum use case separation between the radiating element of the RF source and the end user.

8.1. RF Exposure Evaluation Pertinent to the Requirements of the FCC for Standalone Source(s)

The table below contains the highest measured, calculated or reported field strengths and output power for each RF source.

Radio Access Technology	f Transmit Frequency (MHz)	ERP (mW)	EIRP (mW)
LTE B2	1880	139.6	229.1
900MHz FHSS	904.9	94.4	154.9

The output power levels listed above were used to complete an exemption assessment. The result are as follows:

Radio Access Technology	f Transmit Frequency (MHz)	Time-Averaged ERP (mW)	ERP (W)	ERP _{th} (W)	Exemption Rule	Exemption Results
LTE B2	1880	139.6	0.140	0.768	FCC 1.1307(b)(3)(i)(C)	Exempt
900MHz FHSS	904.9	94.4	0.094	0.463	FCC 1.1307(b)(3)(i)(C)	Exempt

It was determined that the EUT is exempt from routine evaluation per FCC 1.1307(b)(3)(i)(C).

8.2. RF Exposure Evaluation Pertinent to the Requirements of the FCC for Multiple RF Source(s)

The table below contains the highest measured, calculated or reported field strengths and output power for each RF source.

Radio Access Technology	f Transmit Frequency (MHz)	ERP (mW)	EIRP (mW)
LTE B2	1880	139.6	229.1
900MHz FHSS	904.9	94.4	154.9

The output power levels listed above were used to complete an exemption assessment. The result are as follows:

Radio Access Technology	f Transmit Frequency (MHz)	S_c Calculated Power Density (mW/cm ²)	Threshold Limit	Fractional Contribution	Σ Fractional Contributions
LTE B2	1880	0.1	1mW/cm ² MPE	0.05	0.08
900MHz FHSS	904.9	0.1	1mW/cm ² MPE	0.03	

It was determined that the EUT is exempt from routine evaluation per FCC 1.1307(b)(3)(ii)(B).

8.3. RF Exposure Evaluation Relevant to the Requirements of the ISED for Standalone and Multiple RF Sources

The following evaluation(s) was performed at a separation distance >20cm. The separation distance was measured based on the minimum use case separation between the radiating element of the RF source and the end user.

The table below contains the highest measured, calculated or reported field strengths and output power for each RF source.

Radio Access Technology	f Transmit Frequency (MHz)	ERP (mW)	EIRP (mW)
LTE B2	1880	139.6	229.1
900MHz FHSS	904.9	94.4	154.9

The output power levels listed above were used to complete an exemption assessment. The result are as follows:

Radio Access Technology	f Transmit Frequency (MHz)	Nerve Stimulation ¹	SAR ²	Localized APD ³	Localized IPD ⁴	FRL ⁵
LTE B2	1880	N/A	N/A	N/A	N/A	Exempt
900MHz FHSS	904.9	N/A	N/A	N/A	N/A	Exempt

¹Only applicable to inductive systems operating in the 3kHz to 10MHz range with loop outer dimensions less than or equal to 100mm and separation distances greater than and equal to 0.15mm and separation distance less than or equal to 50mm.

²Only applicable to sources operating in the 100kHz to 6GHz range if the separation between the user or bystander is less than and equal to 20cm.

³Only applicable to sources operating in the 7GHz to 30GHz range if the separation between the user or bystander is less than and equal to 20cm.

⁴Only applicable to sources operating in the 6GHz to 30GHz range.

⁵Only applicable to sources operating at or below 6GHz if the separation between the user or bystander is greater than 20cm.

9. Statement of Compliance

The Badger Meter, Incorporated ORION® Cellular HLEX, Model HLEX is in compliance with the FCC and Innovation, Science and Economic Development Canada requirements for RF Exposure at a minimum separation distance of 20cm.

10. Certification

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the FCC and Innovation, Science and Economic Development Canada requirements for RF Exposure test specifications. The data presented in this test report pertains to the EUT as provided by the customer on the test date specified. Any electrical or mechanical modifications made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.