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GEOSPACE TECHNOLOGIES CORPORATION RF EXPOSURE REPORT

SCOPE OF WORK
RF EXPOSURE CALCULATION
ON THE PIONEER

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RF EXPOSURE TEST REPORT

Report Number: 106147890LEX-006

Project Number: G106147890

Report Issue Date: 4/30/2025

Product Name: Pioneer

Product Model: Pioneer

Standards: FCC Title 47 CFR Part 1.1310(e)(1) Limits for
Maximum Permissible Exposure (MPE)

RSS-102 Issue 6 RF Field Strength Limits for
Devices Used by the General Public

EN IEC 62311:2020,
with limits from ICNIRP Guidelines (2020)

Tested by:
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Client:
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1 Introduction and Conclusion

The tests indicated in section 2 were performed on the product constructed as described in section 4. 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
11	FCC Title 47 CFR Part 1.1310(e)(1) Limits for Maximum Permissible Exposure (MPE) (Limits for General Population / Uncontrolled Exposure)	Pass
	RSS-102 Issue 6 RF Field Strength Limits (For Devices Used by the General Public)	Pass
	ICNIRP Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz) (2020) (EN IEC 62311:2020)	Pass



3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	GEOSPACE TECHNOLOGIES CORPORATION
Address:	7007 Pinemont Dr Houston, TX 77040-6601 USA
Contact:	Mark McAllister
Telephone:	2816301341
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Manufacturer Information	
Manufacturer Name:	GEOSPACE TECHNOLOGIES CORPORATION
Manufacturer Address:	7007 Pinemont Dr Houston, TX 77040-6601 USA



4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	Pioneer
Model Number	Pioneer
Hardware Version	N/A
Software Version	N/A
FCC ID	WAOPIO
Wireless Technology	802.15.4
Supported Transmit Bands	2405MHz - 2475MHz
Antenna Gain ¹	3.3dBi
Maximum Output Power	-2.56dBm
Ratings	3.7VDC
Description of Equipment Under Test (provided by client)	
<p>The Pioneer™ is a small, lightweight, single-component, autonomous land wireless seismic data acquisition solution. One GS-5 vertical geophone (5 Hz) internal geophone, battery, 24-bit digitizer, GPS receiver are enclosed in its sealed case. Faster and more efficient operations can be achieved with the use of the Pioneer by eliminating the process of engaging connectors for power and data transfer.</p>	

4.1 Variant Models:

There were no variant models covered by this evaluation.

¹ Values were provided by the client and may affect compliance. Intertek does not make any claims of compliance for values other than those shown.



5 Output Power

Output power was taken from section 8.8 of Intertek report 106147890LEX-003.

8.8 Test Data:

Frequency (MHz)	Output Power (dBm)	Output Power (W)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (W)	Output Power Limit (W)	EIRP Limit (W)
2405	-3.18	0.00048	3.30	0.120	0.001	1	4
2440	-2.86	0.00052	3.30	0.440	0.001	1	4
2475	-2.56	0.00055	3.30	0.740	0.001	1	4



6 Antenna Gain

Antenna gain was taken from Texas Instruments DN0007.

5 Conclusion

The PCB antenna presented in this document performs well for all frequencies in the 2.4 GHz ISM band. Except for two narrow dips, the antenna has an omni directional radiation pattern in the plane of the PCB. These properties will ensure stable performance regardless of operating frequency and positioning of the antenna. Table 2 lists the most important properties for the inverted F antenna.

Gain in XY Plane	1.1 dB
Gain in XZ Plane	3.3 dB
Gain in YZ Plane	1.6 dB
Reflection	< -15 dB
Antenna Size	25.7 x 7.5 mm

Table 2. Summary of the Properties of the IFA



7 FCC RF Exposure Limits

Title 47 CFR Part 1.1310(d)(2):

For operations within the frequency range of 300 kHz and 6 GHz (inclusive), the limits for maximum permissible exposure (MPE), derived from whole-body SAR limits and listed in Table 1 in paragraph (e)(1) of this section, may be used instead of whole-body SAR limits as set forth in paragraphs (a) through (c) of this section to evaluate the environmental impact of human exposure to RF radiation as specified in § 1.1307(b) of this part, except for portable devices as defined in § 2.1093 of this chapter as these evaluations shall be performed according to the SAR provisions in § 2.1093.

Table 1 to § 1.1310(e)(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				
0.3–1.34	614	1.63	*(100)	<30
1.34–30	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.



8 RSS-102 Issue 6 RF Exposure Limits

RSS-102 Issue 6 § 6.6:

Field reference level (FRL) 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 (i.e. mobile devices), except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 1 W (adjusted for tune-up tolerance)
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance)
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz
- at or above 6 GHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 5 W (adjusted for tune-up tolerance)

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

RSS-102 Issue 6 § 5.3.2:

The electric and magnetic field strength reference levels, power density reference levels, and associated reference period for devices employed by the general public (uncontrolled environment) and controlled-use devices (controlled environment) are specified in table 7 and table 8. Note that the power density limits specified in these tables apply to whole body exposure conditions.

Table 7: RF field strength and power density limits for devices used by the general public (uncontrolled environment)

Frequency range (MHz)	Electric field (V _{RMS} /m)	Magnetic field (A _{RMS} /m)	Power density (W/m ²)	Reference period (minutes)
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	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000 / f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000 / f^{1.2}$

Note: f is frequency in MHz.



9 ICNIRP Guidelines (2020) RF Exposure Limits

Table 5. Reference levels for exposure, averaged over 30 min and the whole body, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values).^a

Exposure scenario	Frequency range	Incident E-field strength; E_{inc} ($V\ m^{-1}$)	Incident H-field strength; H_{inc} ($A\ m^{-1}$)	Incident power density; S_{inc} ($W\ m^{-2}$)
Occupational	0.1 – 30 MHz	$660/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	61	0.16	10
	>400 – 2000 MHz	$3f_M^{0.5}$	$0.008f_M^{0.5}$	$f_M/40$
	>2 – 300 GHz	NA	NA	50
General public	0.1 – 30 MHz	$300/f_M^{0.7}$	$2.2/f_M$	NA
	>30 – 400 MHz	27.7	0.073	2
	>400 – 2000 MHz	$1.375f_M^{0.5}$	$0.0037f_M^{0.5}$	$f_M/200$
	>2 – 300 GHz	NA	NA	10

^aNote:

1. “NA” signifies “not applicable” and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz.
3. S_{inc} , E_{inc} , and H_{inc} are to be averaged over 30 min, over the whole-body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither E_{inc} or H_{inc} exceeds the above reference level values.
5. For frequencies of >30 MHz to 2 GHz: (a) within the far-field zone: compliance is demonstrated if either S_{inc} , E_{inc} or H_{inc} , does not exceed the above reference level values (only one is required); S_{eq} may be substituted for S_{inc} ; (b) within the radiative near-field zone, compliance is demonstrated if either S_{inc} , or both E_{inc} and H_{inc} , does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance, and so basic restrictions must be assessed.
6. For frequencies of >2 GHz to 300 GHz: (a) within the far-field zone: compliance is demonstrated if S_{inc} does not exceed the above reference level values; S_{eq} may be substituted for S_{inc} ; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values; and (c) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.



10 Test Procedure

An RF exposure calculation was performed to show that the device was compliant with the general population exposure limits from FCC Title 47 CFR Part 1.1310(e)(1), RSS-102 Issue 6, and ICNIRP Guidelines (2020). The maximum power density was calculated for each transmitter at a separation distance of 20cm using the maximum conducted output power (including tune up tolerance) plus antenna gain, or measured EIRP.

For each transmitter the maximum power density at a 20cm distance using the formula:

$$EIRP(dBm) = Conducted\ Power(dBm) + Antenna\ Gain(dBi)$$

$$EIRP(mW) = 10^{EIRP(dBm)/10}$$

$$Power\ Density\left(mW/cm^2\right) = \frac{EIRP(mW)}{4\pi \cdot (20cm)^2}$$

$$Power\ Density\left(W/m^2\right) = \left(\frac{100cm}{1m}\right)^2 \left(\frac{1W}{1000mW}\right) Power\ Density\left(mW/cm^2\right)$$

For transmitters that could operate simultaneously, the ratio of calculated power density to the corresponding limit for each transmitter was calculated and then summed. If the sum of the ratios was less than 1, that specific combination of transmitters was deemed to comply.



11 Results:

The calculated maximum power density at 20cm was less than or equal to the limits for general population exposure in FCC Title 47 CFR Part 1.1310(e)(1), RSS-102 Issue 6, and ICNIRP Guidelines (2020).

**11.1 FCC RF Exposure Data**

Band / Modulation	Channel	Frequency (MHz)	Max Cond. Power (dBm)	Antenna Gain (dB)	EIRP (dBm)	MPE Value @ 20cm (mW/cm ²)	MPE Limit (mW/cm ²)
802.15.4	11	2405	-3.18	3.3	0.12	0.0002	1.0000
	18	2440	-2.86	3.3	0.44	0.0002	1.0000
	25	2475	-2.56	3.3	0.74	0.0002	1.0000

**11.2 RSS-102 Issue 6 RF Exposure Data**

Band	Channel	Frequency (MHz)	Max Cond. Power (dBm)	Antenna Gain (dB)	EIRP (dBm)	MPE Value @ 20cm (W/m ²)	MPE Limit (W/m ²)
802.15.4	11	2405	-3.18	3.3	0.12	0.0020	5.3554
	18	2440	-2.86	3.3	0.44	0.0022	5.4085
	25	2475	-2.56	3.3	0.74	0.0024	5.4614

**11.3 ICNIRP Guidelines (2020) RF Exposure Data**

Band	Channel	Frequency (MHz)	Output Power (dBm)	Antenna Gain (dB)	EIRP (dBm)	MPE Value @ 20cm (W/m ²)	MPE Limit (W/m ²)
802.15.4	11	2405	-3.18	3.3	0.12	0.0020	10.0000
	18	2440	-2.86	3.3	0.44	0.0022	10.0000
	25	2475	-2.56	3.3	0.74	0.0024	10.0000

**12 Revision History**

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	4/30/2025	106147890LEX-006	JP	MC	Original Issue