Exposure Calculation Report

Sepura Limited
TETRA mobile radio, Model: SCG22 Series Incorporating GPSB4 Fin Antenna and 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)/ 9525-800-41082 (ANT VEH 3/4 UHF 380-400)/9525-800-41084 (ANTVEH 3/4 UHF 410-430) Antenna Options

In accordance with FCC CFR 47 Part 1.1310

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Jon Kenny	RF Manager	Authorised Signatory	17 March 2021

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EXECUTIVE SUMMARY
The calculation of exposure for this product was found to be compliant at minimum distances of 50 cm (Occupational) for all three listed TETRA antenna options, a minimum distance of 1.0 m using antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC), 1.1 m using antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400) and 1.1 m using antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430) with FCC CFR 47 Part 1.1307 assuming continuous exposure of 6 minutes or more. If alternative antennas are used with greater gains, the distance must be recalculated.

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	29 July 2020
2	Recalculation with amendment to TETRA output power.	25 September 2020
3	To modify the FCC ID from XX6SCG2229 to XX6SCG2229W	17 March 2021

Table 1

1.2 Introduction

Applicant	Sepura Limited
Manufacturer	Sepura Limited
Model Number(s)	SCG22 Series
Hardware Version(s)	Pre-production
Software Version(s)	1785 004 10138
Specification/Issue/Date	• FCC 47 CFR Part 1.1310
Order Number Date	PLC-PO016029-1 28/04/2020
Related Document(s)	• OET65:97 Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields • IEEE C95.3:2002 IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to Such Fields, 100 kHz–300 GHz

1.3 Brief Summary of Results

The wireless device described within this report was compliant with the restrictions related to human exposure to electromagnetic fields for both general public and worker/occupational exposures.

The calculations shown in this report were made in accordance with the procedures specified in the applied test specification(s).

1.3.1 Compliance Boundary

Regional Requirement	Configuration	Calculated minimum compliance boundary (m) (rounded up to nearest 0.1 m)	
		Worker/Occupational	General Public
CANADA	TETRA using antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	0.5	1.0
CANADA	TETRA using antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)	0.5	1.1
CANADA	TETRA using antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)	0.5	1.1
CANADA	WIFI using antenna GPSB4	0.2	0.2
CANADA	Bluetooth using antenna GPSB4	0.2	0.2

Table 2 – Compliance Boundary Calculation Results

1.4 Product Information

1.4.1 Technical Description

TETRA mobile radio for use within cars, trucks, mobile and fixed control rooms, motorcycles, boats and trains, with Wi-Fi, Bluetooth, GPS and Ethernet functions.

1.4.2 Transmitter Description

The following radio access technologies and frequency bands are supported by the equipment under test.

Radio Access Technology	Antenna Port	Frequency Band (MHz)	Minimum Frequency (MHz)	Output Power (dBm)	Duty Cycle (%)
Tetra using antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	1	450- 470	450.0	41.5	50.0
Tetra using antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)	1	380 - 400	380.0	41.5	50.0
TETRA using antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)	1	410 - 430	410.0	41.5	50.0
WIFI using antenna GPSB4	2	2412 - 2462	2412	17.0	98.0
Bluetooth using antenna GPSB4	2	2402 - 2480	2402	7.4	77.5

Table 3 – Transmitter Description

1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

Antenna No	Radio Access Technology	Antenna Model	Gain (dBi)	Antenna length (cm)
1	TETRA	9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	7.0	60.0
1	TETRA	9525-800-41082 (ANT VEH 3/4 UHF 380-400)	7.0	77.1
1	TETRA	9525-800-41084 (ANT VEH 3/4 UHF 410-430)	7.0	71.3
2	WIFI	GPSB4	2.0	12.0
2	Bluetooth	GPSB4	2.0	12.0

Table 4 – Antenna description

If other antennas can be used that have greater gains, the minimum separation distances will need to be recalculated.

1.4.4 Equipment Configuration

Simultaneous transmission of TETRA 380 – 400 MHz band and WLAN 2412 – 2462 MHz band. (Shark Fin Antenna GPSB4 and antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)

Simultaneous transmission of TETRA 380 – 400 MHz band and Bluetooth 2402 – 2480 MHz band (Shark Fin Antenna GPSB4 and antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)

Simultaneous transmission of TETRA 410 - 430 MHz band and WLAN 2412 – 2462 MHz band. (Shark Fin Antenna GPSB4 and antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)

Simultaneous transmission of TETRA 410 - 430 MHz band and Bluetooth 2402 – 2480 MHz band (Shark Fin Antenna GPSB4 and antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)

Simultaneous transmission of TETRA 450 - 470 MHz band and WLAN 2412 – 2462 MHz band. (Shark Fin Antenna GPSB4 and antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)

Simultaneous transmission of TETRA 450 - 470 MHz band and Bluetooth 2402 – 2480 MHz band (Shark Fin Antenna GPSB4 and antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)

2 Assessment Details

2.1 Assessment Method

The assessment method is by calculation of the power density S, electric field strength E, magnetic field strength H or magnetic flux density B.

The calculation uses the spherical model applicable under far field conditions.

$$S = E \times H = \frac{E^2}{\eta} = H^2 \times \eta = \frac{P \times G_i}{4 \times \pi \times r^2}$$

Where:
η - Impedance of free space (377 ohm in far field)
P – Average transmitter power W (P_{av} = P_{max} x Duty Cycle)
G_i – Antenna gain ratio relative to isotropic
r – Separation distance m

The magnetic flux density is related to the magnetic field strength by a constant:

$$B = \mu_o \times H$$

Where:
μ_o – Permeability of free space 4 x π E-7 H/m

This assessment assumes that exposure is continuous for 6 minutes or more in accordance with the averaging time required by the exposure standards at the stated minimum compliance boundary separation distance. Exposures of less than 6 minutes at other separation distances are not addressed by this report.

This assessment method of RF exposure is applicable to separation distances of 20 cm or more. Separation distances of less than 20 cm require a Specific Absorption Rate (SAR) assessment.

The far field region boundary depends on the frequency and wavelength and also on the antenna dimension. The boundary of the far field region is calculated below to demonstrate the validity of using the spherical model.

The result is compared to the limits in Annex A to determine compliance or to calculate the required compliance distance. The calculation is based on the lowest frequency in each band as the most onerous requirement as the limits increase with frequency for frequencies above 10-50 MHz (dependent on region).

2.2 Individual Antenna Port Exposure Results

2.2.1 Calculation of Compliance Distance

The frequencies shown in the tables below have been chosen based on the lowest possible frequency that the EUT can transmit. A full list of the regional requirements is shown in Annex A.

Antenna Port	RAT	Antenna	Frequency (MHz)	Minimum Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
1	TETRA	9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	450.0	0.4333	N/A	N/A	N/A
1	TETRA	9525-800-41082 (ANT VEH 3/4 UHF 380-400)	380.0	0.4716	N/A	N/A	N/A
1	TETRA	9525-800-41084 (ANT VEH 3/4 UHF 410-430)	410.0	0.4540	N/A	N/A	N/A
2	WLAN	GPSB4	2412.0	0.0111	N/A	N/A	N/A
2	Bluetooth	GPSB4	2402.0	0.0033	N/A	N/A	N/A

Table 5 – Calculation of Compliance Distance Worker/Occupational

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m for all three TETRA antenna variants.

Antenna Port	RAT	Antenna	Frequency (MHz)	Minimum Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
1	TETRA	9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	450.0	0.9690	N/A	N/A	N/A
1	TETRA	9525-800-41082 (ANT VEH 3/4 UHF 380-400)	380.0	1.0545	N/A	N/A	N/A
1	TETRA	9525-800-41084 (ANT VEH 3/4 UHF 410-430)	410.0	1.0152	N/A	N/A	N/A
2	WLAN	GPSB4	2412.0	0.0249	N/A	N/A	N/A
2	Bluetooth	GPSB4	2402.0	0.0073	N/A	N/A	N/A

Table 6 – Calculation of Compliance Distance General Public

The calculations show that the EUT complies with the general public exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 1.0 m with antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC), 1.1 m with antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400) and 1.1 m with antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430) fitted to the EUT.

The following table shows the regional requirements for the frequencies used in the RF exposure calculation. A full list of the requirements is shown in Annex A.

Regional Requirement	Frequency (MHz)	Worker/Occupational Limit				General Public Limit			
		S Power Density (W/m^2)	E Field (V/m)	H Field (A/m)	B Field (µT)	S Power Density (W/m^2)	E Field (V/m)	H Field (A/m)	B Field (µT)
FCC	450	15.00	N/A	N/A	N/A	3.00	N/A	N/A	N/A
FCC	380	12.67	N/A	N/A	N/A	2.53	N/A	N/A	N/A
FCC	410	13.67	N/A	N/A	N/A	2.73	N/A	N/A	N/A
FCC	2412	50.00	N/A	N/A	N/A	10.00	N/A	N/A	N/A
FCC	2402	50.00	N/A	N/A	N/A	10.00	N/A	N/A	N/A

Table 7 – Limits

2.3 Combined Antenna Port RF Exposure Results

As the frequency of operation for each transmitter is not the same, in order to evaluate compliance with the limit which is dependent on frequency, the fractional exposure value is calculated: The calculated S power density is divided by the limit to get a fractional exposure value. The calculated E and H fields are divided by the limit and squared to get a fractional exposure value. The summation of the fractional RF exposure results for each transmitter provides the combined result. Any values less than one are compliant with the limit.

Calculations are made on an Excel spreadsheet and numbers may not add up exactly due to rounding.

FCC OET 65 specifies the method of summation in clause; Multiple-Transmitter Sites and Complex Environments; with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 0.5 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	450	0.7512	N/A	N/A	N/A
2	WLAN	2412	0.0031	N/A	N/A	N/A
2	Bluetooth	2402	0.0003	N/A	N/A	N/A
Summation Tetra + WLAN			0.7542	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.7514	N/A	N/A	N/A

Table 8 – FCC Worker/Occupational Combined Exposure - (GPSB4 with antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC))

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 1.0 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	450	0.9389	N/A	N/A	N/A
2	WLAN	2412	0.0155	N/A	N/A	N/A
2	Bluetooth	2402	0.0013	N/A	N/A	N/A
Summation Tetra + WLAN			0.9544	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.9403	N/A	N/A	N/A

Table 9 – FCC General Public Combined Exposure - (GPSB4 with antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC))

The calculations show that the EUT complies with the general public exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 1 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 0.5 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	380	0.8895	N/A	N/A	N/A
2	WLAN	2412	0.0031	N/A	N/A	N/A
2	Bluetooth	2402	0.0003	N/A	N/A	N/A
Summation Tetra + WLAN			0.8926	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.8898	N/A	N/A	N/A

Table 10 – FCC Worker/Occupational Combined Exposure - (GPSB4 with antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 1.1 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	380	0.9189	N/A	N/A	N/A
2	WLAN	2412	0.0155	N/A	N/A	N/A
2	Bluetooth	2402	0.0013	N/A	N/A	N/A
Summation Tetra + WLAN			0.9344	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.9203	N/A	N/A	N/A

Table 11 – FCC General Public Combined Exposure - (GPSB4 with antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 1.1 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 0.5 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	410	0.8244	N/A	N/A	N/A
2	WLAN	2412	0.0031	N/A	N/A	N/A
2	Bluetooth	2402	0.0003	N/A	N/A	N/A
Summation Tetra + WLAN			0.8275	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.8247	N/A	N/A	N/A

Table 12– FCC Worker/Occupational Combined Exposure - (GPSB4 with antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430))

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 1.1 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
			Summation for simultaneous exposure; value to be <1			
1	TETRA	410	0.8517	N/A	N/A	N/A
2	WLAN	2412	0.0155	N/A	N/A	N/A
2	Bluetooth	2402	0.0013	N/A	N/A	N/A
Summation Tetra + WLAN			0.8671	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.8530	N/A	N/A	N/A

Table 13 – FCC General Public Combined Exposure - (GPSB4 with antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430))

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, a minimum distance of 1.1 m.

2.4 Far Field Region Boundary Results

The far field region boundary calculation result is shown in Table

Near Field / Far Field Boundary (Ref: IEEE C95.3 Annex B.2)			
RAT/ Configuration Name	Frequency MHz	Reactive Near Field Boundary (Wave Impedance Dependent)	Far Field Boundary (Antennas on axis)
		λ/4 (m)	$2D^2/\lambda$ (m)
TETRA using antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	450.0	0.1667	1.0800
TETRA using antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)	380.0	0.1974	1.5059
TETRA using antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)	410.0	0.1829	1.3895
WIFI using antenna GPSB4	2412.0	0.0311	0.2316
Bluetooth using antenna GPSB4	2402.0	0.0312	0.2306

Table14 – Far Field Boundary

The table below shows the maximum calculated near field / far field region boundaries.

RAT / Configuration	Field Region			Compliance Boundary Location (m) - Occupational	Compliance Boundary Location (m) - General Public
	Reactive Near Field Region (m)	Radiating Near Field Region (m)	Far Field Region(m)		
TETRA using antenna 9525-800-41080 (ANT VEH 5/8 UHF 450-470 UC)	< 0.1667	0.1667 - 1.0800	> 1.0800	0.5	1.0
TETRA using antenna 9525-800-41082 (ANT VEH 3/4 UHF 380-400)	< 0.1974	0.1974 - 1.5059	> 1.5059	0.5	1.1
TETRA using antenna 9525-800-41084 (ANT VEH 3/4 UHF 410-430)	< 0.1829	0.1829 - 1.3895	> 1.3895	0.5	1.1
WIFI using antenna GPSB4	< 0.0311	0.0311 - 0.2316	> 0.2316	0.2	0.2
Bluetooth using antenna GPSB4	< 0.0312	0.0312 - 0.2306	> 0.2306	0.2	0.2

Table 15 - Assessment Method Validity

The table shows that the compliance boundaries are not within the reactive near field region, where the spherical model could lead to a potential underestimate, therefore the approach described in section 2.1 is valid. The spherical model is valid in the far field region and overestimates in the radiating near field region, therefore being a conservative assessment.

2.5 Uncertainty

The basic computation formulas presented in section 2.1 are conservative formulas for the estimation of RF field strength or power density. No uncertainty estimations are required when using these formulas but there is clear guidance on where and when these formulas are applicable.

For the estimate of S, E or H to be conservative, the transmitter power P and antenna gain G_i values shall be the upper bounds of uncertainty therefore maximum values are used.

The spherical formula is valid under far field conditions which are established in section 2.4.

ANNEX A

REGIONAL REQUIREMENTS

Frequency Range (MHz)	Power Density (mW/cm^2) Note 1	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	900/f^2	1842/f	4.89/f
30 - 300	1	61.4	0.163
300 - 1500	f/300	-	-
1500 - 100000	5	-	-

Table A.1 – CFR 47 Pt1.1310 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (mW/cm^2) Note 1	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	180/f^2	824/f	2.19/f
30 - 300	0.2	27.5	0.073
300 - 1500	f/1500	-	-
1500 - 100000	1	-	-

Table A.2 – CFR 47 Pt1.1310 General Public Limits

Note 1: The calculations and limits presented in this report for power density are in units of W/m^2. The conversion factor is; 1 mW/cm^2 = 10 W/m^2.