Exposure Calculation Report

Sepura Limited
TETRA mobile radio, Model: SCG22 Series Incorporating GPSB4 Fin Antenna and AFB-TET Or AFB-UT TETRA Antenna

In accordance with FCC CFR 47 Part 1.1310

Prepared for: Sepura Limited
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EXECUTIVE SUMMARY
The calculation of exposure for this product was found to be compliant at minimum distances of 30 cm (Occupational) and 50 cm (Public) using AFB-TET antenna option and of 30 cm (Occupational) and 50 cm (Public) using AFB-UT antenna option 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	01 May 2020

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	Limited-PO015400-1 10/02/2020
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 at the minimum compliance distances calculated

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
FCC	TETRA + WLAN (GPSB4 with AFB-TET Antenna)	0.3	0.5
FCC	TETRA + WLAN (GPSB4 with AFB-UT Antenna)	0.3	0.5
FCC	TETRA + Bluetooth (GPSB4 with AFB-TET Antenna)	0.3	0.5
FCC	TETRA + Bluetooth (GPSB4 with AFB-UT Antenna)	0.3	0.5

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 (GPSB4 with AFB-TET antenna)	1	380 - 430	380	40.0	50.0*
Tetra using (GPSB4 with AFB-UT antenna)	1	406 - 470	380	40.0	50.0*
WLAN	2	2412 - 2462	2412	17.0	98.0
Bluetooth	2	2402 - 2480	2402	7.4	77.5

Table 3 – Transmitter Description

*Normal TETRA has a 25 % duty cycle for using voice data. The radio may be used as a gateway and can transmit in 2 of 4 slots making a 50 % duty cycle. Packet data transfer allows for 100 % duty cycle, transmitting in 4 of 4 timeslots. Typical occurrence is for a few seconds in a minute and is not likely to transmit for more than 1 minute in 10, therefore is not evaluated.

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	(GPSB4 with AFB-TET antenna)	2	15.4
1	TETRA	(GPSB4 with AFB-UT antenna)	2	14.0
2	WLAN	GPSB4	2	12.0
2	Bluetooth	GPSB4	2	12.0

Table 4 – Antenna description

Note: Higher gain TETRA only antennas are supported by the SCG22 but do not fit to the Multi Fin Antenna (GPSB4). Evaluation covers stated antennas only. 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 (Shark Fin Antenna GPSB4 with AFB-TET antenna fitted) 380 – 430 MHz band and WLAN 2412 – 2462 MHz band.
Simultaneous transmission of TETRA (Shark Fin Antenna GPSB4 with AFB-TET antenna fitted) 380 – 430 MHz Band and Bluetooth 2402 – 2480 MHz band.

Simultaneous transmission of TETRA (Shark Fin Antenna GPSB4 with AFB-UT antenna fitted) 406 – 470 MHz band and WLAN 2412 – 2462 MHz band.
Simultaneous transmission of TETRA (Shark Fin Antenna GPSB4 with AFB-TET antenna fitted) 406 – 470 MHz Band and Bluetooth 2402 – 2480 MHz band.

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	Frequency (MHz)	Minimum Calculated Compliance Boundary (m) at Limit for:			
			S Power Density	E Field	H Field	B Field
1	Tetra using (GPSB4 with AFB-TET antenna)	380	0.2231	N/A	N/A	N/A
1	Tetra using (GPSB4 with AFB-UT antenna)	406	0.2159	N/A	N/A	N/A
2	WLAN	2412	0.0111	N/A	N/A	N/A
2	Bluetooth	2402	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 the listed specifications in Annex A at the point of investigation, a minimum distance of 0.3 m.

Antenna Port	RAT	Frequency (MHz)	Minimum Calculated Compliance Boundary (m) at Limit for:			
			S Power Density	E Field	H Field	B Field
1	Tetra using (GPSB4 with AFB-TET antenna)	380	0.4989	N/A	N/A	N/A
1	Tetra using (GPSB4 with AFB-UT antenna)	406	0.4827	N/A	N/A	N/A
2	WLAN	2412	0.0249	N/A	N/A	N/A
2	Bluetooth	2402	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 the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 m.

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.

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)
380	12.67	N/A	N/A	N/A	2.53	N/A	N/A	N/A
406	13.53	N/A	N/A	N/A	2.71	N/A	N/A	N/A
2412	50.00	N/A	N/A	N/A	10.00	N/A	N/A	N/A
2402	50.00	N/A	N/A	N/A	10.00	N/A	N/A	N/A

Table 2 – 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. The compliance boundary distance has been calculated to ensure the summation is ≤1.

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 0.3 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 using (GPSB4 with AFB-TET antenna)	380	0.2231	N/A	N/A	N/A
2	WLAN	2412	0.0111	N/A	N/A	N/A
2	Bluetooth	2402	0.0033	N/A	N/A	N/A
Summation Tetra + WLAN			0.2234	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.2231	N/A	N/A	N/A

Table 8 – FCC Worker/Occupational Combined Exposure (GPSB4 with AFB-TET antenna)

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.3 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at minimum compliance boundary of 0.3 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 using (GPSB4 with AFB-UT antenna)	406	0.2159	N/A	N/A	N/A
2	WLAN	2412	0.0111	N/A	N/A	N/A
2	Bluetooth	2402	0.0033	N/A	N/A	N/A
Summation Tetra + WLAN			0.2161	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.2159	N/A	N/A	N/A

Table 9 – FCC Worker/Occupational Combined Exposure (GPSB4 with AFB-UT antenna)

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.3 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 using (GPSB4 with AFB-TET antenna)	380	0.4989	N/A	N/A	N/A
2	WLAN	2412	0.0249	N/A	N/A	N/A
2	Bluetooth	2402	0.0073	N/A	N/A	N/A
Summation Tetra + WLAN			0.4995	N/A	N/A	N/A
Summation Tetra + Bluetooth			0.4990	N/A	N/A	N/A

Table 10 – FCC General Public Combined Exposure (GPSB4 with AFB-TET antenna)

The calculations show that the EUT complies with the worker/occupational exposure levels described 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 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 using (GPSB4 with AFB-UT antenna)	406	0.4827	N/A	N/A	N/A
2	WLAN	2412	0.0249	N/A	N/A	N/A
2	Bluetooth	2402	0.0073	N/A	N/A	N/A
Summation Tetra + WLAN			0.4827	0.4827	0.4827	0.4827
Summation Tetra + Bluetooth			0.4833	N/A	N/A	N/A

Table 11 – FCC General Public Combined Exposure (GPSB4 with AFB-UT antenna)

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, a minimum distance of 0.5 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 Name	Frequency MHz	Reactive Near Field Boundary (Wave Impedance Dependent)	Far Field Boundary (Antennas on axis)
		$\lambda/4$ (m)	$2D^2/\lambda$ (m)
Tetra using (GPSB4 with AFB-TET antenna)	380	0.1974	0.1974
Tetra using (GPSB4 with AFB-UT antenna)	406	0.1847	0.1847
Bluetooth	2402	0.0312	0.2306
WLAN	2412	0.0311	0.2316

Table 12 – Far Field Boundary

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

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.1847 m	N/A	> 0.1847 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 13 – Assessment Method Validity – Occupational (Tetra using GPSB4 with AFB-UT antenna)

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.1974 m	N/A	> 0.1974 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 14 – Assessment Method Validity – Occupational (Tetra using GPSB4 with AFB-TET antenna)

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0311 m	0.0311 – 0.2316 m	> 0.2316 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 15 –Assessment Method Validity – Occupational (WLAN using GPSB4 with AFB-UT antenna

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0311 m	0.0311 – 0.2316 m	> 0.2316 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 3 – Assessment Method Validity – Occupational (WLAN using GPSB4 with AFB-TET antenna)

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0312 m	0.0312 – 0.2306 m	> 0.2306 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 17 – Assessment Method Validity – Occupational (Bluetooth using GPSB4 with AFB-UT antenna)

The compliance boundary of 0.3 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0312 m	0.0312 – 0.2306 m	> 0.2306 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.3 m

Table 18 – Assessment Method Validity – Occupational (Bluetooth using GPSB4 with AFB-TET antenna)

The compliance boundary of 0.5 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.1847 m	N/A	> 0.1847 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 19 – Assessment Method Validity – General Public (Tetra using GPSB4 with AFB-UT antenna)

The compliance boundary of 0.5 m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.1974 m	N/A	> 0.1974 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 20 – Assessment Method Validity – General Public (Tetra using GPSB4 with AFB-TET antenna)

The compliance boundary of 0.5m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0311 m	0.0311 – 0.2316 m	> 0.2316 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 21 – Assessment Method Validity – General Public (WLAN using GPSB4 with AFB-UT antenna)

The compliance boundary of 0.5 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0311 m	0.0311 – 0.2316 m	> 0.2316 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 22 – Assessment Method Validity – General Public (WLAN using GPSB4 with AFB-TET antenna)

The compliance boundary of 0.5m is in the far field region and therefore, the approach described in section 2.1 is valid.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0312 m	0.0312 – 0.2306 m	> 0.2306 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 23 – Assessment Method Validity – General Public (Bluetooth using GPSB4 with AFB-UT antenna)

The compliance boundary of 0.5 m is in the far field region and therefore, the approach described in section 2.1 is valid

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0312 m	0.0312 – 0.2306 m	> 0.2306 m
Validity of Regions	Spherical model potential under-estimate: SAR assessment required	Spherical model over-estimate and conservative	Spherical model valid
Compliance Boundary Location	N/A	N/A	0.5 m

Table 24 – Assessment Method Validity – General Public (Bluetooth using GPSB4 with AFB-TET antenna)

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.