Report on the Exposure Calculation of:

Park Air Systems
VHF Amplifier, Model: T6-AV100
UHF Amplifier, Model: T6-AU100

In accordance with EN 50385, FCC Part 2.1091 and Industry Canada RSS-102

Add value.
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Prepared for: Park Air Systems
Northfields
Market Deeping
Peterborough
PE6 8UE
United Kingdom

COMMERCIAL-IN-CONFIDENCE

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SIGNATURE			
NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Jon Kenny	Senior Engineer	Authorised Signatory	13 February 2020

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EXECUTIVE SUMMARY
The calculation of exposure for this product was found to be compliant at the distances calculated in accordance with EN 50385: 2017, FCC Part 2.1091: 2018 and Industry Canada RSS-102: 2015.

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	13 February 2020

Table 1

1.2 Introduction

Objective	To perform electromagnetic field exposure assessment to determine the equipment under test's (EUT's) compliance with the applied specifications.
Applicant	Park Air Systems
Manufacturer	Park Air Systems
Model Number(s)	T6-AV100 and T6-AU100
Hardware Version(s)	1
Software Version(s)	N/A
Specification/Issue/Date	• EN 50385:2017 Product standard to demonstrate the compliance of base station equipment with radiofrequency electromagnetic field exposure limits (110 MHz - 100 GHz), when placed on the market • FCC 47 CFR Part 2.1091: 2018 • Industry Canada RSS-102: 2015
Order Number	67338-0
Date	4 June 2019

Related Document(s)	• EN 62232:2017 Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure • Directive 2013/35/EU on minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). • European Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal, L199, of 1999-7-30, p.59-70. • 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 • RSS-102 Issue 5 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) • Health Canada. Safety code 6 (2015).

1.3 Brief Summary of Results

The wireless devices described within this report are compliant with the restrictions related to human exposure to electromagnetic fields for both general public and worker/occupational exposures at the 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 Compliance Boundary (m) (rounded up to nearest 0.1 m)	
		Worker/Occupational	General Public
EU	VHF single transmitter	1.4	3.1
FCC	VHF single transmitter	1.4	3.1
CANADA	VHF single transmitter	1.7	3.8

Table 2 – T6-AV100 VHF Compliance Boundary Calculation Results

Regional Requirement	Configuration	Calculated Compliance Boundary (m) (rounded up to nearest 0.1 m)	
		Worker/Occupational	General Public
EU	UHF single transmitter	1.4	3.1
FCC	UHF single transmitter	1.4	3.1
CANADA	UHF single transmitter	1.4	3.8

Table 3 – T6-AU100 UHF Compliance Boundary Calculation Results

1.4 Product Information

1.4.1 Technical Description

This report addresses two products; the VHF Amplifier, Model: T6-AV100 and the UHF Amplifier, Model: T6-AU100.

T6-AV100 is an amplifier for use with a ground to air T6 transmitter or transceiver in the VHF aeronautical band.

T6-AU100 is an amplifier for use with a ground to air T6 transmitter or transceiver in the UHF aeronautical band.

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	Minimum Frequency	Output Power	Duty Cycle
		MHz	MHz	dBm	%
T6-AV100: VHF	T6-AV100:1	118.0-136.975	118.0	51.615	100
T6-AU100: UHF	T6-AU100:1	225.0-399.975	225.0	51.615	100

Table 4 – 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	Antenna length
			dBi	cm
T6-AV100:1A	VHF	Amphenol 7500xxx VHF	2	146
T6-AV100:1B	VHF	Park Air Z2 VHF	2	125
T6-AU100:1A	UHF	Amphenol 7502xxx UHF	2	121.6
T6-AU100:1B	UHF	Park Air Z2 UHF	2	121.6

Table 5 – Antenna description

1.4.4 Additional Antenna Data

The following additional antenna data is required to calculate the EU product installation compliance results in accordance with EN 62232:2017 Table 2.

Main Parameter	Detailed Parameter	Value
Side Lobe Suppression	Manufacturers sidelobe level	Omnidirectional dipole, sidelobe N/A
	A_{sl} side lobe suppression value in linear scale	0
Tilt	Manufacturer’s fixed mechanical tilt	Antenna vertical = 0 degree tilt
	Manufacturer’s digital electric tilt range	N/A non-array
	α downtilt in radians	0
Vertical Beamwidth	Manufacturer’s half power width in vertical plane	80 degree
	θ_{bw} Vertical half power beamwidth in radians	1.3963

Table 6 – Additional Antenna Data (1A Amphenol 7500xxx VHF)

Main Parameter	Detailed Parameter	Value
Side Lobe Suppression	Manufacturers sidelobe level	Omnidirectional dipole, sidelobe N/A
	A_{sl} side lobe suppression value in linear scale	0.0001
Tilt	Manufacturer's fixed mechanical tilt	Antenna vertical = 0 degree tilt
	Manufacturer's digital electric tilt range	N/A non-array
	α downtilt in radians	0
Vertical Beamwidth	Manufacturer's half power width in vertical plane	90 degree
	θ_{bw} Vertical half power beamwidth in radians	1.5708

Table 7 – Additional Antenna Data (1B Park Air Z2 VHF)

Main Parameter	Detailed Parameter	Value
Side Lobe Suppression	Manufacturers sidelobe level	Omnidirectional dipole, sidelobe N/A
	A_{sl} side lobe suppression value in linear scale	0.0001
Tilt	Manufacturer's fixed mechanical tilt	Antenna vertical = 0 degree tilt
	Manufacturer's digital electric tilt range	N/A non-array
	α downtilt in radians	0
Vertical Beamwidth	Manufacturer's half power width in vertical plane	85 degree
	θ_{bw} Vertical half power beamwidth in radians	1.4835

Table 8 – Additional Antenna Data (1A Amphenol 7502xxx UHF)

Main Parameter	Detailed Parameter	Value
Side Lobe Suppression	Manufacturers sidelobe level	Omnidirectional dipole, sidelobe N/A
	A_{sl} side lobe suppression value in linear scale	0.0001
Tilt	Manufacturer's fixed mechanical tilt	Antenna vertical = 0 degree tilt
	Manufacturer's digital electric tilt range	N/A non-array
	α downtilt in radians	0
Vertical Beamwidth	Manufacturer's half power width in vertical plane	85 degree
	θ_{bw} Vertical half power beamwidth in radians	1.4835

Table 9 – Additional Antenna Data (1B Park Air Z2 UHF)

1.4.5 Equipment Configuration

Each product is a single transmitter operating with specified antennas.

Note: Installation calculations must be carried out by the installer/operator if a different antenna type is used.

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 – Transmitter power W
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 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.

2.2 Approach for Product Installation Compliance Calculation

EU, EN 62232:2017 specifies additional product installation calculation requirements in clause 6.2.4, extract below. This data is used by the network operator or entity putting the Base Station into service. The separation distance calculations D_m take ground reflection into account and EN 62232:2017 Table 2 Note b specifies a ground reflection factor of 1 (i.e. worst case full in-phase reflection). Additionally, the minimum height H_m is required to be calculated.

For frequencies between 100 MHz and 400 MHz:

$$H_m = \max\begin{cases} 2+\sqrt{\dfrac{EIRP \cdot A_{sl}}{2\pi}} \\ 2+\sqrt{\dfrac{EIRP}{2\pi}}\sin(\alpha + 1.129\theta_{bw}) \end{cases} \qquad D_m = \sqrt{\dfrac{EIRP}{2\pi}} \qquad (6.1)$$

For frequencies between 400 MHz and 2 000 MHz:

$$H_m = \max\begin{cases} 2+\sqrt{\dfrac{EIRP \cdot 200 A_{sl}}{f\pi}} \\ 2+\sqrt{\dfrac{200 \cdot EIRP}{f\pi}}\sin(\alpha + 1{,}129\theta_{bw}) \end{cases} \qquad D_m = \sqrt{\dfrac{EIRP \cdot 200}{f\pi}} \qquad (6.2)$$

For frequencies between 2 000 MHz and 100 000 MHz (i.e. 100 GHz):

$$H_m = \max\begin{cases} 2+\sqrt{\dfrac{EIRP \cdot A_{sl}}{10\pi}} \\ 2+\sqrt{\dfrac{EIRP}{10\pi}}\sin(\alpha + 1{,}129\theta_{bw}) \end{cases} \qquad D_m = \sqrt{\dfrac{EIRP}{10\pi}} \qquad (6.3)$$

where:

f is the frequency of operation of the RBS in MHz;

A_{sl} is the side lobe suppression value in linear scale;

α is the downtilt in radians (both electric and mechanic);

θ_{bw} is the vertical half power beamwidth in radians.

2.3 Individual Antenna Port Exposure Results

2.3.1 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.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
EU	1	VHF	118	N/A	1.3614	N/A	1.3840
FCC	1	VHF	118	1.3525	1.3525	1.3514	N/A
CANADA	1	VHF	118	1.6152	1.6152	1.6152	N/A

Table 10 – T6-AV100 VHF 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, 1.7 m.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
EU	1	VHF	118	3.0243	2.9659	3.0176	3.0088
FCC	1	VHF	118	3.0243	3.0198	3.0176	N/A
CANADA	1	VHF	118	3.7643	3.7645	3.7642	N/A

Table 11 – T6-AV100 VHF 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, 3.8 m.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
EU	2	UHF	225	N/A	1.3614	N/A	1.3840
FCC	2	UHF	225	1.3525	1.3525	1.3514	N/A
CANADA	2	UHF	225	1.3745	1.3745	1.3745	N/A

Table 12 – T6-AU100 UHF 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, 1.4 m.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
EU	2	UHF	225	3.0243	2.9659	3.0176	3.0088
FCC	2	UHF	225	3.0243	3.0198	3.0176	N/A
CANADA	2	UHF	225	3.7643	3.7645	3.7642	N/A

Table 13 – T6-AU100 UHF 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, 3.8 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.

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)
EU	118	N/A	61.00	N/A	0.2000	2.00	28.00	0.0730	0.0920
FCC	118	10.00	61.40	0.1630	N/A	2.00	27.50	0.0730	N/A
CANADA	118	7.01	51.42	0.1364	N/A	1.29	22.06	0.0585	N/A
EU	225	N/A	61.00	N/A	0.2000	2.00	28.00	0.0730	0.0920
FCC	225	10.00	61.40	0.1630	N/A	2.00	27.50	0.0730	N/A
CANADA	225	9.68	60.42	0.1603	N/A	1.29	22.06	0.0585	N/A

Table 14 – Limits

2.4 Combined Antenna Port RF Exposure Results

Not applicable as single transmitter operation only.

2.5 Additional Product Installation Calculation Results

The results for the EU product installation compliance in accordance with EN 62232:2017 Table 2 are:

Regional Requirement	Standard Reference	RAT	Frequency MHz	Antenna	Compliance Distance D_m (m)	Minimum Height H_m (m)
EU	EN 62232 Para 6.2.4	T6-AV100 VHF	118	1A	6.05	8.05
EU	EN 62232 Para 6.2.4	T6-AV100 VHF	118	1B	6.05	7.92
EU	EN 62232 Para 6.2.4	T6-AU100 UHF	225	2A	6.05	8.02
EU	EN 62232 Para 6.2.4	T6-AU100 UHF	225	2B	6.05	8.02

Table 15 – Product Installation Compliance Data

2.6 Far Field Region Boundary Results

The far field region boundary calculation result is shown in Table 16:

Near Field / Far Field Boundary (Ref: IEEE C95.3 Annex B.2, EN 62232 Annex A, Technical Guide for Interpretation and Compliance Assessment of Health Canada's Radiofrequency Exposure Guidelines 7.1)				
RAT Name	Antenna	Reactive Near Field Boundary (Wave Impedance Dependent)	Far Field Boundary (Antennas on axis). Maximum is boundary	
		λ/4 (m)	Rayleigh Range Boundary $2D^2/\lambda$ (m)	Alternative boundary D/2+2.5λ (m) *EN 62232 only*
VHF	1A	0.6356	1.6769	7.0859
VHF	1B	0.6356	1.2292	6.9809
UHF	2A	0.3333	1.5000	3.8333
UHF	2B	0.3333	1.5000	3.8333

Table 16 – Far Field Boundary

The tables below show the maximum calculated near field / far field region boundaries.

The tables below show that the calculated compliance boundaries are in the radiating near field region and therefore, the approach described in section 2.1 is an over estimate of the exposure and therefore a conservative assessment.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	<0.6356 m	0.6356 – 7.0859 m	> 7.0859 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	1.35 – 3.13 m	N/A

Table 17 – T6-AV100 VHF Assessment Method Validity

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	<0.3333 m	0.3333 – 3.8333 m	> 3.8333 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	1.15 – 3.13 m	N/A

Table 18 – T6-AU100 UHF Assessment Method Validity

2.7 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. (Reference EN 62232 clause B.4.1).

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 2.6.

ANNEX A

REGIONAL REQUIREMENTS

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Magnetic Flux Density (µT)
0.1 - 1	-	610	N/A	2/f
1 - 10	-	610/f	N/A	2/f
10 - 400		61	N/A	0.2
400 - 2000		3*f^0.5	N/A	1E-2*f^0.5
2000 - 6000		140	N/A	0.45
6000 - 300000	50	140	N/A	0.45

Table A.1 – EU: Action levels in Directive 2013/35/EU Annex III Table B1 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Magnetic Flux Density (µT)
0.003 - 0.15	-	87	5	6.25
0.15 - 1	-	87	0.73/f	0.92/f
1 - 10	-	87/f^0.5	0.73/f	0.92/f
10 - 400	2	28	0.073	0.092
400 - 2000	f/200	1.375*f^0.5	0.0037*f^0.5	0.0046*f^0.5
2000 - 300000	10	61	0.16	0.2

Table A.2 – EU: Council Recommendation 1999/519/EC Annex II Table 1 General Public 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	900/f^2	1842/f	4.89/f
30 - 300	1	61.4	0.163
300 - 1500	f/300	-	-
1500 - 100000	5	-	-

Table A.3 – FCC CFR 47 Part 2.1091 (2018) 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.4 – FCC CFR 47 Part 2.1091 (2018) 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.

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	10	61.4	0.163
20 - 48	44.72/f^0.5	129.8/f^0.25	0.3444/f^0.25
48 - 100	6.455	49.33	0.1309
100 - 6000	0.6455*f^0.5	15.60*f^0.25	0.04138*f^0.25
6000 - 150000	50	137	0.364

Table A.5 – Health Canada Safety Code 6 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	2	27.46	0.0728
20 - 48	8.944/f^0.5	58.07/f^0.25	0.1540/f^0.25
48 - 300	1.291	22.06	0.05852
300 - 6000	0.02619*f^0.6834	3.142*f^0.3417	0.008335*f^0.3417
6000 - 15000	10	61.4	0.163

Table A.6 – Health Canada Safety Code 6 General Public Limits