

Report on the Exposure Calculation for
Ocean Signal
Class A AIS Transponder,
Model: ATA100
In accordance with IEC 60945

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ENGINEERING STATEMENT

The calculations shown in this report were made in accordance with the procedures described in IEC 60945.

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Calculation	Pete Dorey	21 November 2019	

EXECUTIVE SUMMARY

The calculation of exposure for this product was found to be compliant at 50 cm (AIS) and 20 cm (Wi-Fi) with IEC 60945 Clause 12.2.

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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	21 November 2019

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	Ocean Signal
Manufacturer	Ocean Signal
Model Number(s)	ATA100
Hardware Version(s)	Issue 01.00
Software Version(s)	Issue 0.2.09
Specification/Issue/Date	<ul style="list-style-type: none">IEC 60945:2002 including corrigendum 2008, Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results; Clause 12.2 Electromagnetic radio frequency radiation
Order Number	3123-00
Date	31-October-2016
Related Document(s)	<ul style="list-style-type: none">IEC/EN 62311:2008 Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz to 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 Configuration 1 - Single transmitter - AIS

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.5 m							
	S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
	Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	0.21	100.00	8.81	N/A	0.0234	N/A	0.0294	N/A

Table 1 – Worker/Occupational (100 W/m² limit) Exposure Results

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, 0.5 m.

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.5 m							
	S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
	Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	0.21	10.00	8.81	N/A	0.0234	N/A	0.0294	N/A

Table 2 – General Public (10 W/m² limit) Exposure Results

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, 0.5 m.

1.3.2 Configuration 2 - Single transmitter - Wi-Fi

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m							
	S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
	Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	0.44	100.00	12.94	N/A	0.0343	N/A	0.0431	N/A

Table 3 – Worker/Occupational (100 W/m² limit) Exposure Results

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, 0.2 m.



Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m							
	S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
	Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	0.44	10.00	12.94	N/A	0.0343	N/A	0.0431	N/A

Table 4 – General Public (10 W/m² limit) Exposure Results

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, 0.2 m.

1.3.1 Configuration 3 - Multiple transmitters

Regional Requirement	Calculated RF exposure level at compliance boundary of AIS (0.5 m) and Wi-Fi (0.2 m) as a fraction of the limit			
	S Power Density	E Field	H Field	B Field
	Summation for simultaneous exposure; value to be <1			
IEC 60945	0.0065	N/A	N/A	N/A

Table 5 – Worker/Occupational Exposure Results

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, AIS (0.5 m) and WiFi (0.2 m).

Regional Requirement	Calculated RF exposure level at compliance boundary of AIS (0.5 m) and Wi-Fi (0.2 m) as a fraction of the limit			
	S Power Density	E Field	H Field	B Field
	Summation for simultaneous exposure; value to be <1			
IEC 60945	0.0650	N/A	N/A	N/A

Table 6 – General Public Exposure Results

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, AIS (0.5 m) and Wi-Fi (0.2 m).



1.4 Product Information

1.4.1 Technical Description

ATA100 Class A AIS Transponder.

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	%
AIS	VHF	156-162	156	40.97	1.3
802.11b, 802.11g and 802.11n Wi-Fi	Internal	2412-2484	2412	21.49	100

Table 7 – 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	Minimum Separation Distance
			dBi	cm	cm
1	AIS	VHF	6	150 (typical)	>20 cm
2	802.11b, 802.11g and 802.11n Wi-Fi	Internal	2	1.8	>20 cm

Table 8 – Antenna description

1.4.4 Equipment Configuration

AIS VHF transmitter maybe disabled (RX only). Wi-Fi maybe enabled/disabled and maybe enabled at the same time as AIS transmissions.



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 $4\pi \times 10^{-7}$ H/m

Where additional calculations are required by the regional specifications these are detailed below.

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 Individual Antenna Port Exposure Results

2.2.1 Calculation of Exposure at Specified Separation Distance - AIS

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)	RF Exposure Level at compliance boundary of 0.5 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	1	AIS	156	0.21	100.00	8.81	N/A	0.0234	N/A	0.0294	N/A

Table 9 – AIS Worker/Occupational Individual Transmitter Result

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, 0.5 m.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.5 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	1	AIS	156	0.21	10.00	8.81	N/A	0.0234	N/A	0.0294	N/A

Table 10 – AIS General Public Individual Transmitter Result

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, 0.5 m.

2.2.2 Calculation of Exposure at Specified Separation Distance - Wi-Fi

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)	RF Exposure Level at compliance boundary of 0.2 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	2	802.11b, 802.11g and 802.11n Wi-Fi	2412	0.44	100.00	12.94	N/A	0.0343	N/A	0.0431	N/A

Table 11 – Wi-Fi Worker/Occupational Individual Transmitter Result

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, 0.2 m.



Regional Requirement	Antenna Port	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.2 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
IEC 60945	2	802.11b, 802.11g and 802.11n WiFi	2412	0.44	10.00	12.94	N/A	0.0343	N/A	0.0431	N/A

Table 12 – Wi-Fi General Public Individual Transmitter Result

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, 0.2 m.

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 specified minimum separation distances for the AIS (0.5 m) and Wi-Fi (0.2 m) antennas are different. Since the antennas are not co-located, different separation distances are possible, therefore combined antenna port exposure is calculated at the declared separation distances.

IEC 60945 does not give specific guidance on the method of summation, therefore the method in EN 62311 is used. EN 62311 specifies the method of summation in clause 8.3 with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of AIS (0.5 m) and Wi-Fi (0.2 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	AIS	156	0.0021	N/A	N/A	N/A
2	802.11b, 802.11g and 802.11n WiFi	2412	0.0044	N/A	N/A	N/A
Summation			0.0065	N/A	N/A	N/A

Table 13 – Worker/Occupational Combined Exposure

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, AIS (0.5 m) and Wi-Fi (0.2 m).



Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of AIS (0.5 m) and Wi-Fi (0.2 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	AIS	156	0.0206	N/A	N/A	N/A
2	802.11b, 802.11g and 802.11n WiFi	2412	0.0444	N/A	N/A	N/A
Summation			0.0650	N/A	N/A	N/A

Table 14 – General Public Combined Exposure

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, AIS (0.5 m) and Wi-Fi (0.2 m).

2.4 Far Field Region Boundary Results

The far field region boundary calculation result is shown in Table 15:

Near Field / Far Field Boundary		
RAT Name	Reactive Near Field Boundary (Wave Impedance Dependent)	Antennas - on axis Far Field Region (Ref: EN 62311 Annex A)
	$\lambda/4$ (m)	$2D^2/\lambda$ (m)
AIS	0.4807	2.3404
Wi-Fi	0.0311	0.0052

Table 15 – Far Field Boundary

Table 16 and Table 17 below show the maximum calculated near field / far field region boundaries. The field region location of the compliance boundary is shown. Locations within the reactive near field region are a potential under estimate of the exposure using the approach described in section 2.1.

Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.4807 m	0.4807 m – 2.3404 m	> 2.3404 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	0.5 m	N/A

Table 16 – Assessment Method Validity AIS



Field Region	Reactive Near Field Region	Radiating Near Field Region	Far Field Region
Maximum Boundary	< 0.0311 m	N/A	> 0.0311 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	0.2 m

Table 17 – Assessment Method Validity Wi-Fi

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 (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m) (Converted from μ T)	Magnetic Flux Density (μ T)
All	100	N/A	N/A	N/A

Table A.1 – IEC 60945 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m) (Converted from μ T)	Magnetic Flux Density (μ T)
All	10	N/A	N/A	N/A

Table A.2 – IEC 60945 General Public Limits