Thales Avionics Limited

Operating distance to stay below ICNIRP exposure limits to non-ionising radiation from a Inmarsat L band High Gain Antenna when connected to a TFS Satellite Data Unit Type 82155

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ISSUE RECORD

Issue	Date	By	Comments
Draft A	16/06/06	Will Birkinshaw	1st Draft
B	21/06/06	Will Birkinshaw	Thales comments added and antenna gain figure amended.
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2	24/07/06	Will Birkinshaw	Airbus comments added
2a	23/06/08	Will Birkinshaw	Modified to allow for use of an HGA

CONTENTS

1 INTRODUCTION

1.1 OBJECTIVES

1.1.1 This document calculates the distance from an Inmarsat approved L band High Gain Antenna (HGA), operating within an ARINC 781 compliant Satcom system, beyond which the RF power density falls below the levels defined in the International Council on Non-Ionizing Radiation Protection (ICNIRP) standard.

1.1.2 The ICNIRP standard provides a two-tier set of RF exposure limits. The higher tier is referred to as *Occupational* while the more restrictive lower tier is referred to as *General Population*.

1.1.3 This document uses the *General Population* tier, which is considered more appropriate for the general public and passengers and defines a lower level of RF power density.

1.1.4 The distance applicable to normal operation and that for abnormal multiple fault conditions are calculated.

1.1.5 The HGA represents the highest field strength achievable from an Inmarsat approved installation and hence is applicable to the use of an IGA with the Thales 82155 series SDUs.

1.2 REFERENCE DOCUMENTS

1.2.1 Guidelines on limiting exposure to non-ionising radiation and statements on special applications, R. Matthes, J.H. Bernhardt, A.F. McKinlay (eds.) International Commission on Non-Ionising Radiation Protection Munich 2004 ISBN 3-934994-05-9.

1.2.2 ARINC 781, Mark 3 Aviation Satellite Communication System, Aircraft Installation Provisions 2005.

1.3 SCOPE

1.3.1 The distance derived applies when the Thales TFS SDU Type no 82155 series is used in ARINC 781 compliant installations, with RF power distribution losses defined in ARINC 781 for SDUs without external Flange Mounted HPAs.

1.4 ABBREVIATIONS

D/LNA	Diplexer/Low Noise Amplifier
dB	Decibel
dBic	Decibel relative to an isotropic circularly polarised radiator
dBW	Decibel relative to 1 watt
EIRP	Effective Isotropic radiated power
HPA	High Power Amplifier
ICNIRP	International Commission on Non-Ionising Radiation Protection
IGA	Intermediate Gain Antenna
LRU	Line Replaceable Unit
mW	milli-watt
RF	Radio Frequency
SBB	Swift BroadBand
SDU	Satellite Data Unit
TFS	Top Flight Satcom
TX	Transmit
W	Watt

2 SYSTEM PARAMETERS USED IN THE CALCULATION

2.1 GENERAL

2.1.1 The values of the relevant parameters used in this calculation takes account of two conditions:-

2.1.1.1 Normal operating conditions.

2.1.1.1.1 This condition represents the case of normal system operation using an IGA and supporting a single SBB channel.

2.1.1.2 A multiple fault condition operation.

2.1.1.2.1 The maximum EIRP that can be produced by the Satcom System requires the presence of multiple simultaneous and very specific faults. The faults required to produce this peak level of EIRP are very specific and their effect will be significantly diluted if they are present with other faults or when not all present simultaneously.

2.1.1.2.2 In order to produce the highest possible EIRP level, the antenna gain must increase (see section 2.2 note 1) and the HPA in the SDU must be overdriven (see section 2.2 note 3).

2.1.1.2.3 With normal BITE functionality, these conditions would be detected individually by the SDU and corrective action taken to reduce functionality accordingly. Hence the likelihood of this very specific multiple fault condition occurring is extremely low.

2.1.2 The analysis also uses the lowest installed RF losses allowed by ARINC 781 between the antenna and the SDU. Thus maximising the possible EIRP from the system.

2.1.3 No overall safety margin has been applied, in accordance with ICNIRP, however the likely tolerances in the reporting of the HPA power have been included.

2.2 TFS SYSTEM PARAMETER VALUES

Table 1 Normal operation IGA with 1 SBB channel

Parameter	Value	Comments
Antenna gain (dBic)	N/A	See note 1
RF losses between SDU and antenna (dB)	N/A	See note 2
RF power at O/P of SDU (dBW)	N/A	See note 3
Radiated EIRP (dBW)	16.5	See note 4

Table 2 Multiple fault condition

Parameter	Value	Comments
IGA Antenna gain (dBic)	13	See note 1
RF losses between SDU and antenna (dB)	1	See note 2
RF power at O/P of SDU (dBW)	19	See note 3
Radiated EIRP (dBW)	31	See note 4

Notes:-

1 Antenna Gain

The SDU has RF power control to maintain the radiated EIRP at the required levels to support the services provided. Hence for normal operation, the actual antenna gain is not required for this calculation.

The maximum gain allowed in ARINC781 for an HGA is 17dBic. The gain will fall to ~8dB as the elevation decreases, and will fall below this at the horizon. However, for the purposes of calculation, the antenna gain figure used is 17dBic representing the worst-case conditions.

At low elevations, including the horizon, the antenna gain has been maximised in order to achieve the best coverage performance. Any fault condition resulting in a beam toward the horizon can only produce a level less than or equal to the non-fault gain values, i.e. no fault condition can result in a higher gain towards the horizon than can be achieved during normal operation.

2 RF Losses between SDU and Antenna.

In the normal operating case, the cable loss is included in the EIRP control loop provided by the SDU and hence the cable loss is not required in calculating power density.
ARINC781 allows a maximum of 2.5dB loss between the HPA (SDU in this case) and the antenna. Any fault condition in the RF components in this RF chain can only increase this loss, hence any reduction in this loss can only occur if the installation itself does not utilise the full 2.5dB allowed.
Therefore, to allow for the possibility that the antenna, D/LNA and SDU could be located very closely together, the RF loss used has been reduced to 1dB. This takes account of the nominal loss in the D/LNA of ~0.8dB, which will always be present between the SDU and the antenna, irrespective of the loss in the RF interconnecting cables.

3 SDU RF power

The RF power from the SDU is under system control to maintain the EIRP to support the channels required. Hence the level of SDU RF power is not required for this calculation in normal operation.

The 82155 series TFS SDUs have an in-built HPA, which in normal operation produces a nominal maximum RF output power of 30W. However, under fault conditions, the HPA could be driven into saturation by

multiple simultaneous failures of several BITE checks together with failure of the gain control loop in the HPA.
This is an extremely unlikely event, as faults that could completely disable BITE would be expected to disable the HPA as well.
However, assuming HPA functionality is not disabled, the maximum HPA RF power could reach 80W. Power supply current limiting and ultimately hardware thermal shutdown will limit the duration of this condition to a few minutes only. For the purposes of this analysis 80W (19dBW) has been used as the maximum averaged SDU RF power - as determined by the limiting capability of the SDU internal power supply.

4 Radiated EIRP

The SDU has RF power control to maintain the radiated EIRP at the required levels to support the services provided. Hence in normal operation, for installations with an HGA providing 2 SBB channels, the EIRP is maintained at 23dBW with an expected tolerance of +/-1.5dB. Therefore the maximum averaged EIRP is 24.5dBW. (= 282W)

The radiated EIRP is the sum of the antenna gain (in dB) and the power (in dBW) at the antenna connector. The power at the antenna connector is the SDU power, less the RF losses between the SDU and the Antenna.

In concurrent fault conditions $EIRP = 19 - 1 + 17$ = 35dBW = 3162W

In normal operation

$EIRP = 14.8 - 1 + 13$ =26.8dBW =478W (13dBic a typical HGA gain)

2.3 ICNIRP EXPOSURE LIMITS

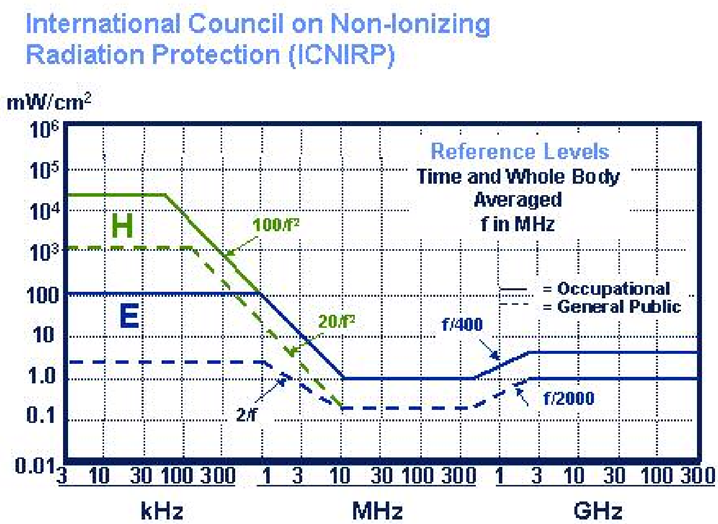

Figure 1

2.3.1 EXPOSURE LEVEL

2.3.1.1 For TFS, f = 1626MHz for the lowest RF power density.

2.3.1.2 Therefore, from Figure 1, the General Public level is f/2000 mW/cm^2. (or f/200 W/m^2)

2.3.1.3 The limiting power density is therefore 8.13W/m^2.

3 CALCULATION

3.1 FORMULAE

3.1.1 The power density S at a distance *d* (metres) is given by

$$S = \frac{EIRP}{4\pi d^2} \text{ W/m}^2 \qquad \text{...... 1}$$

3.1.2 Substituting S from 2.3.1.2 and rearranging equation 1 gives the distance *d* beyond which the required power density is not exceeded is:-

$$d = \sqrt{\frac{200 \cdot EIRP}{4\pi f}} \text{ m} \qquad \text{...... 2}$$

3.1.3 For normal operation, an HGA with any channel combination requiring 30W from the HPA to maintain the required EIRP.

Substituting f = 1626MHz and EIRP = 478W in equation 2, the distance *d* = 2.2m.

3.1.4 For an HGA with an HPA is max RF power fault mode.

Substituting f = 1626MHz and EIRP = 3162W in equation 2, the distance *d* = 5.6m.

3.1.5 For the purposes of this calculation, these distances should be treated as distances measured from the extremity of the antenna radome.

4 CONCLUSIONS

4.1 NORMAL OPERATION

4.1.1 For normal operation using an HGA, the distance from the antenna, beyond which the field strength will not exceed the *General Population* levels specified in ICNIRP, is 2.2m.

4.2 MULTIPLE FAULT MODE

4.2.1 For multiple fault mode operation using an HGA with SDU type 82155, the extreme distance from the antenna, beyond which the field strength will not exceed the *General Population* levels specified in ICNIRP, is 5.6m. However, simultaneous occurrence of the fault conditions necessary to produce the level of EIRP required, make this an extremely unlikely eventuality.