Technical Note: Recommendation ITU-R S.1432 Interference Margins and I/N ratios

Abstract: In this Technical Note, we show how interference margins and I/N ratios are calculated from the apportionments specified in Recommendation ITU-R S.1432. Our calculations are consistent with the overall interference margins given in the Recommendation. This method can be used with definitions of System Noise that include or exclude contributions from various sources of interference. We highlight an alternative and incorrect approach that is inconsistent with the interference margins given in the Recommendation.

Introduction

There have been discussions within ITU in the recent period on appropriate protection criteria for FSS receivers. These discussions have often referenced Recommendation ITU-R S.1432 [1] but with clashing and sometimes confusing interpretations. This paper aims to clarify [1] with respect to definitions of Noise and the calculation of interference margins and I/N ratios.

Two interpretations of ITU-R S.1432

Our interpretation of [1] is that aggregate interference from all sources incident to a FSS satellite receiver is apportioned such that the degradation of the clear sky satellite System Noise, denoted here by $\Delta T/T$, is equal to 32% or 27%, dependent on frequency re-use. As per Section 5 of [1], these criteria correspond to overall interference margins of 1.2 dB or 1 dB respectively. The interference margin M can be calculated using:

Equation 1

$$M = 10.\log\left(1 + \left(\frac{\Delta T/T}{100}\right)\right).$$

We could assume satellite System Noise to be the fundamental level of Noise in the receiver bandwidth plus all other contributions to Noise including the receiver's Noise Figure and feeder losses but *excluding* contributions from interference. Hence, the interference margin M is a degradation of System Noise due to contributions from interference.

The apportionments given in [1] are as follows:

- 25% for all other FSS systems not practising frequency re-use;
- 20% for all other FSS systems practising frequency re-use;
- 6% for all other co-primary services;
- 1% for all other sources.

Each apportionment represents $\Delta T/T$ attributable to a particular source of interference and, using Equation 1, we can calculate the interference margin $M(\Delta T/T)$ associated with each apportionment of $\Delta T/T$ as shown in column 2 of Table 1.

Then $I/N(\Delta T/T)$ associated with each $M(\Delta T/T)$ can be calculated using equation 2 with results given in the final column of Table 1.

Equation 2

$$I/N(\Delta T/T) = 10.\log(10^{(M(\Delta T/T)/10)} - 1).$$

Table 1 $M(\Delta T/T)$ and $I/N(\Delta T/T)$

$\Delta T/T$ (%)	$M(\Delta T/T)$ (dB)	$I/N(\Delta T/T)$ (dB)
25	0.97	-6
20	0.79	-7
6	0.25	-12.2
1	0.04	-20

This interpretation is consistent with [1] since the overall $\Delta T/T$ values of 27% or 32 % correspond to $M(\Delta T/T)$ = 1 dB and 1.2 dB respectively (Equation 1) and the overall $I/N(\Delta T/T)$ = -5.7 dB or -4.9 dB (Equation 2).

Figure 1 shows how [1] apportions a 27% degradation of Noise to various sources of interference, the calculated I/N ratios and overall interference margin of 1 dB.

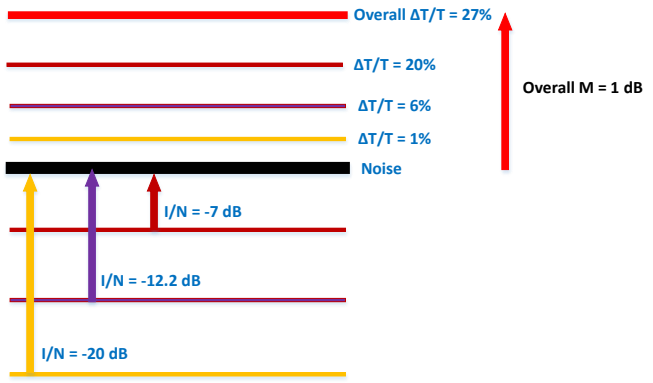

Figure 1 Apportionment scheme (27% degradation)

An alternative interpretation consistent with [1], and quite possibly the intention of the authors, is that $\Delta T/T$ is a degradation of *Thermal Noise*. Therefore, System Noise includes contributions from various sources of interference. In this case, the overall interference margin and the $\Delta T/T$, $M(\Delta T/T)$ and $I/N(\Delta T/T)$ values given in Table 1 are applied to Thermal Noise.

The important point here is that, whether applied to System Noise or Thermal Noise as defined above, the sum of apportionments is consistent with the interference margins in [1].

Alternative and incorrect interpretation of ITU-R S.1432

Various papers have offered an alternative interpretation of [1], apparently based on the approach set out in Recommendation ITU-R SF.1006 [2]. Specifically, System Noise includes interference and the apportionments are defined as percentages of System Noise *due* to interference from various sources, as opposed to the percentage degradation of System Noise or Thermal Noise due to interference. On this basis, the notation $\Delta T/T$ is inappropriate when describing the apportionments and we denote the percentage of System Noise due to interference by p_I and the percentage of System Noise due to an apportionment by p_a.

These notes will show that such an approach is inconsistent with the interference margins of 1 dB and 1.2 dB specified in [1].

If we assume that p_I = 27% or 32%, then $I/N(a)$ can be calculated for each apportionment p_a using Equation 3:

Equation 3

$$I/N(a) = 10.\log\left(\frac{p_a}{100}\right) - 10.\log\left[1 - \left(\frac{p_I}{100}\right)\right].$$

Our results are given in column 2 of Table 2.

Having calculated $I/N(a)$, we can use Equation 4 to determine $\Delta T/T(a)$:

Equation 4

$$\Delta T/T(a) = 100.\left(10^{(I/N(a)\,/10)}\right).$$

Results are shown in Column 3, Table 2.

Table 2 $I/N(a)$ and $\Delta T/T(a)$

p_a (%)	$I/N(a)$ (dB)	$\Delta T/T(a)$ (%)
25	-4.35	36.8
20	-5.62	27.4
6	-10.54	8.82
1	-18.33	1.47

Let $\Delta T/T(i)$ denote the total degradation of Noise given by the sum of $\Delta T/T(a)$ values associated with p_I = 27% or 32%. Then $\Delta T/T(i)$ = 37% for p_I = 27% and $\Delta T/T(i)$ = 47.1% for p_I = 32%. That is, if 27% of System Noise is due to interference then Thermal Noise is degraded by 37% and if 32% of System Noise is due to interference then Thermal Noise is degraded by 47.1%.

Having calculated $\Delta T/T(i)$, we obtain the overall interference margin M using Equation 1. This

delivers $M = 1.37$ dB, when $p_I = 27\%$ and $M = 1.67$ dB, when $p_I = 32\%$. Clearly these results are inconsistent with the interference margins given in [1].

Summary

In this Technical Note, we show that the correct interpretation of [1] requires consideration of the overall interference margin given by the sum of apportionments for FSS systems not practising and FSS systems practising frequency re-use.

An alternative interpretation where the sum of apportionments represents the percentage of System Noise due to interference is inconsistent with the interference margins given in [1].

References

[1] International Telecommunication Union, (2006), Recommendation ITU-R S.1432-1, *Apportionment of the allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz.*

[2] International Telecommunication Union, (1993), Recommendation ITU-R SF.1006, *Determination of the interference potential between Earth stations of the fixed-satellite service and stations in the fixed service.*

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