

RECOMMENDATION ITU-R S.1556

Methodology to determine the $\text{epfd}_{\downarrow}$ level corresponding to the loss of synchronization in geostationary fixed satellite service networks caused by interference from non-geostationary-satellite systems

(Questions ITU-R 231/4 and ITU-R 73/4)

(2002)

The ITU Radiocommunication Assembly,

considering

- a) that loss of synchronization in a geostationary fixed-satellite service (GSO FSS) satellite link can be extremely disruptive to the underlying service being supported;
- b) that loss of synchronization will directly impact the availability of the supported service and that conservative satellite link budget design is dependent on the knowledge of the threshold at which loss of synchronization occurs;
- c) that the measure of unavailability of satellite networks is determined by the combined effects of equipment thresholds, interference and propagation effects;
- d) that the C/N level, at which loss of synchronization occurs, may be of the order of 1 to 4 dB lower than the required C/N level corresponding to the availability threshold (i.e. shortest term objective);
- e) that, in the case of GSO networks which are integrated in terrestrial networks, the network may shut down the link at a higher level than would cause the modem to lose synchronization;
- f) that World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) adopted downlink equivalent power flux-density ($\text{epfd}_{\downarrow}$) limits, including operational limits, applicable to non-GSO systems in certain frequency bands;
- g) that GSO operators need to be able to identify climatological areas where the rain rate is such that links may be susceptible to interference peaks corresponding to the $\text{epfd}_{\downarrow}$ operational limits, and to evaluate the susceptibility to loss of demodulator synchronization,

recommends

- 1 that as a design guideline, the epfd levels corresponding to loss of synchronization in a GSO FSS earth station receiver may be determined by the methodology in Annex 1. Example results are given in Annex 2;
- 2 that the following Notes are part of the Recommendation.

NOTE 1 – The time duration and frequency of occurrence of interfering signals can contribute to the determination of the allowable maximum interference level. It is observed that multiple short interference events can result in a longer period of unavailability, due to the time needed to recover from the loss of synchronization, than fewer long events.

NOTE 2 – If there is unacceptable interference due to $\text{epfd}_{\downarrow}$ levels which are not greater than the operational limits, the GSO network operator has the option of adjusting the link so that the interference is acceptable.

NOTE 3 – In case of GSO FSS networks with lower data rates, the C/N level at which loss of synchronization occurs may be less than that of networks with higher data rates, while the time required for recovery of synchronization may be greater. Further study is needed to determine synchronization threshold levels for networks with data rates higher than 34 Mbit/s.

NOTE 4 – Further study is needed to determine threshold levels for loss of synchronization in links that are integrated in terrestrial networks.

ANNEX 1

This Annex provides a methodology that allows GSO operators to identify climatological areas that may have links that are susceptible to loss of synchronization at interference levels corresponding to the $\text{epfd}_{\downarrow}$ operational limits.

1 Theoretical loss of synchronization epfd calculation

Sensitivity to loss of synchronization due to rain is a global problem to GSO networks and non-GSO interference will increase the probability of loss of synchronization in all rain zones. Loss of synchronization can be extremely disruptive to certain services that, under current circumstances, are adequately provided over satellite networks. Since GSO networks are designed to reduce synchronization losses to near zero per cent of the time, the additional interference from non-GSO systems must also be taken into account.

A simple I/N calculation can be performed to demonstrate whether or not a GSO earth station, receiving a given rain rate, is susceptible to epfd induced loss of synchronization (*sync loss*). The calculation depends on the received C/N : $(C/N)_{\text{sync loss}} = C/(N + I)$, at which loss of synchronization occurs. $(C/N)_{\text{sync loss}}$ is typically in the range of 1 dB to about 4 dB below $(C/N)_{\text{required}}$ needed for the minimum BER performance objective desired for the link (i.e. the availability threshold). A link where $\Delta(C/N) = ((C/N)_{\text{required}} - (C/N)_{\text{sync loss}}) = 1$ dB is representative of 1/2 rate coding while $\Delta(C/N) = 3$ dB is representative of 3/4 rate coding.

Table 1 provides typical modulation and loss of synchronization information for systems with data rates less than 34 Mbits/s¹.

¹ This information, from Recommendation ITU-R S.1522, was used to calculate and evaluate the effects of epfd limits on GSO FSS networks operating in the 14/12 GHz band and whose availability is sensitive to synchronization timing recovery and interference emitted by non-GSO FSS networks.

TABLE 1

Modulation and coding	$C/(N+I)$ (dB)
QPSK rate 7/8	6.0
QPSK rate 3/4	5.3
QPSK rate 1/2	3.5
8-PSK	8.1
16-QAM	11.0

QPSK: quadrature phase-shift keying

16-QAM: 16-quadrature amplitude modulation.

Generally, the amount of C/N degradation to cause loss of synchronization is known (for a given link). Furthermore, the amount of margin needed to protect a network at a given rain rate in a specific frequency band can be estimated (see for example Table 2). This information can be used to calculate the interference levels that will cause a loss of synchronization for GSO links. For some sensitive links such levels may occur during some instances of the inline condition (i.e. GSO earth station, non-GSO satellite and GSO satellite are instantaneously in line).

TABLE 2

Representative rain rate power compensation margins for the 12 GHz band

Downlink availability (%)	Rain rates (mm/h)	5	10	15	20	25	30	35	40	45	50	55	60
99.9	Downlink margin to counteract rate fade (dB)	0.4	0.8	1.3	1.6	1.9	2.3	2.6	2.9	3.2	3.4	3.7	3.9
99.99		1.3	2.9	4.1	5.2	6.2	7.1	7.9	8.8	9.5	10.2	10.9	11.6

NOTE 1 – Rain margin calculated per Recommendation ITU-R P.618 for 99.9% and 99.99% availability. Assuming altitude of all earth stations at 0.25 km, with vertical polarization at latitude of 40° and an elevation angle of 20°.