

RECOMMENDATION ITU-R F.1605

Error performance and availability estimation for synchronous digital hierarchy terrestrial fixed wireless systems

(Question ITU-R 122/9)

(2003)

The ITU Radiocommunication Assembly,

considering

- a) that synchronous digital hierarchy (SDH) and plesiochronous digital hierarchy (PDH) systems play an important role in current fixed wireless systems;
- b) that Recommendations ITU-R F.1491 and ITU-R F.1397 established the error performance objectives for real connections;
- c) that Recommendations ITU-R F.1492 and ITU-R F.1493 established the availability objectives for real connections;
- d) that Recommendation ITU-R P.530 provides methods to allow the prediction of propagation parameters affecting the planning of terrestrial line-of-sight systems;
- e) that suitable path planning and systems design methods are needed to minimize the degradation of fixed radio system operation due to propagation effects,

recommends

- 1 that the error performance prediction methods for SDH radio links (paths and sections) set out in Annex 1 should be adopted for planning terrestrial line-of-sight systems in the respective ranges of parameters indicated.

Annex 1**Prediction of error performance and availability
of line-of-sight SDH radio links****1 Introduction**

SDH networks, or synchronous optical networks (SONET), currently allow radio link systems with capacities in synchronous transfer mode (STM) from 51 Mbit/s (STM-0) to 622 Mbit/s (STM-4). International Recommendations and Standards define the error performance and availability objectives for SDH networks. These objectives are media independent, and still have to be met whenever radio forms a part of the network.

The prediction methods given in this Annex are based on a theoretically-derived relationship between bit error ratio (BER) and the SDH parameters based on errored blocks (EBs). The methods take into account system characteristics such as burst errors along with the parameters needed for predicting the outage time based on different BER thresholds. The term “outage” in this Recommendation is defined as the probability that the BER is larger than a given threshold. It should be noted that the outage intensity (OI), defined in § 2.1 is a distinctly different parameter.

2 Error performance and availability objectives

ITU-T Recommendations G.826 and G.827 give the requirements for error performance and availability, respectively. Since these Recommendations give the end-to-end objectives, other recommendations are needed when dealing with actual radio links. In order to apportion the allowances to individual paths with actual hop lengths, operating radio frequency, etc., a number of additional recommendations have therefore been issued dealing with radio as an SDH network element.

2.1 Error performance and availability parameters

ITU-T Recommendations G.826 and G.828 define a set of block-based error performance events and parameters devoted to in-service error performance monitoring of an SDH path (see Note 1). An EB is one in which one or more bits are in error. An errored second (ES) occurs if there are one or more errored blocks or at least one defect such as a loss of pointer (LoP) during a one-second period. A severely errored second (SES) occurs if there are 30% or more EBs or a defect. SES is a subset of ES. Background block error (BBE) is an EB not occurring as part of an SES. Error performance parameters defined are severely errored second ratio (SESR), background block error ratio (BBER), and errored second ratio (ESR).

Each direction of a path can be in one of two states: available time or unavailable time. The criteria determining the transition between the two states are as follows: A period of unavailable time begins at the onset of 10 consecutive SES events. These 10s are considered to be part of unavailable time. A new period of available time begins at the onset of 10 consecutive non-SES events. These 10s are considered to be part of available time. A path is available if, and only if, both directions are available.

The availability parameters defined are: availability ratio (AR) and mean time between digital path outage (Mo). The converse of AR is the unavailability ratio (UR). Thus, $AR + UR = 1$. The reciprocal of Mo is defined as the outage intensity (OI). Thus, $OI = 1/Mo$. OI is regarded as the number of unavailable periods per year.

NOTE 1 – An SDH path is a trail carrying an SDH payload and associated overhead through the layered transport network between the path-terminating equipment. A digital path may be bidirectional or unidirectional and may comprise of both customer-owned portions and network-operator-owned portions (for more information see ITU-T Recommendations G.803, G.805 and G.828).

The definition of block size and error performance events for SDH multiplex section (MS) and regenerator section (RS) are presented in ITU-T Recommendation G.829. The error performance parameters and objectives for SDH MS and RS on individual digital fixed wireless links are given in the ITU-R F-Series Recommendations.

NOTE 2 – The threshold of 30% EBs is defined for SDH path in ITU-T Recommendations G.826 and G.828, while for SDH MS and RS the threshold value is defined in ITU-T Recommendation G.829.

2.2 Objectives for digital fixed wireless digital paths

The error performance objectives given for digital paths at or above the primary rate (2 048 or 1 544 Mbit/s) are different for national and international portions. The specified objectives must be met for any month. ITU-R has adopted objectives for both national and international paths. For the national portion there is a subdivision into three sections. These are: long haul, short haul and access network sections. The allocation of the error performance objectives for the short haul and access sections shall each make use of a fixed block allocation in the range of 7.5% to 8.5% of the end-to-end objectives. The allocation of the objectives for the long haul section shall make use of a distance-based allocation per 100 km and a fixed block allocation in the range of 1% to 2% of the end-to-end objectives. For apportioning these objectives to real digital fixed wireless links consisting of one or more hops, Recommendations ITU-R F.1397 and ITU-R F.1491 shall be used for the international and national portion respectively.

The availability objectives are defined in ITU-T Recommendation G.827. For real digital fixed wireless links consisting of one or more hops the availability objectives for a link forming part of an SDH path at or above the primary rate are defined in Recommendations ITU-R F.1492 and ITU-R F.1493 for the international and national portions, respectively.

3 Predicting error performance and availability

The relationship between the error performance parameters and BER is evaluated employing both random (Poisson) and burst error (Neyman-A) distributions. Modern radio transmission systems, which implement complex modulation schemes, error correction codes, equalizers, etc., tend to produce clusters or bursts of errors (see Note 1). Typical values for high level modulation (e.g. 128-trellis code modulation (128-TCM)) are 10 to 20 errors per burst.

NOTE 1 – A burst of errors is defined as a sequence of errors which starts and ends with an errored bit such that the time between two errors is less than the memory of the system (e.g. the constraint length of the convolutional code, the code size for block code, etc.).

The SDH prediction methods are based on theoretical assumptions relating BER, which is the fundamental parameter of existing prediction methods, to the error performance events ES, SES and BBE. Since the methods are based on BER, they automatically cover both multipath and rain attenuation. In the following paragraphs, some background information is given followed by step-by-step calculation procedures.

The prediction methods for SDH can also be used for PDH with the following choices:

- use the BER_{SES} closest to the transmission rate (Mbit/s), e.g. a VC-12 for a 2 Mbit/s PDH radio;
- use the BER_{SES} as given in Table 1 (the BER_{SES} is under study for PDH, but only minor differences are expected).

TABLE 1

BER_{SES} for various SDH paths and MS sections

Path type	Bit rate supported (Mbit/s)	$BER_{SES}^{(1), (2)}$	Blocks/s, $n^{(2)}$	Bits/block, $N_B^{(2)}$
VC-11	1.5	$5.4 \times 10^{-4} \alpha$	2 000	832
VC-12	2	$4.0 \times 10^{-4} \alpha$	2 000	1 120
VC-2	6	$1.3 \times 10^{-4} \alpha$	2 000	3 424
VC-3	34	$6.5 \times 10^{-5} \alpha$	8 000	6 120
VC-4	140	$2.1 \times 10^{-5} \alpha$	8 000	18 792
STM-1	155	$2.3 \times 10^{-5} \alpha$ $1.3 \times 10^{-5} \alpha \quad 2.2 \times 10^{-4}$	8 000 192 000	9 940 801

⁽¹⁾ $\alpha = 1$ indicates a Poisson distribution of errors.

⁽²⁾ The blocks/s are defined in ITU-T Recommendations ITU-T G.826 and G.828 for SDH path, in ITU-T Recommendation G.829 for SDH sections. Some STM-1 equipment might be designed with 8 000 blocks/s (19 940 bits/block), but ITU-T Recommendation G.829 defines the block rate and size to be 192 000 blocks/s and 801 bits/block, respectively.

3.1 Prediction of SESR

The procedure for predicting SESR is based on the relationship between SES and BER, where the methods for predicting outage defined by a specified BER are given in Annex 1 of Recommendation ITU-R P.530. Generally the SESR is predicted by:

$$SESR = \int_{BER_A}^{BER_B} f_{SES}(x) g_{BER}(x) dx \quad (1)$$

where:

$f_{SES}(x)$: relationship between SES and the BER

$g_{BER}(x)$: probability density function (PDF) of BER

BER_A and BER_B : integration limits (typical values are 1×10^{-9} and 1×10^{-3}).