RECOMMENDATION ITU-R F.700-2*

ERROR PERFORMANCE AND AVAILABILITY MEASUREMENT ALGORITHM FOR DIGITAL RADIO-RELAY LINKS AT THE SYSTEM BIT-RATE INTERFACE

(Question ITU-R 139/9)

(1990-1992-1994)

The ITU Radiocommunication Assembly,

considering

a) that the error performance objectives at the output of the hypothetical reference digital path, and sections for digital radio-relay systems which may form part of an ISDN, have been specified in Recommendation ITU-R F.594 and Recommendations ITU-R F.695, ITU-R F.696 and ITU-R F.697, in accordance with ITU-T Recommendation G.821 at the 64 kbit/s interface;

b) that ITU-T Recommendation G.821 gives guidelines in its Annex B on how to measure the error performance objectives and specifies in its Annex D provisional translations of error performance measurements at primary bit rates and above into 64 kbit/s error performance parameters;

c) that Recommendation ITU-R F.634 specifies error performance objectives for real digital radio-relay links forming part of a high grade circuit within an ISDN in agreement with b) above;

d) that the concept of unavailability of the hypothetical reference digital path has been defined in Recommendation ITU-R F.557;

e) that it is desirable to establish performance and availability indicators for digital radio-relay links;

f) that the standardization of bit error ratio measurement of digital radio-relay systems is desirable,

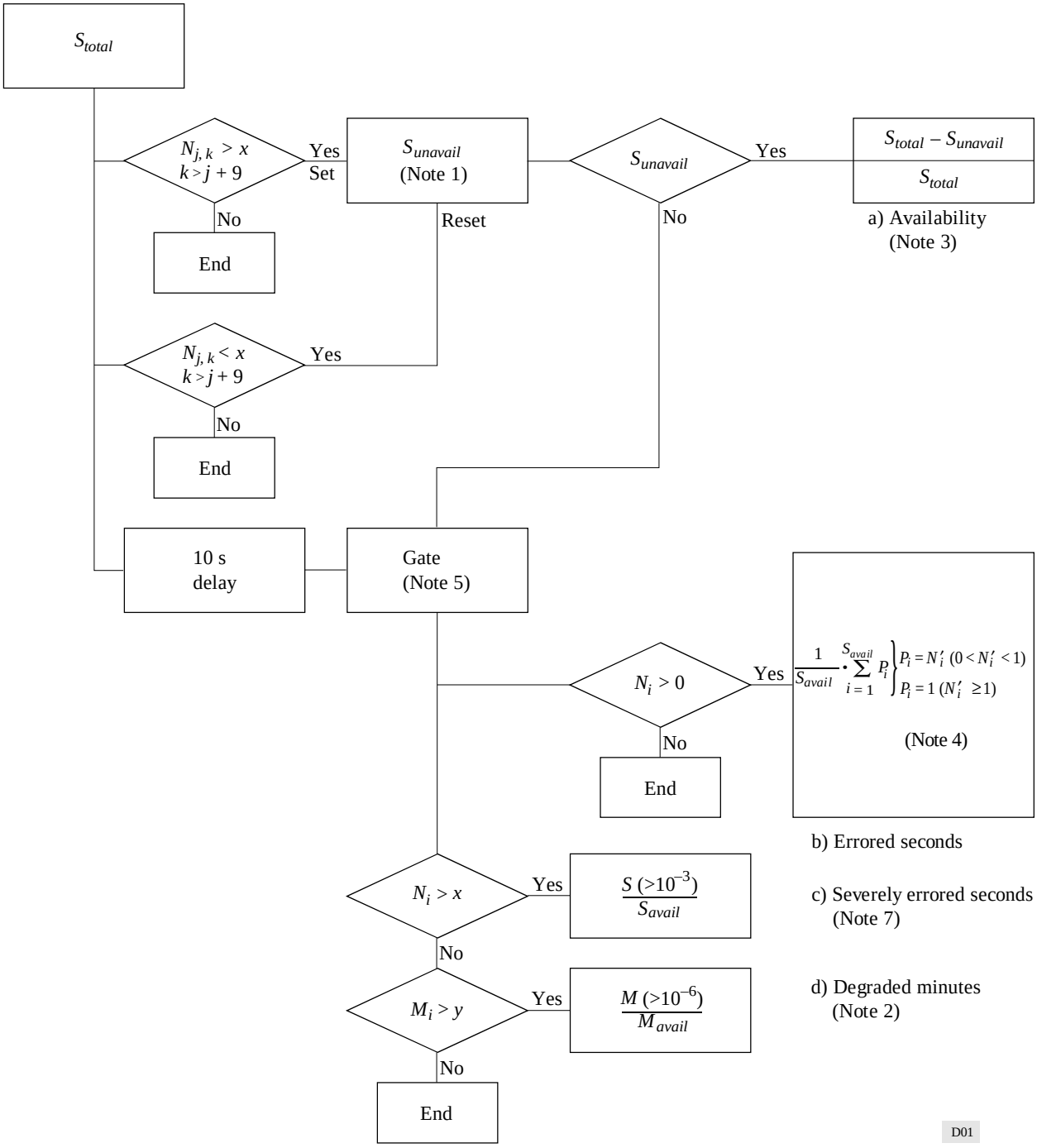
recommends

1. that the error performance and availability measurement at the system bit rate interface, in accordance with the specifications of the above mentioned ITU-R Recommendations and ITU-T Recommendation G.821, should be performed by counting the number of errors at the system bit rate in each 1 s interval and then processing the results using the algorithm shown in Fig. 1 (see Notes 6, 8 and 9).

* This Recommendation should be brought to the attention of Telecommunication Standardization Study Group 4.

FIGURE 1

Measurement algorithm



Legend to Fig. 1:

———— Flow of bit error measurement

———— Flow of logic information

S_{total}: total measured seconds: one month

$S_{unavail}$: unavailable time (s)

S_{avail}: available time (s)

M_{avail}: available time (min) $= \dfrac{S_{total} - S_{unavail}}{60}$ (The result is rounded off to the next higher integer)

$N_{j,k}$: number of bit errors in each second interval at the system bit rate between *j*th second and *k*th second inclusive

N_i: number of bit errors in the *i*th second at the system bit rate

N_i': $N_i \cdot \dfrac{64 \times 10^{-3}}{\text{system bit rate (Mbit/s)}}$ (number of bit errors normalized to the 64 kbit/s level)

P_i: probability of an errored second at the 64 kbit/s level being caused by N_i bit errors at the system bit rate (see Note 4)

$S(> 10^{-3})$: total time (s) during which the BER exceeds 10^{-3} in each second interval

$M(> 10^{-6})$: total time (s) that the BER exceeds 10^{-6}, measured in packets of 60 consecutive 1 s intervals derived by excluding any 1 s interval during which the BER exceeds 10^{-3}

M_i: number of bit errors in the *i*th packet of 60 consecutive 1 s intervals derived by excluding any 1 s interval during which the BER exceeds 10^{-3}

x: number of errors (rounded off to the next higher integer) corresponding to a BER of a 10^{-3} over a 1 s interval at the system bit rate ($x = 10^3 \times$ system bit rate (Mbit/s))

y: number of errors (rounded off to the next higher integer) corresponding to a BER of 10^{-6} over 60 1 s intervals at the system bit rate ($y = 60 \times$ system bit rate (Mbit/s))

Note 1 – With the algorithm shown, a small inaccuracy exists in the case where the measurement is stopped during a period of unavailability. In this case the first 10 s of the unavailability time are missing. The detailed algorithm, realized in error performance monitoring equipment, has to provide for this.

Note 2 – The last packet which may be incomplete is treated as if it were a complete packet with the same rules being applied (see Annex B to ITU-T Recommendation G.821).

Note 3 – The availability figure calculated in this way refers to one transmission direction of the radio-relay link only, whereas the availability concept of Recommendation ITU-R F.557 specifies objectives taking into account the behaviour of both transmission directions simultaneously. To compare the results with these objectives, further processing is needed (see Recommendation ITU-R F.557).

Note 4 – The translation of errored seconds at the system bit rate to errored second statistics at 64 kbit/s follows a linear law as provisionally proposed in Annex D of ITU-T Recommendation G.821 and Recommendation ITU-R F.634. Alternative methods are currently under study (see Annex 1).

Note 5 – The purpose of the gate is to discount the periods of unavailable time from the calculation of errored seconds, severely errored seconds and degraded minutes.

Note 6 – The measurement of RBER is under study (see Recommendation ITU-R F.634).

Note 7 – The percentage of severely errored seconds normalized to 64 kbit/s can be assessed from measurements made at the system bit rate (see Annex 1 to Recommendation ITU-R F.634).

Note 8 – The additional guidance given in Annex 1 should be referred to for the application of this Recommendation.

Note 9 – Error performance and availability measurement algorithm for performance objectives for constant bit rate digital paths at or above the primary rate carried by digital radio-relay systems based on ITU-T Recommendation G.826 is under study. Proposals have been made to delete the degraded minutes (DM) clause from ITU-T Recommendation G.821. When this deletion occurs then modifications to the present Recommendation will be necessary.

ANNEX 1

1. Basic criteria for bit error performance evaluation

The parameter used to describe the digital system performance is the bit error probability, that is the probability of incorrect reception of a single bit. Experimentally the most-used parameter is the so-called error ratio, defined as:

$$\text{Error ratio} = \frac{N_e}{N_t} = \frac{N_e}{B\,t_0}$$

where:

N_e: number of bit errors in time interval t_0

N_t: total number of transmitted bits in the time interval t_0

B: bit rate of binary signal at the point where the measurement is performed

t_0: measuring time interval (error counting time).

When the error generation process is random and stationary and the errors are counted in a sufficiently long interval t_0, the expression (1) can give an estimate of the error probability. The accuracy of this estimation increases as N_e increases, but practical requirements on the measuring time interval usually limit the values of N_e.

The minimum acceptable value of N_e seems to be about 10 and in this case the true error probability is contained in a range equal to $\pm 50\%$ around N_e/N_t with a confidence coefficient of 90%.

2. Relationship between performance objectives at the system bit rate and for 64 kbit/s channel

Performance objectives measurements are generally carried out at the system bit rate whereas the error performance objectives given in ITU-T Recommendations G.821 and G.921 and Recommendation ITU-R F.594 and also the errored seconds objective in Recommendation ITU-R F.634, refer to the 64 kbit/s channel.

This Recommendation uses the same provisional transformation algorithm for ES, SES and DM as used in Annex D of ITU-T Recommendation G.821.

For the purpose of evaluating error performance objectives normalized to 64 kbit/s on the basis of measurement results obtained at the bit rate of a primary digital system or higher order systems, the following method may be used:

– an error sub-stream corresponding to the 64 kbit/s channel is formed by selective demultiplexing from the error stream extracted from the signal transmitted over the system;

– the 64 kbit/s channel error signal thus obtained is processed in accordance with the algorithm given in Annex B to ITU-T Recommendation G.821.

The error stream selective demultiplexing method can also be used to evaluate the performance objectives of various services with bit rates exceeding 64 kbit/s (e.g. sound broadcasting of television) which are component parts of a high bit-rate signal.

3. Out-of-service and in-service measurements

The measurement algorithm stated in ITU-T Recommendation G.821 may be used during set-up and bring-into-service measurements using objectives and measuring intervals differing from the ones in the above-mentioned Recommendation.

The algorithm may also be used in maintenance tests. If it is used during the out-of-service time, the test duration should be kept as short as possible.

The results of in-service measurements on the bases of parity bit violations may be different from the results of pseudo random binary sequence (PRBS) measurements. This must be taken into account if the above-mentioned algorithm is used for in-service measurement.