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DIGITAL SECTIONS AND DIGITAL LINE SYSTEMS

DIGITAL LINE SYSTEMS BASED ON THE 2048 KBIT/S HIERARCHY ON COAXIAL PAIR CABLES

ITU-T Recommendation G.954

(Extract from the *Blue Book*)

NOTES

- 1 ITU-T Recommendation G.954 was published in Fascicle III.5 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).
- 2 In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation G.954

DIGITAL LINE SYSTEMS BASED ON THE 2048 kbit/s HIERARCHY ON COAXIAL PAIR CABLES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

This Recommendation covers digital line systems for the transmission of signals based on the 2048 kbit/s hierarchy on coaxial pair cables and includes systems conveying the following bit rates:

8 448 kbit/s
34 368 kbit/s
139 264 kbit/s
 $4 \times 139\,264$ kbit/s

In the case of $4 \times 139\,264$ kbit/s systems, a digital line muldex equipment combines the functions of multiplexing four digital signals at 139 264 kbit/s and of a line transmission equipment. Details of the digital multiplexing strategy are given in Annex B to this Recommendation.

The requirements for overall performance and interfaces of the corresponding digital line section are given in Recommendation G.921.

2 Transmission media

The systems can be operated on coaxial pairs, as defined in the series G.620 Recommendations, in accordance with Table 1/G.954.

TABLE 1/G.954

Transmission media

System (kbit/s)	Cable Recommendation
8 448	G.621; G.622
34 368	G.621; G.622; G.623
139 264	G.622; G.623
$4 \times 139\,264$	G.623

3 Overall design features

3.1 Availability

The availability objective of the system should be derived taking into account the availability requirement for the hypothetical reference digital section given in Recommendation G.801.

3.2 Reliability

MTBF values should be specified for the line system as a whole taking into account the requirements concerning availability.

3.3 Repeater noise margin

Repeater Noise Margin is defined in Annex A together with suggested measurement techniques. The Noise Margin quantifies the performance of digital regenerators for coaxial pairs. This is a function of BER and repeater spacing loss A_0 (at half the line system baud rate).

At a BER = 10^{-7} and over the loss range of the system $A_1 \leq A_0 \leq A_2$, the Noise Margin should meet the following specifications:

$$\text{Noise Margin (M)} \geq B + C (A_2 - A_0)$$

It has not been possible to recommend specific values for parameters A_1 , A_2 , B and C .

Note - The degrading effect of timing jitter on Noise Margin should be measured by superimposing appropriate jitter on the test signal.

Examples of the values used by some Administrations are given below:

	A_1 (dB)	A_2 (dB)	B (dB)	C
8 448 kbit/s systems	35	85	9	1
34 368 kbit/s systems	34 56 45	84 82 75	7.5 6 12	0.7 0.5 1
139 264 kbit/s systems	65 60	84 84	5.5 7.5	0.7 0.7 → 1

Note - The values do not include any allowance for the effects of jitter.

3.4 Error performance

The design objective for the error ratio of the individual repeater should take into account the network performance objectives given in Recommendation G.821.

4 Specific design features

4.1 Type of power feeding

Although CCITT does not recommend the use of a specific remote power-feeding system for these coaxial line systems, in practice only the constant current d.c. feeding via the inner conductors of the two coaxial pairs of system is used.

These coaxial cable systems may be subject to induced voltages and currents caused by lightning, power lines, railways, etc.

Precautions must be taken to protect the staff from any possible danger arising from the normal operating voltages and remote power-feed currents as well as from the induced voltages and currents.

Many national Administrations have issued detailed rules and regulations for the protection of persons. It is obligatory in most cases to meet these rules and regulations. In addition the CCITT Directives [1] give guidance on these problems.

Precautions are also needed for the protection of the equipment against induced voltages and currents. The equipment should therefore be designed in such a way that it passes the tests specified in Recommendation K.17 [2].

4.2 Nominal repeater spacing

A specific repeater spacing is not recommended but in practice the nominal values indicated in Table 2 are used by most Administrations:

TABLE 2/G.954

Nominal repeater spacings

System (kbit/s)	Nominal repeater spacing (km)		
	Cable Recommendation ^{a)}		
	G.621	G.622	G.623
8 448	4.0	—	—
34 368	2.0	4.0 (Note)	—
139 264	—	2.0	4.5 (Note)
4 × 139 264	—	—	1.5

- a) G.621 refers to 0.7/2.9 mm coaxial pairs.
 G.622 refers to 1.2/4.4 mm coaxial pairs.
 G.623 refers to 2.6/9.5 mm coaxial pairs.

Note - One Administration employs a nominal repeater spacing of 3 km.

4.3 Maintenance strategy

4.3.1 Type of supervision and fault location

In-service monitoring or out-of-service fault location can be used. For bit rates equal to or above 139 264 kbit/s in-service monitoring is recommended.

4.3.2 Fault conditions and consequent actions

The following fault conditions should be detected in addition to those specified in Recommendation G.921 for the relevant digital sections, and the associated consequent actions should be taken:

- a) failure of remote power feeding -
a prompt maintenance alarm should be generated, if practicable;
- b) low error ratio threshold exceeded -
this threshold is $1 \cdot 10^{-5}$ for systems at 8448 kbit/s
and $1 \cdot 10^{-6}$ for systems at higher bit rates;

a deferred maintenance alarm should be generated to signify that performance is deteriorating.

ANNEX A

(to Recommendation G.954)

Definition and measurement of repeater noise margin

A.1 Definition

The noise margin m_n :

$$m_n = SNR/SNR_{ER} \quad (A-1)$$

where

$$SNR = SNR_{th} \cdot F(t, ER) \quad (A-2)$$

The product $SNR_{th} \cdot F(t, ER)$ can be considered the actual signal-to-noise ratio SNR being the measure for the regenerator performance.

SNR_{th} is the theoretical signal-to-noise ratio determined by the system parameters such as output pulse, section loss, noise figure of the regenerator input amplifier etc.

$F(t, ER)$ is the reduction factor due to an off-set from the optimum timing instant (including phase jitter) in conjunction with the pulse realized $S(t)$, the intersymbol interference $I(t)$ and any other disturbance which causes a corruption in the information signal (I_c).

Note - The intersymbol interference and other disturbances are fluctuating processes with bounded distributions. The "mean" reduction factor depends on ER , and, for a ternary signal, is given by:

$$F(t, ER) = \frac{S(t)}{S(0)} - 2 \left\{ \frac{I(t)}{S(0)} - \frac{I_c}{S(0)} \right\} \quad (A-3)$$

where $S(0)$ is the realized pulse at $t = 0$ giving the maximum amplitude.

SNR_{ER} is the signal-to-noise ratio required for an error ratio to ER . For a ternary signal the relation between ER and SNR_{ER} is given by the known Gaussian distribution:

$$ER = \frac{4}{3} P[E] = \frac{4}{3\sqrt{2\pi}} \int_{SNR_{ER}}^{\infty} e^{-x^{1/2}} dx \quad (A-4)$$

A.2 Derived definitions

The noise margin can be measured by applying an external disturbing signal. For that purpose more practical definitions are derived.