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**OBJECTIVE FOR THE MIXED ANALOGUE/
DIGITAL CHAIN OF 4-WIRE CIRCUITS**

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NOTES

- 1 CCITT G-series Recommendation Supplement 29 was published in Fascicle III.1 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).
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OBJECTIVE FOR THE MIXED ANALOGUE/DIGITAL CHAIN OF 4-WIRE CIRCUITS

Draft Recommendation G.136

(This Supplement is proposed for further study during the present study period with the aim to convert the supplement into a Recommendation.)

1 General

In the period of transition from a fully analogue to a fully digital network, there will be, on international and national networks, mixed type chain of 4-wire telephone circuits (see Recommendation G.101, § 4.2), some sections of which can be made with analogue or digital transmission systems.

Considering the fact that the transition period may last for a fairly prolonged time, and also considering the need for guaranteeing a certain quality of transmission on mixed chain of circuits, the CCITT recommends observance of some principles for the composition of mixed chain of circuits as set forth below and some objectives for their parameters.

The main principle in the standardization of mixed circuits lies in the retaining of the standards adopted for the FDM circuits. This would have resulted in retaining the transmission quality over the 4-wire chain formed by the international circuits and national extension circuits.

For some parameters this can be achieved, but as far as some other parameters are concerned due to analogue/digital conversions and errors in digital sections there are some considerable differences in standards and measuring methods.

Objectives for some mixed circuit parameters are contained in a number of G-, Q-, and M-series Recommendations. However, these objectives do not take due account of the addition laws for distortions based on the multitude of mixed circuit structures and specific features of the measuring methods involved.

Considering the importance of retaining the transmission quality during the transition period and attaching great importance to the standardization of mixed analogue/digital circuits the multitudinous types of which emerge while using various kinds of analogue-to-digital conversions, CCITT thinks it worth while to have a specific Recommendation on objectives for mixed analogue/digital circuits and 4-wire chains including both analogue and digital circuits.

The present Recommendation related to mixed 4-wire chain of circuits and the analogue/digital mixed connections dealt with in this Recommendation are those with analogue telephone sets at both ends.

It is based on the existing Recommendations for FDM channel equipment G.232, for PCM channel equipment G.712, for analogue switching centres Q.45, Q.45 *bis*, for digital switching centres Q.551 to Q.554, and takes account of other existing Recommendations of G- and M-series.

Later on in accordance with the study results of Question 26/XII the present Recommendation will have to be supplemented by objectives for mixed chain of circuits formed with the help of various methods of analogue-to-digital conversion such as transmultiplexers (Recommendations G.793, G.794), modems (Recommendations G.941, V.37), transcoders (Recommendation G.761), group codecs (Recommendation G.795), DCME, as well as connections with a digital telephone at one end and an analogue telephone at the other end.

2 Structure of a mixed analogue/digital voice frequency chain of 4-wire circuit

The parameters of a mixed 4-wire chain are essentially dependent on the number of analogue sections and on the number of analogue/digital conversions in the chain.

According to Recommendation G.103 the total number of 4-wire circuits in a 4-wire chain of the maximum length is 12 in exceptional cases (Table 2/G.101) so that it may be assumed that the number of circuits will not exceed 12. The worst cases in terms of distortions occur when:

- all switching centres are digital, and the circuit sections from and to the centres are set up on analogue transmission systems. The number of analogue/digital conversions is then 11, the number of analogue sections is 12;

- all switching centres are analogue, and the circuit sections from and to the centres are set up on digital systems. The number of analogue/digital conversions is 12 in this case, the number of digital sections is 12.

Such cases are very rare. More representative is considered to be a case where the number of analogue/digital conversions makes one half of the maximum number (Recommendation G.103, Annex B), that is 6, and digital islands are available. The structure of such a 4-wire chain is presented in Figure 1. The number of analogue sections is 6, the number of digital sections is also 6. Other structures of mixed 4-wire chain come into the picture when connection of the sections is realized without a switching equipment. These structures are considered in Recommendation M.562 (§ 3.2). The worst case for a circuit of 12 sections without switching centres occurs when digital and analogue sections alternate (see Figure 2), the number of analogue-digital conversions being equal to 6, the number of digital sections to 6, and the number of analogue sections also to 6.

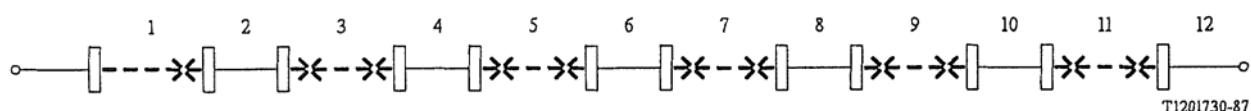


FIGURE 1

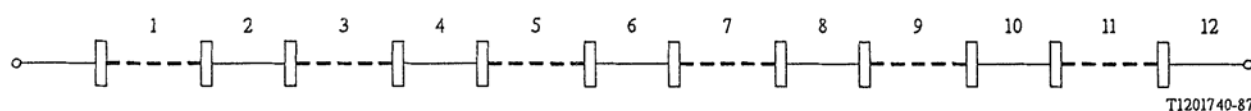


FIGURE 2

Thus, the examination of various structures of mixed analogue/digital voice-frequency chain of circuits shows that for a 4-wire chain of maximum length having 12 sections, it is advisable to establish objectives of distortions based on 6 analogue/digital conversions, 6 analogue and 6 digital sections.

Intermediate variants for combinations of analogue, digital sections and analogue-to-digital conversions will be:

11 analogue sections + 1 a/d conversion
(1 digital section) = 12

.....

6 analogue sections + 6 a/d conversions
(6 digital sections) = 12

It should be borne in mind that the chains may most frequently consist of less than 12 sections. The contribution of switching centres to distortion is negligible, if they do not contain analogue/digital conversions.

3 Objectives for parameters of mixed analogue/digital circuits

3.1 The nominal value of the input/output impedance of the analogue and digital sections and of a switching equipment should be 600 ohms.

3.2 Return loss of the input/output impedance referred to the nominal value of the analogue and digital sections and of a switching equipment should preferably be not less than 20 dB in the 300-3400 Hz band.

Note – For a switching centre and channel FDM equipment, the value of 15 dB is permissible in the 300-600 Hz band (see Recommendation Q.45, § 6.3 and Recommendation G.232, § 7).

3.3 *Unbalance loss in respect to earth*

The existing Recommendations for switching centres (Q.45, Q.553) and channel FDM equipment (G.712) standardize the unbalance loss in respect to the earth in different ways. There are differences in the measuring methods as well. The Recommendation for the FDM-channel equipment (G.232), does not specify this parameter. The question of standardization and methods of measuring this parameter for mixed circuits channels is under study.

Pending the establishment of unified objectives and measuring methods, Recommendation K.10 on the unbalance loss of communication equipment should be referred to in general guidelines in the case of mixed chain of 4-wire circuits.

3.4 *Nominal relative level*

The nominal relative level on the transmit side of each section (analogue and digital) is -14 (-16) dBr. The nominal relative level on the receive side of each section (analogue and digital) is +4 (+7) dBr (see Recommendations G.232, § 11, G.712, § 14, Q.45, § 3 and Q.553 § 2.2)

The nominal relative level at the virtual analogue switching point is

- sending: -3.5 dBr
- receiving: -4.0 dBr for analogue
-3.5 dBr for digital

(See Recommendation G.101, § 5.2.)

The nominal relative value in a mixed circuit is defined for a frequency which is not a subharmonic of the sampling frequency. The recommended tentative value for the frequency is 1020 Hz.

3.5 *Variations of transmission loss with time*

The standard deviation of the transmission loss should not exceed 1 dB.

The difference between mean and nominal value of the transmission loss should not exceed 0.5 dB.

Note – The indicated values are defined in Recommendation G.151, § 3 for a fully analogue circuit under the condition that the channels are part of a single group equipped with automatic regulation.

For mixed chains the stability conditions improve on the one hand because of the existence of digital sections which have a higher stability than analogue ones; but on the other hand in the mixed circuits there is no possibility of a transit automatic regulation of analogue sections, which deteriorates the overall stability. That is why the indicated values should be considered as tentative and are to be confirmed.

3.6 *Attenuation/frequency distortion*

Attenuation/frequency distortion for the whole 4-wire chain should not exceed the values given in Figure 1/G.132.

For mixed chains (without consideration of switching centre distortions) the accumulation law of attenuation/frequency distortions is expressed by the following formula:

$$\Delta a = n_1 \bar{a}_{\text{FDM}} + \sum_{i=1}^{n_2} a_{i\text{PCM}} \pm K \sqrt{\sigma_{\text{FDM}}^2 \cdot n_1} \quad (1)$$

with

n_1 : number of analogue sections;

n_2 : number of analogue/digital conversions;

$\bar{a}_{\text{FDM}}$: average value (determined component) of attenuation/frequency distortions of the analogue sections;

σ_{FDM} : r.m.s. deviation of attenuation/frequency distortions of analogue sections;

a_{PCM} : attenuation/frequency characteristics of analogue/digital equipment;

$K = 1, 2$ or 3 : factor defining the probability of maximum/minimum value of attenuation/frequency distortions.

“K” is usually taken as equal to 3. The justification of the choice for $K = 3$ depending on a given probability can be found in [1, 2].