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SERIES Q: SWITCHING AND SIGNALLING

International automatic and semi-automatic working – General characteristics for international telephone connections and circuits

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Transmission characteristics of an analogue international exchange

ITU-T Recommendation Q.45

Extract of **Red Book Fascicle VI.1 (1984)**

NOTES

1 ITU-T Recommendation Q.45 was published in Fascicle VI.1 of the *Red Book*. This file is an extract from the *Red Book*. While the presentation and layout of the text might be slightly different from the *Red Book* version, the contents of the file are identical to the *Red 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.

Recommendation Q.45

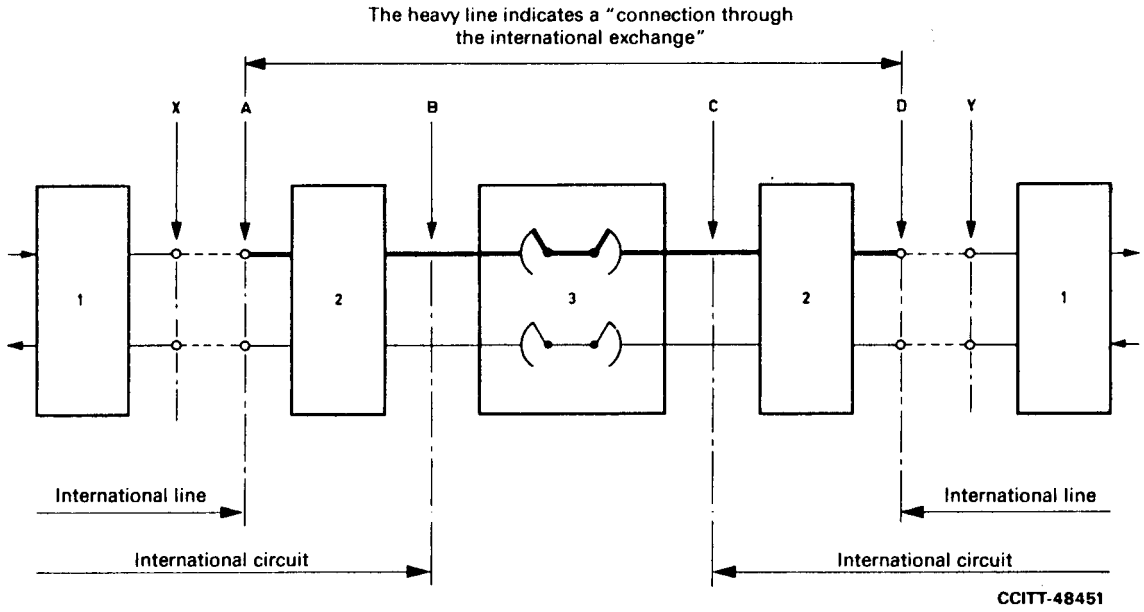
TRANSMISSION CHARACTERISTICS OF AN ANALOGUE INTERNATIONAL EXCHANGE[1)]

1 Introduction

1.1 For the purposes of this Recommendation, an international exchange is a collection of equipment regarded as an entity by the Administration concerned. In the case of an international transit centre, it extends from the end of the incoming international line to the beginning of the outgoing international line (e.g. between such points as A and D in Figure 1/Q.45 or any other suitable pair of points).

In the absence of an international agreement on the choice of the points delimiting an international exchange, it has proved impossible to draw up model specifications showing the limits to be observed for quantities measured between these points. The CCITT recommendations given hereafter have been issued regardless of the actual arrangement.

Automatic international exchanges should be provided with circuit test access points (see Recommendation M.700 [1]) complying with the Recommendation cited in [2]. This Recommendation will ensure that circuit line-up and maintenance testing procedures are referred to points at or near the switchblock (Points B and C of Figure 1/Q.45).



1 = channel translating equipment
2 = incoming and outgoing relay set
3 = automatic switching equipment

Note – Between points X and A and points D and Y, there may be equipment such as echo suppresors, compandors, equalizers, line signal receivers, etc., in addition to the cabling.

FIGURE 1/Q.45
International exchange

1) The transmission characteristics of a digital international exchange are specified in Recommendation Q.507.

1.2 The essential transmission requirements for an international exchange are:

a) The *transmission loss* through the centre should be substantially constant with time and independent of the routing through the centre.

b) *Crosstalk and noise* should be negligible.

c) The *distortions* introduced should be small. These include attenuation distortion, non-linear distortion and intermodulation products.

d) *Impedance* and *balance with respect to earth* at the points in the international exchange to which the lines are connected should be closely controlled.

1.3 The following recommendations apply to new automatic 4-wire international exchanges of the electro-mechanical type. It is desirable that they should apply to new national 4-wire exchanges. They may also be applicable to electronic exchanges having metallic contact crosspoints.

These recommendations are intended to be used only as type tests, acceptance tests, or for special investigations. They do not constitute a complete specification. Generally the recommended tests should be conducted on a sampling basis.

2 Definitions

2.1 *Definition of a "connection through an exchange"*

Crosstalk and noise conditions for a 4-wire international exchange are defined by reference to a "connection through this exchange". By **connection through an exchange** is to be understood the pair of wires corresponding to one direction of transmission (GO direction or RETURN direction) and connecting the input point of one circuit incoming in the exchange and the output point of a different circuit outgoing from the exchange (these input or output points are often taken at the test-jack frame).

A connection through the international exchange is shown by a heavy line in Figure 1/Q.45.

2.2 *Definition of switching equipment input and output points*

Although the virtual switching points, which are points at which the two circuits are considered to be directly connected, are theoretical points, in practice it will always be possible to choose a point considered as the *switching equipment input* for the receive channel of a circuit and a point considered as the *switching equipment output* for the transmit channel of a circuit.

The exact position of each of these points depends on national practice and it is unnecessary for the CCITT to define it. Only the national authority responsible for each international transit centre can fix the position of these points in each case.

The switching equipment input point associated with a receive channel may be such that the nominal relative level is different from –4.0 dBr. Let this nominal relative level be R[2)].

The switching equipment output point associated with a transmit channel may be such that the nominal relative level is different from –3.5 dBr. Let this nominal relative level be S[2)].

Consider a circuit between the switching centre concerned and the adjacent centre. Let T be the nominal transmission loss between virtual switching points at the two ends of the channel of this circuit, which is the receive channel in the centre concerned.

When a transit connection is established through a centre by connecting the receive and transmit channels of one circuit to the transmit and receive channels respectively of another circuit, in order to ensure that the virtual switching points have been connected together with additional loss or gain, the *nominal* value of the attenuation (loss) to be introduced between the switching equipment input and the switching equipment output is $R - S + T$.

2.3 *Definition of the net switching loss*

Let the actual value of the attenuation introduced between the switching equipment input and output points be A. The net switching loss is defined to be equal to the difference between this *actual* value and the *nominal* value of the attenuation. Thus:

$$\text{Net switching loss} = \text{actual loss} - \text{nominal loss}$$
$$= A - (R - S + T).$$

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2) If the value of R is chosen to be higher than the value of S, the level difference can be used to offset any inherent transmission loss in the switching equipment and the requirements of the transmission plan can be met without any need to install supplementary audio-frequency amplifiers.

3 Recommendations concerning transmission loss

3.1 *Net switching loss*

Ideally, the net switching loss of an international exchange would always be zero. That is, the *actual* loss (A) should equal the *nominal* loss ($R - S + T$).

Example – The relationship between the actual switching points and the virtual switching points in a practical international exchange is illustrated in Figure 2/Q.45. In this arrangement:

$R =$ +7 dBr,

$S =$ –16 dBr,

and T is assumed to be 0.5 dB

so that the nominal transmission loss needed between the +7 and –16 dBr points is:

$$(+7) - (-16) + (0.5) = 23.5 \text{ dB}.$$

In practice, different connections established by the switching equipment will introduce different values of net switching loss so that a distribution of net switching losses will arise. The mean value of this distribution should be very close to zero but does not need to be specified.

3.2 *Loss dispersion*

According to the Recommendation cited in [2], circuit test-access points are located at or near the switchblock (points B and C of Figure 1/Q.45). Moreover, the dispersion of loss is mainly due to the diversity of paths in the switchblock. It is therefore only necessary to consider the dispersion of loss between the points B and C.

The standard deviation of loss measured at 800 Hz of all possible paths between points B and C should be as small as possible. For purposes of calculation a value of 0.2 dB may be assumed.

In order to conform to this value, it is considered sufficient that, for purposes of design and acceptance testing, the difference between the losses at 800 Hz of the shortest and longest paths from point B to point C in no case exceeds 0.8 dB. For a practical assessment of the average value of net switching loss, the contribution from the switchblock can be taken as the mean of the maximum and minimum values of loss between points B and C.

These values apply for connections routed directly, and once only, through the switchblock. Due to the fact that the switchblock contains only switches and associated cabling, the actual loss between points B and C in any case can only have positive values.

If special re-entrant trunking arrangements are used, requiring the connection to pass through the switchblock twice (this may be a convenient way to extend the availability of the switching network or to introduce additional equipment, e.g. echo suppressors), the maximum loss and loss dispersion will be increased. In view of this, the re-entrant technique should not be used to such an extent as to increase significantly the mean net switching loss of the exchange.

3.3 *Nonlinear distortion*

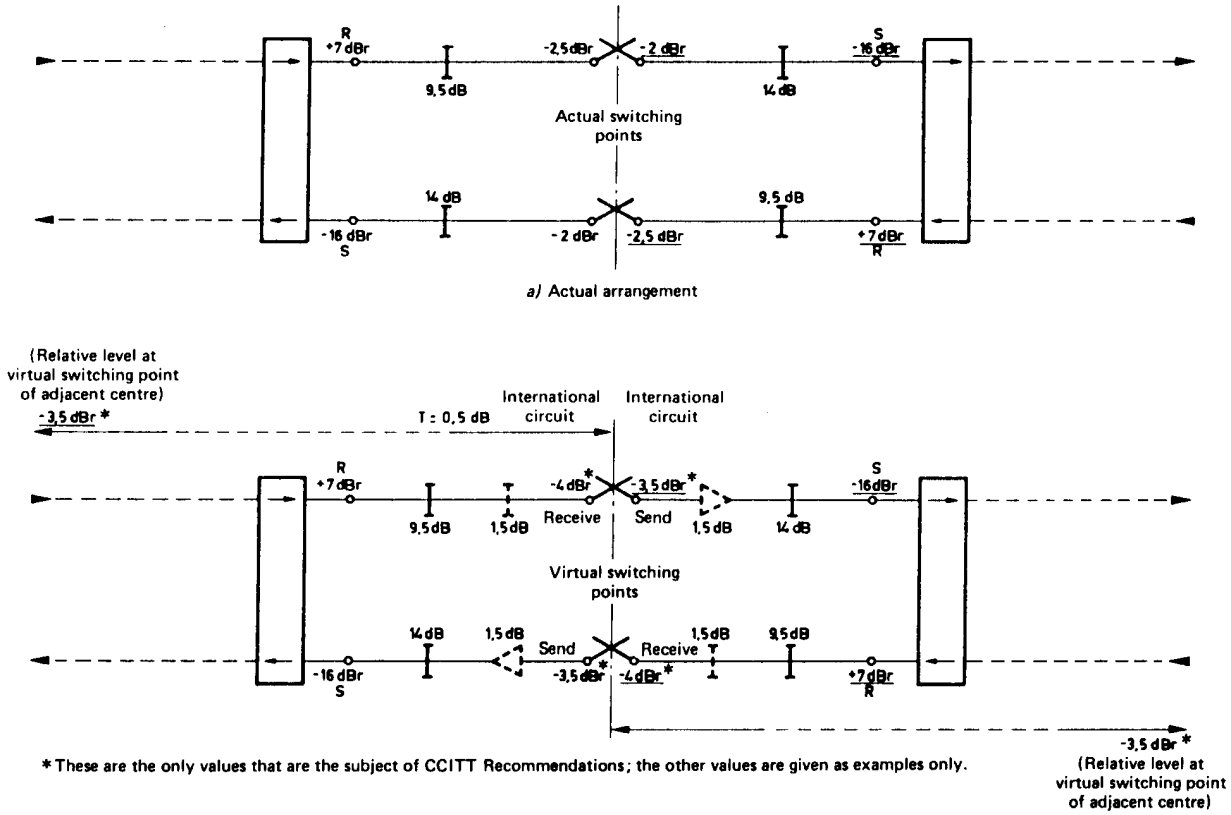
The transmission loss measured on any “connection through the international exchange” should not vary by more than 0.2 dB when the level of the test-tone is varied from –40 dBm0 to +3.5 dBm0.

3.4 *Loss-frequency distortion referred to 800 Hz*

The difference between the transmission loss measured on any “connection through the international exchange” over the frequency bands indicated below and that measured at 800 Hz[3)], should lie within the following limits:

300- 400 Hz: –0.2 dB to +0.5 dB,
400-2400 Hz: –0.2 dB to +0.3 dB,
2400-3400 Hz: –0.2 dB to +0.5 dB.

3) 1000 Hz is an acceptable alternative frequency.



Note – Underlined values of relative level refer to the circuit on the right of the point concerned. Values of relative level not underlined refer to the circuit on the left of the point concerned. In an actual switching centre the virtual switching points would not physically exist.

FIGURE 2/Q.45

Example showing a simplified representation of a transit connection in an international exchange with actual arrangement and possible location of virtual switching points

4 Crosstalk recommendations

4.1 Crosstalk should be measured in exchanges at a frequency of 1100 Hz in accordance with Recommendation G.134 [3].

4.2 *Crosstalk between connections established (between points A and D)*

In an international 4-wire exchange the signal to crosstalk ratio measured at points A and D between any two "connections through the international exchange" (see definition in § 2.1 above) should be 70 dB or better.

This limit of 70 dB should normally apply to the most unfavourable case, in which two "connections" have parallel paths throughout the international exchange. It should be noted that this does not occur in practice, because normal cabling layout is such that when, at one switching stage, two "connections" use adjacent switches, in the following stage the two "connections" generally use switches which are not adjacent.

4.3 *GO to RETURN crosstalk of the same path (between points A and D)*

The signal-to-crosstalk ratio between the two "connections" which constitute the GO and RETURN channels of a 4-wire path established through the international exchange should be 60 dB or better.

5 Noise recommendations

For a 4-wire international exchange, noise measurements should be performed on a "connection through the exchange" during the busy-hour. (The *busy-hour* is defined in [4].) Each channel of the connection should be terminated at points A and D of Figure 1/Q.45, in 600 ohms. The noise should be measured at the downstream end of each channel and should be referred to a point zero relative level in that channel. Thus, in Figure 1/Q.45 the noise in the upper channel is measured at D and the noise in the lower channel is measured at A.

5.1 *Mean noise power during the busy-hour*

The mean of the noise over a long period during the busy-hour should not exceed the following values:

– Psophometrically weighted noise: –67 dBm0p (200 pW0p),

– Unweighted noise: –40 dBm0 (100 000 pW0) measured with a device with a uniform response curve throughout the band 30-20 000 Hz.

Note – A sufficient variety of connections should be chosen to ensure that the measurements are representative of the various possible routes through the exchange.

5.2 *Impulsive noise during the busy-hour*

Noise counts should not exceed 5 counts in 5 minutes at a threshold level of –35 dBm0 (see Annex A to this Recommendation for measurement procedure).

Note – Figure 3/Q.45 shows the maximum number of impulsive noise counts acceptable on a 5-minute period.

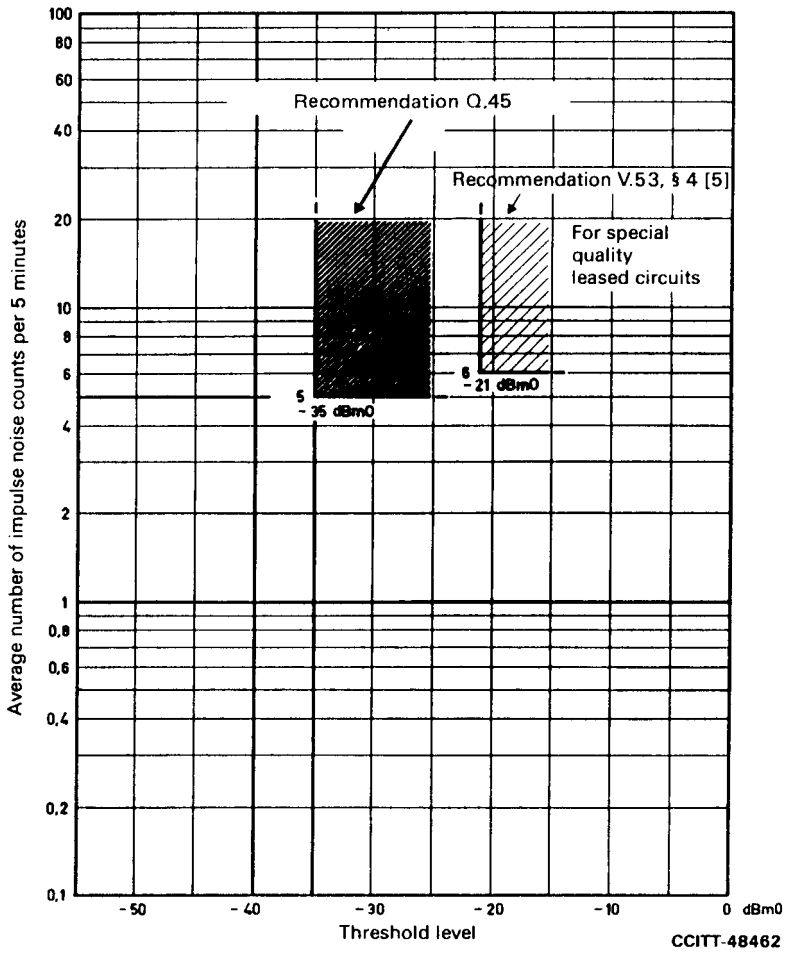


FIGURE 3/Q.45

Impulsive noise requirements for 4-wire exchanges

6 Other transmission recommendations

6.1 *Intermodulation products (measured at A and D)*

The intermodulation products to be taken into account for end-to-end multifrequency signalling and for data transmission are those of the third order, of type $(2f_1 - f_2)$ and $(2f_2 - f_1)$ where f_1 and f_2 are two signalling frequencies.

For a measurement of the intermodulation products, the two frequencies to be used are 900 Hz and 1020 Hz (see [6]). With each frequency f_1 and f_2 at a level of –6 dBm0, the difference between the level of either frequency f_1 or f_2 and the level of either of the intermodulation products at $(2f_1 - f_2)$ or $(2f_2 - f_1)$ should be at least 40 dB.

6.2 *Group delay distortion (measured between A and D)*

The group delay distortion measured on any "connection through the international exchange" over the band 600-3000 Hz should not exceed 100 microseconds.

6.3 *Return loss (measured at A and D, from A towards D and from D towards A)*

At any frequency from 300-600 Hz the return loss measured against 600 ohms should be not less than 15 dB. The corresponding value from 600-3400 Hz should be not less than 20 dB.

6.4 *Impedance unbalance to earth*

6.4.1 The impedance unbalance to earth measured, at points A and D, should not be worse than:

300- 600 Hz: 40 dB;

600-3400 Hz: 46 dB.

Note – Some Administrations guided by their knowledge of local conditions may feel a need to specify a figure for a lower frequency, for instance, 50 Hz.

6.4.2 The degree of unbalance to earth is defined as the ratio u/U measured as shown in a) and b) of Figure 4/Q.45 and is expressed in decibels as the reciprocal of this ratio in transmission units.

The diagrams of Figure 4/Q.45 used for measurement of unbalance differ only in respect of the presence or absence of an earth at the mid-point of the termination. Unbalance measurements according to a) and b) of Figure 4/Q.45 can give quite different results according to the nature of the unbalance.

6.4.3 The CCITT has recommended in 1968 that the set of limit values of § 6.4.1 above should be met for unbalance to earth measured with *both* measuring diagrams according to Figure 4/Q.45.

7 Use of cables specified by the IEC

The cables for telephone exchanges in accordance with the IEC (International Electrotechnical Commission) publication cited in [7] will meet the electrical characteristics required by the CCITT (especially as regards crosstalk) for ordinary exchanges, but this may no longer hold good for larger exchanges with considerable lengths of cable.

In accordance with Recommendation G.231 [8], it will be for the Administrations or the contractors to check whether standard cables will be satisfactory in equipping an exchange which requires telephone cables of exceptional length.

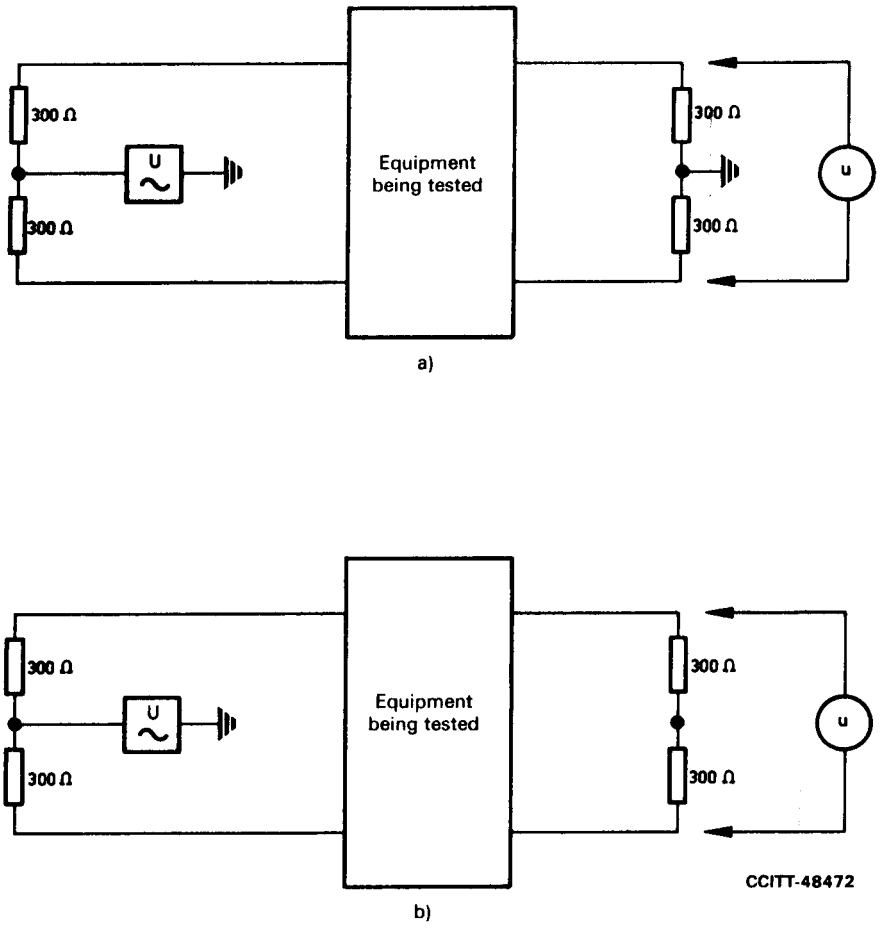


FIGURE 4/Q.45

Measurement of the degree of unbalance to Earth

ANNEX A

(to Recommendation Q.45, § 5.2)

Procedure for impulsive noise measurements

A.1 A test circuit should be formed by setting up a connection across the switching unit and terminating the connection on one side of the exchange by the appropriate closing impedance and on the other by the impulse measuring device in parallel to the closing impedance. Those terminating points should be points A and D in the diagram of Figure 1/Q.45 (or equivalent points) to include the switching equipment of the exchange. Where it is the desire of an Administration, measurements may be made at points X and Y if precautions are taken to ensure that the results apply only to the automatic switching equipment, signalling equipment, echo suppressors, relay sets, pads and cabling of the exchange.

A.2 The measurements should be made using the device specified in Recommendation O.71 [9]. The 600-3000 Hz filter network described in [10] should be in the circuit.

A.3 The measurements should be made at times when the probability of noise occurring is at its highest, that is normally during the busy-hour.

A.4 The time of observation for each test should be five minutes.

Note – The number of different test circuits set up across the exchange for measuring should take into account the size and complexity of the switching unit and should be a number sufficient to represent the various possible types of calls and routes through the exchange.

See also the document cited in [11].

References

[1] CCITT Recommendation *Definitions for the maintenance organization*, Vol. IV, Rec. M.700.

[2] CCITT Recommendation *Four-wire switched connections and four-wire measurements on circuits*, Vol. IV, Rec. M.640, § 2.

[3] CCITT Recommendation *Linear crosstalk*, Vol. III, Rec. G.134.

[4] CCITT Definitions: *Busy hour*, Vol. X, Fascicle X.1 (Terms and Definitions).

[5] CCITT Recommendation *Limits for the maintenance of telephone-type circuits used for data transmission*, Vol. VIII, Rec. V.53, § 4.

[6] CCITT Recommendation *Characteristics of compandors for telephony*, Vol. III, Rec. G.162, § 5.2.

[7] Publication 189 of the I.E.C.

[8] CCITT Recommendation *Arrangement of carrier equipment*, Vol. III, Rec. G.231.

[9] CCITT Recommendation *Specification for an impulsive noise measuring instrument for telephone-type circuits*, Vol. IV, Rec. O.71.

[10] *Ibid.*, § 3.5.

[11] *Measurements of impulsive noise in a four-wire telephone exchange*, Green Book, Vol. VI-4, Supplement No. 7, ITU, Geneva, 1973.