



INTERNATIONAL TELECOMMUNICATION UNION

**ITU-T**

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

**G.105**

**TRANSMISSION SYSTEMS AND MEDIA**

**GENERAL CHARACTERISTICS OF INTERNATIONAL  
TELEPHONE CONNECTIONS AND INTERNATIONAL  
TELEPHONE CIRCUITS**

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**HYPOTHETICAL REFERENCE CONNECTION  
FOR CROSSTALK STUDIES**

**ITU-T Recommendation G.105**

(Extract from the *Blue Book*)

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## NOTES

1 ITU-T Recommendation G.105 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).

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.105

### HYPOTHETICAL REFERENCE CONNECTION FOR CROSSTALK STUDIES

(Geneva, 1980)

#### 1 Purpose

This Recommendation gives guidance concerning the application of Recommendation P.16 [1] in the general switched telephone network and recommends the structure and parameters of a hypothetical reference connection specifically designed for crosstalk studies.

#### 2 General remarks

##### 2.1 Accuracy of fundamental data

2.1.1 There is always some degree of uncertainty in applying to real telephone conversation the results of tests in which subjects were asked to listen attentively to see if they were able to detect the presence of intelligible crosstalk. Furthermore, this type of test cannot be expected to indicate reliably the extent to which a subscriber's confidence in the privacy of his own conversation is undermined by overhearing another conversation. Hence in general the aim should be to reduce the risk of potentially intelligible crosstalk as much as possible.

2.1.2 In applying the calculation method given in Recommendation P.16 [1], errors can occur if the distributions of crosstalk attenuations and loudness ratings are skew, rather than normal, or are truncated by test acceptance procedures. This arises because we are generally seeking low probabilities of encountering intelligible crosstalk which are highly dependent on the tails of distributions being accurately defined. One way of avoiding this difficulty is to apply Monte-Carlo methods as described, for example, in the CCITT manual cited in [2], taking care to make enough iterations to secure the necessary accuracy.

2.1.3 Considerable care must be taken to obtain representative values of the loss and noise in crosstalk paths being studied. In particular, errors arising from small changes in mean values can easily result in the calculated probability of overhearing being in error by a factor of 10 or more (see, for example, [3]).

##### 2.2 Effect of line and room noise

2.2.1 The masking effect of line noise is another aspect which is important and raises some difficulties. On the one hand if, for the purpose of establishing crosstalk limits, the level of line noise is assumed to be negligible, unrealistic demands may be placed on the crosstalk attenuation required to be introduced by items of plant. On the other hand, if it is assumed that circuits and exchanges in service introduce noise power levels comparable with their design objectives, e.g. the well known 4 pW0p/km, the incidence of overhearing may be unacceptably high, particularly when the network is lightly loaded so that noise power levels can be expected to be at their lowest.

As in many transmission studies, a compromise has to be made somewhere between these extremes. In some cases, it may be necessary to rely on measurements of noise power levels on established plant during light and busy traffic periods. However, it must not be overlooked that limits devised now must, if possible, take the future into account. It is a wise principle that the successful performance of equipment in one part of the network should not be dependent upon adventitious imperfections of other parts of the network, particularly if such imperfections are likely to be eliminated or reduced in the future, e.g. by new designs of local exchange or by the extensive use of digital long-distance transmission systems.

2.2.2 Unlike line noise the effect of room noise can be reduced by a determined listener. Hence Recommendation P.16 [1] recommends that negligible room noise be assumed when deriving a design objective for equipment.

### 2.3 Probabilities and distributions involved

2.3.1 When constructing the distribution of crosstalk attenuation introduced by equipment and cables, it is appropriate to consider only the worst (acceptable) values. For example, in a 10-pair cable only the worst disturber for each pair should be taken into account, i.e. 10 values. This distribution should not be diluted by the other 80 better values. In the busy period the worst potential disturber of a particular pair can be relied upon to be activated.

2.3.2 In respect of intelligible crosstalk between local calls established in the same local exchange network, the probability of a potentially disturbing subscriber making a call at the same time as the disturbed subscriber can be significantly low certainly in the case of residential subscribers, although this is probably not the case for business subscribers and PBXs. Information concerning this topic and showing how to calculate the probabilities concerned will be found in [4].

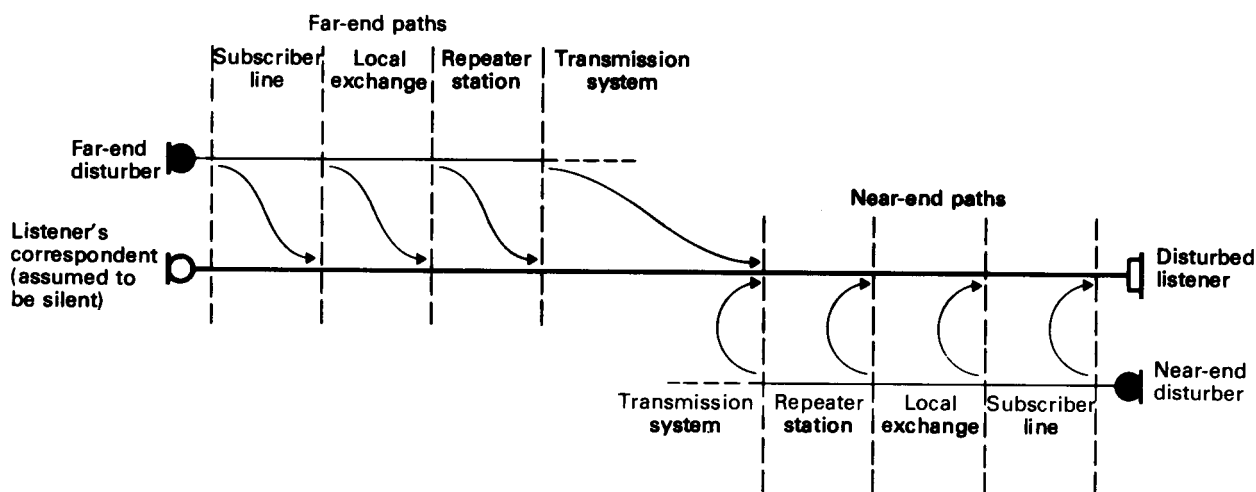
2.3.3 Multiple entries into a telephone connection of intelligible crosstalk signals all at significant levels and all derived from one source is so unlikely an event that it may be ignored for the purposes of deriving design limits. Hence the crosstalk mechanism of interest is assumed to be the dominant one when deriving limits, and all other sources are deemed to be negligible, and may thus attract the whole of the allowance.

However, when a network performance objective for crosstalk has to be divided among the exchanges and circuits making up the connection, it may be necessary to give some consideration to the number of potential crosstalk paths from different sources. For example, crosstalk limits may be assigned to complete paths through an exchange and to complete junction or trunk circuits. Thus, on simple other-exchange connections (ignoring, for the moment, crosstalk arising within local cables) there are three dominant sources of crosstalk, and if, for example, the aim were to be not greater than 1 in 100 for such connections, the probability of overhearing from each source should be reduced to 1 in 300 (assuming equal probabilities and no correlation between the sources).

Figures 1/G.105 and 2/G.105 illustrate some crosstalk paths of significance.

### 3 Hypothetical reference connections for crosstalk

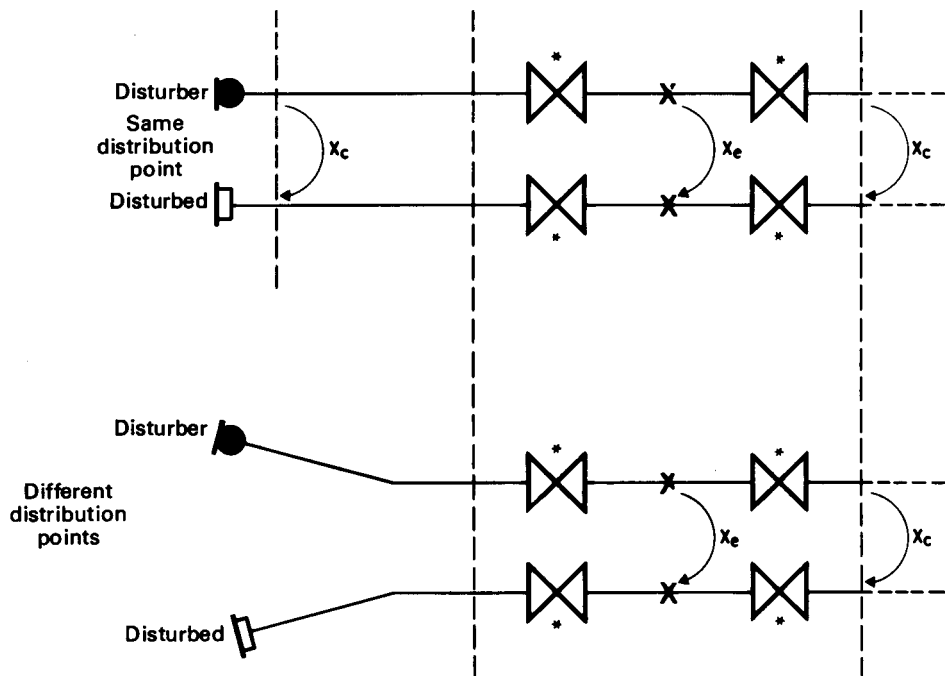
Figure 3/G.105 illustrates the essential elements of two hypothetical reference connections appropriate to crosstalk studies in respect of telephone circuits and exchanges. It will be observed that the connections are much simpler than the corresponding ones in Recommendation G.103 used for studying noise and loss. It would be inappropriate to study the risk of potentially intelligible crosstalk between a pair of 12-circuit connections of near maximum length and noise, in order to arrive at, for example, a limit for channel equipment crosstalk, because the majority use of the channel equipment bought and installed to the specification is in much simpler, quieter, and more numerous connections.



Note - Individual crosstalk limits for "repeater stations" (e.g. multiplexing equipment) and "transmission systems" are not the subject of this Recommendation which only deals with subscriber lines, exchanges, and interexchange circuits. In particular, limits recommended for circuits would be apportioned by the competent CCI Study Group(s).

FIGURE 1/G.105

Some far-end and near-end crosstalk paths of significance when considering potentially intelligible between telephone connections



\* All the subscriber lines are here shown equipped with additional amplification, but this is not always the case in practice.

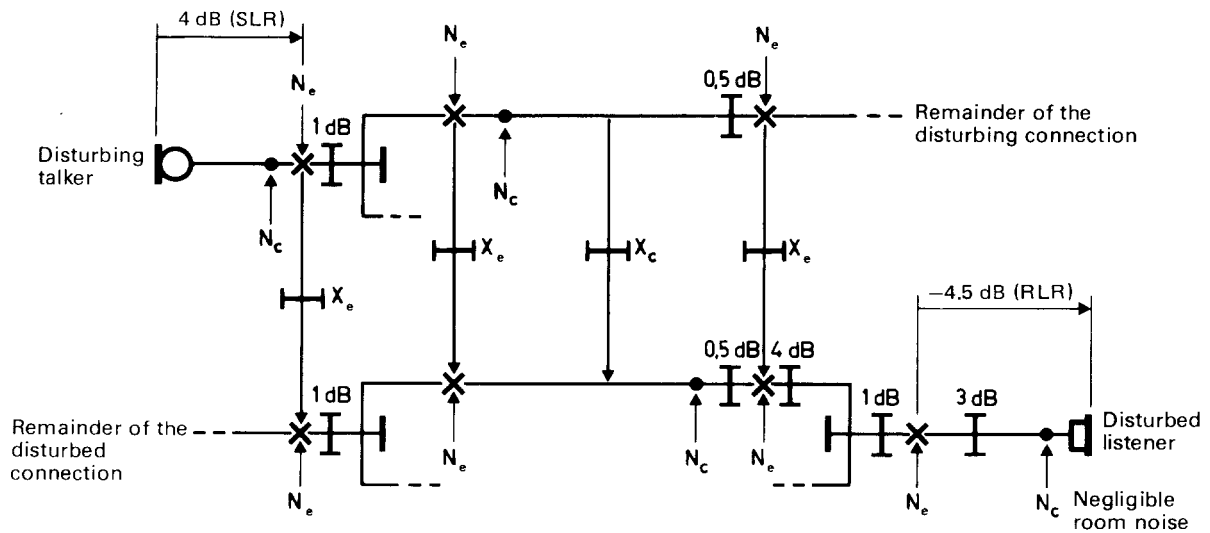
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*Note 1* - On own-exchange calls, overhearing between customers served by different distribution points may be assumed to be due only to exchange crosstalk or to crosstalk arising within local cables (near-end or far-end) on the far side of the exchange switching equipment. For other-exchange calls, the crosstalk paths are assumed to occur within the exchange and between junction or trunk circuits.

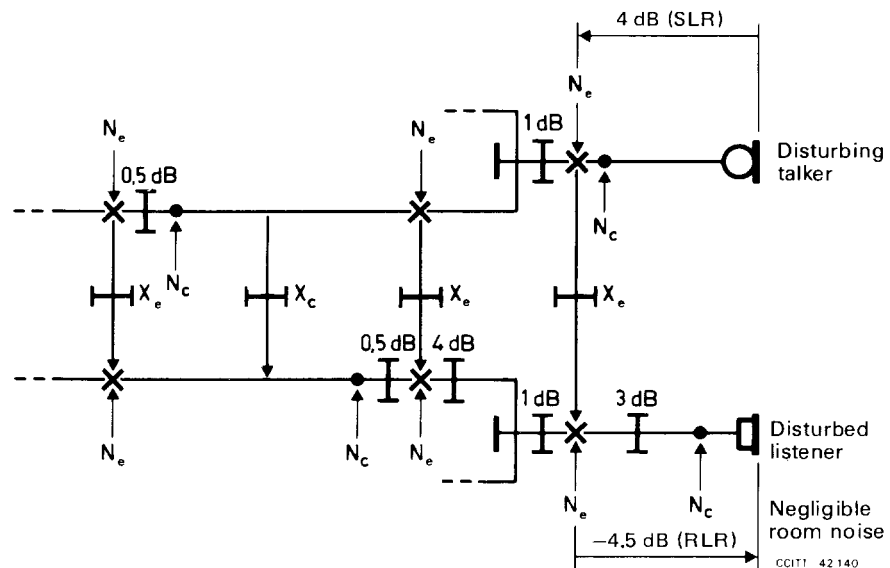
*Note 2* - In the case of overhearing between customers served by the same distribution point, it should also be assumed that crosstalk can arise within the local cable (near-end crosstalk) or other permanently connected equipment. The particular customers who are unfavourably located in this respect will depend to a great extent on the type of local telephone circuits in use. When current-regulated telephones are used, customers on limiting length local lines are most at risk because the sensitivities of the telephone instrument are highest on these lines.

*Note 3* - The effect of additional exchange amplification sometimes associated with long lines must be included where appropriate.

FIGURE 2/G.105  
Some hypothetical crosstalk reference paths for studying crosstalk in the local exchange network



a) Far-end crosstalk paths



b) Near-end crosstalk paths

Note 1 - The disturbed connection is taken to be a very simple one, the disturbed listener being connected to a local exchange co-sited with the trunk exchange (e.g. the first ISC or the national primary centre).

Note 2 - Suitable values for the various circuit and exchange noise powers are

Circuit noise ( $N_c$ ):	subscribers local line:	100 pWp
	4-wire circuit:	500 pW0p
	(Satellite circuit:	10 000 pW0p)
Exchange noise ( $N_e$ ):	local exchange:	50 pWp or pW0p (as appropriate)
	4-wire exchange:	100 pW0p

Note 3 - In accordance with the convention adopted in Recommendation G.103, the send switching level at all exchanges is shown as 0 dBr. In practice, other values of relative level are encountered and must be taken into account in the study.

Note 4 - Only one crosstalk mechanism is assumed to be dominant at any one time.

FIGURE 3/G.105

**Hypothetical reference connections for crosstalk  
between switched telephone connections**

## References

- [1] CCITT Recommendation *Subjective effects of direct crosstalk; Thresholds of audibility and intelligibility*, Vol. V, Rec. P.16.
- [2] CCITT Manual *Transmission planning of switched telephone networks*, ITU, Geneva, 1976.
- [3] *Social Crosstalk in the Local Area Network*, Electrical Communication (ITT), Vol. 49, No. 4, pp. 406-417, 1974.
- [4] LAPSA (P. M.): Calculation of multidisturber crosstalk probabilities, *Bell System Technical Journal*, Vol. 55, No. 7, September 1976.