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Recommendation G.114

MEAN ONE-WAY PROPAGATION TIME

(Geneva, 1964; amended Mar del Plata, 1968, Geneva, 1980;

Malaga-Torremolinos, 1984 and Melbourne, 1988)

The times in this Recommendation are the means of the propagation times in the two directions of transmission in a connection. When opposite directions of transmission are provided by different media (e.g. a satellite channel in one direction and a terrestrial channel in the other) the two times contributing to the mean may differ considerably.

1 Limits for a connection

It is necessary in an international telephone connection to limit the propagation time between two subscribers. As the propagation time is increased, subscriber difficulties increase, and the rate of increase of difficulty rises. Relevant evidence is given in references [1] to [10], particularly with regard to b) below.

As a network performance objective, the CCITT therefore *recommends*
| he following limitations on mean one-way propagation times when echo sources exist and appropriate echo control devices, such as echo suppressors and echo cancellers , are used:

a) 0 to 150 ms, acceptable.

Note — Echo suppressors specified in Recommendation G.161 of the Blue Book [11] may be used for delays not exceeding 50 ms (see Recommendation G.131, § 2.2).

b) 150 to 400 ms, acceptable, provided that increasing care is exercised on connections when the mean one-way propagation time exceeds about 300 ms, and provided that echo control devices, such as echo suppressors and echo cancellers, designed for long-delay circuits are used;

c) above 400 ms, unacceptable. Connections with these delays should not be used except under the most exceptional circumstances.

Until such time as additional, significant information permits Administrations to make a firmer determination of acceptable delay limits, they should take full account of the documents referred to under References in selecting, from alternatives, plans involving delays in range b) above.

Note 1 — The above values refer only to the propagation time between two subscribers. However, for other purposes (e.g. in Recommendation G.131) the mean one-way propagation time of an echo path is to be estimated. The values in § 2 may be used in such estimations.

Note 2 — There is good evidence that echo cancellers fitted at both ends of a long-delay connection generally yield superior performance over current types of echo suppressors. (For further details, see § 2.2 of Recommendation G.131.)

Note 3 — It should be noted that although an echo suppressor and an echo canceller on the same connection are compatible (they can satisfactorily interwork), the full benefits of echo cancellers are only experienced when both ends are so equipped. In particular, an Administration unilaterally replacing

its echo suppressors with echo cancellers will cause little benefit to its own subscriber on international connections if the echo suppressor still remains at the other end.

Note 4 — Available experimental data (Annex A) has indicated that connections with delays somewhat greater than 400 ms may be acceptable provided that echo cancellers conforming to the specifications of Rec. G.165, or other echo control devices with equivalent performance, are used. However, the use of connections with delays greater than 400 ms is not recommended at present and is under study in Question 27/XII.

Note 5 — The use of equipment that introduces clipping, noise contrast, low echo return loss enhancement or other impairments that may degrade echo performance (such as may be the case with hands free telephones, especially in a changing noise environment) may have to be controlled to achieve acceptable transmission quality on connections with delays in the range from 150 to 400 ms. This subject is under study in Question 11/XII.

2 Values for circuits

In the establishment of the general interconnection plan within the limits in § 1 the one-way propagation time of both the national extension circuits and the international circuits must be taken into account. The propagation time of circuits and connections is the aggregate of several components; e.g. group delay in cables and in filters encountered in FDM modems of different types. Digital transmission and switching also contribute delays. The conventional planning values given in § 2.1 may be used to estimate the total propagation time of specified assemblies which may form circuits or connections.

2.1 *Conventional planning values of propagation time*

Provisionally, the conventional planning values of propagation time in Table 1/G.114 may be used.

2.2 *National extension circuits*

The main arteries of the national network should consist of high-velocity propagation lines. In these conditions, the propagation time between the international centre and the subscriber farthest away from it in the national network will be as follows:

a) in purely analogue networks, the propagation time will probably not exceed:

$$12 + (0.004 \times \text{distance in kilometres}) \text{ ms.}$$

Here the factor 0.004 is based on the assumption that national trunk circuits will be routed over high-velocity plant (250 km/ms). The 12 ms constant term makes allowance for terminal equipment and for the probable presence in the national network of a certain quantity of loaded cables (e.g. three pairs of channel translating equipments plus about 160 km of H 88/36 loaded cables). For an average size country (see Figure 2/G.103) the one-way propagation time will be less than 18 ms;

b) in mixed analogue/digital networks, the propagation time can generally be estimated by the equation given for purely analogue networks. However under certain unfavourable conditions increased delay may occur compared with the purely analogue case. This occurs in particular when digital exchanges are connected with analogue transmission systems through PCM/FDM equipments in tandem, or transmultiplexers. With the growing degree of digitization the propagation time will gradually approach the condition of purely digital networks;

H.T. [T1.114]

TABLE 1/G.114

Transmission medium Contribution to one-way propagation time }	{ Remarks	

{
Terrestrial coaxial cable or radio relay system; FDM and digital transmission
}
Allows for delay in repeaters and regenerators
}
	4 µs/km	{

{
Allows for delay in repeaters and regenerators
}		

{
Satellite system
— 14 | 00 km altitude
— 36 | 00 km altitude
}
	. 110 ms 260 ms	Between earth stations only

Half the sum of propagation times in both directions of transmission

a) These values allow for group-delay distortion around frequencies of peak speech energy and for delay of intermediate higher order multiplex and through-connecting equipment.

b) This value refers to FDM equipments designed to be used with a compandor and special filters.

c) For satellite digital communications where the transmultiplexer is located at the earth station, this value may be increased to 3.3 ms.

d) These are mean values: depending on traffic loading, higher values can be encountered, e.g. 0.75 ms (1.950 ms, 1.350 ms or 1.250 ms) with 0.95 probability of not exceeding. (For details, see Recommendation Q.551.)

e) Echo cancellers, when placed in service, will add a one-way propagation time of up to 1 ms in the send path of each echo canceller. This delay excludes the delay through any codec in the echo canceller. No significant delay should be incurred in the receive path of the echo canceller.

TABLEAU 1/G.114 [T1.114], p. 1

c) in purely digital networks between exchanges (e.g. an IDN), the propagation time as defined above will probably not exceed:

$$3 + (0.004 \times \text{distance in kilometers})\ \text{ms.}$$

The 3 ms constant term makes allowance for one PCM coder or decoder and five digitally switched exchanges.

Note — The value 0.004 is a mean value for coaxial cable systems and radio-relay systems; for optical fibre systems 0.005 is to be used;

d) in purely digital networks between susbscribers (e.g. an ISDN), the delay of c) above has to be increased by up to 3.6 ms if burst-mode (time compression multiplexing) transmission is used on 2-W local subscriber lines.

2.3 *International circuits*

International circuits will use high-velocity transmission systems, e.g. terrestrial cable or radio-relay systems, submarine systems or satellite systems. The planning values of § 2.1 may be used.

The magnitude of the mean one-way propagation time for circuits on high altitude communication satellite systems makes it desirable to impose some routing restrictions on their use. Details of these restrictions are given in Recommendation Q.13 [12]. (See also Annex A below.)

ANNEX A
(to Recommendation G.114)

Long propagation delay and echo related

considerations for telephone circuits

A.1 *Introduction*

International connections (see Figure 1/G.103 or Figure 1/G.104) comprising submarine cables, may involve a maximum one-way transmission delay of about 170 ms. This Annex addresses the basic issues of national and international connections which inherently entail comparatively larger one-way transmission delays.

A one hop satellite connection even with an ISL (Inter-Satellite Link) of moderate length introduces one-way transmission delay within the recommended limit of 400 ms. However, a careful analysis of the additional probable delay contributions by digital signal processing (e.g. TDMA, DSI, DCME, 16 kbit/s and 32 kbit/s low bit rate encoding, bit-regeneration, packet-switching, etc.), among other sources, has led to the notion that the recommended limit of 400 ms mean one-way propagation delay may be unnecessarily restrictive.

In light of recent technical improvements in echo-control techniques, it is feasible to consider an extension to this limit. Administrations are encouraged to take note of the continuing nature, as well as need, of further investigations in this area.

For short nearby links, telecommunications cables operated at voice frequencies may also be used in the conditions set out in the introduction to Sub-section 5.4 of Fascicle III.2.

In order to analyse this problem further, consider that two distinct types of effects must be considered in connection with the mean one-way propagation time; namely, echo-related speech quality impairments and pure (transit) delay related conversational difficulty. Echo control devices, i.e. echo suppressors and especially echo cancellers, can be suitably employed for overcoming the former effect.

The 4-wire circuits provides a close approximation to echo-free connections, assuming minimum acoustic coupling across the handset. In the long run with expansion of the ISDN implementation, use of 4-wire circuits is expected in grow. However, 2-wire circuits and their accompanying hybrid connection, as well as other componentes causing echo, are still likely to be present in vaying degrees during the foreseeable future. Thus, the use of modern echo cancellers in satellite circuits is currently regarded as the most effective method for overcoming the echo problem, provided that the characteristics of the echo path to be modeled by the echo canceller are linear and time invariant, or varying only slowly compared with the convergence speed of the echo canceller.

A brief discussion of delay measurements, their effect on circuit quality and the subscriber reaction are provided below.

A.2 *Effect of long transmission delays on the subscriber*

A.2.1 *Early measurements*

Figure A-1/G.114 shows the effect of long transmission delay on the difficulty of conversation experienced by the subscriber. Curve 1 is the result of investigations in 1964 and 1965 [5, 8 *et al* .] where the performance of the first operational satellite Early Bird was tested in circuits between France, the United Kingdom, the United States and the Federal Republic of Germany. The circuits were equipped with early versions of various echo suppressors, had a certain amount of noise power (about 20 | 00 pW0p), and had different bandwidths on the TAT-3 cable route (230-3200 Hz) as opposed to the satellite (170-3400 Hz). Curve 1 (F/P) shows the same interview results on the basis of a fair-or-poor opinion rating by the subscribers.

From curve 1 it can be seen that, at about 400 ms of delay, more than 50% of the subscribers have difficulties with the conversation. A 40% value of difficulty corresponds to a delay of about 300 ms. On the other hand, the percentage of fair-or-poor opinions of the subscribers is about 15% lower than

the percentage of difficulties. This may result from the fact that some of the inquired customers, in spite of the difficulties they had, found the received speech quality good or excellent.

On the basis of these observations, 300 ms of delay was selected as the threshold of difficulty and 400 ms as the maximum allowable delay in international connections for telephony in earlier versions of Rec. G.114.

In addition to these results, other ealier results exist. Williams and Moye [30, 31] investigated the effect of unsuppressed echo on conversations over simulated telephone links with different values of echo return loss and with flat or shaped echo-path frequency characteristics.

Curves 2, 5 and 6 show the results for connections with echo return losses of 37 dB (shaped), 37 dB (flat) and 50 dB (flat or shaped). Curve 4 shows laboratory test results [32] or simulated connections equipped with echo suppressors and with an echo return loss of about 20 dB. These test results were obtained using a linear time invariant echo path.

Figure A-1/G.114 also includes some recent results obtained from circuits with long delay but which were equipped with modern echo cancellers with an echo return loss of about 18 dB [29] (see § A.2.3).

From curves 2 to 6 (which obtained better methods of echo control or high echo return loss values) it can be seen that the influence of longer propagation delay on the difficulties of conversations is much smaller than indicated by curve 1, which used earlier versions of echo suppressors.

Other investigations summarized in [33] which were obtained from circuits having only pure transmission delay (i.e. echo free 4-wire circuits), have shown that mean one-way propagation delays up to 600 ms appear to have no significant influence on the subjective judgements of telephone subscribers.

Figure, p. 2

Figure A-1/G.114 [T2.114), p. 3

A.2.2 *Later measurements*

Following technical advancement, design developments and performance enhancements of echo cancellers [16-19], experiments were conducted by Helder and Lopiparo [20], DiBiaso [21], Post and Silverthorn [22], and others to evaluate the subjective performance of echo suppressors and echo cancellers on satellite and terrestrial facilities in the U.S., Canada and other domestic satellite networks.

Helder and Lopiparo [20] reported results of testing of certain terrestrial, half-hop satellite , and one-hope satellite circuits in the U.S. in 1976 and 1977. DiBiaso's report [21] is based on a study of tests and subjective evaluation of echo control methods performed during 1975-77 by the American Telephone and Telegraph Company (AT&T) and others using the U.S. domestic satellite system (COMSTAR), together with conventional analog echo suppressors (ES), digital echo suppressors (DES) [23] and experimental echo cancellers (EC) [24-25], and examining the cases of terrestrial, half-hop satellite, one-hope satellite and two-hop satellite connections, respectively. A detailed account of these test results is provided elsewhere [26]. A summary of these

test results, represented in terms of the percent of calls rated unacceptable for the various cases mentioned above, is reproduced here in Figure A-2/G.114. The graph demonstrates the improvement possible through the use of the digital echo suppressor and echo canceller in the half-hop and one-hop satellite connections, respectively, to yield performances in these two cases practically equivalent to the terrestrial circuits with echo suppressors. Basically, similar conclusions were reached by using somewhat different criteria for performance and quality; e.g. percent of calls terminated early or percent of calls replaced, or percent of calls needing operator assistance.

Figure A-2/G.114, p.

Half-hop connection refers to the situation when the forward link is via satellite but the return link is terrestrial (or vice-versa).

In 1978, Post and Silverthorn [22] performed an evalutation of nine experimental conditions characterized by generically different methods of echo control on the Trans-Canada Telephone System (TCTS) satellite and certain terrestrial links. Figure A-3/G.114 provides a partial summary of their results in terms of percent of interviews that judged the terrestrial, echo canceller-equipped satellite (S/EC) and echo suppressor-equipped satellite (S/ES) circuits as excellent, good, fair, or poor as regards to quality. Figure A-4/G.114 provides a summary of analogous test results as derived from similar domestic and international satellite and terrestrial networks [22]. These results serve to illustrate the near equivalence of the performance of satellite circuits equipped with echo cancellers and long-haul terrestrial circuits with echo suppressors. These results also demonstrate the poorer performance of echo suppressors as compared to echo cancellers in the satellite link. Consequently, echo suppressors are not considered optimal for satellite links and only echo cancellers are recommended to be employed. For terrestrial applications, the improvement resulting from the use of echo cancellers is expected to be only marginal; and system economy may still justify the use of echo suppressors in the terrestrial links.

The above observations confirm the conclusion that the difficulties experienced by telephone users of satellite networks is primarily due to echo related impairments associated with the long propagation delay. This impairment can be sufficiently reduced with the use of echo cancellers to yield a performance for one-hop satellite connections practically equivalent to that of terrestrial connections [27-28].

Figure A-3/A-4/G.114, p. 5 et 6

A.2.3 *Recent and future measurements*

In 1987, Communications Satellite Corp. (COMSAT) of the U.S.A. performed a series of tests to determine the effectiveness of echo cancellers in terrestrial and satellite circuits, using echo cancellers conforming to Rec. G.165 and a callback interview procedure as per Rec. P.77, Annex A. Details of the procedure were presented recently [29] and a summary of the results is shown in Figure A-1/G.114, curve 3 giving a plot of the percent difficulty as a function of mean one way propagation time. A one way delay value of 45 ms over terrestrial circuits was taken as a reference, and the effect of increasing the delay value to 300 ms and 500 ms over terrestrial and satellite links was evaluated.

It was concluded on the basis of the COMSAT results that no significant difference between 45 ms and 300 ms delays resulted for the ‘‘percent difficulty’’ score. At a 500 ms delay, the percent difficulty score approximately doubled (from 7.3% to 15.8%), but this value is still considerably smaller than earlier results of over 60% [13].

The above results support the view that connections with delays somewhat greater than 400 ms may be accepted provided that echo cancellers conforming to the specifications of Recommendation G.165 or other echo control devices with equivalent performance are used. This may permit accommodation of signal processing and Inter Satellite Links (ISL) with moderate angular separations, without causing any significant or noticeable degradations.

Further tests, measurements and evaluation of subjective performance using state-of-the-art echo cancellers in modern satellite connections should prove to be useful to determine what, if any, additional improvements over these results are likely or achievable.

A.3 *Summary and conclusions*

The transmission impairments associated with long delay circuits are best analysed by separating the echo-induced degradation and the subjective difficulty due to pure delay. Clearly, as shown by the tests cited above, echo suppressors (with fixed break-in sensitivity) used in satellite circuits are far less efficient than echo cancellers. The effectiveness of echo cancellers in removing the echo effect and the associated impairments is sufficient to yield high or acceptable performance in a long delay satellite circuit. Further improvement in the performance of echo cancellers and the associated satellite circuits are continuing. Thus, under these conditions the dominant impairments are associated with the pure delay component.

A number of recent works and continuing interest in the area indicate the possibility of developing and utilizing even more improved and efficient echo cancellers. VLSI fabrication of echo cancellers is also a viable option and this is expected to lead to a significantly lower cost for equipping long delay telephone circuits. Thus, with the use of such suitable devices, the comparatively larger pure delay in international connections is not expected to cause the degree of degradation in the channel quality or efficiency as was experienced in earlier tests without echo control or with echo suppressors with fixed break-in sensitivity. Appropriate use of echo cancellers has been shown

to indeed provide international or national satellite connections yielding quality and performance practically equivalent to the terrestrial connections for telephony. These results only refer to electric echo and additional studies are necessary to determine the effect of acoustic echo (see Note 5 of Question 27/XII).

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Recommendation G.117

TRANSMISSION ASPECTS OF UNBALANCE ABOUT EARTH

(DEFINITIONS AND METHODS)

(Geneva, 1980; amended at Malaga-Torremolinos, 1984 and Melbourne, | 1988)

1 Objective

This Recommendation gives a comprehensive set of prescriptive measurements of various balance parameters for one-port and two-port networks. These are intended for use either in the field or in the factory with relatively simple test apparatus (e.g. standard transmission oscillators, level measuring sets), and a special test bridge. Measuring arrangements for assessing the degree of unbalance are covered in Recommendation O.121 [1], which are consistent with this Recommendation.

The definitions and methods are so devised that the results obtained from separately-measured (or specified) items of equipment (e.g. feeding-bridges, cable pairs, audio inputs to channel translating equipment, etc.) can be meaningfully combined though not necessarily by simple decibel addition. This allows the performance of a tandem connection of such items to be predicted or at least, bounds determined for that performance. Performance in this sense means those features affected by unbalanced conditions, e.g. level of impulsive noise, sensitivity to longitudinal exposure, crosstalk ratios, etc.

2 Principles of the scheme of nomenclature

Many different terms have been used throughout the literature concerning unbalance about earth, some conflicting, or in other respects inadequate. The descriptive titles of the quantities given in this Recommendation are based on the following principles which have been adopted:

a) Mode *conversion* , e.g. a poor (unbalanced) termination will develop an unwanted transverse signal when excited by a longitudinal signal. The measure of this effect is here termed *longitudinal conversion ratio* , and when expressed in transmission units *longitudinal conversion loss* , or LCL

b) When a two-port is involved where for example an excitation at one port produces a signal at the other port, then the designation will include the word *transfer* , for example *longitudinal conversion transfer ratio* and the corresponding *loss* , LCTL.

c) The impedance of the longitudinal path presented by a test object is a key parameter. The term *longitudinal impedance ratio* and the corresponding decibel expression, *longitudinal impedance loss* , are used to characterize the particular measurement defined.

d) Active devices which are sources of signals (e.g. an oscillator, the output port of an amplifier) are additionally characterized by the amount of unwanted longitudinal signal that is present in the output. The key word *output* is now included, to give *longitudinal output voltage* , and the corresponding *longitudinal output level* . When such unwanted signals are expressed as a proportion of the wanted (transverse) signal the key phrase is *output signal balance ratio* , the decibel expression of which is *output signal balance* .

e) Devices which continuously respond to signals (e.g. level-measuring sets, the input port of an amplifier) and which can in principle respond to unwanted longitudinal signals by reason of internal mechanisms (i.e. even if their input impedances were perfectly balanced) are characterized by measures containing the words *input interference* . These measures are *input longitudinal interference ratio* and the

corresponding decibel expression *input longitudinal interference loss* . The long-established and well-defined *common-mode rejection ratio* is maintained. The term *sensitivity coefficient* is avoided, since this is widely used in the Directives [2] and the work of Study Group V with a rather specialized meaning.

f) When a two-port network is involved, the input and output signals may not be the same, for example, they may have different levels, frequencies (FDM modems) or structure (PCM multiplex equipments). These aspects should be taken into account when formulating proposals for the item under test.

g) In the case of receiving devices in which the operation is not a linear continuous function of the level of the input signal (e.g. a group-delay measuring set or a data modem) the key principle is the *threshold* level of the interference; this is the level at or above which an unacceptable amount of

degradation of performance or misoperation occurs. Thus *longitudinal interference threshold voltage* and the corresponding *levels* are obtained.

3 Summary of the descriptive terms used

3.1 *One-port networks*

a) transverse reflexion factor (transverse return loss: TRL),

b) transverse conversion ratio (loss: TCL),

c) longitudinal conversion ratio (loss: LCL),

d) longitudinal impedance ratio (loss: LIL),

e) transverse output voltage (level: TOL),

f) longitudinal output voltage (level: LOL).

(Voltages e) and f) are unwanted signals uncorrelated to the wanted signals.)

3.2 *Two-port networks*

3.2.1 *Separate measurement*

For each port taken separately the one-port measures:

a) transverse reflexion factors (transverse return losses: TRL),

b) transverse conversion ratio (loss: TCL),

c) longitudinal conversion ratios (losses: LCL),

d) longitudinal impedance ratios (losses: LIL),

e) transverse output voltage (levels: TOL), f) longitudinal output voltage (levels: LOL).

3.2.2 *Measurement combined*

In addition the following transfer parameters are for each of the two directions of transmission:

a) transverse transfer ratios (losses: TTL),

b) transverse conversion transfer ratios (losses: TCTL),

c) longitudinal transfer ratios (losses: LTL),

d) longitudinal conversion transfer ratios (losses: LCTL).

3.3 *Signal generating devices*

a) Output signal balance ratio (losses: OSB).

This is in addition to the six one-port measures listed in § 3.1.

3.4 *Signal receiving devices*

a) Input longitudinal interference ratio (loss: ILIL).

b) Longitudinal interference threshold voltage (level).

These are in addition to the six one-port measures listed in § 3.1. If the wanted signal is longitudinal (e.g. as in a signalling system) and the interfering voltage transverse, replace the word *longitudinal* with *transverse* in the descriptive terms.

4 Definitions and measuring techniques based on idealized measuring arrangements

The illustrated definitions in this section assume ideal test bridges (with lossless infinite-inductance centre-tapped coils), zero impedance voltage generators and infinite-impedance voltmeters.

An important aspect of this set of mutually consistent measurements is that the test bridge provides simultaneously defined reference terminations

of Z ohms for the transverse paths, and $Z/4$ ohms for the longitudinal paths. From this starting point, the performance of cascaded items, each measured in the prescribed fashion, can be calculated. This takes account of the fact that the cascaded items do not, in general, exhibit the reference impedances provided by the test conditions.

It simplifies the mathematical treatment if the reference impedance is nonreactive and this also accords with the important objective of being able to use readily-available transmission test-apparatus to obtain field and factory measurement results.

The ideal test bridge configuration used in the following pages is shown in Figure 1/G.117.

The transverse and longitudinal sources E_T and E_L are activated as required by the particular measurement being made. In Figure 6/G.117, neither source is active, and the bridge then provides only passive terminations of Z and $Z/4$.

Note — It would have been in keeping with traditional transmission theory for the parameters to be defined in terms of half the open-circuit e.m.f. However, to harmonize with Recommendation O.121, this Recommendation defines some parameters in terms of $V_{T\backslash d1}$. If the input impedance of the device under test is nominally equal to the driving device, then the two methods are equivalent.

Figure 1/G.117, p.

4.1 *One-port networks*

4.1.1 *Transverse reflexion factor (return loss)*
| see Figure 2/G.117)

Figure 2/G.117, p.

4.1.2 *Transverse conversion ratio (loss)* | see Figure 3/G. 117)

Figure 3/G.117, p.

4.1.3 *Longitudinal conversion ratio (loss)* | see Figure 4/G.117)

Figure 4/G.117, p.

4.1.4 *Longitudinal impedance ratio (loss)* | see Figure 5/G.117)

Figure 5/G.117 p.

4.1.5 *Transverse and longitudinal output voltages (levels)*
| see Figure 6/G.117)

Figure 6/G.117 p.

4.2 *Two-port networks*

These follow similar principles to those defined for one-port networks but now signals can be transferred from one port to the other. The two ports are distinguished by the subscripts 1/1‘ for one end and 2/2‘ for the other. There are two types of measurements:

— those in which the excitation and response are at the same side of the network; these are as already defined for a one-port but will carry a single subscript 1/1 or 2/2‘ as appropriate;

— those in which the excitation and response are at opposite sides of the network. The designation will contain the word transfer and the symbol two subscripts, the order of which indicates the direction of transmission.

4.2.1 *Transverse reflexion factors (return losses)* | see Figure 7/G.117)

Figure 7/G.117, p.

4.2.2 *Transverse transfer ratios (losses) and conversion transfer ratios (losses)* (see Figure 8/G.117)

Figure 8/G.117, p.

4.2.3 *Longitudinal transfer ratios (losses) and conversion transfer ratios (losses)* (see Figure 9/G.117)

Figure 9/G.117, p.

4.3 *Signal generating devices*

In addition to the six one-port measures already defined, an additional measure is required to control the amount of unwanted signal correlated with the wanted signal delivered by the device to the circuit it is connected to. This special measure is the output signal balance ratio (loss).

4.3.1 *Output signal balance ratio (loss)* | see Figure 10/G.117)

Figure 10/G.117, p.

4.4 *Signal receiving devices*

In addition to the six one-port measures already defined, additional measures are required for signal receiving devices to control their sensitivity to unwanted signals. Two cases are important. Firstly, there are receiving devices in which the response is a linear, continuous function of the wanted signal level, e.g. the indication of a level-measuring set. In this case unwanted signals give rise to *inaccuracy* .

In the other kind of receiver such as data modems, group-delay distortion measuring sets, signalling receivers, unwanted signals cause errors or *misoperation* . Two additional measures are defined.

4.4.1 *Input longitudinal interference ratio (loss)* | see Figure 11/G.117)

Figure 11/G.117, p.

4.4.2 *Longitudinal interference threshold voltage (level)*

| see Figure 12/G.117)

Figure 12/G.117, p.

5 Other measurement definitions

5.1 *Common-mode rejection ratio*

This is another quantity that is appropriate to signal receivers and is measured in accordance with the principle shown in Figure 13/G.117, the input terminals being short-circuited and then energized together.

Figure 13/G.117, p.

It is clear that this measure is similar to the input longitudinal interference ratio but since there is no transverse signal (by reason of the short circuit) no longitudinal/transverse conversion mechanism within the test-object is excited. In general, there is no simple relationship between the two measures, as can be seen from the generalized measuring instrument illustrated in Figure 14/G.117, in which the input impedance is unbalanced and the gain ratios of the two halves of the differential amplifier are also slightly different. Provided the value for ε" is as in Figure 14/G.117 and ?63 << 1, the various balance parameters are as indicated. This assumes the common mode rejection ratio is not twice the input longitudinal interference ratio, i.e. there is not a 6-dB difference between their decibel values.

FIGURE 14/G.117, p. 20

References

[1] CCITT Recommendation *Measuring arrangements to assess the degree of unbalance about earth* , Vol. IV, Rec. O.121.

[2] CCITT *Directives concerning the protection of telecommunication lines against harmful effects from electricity lines* , Chapter XVI, ITU, Geneva, 1978.

[3] CCITT Recommendation *Logarithmic quantities and units* , Vol. XIII, Rec. 574, ITU, Geneva, 1986.

[4] CCITT Recommendation *Specification for a psophometer for use on telephone-type circuits* , Vol. IV, Rec. O.41.