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O.9

SPECIFICATIONS FOR MEASURING EQUIPMENT

MEASURING ARRANGEMENTS TO ASSESS THE DEGREE OF UNBALANCE ABOUT EARTH

ITU-T Recommendation O.9
Superseded by a more recent version

(Extract from the *Blue Book*)

Superseded by a more recent version

NOTES

1 ITU-T Recommendation O.9 was published in Fascicle IV.4 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.

Recommendation O.9

MEASURING ARRANGEMENTS TO ASSESS THE DEGREE OF UNBALANCE ABOUT EARTH

(Geneva, 1972; amended at Malaga-Torremolinos, 1984, and at Melbourne, 1988)

1 General

This Recommendation describes arrangements for measuring the following parameters:

– longitudinal conversion loss;
– transverse conversion loss;
– longitudinal conversion transfer loss;
– transverse conversion transfer loss;
– input longitudinal interference loss;
– common-mode rejection;
– output signal balance.

In practice, the above parameters are the seven most significant unbalance parameters. Limits for these parameters, special considerations for test terminations and the measurement frequencies to be used are given in the relevant Recommendation for the item under test.

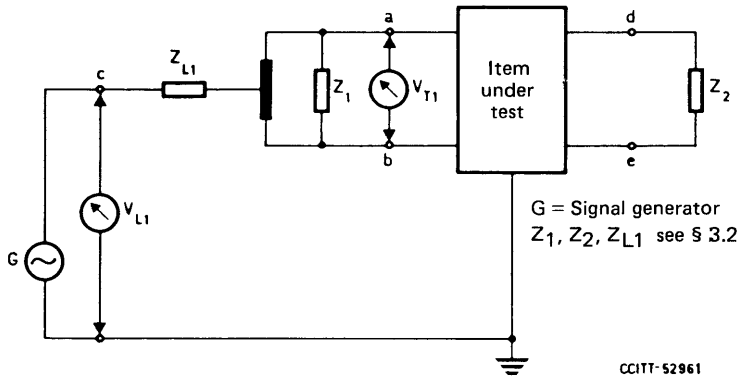
This Recommendation is in agreement with the principles, the nomenclature and the definitions, addressed in Recommendation G.117 [1], which considers the transmission aspects of unbalance about earth. References are made in the following sections, to the appropriate paragraphs/figures of Recommendation G.117 [1].

In § 3, guidance is given regarding the construction of a test bridge along with values of the required components.

2 Measuring arrangements

2.1 *Longitudinal conversion loss (LCL)*

The LCL of a one- or two-port network is a measure (a ratio expressed in dB) of the degree of unwanted transverse signal produced at the terminals of the network due to the presence of a longitudinal signal on the connecting leads. It is measured as shown in Figure 1/O.9. This technique is applicable to either the input or output terminals, e.g., transpose terminals a and b with d and e respectively. (See § 4.1.3 of Recommendation G.117 [1].)



$$\text{Longitudinal conversion loss (LCL)} = 20 \log_{10} \left| \frac{V_{L1}}{V_{T1}} \right| \text{ dB}$$

d01-sc

FIGURE 1/O.9

Measurement of longitudinal conversion loss

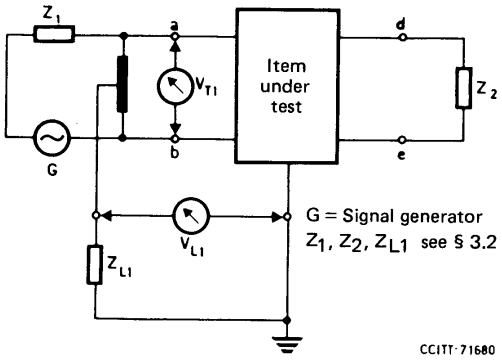
2.2 *Transverse conversion loss (TCL)*

The TCL of a one- or two-port network is a measure (a ratio expressed in dB) of the degree of unwanted longitudinal signal produced at the input (or output) of a network due to the presence of a transverse signal at the same port. TCL is measured as shown in Figure 2/O.9 (see § 4.1.2 of Recommendation G.117 [1]).

2.3 *Longitudinal conversion transfer loss (LCTL)*

The LCTL is a measure (a ratio expressed in dB) of an unwanted transverse signal produced at the output of a two-port network due to the presence of a longitudinal signal on the connecting leads of the input port. It is measured as shown in Figure 3/O.9 (see § 4.2.3 of Recommendation G.117 [1]).

If the item under test exhibits gain or loss between ports a/b and d/e, this must be taken into account when specifying LCTL. In addition to the general requirements of § 3, the measurement range of the test equipment must also take into account the gain or loss of the item under test. In addition, if the item under test performs a signal conversion (e.g., in FDM or TDM multiplexers) then the signal measured at V_{T2} may not be at the same frequency as that of the energizing signal designated V_{L1}. The signal at V_{T2} may even appear in coded form as a digital signal. Further study is required to define these signals and their relationships.



$$\text{Transverse conversion loss (TCL)} = 20 \log_{10} \left| \frac{V_{T1}}{V_{L1}} \right| \text{ dB}$$

Note – The transverse signal is expressed as the voltage at port a/b (or d/e). Any specification referring to the source voltage of the signal generator G will lead to the same result if the input (output) impedance of the item under test equals Z_1 (Z_2).

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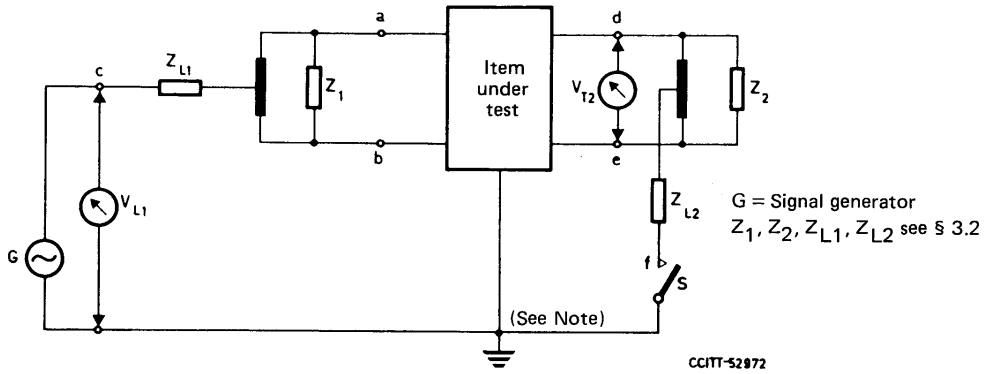
FIGURE 2/O.9

Measurement of transverse conversion loss



Longitudinal conversion transfer loss (LCTL) = $20 \log_{10} \left| \frac{V_{L1}}{V_{T2}} \right|$ dB

Note – Measurements are normally made, and limits specified, with switch S closed. However, for certain equipments, e.g. those described in Recommendation Q.45 [2], it may be necessary to specify limits for LCTL with switch S closed and with switch S open.

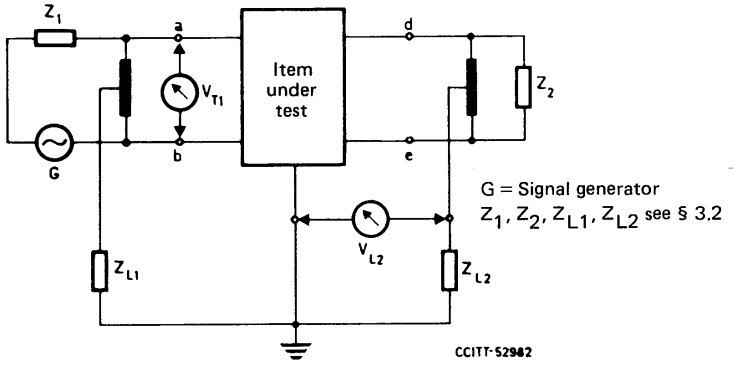
d03-sc

FIGURE 3/O.9

Measurement of longitudinal conversion transfer loss

2.4 *Transverse conversion transfer loss (TCTL)*

Transverse conversion transfer loss is a measure (a ratio expressed in dB) of an unwanted longitudinal signal produced at the output of a two-port circuit due to the presence of a transverse signal at the input port. It is measured as shown in Figure 4/O.9. If a signal conversion is performed by the item under test (e.g., in FDM or TDM multiplexers) then the signal measured at V_{L2} may not be at the same frequency as that of the energizing signal designated V_{T1}. The energizing signal may even be applied in coded form as a digital signal. Further study is required to define these signals and their relationships (see § 4.2.2 of Recommendation G.117 [1]).



Transverse conversion transfer loss (TCTL) = $20 \log_{10} \left| \frac{V_{T1}}{V_{L2}} \right|$ dB

Note – The transverse signal is expressed as the voltage at port a/b. Any specification referring to the source voltage of the signal generator G will lead to the same result only if the input impedance of the item under test equals Z_1.

d04-sc

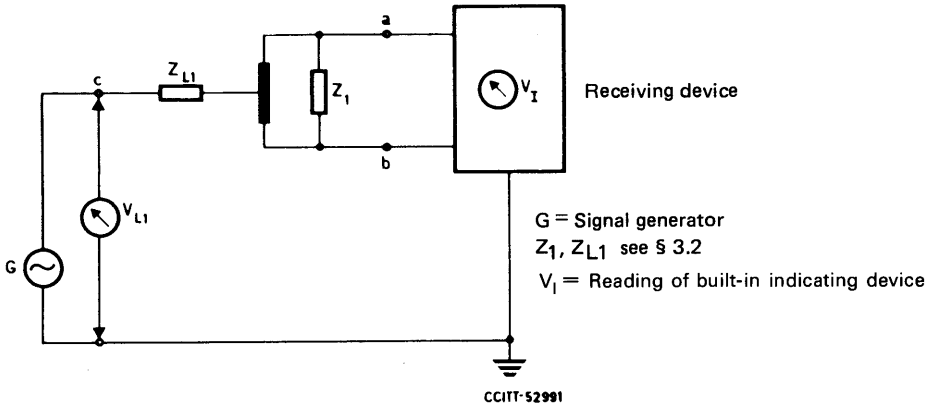
FIGURE 4/O.9

Measurement of transverse conversion transfer loss

2.5 *Input longitudinal interference loss (ILIL)*

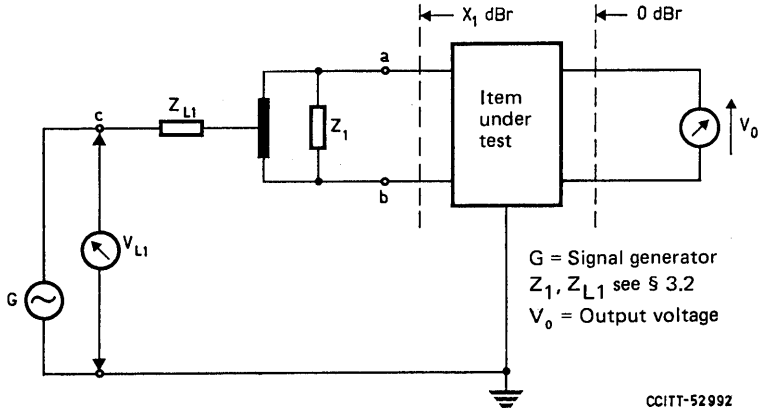
The measurement of this parameter is applicable to receiving devices (e.g., amplifiers, level meters, etc.). ILIL is a measure (a ratio expressed in dB) of the sensitivity of a receiving device to longitudinal disturbances. It is measured as shown in Figure 5a/O.9 and 5b/O.9. In principle, it is similar to the longitudinal conversion loss (LCL) measurement. However, since the measurement is performed internally (using a built-in indicating device) or at the output of the item under test, not only the impedance balance at port a/b, but also the effect of common-mode rejection is measured. (See § 4.4.1 of Recommendation G.117 [1].)

Measurements in accordance with Figure 5b/O.9 are also applicable to devices which perform a signal conversion (e.g. VF/CF side of channel translating equipment, A/D side of PCM multiplex equipment, etc. See § 2, item f of Recommendation G.117 [1]). In this case the measurement at the output of the device under test requires an appropriate analyzer, namely a selective level meter for measurements at channel translators or a digital analyzer (see Recommendation O.133) for measurements at PCM-multiplexers. In the equation in Figure 5b/O.9 it is assumed that V_0 is measured at a 0-dBr point. The quantity X_1 is the relative level at port a/b.



$$\text{Input longitudinal interference loss (ILIL)} = 20 \log_{10} \left| \frac{V_{L1}}{V_I} \right| \text{ dB}$$

a) Measurement of input longitudinal interference loss with item under test containing built-in indicating device



$$\text{Input longitudinal interference loss (ILIL)} = 20 \log_{10} \left| \frac{V_{L1}}{V_0} \right| \text{ dB}$$

Note – Values of X_1 differing from 0 dBr must be taken into account when calculating ILIL.

b) Measurement of input longitudinal interference loss with item under test having external indicating device

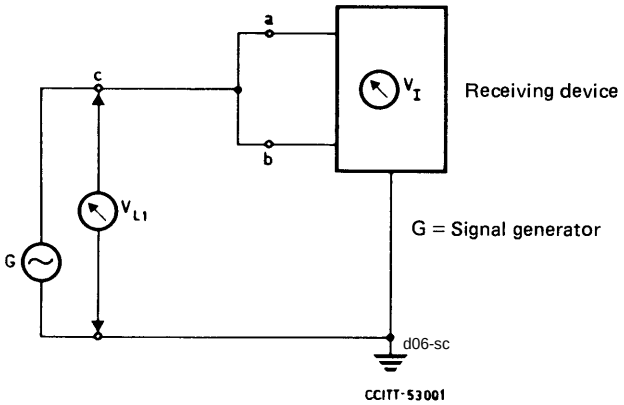
d05-sc

FIGURE 5/O.9

Measurement of input longitudinal interference loss

2.6 *Common-mode rejection (CMR)*

Common-mode rejection is another measurement (a ratio expressed in dB) that is appropriate for receiving devices and is measured as shown in Figure 6/O.9. Note that in this arrangement the input terminals are short-circuited and then energized (see § 5.1 of Recommendation G.117 [1]).



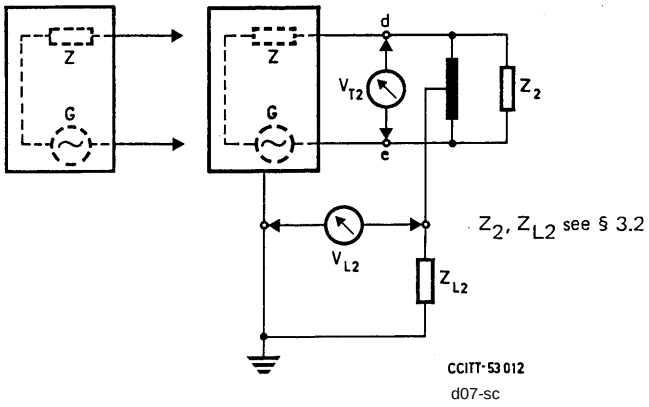
$$\text{Common mode rejection (CMR)} = 20 \log_{10} \left| \frac{V_{L1}}{V_I} \right| \text{ dB}$$

FIGURE 6/O.9

Measurement of common-mode rejection

2.7 *Output signal balance (OSB)*

This measurement (a ratio expressed in dB) is applicable to signal outputs. OSB is a measure of unwanted longitudinal signals at the output of a device. It is measured as shown in Figure 7/O.9 (see § 4.3.1 of Recommendation G.117 [1]).



$$\text{Output signal balance (OSB)} = 20 \log_{10} \left| \frac{V_{T2}}{V_{L2}} \right| \text{ dB}$$

FIGURE 7/O.9

Measurement of output signal balance

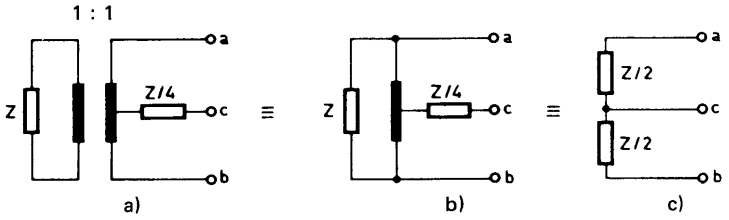
The signal source *G* shown in Figure 7/O.9 can be internal or external to the device under test. OSB measurements are also applicable to devices which perform a signal conversion (e.g. CF/VF side of channel translating equipment. D/A side of PCM multiplex equipment, etc. See § 2, item f of Recommendation G.117 [1]). In this case an appropriate external signal source, namely a signal generator for measurements at channel translators or a digital signal generator (see Recommendation O.133) for measurements at PCM-multiplexers is required.

3 Requirements for the measuring arrangements

3.1 *Inherent balance*

The measuring arrangements shown in Figures 1/O.9 through 7/O.9 include two independent impedances and a centre-tapped inductor arranged as indicated to yield the equivalence of two matched impedances of the value *Z*/2. The coil should be iron-cored with an accurate centre-tapped connection, both the tightly coupled half windings being as symmetrical as possible. The circuits shown in Figure 8/O.9 are electrically equivalent and any one can be used to perform the measurements described in this Recommendation. It should be noted that in the case of option *c)* of Figure 8/O.9, the connection of point c to earth must be made via an impedance which is virtually zero. For very low frequencies, the arrangements *a)* and *b)* of Figure 8/O.9 may be unsuitable and it may be more convenient to use arrangement *c)* of Figure 8/O.9, with a small (e.g., 1 ohm) resistor being inserted in the longitudinal arm, so that a measure of longitudinal current can be obtained to derive the equivalent voltage across *Z*/4.

The inherent balance of any measuring arrangements must be determined and found to be sufficiently good before a measurement is made. This may be done by replacing the equipment being tested with a second test bridge. The inherent longitudinal conversion loss of the measuring arrangements should be 20 dB greater than the limit set for the item under test. This balance should also be obtained when the connections at a and b are reversed. This permits an accuracy in the order of ± 1 dB. An example of a practical test bridge is given in Recommendation G.117, Figure 21/G.117 [1].



Note – Impedance $Z = Z_1$ or Z_2.

FIGURE 8/O.9

Electrical correspondence between centre-tapped coil configuration and centre-tapped resistors

3.2 *Impedances Z_1, Z_2, Z_{L1} and Z_{L2}*

Z_1 and Z_2 are the impedances connected in parallel to the input and/or output port respectively of the item under test. Z_1 and Z_2 are generally within ± 25% of the nominal impedance of the port to which they are connected. If measurements are made via high-impedance input ports, an additional impedance Z_1 should be connected between points a and b. The longitudinal impedances Z_{L1} and Z_{L2} are nominally equal to $Z_1/4$ or $Z_2/4$ respectively. Different values, however, may be used. This may be necessary to more properly simulate operating conditions of the item under test. In such cases the value of Z_{L1} and/or Z_{L2} shall be specified by the Recommendation convering the item under test.

3.3 *Measuring and generating the test signals*

The voltages V_L and V_T are measured with high-impedance voltmeters, and in such a way that the balance is not disturbed. The actual values of the internal impedance and e.m.f. of the generator G are irrelevant if V_{L1} is measured. The design of the item under test may impose a limit on the permissible magnitude of the longitudinal excitation.

When the equipment being tested as shown in Figure 1/O.9 is a signal generating device, V_{T1} must be measured selectively if it is required to measure the longitudinal conversion loss while the signal generator is active. Selective measurements are also preferable when high losses are to be measured.

3.4 *Other considerations*

It may be necessary in some measurements to make provisions for supplying a d.c. line holding current or a d.c. line current termination. In these cases the Recommendation covering the requirements for the item under test shall also specify the requirements for such d.c. line current treatment.

References

[1] CCITT Recommendation *Transmission aspects of unbalance about earth* Vol. III, Rec. G.117.

[2] CCITT Recommendation *Transmission characteristics of an international analogue exchange* Vol. VI, Rec. Q.45.