

An American National Standard

IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band

Sponsor
**Transmission Systems Committee
of the
IEEE Communications Society**

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USA

Foreword

(This Foreword is not a part of ANSI/IEEE Std 455-1985, IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band.)

The first edition of ANSI/IEEE Std 455-1976, IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band, was issued on September 30, 1976.

Following issuance of the standard, members of the Subcommittee on Susceptibility of the IEEE Transmission Systems Committee made extensive measurements of the balance of communications cable pairs and of equipment associated with cable. A subcommittee report on this work, including five papers by individual members, was presented at the 1979 National Telecommunications Conference (NTC 79). See NTC-79 Conference Record, pp 31.1.1–31.5.6. Contributing to this report were D. V. Batorsky, G. A. DeBalko, D. K. Guha, and C. D. Hansell (chairman); W. M. Haynes, Jr, J. A. Olszewski, D. E. Robinson, and D. S. Wilson. Further work on this subject was reported by A. K. Knowles at the 1981 International Conference on Communications (ICC 81). See ICC-81 Conference Record, pp 39.4.1–39.4.5.

Experience gained over the past several years by those who have used the standard and those who have built test equipment intended to comply with its provisions has identified some areas for improvement. On March 11, 1982, the IEEE Standards Board approved a Project Authorization Request from the Susceptibility Subcommittee of the IEEE Transmission Systems Committee to undertake a revision of the standard. This edition, ANSI/IEEE Std 455-1985, is the result of that action.

Some highlights of this revised edition are

- 1) The applicable frequency range has been extended from 1500 Hz to 4000 Hz
- 2) The measurement of longitudinal balance of active devices is addressed. The previous edition addressed longitudinal balance measurement on passive devices only.
- 3) The standard terminating test circuit has been revised to permit more accurate determination of the effects of shunt imbalance.
- 4) The description of required equipment has been expanded to better define the types of voltmeter that are suitable for measuring longitudinal balance in conformance with the standard.
- 5) The recommended calibration procedures have been completely rewritten to improve clarity and eliminate possible sources of error.
- 6) Alternate measurement circuits consistent with CCITT recommendations have been added.
- 7) The measurement of cable-pair balance is addressed briefly. The subcommittee has concluded that the establishment of detailed cable-pair balance measurement requirements is beyond the scope of this standard.

The opinion of the membership of the Susceptibility Subcommittee is that this revision significantly enhances the usefulness of the standard. Special thanks are due L. S. Baker, R. H. Campbell, P. L. Dillon, and A. K. Knowles for their significant contributions to the revised standard.

The members of the Susceptibility Subcommittee of the Transmission Systems Committee of the IEEE Communications Society when this revision was prepared were:

Eugene W. Riley, Chair

G. Y. R. Allen
Melvin J. Anna
Leroy S. Baker
David Boneau
Terry Borgmann
Richard H. Campbell
George A. DeBalko

Philip Dillon
Joseph M. Flanigan
Stanley W. Guzik
Charles D. Hansell
Harold Held
Lal M. Hore
Paul Kish

A. K. Knowles
Peter J. Lo
Henry Mar
Harvey E. Nerhood
J. A. Olszewski
Stan Overby
Frank L. Rose

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Daniel S. Wilson

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IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band

1. Introduction

ANSI/IEEE Std 455-1976 was widely accepted by organizations in the United States and Canada as the standard method for measuring longitudinal balance.

Prior to the issue of the standard in 1976, telephone companies and equipment manufacturers had generally agreed on a definition for longitudinal balance for many years. This agreement extended also to the basic approach followed when measuring balance. Testing a device for balance involves the application of a longitudinal voltage. Then, any resulting metallic voltage is measured, and the ratio of the two voltages is used to develop a balance number.

Unfortunately, agreement ended at about this point. A number of different test circuits were used by different segments of the telephone industry. Although all of the existing test circuits had some merits supporting their use, the mere existence of varied circuits led to differences in test results.

In addition to differences related to the test set, test conditions and procedures can also affect the result. When an item of equipment is to be tested, there is often a test set or procedure, or both, capable of giving any desired result.

Agreement on one way of testing for longitudinal balance had been sought. The first edition of ANSI/IEEE Std 455-1976, IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band, issued September 30, 1976, represented such agreement. Experience gained over the past several years by those who have used the standard and those who have built test equipment intended to comply with its provisions have led to this revised edition. It defines the basic requirements of a standard test circuit. Reasonable tolerances are included so that a test-set designer will find considerable latitude to make the set according to his design.

Besides defining the requirements for a test circuit, this standard specifies test conditions and procedures to be followed when longitudinal balance is measured. As a result, all test sets designed and used in accordance with the

standard will produce a consistent and repeatable balance number for a given test specimen. Similarly, comparing balance numbers for different devices will become more meaningful when all come from tests meeting the standard.

Longitudinal balance, as defined in this standard, specifically refers to longitudinal-to-metallic balance. This differs from the FCC definition for longitudinal balance which refers to metallic-to-longitudinal balance (see Appendix E for details).

2. Purpose and Scope

The purpose of this standard is threefold:

- 1) To define the basic requirements of a test circuit which can be used to measure longitudinal balance. This test circuit will be capable of yielding consistent and repeatable test results.
- 2) To define test conditions to be established while using the test circuit. Standard test conditions are considered vital for obtaining consistent results from a suitable circuit.
- 3) To describe standard test procedures to be followed when the test circuit is operated.

This standard specifies the elements of the test circuit only in general terms to allow considerable freedom when a test set is being designed. It thereby precludes the possibility that only one set of circuit elements will be capable of meeting the standard.

This standard is based on a resistive test circuit, although pure resistance is not essential. Resistive elements are specified because they are generally considered easy to duplicate and balance. Repeatable and consistent balance numbers are the object of issuing this standard.

Balance circuits are used at frequencies extending well into the megahertz range and there may be a need for measuring longitudinal balance at high frequencies. The definition of **degree of longitudinal balance** and the general configuration of the driving test circuit given in this standard are applicable at all frequencies. However, the test circuit impedances and other requirements for measurement outside the voice band are beyond the scope of this standard.

3. Definitions

balanced circuit: A circuit in which two branches are electrically alike and symmetrical with respect to a common reference point, usually ground.

circuit: A network providing one or more closed paths.

communication conductor: A conductor used in a communication network.

device: An item of electric equipment that is used in connection with, or as an auxiliary to, other items of electric equipment.

driving test circuit: A test circuit used to convert an exciting test voltage into balanced longitudinal voltages on tip and ring leads.

element: Any electric device (such as inductor, resistor, capacitor, generator, or line) with terminals at which it may be directly connected to other devices, elements, or apparatus.

frogging: A switching technique whereby the tip and ring leads of the test specimen are reversed relative to the driving or terminating test circuits, or both.

longitudinal balance, degree of: The ratio of the disturbing longitudinal voltage V_s and the resulting metallic voltage V_m of the network under test expressed in decibels, as follows:

$$\text{longitudinal balance} = 20 \log |V_s/V_m| \text{ (dB)}^1$$

¹Here and throughout this standard, log is assumed to mean log to the base 10.

where

V_s and V_m are of the same frequency.

longitudinal circuit: A circuit formed by one communication conductor (or by two or more communication conductors in parallel) with a return through ground or through any other conductors except those which are taken with the original conductor or conductors to form a metallic circuit.

longitudinal impedance: Impedance presented by a longitudinal circuit at any given single frequency.

longitudinal circuit port: A place of access in the longitudinal transmission path of a device or network where energy may be supplied or withdrawn, or where the device or network variables may be measured.

metallic circuit: A circuit of which the ground (earth) forms no part.

metallic impedance: Impedance presented by a metallic circuit at any given single frequency, at or across the terminals of one of its transmission ports.

metallic transmission port: A place of access in the metallic transmission path of a device or network where energy may be supplied or withdrawn, or where the device or network variables may be measured. The terminals of such a port are sometimes referred to as the tip and ring terminals.

NOTE — In any particular case, the transmission ports are determined by the way the device is used, and not by its structure alone.

metallic voltage: The voltage across a metallic circuit.

network: A combination of elements or devices.

nominal metallic impedance: Impedance based on lumped constants of a metallic circuit at a given single frequency.

terminating test circuit: A network connected to a transmission port of a circuit to terminate it in a suitable balanced termination for longitudinal balance testing. This circuit is used when a driving test circuit is connected to one such port and the test specimen has additional transmission ports.

voice band: That part of the audio frequency range that is employed for the transmission of speech. For the purpose of this standard, the voice band extends from 50 Hz to 4000 Hz.

4. Terminal Constraints

To determine the longitudinal balance of a test specimen, a longitudinal voltage V_s is applied through a driving test circuit to both tip and ring leads of the specimen while the resulting metallic voltage V_m is monitored (Metallic voltage may also be called transverse voltage). Balance is expressed as the logarithmic ratio of the longitudinal to metallic voltages.

$$\text{Longitudinal balance} = 20 \log |V_s/V_m| \quad (1)$$

The major factors which influence how the test circuit affects the longitudinal balance of a test specimen include the following items:

- 1) The actual balance of the test specimen
- 2) The longitudinal and metallic impedances of the driving test circuit and the terminating test circuit
- 3) The frequency of the applied test voltage
- 4) The internal balances of the driving test circuit and the terminating test circuit
- 5) The levels of ac and dc signals applied

Because of these interactions, it was possible, in the past, to obtain widely different balances on identical specimens simply by modifying the impedances or balance of the driving test circuit. It is the intent of this standard therefore to specify the values and tolerances of these impedances and the balance in a suitable driving test circuit. Furthermore,