

An American National Standard

IEEE Standard Telephone Loop Performance Characteristics

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

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 820-1984, IEEE Standard Telephone Loop Performance Characteristics.)

Telecommunication operating companies generally agree on the requirements which control the performance of telephone loops, a major factor in the overall performance of the network. This control has been accomplished through a combination of techniques which depend on the characteristics of the commonly used telephone sets and loop facility design rules. However, no industry performance standards have resulted. With the increasingly innovative application of emerging technologies and the current trend toward interconnect of privately owned devices with the public network, it is essential that appropriate standards be established. This is one such standard. This standard will provide for the characterization of loops at customer terminal and switching equipment interfaces and the objective performance evaluation of loop facilities.

Suggestions for improvement of this standard will be welcomed. They should be sent to the

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This standard was prepared by the Loop Performance Working Group of the IEEE Transmission Systems Committee of the IEEE Communications Society. At the time this standard was approved the membership of the working group was as follows:

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IEEE Standard Telephone Loop Performance Characteristics

1. Introduction

1.1 Purpose

The purpose of this standard is to describe quantitatively the performance characteristics of telephone loops and indicate current acceptable performance criteria.

1.2 Scope and Limitations

This standard covers the general parameters and characteristics associated with telephone loops from the subscriber signaling and analog voice frequency interface to the local Class 5 switch interface. It includes only those business and residential lines in the North American public switched network where no special performance requirements are involved.

This standard provides common denominators for subscriber line performance, independent of facility types, construction processes or equipment, and circuit provisioning methods. This standard does not attempt to allocate impairments to the individual facilities and equipments that comprise the subscriber line. Such allocations are performed by the service providers to achieve the overall loop and telephone system performance.

1.3 References

[1] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.¹

[2] ANSI/IEEE Std 455-1976, IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band.

[3] ANSI/IEEE Std 661-1979, IEEE Standard Method for Determining Objective Loudness Rating of Telephone Connections.

[4] CCITT Yellow Book, Supplement no 3, vol v.²

[5] CCITT, COM XII—no 13-E, A Preliminary Loss/Noise—Listener Echo Opinion Model for a Uniform Echo Path Loss, Question: 5, April 1981.

¹ ANSI documents are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

² CCITT documents are available in the US from National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

[6] EIA RS-470-1981, Telephone Instruments with Loop Signaling for Voiceband Applications.³

[7] IEEE Std 743-1984, IEEE Standard Methods and Equipment for Measuring the Transmission Characteristics of Analog Voice Frequency Circuits.⁴

2. Definitions

analog switch: A switch capable of switching analog and digital signals without converting them into a set digital format. Most analog end office switches are two-wire systems which have simple interfaces with the loop.

battery feed: The dc supply and coupling circuit powering the loop.

bridged tap: Any portion of a metallic circuit which is not in the path between the end office and the customer. The bridged tap may be connected at an intermediate location or be an extension of the circuit beyond the customer location. The air associated with the bridged tap introduces a frequency-dependent *bridging loss* in the loop.

central office (CO): The building, one or more switching systems, and related equipment contained therein that provide telephone service.

C-Notched filter: A filter used in front of the noise detector in conjunction with the measurement of noise in certain systems. A tone is transmitted in these systems to activate signal-dependent noise sources, but the tone power should not be included in the measurement. The C-Notched filter has a C-Message weighting transfer function with a sharp notch which removes this tone from the received signal before its power is measured.

customer premises equipment: Any equipment connected by customer premises wiring to the customer side of the network interface.

digital switch: A switch that, internally, performs switching only of digital signals of a set format. It is inherently a four-wire entity, requiring a two-wire to four-wire hybrid at the channel interface when accepting analog signals from two-wire channels.

dual-tone multifrequency (DTMF) signaling: Voiceband signaling by simultaneous transmission of two tones, one from a low-frequency and one from a high-frequency group. Each of these groups consists of four voiceband frequency tones no two of which are harmonically related. Only 12 of the 16 available combinations are currently in use for customer address signaling.

end (Class 5) office (EO): A switching system to which customer premises equipment is directly connected by loops. The switch connects loops to loops and loops to trunks.

four-wire channel: Consists of two unidirectional channels carrying signals in opposite directions.

idle circuit: The condition of a transmission channel in the talk state when no signal is present.

idle line: The state of a loop when the customer premises equipment connected to it is on-hook.

loaded loop: A loop into which lumped inductance (loading coil) is introduced at fixed intervals to compensate for the distributed cable capacitance. The addition of loading coils, properly placed, reduces mid-voiceband loss, flattens the frequency response over most of the voiceband, but creates a sharp cut-off at the high-frequency band edge.

longitudinal (common-mode) signal: The longitudinal voltage is half the algebraic sum of the voltages to ground in the two conductors (tip and ring). The longitudinal current is the algebraic sum of the current in these conductors.

loop: The transmission and signaling channel, with or without gain, between the center of the end office switch and the network interface. It also extends dc power to the network interface.

³ EIA documents are available from Electronic Industries Association, 2001 Eye Street, NW, Washington, DC 20006.

⁴ IEEE documents are available from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

metallic (differential) signal: The metallic voltage is the algebraic difference between the voltages to ground in the two conductors (tip and ring). The metallic current is half the algebraic difference between the current in these conductors.

network interface: The interface between the public switched telephone network and the customers' premises wiring.

power influence: The power of a longitudinal signal induced in a telephone circuit by an electromagnetic field emanating from a conductor or conductors of a power system. In common usage, power influence is synonymous with longitudinal noise.

subscriber carrier: A system that multiplexes customer signals to achieve pair gain in the loop plant. Usually, it consists of

- 1) An end office terminal (EOT); it interfaces with the EO through analog line appearances, one per each implemented loop. If the carrier is a digital system integrated in a digital end office, this terminal and its interfaces are replaced by much simpler all-digital equipment that may be integrated into the switching system.
- 2) A remote terminal (RT); it interfaces with the cable pairs to the customers' premises through analog interfaces, one per each implemented loop.
- 3) A transmission medium between the EOT (or EO in a digital integrated system) and the RT; it provides a control channel for internal EOT/EO-to-RT communication and communication channels for customer traffic. A nonconcentrated system has as many customer channels as implemented loops, with fixed loop-channel assignments. A concentrated system has fewer channels than implemented loops, and changes loop-channel assignments to accommodate changing traffic patterns.

switch (switching system): A system that establishes communication channels among two or more of its interfaces at customers' demand.

two-wire channel: A transmission medium that simultaneously carries, without multiplexing, two signals traveling in opposite directions.

wire center: A central point from which loop feeder networks extend in a tree-like manner into the serving areas associated with the center. One or more end offices may be located at a wire center.

3. General Information

3.1 Performance Classifications

3.1.1 Recommended

This classification describes the operating range that ensures the most desirable performance.

3.1.2 Acceptable

This classification describes the operating range, outside the Recommended Region, that provides satisfactory performance.

3.1.3 Conditionally Acceptable

This classification describes the operating range, outside the recommended and acceptable regions, that, under conditions specified for each parameter, provides satisfactory performance.

3.1.4 Not Recommended

This classification describes the operating range outside the preceding three classifications for which performance may not be satisfactory.

3.2 Types of Loop Facilities

Loop facilities are assumed to have a two-wire analog interface at the customer premises end and a digital or two-wire analog interface at the central office end. The transmission path may extend over metallic pairs the entire distance from the end office switch to the customer interface, or in some cases, a certain portion of the transmission path may be through a carrier-derived channel.

The two-wire metallic pairs may be typically provided by loaded or nonloaded aerial, buried, or underground cables. These two-wire metallic pairs may or may not include loop treatment devices, such as loop extenders and voice frequency repeaters.

3.3 Interface with the Local Switching System

Loop facilities interface with the local switching system in different arrangements. Individual sections of this standard will address requirements as appropriate to define important performance criteria at the customer end of the loops and, where important, also at the switch end.

3.3.1 Analog Switch

With electro-mechanical and other analog switching systems, these interface arrangements are usually two-wire analog terminations at the center of the switch, normally accessible through a test board or other similar points which allow convenient test access to the circuit in question. When measuring loop parameters, care shall be taken to compensate for the effect of the test access path to the center of the switch.

3.3.2 Digital Switch

With digital switching systems, these interface arrangements are four-wire digital terminations at the digital signal bus, considered a virtual center of the switch, where a circuit of interest can be accessed by a system test console providing a codec-derived analog port. For remotely located line equipment homing on the digital-signal bus at the host switch, the virtual switch center remains unchanged at the host, and test access to any loop in question is similarly provided through a codec-derived analog port.

3.3.3 Pair Gain Systems

In some instances, pair gain systems such as line concentrators or subscriber carrier systems may be inserted in, and become part of, the loop facility between the customer location and the switch interface. The switch end interface of the loop however remains the same as defined in 3.3.1 and 3.3.2.

3.4 Interface at Customer Premises

Loop facilities terminate at the network interface on a two-wire basis.

3.5 Use of Statistical Information

Some of the loop performance characteristics in this standard are best defined in terms of their statistical properties. When this is the case, the performance characteristic considered shall be measured on a sufficient number of loops in various categories (that is, short, long, loaded, nonloaded, and carrier) to ensure that the statistical values derived from the sample meet a specified confidence level. Values relating to the characteristic such as, but not limited to, mean, maximum, and standard deviation may then be stated.

3.6 Measurement Procedures

Unless otherwise stated, all measurements will be made in accordance with IEEE Std 743-1984 [7].⁵

4. Performance Characteristics

4.1 Loop Loss

4.1.1 Definition of Loop Loss

First, consideration should be given as to what loss criteria are available before selecting that quantity which is most appropriate. The following are accepted definitions of the four most commonly used measures of power loss, in dB:

$$\text{Insertion loss} = L_i = 10 \log \frac{\text{power delivered to load} \\ \text{(with facility removed)}}{\text{power delivered to load} \\ \text{(with facility inserted)}}$$

$$\text{True Power loss} = L_p = 10 \log \frac{\text{power delivered to input of} \\ \text{facility (with facility inserted)}}{\text{power delivered to load} \\ \text{(with facility inserted)}}$$

$$\text{Available power loss} = L_a = 10 \log \frac{\text{maximum power available} \\ \text{from the source}}{\text{maximum power available to the} \\ \text{load (with facility inserted)}}$$

$$\text{Transducer loss} = L_t = 10 \log \frac{\text{maximum power available} \\ \text{from the source}}{\text{power delivered to the load} \\ \text{(with facility inserted)}}$$

To compute true power loss, it is necessary to determine the power delivered to the input of the loop facility, which is a function of the input impedance of the loop. Because this parameter has wide variation in the plant and cannot be easily determined, this quantity is not a convenient measure of loop loss. The same disadvantage holds for available power loss since it is necessary to determine the output impedance (as seen from the load) of the loop.

Thus, to determine loop loss, it is preferable to calculate either transducer loss or insertion loss, both of which are easily measurable. When the oscillator impedance (reference signal source) and the detector impedance are conjugates, insertion loss equals transducer loss. In reality, the vast majority of office reference signal sources are a resistive 900 Ω . With a detector impedance also of 900 Ω , the choice becomes one of semantics. Even if the office source were 600 Ω and the detector 900 Ω (or vice versa), the difference in the two loss quantities (insertion loss and transducer loss for the same pair of impedances) would only be 0.2 dB. This standard will adopt transducer loss as the measure of loop facility loss, since this is the loss that is actually measured in the field when detector and signal source have different impedances. The transducer loss should be measured by using a 600 Ω detector at the subscriber end and a 900 Ω , 1004 Hz signal source at the central office calibrated to deliver a known reference level to a 900 Ω load. The

⁵Numbers in brackets correspond to those of the references in 1.3.