NIST Special Publication 500-194

Computer Systems Technology

U.S. DEPARTMENT OF COMMERCE
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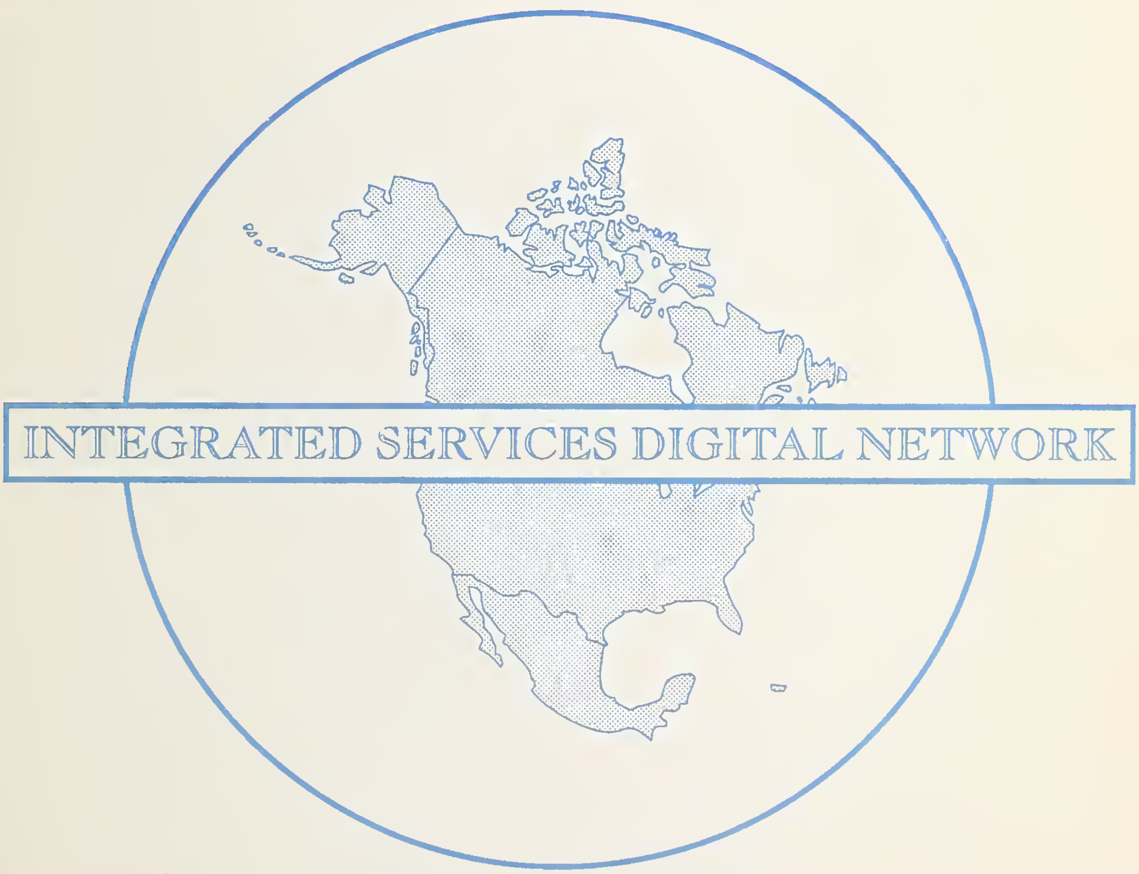
ISDN CONFORMANCE TESTING

Layer 1 – Physical Layer

Part 1 – Basic Rate S/T Interface, User Side



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Layer 1 – Physical Layer

Part 1 – Basic Rate S/T Interface, User Side

Based on work performed by the
North American ISDN Users' Forum

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September 1991

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National Institute of Standards and Technology Special Publication 500-194
Natl. Inst. Stand. Technol. Spec. Publ. 500-194, 88 pages (Sept. 1991)
CODEN: NSPUE2

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1991

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

ISDN Conformance Testing -

Layer 1 - Physical Layer

Part 1: S/T Interface

ABSTRACT

The American National Standard for Telecommunications T1.605-1989 specifies the Layer 1 requirements to provide for satisfactory transmission between a Terminal Equipment (TE) and Network Termination (NT). It describes both the physical interface and the electrical characteristics of the signals appearing at the S and T reference points. Equipment designed to operate on the Integrated Services Digital Network (ISDN) Basic Rate S or T interface must conform with this set of requirements.

This document describes a set of test specifications which test conformance of TEs and NTs to the ISDN Physical Layer at the S/T reference point, as defined in ANS T1.605-1989. These tests were developed and approved by members of North American ISDN Users' Forum (NIU-Forum).

KEYWORDS

Abstract Test Suites, Basic Rate Interface, BRI, Conformance Testing, ISDN, Network Termination, NT, S/T Interface, Terminal Equipment, TE

PREFACE

This document is one of a group of NIST Special Publications that will be issued on Integrated Services Digital Network (ISDN) Conformance Testing. Each publication in this group will focus on a different set of conformance test specifications. The following is a list of the publications in this group:

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Introduction

- This document will discuss the basic concepts of conformance testing and the development of abstract test specifications for conformance testing of ISDN protocols.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Layer 1 - Physical Layer

- Part 1 Basic Rate S/T Interface, User Side describes a set of test specifications which verify conformance of TEs and NTs to the ISDN Physical Layer Basic Access at the S/T reference point, as defined in ANS T1.605-1989, and NIU 89-105.

- Part 2 Basic Rate U Interface, User Side will describe a set of test specifications which verify equipment implementation conformance to the ISDN Physical Layer Basic Access at the U interface, as defined in ANS T1.601-1988 and NIU 89-101.

- Part 3 Primary Rate Interface, User Side will describe a set of test specifications which verify equipment implementation conformance to the ISDN Physical Layer Primary Access at the S, T, and U interface, as defined in ANS T1.408-1990 and the corresponding NIU-Forum Implementation Agreement.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Layer 2 - Data Link Layer, Link Access Procedure on the D Channel (LAPD)

- Part 1 Basic Rate Interface, User Side will define the abstract test specifications to verify equipment implementation conformance to the Layer 2 of an ISDN at the user-network interface, for the BRI access arrangements, as defined in ANS T1.602-1989 and NIU 89-210.

- Part 2 Primary Rate Interface, User Side will define the abstract test specifications to verify equipment implementation conformance to the Layer 2 of an ISDN at the user-network interface, for the PRI access arrangements, as defined in ANS T1.602-1989 and the corresponding NIU-Forum Implementation Agreement.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Layer 3 - Network Access Layer

- Part 1 Basic Rate Interface Circuit Switch Call Control, User Side will define the abstract test specifications to verify equipment implementation conformance to the Layer 3 of an ISDN BRI at the user-network interface for the Basic Call Control Procedures, as defined by ANS T1.607-1990, NIU 90-301, and other corresponding NIU-Forum Implementation Agreements.

- Part 2 Primary Rate Interface Circuit Switch Call Control, User Side will define the abstract test specifications to verify equipment implementation conformance to the Layer 3 of an ISDN PRI at the user-network interface for the Basic Call Control Procedures, as defined by ANS T1.607-1990, NIU 90-302, and other corresponding NIU-Forum Implementation Agreements.

- Part 3 Packet Switched Call Control will define the abstract test specifications to verify equipment implementation conformance to the Layer 3 of an ISDN at the user-network interface for the Packet Switched Call Control Procedures, as defined by ANS T1.608-1990, NIU 89-320, and other corresponding NIU-Forum Implementation Agreements.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Supplementary Services

- This document will define the abstract test specifications to verify implementation conformance to the Supplementary Services at the user-network interface, as defined in ANS T1.610, NIU 90-311, and other appropriate ANS documents and their corresponding NIU-Forum Implementation Agreements.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Packet Mode Bearer Services Control Procedures

- This publication will define the abstract test specifications to verify implementation conformance to the Packet Mode Bearer Services Control Procedures.

✓ Integrated Services Digital Network (ISDN) Conformance Testing - Volume 7 - Terminal Adaption

- This document to the ISDN Circuit-Mode Data Terminal Adaption using Statistical Multiplexing, as defined by ANS T1.612-1990 and the corresponding NIU-Forum Implementation Agreement.

NOTICE OF DISCLAIMER

THESE TESTS WERE DEVELOPED AND APPROVED BY MEMBERS OF THE NORTH AMERICAN ISDN USERS' FORUM (NIU-FORUM). THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) MAKES NO REPRESENTATION OR WARRANTY, EXPRESS OR IMPLIED WITH RESPECT TO THE SUFFICIENCY, ACCURACY, OR USE OF ANY INFORMATION OR OPINION CONTAINED HEREIN. THE USE OF THIS INFORMATION OR OPINION IS AT THE RISK OF THE USER. UNDER NO CIRCUMSTANCES SHALL NIST BE LIABLE FOR ANY DAMAGE OR INJURY INCURRED BY ANY PERSON ARISING OUT OF THE SUFFICIENCY, ACCURACY, OR USE OF ANY INFORMATION OR OPINION CONTAINED HEREIN.

ACKNOWLEDGMENTS

NIST would like to acknowledge the NIU-Forum ISDN Conformance Testing (ICOT) Working Group, and especially the following individuals for their valuable contributions to this document:

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TABLE OF CONTENTS

LIST OF TABLES

1 GENERAL

1.1 Introduction

The American National Standard for Telecommunications T1.605-1989 specifies a minimal set of requirements to provide for satisfactory transmission between a TE and NT. It describes both the physical interface and the electrical characteristics of the signals appearing at the S and T reference points. Equipment designed to operate on the Integrated Services Digital Network (ISDN) Basic Access S or T interface must conform with this set of minimal requirements.

ANS T1.605 has been used as the basis for developing a set of conformance test specifications for the ISDN Physical Layer at the S/T reference point. This document describes these test specifications. The test suites described herein are intended for the use by all members of the North American ISDN Users Forum and adhere to ANS T1.605 to the greatest extent possible. This document will be updated subsequent to any published dates to ANS T1.605.

Unless otherwise stated, the use of the term TE within this document refers to equipment that exists on the terminal side of the basic access interface at S/T reference points. The term NT refers to equipment that exists on the network side of the interface at S/T reference points.

Communication between adjacent layers is conceptual (primitive procedures) and allows description of interactions between functions dedicated to different layers. These primitive procedures do not constrain an implementation, are system internal and therefore cannot be tested in isolation. However, as seen from the outside, the design of equipment shall be such that the sequence of events across the interface must be the same as if the primitives were implemented as described in the relevant standard.

1.2 Purpose

The purpose of this document is to describe a set of accepted test suites which test conformance of TEs and NTs to the Layer 1 requirements specified in ANS T1.605. The specific requirements which this places on equipment are outlined in Section 2. The Static Conformance Requirement (SCR) column in Section 2 indicates whether the requirements is mandatory or optional. A device is considered conformant to ANS T1.605 if it passes all tests for Static Conformance Requirements labeled "mandatory" as well as passes all tests for Static Conformance Requirements labeled "optional" of options it implements. For example, when a TE implements the optional voice capability, it must pass the optional SCR for B-Channel Bit order-voice.

If a device fails any test for SCRs labeled "mandatory" or SCRs labeled "optional" for options it implements, it will be considered as nonconforming to ANS T1.605.

Certain optional requirements may not require the entire option to be implemented. An example of this is multiframing. For these requirements, the equipment manufacturer must specify what portion of the requirement is implemented within their equipment and only that portion of the test suite required to test that functionality will be executed. Test suits falling within this category will be annotated.

1.3 Configurations at User Premises

This section describes the operational configurations to which the requirements of this document apply. Equipment which meets the Layer 1 requirements and does not constrain the use of Layer 1 modes of operation, is able to operate in the following wiring configurations:

1) Short passive bus able to accommodate eight TEs,
2) Extended passive bus,
3) Branched passive bus, or
4) Point-to-point configuration.

1.4 Relationship to other North American ISDN Users' Forum (NIU-Forum) Documents

The Layer 1 requirements in this document apply to all types of equipment connected to the Basic ISDN user-network interface and are requisite for testing, and are additional to the requirements specified in the Layer 2 requirements document and in the Layer 3 requirements document.

1.5 Testing and Approval Methodology

Conformance shall be tested using the tests specified in Section 2 of this document. Those functions and procedures that are indicated in this document as being optional, shall be subject to a conformance test only if they are implemented in the System Under Test (SUT). The means of determining whether an optional function or procedure has been implemented is either by the supplier's declaration or as the result of performing conformance tests on the SUT. Where no declaration is made by the supplier as to the implementation of an optional function or procedure, and the conformance test reveals that the option is incorrectly (or partially) implemented, the option shall be deemed to have been implemented and the equipment shall be tested accordingly.

The user-network interface at the S/T reference points provides the only test access for the purpose of performing conformance tests. However, actions at the user side of the equipment under test (e.g., at the man-machine interface, execution of higher layer processes, at the interface at the R reference point in the case of terminal adapters) shall be used to invoke actions at layer 1 of the B and D Channels within the equipment under test.

Connection of the equipment under test to the tester may be with an integral cord, if the equipment is so equipped, or with a cord conforming to ANS T1.605 requirements if the equipment is equipped with a socket.

When carrying out a test, it may be necessary for the equipment under test to be maintained in the active state of a call. In such cases it may be necessary for the tester to achieve this by procedural means related to functional entities outside the scope of this document. Any actions necessary to prevent the equipment under test from premature clearing shall be indicated by the supplier.

1.6 Information to be provided by the Supplier

The supplier shall provide two kinds of information:

- information with respect to the protocol; Protocol Implementation Conformance Statement (PICS), see Section 2,

- information with respect to the man-machine interface; Protocol Implementation eXtra Information for Testing (PIXIT).

The complete list of the information to be provided by the supplier is a matter between the supplier and the testing house.

1.7 Test Support required of the Supplier

If the equipment to be tested does not provide:-

- access to the B1 and B2 channels externally (See Note 1),

or

- implementation of loopback 4 (manually controlled), and also a test pattern of Info 3 frames with the B1 and B2 channels set to binary zero,

then

the equipment will not support Layer 1 tests requiring specific bit patterns in the B channels.

In this case the supplier shall additionally provide a modified unit for test using the same chip set and interface components as in the equipment under consideration. This test equipment shall provide a means for access to the B1 and B2 channels (See Note 1) to allow insertion of specific test patterns so that necessary Layer 1 tests can be carried out or else an implementation of loopback 4.

Note 1: The interface providing access to the B-Channels may be any mutually agreed upon interface. Such an interface shall be provided either directly on the terminal equipment or else by an adaptor provided by the equipment supplier. One such interface is expanded below as a guide.

- two ports shall be provided, one for B1 and one for B2 access

- the ports will use an interface with EIA-422 balanced drivers/receivers and include the EIA-232 signal lines TD, RD, TC, RC, and SG. The clocks TC and RC can be independent but must be synchronous with the data on TD and RD respectively and operate at a frequency of 64 kbit/s.

- each port will have a standard 25 pin D-type female connector.

In addition to having explicit control of data patterns appearing on the interface, there will be instances when a given test can only be performed when the SUT is in a specific state, i.e., force states G1 (NT) / F3 (TE) for output impedance measurements when transmitting 1's. In these instances, the supplier must provide a means of placing his equipment into these specific states. Testing equipment expressly modified for this type of control is acceptable for conformance purposes.

1.8 Test Environment

All tests specified in Section 2 of this document shall be performed at:-

- an ambient temperature in the range 15°C to 35°C (60°F to 95°F),
- a relative humidity in the range 25% to 75%,
- an air pressure in the range 86.2 kPa to 105.5 kPa (12.5 lb/in^2 to 15.3 lb/in^2).

For terminal equipment which is directly powered (either wholly or partly) from the AC power line, all tests shall be carried out within ±5% of the normal operating voltage. If the equipment is powered by other means and those means are not supplied as part of the apparatus (e.g., batteries, stabilized AC supplies, DC) all tests shall be carried out within the power supply limit declared by the supplier. If the power supply is AC, the tests shall be conducted within 4% of the normal operating frequency. If the terminal equipment is powered across the user-network interface, then Section 2.5 of this document shall apply.

1.9 Layer 1 Requirements

The static conformance requirements in Section 2 of this document define the minimal features and functions which must be supported to ensure operational integrity of ISDN equipment.

1.10 Test Equipment Substitutions

The conformance tests specified in this document are intended to test equipment which exists on the ISDN Basic Access interface at the S/T reference point in accordance with requirements given in ANS T1.605. In the case that tests engineered herein are not aligned with the specifications in ANS T1.605 (there are instances where simpler but slightly more restrictive tests are employed), the specifications in ANS T1.605 will take precedence over those in this document.

The conformance tests described herein have been designed to afford the required accuracy while using the least specialized and widest available test equipment. In some cases this results in cumbersome, manually intensive tests that can be better performed with more costly specialized equipment. The testing organization is free to take advantage of such specialized equipment in any of the following tests. The testing organization that uses different test equipment or test methodologies must, however, demonstrate to their clientele that their tests are at least as comprehensive and as accurate as those contained in this document.

NOTE: Most drawings in this document denote an external NT terminating resistor; however, an NT may be designed with an internal terminating resistor.

1.11 Test Equipment Notes

TEST_CABLE:
Although a TE may be provided with a cord of less than 5 meters in length, it shall meet the requirements of ANS T1.605 when tested with a cord having a minimum length of 5 meters. In cases where the System (TE) under Test is marketed with cords less than 5 meters, the supplier or the test organization will provide a suitable (in accordance with ANS T1.605 9.10) "TEST CABLE" of at least 5 meters. This "TEST CABLE" will be used as required by the various test configurations.

1.12 Referenced Standards

This document is intended to be used in conjunction with the following standard:

CCITT Recommendation G.117, Transmission Aspects of Unbalance about Earth (Definition and Methods).

1.13 Related Standards

The standards listed below are for information only, and are not necessary for use of this document.

CCITT Recommendation I.411, ISDN User-Network Interfaces - Reference Configurations.
CCITT Recommendation I.412, ISDN User-Network Interfaces - Interface Structures and Access Capabilities.
CCITT Recommendation I.430, Basic Rate User-Network Interface Layer 1 Specification.

2 MAPPING TO ANS T1.605-1989

2.1 Overview

The specification breakdown is based on identifying electrical, functional and mechanical conformance parameters for evolving specific test procedures. The following documents[1] are used as reference:

- ANS T1.605-1989[2], "ISDN Basic Access Interface for S and T Reference Points - Layer 1 Specification," October 17, 1988.
- NIU/ACT1/89-002, "ISDN Protocols Conformance Testing - Physical Layer," Draft Report, Dhadesugoor Vaman.
- NIU/ACT1/89-009, "S Interface Test Procedures," Tim Gee.
- NIU/ACT1/89-015, "Contribution to NIU/ACT1 on Power Feeding," Kenneth Molloy.
- NIU/ACT1/89-018, "Transmission Test Procedures," Tim Gee.
- NIU/ACT1/89-019, "NT Receiver Input Delay," Mehdi Mohebbi.
- NIU/ACT1/89-020, "Unexposed Wiring," Ali Rahjou.
- NIU/ACT1/89-021, "B-Channel Bit Order -- Voice," Leslie Fraser.
- NIU/ACT1/89-022, "Activation/Deactivation Procedures," Leslie Fraser.
- NIU/ACT1/89-023, "Frame Relative Bit Positions," Kenneth Molloy.

NOTE: Static Conformance Requirement (SCR) column indicates whether the section is mandatory (M), optional (O), conditional (C), or not applicable (NA).

T/N column indicates TE, NT, or Both (B)

Suite column refers to test section in this document.

(SA) System Under Test requires special access capabilities as indicated in text.

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1 For copies of the NIU-Forum documents, please contact Dawn Hoffman, NIU-Forum Administrator, NIST, Building 223, Room B364 Gaithersburg, MD 20899.

2 Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036

2.2 Specification Breakdown

2.2.1 Electrical Characteristics

Table 2.2.1.1. Basic Electrical Characteristics

T1.605	Parameter	SCR	T/N	Suite	Comments
9.2.2	TE Timing Extraction Jitter	M	TE	5.1.1	
9.3	NT Output Jitter	M	NT	5.1.3	
9.2.3	Total Phase Deviation	M	TE	5.1.2	
9.4	Line Termination, xmtr	O	NT	5.2.3	(SA)
9.4	Line Termination, rcvr	O	NT	5.6.1.3	(SA)

Table 2.2.1.2. Transmitter Output Characteristics

T1.605	Parameter	SCR	T/N	Suite	Comments
9.5.1.1 9.5.1.2 9.5.1.1 9.5.1.2 9.5.1	Output Z, xmtting 0's Output Z, xmtting 0's Output Z, xmtting 1's Output Z, xmtting 1's Output Z while inactive	M M O M M	NT TE NT TE TE	5.2.1 5.2.1 5.2.2.1 5.2.2.2 5.2.4	(SA)
9.5.3.1 9.5.5.1 9.5.5.2 9.5.4	Pulse Shape Pulse Shape Pulse Amplitude Pulse Unbalance	M M M M	B TE TE B	5.3.1 5.3.2 5.3.3 5.4	50 Ω 400 Ω 5.6 Ω
9.5.6.1 9.5.6.2	Longitudinal Conver. Loss Output Signal Balance	M M	B B	5.5.1 5.5.2	

Table 2.2.1.3. Receiver Input Characteristics

T1.605	Parameter	SCR	T/N	Suite	Comments
9.6.1.1 9.6.1.2 9.6.1	TE Input Impedance NT Input Impedance Input Z while inactive	M O M	TE NT TE	5.6.1.2 5.6.1.1 5.6.1.4	Unterminated (SA)
9.6.2.1 9.6.2.2 through 9.6.2.5	Receiver Sensitivity Receiver Sensitivity	M M	TE NT	5.6.3.1 5.6.3.2	Test all specified bus configurations
9.6.3	Receiver Input Delay	M	NT	5.6.2	
9.6.4	Longitudinal Conv. Loss	M	B	5.5.1	Refer to 9.5.6.1

Table 2.2.1.4. Electrical Environment

T1.605	Parameter	SCR	T/N	Suite	Comments
 9.8.1 9.8.1 9.8.1	Unexposed Wiring: DC Voltages AC at 20 Hz. Surges	 O O O	 B B B	 7.1.1 7.1.2 7.1.3	
9.9 9.10	Interconnecting Media Cord Testing	M M	B TE	8.1 8.2	

Table 2.2.1.5. Power Feeding

T1.605	Parameter	SCR	T/N	Suite	Comments
 10.2.2.1 10.2.2.2 10.2.3 10.2.3	Power Avail. from source Normal power, Source 1 Restricted, Source 1 Normal power, Source 2 Restricted, Source 2	 O O O O	 PS PS PS PS	 6.2.1.1 6.2.1.2 6.2.2.1 6.2.2.2	 PS = Power Source (which may be part of NT)
10.4	Current Transient	O	TE	6.1.3	
 10.5 10.5.1 10.5.2	Power Consumption Resistance to Ground Normal power, Source 1 Restricted, Source 1	 O O O	 TE TE TE	 6.2.1.3 6.1.1 6.1.2	 Option if power sink not supported

2.2.2 Functional Characteristics

Table 2.2.2.1. Frame Structure

T1.605	Parameter	SCR	T/N	Suite	Comments
6.4.1	Bit Rate	M	TE	3.1.3.1	Info 1
6.4.1	Bit Rate	M	NT	3.1.3.2	Info 4
	Binary Org. of Frame				
6.4.2.1	TE to NT	M	TE	3.1.1	
6.4.2.1	NT to TE	M	NT	3.1.2	
6.4.2.3	Relative bit positions	M	TE	3.3	
6.4.2.4	B-Channel bit order, PCM	O	TE	3.2	
6.5	Line Code	M	B	3.1.1	

2.2.3 Interface Procedures

Table 2.2.3.1. D-Channel Access Procedure

T1.605	Parameter	SCR	T/N	Suite	Comments
7.1.1	Interframe Fill, 1's	M	TE	4.1.1.1	
7.1.1	Interframe Fill, HDLC	M	NT	4.1.1.2	
7.1.2	Echo on D-Channel	M	NT	3.1.2	
7.1.3	D-Echo Monitoring	M	TE	4.1.2	
7.1.4	Priority Mechanism	M	TE	4.1.2	
7.1.5	Collision Detection	M	TE	4.1.2	

Table 2.2.3.2. Activation/Deactivation

T1.605	Parameter	SCR	T/N	Suite	Comments
7.2.1.1	TE States	M	TE	4.2.1	
7.2.1.2	NT States	M	NT	4.2.2	

Table 2.2.3.3. Frame Alignment Procedures

T1.605	Parameter	SCR	T/N	Suite	Comments
	NT to TE Direction				
7.3.1.1	Loss of Alignment	M	TE	4.3.1	
7.3.1.2	Alignment Regained	M	TE	4.3.1	
	TE to NT Direction				
7.3.2.1	Loss of Alignment	M	NT	4.3.2	
7.3.2.2	Alignment Regained	M	NT	4.3.2	
7.3.3	Multiframing			4.4	Q and S Channels
		O	TE	4.4.1	
		O	NT	4.4.2	
7.4	Idle Code on B-Channels	M	TE	3.1.1	

2.2.4 Layer-1 Maintenance

Table 2.2.4.1. Code Messages and Priorities

T1.605	Parameter	SCR	T/N	Suite	Comments
8.4.2	Loss of Power	O	TE	4.4.1	
8.5.2	Loss of Power	O	NT	4.4.2	
8.4.3	Self Test Request	O	TE	4.4.1	
8.5.4	Self Test Indication	O	NT	4.4.2	
8.5.3	Report of Error (DTSE)	O	NT	4.4.2	
8.4.4	Loopback Request	O	TE	4.4.1	
8.5.6	Loopback Indication	O	NT	4.4.2	
8.5.7	Loss of Received Signal	O	NT	4.4.2	
8.4.1	Idle Channel (NORMAL)	O	TE	4.4.1	
8.5.1	Idle Channel (NORMAL)	O	NT	4.4.2	

3 FUNCTIONAL CHARACTERISTIC TESTS

3.1 Binary Organization of Frame

Binary Organization testing requires specific data patterns to be transmitted by the SUT. This will be done by the most appropriate means, i.e., loopback, serial interface or other, as determined by the person performing the test.

3.1.1 Binary Organization TE to NT

PURPOSE:
To verify that the TE presents the proper frame to the NT.

EQUIPMENT:
A Layer 1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

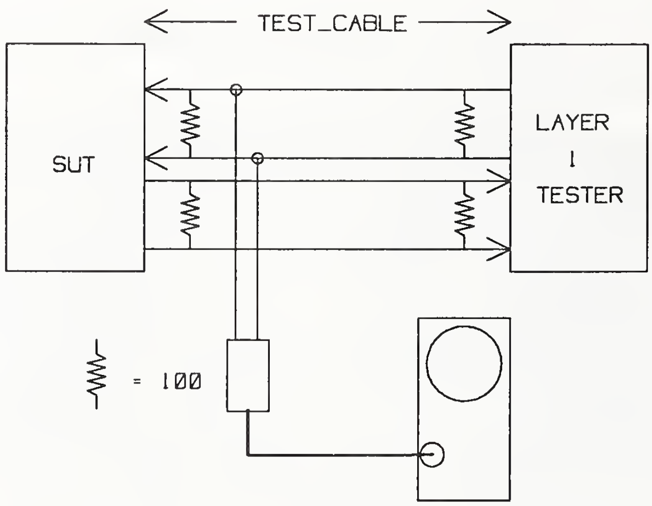


Figure 1

PROCEDURE:
To examine the bitwise organization of the frame, connect a Layer 1 Tester and a TE as the System Under Test (SUT) together with a 5 meter cable (See Figure 1). Configure the Layer 1 Tester as an NT and establish a layer 1 link between the two. After placing the SUT in loopback mode, set and reset each bit in turn in each of the outgoing frame data channels. Only one channel will be manipulated at a time. The other idled channels will transmit all 1's. Observing the TE's transmitted frame, verify that the looped data appears within the appropriate channel in accordance with the loopback function of the SUT, that the frames are properly balanced and that no extraneous data appears in the idled channels.

Proper polarity of the TE transmitted signal is checked by examining the transmitted signal at the connector of the SUT. Connect the balanced probes across pins 3 and 6 of the interface connector with the positive probe connected to pin 3. The framing pulse should be positive with respect to a transmitted 1 on the oscilloscope. Figures 23 and 24 of ANS T1.605 depicts the pin orientation.

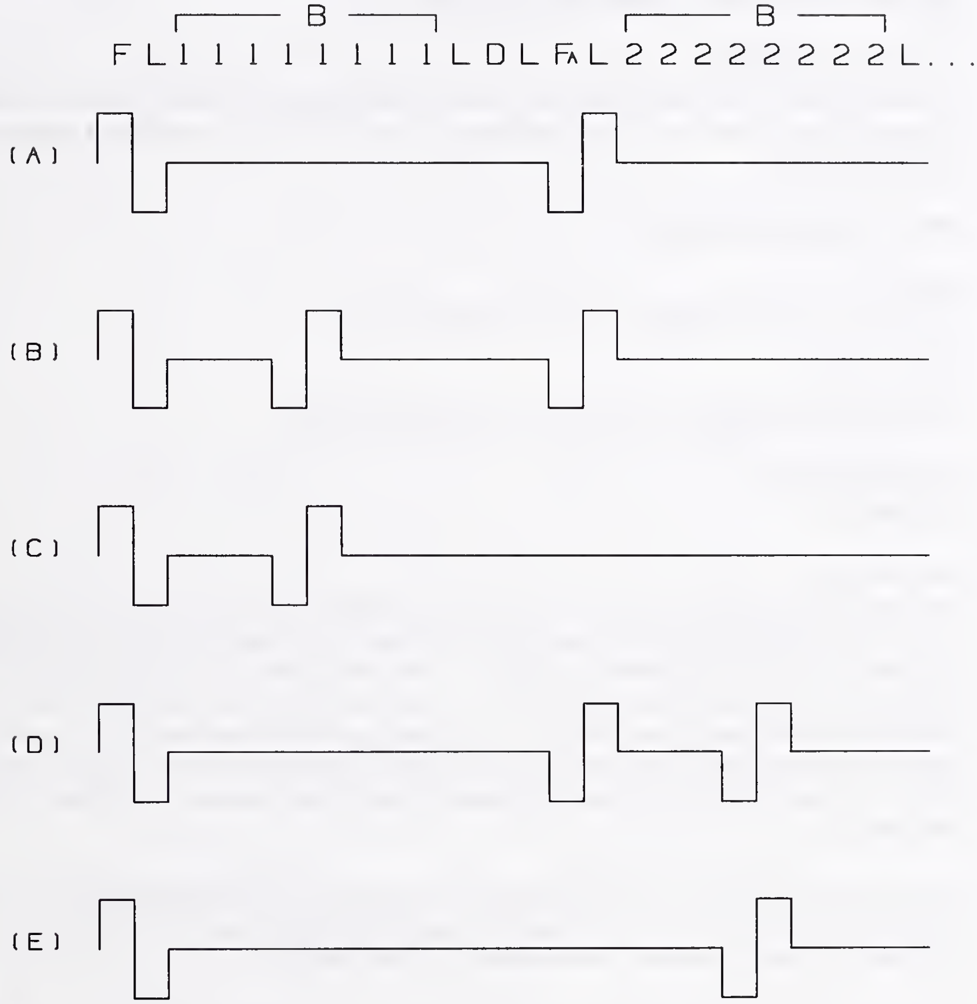


Figure 2

To check the code violations, perform the following actions with the TE in state F7. Transmit all 1's on the TE's data channels. Set the Layer-1 Tester so that the NT's Fa bit is a constant ZERO (no multiframe signalling). Inspect the outgoing frame from the TE for code violations as in Figure 2 (A). Set the TE so that "11100111" is transmitted in the first B1 octet.

The outgoing frame should resemble Figure 2 (B). Set the NT so that it provides "Q-Bit" identification. TE's that support multiframing should now be configured to transmit the IDLE code over the "Q" channel. When the "Q-Bit" is valid, the outgoing frame should look like Figure 2 (C). Set the TE so that the B1 channel is all 1's and that the first B2 octet contains "11100111".

When the "Q-Bit" is not valid the outgoing frame should resemble Figure 2 (D). When the "Q-Bit" is valid, the outgoing frame should look like Figure 2 (E).

PASS-FAIL CRITERIA:
To pass, all data must be correctly placed in the outgoing frame, the data must be correctly balanced, all code violations must be correctly implemented, and the "Q-Bit" must be in accordance with Table 5 of ANS T1.605.

3.1.2 Binary Organization NT to TE

PURPOSE:
To verify that the NT presents the proper frame to the TE.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:
See Figure 1.

PROCEDURE:
To examine the bitwise organization of the frame, connect a Layer-1 Tester and an NT as the System Under Test (SUT) together with a test cable (See Figure 1). Configure the Layer-1 Tester as a TE and establish a layer 1 link between the two. After placing the SUT in loopback mode, set and reset each bit in turn in each of the data channels. Only one channel will be manipulated at a time. The other idled channels will transmit all 1's. Observing the NT's transmitted frame, verify that the looped data appears within the appropriate channel in accordance with the loopback function of the SUT. The transmitted frame should be properly balanced, and no extraneous data should appear in the idled channels.

NT transmitted polarity is checked by connecting the balanced probes across pins 4 and 5 with the positive probe connected to pin 4. The framing pulse should be positive with respect to a transmitted 1. Figures 23 and 24 of ANS T1.605 depicts the pin orientation.

To check the code violations, perform the following actions with the NT in state G4. Transmit all 1's on the NT's data channels. Inspect the outgoing frame (NOTE: With multiframing disabled or during frames when the "Q-Bit" is not identified) from the NT for code violations as in Figure 3 (A). Set the NT so that "11100111" is transmitted in the first B1 octet. The outgoing frame should resemble Figure 3 (B).

The following tests will be done if the NT is to support multiframe signalling. Set the NT so that multiframe signalling is enabled. Next, set the NT so that "11100111" is transmitted in the first B1 octet. When the "Q-Bit" is valid, the outgoing frame should look like Figure 3 (C). Check that the Fa/N reversal ("Q-Bit" valid) occurs every fifth frame while multiframe is enabled. Set the NT so that the B1 channel is all 1's and that the first B2 octet contains "11100111".

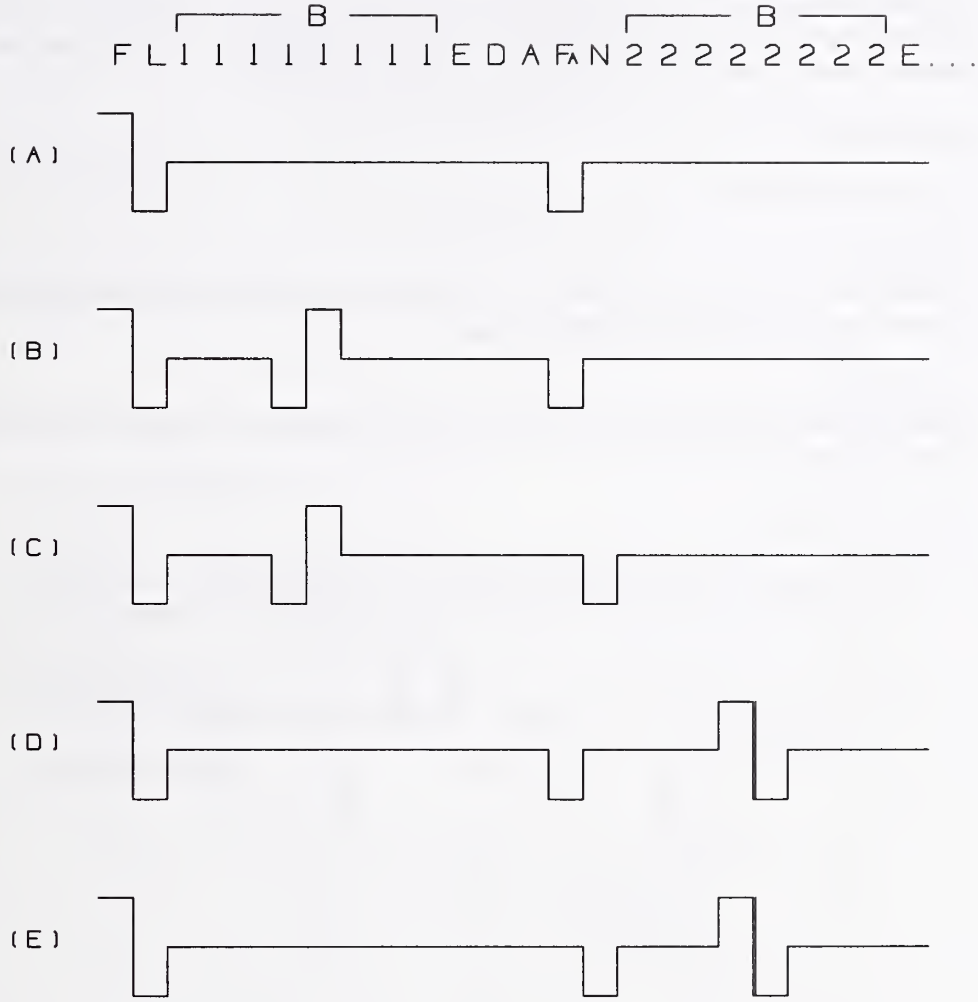


Figure 3

When the "Q-Bit" is not valid the outgoing frame should resemble Figure 3 (D). When the "Q-Bit" is valid, the outgoing frame should look like Figure 3 (E).To check that the NT properly echoes the D-Channel first set all the D-Bits to 1's in the TEs D-Channel. All the E-Bits should be 1's. Set the first of the TE's D-Bits to 0 and examine the next frame returned by the NT. The corresponding E-Bit should agree. Continue this procedure with the remaining three D-bits. For further testing of the echo channel see Section 5.6.2.1.

Have the tester transmit all 1's (INFO-1) and observe that the NT transmits a valid INFO-2 frame. The "A" bit, all "B-Channel" bits, "D", and "Echo" bits should be set to binary zeros. The "N" and "L" should be set according to normal coding rules.

PASS-FAIL CRITERIA:
To pass, all data must be correctly placed in the outgoing frame, the data must be correctly balanced, all code violations must be correctly implemented, and if required, the "Q-Bit" signal must operate as described above. The INFO-2 frame must be properly generated.

3.1.3 Line Bit Rates

3.1.3.1 Bit Rate of TE INFO-1

PURPOSE:
To verify that the TE can transmit the correct INFO-1 frame and that the free running clock of the TE generates the correct timing for INFO-1.

EQUIPMENT:
Electronic Counter referenced to a primary frequency standard, and a Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

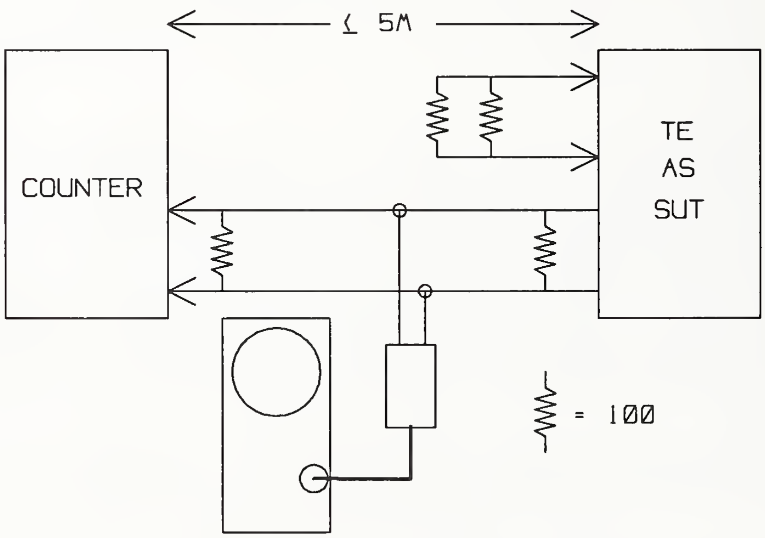


Figure 4

PROCEDURE:
For evaluation of INFO-1 frame, connect frequency meter, and SUT as shown in Figure 4. Set the frequency meter to assemble data over a 10 second (s) period (10 s Gate). The TE as the SUT is then given an activation request so that it transmits an INFO-1 frame, and the measurement is made.

PASS-FAIL CRITERIA:
The INFO-1 signal should have the appearance and timing as depicted in Figure 5. Limits on the period are 41.663 microseconds (μs) to 41.671 μs inclusive

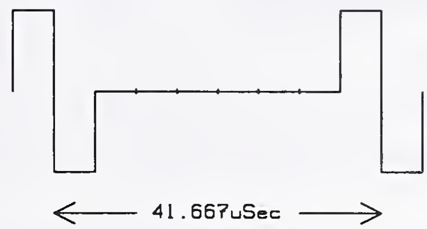


Figure 5

3.1.3.2 Bit Rate of NT INFO-4

PURPOSE:
ISDN requires that the TE be locked to the NT and derive all of its timing information from this NT. The following test will verify that the NT is generating its frames at the proper rate.

EQUIPMENT:
Electronic Counter referenced to a primary frequency standard, a Layer-1 Tester.

CONFIGURATION:

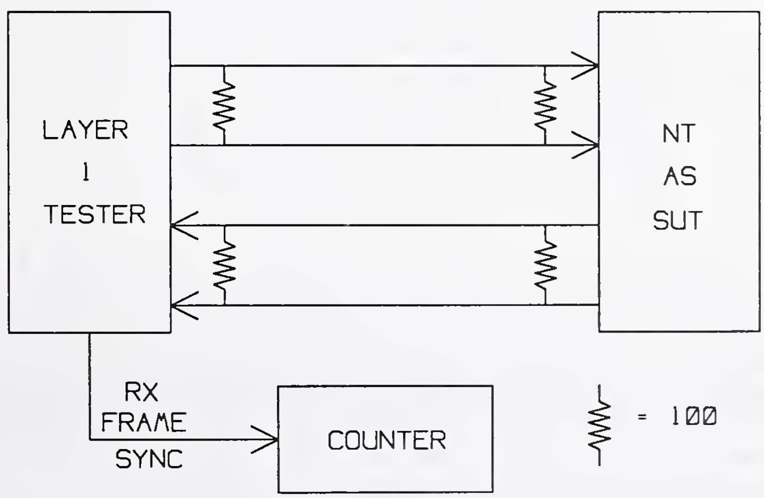


Figure 6

PROCEDURE:
Connect the equipment as shown in Figure 6. Insure that the NT is in free-running mode, i.e., not locked to system clock. After establishment of a layer-1 link, use the framing sync signal coming from the tester to establish the frame rate. Set the counter to gather data over a 10 s interval (10 s Gate). Measure the time between frame sync signals with the counter. The INFO-4 bit rate is the reciprocal of this count multiplied by 48.

PASS-FAIL CRITERIA:
Result must be between 191980 Bit/s and 192020 Bit/s inclusive.

3.2 B-Channel Bit Order

PURPOSE:
To verify that when using the B-Channel for PCM voice, the Most Significant Bit (MSB) Sign Bit is transmitted first.

EQUIPMENT:
A Layer-1 Tester, and a Tone Generator.

CONFIGURATION:

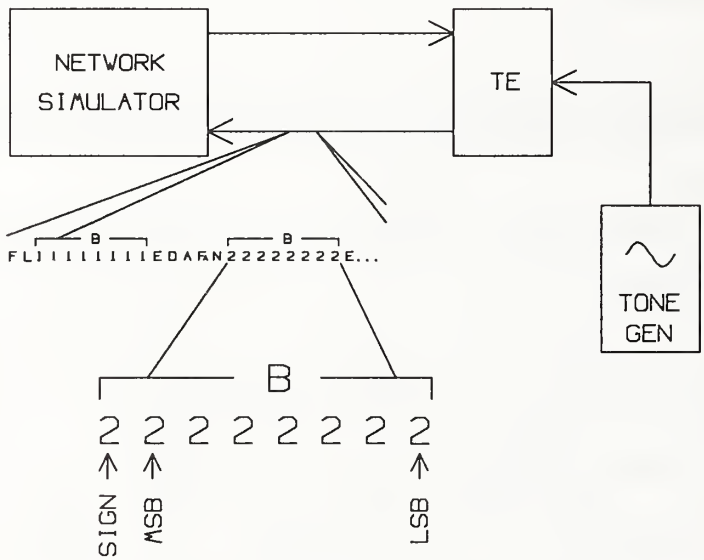


Figure 7

PROCEDURE:
Establish a call on a particular B-Channel. Obtain a bit pattern representation of both octets of the B-Channel selected. The pattern on the test equipment will change as you increase the amplitude of the tone encoded on the PCM path. Because the Mu-Law encoding is byte aligned, verification of bit order can be made by inspection of the octets in the test channel.

The sign bit is identified as the first bit transmitted in the selected B-Channel Octets. After identifying the sign bit, set the tone generator for the minimum signal it can deliver. Increase the amplitude of the tone generator until you detect activity on the B-Channel octets. A small amplitude will only affect the least significant positions in this octet. The most significant will remain idle at 1. As the voltage level of the tone generator is increased, you should see increased activity within the octet moving from right (LSB) to left (MSB).

PASS-FAIL CRITERIA:
The data must be properly encoded.

3.3 Relative Bit Positions

PURPOSE:
To determine if the TE properly implements the two bit offset between the incoming NT frame and the outgoing TE frame.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

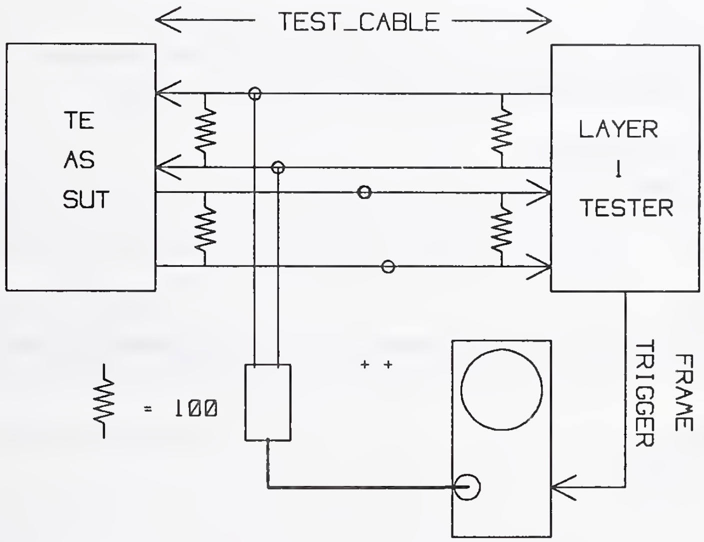


Figure 8

PROCEDURE:
Measurements are made at the terminals of the TE to eliminate the effects of cable delay. Jitter phase deviation on the transmitted TE signal are ignored during this test. These will be handled later. After the establishment of a layer-1 link, the oscilloscope is triggered on the NT frame. The F-L transition is captured on the digital oscilloscope. Next, the F-L transition of the TE is captured. The time between these two transitions (as they pass through zero volts) is the relative bit position.

PASS-FAIL CRITERIA:
Result must be between 10.06 µs and 11.20 µs inclusive.

4 INTERFACE PROCEDURE TESTS

4.1 D Channel Access Control

4.1.1 Interframe Fill

4.1.1.1 TE-to-NT

PURPOSE:
To examine the interframe fill character within an ISDN frame and insure that is as specified in ANS T1.605.

EQUIPMENT:
A Layer-1 Tester.

CONFIGURATION:
Same as Figure 8. The probes will be connected to the TE's transmitter output (Pin 3 and 6).

PROCEDURE:
Establish a layer-1 communications link between the tester and the SUT. With no D-Channel message queued in the SUT, examine the D-bits of the transmitted frame.

PASS-FAIL CRITERIA:
Only 1's should be transmitted.

4.1.1.2 NT-to-TE

PURPOSE:
To examine the interframe fill character within an ISDN frame and insure that is as specified in ANS 605.

EQUIPMENT:
A Layer-1 Tester.

CONFIGURATION:

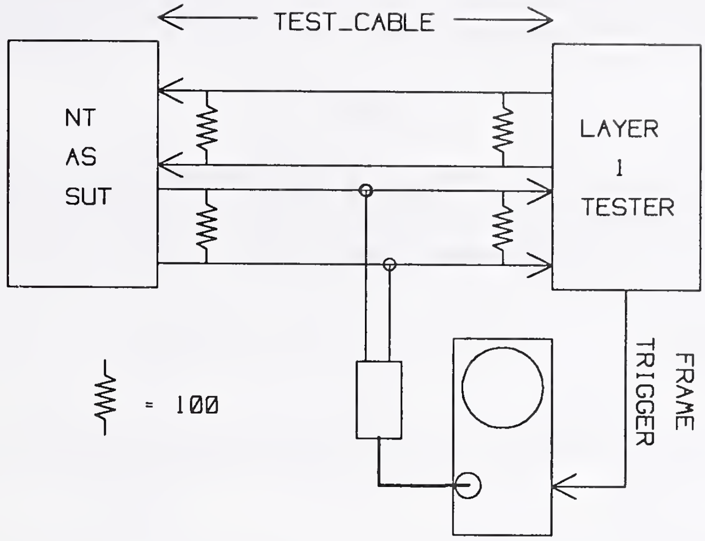


Figure 9

PROCEDURE:
Establish a layer-1 communications link between the tester and the SUT. With no D-Channel message queued in the SUT, examine the D-bits of the transmitted frame.

PASS-FAIL CRITERIA:
The interframe fill may be either all 1's or repetitions of the octet "01111110". This octet may start in any of the D-bit positions.

4.1.2 D-Channel Echo Response

4.1.2.1 Collision Recovery

PURPOSE:
To verify that collisions on the D-Channel are handled in the manner prescribed in ANS T1.605.

EQUIPMENT:
A Layer-1 Tester.

CONFIGURATION:
Connected as shown in Figure 1. The oscilloscope, optional for this test, is to verify activity on the line.

PROCEDURE:
Establish a layer-1 communications link between the SUT (as TE) and the tester (as NT). Program the tester to trigger on an incoming message from the TE SUT. A D-Channel message is queued and transmitted on the TE. On receiving a programmed number of D-bits (generally between 0 and 10 after detecting a starting flag on the D channel) the tester inverts (continuously) the echo bits to simulate a D channel collision. The tester then records the incoming D channel activity after the collision. Run this test triggering on an odd number of D-bits and again with an even number.

PASS-FAIL CRITERIA:
All 1's should be on the D-Channel immediately following inversion of the E-Bits. Proper operation of the SUT after the E-Bits are no longer inverted is tested in Section 4.1.2.2 below.

4.1.2.2 Priority

PURPOSE:
On release of the D-Channel by another device on the passive bus, the SUT should seize the free channel and properly transmit a message in accordance with ANS T1.605. This test should be performed on all supported message classes.

EQUIPMENT:
A Layer-1 Tester.

CONFIGURATION:
Connected as shown in Figure 1. The oscilloscope, optional for this test, is to verify activity on the line.

PROCEDURE:
Establish a layer-1 communications link between the tester and the SUT. Set the tester to either echo the inverted incoming D channel data or place all 0's in the E channel. From the SUT's point of view, this simulates some other device having control of the D-Channel. Manipulate the SUT so that it queues one or more D-Channel messages for transmission (i.e., Go off hook). The SUT should recognize that it does not have control of the channel and respond accordingly. At the command to start the priority test, the tester correctly echoes the incoming D channel thus freeing the D-Channel. The tester now totals the number of 1's in the D-Channel coming from the TE until a 0 (the leading bit in the LAPD flag) is received. This total is reported as the priority.

The tester now monitors the SUT's transmitted packet, scanning for the closing LAPD flag. After the occurrence of the SUT's closing flag, the tester waits for 9 idle ones to be transmitted by the SUT at which time the tester simulates a busy D-Channel again. The tester keeps the D-Channel busy long enough for another LAPD message to be queued (at least 1 second). After the 1 second timeout, presumably the SUT has the second message queued up for transmission, the tester frees the D-Channel. Again the tester totals the number of 1's in the D channel transmitted by the TE until a zero is received. This total will be reported as the "Trailing Count." The trailing count will be halted at the receipt of a zero, signaling the start of the second message, or the count of 11, which ever is less.

PASS-FAIL CRITERIA:
With the D-Channel busy and also with the 9 idle ones after the cessation of the first message, the SUT should not allow a message to be transmitted. On release of the channel by the tester, the proper priority should measured. The priority may be inferred by the class of the received message. The trailing count shall be no less than one plus the priority of the subsequent message.

4.2 Activation-Deactivation

4.2.1 TE

PURPOSE:
To check that the terminal correctly executes the activation/deactivation procedures.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

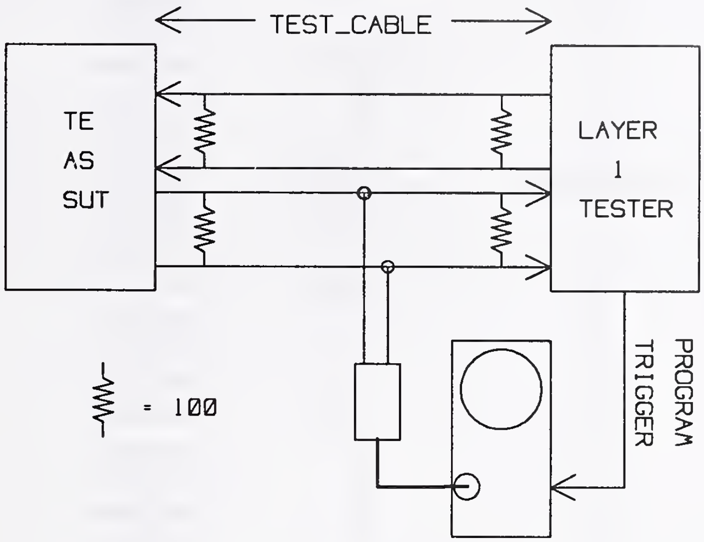


Figure 10

PROCEDURE:
<u>Stimulus:</u>
Three different types of stimuli will be used. They are

1) Power supply connected and disconnected,
2) Info signals applied from Network Simulator,
3) An activation request initiated by the SUT.

<u>Test Cases:</u>
The following set of test cases may be used for all three types of terminals as represented in Tables 3, E1 & E2 of ANS T1.605 (see Tables 4.2.1.2, 4.2.1.3 and 4.2.1.4). The differences in the three tables are in the power related rows. For abstract test case purposes you may treat them as equivalent (see Table 4.2.1.1). The following terms need definition.

"PH-AR"	This represents send of the PH-Activation Request primitive or any equivalent action by the SUT.
"T3 Expires"	This represents the expiration of the SUT's T3 timer. This timer is only specified as not to exceed 30 s.
IX	A specific pattern used to represent the "any signal" condition. Info X is a 0+,0-, and 46 1's.
IY	A specific pattern used to represent a frame loss condition. It is an Info-4 with a single code violation.
Power Supply	This is used to represent whatever power source is in effect at the time (Local, SRC1 or SRC2).

Test Case	Initial State	Stimulus	Trigger Timing	Results	Comment
1.	F3	"PH-AR"	immediate	I1	
2.	F3	I2	immediate	I3	
3.	F3	I4	immediate	I3	
*4.	F4	"T3 Expires"	immediate	I0 or I1	Note 1
*5.	F4	IX	immediate	I0	
*6.	F4	I2	wait 5 ms	I0 or I3	Note 2
*7.	F4	I4	wait 5 ms	I0 or I3	Note 2
*8.	F5(via IX)	"T3 Expires"	immediate	I0	Note 3,4
*9.	F5	I2	≥ 100 ms	I3	
*10.	F5	I4	≥ 100 ms	I3	
*11.	F6	"T3 Expires"	immediate	I0 or I3	Note 4,7
12.	F6	I0	immediate	I0	
13.	F6	I4	immediate	I3	Note 3
14.	F6	IY	immediate	I0	
15.	F7	I0	immediate	I0	Note 5
16.	F7	I2	immediate	I3	
17.	F7	IY	immediate	I0	Note 5
18.	F8	I2	immediate	I3	Note 6
19.	F8	I4	immediate	I3	
20.	F4	Disconnect Power Supply	immediate	I0	
21.	F6	Disconnect Power Supply	immediate	I0	
22.	F7	Disconnect Power Supply	immediate	I0	Note 5

* Not applicable if TE cannot initiate activation.

Notes:

1. The state F4 is always entered from F3 by a SUT initiated activation request ("PH-AR"). The standard specifies that the TE timer must be started upon receipt of the "PH-AR." The network simulator, seeing an I1 signal, will know the SUT is in state F4. NOTE: there is the possibility of an instantaneous F3 to F4 transition due to internal PH-Act requests after expiration of TE timer.
2. A terminal that is capable of recognizing an I2 or an I4 within 5 ms may transition to F6 or F7 (transmitting an I3). All others must go to F5 (transmitting an I0).
3. Because this state transition does not result in a change of Info signal, the only thing this test case can do is verify no signal change occurs.
4. The only way to get the T3 timer started is to start out in F3 with a "PH-AR" or equivalent.
5. There is no external way to distinguish F6 from F7 so this test case could be seen as a duplicate of the F6 test case. If your procedure to enter state F6 includes transitions from F4 via I2 and then I4, then this could be used to verify nothing bad happened.
6. State F8 transmits an I0. This setup procedure should be via F6 or F7 so as to insure you are in the correct state.
7. There is the possibility of an instantaneous F3 to F6 transition due to internal PH-Act requests after expiration of TE timer

PASS-FAIL CRITERIA:
Must successfully perform all appropriate transitions.

Table 4.2.1.1. Generic State Table for all TEs

STATE	Inactive	Sensin	Deactive	Awaiting_ID_signal_Sync			Active	Loss_Frame
EVENT	I0	I0	I0	I1	I0	I3	I3	I0
Main Pwr on*	NA	-	-	-	-	-	-	-
Loss of Main Pwr	-	NA	NA	20	NA	21	22	NA
Loss of Pwr SRC1 or 2**	-	NA	NA	20	NA	21	22	NA
PH-ACT Req.	/	I	1	I	I	-	I	-
T3 Expires	/	/	-	4	8	11	-	-
Receive I0	/	NA	-	-	-	12	15	NA
Receive Any	/	-	-	5	-	/	/	-
Receive I2	/	NA	2	6	9	-	16	18
Receive I4	/	NA	3	7	10	13	-	19
Loss Frame	/	/	/	/	/	14	17	-

* - Main power could be local power or power source 1 or 2.
** - The ability to detect a loss of power source 1 or 2 is an option.

LEGEND:
- \- No change. No action.
- I Impossible by definition.
- / Impossible by situation.
- NA Not testable via external observation.
- \# Test case number in the attached test suite.

Table 4.2.1.2. TE with Power Source 1 or 2 (Table 3 in T1.605)

STATE	Inactive	Sensing	Deactive	Awaiting_ID_signal_Sync			Active	Loss_Fra
EVENT	F1 I0	F2 I0	F3 I0	F4 I1	F5 I0	F6 I3	F7 I3	F8 I0
Pwr On .. Detect SRC1 or SRC2	NA	-	-	-	-	-	-	-
Loss of Pwr	-	NA	NA	20	NA	21	22	NA
No SRC1 or 2	-	NA	NA	20	NA	21	22	NA
PH-ACT Req.	/	I	1	I	I	-	I	-
T3 Expires	/	/	-	4	8	11	-	-
Receive I0	/	NA	-	-	-	12	15	NA
Receive Any	/	-	-	5	-	/	/	-
Receive I2	/	NA	2	6	9	-	16	18
Receive I4	/	NA	3	6	10	13	-	19
Loss Frame	/	/	/	/	/	14	17	-

LEGEND:

-	No change. No action.
I	Impossible by definition.
/	Impossible by situation.
NA	Not testable via external observation.
#	Test case number in the attached test suite.

Table 4.2.1.3. TE with Local Power & Unable to Detect Power Source 1 or 2 (Table E1 in T1.605)

STATE	Inactive	Sensing	Deactive	Awaiting_ID_signal_Sync			Active	Loss_Frame
EVENT	F1 I0	F2 I0	F3 I0	F4 I1	F5 I0	F6 I3	F7 I3	F8 I0
Loss of Local Power	/	NA	NA	20	NA	21	22	NA
Appearance of Local Power	NA	/	/	/	/	/	/	/
PH-ACT Req.	/	I	1	I	I	-	I	-
T3 Expires	/	/	-	4	8	11	-	-
Receive I0	/	NA	-	-	-	12	15	NA
Receive Any	/	-	-	5	-	/	/	-
Receive I2	/	NA	2	6	9	-	16	18
Receive I4	/	NA	3	7	10	13	-	19
Loss Frame	/	/	/	/	/	14	17	-

LEGEND:

- \- No change. No action.
- I Impossible by definition.
- / Impossible by situation.
- NA Not testable via external observation.
- \# Test case number in the attached test suite.

Table 4.2.1.4. TE with Local Power and Able to Detect Power Source 1 or 2 (Table E2 in T1.605)

STATE	Inactive		Sensing	Deactive	Awaiting_ID_signal_Sync			Active	Loss_Fra
EVENT	F1 I0		F2 I0	F3 I0	F4 I1	F5 I0	F6 I3	F7 I3	F8 I0
	F1.0	F1.1							
Loss of Local Pwr	NA	NA	NA	NA	20	NA	21	22	NA
Appearance of Local Pwr	NA	/	/	/	/	/	/	/	/
Detection of Pwr SRC1 or 2	/	NA	/	/	/	/	/	/	/
No SRC1 or 2	/	/	NA	NA	20	NA	21	22	NA
PH-ACT Req.	/	/	I	1	I	I	-	I	-
T3 Expires	/	/	/	-	4	8	11	-	-
Receive I0	/	/	NA	-	-	-	12	15	NA
Receive Any	/	/	-	-	5	-	/	/	-
Receive I2	/	/	NA	2	6	9	-	16	18
Receive I4	/	/	NA	3	7	10	13	-	19
Loss Frame	/	/	/	/	/	/	14	17	-

LEGEND:

- \- No change. No action.
- I Impossible by definition.
- / Impossible by situation.
- NA Not testable via external observation.
- \# Test case number in the attached test suite.

4.2.2 NT

PURPOSE:
To check that the Network Termination device correctly executes the activation/deactivation procedures.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

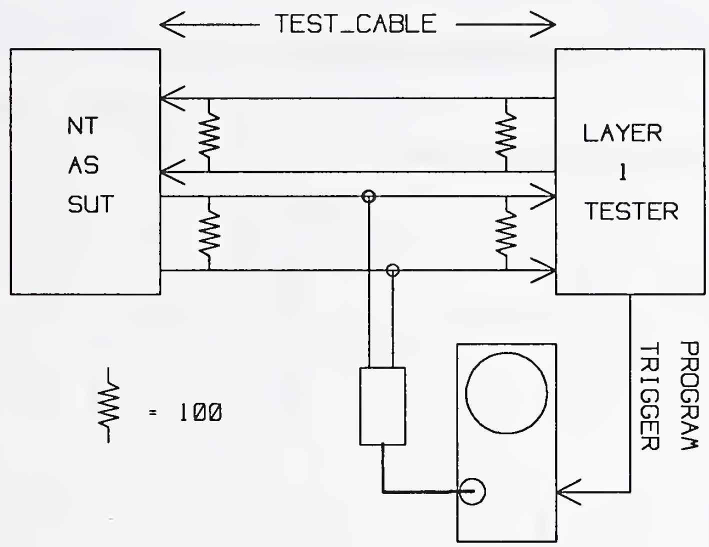


Figure 11

PROCEDURE:
Stimulus:
Two different types of stimuli will be used. They are:
1) Info signals applied from Terminal Simulator,
2) An activation request initiated by the SUT.

Test Cases:
See Table 4.2.2.1.

Test Case	Initial State	Stimulus	Trigger Timing	Results	Comment
*1.	G1	"PH-AR"	immediate	I2	
*2.	G1	I1	≤ 1 s	I2	Note 1
*3.	G2	"MPH-DR"	immediate	I0	
*4.	G2	"T1 Expires"	immediate	I0	
5.	G2	I1	immediate	I2	
6.	G2	I3	≤ 500 ms	I4	Note 2
*7.	G3	"MPH-DR"	immediate	I0	
8.	G3	I0	≤ 25 ms	I2	
9.	G3	IY	≤ 25 ms	I2	
*10.	G4	"PH-AR"	immediate	I2	

* Not applicable if NT is "active always"

Note 1: Delays "Da", as long as 30 seconds are acceptable under abnormal (nonfault) conditions i.e., when retraining.

Note 2: Delays "Db", as long as 15 seconds are acceptable under abnormal (nonfault) conditions provided that the sum of delays "Da" and "Db" is not greater than 30 seconds.

PASS-FAIL CRITERIA:
Must successfully perform all appropriate transitions.

Table 4.2.2.1. NT Activation Procedures (Table 4 in T1.605)

STATE / EVENT	Deactivated G1 I0	Pending_Act G2 I2	Active G3 I4	Pending_Deact G4 I0
PH-ACT Req.	1	-	I	10
MPH-Deact Req.	I	3	7	I
T1 Expires	-	4	/	-
Receive I0	-	-	8	NA
Receive I1	2	5	/	-
Receive I3	/	6	-	-
Loss Frame	/	/	9	-

LEGEND:
- No change. No action.
I Impossible by definition.
/ Impossible by situation.
NA Not testable via external observation.
\# Test case number in the attached test suite.

4.3 Frame Alignment Procedures

4.3.1 TE Alignment

PURPOSE:
To verify the proper dynamic performance of the TE when presented with improper frames.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

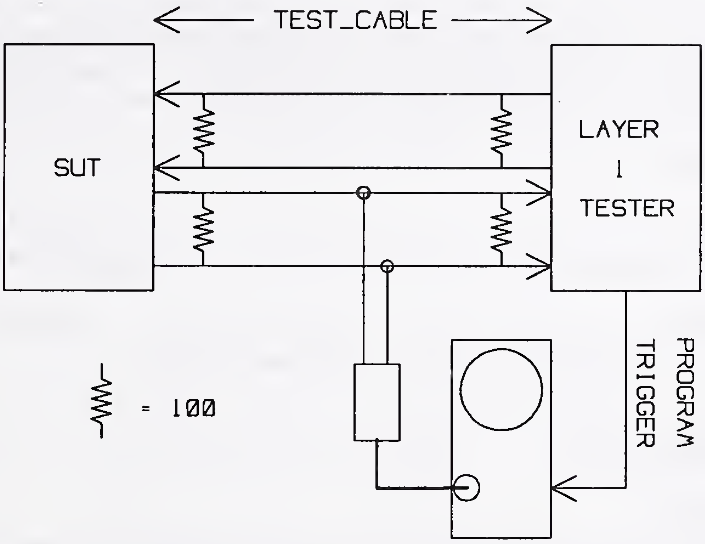


Figure 12

PROCEDURE:
The tester is configured to be an NT and is connected to the SUT as shown above. The operator initiates a layer-1 connection between the tester and the SUT. After normal establishment of the communications link, two complete frames are built in the tester's memory, FRAME1 and FRAME2. The operator specifies how many times each of these frames will be transmitted. The tester will then transmit FRAME1 the programmed number of times, i.e., FRAME1(n1), then transmit FRAME2 its programmed number of times, FRAME2(n2), and then loop back to the beginning to continue the process again.

For TE Frame Alignment testing, FRAME1 contains a standard ISDN INFO-4 frame with 1's in the B channels and D channel. FRAME2 is INFO-4 frame that violates the 14 bit criterion, At the start of FRAME2 transmission (FRAME1 in the case of Test_3), the oscilloscope is triggered to record the results.

This test is run three times with the following parameters:

Test_1:	FRAME1(50),	FRAME2(1);
Test_2:	FRAME1(50+M),	FRAME2(N+3);
Test_3:	FRAME2(50+N),	FRAME1(M+3).

PASS-FAIL CRITERIA:
If the SUT transitions to F8 when subjected to Test_1, the SUT fails. If the SUT does not transition to F8 between FRAME2(N) and FRAME2(N+1) in Test_2, the SUT fails. If the SUT does not transition to F7 between FRAME1(M) and FRAME1(M+1) in Test_3, the SUT fails.

NOTE: "N" is the number of frames violating the 14 bit criterion which causes the SUT to determine that Loss of Sync has occurred. "M" is the number of frames obeying the 14 bit criterion which causes the SUT to determine that Sync has been regained. The supplier will provide both "M" and "N" before the test. "N" must equal or exceed two. "M" must equal or exceed three.

4.3.2 NT Alignment

PURPOSE:
To verify the proper dynamic performance of the NT when presented with improper frames.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:
Same as above in 4.3.1.

PROCEDURE:
The tester is configured to be a TE and is connected to the SUT as shown above. The operator initiates a layer-1 connection between the tester and the SUT. After normal establishment of the communications link, two complete frames are built in the tester's memory, FRAME1 and FRAME2. The operator specifies how many times each of these frames will be transmitted. The tester will then transmit FRAME1 the programmed number of times, i.e., FRAME1(n1), then transmit FRAME2 its programmed number of times, FRAME2(n2), and then loop back to the beginning to continue the process again.

For NT Frame Alignment testing, FRAME1 contains a standard ISDN INFO-3 frame with 1's in the B channels and D channel. FRAME2 is an INFO-3 frame that violates the 13 bit criterion. At the start of FRAME2 transmission (FRAME1 in the case of Test_3), the oscilloscope is triggered to record the results.

This test is run three times with the following parameters:

Test_1:	FRAME1(50),	FRAME2(1);
Test_2:	FRAME1(50),	FRAME2(2);
Test_3:	FRAME1(50+M),	FRAME2(N+3);
Test_3:	FRAME2(50+N),	FRAME1(M+3).

PASS-FAIL CRITERIA:
If the SUT transitions to G2 when subjected to Test_1, the SUT fails. A G2 transition in Test_2 in an NT supporting multiframe is a failure. If the SUT ceases transmission of Info-2 before four FRAME1 frames in Test_3, the SUT fails.

If the SUT does not transition to G2 between FRAME2(N) and FRAME2(N+1) in Test_3, the SUT fails. If the SUT does not transition to G4 between FRAME1(M) and FRAME1(M+1) in Test_4, the SUT fails.

NOTE:
"N" is the number of frames violating the 14 bit criterion which causes the SUT to determine that Loss of Sync has occurred. "M" is the number of frames obeying the 14 bit criterion which causes the SUT to determine that Sync has been regained. The supplier will provide both "M" and "N" before the test.

4.4 Multiframing Procedures

4.4.1 Q Channel Messaging

PURPOSE:
To verify the proper implementation of the Q channel in TEs that support this optional capability

EQUIPMENT:
System Under Test (TE)
Layer 1 Tester

CONFIGURATION:

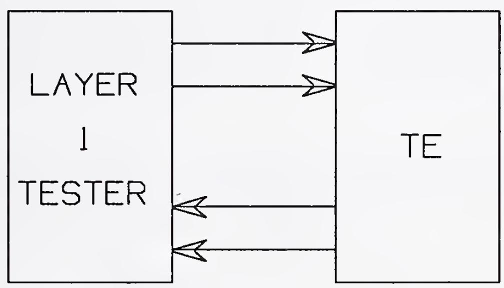


Figure 13

PROCEDURE:
The System Under Test (SUT) must be connected to the Layer 1 Tester. For this case, the Layer 1 tester must simulate an NT1 and must be capable of identifying, reading and displaying Q-channel messages as they are received. Testing should proceed as outlined below.

1. Connect the SUT to the Layer 1 Tester (NT1 Simulation mode) and establish layer 1 communications. The tester should receive continuous IDLE messages.

2. While the layer 1 tester is receiving the IDLE code, initiate a B1 loopback. The layer 1 tester should be receiving continuous LB1 Request messages from the SUT. Release the loopback. The tester should now be receiving IDLE messages from the SUT. Establish a B2 channel connection and

request a loopback. The tester should now be receiving continuous LB2 requests. Release the loopback. The tester should now receive the IDLE code.

3. Initiate an LB1/2 Request. The Layer 1 tester should be receiving continuous LB1/2 messages from the SUT. From the SUT, send an LB2 Request. The Layer 1 tester should now receive continuous LB2 Request messages. This should be repeated for the LB1 Request.

4. Establish a B1 channel loopback. Request a self test of the NT1. The tester should indicate the cessation of LB1 Request messages and detect receipt of at least six valid ST Request messages.

5. While receiving the Idle message from the SUT, disconnect power to the SUT. The Layer 1 tester should detect at least one but no more than three LP messages. Step 5 should be repeated ten times and the tester should receive at least one LP message in each case.

6. Step 5 should be repeated several times with the SUT transmitting the LB1 Request message.

7. Repeat step 1-6 with the Layer 1 tester transmitting LRS.

4.4.2 S Channel Messaging

PURPOSE:
To verify the proper implementation of the S Channel in NT1s that support this optional capability.

EQUIPMENT:
System Under Test (NT1)
Layer 1 Tester
Bit Error Rate Tester

CONFIGURATION:

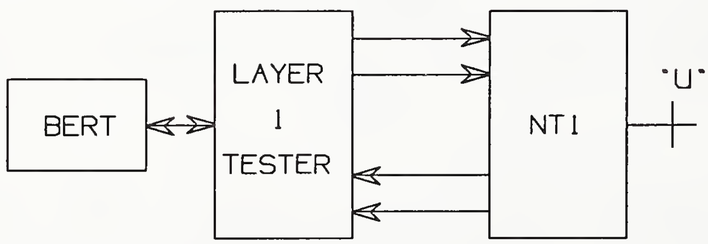


Figure 14

PROCEDURE:
The ability to test certain NT1 S Channel messages requires a synchronized U-Interface signal to be present at the network side of the NT1. IDLE messages will only be transmitted while the network signal is present and DTSE-IN, DTSE-OUT, and DTSE-IN&OUT can only be tested if the tester has the ability to corrupt the CRC and control the febe bit received by the NT1.

1. The Layer 1 tester should be connected to the SUT under test and layer 1 communications established.

2. If a U-Interface signal is present, the layer one tester should receive continuous IDLE messages. If it is not, the tester should receive continuous LRS messages.

3. The tester should generate continuous LB1 Request messages. The SUT should establish a B1 channel loopback and respond with continuous LB1I messages. The BERT should be used to verify that a B1 loopback is present. Cease sending the LB1 message. The SUT should drop the loopback and resume sending the Idle message (or the LRS message if U-I/F signal is absent). Repeat step 3 for B2 loopbacks and B1/B2 loopbacks.

4. The tester should generate a continuous pattern of two LB1 Request messages followed by an Idle message. The SUT should not respond and continue to send Idle messages in return.

5. DTSE-IN & OUT can only be tested if the U-Interface exists as outlined above. IF this capability does not exist, proceed to step 6. Connect a U-Interface signal to the SUT allow time for synchronization. The SUT should now be sending an Idle message. Corrupt the CRC on the U-interface in one superframe. The Layer 1 tester should receive one DTSE-IN message from the SUT. Set the febe=0 in one superframe. The Layer 1 tester should receive one DTSE-OUT message from the SUT. Both corrupt the CRC and set the febe=0 in one superframe. The Layer 1 tester should receive one DTSE-IN&OUT message from the SUT.

6. The tester should generate a series of two consecutive ST Request messages followed by an Idle message. The SUT should not react and should continue to send Idle messages. The tester should then generate a series of six consecutive ST Request messages. The SUT should initiate a self test, transmit STI messages for the duration of the test and provide at least six consecutive STP or STF messages at the conclusion of the test.

7. Disconnect power from the SUT. The layer one tester should receive at least one valid LP message. Repeat this step ten times to ensure consistent receipt of at least one LP message. Repeat this step while the SUT is in a loopback condition.

5 BASIC ELECTRICAL CHARACTERISTICS

5.1 Jitter and Phase

NOTE_1:
The test configuration as specified in ANS T1.605 Section 9.2.2 requires the following connections:

1) Point to point with 6 dB attenuation at 96 kHz,
2) Short Passive Bus with 8 Terminals clustered far,
3) Short Passive with SUT near NT and 7 other clustered at far end,
4) Ideal test (back to back).

All of the tests in the following sections are run with these configurations. Setup methods for these configurations are covered in Appendix H of ANS T1.605 and are schematically indicated in the configuration figures by a CONFIG box.

NOTE_2:
The tests outlined below in Section 5.1.1 and 5.1.2 incorporate a simplified test setup. This results in a slightly more restrictive implementation of the tests as defined in Section 9.2.1 and 9.2.3 of ANS T1.605.

NOTE_3:
The tests in Sections 5.1.1 and 5.1.2 require that specific data patterns be presented to the SUT. Each of the physical configurations in NOTE_1 will be tested with the following data:

1) A continuous sequence of frames with 1's in both B-Channels and the D-Channel,
2) A repetitive sequence, at least 10 seconds in duration, of 40 continuous FRAME_1's followed by 40 continuous FRAME_2's.

   FRAME_1: Made up of "10101010" in all of the B-Octets and 1's in the D-Channel.
   FRAME_2: Made up of all binary zeros in the B1, B2 and D channels.

3) Pseudorandom pattern of a length 2^{19}-1 in the B1, B2 and D channels.

5.1.1 TE Timing Extraction Jitter

PURPOSE:
To measure the jitter on the output signal of the TE referenced to the NT clock.

EQUIPMENT:
Obviously this measurement could be easily made with a test instrument specifically designed to test ISDN jitter. If one is not available, conformity can be established using the equipment and procedures listed here.

A Layer-1 Tester, Digital Oscilloscope with Balanced Probes, a Jitter Generator, and Signal Generator.

CONFIGURATION:

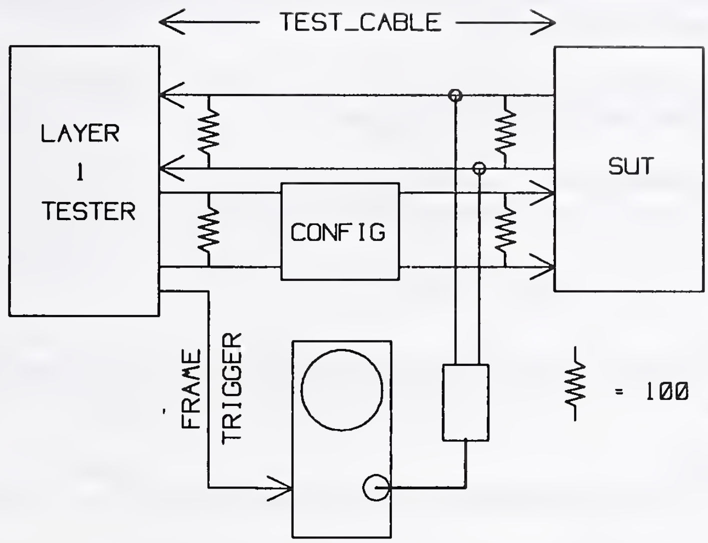


Figure 15

PROCEDURE:
After connecting the equipment as shown in Figure 15, establish a layer-1 connection between the SUT and the tester. Since the oscilloscope is triggered by the NT, i.e., the jitter reference for the system, the TE jitter can be directly read on the digital oscilloscope using the procedure detailed below. This procedure approximates the effect of the 30 Hz high pass filter mentioned in ANS T1.605.

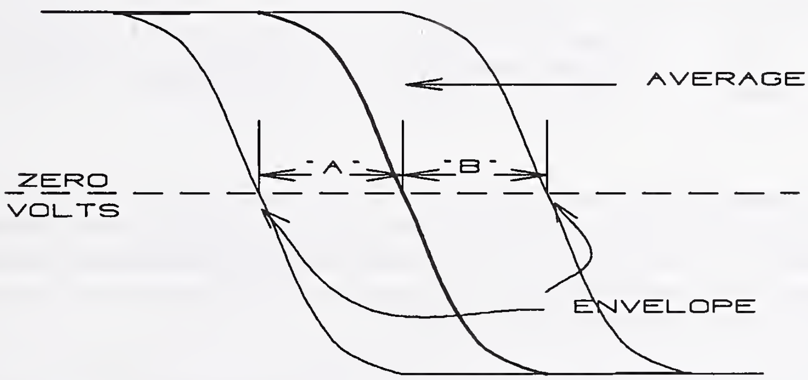


Figure 16

Center the F-Bit to L-Bit transition transmitted by the TE-SUT upon the digital oscilloscope display and make a 5 second average of this transition. Store this waveform for use in evaluating the jitter information to be taken next. The jitter information is obtained by creating an envelope of 128 consecutive TE F to L transitions. The jitter information is considered valid when the 5 second average bisects the envelope at the zero volt point, i.e., time "A" and time "B" in Figure 16 are within 20 nanoseconds (ns) of each other.

This measurement is to be made with a timing sensitivity to insure an accuracy of ±4 ns. On most digital oscilloscopes this is around 500 ns/cm.

PASS-FAIL CRITERIA:
The width of the envelope at the zero volt level must be less than 730 ns (± 7%).

5.1.2 Total Phase Deviation, Input to Output

PURPOSE:
To insure that the phase characteristics of the SUT are such that will allow proper operation on a passive bus.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes, a Jitter Generator, and Signal Generator.

CONFIGURATION:
See Figure 15.

PROCEDURE:
Using the configurations and data patterns as mentioned in 5.1, perform this test over the following matrix of conditions:

Table 5.1.2.1. Matrix of Conditions

Jitter	Freq	191981	192000	192020
50 Hz	(5%)	TEST_1	TEST_2	TEST_3
2000 Hz	(5%)	TEST_4	TEST_5	TEST_6

After making a layer-1 connection between the tester as NT and the SUT as the TE, locate the F to L transition on the NT frame. Where this transition crosses zero volts is the reference for subsequent measurements. Next locate the F to L transition of the TE frame immediately following the reference transition. Measure the time from the reference zero crossing to the zero crossing of this transition. This time will be referred to as the OFFSET.

Timing accuracy should be on the order of ±10 ns (Roughly equivalent to a digital scope set to 2 μs/cm).

PASS-FAIL CRITERIA:
The OFFSET plus "B" time from 5.1.1 must not exceed 11.20 μs. The OFFSET minus "A" time from 5.1.1 must not be less than 10.05 μs.

5.1.3 NT Jitter Characteristics

PURPOSE:
To test that the NT's Jitter Characteristics are in accordance with ANS T1.605 Section 9.3.

EQUIPMENT:
This measurement is best made with a test instrument specifically designed to test ISDN jitter.

CONFIGURATION:
As required by the test equipment.

PROCEDURE:
Establish a Layer-1 connection. Place all zeros in the B and D channels. In accordance with the test equipment manufacturers instructions, measure the jitter.

PASS-FAIL CRITERIA:
Peak-to-Peak Jitter at the following frequencies should be no greater than the amount shown.

5 Hz	50% of an ISDN bit
17 Hz	25% "
50 Hz	5% "
2000 Hz	5% "

5.2 Transmitter Output Impedance

5.2.1 Transmitting Zeros (Unterminated)

PURPOSE:
To insure that the output impedance has a significantly high lower bound for proper operation on the passive bus.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

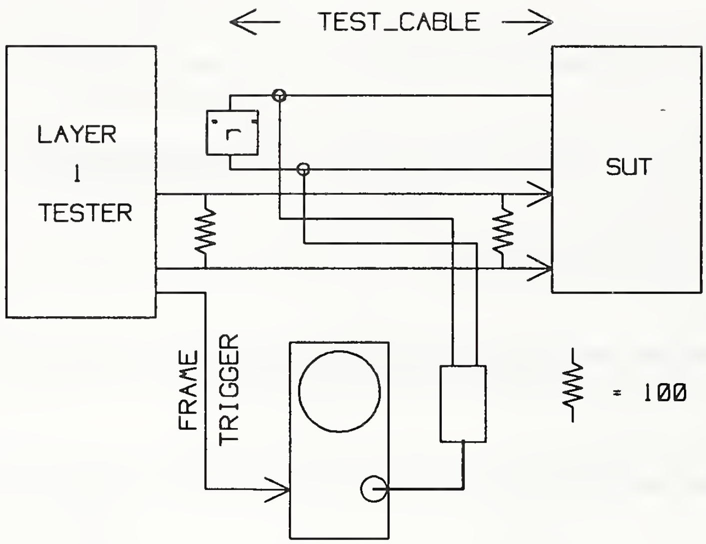


Figure 17

PROCEDURE:
Arrange the equipment as shown in Figure 14 and establish the link. Put the SUT into loop back mode and adjust the outgoing frame so that the first ten bits of the incoming frame are "0011011011...". All impedance measurements are taken using the expanded oscilloscope image of the fifth and eighth zero in this frame. The following readings must be taken with a voltage accuracy of at least ± 1 mV (10 bit accuracy).

First measure the output impedance in the vicinity of 50 Ω. Record the amplitude of the voltage across "r" with r=55 Ω as VHi. Change "r" to 45 Ω and recorded the voltage across "r" as VLow. The output impedance is then calculated by the formula

$$Z_0 = ((45*55)*(VHi-VLow))/(55*VLow-45*VHi).$$

Next measure the output impedance in the vicinity of 400 Ω. VHi is measured when "r" is 440 Ω. VLow is measured when "r" is 360 Ω.

$$Z_0 = ((360*440)*(VHi-VLow))/(440*VLow-360*VHi).$$

For an NT designed with an internal terminating resistor, it may not be possible to conveniently disconnect that resistor for this test. For the purposes of compliance, run the test outlined above with an external resistor of r = 100 Ω and record the voltage V50. Next record the open circuit voltage as V100. The output impedance is then calculated by the formula

$$Z_0 = ((100*50)*(V100-V50))/(100*V50-50*V100).$$

PASS-FAIL CRITERIA:
Z_0 must be at least 20 Ω.

5.2.2 Transmitting Ones (Unterminated)

5.2.2.1 NT

PURPOSE:
To demonstrate that the transmitter output impedance is sufficiently high when no zeros are being transmitted. Perform this test only if the NT is not internally terminated or the internal termination can be removed.

EQUIPMENT:
An Impedance Analyzer.

CONFIGURATION:

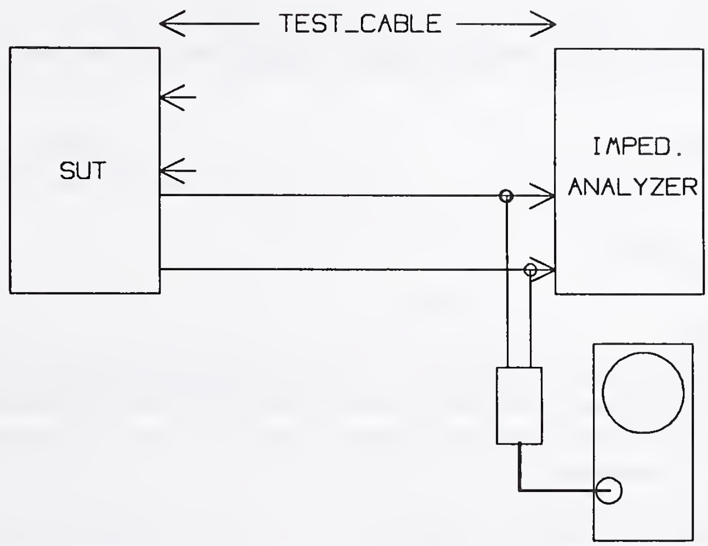


Figure 18

PROCEDURE:
Connect the equipment as in Figure 18. For this test the transmitter termination resistor R is removed. Place the SUT in state G1 and measure the impedance with an injected signal level of 0.1 volts RMS. Sweep the impedance measurement frequency from 2 kHz to 1 MHz with measurements taken at no less than 10 per decade.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 106 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 106 kHz and <= 1 MHz:

$$Mag\_Z >= 2.650E8/Freq\ \Omega$$

5.2.2.2 TE

PURPOSE:
To demonstrate that the transmitter output impedance is sufficiently high when no zeros are being transmitted.

EQUIPMENT:
An Impedance Analyzer

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as in Figure 18. For this test the transmitter termination resistor R is removed. Place the SUT in state F3 and measure the impedance with an injected signal level of 0.1 volts RMS. Sweep the impedance measurement frequency from 2 kHz to 1 MHz with measurements taken at no less than 10 per decade.

Set the impedance analyzer to 96 kHz and increase the signal level to 1.2 volts peak (0.848 VRMS). Measure the peak current into the SUT.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 80 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 80 kHz and <= 1 MHz:

$$Mag\_Z >= 2.00E8/Freq\ \Omega$$

Maximum peak current with 1.2 volt injected signal must be no greater than 0.6 mA.

5.2.3 Transmitter Terminated

PURPOSE:
To verify proper termination of the SUT. This test will be run only if the SUT is to support termination internal to the system, i.e., not rely on an external terminating resistor.

EQUIPMENT:
An Impedance Analyzer.

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as shown in Figure 18. For this test the transmitter is setup so that it performs line termination. Place the SUT in state F3 (G1 for the NT) and measure the impedance with an injected signal level of 0.1 volts RMS. The magnitude of the impedance is measured at 20 kHz, 200 kHz, and 1 MHz.

PASS-FAIL CRITERIA:
The magnitude of the impedance must exceed

$$|Mag\_Z| \,||\, 95\ \Omega$$

Where |Mag_Z| is provided by Figure 13 of ANS T1.605.

5.2.4 Transmitter Impedance Powered Off

PURPOSE:
To insure that the SUT does not inappropriately load the network when powered off. The impedances measured are those required of a TE. The NT is not tested because once the NT is powered off, the network, by definition, is down.

EQUIPMENT:
An Impedance Analyzer.

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as in Figure 18. For this test the transmitter termination resistor R is removed. Turn off power to the system under test. Measure the impedance with an injected signal level of 0.1 volts RMS. The magnitude of the impedance is measured at 2 kHz, 20 kHz, 80 kHz, 300 kHz, and 1 MHz

Set the impedance analyzer to 96 kHz and increase the signal level to 1.2 volts peak (0.848 VRMS). Measure the peak current into the SUT.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 80 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 80 kHz and <= 1 MHz:

$$Mag\_Z >= 2.00E8/Freq\ \ \Omega$$

Maximum peak current with 1.2 volt injected signal must be no greater than 0.6 mA.

5.3 Pulse Shape and Amplitude

5.3.1 Fifty Ohm Load (50 Ω)

PURPOSE:
To verify that the transmitter is providing pulses of the proper shape and amplitude.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:

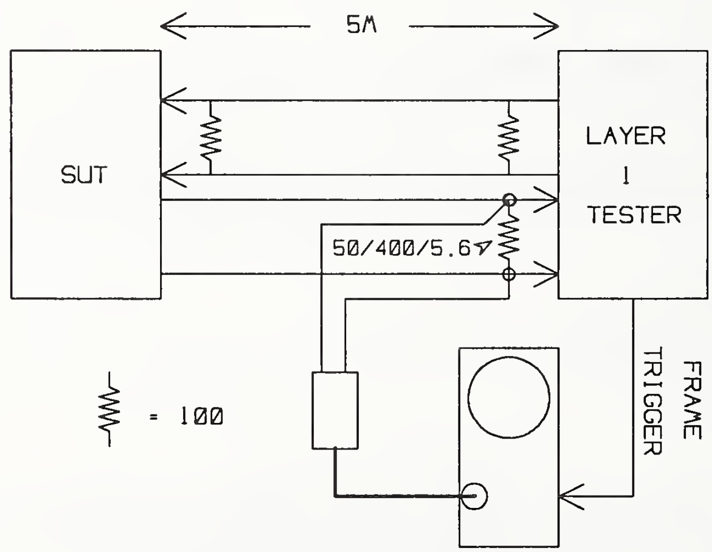


Figure 19

PROCEDURE:
Connect the equipment as shown in Figure 19. Configure the tester to provide the proper network termination (TE or NT). The tester should have a sufficiently high input impedance so as to not affect the results of the test. Establish the communications link with the SUT. Put the SUT into loop back mode and adjust the outgoing frame so that the first ten bits of the incoming frame are "0011011011...". All amplitude measurements are taken using the expanded oscilloscope image of the

fifth and eighth zero in this frame. These images are compared to the template in ANS T1.605 Figure 15 and are stored for use in pulse balance calculations and 5.6 Ω termination tests.

The measurements should be taken with a voltage accuracy of at least ± 4 mV (Roughly equivalent to 200 mV/cm).

PASS-FAIL CRITERIA:
The recorded pulses must lay within the template.

5.3.2 Four Hundred Ohm Load (400 Ω)

PURPOSE:
To verify that the transmitter is providing pulses of the proper shape and amplitude when terminated in 400 Ω.

EQUIPMENT:
Same as in 5.3.1.

CONFIGURATION:
Same as in Figure 19 except the SUT's termination resistor is changed to be 400 Ω.

PROCEDURE:
Connect the equipment as shown in Figure 19. Configure the tester to provide the proper network termination (TE or NT). Establish the communications link with the SUT. Put the SUT into loop back mode and adjust the outgoing frame so that the first ten bits of the incoming frame are "0011011011...". All amplitude measurements are taken using the expanded oscilloscope image of the fifth and eighth zero in this frame. These images are compared to the template in ANS T1.605 Figure 16.

The measurements should be taken with a voltage accuracy of at least ± 4 mV (Roughly equivalent to 200 mV/cm).

PASS-FAIL CRITERIA:
The recorded pulses must lay within the template.

5.3.3 Five Point Six Ohm Load (5.6 Ω)

PURPOSE:
To verify that the transmitter is providing pulses of the proper amplitude when terminated in 5.6 Ω.

EQUIPMENT:
Same as in 5.3.1.

CONFIGURATION:
Same as in Figure 19 except the SUT's termination resistor is changed to be 5.6 Ω.

PROCEDURE:
Connect the equipment as shown in Figure 19. Configure the tester to provide the proper network termination (TE or NT). Establish the communications link with the SUT. Put the SUT into loop back mode and adjust the outgoing frame so that the first ten bits of the incoming frame are "0011011011...". All amplitude measurements are taken using the expanded oscilloscope image of the

fifth and eighth zero in this frame. Compare the peak of the transmit wave form with the peak stored from 5.3.1.

The measurements should be taken with a voltage accuracy of at least ± 4 mV (Roughly equivalent to 200 mV/cm).

PASS-FAIL CRITERIA:
5.6_Ω_Peak must be no more than 0.15 Volts.

5.4 Pulse Balance

PURPOSE:
To insure that the DC balance of the line will be maintained.

EQUIPMENT:
A Layer-1 Tester, Digital Oscilloscope with Balanced Probes.

CONFIGURATION:
Connected as in Figure 19 with a 50 Ω load.

PROCEDURE:
The following procedures will be performed on the two waveforms captured in 5.3.1. Integrate the positive pulse from 1 μs before the rising edge to 1 μs after the falling edge. Integrate the negative pulse from 1 μs before the falling edge to 1 μs after the rising edge.

If waveform integration is not available, compliance can be demonstrated by manually integrating via summation of the areas of the following rectangles.

Rectangle_1:	Height = 0.2 volts Width = Pulse width at 0.1 volts
Rectangle_2:	Height = 0.2 volts Width = Pulse width at 0.3 volts
Rectangle_3:	Height = 0.1 volts Width = Pulse width at 0.45 volts
Rectangle_4:	Height = 0.1 volts Width = Pulse width at 0.55 volts
Rectangle_5:	Height = Max Pulse height - 0.6 volts Width = Pulse width at 0.7 volts

PASS-FAIL CRITERIA:
The relative difference between the pulses must be no greater than 5%.

$$\frac{(\text{Area(Positive)}-\text{Area(Negative)})}{\text{Area(Positive)}} \quad <= \quad 5\%$$

5.5 Unbalance about Earth

5.5.1 Longitudinal Conversion Loss

PURPOSE:
To insure that the equipment under test does not upset the balance of the line.

EQUIPMENT:
An Impedance Analyzer, and An ISDN Balance Bridge.

NOTE: The ISDN Balance Bridge is constructed as shown in ANS T1.605 Figure 17/18.

CONFIGURATION:
Equipment connected as shown in ANS T1.605 Figure 17.

PROCEDURE:
The following tests will be made under all possible power feed conditions as well as all possible connections of the equipment to ground. The measurements will be carried out with the SUT in these states:

1) Deactivated (F3 or G1)...Testing both Transmitter and Receiver,
2) Power off...Testing both Transmitter and Receiver,
3) Activated (F7 or G3)...Testing the Receiver.

The SUT will be tested at a minimum of the following frequencies: 10 kHz, 30 kHz, 100 kHz, 300 kHz, 600 kHz, and 1 MHz. The signal injection level will be 1 volt RMS.

PASS-FAIL CRITERIA:
The magnitude of the LCL at the stated frequency will be no less than the values shown.

10 kHz	54 dB
30 kHz	54
100 kHz	54
300 kHz	54
600 kHz	48
1 MHz	43.5

5.5.2 Output Signal Balance

PURPOSE:
To insure that the equipment under test does not upset the balance of the line.

EQUIPMENT:
An Impedance Analyzer, An ISDN Balance Bridge, and a Layer-1 Tester.

NOTE: The ISDN Balance Bridge is constructed as shown in ANS T1.605 Figure 17/18.

CONFIGURATION:
Equipment connected as shown in ANS T1.605 Figure 18.

PROCEDURE:
Configure the tester to provide the appropriate termination and establish a layer-1 connection. The SUT's transmitted frame will consist of binary zeros in both B channels and, if possible, all zeros in the D channel. See ANS T1.605 Figure 18 and CCITT Recommendation G.117 for more details on this test.

The Output balance will be measured at least at the following frequencies; 96 kHz, 288 kHz, 480 kHz, and 672 kHz. These correspond to spectral maxima of the ISDN signal. NOTE: Limits on equipment sensitivity cause erratic results at spectral minima. NOTE: Level measurements should be made with a resolution bandwidth of 1 kHz.

PASS-FAIL CRITERIA:
The magnitude of the Output Signal Balance at the stated frequency will be no less than the values shown.

96 kHz	54 dB
288 kHz	44.4
480 kHz	40
672 kHz	37.1

5.6 Receiver Input Characteristics

5.6.1 Receiver Input Impedance

5.6.1.1 NT

PURPOSE:
To demonstrate that the receiver input impedance is sufficiently high. Perform this test only if the NT is not internally terminated or the internal termination can be removed.

EQUIPMENT:
An Impedance Analyzer.

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as in Figure 18. For this test the receiver termination resistor R is removed. Place the SUT in state G1 and measure the input impedance with an injected signal level of 0.1 volts RMS. Sweep the impedance measurement frequency from 2 kHz to 1 MHz with measurements taken at no less than 10 per decade.

Set the impedance analyzer to 96 kHz and increase the signal level to 1.2 volts peak (0.848 VRMS). Measure the peak current into the SUT.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 106 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 106 kHz and <= 1 MHz:

$$Mag\_Z >= 2.650E8/Freq\ \ \Omega$$

Maximum peak current with 1.2 volt injected signal must be no greater than 0.5 mA.

5.6.1.2 TE

PURPOSE:
To demonstrate that the receiver input impedance is sufficiently high.

EQUIPMENT:
An Impedance Analyzer

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as in Figure 18. For this test the receiver termination resistor R is removed. Place the SUT in state F3 and measure the impedance with an injected signal level of 0.1 volts RMS. The magnitude of the impedance is measured at 2 kHz, 20 kHz, 80 kHz, 300 kHz, and 1 MHz.

Set the impedance analyzer to 96 kHz and increase the signal level to 1.2 volts peak (0.848 VRMS). Measure the peak current into the SUT.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 80 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 80 kHz and <= 1 MHz:

$$Mag\_Z >= 2.00E8/Freq\ \ \Omega$$

Maximum peak current with 1.2 volt injected signal must be no greater than 0.6 mA.

5.6.1.3 Receiver Terminated

PURPOSE:
To verify proper termination of the SUT. This test will be run only if the SUT is to support termination internal to the system, i.e., not rely on an external terminating resistor.

EQUIPMENT:
An Impedance Analyzer.

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as shown in Figure 18. For this test the receiver is setup so that it performs line termination. Place the SUT in state F3 (G1 for the NT) and measure the impedance with an injected signal level of 0.1 volts RMS. The magnitude of the impedance is measured at 20 kHz, 200 kHz, and 1 MHz.

PASS-FAIL CRITERIA:
The magnitude of the impedance must exceed

$$|Mag\_Z| \; || \; 95\ \Omega$$

Where |Mag_Z| is provided by Figure 13 of ANS T1.605.

5.6.1.4 Receiver Impedance Powered Off

PURPOSE:
To insure that the SUT does not inappropriately load the network when powered off. The impedances measured are those required of a TE. The NT is not tested because once the NT is powered off, the network, by definition, is down.

EQUIPMENT:
An Impedance Analyzer

CONFIGURATION:
See Figure 18.

PROCEDURE:
Connect the equipment as in Figure 18. For this test the receiver termination resistor R is removed. Place the SUT in state F3 and measure the impedance with an injected signal level of 0.1 volts RMS. The magnitude of the impedance is measured at 2 kHz, 20 kHz, 80 kHz, 300 kHz, and 1 MHz.

Set the impedance analyzer to 96 kHz and increase the signal level to 1.2 volts peak (0.848 VRMS). Measure the peak current into the SUT.

PASS-FAIL CRITERIA:
The magnitude of the impedance at each frequencies must be greater than the following values:

Frequency >= 2 kHz and <= 20 kHz:

$$Mag\_Z >= 0.125 * Freq\ \Omega$$

Frequency > 20 kHz and <= 80 kHz:

$$Mag\_Z >= 2500\ \Omega$$

Frequency > 80 kHz and <= 1 MHz:

$$Mag\_Z >= 2.00E8/Freq\ \ \Omega$$

Maximum peak current with 1.2 volt injected signal must be no greater than 0.6 mA.

5.6.2 Receiver Input Delay

5.6.2.1 Absolute Delay

PURPOSE:
To verify that the NT will function with the specified round trip delay created by the transmission lines. This test lumps all delays on the line going to Layer-1 Tester (TE) to insure that any failure modes found are timing, not amplitude, sensitive.

EQUIPMENT:
A Layer-1 Tester and a Analog Line Delay Simulator.

CONFIGURATION:

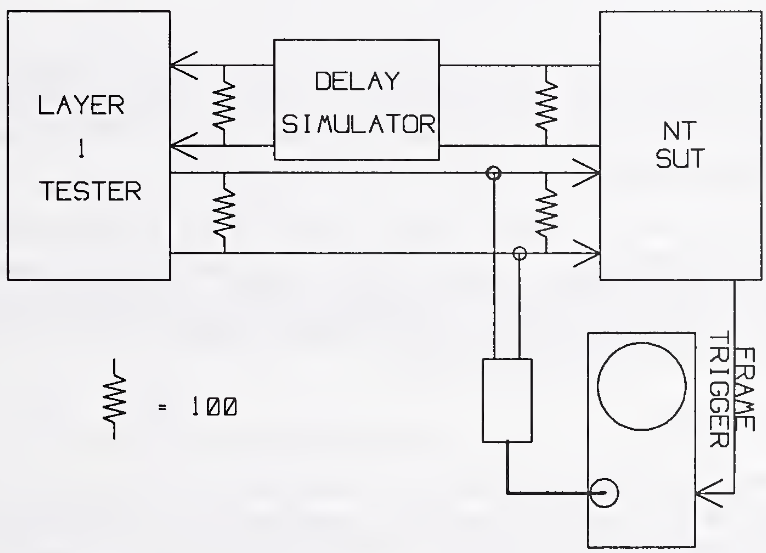


Figure 20

PROCEDURE:
Set up the equipment as shown in Figure 20. Configure the Layer-1 Tester as a TE and establish a communications link between the TE and the NT(SUT). The absolute delay is measured by

comparing the F to L transition of the NT's transmitted frame to the similar transition of the TE's frame measured at the NT's receiver. These timing measurements must be made no more than 20 cm from the NT's ISDN connector. A complete reacquisition of the link is performed after a change in delay.

After establishing the appropriate delay time, the tester should transmit D-Channel messages and monitor the Echo channel for errors. The B-Channel will be idle with 1's. The delay test consists of the two suites:

SUITE_1: NT configured for the Short Passive Bus (Fixed-Timing). Test in 1 μs intervals from 10.42 to 14 μs.
SUITE_2: NT configured for Point-to-Point/Extended Passive Buss (Adaptive-Timing). Test in 1 μs intervals from 10.42 to 42 μs.

PASS-FAIL CRITERIA:
One minute transmission with no errors in the echo channel indicates the NT is operating properly with that delay.

5.6.2.2 Differential Delay

Accomplished in Section 5.6.3.2.4.

5.6.3 Receiver Sensitivity/Transmission Testing

The following tests represent a realistic interpretation of the performance requirements for ISDN Basic Rate S/T Layer-1 devices within a system environment. Each of the configurations listed below, unless otherwise noted, will be connected with either actual ISDN cable or a lumped sum wire line simulator mimicking the performance of ISDN cable.

The cable lengths in the figures are only a general objective. The actual distances obtained will be dependent on the characteristics of the actual cable used. The test suites will state a desired attenuation or group delay at a particular frequency. The physical dimensions of a particular test setup will be manipulated to obtain attenuation and delay criteria.

The following test suites require a modest amount of control of the System Under Test (SUT). In order to be tested the SUT must controllable to the extent that the test operator must be able to instruct the SUT to initiate an ISDN activation sequence. In addition, the test operator must be able to instruct the SUT to enter and exit a digital loop-back mode, i.e., have the SUT loop its receive B & D channels back toward the loop interface.

5.6.3.1 Testing the TE

The intent of this section is to test the performance of the SUT's receiver. While diagrams do not explicitly show so, impairments should be applied only at the SUT's receiver. The line from the SUT's transmitter to the Layer-1 tester will be as short as practical. Any problems that may occur because of round trip delays should be uncovered in other tests.

5.6.3.1.1 Point-To-Point

PURPOSE:
To verify that the receiver is sensitive enough to operate at the longest distance expected while not so sensitive as to be confused with near in-band noise.

EQUIPMENT:
A Layer-1 Tester, Jitter Generator, Signal Generator, and a Wire Line Simulator or Actual Wiring.

CONFIGURATION:

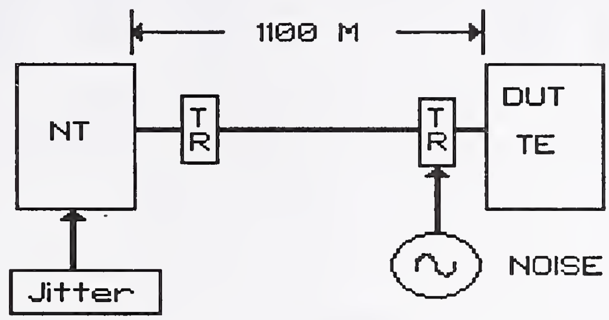


Figure 21

PROCEDURE:
Set the cable distance to obtain an attenuation of -7.5 dB at 96 kHz. Adjust the NT output to nominal signal level.

This test will be performed with the noise source (an oscillator) set first to a 200 kHz sine wave and then repeated with the source set to 2 MHz. The amplitude will be adjusted to obtain a 100 mV peak-to-peak signal across the termination resistor at the input to the receiver of the SUT. The impedance of the noise generator must be greater than 1000 Ω.

At each frequency of impairment, the SUT must transfer data with 5% NT jitter. The frequency of this jitter will be first set to 50 Hz and then to 7000 Hz.

The SUT will be placed in Digital Loop back mode. Independent random data will be transferred on both the B1 and B2 channels. While the data is simultaneously being transmitted on both B-Channels, only one channel need be tested for data integrity at a time.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.1.2 Back-To-Back

PURPOSE:
To test that any point to point equalization does not overcompensate. Also tests that saturation of the receiver does not occur at high signal levels.

EQUIPMENT:
A Layer-1 Tester

CONFIGURATION:

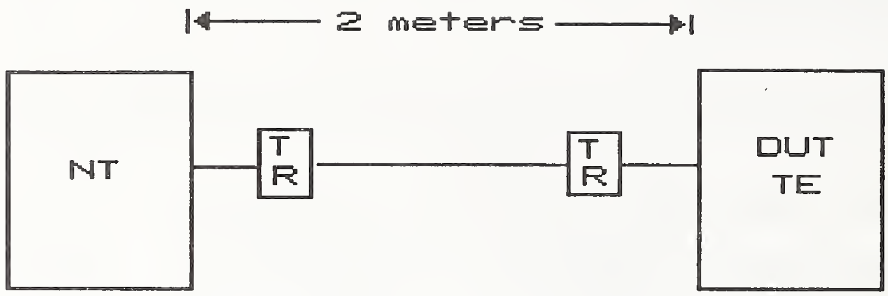


Figure 22

PROCEDURE:
Adjust the NT output to +1.5 dB above nominal signal level (0.892 V peak).

The SUT will be placed in Digital Loop back mode. Independent data will be transferred on both the B1 and B2 channels. Only one channel will be tested for data integrity at a time.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.1.3 Short Passive Bus, SUT near NT:

PURPOSE:
To evaluate the TE's receiver sensitivity to the reflected pulse returning from the 250 meter stub.

EQUIPMENT:
A Layer-1 Tester, Signal Generator, and a Wire Line Simulator or Actual Wiring.

CONFIGURATION:

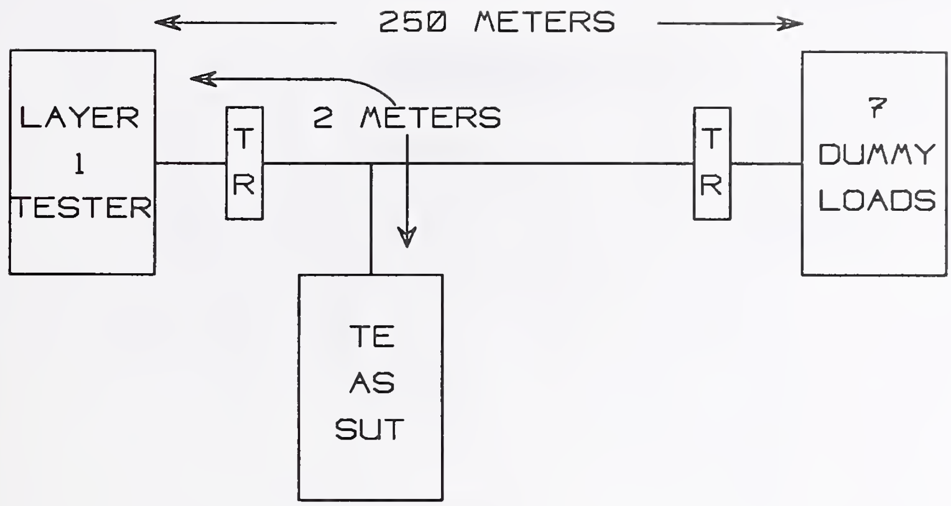


Figure 23

PROCEDURE:
Configuration as shown in Figure 23. The cable distance from the SUT to the NT will be no more than 2 meters. Add sufficient cable to position the loads 1μs away (unloaded). The maximum 1 μs delay is measured by comparing the 0-volt crossing of the frame pulse (F) and its associated balance bit pulse (L) at the NT, to the corresponding F to L transition at the TE end of the cable. The seven clustered loads are simulated by the parallel combination of:

An inductor = 2.86 millihenries (mH),
A capacitor = 0.0056 microfarads (μF),
and a resistor = 560 Ω.

This test will be performed with the impairments as outlined in Section 5.6.3.1.1.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.1.4 Short Passive Bus, SUT and Loads far:

PURPOSE:
To test the ability of the TE's transmitter to drive into a large number of devices.

EQUIPMENT:
A Layer-1 Tester, Signal Generator, and a Wire Line Simulator or Actual Wiring.

CONFIGURATION:

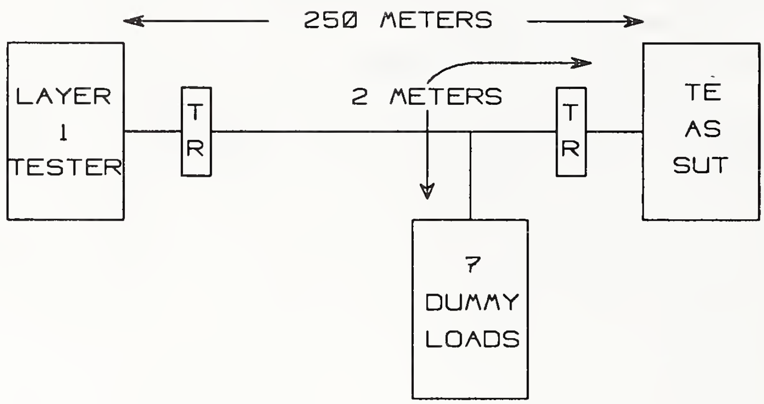


Figure 24

PROCEDURE:
Configuration as shown in Figure 24. Add sufficient cable to position the TE and loads 1μs away (unloaded). The maximum 1 μs delay is measured by comparing the 0-volt crossing of the frame pulse (F) and its associated balance bit pulse (L) at the NT, to the corresponding F to L transition at the TE end of the cable. The seven clustered loads are simulated by the parallel combination of:

An inductor = 2.86 mH,
A capacitor = 0.0056 μF,
and a resistor = 560 Ω.

This test will be performed with the impairments as outlined in Section 5.6.3.1.1.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.2 Testing the NT

The intent of this section is to test the performance of the SUT's receiver. While diagrams do not explicitly show so, impairments should be applied only at the SUT's receiver. The line from the SUT's transmitter to the Layer-1 tester will be as short as practical. Any problems that may occur because round trip delays should be uncovered in other tests.

5.6.3.2.1 <u>Back-to-Back</u>

PURPOSE:
To test that any point to point equalization does not overcompensate. Also tests that saturation of the receiver does not occur at high signal levels.

EQUIPMENT:
A Layer-1 Tester.

CONFIGURATION:

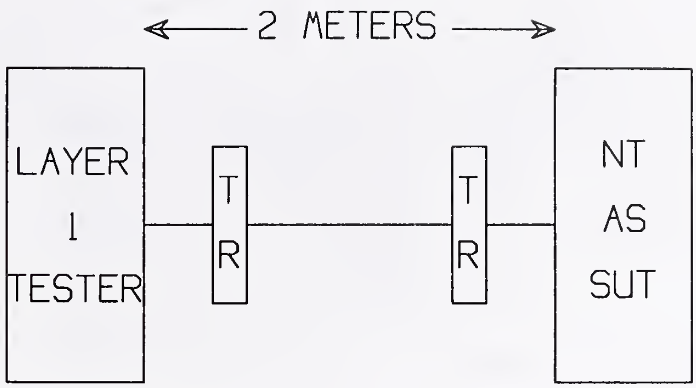


Figure 25

PROCEDURE:
The test will be configured as shown in Figure 25. The length of cable connecting the TE and the SUT-NT will be no more than two meters. Adjust the TE output to +1.5 dB above nominal signal level (0.892 V peak).

No impairments are required for this test. Data will be as stated in Section 5.6.3.1.1.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.2.2 <u>Point-to-Point</u>

PURPOSE:
To test the sensitivity and selectivity of the NT's receiver. In addition, timing sensitivity problems within the NT are probed.

EQUIPMENT:
A Layer-1 Tester, Signal Generator, and a Wire Line Simulator or Actual Wiring.

CONFIGURATION:

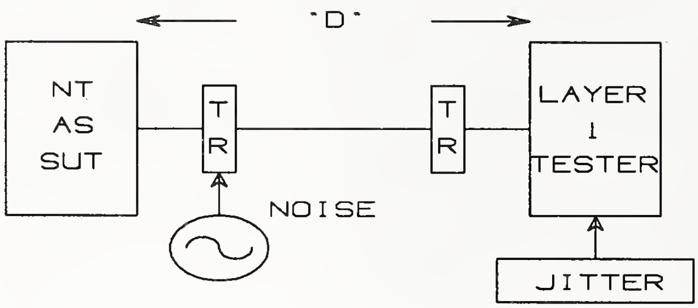


Figure 26

PROCEDURE:
Adjust the TE output to the nominal signal level.

The test will be configured as shown in Figure 26. Due to the potential sensitivity of the NT to round trip timing delays, this test will be performed five times with "D" set to obtain attenuations of -1.5, -3.0, -4.5, -6.0 and -7.5 dB. A complete reacquisition of the link is performed after a change in distance. NOTE: If the test operator is satisfied that there is no problem with round trip timing as a result of testing Section 5.6.2.1, only the -7.5 dB distance test is required.

This test will be performed with the noise source (an oscillator) set first to a 200 kHz sine wave and then repeated with the source set to 2MHz. The amplitude will be adjusted to obtain a 100 mV peak-to-peak signal across the termination resistor at the input to the receiver of the SUT.

The SUT will be placed in Digital Loop back mode. Independent random data will be transferred on both the B1 and B2 channels. While the data is simultaneously being transmitted on both B-Channels, only one channel need be tested for data integrity at a time.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.2.3 Short Passive Bus (SPB):

PURPOSE:
To verify that the NT is capable of simultaneously receiving data from two TEs operating at a maximum timing offset from each other.

EQUIPMENT:
A Layer-1 Tester, two TEs, a Wire Line Simulator/Actual Wire, and a Signal Generator.

CONFIGURATION:

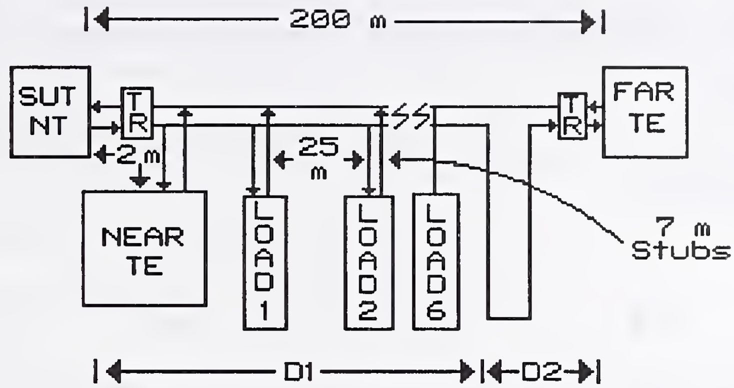


Figure 27

PROCEDURE:
The intention of the Short Passive Bus is to provide operational interconnections between eight TEs and one NT at distances up to 200 meters. It is further intended that the TEs can be randomly dispersed along this length. Figure 27 depicts a test configuration to verify the ability of the NT to support such a bus.

Two operational TEs will be required, one next to the NT and the other at the far end of the SPB. The other six TEs will be simulated by passive loads connected as shown with 7 meter connecting cables. Each of the cables will be terminated with a load consisting of the parallel combination of:

An inductor = 22 mH,
A capacitor = 800 picofarads (pF),
and a resistor = 3920 Ω.

The simulation of the allowable timing offsets necessitate a differential signal path for this test. The length of cable the Far TE must drive is set to the SPB goal of 200 meters. This minimizes test induced distortions of the received signal presented to the NT under test. The length of cable the NT will drive to the Far TE is made up of two lengths, "D1+D2". "D1" is set to obtain a delay of 1 µs of group delay at 96 kHz (unloaded). "D2" will be adjusted to obtain a timing difference of 3.27 µs (loaded) between the two TE frames as seen by the NT receiver input.

The Near TE will digitally loop back the B1 channel and the Far TE will digitally loop back the B2 channel. Independent data will be transferred on both the B1 and B2 channels. Only one channel will be tested for data integrity at a time. After successful completion of this test, channel assignments will be reversed, i.e., the Near TE will loopback B2 and the Far will loopback B1. For the sake of convenience, this test can also be performed with the NT being placed in digital loopback and the TEs becoming the data pumps.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period.

5.6.3.2.4 Extended Passive Bus (EPB):

PURPOSE:
To verify that the NT, operating on an adaptive timing scheme, is capable of simultaneously receiving data from two TEs operating at a maximum timing offset from each other.

EQUIPMENT:
A Layer-1 Tester, two TEs, a Wire Line Simulator/Actual Wire, and a Signal Generator.

CONFIGURATION:

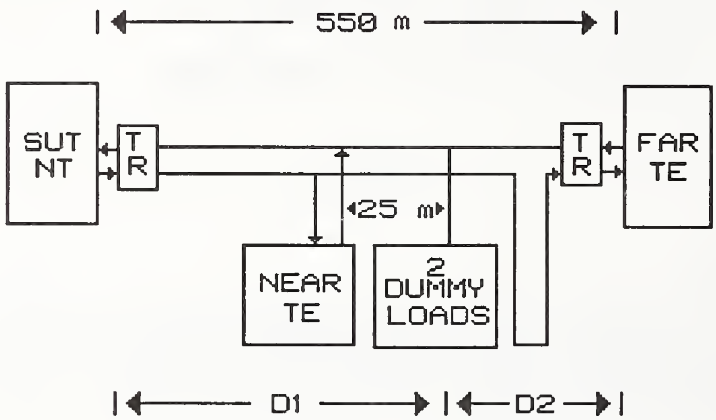


Figure 28

PROCEDURE:
The extended passive bus is used to drive a clustered group of TEs at some intermediate distance from the NT. While the numbers of TEs, their relative distances, and the intermediate distance from the NT are open issues, the goal here will be to verify service to four TEs within 50 meters of each other at a distance of 500 meters from the NT. Figure 28 depicts a test to evaluate such service.

Two operational TEs will be required, one each at the two extremes of the cluster. The other two TEs will be simulated by the previously mentioned passive loads, connected as shown with 7 meter connecting cables. The simulation of the allowable timing offsets necessitate a differential signal path for this test. Adjust the cable between the two terminating resistors to obtain an attenuation of 3.8 dB at 96 kHz. This distance is D1. The length of cable the NT will drive to the Far TE is made up of two lengths, "D1+D2". "D2" will be adjusted to obtain a timing difference of 1.64 µs between the two TE frames as measured at the NT receiver input. This will be approximately 250 meters.

Channel activity will remain as outlined in Section 5.6.3.2.3.

PASS-FAIL CRITERIA:
Data passed error free for a two minute period in each channel.

6 POWER FEEDING

Purpose:
These tests measure the power consumption of a TE under a variety of conditions. Referencing ANS T1.605 paragraph 10.5. These tests cover Power Source 1 Configuration for both Normal and Restricted Mode.

Note: Power Source 2 and 3 Configurations are not covered in present specifications.

6.1 TE Power Consumption

6.1.1 Normal Power Conditions

PURPOSE:
This test measures the power consumption of a TE in Power Source 1 Configuration and Normal Power Conditions. The Power Consumption is the product of the DC voltage and current measured at the terminals of the TE under test. Typical wiring resistance (R = 30 Ω) is included to assure that the TE is not dependent on a zero impedance power source. The Layer-1 Tester is used to establish and verify the appropriate TE States.

EQUIPMENT:
Variable DC Power Source (24-56.5 volts)
DC Voltmeter
DC Ammeter
Power Coupling and Test Setup
Layer-1 Tester

CONFIGURATION:

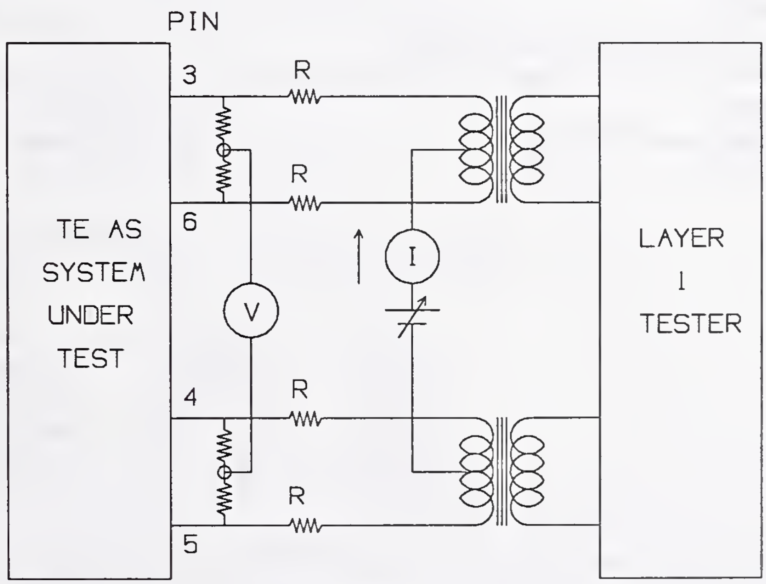


Figure 29

PROCEDURE:
The power consumption is calculated at the Lower (24 volts dc), Nominal (48 volts dc), and the Upper (56.5 volts dc) limits of the power source. For each supply voltage the TE is evaluated in the following states: Activated, Deactivated, and, Local Action.
The following tests shall be performed at Supply Voltages of:

Lower Limit, 24 Vdc
Nominal, 48 Vdc
Upper Limit, 56.5

PASS-FAIL CRITERIA:

TE State	Limit	ANS T1.605 Reference
Activated	<= 1.0 watt	10.5.1
Deactivated*	<= 0.1 watt	10.5.1
Local Action	<= 1.0 watt	10.5.1

* If the TE is designed to maintain a deactivated state and go into a low power mode.

6.1.2 Restricted Mode Power Conditions

PURPOSE:
This test measures the power consumption of a TE in Power Source 1 Configuration and Restricted Power Conditions. The Power Consumption is the product of the DC voltage and current measured at the terminals of the TE under test. Typical wiring resistance ($R = 30\ \Omega$) is included to assure that the TE is not dependent on a zero impedance power source. The Layer-1 Tester is used to establish and verify the appropriate TE States.

EQUIPMENT:
Variable DC Power Source (32-56.5 volts)
DC Voltmeter
DC Ammeter
Power Coupling and Test Setup
Layer-1 Tester

CONFIGURATION:

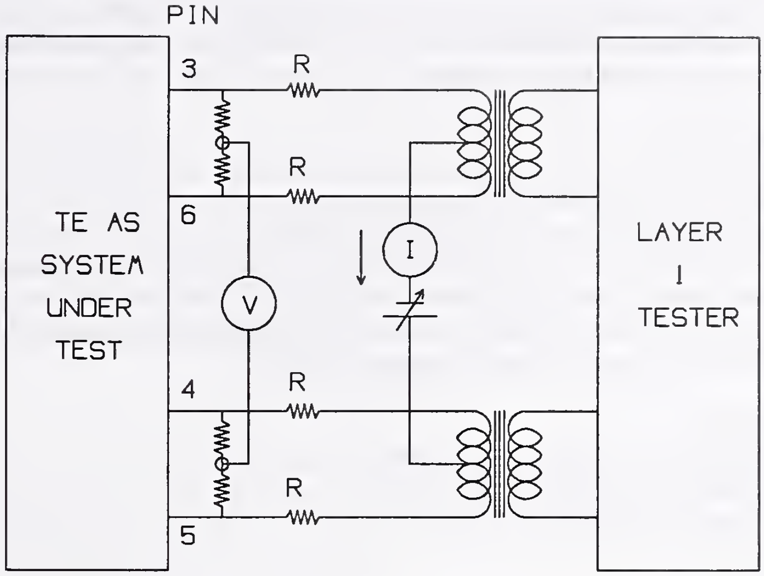


Figure 30

PROCEDURE:
The power consumption is calculated at the Lower (32 volts dc), Nominal (48 volts dc), and the Upper (56.5 volts dc) limits of the power source. For each supply voltage the TE is evaluated in the following states: Activated, Deactivated, Local Action and Nondesignated as specified in ANS T1.605 10.5-10.5.2.2. Note that the voltage source polarity has been reversed to indicate Restricted Mode.

Power Source 1, Restricted Power Condition

The following tests shall be performed at Supply Voltages of:
- Lower Limit, 32 V dc
- Nominal, 48 V dc
- Upper Limit, 56.5

PASS-FAIL CRITERIA:

TE State	Limit	ANS T1.605 Reference
Activated	<= 380 mW	10.5.2
Deactivated	<= 25 mW	10.5.2
Local Action	<= 380 mW	10.5.2
Nondesignated*	0.0 W	10.5.2.2
Any State**	<= 3 mW	10.5.2.2
Any State***	>= 1 MΩ	10.5, 10.5.2.2

* Locally powered or normally powered that does not make use of a connected/disconnected detector.

** Locally powered with connected detector.

*** Locally powered without a Connected Detector. A TE that is not powered from power source 1 and does not use the detection of power source 1 as a means of determining connection status shall present a resistance of at least 1 MΩ between the interface local pairs 3-6 and 4-5 and between either pair and ground. (ANS T1.605 10.5)

6.1.3 Current Transient

PURPOSE:
This test measures the rate of change of current drawn by the TE. This power surge is measured during connection of the TE to a powered line. If restricted mode is supported, the test is also performed during a change from Normal to Restricted, and Restricted mode power conditions. The Layer-1 Tester is used to establish and verify the appropriate TE states. The Layer-1 Tester should be requesting an Activated TE State throughout the Test.

EQUIPMENT:
Variable DC Power Source (24-56.5 volts)
Digital Oscilloscope with current probe
Power Coupling and Test Setup
Layer-1 Tester

CONFIGURATION:

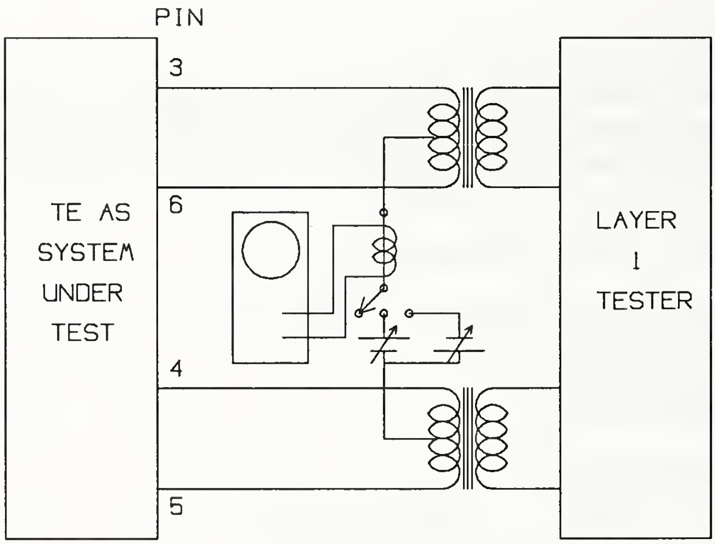


Figure 31

PROCEDURE:
The test is performed in Normal mode, change from Restricted to Normal mode (if supported), and Restricted mode (if supported). Both B-Channels will contain all zeros.

For Normal Mode the following tests shall be performed at Supply Voltages of:

Lower Limit, 24 V dc
Nominal, 48 V dc
Upper Limit, 56.5

For Restricted Mode the following tests shall be performed at Supply Voltages of:

Lower Limit, 32 V dc
Nominal, 48 V dc
Upper Limit, 56.5

PASS-FAIL CRITERIA:
The test limit is less than or equal to 5 milliamperes per μs (paragraph 10.4 of ANS T1.605). This measurement will be made 100 mS after the transient, and integrated over the next 50 mS.

6.2 NT Power Source

The following tests refer to the NT Power Source. NET3 recommendation for these tests is not available.

PURPOSE:
The following tests confirm that the NT Power Source satisfies the specifications for DC output voltage over the expected range of loads (ANS Reference T1.605, 10.2). The tests cover both Normal and Restricted Power Conditions as well as resistance to ground for Power Source 1. Tests for Power Source 1 and Power Source 2 are also included.

6.2.1 Power Source 1

6.2.1.1 Normal Power Condition

EQUIPMENT:
Variable Resistive Load (1 watt capacity minimum)
DC voltmeter
DC ammeter
Power Coupling Setup

CONFIGURATION:

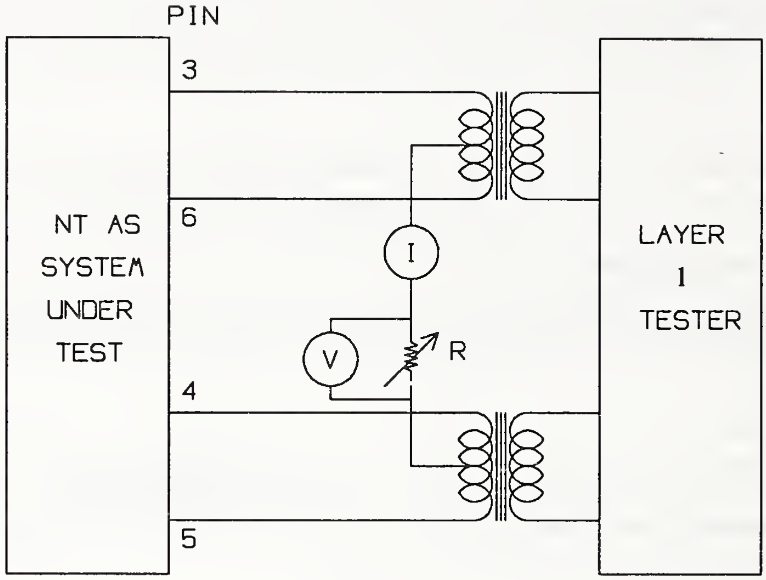


Figure 32

PROCEDURE:
With the NT in Normal Mode, the test is started with a high value of R (approximately 100 kΩ). R is decreased until at least 1 watt or the maximum power rating of PS1, is dissipated in R (approximately 2.5 kΩ for 1 watt). The NT power source voltage is measured throughout the test.

Data will be recorded at the highest value of R, the lowest value of R (power dissipation = 1 watt or the PS1 rating) and at 4 other values in between.

PASS-FAIL CRITERIA:
The voltage shall be within the range of 34 to 56.5 volts for all readings (ANS T1.605, 10.2.2.1).

6.2.1.2 Restricted Power Condition

EQUIPMENT:
Same as Section 6.2.1.1.

CONFIGURATION:
Same as Section 6.2.1.1.

PROCEDURE:
With the NT in Restricted Mode, the test is started with a high value of R (approximately 100 kΩ). R is decreased until 420 milliwatts is dissipated in R (approximately 6 kΩ). The NT power source voltage is measured throughout the test.

Data will be recorded at the highest value of R, the lowest value of R (power dissipation = 420 milliwatts) and at 4 other values in between.

PASS-FAIL CRITERIA:
The voltage shall be reverse polarity and within the range of 34 to 56.5 volts for all readings (ANS T1.605, 10.2.2.2).

6.2.1.3 Resistance To Ground

EQUIPMENT:
An Ohmmeter.

PROCEDURE:
The resistance to ground shall be measured separately for both NT Power Source 1 Pairs (Pair 3-6, and Pair 4-5).

PASS-FAIL CRITERIA:
The resistance shall be less than 1 MΩ (ANS T1.605 Figure 22, Note 7).

6.2.2 Power Source 2

6.2.2.1 Normal Power Condition

PURPOSE:
The following tests confirm that the NT Power Source 2 satisfies the specifications for DC output voltage over the expected range of loads (ANS T1.605, 10.2.3 and 10.3.2.2). The tests cover NT Power Source 2 configuration in both Normal and Restricted Modes.

EQUIPMENT:
Variable Resistive Load (7 watt capacity minimum)
DC Voltmeter
DC Ammeter
Power Coupling Setup

CONFIGURATION:

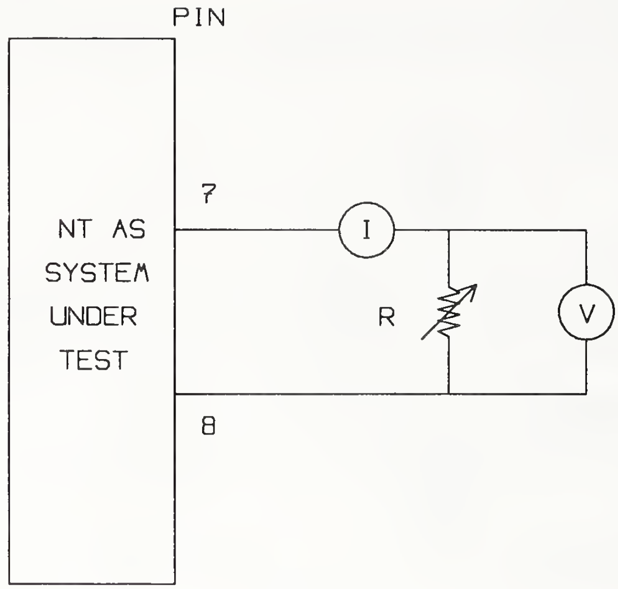


Figure 33

PROCEDURE:
With the NT in Normal Mode, the test is started with a high value of R (approximately 100 kΩ). R is decreased until 7 watts is dissipated in R (approximately 350 Ω). The NT power source voltage is measured throughout the test.

Data will be recorded at the highest value of R, the lowest value of R (power dissipation = 7 watt) and at 4 other values in between.

PASS-FAIL CRITERIA:
The voltage shall be within the range of 32 to 56.5 volts for all readings (ANS T1.605, 10.2.2.3 and 10.3.2.1).

6.2.2.2 Restricted Power Condition

CONFIGURATION:
See Figure 33.

PROCEDURE:
With the NT in Restricted Mode, the test is started with a high value of R (approximately 100 kΩ). R is decreased until 2 watts is dissipated in R (approximately 1.2K Ω). The NT power source voltage is measured throughout the test.

Data will be recorded at the highest value of R, the lowest value of R (power dissipation = 2 watts) and at 4 other values in between.

PASS-FAIL CRITERIA:
The voltage shall be reverse polarity and within the range of 32 to 56.5 volts for all readings (ANS T1.605, 10.2.2.3 and 10.3.2.2).

7 ELECTRICAL ENVIRONMENT

7.1 Unexposed Wiring

Ground in the following drawings is referenced to the equipment's power source (Mains ground).

In all of the tests outlined below, the devices will be tested in State F4 if a TE and in State G2 if an NT. If the SUT can be either, perform the environmental tests in TE mode.

The PASS-FAIL CRITERIA for all of the tests below is that the SUT should not be damaged by the stresses. It is sufficient for compliance that the SUT pass the Point-to-Point tests outlined in Section 5.6.3.2.2 or 5.6.3.1.1. Only one data channel need be tested.

7.1.1 DC Testing

PURPOSE:
To check the survivability of the SUT when a continuous DC voltage of 56.5 volts (current limited to 0.5 amperes) is connected to its terminals.

EQUIPMENT:
A DC supply and a Switching Matrix.

CONFIGURATION:

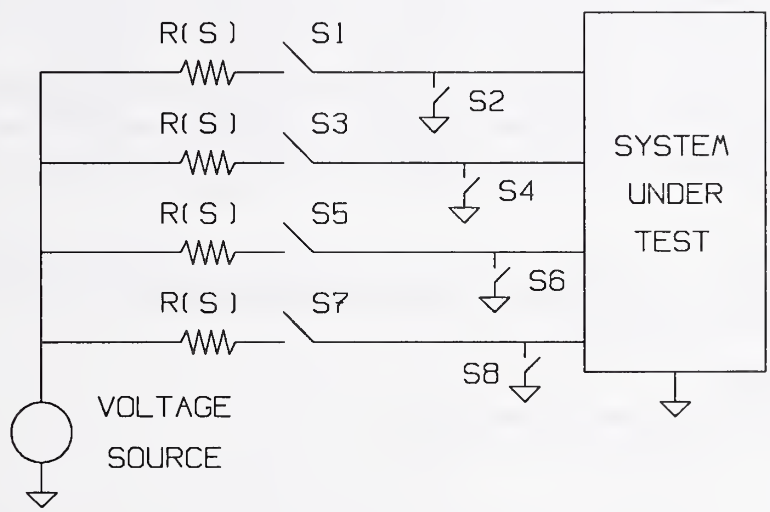


Figure 34

PROCEDURE:
With R(S) given as 113 Ω, connect the equipment as shown in Figure 34. Adjust the DC supply to 56.5 volts and set the switches as instructed in Table 7.1.1.1 Test Case 1. After a five minute exposure, repeat with the next Test Case. Continue until all the Test Cases have been completed.

PASS-FAIL CRITERIA:
The SUT must function properly after the completion of the test.t

Table 7.1.1.1. DC Test Cases

TEST CASE	S1	S2	S3	S4	S5	S6	S7	S8
1	closed	open	open	closed	open	open	open	open
2	closed	open	open	open	open	closed	open	open
3	closed	open	open	open	open	open	open	closed
4	open	closed	closed	open	open	open	open	open
5	open	open	closed	open	open	closed	open	open
6	open	open	closed	open	open	open	open	closed
7	open	closed	open	open	closed	open	open	open
8	open	open	open	closed	closed	open	open	open
9	open	open	open	open	closed	open	open	closed
10	open	closed	open	open	open	open	closed	open
11	open	open	open	closed	open	open	closed	open
12	open	open	open	open	open	closed	closed	open
13	closed	open	closed	open	closed	open	closed	open

7.1.2 AC Testing

PURPOSE:
To check the survivability of the SUT when a pulsed AC voltage of 200 volts peak-to-peak (20 Hz) is connected to its terminals.

EQUIPMENT:
A Signal Generator, and a Switching Matrix

CONFIGURATION:

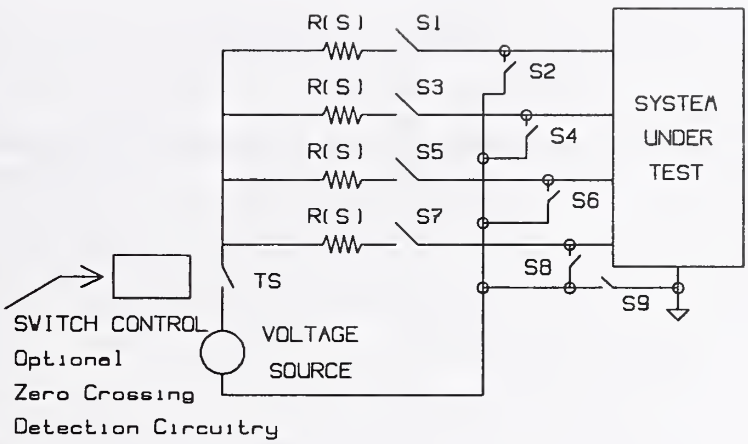


Figure 35

PROCEDURE:
From the literature supplied with the signal generator, determine its output impedance, Z_{out}. R(S) is defined to be 1500 - Z_{out} Ω. Connect the equipment as shown in Figure 35. With all the switches open, adjust the signal source to 200 volts peak-to-peak as measured across the voltage source.

A time switch (TS) is placed between the voltage source and the rest of the circuit to connect and disconnect the voltage source (Figure 35). The timing for TS is two seconds MAKE and four seconds BREAK. All the Test Case connections as shown in Table 7.1.2.1 will be tested. Each Test Case will be run for at least five minutes.

PASS-FAIL CRITERIA:
The SUT must function properly after the completion of the test.

Table 7.1.2.1. AC Testing

Test Case	S1	S2	S3	S4	S5	S6	S7	S8	S9
1	closed	open	open	closed	open	open	open	open	closed
2	closed	open	open	open	open	closed	open	open	closed
3	closed	open	open	open	open	open	open	closed	closed
4	open	closed	closed	open	open	open	open	open	closed
5	open	open	closed	open	open	closed	open	open	closed
6	open	open	closed	open	open	open	open	closed	closed
7	open	closed	open	open	closed	open	open	open	closed
8	open	open	open	closed	closed	open	open	open	closed
9	open	open	open	open	closed	open	open	closed	closed
10	open	closed	open	open	open	open	closed	open	closed
11	open	open	open	closed	open	open	closed	open	closed
12	open	open	open	open	open	closed	closed	open	closed
13	closed	open	closed	open	closed	open	closed	open	closed
14	closed	open	open	closed	open	open	open	open	open
15	closed	open	open	open	open	closed	open	open	open
16	closed	open	open	open	open	open	open	closed	open
17	open	closed	closed	open	open	open	open	open	open
18	open	open	closed	open	open	closed	open	open	open
19	open	open	closed	open	open	open	open	closed	open
20	open	closed	open	open	closed	open	open	open	open
21	open	open	open	closed	closed	open	open	open	open
22	open	open	open	open	closed	open	open	closed	open
23	open	closed	open	open	open	open	closed	open	open
24	open	open	open	closed	open	open	closed	open	open
25	open	open	open	open	open	closed	closed	open	open

7.1.3 Surge Testing

PURPOSE:
To check the survivability of the SUT when multiple surges of 1000 volts strike the interconnecting conductors.

EQUIPMENT:
A DC Power Supply

CONFIGURATION:

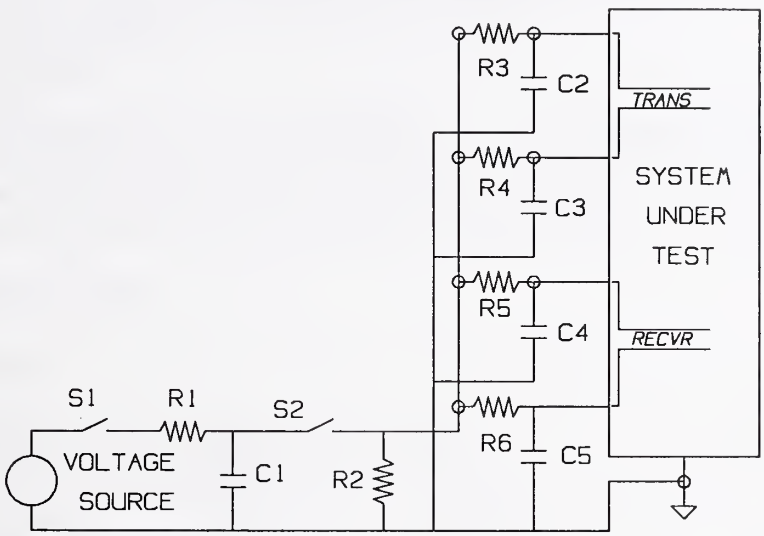


Figure 36

PROCEDURE:
The values of the resistors and capacitors are:

R1=2 kΩ, C1=2 μF, R2=36.5 Ω, R3=R4=R5=R6=15 Ω, C2=C3=C4=C5=0.015 μF.

NOTE: Resistor values are 1% tolerance. Capacitor values are 5% non-polarized. C2-C5 must be additionally screened to be within 1% of each other. Both R1 and R2 should be at least 2 Watts non-inductive. The voltages present on switches S1 and S2 are **POTENTIALLY DANGEROUS**. These switches must offer sufficient dielectric strength (2000 V) to avoid personal injury. Switch S2 must be capable of handling a 30A surge when it is initially closed. A relay is suggested for both of these switch applications.

Connect the equipment as shown in Figure 36 and set the voltage source to 1000 volts (measured open circuit). The components listed above will generate a surge pulse with a rise-time of about 1 μs and a fall time to the 50% point of 50 μs. Surge testing will be performed in the following manner.

Open S2 and close S1; this charges C1 to 1000 volts. The time to charge will be less than 0.5 s. Open S1 and close S2 to deliver the surge to the SUT. Repeat this sequence 10 times in 10 s. Wait one minute and then continue with another burst of 10 surges. Repeat until the SUT has been exposed to 50 surges. Reverse the polarity of the voltage source and repeat the process subjecting the SUT to 50 surges of the opposite polarity.

PASS-FAIL CRITERIA:
The SUT must function properly after the completion of the test.

8 MEDIA

8.1 Interconnecting Media

The media is one of the most important links in the communication chain extending from the transmitter to the receiver and, at this point, the one least specified by ANS T1.605. The final performance of the system with respect to:

1) Maximum allowable distance between NT and TE,
2) Maximum distance between TE's on the Short/Extended Passive bus,
3) Maximum allowable NT Receiver Timing Offset,
4) Noise sensitivity,
5) Throughput,

is primarily determined by the characteristics of the wire connecting the system together. Literally a host of differing wire types has no trouble meeting the specified points in ANS T1.605 Section 9.9. Distance tests, on the same equipment, has demonstrated that the maximum Point-to-Point distance can vary from 1400 meters to below 900 meters depending only on the cable used.

8.2 Access TE Cord

8.2.1 Capacitance

PURPOSE:
To verify that the cord capacitance is within limits.

EQUIPMENT:
An Impedance Analyzer.

PROCEDURE:
Loosely coil the cable on a ground plane. Terminate each end of the cable pair not currently being tested in 100 Ω. Set the analyzer to inject a 96 kHz signal at an amplitude of 100 mV RMS. Measure the capacitance.

8.2.1.1 Cords Less than or equal to 7 meters

PASS-FAIL CRITERIA:
Must be no more than 300 pF.

8.2.1.2 Cords to 10 meters

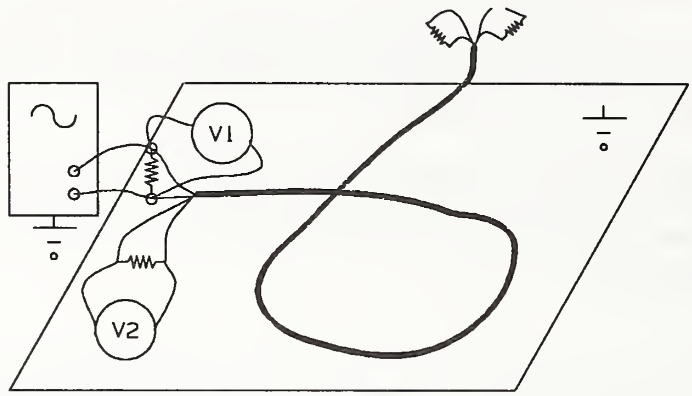
PASS-FAIL CRITERIA:
Must be no more than 350 pF.

8.2.2 Crosstalk

PURPOSE:
To verify that the Crosstalk is within specifications.

EQUIPMENT:
A Signal Generator and a Voltmeter (Network Analyzer), Balun (if necessary).

CONFIGURATION:



$$CrossTalk = 20 * LOG\left(\frac{V1}{V2}\right)$$

Figure 37

PROCEDURE:
Connect the equipment as in Figure 37. Loosely coil the cable on a ground plane. Terminate each end of the cable pair in 100 Ω. Set the generator to inject a 96 kHz signal at an amplitude of 500 mV RMS. Measure the crosstalk.

PASS-FAIL CRITERIA:
Must be no less than 60 dB.

8.2.3 Characteristic Impedance

PURPOSE:
To verify that the Characteristic Impedance is within specifications.

EQUIPMENT:
An Impedance Analyzer.

PROCEDURE:
Loosely coil the cable on a ground plane. Terminate each end of the cable pair not currently being tested in 100 Ω. Set the analyzer to inject a signal of 96 kHz at an amplitude of 100 mV RMS. Connect one end of the cable to the impedance analyzer. Open circuit the opposite end. Measure the complex impedance, Z_{oc}. Short circuit the opposite end. Measure the complex impedance, Z_{ss}.

$$\text{Characteristic Impedance} = Abs(SQRT(Z_{oc} * Z_{ss}))$$

NOTE: Both the SQRT and * are COMPLEX operations.

PASS-FAIL CRITERIA:
Must be greater than 75 Ω.

8.2.4 Resistance

PURPOSE:
To insure that the resistance of the connecting wire is within specifications.

EQUIPMENT:
A Low-Resistance Ohmmeter.

PROCEDURE:
As per the ohmmeters operating instructions, measure the resistance of a single connector.

PASS-FAIL CRITERIA:
Shall not exceed 3.00 Ω.

NIST-114A
(REV. 3-90)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NUMBER
NIST/SP-500/194

2. PERFORMING ORGANIZATION REPORT NUMBER

3. PUBLICATION DATE
September 1991

4. TITLE AND SUBTITLE
Integrated Services Digital Network Conformance Testing - Layer 1 - Physical Layer
Part 1 - Basic Rate S/T Interface, User Side

5. AUTHOR(S)
Shukri A. Wakid and Kathleen M. Roberts

6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)
U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

7. CONTRACT/GRANT NUMBER

8. TYPE OF REPORT AND PERIOD COVERED
Final

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)
Same as item #6

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

The American National Standard for Telecommunications T1.605-1989 specifies the Layer 1 requirements to provide for satisfactory transmission between a Terminal Equipment (TE) and Network Termination (NT). It describes both the physical interface and the electrical characteristics of the signals appearing at the S and T reference points. Equipment designed to operate on the Integrated Services Digital Network (ISDN) Basic Rate S or T interface must conform with this set of requirements.

This document describes a set of test specifications which test conformance of TEs and NTs to the ISDN Physical Layer at the S/T reference point, as defined in ANS T1.605-1989. These tests were developed and approved by members of North American ISDN Users' Forum (NIU-Forum).

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)
Abstract Test Suites; Basic Rate Interface; BRI; Conformance Testing; ISDN; Network Termination; NT; S/T Interface; Terminal Equipment; TE

13. AVAILABILITY

X	UNLIMITED
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14. NUMBER OF PRINTED PAGES
88

15. PRICE

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