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Functional Criteria for the DS1 Interface Connector

Technical Reference

NOTICE

This Technical Advisory is published by BellSouth Telecommunications, Incorporated and informs the telecommunications industry of criteria that describe the chracteristics and features needed for operation of a DS1 Interface Connector in BellSouth Telecommunications, Inc. Much of this criteria has been taken from Bellcore TR−TSY−000312, *Functional Criteria for the DS1 Interface Connector.*

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FUNCTIONAL CRITERIA FOR THE DS1 INTERFACE CONNECTOR

CONTENTS

FUNCTIONAL CRITERIA FOR THE DS1 INTERFACE CONNECTOR

1. INTRODUCTION

1.1 Purpose and Scope of Document

The purpose of this document is to inform the telecommunications industry of BellSouth Telecommunications, Inc., (BST) view of criteria that describe the characteristics and features needed for operation of a DS1 Interface Connector in BST. This document does not specify a complete definition of a specific product design.

The DS1 Interface Connector (herein called “the connector”) is intended for installation on the network side of the Network Interface (NI), the demarcation point between the Local Exchange Carrier (LEC) and Customer Installation (CI). The connector is intended for use on a digital transmission medium consisting of metallic cable pairs and provides a network/customer interface for services operating at the DS1 (1.544 Mbps) rate. The line code of the DS1 signal is bipolar (Alternate Mark Inversion (AMI)), except where intentional bipolar violations are introduced by B8ZS (Bipolar with 8−Zero Substitution).

The criteria contained in this document represent minimum requirements. BST, in its consideration of a particular DS1 Interface Connector, may consider supplier claims for performance items not covered by criteria in this document or supplier claims that performance exceeds that required by the criteria as additions or modifications to the criteria.

1.2 Organization of the Document

The criteria in this Technical Advisory (TA) are divided into generic requirements, objectives and options. Criteria that have the greatest effect on service, DS1 Interface Connector operation or BST procedures are listed as requirements. Throughout this document the work “shall” or “is required” will be used to identify generic requirements. Failure to meet such requirements may cause application restrictions or improper functioning of the connector. Objectives represent long term goals to be achieved in the telephone plant or a criteria included in an effort to provide universal product compatibility. Throughout this document the word “should” will be used to identify objectives. Products meeting the objectives as well as the requirements may provide some benefit in either performance or scope of application. Objectives may be reclassified as requirements in the future. Options are features that enhance connector performance in certain applications. Options may be included at the discretion of the manufacturer or requested by BST.

The requirements, objectives and options in this document are intended to be as independent of implementation as practicable. There is no intent of inhibiting innovation. If application of new technologies are restricted by these criteria, the criteria may be reconsidered. In general, a change will be made if it is demonstrated that the new technology will result in an overall improvement in performance, or will provide an economic benefit with no significant degradation in overall service and performance.

Specific descriptions of possible designs contained in this document are given merely to provide a clear presentation of the proposed generic requirements.

The remainder of this document is organized as follows.

Section 2 describes the application of a DS1 Interface Connector in the network. It defines terminology that will be used throughout the document. There is a discussion about the Local Exchange Carrier cable facility the connector will interface with and a summarization of the criteria which characterize a DS1 Interface Connector. In addition, there is a general discussion on the methods of loopback activation and deactivation and the tradeoffs associated with the use of each. This section contains no requirements.

Section 3 provides in detail the criteria that describe required characteristics and necessary features.

Sections 4 through 8 provide a variety of miscellaneous requirements for the DS1 Interface Connector, including physical requirements, environmental requirements, electrical requirements and electrical safety, documentation and identification, and quality and reliability requirements.

In general, products shall be manufactured in accordance with the following: Federal Communications Commission (FCC) Requirements, National Electric Code Requirements, Underwriters Laboratories (UL) Requirements, Department of Labor – Occupational Safety and Health Standards (OSHA) (e.g., Part 1910[25]), other applicable Federal, State and local requirements including, but not limited to, statutes, rules, regulations, orders or ordinances, or otherwise imposed by law. Where requirements are not specified in this document, contractual technical requirements or other applicable documents, the manufacturer's requirements consistent with industry standards shall be met. Where published industrial standards contain a number of classes, the highest class (i.e., most stringent) is typically appropriate. The quality of commercially available materials, hardware, components, etc., used in the manufacture of products shall be such that product integrity is not compromised.

Questions regarding acceptability of industry standards, materials, hardware, components, etc., shall be resolved by written correspondence between the manufacturer and BST, or its designated representative, but such resolutions and interpretations shall not in any way relieve the manufacturer of either its responsibility to comply with standards or requirement imposed by law, or its ultimate responsibility for the design, safety, and performance of its products. The manufacturer shall perform further tests and employ more stringent requirements than those referred to in this document, to assure product safety and reliability, as necessitated by the product in issue and the conditions under which it is used.

Section 9 contains a list of references used in preparation of this document. Section 10 contains a glossary of terms.

2. DS1 INTERFACE CONNECTOR APPLICATION

2.1 General Description

The DS1 Interface Connector is a four−wire device intended for installation on the network side at the Network Interface (NI) (see Figure 1). The tip (T) and ring (R) leads transmit the signal from the Customer Installation (CI) to the Local Exchange Carrier (LEC). Throughout this document, this signal will be termed the CI signal and the transmission path will be termed side two. Similarly, the T1 and R1 leads transmit the signal from the LEC to the CI. This signal will be termed the LEC signal and the transmission path will be termed side one.

Throughout this document the connector may be identified as being in either the normal state or the maintenance state. The maintenance state is characterized by the connector looping the LEC signal from the side one transmission path back to the Local Exchange Carrier on the side two transmission path. This will cause the interruption of the transmission of the CI signal to the Local Exchange Carrier and the interruption of the transmission of the LEC signal to the Customer Installation. The only change in the signal will be regeneration that will occur when the connector has been optioned for it in the maintenance state. The physical path within the connector between the side one and side two conductors during the maintenance state shall be termed the looped transmission path. The normal state is characterized by the connector passing the LEC signal across the NI to the Customer Installation and passing the CI signal across the NI to the Local Exchange Carrier.

The most important requirement of the DS1 Interface Connector is signal loopback. This requirement provides a maintenance function to the Local Exchange Carrier for T1 transmission lines. The connector is essential for clearly sectionalizing troubles between the Local Exchange Carrier and Customer Installation, which includes customer cabling.

The connector is intended to enhance carrier maintenance operations and improve customer service. It in no way precludes functionality that might be located in the Customer Installation.

2.2 Discussion of Local Exchange Carrier Cable Facility

The predominant type of LEC exchange cable that the connector will connect to is nonloaded, staggered−twist polyethylene−insulated cable (PIC) or pulp−insulated cable. This cable has a capacitance ranging from 0.073 to 0.086 microfarads per mile and a nominal characteristic impedance of 100 ohms at 772 kHz.

However, embedded in the Local Exchange Carrier's plant is a small amount of Metropolitan Area Trunk (MAT) and Intercity and Outstate Trunk (ICOT) cable. This cable has a capacitance ranging from 0.052 to 0.072 microfarads per mile and nominal characteristic impedance of 120 ohms at 772 kHz.

2.3 The anticipated application of DS1 Connectors fall into two categories. One application is between BellSouth and a DS1 end−user. The other application is between BellSouth and other carriers (such as Interexchange carriers) where a small number of DS1 circuits are deployed at a location. This application is denoted the carrier−to−carrier application.

2.3.1 Connectors should be clearly designated, and easily identifiable, as appropriate for use at either end−user locations, or at carrier locations. Functions appropriate for the two applications are shown below:

Application	Function
Both	DC Isolation between the Local Exchange Carrier and the end−user.
Both	DC Power loop: Simplexed current applied on the side one conductors by the Local Exchange Carrier (LEC) will be looped back to the LEC on the side two conductors within the connector.
End−user	DC Power through: Simplexed current applied on the conductors by the Local Exchange Carrier is passed across the NI to the end−user.
Both	Signal Loopback: On command the connector must loop the LEC signal from the side one transmission path back to the Local Exchange Carrier on the side two transmission path. This will cause the interruption of the transmission of the CI signal to the Local Exchange Carrier and the interruption of the transmission of the LEC signal to the Customer Installation.
Both	Loopback Indication Signal: The connector must transmit a loopback indication signal to the CI on the side one transmission pair when the connector is in the maintenance state.
End−user	Signal Regeneration in the loopback path: The connector shall always provide a regenerator in the looped transmission path for regeneration of the LEC signal. This regenerator will meet line repeater requirements. The loopback command detector will use the regenerated LEC signal to determine if a loopback activation/deactivation command is present on the side one transmission path.
Carrier	Signal Regeneration in the side one path: The connector will provide a regenerator in the side one path. This generator will meet DSX−1 requirements. This regenerator will also be in the loopback path. The loopback command detector will use the regenerated LEC signal to determine if a loopback activation/deactivation command is present on the side one transmission path.
End−user	LBO in the loopback path: The connector will provide LBO in the loopback path.
Carrier	LBO in the side two path: The connector will provide LBO in the side two path. This LBO will also be in the loopback path.
End−user	Signal Limiters: The connectors will limit the peak voltage from the end−user to a selectable level appropriate for either 0, 7.5 or 15 dB of LBO implemented in the end−user's equipment. The signal limiter switch will be gang−switched with the LBO in the loopback path.

Figure 2 is a block diagram illustrating the necessary functions of a DS1 Interface Connector.

2.4 Discussion of Loopback Activation/Deactivation Methods

This discussion summarizes the loopback activation and deactivation methods and points out their tradeoffs. All criteria for the methods discussed in this section are presented in Section 3.7. The methods discussed are manual control, dc control, loopback activation/deactivation using framed, inband codes and loopback activation/deactivation using codes transmitted on the data link (DL) of the Extended Superframe Format (ESF)[1].

(a) **Manual Control:** A switch or locking button on the connector will be used for local activation of signal loopback. This method requires the dispatching of field forces to the location of the connector to activate and deactivate the loopback feature.

(b) **DC Control:** The application of voltage on a cable pair separate from the side one and side two transmission pairs will activate loopback. Removal of the voltage on this pair will deactivate loopback. This method requires that a cable pair be dedicated for the sole purpose of signal loopback activation/deactivation. This cable pair will only run from the serving Central Office (CO) to the connector.

(c) **Unframed and Framed Inband Codes:** The application on the side one transmission path of unframed and framed inband codes will cause loopback activation and deactivation. Unframed codes may severely limit the location in the network where remote loopback activation will be performed, because unframed codes will trigger alarms in equipment such as Digital Cross−Connect Systems (DCSs)[9]. Framed codes will not limit the location of remote loopback activation since they may be applied at any point in the network without triggering alarms. On the other hand, test sets that generate an unframed DS1 rate signal for application to cable pairs tend to be simpler in circuit complexity compared to test sets which generate framed DS1 rate signals.

Both inband methods use the 192 information bits of the DS1 frame to carry the loopback activation/deactivation codes. This use of inband codes violates Clear Channel Capability, which is the characteristic of a DS1 signal in which the 192 information bits (excluding the 193rd framing bit) can carry any combination of “ones” and “zeros”. This violation of Clear Channel Capability will not be appropriate for ISDN Primary Access.

(d) **ESF Data Link:** In Bellcore Technical Advisory TA−TSY−000754, entitled “ISDN Primary Rate Access, Transport System Requirements”[3], a new framing format, named ESF (Extended Superframe Format)[1], has been adopted for the LEC and CI signals. The Extended Superframe consists of 24 consecutive frames; each frame is a set of 192 information digit time slots preceded by a one digit time slot containing the Framing (F) bit, for a total of 193 digit time slots per frame. The 8 kbps F time slot is divided into a 2 kbps Framing Pattern Sequence (FPS), a 2 kbps Cyclic Redundancy Check (CRC) and a 4 kbps data link (DL). There are two formats defined for the transmission of signals over the data link; a bit−oriented format and a message−oriented format.

The 4 kbps ESF data link will be used to activate and deactivate the loopback function of the connector. The bit−oriented format will be used on the DL for the transmission of the loopback activation and deactivation sequences. A bit−oriented signal format overwrites any other signals on the data link with the loopback code sequences. The code sequences are received and processed by all network equipment between the remote application point of the loopback activation/deactivation code sequences and the connector.

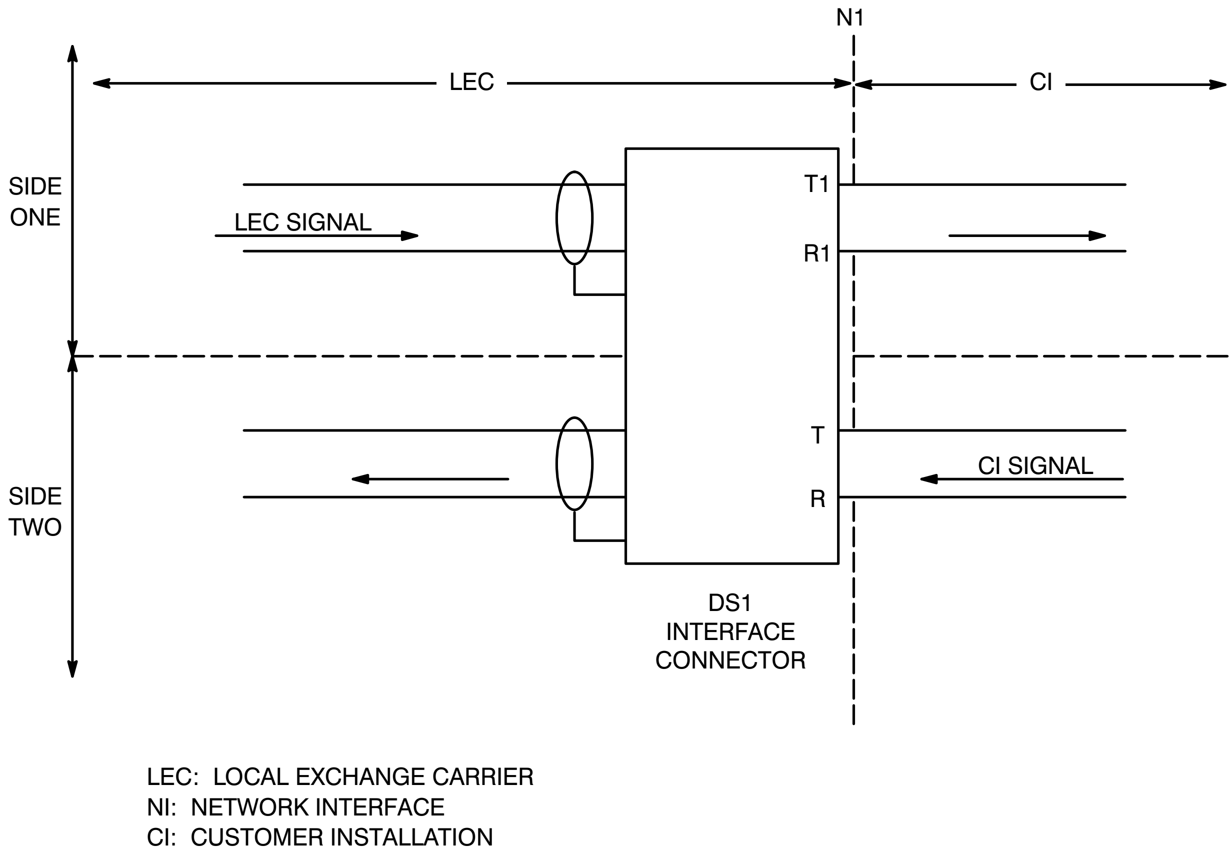
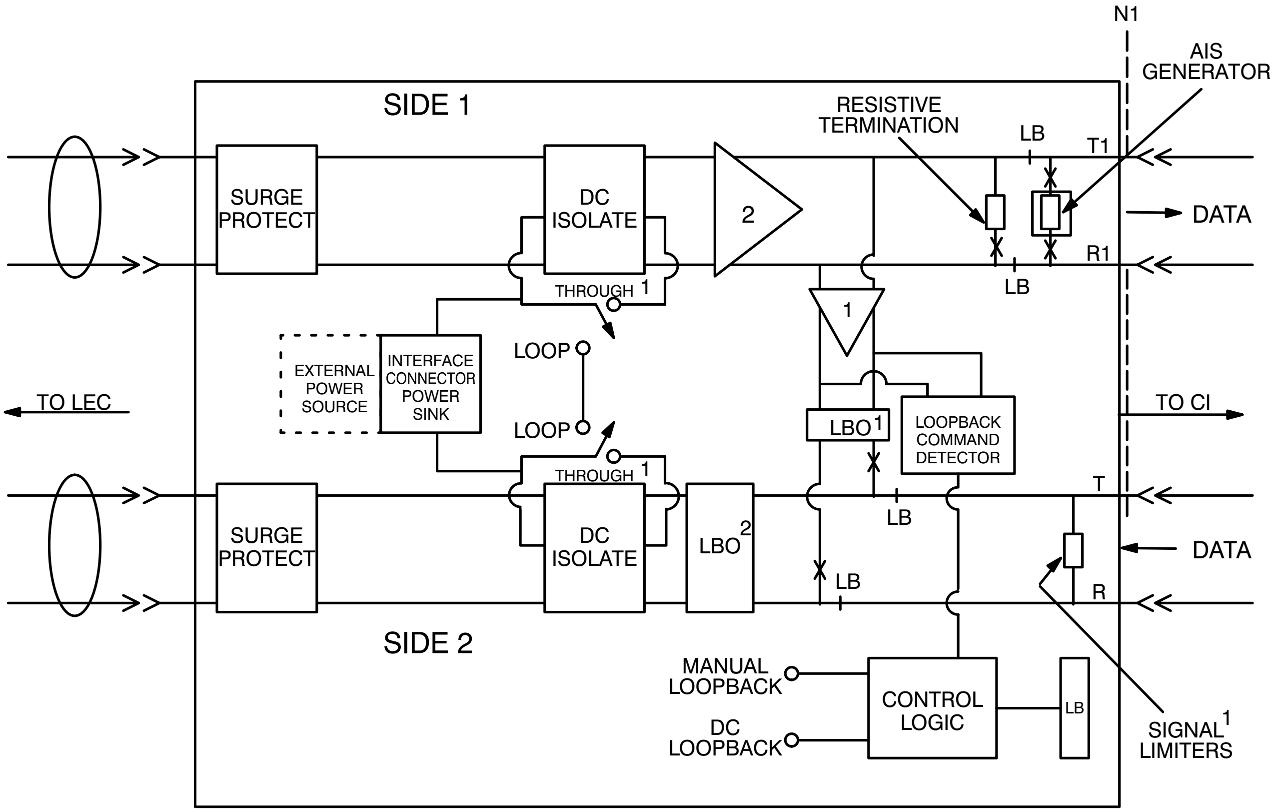


FIGURE 1 − DEPLOYMENT OF CONNECTOR AT THE NI



1 ONLY IN UNITS DESIGNED FOR END−USER APPLICATIONS

2 ONLY IN UNITS DESIGNED FOR CARRIER−TO−CARRIER APPLICATIONS

FIGURE 2 − DS1 INTERFACE CONNECTOR FUNCTIONS

3. DS1 INTERFACE CONNECTOR CRITERIA

3.1 Physical Interface to the LEC Cable and the CI

The physical interconnection between the Local Exchange Carrier cable facility and the connector is required to be a screwdown/hardwire connection. It shall be a secured connection, not easily accessed or removed by anyone other than a BST craftsperson.

The interconnection between the connector and the CI shall be via one of four Universal Service Ordering Code (USOC) plug and jack connectors: RJ48C, RJ48X, RJ48M, or RJ48H. These plug and jack connectors are shown in FCC Rules and Regulations, Subpart F of Part 68 supplemented by Public Notice 2526[8]. Figures 3, 4, 5, and 6 illustrate the pin configurations for the RJ48C, RJ48X, RJ48M, and RJ48H plugs and jacks respectively. It is anticipated that the RJ48M and RJ48H jacks will be used for multiple DS1 Interface Connector arrangements. The pin configurations of Figures 5 and 6 show that the RJ48H jack can accommodate a greater number of DS1 Interface Connectors in a multiple arrangement than the RJ48M jack.

3.2 Connector Powering

The connector shall be powered from one of three sources: the T1 span line, an external ac source, or an external dc source. Powering of the connector via an external (ac or dc) source is desired when the LEC DS1 cable facility is derived from a higher rate multiplexer (DS1/3). The higher rate multiplexer does not provide a simplex current source, making span line powering of the connector impossible.

3.2.1 Span Line Powering and Simplex Power Configurations

Span line powering is supplied from the office battery via the office repeater using a combination of ground and −48, −130, and +130 volt office battery. The various combinations of office battery and ground used by these line powering repeaters provide for power loop voltages of 48, 130, 178, and 260 volts. In the 201−type office repeater, the line current is manually set by means of a resistor and must be maintained within 130 to 150 mA. In the 206−, 221−, 231−, and 236−type office repeaters, the line current is held to nominal values by means of automatic line current regulators contained in the line powering repeaters. The range of regulated line currents is 141 mA +/− 2 mA for standard T1 lines and 60 mA +/− 3 mA for low power T1 lines.

The connector shall function properly when in the presence of voltages in the range of 48 to 260 volts and line currents in the range of 57 mA to 150 mA.

The total voltage drop of a DS1 Interface Connector shall be defined as the summation of the voltage drop across side one plus the voltage drop across side two. For a line current of 60 mA +/− 3 mA, the total voltage drop of the connector shall be less than or equal to 15.0 volts with the line build−out on side two set to 0 dB.

The connectors intended for end−user locations shall provide a power loop option for the transmission path of the simplex power applied by the Local Exchange Carrier on the conductors. The two configurations are designated as “loop” and “through” and are described as follows:

- Loop − When the loop configuration is selected, the simplex current applied on the side one conductors by the LEC shall be looped back to the LEC on the side two conductors within the connector. This configuration is shown in Figure 7.

- Through − When the through configuration is selected, the simplex current applied on the conductors by the LEC shall be passed across the NI to the Customer Installation. This configuration is shown in Figure 8.

From Technical Reference Pub 62411[2], the simplex resistance beyond the NI that will be powered by the span may range between a minimum of 0 ohms and a maximum of 1120 ohms. The resistance includes all components of the CI, including cabling. If the connector is selected to provide the through configuration, there is the possibility that the Customer Installation will present an open circuit to the connector, causing the Local Exchange Carrier span to lose power. As an option, the connector shall sense the open circuit condition of the CI. The connector must increase its voltage drop by an amount equal to the drop of the CI and loop the span power so the span remains powered. When the CI presents a termination to the connector and the open circuit condition ceases to exist, the connector shall revert to the through configuration.

3.2.2 AC Powered DS1 Interface Connector

If the interface connector is powered from an ac power source, it shall meet the criteria of this document with a voltage of 117 +/−12 volts ac with a frequency of 60 +/− 5 Hz. The supplier shall provide the minimum, maximum, and typical ac power and current requirements for the connector.

The supplier should contact BST to determine any requirements imposed on the DS1 Interface Connector by local electric codes.

3.2.3 External DC Powered DS1 Interface Connector

It is anticipated that external dc powered interface connectors will be used on DS1 facilities derived from higher rate multiplexers. Colocation of the multiplexer and the interface connectors in the field or on the customer's premises is expected to be the predominant situation. Requirements for external dc powering of the interface connector are based on requirements found in TR−TSY−000009[21] and TR−TSY−000057[22].

(a) **External DC Working Voltages**

The connector shall be powered from a nominal −48 Volt battery and shall meet the criteria of this document with a dc input voltage between −42.75 and −55 Volts dc. Transient conditions may occur where the voltage may reach −60 Volts dc for a time period $\leq$ 200 milliseconds.

The minimum magnitude negative voltage assumes a maximum voltage drop of 1 Volt (battery and return leads) between the external battery and the interface connector.

(b) **External DC Voltage Emergency Limits**

The connector shall not be damaged if the external dc voltage supplied to the connector is between 0 Volts dc and −56 Volts dc. Transient conditions may occur where the voltage may reach −60 Volts dc for a time period $\leq$ 200 milliseconds.

(c) **Power Source Noise**

The connector shall meet the criteria of this document when it is powered from a dc power system with:

(1) A voiceband noise component $\leq$ 56 dBrnc.

(2) A noise voltage $\leq$ 100 millivolts rms in any 3 kHz band between 10 kHz and 20 MHz.

(3) A peak−to−peak noise voltage $\leq$ 300 millivolts.

Any noise induced on the dc power system by the interface connector must be:

(1) $\leq (9 + 10 \log I)$ dBrnc (with respect to 600 ohms) in the voiceband,

(2) $\leq \sqrt{I}$ millivolts rms in any 3 kHz band between 10 kHz and 20 MHz,

(3) $\leq$ 250 millivolts peak−to−peak,

where I is the maximum current drain of the connector at any dc voltage input as specified in paragraph 3.2.3.(a).

(d) **Current Drains**

The supplier shall specify the minimum, maximum, and typical current drains for the dc power supply used by the interface connector.

3.3 Longitudinal Balance

The longitudinal balance of the connector shall be greater than 35 dB from 50 kHz to 1.5 MHz. The following test conditions apply:

(1) The longitudinal excitation signal is applied at the connector − LEC cable interface with the connector in the maintenance state.

(2) The longitudinal excitation signal is applied at the connector − LEC cable interface with the connector in the normal state.

(3) The longitudinal excitation signal is applied at the connector − CI interface with the connector in the normal state.

For each of the above test conditions (1, 2, and 3), the requirement shall be met with the connector in each of the following configurations:

(a) Loop power configuration, regenerated LEC signal applied to side two.

(b) Loop power configuration, LEC signal without regeneration applied to side two.

(c) Through power configuration, LEC signal without regenerated LEC signal applied to side two.

(d) Through power configuration, LEC signal without regeneration applied to side two.

3.4 Input Impedance

While the connector is in the normal state, the input impedance seen at any one part of the connector with the other three ports terminated in 100 ohm resistive loads shall be 100 ohms +/− 22 ohms at 772 kHz. Figure 9 shows the measurement arrangement for port A. All ports (A, B, C, and D) shall meet this input impedance requirement.

While the connector is in the maintenance state, the input impedance seen at any one port of the connector with the other three ports terminated in 100 ohm resistive loads shall be 100 ohms +/−22 ohms at 772 kHz. All ports (A, B, C, and D) shall meet this input impedance requirement.

As an option, the input impedance seen at any one port of the connector with the other three ports terminated in 120 ohm resistive loads shall be 120 ohms +/− 22 ohms at 772 kHz. All ports (A, B, C, and D) shall meet the input impedance requirement. The input impedance requirement shall be met when the connector is in the normal state and when the connector is in the maintenance state.

3.5 Insertion Loss

The insertion loss is defined as the ratio of the power measured at the NI before insertion of the connector to the power measured after insertion of the connector into the transmission path. The insertion loss shall be no greater than 1.0 dB at 772 kHz for side one and no greater than 1.0 dB at 772 kHz for side two with the selectable LBO on side two set to 0 dB.

3.6 Line Build−Out

A selectable LBO is required (see Section 2.3.1). Line build−out ranging from 0 dB to 22.5 dB loss at 772 kHz in steps of 7.5 dB (0.0, 7.5, 15.0, 22.5) shall be provided.

The LBO unit loss shall have a shaped frequency characteristic; a flat loss at all frequencies is not adequate. See Reference 8 for the required transfer function at the LBO.

3.7 Signal Loopback

The primary function of the connector is to provide to the Local Exchange Carrier the capability to remotely loop the side one and side two conductors at the NI. The connector is essential for clearly sectionalizing troubles between the Local Exchange Carrier and the Customer Installation. In the maintenance state the LEC signal on the side one path is looped back to the Local Exchange Carrier on the side two path. This causes the interruption of the transmission of the LEC signal to the Customer Installation and the interruption of the transmission of the CI signal to the Local Exchange Carrier.

Regardless of the method of loopback activation, it is required that a light−emitting diode (LED) or similar indicator be provided on the connector to indicate when the connector is in the maintenance state. When the connector is in the maintenance state, the indicator shall be on. When the connector is in the normal state, the indicator shall be extinguished.

3.7.1 Manual Control

The manual control method is a required method for loopback activation and deactivation. A switch or locking button shall be provided on the connector to be used for local activation by the field forces. The switch or locking button for the loopback function shall be marked clearly for this purpose so as not to be confused with other switches or locking buttons in the unit. If loopback has been activated in the connector by either the manual control method, the inband signal control method, or the ESF data link method, loopback deactivation by manual controls shall put the connector in the normal state.

3.7.2 ESF Data Link Control

The Extended Superframe Format is illustrated in Figure 12. This format provides a datalink that may be used to carry loopback commands. The connector shall be capable of optionally recognizing, and acting on, loopback activation and deactivation codes in the ESF datalink as defined in Ref. 28. When the ESF datalink option is employed, the connector shall comply wth Ref. 28 with regard to removing loopback.

3.7.3 Inband Signal Control

The inband signal control method is a required method of loopback activation and deactivation. Loopback activation and deactivation shall occur with the transmission of inband, framed or unframed, DS1 rate codes. The circuitry in the connector shall recognize both framed and unframed inband codes. The transmission on side one is interrupted and the loopback activation and deactivation code sequences are transmitted on the pair. Access to this pair is via a Digital Signal Cross−Connect (DSX−1) frame or a Digital Test Access Unit (DTAU)[19], both located in a remote facility.

When the code sequences are framed, the framing pattern (Superframe format) may overwrite a bit in the repetitive code pattern or may be inserted between bits in the repetitive code pattern. The overwriting of a code sequence bit by the framing bit (193rd bit) is shown in Figure 9. The insertion of the framing bit (193rd bit) between code sequence bits is shown in Figure 10. The loopback command detector will see errors in the code sequence caused by either technique (insertion or overwrite) for framing the code sequence in the Superframe format. This “known” error rate has been included in the error rate requirement for the detection of the loopback activate/deactivate codes. **It is not necessary for the loopback command detector to frame on the framing bit of the Superframe format.** The use of a framed, inband code is preferred when equipment such as a DCS intervenes between the point of application of the code sequence and the connector. Framed sequences will not trigger loss of frame alarms in equipment that needs a framed input such as DCS[9].

The following are the requirements for loopback activation and deactivation using framed or unframed inband codes.

Loopback Activation: The repetitive pulse pattern “11000” (2 in 5), applied to the side one transmission path, shall put the connector in the maintenance state. The connector shall not switch to the maintenance state until the loopback activation code sequence has been detected for at least five seconds. The connector shall switch to the maintenance state in less than or equal to six seconds after the loopback activation code sequence has been applied to the line. The connector shall detect the loopback activation code sequence if and only if an error rate of 1E−03 or less is present. This error rate includes logical errors and errors due to bipolar violations. The connector shall remain in the maintenance state when the code is removed.

Loop Deactivation: The repetitive pulse pattern “11100” (3 in 5), applied to the side one transmission path, shall put the connector in the normal state. The connector shall not switch to the normal state until the loopback deactivation code sequence has been detected for at least five seconds. The connector shall switch to the normal state in less than or equal to six seconds after the loopback deactivation code sequence has been applied to the line. The connector shall detect the loopback deactivation code sequence if and only if an error rate of 1E−03 or less is present. This error rate includes logical errors and errors due to bipolar violations. The connector shall remain in the normal state when the code is removed.

3.7.4 DC Control

As an **option**, an additional method, termed dc control, may be incorporated to activate the loopback function. If this option is provided, the following requirements shall be met.

The impedance of the connector in the dc loopback transmission path shall be 400 ohms.

The voltage applied to the dc loopback pair shall be from the standard nominal −48 Volt dc central office power system. This voltage may vary from −42.5 Volts dc to −52.5 Volts dc. The dc loopback circuit resistance is the sum of the dc loopback pair resistance and the connector impedance in the dc loopback path (400 ohms). The loop current on the dc loopback pair varies inversely with the dc loopback circuit resistance. The loop current applied to the dc loopback pair shall be a minimum of 20 mA for the maximum length dc loopback pair (1910 ohms loop resistance) and a minimum of 40 mA for a zero length dc loopback pair. The maximum current limits for the two loop lengths should not exceed 1.5 times the minimum values.

The maintenance state shall be activated when greater than 20 mA is received at the connector over a cable pair separate from the side one and side two LEC cable pairs. The normal state shall be activated when the current received at the connector over the cable pair is less than 5 mA.

The dc loopback detector of the connector shall meet the requirements of the following sections of this document: 6.1.1, 6.1.2, 6.1.5, 6.1.6, 6.1.7, and 6.2.

The physical interconnection between the dc cable pair and the connector is required to be a screw-down/hardwire connection. It shall be a secured connection, not easily accessed or removed by anyone other than a BST craftsperson.

3.8 Loopback Indication Signal Transmission to the CI

When the connector is put in the maintenance state, the connector shall transmit a loopback indication signal to the CI on the side one transmission pair. The time period between the interruption of the LEC signal at the NI to the application of the loopback indication signal on side one shall be less than 64 microseconds. This signal shall be transmitted for the duration of the time the connector is in the maintenance state. The loopback indication signal shall be removed from the pair when the connector is put in the normal state.

The loopback indication signal shall be an Alarm Indication Signal (AIS), an unframed “all−ones” signal, for either a Superframe Format DS1 Facility or an Extended Superframe Format DS1 Facility. It shall be applied to the side one transmission pair when the maintenance state is triggered by any one of the methods of Section 3.7.

The transmission of the AIS will cause the detecting DS1 terminal to switch to an appropriate out−of−service condition. In newer equipment, the detection of the AIS will cause alarm activation to be inhibited and, after a preset delay, an AIS status indication to be activated. For older DS1 terminal equipment, the transmission of the AIS signal downstream may cause alarms to be generated which may be misleading. For a DS1 terminal already in an out−of−service condition caused by the detection of a yellow signal, the transmission of the AIS across the NI ensures that the terminal remains “busied out”. Also, for newer equipment, the transition from the detection of the yellow signal to the AIS will inform the detecting DS1 terminal that maintenance activity (i.e., signal loopback) is being performed. In both cases the transmission of the AIS during signal loopback keeps downstream regenerators alive.

3.9 Signal Regeneration

The connector shall provide a regenerator in either the looped or through (see Section 2.3.1) transmission path for regeneration of the LEC signal (see Figure 2). The loopback command detector shall use the regenerated LEC signal to determine if a loopback activation/deactivation pulse pattern is present on the side one transmission path. The regenerator and loopback command detector shall present a high impedance to the side one transmission path so there is no interference with the LEC signal causing a degradation in service. Regeneration of the LEC signal shall not change the framing format or remove bipolar violations. The regenerator used in an end−user connector shall comply with repeaters in Bellcore Compatibility Bulletin CB−113, entitled “The Low Power T1 Line Repeater Compatibility Specification”[4].

The regenerator in a carrier−to−carrier connector shall provide a DSX−1 complaint output pulse, as described in Ref. 9.

3.10 Timing Jitter

Timing jitter is defined as the short term variations of the significant instances of a digital signal from their ideal positions in time, where short term implies phase oscillations of frequency greater than or equal to 10 Hz. (Significant instances include, for example, optimum sampling instances.)[7] Long term variations (where the variations are of a frequency less than 10 Hz) correspond to wander and are not addressed here.

The three principal means for characterizing individual digital equipments in terms of jitter are jitter tolerance (jitter accommodation), jitter transfer, and jitter generation.

3.10.1 Input Jitter Tolerance

Input jitter tolerance is defined as the maximum amplitude of sinusoidal jitter at a given jitter frequency which, when modulating the signal at a connector input port, results in no more than two errored seconds cumulative, where these errored seconds are integrated over successive 30−second measurement intervals, and the jitter amplitude is increased in each succeeding measurement interval.

The requirement on input jitter tolerance is specified in terms of compliance with the jitter mask of Figure 13. This mask represents a combination of points, each of which corresponds to a minimum amplitude of sinusoidal jitter at a given jitter frequency which, when modulating the signal at a connector input port, results in two or fewer errored seconds in a 30−second measurement interval. Testing of the connector to this template is necessary, but not sufficient, to ensure adequate tolerance to network jitter.

3.10.2 Jitter Transfer

The transfer of jitter through the connector is characterized by the relationship between the applied input jitter and the resulting output jitter as a function of frequency. The requirement for jitter transfer is specified in terms of a jitter transfer function, which is defined as the ratio of the output jitter spectrum to the applied (deterministic) input jitter spectrum. The requirement on jitter transfer is specified in terms of compliance with the jitter transfer function of Figure 14.

The requirements for input jitter tolerance and jitter transfer shall be met with the connector in each of the following test arrangements:

(1) With the connector in the maintenance state and a regenerated LEC signal applied to the side two transmission path, a jittered LEC signal is applied to port A (see Figure 9 for port designations) and the appropriate measurement (errored seconds or jitter in Unit Intervals (UIs)) is taken on port D.

(2) With the connector in the normal state and a regenerated LEC signal applied to the side one transmission path, a jittered LEC signal is applied to port A and the appropriate measurement (errored seconds or jitter in Unit Intervals) is taken on port B. This test arrangement makes sense if and only if the connector has the capability to apply a regenerated LEC signal onto the side one transmission path (see Section 3.9).

3.10.3 Jitter Generation

Jitter generation is defined as the process whereby jitter appears at the output port of the digital equipment in the absence of applied input jitter. Requirements on jitter generation are currently under study and will be provided at a later date.

3.11 Signal Limiting

Connectors intended for end−user applications shall provide signal limiting capability. The signal limiter shall be gang−switched with the LBO in the loopback path.

The signal limiter associated with 0 dB at LBO shall be null, i.e., no limiting is required. When the LBO is set to 7.5 dB, the signal limiter shall limit any CI signal (negative or positive) to a value between 1.2 and 1.5 volts. When the LBO is set to 15 dB, the signal limiter shall limit any CI signal (negative or positive) to a value between 0.6 and 0.75 volts. When the LBO is set to the 22.5 dB, the signal limiter shall limit any CI signal (negative or positive) to a value between 0.6 and 0.75 volts.

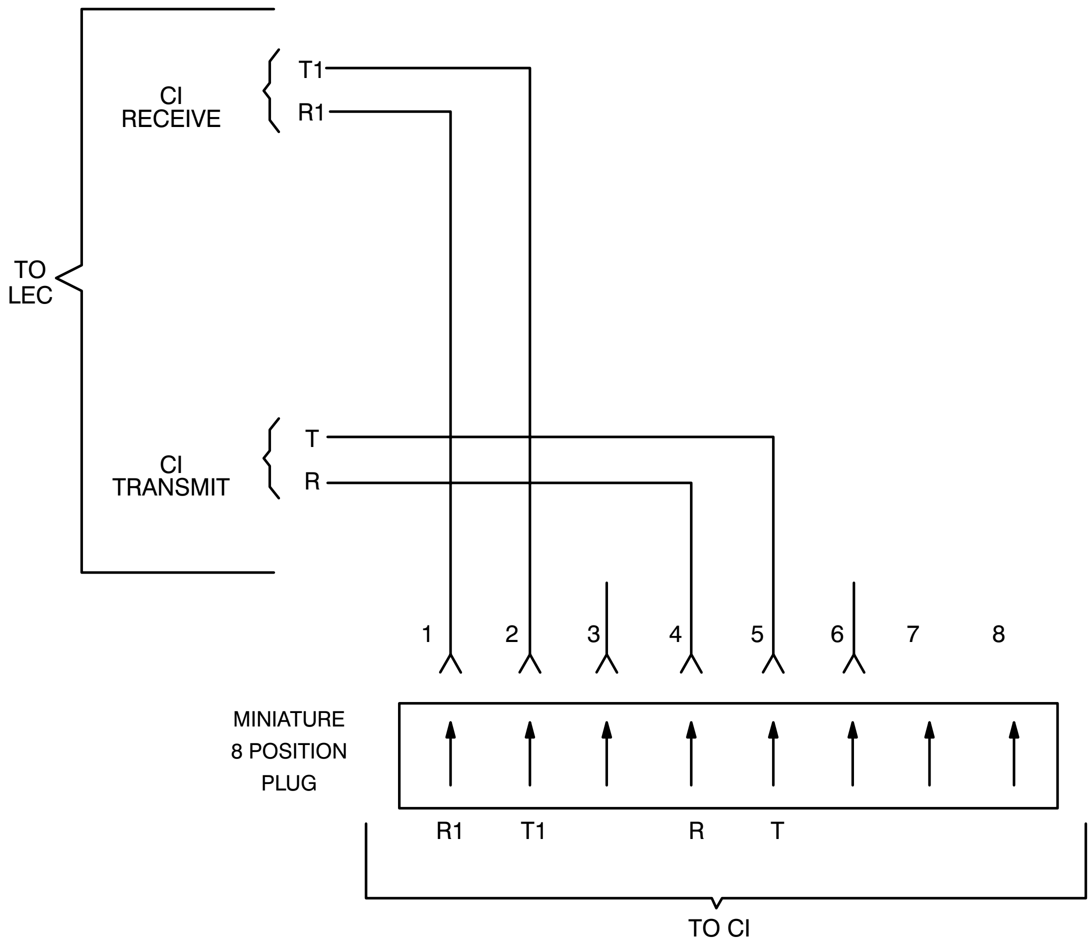
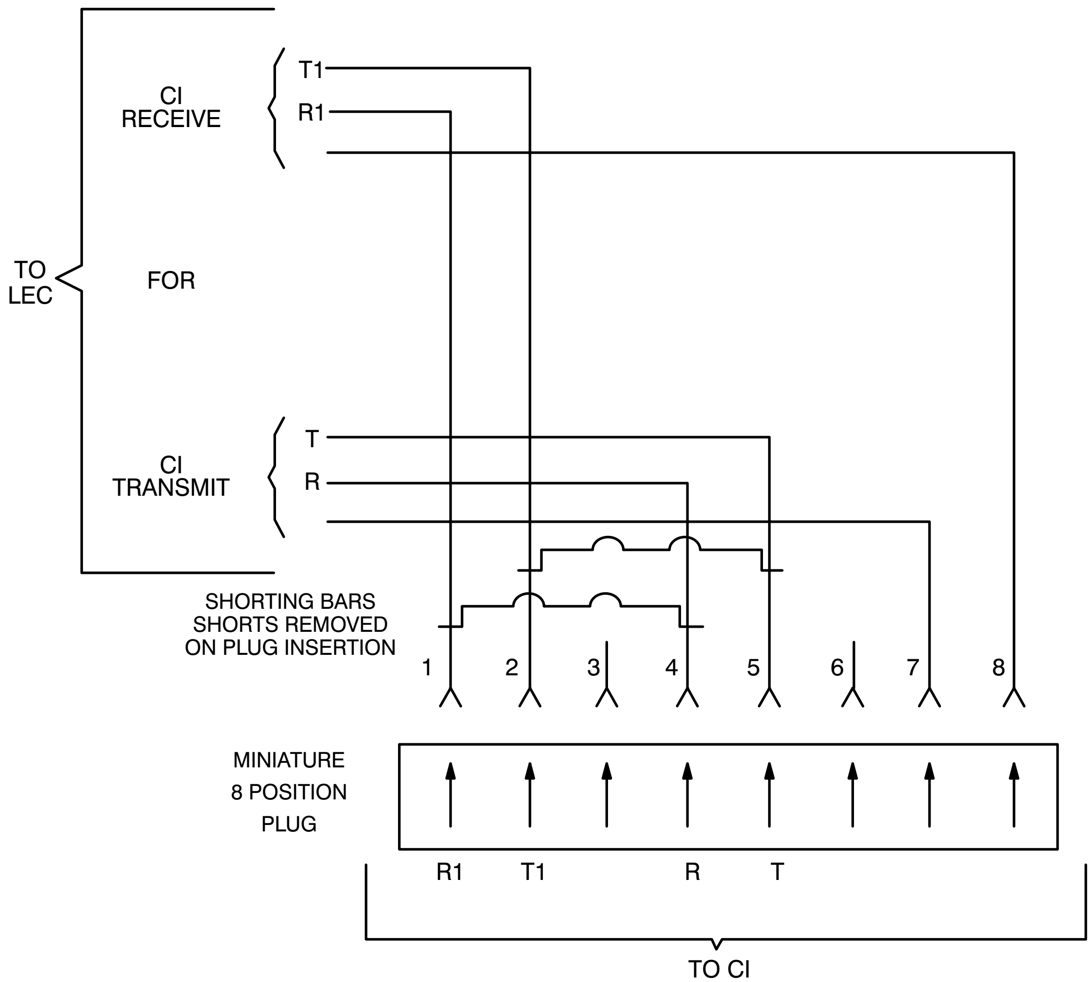
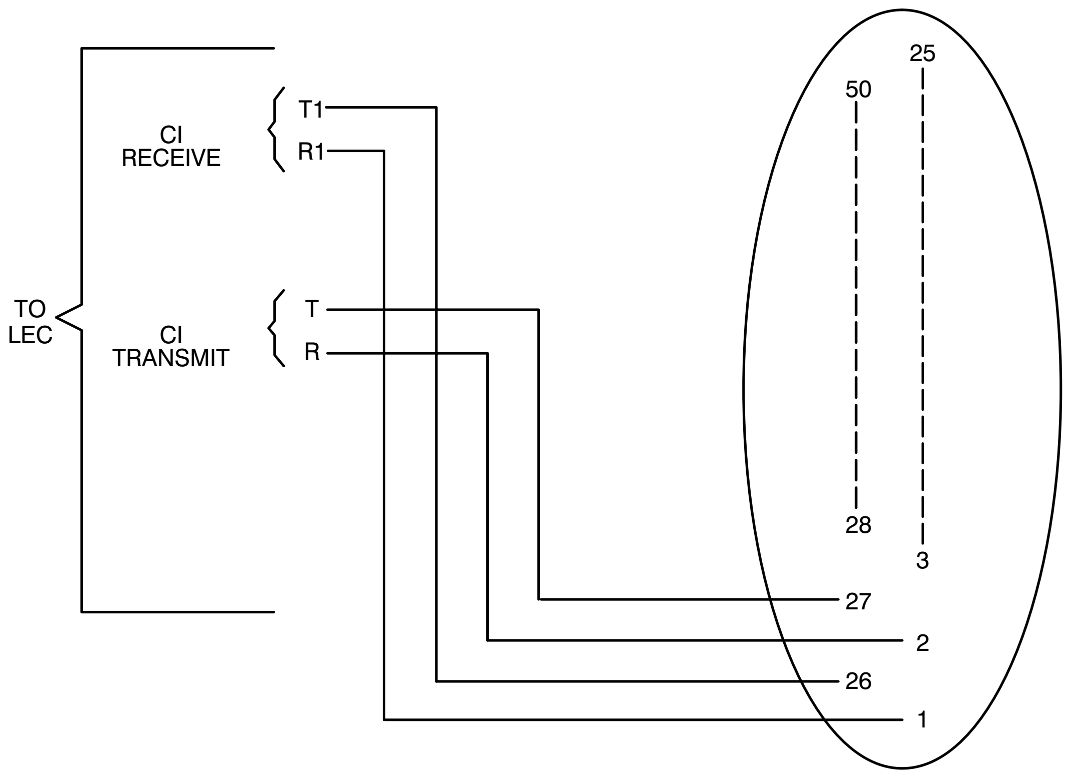


FIGURE 3 − CONNECTOR PIN ASSIGNMENTS RJ48C



Note: Shorting bars connect pin 1 to pin 4 (R1 to R) and pin 2 to pin 5 (T1 to T) hen plug is removed.

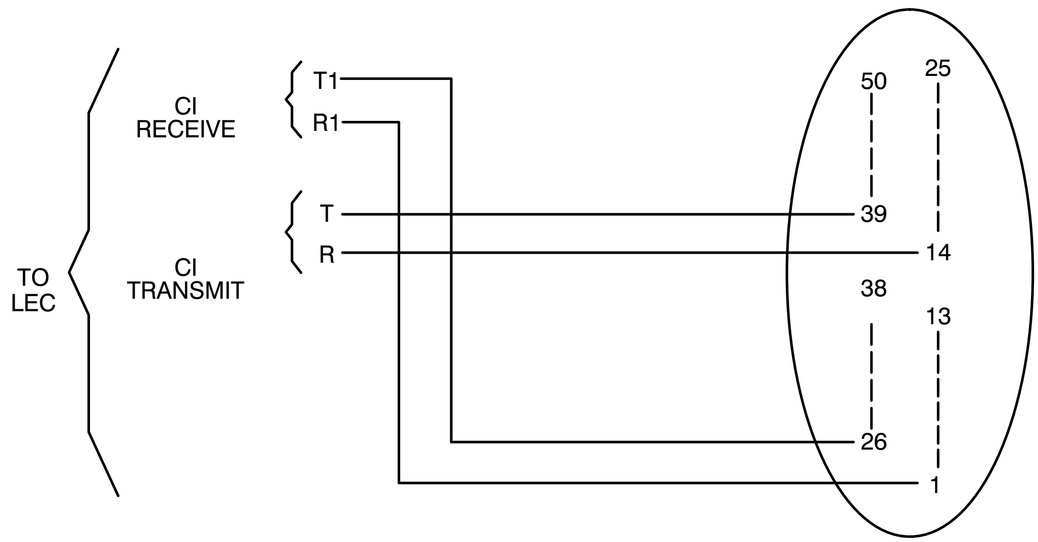
FIGURE 4 − CONNECTOR PIN ASSIGNMENTS RJ48X



POSITION

LINE	T1	R1	T	R
1	26	1	27	2
2	29	4	30	5
3	32	7	33	8
4	35	10	36	11
5	38	13	39	14
6	41	16	42	17
7	44	19	45	20
8	47	22	48	23

FIGURE 5 − CONNECTOR PIN ASSIGNMENTS RJ48M



POSITION

LINE	T1	R1	T	R
1	26	1	39	14
2	27	2	40	15
3	28	3	41	16
4	29	4	42	17
5	30	5	43	18
6	31	6	44	19
7	32	7	45	20
8	33	8	46	21
9	34	9	47	22
10	35	10	48	23
11	36	11	49	24
12	37	12	50	25

FIGURE 6 − CONNECTOR PIN ASSIGNMENTS RJ48H

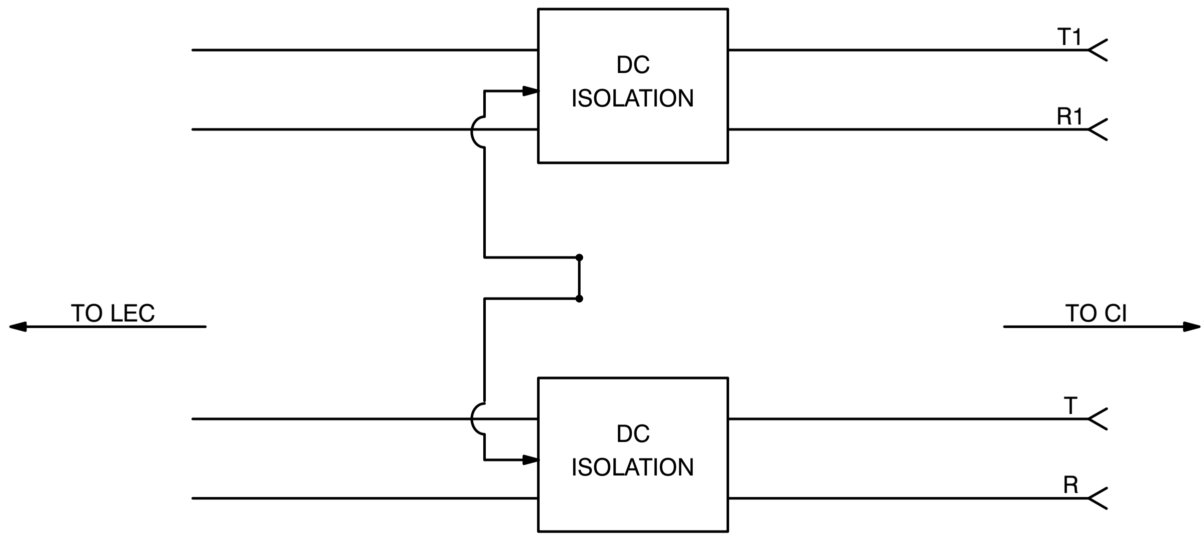


FIGURE 7 − LOOP POWER OPTION CONFIGURATION

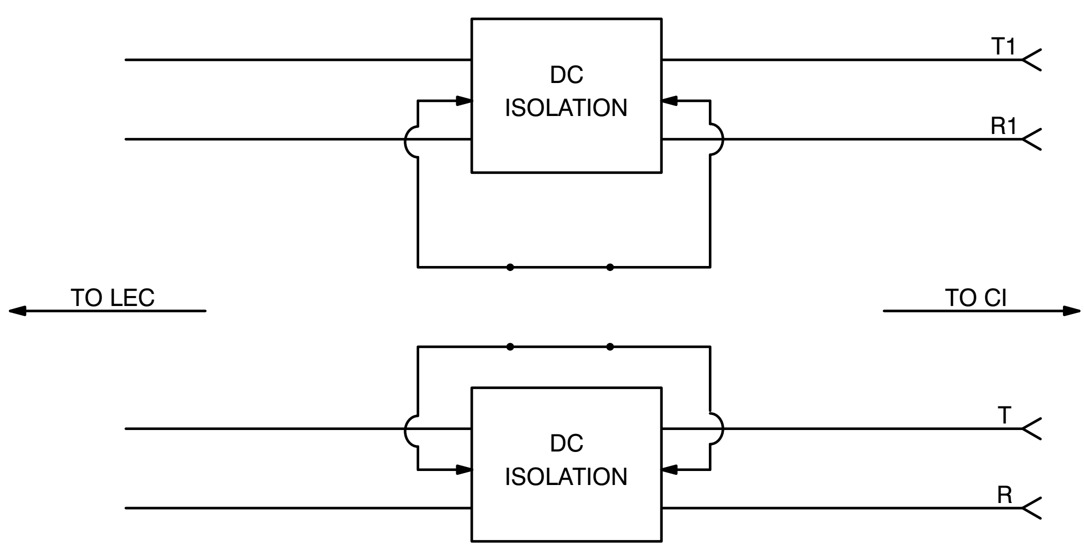


FIGURE 8 − THROUGH POWER OPTION CONFIGURATION

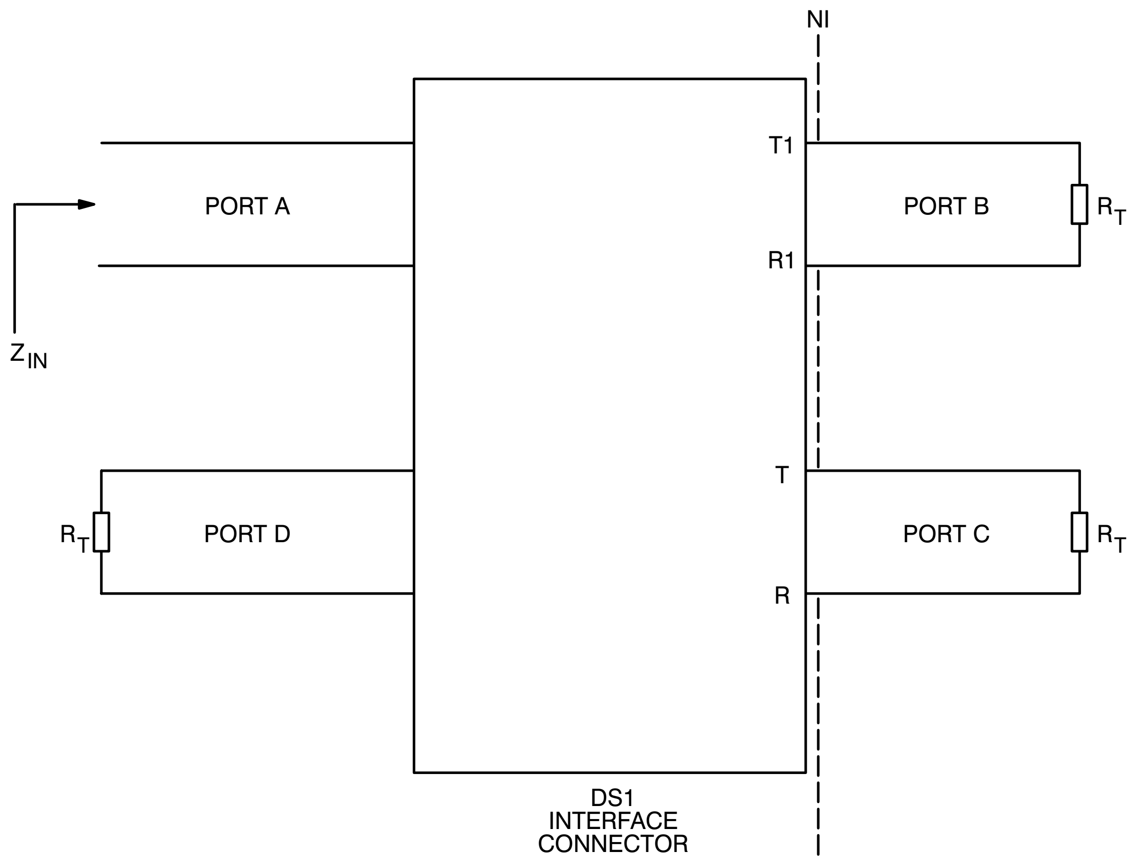


FIGURE 9 − INPUT IMPEDANCE REQUIREMENT−PORT DESIGNATIONS

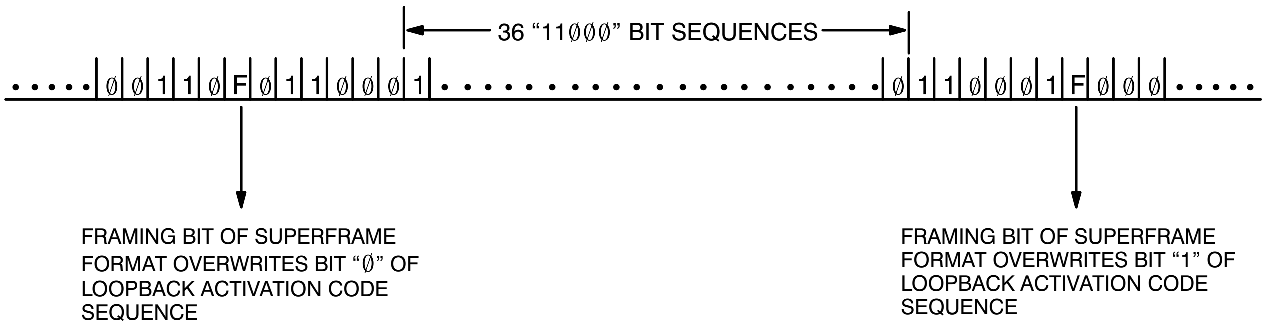


FIGURE 10 − OVERWRITE OF LOOPBACK CODE BIT BY FRAMING BIT

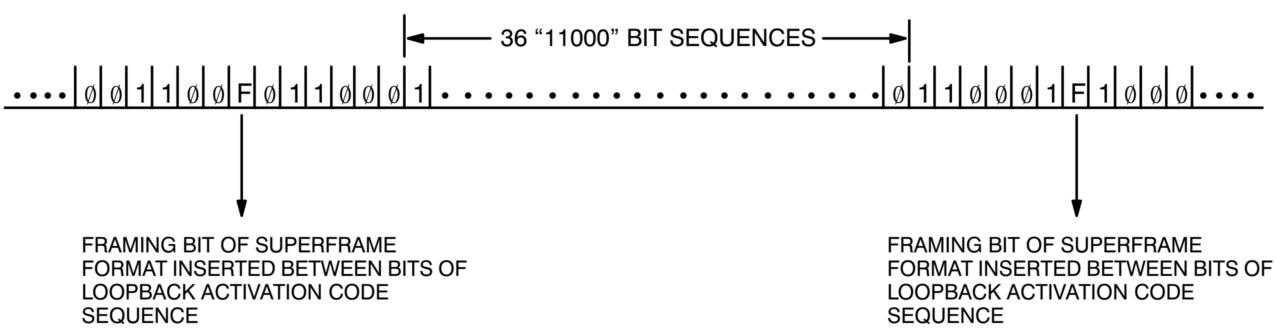


FIGURE 11 − INSERTION OF FRAMING BIT INTO LOOPBACK CODE SEQUENCE

FRAME NO	F BITS				BIT USE IN EACH TIME SLOT		SIGNALING BIT USE OPTIONS			
	BIT NO	FPS	DL	CRC	TRAFFIC	SIG	T	2	4	16
1	0	–	m	–	1–8	–				
2	193	–	–	C1	1–8	–				
3	386		m	–	1–8	–				
4	579	0	–	–	1–8	–				
5	772	–	m	–	1–8	–				
6	965	–	–	C2	1–7	8	–	A	A	A
7	1158	–	m	–	1–8	–				
8	1351	0	–	–	1–8	–				
9	1544	–	m	–	1–8	–				
10	1737	–	–	C3	1–8	–				
11	1930	–	m	–	1–8	–				
12	2123	1	–	–	1–7	8	–	A	B	B
13	2316	–	m	–	1–8	–				
14	2509	–	–	C4	1–8	–				
15	2702	–	m	–	1–8	–				
16	2895	0	–	–	1–8	–				
17	3088	–	m	–	1–8	–				
18	3281	–	–	C5	1–7	8	–	A	A	C
19	3474	–	m	–	1–8	–				
20	3667	1	–	–	1–8	–				
21	3860	–	m	–	1–8	–				
22	4053	–	–	C6	1–8	–				
23	4246	–	m	–	1–8	–				
24	4439	1	–	–	1–7	8	–	A	B	C

NOTES: **Frame 1 transmitted first.**
Frames 6, 12, 18 and 24 are denoted signaling frames.
FPS – Framing Pattern Sequence (...001011...)
DL – 4kb/s Data Link (Message Bits m)
CRC – CRC–6 Cyclic Redundancy Check (Bits C1–C6)
Option T – Traffic (Bit 8 not used for robbed–bit signaling)
Option 2 – 2–State Signaling (Channel A)
Option 4 – 4–State Signaling (Channels A and B)
Option 16 – 16–State Signaling (Channels A, B, C, and D)

FIGURE 12 – EXTENDED SUPERFRAME FORMAT

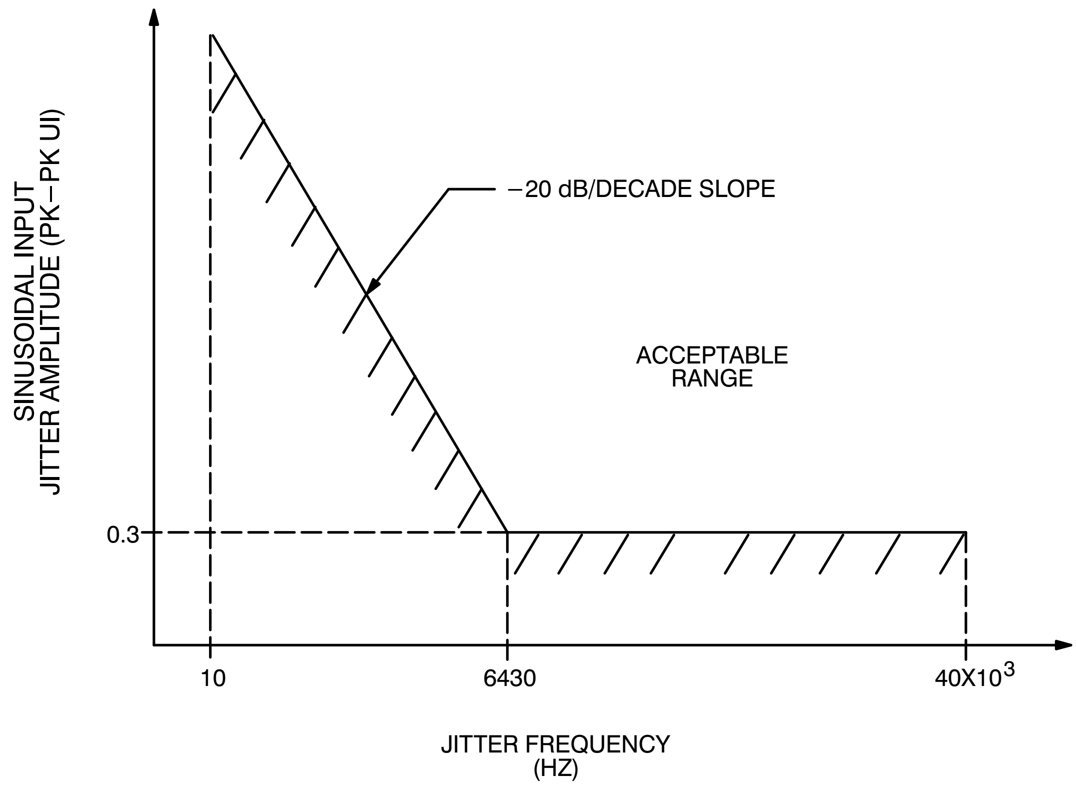


FIGURE 13 − DS1 SINUSOIDAL INPUT JITTER TOLERANCE

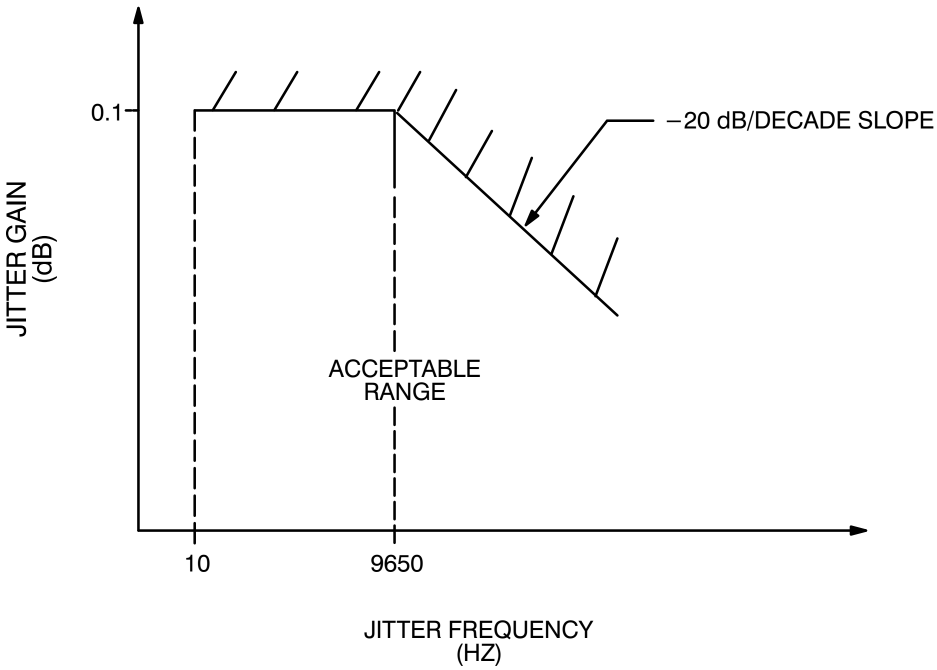


FIGURE 14 − DS1 JITTER TRANSFER FUNCTION

4. PHYSICAL REQUIREMENTS

4.1 Shock

The maximum shocks to the equipment occur in the nonoperating state and result from handling in commercial transportation, storage, and during installation. Shock design criteria are expressed as drop heights and are divided into two categories: criteria for unpackaged equipment and criteria for packaged equipment. The criteria for unpacked equipment represents the handling shocks incurred by the equipment during the unpackaging and installation at a location. The criteria for packaged equipment represents the handling shock input to the exterior of the shipping packages during commercial transportation. No equipment should sustain physical damage or degradation in functional performance when subjected to these shocks.

Packaged Equipment, Handling Drop Test: The handling drop test for packaged equipment consists of face and corner drops and may be conducted in the following manner:

1. The test should be performed on normally packaged equipment units. The packaged equipment should be capable of surviving a single drop on each face or corner from a drop height of 30 inches. For corner drops, the equipment should be oriented at impact such that a straight line drawn through the struck corner and package geometric center is approximately perpendicular to the impact surface.
2. The test should be performed on a smooth, level concrete floor (or similarly unyielding surface).
3. It may be possible to drop the equipment from a hand−held position. Where a lifting−release device is used, it should not, upon release, impart rotational or sideward forces to the equipment package.
4. The package is to be dropped within +/− 1 inch of the specified drop height.
5. One minute should be allowed between drops for the cushioning to recover its shape.
6. The vendor should decide the number of equipment units to be used to accomplish item 1. In some situations it may be necessary to use a single equipment unit for all test drops. In any case, if after a drop, the container/package is seen to be damaged, or the equipment unit is heard to be damaged, the testing should be halted. The physical designer should determine whatever action is necessary. This may involve replacing the shipping container, assessing required design improvements to the equipment unit, replacing the equipment unit, etc. If the shipping container is significantly damaged before three drops are completed, the packaging organization should be consulted. If such damage occurs after three drops, the container may be replaced before the remaining drops are completed. After the physical designer has taken the necessary action, the last completed drop should be repeated before the remaining drops are made.

Unpacked Equipment, Installation Drop Test: The installation handling drop tests for unpackaged equipment consists of free−fall drops and may be conducted in the following manner:

1. The test should be performed on an unpacked equipment unit. The equipment should be dropped once from a drop height of 4 inches on each possible rest face and the adjacent corners.
2. The test should be performed on a smooth, level concrete floor (or similarly unyielding surface).
3. It may be possible to drop the equipment from a hand−held position. Where a lifting−release device is used, it should not, upon release, impart rotational or sideward forces to the equipment package. For corner drops, the equipment should be oriented at impact such that a straight line drawn through the struck corner and equipment geometric center is approximately perpendicular to the impact surface.

4.2 Vibration

The equipment suffers maximum vibration in the non–operating, packaged condition, during commercial transportation. Figure 15 specifies the vibration environment that occurs in commercial transportation, including transport by rail, truck, ship and aircraft. The equipment should sustain no physical damage or degradation in functional performance when subjected to the vibration test conducted in the following manner:

1. The test should be performed once along each of the three mutually perpendicular axes of the equipment.

2. The packaged equipment should be mounted (resting on its normal shipping base or side) securely on the vibration machine.

3. The input acceleration should be mounted with a suitable transducer.

4. The package should be subjected to a single sine sweep, given in Figure 15, corresponding to its anticipated mode of transportation. The indicated frequency sweep may be performed continuously or sequentially, depending on the capability of the test facility. The upper frequency limit may be reduced to 60 Hz if packaging isolation occurs below this point.

4.3 Packaging and Shipping

The packing and packaging of connectors for shipment shall conform to the criteria of Bellcore Technical Reference TR–TSY–000081, "Packaging, Packing, Palletization and Marking Requirements"[16].

4.4 Materials

The following materials criteria are intended to help ensure that the connector will perform properly in the BST environment.

- All materials and processing shall be compatible so that the combinations employed do not cause corrosion or stress–cracking.

- Metals shall be resistant to and/or protected against corrosion, stress–cracking, and pitting.

- Current–carrying wire terminals and associated parts, such as nuts and washers, shall be made from brass, bronze, or equivalent copper alloys. Ferrous materials or aluminum shall not be employed.

- No silicone mole release agents shall be used.

Silver–plated or silver conductive materials shall not be used where there is a possibility of silver migration that could cause circuit malfunction, especially where these materials are separated by or associated with materials that can absorb moisture. Tin, zinc, or cadmium finished materials shall not be used when air surfaces could be close to electrical circuits and where filamentary metallic growth could cause short circuits resulting in circuit malfunctions.

4.5 Mechanical Safety – Construction

The following criteria are intended to help insure that the connector is constructed such that it is not hazardous to customers, installers, or repair technicians.

- The connector shall not have any sharp edges, corners, etc.

- The connector shall not have any pre–loaded springs or any elements that could be released during disassembly to become missiles.

- The connector shall be free of dust, dirt, solder splatters, bits of wire, and excessive grease and corrosion. Assembly welds, rivets, screws, etc., shall be secure.

4.6 Fire Resistance

Fire resistance requirements for all equipment materials, wire, and cable are contained in Section 4.3[12] of Bellcore Technical Reference TR–EOP–000063[26]. Components selected for use in assemblies shall be fire resistant when tested according to TA–TSY–000357[27], Section entitled “Flammability”[15].

It is the intention that no flammable parts (materials, wire and cable, and components that do not meet the requirements of the above paragraph) be contained in equipments. Should equipments contain such parts, then a list of all such flammable parts shall be supplied to BST, with the appropriate test data together with the exact volumetric distribution of said items in the product and their individual weights.

4.7 Electrical and Mechanical Integrity

The equipment’s electrical and mechanical integrity, as well as the inherent reliability of all its components and assemblies, shall be retained after exposure to all processes employed during manufacturing and assembly (e.g., handling, fluxing, soldering, and cleaning).

It is the responsibility of the manufacturer to satisfactorily demonstrate that each assembly and generic component type meets the requirements of the above paragraph. The demonstration shall include proof of the electrical and mechanical integrity and reliability of both components and assemblies upon exposure to an accelerating temperature and humidity ambient. The above data shall be made available to BST, upon request.

Where a novel or new technology is introduced by an equipment manufacturer, it is the responsibility of the manufacturer or demonstrate the inherent reliability of such technology by means of accelerated testing. A novel or new technology may be one that has not previously been used, one that has not previously been used in telecommunications, or one that has not previously been used by the particular equipment manufacturer. Reliability test data shall be made available to BST, upon request.

VIBRATION SOURCE	CURVE	FREQ RANGE Hz	SWEEP RATE OCTAVES MINI
COMMERCIAL TRANSPORTATION (RAIL, TRUCK, SHIP, JET AIRCRAFT)	1	5−100 100−500	0.1 0.25
COMMERCIAL TRANSPORTATION (RAIL, TRUCK, SHIP, JET, RECIPROCATING OR TURBOPROP)	2	5.50 50−500	0.1 0.25

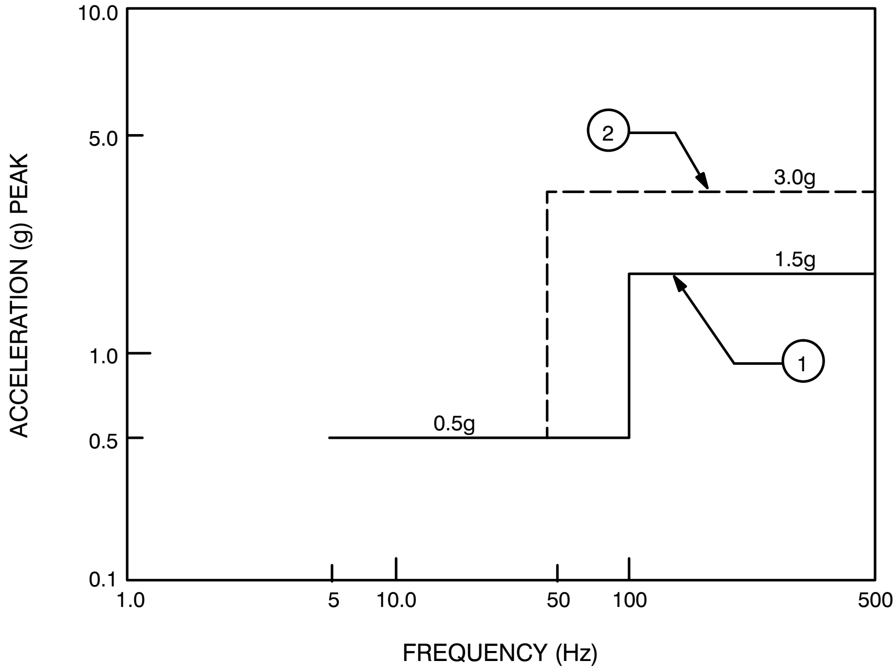


FIGURE 15 − TRANSPORTATION VIBRATION − PACKAGED EQUIPMENT

5. ENVIRONMENTAL REQUIREMENTS

The operating characteristics of the DS1 Interface Connector shall remain unchanged when exposed to extremes in temperature and humidity, as well as rapid changes in environmental conditions.

5.1 Operational Ambient

The NI will generally be located at a point inside the customer's building or complex in a location with no environmental control. Since the connector is located on the network side of the NI, the connector will be exposed to the same environment as the NI. For this case, the following requirements and objectives apply:

> The connector, when placed in an indoor environment with no environmental control, shall be capable of continuous operation at temperatures between 0°F (−18°C) and +120°F (+49°C) and relative humidities between 5 percent and 95 percent, except that above +84°F (+29°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 168 grains per pound of dry air (e.g., 34 percent relative humidity at +120°F (+49°C)). As an objective, the connector should operate properly from 0°F (−18°C) to +122°F (+50°C).

In some cases, however, it may be necessary to place the connector in a hostile environment in locations such as poles, pedestals or manholes. As an option, an environmental protective packaging may be used to permit flexibility of location. When the connector is placed in an outdoor environment, the following requirements and objectives apply:

> The connector, when placed in an outdoor environment, should be capable of continuous operation at temperatures between −30°F (−34°C) and +140°F (+60°C) and relative humidities between 5 percent and 95 percent, except that above +84°F (+29°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 168 grains per pound of dry air (e.g., 19 percent relative humidity at +140°F (+60°C)).

To demonstrate compliance with the above requirements, the connector is tested for continuous operation at the low temperature point, the high temperature, high specific humidity point and the high relative humidity, high specific humidity point. The connector is allowed to reach temperature stabilization in the specific temperature and humidity environment. Stabilization is defined as the condition in which a centrally located component of the connector does not change its temperature by more than 3.6°F (2°C) per hour. The connector is then soaked for 30 minutes or longer and checked for proper operation at the required temperature and humidity condition.

5.2 Storage and Transportation Environment

During transportation or in storage, the equipment may be exposed to extremes in ambient temperature and humidity. The equipment shall be operational after being subjected to cyclic variations and thermal shocks over the following limits:

Temperature:	−40°F through +140°F
Relative Humidity:	10% through 95% (maximum absolute humidity of 0.024 lb. or water per lb. of dry air)

The following test methods analyze the capability of equipment to withstand the temperature and humidity environments encountered during shipping and storage. These tests are all non−operational tests; however, appropriate electrical measurements should be made on equipment both before and after each test. These tests must be imposed on equipment in the packaged state. If, for some reason, this is not possible, at the discretion of BST these tests may be conducted on equipment in the unpackaged state.

High–Temperature Thermal Shock

This test may be performed as follows:

1. The thermocouples should be mounted at appropriate points in the equipment in order to determine the point in time at which the equipment temperatures are stabilized.
2. Initial electrical measurements should be performed prior to testing. The equipment should not be operated during test.
3. Chamber ambient temperature and RH (Relative Humidity) should be continuously monitored during the test.
4. The chamber ambient temperature should be increased according to Figure 16, at a rate of approximately 30°F/hour to 150°F with a RH of approximately 10%.
5. The above conditions should be maintained until the rate of change of equipment temperature is less than 2°F/hour.
6. The thermal shock should be administered by decreasing the chamber temperature from 150°F to room temperature (70°F) in five minutes or less.
7. 70°F should be maintained until equipment temperatures have again stabilized.
8. Pretest electrical measurements should be repeated.

Low–Temperature Thermal Shock

This test may be performed as follows:

1. Items 1 through 3 of the **High–Temperature Thermal Shock** test should be repeated.
2. The chamber ambient temperature should be decreased according to Figure 17, at a rate of approximately 30°F/hour to −40°F while maintaining a RH as low as possible.
3. The above conditions should be maintained until the rate of change of equipment temperature is less than 2°F/hour.
4. The thermal shock should be administered by increasing the chamber temperature from −40°F to room temperature (70°F) in five minutes or less.
5. 70°F should be maintained until equipment temperatures have again stabilized.
6. Pretest electrical measurements should be repeated.

Cyclic Temperature–High Relative Humidity

This test may be performed as follows:

1. Items 1 through 3 of the **High–Temperature Thermal Shock** test should be repeated.
2. Starting from room temperature (70°F), the temperature should be raised, according to Figure 18, at a rate of approximately 25°F/hour to 82°F, maintaining a RH approximately 95%. It should be maintained until the rate of change of equipment temperature is less than 2°F/hour.
3. Chamber ambient temperature should be decreased at a rate of approximately 7°F/hour to a temperature of 30°F, maintaining a RH of approximately 95%.

4. The above conditions should be maintained until the rate of change of equipment temperature is less than 2°F/hour.

5. Chamber ambient temperature should be increased at a rate of approximately 25°F/hour, maintaining a RH of approximately 95%.

6. This test cycle should be repeated three times.

7. Pretest electrical measurements should be repeated.

Cyclic Temperature−Low Relative Humidity

This test may be performed as follows:

1. Items 1 through 3 of the **High−Temperature Thermal Shock** test should be repeated.

2. Starting from room temperature (70°F), the temperature should be raised, according to Figure 19, at a rate of approximately 25°F/hour to 150°F, maintaining a RH of approximately 10%.

3. 150°F at 10% RH should be maintained until the rate of change of equipment temperature is less than 2°F/hour.

4. Chamber ambient temperature should be decreased at a rate of approximately 7°F/hour to a temperature of −40°F, maintaining a RH of approximately 10% (facility permitting).

5. A temperature of −40°F should be maintained until the rate of change of equipment temperature is less than 2°F/hour.

6. Chamber ambient temperature should be increased at a rate of approximately 25°F/hour, maintaining a RH of approximately 10%.

7. This test cycle should be repeated three times.

8. Pretest electrical measurements should be repeated.

5.3 Altitude

The connector shall remain operational when installed at locations from 200 ft. below sea level to 10,000 ft. above sea level.

5.4 Fungus Resistance

Under conditions of high temperature and humidity, fungus shall not develop on organic materials that can cause embrittlement and lead to loss of insulation resistance. The use of materials that require fungicide treatment to meet the criteria is prohibited. The connector shall be tested in accordance with the American Society of Testing Materials Standard, ASTM G−21 “Determining Resistance of Synthetic Polymeric Materials to Fungi”[11]. A “0” rating is required.

5.5 Airborne Contaminants

The connector shall be designed to operate satisfactorily in environments with the average yearly levels of contamination listed below. These average yearly levels (the constantly varying level averaged over one year to a single value) exceed representative values by a margin deemed adequate to ensure connector performance, and at the same time are not overly conservative.

Contaminant	Annual Avg. Concentration

Particulate Matter	185 ug/m^3
Nitrate Particulate Matter	12 ug/m^3
Total Hydrocarbons	10 ppm
Sulphur Dioxide	50 ppb
Oxides of Nitrogen	300 ppb
Photochemical Oxidants	50 ppb
Hydrogen Sulfide	10 ppb
Gaseous Chloride	10 ppb

In this table, ug/m^3 stands for micrograms per cubic meter of ambient air and ppm and ppb stand for parts per million and parts per billion of ambient air, respectively.

5.6 60 HZ Induction, Connector−LEC Cable Interface

The connector shall operate properly with up to 100 Vrms 60 Hz (and corresponding odd harmonics of 60 Hz[10]) applied from an induction test source to the digital lines connected to the connector−LEC cable facility interface. The induction test source must permit a short circuit longitudinal current of at least 100 mA rms (50 mA rms per conductor) when the digital line conductors are shorted and grounded at the connector−LEC cable facility interface under test.

5.7 Electromagnetic Interference

Section 15.1 of the LATA Switching Systems Generic Requirements (LSSGR TR−TSY−000064)[20] provides the Electromagnetic Compatibility (EMC) requirements and objectives and the associated measurement procedures for switching systems. However, the emission and immunity requirements and objectives of TR−TSY−000064 are applicable to the DS1 Interface Connector. These EMC requirements and objectives are established so that the following goals may be accomplished:

(1) A DS1 Interface Connector complies with the specifications of Subpart J of Part 15 of the Federal Communications Commission (FCC) rules.

(2) A DS1 Interface Connector has intrasystem EMC.

(3) Intersystem EMC exists between a DS1 Interface Connector and other electronic equipment in the surrounding environment.

The requirements contained in Section 15.1 of the LSSGR include limits on radiated and conducted noise emissions from a system and levels of radiated and conducted noise to which the system should be immune. Uniform methods of measurement of the emission and immunity levels are also covered.

Compliance with the emission and immunity requirements and objectives of Section 15.1 of the LSSGR should be demonstrated. In the case where the DS1 Interface Connector is considered a Class B computing device, the appropriate emission limits in Subpart J of part 15 of the FCC Rules apply. See FCC Part 15, Subpart A, Section 15.4−p of Chapter 1 of Title 47 of the Code of Federal Regulations of definition of “Class B computing device”.

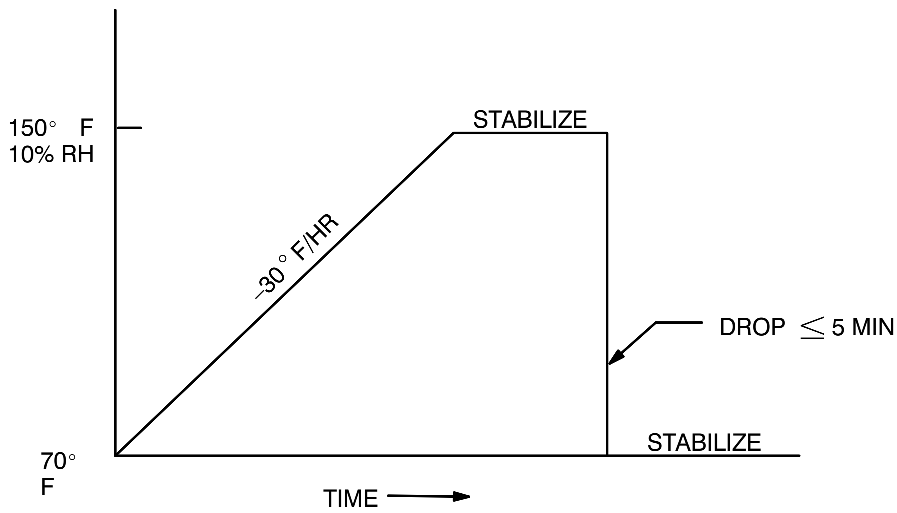


FIGURE 16 − HIGH TEMPERATURE THERMAL SHOCK TEST

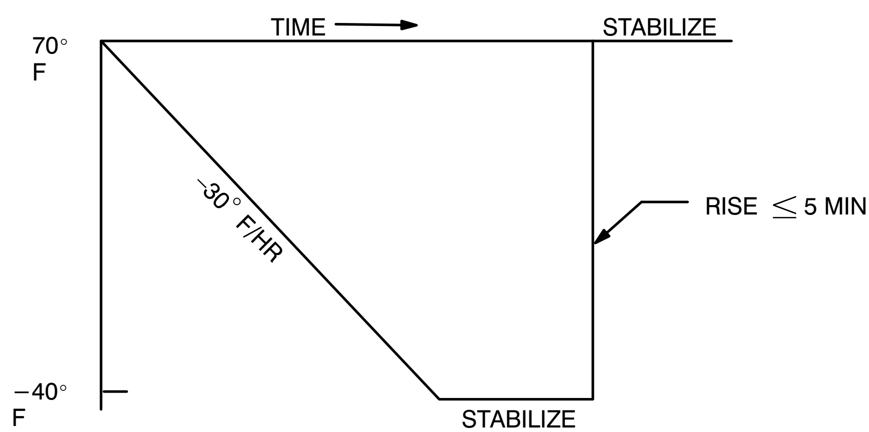


FIGURE 17 − LOW TEMPERATURE THERMAL SHOCK TEST

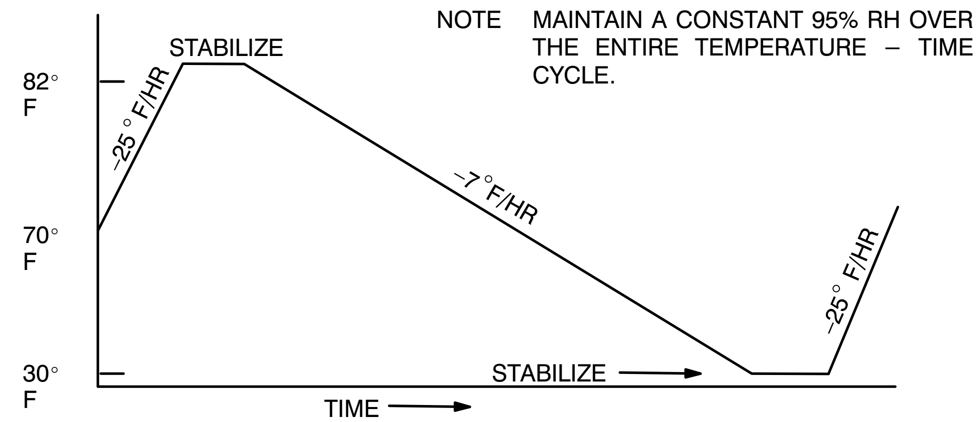


FIGURE 18 – HIGH HUMIDITY–CYCLIC TEMPERATURE TEST

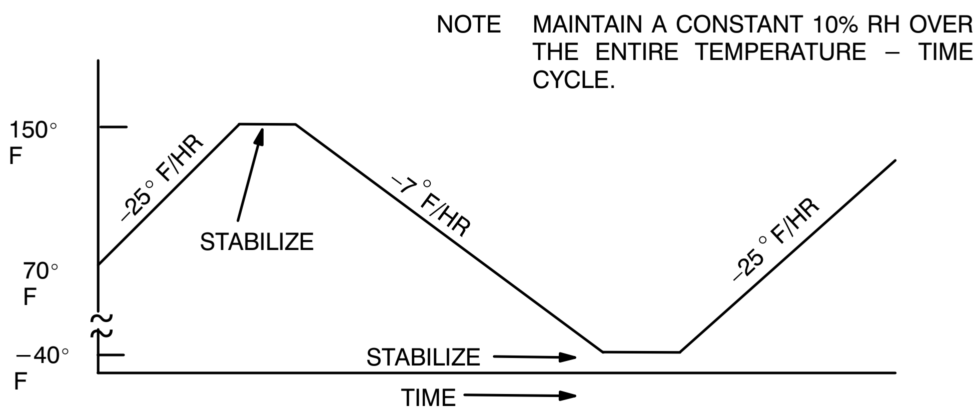


FIGURE 19 – LOW HUMIDITY–CYCLIC TEMPERATURE TEST

6. ELECTRICAL REQUIREMENTS AND ELECTRICAL SAFETY

Throughout Section 6, any reference made to T, R, T1 and R1 leads applies to the connector−LEC four wire interface. This is contrary to the naming convention used in previous sections where the T, R, T1, and R1 lead designations applied to the connector−CI interface. The referencing of lead designations to the connector−LEC four wire interface shall be used in this section and this section only.

6.1 Electrical Protection

Outside plant cable pairs entering the customer premises may be exposed to electrical surges resulting from lightning and commercial power system disturbances. Despite the presence of protective devices at the customer location, some of these disturbances are impressed on the connector. The connector shall withstand certain surges without damage and shall fail in a safe manner under infrequent stress. The following is the lightning and power exposure electrical protection criteria that the connector shall meet.

Table 6−1 defines two sets of electrical protection connections which will be referred to in defining the criteria of this section.

Table 6−1
Test Connections

Test Connections	Stress Applied to: Two−Wire Interface (dc loopback detector only)	Stress Applied to: Four−Wire Interfaces
A	1. Tip to Grd, Ring Grounded 2. Ring to Grd, Tip Grounded 3. Tip to Grd, Ring to Grd, Simultaneously	1, Applied to each lead (T, R, T1, R1) with other three leads grounded 2. T and R to ground, T1 and R1 grounded 3. T1 and R1 to ground, T and R grounded
B	1. Tip to Grd, Ring to Grd, Simultaneously	1. T, R, T1 and R1 simultaneously to ground

The following notes apply to Tables 6−2 through 6−5

1. Peak voltage is the minimum peak open circuit voltage of the surge source.

2. Peak current is the minimum peak current that the surge source can deliver into a short circuit. The value in the table is current per conductor. If a surge is applied between ground and N conductors, the current value in the table must be multiplied by N for 1 <= N <= 4. For N greater than 4, the current value should be multiplied by 4.

3. The first number in the waveform column is the maximum risetime of the surge. This rise time is the time interval between the 10% of peak and 90% of peak points on the leading edge multiplied by 1.25 (see TR−EOP−000001[10], page 4).

4. The second number in the waveform column is the minimum decay time of the surge. Decay time is the time interval between the 10% of peak point on the leading edge and the 50% of peak point on the trailing edge (see TR−EOP−000001[10], page 4).

6.1.1 First Level Lightning Tests

The connector shall not be damaged and shall operate properly after the application of Surges 1 and 2 or Surge 3 of Table 6−2. If Surge 3 is used, Surges 1 and 2 do not have to be applied. The tests shall be performed with the connector in operating condition and with the connector in the normal state and the maintenance state. These tests shall be performed with all primary lightning protection removed. The surges shall be applied to the A test connections of Table 6−1. The first level tests shall be performed under two conditions: once with all leads that may be connected to cable pairs terminated as they would be in normal service, and once with all other leads grounded. The surges shall be applied to all connector leads that may be connected to outside plant cable pairs.

As an objective, the connector should not be damaged and should operate properly after the application of Surge 4 of Table 6−2. The surge should be applied to the B Test Connections of Table 6−1.

Table 6−2
First Level Surge Tests

Surge	Peak Voltage (Volts)	Waveshape (microseconds)	Peak Current (Amperes)	Repetitions Each Polarity
1	+/−600	10/1000	100	50
2	+/−1000	10/360	100	50
3	+/−1000	10/1000	100	50
4	+/−2500	2/10	500	10

6.1.2 Second Level Lightning Tests

The connector shall not become a fire, safety or electrical shock hazard after application of the second level surges of Table 6−3. Surge 1 in this table shall be applied to the A Test Connections of Table 6−1. Surge 2 shall be applied to the B Test Connections of Table 6−1. The surges shall be applied to the same leads and under the same conditions as specified for the first level tests.

Table 6−3
Second Level Surge Tests

Surge	Peak Voltage (Volts)	Waveshape (microseconds)	Peak Current (Amperes)	Repetitions Each Polarity
1	+/−1000	10/2500	200	10
2	+/−5000	2/10	500	1

The tests in Sections 6.1.3 and 6.1.4 apply only to DS1 Interface Connectors that are externally ac powered.

6.1.3 DS1 Interface Connector AC Power Connections − First Level Lightning Tests

The connector shall not be damaged and shall meet the criteria of this document after the surge of Table 6−4 is applied to the commercial ac power connection. The surge shall be applied to both locations specified below:

(a) Between the phase conductor and neutral conductor, with the green−wire ground of the connector to the neutral conductor.

(b) Between the neutral conductor and phase conductor, with the green−wire ground of the connector connected to the phase conductor.

Table 6−4
First Level Surge Test

Surge	Peak Voltage (Volts)	Waveshape (microseconds)	Peak Current (Amperes)	Repetitions Each Polarity
1	+/−2500	2/10	1000	4

6.1.4 DS1 Interface Connector AC Power Connections – Second Level Lightning Tests

The connector shall not become a fire, safety, or electrical shock hazard after the application of the surge of Table 6–5. The surge shall be applied to the same connections specified for the first level lightning tests for the connector ac power connections.

Table 6–5
Second Level Surge Test

Surge	Peak Voltage (Volts)	Waveshape (microseconds)	Peak Current (Amperes)	Repetitions Each Polarity
1	+/–5000	2/10	1000	1

6.1.5 First Level Power Exposure Tests

The connector shall not be damaged and shall operate properly after the application of AC Test 1 of Table 6–6. These first level tests shall be performed under two conditions: once with all leads that may be connected to cable pairs terminated as they would be in normal service, and once with all leads grounded. The test shall be applied to all connector leads that may be connected to outside plant cable pairs.

An an objective, the connector shall not be damaged and shall operate properly after the application of AC Tests 2 through 5 of Table 6–6. These tests are applied to the same leads and under the same conditions specified above.

Table 6–6
First Level AC Tests

<table>
<tr><th>AC Test</th><th>60 Hz Voltage (Volts rms)</th><th>Resistance Per Line Conductor (ohms)</th><th>Duration</th><th>Primary Protectors</th><th>Applied To</th></tr>
<tr><td>1
2
3</td><td>0–50
50–100
100–600</td><td>150
600
600</td><td>15 min.
15 min.
60, 1 sec. applications</td><td>Removed
Removed
Removed</td><td>A Test Connections Table 6–1</td></tr>
<tr><td>4</td><td>1000</td><td>1000</td><td>60, 1 sec. applications</td><td>Operative Protector In Place</td><td rowspan="2">B Test Connections Table 6–1 Figure 20</td></tr>
<tr><td>5</td><td colspan="2">See Figure 20</td><td>60, 5 sec. applications</td><td>Removed</td></tr>
</table>

6.1.6 Second Level Power Exposure Tests

The connector shall not become a fire, safety or electrical shock hazard after application of the Second Level AC Tests of Table 6−7. The tests shall be applied to the same leads and under the same conditions as specified for the First Level AC Tests. The primary protectors shall be removed. If the supplier specifies that fuses or heat coils must be used on a lead, they may be installed on that lead during these tests.

Table 6−6
Second Level AC Tests

AC Test	Test For	60 Hz Voltage (Volts rms)	Source Resistance (ohms)	Duration	Applied To
1	Secondary Power Contact	0−300	<= 3	15 min.	
2	Primary Power Contact	300−600	<= 3	5 sec.	A Test Connections Table 6−1
3	Fault Induction	0−600	600 per conductor	15 min.	
4	High Impedance Induction	See Figure 20		15 min.	Figure 20

6.1.7 Second Level Power Exposure Tests for Customer Premises Mounted Interface Connector

The connector shall not become a fire hazard when it is tested in accordance to the criteria in this section. Untreated cotton cheesecloth, wrapped around the mounting or case, must be used as an indicator to determine if a fire hazard exists. A fire hazard is defined as the existence of temperatures, sparks or flame sufficient to (a) cause ignition or charring of untreated cotton cheesecloth used as an indicator, (b) produce harmful quantities of toxic fumes, or (c) cause the escape of molten material which can ignite or char untreated cotton cheesecloth used an an indicator.

The connector, exclusive of connected terminal equipment, shall not permit excessive current to flow in the event of a power fault (contact or induction) to the telephone outside plant.

The connector shall not become a fire hazard when subjected to voltages on terminals as described below:

(1) A 60 Hz voltage up to 600 V rms applied:

For two−wire interface (dc loopback detector only):

(a) to T and R to ground (see Figure 21).

(b) between T and R leads (see Figure 22).

For four–wire interface

(a) to each lead (T, R, T1, R1) with the other three leads grounded (see Figure 23).

(b) to T and R to ground, T1 and R1 grounded (see Figure 24).

(c) to T1 and R1 to ground, T and R grounded (see Figure 24).

(d) to T, R, T1, and R1 simultaneously to ground (see Figure 25).

(2) A 60 Hz voltage up to 300 V rms applied between exposed conductive surfaces and ground.

The test circuit fuse of Figures 21 through 25 must have the following characteristics:

Maximum Operating Time (Seconds)	Current (Amperes)
210	1.7
60	2.0
10	3.0
1	8.0

The above criteria apply with an initially applied continuous 60 Hz voltage of up to 30 volts rms or such lower voltage as necessary to limit the current which flows to 100 milliamperes. The voltage is increased thereafter at a rate which does not result in an increase in voltage or current of more than 20 percent in any 15 minute interval until one of the following occurs:

(1) The voltage reaches the maximum 600 V rms.

(2) The test circuit fuse operates.

(3) The connector fails open–circuited.

If the test circuit fuse operates during the test, the connector has permitted excessive current to flow and has failed the test.

If the connector fails open–circuited prior to (1) or (2) above, then an original connector (previously unstressed) shall neither become a fire, safety or electrical shock hazard nor operate the test circuit fuse when subjected to the maximum voltage specified above for 15 minutes.

On a test of the Connector–to–LEC four wire interface, the opposite side terminals must be terminated according to their exposure in service. Exposed conductive surfaces shall be grounded during ac fire hazard testing.

In order to ensure that all possible paths for current flow during ac fire hazard testing are examined, tests must be conducted for the different states the connector can assume (e.g., normal state and maintenance states for signal loopback, through and loop powering modes).

The tests of Section 6.1.6 do not have to be applied to the Connector–LEC four wire interface should it pass this test.

National Electric Code requirements are in the process of being formulated that may require the DS1 Interface Connector to be listed by a recognized national testing laboratory. One such laboratory, Underwriters Laboratories, has a standard, UL–1459, which became effective October 1, 1990.

6.2 Electrical Safety Criteria

These criteria are intended to protect craftspersons from harm by limiting the voltage and current intentionally applied to communication circuits. Sources complying with these criteria need not be de-energized before craftsperson contact is allowed. Sources beyond these limits should be designed to preclude inadvertent contact and should be deactivated before craftsperson contact is permitted.

The material presented under this heading describes certain minimum criteria that, in BST's view, should be applied to test the unit for safe and proper operation in the field. The manufacturer shall perform further tests and employ more stringent requirements than those provided under this heading, to assure product safety and reliability, and to comply with all applicable Federal, State and local requirements, as necessitated by the product in issue and the conditions under which it is used.

Voltage limits specified below should be interpreted as the reading of a voltmeter with an internal impedance much greater than the source impedance. Similarly, current limits correspond to the reading of an ammeter whose internal impedance is much less than the source impedance.

Voltages are classified according to their durations. **Continuous source limits** apply for signals which exist for longer than 5 seconds. **Duration–limited** signals fall into two categories. For voltages lasting from 0.01 to 5 seconds, the **interrupted voltage limits** are applicable. Voltages of duration less than 0.01 second are subject to the **transient voltage limits**. A DS1 Interface Connector is intended for installation on metallic pairs providing a DS1 service. Taking this into account, only limits for continuous source signals need be defined in this Technical Reference.

The following criteria constitute voltage and current limitations on the sources that may be applied to the network. In addition, an overall **power limitation** applies to these sources. **Leakage current limitations** are established to prescribe the maximum current which may be drawn from an exposed surface on an equipment.

6.2.1 Continuous Source Requirements

Continuous voltages for which barehand contact is permitted are divided into Classes A1, A2, and A3.

The criteria below specify the maximum voltage and current and associated levels of accessibility which may be provided to three classes of persons: telephone customers and the general public––"customers"; BST employees in general––"personnel" (e.g., operators); and BST employees trained to work with electrical circuits––"trained personnel" (e.g., craftspersons). Energized electrical leads and terminals are designated "sources".

Three levels of diminishing accessibility are defined: exposed; restricted access; and inaccessible. A lead on a terminal is exposed if it may be contacted with the small end of the accessibility probe (see Figure 26), where dimension "A" is 3.5 cm (1.4 inches). It has restricted access if it is not exposed but may be contacted with the small end of the accessibility probe where dimension "A" is 9.0 cm (3.5 inches). A lead or a terminal is inaccessible if it **cannot** be contacted with the small end of the accessibility probe where dimension "A" is 9.0 cm (3.5 inches). The accessibility to a given class of persons is determined with those equipment enclosures in place which would be in place during normal operation by that class of persons.

Class A1 voltage sources (see below) should be inaccessible or have restricted access for contact by customers and may be exposed for contact by personnel and trained personnel. Shrouded or guarded connectors (e.g., modular plugs and jacks, Amphenol miniature ribbon and D subminiature connectors) with Class A1 sources connected to their pins are considered to provide adequate protection of customers and BST personnel.

Class A2 voltage sources (see below) should be inaccessible for contact by customers, should be inaccessible or have restricted access by personnel, and may be exposed for contact by trained personnel. Customers and BST personnel are adequately protected from contact with Class A2 sources, if these sources appear on pins of shrouded or protected connectors as described above.

Class A3 voltage sources (see below) should be inaccessible for contact by customers and personnel. Equipment that is powered by or that generates Class A3 voltage should have restricted access for contact by trained personnel, but may be exposed for contact by trained personnel with the following precautions. When an enclosure or baffle is removed, or when energized electrical circuits are otherwise exposed for contact by trained personnel, Class A3 sources should be segregated from Class A1 or A2 sources by appropriate insulation, baffling, or location to prevent inadvertent contact. Designed appearances of Class A3 voltage sources on equipment that is powered by or that generates such voltages should be labeled where trained personnel are normally intended to contact them for service operation.

Class B voltage sources (see below) should be de−energized before contact is allowed. With normal equipment enclosures in place, it should not be possible to contact Class B sources with the small end of the accessibility probe (see Figure 26) with the 5.08 cm (2 inch) ring removed. Protection covers carrying warning labels for Class B sources should not be removable without the use of tools and/or a key. When an enclosure or baffle is removed to permit access to Class A1, A2, or A3 sources, Class B sources should have restricted access for contact by trained personnel.

Class C voltage source: an electrical source in excess of Class B limits. Class C sources require protection beyond the scope of this document.

For use in defining continuous voltage limits, a frequency−weighted equivalent ac voltage, V_e, is used to take into account the frequency dependence of the skin resistance and the let−go current threshold. The equivalent ac voltage V_e of a sinusoidal waveform frequency f and peak amplitude V is

$$V_e = W(f)V$$

where

$$W(f) = 1.0, \qquad 0 < f < 60 \text{ Hz},$$

$$W(f) = \frac{0.75}{1 + (f/2200)} \sqrt{\frac{1 + (f/65)^2}{1 + (f/930)^2}} \qquad 60 \text{ Hz} <= f <= \text{kHz},$$

$$W(f) = 1.93, \qquad 10 \text{ kHz} < f$$

and f is the frequency in Hz of component V.

Similarly, a frequency−weighted equivalent current, I_e, is employed for a sinusoidal current waveform of peak amplitude I, and is defined by

$$I_e = \frac{I}{1 + (f/2200)}, \quad 0 < f \leq 10 \ kHz \ ,$$

$$I_e = 0.18I, \quad 10 \ kHz \ < f \ ,$$

where f is the frequency in Hz.

For an ac signal composed of more than one frequency component, the sum of the equivalent voltages or equivalent currents of the individual components is the relevant parameter.

These voltage limits apply between each terminal and ground with all the other terminals first open–circuited, then individually grounded.

(a) **Class A1 Voltage Limits**

Class A1 voltages are those in excess of leakage limits of Section 6.2.3 but less than the following:

(1) **DC Voltages:** DC voltages less than 30 volts to ground are acceptable. Voltages exceeding 30 volts but less than 200 volts are permitted if the current is limited to 0.15 mA dc, that is, the load line of a dc Class A1 source should lie entirely within the acceptable region of Figure 27a.

(2) **AC Voltages:** Equivalent voltages less than 14.1 volts peak to ground are permitted. Equivalent voltages exceeding 14.1 volts peak but less than 200 volts peak are acceptable if the equivalent current is limited to 0.15 mA peak, that is, the load line of an ac Class A1 source should lie entirely within the acceptable region of Figure 27b.

(3) **Combined AC and DC Voltages:** The limits on combined equivalent ac and dc voltages to ground are specified by the acceptable region of Figure 6–8c. However, higher combined voltages up to 200 volts peak are permissible if the peak equivalent ac current component, I_e, and dc current component, I_{dc}, satisfy

$$\frac{|I_e|}{1.0\ mA} + \frac{|I_{dc}|}{5.0\ mA} <= 1$$

as indicated in Figure 27d.

(b) **Class A2 Voltage Limits**

Class A2 voltages are voltages in excess of Class A1 limits but less than the following:

(1) **DC Voltages:** DC voltages less than 80 volts to ground are acceptable. Voltages exceeding 80 volts but less than 200 volts are permitted if the current is limited to 5.0 mA dc, that is, the load line of a dc Class A2 source should lie entirely within the acceptable region of Figure 28a.

(2) **AC Voltages:** Equivalent voltages less than 42.4 volts peak to ground are permitted. Equivalent voltages exceeding 42.4 volts peak but less than 200 volts peak are acceptable if the equivalent current is limited to 1.0 mA peak, that is, the load line of an ac Class A2 source should lie entirely within the acceptable region of Figure 28b.

(3) **Combined AC and DC Voltages:** The limits on combined equivalent ac and dc voltages to ground are specified by the acceptable region of Figure 28c. However, higher combined voltages up to 200 volts peak are permissible if the peak equivalent ac current component, I_e, and dc current component, I_{dc}, satisfy

$$\frac{|I_e|}{1.0\ mA} + \frac{|I_{dc}|}{5.0\ mA} <= 1$$

as indicated in Figure 28d.

(c) **Class A3 Voltage Limits**

Class A3 voltages represent the upper limit of voltages which may be contacted barehanded. Special precautions in the design and handling of equipment or facilities using A3 voltages will be necessary.

Class A3 voltages are voltages in excess of Class A2 limits but less than the following:

(1) **DC Voltages:** DC voltages less than 140 volts to ground are acceptable. Voltages exceeding 140 volts but less than 200 volts are permitted if the current is limited to 10.0 mA dc, that is, the load line of a dc Class A3 source should lie entirely within the acceptable region of Figure 29a.

(2) **AC Voltages:** Equivalent voltages less than 70.0 volts peak to ground are permitted. Equivalent voltages exceeding 70.0 volts peak but less than 200 volts peak are acceptable if the equivalent current is limited to 3.0 mA peak, that is, the load line of an ac Class A3 source should lie entirely within the acceptable region of Figure 29b.

(3) **Combined AC and DC Voltages:** The limits on combined equivalent ac and dc voltages to ground are specified by the acceptable region of Figure 29c. However, higher combined voltages up to 200 volts peak are permissible if the peak equivalent ac current component I_e, and dc current component, I_{dc}, satisfy

$$(I_e/3mA)^{1/2} \ + \ (I_{dc}/10mA)^{1/2} \ \ <= 1$$

as indicated in Figure 29d.

(d) Class B voltages are those which exceed the Class A3 limits but which have voltages below 600V dc to ground or 600V ac to ground or 1000V ac rms between metal parts.

6.2.2 Power Limitation

Sources that may be applied to communication wiring are further limited to a rating of less than 100 volt−amperes.

6.2.3 Leakage Currents From Exposed Surfaces

Surfaces of equipment and of interconnecting cords or cables, with any removable housing or cover in place and with interconnecting cords or cables connected, which may be contacted with the small end of the accessibility probe (see Figure 26) where dimension “A” is 3.5 cm (1.4 inches), are considered exposed surfaces. Exposed surfaces, with the exception of those listed in the next paragraph, should meet the specified leakage current limits under normal conditions of applied voltages and for all modes of operation of said equipment.

The sole exceptions to exposed surfaces which should meet the leakage requirements are those portions of the electrical network which should be accessible to personnel and trained personnel for normal operations (e.g., terminals, connectors, and conductors) provided the exempt exposures are exposed only to personnel and trained personnel. The voltages, currents, and power associated with these exempt exposures are limited by the continuous source requirements described in Section 6.2.1 and the power limitations of Section 6.2.2.

(a) The current from any 100 cm^2 (15.5 in^2) area or the entire area, whichever is smaller, of exposed surfaces (exclusive of grounded metal surfaces) flowing through a 1500 ohm resistor to ground should be less than 0.3 mA peak.

(b) The current from any 1 cm^2 (0.155 in^2) area of exposed surface (exclusive of grounded metal surfaces) flowing through a 10,000 ohm resistor to ground should be less than 0.15 mA peak.

(c) The current flowing through a 10,000 ohm resistor connected between any two areas of exposed surface (exclusive of grounded metal surfaces) of 1 cm^2 (0.155 in^2) each should be less than 0.15 mA peak.

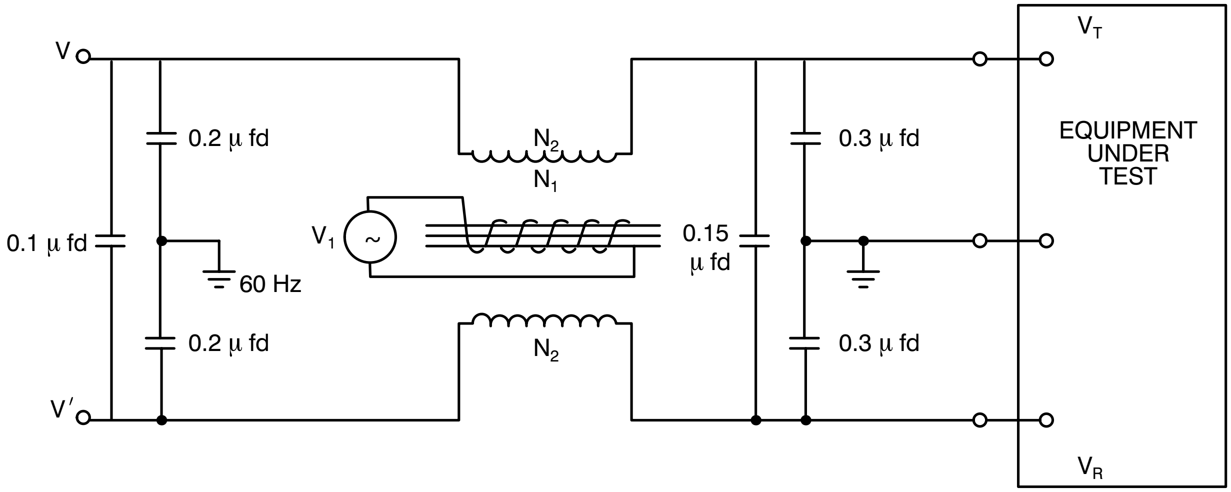
For ac voltages, a frequency−weighted equivalent current is used. The equivalent ac leakage current, I_{ie}, of a sinusoidal waveform of peak amplitude I is:

$$I_{ie} = (1 + (f/300)^2)^{-1/2} I, \quad o < f <= 10 \; kHz,$$

$$I_{ie} = (0.03 \; I), \quad 10 \; kHz < f \; ,$$

where f is the frequency of Hz.

For ac signals composed of more than one frequency, the peak of the sum of equivalent leakage currents is the relevant parameter. Transients less than 10 ms long should result in peak leakage currents less than $I_{LIMIT} \sqrt{10/t}$ where I_{LIMIT} is the appropriate current limit from 1, 2, or 3 above and t is the duration of the transient (in milliseconds). For the purpose of determining compliance with these criteria, a conducting surface or metal part should be considered grounded only if it is grounded intentionally in accordance with National Electric Code, Art. 250. If it is not securely grounded by design and construction, such a conducting surface should be considered ungrounded. Compliance with the above is then required with any such connection removed.



NOTES

(1) EQUIPMENT TO BE TESTED WITH NORMAL TERMINATIONS AND POWER.

(2) FIRST LEVEL REQUIREMENTS TO BE MET AS V_1 IS INCREASED FROM ZERO TO THE MAXIMUM VOLTAGE AND RESULTING IN EITHER V OR V′ EXCEEDING 600 VRMS OR THE PEAK OF EITHER V_T OR V_R EXCEEDING THE DC BREAKDOWN VOLTAGE OF THE PRIMARY PROTECTOR. THE SECOND LEVEL REQUIREMENTS TO BE MET AS V_1 IS INCREASED FROM ZERO TO THE MAXIMUM VOLTAGE NOT RESULTING IN EITHER V_1, V′, V_T OR V_R EXCEEDING 600 VRMS.

(3) THE CAPACITORS IN THE TEST NETWORK SHOULD HAVE ADEQUATE VOLTAGE AND DISSIPATION RATINGS.

(4) PRIMARY−TO−SECONDARY TURN RATIO OF TRANSFORMER IS ARBITRARY BUT MUST BE SAME ON EACH SECONDARY (LINE CONDUCTOR).

(5) SOURCE V_1 SHALL HAVE A MINIMUM VOLT−AMPERE RATING OF 50 VA.

(6) PRIMARY PROTECTOR REMOVED.

FIGURE 20 − HIGH IMPEDANCE INDUCTIVE SOURCE TEST CIRCUIT

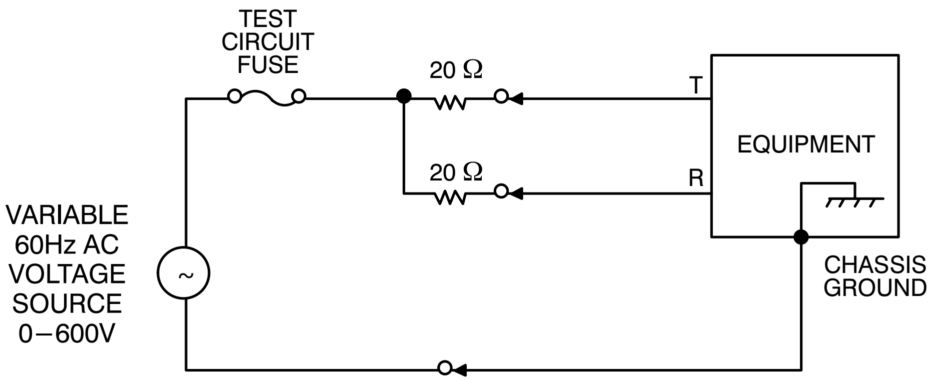


FIGURE 21 − LONGITUDINAL TWO WIRE TEST CIRCUIT

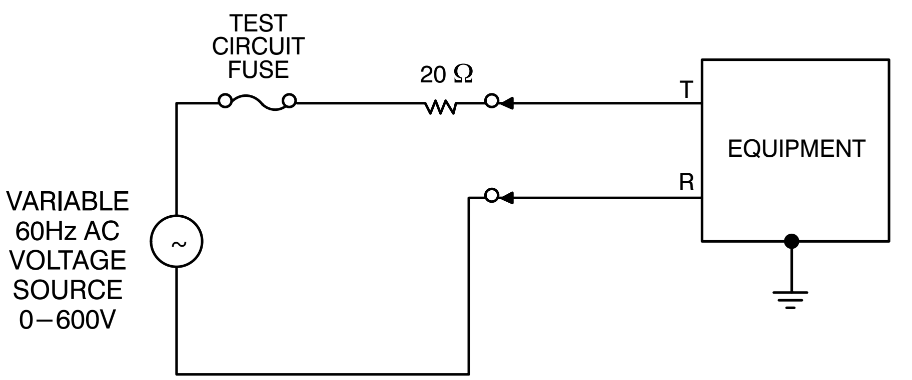


FIGURE 22 − METALLIC TWO WIRE TEST CIRCUIT

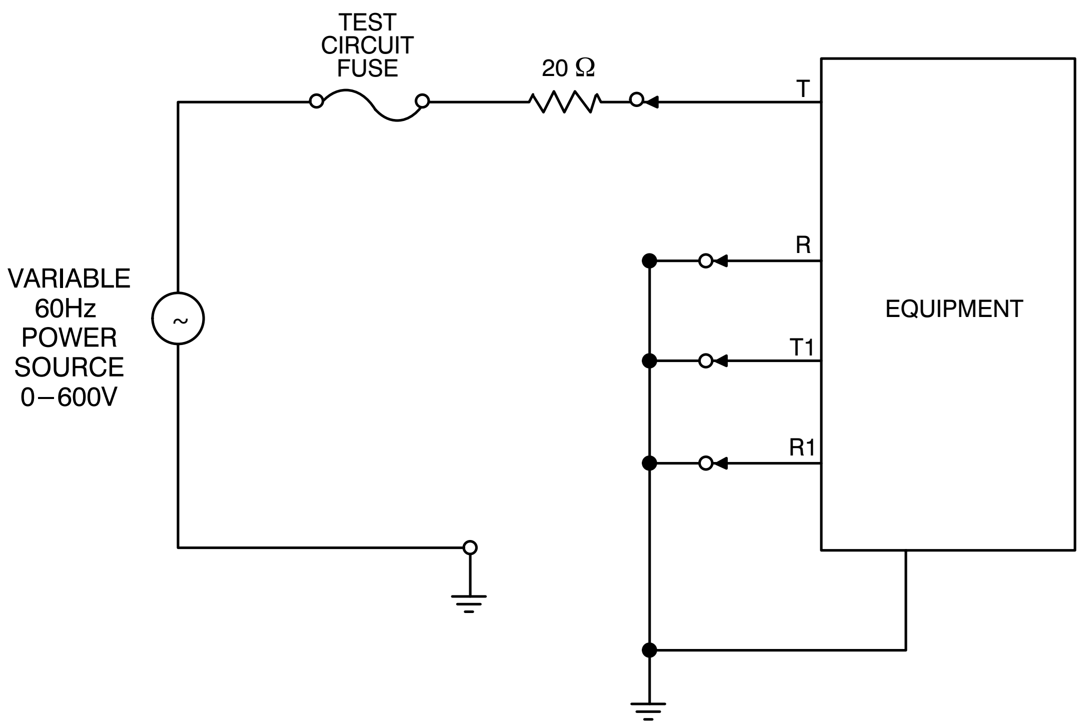


FIGURE 23 − METALLIC FOUR WIRE TEST CIRCUIT

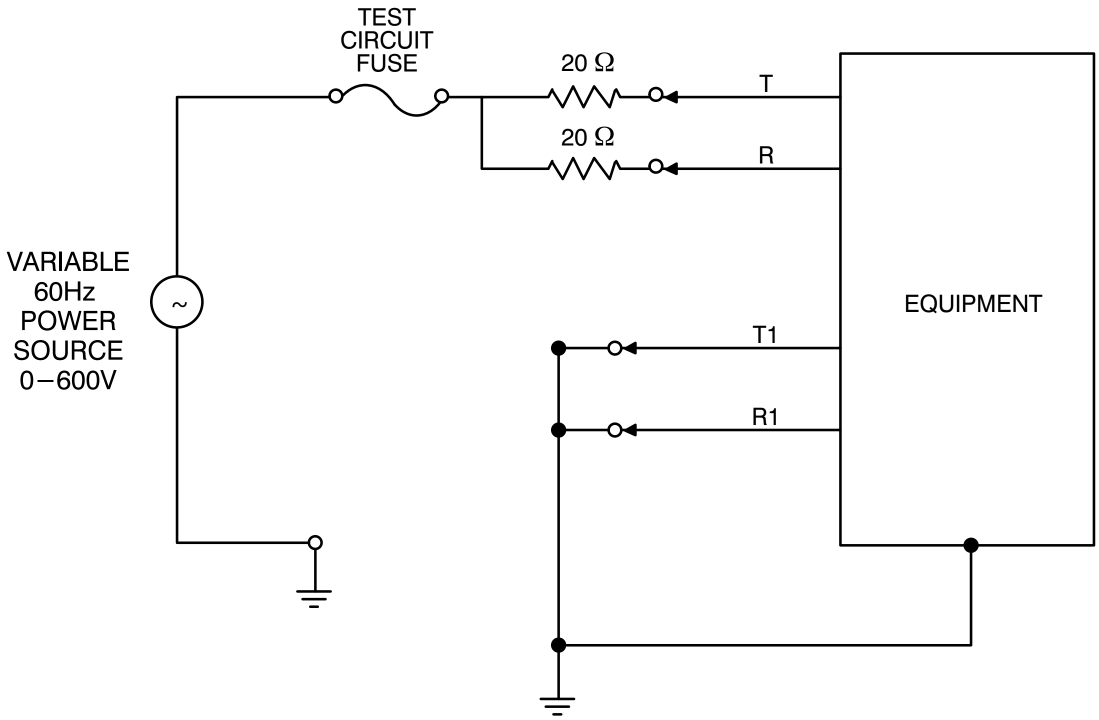


FIGURE 24 − LONGITUDINAL FOUR WIRE TEST CIRCUIT

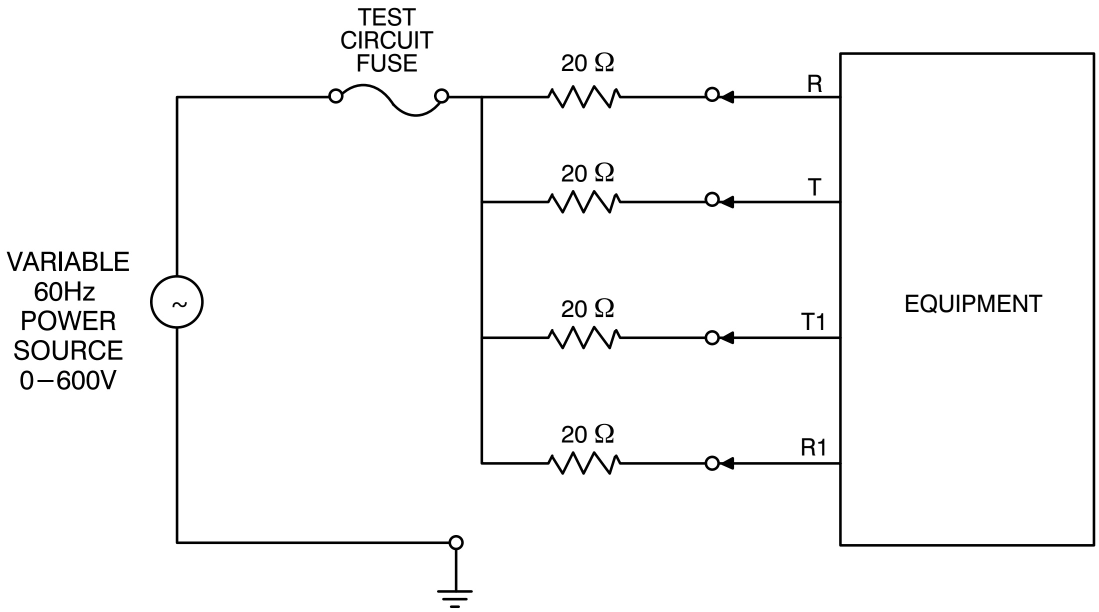


FIGURE 25 − LONGITUDINAL FOUR WIRE TEST CIRCUIT

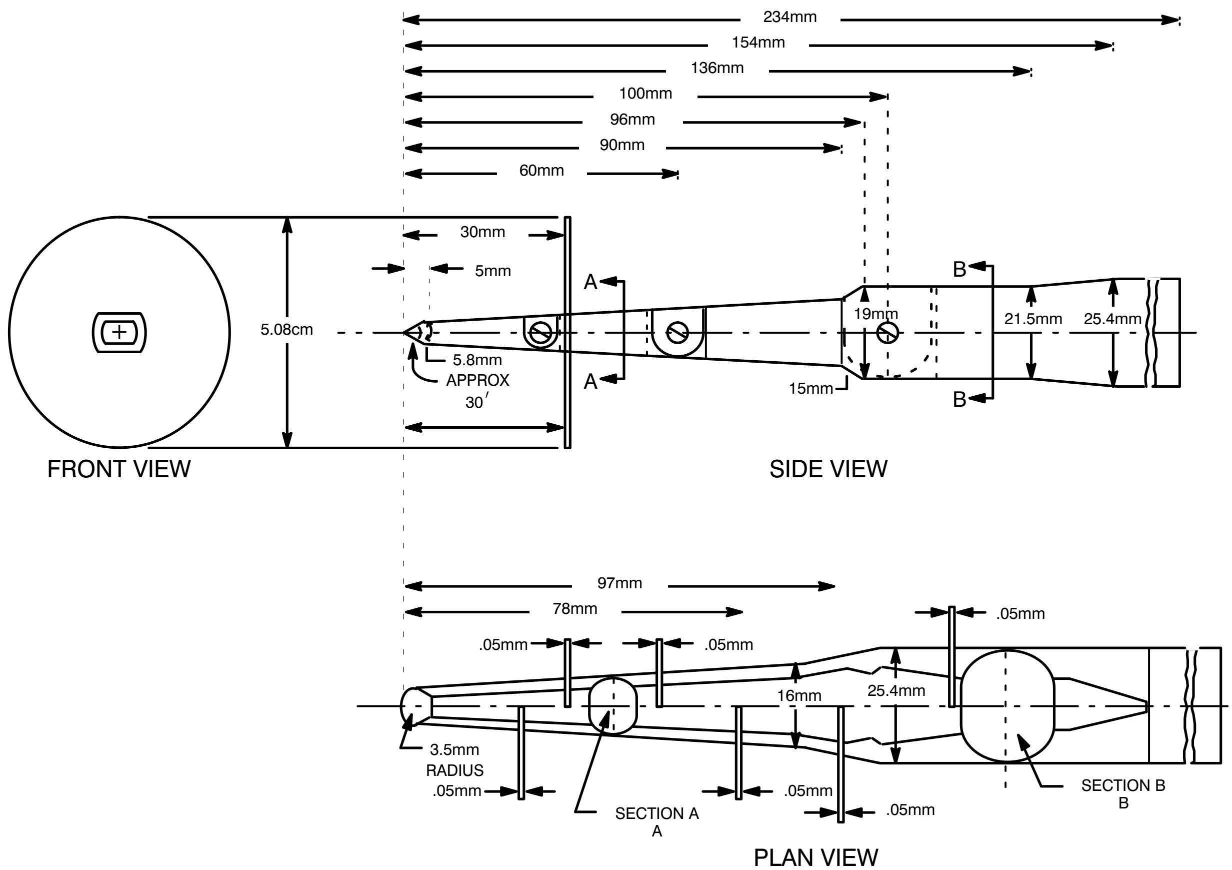
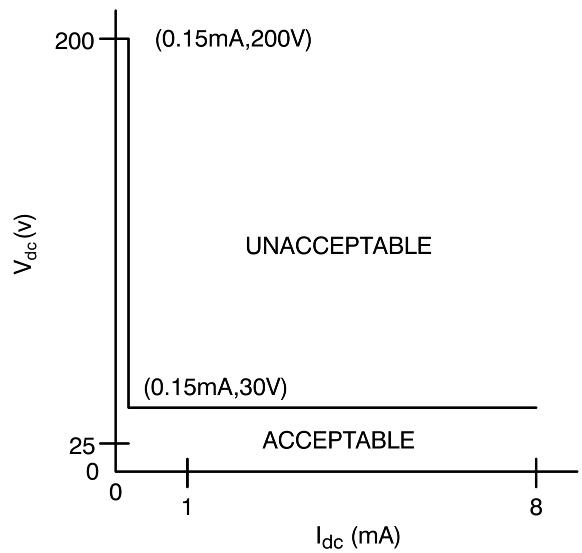


FIGURE 26 − ACCESSIBILITY PROBE

a) DC ONLY



b) AC ONLY

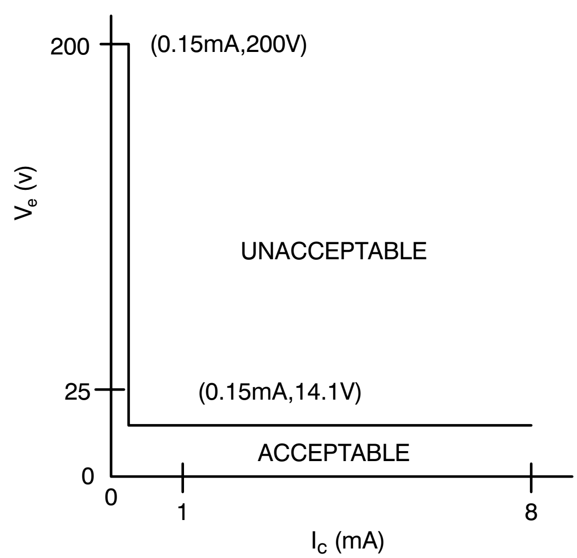
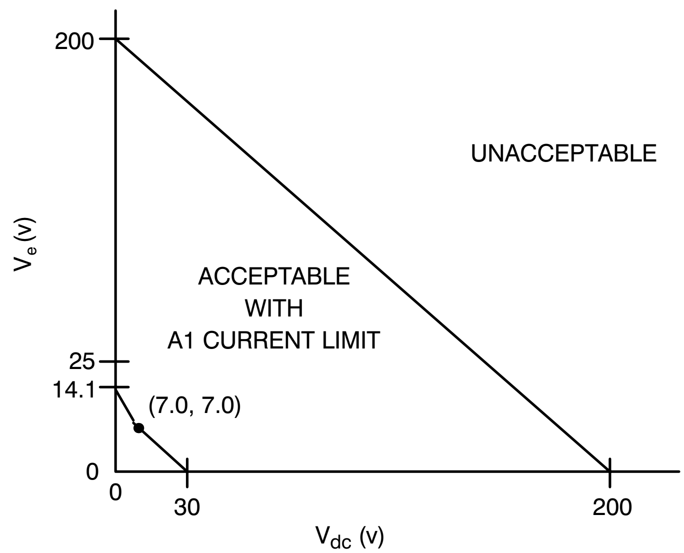


FIGURE 27 − CLASS A1 VOLTAGE LIMITS (A) (B)
Page 1 of 2

c) AC AND DC COMBINED



d) CURRENT LIMITS FOR HIGHER COMBINED VOLTAGES

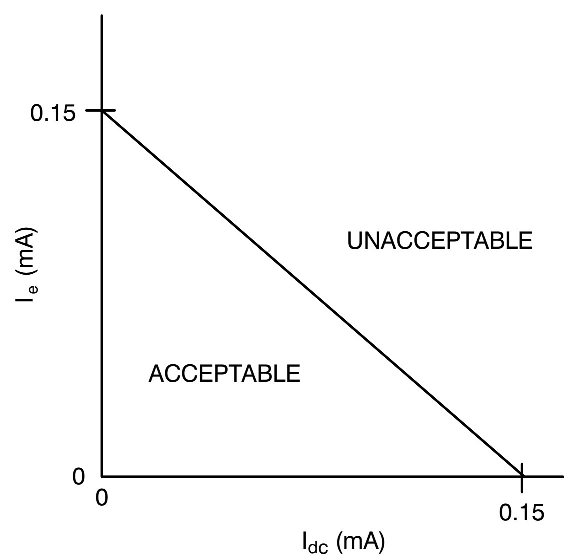
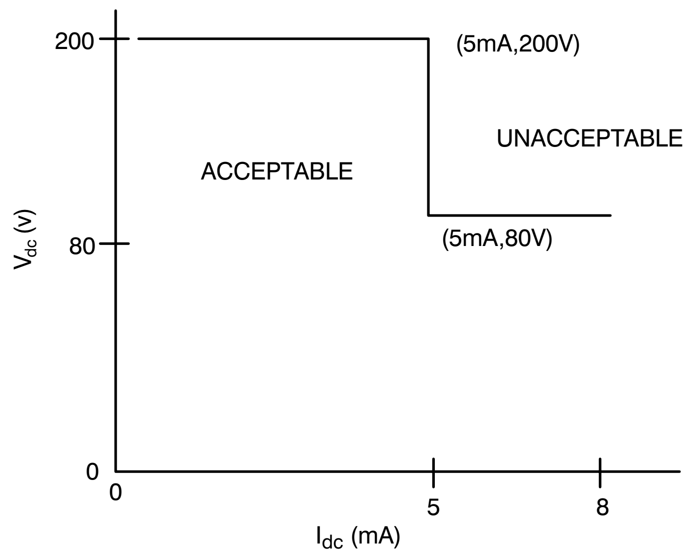


FIGURE 27 − CLASS A1 VOLTAGE LIMITS (C) (D)
Page 2 of 2

a) DC ONLY



b) AC ONLY

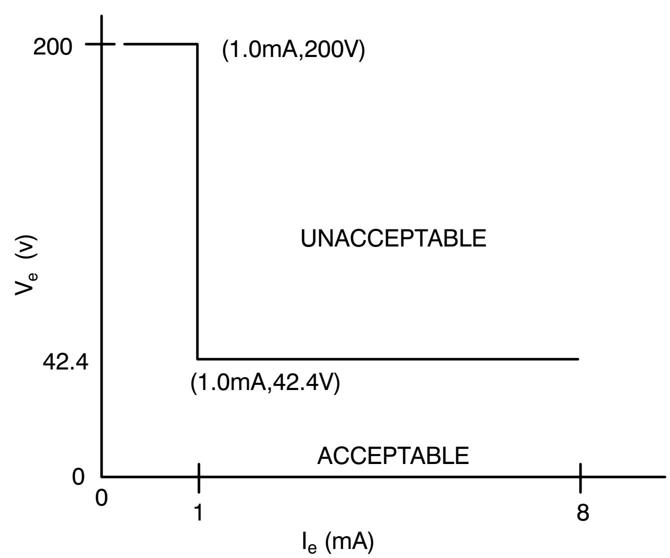
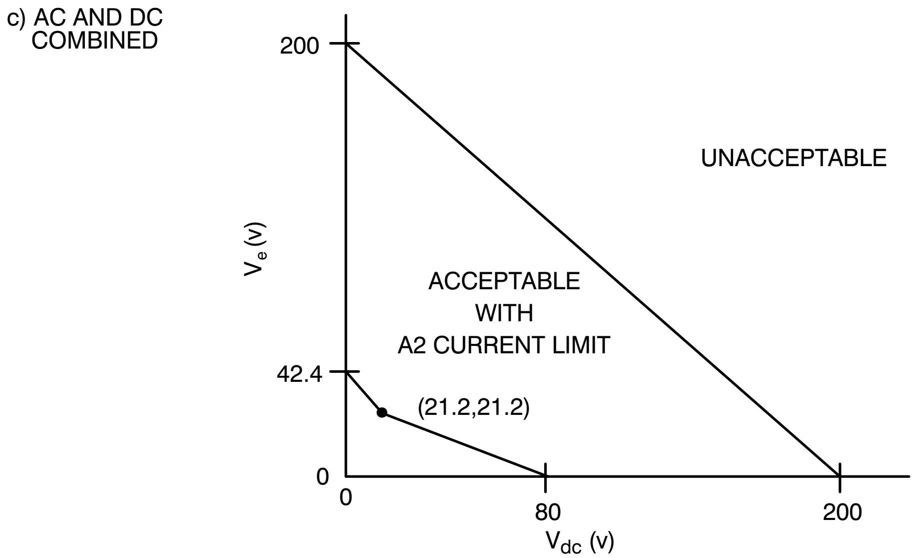


FIGURE 28 − CLASS A2 VOLTAGE LIMITS (A) (B)
Page 1 of 2



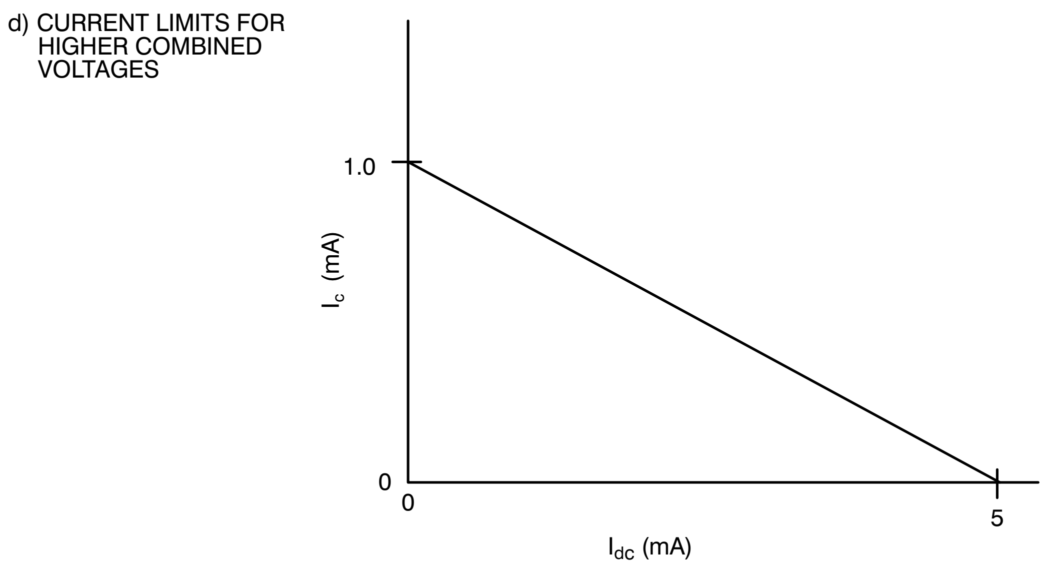
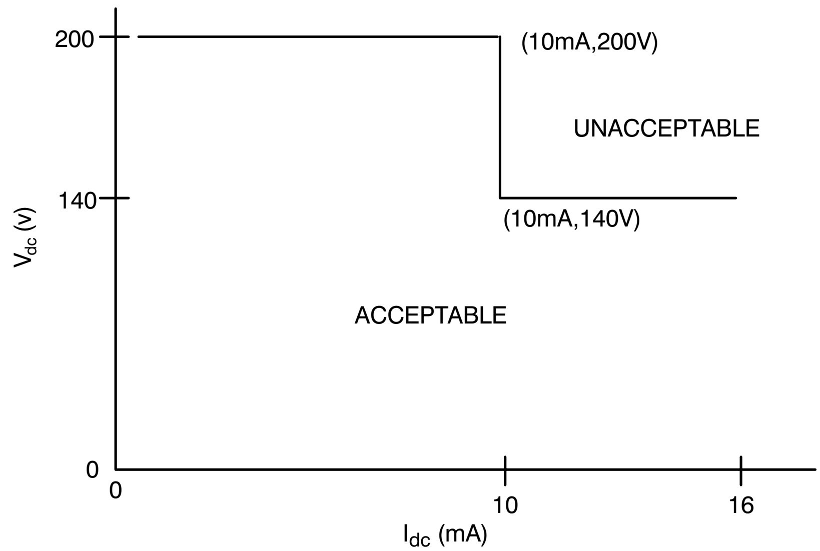


FIGURE 28 – CLASS A2 VOLTAGE LIMITS (C) (D)
Page 2 of 2

a) DC ONLY



b) AC ONLY

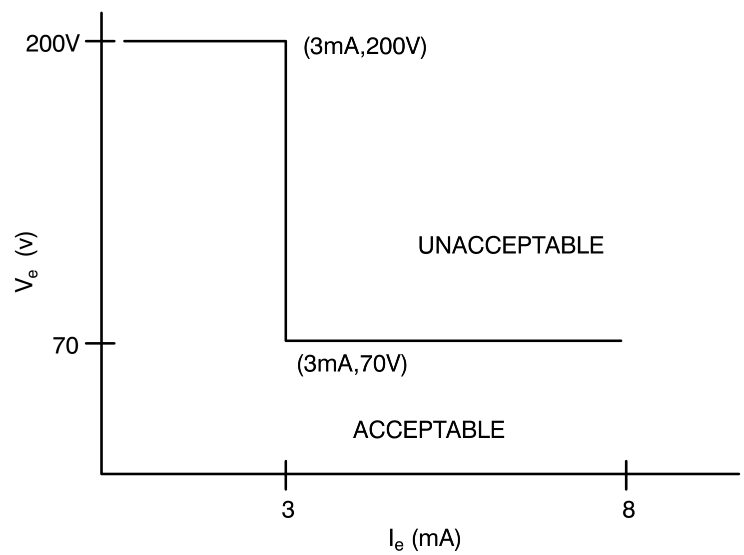
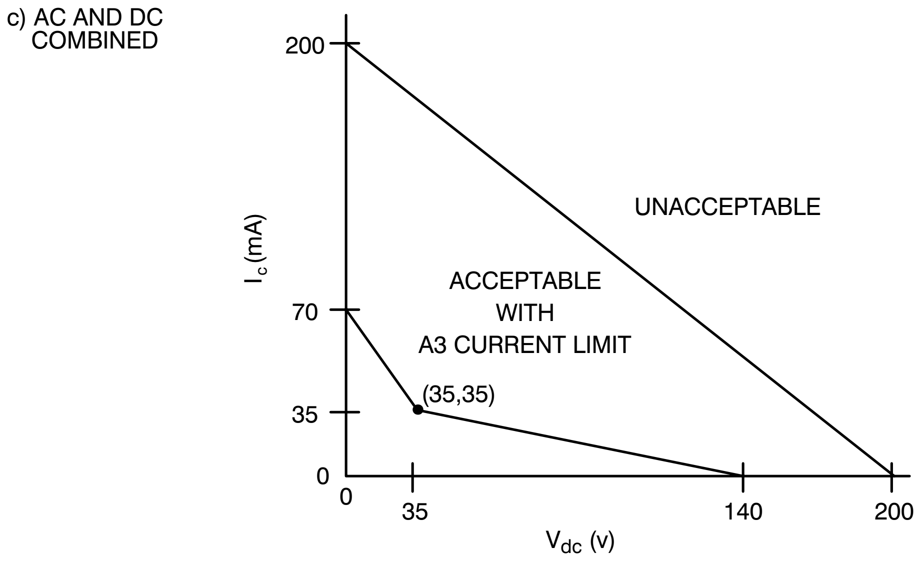


FIGURE 29 − CLASS A3 VOLTAGE LIMITS (A) (B)
Page 1 of 2



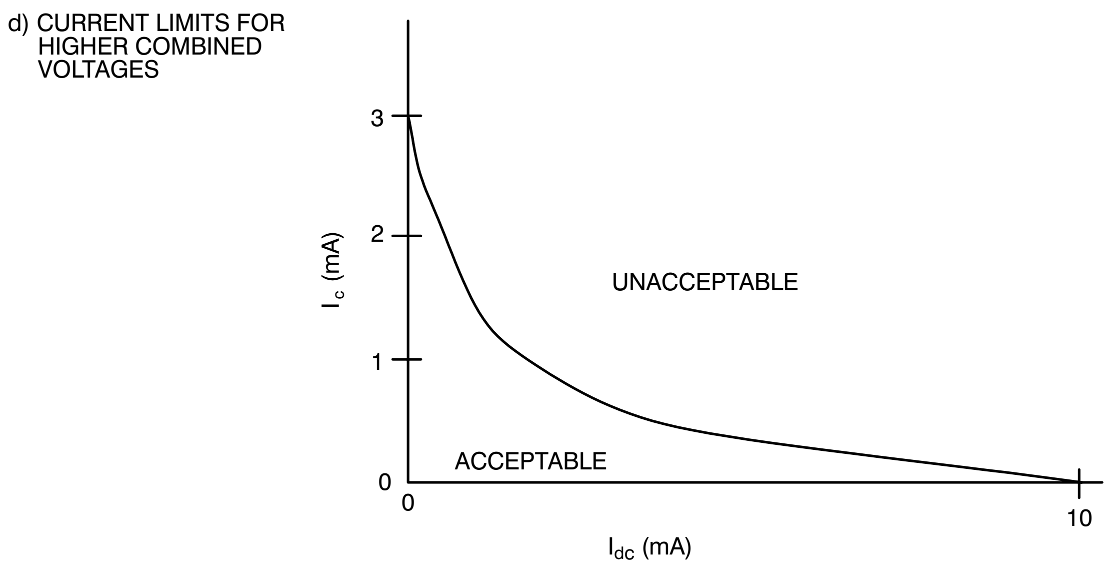


FIGURE 29 − CLASS A3 VOLTAGE LIMITS (C) (D)
Page 2 of 2

7. DOCUMENTATION AND IDENTIFICATION

7.1 Documentation

A supplier shall provide documentation that will permit an operating company to readily plan, order, engineer, install and maintain the connector. These documents must cover the following areas:

- Connector Description
- Connector Engineering
- Connector Installation
- Connector Maintenance
- Connector Ordering Information

The suppliers should contact BST for documentation format and content requirements.

7.2 Equipment Coding

The connector shall meet the equipment coding requirements of TR–ISD–000325[23]. These criteria include the provision of Common Language Equipment Identification (CLEI) codes for the DS1 Interface Connector. CLEI code criteria are contained in TR–TAP–000485[13] and TR–795–25540–84–02[14].

7.3 Identification

The connector shall be readily identifiable by marking the outside “DS1 Interface Connector”. The connector shall be marked with the manufacturer’s model number, and the month and year of manufacture. In addition, marking shall be provided to identify the individual line connections and terminations. Markings shall be correct and legible, shall remain legible for the life of the connector, and shall withstand smearing or removal by rubbing.

The intended application of the DS1 Connectors, i.e., end–user or carrier–to–carrier, shall be clearly designated and readily identifiable.

8. QUALITY ASSURANCE AND RELIABILITY

8.1 Quality Assurance

8.1.1 Quality Program Analysis

The manufacturing process, test and inspection procedures, and quality program used by a manufacturer shall be adequate to assure that technical requirements and customer end–point requirements are met. Quality Assurance criteria in this area cover, for example, the ability of the factory testing program to assure product operability and functionality. Details of the quality program criteria are documented in Technical Reference TR–TSY–000039 entitled, “Quality Program Analysis”[17].

The supplier shall, upon request, make available to an operating company or its representative all documentation and information that describes controls, procedures and standards used for manufacture, in–process testing, final product inspection and testing, calibration and maintenance of tools and tool sets, control of non–conforming materials/product, periodic product qualification testing, and all other aspects of the quality program.

The supplier should, upon request, allow the performance of an on–site analysis of the above topics at the factory.

8.1.2 Product Quality Surveillance

The supplier shall, upon request, allow BST to verify the ongoing quality and reliability of the product by means of an on−site quality surveillance program. Details of this program are normally addressed during contract negotiations. This program can consist of up to four major activities:

(a) Analysis of the supplier's final test/inspection results that demonstrate conformance to agree-d−upon criteria. This data shall be made available prior to the shipment of the product.

(b) Monitoring of the supplier's quality control program and process controls to assure proper implementation of the supplier's documented quality program.

(c) Inspection and test of a sample of the product that is ready for shipment. Sample size is based on quality and quantities of the product submitted for inspection. Testing is performed by the supplier, for the customer, on supplier facilities.

(d) Periodic product qualification testing to assure conformance to design criteria not normally tested in routine quality control efforts.

8.2 Reliability

8.2.1 End Use and Life Expectancy

The product designed and manufactured in accordance with the generic requirements of this documentation shall be capable of meeting all criteria for a period of twenty years. It is assumed that once a connector is place in service, it will be left in place when the line is disconnected, to be reused when service is reconnected. Because of possible rough handling, long periods of inactivity and the wide range of temperature and humidity to which a connector may be subjected, components, particularly capacitors, must be carefully selected in order to achieve the desired life expectancy. Since a connector is intended for use in sectionalizing troubles between the Local Exchange Carrier and the Customer Installation, its steady−state failure rate should be well below the failure rate of devices and associated wiring in the loop span of the Local Exchange Carrier and of devices and wiring in the Customer Installation. This is necessary in order to avoid undue increases in maintenance activity resulting from the installation of a DS1 Interface Connector.

8.2.2 Reliability Objective − Steady−State

The steady−state reliability objective is 1500 FITs (failures per 10^9 operating hours), of which no more than 900 FITs result in Service Affecting failures as perceived by a customer. Service Affecting FIT rates shall be calculated using the worst−case operational configuration in terms of powering configurations, signal regeneration options, line build−out settings, etc. This Service Affecting reliability objective is equivalent to 0.8 failures per 100 connectors per year.

The remaining 600 FITs are allocated to failures that may affect connector performance while in the maintenance state but will be transparent to the customer while the connector is in the normal state.

8.2.3 Infant Mortality

The failure rate of a connector during the first year of service (infant mortality) is directly related to the steady−state failure rate and the amount of operating time accumulated by the connector or its piece parts, prior to the in−service use. For example, if a connector experiences no prior operating time, the first year Service Affecting failure rate can be expected to be four times the steady−state value, or 3.2 failures per 100 connectors (assuming that the FIT rate is 900).

8.2.4 Reliability Predictions

Upon request, the supplier shall provide reliability predictions performed in accordance with the latest issue of Technical Reference TR−TSY−000332 entitled, “Reliability Prediction Procedure for Electronic Equipment”[18]. The predictions should provide steady−state failure rates and infant mortality multipliers based on the supplier’s current practices and design. The results should be accompanied by sufficient information to allow a verification of the results.

In the course of performing a reliability prediction, the supplier shall use a failure rate multiplier of 1.5 to reflect the intended use environment.

9. REFERENCES

1. Technical Reference TR−TSY−000194, "Extended Superframe Format (ESF) Interface Specification", Issue 1, December, 1987.

2. Technical Reference Pub 62411, "High Capacity Digital Service Channel Interface Specification", September, 1983, plus Addendum 1, October, 1984.

3. Technical Advisory TA−TSY−000754, "ISDN Primary Rate Access, Transport System Requirements", Issue 1, To Be Issued.

4. Compatibility Bulletin CB−113, "The Low Power T1 Line Repeater Compatibility Specification", Issue 2, April, 1978.

5. H. Cravis and T. V. Crater, "Engineering of T1 Carrier System Repeatered Lines", The Bell System Technical Journal, pp. 431−486, March, 1963.

6. Technical Reference Pub 43801, "Digital Channel Bank Requirements and Objectives", November, 1982.

7. Technical Reference TR−TSY−000499, "Transport Systems Generic Requirements (TSGR): Common Requirements", Issue 1, December, 1987.

8. FCC Rules and Regulations, Subpart F of Part 68 supplemented by Public Notice 2526, "New Part 68 Plugs and Jacks Adopted", February 10, 1986.

9. Technical Reference TR−TSY−000170, "Digital Cross−Connect System Requirements and Objectives", Issue 1, November, 1985.

10. Technical Reference TR−EOP−000001, "Lightning, Radio Frequency and 60 Hz Disturbances at the Bell Operating Company Network Interface", Issue 2, June, 1987.

11. American Society for Testing Materials (ASTM), G−21, "Determining Resistance of Synthetic Polymeric Materials to Fungi".

12. American Society for Testing Materials (ASTM), D−2863−77, "Flammability of Plastics Using the Oxygen Index Method".

13. Technical Reference TR−TAP−000495, "Common Language® CLEI Code Assignment and Marking Requirements", Issue 1, April, 1987.

14. Technical Reference TR−795−25540−84−02, "Common Language® Identification of Manufacturers of Telecommunications Products", January, 1984.

15. Underwriters Laboratories Standard UL 94, "Test for Flammability of Plastic Materials for Parts in Devices and Appliances: Vertical Burning Test for Classifying Materials", 94, V−0, 94 V−1, or 94 V−2.

16. Technical Reference TR−TSY−000081, "Packaging, Packing, Palletization and Marking Requirements", Issue 1, December, 1984.

17. Technical Reference TR−TSY−000039, "Quality Program Analysis", Issue 2, June, 1985.

18. Technical Reference TR−TSY−000332, "Reliability Prediction Procedure For Electronic Equipment", Issue 1, September, 1985 and April, 1986 revision.

19. Technical Advisory TA−TSY−000044, "Digital Test Access Unit Functional Specifications", Issue 3, April, 1987.

20. Technical Reference TR−TSY−000064, "LATA Switching System Generic Requirements (LSSGR)", Issue 2, July, 1987. (Section 15.1 is available in "Electromagnetic and Electrical Environment", Module TR−TSY−000515, Issue 2, July, 1987.)

21. Technical Reference TR−TSY−000009, "Asynchronous Digital Multiplexer, Requirements and Objectives", Issue 1, May, 1986.

22. Technical Reference TR−TSY−000057, "Functional Criteria for Digital Loop Carrier Systems", Issue 1, April, 1987 and TA−TSY−000057, Issue 3, November, 1987 supplement.

23. Technical Reference TR−ISD−000325, "Equipment Information Required From Suppliers For Operations Systems", September, 1986.

24. T1X1.4/87−127, "American National Standard for Telecommunications − Digital Hierarchy − Formats Specifications".

25. Part 1910 − Occupational Safety and Health Standards (OSHA), Title 29 − Labor, Chapter XVII − OSHA, Department of Labor, April 30, 1975.

26. Technical Reference TR−EOP−000063, "Network Equipment−Building System (NEBS), Generic Equipment Requirements", Issue 2, December, 1986.

27. Technical Reference TR−TSY−000357, "Component Reliability Assurance Requirements for Telecommunications Equipment", Issue 1, December, 1987.

28. ANS T1.408−199

<u>NOTE</u>

All Bellcore documents are subject to change and their citation in this document reflects the most current information available at the time of this printing. Readers are advised to check current status and availability of all documents.

Technical Advisories (TAs) are preliminary documents describing Bellcore's proposed generic requirements. To obtain TAs, write to:

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10. GLOSSARY

Bipolar (Alternate Mark Inversion (AMI)) Signal: A pseudo−ternary signal, conveying binary digits, in which successive "ones" (marks, pulses) are of alternating, positive (+) and negative (−) polarity, equal in amplitude, and in which a "zero" (space, no pulse) is of zero amplitude.

Bipolar Violation (BPV): In a bipolar signal, a "one" (mark, pulse) which has the same polarity as its predecessor.

Bipolar with 8−Zero Substitution (B8ZS): A code where eight consecutive "zeros" are placed with the sequence 000+−0−+ if the preceding pulse was +, and with the sequence 000−+0+− if the preceding pulse was −, where + represents a positive pulse, and − represents a negative pulse and 0 represents no pulse.

Clear Channel Capability (CCC): A characteristic of a DS1 transmission path in which the 192 "information" bits in a frame can carry any combination of "zeros" and "ones".

Customer Installation (CI): Equipment and wiring at the customer's location on the customer side of the Network Interface. The customer may be an end−user of another carrier.

Cyclic Redundancy Check (CRC): A method of checking the integrity of received data, where the check uses a polynomial algorithm based on the content of the data preceding it. The sender appends the result to the data. The receiver also calculates the CRC code and compares the result with that received from the far terminal. This comparison then provides an error checking mechanism.

DS1 (Digital Signal Level 1): A digital signal transmitted at the nominal rate of 1.544 Mbps.

Digital Cross−Connect System (DCS): A DCS is a centrally controlled terminal that provides per channel 64 kbps (DS0 rate) cross−connection and test access for digital signals that terminate at the DS1 rate. It can connect any DS0 circuit from one line to any other line from a local and remote control location. The DCS redistributes individual DS0 channels among T1, other DS1, or higher level facilities at the digital level, and provides DS0 test access.

Digital Test Access Unit (DTAU): This system provides, to a remote test system, test access to voiceband, DS0, channels or subrate digital channels that are time division multiplexed into a standard pulse code modulated DS1 or DS1C signal.

DSX−1 Cross Connect: These equipment frames are made up of jack panels which serve as cross−connection points and as common locations in the central office for the interconnection of digital facilities operating at the DS1 rate (e.g., channel banks, multiplex equipment and transmission facilities). These cross−connect frames also serve as access points for service restoration, rearrangements and testing for trouble identification, isolation and location.

Extended Superframe Format (ESF): The Extended Superframe Format is the preferred framing format for all new designs of DS1 rate terminals, or equipment that frames on a pattern using the 193rd Framing (F) bit position of the 1.544 Mbps DS1 signal. The extended superframe consists of twenty−four consecutive frames where each frame is a set of 192 information digit time slots preceded by one digit time slot containing the F bit. ESF is a structure in which the F bits are divided into a 2 kbps Framing Pattern Sequence, a 2 kbps Cyclic Redundancy Check sequence and a 4 kbps Data Link.

Framing Pattern Sequence (FPS): A sequence used in the ESF structure to identify the frame and the extended superframe boundaries. When the 192 information digit time slots are channelized, the FPS bits are used to identify the robbed−bit signaling frames and associated signaling channels A, B, C and D.

Intercity and Outstate Trunk (ICOT): This cable is typically used in T1 Outstate (T1/OS) applications. The cable may be air core screened (AC ICOT) in which case the capacitance value is 52 nanofarads per mile or the cable may be waterproof screened (WP ICOT) in which case the capacitance value is 60 nanofarads per mile. Both cables utilize 24 gauge pairs for conductors and provide dual−expanded PIC (DEPIC) types of insulation for these conductors.

In−Band: Using or involving the information digit time slots of a DS1 frame: i.e., bit assignments of a frame exclusive of the framing bit.

Integrated Services Digital Network (ISDN) Primary Access: One of the two forms of ISDN access, Primary Access provides up to 1536 kbps of information divided into a number of channel structures. Primary Access supports combinations of a 64 kbps D channel, 64 kbps B channels, and 384 kbps H0 channels or a 1536 kbps H1 channel. The D channel is used to carry signaling for the B, H0 and H1 channels (although it may be configured to carry customer information in a message oriented format in addition to the signaling information) which carry the customer information.

Line Build−Out Network (LBO): An LBO is used to increase the electrical length of a cable section. These networks range in complexity from a simple capacitor that simulates the capacitance of the missing cable length, to artificial cable sections. Network complexity increases as the frequency range over which the network has to operate increases.

Local Exchange Carrier (LEC): An organization that provides intraLATA telecommunications service to the public.

Loopback: A state of a transmission facility in which the received signal is returned towards the sender.

Metropolitan Area Trunk (MAT) Cable: This cable is a low−capacitance (64 nanofarads/mile) cable designed for major metropolitan routes that may economically utilize 1400 to 1800 pair complements. Cable pairs are 25 gauge copper with expanded plastic insulation. Their transmission characteristics make them approximately equivalent to 22 gauge pulp−insulated cable pairs for T1 systems. The new design produces characteristic impedances different from those of earlier designs; as a result, somewhat different terminating impedances must be used in the affected equipment.

Network: A collection to transmission and switching facilities used by a Local Exchange Carrier to establish communication channels between Customer Interfaces.

Network Interface (NI): The point of demarcation between the Local Exchange Carrier (LEC) facility and the Customer Interface.

Polyethylene−insulated Cable (PIC): This cable is characterized by a capacitance value of 83 nanofarads per mile. The conductors of this cable are insulated with polyethylene. The cable comes in assorted gauges including 17 (waterproof only), 19, 20 (waterproof only), 22, 24, 25 (non−waterproof) and 26.

Pulp−insulated cable: This cable is characterized by a capacitance value of 85 nanofarads per mile. The insulation is wood pulp formed on the conductors in a process similar to paper making. The cable comes in 22, 24 and 26 gauge.

Serving Central Office (CO): The central office which interfaces to the Network Interface via a T1 repeatered loop span.

Span[5]: A collection of repeatered lines between office repeater bays, where each repeatered line consists of two pairs of wires, one for each direction of transmission, and the necessary regenerative amplifiers. A repeatered line for a particular system (terminal to terminal) is made up by interconnecting span lines at the offices along the route. It is simpler to administer, operate and maintain the large number of telephone circuits that are needed in typical central office areas if the T1 lines are thought of as composing the spans to which they belong, rather than identifying the lines by their ultimate terminals.

Superframe (SF): A superframe consists of twelve consecutive frames where a frame is a set of 192 information digit time slots preceded by one digit time slot containing the Framing (F) bit. The framing sequence consists of a 101010 sequence carried in odd−numbered frame positions interleaved with a 111000 sequence carried in the even−numbered frame positions. This combination of sequences, producing a composite framing sequence 110111001000, forms a time−shared combination of a terminal frame pattern and a signaling frame pattern. The terminal framing pattern is used to identify frame boundaries. The signaling framing pattern is used to identify frame boundaries. The signaling framing pattern is used to identify superframe boundaries and, when the 192 digit time slots are channelized, is used to identify the robbed−bit signaling frames and associated signaling channels A and B. (Note in earlier equipment designs, the transmitted framing sequence was an alternate “1” and “0” pattern giving 10101010... as the framing pattern.)

T1 Transmission Line: A full duplex digital transmission facility that is composed of two twisted metallic pairs and regenerators that carry one DS1 signal.

Unit Interval (UI): The longest interval of time such that the nominal duration of the signal elements in a synchronous system or the start and information elements in a start−stop system are whole multiples of this interval. For a DS1 service, a Unit Interval equals 648 ns (the period of a DS1 pulse).

Zero Byte Slot Interchange (ZBTSI): A technique for providing bit sequence independence for networks with restricted transport capability stemming from the use of the AMI line code. Two kbps of overhead information, carried within the ESF data link, is required in order for the ZBTSI algorithm to function properly.