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Data Communications

TECHNICAL REFERENCE

ACCUNET® T1.5 SERVICE

DESCRIPTION
AND
INTERFACE SPECIFICATIONS

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Director - Services/Product
Management Support

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1. INTRODUCTION

This Technical Reference provides Interface Specifications needed to insure compatibility between ACCUNET® T1.5 Service and its associated service functions, and Customer Premises Equipment (CPE). It contains information necessary for connecting CPE to ACCUNET T1.5 circuits to obtain service with the performance characteristics identified in Section 3.

Within this document the terms CPE, DTE, and NCTE are used. CPE (Customer Premises Equipment), and DTE (Digital Terminal Equipment) are often-used terms indicating equipment at the customer's premises, while NCTE (Network Channel Terminating Equipment) refers to a device that interfaces to the Network on one interface, and to the DTE on the other interface. NCTE functionality can be found in Channel Service Unit (CSU) equipment. DTE may also include CSU functionality as an integral part of the equipment package.

For ease of reference, and in conformance with definitions used by ANSI[1] and EIA[3], the term CI (Customer Installation) will be used where feasible in this document, to denote all equipment and wiring at the customer's location, on the customer-side of the Network Interface (NI), and which might include NCTE, CPE, CSU's, and DTE. See Figure 1.

1.1 Contents

The document consists of 8 sections and two appendices which cover the following subjects:

Section 1. Introduction
Section 2. Service Description
Section 3. Performance And Availability
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Section 5. Customer Premises Equipment Characteristics
Section 6. Synchronization And Timing
Section 7. Network Alarm And Status Conditions
Section 8. Testing And Maintenance

APPENDIX A: Jitter At The Network Interface
APPENDIX B: Timing Reference Degradation Thresholds

This document includes a description of the basic ACCUNET T1.5 Service and its associated service functions, circuit descriptions, technical parameters, and physical interface requirements for the proper connection and operation of equipment at the CI with the service. It also covers the NI specifications to be used on either customer premises-to-customer premises (Figure 2) or customer premises-to-Central Office configurations (Figure 3).

Sections 1 through 8 of this document contain descriptive material covering ACCUNET T1.5 Service and *requirements* for CPE interconnected to the Network.

Appendices A and B are provided as supplementary information to assist system designers, equipment manufacturers, and Network users to understand the relationship between CP and (AT&T) Network elements, and the need to consider their interactions when planning or evaluating the overall performance of a customer's network.

It is intended that the material contained in Appendices A and B be used as guidelines for the design and implementation of CPE and facility installations to be used with ACCUNET T1.5 Service.

1.2 Relationship To Industry Standards

The requirements provided in this document are in compliance with FCC Regulations[2] and agree with generally recognized Telecommunications Industry interconnection requirements, when appropriate. These requirements are referenced when necessary for clarification. Current (or proposed) ANSI[1], EIA[3] or BELLCORE [16][19] Standards are implied, when they are mutually consistent. These are augmented, when needed, by specific ACCUNET T1.5 Service compatibility requirements which must be met to ensure the proper functioning of the service offering.

In conformance with the approach used in these standards, this document uses the word "shall" to signify a mandatory requirement, and the word "should" to indicate recommended or advisory criteria.

1.3 Relationship To Other AT&T Technical References

AT&T Technical Reference 62411 defines the requirements for the physical and electrical interface, the signal format, and other technical criteria associated with ACCUNET T1.5 Service and its service function options.

Specifications pertaining to other AT&T Service Offerings or related applications can be found in the following AT&T Technical References:

TR 41457: SKYNET® Digital Service[4]

TR 62310: Digital Data System Channel Interface Specification[5]

TR 41458: Special Access Connections To The AT&T Communications Network For New Service Applications[6]

TR 54070: M-44X Multiplexing, A Service Function of ACCUNET T1.5[9]

TR 54015: Customer Controlled Reconfiguration - A Service Function of ACCUNET T1.5 Service[10]

TR 54016: Requirements for Interfacing Digital Terminal Equipment to Services Employing the Extended Superframe Format[13]

TR 54075: 56 kb/s Subrate Data Multiplexing - A Service Function of DATAPHONE Digital Service[14]

TR 60110: Digital Synchronization Plan[18]

TR 54017: Automatic Protection Capability - A Service Function of ACCUNET T1.5[8]

TR 41449: AT&T Integrated Services Digital Network (ISDN) PRI Interface Specification[11]

TR 41459: AT&T Integrated Services Digital Network (ISDN) PRI and Special Application Specification[12]

2. ACCUNET T1.5 SERVICE

2.1 Service Description

ACCUNET T1.5 Service is a two-point, dedicated, high capacity, digital service provided on terrestrial digital facilities capable of transmitting 1.544 Mb/s. The interface to the customer is a 4-wire DS1 metallic interface referred to as the Network Interface (NI), which may be provided via

T1 carrier or a higher order multiplexed facility. The signals which cross the NI may not be symmetrical and are discussed in Sections 4.7.2.4 and 4.7.2.5. The specific routing and type of technology of the digital facilities used to provide ACCUNET T1.5 Service is determined by AT&T.

2.1.1 Circuit Configurations

ACCUNET T1.5 Service may be configured to provide information transport from:

1. Customer Premises to Customer Premises (Figure 2)
2. Customer Premises to an AT&T Central Office (CO) for connection to a Service Function (Figure 3)
3. Two AT&T Central Offices each connecting to a service function (Figure 4)
4. A customer premises and an AT&T Central Office for access to ACCUNET Reserved 1.5 Service or a SKYNET Digital Service (Figure 5).

There are several service functions available to increase the flexibility and usefulness of ACCUNET T1.5 Service. These are discussed in detail in Section 2.2.

2.1.2 Access Arrangements

Customers may elect to have AT&T provide access to ACCUNET T1.5 Service under FCC Tariff No. 11. In this case AT&T provides an Access Coordinating Function. Likewise, customers may provide access themselves or may acquire access through a third party.

2.1.2.1 AT&T Coordinated Access

Non-AT&T provided access which is coordinated by AT&T will be ordered at the time the customer initiates a Service Order. In providing coordinated access, AT&T assumes the responsibility for the following functions:

1. Design
2. Ordering
3. Installation coordination
4. Preservice testing and service turn-up
5. Trouble sectionalization
6. Restoration coordination

2.1.2.2 Customer Provided Access

Customer Provided Access (CPA) is a method by which customers can furnish their own access to the AT&T Central Office. The serving office must be designated as an ACCUNET T1.5 Serving Office (SO) for interconnection to AT&T services.

The customer has total responsibility for the engineering, installation, and operation and maintenance of the access system up to the AT&T interface. AT&T will provide the installation, maintenance and testing support that is necessary to interconnect the CPA to the AT&T DS1 interface, a Digital Cross-connect Frame (DSX-1). The facilities may be provided by either a Local Exchange Company (LEC) or other vendors. The interface specifications associated with CPA may be found in Compatibility Bulletin (CB) 119[7]

2.1.2.3 Turnkey Customer Provided Access

A Turnkey Customer Provided Access (TCPA) is an arrangement under which AT&T will design, engineer, furnish, and install as well as maintain a complete access system from the customer's premises to the AT&T Central Office. The unique feature of this arrangement is that the customer owns the entire access system. The TCPA consists of AT&T standard products, and is provided on a contractual basis.

2.2 Service Functions

A number of service functions are available with ACCUNET T1.5 Service which increase the flexibility of the basic service and are available in designated AT&T Central Offices. The following sections provide brief descriptions of these service functions and any limitations on their use. Additional information may be obtained from the technical publications listed in the Reference section.

2.2.1 Transfer Arrangements

Transfer Arrangements are service functions which offer the customer the ability to change the terminating location point of their ACCUNET T1.5 circuits. Transfer Arrangements are available in two configurations. Figure 6 illustrates a configuration in which the customer can terminate an ACCUNET T1.5 channel at an alternate user location. Figure 7 illustrates a second configuration offering the customer the ability to terminate an ACCUNET T1.5 channel to either a DS1 Switch Port for connection to ACCUNET Reserved 1.5 Service, or to an ACCUNET T1.5 interoffice channel.

Transfer Arrangements cannot be used with an M-24 Service Function (Section 2.2.3) when that service function interconnects with either Private Line Switched services or Public Switched Network services. This restriction is imposed to prevent the generation of Network maintenance alarms which occur when Central Office equipment senses a loss of signal.

Transfer Arrangements can be activated by two possible arrangements. One arrangement used to effect the transfer uses a DC control path, when available, which must be obtained by the customer.

An alternate arrangement utilizes a dial-in capability. This method of control requires the customer to access the Transfer Arrangement through a data set. After entering a six-digit security code, the customer follows a dialog prompted by the controller, to effect the transfer.

2.2.2 Automatic Protection Capability (APC)

APC provides protection against performance degradation or circuit failure due to access line (DS1 Channel) faults. Protection is furnished through the use of a switching arrangement that automatically switches to an alternate access line when the working channel fails. The customer must order a spare channel and provide customer premises automatic protection switching equipment that meets the compatibility requirements of AT&T Technical Reference 54017.[8]

2.2.3 M-24 Multiplexing

M-24, as shown in Figure 8, provides multiplexing functionality in an AT&T CO which permits the user to connect 24 derived channels of an ACCUNET T1.5 circuit to combinations of switched and non-switched voice grade private line services offered by AT&T. With an M-24 Service Function, Integrated Access will be available to such Private Line and Public Switched Network services as Enhanced Private Switched Communication Service (EPSCS), ACCUNET Switched 56 Service, Software Defined Network (SDN), MEGACOM* Service, MEGACOM 800 Service, and other voice grade private line services described in FCC Tariff No. 9.

With the M-24 Digital Data Throughput (M24/DDT) option, interconnection between ACCUNET T1.5 Service and 56 kb/s DATAPHONE® Digital Service (DDS) is made available.

2.2.4 M-44X Bit Compression Multiplexing

Using ADPCM bit compression multiplexing techniques, M-44X Multiplexing provides the capability to combine two DS1 channels, each carrying up to 24 DS0s, on one DS1 channel, when no signaling capability is required. A maximum of 44 DS0 channels are available for customer use where signaling is required.

M-44X Multiplexing can be ordered alone or in combination with other ACCUNET T1.5 service functions such as M-24 Multiplexing, Customer Controlled Reconfiguration (CCR), and Bandwidth Management Service (BMS). M-44X is available in two configurations, Customer Premises-to-Central Office (Figure 9a) and Central Office-to-Central Office (Figures 9b). CPE used for M-44X functionality must be compatible in compression technique, frame structure, and bundle[1] construction with the Network multiplexer, as described in AT&T Technical Reference 54070.[9]

2.2.5 Customer Controlled Reconfiguration (CCR)

Customer Controlled Reconfiguration (CCR) is a service function of ACCUNET T1.5 Service through which a customer can dynamically allocate groups of one or more DS0 channels contained within a dedicated ACCUNET T1.5 network without the need to involve AT&T (Figure 10). A full description of CCR and its associated requirements can be found in AT&T Technical Reference 54015.[10]

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* *Service Mark of AT&T*

1. *A bundle is a contiguous set of six DS0s. See Section 3.4 for additional information.*

2.2.6 Bandwidth Management Service (BMS)

Bandwidth Management Service (BMS) is a service function of ACCUNET T1.5 Service which allows a customer to electronically exercise control over the configuration of DS0 channels within a network consisting of inter-office T1.5 circuits, Node Controllers, and a System Controller located in an AT&T CO (Figure 11). Reconfigurations at the DS0 and multiple DS0 (Channel Group) level may be executed interactively on customer demand, automatically according to a prearranged schedule, or automatically with priority re-routing upon the failure of any inter-office T1.5 circuit.

2.2.7 The Primary Rate Interface (PRI)

The PRI Service Function of ACCUNET T1.5 Service provides 23 "B" (bearer) Channels and one "D" Channel (used for signaling, control, and user data) between a Customer location and an AT&T CO. The D-Channel uses the CCITT Recommendation Q.931 layer three protocol procedures, as specified in[20] and AT&T Technical Reference 41449[11] and 41459).[12]

The PRI provides the interface between a DS1 Channel and AT&T MEGACOM Service, AT&T MEGACOM 800 Service, or Switched 56 kb/s Digital Service when available at the same AT&T CO.

3. PERFORMANCE AND AVAILABILITY

3.1 Quality Objectives

Service performance objectives for ACCUNET T1.5 circuit configurations outlined in section 2.1.1 are provided in the following sections. Reports of deviations from these specifications will be accepted from customers, and upon release of the circuit to AT&T, the trouble will be verified, sectionalized and repaired. If the customer does not release the circuit to AT&T for testing, AT&T will not be responsible for the performance of the circuit and will not be required to rebate for outages occurring on the circuit.

AT&T has deployed Extended Superframe Format capabilities in its network. ESF-compatible Channel Service Units (CSUs) or customer premises multiplexers, PBXs etc. with capabilities that are described in Technical Reference 54016[13], will enable customers to monitor their own circuit performance and allow AT&T to gather CP to Central Office (CO) performance data on-line, and permit non-intrusive sectionalization. Functionalities of ESF-compatible customer premises equipment will help sectionalize troubles expeditiously, thus resulting in faster repair time and reduced outages.

3.1.1 Availability Objectives

Availability is a measure of the time during which the circuit is available for use. This measurement is the complement of Outage (%Availability = 100 - %Outage). An outage begins when the customer releases a circuit to AT&T for repair and ends when AT&T returns the circuit to the customer. AT&T intends to move towards an availability definition based on ESF failed seconds.

The Availability objective for a customer premises-to-customer premises ACCUNET T1.5 circuit is 99.7% when measured between Network Interfaces over a 3 month period. The availability objective is also modeled on a piece part basis. For access lines, the availability objective is 99.925% which equates to 1.64 hours of outage per quarter. For the internodal link (CO-CO) the availability objective is 99.85%, which equates to 3.28 hours of outage per quarter. The availability measurement for one quarter is independent of the availability in the previous quarter.

AT&T is continuously striving to provide better service availability by introducing rapid restoration techniques and service quality improvement measures. It is recommended that, for analysis, AT&T be informed of the time of day and duration of all trouble conditions.

3.1.2 Performance

Performance is a measure of the operational quality of a circuit during the time it is in use. Measurement of this parameter is performed by counting the number of errored seconds which occur within a given period of time. Errored seconds are normally separated by many error free seconds. Short durations of errored seconds may be expected and will come clear without a repair action. At times, the network experiences periods of error bursts during which a large proportion of bits are in error.

Two new parameters, *Severely Errored Seconds (SES) and Consecutively Severely Errored Seconds (CSES),* which characterize these bursts are introduced in this Technical Reference, and SES objectives for the CO-to-CO segments are given. AT&T is now actively pursuing the establishment of access and end-to-end ES, SES and CSES objectives for DS1 services in T1Q1.4.

3.1.2.1 Performance Parameters

The Bit Error Ratio (BER) has been customarily used to express the accuracy with which bits of digital information are transported over a digital transmission line. In baseband digital systems like ACCUNET T1.5, field tests and measurements indicate that bit errors often occur in clusters. Thus, the BER does not describe the operational characteristics of the T1.5 channel adequately. A better way of describing the performance of the service is to measure the *Error-Free Seconds (EFS)* of the channel. EFS provides a gross measure of the performance of ACCUNET T1.5 Service.

The network will at times generate periods of error bursts during which a large fraction of bits are in error. These periods occur even on circuits well within the Errored Seconds criteria. Such events can sometimes have serious impact on customer applications. *Severely Errored Seconds (SES)* and *Consecutive Severely Errored Seconds (CSES)* are parameters that characterize these burst phenomena.

The error parameters ES and SES have been defined in CCITT Recommendation G.821[21] and are reproduced here for reference. Different equipment vendors and communication service providers have implemented these definitions differently. AT&T's current implementation for measuring these parameters for the ACCUNET T1.5 service accommodates both the Extended Superframe Format and the D4 framing format. The details of AT&T's ESF implementation of ES and SES are provided in Technical Reference 54016[13]

3.1.2.1.1 Error Free Seconds (EFS) / Errored Seconds (ES)

An Error Free Second for a DS1 channel is defined as any second of data in which no bit errors are received. In other words, all the 1,544,000 bits received in a second are received as transmitted. An Errored Second is any second in which one or more bits are in error.

The proportion of error free seconds is the ratio of one-second intervals not containing any bit errors to the total number of seconds in an observation period, which is usually 24 hours. This proportion is expressed as percent error free seconds (% EFS).

3.1.2.1.2 Severely Errored Seconds (SES)

A parameter which characterizes the bursty nature of the service is the Severely Errored Second (SES). This parameter is specified by CCITT Recommendation G.821 for control of overall burst quantity, which allows network designers to better determine the realized performance of their network. A Severely Errored Second (SES) is any second in which the Bit Error Ratio (BER) is worse than 1×10^{-3}.

3.1.2.1.3 Consecutive Severely Errored Seconds (CSES)

CSES is an event of 3 to 9 consecutive SESs, i.e. a period of 3 to 9 seconds in which every second has a BER worse than 1×10^{-3}. Note that if there are more than 9 consecutive SESs, the circuit is considered to be in the unavailable state, according to the CCITT Recommendation G.821. The unavailable state is referred to as the failed signal state in AT&T's Technical Reference 54016[13].

3.1.2.2 Performance Objectives

The 24 hour performance objectives for ACCUNET T1.5 circuits are shown in Tables 3.1, 3.2, and 3.3 for CP-to-CP, CO-to-CO and CP-to-CO respectively. These objectives are mileage banded and given separately for each end-to-end, inter-office, and access link. End-to-end objectives are obtained by adding the contributions of the inter-office and access sections. The number of access sections may range from zero to two, depending on the circuit configuration. The circuit mileage for banding in Tables 3.1 and 3.2 represent the CO-to-CO airline miles. Mileage banding of access performance is not necessary since access circuits are typically less than 10 miles.

TABLE 3.1. ACCUNET T1.5 PERFORMANCE : CP-TO-CP (END-TO-END)

CIRCUIT LENGTH (AIRLINE MILES)	PERFORMANCE		
	ES/DAY	%EFS	SES/DAY
< 250	2246	97.40	*
250 to 1000	2506	97.10	*
> 1000	2765	96.80	*

TABLE 3.2. ACCUNET T1.5 PERFORMANCE : CO-TO-CO (INTER-OFFICE)

CIRCUIT LENGTH (AIRLINE MILES)	PERFORMANCE		
	ES/DAY	%EFS	SES/DAY
< 250	86	99.90	10
250 to 1000	346	99.60	35
> 1000	605	99.30	50

TABLE 3.3. ACCUNET T1.5 PERFORMANCE : CP-TO-CO (ACCESS)

PERFORMANCE		
ES/DAY	%EFS	SES/DAY
1080	98.75	**

** No objectives available*
*** Until an Industry Standard is available, the customer may allocate 4 SES/day for each access link, for planning purposes.*

For ACCUNET T1.5 circuits employing ESF, compatible CSUs have an ESF error event register which counts CRC-6 error events[13].

A discussion of the CRC-6 error counts needs to be noted here. Deliberations are underway in the Standards Bodies (T1E1 and T1M1) to define the ESF error parameters (SES in particular) in terms of the number of CRC-6 error events in one second. While there is currently agreement that any second with an OOF event is an SES, the number of CRC-6 error events that define an SES remains to be finalized. Such deliberations notwithstanding, it is worth mentioning that the total CRC-6 counts read on CSUs which are ESF compatible as defined in AT&T Technical Reference 54016 provide a gross account of error performance that do not necessarily convey detailed performance information. For example, there can be up to **333** CRC-6 error events in a second. Thus a CRC-6 error count of 1998 could be due to 6 seconds with 333 CRC-6 errors in each second or result from 1998 seconds with **one** CRC-6 error in each second. Clearly, there are numerous other combinations of CRC-6 errors and number of seconds in error which would yield the same 1998 CRC-6 error count. Therefore, it is recommended that this counter not be used as a DS1 performance indicator. Instead, the ES (and SES, if available) counter readings should be used to track the performance of a circuit.

3.1.2.3 Burstiness

Occasionally, the network will generate error bursts of longer duration during which a large fraction of bits are in error. An outage can be caused by a burst during which the Bit Error Ratio is 1×10^{-2} or worse. However, such bursts are usually of short duration and will come clear without repair action. This type of error burst generally results in OOF conditions, where all the blocks of data in a second are damaged. When error bursts are less than 2.5 seconds, CPE should remain operational, i.e., it should not generate either local or facility alarms or initiate trunk conditioning. If intervals greater than 2.5 seconds are experienced, CPE should generate a "Red" CFA (Carrier Failure Alarm) as defined in Section 7.0 and transmit a "Yellow" Alarm Signal in the direction opposite to that from which the burst was received. Studies have indicated that the error burst events characterized by CSES (i.e. a period of 3 to 9 consecutively severely errored seconds) cover more phenomena than the events described in the preceding paragraph (i.e. error bursts of 1×10^{-2} BER or worse for 2.5 seconds or more). For example, it is known that CSES events affect picture and facsimile transmission quality. Occurrences of these types of error bursts should be monitored by counting either "Red" CFAs or CSESs.

3.1.2.4 Delay

ACCUNET T1.5 circuits will experience one way absolute delay of no more than 60 ms end-to-end. Because of reconfigurations within the network that can be performed by AT&T, its access providers or a customer using CCR or BMS capabilities, this delay may not remain constant on a given connection over time. Customers should ensure that the delay associated with CPE in addition to the ACCUNET T1.5 transmission delay, falls within the range which is acceptable to their applications.

4. FORMAT AND INTERFACE SPECIFICATIONS

4.1 DS1 Framing

To ensure proper circuit operation and general Network integrity, the customer's DTE must provide output signals that are compatible with the Network and the digital hierarchy. Except for U.S. Government Agencies, only the following two DS1 framing formats are acceptable for use on ACCUNET T1.5 circuits. These are the Superframe Format and the Extended Superframe Format (ESF). (An unframed DS1 signal format may be used by U.S. Government Agencies and others furnishing service to them).

4.1.1 Superframe Format

The Superframe format, previously referred to as D4 Type framing, consists of 12 frames of 193 bits each for a total of 2316 bits. Each 193 bit frame consists of 192 bits preceded by one framing bit (the F bit). Figure 12 shows that the framing bit is time shared to both synchronize the terminal equipment and to identify the signal framing. Terminal framing (Ft) identifies the frame boundaries and Signal framing (Fs) identifies frames 6 and 12 in which signaling bits, A and B respectively, are transmitted when the service application is channelized voice.

To minimize service impairments, customers should avoid the unintentional emulation of framing patterns (see Figures 12 and 13), or alarm signals such as the "Yellow" CFA (see Section 7.4).

4.1.2 Extended Superframe Format (ESF)

The Extended Superframe Format "extends" the DS1 superframe structure from 12 to 24 frames (see Figure 13) for a total of 4632 bits. It redefines the 8 kb/s channel consisting of framing bits previously used exclusively for terminal and robbed bit signaling synchronization. The ESF format consists of a 2 kb/s channel for basic frame and robbed-bit signaling synchronization, 2 kb/s for a Cyclic Redundancy Check (CRC-6) code, and 4 kb/s for a data link as shown in Figure 14. Complete specifications pertaining to the ESF requirements are contained in AT&T Technical Reference 54016.[13]

Although the Superframe format is currently acceptable for use with the earlier ACCUNET T1.5 Service offerings, new service functions such as BMS require ESF. Customers should recognize that ESF provides advantages such as in-service monitoring and trouble sectionalization capability.

4.2 Line Coding

Line coding requirements for transmission using ACCUNET T1.5 Service are discussed in this section.

4.2.1 Bipolar Format

The line code for the DS1 signal shall be bipolar, except where intentional bipolar violations are introduced by B8ZS (Section 4.2.2). The bipolar signaling technique consists of transmitting a binary "0" as zero volts, while a binary "1" is transmitted as either a positive or negative pulse, opposite in polarity to the previous 1. In addition, it is necessary to meet certain pulse (one's) density requirements (see Section 5.5) to ensure proper ACCUNET T1.5 circuit performance. A bipolar violation occurs when the alternate polarity rule is violated.

4.2.2 B8ZS (Bipolar Eight Zero Substitution)

B8ZS will be the only acceptable coding technique for use with ACCUNET T1.5 Service to provide 64 kb/s Clear Channel Capability (64 CCC). When offered, 64 CCC will be available only with ESF. Its use allows the Network to transmit DS0 (64 kb/s) or n×DS0 (where n can equal 1-24 [max 1.536 Mb/s]) signals unconstrained by ones density and number of consecutive zeros requirements. The use of B8ZS for ACCUNET T1.5 Service is dependent upon the use of customer equipment capable of transmitting and receiving B8ZS coding, as well as the deployment of B8ZS compatible transmission, test, and maintenance equipment within the AT&T Network and the provision of compatible facilities by the access provider. Additional details on this capability can be found in Section 5.6.

4.3 DS0 Channelization

CPE required to function with channelized ACCUNET T1.5 Service Functions, must present the information contained in the DS1 bit stream (i.e 24 DS0 channels), in a sequential stream of 8 bit (byte) words. A sequence of 24 bytes (one for each of the 24 channels of a DS1), plus a framing bit, constitutes a Frame. A Superframe consists of 12 frames (2316 bits). This structure is shown in Figure 12, and the Extended Superframe (ESF) structure is shown in Figure 13.

If the DS1 is used to transmit channelized information to the ACCUNET T1.5 M-24 Service Function, D4 type channel sequence must be used. This channel arrangement requires a sequential assignment of the DS1 channels corresponding to the M-24 multiplexer time-slot arrangement, i.e Channel #1 = Time Slot #1, Channel #2 = Time Slot #2, etc.

Use of the M-24 Service Function and Digital Data Throughput Option with either a pure 56Kb/s DDS CO-to-CP configuration, or with DATAPHONE Subrate Data Multiplex (SDM) functionality at the CP, requires that the data bits in the customer application be positioned on the DS0 channels of the ACCUNET T1.5 (DS1) circuit according to specific formats. Figure 15 illustrates the positioning of data bits for 56 kb/s transmission. Information describing these options may be found in AT&T Technical References 62310[5] and 54075.[14]

4.4 Bit Compression Multiplexing

When a customer uses the Bit Compression Multiplexing (BCM) M-44X Service Function, there are special restrictions placed on the arrangement of the DS0 channels for compatibility with the Network located multiplexer. Various arrangements of signals within the DS1s are available to the customer through use of template (bundle) options. AT&T Technical Reference 54070[9] should be consulted for information about the M-44X Service Function of ACCUNET T1.5.

4.5 Signaling

Two signaling formats are supported when using ACCUNET T1.5 to interconnect to ACCUNET T1.5 channelized Service Functions. The two signaling formats are:

- Robbed Bit Signaling (RBS)
- ISDN PRI Message Oriented Signaling (ISDN PRI)

Although RBS is supported with all ACCUNET T1.5 service functions, the application of ISDN PRI is currently limited to the ACCUNET T1.5 Primary Rate Interface Service Function (see Section 2.2.8). Customers should consult with their local AT&T sales representatives for clarification of current restrictions.

4.5.1 Robbed Bit Supervisory Signaling

Conventional robbed bit signaling uses A & B bits extracted from every 6th sequential frame of a Superframe signal for trunk supervision (see Figure 12). When ESF is used the number of robbed signaling bits per ESF doubles with the addition of C and D signaling bits, providing 16 possible signaling states (see Figure 14). When only 4 state signaling is required, the A and B bits associated with the 6th and 12th frames are mapped into the C and D bits of the 18th and 24th frames, respectively. Robbed Bit Signaling is described in AT&T Technical Reference 43801.[15] Additional details on special access signaling can be found in Technical Reference 41458[6].

4.5.2 ISDN PRI Signaling

The ISDN PRI is a multipurpose high-speed (1.544 Mb/s) multiplexed digital interface structured to contain bearer (B) channels for transport of end-user information. It provides a message oriented D-Channel (out-of-band) signaling technique, using CCITT Recommendation I.441 (Q.921, or LAPD) and I.451 (Q.931) protocols. The protocols are fully described in Parts III and IV of Technical Reference 41449[11].

A customer access arrangement to ISDN PRI must have at least one D channel, which must be in time slot 24 of the DS1 transport.

4.6 Customer Premises Network Interface

4.6.1 Physical Interface

This section describes the physical connection at the NI. Provisioning of the physical interface for registered digital terminal equipment is provided through two possible connector arrangements. The first, for existing applications, is a subminiature 15-pin female connector, number DA-15S [International Standards Organization (ISO) 4903]. The cable coming from the customer should be terminated in a 15-pin subminiature male connector.

The NI connector pin assignment is as follows:

1,9 = Send Data
1 = Send Data (Tip)
9 = Send Data (Ring)
3,11 = Receive Data
3 = Receive Data (Tip)
11 = Receive Data (Ring)

Pins 2 and 4 are reserved for Network use.

Pins 10, 12, 13, 14, and 15 are not used.

The second arrangement consists of a series of connectors available for use on new applications, and identified by the Universal Service Ordering Codes (USOC) Connectors RJ48C and RJ48X. These 8-pin connectors, which accomodate 4 DS1's, have identical pin assignments, however the RJ48X is the recommended terminating device since it provides a physical loopback when CPE connected to it is unplugged. These connectors are compatible with ISDN standards.

When more than 4 DS1's are to be connected, the 50 pin USOC RJ48M or RJ48H connectors may be used. Of these two 50 pin connectors which accommodate up to 8 DS1's, the RJ48H is the preferred multi-circuit connector[2]. These connectors are listed in Subpart F of Part 68, FCC Rules and Regulations, supplemented by Public Notice 2526-February 10, 1986, and specified in references[2] and[3]. Figures 16 through 19 show these connectors.

4.6.2 Electrical Characteristics

The electrical specifications contained herein describe the DS1 signals delivered to the access providing carrier and to the CPE at the Network Interface (NI) which is shown in Figure 1. These specifications are in compliance with the BELLCORE PUB 62508[16] and the proposed ANSI T1E1/88-001R1 Standard.[1] Where necessary, these specifications are augmented by specific ACCUNET T1.5 Service requisites.

4.6.2.1 Powering

Signal regeneration and loop-back functionality at the Customer's Premises are required for the proper maintenance of ACCUNET T1.5 Service. Consequently, power shall be present at the CI at all times except in the event of a commercial power failure.

The powering for NCTE functionality at the customer's DTE for 1.544 Mb/s circuits placed in service for the first time on or after February 16, 1988 shall be provided by either the access provider or the customer[2]. DTE existing prior to that date will continue to receive line power from access providers, via either a regulated 60 mA or 140 mA dc current to the cable pairs through use of simplexing transformers in the serving central office.[2]

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2. *The powering requirement for 1.544 Mb/s service DTEs existing prior to 2-16-88 will become optional after 12-18-89 per FCC Report and Order, October 23, 1987: Part 68.318 (b). In addition, after that date DTE will no longer be required to contain a "Continuity Of Output (i.e. keep-alive) Signal capability for FCC Registration purposes.*

The circuitry consists of a current regulator, powering regenerator, Zener diode, cables and a return path to the power supply. The regulating office repeater provides both current regulation and battery return path, while the loop is made continuous by looping through the customer's DTE, as is illustrated in Figure 20. Under this arrangement, the customer's DTE will be provided line power for the functionality. At the DTE, the simplex current is passed through circuitry to develop the power supply voltage needed for the circuits. The maximum simplex resistance beyond the NI which will be powered over the loop is 1120 ohms. This maximum resistance value includes all wiring, DTE circuitry, and any additional circuit components which are needed to provide service.

Customers who order new 1.544 Mb/s service on or after February 16, 1988 must determine whether their access provider will supply line power. New installations that are powered by the access provider must be capable of receiving power from the line. Where access-provider line power is not available or used, customers must ensure that their DTE contains a premises power option.

To insure protection to the Network and the customer from hazardous voltage and current, the following must be adhered to. The signals that the terminals encounter at the NI are of three types: 1) normal telephone system voltages and currents, 2) voltages and currents due to maintenance activities and 3) voltages and currents which appear at the NI as a result of environment (induced voltages, lightning hits, etc.). This document describes normal telephone system voltages and currents, those due to maintenance activities and terminal characteristics that are required for compatibility with the Network.

4.6.2.2 Signal Specifications

The following signal specifications describe characteristics for all signals at the NI as specified in[1]. Differences between the Network and the CI signals are identified in Sections 4.6.2.4 and 4.6.2.5. DTE shall not apply voltages to the Network other than those described in Section 4.6.2.3 of this document.

4.6.2.2.1 Transmission Line Rate

The electrical signals delivered to the Network and to the CI at the NI, must be T1 type bipolar, except where intentional bipolar variations are introduced by B8ZS (see Section 4.2.2), operating at the nominal DS1 rate of 1.544 Mb/s ± 50 b/s.[3]

4.6.2.2.2 Test Load

A termination of 100 ohms ± 5% resistive shall be used at the NI for the evaluation of signal characteristics.

3. Older equipment has rate variations up to ± 200 b/s.

4.6.2.3 Standard Pulse Characteristics

4.6.2.3.1 Pulse Shape

An isolated pulse, both positive and inverted negative, shall have an amplitude between 2.4 and 3.6 volts, measured at the center of the pulse, and fit the normalized template shown in Figure 21 when scaled by a constant factor. Figure 21 also defines the corner points of the pulse template.

4.6.2.3.2 Power Levels

For an all "ones" transmitted pattern, the power in a 2 to 3 kHz band centered at 772 kHz shall be in the range of 12.0 to 19.0 dBm and the power in a 2 to 3 kHz band centered at 1544 kHz shall be at least 25 dB less.

4.6.2.3.3 Pulse Imbalance

In any window of 17 consecutive bits, the maximum variation in pulse widths (half amplitude) shall be less than 20 ns.

4.6.2.3.4 60 Hz Variations In Pulse Amplitude

Pulse amplitude may vary at a 60 Hz rate as a result of the presence of 60 Hz longitudinal currents in the powering loops of T1 line regenerators. In such cases the envelope of pulse amplitudes shall be limited as shown in Figure 22. Any pulse amplitude in the range of 2.4 V to 3.45 V may be used as the 100% point in Figure 22.

4.6.2.4 Network To The NI

The Network signal at the NI shall meet the signal specifications of Section 4.6.2.2 except that:

1. The pulse characteristics shall be those of a standard pulse (Section 4.6.2.3) transmitted through a cable pair with a loss in the range of 0.0 to 16.5 dB at 772 kHz between 100 ohm terminations, and
2. The lower limit on the standard pulse amplitude shall be 2.25 V rather than 2.4 V.

The customers must seek the assistance of the access provider in determining the characteristics of the cable between the last repeater and the customer premises to determine the appropriate Line Build Out settings for terminating CPE. Where AT&T coordinates the provisioning of access, AT&T will provide this information.

4.6.2.5 Customer To The NI

The customer's signal must not cause harm in the Network, and shall meet the specifications of Section 4.6.2.2 except that:

1. The pulse characteristics shall be those of a standard pulse (Section 4.6.2.3).
2. The lower limit on the pulse amplitude shall be 2.0 V.

Note: This allows a nominal 1.5 dB attenuation at 772 kHz in the CI wiring.

See comment in 4.6.2.4 above concerning Line Build Out responsibility.

4.7 Jitter

Customer premises digital equipment which is interconnected to 1.544 Mb/s circuits, must work in the presence of jitter. Jitter may introduce a number of impairments such as errors, outages, slips, crosstalk and other degradations to the original signal. Thus, jitter is a particularly important parameter for the types of DTE connected to the network interface.

Jitter is defined as short-term variations of the significant instants of a digital signal from their ideal positions in time. Wander on the other hand, is accepted as long-term variations of the same instants, generally with variations below 10Hz.

In properly designed digital transmission systems jitter arises from three principal sources: digital regenerators, multiplexers, and jitter hits. Regenerator jitter is introduced by imperfections in the timing recovery process, whereas multiplexer jitter is mainly related to the stuffing mechanism used to synchronize the low-speed incoming pulse streams. The seldom occurring jitter (phase) hits are attributed to a transient behavior of clock sources[4] or other sudden changes in transmission facilities. Jitter accumulation or propagation through the network is a complex nonlinear process that can be characterized conveniently only in a simplified way. With respect to jitter, the Network Interface (NI) is a technically artificial division. Jitter occurring at the NI depends on the equipment and facilities connected on both sides of the NI. As such, proper engineering of facilities and DTE is required to provide satisfactory performance.

Jitter characteristics are strongly dependent on the pattern of the digital signals transmitted (combination of ones and zeros). The current quasi-random test signals (QRTS), Figure 23, express, to some extent, the behavior of commonly transmitted signals. However, the final evaluation of jitter associated problems should be done with live traffic to verify that high quality service will be realized.

These guidelines are provisional and will be updated, as necessary, to maintain consistency with the jitter standards which may be adopted by national standards organizations.

The jitter specifications in sections 4.7.1 - 4.7.2 apply at the Network Interface (NI) of ACCUNET T1.5 Service to the DTE at the customer location. Appendix A provides an additional discussion of jitter at the NI.

4.7.1 Input Jitter Tolerance

Input jitter tolerance specified for the digital line termination on the DTE expresses the relation of a jitter level to bits in error. The specified input jitter tolerance of the synchronizer (clock recovery circuit), if used to extract clock from the incoming signal, relates a jitter level to the loss of

4. *See Section 6, Synchronization And Timing, for related discussion on timing clock sources.*

synchronization.

Measured using the standard AT&T quasi-random test signal (QRTS) (Figure 23) operating at 1.544 Mb/s in a noise-free environment, the DTE line interface connected to the NI shall operate satisfactorily with sinusoidal input jitter having the characteristics shown in Figure 24. This template represents the minimum acceptable tolerance level for DTE together with an office repeater or CSU if used.

Tolerance to input jitter should be tested at a number of spot test frequencies. Jitter amplitude should be subsequently increased to the level at which the onset of errors (1 bit in error for jitter frequencies up to 10 kHz, 5 bits in error or minimum achievable number of bit errors, for higher frequencies) occurs in a 60 second measuring time interval. A faster method that can be used is to find two jitter amplitudes which differ by less than the desired accuracy (e.g. 5% up to 10 kHz, 10% for higher frequencies) and for which no bit is in error for the lower amplitude, while some errors are observed for the higher amplitude. The tolerance is accepted to be equal to the lower amplitude. The measuring interval must be held constant for measurements at all individual frequencies. For DTE with a zero suppression scheme based on DS0 subchannels, a measuring time interval of 71 seconds can be used with statistical hypothesis testing. An error distribution should first be constructed with no input jitter present. Error distributions for different input jitter amplitudes are then compared to this base distribution to make a decision about which jitter amplitude causes a statistically different error distribution. In all situations the QRTS bit pattern should not be changed before it is applied to the DTE, and all bits of the DS1 signal level must be observed for errors.

If timing is recovered from the incoming signal and used to clock the outgoing signal, the synchronizers (including bridging repeaters) shall have a minimum acceptable tolerance represented by the template (solid line) in Figure 25. The synchronizer shall be able to resynchronize if the jitter is below the dashed line in Figure 25. This limits the synchronizer hysteresis if existent. The loss of synchronization or permanent change to holdover mode specifies the input jitter tolerance of synchronizers.

Manufacturers of DTE are required to provide, at least for the units tested, necessary modifications such as loopback capability after the synchronizer, disabling of zero suppression schemes, etc., to verify the compliance with the requirements. The modifications, in no way, should result in higher tolerances than those encountered with unmodified units.

At low frequencies, the jitter (wander) tolerance can be limited by the size of the buffer (if used) in the DTE. In this case the minimum size of the buffer must be 193 bits (one frame), plus additional storage of 138 bits to accommodate hysteresis. This provides, at low frequencies, the minimum jitter (wander) tolerance of 138 UI (1 UI $\equiv$ 1bit $\equiv$ 648 ns $\equiv$ 360°). For existing equipment, additional storage of 28 bits can be acceptable.

It is recommended that all new DTE designs be engineered to have a tolerance specification which is better than the requirements represented by the template to ensure problem free operation. This is especially important if a higher order facility is used to provide access.

4.7.2 Output Jitter Generation

An important component of the total jitter which is encountered by the Network, is the jitter occurring at the output of the DTE on the customer's side of the NI when no jitter is present at the input. This component is measured using the standard AT&T QRTS (Figure 23) through the scheme shown in Figure 26. (Live traffic may be used if convenient.) The jitter produced at this point shall not exceed the following levels: at point 1, 0.05 UI peak-to-peak (2 mV rms); at point 2, 0.025 UI (1.25 mV rms); at point 3, 0.025 UI (1 mV rms); at point 4 (10 Hz - 8 kHz bandwidth), 0.02 UI (0.8 mV rms) (1V $\equiv$ 1 UI). The RMS values are given here for comparison and should not be used without peak-to-peak measurements. If necessary, a Spectrum Analyzer should be used to obtain a spectrum of the generated jitter.

4.7.3 Jitter Transfer Function

Jitter transfer functions express the amount of jitter that is delivered from the input to the output of the DTE. The transfer function must be measured from the termination of the DS1 level facility that is providing the synchronization clock (output clock) for the DTE to the output DS1. For all other DS1 facilities the transfer function should be zero. DTE which use stratum 2 or stratum 3 clocks (with corresponding narrow phase-locked loops) transfer the maximum tolerable input jitter amplitude (for all jitter frequencies) to a value below the levels identified in the section on Output Jitter Generation (section 4.7.2). As shown in Figure 27, DTE which use stratum 4 or lower clocks is acceptable if it exhibits a transfer function without peaking, located in the band between templates "a" and "b". For uniformity and optimal operation, the transfer function of new equipment should not have a corner frequency above 6 Hz.

Jitter transfer functions can be measured using the scheme shown in Figure 28. The quasi-random signal (Figure 23) is modulated at approximately 75% of the jitter input tolerance at spot frequencies in the band from 10 Hz to 40 kHz. A spectrum analyzer with a window bandwidth of 1 Hz in 10-100 Hz range, 4 Hz in 100-1000 Hz range and 10 Hz above 1 kHz should be used for the measurement.

When in maintenance line-loopback condition before the DTE synchronizer, but after the regenerator, AT&T requirements for T1 regenerators apply. The relation of jitter levels at the NI to an error-free operation is discussed in Appendix A.

5. CUSTOMER PREMISES EQUIPMENT CHARACTERISTICS

5.1 Required Functions

Customer premises equipment shall provide for certain functions which are required to ensure the proper performance of ACCUNET T1.5 Service. These functions, usually performed by the Channel Service Unit (CSU), consist of signal regeneration and loop-back capability for trouble sectionalization. As indicated in Section 1, CSU functionality may be incorporated as an integral part of the customer provided equipment performing other DTE functions, or provided by a separate piece of equipment. In either case, the customer is responsible for providing CSU functionality at each termination of DS1 channel service on a customer's premises.

5.2 Alarm Indication Signal (AIS)

To prevent the disruption of service provided by certain Network equipment, it is recommended that DTE contain circuitry which will transmit an Alarm Indication Signal (AIS) to the NI upon a loss or disruption of the originating signal. The AIS shall be an unframed all "ones" signal.

5.3 Loopbacks

To conduct circuit testing and single-ended fault sectionalization of the digital line, a Line Loopback (LLB) shall be provided. The LLB provides the Network with a means to test the DS1 circuit on an out-of-service basis and perform single-ended fault location. It is illustrated in Figure 29.

Note that the detection circuitry within the DTE must be capable of receiving loopback codes (discussed in Sections 5.3.1 and 5.3.2) from Network timed control signals, and that the DTE shall be capable of performing the loopback function without producing transmission or synchronization slip impairments.

5.3.1 Line Loopback Using The Superframe Format

A latching loopback is set up with a framed in-band control signal which indicates to the circuitry in the DTE that the receive signal should be looped back to the transmit pair. The line loopback functions shall operate upon receipt of the following pulse pattern codes:

1. Activate:

   A framed DS1 signal consisting of repetitions of four "zeros" followed by one "one", with the framing bits overwriting the pattern.

2. Deactivate:

   A framed DS1 signal consisting of repetitions of two "zeros" followed by one "one", with the framing bits overwriting the pattern.

   In the presence of these respective patterns, the DTE shall activate or deactivate the LLB function in no sooner than 4.5 seconds, and no longer than 6.5 seconds.

While in a loopback state, DTE shall not remove bipolar violations.

The Line Loopback shall also operate upon receipt of the patterns in 1 and 2 above without framing to accommodate equipment permitted to send unframed (non-standard) control signals[1].

5.3.2 Line Loopback Using the ESF

Access to the Line Loopback feature when using the ESF format is through use of ESF Data Link Messages used to carry control signals (and performance information) across the NI. Details concerning loopback capability when using ESF may be found in ANSI T1E1/88–001R1[1].

5.3.3 ISDN PRI

It is planned that customers with an access configuration to the ISDN PRI Service Function may assign a line appearance in their CPE to a 64 kb/s (non-inverting) digital loopback, permitting operational and bit error rate tests from the Network without the need for customer interaction. AT&T Technical Reference 41459[12] should be consulted for additional information on the ISDN PRI.

5.4 Longitudinal Balance

To comply with Part 68.310 of the F.C.C. Rules And Regulations[2] and to ensure proper operation, longitudinal balance of the NCTE interface in the transmit and receive paths shall be greater than 35 dB from 50 kHz to 1.544 kHz for each path. Longitudinal balance is measured using a test circuit having a metallic impedance of 100 ohms and a longitudinal impedance of 500 ohms.[3]

5.5 Pulse Density

To ensure adequate timing recovery of the regenerative digital facilities and therefore ACCUNET T1.5 circuit performance, it is necessary to meet certain pulse density requirements. These requirements are outlined in the following sections.

5.5.1 Unchannelized Circuits

The following pulse density requirements shall be met when an unchannelized signal is transmitted. The DTE must not transmit more than 15 zeros in a row, and in each time window of 8 X (n+1) bits (where n can equal 1 through 23), there should be at least "n" ones present. Customer data signals which do not meet the specified zeros constraint shall be altered by the customer's equipment prior to transmission on the Network. Under conditions where the line code restrictions are not met, the end-to-end performance will degrade and such degradation will not be included in the overall performance specified in Section 3. If the line signal fails to meet the pulse density requirements for ACCUNET T1.5 Service and culminates in the dispatch of repair personnel, AT&T will remove the circuit from operation to ensure that harm does not occur to the Network. In addition, customers may be charged a maintenance service charge for the dispatch.

5.5.2 Channelized Circuits

ACCUNET T1.5 circuits which follow the channelization procedures outlined in Section 4.3 and which terminate in service functions within the Network shall have a minimum pulse density of one "1" in each byte of eight pulses. The purpose is to preclude long strings of zeros and ensure adequate timing energy.

5.6 64 kb/s Clear Channel Capability (64CCC)

5.6.1 General and Basic Definition

"Clear Channel Capability is a characteristic of a DS1 transmission path in which the 192 information bits in a frame can carry any combination of zeros and ones."[5] 64CCC provides users with 64 kb/s of channel capability thus allowing 1.536 Mb/s of transmission on DS1 rate digital

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5. *Proposed Text for ANSI/EIA 547; ANSI EIA Standard For NCTE For DS1 Service, Contribution TR 41.4/88-3-007; April 7, 1988*

circuits. (See related discussion on Pulse Density restriction in Section 5.4.) Clear Channel Capability, as an option for ACCUNET T1.5 Service customers, will be implemented *exclusively* through use of B8ZS line encoding both on the access and interoffice channel (IOC) segments, thus providing end-to-end B8ZS Clear Channel Capability.

With B8ZS coding, each block of eight consecutive "zeros" is removed and the B8ZS code inserted in their place. The "zeros" in the 4th and 7th positions are replaced with bipolar violations ("v" s), and the 5th and 8th bit positions are replaced with valid "ones". This substitution process is illustrated in Figure 30.

If for example, the pulse preceding the all "zeros" byte is transmitted as a positive pulse (+), the inserted code is 000+-0-+. If the pulse preceding the inserted code is a negative pulse (-), the inserted code is 000-+0+-.

5.6.2 Decoding B8ZS Signals

To decode B8ZS coded signals, equipment receiving DS1 signals should continuously monitor the incoming DS1 level for B8ZS coded words. When a B8ZS code word is detected it should be replaced by eight "zeros".

6. SYNCHRONIZATION AND TIMING

6.1 General

Whenever synchronous digital signals are being transported over an ACCUNET circuit, the receiving end must operate at exactly the same average frequency as the transmitting end to prevent loss of information. When digital signals traverse a network consisting of digital transport facilities, switching nodes, multiplexers, and transmission interfaces, the task of keeping all the entities operating at the same frequency so that no information is lost or repeated is referred to as network synchronization.

There are two general classes of customer networks which use ACCUNET T1.5 services: (1) entirely private networks and (2) networks using AT&T central office functions to access AT&T services. As shown in Figure 2, an entirely private network contains no AT&T central office functionality. Guidelines contained in AT&T Technical Reference 60110[18] instruct customers on how they may configure a customer premises-to- customer premises network, using a customer-provided timing source.

A network which utilizes AT&T Central Office functionality contains one or more central office connections as shown in Figure 3. Central office connections to AT&T services or ACCUNET T1.5 Service Functions may or may not provide stratum 1 traceable timing, which is defined in the ANSI Standard, "Synchronization Interface Standards for Digital Networks".[17] Examples of AT&T services or ACCUNET T1.5 Service Functions which provide stratum 1 traceable timing via ACCUNET T1.5 are MEGACOM, MEGACOM 800, SDN (Software Defined Network), CCR, BMS, Digital EPSCS, and M-24. Examples of ACCUNET Service Functions which may not provide stratum 1 traceable timing are Transfer Arrangements, Automatic Protection Capability (APC), M-44 and M-24. If access to any stratum 1 traceable AT&T service is provided by ACCUNET T1.5 Service the customer shall derive timing either from the AT&T Network or from an equivalent stratum 1 clock source. All DTE in customer networks with traceable timing shall have a timing reference traceable to a clock with stratum 1 accuracy, and shall follow the AT&T

hierarchical plan as described in AT&T Technical Reference 60110.[18]

A synchronization plan must be developed to ensure proper operation of a digitally interconnected customer network.

6.2 Synchronization Equipment Requirements

CPE which connect to AT&T central office provided services must be stratifiable so that CPE clocks can be properly placed in the synchronization hierarchy and synchronization plans can be made consistent with AT&T Network synchronization. Such CPE must meet stratum 2, 3, or 4 clock requirements. CPE clocks which do not connect to AT&T central office provided services should be stratifiable, and shall have a free run accuracy of at least 3.2×10^{-5}. The stratum level requirements are specified in[17] and summarized in Table 6.1.

In addition to the stratum level performance requirements, CPE should be able to handle degraded timing reference conditions as described in Appendix B, without the propagation of impairments such as significant phase hits (TIE), error bursts, or misframes. This is mandatory for equipment which is intended to receive timing via an ACCUNET T1.5 circuit from a clock at another location, and is used to supply timing to other clocks (a condition called transferal of timing). This includes CPE used in either customer premises-to-customer premises or customer premises-to-public network configurations. Examples of such equipment include, but are not limited to, Digital Private Branch Exchanges, T1 Multiplexers, and DS1/DS0 Switches or Cross Connects.

To avoid the propagation of impairments and to meet ACCUNET T1.5 Severely Errored Second performance objectives, all CPE (regardless of stratum level) which transfer timing shall meet the maximum time interval error (i.e. peak-to-peak phase change as defined in[17]). In response to a rearrangement activity such as switching of timing reference, changeovers of active synchronization hardware, and for all possible changes in clock mode, the clock shall allow a maximum time interval error (MTIE) at the outputs of the digital CPE of no more than 1000 nanoseconds. The rate of change of the time interval error (rate of phase change) under the same conditions shall be no more than 1/8 unit intervals (81 ns.) over any 2048 unit interval (1.326 ms.) period. The MTIE and phase slope requirements must also be met under all timing reference degradations, independent of whether a switch reference has occurred. This will assure that impairments will not propagate, and when incorporated in a clock having the timing reference degradation thresholds identified in Appendix B, will result in networks with proper synchronization performance.

All stratum 2, stratum 3, and stratum 4 Type I clocks satisfy the above requirements and can be used to transfer timing. Stratum 4 Type II clocks do not meet the above criteria, shall not act as timing references and transfer timing to other equipment, and can only terminate timing. In addition, it should be noted that stratum 4 Type II clocks may propagate impairments on all outgoing DS1 lines, including those which return to the timing reference, as well as those which connect to other nodes.

In addition, the clock synchronization system used in customer equipment shall provide the following functional capabilities:

a. Maintain phase lock with a timing signal which is designated as the timing reference and is derived from either: 1) a suitable digital traffic-carrying facility, or 2) an external timing-only line fed directly into a dedicated non-traffic timing input port.

b. Provide jitter filtering (as defined in Section 4.8) to improve short term stability.

c. Provide a stable holdover and/or free-running capability (as defined in Table 6.1) in the temporary absence of a synchronization reference signal.

d. Select between primary and secondary references, when available, which includes monitoring the quality of each reference continuously and switching between them when the current reference is degraded.

e. Tolerate, without degradation of the output timing, the impaired timing reference conditions referred to in Appendix B.

A summary of the stratum level requirements is given in the following table.

TABLE 6.1. *STRATUM LEVEL REQUIREMENTS*

	Stratum 2	*Stratum 3*	*Stratum 4 Type I*	*Stratum 4 Type II*
Accuracy	1.6×10^{-8}	4.6×10^{-6}	3.2×10^{-5}	3.2×10^{-5}
Holdover	1×10^{-10} *in* 1^{st} *24 hours*	$\leqslant$ *255 DS1 frame slips in* 1^{st} *24 hours*	*Not Required*	*Not Required*
Availability	*Duplicated Clock Hardware*	*Duplicated Clock Hardware*	*Single Clock Hardware*	*Single Clock Hardware*
MTIE During Rearrangement	*MTIE* $\leqslant 1\ \mu sec$ *Phase Change Slope: 81 ns. in any 1.326 ms.*	*MTIE* $\leqslant 1\ \mu sec$ *Phase Change Slope: 81 ns. in any 1.326 ms.*	*MTIE* $\leqslant 1\ \mu sec$ *Phase Change Slope: 81 ns. in any 1.326 ms.*	*No Requirement*
Pull-In Range	3.2×10^{-8}	9.2×10^{-6}	6.4×10^{-5}	6.4×10^{-5}
External Timing Port Available	*Yes*	*Yes*	*Optional*	*Optional*
Application	*Transfers timing.*	*Transfers timing.*	*Transfers timing.*	*Terminates timing.*

6.3 Timing References

To increase the availability of a timing reference, the clock in equipment which intends to transfer timing shall be capable of accepting more than a single synchronization reference source (e.g., one primary and one or more secondaries). In such equipment, when configured with a secondary reference source, an automatic means shall be provided to switch the clock timing reference from the primary to the secondary reference source in the case of excessive errors, or upon failure of the primary reference, as discussed in Appendix B. The switch of reference shall occur from primary to secondary and meet the MTIE requirement of Section 6.2.

Both references should be continuously monitored. When performance of the current reference degrades to a point where the clock is unable to adequately track the timing signal, the reference will be identified as out of specification. If the current reference is out of specification (and the backup reference is within specification), an automatic switchover to the backup is initiated. Reference switchover shall not occur before the timing reference has experienced input jitter above the tolerances given in Section 4.8, or a phase hit of 1000 ns. with phase slope less than, or equal to 6.1×10^{-5}. Reference switchover should not occur before the error thresholds, defined in Appendix B, are reached.

If the original reference is subsequently determined to be restored to specification, an automatic switchback to the original may be initiated if such a switchback does not produce impairments. All CPE, regardless of stratum level or type, must meet the MTIE and phase slope requirements if the clock performs an automatic switchback. To prevent chatter due to repeated automatic switching between two references, a time-out mechanism of not less than 10 seconds is desirable.

References can run at any bit rate that is an integral multiple of 8 kb/s from 56 kb/s to 1.544 Mb/s. The equipment should be capable of accepting timing from any domestic facility to which it interfaces and accept a DS1 timing reference. An external timing reference interface shall be available on stratum 2 and 3 clocks and shall be capable of accepting a DS1 timing reference. An external reference refers to a timing-only circuit which supplies reference directly to the CPE clock via a dedicated (non-traffic) timing input port. A DS1 external timing reference interface is desirable for stratum 4 clocks. The reference rate requirements should be consistent with[17], except for the 2.048 analog reference requirement for stratum 2 equipment.

7. NETWORK ALARM AND STATUS CONDITIONS

In this section, thresholds for the various conditions which activate alarm or status conditions in Central Offices are described. These thresholds are detected by either the Network equipment or the NCTE, which may be integral to the DTE.

7.1 Loss Of Signal (LOS) Condition

A Loss Of Signal (LOS) condition shall be declared when any of the three following conditions have occurred:

1. The DTE has determined that 100 (-20, +75) consecutive pulse positions with no pulses have occurred.
2. The DTE has determined that 175 ± 75 successive pulse positions with no pulses have occurred.[19]
3. The DTE has determined that 231,600 (150 msec) successive pulse positions with no pulses have occurred.[3]

In summary, until an industry standard has been agreed upon, an LOS shall be declared when between 80 to 231,600 consecutive pulse positions with no pulses have occurred.[6]

7.2 Out Of Frame (OOF) Condition

An Out Of Frame (OOF) condition shall be declared when either Network equipment or DTE senses errors in the framing pattern. This occurs when any two of four, any two of five, or any three of five consecutive terminal framing bits received contain bit errors in the framing pattern. An OOF condition clears when reframe occurs.

7.3 Reframe Duration

The maximum average reframe time shall be less than 50 milliseconds in the absence of errors.[7]

7.4 Red and Yellow Carrier Failure Alarms (CFA)

A "Red" Carrier Failure Alarm (CFA) is defined as a incoming detected failure of a carrier system. It may be triggered by either a continuous loss of framing or by an intermittent out-of-frame condition in an incoming signal. A "Red" CFA is declared and cleared using the following algorithms:

On detection of an LOS or OOF not caused by an All-Ones or AIS, a rise slope type integration process starts that declares a "Red" CFA after 2.0 to 3.0 seconds of *continuous* LOS or OOF. If the LOS or OOF is *intermittent*, the integration process shall decay at a slope of from 1/4 to 1/15 of the rise slope during the period when the signal is normal (i.e., for a 1/5 rise slope, 100 msec.

"Red" CFA is cleared when no LOS or OOF conditions occur in 10 to 20 contiguous seconds. Ongoing studies indicate that many customers would prefer a much shorter restoration time. Consideration should be given to the provision of a user selectable restoration time between 0 and 20 seconds.

A "Red" CFA shall cause a "Yellow" CFA signal to be transmitted to the far end, via the outgoing bit stream. The "Yellow" CFA signal must be transmitted continuously until the "RED" CFA condition no longer exists. This is done by forcing the second bit to zero in all channels of a DS-1 using the Superframe format. For the Extended Superframe format, a repetitive 16-bit pattern consisting of 8 "ones" followed by 8 "zeros" (1111111100000000) is transmitted continuously, for a minimum of one second, over the ESF data link.

A "Yellow" CFA is declared at a receiving terminal after the "Yellow" CFA signal has been detected and timed. The "Yellow" CFA must be detected in one second or less even in the presence

6. *The wide divergence between these alternative specifications is not critical since the LOS event is not reported until the condition is timed for several seconds.*

7. *The maximum average reframe time is the average time to reframe when the maximum number of bit positions must be examined for the framing pattern. It is important that any framing strategy which is implemented not lock onto a spurious framing signal (i.e., false framing protection is required).*

of a 1 × 10^{-3} BER. The minimum detection time is 335 msec. for the SF format and 28 msec. for the ESF format. The recommended detection/clear algorithm for the ESF format is that a "Yellow" CFA shall be declared if the "Yellow" CFA signal pattern occurs in at least seven out of ten contiguous 16-bit pattern intervals. A "Yellow" CFA is cleared if the "Yellow" CFA signal pattern does not occur in ten contiguous 16-bit signal pattern intervals.

7.5 Alarm Indication Signal (AIS) CFA

An AIS is transmitted in lieu of the normal signal to maintain transmission continuity and to notify the receiving terminal that there is a transmission fault located either at the transmitting terminal or upstream of the transmitting terminal.

An "AIS" CFA is detected by monitoring for both OOF and All-Ones conditions. The All-Ones condition must be detectable in the presence of a 1 × 10^{-3} BER. An AIS condition is declared when both OOF and All-Ones conditions are present at the same time. The AIS condition clears when either the OOF, or All-Ones, or both conditions clear. Since the AIS does not contain framing information, an AIS will cause a "RED" CFA. An "AIS" CFA should be declared instead if the AIS condition persists after the "RED" CFA is detected. An "AIS" CFA is cleared when the "RED" CFA is cleared.

8. TESTING AND MAINTENANCE

A telephone number for the Control Test Center will be provided by AT&T at the time of service installation. Testing and repair by AT&T can be performed most efficiently when a complete and accurate description of the difficulty is provided by the customer. Information such as the trouble, time of day, duration, etc. should be provided when reporting trouble.

When customers encounter problems, it is essential they check their equipment for proper operation prior to reporting trouble. This will eliminate the unnecessary dispatch of repair personnel by both AT&T and its local access provider. Customers will be required to pay a maintenance service charge if a problem is isolated to the customer's equipment, after service personnel have been dispatched. Diagnostic capabilities which may be part of customers equipment, such as CPE-to-CPE loopback capability, can be useful in trouble isolation. It is recommended that customer personnel be acquainted with the basic equipment layouts, visual indicators on CPE, and be knowledgeable in fundamental maintenance techniques.

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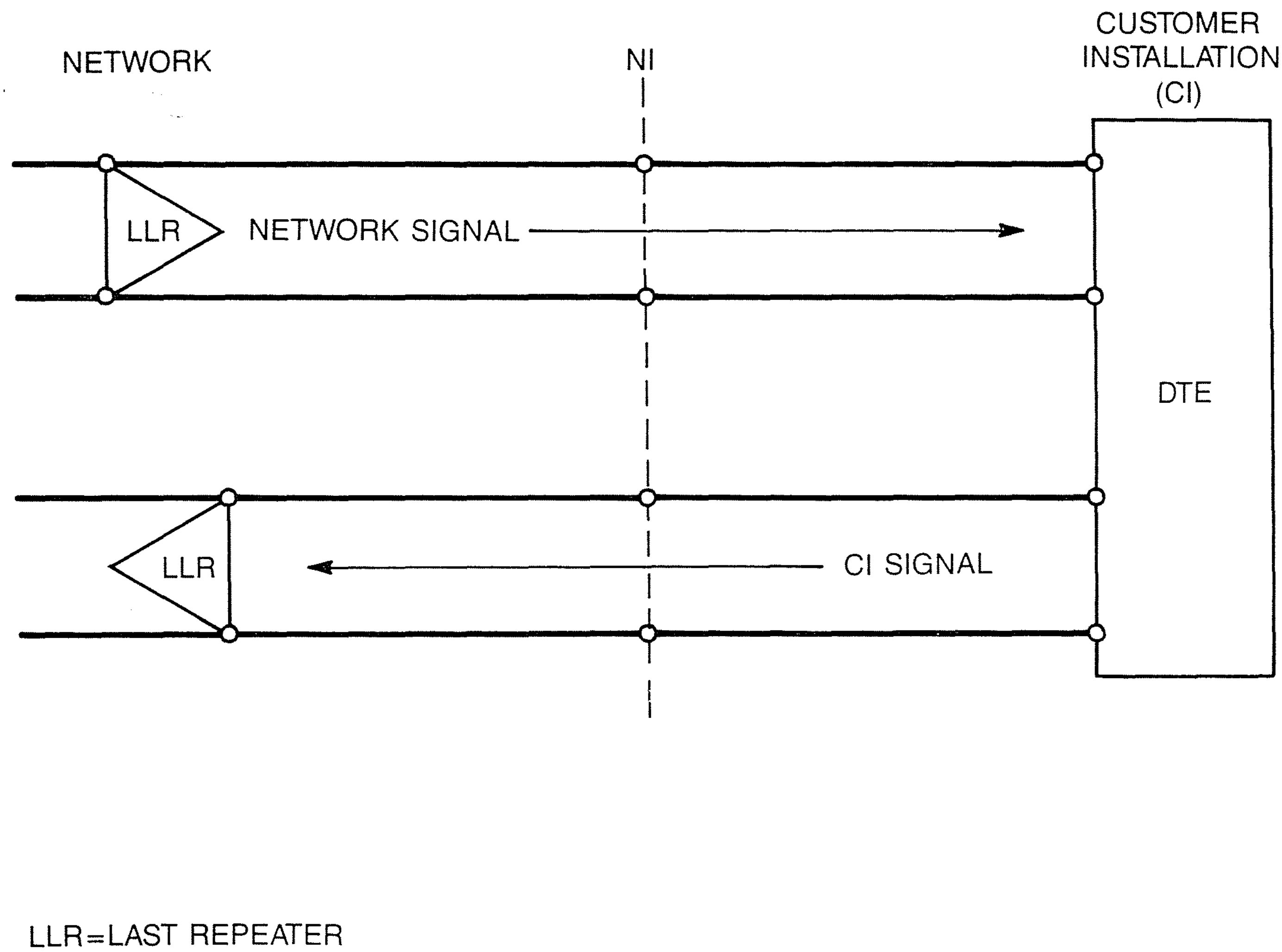
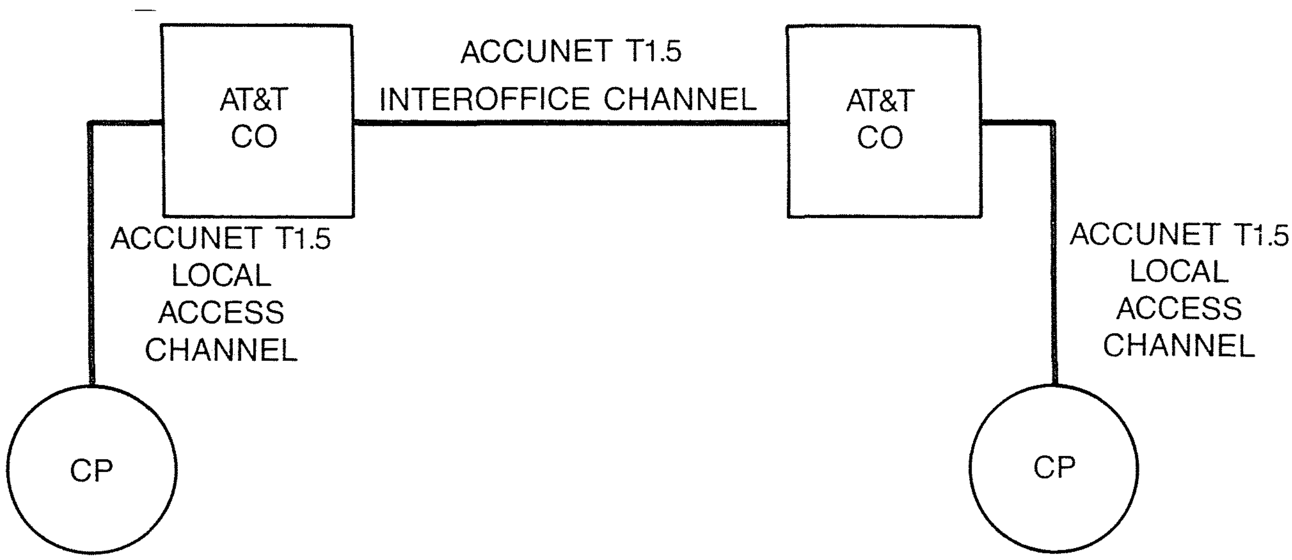


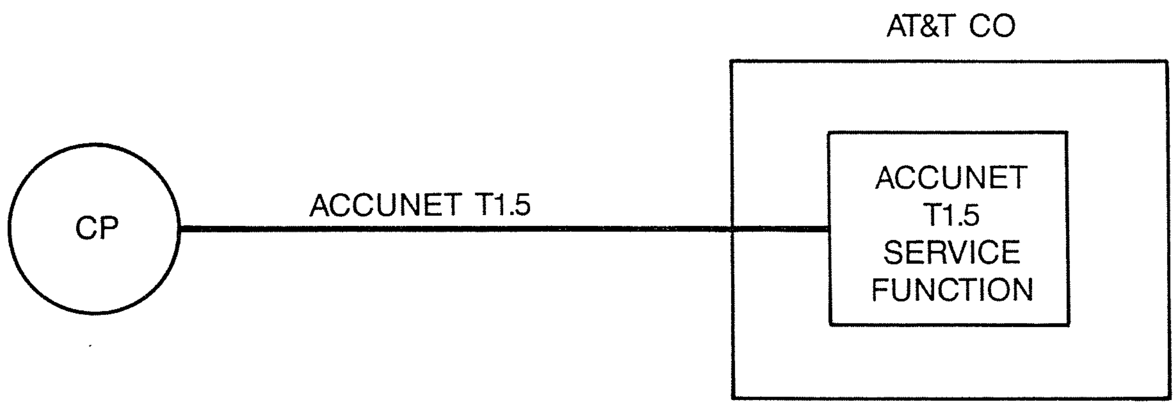
ACCUNET T1.5 SERVICE NETWORK INTERFACE (NI)

FIGURE 1



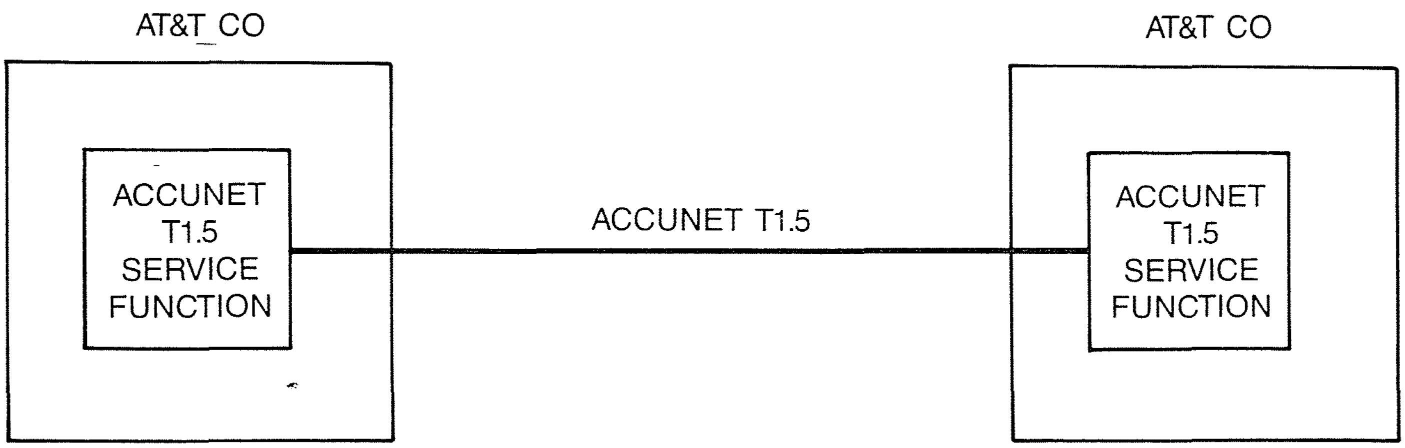
ACCUNET T1.5 SERVICE
CUSTOMER PREMISES-TO-CUSTOMER PREMISES
CONFIGURATION

FIGURE 2



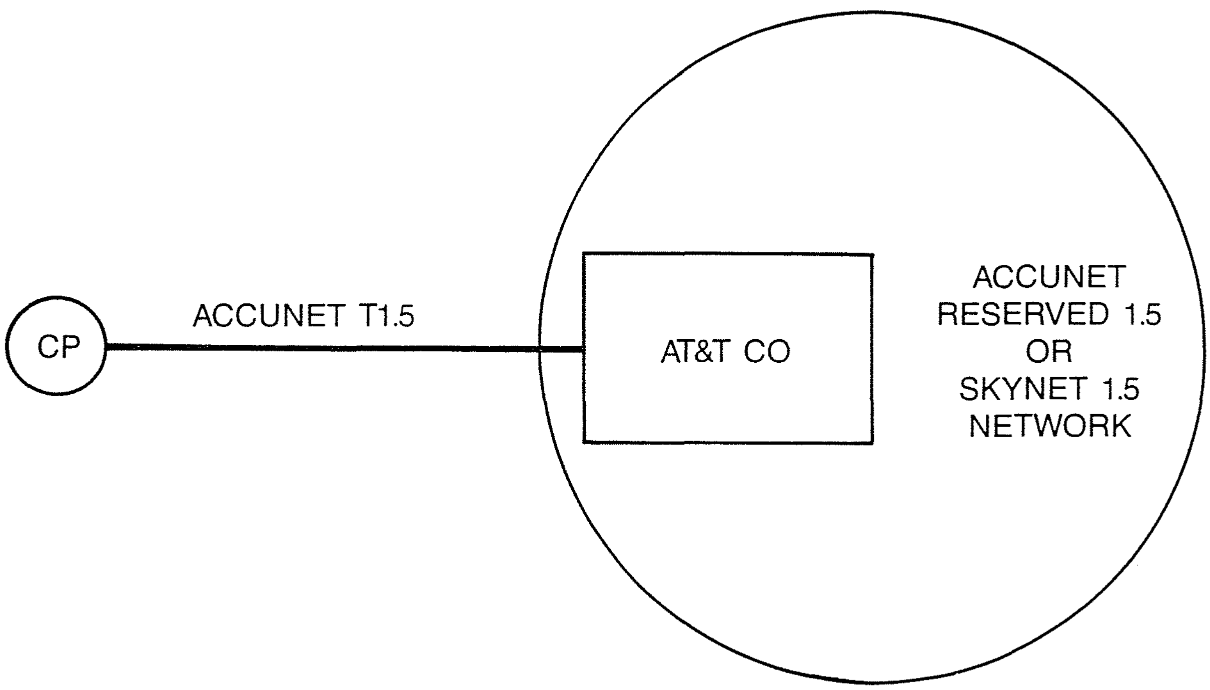
ACCUNET T1.5 SERVICE
CUSTOMER PREMISES-TO-CENTRAL OFFICE
SERVICE FUNCTION CONNECTION

FIGURE 3



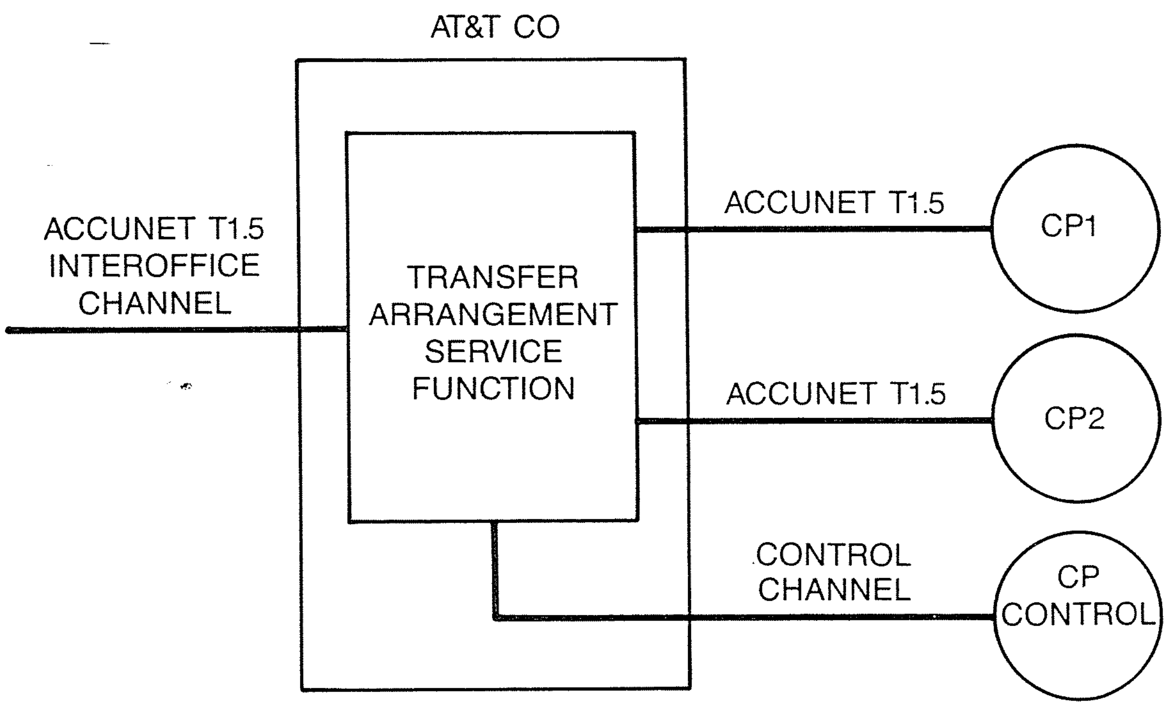
ACCUNET T1.5 SERVICE
CENTRAL OFFICE-TO-CENTRAL OFFICE
SERVICE FUNCTION CONNECTION

FIGURE 4



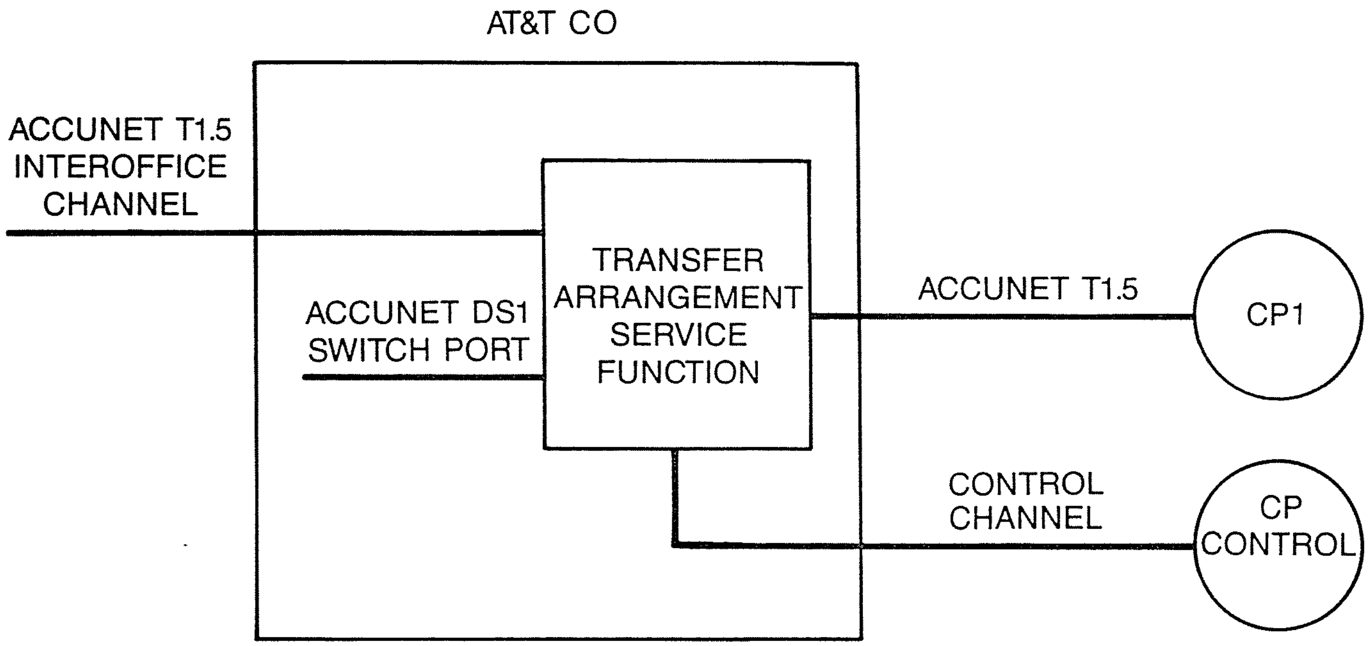
ACCUNET T1.5 SERVICE
CUSTOMER PREMISES-TO-CENTRAL OFFICE
ACCUNET RESERVED 1.5 OR SKYNET 1.5

FIGURE 5



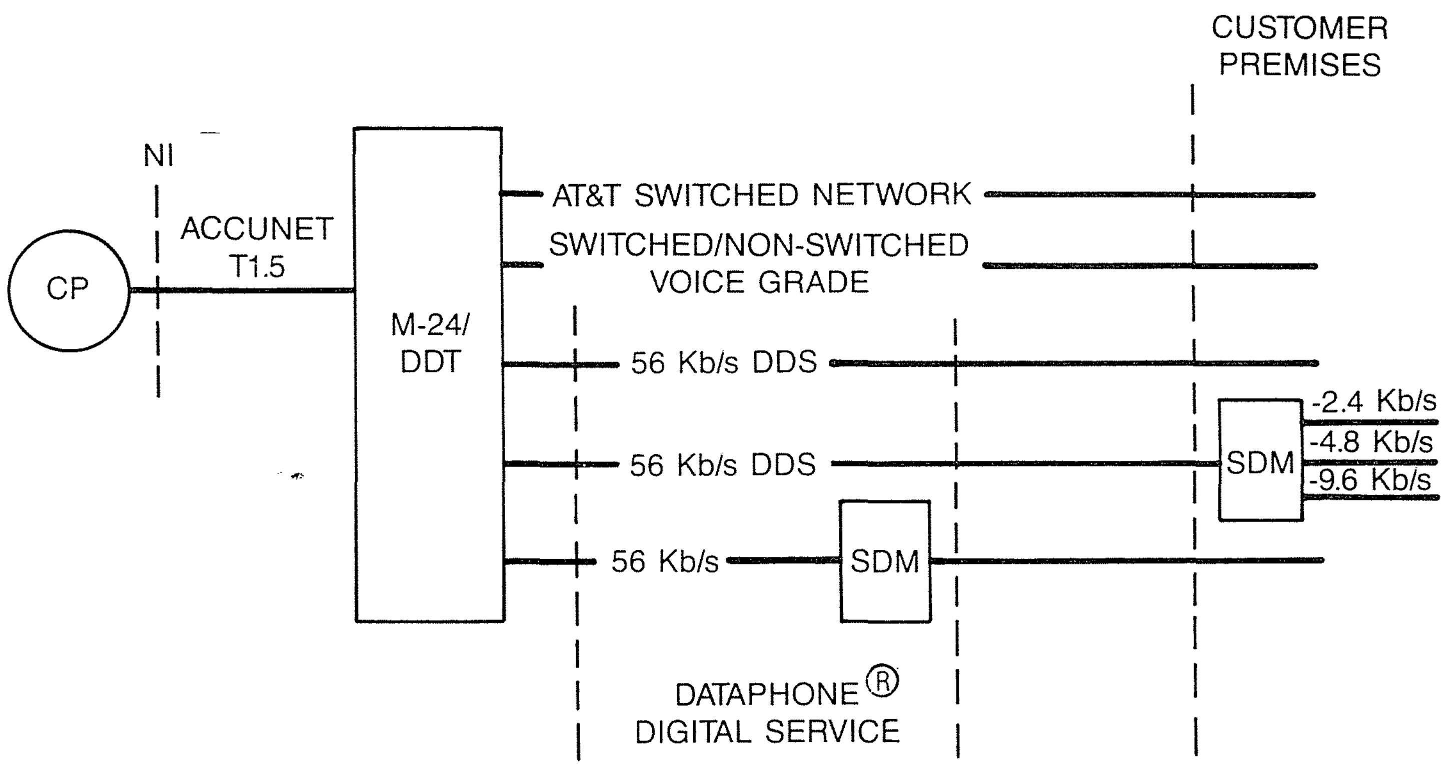
ACCUNET T1.5 SERVICE
TRANSFER ARRANGEMENT A

FIGURE 6



ACCUNET T1.5 SERVICE
TRANSFER ARRANGEMENT B

FIGURE 7



ACCUNET T1.5 SERVICE
M-24 MULTIPLEXING SERVICE FUNCTION

FIGURE 8

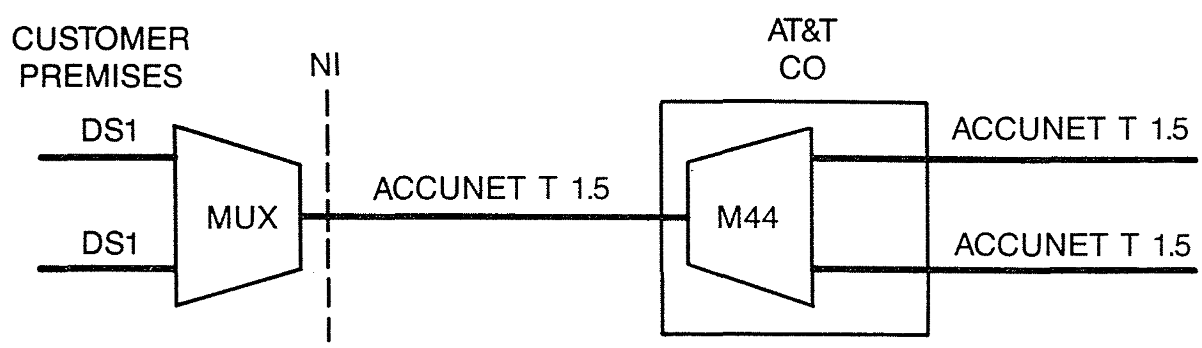


FIGURE 9A
CP - CO

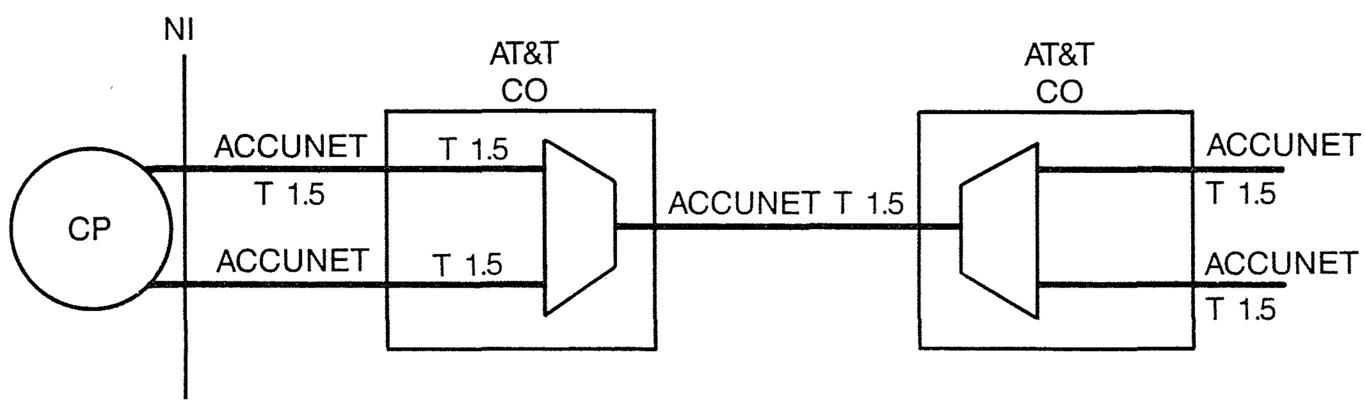
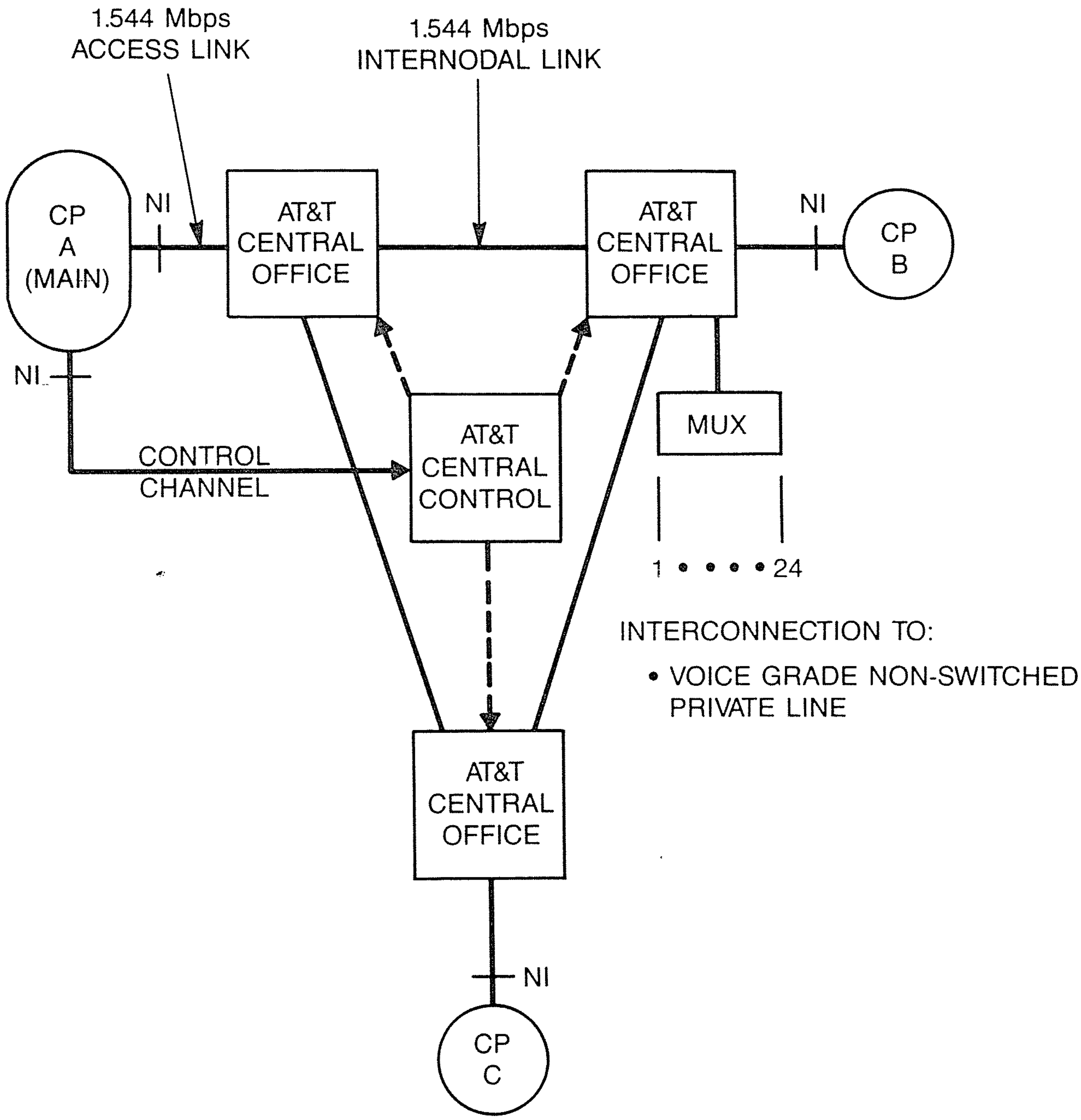


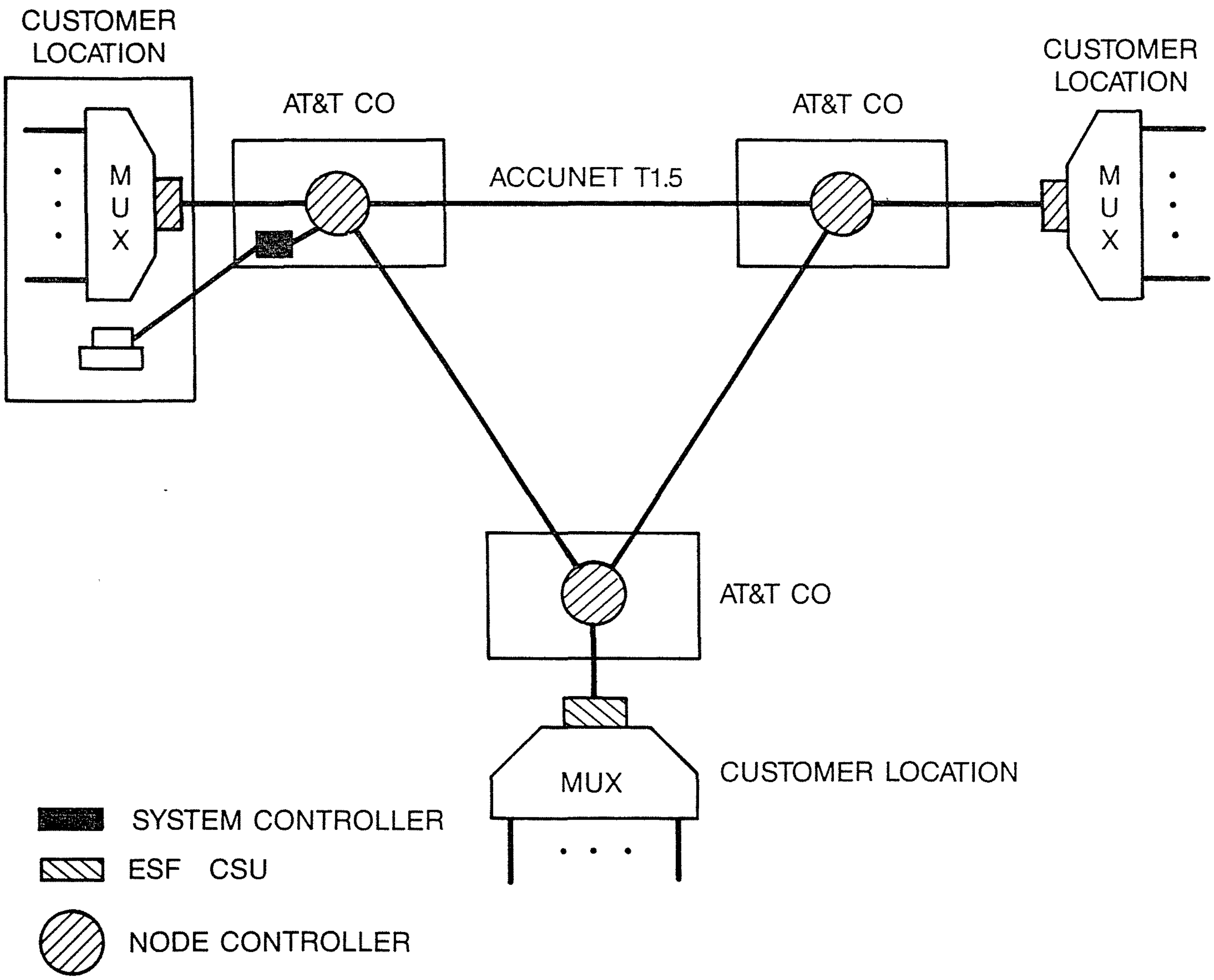
FIGURE 9B
CO - CO

M-44X MULTIPLEXING



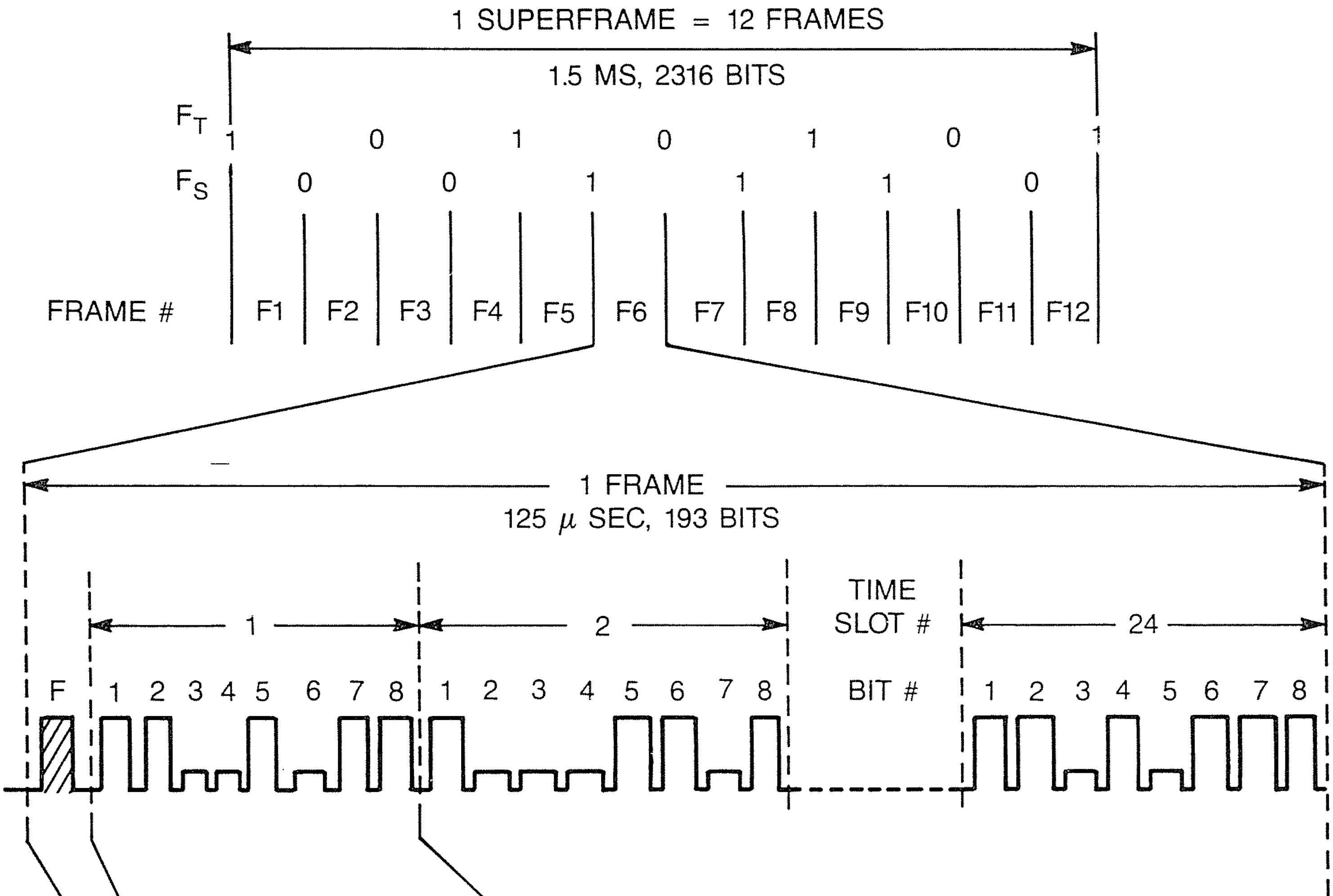
CUSTOMER CONTROLLED RECONFIGURATION

FIGURE 10



BANDWIDTH MANAGEMENT SERVICE (BMS) FUNCTION

FIGURE 11

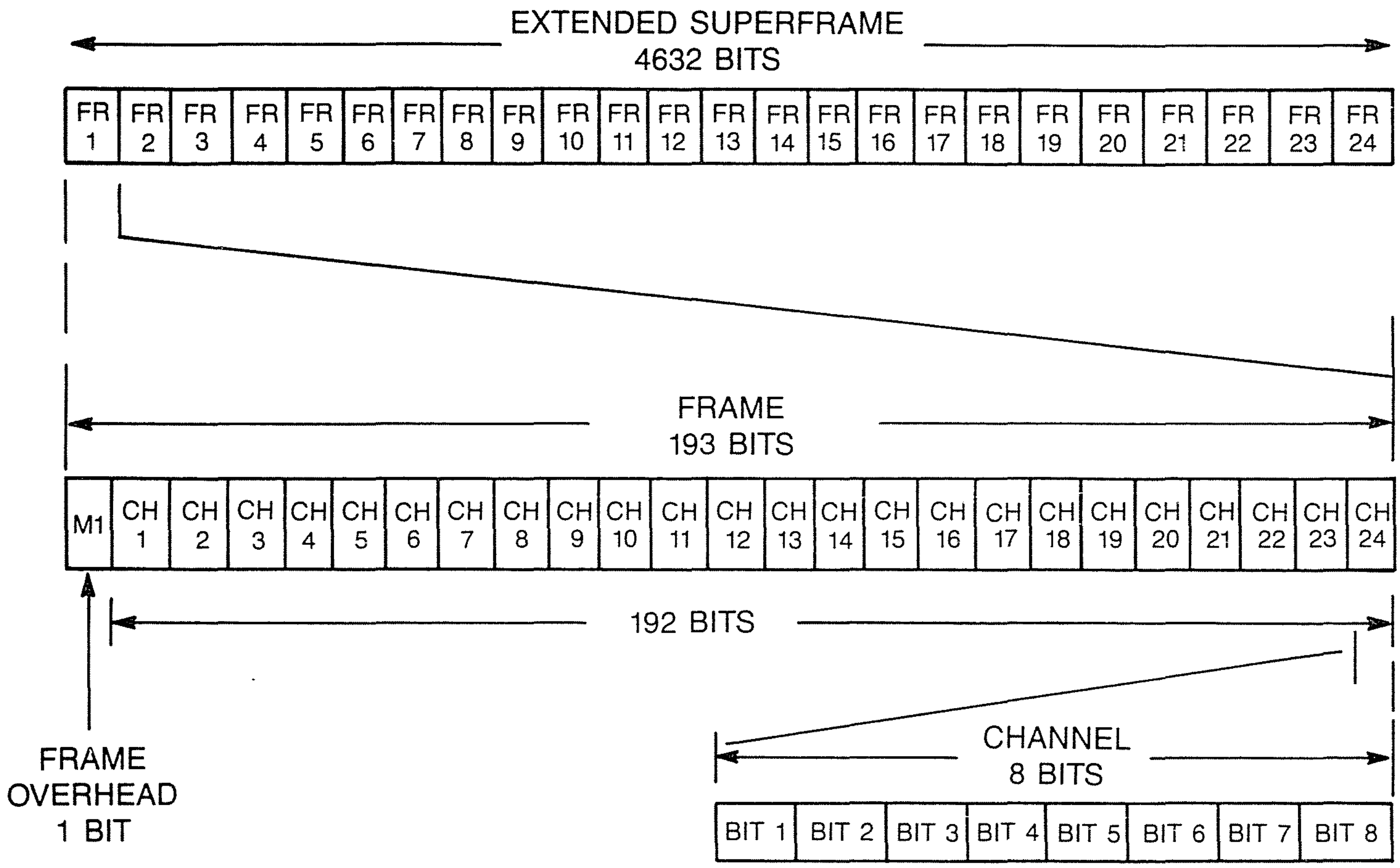


FRAME #	F	d1	d2	d3	d4	d5	d6	d7	d8		
1	1	V	V	V	V	V	V	V	V		8 - BIT VOICE
2	0	V	V	V	V	V	V	V	V		
3	0	V	V	V	V	V	V	V	V		
4	0	V	V	V	V	V	V	V	V		
5	1	V	V	V	V	V	V	V	V		
6	1	V	V	V	V	V	V	V	A	SIGNALING FRAME,	7 - BIT VOICE
7	0	V	V	V	V	V	V	V	V		8 - BIT VOICE
8	1	V	V	V	V	V	V	V	V		
9	1	V	V	V	V	V	V	V	V		
10	1	V	V	V	V	V	V	V	V		
11	0	V	V	V	V	V	V	V	V		
12	0	V	V	V	V	V	V	V	B	SIGNALING FRAME,	7 - BIT VOICE

V = BIT USED FOR VOICE/DATA
A&B = SIGNALING BITS
d = DATA (INFORMATION) BITS

SUPERFRAME FORMAT TYPE CHANNELIZATION

FIGURE 12



EXTENDED SUPERFRAME FRAME STRUCTURE

FIGURE 13

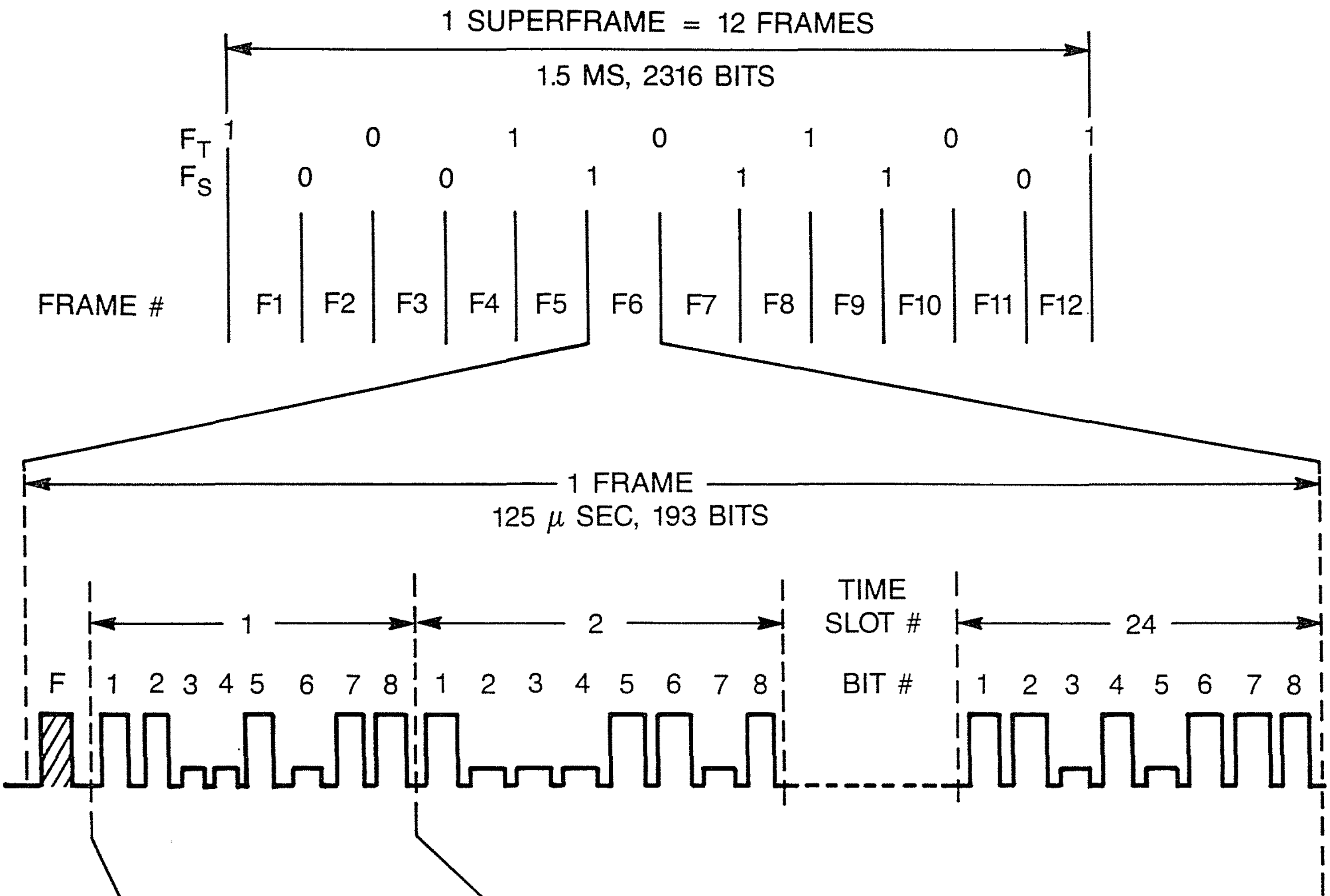
FRAME NO.	F BITS				BIT USE IN EACH TIME SLOT		SIGNALING BIT USE OPTION	
	BIT NO.	FPS	DL	CRC	TRAFFIC	SIG	T	SIGNALING CHANNEL 2 4 16
1	0	—	m	—	1-8	—		
2	193	—	—	C1	1-8	—		
3	386	—	m	—	1-8	—		
4	579	0	—	—	1-8	—		
5	772	—	m	—	1-8	—		
6	965	—	—	C2	1-7	8	—	A A A
7	1158	—	m	—	1-8	—		
8	1351	0	—	—	1-8	—		
9	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 D

NOTES:

(1) FRAME 1 TRANSMITTED FIRST.
(2) FRAMES 6, 12, 18, AND 24 ARE DENOTED SIGNALING FRAMES.
(3) FPS-FRAMING PATTERN SEQUENCE (...001011...).
(4) DL-4-kbit/s DATA LINK (MESSAGE BITS m).
(5) CRC-CRC-6 CYCLIC REDUNDANCY CHECK (BITS C1-C6).
(6) OPTION T - TRAFFIC (BIT 8 NOT USED FOR ROBBED-BIT SIGNALING).
(7) OPTION 2 - 2-STATE SIGNALING (CHANNEL A)
(8) OPTION 4 - 4-STATE SIGNALING (CHANNELS A AND B)
(9) OPTION 16 - 16-STATE SIGNALING (CHANNELS A, B, C, AND D)

EXTENDED SUPERFRAME FORMAT

FIGURE 14



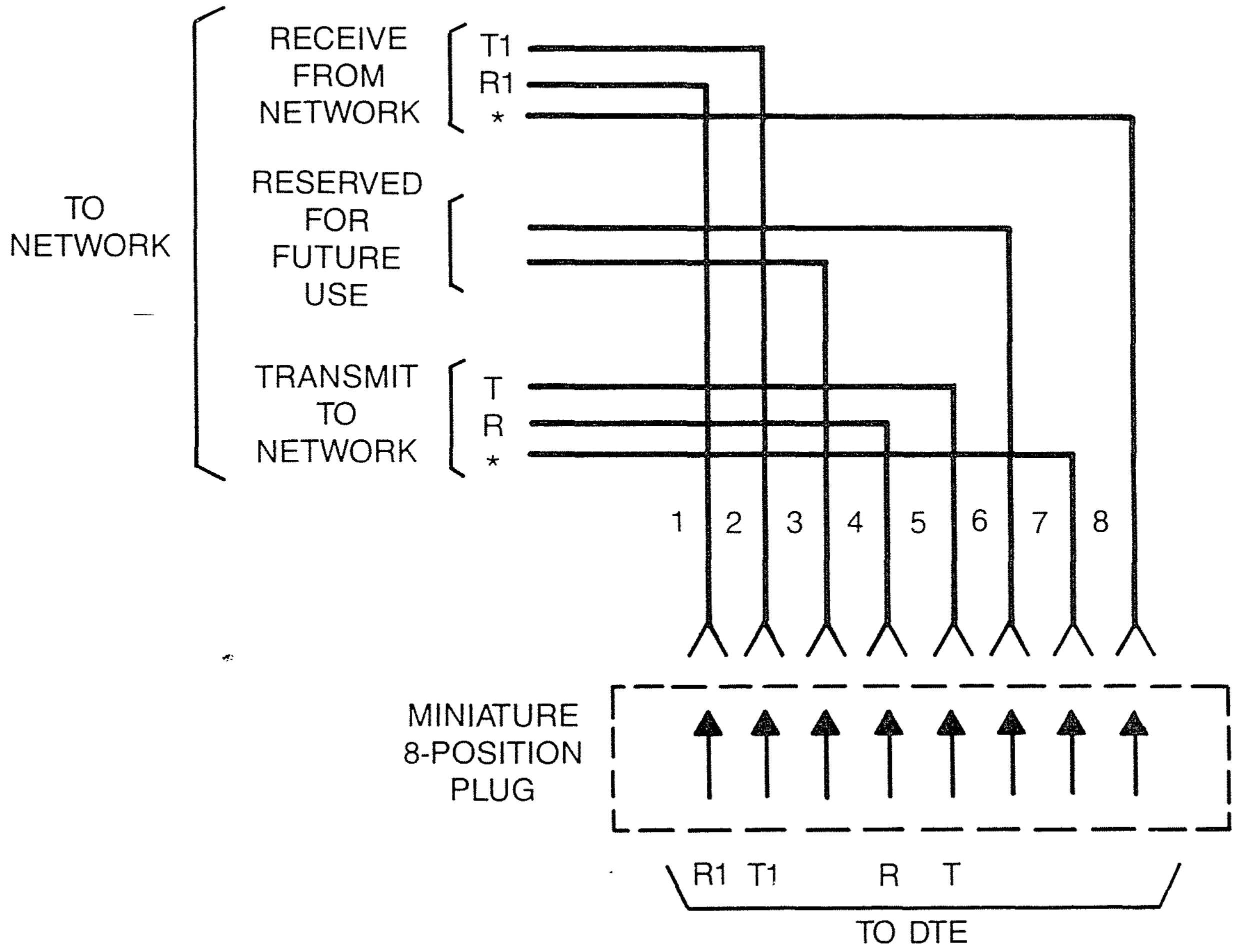
FRAME #	d1	d2	d3	d4	d5	d6	d7	d8
1	D	D	D	D	D	D	D	C
2	D	D	D	D	D	D	D	C
3	D	D	D	D	D	D	D	C
4	D	D	D	D	D	D	D	C
5	D	D	D	D	D	D	D	C
6	D	D	D	D	D	D	D	C
7	D	D	D	D	D	D	D	C
8	D	D	D	D	D	D	D	C
9	D	D	D	D	D	D	D	C
10	D	D	D	D	D	D	D	C
11	D	D	D	D	D	D	D	C
12	D	D	D	D	D	D	D	C

D - CUSTOMER DATA BIT

C - NETWORK CONTROL BIT
=1 DATA MODE
=0 CONTROL MODE

56 Kb/s DATA TRANSMISSION

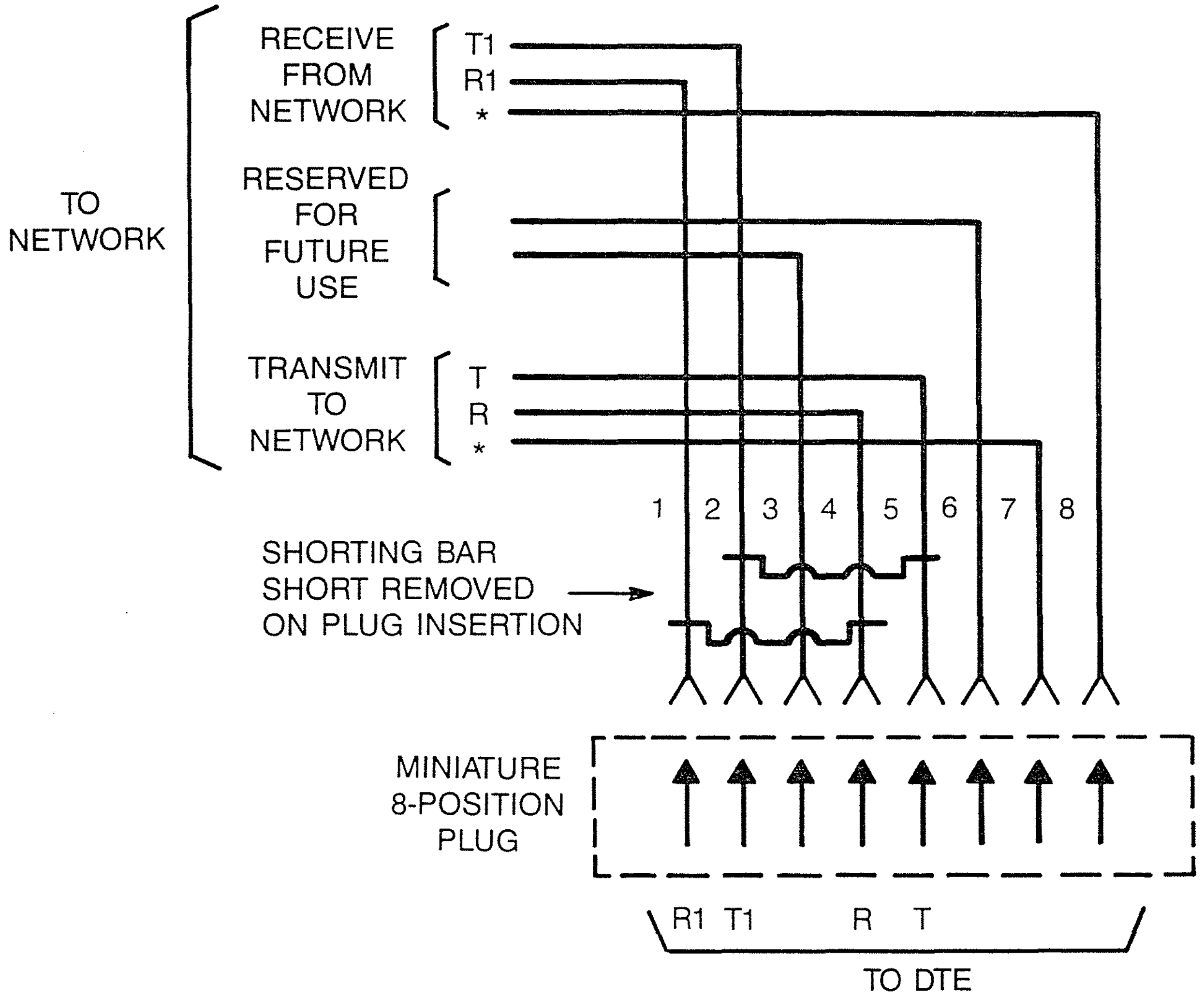
FIGURE 15



*PINS 7 & 8 PROVIDE CABLE SHIELD INTEGRITY

USOC CONNECTOR RJ 48C
(8 POSITION JACK)

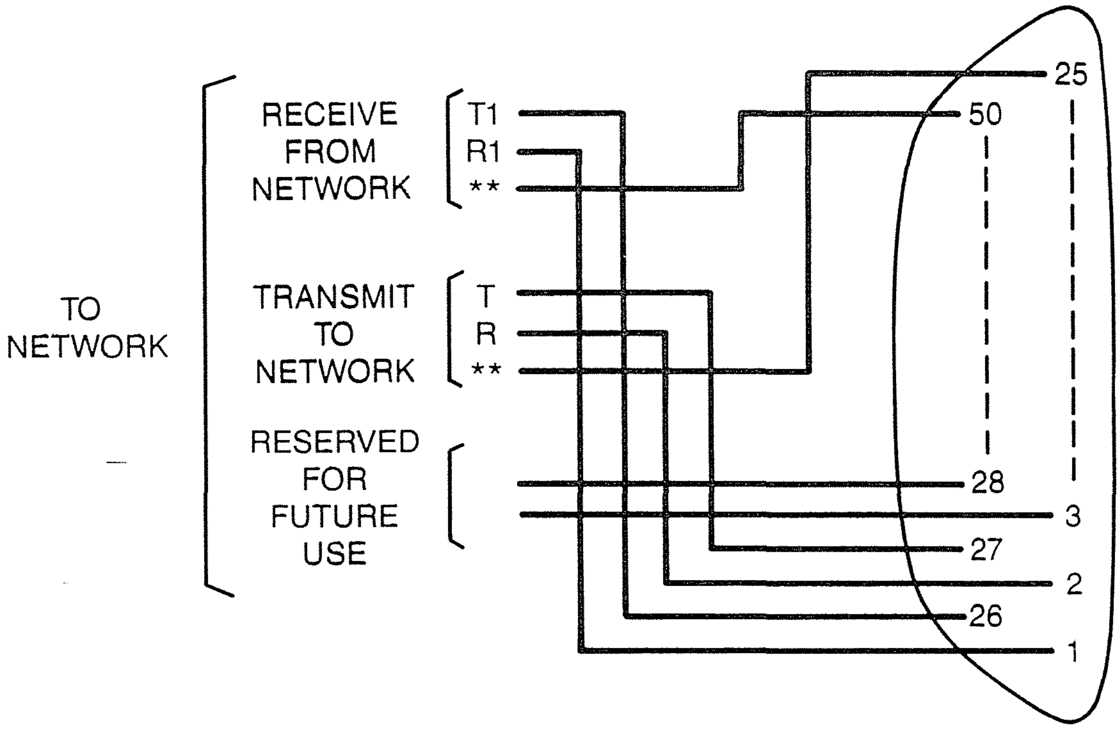
FIGURE 16



*PINS 7 & 8 PROVIDE CABLE SHIELD INTEGRITY

USOC CONNECTOR RJ 48X
(8 POSITION JACK WITH SHORTING BARS)

FIGURE 17



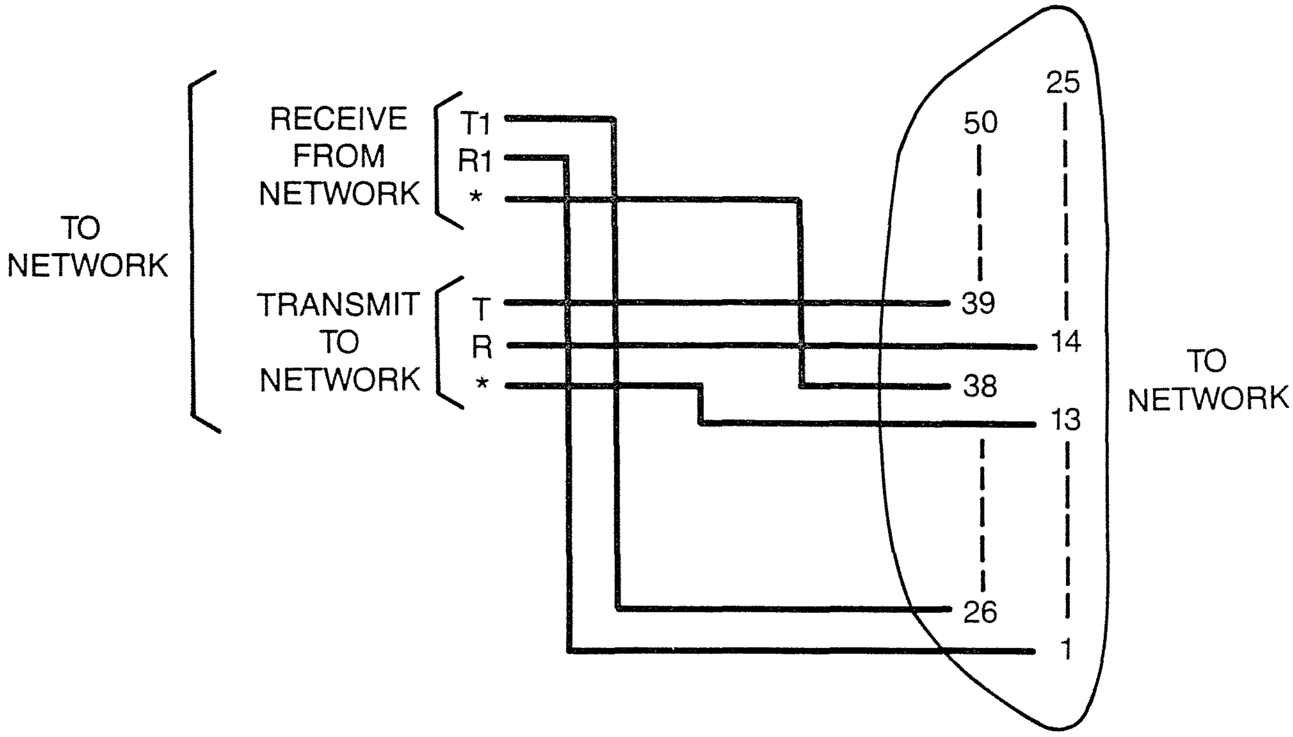
POSITION

LINE	T1	R1	T	R	*	*
1	26	1	27	2	28	3
2	29	4	30	5	31	6
3	32	7	33	8	34	9
4	35	10	36	11	37	12
5	38	13	39	14	40	15
6	41	16	42	17	43	18
7	44	19	45	20	46	21
8	47	22	48	23	49	24

*PINS RESERVED FOR FUTURE USE
**PINS 25 & 50 PROVIDE CABLE SHIELD INTEGRITY

USOC CONNECTOR RJ 48M
(50 POSITION MINIATURE RIBBON JACK)

FIGURE 18



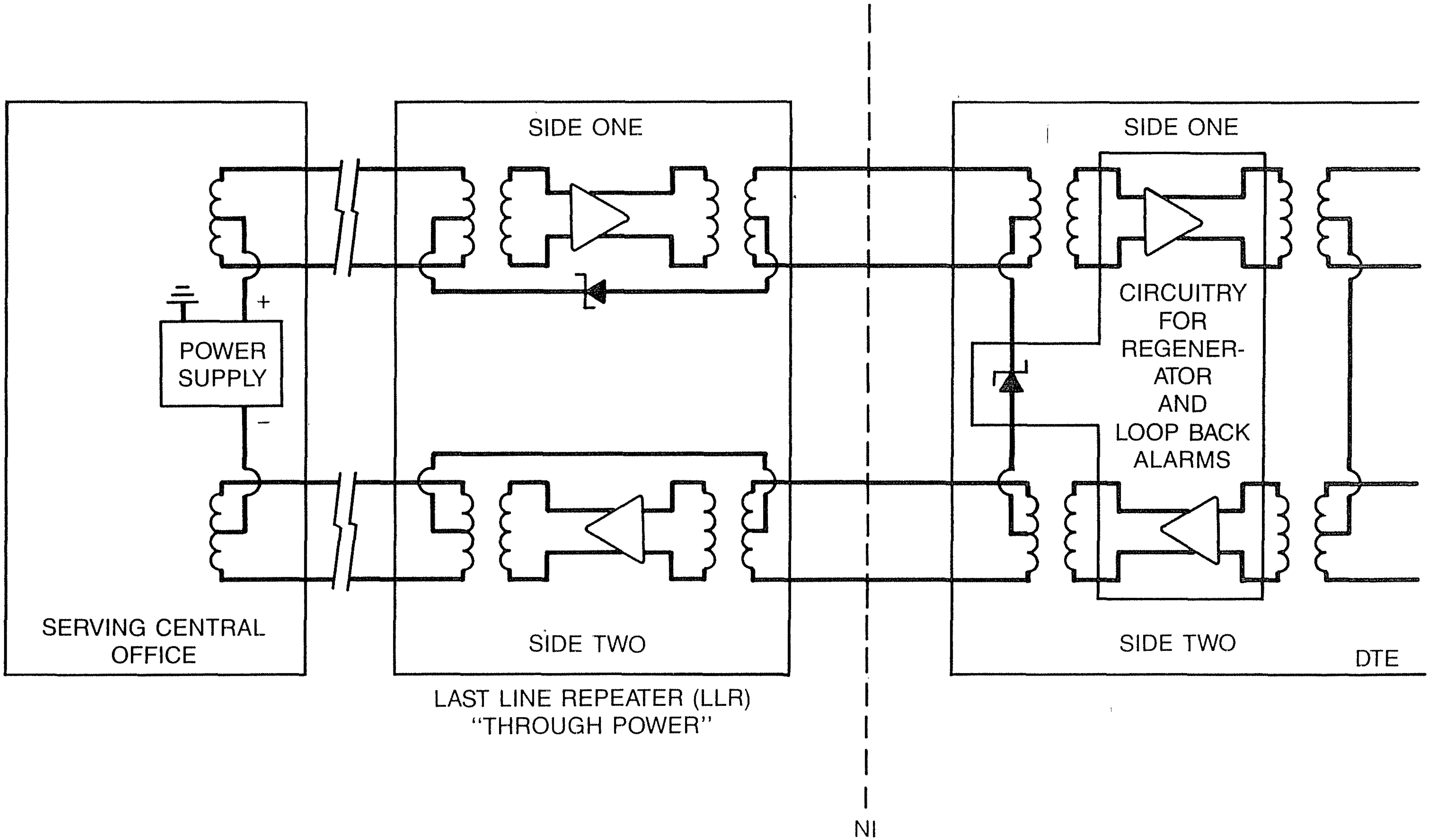
POSITION

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

*PINS 13 & 38 PROVIDES CABLE SHIELD INTEGRITY
THIS IS THE PREFERRED MULTI-CIRCUIT CONNECTOR

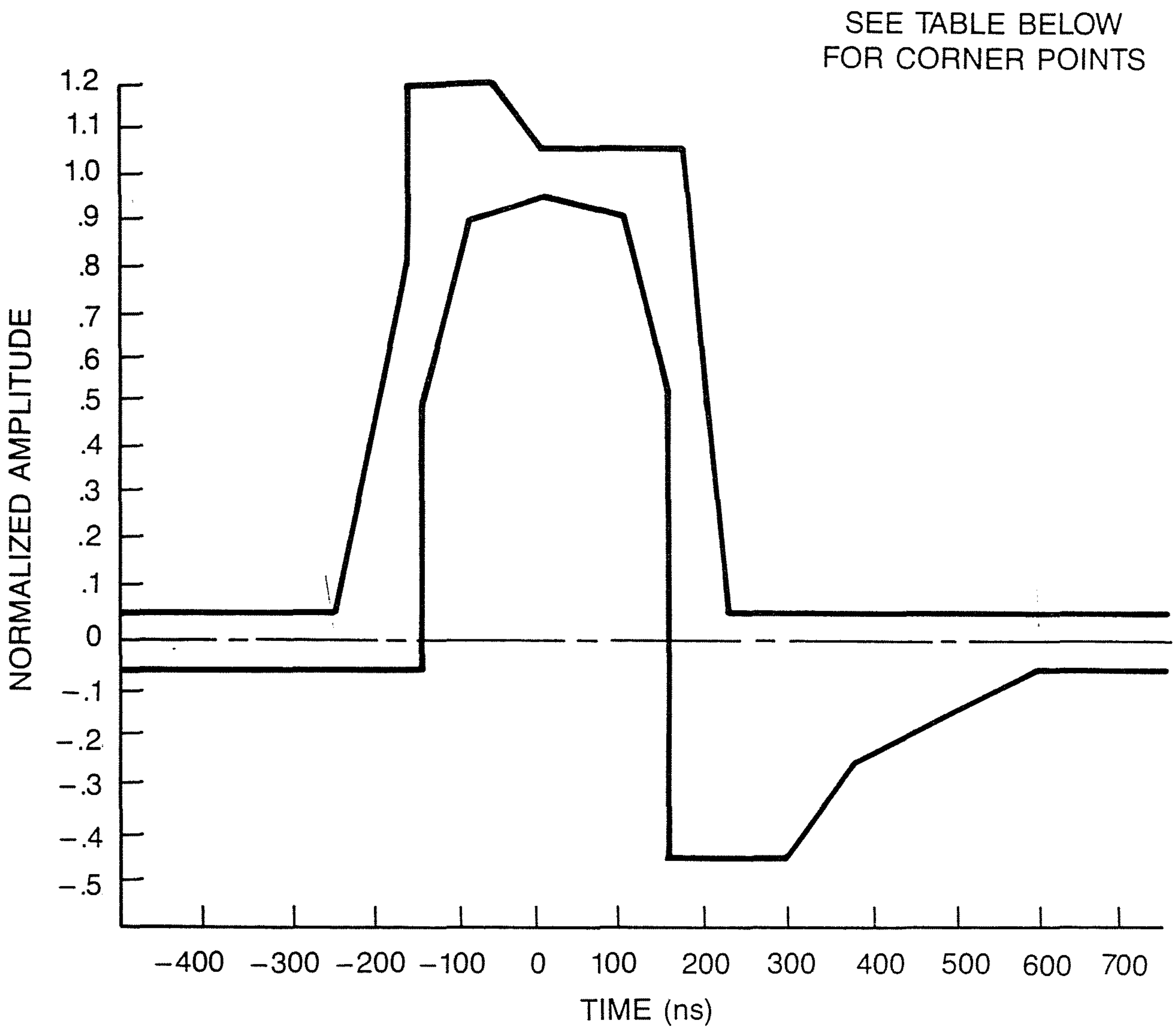
USOC CONNECTOR RJ 48H
(50 POSITION MINIATURE RIBBON JACK)

FIGURE 19



SIMPLEX POWER ARRANGEMENT

FIGURE 20



MAXIMUM CURVE

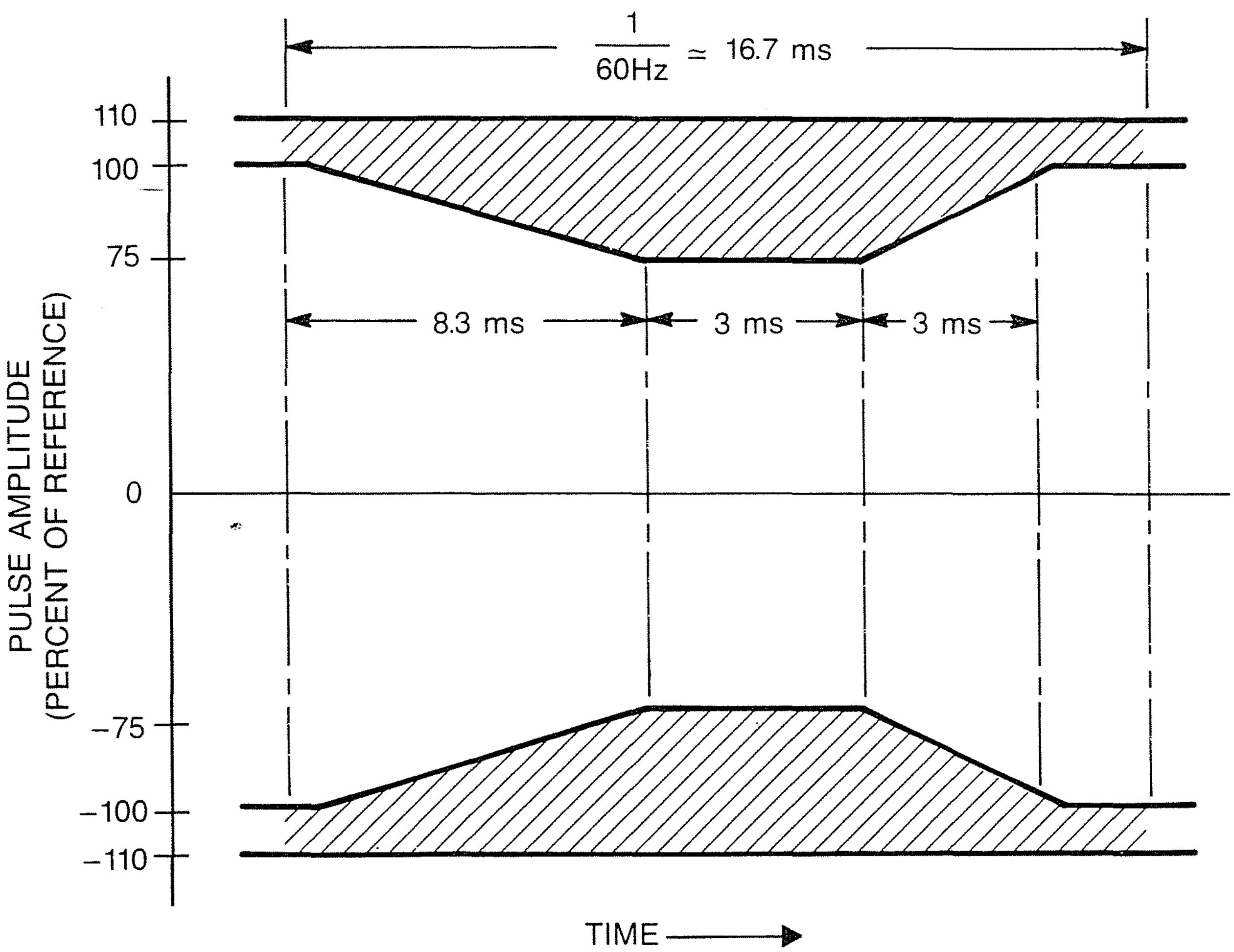
TIME	Nanoseconds	−500	−258	−175	−175	−75	0	175	228	500	750	—	—
	Unit Intervals	−.77	−.40	−.27	−.27	−.12	0	.27	.35	.77	1.16	—	—
NORMALIZED AMPLITUDE		.06	.06	.8	1.20	1.20	1.05	1.05	.05	.05	.05	—	—

MINIMUM CURVE

TIME	Nanoseconds	−500	−150	−150	−100	0	100	150	150	300	396	600	750
	Unit Intervals	−.77	−.23	−.23	−.15	0	.15	.23	.23	.46	.61	.93	1.16
NORMALIZED AMPLITUDE		−.05	−.05	.5	.9	.95	.9	.5	−.45	−.45	−.26	−.05	−.05

ISOLATED PULSE TEMPLATE AND CORNER POINTS

FIGURE 21



1. ENVELOPE OF PULSE AMPLITUDES SHALL LIE WITHIN THE SHADED AREA.
2. REFERENCE (100 PERCENT POINT) MAY BE ANY AMPLITUDE IN THE RANGE OF 2.4V TO 3.45V.

PULSE AMPLITUDE ENVELOPE WITH 60 Hz LONGITUDINAL CURRENTS

FIGURE 22

1. PULSE RATE:	$1.544 \times 10^6 \pm 50$ PULSES PER SECOND.
PULSE SHAPE:	AS DEFINED IN SECTION 5.7, AND FIGURE 34 EXCEPT THAT THE PULSE HEIGHT, A, SHALL BE $A = 3.00 \pm 0.3$ VOLTS.*
3. SIGNAL FORMAT:	THE SIGNAL SHALL BE BIPOLAR WITH A PULSE DUTY CYCLE OF 50%. EACH PULSE IS OF OPPOSITE POLARITY WITH RESPECT TO THE PREVIOUS PULSE REGARDLESS OF THE NUMBER OF INTERVENING ZEROES.
4. SIGNAL RANDOMIZATION:	THE "RANDOM" SIGNAL IS A QUASI-RANDOM, 1,048,575 BIT SEQUENCE GENERATED BY A 20 STAGE SHIFT REGISTER WITH FEEDBACK TAKEN FROM THE 17th AND 20th STAGES. THE OUTPUT SIGNAL IS TAKEN FROM THE 20th STAGE AND AN OUTPUT BIT IS FORCED TO BE A "1" WHENEVER THE NEXT 14 BITS ARE ALL "0".

THE QUASI-RANDOM SEQUENCE SATISFIES THE FOLLOWING:

$Q_{n+1}(k+1) = Q_n(k), \; n = 1,2 \ldots 19.$

$Q_1(k+1) = Q_{17}(k) \oplus Q_{20}(k)$

$RD(k) = Q_{20}(k) + \overline{Q_6(k) + \ldots + Q_{19}(k)}.$

WHERE $Q_n(k)$ = PRESENT STATE FOR nth STAGE.

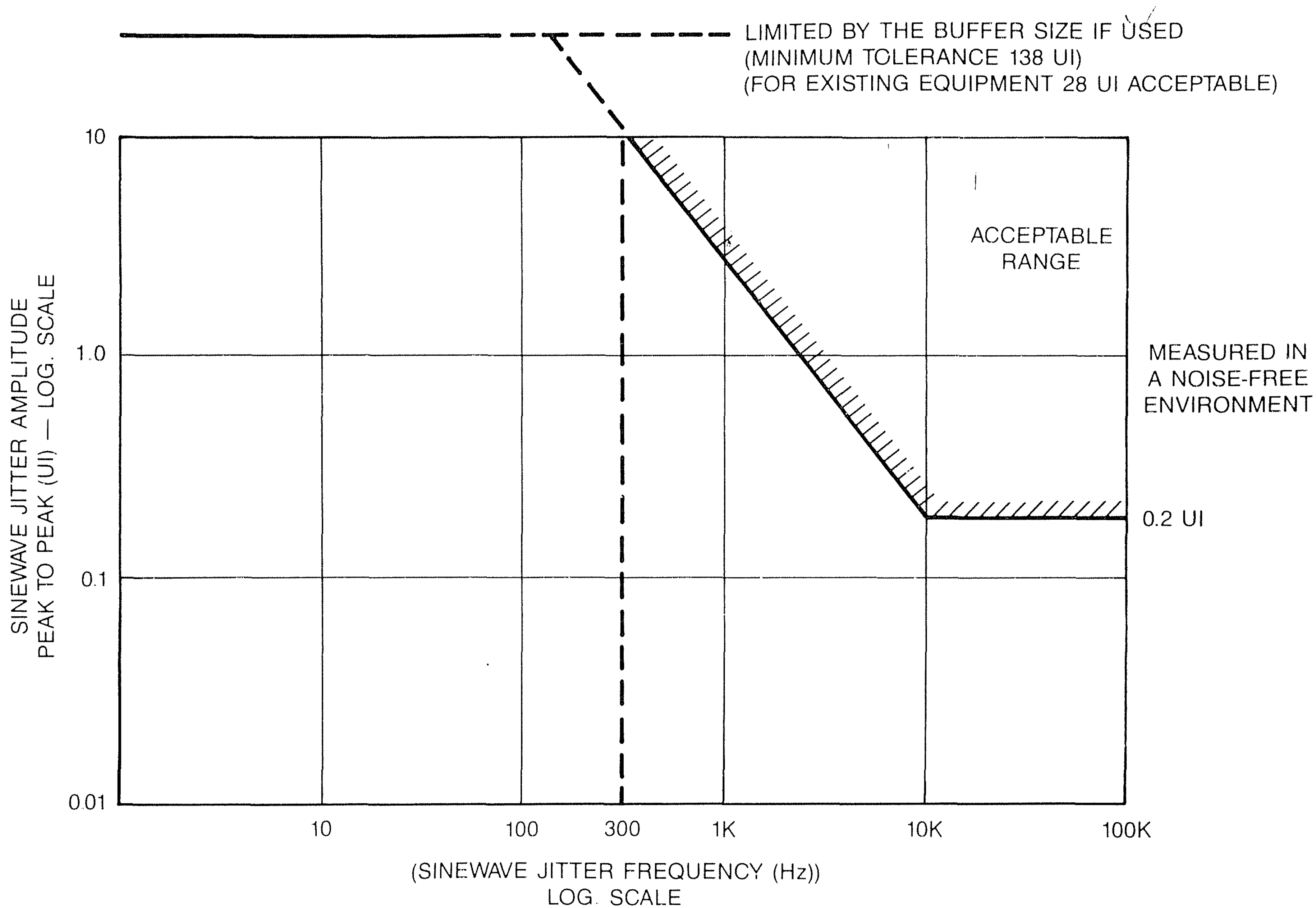
$Q_n(k+1)$ = NEXT STATE FOR Nth STAGE.

AND $RD(k)$ = PRESENT VALUE OF OUTPUT.

*NOTE: FOR ZERO LOSS IN SUMMATION NETWORK, PULSE AMPLITUDE MUST BE COMPENSATED FOR ANY NETWORK LOSS.

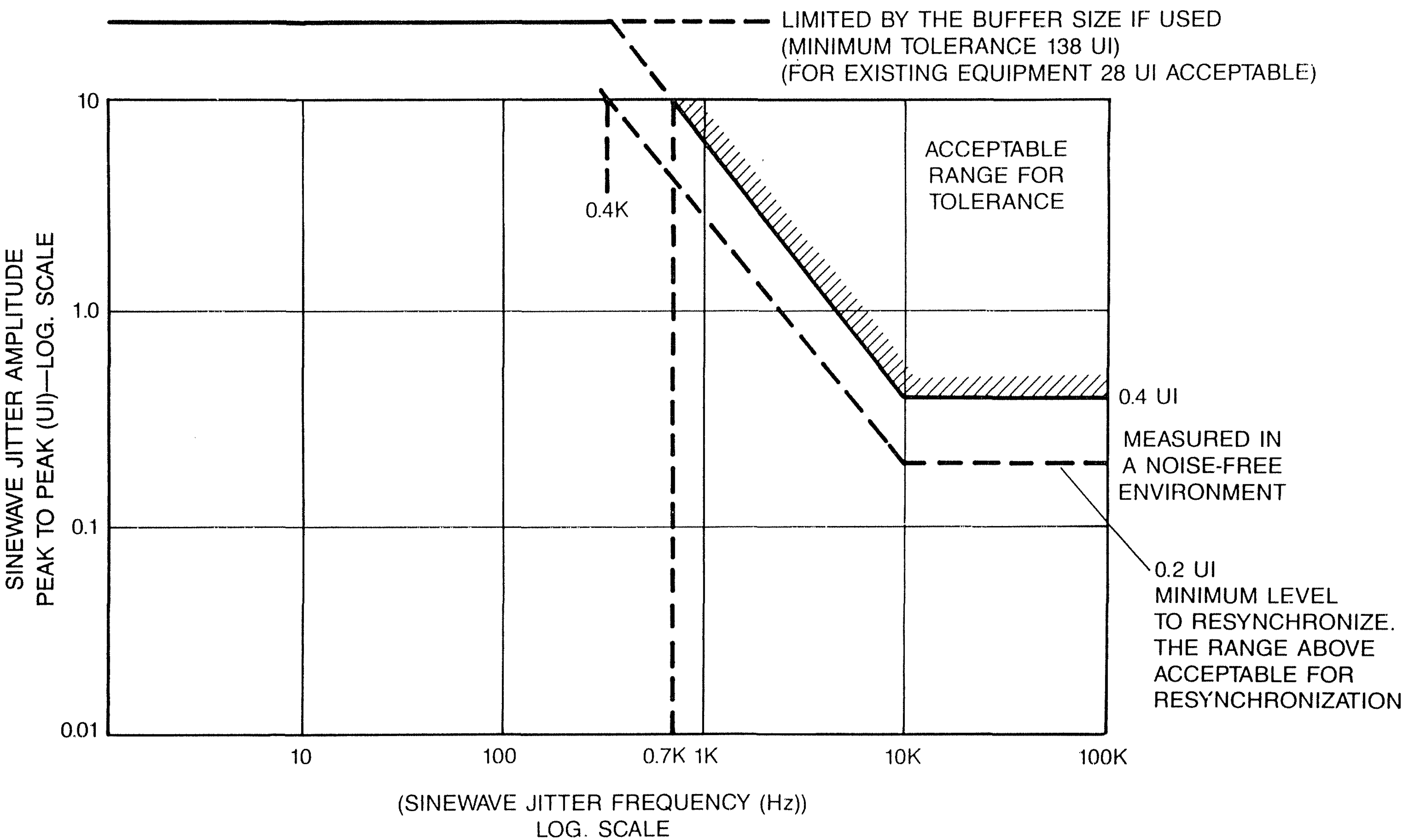
QUASI RANDOM SIGNAL SOURCE

FIGURE 23



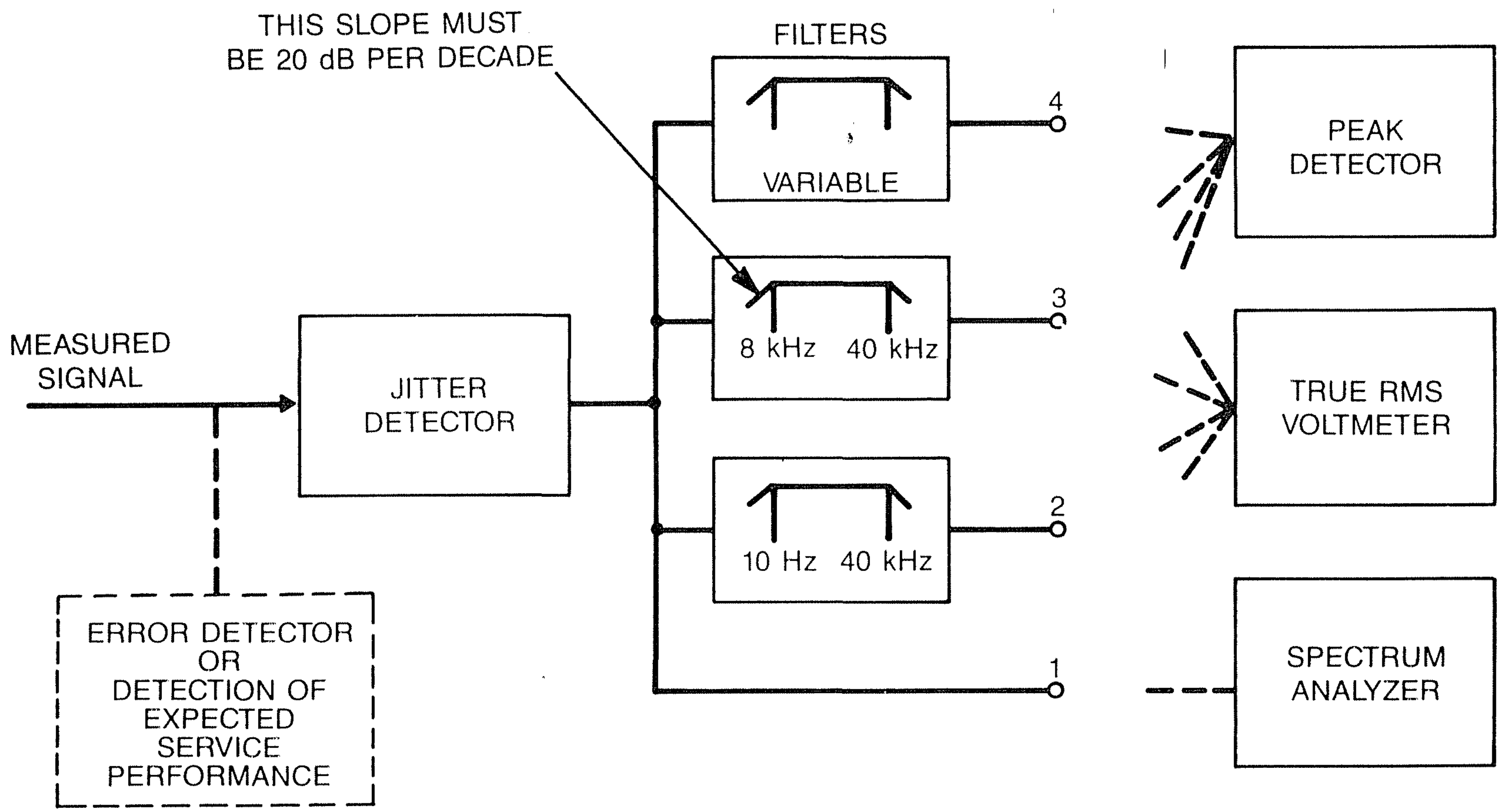
INPUT JITTER TOLERANCE OF THE DTE

FIGURE 24



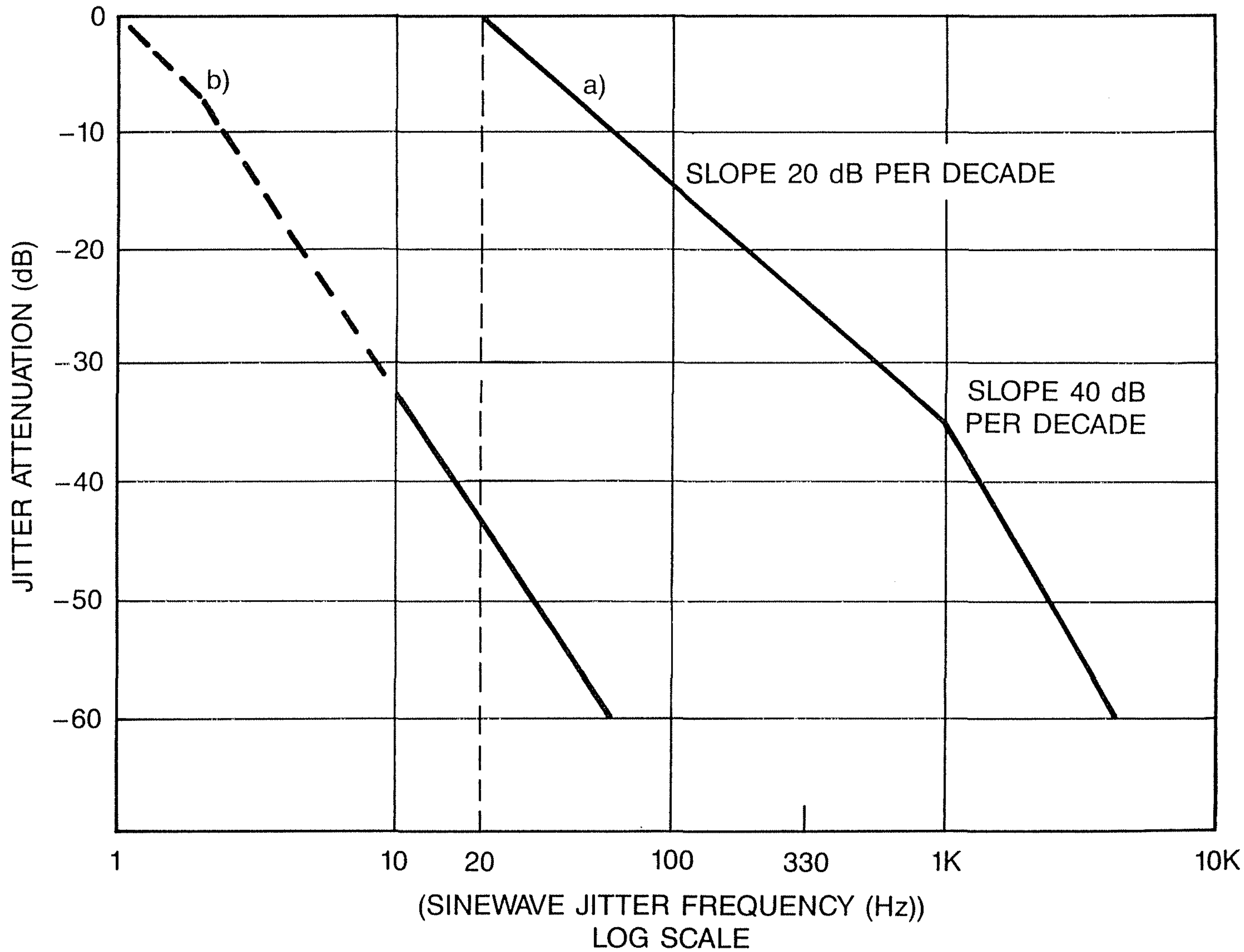
INPUT JITTER TOLERANCE OF THE SYNCHRONIZER (THE CLOCK RECOVERY CIRCUIT)

FIGURE 25



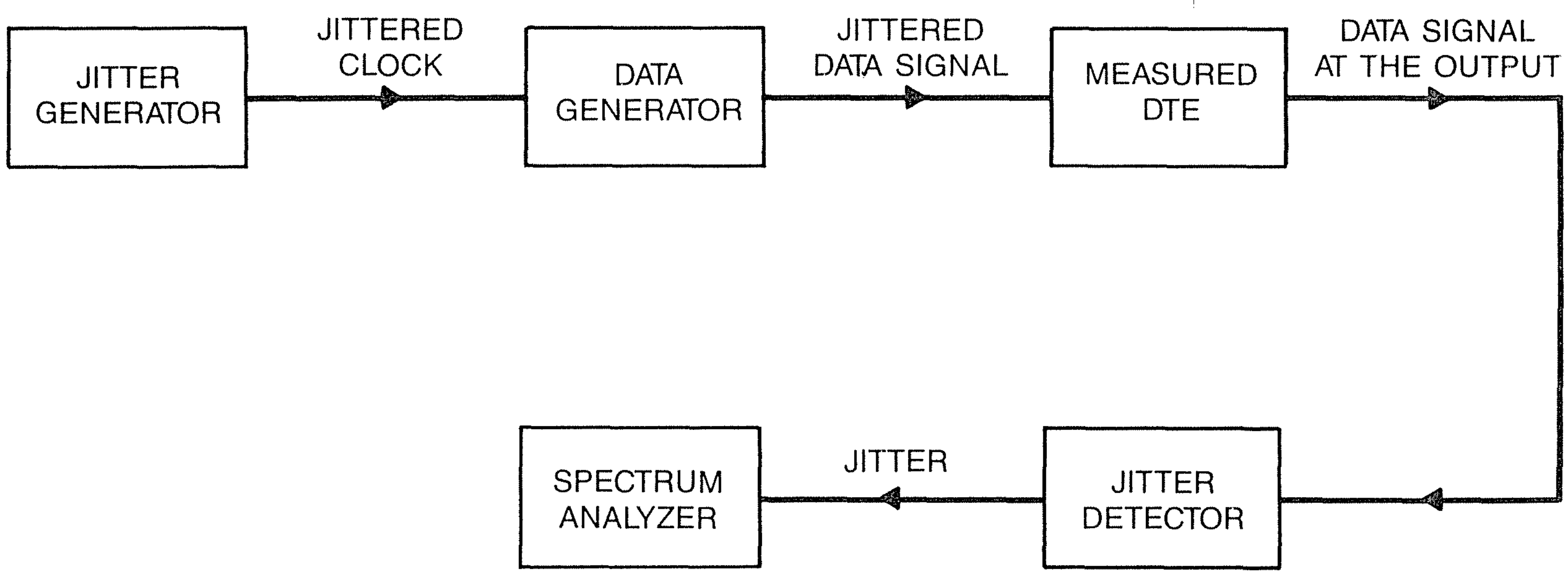
MEASUREMENT OF GENERATED JITTER AND JITTER AT THE NI

FIGURE 26



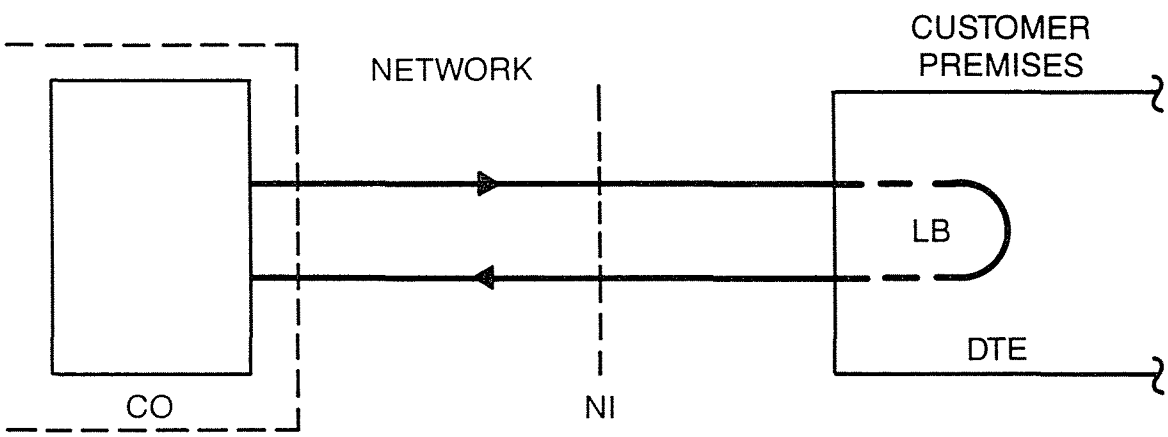
DTE JITTER TRANSFER FUNCTION

FIGURE 27



MEASUREMENT OF THE DTE JITTER TRANSFER FUNCTION

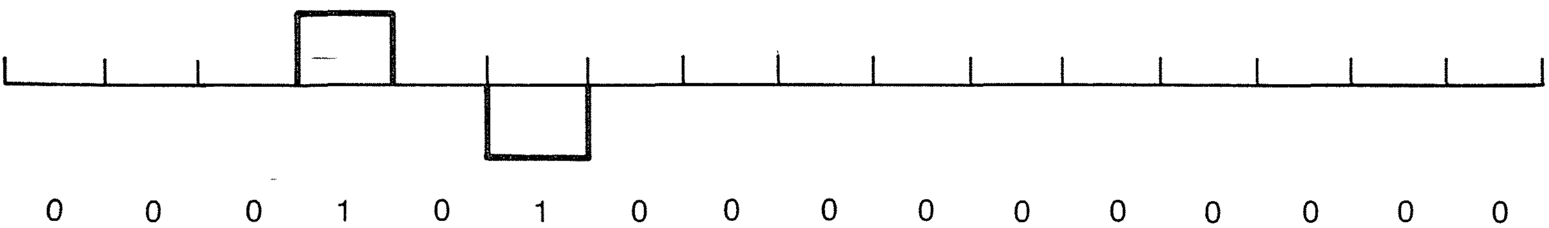
FIGURE 28



LOOP BACK

FIGURE 29

SIGNAL WITH EIGHT CONSECUTIVE ZEROS



SIGNAL WITH B8ZS REPLACEMENT:
(B8ZS CODED SIGNAL)

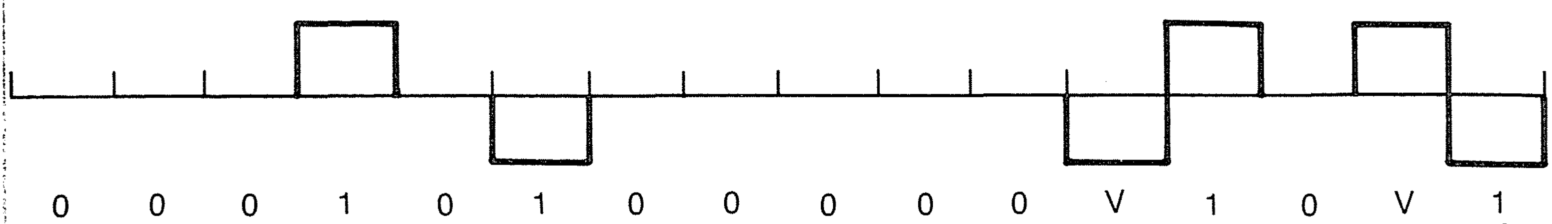


FIGURE 30

APPENDIX A

Jitter At The Network Interface

Jitter At The Network Interface

1. Jitter At The NI

Sections 4.7.1 - 4.7.3 outline the ACCUNET T1.5 Service jitter requirements for Digital Terminal Equipment (DTE). The following discussion is included to address the jitter at the NI from the Network and the Customer Premises.

1.1 Jitter–From The Network At The NI

It is expected that under normal conditions and for signals without irregular bit patterns, network jitter will not exceed levels which can cause errors in DTE with input jitter tolerances defined in Section 4.7.1. Jitter from the network (network jitter) at the NI should be measured using the scheme shown in Figure 26 with the following modifications. The measurement should be made at points 1, 2 and 3. The measured signal should be practically error free, or satisfy the expected service performance. Specifically, momentary signal interruptions or error bursts cannot exist. The live traffic signal is normally used, however, in preservice testings or troubleshooting the quasi-random signal (Figure 23) or special bit pattern signal (see below and Figure A-1) should be used. The influence of the jitter spectrum is expressed by inserting specified filters in front of the jitter peak detector. For detailed evaluation the variable filter at point 4 may be used. The bandpass cut-off-frequencies are moved together from both sides until about 90% of originally observed peak-to-peak value is obtained. The low and high cut-off frequencies then indicate the frequency band that contributes mainly to the peak value. This information can be used to evaluate if the jitter level can be tolerated by equipment or facilities connected to the other side of the NI. A Spectrum Analyzer can be used to observe any irregular spectrum as for example, excessive peaks at one or few jitter frequencies.

Network jitter depends on many operational situations (e.g. equipment configurations) in the network and the bit pattern of the transmitted signal. The character of the network jitter is close to a random process superimposed with seldom occurring jitter hits, and a lengthy observation (measurement) is generally needed for full evaluations. Proposed standards in T1X1.3 specify maximum permissible network output jitter for the 10 Hz to 40 kHz and the 8 kHz to 40 kHz bands. The measurement interval is not specified, but a minimum of one minute is recommended. For complete evaluation, jitter measurement should be conducted for longer periods, such as one day. However, in many instances, a shorter measurement interval is sufficient to both characterize the amount of network jitter as well as to evaluate the available jitter margins.

Essentially, network facilities can be divided into three classes, depending on the measurement intervals required to characterize the encountered jitter levels with a high degree of confidence. The following table indicates the three classes of facilities, with the corresponding measuring intervals required to characterize the jitter level and hence, evaluate the available jitter margin.

TABLE A1. NETWORK FACILITY CLASSES

Facility Class	Length of Measuring Interval	Point of Measurement	Jitter Level UI_{p-p}
1	15 min	3	0.05
	15 min	2	1.0
2	60 min	3	0.1
	60 min	2	2.5
3	1 day	3	0.15
	1 day	2	5.0

Since one does not know a priori which class of facility is being encountered, it is recommended to make the jitter measurements for the shortest interval (i.e. 15 minutes). If both of the levels indicated for facility Class 1 are not exceeded, there is no need to measure for a longer period. If either level is exceeded, measurements should be made for 60 minutes. Again, if both of the levels for facility Class 2 are not exceeded, there is no need to measure for a longer period. If either of the corresponding jitter levels for facility Class 2 are exceeded however, measurement needs to be made for one day. The important thing to note here is that there are no implications of superior (or inferior) quality associated with the classification of facilities shown in the table. These are simply guidelines to minimize the time spent to adequately characterize network jitter.

If service impairments persist under these conditions, the DTE should be tested to assure compliance with the specifications outlined earlier. If higher jitter levels are observed, a detailed analysis has to be done to evaluate the problem.

Higher levels of jitter can accumulate in T1/T1C repeatered lines if a special pattern signal is transmitted. This behavior is attributed mainly to the operation of automatic line build-out circuits (ALBO). The following test signal or repeatered 8-bit patterns should be used if jitter characteristics of repeaters or jitter accumulation in T1/T1C lines need to be evaluated. There are 35 distinct permissible patterns, as indicated in Figure A-1. The frequency of switching between patterns should be in the range of 25 Hz to 500 Hz (25 Hz is preferable); i.e., each of the patterns shall be present for half of the period of the switching frequency. The measurement interval can be made shorter as the test signal represents a worst combination of 8 bit blocks.

In general, the network jitter has a dense bandpass limited spectrum with some possible distinct peaks. One or few jitter frequencies do not completely determine the jitter peak value.

1.2 Jitter From The Customer Premises At The NI

Jitter from the customer premises side of the NI should be measured in a way similar to that discussed in the section on output jitter. The measurement should be realized at points 1, 2, and 3 (see Figure 26).

The measured jitter at this point is composed of the generated output jitter and the jitter transferred from the network side of the NI through the DTE. If the outcome of this measurement in a 10 minute interval is above 0.05 UI (peak-to-peak) at point 3, or 1 UI at point 2, a longer measuring period of one day is appropriate. If the measurement continues to show this level of jitter, the DTE should be tested to confirm compliance with the specifications outlined earlier. The variable filter at point 4 can be used to evaluate the jitter frequency bandwidth. This information can be used to investigate if the jitter can cause problems in connected facilities, or will be suppressed.

In some situations, it is advisable to measure the available jitter margin. This may be important if new services are implemented, or signals with irregular patterns are transmitted. The jitter margin is the amount of sinusoidal jitter (at particular frequencies) that can be added to the existing jitter to cause just the beginning of the service impairments. The measurement should use a live traffic signal or, during preservice testing, the quasi-random signal. The measuring scheme is shown in Figure A-2. The procedure for the input jitter tolerance measurement from Section 4.7.1 applies. It is advisable to first measure the network jitter spectrum. The jitter frequencies can be then chosen in coincidence with the spectrum peaks. Section 4.7.3 describes the setting of the spectrum analyzer. The averaging over 50-100 time windows should be used, to obtain an average spectrum of the network jitter if analyzers based on FFT are used.

1.3 Interface To Other Networks Or Facilities

The jitter levels presented above apply at the Network Interface (NI) of ACCUNET T1.5 Service to Digital Terminal Equipment at the customer location. If other networks or facilities are connected, different jitter evaluations are needed. It is necessary to consider jitter accumulation, in addition to the previously discussed jitter characteristics. Accumulated jitter at all points in a network (facilities), on both sides of the NI, shall be at levels safe enough that the tolerance of any equipment used in the connection is not exceeded. Another significant difference is the possible presence of asynchronous multiplexers (MUX 1-X), or other devices which may have jitter tolerances only slightly above 5 UI_{p-p} below 500 Hz on the customer side of the NI.

If the connection at the network side of the NI is connected to synchronous machines (such as digital switches, digital cross-connects, synchronous multiplexers, DPBX's, etc.), the jitter from the connected facility should be investigated as outlined in Section 1.1 (Jitter From The Network). The jitter from the network will be low, at levels close to the equipment generated jitter (see Section 4.7.2).

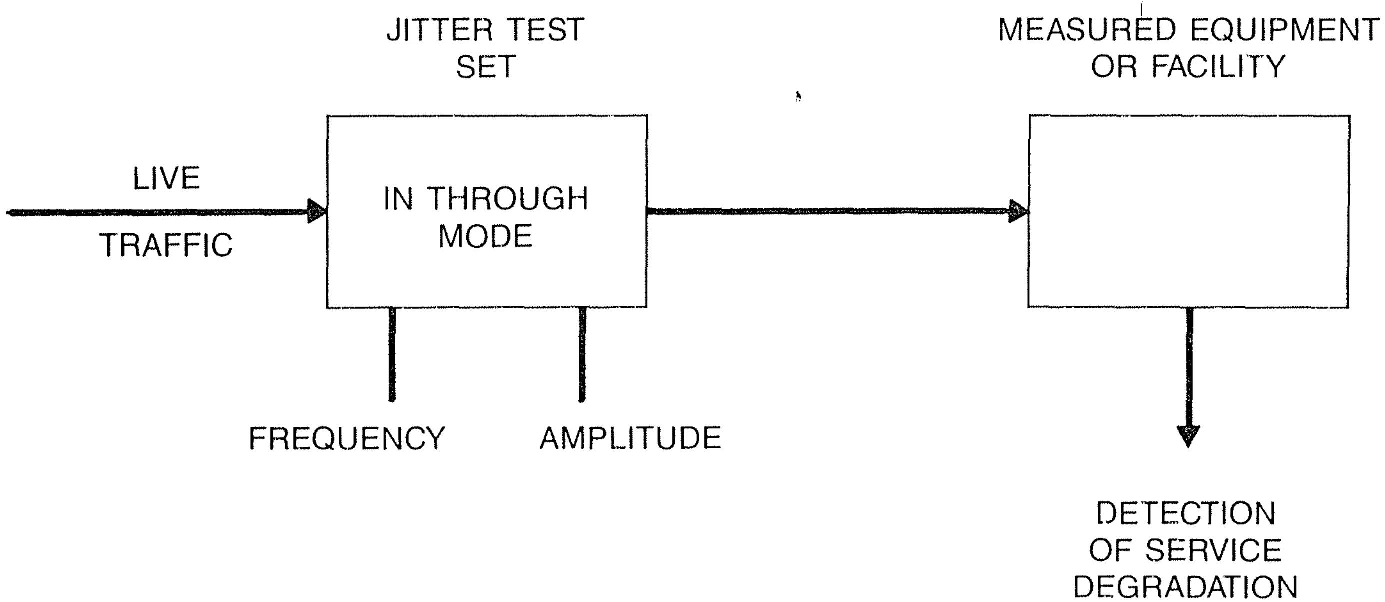
In all other situations a jitter accumulation from a clock source to the next clock source must be considered. Operations free of jitter problems can generally be expected if the jitter levels at the NI measured in 60 minute intervals, do not exceed 0.1 UI_{p-p} at point 3 and 1.5 UI_{p-p} at point 2 on the output of a customer connected facility, and 0.1 UI_{p-p} and 3 UI_{p-p} respectively, from the network side. Jitter accumulation evaluation is needed if any jitter level is higher. Detailed investigation is necessary if jitter levels above 5 UI_{p-p} are encountered.

PATTERN NUMBER	PATTERN	WEIGHT*	PATTERN NUMBER	PATTERN	WEIGHT*
1	1000 0000	8	19	1101 0010	8
2	1100 0000	8	20	1100 1100	4
3	1010 0000	8	21	1100 1010	8
4	1001 0000	8	22	1010 1010	2
5	1000 1000	4	23	1111 1000	8
6	1110 0000	8	24	1111 0100	8
7	1101 0000	8	25	1111 0010	8
8	1100 1000	8	26	1110 1100	8
9	1100 0100	8	27	1110 1010	8
10	1100 0010	8	28	1110 0110	8
11	1010 1000	8	29	1101 1010	8
12	1010 0100	8	30	1111 1100	8
13	1111 0000	8	31	1111 1010	8
14	1110 1000	8	32	1111 0110	8
15	1110 0100	8	33	1110 1110	4
16	1110 0100	8	34	1111 1110	8
17	1101 1000	8	35	1111 1111	1
18	1101 0100	8			

*PROBABILITY—WEIGHT/255

EIGHT—BIT—PATTERNS

FIGURE A-1



JITTER MARGIN MEASUREMENT AT THE INPUT OF EQUIPMENT OR FACILITY

FIGURE A-2

APPENDIX B

Timing Reference Degradation Thresholds

Timing Reference Degradation Thresholds

1. General

This Appendix presents suggested clock thresholds for timing reference degradations and equipment evaluation guidelines. The degradation thresholds are useful to minimize slips by limiting excessive switching of reference. The equipment evaluation guidelines may be used to determine clock performance and stratum levels.

1.1 Timing Reference Degradation Thresholds

The timing reference of CPE clocks will experience line degradations such as Severely Errored Seconds (SES). Proper synchronization requires that CPE clocks handle such line imperfections with minimal impact on the clock (CPE will typically shift in phase when presented a reference impairment). If the clock's reference is degraded, as defined below, and the clock's secondary timing source is not degraded, then the phase shift of the clock must be less than the MTIE and phase slope requirements of Section 6.2 for stratum 2, stratum 3, and stratum 4 Type I clocks, independent of whether a switch of reference occurs.

To minimize excessive switching of the timing reference and the accumulation of phase movements, a clock should not initiate a switch of reference until the timing reference has become degraded. A timing reference is not considered degraded until the following reference line conditions occur (in any combination):

a. Loss of signal for .10 sec.

b. Error bursts of a duration of 2.5 seconds or more, at bit error ratios worse than 10^{-3}.

c. A phase hit of 1000 ns. with a phase slope more than, or equal to 6.1×10^{-5}.

d. Input jitter above the tolerances given in Section 4.7.1.