

Data Communications
TECHNICAL REFERENCE

ACCUNET® T1.5 SERVICE

DESCRIPTION
AND
INTERFACE SPECIFICATION

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AT&T

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If further information is required, please contact:

*Director
NSDI Business Special Services
AT&T
Bedminster, NJ 07921*

CONTENTS

1. INTRODUCTION	7
1.1 Contents	7
1.2 Relationship To Industry Standards	8
1.3 Relationship to Other AT&T Technical References	8
2. ACCUNET T1.5 SERVICE	9
2.1 Service Description	9
2.1.1 Circuit Configurations	9
2.1.2 Access Arrangements	9
2.1.2.1 AT&T Provided Access	9
2.1.2.2 AT&T Coordinated Access	9
2.1.2.3 Customer Provided Access	10
2.1.2.4 Turnkey Customer Provided Access	10
2.2 Service Functions	
2.2.1 Transfer Arrangements	10
2.2.2 Access Protection Capability (APC)	11
2.2.3 Network Protection Capability (NPC)	11
2.2.4 M24 Multiplexing	11
2.2.5 M44 Bit Compression Multiplexing	11
2.2.6 Customer Controlled Reconfiguration (CCR)	12
2.2.7 Bandwidth Management Service (BMS)	12
2.2.8 Bandwidth Management Service - Extended (Supervisory Data Link Protocol)	12
2.2.9 Bandwidth Management Service - Extended (External Supervisory Data Link Protocol)	12
2.2.10 The Primary Rate Interface (PRI)	13
2.2.11 ACCUNET Information Manager (AIM)	13
2.2.12 ACCUNET Spectrum of Digital Services (ASDS)	13
3. PERFORMANCE AND AVAILABILITY	13
3.1 Performance	14
3.1.1 Performance and Availability Parameters	14
3.1.1.1 Error Seconds (ES) and Error-Free Seconds (EFS)	14
3.1.1.2 Severely Errored Seconds (SES)	15
3.1.1.3 Unavailable Seconds (UAS)	15
3.1.1.4 Loss of Frame Count (LOFC)	15

3.1.1.4.1	Short Failure Event Count (SFEC)	16
3.2	Performance And Availability Objectives	16
3.2.1	Performance Objectives	16
3.2.2	Availability Objectives	16
3.2.3	Burstiness	18
3.2.4	Delay	18
4.	FORMAT AND INTERFACE SPECIFICATIONS	19
4.1	DS1 Framing	19
4.1.1	Superframe Format	19
4.1.2	Extended Superframe Format (ESF)	19
4.1.3	Extended Superframe Format With Enhanced Parameter Set	19
4.2	Line Coding	20
4.2.1	Bipolar Format	20
4.2.2	B8ZS (Bipolar Eight Zero Substitution)	20
4.2.3	Decoding B8ZS Signals	20
4.3	DS0 Channelization	20
4.4	Bit Compression Multiplexing	21
4.5	Signaling	21
4.5.1	Robbed-Bit Signaling	21
4.5.2	ISDN PRI Signaling	21
4.6	Customer Installation Network Interface	22
4.6.1	Physical Interface	22
4.6.2	Electrical Characteristics	22
4.6.2.1	Powering	22
4.6.2.2	Signal Specifications	23
4.6.2.2.1	Transmission Line Rate	23
4.6.2.2.2	Test Load	24
4.6.2.3	Standard Pulse Characteristics	24
4.6.2.3.1	Pulse Shape	24
4.6.2.3.2	Power Levels	24
4.6.2.3.3	Pulse Imbalance	24
4.6.2.3.4	60 Hz Variations In Pulse Amplitude	24
4.6.2.4	Network To The NI	24
4.6.2.5	Customer To The NI	24
4.7	Jitter	25

4.7.1	Input Jitter Tolerance	25
4.7.2	Output Jitter Generation	26
4.7.3	Jitter Transfer Function	26
5.	CUSTOMER PREMISES EQUIPMENT CHARACTERISTICS	27
5.1	Required Functions	27
5.2	Alarm Indication Signal (AIS)	27
5.3	Loopbacks	27
5.3.1	Line Loopback Using The Superframe Format	28
5.3.2	Line Loopback Using the ESF	28
5.3.3	Payload Loopback Using the ESF	28
5.3.4	ISDN PRI Digital Loopback	29
5.4	Longitudinal Balance	29
5.5	Pulse Density	29
5.5.1	Unchannelized Circuits	29
5.5.2	Channelized Circuits	29
5.6	64 kb/s Clear Channel Capability (64CCC)	29
6.	SYNCHRONIZATION AND TIMING	30
6.1	General	30
6.2	Synchronization Equipment Requirements	30
6.3	Timing References	32
7.	NETWORK ALARM AND STATUS CONDITIONS	33
7.1	Loss of Signal (LOS) Condition	33
7.2	Out Of Frame (OOF) Condition	34
7.3	Reframe Duration	34
7.4	Carrier Failure Alarms (CFAs)	34
7.5	Types Of Carrier Failure Alarms and Signals	34
7.5.1	AIS CFA	34
7.5.2	AIS (Alarm Indication Signal)	34
7.5.3	Red CFA	34
7.5.4	Yellow Alarm Signal	34
7.5.5	Yellow CFA	35
7.6	Conditions Causing The Initiation Of Carrier Failure Alarms	35
8.	TESTING AND MAINTENANCE	35
	APPENDIX A	36
1.	Jitter At The NI	37

1.1 Jitter From The Network At The NI	37
1.2 Jitter From The Customer Installation At The NI	38
1.3 Interface to Other Networks Or Facilities	39
APPENDIX B	40
1. General	41
2. Timing Reference Degradation Thresholds	41
REFERENCES	42

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 Installation, while NCTE (Network Channel Terminating Equipment) refers to equipment 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(2), the term CI (Customer Installation) is used when 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

Section 4. Format And Interface Specifications

Section 5. Customer Premise 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 CI equipment 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 stated in this document are in compliance with FCC Regulations(3) and agree with generally recognized Telecommunications Industry interconnection requirements, when appropriate. These requirements are referenced when necessary for clarification. Current ANSI(1), EIA(2), or BELLCORE(4) Standards are implied, when they are mutually consistent. Those 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, hereafter referred to as TRs:

- TR 41449: AT&T Integrated Services Digital Network (ISDN) Primary Rate Interface Specification(5)
- TR 41457: SKYNET® Digital Service(6)
- TR 41458: Special Access Connections To The AT&T Communications Network For New Service Applications(7)
- TR 41459: AT&T Integrated Services Digital Network (ISDN) Primary Rate Interface and Special Application Specification(8)
- TR 54015: Customer Controlled Reconfiguration - A Service Function of ACCUNET T1.5 Service(9)
- TR 54016: Requirements for Interfacing Digital Terminal Equipment to Services Employing the Extended Superframe Format(10)
- TR 54017: Automatic Protection Capability - A Service Function of ACCUNET T1.5(11)
- TR 54019: International ACCUNET Digital Services - Description And Network Interface Specifications(12)
- TR 54070: M44 Multiplexing - A Service Function of ACCUNET T1.5(13)
- TR 54075: 54 kb/s Subrate Data Multiplexing - A Service Function of DATAPHONE® Digital Service(14)
- TR 60110: Digital Synchronization Network Plan(15)
- TR 62310: Digital Data System Channel Interface Specification(16)
- TR 62412: Network Management For AIM®, ABM®, and Direct Access Services(17)
- TR 62414: Bandwidth Management Service - Extended (Supervisory Data Link Protocol), A Service Function of ACCUNET T1.5 Service(18)
- TR 62414A: Bandwidth Management Service - Extended (External Supervisory Data Link Protocol), A Service Function of ACCUNET T1.5(19)

- TR 62415: Access Specification For High Capacity (DS1/DS3) Dedicated Digital Services(20)
TR 62419: Bandwidth Management Service - A Service Function of ACCUNET T1.5 Service(21)
TR 62421: ACCUNET SPECTRUM of Digital Services(22)

2. ACCUNET T1.5 SERVICE

2.1 Service Description

ACCUNET T1.5 Service provides full-duplex, point-to-point, high capacity digital service on dedicated terrestrial digital facilities capable of transmitting 1.544 Mb/s. The interface in 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 we discussed in Sections 4.6.2.4 and 4.6.2.5. 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 as follows:

- (1) Customer Installation to Customer Installations (Figure 2).
- (2) Customer Installation 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 Installation and an AT&T Central Office for access to ACCUNET Reserved Digital Service or SKYNET Digital Service (Figure 5).

There are several 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. Alternatively, customers may provide access themselves or may acquire access through a third party. *It is recommended that the provisioning of such access conform to the guidelines of TR 62415.*

2.1.2.1 AT&T Provided Access

Under this option, AT&T provides local channel service with rates filed in FCC Tariff No. 11, and an Access Coordination Function (ACF).

2.1.2.2 AT&T Coordinated Access

Access which is coordinated by AT&T, is ordered at the time the customer initiates a Service Order. When providing *coordinated access*, AT&T assumes responsibility for following functions:

- (1) Design

- (2) Ordering
- (3) Installation coordination
- (4) Preservice testing and service turn-up
- (5) Trouble sectionalization
- (6) Restoration coordination

2.1.2.3 Customer Provided Access

With Customer Provided Access (CPA) customers furnish their own access from their CI to the serving AT&T Central Office. Customers choosing the CPA option should consult TR 62415⁽²⁰⁾ in addition to this document for details concerning DS1 (1.544 Mb/s) access to the AT&T Network. The serving office must be designated as an ACCUNET T1.5 Point Of Presence (POP) for interconnection to AT&T services.

The customer has total responsibility for the engineering, installation, operation, and maintenance of the access system terminating at the AT&T interface. AT&T provides the installation, maintenance and testing support required to interconnect CPA to the AT&T DS1 interface, which is usually a Digital Cross-Connect Frame (DSX-1). CPA facilities may be provided by either a Local Exchange Company or other vendor.

2.1.2.4 A 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 Function

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

2.2.1 Transfer Arrangements

Transfer Arrangements are service functions that offer customers the ability to switch traffic from one premises to another. 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 digital Service, or to an ACCUNET T1.5 interoffice channel.

Transfer Arrangements cannot be used with an M24 Multiplexing Service Function (Section 2.2.4) 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 that occur when Central Office equipment senses a loss of signal.

Transfer Arrangements can be activated by two possible arrangements. One option, which is not always available, uses a DC control path which must be obtained by the customer, to effect the transfer.

The second arrangement allows a customer to access the Transfer Arrangement via a data set using dial-in capability. After entering a six-digit security code, the customer follows a dialog prompted by the controller, to effect a transfer.

2.2.2 Access Protection Capability (APC)

APC provides protection against performance degradation and circuit failure in DS1 access lines. Protection is furnished through the use of a switching arrangement that automatically switches service to an alternate access line when the working access line fails or degrades. The customer must order a spare access line and provide CI automatic protection switching equipment that meets the compatibility requirements of TR 54017⁽¹¹⁾.

2.2.3 Network Protection Capability (NPC)

This service function, offered at AT&T Central Offices where facilities are available, provides protection against failure of an Inter Office Channel (IOC). Protection is furnished through the use of a switching arrangement that automatically switches to a separately routed protection channel when the working channel fails.

2.2.4 M24 Multiplexing

M24, as shown in Figure 8, provides multiplexing functionality in an AT&T CO that 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 M24 Service Function, Integrated Access is available to such Private Line and Public Switch Network services as ACCUNET Spectrum of Digital Services (ASDS), 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.

2.2.4 M44 Bit Compression Multiplexing

Using ADPCM (Adaptive Differential Pulse Code Modulation) bit compression multiplexing techniques, M44 Multiplexing provides the capability to combine the signals from two DS1 channels for transport over one DS1 channel. Where robbed-bit signaling is not required, M44 can accommodate all 48 DS0's of the two DS1 channels. A maximum of 44 DS0 channels are available for customer use where robbed-bit signaling is required.

M44 Multiplexing can be ordered alone or in combination with other ACCUNET T1.5 service functions such as M24 Multiplexing, Customer Controlled Reconfiguration (CCR), Bandwidth Management Service (BMS), or Bandwidth Management Service - Extended (BMS-E). M44 is available in two configurations, Customer

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Installation-to-Central Office (Figure 9a) and Central Office-to-Central Office (Figures 9b). CPE used for M44 functionality must be compatible with the Network multiplexer, including compression technique, frame structure, and bundle construction. See TR 54070 for additional information about this service function.

2.2.6 Customer Controlled Reconfiguration (CCR)

Customer Controlled Reconfiguration (CCR) is a service function of ACCUNET T1.5 Service permits a customer to dynamically allocate groups of one or more DS0 channels contained within a dedicated ACCUNET T1.5 network. This allocation capability (illustrated in Figure 10) requires no involvement by AT&T. A full description of CCR and its associated requirements can be found in TR 54015.

2.2.7 Bandwidth Management Service (BMS)

Bandwidth Management Service (BMS) is a service function of ACCUNET T1.5 Service that allows a customer to exercise electronic control over a 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. The basic network architecture of BMS is depicted in Figure 11A. 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. Further information describing BMS can be found in TR 62419.

2.2.8 Bandwidth Management Service - Extended (Supervisory Data Link Protocol)

The BMNS-E (SDLP) service function of ACCUNET T1.5 extends the features of BMS to SDL-compatible CPE via DS1-access circuits that support SDL(1). This service utilizes part of the 1.544Mb/s (DS1) digital interface to transport the SDL message-oriented protocol, using out-of-band signals, to provide the customer with the capability to control and configure both the AT&T and the SDL-compatible premises parts of an end-to-end network. Customers may be provided, through the SDL-compatible CPE, with alarm and non-disruptive performance monitoring features, trouble reporting, and testing capabilities. The basic network architecture for BMS-E is depicted in Figure 11B. Further information describing BMS-E (SDLP) can be found in TR 62414.

2.2.9 Bandwidth Management Service - Extended (External Supervisory Data Link Protocol)

The BMS-E (ESDLP) service function of ACCUNET T1.5 provides the identical network management capabilities offered with BMS-E (SDLP) as identified above, but uses a channel that is physically separate from the one used to transport customer traffic. This channel, a lower rate digital or Vice Grade Private Line (VGPL), provides an independent facility for carrying out-of-band signaling and SDL control protocol to interconnect the control

1. AT&T Supervisory Data Link protocol

network and the network management system. Additional information on BMS-E (ESDLP) can be found in TR 62414A.

2.2.11 The Primary Rate Interface (PRI)

The PRI Service Function of ACCUNET T1.5 Service provides 23 “B” (bearer) Channels and one “D” Channel between a Customer location at an AT&T CO. A multiple PRI configuration consisting of several DS1 Channels, may be arranged with a single “D” Channel common to all the “B” Channels, allowing some DS1s to contain 24 “B” Channels.

The D-Channel, used for signaling, control, and user data, uses the CCITT Recommendation Q.931 layer three protocol procedures as specified in TR 41449, TR 41449 and CCITT Document AP VIII-84-E⁽²³⁾.

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 they are available at the same AT&T CO.

2.2.12 ACCUNET Information Manager (AIM)

AIM is an ACCUNET T1.5 and - where available, ACCUNET Spectrum of Digital Services (ASDS)² service function which provides customers with configuration, fault-management and performance-management information for their ACCUNET T1.5 circuits. The AIM interface requires customers to use a controller at the CI to communicate with the AT&T network controller through a private-line connection. The architecture of the AIM interface is shown in figure 11C. Additional information on AIM can be found in TR 62412.

2.2.13 ACCUNET Spectrum of Digital Services (ASDS)

ASDS provides a common core digital network for the transmission of voice or data on single DS0 channels. It provides the capability for the tailoring of requirements for High Capacity digital technology on internodal transport, combined with various access methods in building a network. The service offers a DS1 interface for both analog and digital access at the AT&T Point of Presence (POP) and guarantees digital point-to-point transmission through the AT&T network. The architecture is depicted in Figure 31. Additional information on ASDS can be found in TR 62421.

3. PERFORMANCE AND AVAILABILITY

Performance is a measure of the operational quality of a circuit during the time it is in use. Availability is a measure of the time during which the circuit is available for use.

In its endeavor to provide quality service to end users and maintain the highest performance characteristics for ACCUNET T1.5, AT&T has deployed Extended Superframe Format capabilities in its network. ESF-compatible Channel Service Units (CSUs), customer premises multiplexers, and PBXs etc, with capabilities as described in TR

54016 enable customers to monitor their own circuit performance and allow AT&T to gather Customer Interface (CI) to Central Office (CO) performance data on-line and perform non-intrusive sectionalization. Use of ESF-compatible CI equipment helps to sectionalize troubles expeditiously, resulting in faster repair time and reduced outages. AT&T is continually striving to provide better service availability by introducing rapid restoration techniques and service quality improvement measures. When reporting problems it is recommended that customers inform AT&T of the time of day and duration of all trouble conditions not opened as trouble tickets, so that an appropriate analysis of the trouble can be made.

3.1 Performance

The measurement of performance is quantified 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. These periods occur on circuits will within the Errored Seconds criteria. Objectives for Severely Errored Seconds (SES), a parameter which characterizes these burst phenomena, are shown for the first time for ACCUNET T1.5 access and end-to-end circuits in Tables 3.1 and 3.3 of this document.

3.1.1 Performance And Availability Parameters

AT&T's current implementation for determining performance and availability parameters for ACCUNET T1.5 service accommodates both D4 and ESF framing formats. Bit Error Ratio (BER) derived parameters are used to measure the performance of D4 formatted bit streams, while CRC6 derived parameters are employed when measuring the transmission performance of ESF formatted data³. CCITT Recommendation G.821⁽²⁴⁾ and CRC6 definitions from TR 54016 for Errored Second (ES) and Severely Errored Second (SES) performance parameters are reproduced here for reference.

3.1.1.1 Errored Seconds (ES) and Error-Free Seconds (EFS)

An *ES* is any second in which one or more bits are in error or contain one or more CRC6 error events⁴ or Out of Frames (OOFs)⁵.

In baseband digital systems like ACCUNET T1.5 field tests and measurements indicate that intermittent error bursts normally occur in clusters, and their effect on the operational characteristics of the service is not adequately described by the *ES* parameter. A better way of describing the performance of ACCUNET T1.5 Service is to determine the number of *Error-Free Seconds (EFS)* occurring on the channel.

An Error-Free Second for a DS1 channel is defined as any second of data transmission during which no bit errors are received. In other words, in an error-free second, all 1,544,000 bits are received as transmitted. The percentage of error-free seconds is the ratio of one-second intervals without bit errors to the total number of seconds in an observation period, (usually 24 hours). This proportion is expressed as percent error-free seconds (% EFS). Daily performance objectives for this parameter are shown in Tables 3.1, 3.2, and 3.3.

3. Details of AT&T's implementation of CRC6 technology for ESF performance monitoring is provided in TR54016

4. A CRC6 error event occurs when the CRC6 algorithm used to check the contents of an extended superframe indicates an error in transmission.

5. See sections 3.1.1.4 and 7.3 for a discussion of OOF.

Severely Errored Seconds (SES)

An *SES* is any second in which the BER is worse than 1×10^{-3} or contains 320 or more CRC6 error events or 1 or more OOFs. This parameter, which is used to derive the *UAS* parameter, characterizes the bursty nature of errors when they are present in the service, and assists network designers in determining the attained performance of their network. As discussed in TR 54016, when monitoring ESF formatted DS1 signals an SES is defined as a second with 320 or more CRC6 error events or 1 or more OOFs.

3.1.1.3 Unavailable Seconds (UAS)

Unavailable Seconds are a count of one-second intervals during which service is unavailable. The period of time during which such one-second intervals occur is referred to as the unavailable signal state.

An unavailable signal state is declared at the onset of 10 consecutive SES. An unavailable signal state is cleared at the onset of 10 consecutive seconds with no SES.

3.1.1.4 Loss Of Frame Count (LOFC)

An *LOFC* is a count of the number of times a "Loss Of Frame" has been declared. This parameter, which measures an accumulation of short failure events, *replaces* Consecutive Severely Errored Seconds (CSES). The process employed to detect LOFs is the same one used to detect CFAs⁶.

A Loss Of Frame is declared when, on detection of a *Loss Of Signal (LOS)*⁷ or *OOF*, a rise slope type integration process starts which declares an LOF after 2.5 (± 0.5) seconds of continuous LOS or OOF. If the LOS or OOF is intermittent, the integration process shall decay at a slope of 1/5 the rise slope during the period when the signal is normal. Thus, if the ratio of an LOS or OOF to a normal signal is greater than 1/5, a Loss Of Frame will be declared.

An LOF is cleared if no LOS or OOF conditions occur during a variable minimum-clearing time-period which can vary from one second up to fifteen contiguous seconds, depending upon the application.

As an example, let a counter increment once every three milliseconds during an LOS or OOF. When the counter reaches 834 (i.e. 2.5 seconds), an LOF event is declared and the LOFC is incremented. During intermittent LOF and OOF events, the counter will be decremented once during every 15 millisecond period when the signal is normal.

AT&T has included the LOFC measurement in an enhanced set of performance and availability parameters⁸ which all new equipment deployed in the AT&T network after January 1, 1991 with support, in addition to the currently required basic set⁹.

6. Certain Standards bodies currently use (LOF) Loss Of Frame terminology in lieu of CFA (carrier Failure Alarm).

7. See section 7.2 for discussion of LOS

8. See section 4.1.3 in this document and(10) for additional information about the enhanced performance and availability parameters.

9. The basic set consists of the ES and UAS performance parameters described here in greater depth in TR 540156.

3.1.1.4.1 Short Failure Event Count (SFEC)

The *SFEC* is a subset of the LOFC parameter and consists of counts of all LOF events less than 2 minutes in duration. The SFEC parameter has been found useful to characterize the Short Failures which affect certain applications in dedicated digital services. Preliminary objectives for SFEs are shown in Tables 3.1, 3.2, and 3.3 for ACCLTNET T1.5 end-to-end, inter-office, and access circuits, respectively.

3.2 Performance And Availability Objectives

3.2.1 Performance Objectives

The 24 hour performance objectives for ACCUNET T1.5 circuits are shown in Tables 3.1, 3.2, and 3.3 for CI-to-CI, CO-to-CO, and CI-to-CO respectively. 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 obligated to rebate for outages occurring on the circuit.*

The "traditional" method of computing end-to-end performance objectives for circuits by adding the individual values for their access and Inter-Office-Channel (IOC) portions, results in a "worst case" performance objective. More realistic objectives are shown in the following tables, resulting from the use of statistical combinations of actual access and IOC data gathered by on-line monitoring of a large number of DS1 circuits over a period of one year.

3.2.2 Availability Objectives

The availability objectives for ACCUNET T1.5 circuits are shown in Tables 3.1, 3.2, and 3.3. They are provided on both an annual and a quarterly basis. The quarterly objectives shown limit the maximum outage time a circuit can experience during a single quarter. It should be recognized that the outage time allocated for each quarterly objective is independent of performance results experienced during previous quarters, and that the annual objective is not necessarily four times the quarterly figure, so as to further tighten performance over the long term.

Availability is the complement of Outage, i.e. $\% \text{ Availability} = 100 - \% \text{ Outage}$. 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 the UAS parameter.

The availability objectives for a CI-to-CI ACCUNET T1.5 circuit are mileage dependent and are as given in Table 3.1 when measured between Network Interfaces over one year and three month periods. Table 3.2 gives the mileage banded availability objectives for the internodal (CO-to-CO) link. For access lines, both the yearly and quarterly availability objective is 99.9750%, which equates to 2.19 and .55 hours of outage respectively (see Table 3.3). Note that the end-to-end availability objectives shown in Table 3.1 are not sums of respective access and IOC values shown in Tables 3.2 and 3.3, but indicate AT&T's objectives for managing the service from CI-to-CI.

Table 3.1. ACCUNET T1.5 PERFORMANCE: CI-TO-CI (END-TO-END)

Circuit Length (Airline Miles)	Performance				Availability	
	ES/Day	% EFS/Day	SES/Days	SFE/Month	%/Year	%/Quarter
<250	45	99.95	6	4	99.90	99.82
250 to 1000	50	99.94	8	4	99.87	99.80
>1000	55	99.935	10	4	99.85	99.77

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

Circuit Length (Airline Miles)	Performance				Availability	
	ES/Day	% EFS/Day	SES/Days	SFE/Month	%/Year	%/Quarter
<250	5	99.994	2	3	99.98	99.97
250 to 1000	10	99.988	4	3	99.97	99.94
>1000	15	99.983	6	3	99.96	99.92

TABLE 3.3. ACCUNET T1.5 PERFORMANCE; CI-TO-CO (ACCESS)

Performance				Availability	
ES/Day	% EFS/Day	SES/Days	SFE/Month	%/Year	%/Quarter
100	99.977	2	1	99.975	99.975

3.2.3 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, CI equipment shall remain operational, i.e., it shall not generate either local or facility alarms or initiate trunk conditioning. If intervals greater than 2.5 seconds are experienced, CI equipment shall generate a "Red" CFA (Carrier Failure Alarm) as defined in Section 7.4 and transmit a "Yellow" Alarm Signal in the direction opposite to that from which the burst was received. The Short Failure Event (SFE) parameter *Loss Of Frame Count (LOFC)* discussed in section 3.1.1.3 is useful for analyzing the effects of very short outages severe enough to disrupt dedicated digital services.

Occurrences of these types of error bursts should be quantified by counting "Red" CFAs or LOFCs.

3.2.4 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 US Government Agencies, only the following two DS1 framing formats are acceptable for use on ACCUNET T1.5 circuits.

These are the Superframe Format (SF) and the Extended Superframe Format (ESF). An unframed DS1 signal format may be used by US Government Agencies and their vendors upon written consent from AT&T.

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 signaling frames. 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 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 TR 54016.

Although the Superframe format is currently acceptable for use, certain services such as BMS and AIM require ESF. Customers should recognize that ESF provides advantages such as in-service monitoring and trouble sectionalization capability.

4.1.3 Extended Superframe Format With Enhanced Parameter Set

As of January 1, 1991, AT&T will implement within its network, the collection of an enhanced set of performance parameters which are specified in TR 54016(10). These parameters are intended to meet the needs of customers requiring a more comprehensive set of performance measures than currently available. To encourage their use, AT&T will require equipment vendors to include the Enhanced Parameter Set functionality in modified and redesigned CI equipment submitted for network compatibility tests after January 1, 1991. The new parameters are backwards compatible in all respects to the existing version of ESF, however their use by the customer is optional and AT&T will continue to allow the connection of CI equipment conforming to the May 1986 TR 54016 specifications. A detailed discussion of the ESF enhanced parameter set, its implementation by AT&T, and its relationship to the ANSI T1.403 standard^[1] can be found in TR 54016.

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 signal 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 pulse. 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 is 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 is available only with ESF. Its use allows the Network to transmit DS0 (64 kb/s) or nxDS0 (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.

With B8ZS coding, each block of eight consecutive "zeros" is removed and is replaced with an eight-bit B8ZS code containing bipolar violations in the 4th and 7th bit positions of the substituted code. If the pulse preceding the substituted code is transmitted as a positive pulse (+), the substituted code is 000+-0-+. If the pulse preceding the substituted code is transmitted as a negative pulse (-), the substituted code is 000-+0+-. In each case, the bipolar violations occur in the fourth and seventh bit positions. This substitution process is illustrated in Figure 30.

4.2.3 Decoding B8ZS Signals

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

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.

If the DS1 is used to "transmit channelized information to the ACCUNET T 1.5 M24 Service Function, D4 type channel sequencing shall be used. This channel arrangement requires a sequential assignment of the DS0 channels corresponding to the M24 multiplexed time-slot arrangement, i.e. Channel #1 = Time Slot #1, Channel #2 = Time Slot #2, etc.

Use of the M24 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 TR's 54075 and 62310.

4.4 Bit Compression Multiplexing

When a customer uses the Bit Compression Multiplexing (BCM) M44 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. Information about the M44 Service Function of ACCUNET T1.5 may be found in TR 54070.

4.5 Signaling

Two signaling formats are supported when using ACCUNET T1.5 to interconnect to ACCUNET T1.5 channelized Service Functions. The 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 use of ISDN PRI is currently limited to the ACCUNET T1.5 Primary Rate Interface Service Function (see Section 2.2.10). Customers should consult with their local AT&T sales representatives for clarification of current restrictions.

4.5.1 Robbed-Bit Signaling

Conventional robbed-bit signaling uses the least significant bit of a DS0 channel in every 6th sequential DS1 frame. The Superframe Format, consisting of 12 frames, identifies 2 signaling channels: A and B (see Figure 12). This allows up to 4 possible signaling states. When only 2-state signaling is required, the A bit associated with the 6th frame shall be mapped into the B bit associated with the 12th frame. When 3 or 4-state signaling is required, the A and B bits shall be transmitted in the 6th and 12th frame, respectively.

The Extended Superframe Format, consisting of 24 frames, identifies 4 signaling channels: A, B, C, and D (see Figure 14). This allows up to 16 possible signaling states. When only 2-state signaling is required, the A bit associated with the 6th frame shall be mapped into the B, C, and D bits associated with the 12th, 18th, and 24th frames, respectively. When only 3 or 4-state signaling is required, the A bit associated with the 6th frame shall be mapped into the C bit associated with the 18th frame and the B bit associated with the 12th frame shall be mapped into the D bit associated with the 24th frame. When 5 to 16-state signaling is required, the A, B, C, and D bits shall be transmitted in the 6th, 12th, 18th, and 24th frame, respectively.

Robbed-bit signaling is described in TR 43801, Digital Channel Bank Requirements And Objectives, November 1982.⁽²³⁾ Additional details on special access signaling can be found in TR 41458, Special Access Connections To The AT&T Network, April 1990.⁽⁷⁾

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 uses 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 TR 4 1449.

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 Installation 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 different connector arrangements. The first four connectors identified can be used for all applications, including ISDN. They are identified by the RJ48 Universal Service Ordering Codes (USOC). The RJ48C and RJ48X 8-pin connectors 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.

When more than one DS1 is to be connected, the 50 pin USOC RJ48M or RJ48H connector may be used. The RJ48M or RJ48H can accommodate 8 and 12 DS1s respectively. The RJ48H is the preferred multi-circuit connector⁽³⁾. These connectors conform to generic specifications identified in Subpart F of Part 68, FCC Rules and Regulations, supplemented by Public Notice 4609-September 21, 1988, and are specified in references ⁽¹⁾ and ⁽²⁾. Figures 16 through 19 show these connectors and should be consulted to verify correct pin assignments.

An alternative arrangement, *used with older, non-ISDN embedded-base equipment*, consists of 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.

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) (shown in Figure 1) during periods of normal service and maintenance activity. These specifications are in compliance with the BELLCORE PUB 62508⁽⁴⁾ and the ANSI Standard⁽¹⁾ T1.403-1989. Where necessary, these specifications are augmented by specific ACCUNET T1.5 Service requirements.

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 customers⁽³⁾. 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 office¹⁰.

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 ordering new 1.544 Mb/s service 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, manufacturers of CPE and ACCUNET T1.5 customers shall comply with Part 68, Subpart D, of the FCC Rules and Regulations^[3] and Section 8.1.3 (Minimum Protection Criteria) of Tariff F.C.C. No. 9, respectively.

4.6.2.2 Signal Specifications

The following signal specifications describe characteristics for all signals at the NI as specified in ANSI T1.403⁽¹⁾. Differences between the Network and the CI signals are identified in Sections 4.6.2.4 and 4.6.2.5. CI equipment shall not apply voltages to the Network other than those described in Section 4.6.2.3 of this document. At the time of service installation, the appropriate output pulse option setting of the CI equipment (as described in and required by Part 68.308 of the FCC Rules and Regulations⁽³⁾) should be selected by the customer. Assistance from the local access provider may be required to determine the correct Line Buildout attenuation needed to match the loss of the end-section of the carrier's cable.

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 \pm 50 b/s¹¹.

10. *The powering requirement for 1.544 Mb/s service DTEs existing prior to 2-16-88 became optional after 12-18-89 per FCC Report and Order, October 23, 1987: Part 68.318(b). In addition, after that date DTE ws no longer required to contain a "Continuity Of Output (i.e. keep-alive) Signal capability for FCC Registration purposes. However, as in the case for ACCUNET T1.5 Service, carriers may require CPE to support AIS (i.e. keep-alive) functionality.*

11. *Older equipment has rate variation up to \pm 200 bis.*

4.6.2.2.2 Test Load

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

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 4.6.2.3.1 with the following exceptions:

- (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.
- (2) The lower limit on the standard pulse amplitude shall be 2.25 V rather than 2.4 V.

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 and 4.6.2.3 with the following exceptions:

- (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.

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 sources¹² 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 T 1.5 Service to the DTE at the Customer Installation. 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 relationship between 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 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 effort for jitter frequencies up to 10 kHz, 5 bits in error or minimum achievable number of bit efforts, for higher frequencies) occurs in a 60 second measuring time interval. A faster method that can be used, is to find two jitter amplitudes differing by less than the desired

12. See section 6, Synchronization And Timing, for related discussion on timing clock sources.

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 instances the resulting QRTS bit pattern should not be changed before it is applied to the DTE, (i.e., the pattern should remain the same), 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 = 1 bit = 648 ns = 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 = 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 DSI. For all other DSI facilities that do not provide a synchronization signal, 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). DTE

which use stratum 4 or lower clocks are acceptable if they exhibit a transfer function, without peaking, located in the band between templates "a" and "b", as shown in Figure 27. For uniformity and optimal operation, the transfer function of new equipment should not have a corner frequency above 6 Hz.

Some designs based on digital technology, transfer input jitter frequencies to different output frequencies. For all DTE, the maximum dense-broadband input jitter between 10 Hz and 300 Hz shall be attenuated by at least -25 dB, when measured using an 8-to-40 kHz filter (point 3 Figure 26). An observation interval of 5 minutes should be used. Dense-broadband input jitter, as it appears in the network, can be approximated by looping back a single DS1 input signal between two back-to-back DS1-to-DS3 (M13) multiplexers, 28 times. Alternatively, another way is to modulate the signal in the test methodology described below, with "white noise" limited to 300 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 that 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 required 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. See Section 7 for additional information concerning AIS.

5.3 Loopbacks

To conduct circuit testing and single-ended fault sectionalization of the digital line, a Line Loopback (LLB) and Payload Loopback (PLB) capability 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 equipment at the Customer Installation (CI) 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 equipment at the CI 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. Actuate

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

2. Deactuate

A framed DSI 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 equipment at the CI shall actuate or deactuate the LLB function in a period no shorter than 4.5 seconds, and no longer than 5.5 seconds.

While in a loopback state, CI equipment 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 will be found in ANSI T1.403-1989⁽¹⁾ and TR 54016⁽¹⁰⁾.

5.3.3 Payload Loopback Using the ESF

The PLB is a logical loopback that is intended to test as much of the CI at the DS1 level as possible, and is supported only by the ESF format. "When a payload loopback is activated, the received information bits (192 information bits per frame) are transmitted in the outgoing direction. The framing bits (frame synchronization, CRC-6, and data link) are originated at the point of the payload loopback. The payload loopback shall maintain bit-sequence integrity¹³ for the information bits; however, the payload need not maintain the integrity of eight-bit time-slots, frames, or superframes⁽¹⁾. Additional information concerning the actuation and release of the PLB and its ESF maintenance-message protocol can be found in references ⁽¹⁾ and ⁽¹⁰⁾. The PLB is illustrated in Figure 29.

13. This requires that the timing of the transmitted payload loopback signal be synchronized with the timing of the received payload loopback signal.

5.3.4 ISDN PRI Digital Loopback

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. TR 41459 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, 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, as outlined in the following sections. When customer data signals do not meet the prescribed pulse density requirements, the errors are corrected by means of Zero Code Suppression (ZCS) techniques.

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 $8 \times (n+1)$ bits (where n can equal 1 through 23), there should be at least ' n ' ones present. Customer data signals that 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 incur a maintenance service charge for the dispatch.

5.5.2 Channelized Circuits

In the case of channelization by the Network, and when Clear Channel Capability is not provided, the contents of an all zero, eight-bit time slot may be changed. The quasi-random test signal (Figure 23) may be transmitted without meeting these pulse density requirements⁽¹⁾.

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

Clear Channel Capability is a characteristic of a DS1 transmission path in which the 192 information bits in a frame can represent any combination of zeros and ones. 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. Thus, 64CCC implemented through B8ZS, provides users with 64 kb/s of channel capability, and on properly configured DS1 circuits, allows 1.536 Mb/s of data transmission. (See related discussions on B8ZS and Pulse Density restriction in Sections 4.2.2 and 5.5.)

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 that 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 TR 60110⁽¹⁵⁾ instruct customers on how they may configure a customer premises-to-customer premises network, using a customer-provided timing source.

A network that uses 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, as is discussed in the ANSI Standard "Synchronization Interface Standards for Digital Networks"(26). 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 M24. Examples of ACCUNET Service Functions which may not provide stratum 1 traceable timing are Transfer Arrangements, Automatic Protection Capability (APC), M44 and M24. 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 TR 60110.

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

6.2 Synchronization Equipment Requirements

CPE that 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 ⁽²⁷⁾, 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 that 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, DS1 and 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) that transfer timing shall meet the maximum time interval error (i.e. peak-to-peak phase change as defined in ^[27]). In response to a rearrangement activity such as switching of timing reference, changeovers of active synchronization hardware, and 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 Enhanced clocks satisfy the above requirements and can be used to transfer timing. Stratum 4 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 clocks may propagate impairments on all outgoing DS1 lines, including those which return to the timing reference, as well as those that connect to other nodes.

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

- (1) Maintain phase lock with a timing signal that is designated as the timing reference and is derived from either a) a suitable digital traffic-carrying facility, or b) an external timing-only line fed directly into a dedicated non-traffic timing input port.
- (2) Provide jitter filtering (as discussed in Section 4.7) to improve short term stability.
- (3) Provide a stable holdover, or free-running capability, or both (as defined in Table 6.1) in the temporary absence of a synchronization reference signal.
- (4) 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.
- (5) 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 Table 6.1.

TABLE 6.1. STRATUM LEVEL REQUIREMENTS

	Stratum 2	Stratum 3	Stratum 3 Enhanced	Stratum 4
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	≤ 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 $\leq 1 \mu\text{sec}$ Phase change slope: 81 ns. in any 1.326 ms.	MTIE $\leq 1 \mu\text{sec}$ Phase change slope: 81 ns. in any 1.326 ms	MTIE $\leq 1 \mu\text{sec}$ Phase change slope: 81 ns. in any 1.326 ms	Not Required
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	Transfers Timing

*Holdover is defined as the operating condition of a clock when its local oscillator is not locked to an external reference, but is using storage techniques to maintain its accuracy with respect to the last known frequency comparison with a synchronization reference.

**Equipment in a given stratum may receive timing from an equal or higher stratum. Therefore, a clock in a given stratum shall be capable of pulling into synchronization with a clock of equal or higher stratum level.

6.3 Timing References

In order to provide a readily accessible timing reference, the clock used in equipment used 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 4.7, 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 those in ANSI T1.101 - 1987⁽²⁶⁾, 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 events that generate alarm signals or activate alarm status conditions are described. The term alarm *signal* refers to the information transmitted upstream or downstream warning that a system failure has been detected, whereas an alarm *state* refers to a condition activated at a terminal alerting that maintenance action is required.

7.1 Carrier Failure Alarms

The thresholds exist in Network Central Office Equipment (NCOE) or CPE deployed at CIs to monitor digital facilities and generate unique Carrier Failure Alarms (CFAs) when they detect the presence or absence of certain signal conditions. The equipment initiates an "alarm timing-cycle" function when detecting a failure on an incoming line triggered by a continuous loss of framing, an intermittent out-of-frame condition, or a loss of signal.

7.2 Loss Of Signal (LOS) Condition

A Loss Of Signal (LOS) condition shall be declared when the NCTE has determined that 175 ± 75 successive pulse positions with no pulses of either positive or negative polarity have occurred¹⁴.

14. Two older definitions of LOS are: no pluses for 100 -20, +75 pulse positions; and 150 msec.

7.3 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. Depending upon the equipment, 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.

7.4 Reframe Duration

The maximum average reframe time shall be less than 50 milliseconds in the absence of errors¹⁵.

7.5 Carrier Failure Alarms (CFAs)

CPE located at CIs and NCOE in the AT&T Network are deployed to monitor digital facilities and generate unique Carrier Failure Alarms (CFAs) when they detect the presence or absence of certain signal conditions. They initiate an "alarm timing-cycle" function when a failure is detected on an incoming line. The timing-cycle function may be triggered by a continuous loss of framing, an intermittent out-of-frame condition, or a loss of signal.

7.6 Types Of Carrier Failure Alarms and Signals

CFAs may be categorized as an AIS CFA, "Red" CFA, or a "Yellow" CFA.

7.6.1 AIS CFA

An AIS CFA is an alarm *state* existing at a downstream receiving terminal resulting from that terminal's detection of an Alarm Indication Signal (AIS) from upstream equipment.

7.6.2 AIS (Alarm Indication Signal)

An 'AIS', also referred to as a "Keep-Alive" or "Blue" signal, is an unframed "all-ones" *signal* that is transmitted in lieu of a normal signal upon loss of originating signal, or when any action is taken that would cause a signal disruption. It is used to maintain transmission continuity and to notify downstream receiving terminals of a transmission fault located either at the transmission equipment or upstream of the transmitting equipment.

7.6.3 Red CFA

A "Red" CFA is an alarm *state* existing at a downs terminal's detection, on an incoming line, of a system failure. receiving terminal, resulting from a system failure.

15. *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 that is implemented not lock onto a spurious framing signal (i.e., false framing protection is required).*

7.6.4 Yellow Alarm Signal

A "Yellow" *signal* also known as a Remote Alarm Indication (RAI) signal, indicates a carrier failure in the transmit direction, and *shall* be automatically transmitted in the outgoing direction for a minimum of one second when a terminal determines that it has effectively lost the incoming signal.(1)

7.6.5 Yellow CFA

A "Yellow" CFA alarm *state* is activated at a terminal as a result of that terminal's detection of a "Yellow" alarm *signal* received from a terminal which is in a "Red" CFA alarm *state*.

7.7 Conditions Causing The Initiation Of Carrier Failure Alarms

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 CFA after 2.5 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. OOF would require a 500 msec. of normal signal for an integration counter to reset to zero). The CFA is cleared when no LOS or OOF conditions occur during a variable minimum-clearing time-period which can vary from one second up to fifteen contiguous seconds, depending upon the application.

A CFA *state* shall cause a "yellow" *signal* to be transmitted upstream 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. The "Yellow" CFA *signal* is generated 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" (11111110000000) is transmitted continuously for a minimum of one second, over the ESF data link.

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

An AIS *signal* 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 CFA" 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 initially activate a "Red" CFA *state*. If the incoming AIS *signal* persists after the "Red" CFA *state* is activated, an "AIS CFA" *state* should be declared. An "AIS CFA" *state* is cleared when the condition which triggered the "Red" CFA *state* is cleared.

8. TESTING AND MAINTENANCE

A telephone number for reporting trouble to the Customer Test Center will be provided by AT&T when an ACCUNET T1.5 circuit is made available to a customer for use. When customers encounter problems, it is essential they check their equipment for proper operation prior to reporting trouble. When diagnostic capabilities such as CPE-to-CPE loopback capability are part of customer equipment, they may be used to identify problems and isolate faults to a specific customer location, eliminating the unnecessary dispatch of repair personnel by both AT&T and its local access provider. When complete and accurate trouble descriptions are reported, more economical trouble resolution can be obtained.

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 Installation.

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 that can cause errors in DTE with input jitter tolerances defined in Section 4.7. I. 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 T1X1.6 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/TIC 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/TIC 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 Installation At The NI

Jitter from the customer installation side of the NI should be measured in a way similar to that discussed in the section on output jitter. The measurement should be made 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 with 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 the beginning of 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 measure the network jitter spectrum first. 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 Fast Fourier Transform (FFF) are, used.

1.3 Interface To Other Networks Or Facilities

The jitter levels discussed 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 can occur due to the possible presence of asynchronous DS1 to higher-level multiplexers on the customer side of the NI which are part of a customer-maintained network. In such cases, these CI multiplexers (or other devices) may exhibit jitter tolerances only slightly above $5 U_{I_{p-p}}$ below 500 Hz.

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 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 $0.1 U_{I_{p-p}}$ at point 3 and $1.5 U_{I_{p-p}}$ at point 2 on the output of a customer connected facility, and $0.1 U_{I_{p-p}}$ and $3 U_{I_{p-p}}$ respectively, from the network side. Jitter accumulation evaluation is needed if any jitter level is higher. Detailed investigation is necessary if jitter levels above $5 U_{I_{p-p}}$ are encountered.

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.

2. *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 clocks (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 2 for Stratum 2, Stratum 3, and Stratum 4 Enhanced 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. Lost of single 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 6.1×10^{-5} .
- d. Input jitter above the tolerances given in Section 4.7.1.

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