Qwest Corporation Technical Publication

1.544 Mbit/s Channel Interfaces

Technical Specifications for

Network Channel Interface Codes Describing Electrical Interfaces at Customer Premises and at Qwest Central Offices

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NOTICE

Technical Publication 77375 is a reference document providing technical disclosure information for all the 1.544 Mbit/s Network Channel Interface (NCI) codes Qwest supports.

DS1 is used in this document to denote the Digital Signal Level 1 (1.544 Mbit/s) transmission data rate. Where *DS1 Service* is listed, the information describes a specific product offering provided by Qwest.

This document provides technical parameters for:

- Required characteristics of Qwest and Customer signals at 1.544 Mbit/s channel interfaces to End-Users and Carriers.
- NCI codes used to encode the signal characteristics of the interfaces, and list those that may be used when ordering Qwest 1.544 Mbit/s channels.
- Characteristics of the DS1 Rate Synchronization Interface.

Technical Publication 77375 is intended to be used with other Qwest Technical Publications and with Qwest *Service Publication*s, which provide both the Network Channel and Network Channel Interface codes needed to order 1.544 Mbit/s channels related to specific services.

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1. Introduction

1.1 Purpose

Technical Publication 77375 is a reference document providing technical disclosure information for 1.544 Mbit/s Network Channel Interface (NCI) codes that Qwest supports.

1.2 Scope

DS1 is used in this document to denote the Digital Signal Level 1 (1.544 Mbit/s) transmission data rate. Where *DS1 Service* is listed, the information describes a specific product offering provided by Qwest.

This document provides technical parameters for:

- Required characteristics of Qwest and Customer signals at 1.544 Mbit/s channel interfaces to End-Users and Carriers.
- Network Channel Interface codes used to encode the signal characteristics of the interfaces, and list those that may be used when ordering Qwest 1.544 Mbit/s channels.
- Characteristics of the DS1 Rate Synchronization Service interface.

Technical Publication 77375 is intended to be instructive and used with other Qwest Technical Publications or with Qwest *Service Publication*s. Service publications provide both the Network Channel and Network Channel Interface codes needed to order 1.544 Mbit/s channels related to specific services. An example of a Service Publication is PUB 77200, *Qwest DS1 Service and Qwest DS1 Rate Synchronization Service – Network Channel and Network Channel Interface Code Combinations*.

1.3 Reason for Reissue

This technical publication is being reissued to:

- Add new customer-orderable options for ANSI ESF with Network Performance Report Messaging (NPRM)
- Provide further information on DS1 Rate Synchronization interface availability requirements
- Miscellaneous updates including references

1.4 End-User and Carrier Customer Premises - Mandated Differences

Both End-Users and Carriers may purchase 1.544 Mbit/s channels with a number of optional enhancements.

The Federal Communications Commission (Code of Federal Regulations Title 47, Part 68) mandates certain technical differences between interfaces provided at End-user premises and at Carrier premises, and these differences are explained in appropriate sections of this publication. *The differences have no qualitative effect on the service being provided.*

When a Carrier orders services, not for resale, but for their own internal use, the appropriate End-user interface(s) should be ordered.

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2. Overview of Qwest DS1 Service

2.1 Service Descriptions

In the North American hierarchy of digital bit-rates, 1.544 Mbit/s is defined as *Digital Signal level 1*, the short form of which *(DS1)*, will generally be used throughout this document.

Qwest Private Line Transport DS1 Service is a high capacity, high performance information channel designed to do a lot more than just transport digital signals from Point A to Point B. Qwest DS1 is a dedicated, end-to-end digital transport service designed for full duplex, point-to-point transmission at 1.544 Mbit/s. Because transmission is digital from end-to-end, the signal is clean and pure; free of crosstalk, amplified noise and distortion. Network control centers in major cities throughout the Qwest territory ensure exacting standards of reliability 24 hours a day, seven days a week.

Qwest Private Line Transport DS1 Service offers long distance carriers digital transport within Qwest's 14-state territory. The network links the population centers of this vast geographic region together, giving carriers the ability to provide virtually unlimited service to their subscribers wherever they reside or do business. The service can offer increased value to your own subscribers because Qwest DS1 Service on your network provides security, reliability, protection, and rate stability.

If you're a medium to large sized, sophisticated user with substantial transmission needs, Qwest's Private Line Transport DS1 Service can boost your productivity, conserve your capital and enhance the functionality of your software and terminal equipment.

2.2 Benefits

- End-to-end digital connectivity to consolidate voice, data and video transmission channels into one cost-effective high capacity channel
- Multiplex your circuits to derive voice and data channels
- Build a reliable disaster recovery plan
- Multiplex numerous low-speed lines onto a single, high-speed circuit
- Connect distributed hosts
- Link Local Area Networks (LANs)
- Enjoy sub-second response time
- Even change and rearrange your network facilities any way you want to any time you need to with DS1 and COMMAND A LINK℠. This service is described in Qwest Technical Publication 77371, *COMMAND A LINK℠ Technical Description and Interface Combinations*.

2.3 Optional Enhancements

2.3.1 Central Office Multiplexing

Central Office Multiplexing gives flexibility to DS1 and DS0 voice grade services with its ability to interleave a number of lower bit-rate channels into a higher bit-rate channel or to perform the reverse. DS1 multiplexing includes DS1 to analog (voiceband signals) and DS1 to DS0 (digital data signals). Multiplexing allows you to link dispersed locations to a central site with up to 24 channels derived from each DS1 circuit.

2.3.2 Clear Channel Capability

Clear Channel Capability increases the available bandwidth by 14%, fully utilizing the available 1.536 Mbit/s payload of a 1.544 Mbit/s channel. With DS1 Clear Channel Capability there is no constraint on the quantity of zero's in the customer transmitted data in the 1.544 Mbit/s bit stream.

2.3.3 Extended Superframe

Extended Superframe (ESF) promotes better performance monitoring, provides more complete network information for users and functions as a common measure of performance. There are several variations of ESF available that are discussed in Chapter 3.

2.3.4 Customer Controlled Reconfiguration

Customer Controlled Reconfiguration combines DS1 with Qwest's COMMAND A LINK℠ Service to put users in control of their network facilities and functions at all times, on a real-time basis. The touch of a few terminal keys is all it takes to reconfigure channels for maximum efficiency and cost savings. Network changes can be executed immediately, or scheduled for specific times in the future.

Example: Several of your firm's offices communicate with each other constantly during normal business hours. At night and on weekends, however, their circuits fall silent. With COMMAND A LINK℠, you can easily reconfigure your DS1 circuits to link those offices with your main data storage facility. The offices can transmit their data to storage during the night, and then re-connect with each other in time for the next day's business. You've made the most of your host and remote terminals, kept circuit's idle time to a minimum and moved necessary information without disrupting your normal business routine.

2.3.5 Synchronization

When customers need to synchronize digital terminals at their Hubs, a Qwest synchronization interface may be ordered where it is available. The DS1 rate synchronization signal, available where Qwest has Synchronous Optical Network (SONET) transport equipment on your premises, is traceable to a Stratum 1 Reference Clock.

2.4 Applications

2.4.1 Disaster Recovery

When host computers go down, business grinds to a halt. With DS1 and COMMAND A LINK℠, however, customers can recover operations in a matter of minutes simply by issuing a command to switch to a backup computer center in another location. When the emergency is over, the user simply issues another command, which re-links the circuits between headquarters and the primary host computer.

2.4.2 Improved Front-End Processor Performance

The more data a front-end processor is asked to handle, the slower the response time and the lower the performance for all devices attached to the host. By switching heavy, continuous data traffic (such as file transfer) away from the host and onto DS1 channels, users find they can free up the front-end device to do what it does best; manage terminal to host transactions. The result is improved response time for terminal users.

There's an important dimension of economy, too, since channel to channel devices which interconnect with DS1 circuits are much less costly than purchasing a new front-end processor.

2.4.3 Centralized Data Processing

Connecting a headquarters-based host with a number of remote terminals is easy and economical with DS1. For example, a firm needs to link its host at location *A* with ten 9.6 kbit/s terminals and two 19.2 kbit/s terminals housed at location *B*. A DS1 circuit coupled with a CSU/DSU and a customer provided subrate multiplexer at each site allows the user to transport data at 1.544 Mbit/s over a single, four-wire circuit instead of individual lines for each terminal. This arrangement costs about the same as leasing a dozen individual lines, but uses only about 10 percent of the DS1's circuit's capacity. There's ample bandwidth in reserve for future growth.

2.4.4 High-Speed Host to Host Channel Networking

Multiple location hosts are becoming commonplace in large organizations. To promote maximum networking functionally, users are connecting these devices via DS1 circuits. Here are a few of the applications being explored.

- Load Balancing
  It is a perennial problem for data processing managers. Users are demanding increasingly fast response, and there's only one way to provide it: more processing power. But why invest in another host which will likely sit idle during off-peak hours? Now Data Processing managers can connect multiple location hosts with high-capacity digital circuits, thereby balancing peak loads, providing enhanced response time and avoiding the high cost of additional hardware.
- Task Specialization
  Some host processors are better suited to certain tasks than others. By connecting multi-vendor hosts on a Qwest DS1 high-speed network, users can allocate specific tasks to the most appropriate processor, and can even write new applications to make the most of their resources.
- Improved Resource Sharing
  Many organizations need to share information between and among distributed locations. With these locations linked by high-capacity DS1 circuits, users find themselves transmitting more information and more kinds of information than ever before. The availability of additional capacity releases pent-up demands for information and promotes internal communication.

2.4.5 Remote Data Center

Applications formerly limited to local environments can easily take on wide-area dimensions with DS1. By employing DS1, users can extend high-speed host channels to remote locations for a wide variety of applications, including:

- Remote Database Backup
  The large capacity of DS1 allows for fast, economical backup and eliminates the need for physical transport of data to a remote location.
- Remote Printing
  With high-speed printers now capable of operating at 2,000 to 20,000 lines per minute, DS1 provides the data transmission path for large and continuous printing operations typical of government agencies, insurance companies and financial institutions.

- Remote Check Sorting
  Financial institutions are simplifying their remote check sorting operations by placing sorting devices at branch locations, then linking them to centralized data processing facilities. Digital circuits easily facilitate the speeds necessary to process 1,000 checks per second.
- Sub-second Response Time
  Optimum response time can be a reality for your organization. Simply bypass the front-end processor and connect your terminals directly to a Qwest DS1 circuit.

2.4.6 Inter-PBX Voice Communications

By using DS1 and the appropriate interface equipment at each end of the circuit, a firm can interconnect two locations with 24-channel capacity for voice and data communications. The service handles inter-PBX voice traffic efficiently, allows for transfer of calls from outside the system, yields substantial cost savings and offers digital data transport capability for digital PBX's.

2.4.7 Integrated Voice/Data

In the past, high bandwidth channels have most often been reserved for linking major processing nodes, since there's rarely been great enough demand for the full DS1 bandwidth at remote end user locations.

Major data processing operations are replacing low-speed multiplexer "tail" circuits with small DS1 tail circuit rings linked to a larger DS1 backbone. This configuration delivers integrated voice and data services to multiple locations. Costs are lower, performance is higher and there is ample bandwidth in reserve for future needs. This makes efficient use of DS1 circuits by offering dynamic bandwidth allocation and automatic rerouting capabilities.

2.4.8 CAD-CAD

DS1 Services are tailor-made for high-speed file transfer. Computer Aided Design (CAD) to CAD transfer, previously expensive because of the bandwidth required, is becoming a standard network tool, thanks to the capacity and economy of Qwest DS1. Computer aided designs are finding their way onto Local Area Networks in increasing numbers. Wide area networks also are becoming a factor, allowing geographically distributed CAD workstations to share drawings more interactively than ever before via digital circuits.

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3. DS1 Characteristics

This chapter explains some of the characteristics of DS1 multiplexing and transmission that should be considered when planning the use of a DS1 service. The section is only for information to assist in selecting from many options available; it contains no interface requirements.

DS1 channel interface options include a choice of a *frame format* and *line code* of the digital signal. Each of these has service quality implications. Terminal equipment at both ends of a DS1 channel must use the same line code and must use compatible frame formats. Vendors of End-user customer equipment will usually include recommendations, with their equipment, the interface characteristics to be ordered from the telephone company. The vendors' option list will be based on the features available in their equipment. Not all terminal equipment or *Network Channel Terminating Equipment* (NCTE) has equal capabilities so some options should be considered before equipment is selected.

3.1 Frame Formats

All DS1 frame formats include a repeated reference-sequence of bits (frame-bits) that enclose transmitted user data, providing the ability for receivers of the signal to identify byte and frame boundaries for demultiplexing the data. Some frame formats not only provide this elementary synchronizing function, but they also provide optional enhancements that greatly improve the ability of customer and/or their Carrier(s) to monitor the quality of the signal being transported. Frame formats and their advantages and disadvantages are discussed below.

3.1.1 Superframe (SF)

The *Superframe* frame format is also known as *D4* framing. One Superframe consists of 12 DS1 frames. The SF *frame pattern* is 12 bits in length, and one bit of the pattern is transmitted sequentially as the 1st bit of each DS1 frame. Performance monitoring of a SF framed DS1 signal is limited to:

- Observing whether the monitoring equipment is synchronized to the received signal
- Observing whether, in the received frame pattern, any frame-bits fail to agree with the reference sequence, indicating a frame-bit has been changed in value during transmission
- Observing whether a line code error has occurred. Line codes are discussed later in this chapter
- Qwest will continue to support customers who use the SF format, and has only the limited ability to measure performance of a SF framed DS1.

3.1.2 Extended Superframe (ESF) - General

There are multiple versions of the *extended Superframe* frame format. In all versions, the extended Superframe is 24 DS1 frames in length, and the ESF frame pattern is only 6 bits in length. Since there is one "frame-bit" per DS1 frame, it leaves 18 bits per ESF frame for other purposes, enabling a potential for enhanced performance monitoring.

In all ESF versions, the 18 bits per ESF frame that are not needed to synchronize the equipment, are time-shared (time division multiplexed or TDM) to provide:

- A channel for the transmission of a CRC-6 (6 bit Cyclic Redundancy Check) value, and
- A 4 kbit/s data link

The CRC value, (the remainder of a polynomial calculated from the binary values of the transmitted data) is transmitted by the transmitting terminal, in the CRC-6 channel. The receiving terminal and monitoring units in Central Offices calculate CRC-6 from the received data and compare it to the CRC-6 value that is received through the CRC-6 channel. A Failure in matching the two values indicates error in the data of the preceding extended Superframe.

Performance monitoring using any ESF version to frame a DS1 signal, includes:

- Observing whether the monitoring equipment is byte and frame synchronized to the received signal
- Observing whether, in the received frame pattern, any frame-bits fail to agree with the reference sequence, indicating a frame-bit has been changed in value during transmission
- Observing whether a line code error has occurred. Line codes are discussed later in this chapter, and
- Use of the CRC-6 to detect errors in the End-user data

Enhancements based on the use of the 4 kbit/s data link differentiate the several versions of ESF.

3.1.3 Earliest Version of ESF

Initially, the ESF data link was used only to transmit failure messages (yellow alarm) to the distant terminal. This version of ESF is still in wide use. Use of the CRC-6 permits determination of signal quality <u>at the monitoring locations</u>, but no network management information is transmitted on the data link.

3.1.4 Later Versions of ESF

In the early 1980's, a version of ESF was developed wherein End-user NCTE (typically the Channel Service Unit) analyzes the received signal, and stores the performance information in memory. One or more times each 24 hours, the End-user's long-distance Carrier sends a polling message in the ESF data link to the NCTE, and the NCTE responds by transmitting its stored data on the data link to the Carrier for analysis. This method has been adapted for use by many InterExchange Carriers.

This version has advantages over the earlier version of providing after-the-fact knowledge of how the signal was received at the End-user premises.

Qwest performance monitoring equipment will disregard the vendor proprietary poll and respond messages if they do not conflict with standard messages. Qwest transmission and performance monitoring equipment will not interfere with the transmission of proprietary messages on the ESF data link.

3.1.5 ANSI ESF

In 1989, the telecommunications industry completed defining, and then approved under the auspices of the American National Standards Institute (ANSI) through Telecommunications Committee T1, a new version of ESF called *ANSI ESF*.

In the ANSI Standard for DS1, the ESF data link, in addition to being used for alarm transmission, is used for the transmission of a once per second *Performance Report Message* (PRM) generated by the DS1 terminals or NCTE.

ESF performance monitoring equipment being deployed within Qwest, includes the processes listed previously for all versions of ESF, and it also reads the once per second PRM and compares the performance with objective thresholds. If the thresholds are exceeded, maintenance personnel are alerted. Early and late versions of ESF equipment may be intermixed, but any network management capability of the more intelligent terminal may be negated.

Some newer End-user NCTE is designed for dual version conformity: It will generate the Performance Report Message of the ANSI ESF format, and it also responds to proprietary polling messages on the ESF data link, as described above.

3.1.6 Network Performance Report Message (NPRM)

PRMs are normally transmitted by DS1 path terminations and inserted in the data link at generating points of the ESF frame structure presenting a view of the received DS1 signal as "seen" by the path terminating Network Element (NE).

Network Performance Report Message (NPRM) information may also be written into the ESF data link in order to further sectionalize trouble conditions along the DS1 path. When provided by Qwest, NPRM may then be used to determine whether errors in the DS1 path originate within the Qwest network or customer side of the Network Interface (NI).

NPRM is an ANSI ESF option, where available at End User premises locations and requires placement of specific DS1 terminating equipment with appropriate facilities in the Qwest local network. A customer may request NPRM via the NCI codes listed in Chapter 4 and Qwest will determine if the capability can be provided (or not).

See ANSI T1.403-1999, *Network and Customer Installation Interfaces – DS1 Electrical Interface* for further information on the application and format of NPRM messages.

3.1.7 T1DM

T1DM framing is in wide use by multiplexers that process <u>only</u> digital data channels. T1DM was designed before ESF, and the first bit of each DS1 frame uses the same pattern as SF (D4). Consequently, the Network Channel Interface (NCI) Code for T1DM is the same code used for SF. It is its Network Channel (NC) Code that distinguishes the T1DM format from the SF format. See Qwest Service Publication 77200, *Qwest DS1 Service and Qwest DS1 Rate Synchronization Service – Network Channel and Network Channel Interface Code Combinations* for the code combinations to order T1DM.

The unique property of the T1DM format is that channel 24 does not contain user data, but is used for the following:

- bits 1 through 5 and bit 8, transmit a 6-bit frame pattern (called the T1 frame pattern) to speed-up loss-of-frame recovery. SF and ESF reframe in 50 milliseconds or less, but T1DM can reframe in as little as 125 microseconds.
- bit 6 transmits yellow alarm. In this manner, yellow alarm is transmitted in the time of only 1 DS1 frame, permitting a rapid switch to a DS1 protection channel if one is available.

The T1DM framed multiplexer multiplexes and demultiplexes 23 DS0-A and/or DS0-B signals to and from a DS1. DS0-B signals require additional multiplexing, such as Subrate Data Multiplexing (SRDM).

3.1.8 Free Framing

Free framing is also known as *unframed*. This denotes a 1.544 Mbit/s signal that uses a proprietary frame format and signal structure, or the format is encrypted (scrambled) so it is not discernible. Monitoring of the signal is limited to observing whether a line code violation has occurred. Performance monitoring is not available with an unframed signal.

3.2 Other Frame Format Considerations - Alarms

DS1 equipment terminals send alarm information between each other. When SF framing is used customer data can mimic alarm signals and cause short-term, difficult to locate, interruptions to service. The two alarms are:

- Alarm Indication Signal (AIS) is transmitted to denote a failure of the local multiplexer or other terminal equipment. In Superframe, the signal is typically an unframed all-ones signal at the 1.544 Mbit/s rate, but the signal can also be framed, all-ones.
- Yellow Alarm is transmitted to denote failure of the received DS1 signal. In SF, the signal is sent by setting bit 2 in each of the 24 channel time-slots, to zero for one second.

Receipt of either of the two alarms will cause the receiving equipment to terminate all calls in progress. This is a normal process for an abnormal condition.

When DS1's are carrying digitally encoded analog signals, it is exceedingly unlikely that the signal will ever mimic an alarm signal to a receiver. However, when digital data is being transported the possibility of mimicking Yellow Alarm increases, particularly when *mark-inversion* data coding is used. In mark-inversion, a binary zero is transmitted as a mark and a binary 1 is transmitted as a space, to improve 1's density of the DS1 signal.

All versions of ESF avert this problem by transmitting AIS and Yellow alarms in the ESF data link and T1DM uses a bit in time-slot 24.

Because SF terminal equipment generates and responds to alarm messages transmitted within the bandwidth normally occupied by customer data, SF is not a preferred frame format to use if there are DS1 Clear Channel requirements.

3.3 DS1 Clear Channel and Line Codes

DS1 transmission has requirements on the minimum number of binary zeros that should be consecutively transmitted. This is commonly expressed as the inverse, which is *ones density*. When ones density is permitted to become too low, recovery of the DS1 signal by receivers becomes more difficult. Jitter increases and bit errors will result. Simultaneously, network equipment may respond by generating alarms, alerting maintenance personnel of a service problem. Low ones density in any portion of the DS1 signal will affect all the channels in the DS1.

The multiplexer design maintains a suitable level of 1's density when digitally encoded voice-band signals or conventional Digital Data signals up to and including 56 kbit/s, are being transported. In each data byte, there will always be at least one binary 1. For transmission of these signals, the *Alternate Mark Inversion* (AMI) line code is suitable.

It is advisable to use a DS1 Clear Channel option in the following to assure a suitable level of 1's density:

- 64 kbit/s digital data
- Aggregations of 64 kbit/s for video transmission (384 kbit/s, 768 kbit/s, etc.)
- Aggregations of 64 kbit/s for Nx64 bandwidths of digital data where N= 2 to 24.

3.3.1 Alternate Mark Inversion (AMI) Line Code

Bipolar *Alternate Mark Inversion* is a line code algorithm wherein alternate binary 1's (called marks) are transmitted with opposite polarity and binary 0's are transmitted as absence of a pulse during a unit interval of the bit-rate. This is not the same as mark-inversion discussed previously.

3.3.2 DS1 Clear Channel - B8ZS

DS1 Clear Channel (DS1 CC) or DS1 Clear Channel Capability denotes that a 1's density management process is active in the terminal and transmission equipment so user data can contain any number of consecutive binary 0's.

The conventional means of providing DS1 CC is the use of B8ZS (binary 8 zero substitution) line code.

3.3.3 Binary 8 Zero Substitution (B8ZS) line code

B8ZS modifies the AMI line code algorithm by replacing all occurrences of eight consecutive binary zeros with a standard code word containing high 1's density. Receiving equipment replaces the code word with eight zeros. The B8ZS code word is transmitted in a manner such that it cannot be mimicked by customer data. In other documents, B8ZS may be called <u>Bipolar</u> 8 Zero Substitution.

3.4 DS1-to-Voice and Data Multiplexing - Where did all the bits go?

It is often difficult to perceive the relationships between voice channels and digital data channels, to the DS1 signal, and the twenty-four 64 kbit/s channels that it transports. The following attempts to explain it.

3.4.1 DS1 Framing by the Multiplexer

The DS1 frame pattern uses 8 kbit/s of the 1.544 Mbit/s rate, leaving 1.536 Mbit/s for signals to be transported within the framing envelope. Channelized DS1 multiplexes 24 *time-slots* of 64 kbit/s each to achieve the 1.536 Mbit/s 'payload'. The time-slot may be used as channels to transport a voice or data signal, or as shown for the T1DM format, it may transmit special information associated with transporting the remainder of the time-slots.

3.4.2 Voice Channels

Besides transporting voiceband signals, many multiplexers must also transport the supervision status of voiceband channels: Is a channel (circuit) *on-hook* or *off-hook*? *Robbed-bit signaling* is used to transmit the this information as follows:

In 5/6ths of the DS1 frames, voiceband signals are digitally encoded to 64 kbit/s (8 bits per frame), and no signaling status is transmitted. In 1/6th of the DS1 frames, voiceband signals are encoded to only 7 bits, and signaling status is sent on bit 8 of each channel. An all zero byte will be altered by placing a binary 1 in bit 7. This is characteristic of all voiceband channel units. This meets the DS1 AMI minimum pulse density requirements.

3.4.3 Digital Data Channels - Subrates in the DS0-A Format

Technical Publication 77312, *Qwest Digital Data Service Technical Description* is an excellent reference document for DDS formats and description.

- 2.4, 4.8, 9.6 kbit/s: These rates are bit-stuffed (replicated 20, 10, or 5 times respectively) into bit positions 2-7 of the 64 kbit/s channel. Because multiple copies of the signal are transmitted, receivers can perform some error correction, improving bit-error ratios by as much as 3 orders of magnitude. Customer Request-To-Send (RTS) is transmitted as a binary 1 in the control channel, which is bit 8. Modern designs of terminal equipment set bit 1 to binary 1. This meets the DS1 AMI minimum pulse density requirements.
- 19.2 kbit/s: The signal is replicated 2 times to permit error correction, and it includes a frame pattern in bit 1 to identify the boundaries of the 19.2 kbit/s data within the 64 kbit/s channel. Customer Request-To-Send (RTS) is transmitted as a binary 1 in the control channel, which is bit 8. This meets the DS1 AMI minimum pulse density requirements.

3.4.4 Digital Data Channels - 56 and 64 kbit/s

- 56 kbit/s: Customer data is transmitted in bits 1-7, and bit 8 is a control bit. Customer RTS is transported by setting bit 8 to a binary 1. This meets the DS1 AMI minimum pulse density requirements.
- 64 kbit/s: Customer data is transmitted in bits 1-8. RTS is contained within the customer's data protocol. Control bits are in-band. Equipment designed for this data rate does not inherently meet DS1 1's density requirements, so a DS1 Clear Channel option should be used or performance may be degraded.

3.5 Data Rate Synchronization

With one exception, it is vital that the transmission rate of a DS1 be identical in both directions. The exception is that voiceband signals may be multiplexed by simple multiplexers (not a digital switch), each using its internal clock. Failure to synchronize DS1's terminating in a digital switch on either end will result in general failure of digital switched services, higher noise levels on analog services, and voiceband data failures at 1200 baud and above.

Additionally, if there is a requirement for digital connectivity of channels derived from separate DS1's, it is vital that the data rate of each DS1 be identical.

A good source of synchronization information is ANSI EIA/TIA-594-1991, *Private Digital Network Synchronization*. Another valuable reference is ANSI T1.101 (now ATIS-0900101.2006), *Synchronization Interface Standard*. Planning of synchronization, the invisible network, is as important as planning the digital channels.

The DS1 data rate is determined by clocks contained within the terminal equipment (multiplexer) unless those clocks are synchronized in some manner. DS1 multiplexer internal clocks typically have a stability of ± 50 bits/s (Stratum 4 clock), which is not suitable for digital connectivity with another digital bit stream having a separate timing reference, regardless of its stability.

When Qwest transports a DS1 between two customer locations without providing some type of terminal multiplexing, the data-rate synchronization is controlled entirely by the customer's terminal multiplexers. Facility multiplexers, i.e., DS1 to DS3, do not retime the DS1 signal, but transport the DS1 signal asynchronously, maintaining the bit-rate as received.

When DS1-to-voice and digital data, or DS1-to-DS0 multiplexing is ordered from Qwest, the Qwest multiplexers impress system timing on the DS1 channel. Under normal conditions the data rate will be 1.544 $\pm 1 \times 10^{-11}$ Mbit/s (Stratum 1 clock).

Chapter 7 of this publication describes a synchronization service interface that may be ordered (where available), which provides a unique signal that is traceable to a Stratum 1 clock.

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4. Compatible Network Channel Interface (NCI) Codes

Electrical signal specifications at an Interface are encoded into *NCI codes*. Customers provide a *Network Channel Interface (NCI) code* to Qwest to advise the Engineer of the specific technical requirements at a Network Interface.

This chapter provides compatibility information for the DS1 NCI codes that may be used at a DS1 interface with Qwest. Not all Interfaces are available with all Qwest services. Other Technical Publications or Service Publications discuss the services that may be available using interfaces disclosed in this publication.

The definitions of NCI codes are discussed in this chapter. Technical specifications of each NCI are in the following chapter.

4.1 NCI Code Function

Optional NCI coding for DS1 interfaces provides the following:

- Frame format - several options:
  - Superframe (SF) (also used in combination with an NC code to obtain T1DM)
  - ANSI Extended Superframe (ESF)
  - Non-ANSI ESF
  - Free Framing
- Line code - two options:
  - Alternate Mark Inversion (AMI)
  - Binary 8 Zero Substitution (B8ZS)
- The interface at Carrier or End-user premises:
  - If the interface is at a Carrier premises, there are two NCI Protocol Code options: *DJ* or *DS*.
  - If the interface is at an End-user premises, the NCI Protocol Code is *DU*. There are two Protocol Option Codes: Conventional Interface or DSX-1 Interface along with the option to request the service with Network Performance Report Messaging (NPRM).

4.2 NCI Code Form and Components

4.2.1 NCI Code Form

The NCI code format has fields not used for digital services. Only those fields relevant to DS1 interfaces are discussed here. A DS1 NCI code has the form *04DU9.1KN*. The period between the 9 and 1 is a delimiter, which is used to improve clarity. It causes the *Protocol Option Code*, discussed later, to standout. An NCI code has no dashes (-).

4.2.2 NCI Code Components

A DS1 NCI Code has four components as shown in Figure 4-1:

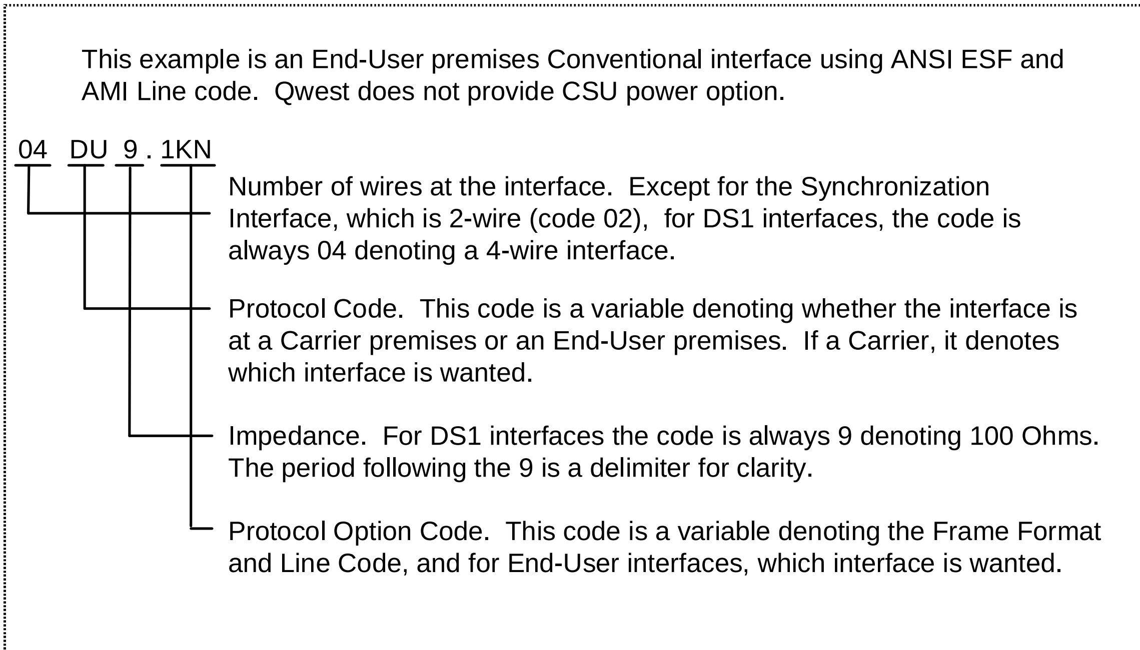

Figure 4-1: NCI Code Components

4.3 Protocol Codes - CS, DJ, DS, DU

Figure 4-2 depicts the NCI Protocol Codes that may be used at interfaces with Qwest and shows in addition to the relationship of the Protocol Code to a particular premise.

Protocol Code *DU* denotes the interface between Qwest and End-user equipment at an End-user premise. It is commonly called an *Access Interface*. Protocol Option codes, discussed later, provide two interface options: a *Conventional Interface* and a *DSX-1 Interface*.

Protocol Codes *CS* and *DS* provide a signal that conforms to DSX-1, which is part of the North American digital hierarchy for the cross-connect of digital signals. The interfaces are used at Carrier premises. Technically, *CS* and *DS* are identical, but *CS* further denotes that the channel terminates on a Qwest Digital Cross-connect System (DCS).

Protocol Code *DJ* (Design Jointly) also denotes an interface at a Carrier premises. The signal parameters are subject to negotiation between the Qwest Engineer and the customer. *DJ* is not supported nationally by ANSI Standards, but it meets the needs of many Carrier applications. Other protocol codes, 'QB' and 'QE' may be used only by Competitive Local Exchange Carriers (CLECs) at specific locations. These codes are discussed in appropriate technical publications for CLEC applications.

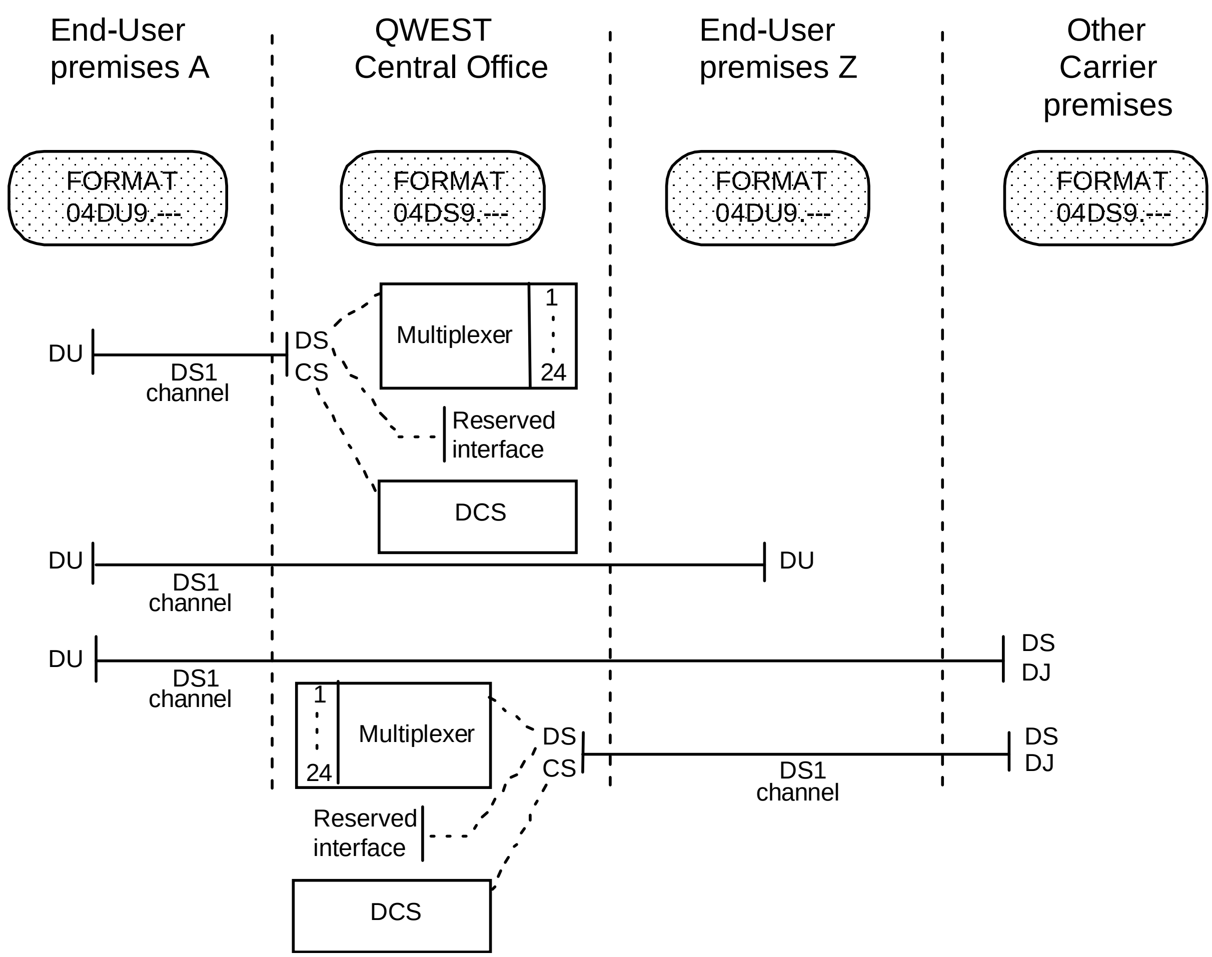

Figure 4-2: NCI Protocol Codes used by Qwest and their Application

4.4 Protocol Option Codes - Master list

DS1 terminal equipment varies in its frame format and line code capability, so not every Protocol Option code is available for every service. Table 4-1 lists the Protocol Option codes that may be used with Qwest DS1 channels. Additionally, the table provides the Option Code suffix for selection of the End-user premises Conventional and DSX-1 interfaces.

Table 4-1: DS1 Protocol *Option Codes*

Permissible End-user premises interface, Protocol Option Codes		Permissible Carrier premises interface, Protocol Option Codes	
Code	**Meaning**	**Code**	**Meaning**
AN AX	Free Framing with B8ZS / Conventional interface / CSU power = no Free Framing with B8ZS / DSX-1 interface	15J	Free Framing / B8ZS
BN BX	SF / AMI / Conventional interface / CSU power = no SF / AMI / DSX-1 interface	15	SF / AMI
CN CX	non-ANSI ESF / AMI / Conventional interface / CSU power = no non-ANSI ESF / AMI / DSX-1 interface	15K	non-ANSI ESF / AMI
DN DX	SF / B8ZS / Conventional interface /CSU power = no SF with B8ZS / DSX-1 interface	15B	SF / B8ZS
SN SX	non-ANSI ESF / B8ZS / Conventional interface/ CSU power = no non-ANSI ESF / B8ZS / DSX-1 interface	15S	non-ANSI ESF / B8ZS
1KN 1KP 1KX 1XP	ANSI ESF / AMI / Conventional interface / CSU power = no ANSI ESF / AMI / Conventional interface / NPRM / CSU power = no ANSI ESF / AMI / DSX-1 interface ANSI ESF / AMI / DSX-1 interface / NPRM	1K	ANSI ESF / AMI
1SN 1NP 1SX 1SP	ANSI ESF / B8ZS / Conventional interface / CSU power = no ANSI ESF / B8ZS / Conventional interface / NPRM / CSU power = no ANSI ESF / B8ZS / DSX-1 interface ANSI ESF / B8ZS / DSX-1 interface / NPRM	1S	ANSI ESF / B8ZS

AMI Bipolar Alternate Mark Inversion line code: See ANSI T1.102, *Digital Hierarchy – Electrical Interfaces* or ANSI T1.403-1999, *Network and Customer Installation Interfaces – DS1 Electrical Interface*

B8ZS Binary, 8 Zero Substitution line code: See ANSI T1.102 or ANSI T1.403

ESF Extended Superframe format:
ANSI ESF – Frame format only: See ANSI T1.403
Non-ANSI ESF – Frame format only: See AT&T Technical Reference 54016, *Requirements for Interfacing Digital Terminal Equipment to Services Employing the Extended Superframe Format* and similar proprietary documents

SF Superframe format – Frame format only: See Telcordia GR-54-CORE, *DS1 High-Capacity Digital Service End User Metallic Interface Specifications*

4.5 Complete NCI Codes - Master list

Table 4-2 lists the NCI codes that may be used with Qwest DS1 channels. Additionally, it is a compatibility chart relating each code to each other, to a plain language description, and to a location.

Table 4-2: NCI Codes - Compatible Interface Combinations

Definition of Network Channel Interface Code and Protocol Option Code	Qwest CO premises Options	Other Carrier premises Options	End-user premises Options
Free Framing Line code = B8ZS	04DS9.15J	04DJ9.15J 04DS9.15J	04DU9.AN 04DU9.AX
Frame Format = Superframe (SF) Line code = Alternate Mark Inversion (AMI)	04CS9.15 04DS9.15	02DJ9.15*** 04DJ9.15 04DS9.15	02DU9.BN*** 04DU9.BN 04DU9.BX
Frame Format = Superframe (SF) Line code = Binary, 8 Zero Substitution (B8ZS)	04CS9.15B 04DS9.15B	04DJ9.15B 04DS9.15B	04DU9.DN 04DU9.DX
Frame Format = non-ANSI Extended Superframe (ESF) Line code = Alternate Mark Inversion (AMI)	04CS9.15K 04DS9.15K	04DJ9.15K 04DS9.15K	04DU9.CN 04DU9.CX
Frame Format = non-ANSI Extended Superframe (ESF) Line code = Binary, 8 Zero Substitution (B8ZS)	04CS9.15S 04DS9.15S	04DJ9.15S 04DS9.15S	04DU9.SN 04DU9.SX
Frame Format = ANSI Extended Superframe (ESF) Line code = Alternate Mark Inversion (AMI)	04CS9.1K 04DS9.1K	04DJ9.1K 04DS9.1K	04DU9.1KN 04DU9.1KP 04DU9.1KX 04DU9.1XP
Frame Format = ANSI Extended Superframe (ESF) Line code = Binary, 8 Zero Substitution (B8ZS)	04CS9.1S 04DS9.1S	04DJ9.1S 04DS9.1S	04DU9.1SN 04DU9.1NP 04DU9.1SX 04DU9.1SP

EACH CODE IS COMPATIBLE WITH ITSELF,
WITH THE OTHER CODES WITHIN THE SAME BOX,
AND WITH THE CODES IN THE OTHER BOXES IN THE SAME ROW

Note: *** 02DU9.BN and 02DJ9.15 are used only for the Synchronization interface.

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5. End-User Premises Network Interfaces: Fundamental Options & Limitations

This chapter defines the physical and electrical parameters to be met at the Network Interface (NI) by both Qwest and the customer at the End-user premises.

Qwest provides two fundamentally different Network Interface options at the End-user premises. One is called the Conventional Interface, and the other is called the DSX-1 Interface. Due to technical and FCC regulatory reasons the DSX-1 Interface has a limited availability, but the Conventional Interface is ubiquitously available.

A basic limitation of the DSX-1 Interface is that it is available only where Qwest is transporting the DS1 channel on a fiber cable serving a multiplexer located on the customer premises.

The Conventional interface and the DSX-1 Interface share a number of specifications which are described in the following sections. Information specific to the two interfaces may be found in Sections 5.4 and 5.5, respectively.

5.1 DS1 Channel Delivery Methods

Unless a service option is selected that requires delivery of the DS1 channels on fiber cable, DS1 channels will be transported on whatever facilities are available at the time the order is received.

Facilities that may be available for assignment are:

- Metallic cable pairs from the local Central Office building
- Metallic cable pairs from a fiber cable served multiplexer near the customer premises.
- On-premises metallic cable pairs from a fiber cable serving a multiplexer located at the customer premises.
- A combination of the above facility types

5.2 The End-User Premises Network Channel Interface, Protocol Code

The *NCI Protocol Code* at the End-user premises is *DU*.

5.3 Common Signal Requirements at the NI - Qwest and End-User (EU) Signals

The requirements in this section apply to both the Conventional Interface and the DSX-1 Interface. Each of the two interface options has other requirements, which are outlined in following sections.

Where appropriate in this section, a distinction is made between signals being originated at two customer premises (point-to-point service), and signals resulting from Qwest Central Office (CO) terminal multiplexing, e.g., DS1-to-voice multiplexing.

In point-to-point service, most characteristics of signals are controlled by the customer's multiplexer or other terminal equipment. This includes transmission rate, line code, and frame format. If transmission rate (data rate) synchronization is required, it must be done by the customer; synchronization is inserted at the terminal multiplexer(s).

Qwest terminal multiplexer clocks are synchronized by a Primary Reference Source clock, so the DS1 transmission rate has a bit rate accuracy of $1x10^{-11}$ bit/s.

5.3.1 Transmission Rate

- Customer point-to-point service: In both directions of transmission, the transmission rate of the DS1 signal shall be in the range of 1.544 Mbit/s ± 50 bit/s.
- When service includes Qwest terminal multiplexing: In both directions of transmission, the transmission rate of the DS1 signal shall be 1.544 Mbit/s ± $1x10^{-11}$ bit/s. Customers may achieve the required data rate accuracy by one of two common means.
- Loop time their terminal, using received timing to control the transmitter timing.
- Time the terminal from another digital signal source traceable to the same or another Primary Reference Frequency.

5.3.2 Line Code

- The line code shall be bipolar Alternate Mark Inversion (AMI), except where intentional bipolar violations are introduced by B8ZS.
- Additionally, the line code shall be one of those offered for the specific service for which the DS1 channel will be used (may be specified in other Qwest service related Technical Publications or Service Publications, e.g., Digital Switched Services℠ (DSS), Command A Link℠, etc.).

5.3.3 Frame Format

- The frame format shall be one of those listed in Chapter 4.
- Additionally, the frame format shall be one of those offered for the specific service for which the DS1 channel will be used (may be specified in other Qwest service related Technical Publications or Service Publications, e.g., DSS, Command A Link℠, etc.).

5.3.4 Impedance

- Impedances at the NI shall be nominally 100 Ohms.
- A termination of 100 Ohms ± 5% resistance shall be used for the evaluation of signal characteristics.

5.3.5 Test Frequency

- When evaluating attenuation characteristics of a metallic facility, a frequency of 772 kHz shall be used.

5.3.6 Pulse Imbalance

It is not necessary to verify that the following requirement is met unless an otherwise unexplained high bit-error rate exists.

- While observing the unattenuated signal in any window of 17 consecutive bits, the maximum variation in pulse amplitudes shall be less than 200 mV, and the maximum variation in pulse widths (half amplitude) shall be less than 20 ns. This unattenuated signal is later described in paragraphs 5.4.3.1 and 5.4.3.2.

5.3.7 60 Hz Variations in Pulse Amplitude

Signal pulse amplitude may vary at a 60 Hz rate from the presence of 60 Hz longitudinal currents in the powering loops of line regenerators, whether they are in Qwest or customer owned cable. It is not necessary to verify that the following requirement is met unless an otherwise unexplained high bit-error rate exists.

- While observing the unattenuated signal at the regenerator nearest the NI, the 60 Hz modulation of the DS1 signal shall not exceed 0.5v. This unattenuated signal is later described in paragraphs 5.4.3.1 and 5.4.3.2,

5.3.8 Jitter and Wander

Network and customer signal Jitter and Wander shall conform to the requirements of ANSI T1.403-1999, *Network and Customer Installation Interfaces – DS1 Electrical Interface*.

5.4 Conventional Interface Requirements

A simplified diagram of an arrangement using the Conventional Interface is shown in Figure 5-1 on page 5-11.

The following requirements apply in addition to the requirements of Section 5.3

5.4.1 Physical Network Interface

The physical NI for this interface option is a Registration Jack. Please refer to T1E1 Technical Report No. 5, *Network and Customer Installation Interface Connector Wiring Configuration Catalog* for more information.

5.4.1.1 Specifying the Network Interface Connector

The customer must specify to Qwest at the time a DS1 channel is ordered, the physical NI connector they want Qwest to provide. These connectors are generically known as Registration Jacks, thus the RJ prefix. Besides being the Registration Jack placed on Public Notice by the Federal Communication Commission, they are also the Universal Service Order Code (USOC) used for ordering the connector from Qwest. The customer NI options are:

- RJ48C For the interconnection to one DS1 channel
- RJ48H For the interconnection to as many as 12 DS1 channels
- RJ48MFor the interconnection to as many as 8 DS1 channels

Other non-Qwest documents may list a RJ48X connector. The RJ48X is not offered by Qwest because its use can cause cross talk into other DS1 channels. For this technical reason, if an RJ48X jack is inadvertently ordered, Qwest will substitute a RJ48C for it. Wiring of the transmission paths of the two jacks is identical.

Registration Jack wiring configurations and examples of their application are shown in Figures 5-2 for the RJ48C, Figure 5-3 for the RJ48H, and Figure 5-4 for the RJ48M on pages 5-12 to 5-14.

5.4.1.2 Specifying the *Channel Position* Assignment within a NI Connector

When the RJ48M or RJ48H connector is ordered, the customer must advise Qwest, for each DS1 channel ordered, which channel to wire to what position (1 to 8 or 12 respectively) of the connector. Figures 5-3 and 5-4 list the positions within the connectors.

5.4.1.3 Specifying the NI *Connector Number* in a Large Installation

In an installation where there are multiple RJ48H or M connectors, the connectors will be consecutively numbered at the time of their installation, beginning with number 1 *for each connector type*. In this multiple connector environment the customer must also provide the connector number: Typical information provided by the customer might be to "put the first circuit of this order on RJ48H connector number 3, position 7; put circuit 2 on connector 3, position 8; put circuit 3 on connector 4, position 1."

5.4.2 Powering and Sealing Current Arrangements

5.4.2.1 Power to the Channel Service Unit

Effective October 26, 1995, a Channel Service Unit (CSU) must be powered by a customer provided source. Frequently, the customer provided source will be a small wall-mounted transformer.

5.4.2.2 Obsolete CSU Information

Some older, installed CSUs require 140 mA for operation and may have received dc current from Qwest if this feature was purchased prior to October 26, 1995. The customer may continue to receive it under the following conditions:

- The CSUs must remain at the premises at which they are now receiving network dc current.
- If Qwest moves the DS1 channel from cable transport to a multiplexer, advance notice will be provided so arrangements can be made for customer provided power. However, if the customer elects to move the service to different premises, the customer shall not keep the CSU power feature.

When the older installed equipment is used, the simplex current shall be nominally 140 mA. The algebraic difference between the simplex voltages of two polarities may exceed 150 volts.

Note: The customer is cautioned that their technicians should be trained to anticipate this voltage magnitude at the NI. Qwest advises conversion to local power or replacement of the equipment.

5.4.2.3 Sealing Current Considerations

In telecommunications jargon, a *Dry* cable section is one that does not have a dc current flowing through it. Depending on the types of splices used to connect wires between lengths of cable, oxides that develop on exposed wires can cause the junction between the wires to form a high-resistance. This high-resistance may cause the transmission path to deteriorate.

When dc current flows in the conductors, it breaks down the oxides at the junction of the two wires *sealing* them to maintain the intended low-resistance path, assuring proper signal transmission. The dc current Qwest uses to power its line regenerators also seals the cable pair splices.

Customers should consider the *dry vs. sealed* aspects of their cables and equipment. CSU equipment manufacturers and vendors should be able to provide detailed information about sealing current methods. Figure 5-5 on page 5-15 is a simplified sketch showing a sealing current configuration.

5.4.2.4 Qwest Participation When the Customer Provides Sealing Current

The Qwest provided DS1 Connector, when provided, will connect the customer's transmit simplex to the customer receive simplex to provide a return path for the customer provided sealing current if sealing voltage is applied.

5.4.2.5 Customer Provided Sealing Current Magnitude Recommendation and Requirement

It is recommended that sealing current be limited to 20 mA. Sealing current shall not exceed 60 mA.

5.4.3 Digital Signal Requirements - Pulse Shape, Amplitude, and Attenuation

5.4.3.1 Signal from Qwest to Customer

- At the point of origin or regeneration, binary 1 pulses shall nominally meet the requirements of DSX-1 and have a peak-to-base amplitude between 2.25 and 3.6 volts. Power in a 2 to 3 kHz band centered at 1.544 kHz shall be at least 25 dB less than the power in a 2 to 3 kHz band centered at 772 kHz.
- The signal will then be transported to the NI by a cable having attenuation in the range of 0 to 16.5 dB.

5.4.3.2 Signal from Customer to Qwest

Customers shall meet the following requirements by using a Channel Service Unit (CSU), a class of digital Network Channel Terminating Equipment (NCTE), registered as complying with the requirements of Part 68 of the FCC rules and regulations, Code of Federal Regulations Title 47. CSUs are designed to meet the standard interface requirements given below and the requirements of the customer's terminal equipment that is connected to the CSU.

1. With the CSU transmit Line Build-Out (LBO) set to zero attenuation (Position A), binary 1 pulses shall nominally meet the requirements of DSX-1 and have a peak-to-base amplitude between 2.4 and 3.6 volts. Power in a 2 to 3 kHz band centered at 1.544 kHz shall be at least 25 dB less than the power in a 2 to 3 kHz band centered at 772 kHz.
2. The customer signal should then be transported to the NI by a connecting cord and/or cable pair with a loss in the range of 0.0 to 5.5 dB. A 5.5 dB attenuation allocation for customer cable and wire is always available. Whatever part of Qwest's 16.5 dB allocation is not used may be used by the customer if needed in lieu of a higher value LBO.
3. Additional signal attenuation may be required. When it is required as outlined below, it may be inserted by selecting the 7.5 dB (Position B) or 15 dB (Position C) transmit Line Build-Out option in the CSU. These settings and values are standard capabilities in all CSUs.

The need for signal level control is dictated for cross-talk control in addition to the attenuation of the assigned network facility. For this reason, Qwest shall advise the customer of the required attenuation, expressed in dB.

4. The total customer attenuation (LBO, wire, cable, and connectors) shall be within ± 4.0 dB of the value specified by Qwest.

Equipment providing Line Build-Out of 7.5 dB shall be designed according to the transfer function given in Table 5-1. 15 dB may be obtained by passing the signal through an additional network of the same design.

Table 5-1: Transfer Function for 7.5 dB Line Build-Out

$$\frac{V_{out}}{V_{in}} = \frac{n_2 S^2 + n_1 S + n_0}{d_3 S^3 + d_2 S^2 + d_1 S + d_0}$$

Where:
$n_0 = 1.649 \times 10^{6}$
$n_1 = 7.9861 \times 10^{-1}$
$n_2 = 9.2404 \times 10^{-8}$
$d_0 = 2.1612 \times 10^{6}$
$d_1 = 1.7223$
$d_2 = 4.575 \times 10^{-7}$
$d_3 = 3.8307 \times 10^{-14}$
$S = j\, 2 \bullet f$
f = frequency (Hertz)

5.5 DSX-1 Interface Requirements

Technical requirements for this interface are a sub-set of the Conventional Interface requirements, i.e., when the Qwest and customer cable, and wire attenuation are both at the 0 dB end of their range, the signal characteristics are DSX-1. This is possible when the customer equipment is in close proximity to the Qwest multiplexer.

For this interface option the customer is not required to use a Channel Service Unit (CSU). Final judgment about the applicability of this interface option rests with the customer. In addition to protecting the network from harm, the CSUs also provide some assurance of compatibility between the Qwest provided DS1 channel and the customer provided terminating equipment.

Qwest believes there is little potential that customer wiring or equipment will cause harm to the network, and that if a fault should occur, harm will be limited to damage to the Qwest multiplexer's DS1 port. The remainder of the network, including its personnel, will be protected by the optical fiber serving the multiplexer. In view of this, customer NCTE (the CSU) to provide such protection will not be required.

Technical requirements given below for this interface require that the Qwest and customer signals both meet the stringent requirements of DSX-1 within a loss window equivalent to 85 feet of 22-gauge cross-connect wire. This would permit cabling to and from the DSX-1 interface of up to 655 feet of 22-gauge office cable, with an overall shield. This cable is widely known as 22 AWG ABAM.

Note: Excessive attenuation in the customer cable can cause bit-errors in either direction of transmission. If it is later determined that the customer and Qwest equipment are not compatible with this interface, it will require issuance of another service order, at the customer expense, to redesign the circuit to provide the Conventional Interface.

The following requirements apply, in addition to the requirements of Section 5.3

A simplified diagram of an arrangement using the DSX-1 Interface is shown in Figure 5-6 on page 5-16.

5.5.1 Physical Network Interface

The NI shall be the ends of metallic cable pairs or jumper wire pairs. For each DS1 channel, there shall be one 2-wire twisted pair transmitting signals from Qwest to the customer, and one 2-wire twisted pair transmitting signals from the customer to Qwest. The cable gauge shall be 22 or 24. Jumpers will be clearly tagged for transmission direction. When a large number of channels is being interconnected via a cable, a sheet of paper may be exchanged listing the assignments using the standard cable color-code, in lieu of tagged ends.

Default: Qwest will provide jumper pair or cable pair ends to the customer. The jumper or cable running length will be no longer than 85 feet from the Qwest DSX-1 measurement point.

Option: As a convenience to the customer, the customer may hand-off their cable or jumper wire ends to Qwest at the Qwest equipment, providing sufficient length to enable Qwest to terminate the wires in the Qwest equipment. If this is done, Qwest will assume ownership of that portion of the jumpers or cables that enter the Qwest equipment rack or cabinet. If this option is wanted, the customer should advise the Qwest installation personnel at the time the service is being installed.

5.5.2 Powering and Sealing Current Arrangements

DC power shall not be applied to the transmission paths exchanged at the NI.

5.5.3 Digital Signal Requirements - Pulse Shape and Amplitude

5.5.3.1 Bi-directional Signal Requirements - Pulse Shape

At the wire ends denoting the NI, which shall be within 85 feet of the Qwest DSX-1 measurement point, an isolated pulse, both positive and inverted negative, shall fit within the bounds of the maximum and minimum curves described by the corner-points given in Tables 5-2 and 5-3. When plotted to a graph or electronic instrument, these tables provide DSX-1 templates for newer and older equipment, respectively. It is preferred that equipment meets the requirement for newer equipment. An observed pulse may be scaled vertically by a constant factor, for best fit within the template.

For an example, see Figure 5-7 on page 5-17, which plots the points of Table 5-2 to show the DSX-1 template.

Table 5-2: DSX-1 Corner Points for Newer Equipment

Maximum Curve

Time Unit Intervals	-.77	-.39	-.27	-.27	-.12	0.0	.27	.35	.93	1.16
Normalized pulse amplitude	.05	.05	.8	1.15	1.15	1.05	1.05	-.07	.05	.05

Minimum Curve

Time Unit Intervals	-.77	-.23	-.23	-.15	0.0	.15	.23	.23	.46	.66	.93	1.16
Normalized pulse amplitude	-.05	-.05	.5	.95	.95	.9	.5	-.45	-.45	-.2	-.05	-.05

Table 5-3: DSX-1 Corner Points for Older Equipment

Maximum Curve

Time Unit Intervals	-.77	-.39	-.27	-.27	-.12	0.0	.27	.34	.58	1.16
Normalized pulse amplitude	.05	.05	.8	1.22	1.22	1.05	1.05	.08	.05	.05

Minimum Curve

Time Unit Intervals	-.77	-.23	-.23	-.15	-.04	.15	.23	.23	.42	.66	.93	1.16
Normalized pulse amplitude	-.05	-.05	.5	.95	.95	.9	.5	-.62	-.62	-.2	-.05	-.05

5.5.3.2 Bi-directional Signal Requirements - Pulse Amplitude

While meeting the pulse shape requirement, the amplitude of isolated pulses, both positive and inverted negative, shall be in the range of 2.4 and 3.6 volts. Power in a 2 to 3 kHz band centered at 1.544 MHz shall be at least 25 dB less than the power in a 2 to 3 kHz band centered at 772 kHz.

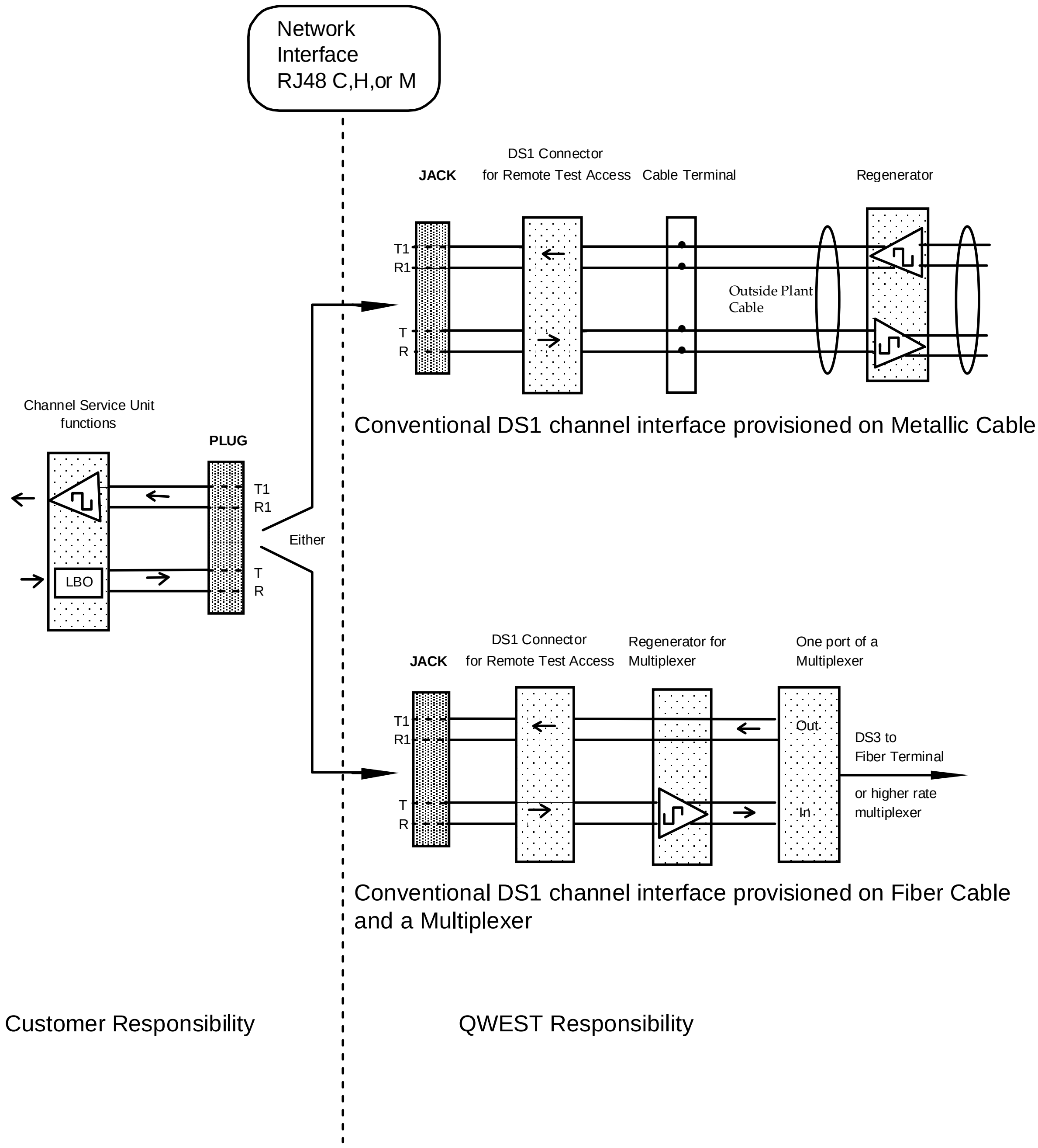
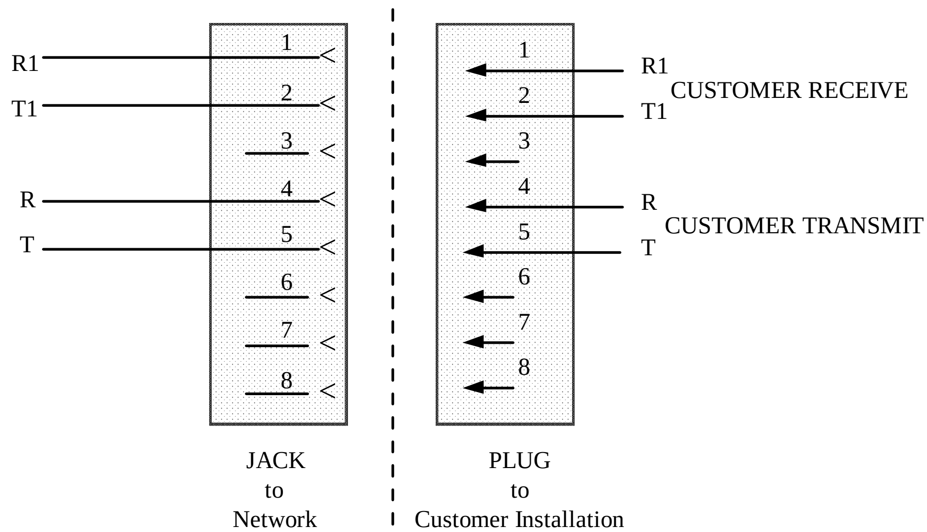


Figure 5-1: Typical Arrangement for the Conventional Network Interface

JACK TYPE: 8 PIN MINI-MODULAR **NCI CODES:** 04DU9. _ _ _

WIRING DIAGRAM:



APPLICATION:

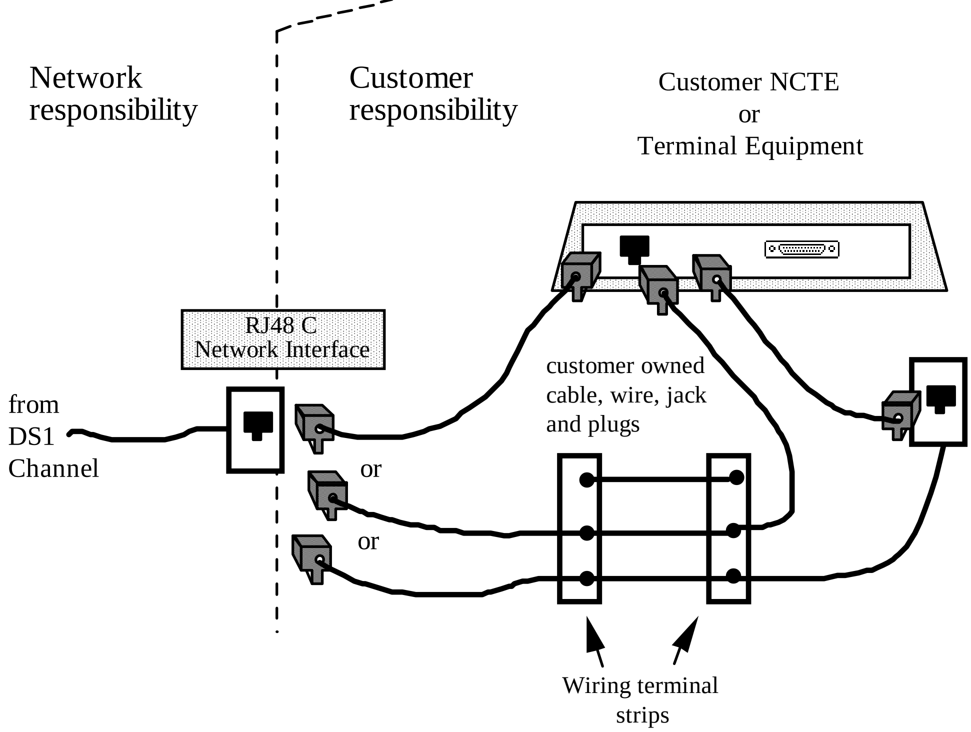
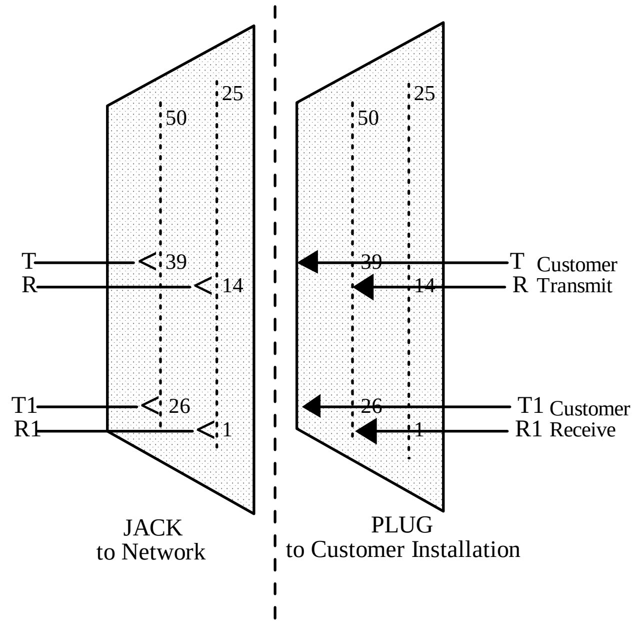


Figure 5-2: RJ48C Network Interface Wiring and Application

JACK TYPE: 50 PIN - 12 CIRCUIT CONFIGURATION **NCI CODES:** 04DU9. _ _ _

WIRING DIAGRAM:



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

APPLICATION:

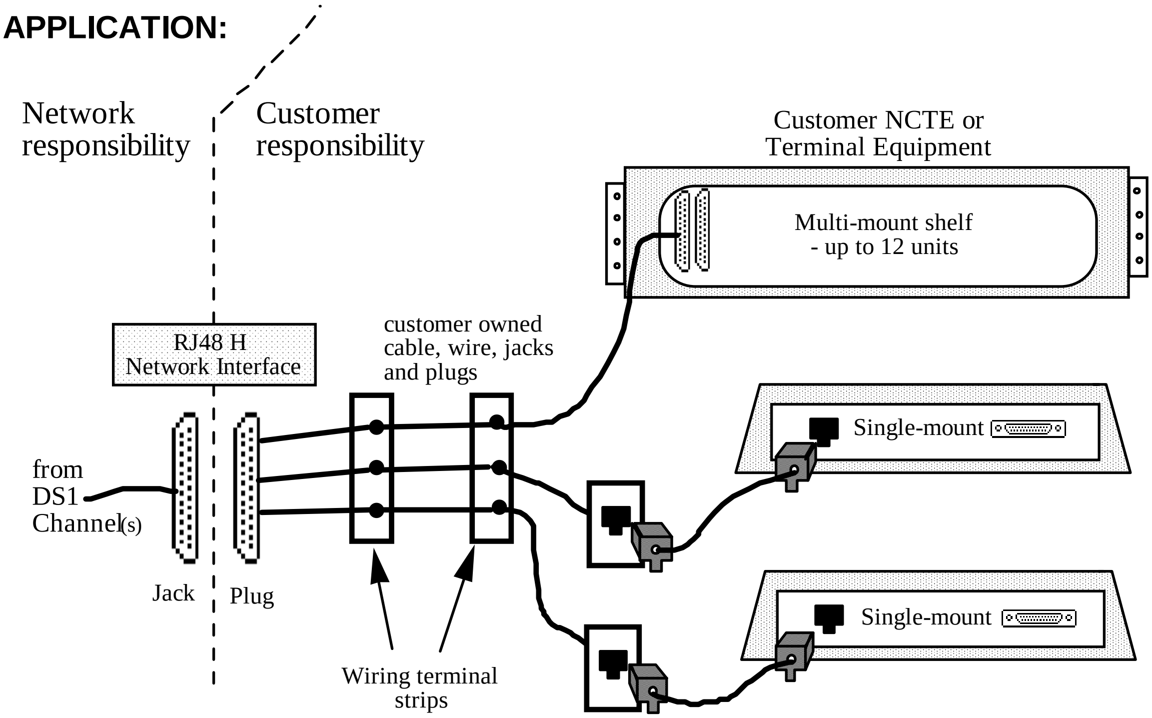
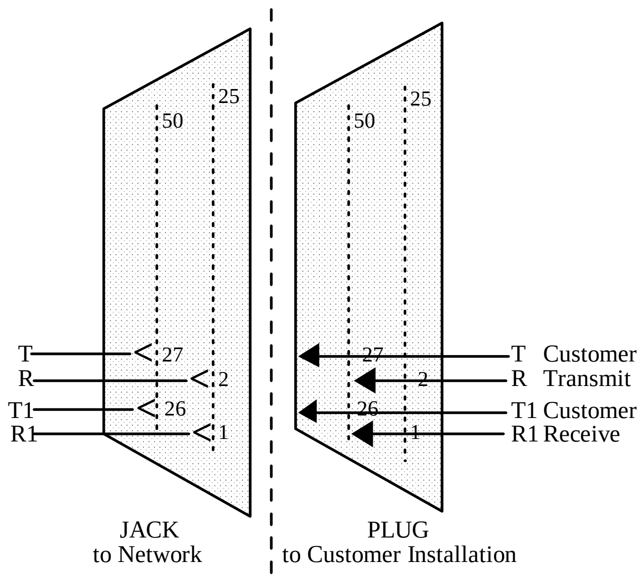


Figure 5-3: RJ48H Network Interface Wiring and Application

JACK TYPE: 50 PIN - 8 CIRCUIT CONFIGURATION **NCI CODES:** 04DU9. _ _ _

WIRING DIAGRAM:



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

APPLICATION:

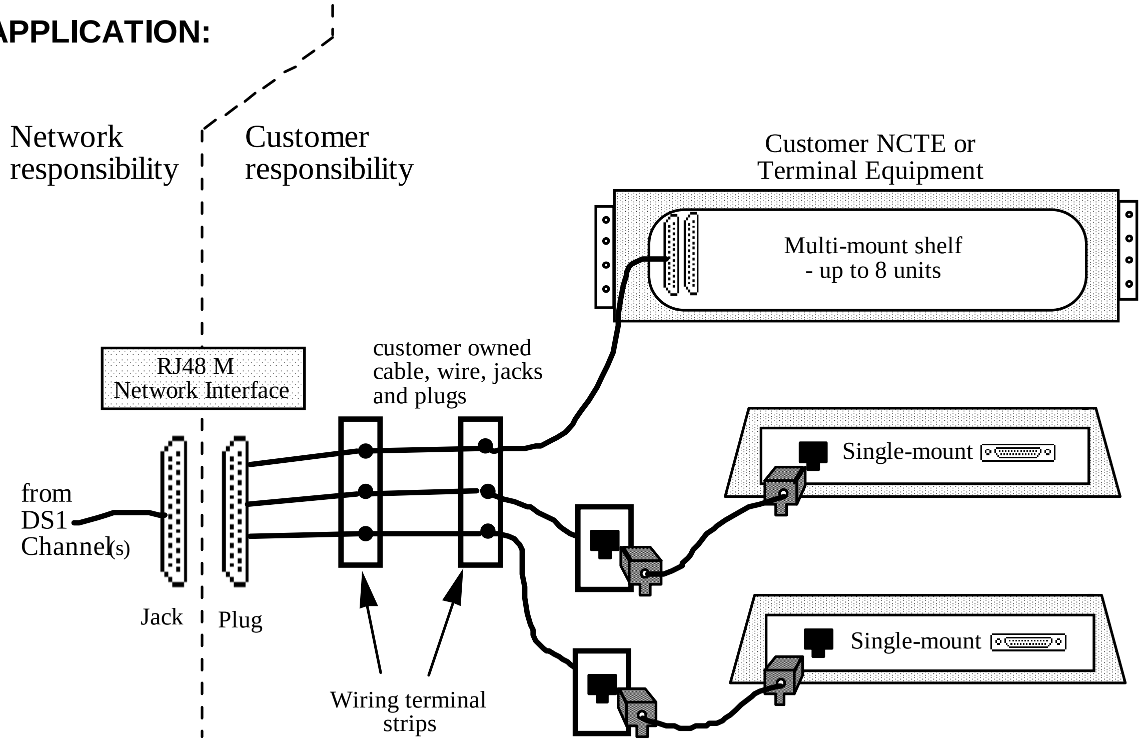
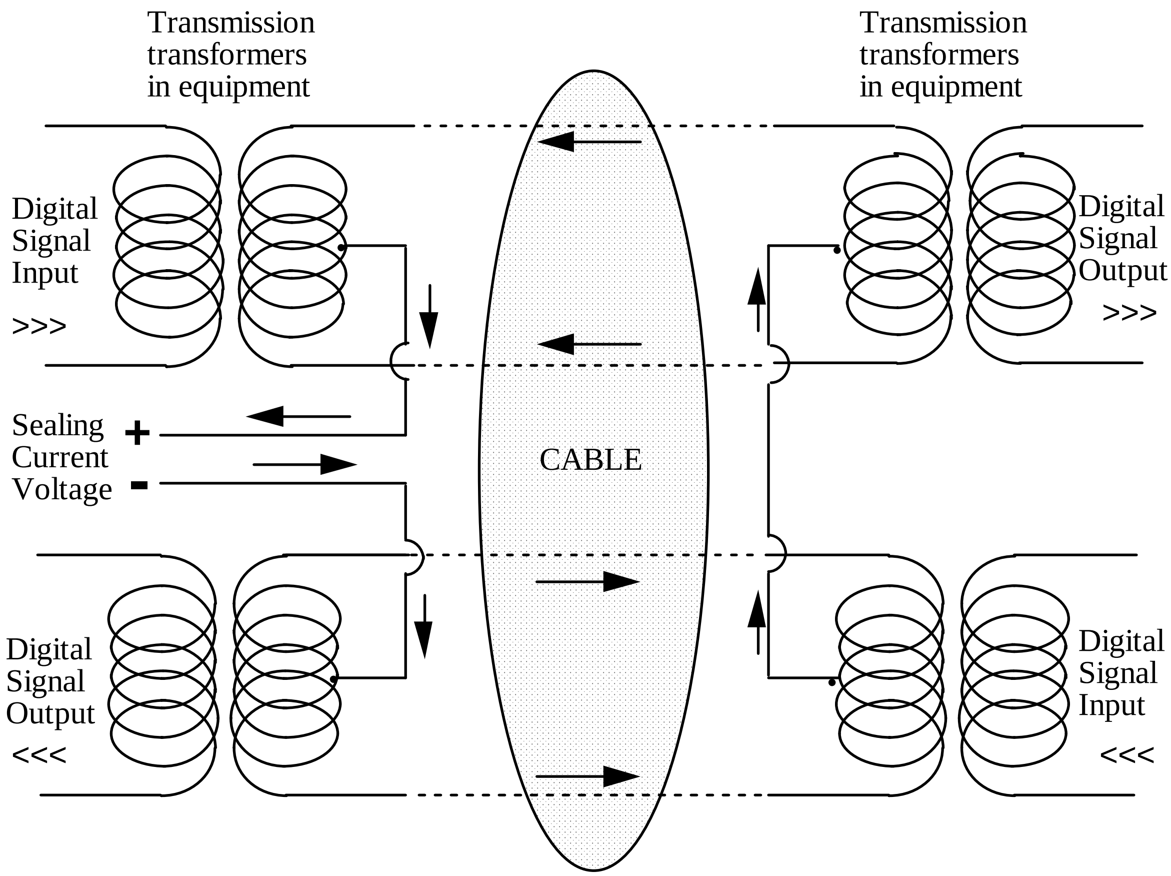


Figure 5-4: RJ48M Network Interface Wiring and Application



Note that direct current voltage to generate sealing current is applied to each cable pair longitudinally via the simplex connections of the transformers so the voltage neither adds nor subtracts to or from, the digital signal being transported transversely on the pairs.

Figure 5-5: Sealing Current Configuration Example

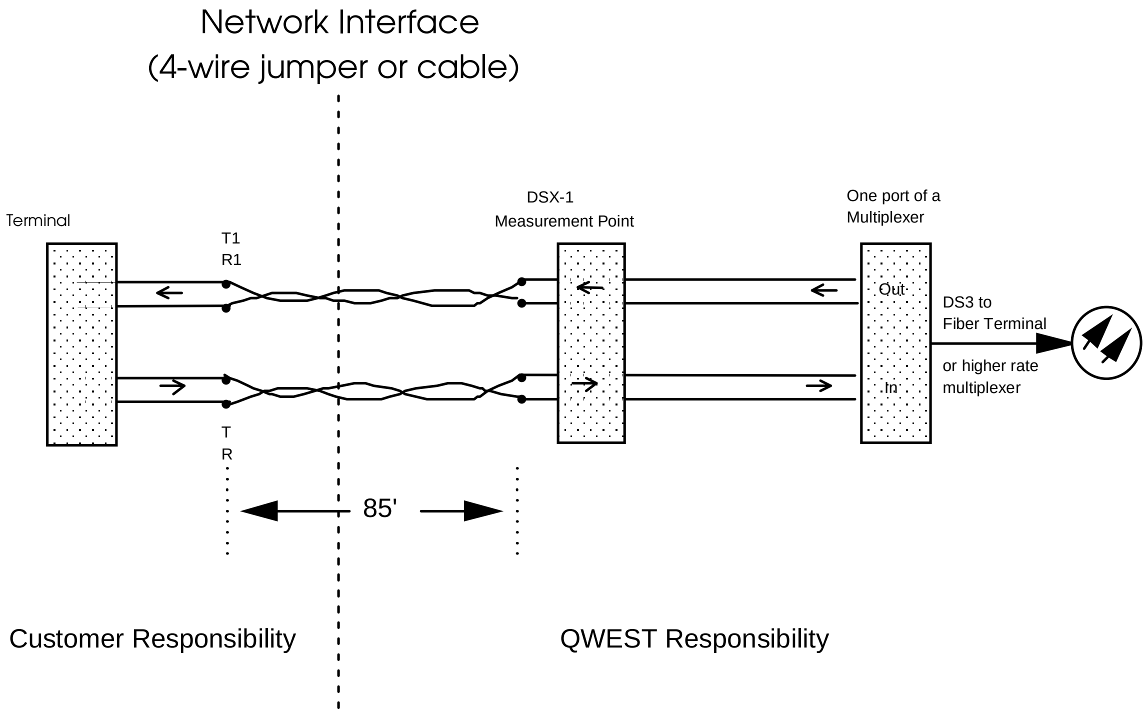


Figure 5-6: Typical Arrangement for the DSX-1 Network Interface

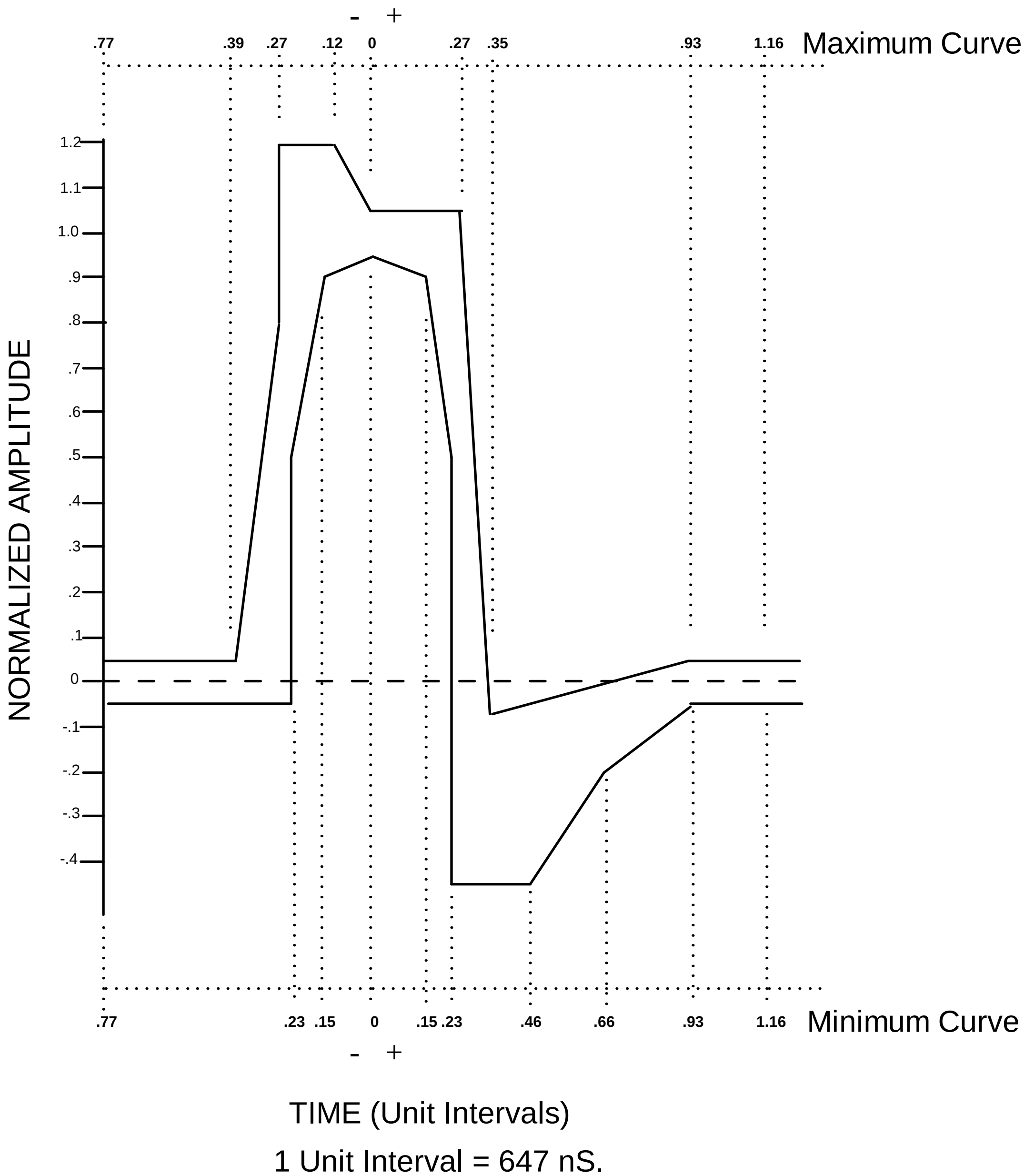


Figure 5-7: DSX-1 Template formed by plotting the points of Table 5-2 or 6-1

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Tables

6. NCI Protocol Code CS, DS and DJ Interfaces - Requirements

6.1 General

6.1.1 Terms and Descriptions

This chapter defines the physical and electrical parameters of interfaces at Carrier premises. Carrier Premises interfaces include those in Qwest Central Offices (COs) and at other Carrier Premises. For brevity, the following terms will be used in this chapter:

CXR:	A Carrier other than Qwest
CXR interface:	An interface at a CXR premises
CO:	Qwest Central Office
CO interface:	An interface at a Qwest CO
EU:	End-User

As shown in the chapter on NCI codes, interfaces described by the DS and CS NCI Protocol Codes are used as CO interfaces. The electrical signal characteristics of CS and DS are identical and use of the CS code is limited to denoting that a DS1 channel has a CO interface to a Qwest Digital Cross-connect System (DCS). Whenever an attribute or requirement is given for the DS Protocol Code at a CO, it shall be understood that it also applies to the CS Protocol Code.

CXR interfaces may be ordered by using the DS and DJ codes.

In the following paragraphs, the term *should* denotes a recommendation and *shall* denotes a requirement.

6.1.2 Source of Signal Characteristics

When a DS1 channel does not terminate on (interconnect with) a Qwest terminal multiplexer, digital switch, DCS or similar device, most characteristics of the DS1 signals are controlled by the terminal equipment at the CXR or the EU premises. This includes transmission rate and rate stability, line code, and frame format. If Qwest terminal multiplexing is not ordered, and transmission rate (data rate) synchronization is required, it must be done by the CXR or EU: Synchronization is a function of terminal multiplexer(s) and equipment having similar functions.

Qwest terminal multiplexer clocks are synchronized by a Primary Reference Frequency, which has a bit rate accuracy of 1×10^{-11} bit/s.

6.2 Bi-directional Requirements Common to CS/DS and DJ Interfaces

6.2.1 Transmission Rate and Stability

Channel without Qwest CO terminal multiplexing: In both directions of transmission, the transmission rate of the DS1 signal shall be in the range of 1.544 Mbit/s ± 200 bit/s and should be in the range of 1.544 Mbit/s ± 50 bit/s.

Channel with Qwest terminal multiplexing: In both directions of transmission, the transmission rate of the DS1 signal shall be 1.544 Mbit/s ± $1x10^{-11}$ bit/s. The required data rate accuracy may be achieved by one of two common means.

- Loop time the terminal, using the bit rate received from Qwest to control the transmitter timing.
- Time (clock) the terminal from another digital signal source traceable to the same or another Primary Reference Frequency.

6.2.2 Line Code

The line code shall be bipolar Alternate Mark Inversion (AMI), except where intentional bipolar violations are introduced by B8ZS (binary 8 zero substitution).

If a CO option is ordered (e.g., COMMAND A LINK$^{SM.}$), the line code shall be selected to be compatible with the CO feature. The selected option's line code shall be encoded to the NCI Protocol Option code. Further information can be obtained from Qwest Technical Publication 77371, *COMMAND A LINK^{SM} Technical Description and Interface Combinations*.

6.2.3 Frame Format

The signal shall be framed, and the frame format shall be one of those listed in the section on NCI codes.

If a CO option is ordered, the frame format shall be selected to be compatible with the CO feature. The selected frame format option shall be encoded to the NCI Protocol Option code.

6.2.4 Impedance

The impedance shall be nominally 100 Ohms. A termination of 100 Ohms ± 5% resistance shall be used for the evaluation of signal characteristics.

6.2.5 Test Frequency

When evaluating cable attenuation characteristics, a frequency of 772 kHz shall be used.

6.2.6 Pulse Imbalance

It is not necessary to verify that the following requirement is met unless an otherwise unexplained high bit-error rate exists.

- While viewing a regenerated (nominal DSX-1) signal in any window of 17 consecutive bits, the maximum variation in pulse amplitudes shall be less than 200 mV, and the maximum variation in pulse widths (half amplitude) shall be less than 20 ns. A test regenerator can be used if required to view a regenerated nominal DSX-1 signal.

6.2.7 60-Hz Variations in Pulse Amplitude

It is not necessary to verify that the following requirement is met unless an otherwise unexplained high bit-error rate exists. Signal pulse amplitude may vary at a 60 Hz rate from the presence of 60-Hz longitudinal currents in the powering loops of line regenerators, whether they are in Qwest, CXR, or EU owned cable.

- While viewing a regenerated (nominal DSX-1) signal, the 60 Hz modulation of the DS1 signal shall not exceed 0.5v. A test regenerator can be used if required to view a regenerated nominal DSX-1 signal.

6.3 Requirements Unique to the DS Interface

6.3.1 Interface in a Qwest CO

Channel interfaces within a Qwest CO may be at a DSX-1 Cross-connect panel, or at the discretion of Qwest, there may be no discernible DSX-1 interface. In the latter instance the DS1 signal may be processed within an Electronic Digital Cross-connect System and passed through an office within a higher rate bit stream without having a physical interface. When this is done, it will be transparent to the customer and the DS NCI Protocol Code is still appropriate, because all the concerns for digital signal cross-connect will have been observed.

All the appropriate requirements in the following paragraphs, which are for a DS interface at a CXR premises, will also be met at a CO when such is appropriate.

6.3.2 Qwest Equipment on the CXR Premises

In order to provision the NCI Protocol Code DS interface, Qwest requires space, power, and a suitable environment for Qwest provided regenerators or multiplexers that may be needed. Access to the equipment space shall be provided for Qwest installation and maintenance personnel.

6.3.3 Bi-directional Signal Requirements - Pulse Shape

At the interface, bi-directionally, an isolated pulse, both positive and inverted negative, shall fit within the bounds of the maximum and minimum curves described by the corner-points given in Tables 6-1 and 6-2. When plotted to a graph or electronic instrument, these tables provide DSX-1 templates for newer and older equipment, respectively. It is preferred that equipment meet the requirement for newer equipment. An observed pulse may be scaled vertically by a constant factor, for best fit within the template.

For an example, see Figure 5-7 on page 5-17, which plots the points of Table 6-1 to show the DSX-1 template.

Table 6-1: DSX-1 Corner Points for Newer Equipment

Maximum Curve

Time Unit Intervals	-.77	-.39	-.27	-.27	-.12	0.0	.27	.35	.93	1.16
Normalized pulse amplitude	.05	.05	.8	1.15	1.15	1.05	1.05	-.07	.05	.05

Minimum Curve

Time Unit Intervals	-.77	-.23	-.23	-.15	0.0	.15	.23	.23	.46	.66	.93	1.16
Normalized pulse amplitude	-.05	-.05	.5	.95	.95	.9	.5	-.45	-.45	-.2	-.05	-.05

Table 6-2: DSX-1 Corner Points for Older Equipment

Maximum Curve

Time Unit Intervals	-.77	-.39	-.27	-.27	-.12	0.0	.27	.34	.58	1.16
Normalized pulse amplitude	.05	.05	.8	1.22	1.22	1.05	1.05	.08	.05	.05

Minimum Curve

Time Unit Intervals	-.77	-.23	-.23	-.15	-.04	.15	.23	.23	.42	.66	.93	1.16
Normalized pulse amplitude	-.05	-.05	.5	.95	.95	.9	.5	-.62	-.62	-.2	-.05	-.05

6.3.4 Bi-directional Signal Requirements - Pulse Amplitude

The amplitude of isolated pulses, both positive and inverted negative, shall be in the range of 2.4 and 3.6 volts.

6.3.5 Other Voltages at the Interface

No other signals, including dc voltages, shall be present at the interface.

6.3.6 Physical Interface

The NI shall be metallic cable pair or jumper wire pair ends; one 2-wire twisted pair transmitting signals from Qwest to the customer, and one 2-wire twisted pair transmitting signals from the customer to Qwest, per DS1 channel. The cable gauge shall be 22 or 24. Jumpers will be clearly tagged for transmission direction. If a cable is used, because of the large number of channels being interconnected, in lieu of tagged ends a cable pair running sheet may be provided which provides the assignments using the standard cable color-code.

Qwest and the CXR will individually connect the wire ends to their DSX-1 Cross-connect panels or other connecting arrangement.

6.4 Requirements Unique to the DJ interface

6.4.1 Qwest Equipment at the Carrier Premises

When provisioning the NCI Protocol Code DJ interface, Qwest will not place regeneration equipment on the customer's premises. A specific advantage of the DJ interface is that Qwest does not usually require equipment space or power within the CXR premises. The interface can be remote from the CXR equipment building.

6.4.2 Responsibility of CXR

The CXR shall provide the name and telephone number of a responsible technical person appointed to represent the CXR, to assist Qwest personnel by providing information identified below, and to make agreements appropriate to permit engineering the interface.

The CXR shall advise Qwest of the terminal, frame or other equipment identified as the point of termination.

The CXR shall provide circuit transmission information on their owned and maintained facilities and equipment, as follows:

- Length of cable between the interface (Point of Termination) and the CXR repeater or equivalent unit
- Gauge, capacitance per kft, and whether cable conductors are plastic or pulp insulated
- Whether the cable is screened or shielded. If neither, are the transmit and receive pairs in separate cables? If not, what is the binder group and pair information?
- Total simplex resistance of the cable plus the repeater power supply

6.4.3 Responsibility of Qwest

Qwest will contact the CXR representative, and provide a negotiated design for the interface. The design will provide information that will enable the CXR to complete engineering and installation of its portion of the facility.

In cases where the channel interface is at CXR premises, Qwest may place a loopback connector at its side of the interface. This loopback connector provides Qwest the ability to permit remote addressable out of service loopback from its CO. The CXR may also access the loopback connector remotely for trouble testing. This device has approximately 1 dB of insertion loss, this loss is considered in overall design of the channel.

6.4.4 DSX-1 Interface Requirements

The following will be accepted as a given based on standard equipment design and selection:

- For an all-ones signal, the power in 3kHz ± 1 kHz band centered at 772 kHz shall be between 12.6 dBm and 17.9 dBm. The power in 3 kHz ±1 kHz band centered at 1.544 MHz shall be at least 29 dB below that at 772 kHz.
- For Qwest and CXR signals (signal from a CXR provided span regenerator), binary 1 pulses shall nominally meet the requirements of DSX-1 and have a peak-to-base amplitude between 2.25 and 3.6 volts at the last generator.
- For CXR signal, (signal **not** from a CXR provided span regenerator), binary 1 pulses at the CXR equipment shall meet the requirements of DSX-1 and have a peak-to-base amplitude between 2.4 and 3.6 volts

6.4.5 Transmission Design Rules

Terminal End-Section (TES) attenuation from the last Qwest repeater to the Office Repeater (OR) or span repeater of the CXR shall be no more than 22 dB. This value shall include any Line Buildout (LBO) contained within an OR. Typical values found in an OR are 0, 4.5 or 7.5 dB, for controlling Near-end Crosstalk (NEXT). Include 1 dB loss in the design if a DS1 connector is deployed. The TES shall have no less attenuation than 14 dB. The composite expression therefore, is:

Qwest attenuation + CXR attenuation + CXR LBO • 14 dB or • 22 dB

The attenuation allocation is:

- Qwest attenuation shall have a value between 0 dB and 19 dB
- CXR attenuation shall have a value between 0 dB and 3.0 dB

Any attenuation allocated to either organization and not used, may be used by the other if the facility is tolerant.

If the Qwest facility attenuation is greater than 19 dB or if the facility will not permit that value, Qwest shall place a regenerator in a location that will meet the above requirements.

If the CXR requires a larger attenuation budget and Qwest has no excess to share, then the CXR shall place a repeater such that the above requirements are met.

If the TES is shorter than 14 dB, Qwest will insert LBO in the direction toward the Qwest repeater, to achieve a TES attenuation of 18 ± 4 dB.

If the CXR repeater is intolerant to the signal level of a short TES, the CXR shall insert LBO as required in the direction toward their repeater.

6.4.6 Repeater and Sealing Current Power

The TES may be span powered by Qwest at 60 mA, using a current regulated supply. Maximum voltage at the interface will be 80 volts DC (assuming a simplex path of about 1300 Ohms in the cable and CXR repeater).

The CXR repeater shall be a power-looping type and provide a return path for the repeater/sealing current.

6.4.7 Physical Interface

There are several options for this physical interface:

- RJ48C (See Figure 5-2)
- RJ48H (See Figure 5-3)
- RJ48M(See Figure 5-4)
- Jumper Wire (Similar to Figure 5-6)
- Mutually agreeable connecting block

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7. Synchronization Interface

7.1 Availability

A DS1 Rate Synchronization interface is available in the limited instances where both of the following two primary requirements are met:

- Qwest is delivering services to the customer premises using SONET ADMs (e.g., Line Terminating Equipment multiplexing incoming embedded Synchronous Payload Envelopes) that has the capability to supply (two) DS1 timing reference signals.
- The DS1 signal must be traceable to a Stratum 1 Primary Reference Source (via DS1 timing inputs for synchronization from the BITS clock in the CO) making it suitable for synchronizing customer's Stratum 2 or Stratum 3 clocks.

7.2 Application

Customers may use the Primary Reference Signal (PRS) of the Synchronization (sync) Interface, to synchronize their terminal synchronization equipment, to ensure all digital equipment is operating at an accurate and specific bit-rate. Synchronization to a PRS assures long term error free (timing errors) digital interconnectivity of channels. The Qwest synchronization signal is suitable for synchronizing Stratum 2 and Stratum 3 clocks. These clocks may be found in customer synchronization equipment to provide long to medium term holdover timing should the PRS traceable signal be lost.

7.3 Customer Equipment Synchronization

Terminal equipment transporting digital signals must transmit and receive at the exact same bit-rate. Some customer terminals interconnected by a DS1 channel, are synchronized, but operate at 1,544,000 ± 50 bit/s; which is satisfactory for two terminals not requiring connectivity to other digital services. However, when customer terminal equipment is interconnected by a channel to a Qwest Central Office terminal, the bit-rate must be synchronized by a signal source traceable to a Stratum 1 Clock. As mentioned above, this signal is commonly called a Primary Reference Signal (PRS). Thus synchronized, DS1 terminals, for example, will operate at 1,544,000 ± 1×10^{-11} bit/s.

Customers have a variety of synchronization options. As noted in other chapters of this publication, synchronization (also called timing) may be derived from a received digital bitstream from a distant terminal that is operating at a precision frequency, because it is synchronized by a signal source *traceable* to a PRS. The term *traceable* denotes the received signal has the long-term frequency stability attributes of the clock generating the signal, wherever the clock is located. A Stratum 1 clock has a long-term frequency stability of 1×10^{-11} bit/s.

Before it is decided to use an incoming DS1 channel signal as a synchronization source, it is necessary to compare the *jitter and wander* characteristics of the DS1 channel interface, with the signal requirements of the clock within the customers synchronizing equipment. Because of the unique properties of the highly stable Stratum 2 clocks, they probably will not be compatible with the normal amount of jitter and wander that might be present at a DS1 channel Network Interface. Stratum 3 clocks probably are compatible.

Other customer options for obtaining a PRS are:

- Purchase a Stratum 1 clock (they tend to be quite expensive).
- Purchase a Global Positioning System (GPS) Receiver designed with a PRS output.
- Purchase a LORAN receiver designed with a PRS output.
- Where available, use the Qwest Synchronization interface.

The ultimate solution is usually to obtain two different PRS sources, using one as a Primary and the other as a Secondary.

7.4 Description of the Synchronization Signal

Except for the interface being two-wire rather than four-wire, the signal is identical to the "Conventional Interface" described in Chapter 5, with only a few important differences.

7.4.1 Frame Format and Line Code

Superframe, also known as D4 frame format is used. The Line-code is Alternate Mark Inversion (AMI).

7.4.2 NCI Code

The Network Channel Interface (NCI) code at the end-user premises is 02DU9.BN and the NCI code at a carrier premises is 02DJ9.15.

7.4.3 Payload content

The payload, i.e., the 192 information bits of each DS1 frame are all binary 1's. A framed or unframed all 1's signal is usually considered an Alarm Indicating Signal (AIS). Customers should verify that their equipment using this interface does not react to it as an AIS signal.

7.4.4 Signal Attenuation

End-user Premises

In agreement with the Conventional Interface specifications, the signal is originated as a DSX-1 signal which is then attenuated in the range of 0 to 16.5 dB by the intervening cable between the SONET add-drop multiplexer and the Network Interface.

Carrier Premises

In agreement with the DJ specifications, the signal is originated as a DSX-1 signal, which is then attenuated in the range of 0 to 19 dB by the intervening cable between the SONET add-drop multiplexer and the Network Interface.

7.4.5 Derivation of the Synchronization Signal

The DS1 rate synchronization signal is a derived signal whose frequency is locked to the incoming OC-n or Optical Carrier rate signal. The OC-n is the entire optical payload of the transport system. Since the OC-n rate has no pointer adjustments, but is a stable transmission path, it is suitable as a reference frequency.

The OC-n frequency is divided down to a DS1 rate, which is then framed and line-coded. Thus the OC-n frequency stability is imposed onto the DS1.

7.4.6 Jitter and Wander

The Jitter and Wander characteristics of the signal will conform to specifications described in ANSI T1.101 (now ATIS-0900101.2006), *Synchronization Interface Standard*.

7.4.7 Service Objective

The performance objective of the Stratum 1 traceable signal, which has a long term frequency stability of $\pm 1 \times 10^{-11}$ bit/s, equates to 1 frame slip in 72 days in a worse case scenario (one frame slip is defined as 193 user interface of change). The availability of the service is 99.925% based on a 12 month time period.

7.4.8 Signal Characteristics When SONET Path is Broken

Should the OC-n signal being used for the synchronization reference become unsuitable, the signal at the synchronization interface will change to unframed and its frequency stability will change to ± 20 ppm, which is non-Stratum rated stability.

7.5 Physical Interface

The physical interface is one of those described in Chapter 5 for End-Users and Chapter 6 for Carriers. Due to the importance of the synchronization signal, if a Registration Jack is selected, Qwest recommends the use of a RJ48H or RJ48M for their security, but the interface will be provided on a RJ48C if requested. Because the signal is one-way toward the customer, only the "Customer Receive," i.e., the T1 and R1 leads, will be wired. For example, if a RJ48M is ordered, and the customer requests the interface to be wired to Position 1, the customer will find the signal on pins 26 and 1 of the connector.

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8. Performance Objectives

Table 8-1 provides the Acceptance Limits, Immediate Action Limits, and Performance objective for Qwest DS1 channels. Other Qwest Publications may supersede these objectives for services provided only on fiber.

In Table 8-1, the arbitrary designation of *Configuration Type* is used to provide objectives for two different service configurations:

- *Configuration Type A*, is two local channels (one from each of two customer premises) interconnected at a Qwest Central Office. The local channels may be connected by inter-office facilities.
- *Configuration Type B* is one channel between a customer premises and a Carrier Point of Termination. The Carrier Point of Termination may be in a Qwest Central Office or at another Carrier premises.

Table 8-1: Error Free Seconds and Availability Performance Objectives

	Error Free Seconds *(see Note 1)*		Errored Seconds *(see Note 2)*		Availability *(see Note 3)*	
Configuration Type	A	B	A	B	A	B
Performance Objective	99.5%	99.75%	0.50%	0.25%	99.75%	99.925%

Notes:

1. An Error-free second is any second in which no bit-errors are received and it is usually determined for a 24-hour period.
2. An Errored-second is any second in which one or more bit errors are received and it is usually determined for a 24-hour period.
3. A circuit is unavailable when the Bit Error Ratio (BER) is less than 10^{-3} for a period of 10 consecutive seconds. Also, the availability is expressed as during 12 consecutive months.

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Figure

9. Maintenance Capabilities

9.1 Centralized Remote Testing Capabilities

The ability to provide exceptional DS1 service to Qwest customers is dependent upon the ability to test DS1 channels from a centralized test center.

This is done by remote test access via a test system having the capability of monitoring DS1 performance, and generating framing, line codes, and stress patterns required to provision and maintain DS1 service.

In conjunction with the remote test system, Qwest often has the ability to remotely loop-back an intelligent device on the Qwest side of the Network Interface (see Figure 9-1).

The device, a *DS1 Loopback Connector,* detects and responds to defined loopback command codes by connecting the signal received from the Network at or near the Network Interface, back to the Network. This looping capability allows stress patterns to be transmitted and received by the remote test system from a centralized test center for the purpose of analyzing the received signals for trouble isolation. The DS1 Loopback Connector is a passive device which means that it is transparent to the functions of the customer's equipment and DS1 signal, until its loopback capability is activated. It has less than 1 dB of insertion loss, with negligible affect on the shape of a DSX-1 pulse.

The remote monitor and test capability negates the need to dispatch a technician on every trouble report to perform manual testing, greatly aiding trouble clearing time.

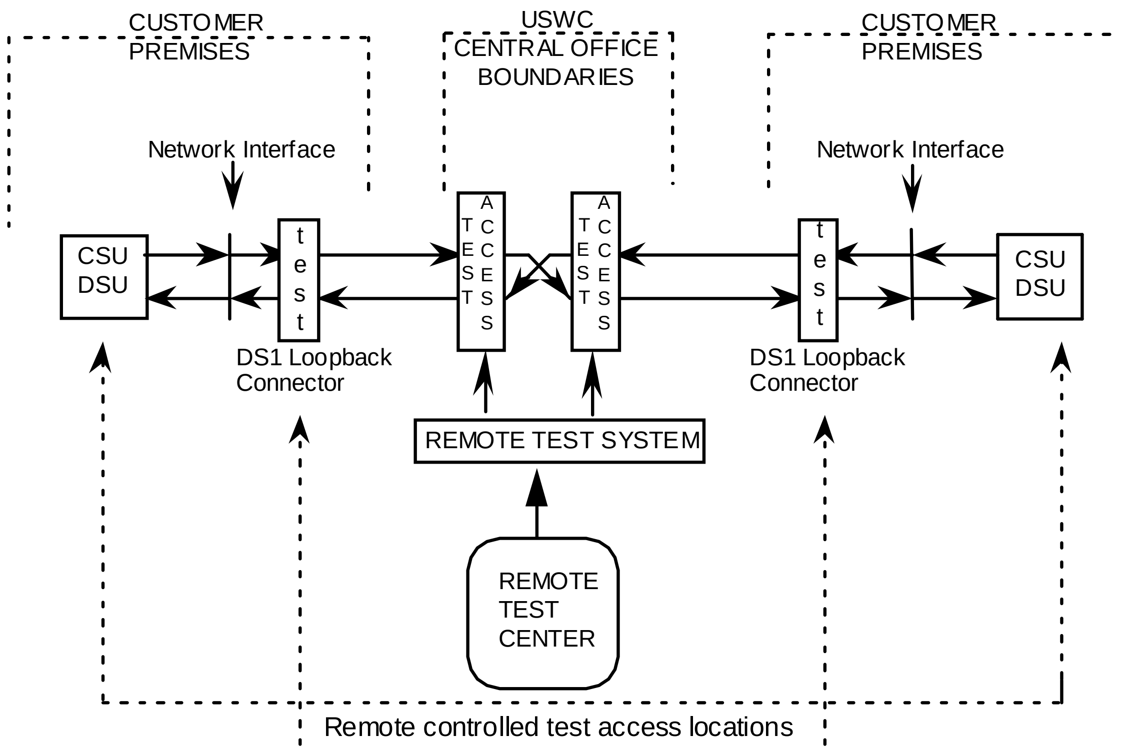

Figure 9-1: Remote Test Access Capability - Typical

Where provided, an additional remote loop back capable device is the customer's Channel Service Unit (CSU). CSUs use loopback codes that are different from the DS1 Loopback Connector codes, so each can be independently activated. In addition to being able to send commands to the DS1 Loopback Connector, Qwest remote test systems are also programmed with the CSU loopback codes, further aiding the ability to sectionalize trouble without dispatching either Qwest or customer's maintenance people.

By remotely accessing, in turn, the CSU and DS1 Loopback Connector loopbacks, it can be determined whether the trouble is in the Qwest channel or wiring, or in the customer wiring or CSU. Loopback codes for the CSU and the DS1 Loopback Connector are listed in ANSI T1.403-1999, *Network and Customer Installation Interfaces – DS1 Electrical Interface*.

9.2 Remote Surveillance of the DS1 Signal

Typical Central Office test access equipment shown in Figure 9-1 includes full and real-time DS1 performance monitoring capability. See Chapter 3 for a discussion of the performance monitoring potential of the various frame formats of DS1 signals.

For Super Frame, there is minimum monitoring benefit, but with ANSI Extended Superframe, there is maximum benefit. ANSI ESF provides Qwest with the ability to view the performance of the signal received by the customer's equipment. It also enhances the capability of determining the location of trouble when performance monitoring equipment reports that quality parameters are not being met.

Qwest will provide proactive maintenance commensurate to the framing format selected by the customer.

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10. Definitions

10.1 Acronyms

AIS	Alarm Indicating Signal
AIS	Alarm Indication Signal
AMI	Alternate Mark Inversion
ANSI	American National Standards Institute
AWG	American Wire Gauge
B8ZS	binary 8 zero substitution
CAD	Computer Aided Design
CLEC	Competitive Local Exchange Carrier
CO	Central Office
CRC-6	6 bit Cyclic Redundancy Check
CSU	Channel Service Unit
DC	Direct Current
DCS	Digital Cross-connect System
DSS	Digital Switched Services$^{SM.}$
DSU	Data Service Unit
ESF	Extended Superframe
EU	End-User
GPS	Global Positioning System
LAN	Local Area Network
LBO	Line Buildout
Mbit/s	Megabits per second
NC	Network Channel
NCI	Network Channel Interface
NCTE	Network Channel Terminating Equipment
NEXT	Near-end Crosstalk
NI	Network Interface
PRM	Performance Report Message
NPRM	Network Performance Report Message

PRS	Primary Reference Signal
RTS	Request-To-Send
SF	Superframe
SONET	Synchronous Optical Network
SRDM	Subrate Data Multiplexing
TES	Terminal End-Section
USOC	Uniform Service Order Code a.k.a., Universal Service Order Code

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11. References

11.1 American National Standards Institute Documents

ATIS-0900101.2006	*Synchronization Interface Standard*
ANSI T1.102-1993 (R1999)	*Digital Hierarchy – Electrical Interfaces*
ANSI T1.107-2002 (R2006)	*Digital Hierarchy – Formats Specifications*
ANSI T1.223-1997	*Information Interchange - Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Cods for the North American Telecommunications System*
ANSI T1.403-1999	*Network and Customer Installation Interfaces – DS1 Electrical Interface*
ANSI T1.403b-2002 (R2005)	*Supplement to T1.403-1999*
ANSI T1.510-1999 (R2004)	*Network Performance Parameters for Dedicated Digital Services for Rates Up to and Including DS3 – Specifications*
ANSI EIA/TIA-547-1989	*Network Channel Terminating Equipment for DS1 Service*
ANSI EIA/TIA-594-1991	*Private Digital Network Synchronization*
T1E1 Technical Report No. 5	*Network and Customer Installation Interface Connector Wiring Configuration Catalog*

11.2 Telcordia Documents

GR-54-CORE	*DS1 High-Capacity Digital Service End User Metallic Interface Specifications*
GR-342-CORE	*High-Capacity Digital Special Access Service Transmission Parameter Limits and Interface Combinations*
GR-436-CORE	*Digital Network Synchronization Plan*
GR-499-CORE	*Transport Systems Generic Requirements (TSGR): Common Requirements*
ISI-SR-STS 000307	*NC/NCI Code Dictionary Industry Support Interface*

11.3 Other Publications

Federal Communications Commission	Code of Federal Regulations Title 47, Part 68
AT&T TR 54016	*Requirements for Interfacing Digital Terminal Equipment to Services Employing the Extended Superframe Format*, September 1989

11.4 Qwest Technical and Service Publications

PUB 77200	*Qwest DS1 Service and Qwest DS1 Rate Synchronization Service*, Issue F, September 2001
PUB 77204	*Qwest Digital Data Service Product Description, Applications, and Interface Combinations*, Issue E, September 2001
PUB 77312	*Qwest Digital Data Service Technical Description*, Issue G, September 2001
PUB 77344	*Diversity and Avoidance*, Issue B, September 2001
PUB 77371	*COMMAND A LINK[SM] Technical Description and Interface Combinations*, Issue E, November 2007
PUB 77386	*Interconnection and Collocation for Transport and Switched Unbundled Network Elements and Finished Services*, Issue M, October 2007

11.5 Document Ordering Information

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

- American National Standards Institute (ANSI) documents may be obtained from:

  American National Standards Institute
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  New York, NY 10036
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  Telex: (201) 275-2090
  Phone: (800) 521-CORE (2673) (U.S. and Canada)
  Phone: (908) 699-5800 (Others)
  Fax: (908) 336-2559
  Web: http://www.telcordia.com

- Federal Communications Commission (FCC) Code of Federal Regulations Title 47, Part 68 may be obtained from:

  Superintendent of Documents
  Government Printing Office
  Washington D.C. 20402
  Phone: (202) 783-3238

- AT&T Technical References (TRs) may be obtained from:

  Howard Press
  1026 West Elizabeth Avenue
  Linden, NJ 07036
  Phone U.S. Orders: (888) 387-8852
  Phone International Orders: (908) 523-2257
  Fax: (908) 862-6722

- Qwest Technical Publications may be obtained from:

  http://www.qwest.com/techpub

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