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DS-1 HIGH-CAPACITY DIGITAL SERVICE

OVERALL DESCRIPTION

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DS-1 HIGH-CAPACITY DIGITAL SERVICE OVERALL DESCRIPTION

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1.0 GENERAL

1.01 This practice, intended for general use by Operations and Engineering personnel, provides an overall description of DS-1 high-capacity digital service. A general knowledge of digital transmission systems, such as T1, fiber, and digital radio, is helpful in using this section.

1.02 This practice is being reissued for the following reasons:

- To add access-service principles and terms.
- To include information on customers applications of these services, including primary-rate access (PRA) for the Integrated Services Digital Network (ISDN).
- To cover clear-channel capability (CCC) and bipolar-with-eight-zeroes-substitution (B8ZS) coding.
- To update the coverage of customer-provided cable and terminating equipment.
- To add coverage of customer controlled digital cross-connection systems (DCSs), fiber-only services, and "fractional T1" service.

Since this is a general reissue, arrows to show changes are omitted.

1.03 DS-1 high-capacity digital service provides two-point transmission of pulses at a rate of 1.544 Mb/s. The service is four-wire, full-duplex and handles serial, bipolar, isochronous data. The circuit providing this service terminates at the customer

location in a network interface (NI). It is connected to customer-premises equipment (CPE) which may include an automatic protection switch (APS).

1.04 Related practices for design, installation, and maintenance of these services are as follows:

- BR 314-645-500 DS-1 Digital Service - Maintenance and Test Procedures
- BR 365-800-500 Digital Carrier Systems - Verification Test for B8ZS Capability
- BR 855-351-190 Digital Carrier Systems - Application of B8ZS Coding
- BR 880-610-100 DS-1 Digital Service - Engineering Considerations

2.0 DESCRIPTION

General

2.01 The basic DS-1 digital service provides transmission of customer data, voice, or compressed video. The service is provided over digital facility sections that extend to the customer location and terminate in a channel service unit (CSU) or an APS on the customer side of the network interface. The CSU or APS is an essential part of the digital line/facility that monitors and regenerates data from the local customer to ensure that the digital-line pulse requirements are met. However, the exchange-carrier maintenance responsibility ends at the NI.

2.02 A standard T1 signal is used for transmission over the digital line. It contains bipolar, 50% duty cycle, return-to-zero pulses. This format is shown in Fig. 1. The signal format is a sequence of digital ones and zeroes. The zeroes of the sequence are at the zero-voltage level, while the ones are alternately positive and negative with respect to the zero level, also known as "alternate marks inverted." Any failure to follow this rule results in a bipolar violation (BPV). The fundamental advantage of this transmission code is that the average dc energy in the bipolar pulse train is zero, thus permitting the repeaters to be transformer-coupled to the digital line. The repeaters respond only to the presence of a pulse in a particular time slot. If a pulse is present, they generate a new pulse. Therefore, a completely new pulse train results that is essentially free of noise and distortion.

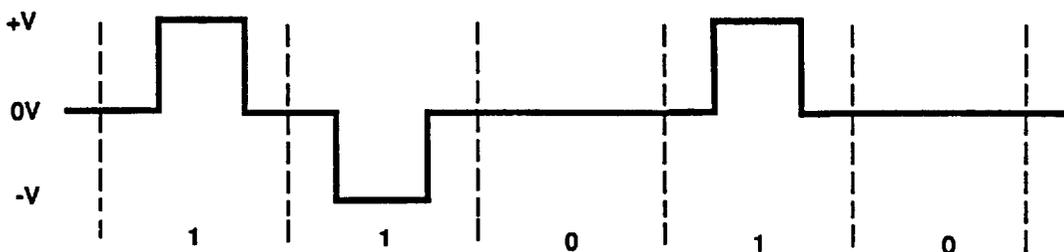


Fig. 1 - Bipolar Return-to-Zero Format

2.03 A typical name for this general offering is High Capacity Digital Service (HCDS). However, individual exchange carriers have their own names for this offering. The trade press widely refers to these channels as "T-1" service, even though T1 span lines are only one of the types of facility that they use. The service is generally interoffice.

2.04 The channel may be arranged for CCC, in which case the customer may send any combination of ones and zeroes (in conjunction with a normal framing pattern). If so, the line code may be modified to B8ZS, or a coding technique termed zero-byte time-slot interchange (ZBTSI) may be used. B8ZS coding is described in BR 365-800-500.

Applications

2.05 Customer applications for this channel include provision of groups of 24 tie trunks between digital private branch exchanges (PBXes), usage as a backbone facility for on-premises data multiplexers, interconnection of local-area networks (LANs) for data, switch access for multimegabit data service, use for groups of 24 off-premises PBX stations, and other high-capacity/high-speed applications. With low-bit-rate-voice (LBRV) terminals, users can obtain 44 or 48 voice circuits from a DS1 service instead of 24. With other processing techniques like digital silence elimination added to LBRV, 96 voice circuits are feasible on a DS-1. Fig. 2 shows an unchannelized DS-1 service of the type widely used in these networks for local access to an interexchange carrier (IC) terminal.

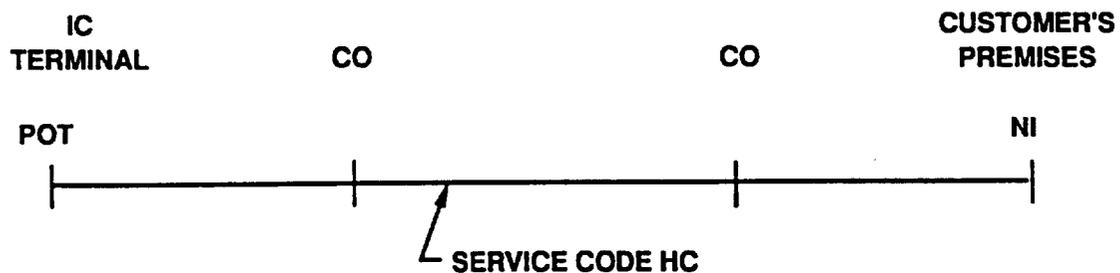


Fig. 2 - Unchannelized DS-1 Access Service

2.06 Highly developed terminals are available for customers to use on their DS-1 circuits. Termed "resource managers," they can be optioned to serve as programmable digital cross-connect systems, channel banks, drop-and-insert multiplexers, LBRV coders, statistical data multiplexers, and remote network management systems. Via a flexible framing process, they can mix voice with data at the usual speeds (4.8 kb/s, 56 kb/s, etc.) or special speeds like 512 kb/s. In the larger networks, "compressed" video at 56 kb/s, 384 kb/s, or 1.344 Mb/s can be handled along with voice and data. They thus allow the integration of formerly separate PBX and data networks. Further, they provide automatic restoration switching if one of the DS-1 channels in a multicircuit network fails.

2.07 ICs, and some exchange carriers as well, offer "fractional T1" service. This offering generally applies to the line mileage between two DCSes. The tariff billing is in terms of a part of a DS1, typically equivalent to a block of four voice channels. This replaces the older concept of billing for individual voice circuits. Fig. 3 shows an interoffice service of this type, extending between two DCSes. Cross-connections in the DCSes may be under control of the customer via a dial-in data link. The customer loop facility is built as a complete DS-1.

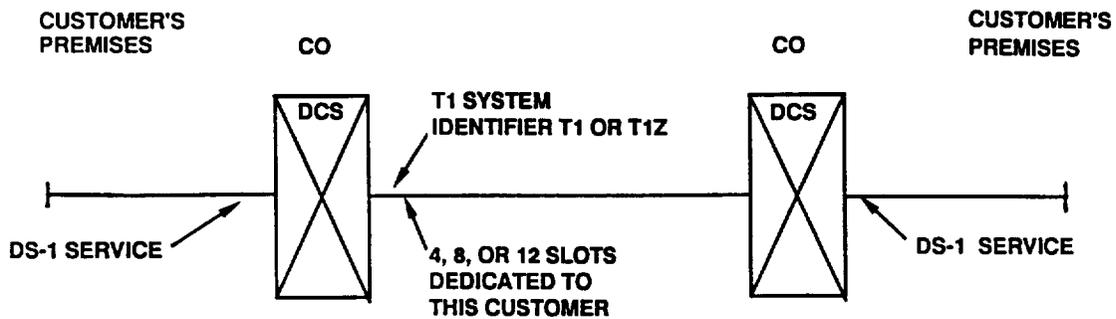


Fig. 3 - "Fractional T1" Service

2.08 A DS-1 service may terminate in a central-office switch. An example (Fig. 4) is for direct-in-dialing service, where 24 circuits terminate on the trunk side of a digital switch set up for trunk-with-line-treatment operation. This is common for connection to large PBXes or Radio Common Carrier (RCC) terminals.

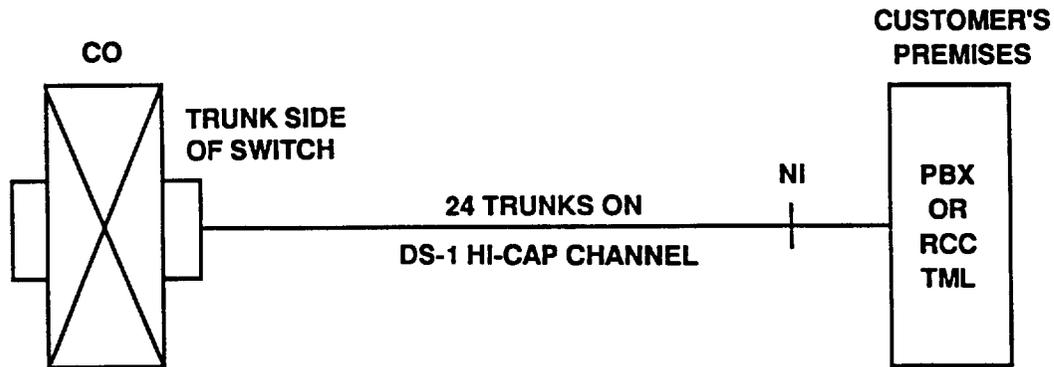


Fig. 4 - Direct-In-Dialing Trunks on DS-1 Facility

Fig. 5 shows a primary-rate access line for ISDN use, providing 23 "B" channels for voice or data use and one "D" channel for signaling.

2.09 The growth in demand for DS-1 services in recent years has been phenomenal, and is believed to account for a reversal of the historic steady pattern of growth of special-services circuit counts.

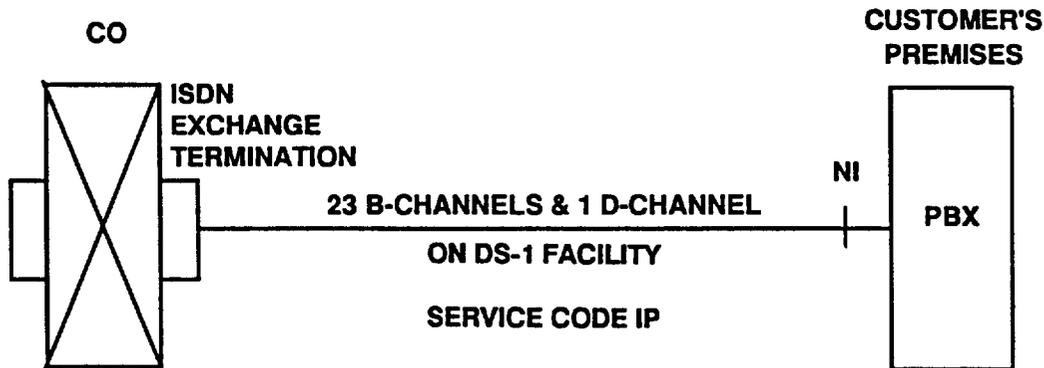


Fig. 5 - ISDN Primary-Rate Access Line

Facilities

2.10 The DS-1 digital service normally uses a combination of digital technology, such as T1, T1C, and fiber optics, for the local loops. Interoffice facilities may be T1 span lines, channels on T1C systems, or channels on fiber or digital radio systems.

2.11 Fig. 6 shows a block diagram of a complete DS-1 service. In its simplest form, the circuit connects two stations by means of one central office. The facility can consist of a series of digital spans, each span consisting of a T-carrier repeatered line terminated at each end in repeaters and/or a channel on a higher-capacity digital system (T1C, T3, etc.) There are two general types of spans used in providing service: loop and interoffice.

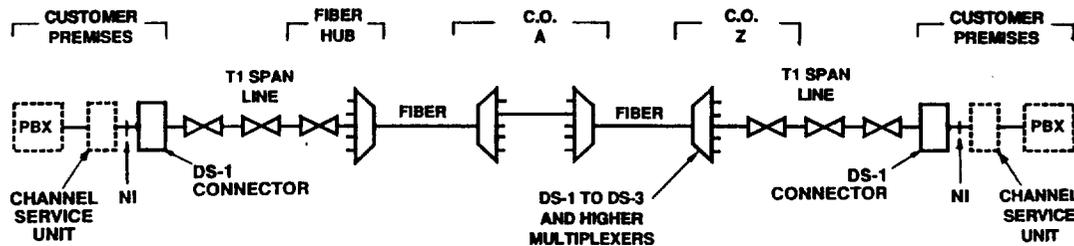


Fig. 6. - Complete DS-1 Service

2.12 A loop span connects the CPE to the central office over T1 repeatered facilities. The loop span terminates in the NI at the customer premises. At the CO, it passes through a line terminating unit (LTU) or an office repeater bay (ORB), and terminates at a digital signal cross-connection (DSX) frame.

2.13 An interoffice span connects two central offices by means of ORBs. In central offices having separate DSX bays for loop and interoffice facilities, the two DSXes are joined by a tie cable (up to 85 feet long) or an intraoffice tie span with repeater (for greater lengths).

2.14 In at least one company, a tariff offering is available of DS-1 services with

guaranteed use of fiber facilities. In this case, there is normally an exchange-carrier multiplexer at the customer's site to derive DS-1 channels. The customer interface may then be a DSX-1 type signal with defined voltage and pulse shape, rather than the less defined form that arrives from a span line.

CPE for DS-1 Digital Termination

2.15 Where a loop T1 span terminates on a customer's premises, a CSU is normally needed. These were originally considered to be network channel terminating equipment (NCTE) to be supplied by the exchange carrier. However, under current requirements of the Federal Communications Commission (FCC), the CSU is treated as CPE to be FCC-registered and supplied by the end user. The FCC policy is subject to Region interpretation and official waivers granted by the Commission, as well as ongoing changes in the regulatory climate.

2.16 The customer premises equipment, usually a CSU, interfaces the network with a transmit and a receive pair using the T1 bipolar signal format. The customer data signal at the NI must satisfy the pulse-density requirement of the T1 line (a minimum of 3 pulses in any 24 timeslots) and zero-sequence constraints (no more than 15 consecutive zeros). The CSU provides circuitry to monitor data input to the network, if necessary, to add pulses to meet the requirements of the digital line.

2.17 The CSU functions are not necessarily housed in a separate unit, but may be integrated with other equipment, for example, a digital PBX. In early installations, the CSU was provided by the exchange carrier.

2.18 The CSU provides the following functions:

- Serves as a bipolar interface to the T1 digital line.
- Monitors the data transmitted and, when necessary, adds pulses.
- Removes bipolar violations. (This feature must be optioned out where B8ZS coding is used.)
- Regenerates the received data and terminates the digital line.
- Includes one or more loopback points for testing the digital loop.

2.19 The critical circuitry of the CSU (regenerators, keep-alive, and line loopbacks) was originally powered from the T1 line (power simplex circuit). Span-powering current, 60 mA DC, was passed across the customer interface. That arrangement is no longer required.

Interface Codes

2.20 Under FCC registration rules, four standard jacks are used for DS-1 services terminating at ordinary customers' premises:

- RJ48C is a basic one-circuit modular interface.
- RJ48X is a one-circuit jack whereby the DS-1 cable pairs are looped, receive to transmit, when the customer's cable is unplugged.
- RJ48M is an eight-circuit ribbon-socket interface.
- RJ48H is a 12-circuit connector, with transmit and receive pairs segregated.

2.21 On the multicircuit interfaces, the exchange carrier is to wire circuits to the groups of connector pins in the sequence designated by the customer. On any of the interfaces, where shielded cable is used, the shield is not to be carried through the interface. Pin connections for the jacks are shown in Fig. 7.

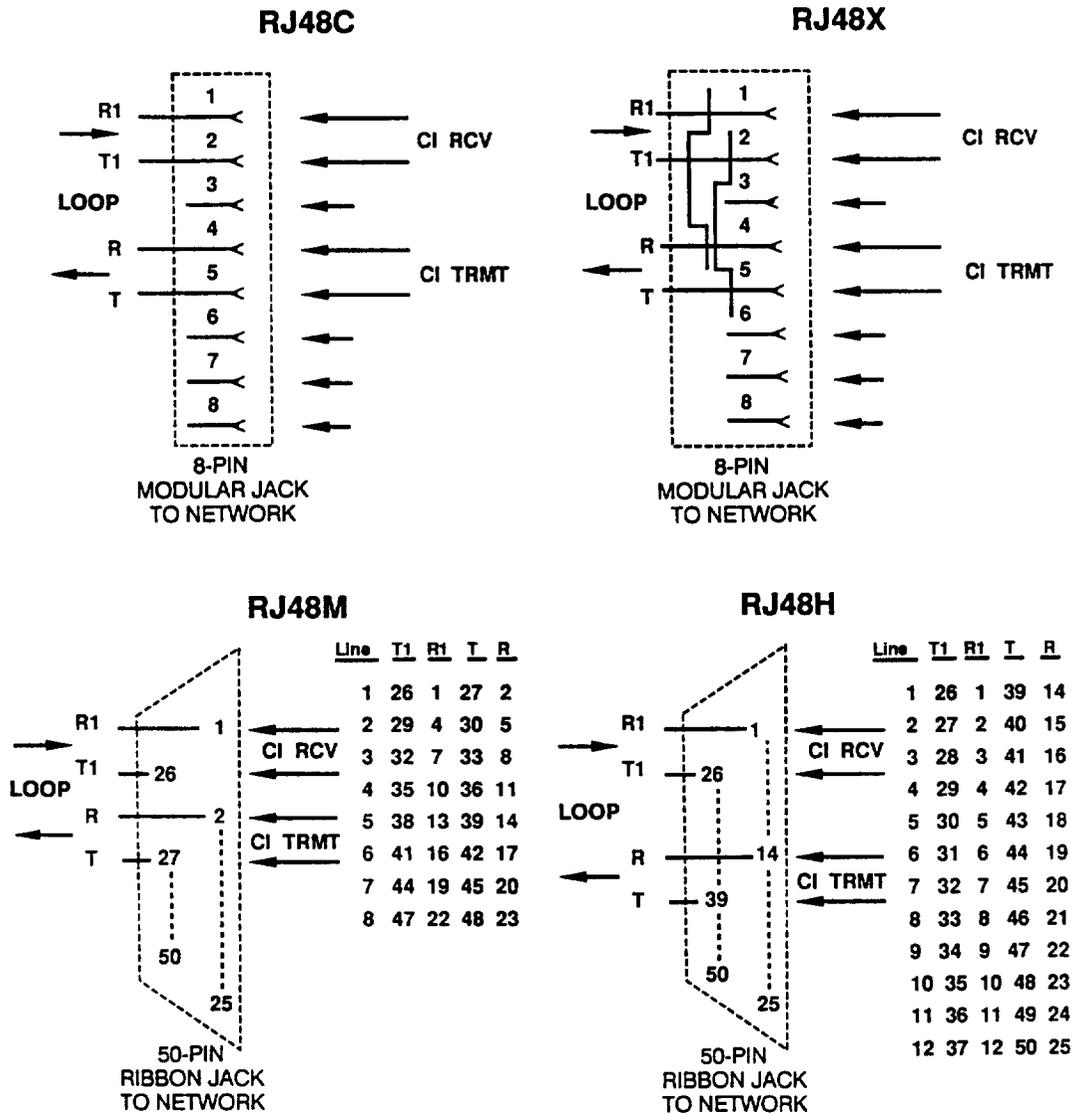


Fig. 7 - Pin Connections for Registration Jacks

2.22 These codes do not apply at interexchange carriers' terminals, where the usual interface is, or is close to, a DSX-1 cross-connection bay.

2.23 On exchange-access services in particular, the type of interface is specified by a network channel interface (NCI) code. The current set of these codes is listed in BR 880-610-100.

DS-1 Connector

2.24 In the newest installations, there may be a DS-1 connector (a maintenance terminating unit, or "smart jack") that provides minimum loopback testing capability. Fig. 8 shows the circuitry in a DS-1 connector. This device provides the minimum circuitry to (1) complete the span power loop, (2) isolate the customer interface from span powering voltages, (3) detect a loopback code from the central office, and (4) complete the loopback path. No attempt is made to regenerate the customer's signal. In ISDN terms, the connector is a Network Terminator 1 (NT1).

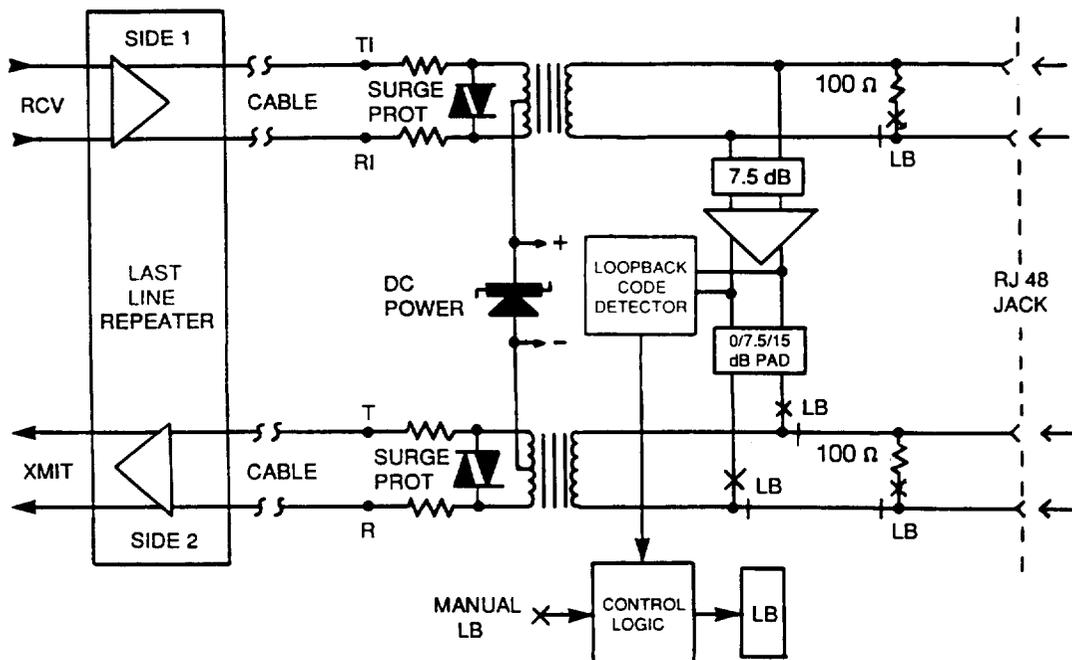


Fig. 8 - DS-1 Connector

CPE Loopbacks

2.25 Loopbacks are activated by different means:

2.26 By a code on the DS-1 line. This LB is activated when the network tester sends a 5-second application of a continuous repetitive code signal on the DS-1 line. The code is 5 bits, 00001. The loopback is deactivated when the network sends a continuous repetitive code signal (001) for a period of 5 seconds. For services involving the Extended Superframe (ESF) framing format, the loopback codes are given in BR 314-645-500.

2.27 With a separate control pair. In very early installations, a separate remote-test control pair controls loopbacks. The loopback is operated by applying dc current to the control pair. This gives a Test Loopback (TLB) at a point near the customer interface, after regeneration and removal of BPVs. As an option depending

on the equipment, sending control current of the opposite polarity causes a loopback closer to the network, called the line loopback (LLB), before regeneration. Either loopback is released when the dc voltage is removed from the control pair. The control pair is routed to the Serving Test Center (STC) or other location that is assigned test responsibility. Because of the difficulty of obtaining a dc control path in today's network, this control method is no longer common.

Automatic Protection Switch

2.28 Additional service functions are available, at the option of the customer. As shown in Fig. 9, automatic protection switching may be ordered on the loop portion of the circuit to improve availability, with either normal or diverse routing for the protection channel. On the line side, the APS monitors the facility and switches as a result of signal degradation (loss of signal, excessive cyclic redundancy errors, or, for services not using B8ZS coding, bipolar violations). On the equipment side, the APS monitors incoming signals for irregularities and provides a keep-alive signal on the line facility.

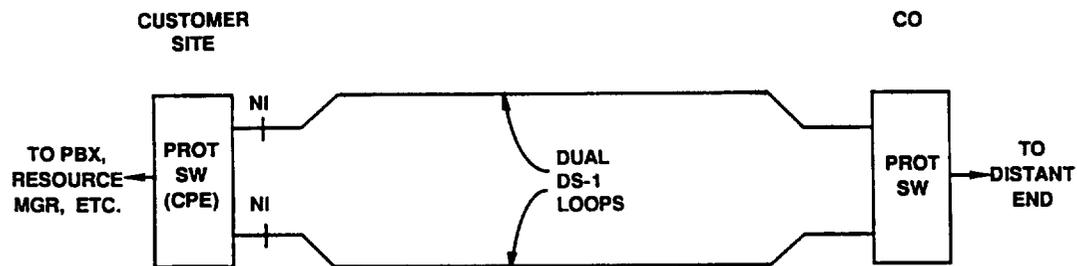


Fig. 9 - Automatic Protection Switching

Central Office Multiplexing

2.29 The central office (CO) multiplexing option, used in conjunction with compatible customer-provided equipment at the customer's site, provides for 24 voice grade (or DS-0 data) connections at the CO. This option is most popular with ICs, but is often provided to general customers as well. Fig. 10 shows an IC access ser-

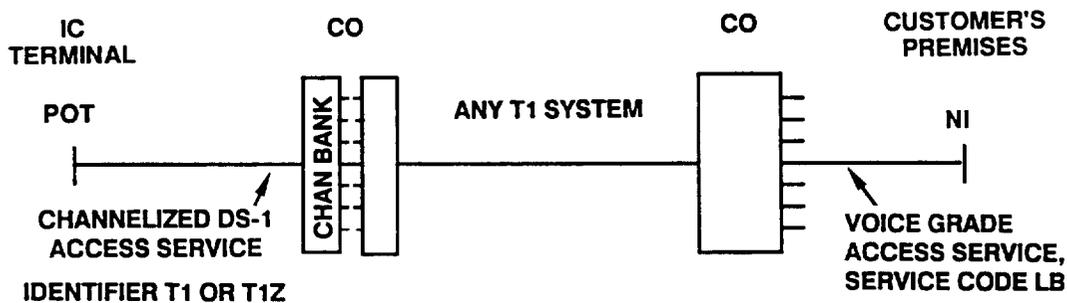
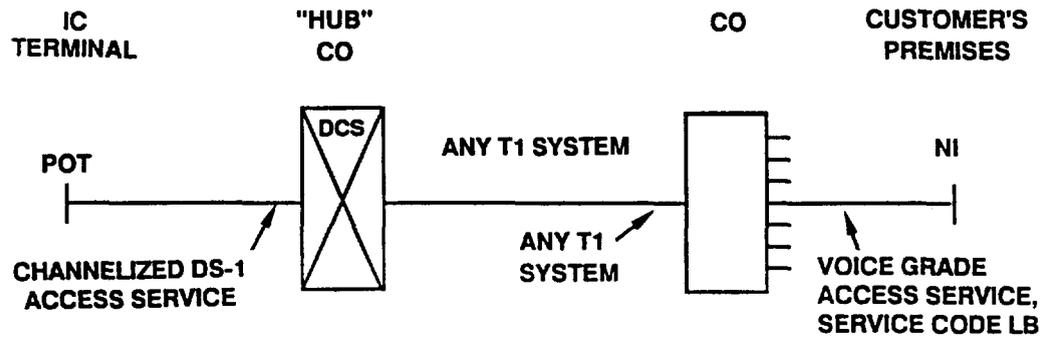


Fig. 10 - DS-1 Access Service, Channelized with a Bank

vice, channelized with a multiplexer at a "hub" central office, with individual channels being extended to a customer's premises via an interoffice carrier system. Depending on the customer's order, the multiplexer may be a channel bank (D4 or equivalent) or a digital-data multiplexer like the T1DM.

2.30 Fig. 11 shows a DCS being used for the same purpose. The DCS may be used as a normal cross-connection system, controlled by the exchange carrier, or may be customer-controlled by a data link or dial-in connection.



IDENTIFIER T1 OR T1Z

Fig. 11 - DS-1 Access Service, Channelized with a DCS

Transfer Arrangement

2.31 The transfer arrangement permits a customer to transfer a channel between two local channels. The transfer arrangement is shown in Fig. 12. The two local channels may terminate at the same or different premises. The transfer from one

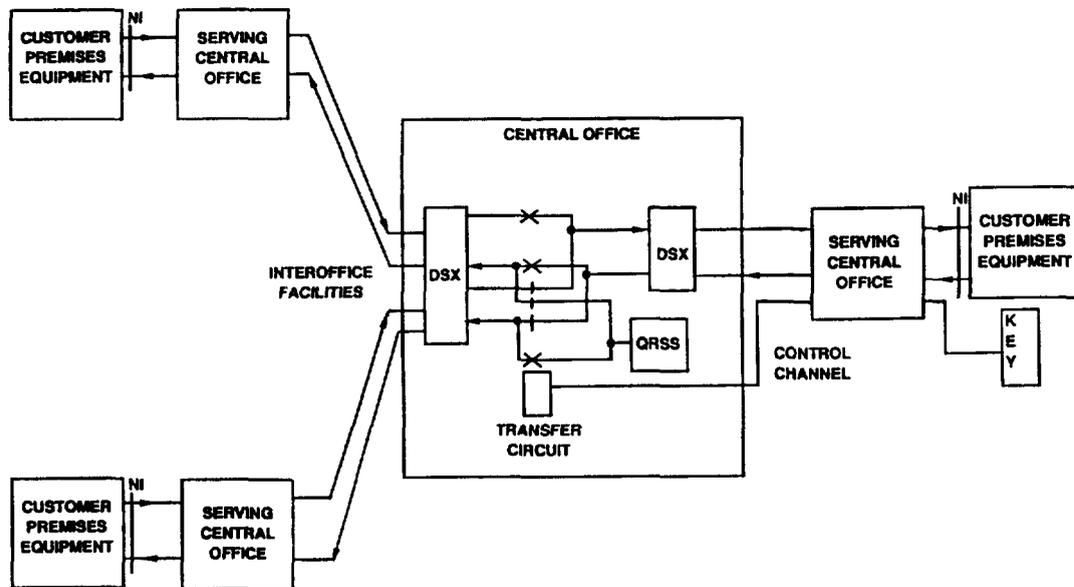


Fig. 12 - Transfer Arrangement

channel to the other is accomplished with a customer-operated key located at one of the three circuit termination points or a dial-up port of a microprocessor located in the CO. The key activates a control circuit. It is recommended that the transfer arrangement at the CO provide a signal source, such as a quasi-random signal source (QRSS), on the T1 line not in use. At the customer's option, protection switching, multiplexing, or both can be provided on this service along with the transfer feature.

Higher-Capacity Interfaces

2.32 Particularly for use for access to ICs' terminal sites, interfaces at DS-3 level are common. DS-1 services may be carried as individual channels of a higher-level digital service. Fig. 13 shows a group of DS-1s carried as the 28 channels of a DS-3. DS-2, DS-1C, and custom-developed interfaces may also be offered but are uncommon.

IC TERMINAL

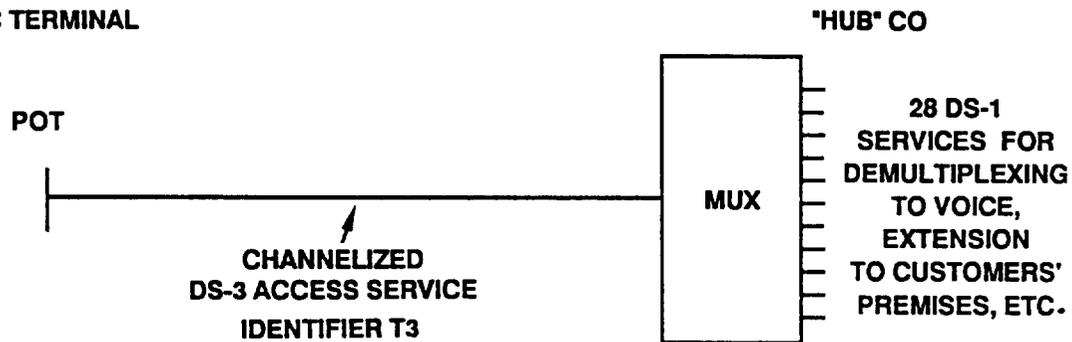


Fig. 13 - DS-1 Services Carried on a DS-3 Service

Fiber-Only Services

2.33 At least one company offers DS-1 services with guaranteed use of fiber facilities. These assume the use of fiber loop plant to the customer's site(s) and multiplexers to derive DS-1 channels.

Service-Order Considerations

2.34 Installation of the basic service requires digital facilities between customer location A and customer location Z. To provide these facilities, a universal service order (USO) or access service order (ASR) will be issued containing the circuit identification (special-service code like DH, or carrier-system identifier like T1Z). The "S & E" section of the order will typically show: T11L7KS/DES DIGITAL STN LINE 1.544 MB/S. Processing of the order follows local procedures for administering designed services. There is usually a special procedure for handling high-capacity services.

Identifier Codes

2.35 A nonchannelized DS-1 service, that is, a simple point-to-point channel, is

identified by one of the following special-services codes:

- DH Digital Service (ordinary commercial applications)
- FL Fractional T1 (ordinary commercial applications)
- HL Digital Service - Fiber (for those tariff offerings that guarantee use of only fiber facilities)
- HX Fractional T1 (access service)
- IP ISDN Primary-Rate Access
- UH Digital High Capacity (for "restructured" access-style services)
- UM High Capacity Custom (for "restructured" access-style services, with specially developed performance limits)
- HC High Capacity, 1.544 Mb/s (access service)

2.36 A third letter of "Z" indicates that CCC is required, for example 77DHZA or 77HLZA. "IP" services always require CCC via a B8ZS interface. A third letter of "J" indicates a channel for use with customer control of a DCS. The fourth letter may convey special information on the DS-1 service: "E" indicates a customer-reconfigurable service, while "Z" may indicate a use of the DS-1 in a Company-official reconfigurable network.

2.37 A channelized service, one that involves central-office multiplexing to voice or DS-0 data channels, switching, or digital cross-connection, is generally identified as a T1 carrier system between two points, e.g., the 107 T1 LOC A - LOC Z. If CCC is required, the system identifier becomes T1Z (for B8ZS coding) or T1ZZ (for ZBTSI). Most of these systems are "one-ended," with an exchange-carrier terminal on one end and a network interface (point of termination) at the other.

2.38 In some companies, for the purpose of inventory records the practice on unchannelized services is to build a "single-channel" T1 carrier system between the two customer locations, and then to assign the high-cap service (DH, HC, etc.) to that system.

2.39 For CCC services that use B8ZS coding, designation cards on DSX-1 frames and ORBs should be marked with the full B8ZS designator (DHZA, T1Z, etc.) so that maintenance people know to expect a B8ZS-coded signal.

3.0 ACRONYMS

3.01 The following terms receive multiple use in this practice.

APS	Automatic Protection Switch
B8ZS	Bipolar with Eight-Zeroes Substitution
BPV	Bipolar Violation
CCC	Clear Channel Capability
CPE	Customer Premises Equipment
CSU	Channel Service Unit
DCS	Digital Cross-Connection System
DSX	Digital Signal Cross-Connect

FCC	Federal Communications Commission
IC	Interexchange Carrier
ISDN	Integrated Services Digital Network
NI	Network Interface
ORB	Office Repeater Bay
PBX	Private Branch Exchange
ZBTSI	Zero-Byte Time-Slot Interchange

4.0 REFERENCES

4.01 The following practices, in addition to those listed in 1.04, provide more detailed information.

365-200-100	Digital Transmission Systems - T1 Digital Line - General Description
365-228-500	Digital Transmission Systems - T1 Digital Line - Digital Data System Qualification Test