SECTION 314-900-100
Issue 4, December 1981

PRIVATE LINE SERVICE
OVERALL DESCRIPTION
DIGITAL DATA SYSTEM

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1. GENERAL

1.01 This section provides an overall transmission description of the Digital Data System (DDS). The description is based on the integration of several individual components into a system meeting a set of overall transmission objectives.

1.02 This section is reissued for the following reasons:

- To add information about subrate dataport channel units as used in a SLC* 96 Subscriber Loop Carrier System. This information includes the digital signal at zero level dataport channel unit at 56 kb/s (DS0 DP 56 KB).
- To add information about the Automated Bit Access Test System, the Bit Access Test System, and the Line Access Test System.
- To add information about the hybrid and multiplex offices and the DDS office hierarchy.
- To add information about the ED-73669-30 composite clock cross-connect assembly.
- To add information about a single circuit off-net extension arrangement.

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- To add information about the Digital Transmission Surveillance System.

Revision arrows are used to emphasize the more significant changes.

2. INTRODUCTION

A. System Summary

2.01 The DDS is a general purpose facility network for data transmission. A major use of the network is for DATAPHONE* data communications service, a private line synchronous data transmission service. Data transmission occurs in both directions simultaneously (full duplex transmission). A synchronization network ensures that the transmission is synchronous; that is, that the data is accepted from and delivered to the DDS at network-controlled clock times.

2.02 The DDS provides point-to-point and multipoint (multistation) service. Multipoint service eliminates the need for an individual data route between a centralized customer location and each of its branches. The DDS accepts data rates of 2.4, 4.8, 9.6, and 56 kb/s. There is no provision for alternate voice or voice coordination. The basic data rates are multiplexed to achieve efficient fills on the transmission facilities and on shared equipment. Offices are arranged in a hierarchy from hub offices to end offices. A hub office serves as the cross-connect and testing point for all circuits that have end points in its serving area.

B. Comparison of Analog and Digital Transmission

2.03 The DDS is designed to transmit data in digital form. A bit is a unit of digital information. Bits are represented by the presence or absence of pulses during each of a periodic series of specific time intervals and are commonly known as 1s (pulses) and 0s (no pulses). Once the pulses have been formed, their exact amplitude is of little significance; therefore, digital pulses may be freely regenerated between two points of transmission. The only restriction on regeneration is that it must occur before extraneous signals and noise have obscured the 1s and 0s. This risk of error is minimized by the proper spacing of regenerators. Noise and distortion that normally accumulate in analog signals are completely removed each time a digital signal is regenerated. In addition, the DDS, being strictly digital from end to end, eliminates the need for the digital-to-analog-to-digital conversion required by analog data transmission facilities, and thus, eliminates the cost and complexity of extra equipment and the distortion caused by repeated conversions.

C. Integration Into Present Digital Hierarchy

2.04 The DDS has been designed to be integrated into the digital hierarchy, which is divided into levels according to data rate. The higher the data rate, the higher the level in the hierarchy. A 1.544-Mb/s rate defines the first level in the hierarchy, called the DS-1 level. ▶The DDS transmits to these facilities at the DS-1 level. This level may be multiplexed into higher rate facilities, but it is still used as a 1.544 Mb/s facility (Fig. 1). Facility information is documented in the appropriate Bell System Practice division according to the type of facility.◀

2.05 The 1.544-Mb/s DS-1 signal is organized into frames of 193 bits each. Each frame is subdivided into twenty-four 8-bit bytes, accounting for 192 bits. The 193rd bit is used for frame synchronization. A rate of 8,000 frames per second can be derived by dividing the total number of bits per second by the number of bits per frame (1,544,000 ÷ 193). Each of the twenty-four 8-bit bytes represents one channel. Therefore, each channel contains information at the rate of 64 kb/s (8 bits × 8000 frames per second), and the DS-1 signal consists of twenty-four 64-kb/s data channels multiplexed into a single 1.544-Mb/s data stream. Typically, the 24th channel byte is used for frame synchronization (in addition to the 193rd bit), so only the first 23 bytes in a frame carry customer data.

2.06 The 64-kb/s data rate is called the DS-0 level. Each DS-0 channel can carry customer data from a single 56-kb/s station or from a number of lower rate stations. A DS-0 level signal is divided into two types of signals: DS-0A and DS-0B (paragraph 3.07).

2.07 The digital signal at the customer service (DS-CS) level represents the customer data rate (2.4, 4.8, 9.6, or 56 kb/s).

3. DDS SIGNAL STRUCTURE

A. Customer Stations and Local Loops

3.01 The DDS channel is terminated at the customer location in one of two possible equip-

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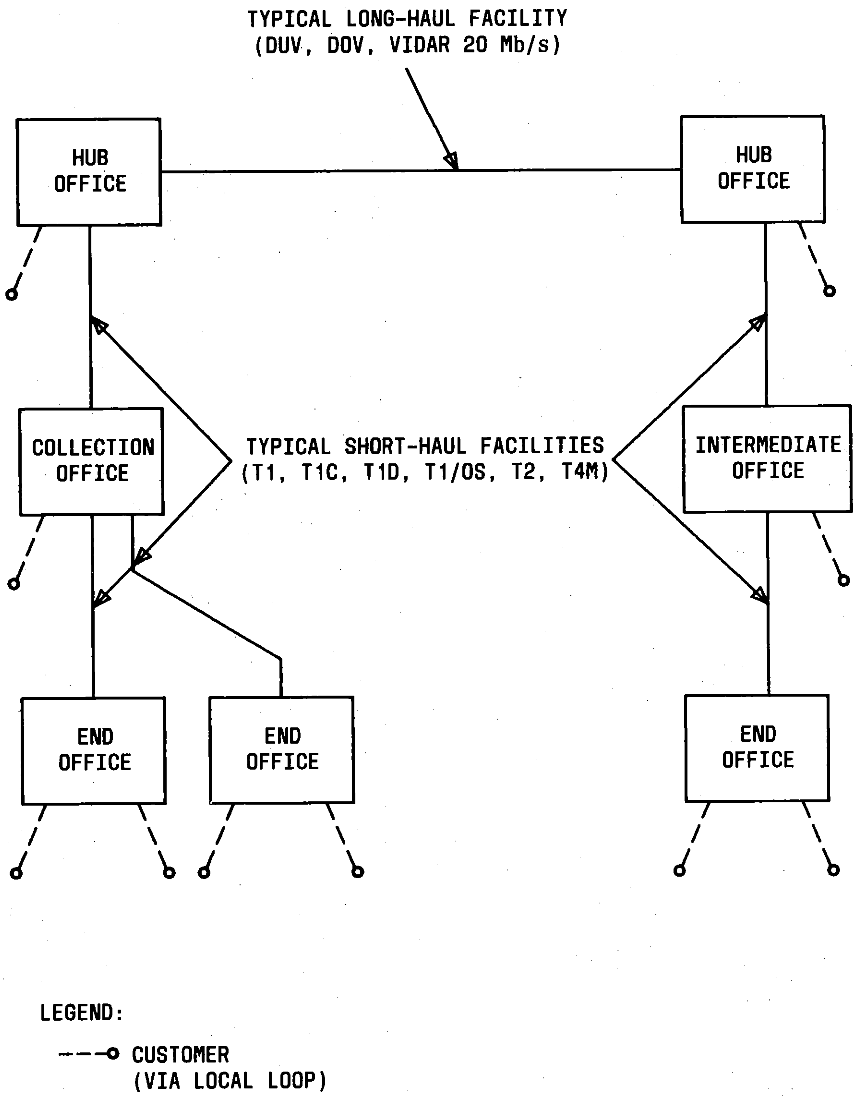


Fig. 1—DS-1 Transmission Facilities

ment arrangements. In one arrangement, the customer provides his own timing recovery and interface circuitry. The DDS provides loop cable equalization and maintenance testing capabilities. In the other arrangement, a single piece of DDS equipment at the customer location provides these functions.

3.02 The connection between the customer and the office is a 4-wire loop. A balanced bipolar signal is transmitted over this local loop. The signal is still at the customer data rate and is in a modified bipolar return-to-zero (BPRZ) format, as shown in Fig. 2A. Signaling capability is provided by transmitting successive pulses of the same polarity, deliberately violating the bipolar encoding rule. This type of signaling is used for two main purposes: (a) to show that a channel is idle and (b) to perform loopback tests over the local loop.

B. Office Channel Terminating Equipment

3.03 ➧In a DDS office, the local loop is terminated by an office channel unit (OCU) or OCU dataport (OCU DP) channel unit that receives data from and transmits data to the customer. The OCU or OCU DP provides byte organization and timing and produces a 64-kb/s (DS-0 level) signal toward the network. A different OCU or OCU DP is required for each customer rate. The output of the OCU toward the network is always in a 64-kb/s bipolar nonreturn-to-zero (BPNRZ) format, as shown in Fig. 2B. The OCU DP output is put into a 64-kb/s time slot of 1.544 Mb/s signal. The OCU is a plug-in unit unique to DDS. The OCU DP is a special services plug-in unit for use in D3 or D4 type channel banks and the remote terminal of a SLC 96 Subscriber Loop Carrier System.◀

3.04 The 56-kb/s customer data stream is divided into 7-bit bytes of information at the OCU. To each of these bytes, one control (C) bit is added, forming a sequence of 8-bit bytes. The control bit is a 1 if the byte contains customer data or a 0 if the byte contains network control information such as the idle code. Since a 56-kb/s data stream is organized into eight thousand 7-bit bytes every second, an extra bit added to each byte means that 8000 additional bits are added to the stream each second. The result is a 64-kb/s (DS-0 level) stream.

3.05 The subrate (2.4, 4.8, and 9.6 kb/s) data streams are organized into 6-bit information bytes. In addition, a zero is added at the front of each byte for later use by a multiplexer and a control bit is added at the end. The subrate byte is then repeated the number of times required to achieve the 64-kb/s rate (a technique known as byte stuffing). For example, at the 9.6-kb/s data rate, 9600 customer data bits are sent toward the network every second. Two bits are added for every six of these to form bytes, a total of 3200 more bits every second. Each byte is repeated five times. The mathematics of this example of byte

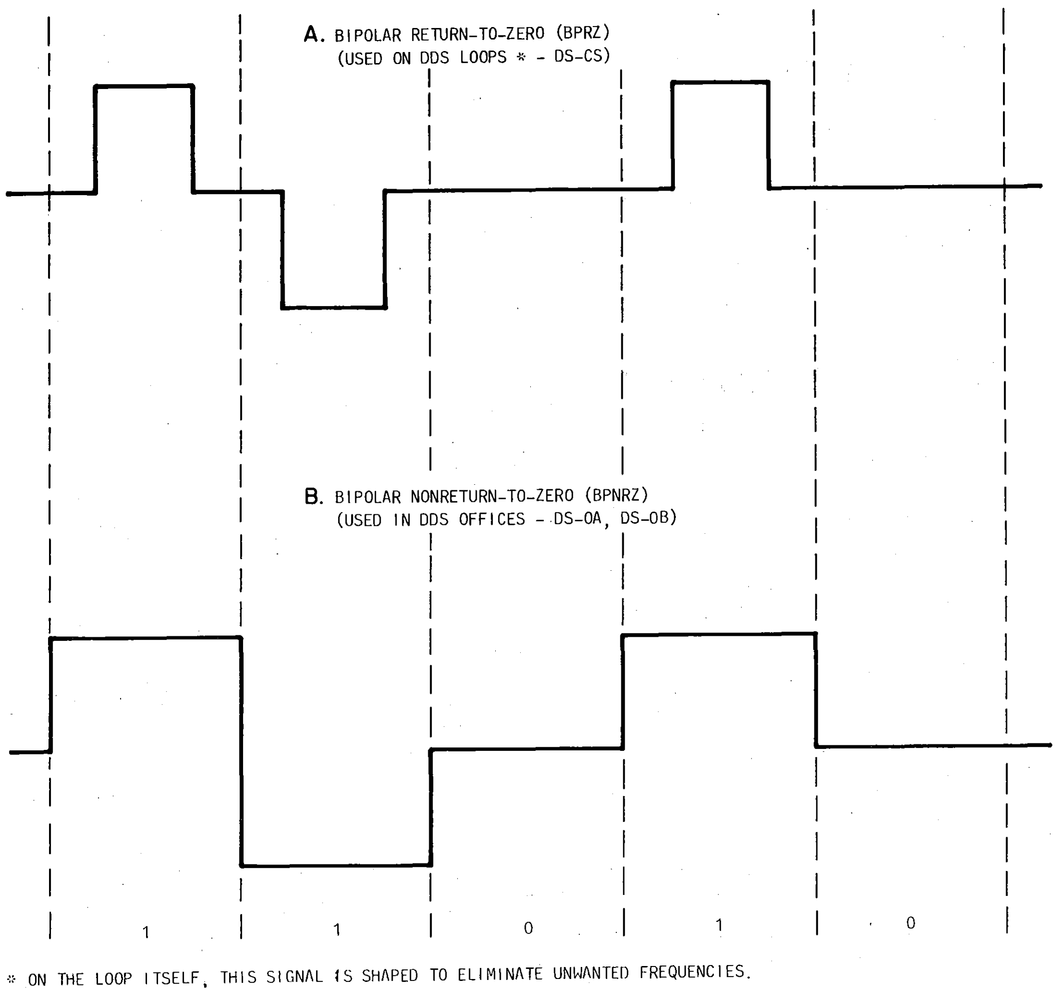


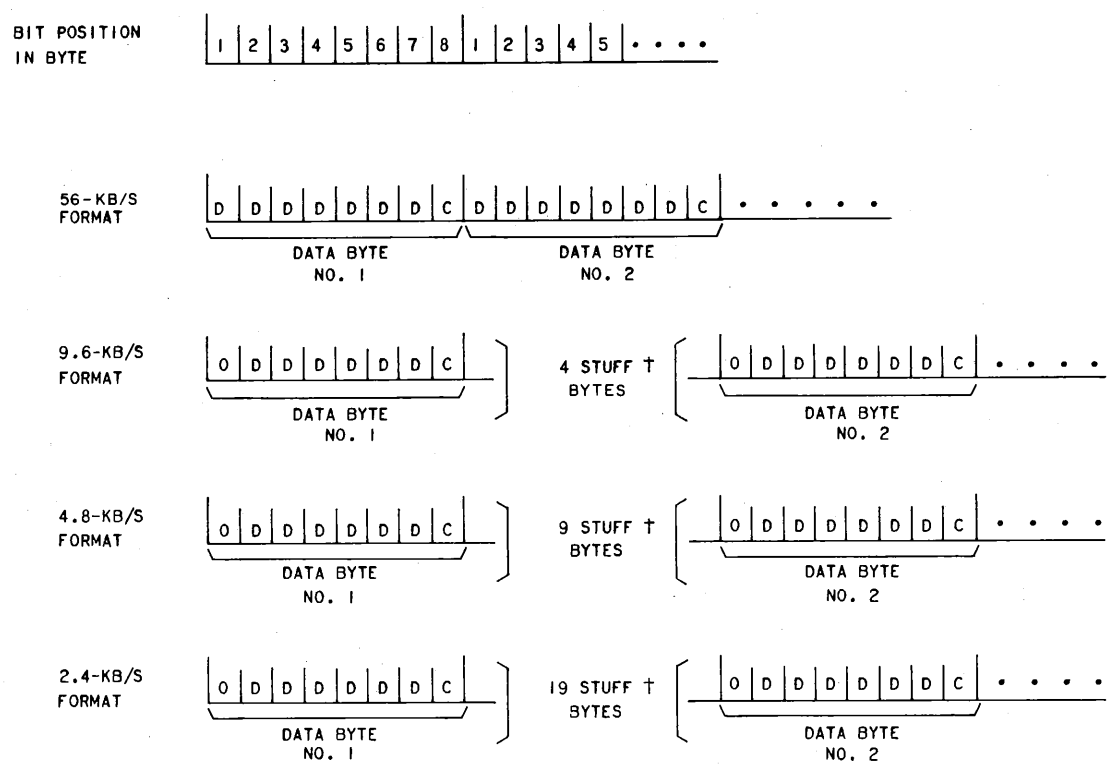
Fig. 2—Bipolar Formats

stuffing is (9600 + 3200) × 5 = 64 kb coming from the OCU or OCU DP every second. Figure 3 shows the output signals of an OCU or dataport channel unit toward the network and illustrates byte stuffing.

3.06 Even after the customer data has been byte stuffed, the information rate is still the same as it was originally. The bytes have merely been repeated the proper number of times (according to customer rate) to achieve a 64-kb/s data stream. The data stream is then at the DS-0A signal level; that is, it contains data from only one customer.

C. First Stage Multiplexing

3.07 ***First*** stage multiplexing is necessary in order to make ***second*** stage multiplexing more efficient. If the 64-kb/s DS-0A signal is formed from a 56-kb/s customer data rate, each byte contains new customer data. The 8000 bits added each second to the 56-kb/s customer data rate are all supervisory bits. None of the customer bytes are repeated; and a DS-0A signal that contains the 56-kb/s customer rate bypasses first stage multiplexing, since it is already carrying the maximum amount of customer information. The DS-0A signals formed from subrate customer inputs (2.4, 4.8, and 9.6 kb/s) use byte stuffing to reach the 64-kb/s rate. Table A shows the number of times each subrate information byte is repeated to form a 64-kb/s signal. For example, a 2.4-kb/s information byte must be repeated 20 times each second to reach the DS-0A level. The first stage multiplexer time division multiplexes 20 different DS-0A signals into a single DS-0B signal that contains 20 different 2.4-kb/s information bytes. Therefore, a DS-0B level signal could contain data from as many as 20 custom-



C-CONTROL BIT *
D-DATA BIT

* THE CONTROL BIT IS A LOGICAL 1 IF THE BYTE CONTAINS CUSTOMER DATA, AND A LOGICAL 0 IF THE BYTE CONTAINS CONTROL INFORMATION (FOR EXAMPLE, CONTROL INFORMATION INDICATING IDLE CODE IS 1111110).

† A STUFF BYTE IS A REPETITION OF THE PREVIOUS DATA BYTE (IE, DATA BYTE NO. 1 IS REPEATED THE NUMBER OF TIMES INDICATED).

Fig. 3—Output Signals of OCU or DP Channel Unit Toward Network

ers. The numbers in Table A also represent how many subrate channels can be multiplexed together by the first stage multiplexer.

TABLE A

BYTE STUFFING

DATA RATE (KB/S)	NUMBER OF BYTE(S) REPEATED IN DS-0A SIGNAL
56	1
9.6	5
4.8	10
2.4	20

3.08 To achieve maximum packing efficency, a different multiplexer is required for each subrate. Because of the uniform 64-kb/s data stream coming from the OCU or OCU DP, however, a first stage multiplexer can accept data at a rate lower than or equal to its designated capability. A 9.6-kb/s multiplexer, for example, can accept 2.4- or 4.8-kb/s data streams, but at a loss in efficiency, since it can accept no more than five channels even at the lower rates. Accordingly, two different subrate multiplexers may be employed: (a) a multiplexer that is arranged to operate at any of the subrates and therefore, efficiently packs together the maximum number of subrate channels and (b) a multiplexer that accepts a limited number of subrate channels. The latter is physically integrated with the OCU equipment, whereas the former is physically separate.

D. Second Stage Multiplexing

3.09 Second stage multiplexing integrates the DS-0 signal into the hierarchy of Bell System digital transmission equipment. The output of this multiplexing stage is a 1.544-Mb/s bit stream. The output signal is at the DS-1 level in the digital hierarchy.

3.10 Multiplexing from the DS-0 signal to the DS-1 signal can be accomplished by two different types of multiplexers. The ***first type of multiplexer*** accepts a maximum of twenty-three 64-kb/s data streams and selects one 8-bit byte from each in succession. A 24th byte and a single additional bit, which together are used for synchronization, are then added to form a standard T1 frame of 193 bits (Fig. 4). Eight thousand of these frames are placed on the line every second, resulting in a 1.544-Mb/s bit stream.

3.11 If channel 1 of the T1 frame carries a 56-kb/s customer, the customer data appears in the channel 1 slot every frame. If channel 1 contains a subrate customer, the data appears in the channel 1 slot once every 5, 10, or 20 frames, depending on the rate. For example, the data from a 9.6-kb/s customer appears every fifth frame. The other four frames contain data from four other 9.6-kb/s customers in that slot. As shown in Fig. 4, a subrate data byte contains six information bits. One 9.6-kb/s customer has 6 information bits every 5 frames, resulting in 6/5 information bits per frame. At 8000 frames per second, the resulting data rate is $8000 \times 6/5$, or 9.6 kb/s. Thus, the two multiplexing stages do not alter the customer data rate; rather, they simply "pack" many customers together on a single line to achieve a more efficient transmission of data. Table B shows the maximum number of customer data channels of each rate that can be multiplexed at the DS-1 signal level with this type of multiplexer.

3.12 The ***other type of multiplexer*** used in second stage multiplexing constructs the T1 signal in basically the same manner as the first. Here, however, the T1 frame may carry simultaneously data channels and pulse code modulation (PCM) voice channels received from a D1D, D2, D3, or D4 channel bank. This multiplexer is used only in the metropolitan area, not on long-haul facilities.

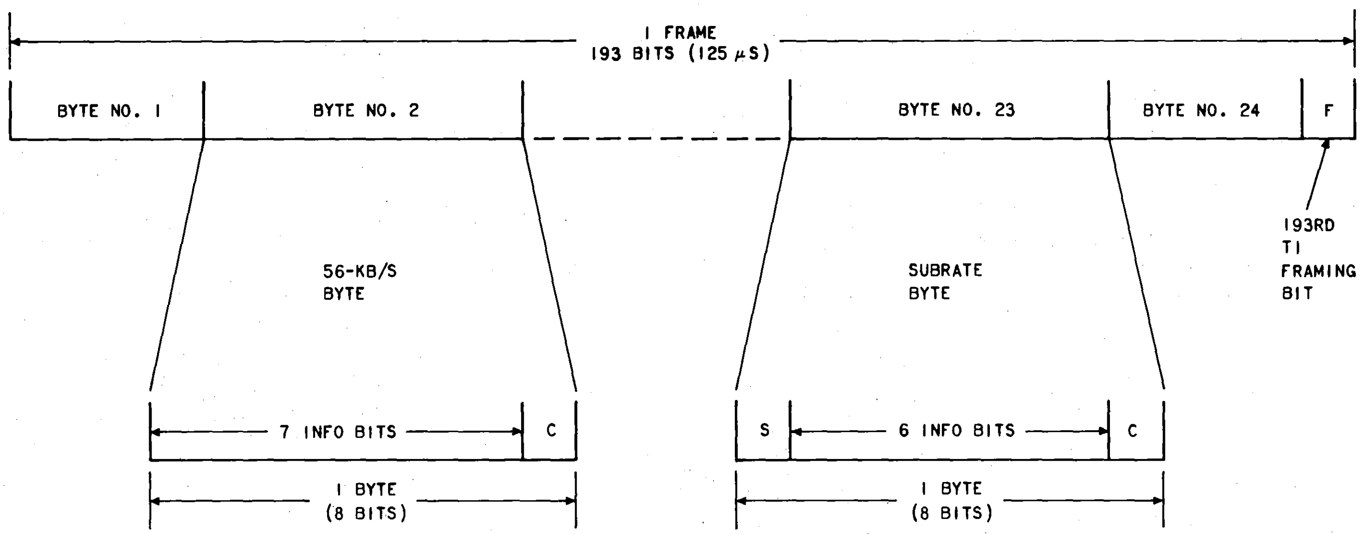
4. NETWORK STRUCTURE

A. End-to-End Connection

4.01 The overall DDS network structure extends from customer interface to customer interface, as shown in Fig. 5. A 4-wire local loop connects the customer to a DDS office. This office may be any of the offices shown in Fig. 5, depending on its location in the serving area. The customer signal may be multiplexed with other customer signals. Assuming the receiving customer is in a distant digital serving area (DSA), the multiplexed signal is sent over long-haul facilities and possibly short-haul facilities at each end. Then, the multiplexed signal undergoes the reverse process (demultiplexed) and is routed to the proper customer over a local loop.

B. Long Haul

4.02 A 3-level hierarchy for intercity circuit routing is employed in the DDS. Sufficient de-



F-BIT: USED BY SECOND STAGE MULTIPLEXER TO RECOGNIZE BYTE POSITIONS.
S-BIT: USED BY FIRST STAGE MULTIPLEXER TO RECOGNIZE BYTE POSITIONS.
C-BIT: USED TO SATISFY TI 1s DENSITY OR TO INDICATE A CONTROL CODE.
56-KB/S BYTE: CARRIES 7 CUSTOMER BITS PER FRAME EVERY FRAME.
SUBRATE BYTE: CARRIES 6 CUSTOMER BITS PER FRAME EVERY 5, 10, OR 20 FRAMES WHEN FIRST STAGE MULTIPLEXING IS USED. IF NOT USED, SUBRATE BYTE APPEARS EVERY FRAME.
FRAME RATE: 8000 FRAMES/SECOND

Fig. 4—Frame of T1 Data Stream

TABLE B

EFFECT OF MULTIPLEXING

DATA RATE (KB/S)	MAXIMUM NUMBER OF CHANNELS AT DS-1 SIGNAL LEVEL
56	23
9.6	115
4.8	230
2.4	460

mand between any pair of locations results in an express path between those locations, but all other circuits are routed through the hierarchy to improve the utilization of facilities. As shown in Fig. 6, each class 3 (metro) city has a single class 2 (sectional) city to which it routes all nonexpress circuits. Similarly, each class 2 city has a single class 1 (regional) city to which it routes all nonexpress circuits.

4.03 Long-haul transmission for the DDS is at the DS-1 level in the digital hierarchy. ➧Typical long-haul facilities (Fig. 1) include data under voice (DUV) on TD2, TD3, or TH radio, data over voice (DOV) on L4/L5 cable, and TRW Vidar 20 Mb/s using DM-12A terminals on TD-2 radio.

C. Digital Serving Area

4.04 A DSA for the DDS is a geographical area, usually metropolitan, defined in the appropriate tariff. Typical short-haul facilities (Fig. 1) are used between DDS offices within a DSA. The DDS

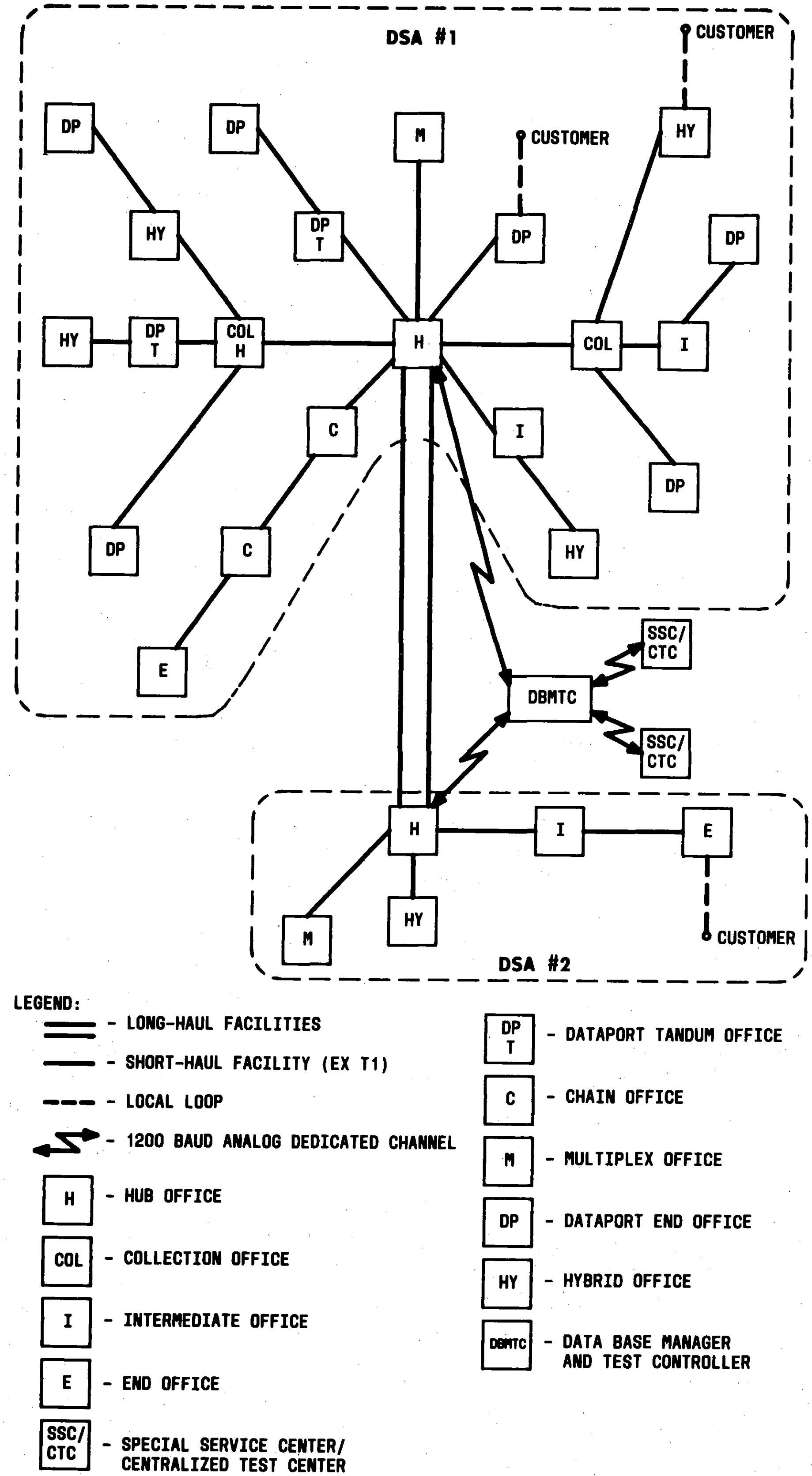


Fig. 5—Overall DDS Network Structure (Simplified)

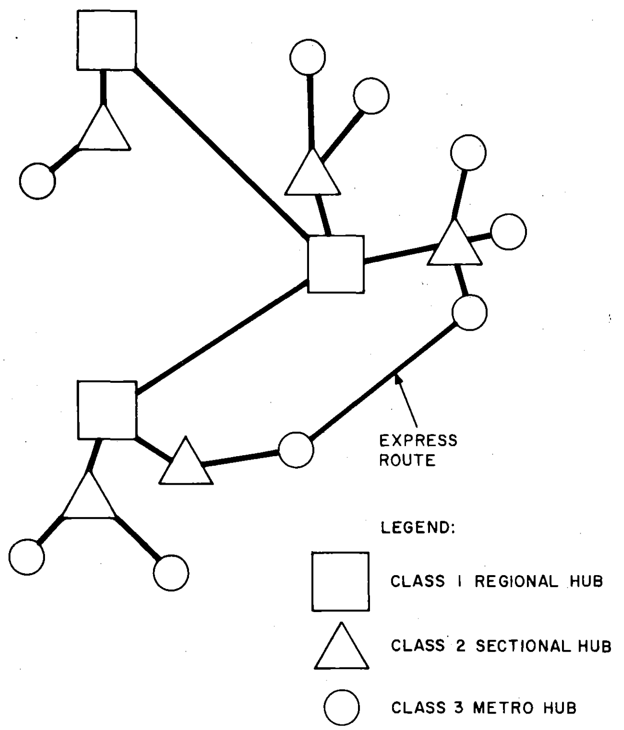


Fig. 6—Diagram of DDS Long-Haul Routing Structure

offices depicted in Fig. 5 serve as circuit concentration points which provide efficient fills of facilities. By aligning these offices within the DSA and between DSAs, certain basic structural names are created, such as hub office, collection office, intermediate office, and end office.

4.05 The DDS offices use many different equipment arrangements that result in different names for these offices. The equipment names along with the structural names associated with DDS offices create considerable confusion. To help alleviate this confusion, the following paragraphs define the more common office names.

4.06 Hub offices are distinguished in two different ways to identify their important characteristics: (a) position in the long-haul routing hierarchy and (b) DSA function. The hub office serves as the cross-connect and testing point for circuits that have end points in their serving area. It also serves as a concentration point for the efficient packing of data streams that are transmitted over long-haul facilities. The hub office is the interface between the DSA and the long-haul facilities. Customer circuits are routed to the hub individually over 4-wire local loops or in multiplexed streams over short-haul facilities from other offices. Multiplexed customer streams are necessary because the radius of a DSA often exceeds the range of the local loops.

4.07 A ***hub office*** multiplexes, demultiplexes, and provides manual testing or remote access testing. Manual testing is provided by a 950A testboard or Bit Access Test System (BATS). The BATS is also known as a KS-21899 data test system. Remote access testing is accomplished by using the Automated Bit Access Test System (ABATS) and Automated Line Access Test System (ALATS). The ABATS/ALATS is remoted to a data base manager and test controller (DBM and TC) and receives commands from a Special Service Center/Centralized Test Center (SSC/CTC). A hub office that provides DDS testing assumes the administrative and maintenance responsibilities as specified in Section 660-230-100.

4.08 All DDS hub offices were originally intended to have testing capability, but some hubs function more like an intermediate office with respect to customers and circuit fill. These hubs are called skinny hubs. The DDS circuits in the skinny hubs are tested from another hub office by back-hauling these circuits. Back-hauling will continue until such time as a skinny hub can justify the expense of providing circuit testing capability.

4.09 A ***collection office*** and an ***intermediate office*** serve as concentration points for the efficient packing of data streams that are sent to a hub office. Both offices may receive data streams over short-haul facilities and local loops. A collection office is connected to other DDS offices (more than one). An intermediate office is connected to only one end office. Neither a collection office or an intermediate office has circuit testing responsibility.

4.10 An ***end office*** passes on toward the hub office circuits that entered that office over local loops. A large end office has the potential of becoming an intermediate or collection office because it contains the same type of equipment.

4.11 Offices within a DSA are linked together in tree-like structures to achieve efficient fills of the short-haul facilities. These offices may be associated with other office terms, such as dataport, chain, hybrid, and multiplex, depending on their equipment in providing digital data service.

(a) A dataport office is an office serving local customers and employing carrier systems equipped with dataport channel units for its interoffice facilities. The carrier systems at the present time encompass a digital transmission system using the D3 and D4 channel banks and a SLC 96 Subscriber Loop Carrier System.

(b) A dataport tandem office uses D3 or D4 channel banks configured back to back. These banks are equipped with DS0-DP channel units. This configuration functions like an intermediate or collection office, depending on the number of end offices feeding the tandem office.

(c) A multiplex office is an office having two stages of multiplexing. The first stage may use integrated submultiplexers, and the second stage uses T1DM, T1WB4, or T1WB5 to extend dataport facilities.

(d) A hybrid office is an office in which signals from several local customers are multiplexed together. The resulting DS-0 level signal is fed over dataport facilities toward the hub. The office thus uses a hybrid of conventional DDS and dataport techniques.

(e) A chain office is an office equipped with a T1WB4 or T1WB5 that is operated in the chained data mode. Additional DS-0 signals may be added to the DS-1 signal at the chain office. No more than two chain offices should share a single short-haul facility.

4.12 The offices in the DSA can be arranged in two possible configurations:

(a) The star configuration uses no collection or intermediate offices. All short-haul facility connections go from the hub office directly to an end office. This arrangement is used in areas where large numbers of customers can be reached by local loop from an end office.

(b) The collection or concentration point configuration uses collection or intermediate offices to achieve more efficient facility fills. In this arrangement, end offices are connected to a collection or intermediate office in a star-like manner and the collection or intermediate office is in turn connected to the hub office in a star-like manner.

D. Local Loops

4.13 The customer location and the DDS office are normally connected by a 4-wire nonrepeatered local loop. If, however, the customer location is beyond the maximum range of the nonrepeatered loop, other arrangements must be used. For 56-kb/s customers only, regenerative repeaters can be used to extend the range of the 4-wire loop. Another possible arrangement is off-net extensions. Some local loops are routed through a non-DDS serving office (called a baseband office) and then over interoffice cable to a DDS office.

E. Off-Net Extensions

4.14 The DSA for the DDS is defined in the appropriate tariffs. Customers served by end offices located within the DSA receive on-net DDS service. If a customer is located outside an area defined by the tariff, DDS service may be provided in one of two ways: (1) the present tariff can be supplemented to add the central office which serves the customer, or (2) service may be provided from a present DDS hub office using an off-net extension. Off-net extensions connect to the DDS only at hub offices and are available in a single circuit or a multiple circuit arrangement.◆ A typical arrangement is shown in Fig. 7. The subrate configuration (Fig. 7A) uses analog data sets. The off-network extension bay requires "essential" ac power, that is, power that can be switched either automatically or manually to a backup source. A buffer device, the 831A data auxiliary set, provides the interface with the DDS. The 56-kb/s configuration (Fig. 7B) makes use of a digital data group terminal (DDGT) over analog facilities. Testing access to the analog connection is provided from an analog test center.

5. EQUIPMENT FUNCTIONAL DESCRIPTION

A. Introduction

5.01 Figure 8 shows an example of the DDS office structure in a DSA, including the equipment that the offices may contain. In one DSA, the customer signal is multiplexed with others and sent over long-haul facilities to another DSA, where it is demultiplexed and routed to the proper point.

B. Customer Stations

5.02 The data service unit (DSU) provides the following: a complete customer interface, including clock recovery, regeneration, network protection, loop cable equalization, maintenance testing capability, and the circuitry necessary to transfer the customer signals to and from the DDS network.

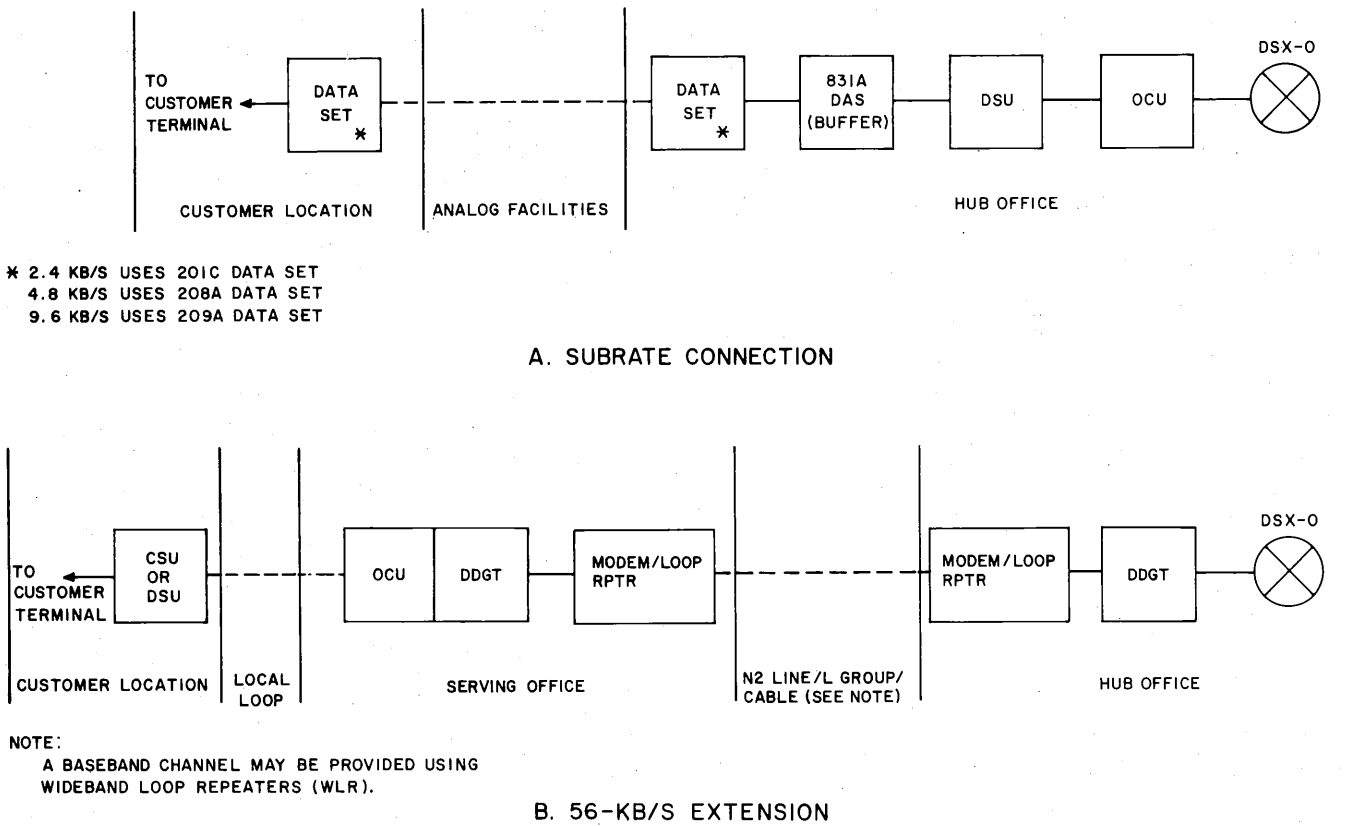


Fig. 7—DDS Off-Net Extensions

5.03 The transmit section of the DSU samples and encodes the serial data coming from the customer into a modified bipolar format. Sequences of six or seven consecutive 0s in the data stream, depending on service rate, are replaced with zero suppression codes. The signal is finally converted into a balanced, limited, bipolar signal and is transmitted to the local loop through a line-coupling transformer and a lightning protection arrangement.

5.04 The functions performed by the DSU in the receive direction are slightly more complex than those in the transmit direction. Loss is added to the signal path to compensate for differences in local loop length. The signal is filtered, equalized, and amplified to overcome transmission loss. Clock recovery circuitry derives a sampling clock from the received signal. This clock is used to regenerate the incoming bipolar pulses. The regenerated data stream is examined for a zero suppression code or for one of the network control codes. If a zero suppression code is detected, the code is replaced by the appropriate 0s. If a network control code is detected, the appropriate indication is given to the customer.

5.05 The channel service unit (CSU) provides data terminal access to a DDS channel at a 4-wire balanced interface. The CSU provides network protection, equalization, and maintenance access. The customer must provide his own clock recovery, interface circuitry, regeneration, and bipolar signal encoding and decoding.

C. Office Equipment

OCU and Integral Subrate Multiplexer (ISMX)

5.06 The OCU terminates the local loop in the DDS office. It receives data at the customer data rate and provides a 64-kb/s output signal toward the network. This signal is organized into 8-bit bytes.

5.07 Timing signals of 64- and 8-kHz pulse streams are passed to all OCUs within an office from the office clock system. These signals are the office bit and byte rates, respectively.

5.08 The receiving section of the OCU first equalizes, filters, and amplifies the signal from the loop to provide a standardized line signal. Then it retimes the received signal with the 64- and 8-kHz clocks to convert these signals to the byte-organized "universal" office format (paragraphs 3.03 through 3.06).

5.09 The transmit section of the OCU formats data coming from the network into the basic data rate of the customer for transmission over the local loop. It performs the same function on control codes coming from the hub office and going to the customer DSU or CSU. The signal is level-controlled and shaped before being sent over the loop.

5.10 Included in the OCU shelf is a driver-terminator (D-T) circuit which provides a direct interface between the OCU and the subrate data multiplexer (paragraph 5.12). In some offices, subrate multiplexing is accomplished by replacing the D-T circuit with an ISMX. The ISMX provides a direct interface between the OCU and the second stage multiplexer (paragraphs 5.17 and 5.20) and also provides splitting jack access to the individual signals.

5.11 The ISMX is available in a 5-channel and a 10-channel arrangement. Both arrangements are more economical in some offices than a subrate data multiplexer (SRDM). The 5-channel ISMX can multiplex a maximum of five subrate channels into a 64-kb/s data stream and will accept any subrate data stream of 2.4, 4.8, or 9.6 kb/s. It does not have a performance monitor or a spare. The 10-channel ISMX can multiplex a maximum of ten subrate channels into a 64-kb/s data stream and will accept up to ten 2.4-kb/s or 4.8-kb/s channels. The rates can be mixed. It is protected by internal duplication and by alarms.

Dataport Channel Units

5.12 ♦There are two types of dataport channel units: the OCU and the DS0. The OCU DP terminates the local loop in a DDS dataport end office. It receives data at the customer data rate and provides a 64-kb/s signal toward a DS0 DP located in a DDS intermediate, collection, or hub office. The DP plugs into a channel unit position of a D3 or D4 channel bank or SLC 96 subscriber loop carrier access system bank. The DP processes a DDS digital input and inserts it into the T1 digital line (or in the case of a D4 bank using T1C or T2) by action of properly optioned common bank equipment. Specific changes to the common equipment and DDS timing are described fully in the following Sections:

- 365-150-107—D3B Channel Bank, Dataport Operation
- 365-170-120—D4 Channel Bank, Dataport Channel Unit Description
- 363-202-400—Central Office Terminal, SLC-96 Subscriber Loop Carrier System
- 363-202-401—Remote Terminal, SLC-96 Subscriber Loop Carrier System♦

SRDM and Subrate Performance Monitor (SPM)

5.13 The SRDM is a synchronous time division multiplexer, the output of which is a 64-kb/s data stream efficiently packed with information for second stage multiplexing. The 2.4-kb/s SRDM can multiplex up to 20 channels; the 4.8-kb/s SRDM, up to 10 channels; and the 9.6-kb/s SRDM, up to 5 channels.

5.14 The SRDMs are byte oriented. Each channel port is sequentially scanned, and one byte is multiplexed onto the 64-kb/s line. A zero appears in the first bit position of each byte coming from the OCU or DP. The SRDM uses this position to insert multiplex framing bits. Each subrate has a different framing pattern.

5.15 At the same time as it multiplexes, the SRDM demultiplexes an incoming 64-kb/s data stream for distribution to individual customers or to multipoint junction units (MJUs) for multipoint service (paragraph 5.39 and Part 8). The framing bits inserted into the bytes by the SRDM at the far-end allow the demultiplexer to identify the byte of each channel. Individual channel outputs from the SRDM are sent to the appropriate OCUs, DS0 DPs, or MJUs.

5.16 The SPM (data multiplexer) can scan a maximum of 48 SRDM terminals and a spare about once every 1/2 second. If equipment is installed, the SPM determines the data rate and then tests for proper framing and data transmission in both directions. It passes on to the next terminal if all tests are

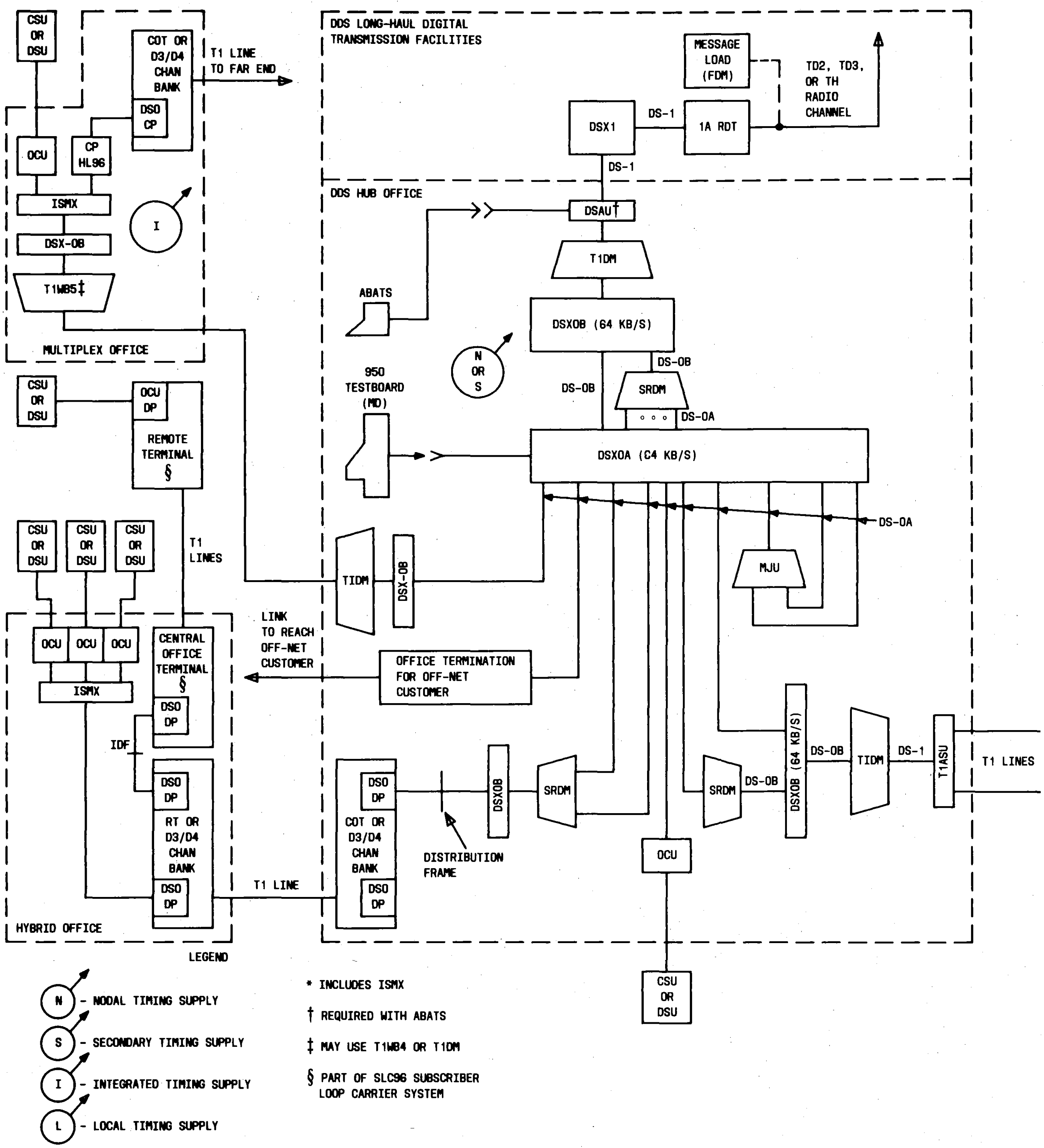


Fig. 8—Example of DSA Structure (Sheet 1 of 2)

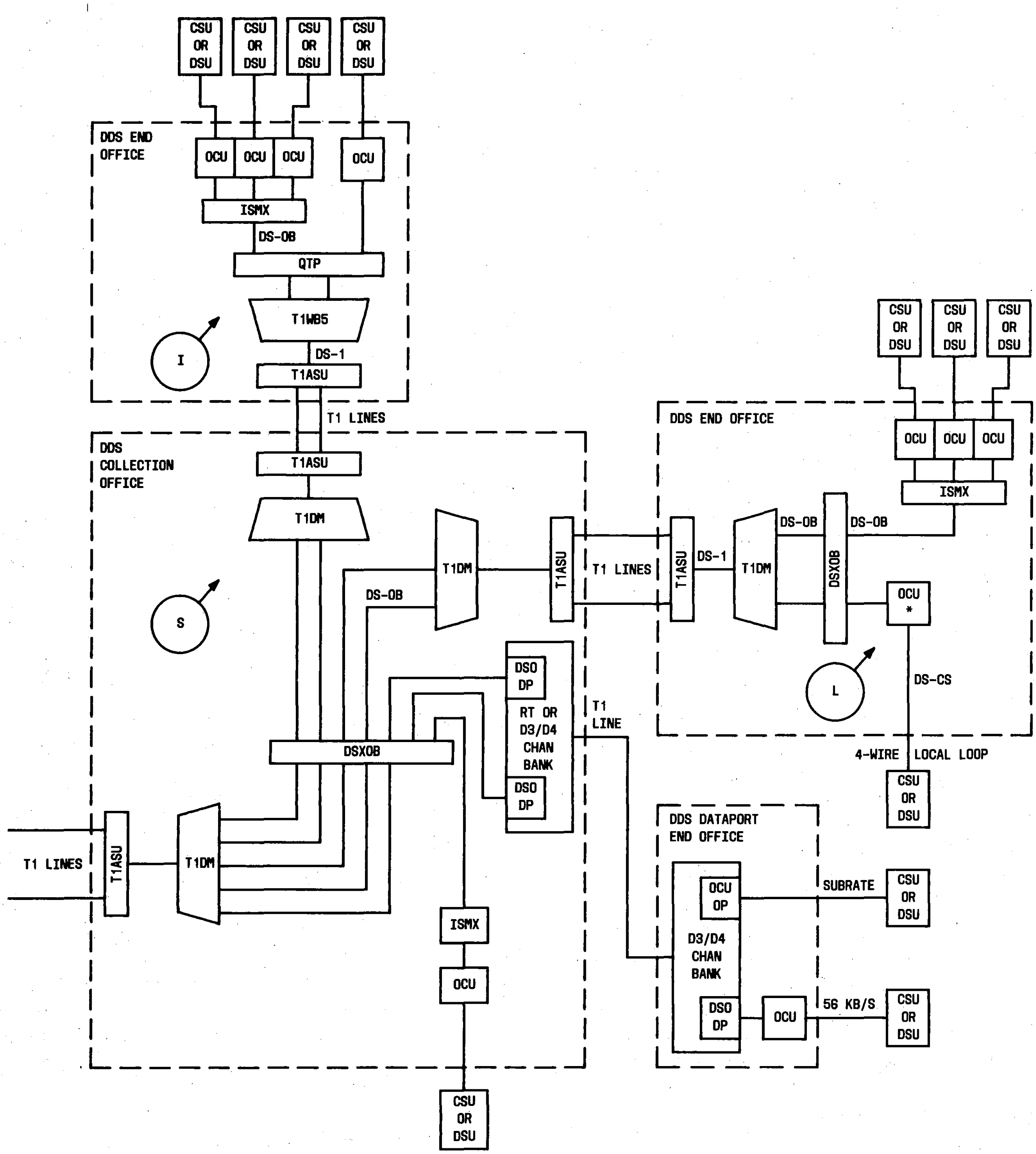


Fig. 8—Example of DSA Structure (Sheet 2 of 2)

normal. If a protection switch is needed, the SPM automatically provides the proper rate spare, lights an alphanumeric display to assist in troubleshooting, and actuates an office alarm.

T1DM and T1DM-PM

5.17 The T1 data multiplexer (T1DM) can multiplex a maximum of 23 DS-0 signals with a synchronization byte and with a single framing bit into a 1.544-Mb/s data stream. It has 23 input ports, each of which can accept a 64-kb/s data stream (composed of byte-stuffed subrate data, multiplexed subrate data, or 56-kb/s data). One byte from each incoming stream is selected in succession at each port. The bytes are arranged into the standard 193-bit frame format used on T1 digital lines. To build a complete frame, the 23 data bytes are combined with a single "sync byte" and a single framing bit, which are used in combination to furnish synchronization information to the receiving T1DM. The frames are then applied to the T1 digital line at a rate of 8000 frames per second to achieve the 1.544-Mb/s line rate.

5.18 The T1DM uses the 64-kHz office clock for sampling the 64-kb/s data signal and the 8-kHz clock to indicate the control bit in the byte. For the demultiplexer to present incoming data at the right time, the phase of the office clock and of the incoming T1 digital line frame must be uniquely related. The T1DM contains a variable 256-bit buffer called the elastic store to provide a means for aligning the incoming data stream with the office clock. Thus, the demultiplexer input (output of the elastic store) and the multiplexer output are in phase, since both have the same relation to the office clock.

5.19 The T1DM has a performance monitor (T1DM-PM) located in the office bay equipment. The T1DM-PM can scan a maximum of 16 T1DMs, including a spare, as well as itself about once every 1/2 second. If the data flow is abnormal, the T1DM-PM automatically switches to the spare, lights an alphanumeric display to assist in troubleshooting, and actuates an office alarm.

T1WB4 and T1WB5

5.20 The T1WB4 data-voice multiplexer (T1WB4) permits the efficient use of a digital carrier by allowing data and PCM voice from a D1D, D2, D3, or D4 channel bank or central office terminal (COT) of a SLC 96 Subscriber Loop Carrier System to be multiplexed together. It can, however, operate in the absence of D banks. A maximum of 12 data (DS-0) channels may be multiplexed into a 1.544-Mb/s stream, and the PCM voice channels may occupy the remaining slots (total capacity of 24 channels). An unassigned channel code is sent over any unused channels. The DS-1 stream produced is in the regular 193-bit T1 format. Data bytes and voice bytes may appear in any preselected order.

5.21 ➧The T1WB5 data-voice multiplexer (T1WB5), like the T1WB4, can multiplex data and PCM voice from a D-type channel bank or a COT of a SLC 96 Subscriber Loop Carrier System together on a T1 line. The T1WB5, however, is usually used to multiplex a maximum of 23 data channels into a 1.544-Mb/s stream.➧

5.22 A T1WB4 or T1WB5 can, with an extra circuit pack, generate a T1 bit stream that can be terminated in a T1DM. The circuit pack, called a byte framing generator, is inserted into the 24th channel and generates the same bit pattern as the T1DM. In this arrangement, the maximum number of data channels is 23 and voice sharing is not possible. This is the normal use of the T1WB5.

5.23 Like the T1DM, the T1WB4 and T1WB5 use a 64-kHz clock signal for sampling and an 8-kHz clock signal to identify the eighth bit of each byte. They also have elastic stores that enable the demultiplexer to present the data to the output when the 64- and 8-kHz clock signals dictate.

5.24 The T1WB4 and T1WB5 contain 1-for-1 automatic protection spares for common equipment circuits and an alarm control unit (ACU) that indicates the status of these circuits and of all incoming and outgoing DS-1 signals. A failure in the common circuitry causes an automatic switch to spare common circuitry. In a data-voice mode, a failure in the incoming voice signal causes an automatic switch to an independent data mode of operation to maintain data service.

Cross-Connects and Panels

5.25 At end and intermediate offices, subrate data and 56 kb/s data connect to a panel. This panel serves as a test access point for portable test sets and as a connecting point between the OCU and the first stage multiplexer. The panel may be a subrate data multiplexer jack and connector panel (SM-JCP), a multiplexer jack and connector panel (M-JCP), or a quad terminal panel (QTP). The last two panels are preferred because end offices use ISMX to M-JCP instead of SRDM to SM-JCP. An end or intermediate office using a T1DM (J70177A) bay may be connected to a QTP.

5.26 After first stage multiplexing (ISMX), 56-kb/s data and subrate data are connected to an M-JCP. The M-JCP provides test access to each multiplexer port and serves to connect the ISMX or OCU to the second stage multiplexer or back-to-back channels between two second stage multiplexers or both.

5.27 The M-JCP is used in end and intermediate office bay arrangements that contain T1DMs, T1WB5s, and T1WB4s. The QTP is the same as used in the digital system cross-connect (DSX-0) for use in T1WB5 and T1DM bay arrangements.

5.28 In hub offices, the DSX-0A provides routing for subrate data signals to the appropriate SRDM and 56-kb/s data signals to the DSX-0B. The DSX-0B connects T1DM, T1WB5, and T1WB4 ports with SRDMs and connects ports together for through or bypass circuits. Because of the universal 64-kb/s DS-0 signal, identical hardware can be used for the DSX-0A and the DSX-0B. However, any disturbance of the signals appearing at the DSX-0B can affect many customers, whereas appearances at the DSX-0A are typically dedicated to only one customer. Dataport signals can come in mixed and appear at the DSX-OA.

5.29 The QTP, which is one panel of a DSX-0, provides routing of 64-kb/s DS-0B level signals to the ports of a T1WB5. The QTP allows for T1WB5 port selection but does not provide monitoring or test access.

5.30 When traveling from one office to another, the DS-1 signal leaves one office and enters the next office through a digital cross-connect for the DS-1 level (DSX-1 or equivalent). The DSX-1 serves as an interconnection point and provides monitoring and splitting test access to DS-1 channels.

➧Testing

5.31 A hub office has DSX-0A access and test capability for customer circuits in a DSA. The hub office test arrangement may be a 950A testboard, KS-21899 data test system (also called bit access test system), or an ABATS with ALATS. The ABATS has DSX-1 access in addition to DSX-0A access. The DSX-1 access is accomplished by using digital signal level 1 access units (DSAUs).

5.32 The 950A testboard (manufacture discontinued) contains a jack field, telephone circuits, a digital transmitter, and a digital receiver capable of sending and receiving synchronized digital signals.

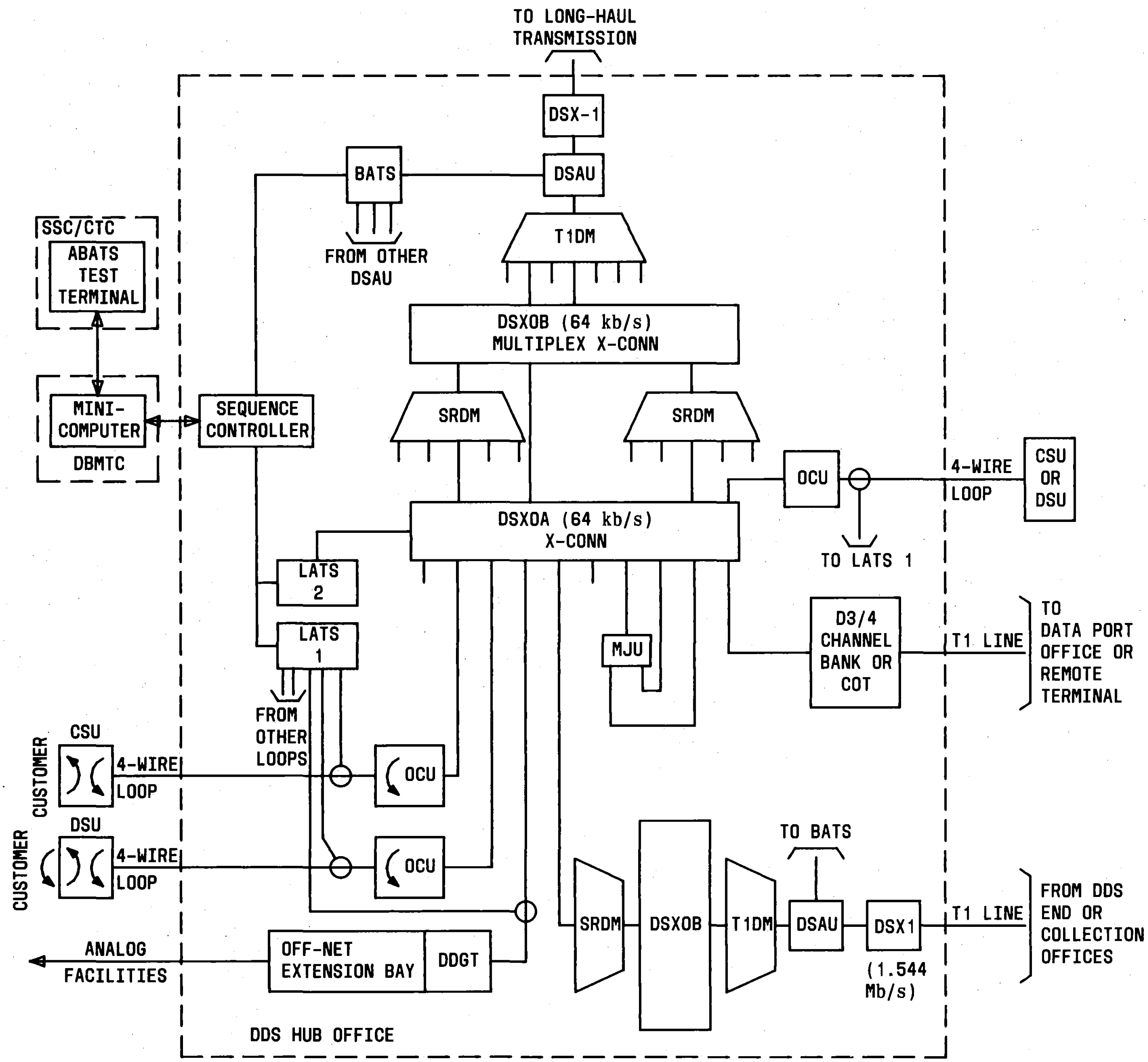
5.33 The ABATS has remote testing access from an SSC/CTC which is located away from a hub office. An SSC/CTC has testing responsibilities for more than one hub office. The model 40 test terminal, minicomputer, and ABATS equipment at the hub office are interconnected by 1200-baud analog dedicated channels. A block diagram of this arrangement is shown in Fig. 9.➧

Timing Supplies

5.34 Each office in the DDS contains a timing supply to provide timing information (both byte and bit timing) to all other DDS equipment in the office. The nodal timing supply (NTS) is normally used in hub offices. The secondary timing supply (STS) may be used in hub, intermediate, or large end offices. Small end or chain offices use the integrated timing supply (ITS) associated with the T1WB4 or T1WB5. Other offices in the DDS contain the local timing supply (LTS) in T1DM bay arrangements.

5.35 ➧The ED-73669-30 G1 composite clock cross-connect panel assembly provides the capability of cross-connecting DDS clock to D3 and D4 channel banks on an as-needed basis. A group of timing taps is cabled from the office timing supply (OTS) to this small cross-connect field assembly. Each channel bank bay is cabled to the ED-73669-30 assembly. In this way, entire bays can be prepared to receive timing, with those later needing timing to be cross-connected quickly to meet customer service intervals. This method is crucial when it is necessary to conserve timing taps. Such cases are (a) when using an LTS with 42 taps or an integrated timing supply with 6 taps, (b) when there are many DDS bays which are using CP HL49 that requires two timing taps for each DDS bay, and (c) when there are large numbers of D3 and/or D4 bays.

5.36 The ED-73669-30 assembly is mounted in the D-bank area, such as a miscellaneous bay or at the top of the DSX-1 bay. The DSX-1 bay is electri-



LEGEND:

ABATS - DDS AUTOMATED BIT ACCESS TEST SYSTEM
BATS - BIT ACCESS TEST SYSTEM MEARSURES DIGITAL TRANSMISSION PARAMETERS TO AND FROM NEAR AND FAR CUSTOMER LOCATIONS
CSU - CHANNEL SERVICE UNIT
DSAU - DIGITAL SIGNAL LEVEL 1 ACCESS UNIT
DSX - DIGITAL SIGNAL LEVEL 1 CROSS CONNECT
LATS - LINE ACCESS TEST SYSTEM MEASURES VOLTAGE, RESISTANCE, AND CAPACITANCE OF 4-WIRE LOOP
MJU - MULTIPORT JUNCTION UNIT
OCU - OFFICE CHANNEL UNIT
SRDM - SUBRATE DATA MULTIPLEXER
T1DM - T1 DATA MULTIPLEXER
SSC - SPECIAL SERVICE CENTER
CTC - CENTRALIZED TEST CENTER
DBMTC - DATA BASE MANAGER AND TEST CONTROLLER
COT - CENTRAL OFFICE TERMINAL OF SLC96 SUBSCRIBER LOOP CARRIER SYSTEM

Fig. 9—Block Diagram of Hub Office Using ABATS

cally compatible and in an area where each jumper is handled with extra caution because each jumper carries multiple circuits. The ED-73669-30 assembly is capable of the same output as the DDS timing bay, plus 180 channel-bank bays. Also, it can be expanded to 180 more bays.

5.37 Timing to the channel banks uses one tap per 11-foot bay, not per bank or per digroup. Timing is multipled to all banks in the bay, so each tap appears at up to 7 digroups on D3 banks or 12 digroups on D4 banks. Nondataport banks in the bay have timing available but simply don't use it.◀

T1ASU

5.38 The T1 automatic standby unit (T1ASU), using two separate detectors, monitors a T1 digital line for bipolar violations and for the absence of 16 or more consecutive bits. Continuous output from either or both of these detectors causes an automatic switch to a standby line in 1 second. The T1ASU continues to monitor the failed primary line; and if the line is found to be restored, service is returned manually.

MJU

5.39 The MJU is employed in hub offices to establish a circuit between a control station (usually a computer) and two or more remote terminals, all operating at a uniform rate. The MJU adds multiparty duplex capability to the basic point-to-point duplex capability of the DDS. Multipoint service is discussed more fully in Part 8.

D. Long-Haul Equipment

5.40 The 1A radio digital terminal (1A-RDT) is typically used for long-haul transmission. Other approved facilities for long-haul usage in DDS are DOV and Vidar 20 Mb/s. The DOV derives two DS-1 digital signal channels from the spectrum above group 6 (19.66 to 21.38 MHz) on L4 carrier. A Vidar 20 Mb/s facility is provided over TD-2 radio using DM-12A terminals and provides twelve DS-1 signal channels.

5.41 Only the 1A-RDT is discussed here because it is the primary long-haul facility in use for DDS. In the direction toward the long-haul network, the 1A-RDT accepts DS-1 signals from a T1DM (through a DSX-1). It reduces the DS-1 signal to a 0- to 500-kHz bandwidth and provides this modified signal to interface and combine equipment for transmission over a radio channel. In the opposite direction, the 1A-RDT reverses this operation and delivers the DS-1 signal to the T1DM receiver. Both the 1A-RDT and the interface equipment required to insert the signal into the radio channel comprise the 1A Radio Digital System (1A-RDS).

6. NETWORK SYNCHRONIZATION

6.01 A timing network is employed in the DDS to ensure that sampling at the DS-1 level and below takes place at the same frequency and phase throughout the network. If timing control is broken, data transmission that traverses the break may be subject to skipping or to double reading of bytes. This occurrence, known as a "slip," may seriously impair data service. Inherent stability of the NTSs, however, is such that timing control will generally be reestablished before slips can occur.

6.02 The timing control network is made up of the connections between a hierarchy of timing supplies that are all ultimately slaved to a single master timing supply (MTS) through a tree-like network. No closed loops are allowed in the timing network (Fig. 10). The hierarchy of the timing supplies is, from the top down, MTS, NTS, STS, LTS, and T1WB4 or T1WB5. Timing supplies may be slaved to other timing supplies that are higher or equally positioned in the hierarchy, but ***never*** to another timing supply that is lower in the hierarchy.

6.03 All the timing supplies in the hierarchy are provided with redundant circuits. Therefore, if a circuit fails, the timing supply can continue to provide the proper timing signals.

6.04 The MTS is actually an NTS that is slaved to the Bell System reference supply at Hillsboro, Missouri. All other NTSs are slaved indirectly to this MTS. The NTS extracts the framing bits from one of two selected incoming DS-1 signals before it reaches any multiplexer. A phase-locked loop forces an internal oscillator to agree in frequency and phase with this input signal. The oscillator output is divided down to 8 kHz, from which the output of the NTS is formed. This output is a bipolar signal that contains both byte timing (8 kHz) and bit timing (64 kHz) in a single waveform (Fig. 11). This waveform is distributed to all other equipment bays in the office. Even if the input signal is lost, the internal oscillator is

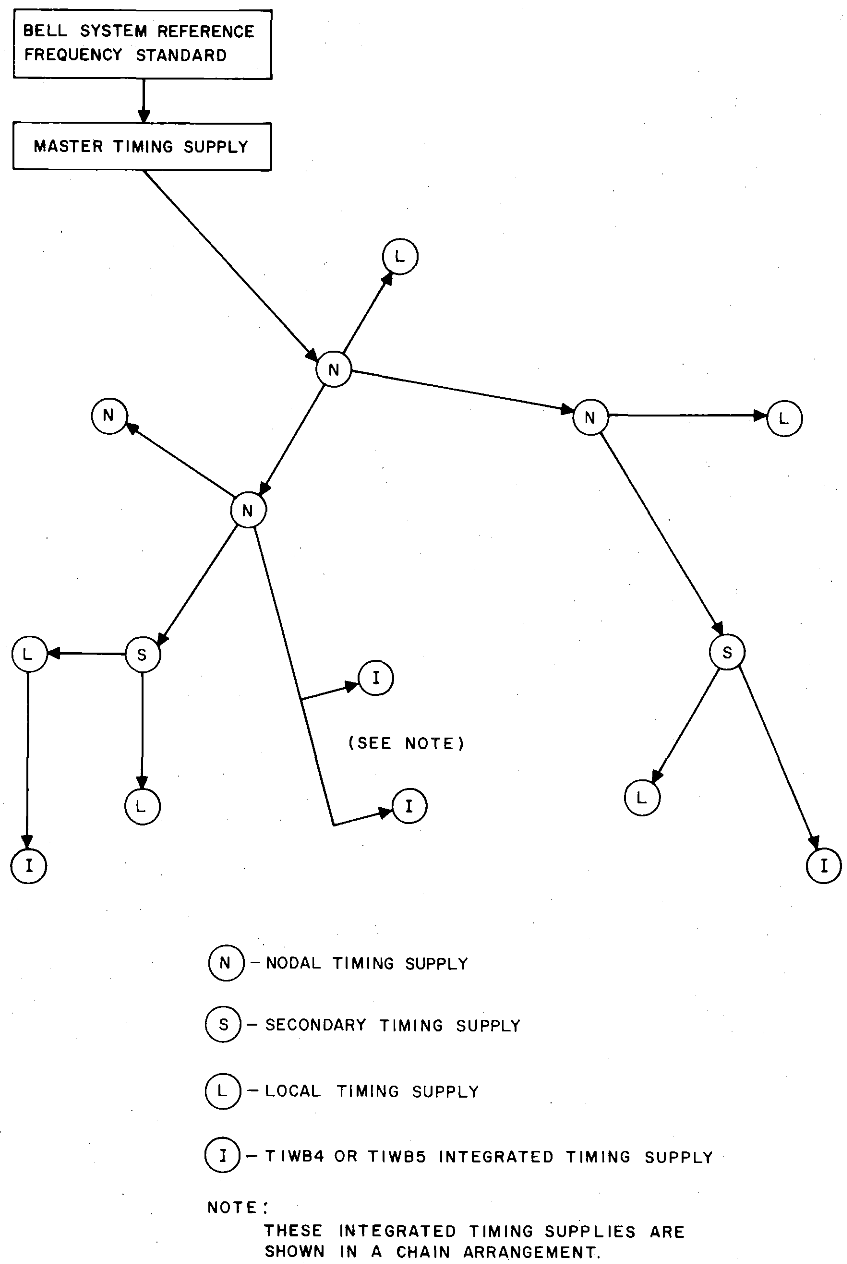


Fig. 10—Synchronous Timing Network

stable enough to supply useful timing information for at least two weeks without severe degradation of service.

6.05 The STS is made up of many of the same circuits as the NTS, but its internal oscillator is not as stable when its input signal is lost. Therefore, the STS can bridge outages of only 5 seconds maximum without slips. Network connection is made in the same manner as in the NTS. Protection is provided by supplying redundant units for the main circuits.

6.06 The LTS is electrically and logically identical to the STS, but it provides other circuit functions not related to office timing. All offices that con-

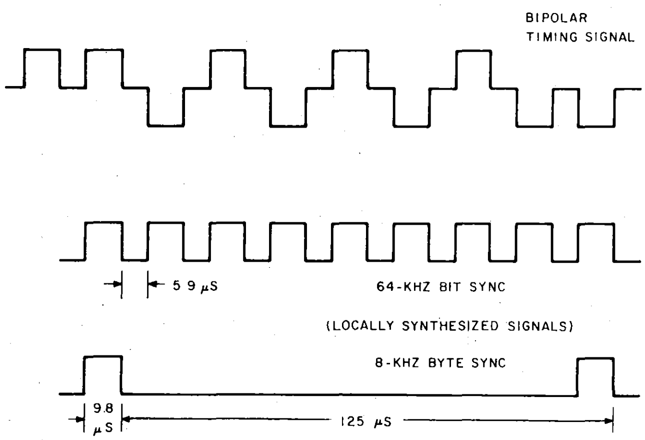


Fig. 11—Output Waveforms

tain a T1DM must also have an LTS (or a timing supply higher in the timing hierarchy). The LTS is located in local offices that use T1DM and OCU bay arrangements.

6.07 The T1WB4 or T1WB5 has an integrated timing supply that can extract 1.544-MHz timing from the T1 digital line and derive the required 8- and 64-kHz signals from it. Therefore, a separate timing supply is not required in a T1WB4 or T1WB5 office, since all the equipment runs off the integrated timing supply. However, a T1WB4 or T1WB5 should receive timing from an LTS, STS, or NTS if one is available in the office.

6.08 ♦Dataport channel units function as part of the DDS network and hence must be synchronized to the DDS timing hierarchy. External clocking from the office timing supply at a hub or intermediate office must be distributed to all banks in that bay that are intended for dataport applications. End offices are loop timed by an equipment option. The loop option is set at the data logic unit or office interface unit for D3 or D4 type channel banks and at the special services unit of the remote terminal for a SLC 96 Subscriber Loop Carrier System.♦

7. DDS BAY ARRANGEMENTS

A. Equipment Assemblies

7.01 Most DDS office equipment (multiplexers, OCUs, timing supplies, power distribution equipment, etc) is supplied in prewired shelf assemblies. Plug-ins (circuit packs, power units, etc) are inserted into the shelves. A diagram of a typical assembly with plug-ins is shown in Fig. 12.

B. Equipment Bays

7.02 The equipment assemblies are arranged in different subsystems and are available in two bay sizes of cable-duct framework, 11 feet 6 inches and 7 feet. A subsystem may be supplied in a single 11-foot 6-inch frame or in a 7-foot, 1- or 2-bay arrangement, the latter using either two single-bay frames or a single double-bay frame. An exception to these bay arrangements is the 1A-RDT bay, which is also supplied in a 9-foot unit. A 1A-RDT bay contains only 1A-RDT equipment.

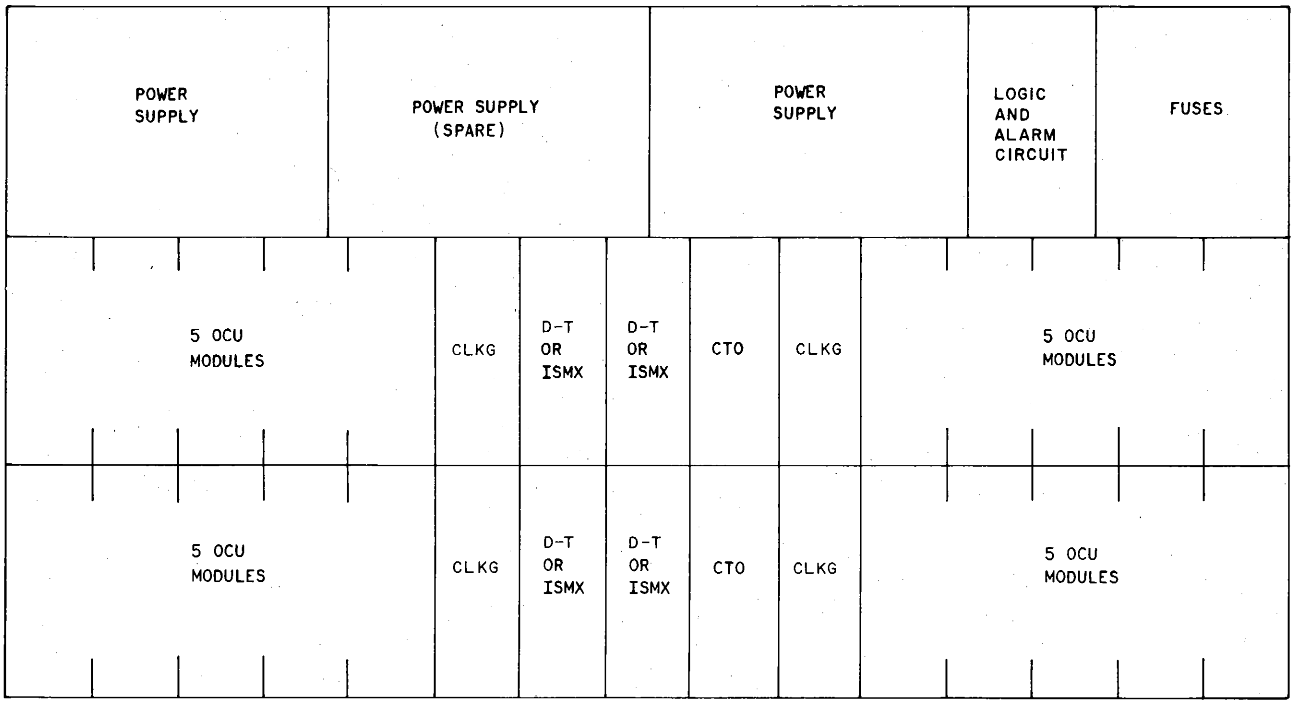
7.03 The DDS bay arrangements provide flexibility in office growth. Two different 7-foot double-bay arrangements are shown in Fig. 13. They both contain T1DMs for a hub office, but one is in a minimum startup configuration and the other is fully equipped. Other equipment is similarly arranged.

7.04 The NTS and the STS are housed in their own separate bays. The LTSs used in end offices are arranged in a prewired shelf assembly with two T1DM shelves. The LTS distributes timing directly to the equipment in its own single- or double-bay arrangement. Timing is distributed to all other office bays and to all hub office bays (from the NTS or the STS) through the bay clock, power, and alarms (BCPA) circuit. The BCPA circuit accepts the standard timing waveform from the office timing supply and then distributes the waveform to all equipment in its own single- or double-bay arrangement. The BCPA circuit also contains alarm indicators and the power distribution fusing for its own single- or double-bay arrangement.

7.05 The BCPA shelf is always located near eye level and is in the left-hand bay of a 2-bay arrangement. The spare T1DM is always located immediately below the T1DM-PM in any T1DM bay arrangement, and the SRDM spare and the SPM are always located in the fifth shelf of an SRDM bay.

D3 and D4 Channel Banks

7.06 The subrate dataport channel units can only be plugged into positions 4, 5, 16, and 17 of a properly wired and equipped D3 channel bank (Fig. 14). The 56 KB units can occupy only adjacent posi-



NOTES:
1. EACH GROUP OF FIVE OCU MODULES MUST BE THE SAME RATE
2. CTO - COMMON TIMING AND OSCILLATOR
3. D-T - DRIVER-TERMINATOR
4. CLKG - 2.4-KB/S, 4.8-/9.6-KB/S, OR 56-KB/S CLOCK GENERATOR
5. ISMX - 5-CHANNEL INTEGRAL SUBRATE MULTIPLEXER

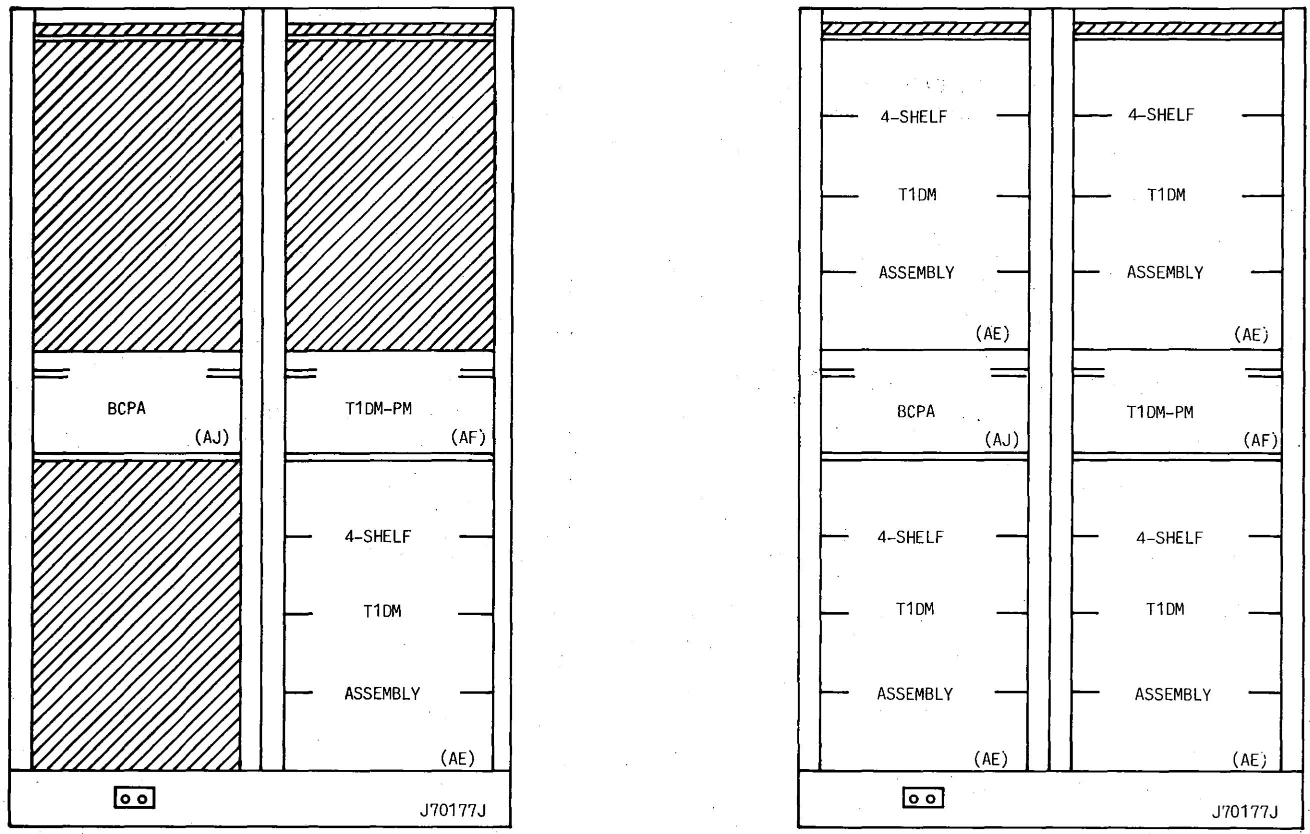
Fig. 12—Typical DDS Equipment Assembly

tions: 3 and 4, 4 and 5, 5 and 6, or 15 and 16, 16 and 17, 17 and 18. The units may be plugged into any slot of a D4 channel bank. The D3 channel bank requires a common equipment plug-in called a data logic unit (DLU), which replaces the INTERFACE or 1 kHz CG and, where used, the reframe counter plug-ins. Interunit wiring between the units and DLU is accomplished via small connectors at the front of the D3 channel bank. The D4 channel bank requires an office interface unit-2 (OIU-2) plug-in in place of the OIU plug-in (Fig. 15). Dataport channel units may be plugged into any slot of a D4 channel bank. Two OIU-2 options must be set that concern timing (external or loop) and selection of common unit circuitry (A digroup or B digroup). The D4 channel banks coded ED-3C650-30 and mounted in J98726A, B, and C frames require wiring modification to allow dataport use. The D4 channel banks coded ED-3C650-31 and mounted in J98726E, F, and G frames require no modification. When the D4 channel bank is used in Mode 2 (T1C), the List 1A version of the syndes unit (J98726AG, L1A) must be provided in addition to the OIU-2. The D3 and D4 channel banks in mode 2 must be removed from service to change these common units.

➧SLC 96 Subscriber Loop Carrier System

7.07 Dataport channel units may be used in a SLC 96 Subscriber Loop Carrier System as shown in Fig. 16. These units are the same OCU DP and DS0 DP channel units as that used for D4 channel banks (same list codes). The dataport function of providing local or external clocking is done by the special service unit (SSU). The number of DP channel units per shelf is limited, depending on the operating mode of the carrier system. A general description is documented in Section 363-202-100.

7.08 The usual application of dataports in carrier systems is to extend the digital serving area into the suburban and rural areas without adding



A. MINIMUM STARTUP CONFIGURATION

B. FULLY EQUIPPED

Fig. 13—7-Foot T1DM Double-Bay Arrangement

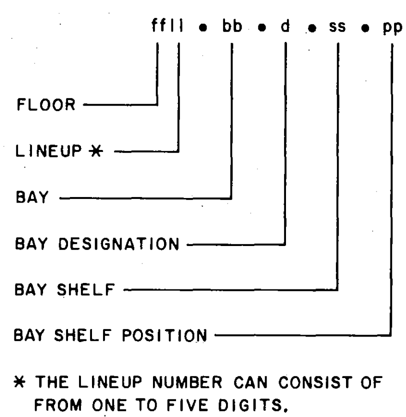
cable pairs. A COT is housed in an existing building and connects to a remote terminal (RT) that is located in a hut or building in the area to be served. T-Carrier lines connect the COT and RT. Both the COT and RT must be equipped with the SSU for dataport channel unit applications.

7.09 Synchronization for dataports in SLC 96 Subscriber Loop Carrier Systems is similar in concept to a D-type channel bank operation. The COT is put into an external time mode by its SSU, with the clock being supplied from an office timing supply in that end office. The office timing supply is fed from an office higher in the DDS network. A DS0 DP in the COT passes and receives the digital signal with the error correction option used as needed. The COT sends and receives data over its T-Carrier facilities to the RT.

7.10 The RT is loop-timed by its SSU and directly serves the customers by local cable pairs. The OCU DPs are mounted in the RT and provide all the subrates or the 56-kb/s rate. The RT may be referred to as a "mini" end office.

C. Equipment Addressing

7.11 A scheme of equipment addresses is used in the DDS to indicate the exact location of equipment in an office, as follows.



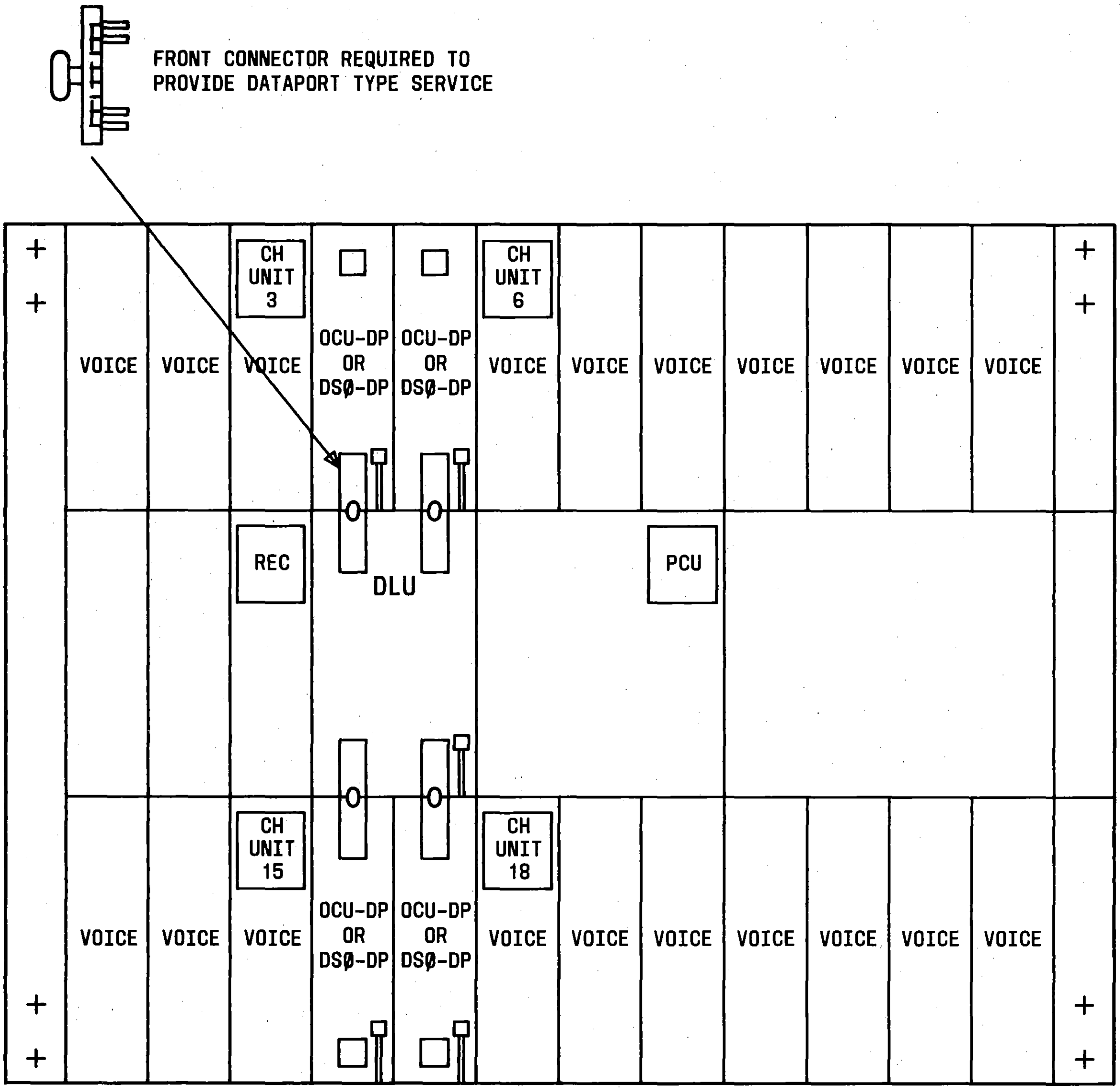


Fig. 14—D3 Channel Bank Arranged for Four D3 Dataport Channel Units in Positions 4, 5, 16, and 17

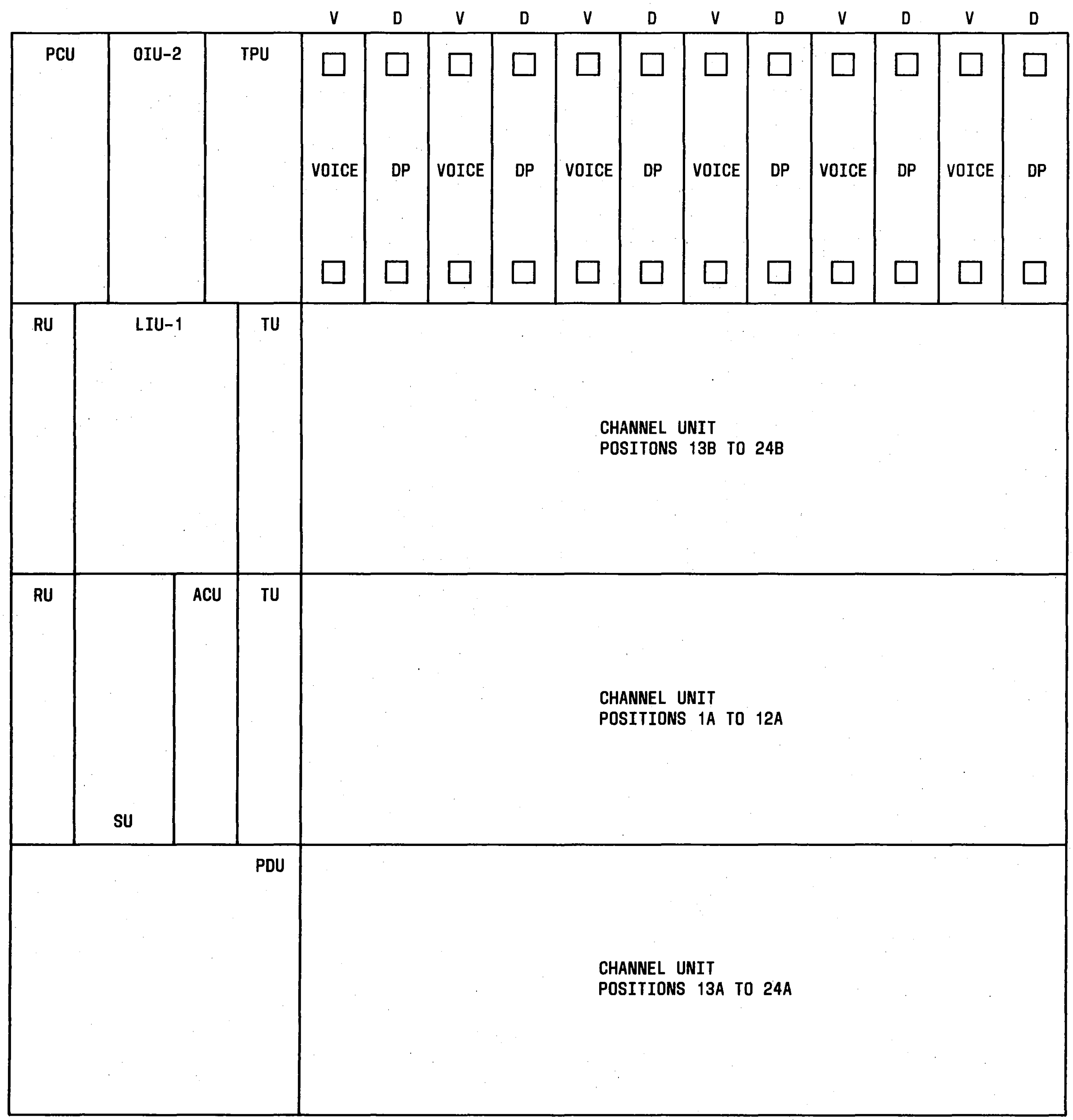


Fig. 15—D4 Channel Bank Arranged for Six Dataport Channel Units in Positions 3B, 4B, 6B, 7B, 8B, and 11B

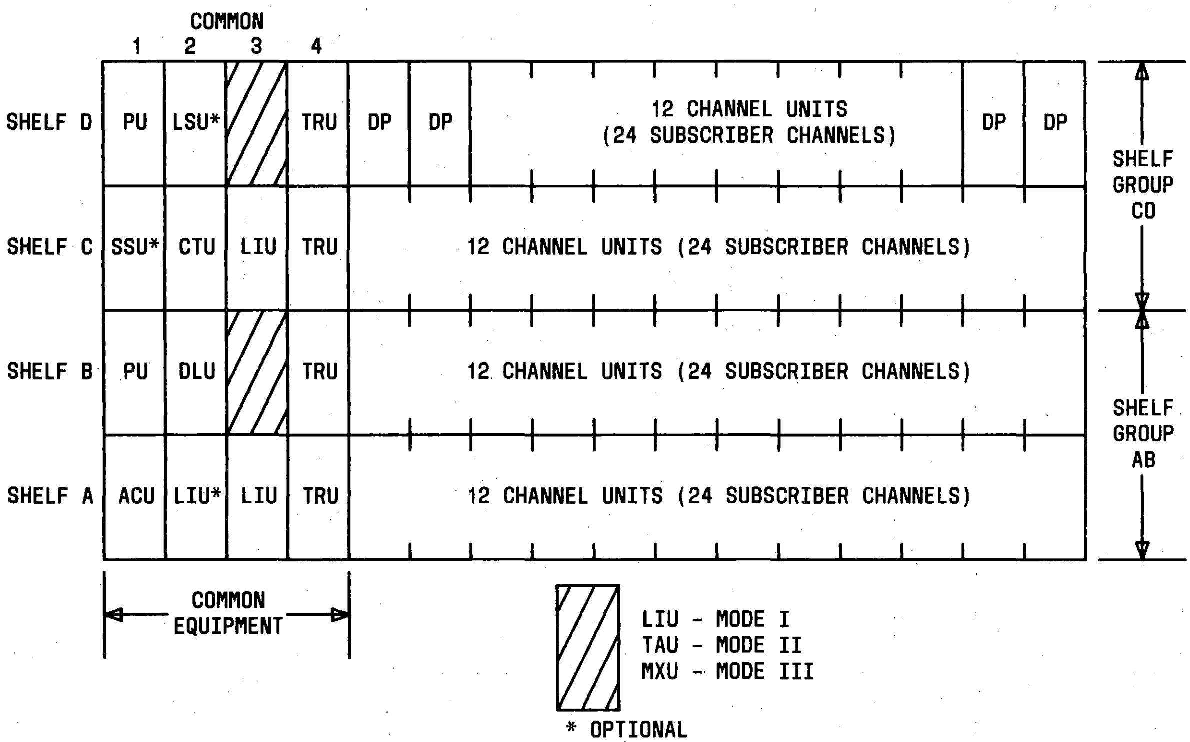


Fig. 16—SLC 96 Subscriber Loop Carrier System Channel Bank

The address of a given piece of equipment consists of as much of the addressing format as is required to distinguish it from other similar equipment. Position d in the addressing format is one of the following capital letters: F (front-mounted bay of a 2-sided bay), B (back-mounted bay of a 2-sided bay), L (left side of a double-bay frame), or R (right side of a double-bay frame).

7.12 All DDS bay arrangements are stamped with the appropriate bay and shelf location numbers at the time of installation. This stamping eliminates guesswork about shelf location, especially within partially-equipped bays.

T1WB4 and T1WB5

7.13 Each shelf of a T1WB4 or T1WB5 assembly is addressed according to the addressing format ***ffll.bb.d.ss***. For example, 1003.11.F.12 indicates floor 10, lineup 03, bay 11, front-mounted bay, bay shelf 12. For assignment purposes, the addressable shelves within these assemblies are those containing the channel circuit packs.

SRDM

7.14 The equipment address for the SRDM allows for the addressing of quarter- or half-shelves according to the addressing format ***ffll.bb.d.ss.pp***. The pp can be any of the numbers listed in Table C. For example, 0102.08.F.03.11 indicates floor 01, lineup 02, bay 08, front-mounted bay, bay shelf 03, 4.8 or 9.6 SRDM in first quarter-shelf.

ISMX

7.15 The 5-channel ISMX uses the addressing format ***ffll.bb.d.ss.pp***. The pp can be any of the numbers listed in Table D. For example, 1004.06.F.11.10 indicates floor 10, lineup 04, bay 06, front-mounted bay, bay shelf 11, left half-shelf. The 10-channel ISMX uses the addressing format **ffll.bb.d.ss**. For example, 0703.09.F.06 indicates floor 07, lineup 03, bay 09, front-mounted bay, bay shelf 06. The pp number is not used here, since there is only one 10-channel ISMX for each OCU shelf.

TABLE C

PP NUMBER MEANING IN AN SRDM

PP NUMBER	MEANING
10	2.4 SRDM in Left Half-Shelf
11	4.8 or 9.6 SRDM in First (Leftmost) Quarter-Shelf
12	4.8 or 9.6 SRDM in Second Quarter-Shelf
20	2.4 SRDM in Right Half-Shelf
21	4.8 or 9.6 SRDM in Third Quarter-Shelf
22	4.8 or 9.6 SRDM in Fourth (Rightmost) Quarter-Shelf

OCU

7.16 The OCUs use the addressing format ***ffll.bb.d.ss.pp***. The pp, which indicates the plug-in, can be any of the numbers listed in Table E. For example, 0115.17.F.14.21 indicates floor 01, lineup 15, bay 17, front-mounted bay, bay shelf 14, plug-in 1 in right half-shelf.

MJU

7.17 Individual MJUs, each consisting of one or two circuit packs, may be addressed according to the addressing format ***ffll.bb.d.ss.pp***. The pp number can be 1 through 8, since there are eight MJUs for each shelf. For example, 0216.18.F.02.07 indicates floor 02, lineup 16, bay 18, front-mounted bay, bay shelf 02, MJU 07.

Full-Shelf Assemblies

7.18 Full-shelf assemblies, such as T1DMs, BCPA circuits, etc, are addressed according to the

TABLE D

PP NUMBER MEANING IN AN ISMX

PP NUMBER	MEANING
10	5-Channel ISMX in Left Half of an OCU Shelf
20	5-Channel ISMX in Right Half of an OCU Shelf

addressing format ***ffll.bb.d.ss*** where ss indicates the bay shelf number.

D. ♦Dataport Channel Unit Applications

7.19 One basic application will be in extending subrate service to an end office from the hub office, as shown in Fig. 17. The channel bank bay at the hub office receives DDS composite clock from the office timing supply. Timing at end offices is derived from the DS-1 signal by the DLU or OIU-2 (not shown in figure). Only selected channel banks within the bay are optioned to accept the clock. For this subrate application, the error correction feature of the OCU DP is optioned ***in***. For 56-kb/s service, a 56 KB DS0 DP at a hub office and a 56 KB OCU DP at the end office are used. Error correction is selected for multiplex subrate data or 56-kb/s data; otherwise, select the ***out*** option (no error correction). Additional dataport information is documented in Section 365-170-120.♦

8. MULTIPOINT SERVICE

8.01 To set up a DDS multipoint circuit, an MJU is employed in hub offices to connect a control station with a maximum of four branches of the circuit (Fig. 18). In the direction away from the control station, the MJU merely splits the signal and sends it on to all the remote stations downstream from the MJU. The customer must provide his own coding to allow each remote station to pick out its own message. In the direction toward the control station, the MJU simply passes the messages from its branches on to the control station. The customer must ensure that two messages are never sent toward the control station simultaneously, since the MJU will combine them and will probably cause them to be garbled. The MJU is independent of data rate because it receives and delivers uniform 64-kb/s signals.

8.02 A single MJU can combine a maximum of four branches into one signal. More branches can be combined at a single hub office or at various hub offices by cascading the MJUs, as shown in Fig. 19.

9. MAINTENANCE FEATURES

A. Automatic Monitoring and Protection Switching

9.01 Performance monitoring is used at various points in the DDS hierarchy to ensure that equipment is performing at or above its required performance level. To provide continuity of service, protection switching to spare equipment takes place when these thresholds of performance are not met. Some equipment, such as certain T1 lines and the T1WB4 and T1WB5 common equipment, are protected on a 1-for-1 basis by automatic monitoring and switching. The T1DM is protected on a 1-for-11 or fewer basis (1-for-16 for a double 7-foot bay), and the SRDM on a 1-for-48 or fewer basis. Both are protected with automatic monitoring and switching. The multiplexing equipment is monitored only for its own errors, independent of transmission errors. The 1A-RDT has automatic internal monitoring, but switching must be done manually. The 1A-RDT is manually protected on a 1-for-8 basis.

B. Alarm and Status Indications

9.02 Transmission terminals and multiplexing equipment provide alarm indications at the offices in which they are located. These alarms may be telemetered to a centralized test center or to another appropriate maintenance center. Failures that occur in the DSU, CSU, local loop, OCU, DP, or 5-channel ISMX (other than OCU-ISMX power failures) are not reported by means of alarms.

TABLE E

PP NUMBER MEANING IN AN OCU

ADDRESS	MEANING
11	Plug-In 1 in Left Half-Shelf
12	Plug-In 2 in Left Half-Shelf
13	Plug-In 3 in Left Half-Shelf
14	Plug-In 4 in Left Half-Shelf
15	Plug-In 5 in Left Half-Shelf
21	Plug-In 1 in Right Half-Shelf
22	Plug-In 2 in Right Half-Shelf
23	Plug-In 3 in Right Half-Shelf
24	Plug-In 4 in Right Half-Shelf
25	Plug-In 5 in Right Half-Shelf

C. Status Bytes

9.03 Certain status bytes are generated by various equipment in the DDS to notify other sections in the system of the network status. These bytes are generated to indicate an idle customer channel, a loopback test (paragraph 9.04) or other tests, a second stage multiplexer out of synchronization, an unassigned second stage multiplexer channel, or an MJU test alert.

D. Loopback Tests

9.04 The loopback tests are initiated by different loopback commands. They can be initiated by use of test sets that are portable or located in a manual testboard or automatically by ABATS. The purpose of the loopback tests is to isolate trouble in the local distribution facilities.

E. Test Access

9.05 In the hub office, the 950A testboard, BATS (KS-21899 Data Test System), or ABATS/ALATS provides centralized test access for the DDS. In addition to direct test access, bridging bipolar access points at the 64-kb/s level for portable test equipment are provided with the terminal equipment (eg, OCU, MJU, and DDGT) and multiplexing equipment (eg, T1DM and SRDM). The DSX-1 provides monitoring and splitting (transmit and receive) test access to DS-1 channels used in the DDS.

9.06 Test access at the local office level uses portable test equipment only. The jack and connector panels provide splitting and monitoring access at the 64-kb/s level. Bridging access at the terminal equipment (eg, OCU, etc) and multiplexing equipment (eg, T1DM, ISMX, etc) is also available. The ISMX provides splitting and bridging access to individual circuits at the logic level, and the DSX-1 provides monitoring and splitting test access to DS-1 channels.

F. ♦Digital Transmission Surveillance System

9.07 This system provides a means of monitoring the performance of DS-1 facilities between DSAs. The performance data is gathered and stored by a surveillance unit (SU). The SU transmits the information to a central minicomputer upon a poll from the minicomputer. The polled information becomes a data base for the generation of DTSS reports, which are categorized into real-time and administrative reports. These reports will aid in the maintenance and isolation of trouble for the DDS.♦

10. REFERENCES

10.01 Tables F, G, and H give a comprehensive list of references providing more detailed information. References for customer stations and local loops are given in Table F; for office equipment, including the type of office in which the equipment can be found, in Table G; and for transmission, in Table H. The letter(s) in parentheses following the section number indicates the content of the section as follows:

(D) Description

(M) Maintenance

(T) Test

(I) Installation

(C) Connection

(O) Ordering (summarizing specification)

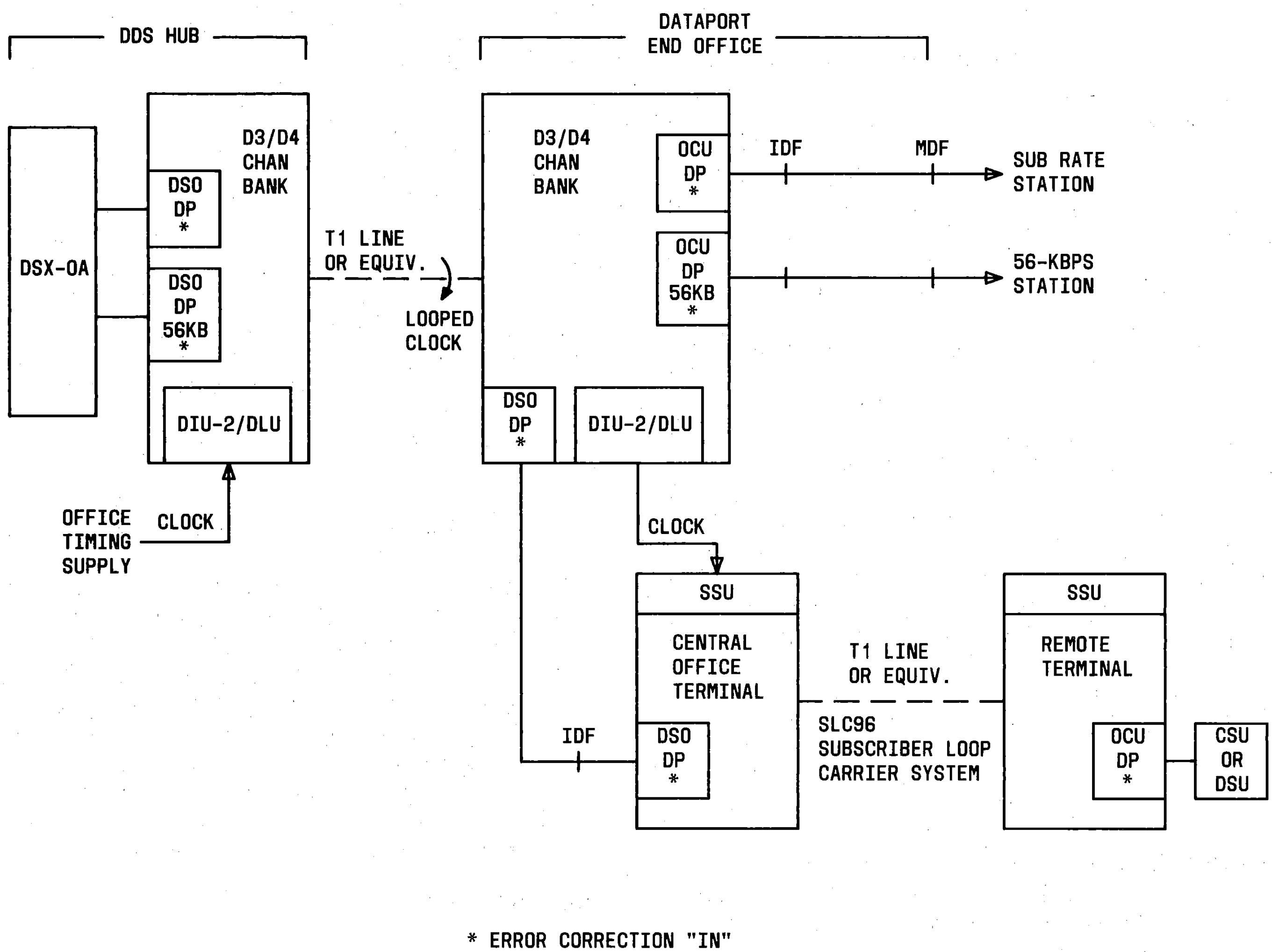


Fig. 17—♦Typical Dataport Applications♦

(CV) Conversion

(ID) Identification

(OPR) Operation

(TOP) Task Oriented Practice

11. GLOSSARY

♦***ABATS:*** Automated Bit Access Test System. A remote test system capable of testing bidirectionally on DDS. It replaces the 950-type testboard which is used for centralized circuit test access.

BATS: Bit Access Test System, also called KS-21899 data test system. The BATS consists of the equipment mounted in a hub office which can be manually or remotely (ABATS) operated.♦

BCPA Shelf: Bay clock, power, and alarms shelf. A DDS equipment shelf used in conjunction with the timing source for providing power and timing to equipment within the bays and for accommodating alarms from that equipment.

BPNRZ: Bipolar nonreturn-to-zero. A 3-level code in which alternate 1s change sign (for example, 1011 becomes +1, 0, −1, +1) and in which transitions between adjacent 1s do ***not*** pause at the zero voltage level (Fig. 2B).

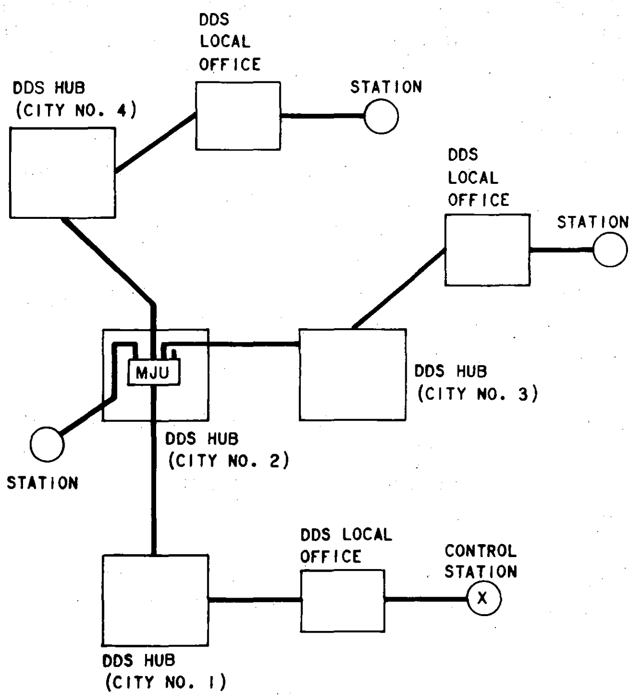


Fig. 18—Station Multipoint Circuits

BPRZ: Bipolar return-to-zero. Same as BPNRZ except that transitions between adjacent 1s pause at the zero voltage level (Fig. 2A).

BPV: Bipolar violation. A violation of the alternating +1, −1 pattern in a 3-level code.

Byte: In the DDS, refers to a group of eight consecutive binary digits associated with a single customer.

Byte Stuffing: In the DDS, the technique by which the bit rate of a digital stream is increased by repeating bytes and transmitting them at a faster rate. The information content of the stream is not increased.

Chain: An arrangement using T1WB4s or T1WB5s, or both, to allow a small local end office and no more than two chain offices to share a single T1 facility.

Chain Office: An office having a T1WB4 or T1WB5 that is operated in the chained data mode.

Collection Office: An office in the DDS that serves as a channel concentration point from more than one other office. It has the equipment configuration of a hub office but does not perform the hub functions. All

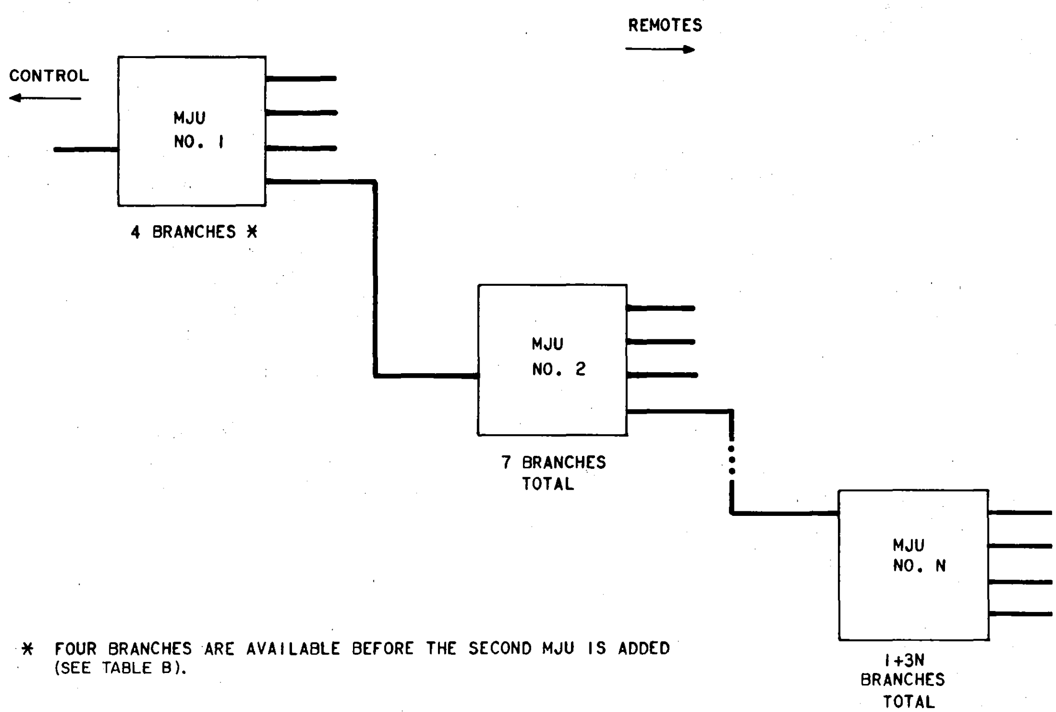


Fig. 19—Cascading of MJUs

TABLE F

REFERENCES FOR CUSTOMER STATION ARRANGEMENTS AND LOCAL LOOPS

EQUIPMENT	SECTIONS
550A-Type CSU	595-100-100 (D) 595-100-200 (I) 595-100-300 (M) 595-100-500 (T) 595-100-180 (O)
500A-Type DSU	595-200-100 (D) 595-200-200 (I) 595-200-300 (M) 595-200-500 (T) 595-200-180 (O)
56-kb/s Regenerative Repeater (Office Mounted)	314-920-100 (D) 314-920-300 (M) 314-920-500 (T)
56-kb/s Regenerative Repeater (Outside Mounted)	640-251-106 (D) (I) 640-251-107 (T) (M)

data channels appearing at a collection office are routed to a hub office for testing and cross-connection.

Control Signals: Signals in byte format used for synchronization, status indication, and remote testing.

CP: Circuit pack. A unit that contains part of the DDS circuitry and that can be inserted into equipment shelves where required.

Cross-Connect: A piece of hardware used to interconnect line terminating equipment, multiplexers, and other equipment. Access to signals is often available through jacks associated with a testboard located near the cross-connect.

➧***CSU:*** Channel service unit. A unit located on the customer premises that terminates a DDS channel and that is used with the customer's logic and timing recovery circuitry. See Section 595-100-100 for 550A CSU and Section 595-105-100 for 551A CSU.

DBM and TC: A central location that contains PDP* 11/70 minicomputers that are used to provide a data base and test controller for ABATS.⧏

DDGT: Digital data group terminal. A terminal providing the electrical interface between a DDS channel at the DS-0 level and a duplex analog group band transmission facility.

DDS: Digital Data System. A system providing private line, point-to-point and multipoint, and duplex data transmission.

➧***DOV:*** Data over voice is a technique used on digital facilities that derives two 1.544 Mb/s digital channels from the spectrum above mastergroup 6 (19.66 to 21.38 MHz) in L4 carrier systems.⧏

DP: Dataport allows DDS to be extended to areas with only a few customers. See DS0 DP and OCU DP channel units.

DSA: Digital serving area. The combined geographical serving areas of a set of DDS serving offices as specified in the appropriate tariff or tariffs. The DDS office serving areas making up a DSA are not necessarily contiguous, and a DSA may overlap state and associated company boundaries. A typical DSA encompasses one urban area of a single associated company.

DSAU: DS-1 signal access unit. A plug-in circuit pack used in DDS hub offices that provides full duplex access to a DS-1 signal to facilitate centralized maintenance and testing.

DS-CS: Digital signal at the customer service level. A modified BPRZ signal at one of the customer data rates (2.4, 4.8, 9.6, or 56 kb/s). The bipolar format is modified by the inclusion of bipolar violations for network control.

DSU: Data service unit. A terminal located on the customer premises to access the DDS. See Section 595-200-100 for 500A DSU and Section 595-200-101 for 500B DSU.

DS-0: Digital signal at the 0 level. A BPNRZ signal at the 64-kb/s rate.

DS-0A: A DS-0 signal that carries data for only one customer. For subrates, customer data is byte stuffed

*Trademark of Digital Equipment Corporation

♦TABLE G♦

REFERENCES FOR GENERAL OFFICE EQUIPMENT

EQUIPMENT	TYPE OF OFFICE: END	INTERMEDIATE	COLLECTION	HUB	SECTIONS
OCU	✓	✓	✓	✓	314-910-100 (D) 314-910-300 (M) 314-910-500 (T)
ISMX	✓	✓	✓		
DSAU				✓	314-960-100 (D) 314-960-300 (M)
5V Power Supply Shelf	✓	✓	✓	✓	314-970-101 (D)
M-JCP and SM-JCP	✓*				314-970-100 (D)
QTP	✓†				314-914-100 (D) 314-914-300 (M) 314-914-400 (C)
DSX-0	✓	✓	✓	✓	
SRDM			✓	✓	314-911-100 (D) 314-911-300 (M) 314-911-501 (T) 314-911-502 (T)
SPM			✓	✓	314-983-110 (D) 314-983-310 (M) 314-983-510 (T)
T1DM	✓	✓	✓	✓	314-912-100 (D) 314-912-300 (M) 314-912-500 (T)
T1DM-PM	✓	✓	✓	✓	314-983-100 (D) 314-983-300 (M) 314-983-500 (T)
T1WB4	✓			✓	314-915-100 (D) 314-915-300 (M) 314-915-501 (T)
T1WB5	✓		✓		314-915-110 (D) 314-915-310 (M) 314-915-510 (T)
T1ASU	✓	✓	✓	✓	365-200-104 (D) 365-200-204 (I) 365-200-504 (T)
DSX-1	✓	✓	✓	✓	365-301-101 (D)

See notes at end of table.

♦TABLE G (Contd)♦

REFERENCES FOR GENERAL OFFICE EQUIPMENT

EQUIPMENT	TYPE OF OFFICE				SECTIONS
	END	INTERMEDIATE	COLLECTION	HUB	
LTS	✓	✓	✓		314-913-120 (D) 314-913-320 (M) 314-913-520 (T)
BCPA Circuit	✓	✓	✓	✓	314-916-100 (D) 314-916-300 (M) 314-916-500 (T)
KS-20908 (Receiver)	✓	✓	✓	✓	107-601-100 (D)
KS-20908 (Transmitter)	✓	✓	✓	✓	107-600-100 (D)
NTS				✓	314-913-110 (D) 314-913-310 (M) 314-913-510 (T)
STS		✓	✓	✓	314-913-115 (D) 314-913-215 (CV) 314-913-315 (M) 314-913-515 (T)
950A Testboard				✓	666-600-100 (D) 666-600-300 (M) 666-600-500 (T)
KS-21899 DTS				✓	107-605-100 (D) 107-605-200 (I) 107-605-300 (OPR) 107-605-500 (M)
DDGT	✓‡			✓	314-918-100 (D) 314-918-300 (M)
MJU				✓	314-917-100 (D) 314-917-300 (M) 314-917-500 (T)
Off-Net Extension (Subrate)				✓	314-919-100 (D) 314-919-200 (I) 314-919-300 (M) 314-919-500 (T)
831A Data Auxiliary Set				✓	598-083-101 (ID)

See notes at end of table.

TABLE G (Contd)

REFERENCES FOR GENERAL OFFICE EQUIPMENT

EQUIPMENT	TYPE OF OFFICE: END	INTERMEDIATE	COLLECTION	HUB	SECTIONS
Dataport Channel Unit					
D3B Channel Bank	✓	✓	✓	✓	365-150-107 (D)
D4B Channel Bank	✓	✓	✓	✓	365-170-120 (D)
Central Office Terminal §	✓	✓	✓	✓	363-202-400 (TOP)
Remote Terminal §	✓	✓	✓	✓	363-202-401 (TOP)

* Not used in T1WB5 bay and newer T1DM bay

† Used in T1WB5 bay and T1DM bay

‡ Used in non-DDS end (serving) office

§ Part of SLC 96 Subscriber Loop Carrier System

as necessary to obtain the DS-0 signal level. Only DS-0A data signals appear at the DSX-0A.

DS-0B: A DS-0 signal identical to a DS-0A signal when carrying 56-kb/s customer data, but capable of carrying data for several subrate customers. For subrates, successive bytes carry data for different customers so that each customer-generated bit appears only once in the DS-0B signal. DS-0B data signals appear at the DSX-0B.

DS0 DP: Digital signal at 0 level dataport channel unit. A plug-in circuit pack that is used to recover a DS-0 signal for further connections. The input and output signals of the DS0 DP are at the 64-kb/s rate.

DS-1: Digital signal at the first level. A BPRZ T1 signal at the 1.544-Mb/s rate.

DS-2: Digital signal at the second level. A BPRZ signal at the 6.312-Mb/s rate.

DSX-0: A digital cross-connect used to interconnect equipment at the DS-0 level.

DSX-0A: The digital cross-connect at a DDS hub office where individual customer circuits are properly routed.

DSX-0B: The digital cross-connect at a DDS hub office used to connect multiplexed signals together, such as T1DM and T1WB4/B5 ports with SRDMs, and to connect T1DM or T1WB4/B5 ports, or both, together.

DSX-1: A digital cross-connect used to interconnect lines and equipment, to provide patch capability, and to provide test access at the DS-1 level.

D-T: Driver terminator. A circuit pack used in an OCU shelf when individual OCU outputs are required from the shelf.

Duplex: A communications mode in which transmission can occur in both directions simultaneously (sometimes referred to as full duplex).

End Office: In a DDS digital serving area, a local office that passes on toward the hub only circuits that entered the office over local loops.

Frame: Twenty-four bytes plus one framing bit (193 bits) on a T1 line.

Hub Office: An office in the DDS that combines T1 data streams from a number of local offices into signals suitable for transmission over DDS facilities at the DS-1 level or above (see ***collection hub, regional hub, sectional hub,*** and ***metro hub***). A hub office has test capability provided by a 950A testboard or KS-21899 data test system (also called BATS) or automated bit access test system.

Idle Code: A bipolar violation sequence transmitted by the DSU to indicate that no data is being sent over the line by the customer.

TABLE H

♦REFERENCES FOR TRANSMISSION♦

SUBJECT	SECTIONS
Customer Loop	314-410-310 (M) 314-410-510 (T)
DS-0 Facility	314-902-200 (I)
DS-1 to DS-1	314-903-300 (M)
DS-1 Facility	314-903-200 (I)
Hub Identification Code Plan	314-901-011 (D)
Point-to-Point and Multipoint Circuits	314-901-200 (I)
Overall DDS	314-900-100 (D) 314-900-300 (M)
2-Point and Multipoint	314-901-300 (M) 314-901-500 (T)
T1 Line Qualification	365-228-500 (T)
1A-RDT	356-454-010 (D) 356-454-020 (M) 356-454-1ZZ (D) 356-454-3ZZ (OPR) 356-454-5ZZ (T)

Intermediate Office: In a DSA, a local office that passes on toward the hub office circuits that entered it from one end office in addition to those that entered it over local loops.

ISMX: Integral subrate multiplexer. A subrate multiplexer arrangement used only in local offices in which the subrate multiplexing function is contained within the OCU shelves.

JCP: Jack and connector panel. A unit used in a local office to connect the various pieces of equipment and to provide test access for portable test sets (see ***M-JCP*** and ***SM-JCP***).

Local Loop: That portion of an individual customer's channel between the station and its associated OCU dataport channel unit.

Local Office: A DDS office concentrating on-net customer circuits into T1 streams for transmission to a hub office.

Long Haul: Transmission distances typically beyond 50 miles, using the 1A-RDS, DOV, Vidar 20 Mb/s, or other digital transmission systems.

Loopback: A testing procedure causing a received signal to be returned to its source.

LTS: Local timing supply. A common timing source for a DDS local office. In the absence of input timing information, this unit has the same stability as the STS.

Metro Hub Office: A hub office at the lowest of three levels in the long-haul interhub routing hierarchy. Also referred to as a class 3 office.

M-JCP: Multiplexer jack and connector panel. A jack and connector panel that gives access to the DS-0B level ports of a T1DM, T1WB4, or T1WB5.

MJU: Multipoint junction unit. A unit employed at a DDS hub office to link together three or more segments of a multipoint circuit.

MTS: Master timing supply. A modified NTS that receives input timing information from the Bell System Reference Frequency Standard and that provides this timing information to the rest of the DDS.

Multipoint Circuit: A circuit with more than two stations. One station is designated the control station. Multipoint circuits are used to provide multistation service.

NTS: Nodal timing supply. A common timing source for a DDS office. This unit is highly stable in the absence of input timing information.

OCU: Office channel unit. A terminal, located in the central office, that terminates the customer's local loop and that provides access to the DDS by converting DS-CS level signals to DS-0A level signals.

♦***OCU DP:*** Office channel unit dataport. A plug-in circuit pack that terminates the customer's loop for data speeds of 2.4, 4.8, 9.6, and 56 kb/s. The OCU DP output is put into a 64-kb/s time slot directly or the T-carrier system.♦

Off-Net: A location not in a DSA.

On-Net: A location within a DSA.

PCM: Pulse code modulation. The process in which analog signals are sampled, quantitized, and coded into a digital bit stream.

QTP: Quad terminal panel. A panel of a DSX-0 providing routing of 64-kb/s DS-0B level signals to the ports of a T1WB5.

Regional Hub Office: A hub office at the highest of three levels in the long-haul interhub routing hierarchy. Also referred to as a class 1 office.

Sectional Hub Office: A hub office at the second of three levels in the long-haul interhub routing hierarchy. Also referred to as a class 2 office.

♦***Short Haul:*** Transmission distances typically less than 50 miles.

Skinny Hub: A hub that was originally intended to have testing capability that was never instituted. It functions like an intermediate office.♦

Slip: A defect in timing that causes a single bit or a sequence of bits to be skipped or read twice.

SM-JCP: Submultiplexer jack and connector panel. A jack and connector panel that gives access to DS-0A level signals in a local office.

SRDM: Subrate data multiplexer. A submultiplexer arrangement, used primarily in hub offices, that combines a number of DS-0A data streams into a single DS-0B 64-kb/s signal.

STS: Secondary timing supply. A common timing source for a DDS office. This unit may be used in hub and large local offices.

Subrate: In the DDS, the 2.4-, 4.8-, and 9.6-kb/s customer data rates.

TDM: Time division multiplexing. The process of combining a number of lower rate digital signals into a higher rate signal by sampling each one in order.

Testing Area: A geographic area including all DDS customer stations that home on a single hub office.

T1 Digital Line: A digital transmission line, used for short-haul work, that carries data at the DS-1 (1.544-Mb/s) rate.

T1ASU: T1 automatic standby unit. A unit that monitors a regular T1 line and its standby T1 line. It automatically switches to the standby, based on the bipolar violation rate of the regular line.

T1DM: T1 data multiplexer. A multiplexer capable of time division multiplexing synchronizing bits and a maximum of 23 DS-0 (64-kb/s) signals into a single DS-1 signal.

T1WB4: T1WB4 data-voice multiplexer. A piece of equipment capable of time division multiplexing a maximum of 12 DS-0B data channels with PCM-encoded voice channels from a voice channel bank into a DS-1 stream.

T1WB5: T1WB5 data-voice multiplexer. A piece of equipment capable of time division multiplexing a maximum of 23 DS-0B data channels with a T1DM at the hub office.

♦***Vidar 20 Mb/s:*** A long-haul transmission system that provides twelve DS-1 channels over TD-2 radio using DM1-2 terminals.♦

1A-RDS: 1A Radio Digital System. A system that provides for the transmission of one DS-1 signal over a microwave radio link.

1A-RDT: 1A radio digital terminal. The part of the 1A-RDS that converts the DS-1 signal into a signal suitable for transmission over radio.