

# PRELIMINARY

**Bell System Data Communications  
TECHNICAL REFERENCE**

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**DATAPHONE<sup>®</sup> SWITCHED  
DIGITAL SERVICE  
DATA  
SERVICE UNIT  
INTERFACE SPECIFICATIONS**

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**MARCH 1976**

ENGINEERING MANAGER – DATA NETWORK SERVICES



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## 501A DATA SERVICE UNIT

### TECHNICAL SPECIFICATION SUMMARY

Data Rate: 56 kb/s

Operation: Synchronous with timing control from Switched Digital Data System at specified rate of 56 kb/s

Multiple Arrangements: Stackable units (up to 3)

Data Interchange Interface

Signal Requirements:

EIA RS-232-C and CCITT Recommendation V.35

Automatic Calling Interface

Requirements: EIA RS-366

Principal Operating Mode:

Duplex (Half-Duplex and Simplex Operation Possible)

Data Terminal Connector:

Automatic Calling Interface - 25 pin connector: Cinch or Cannon Type DB-19604-432 or AMP 205784-1 or equivalent plug with Cinch DB-51226-1 hood or equivalent

Data Interchange Interface - 34 pin connector: Winchester MRA (C)-34P-JTC6-H8, or Burndy MS34 PM-124, or AMP 5-202431-2 or equivalent

Environmental Requirements:

Ambient Temperature Range: 40° to 120°F

Relative Humidity: Less than 95%

Control Functions:

Request to Send - Clear to Send Delay - 22 to 23 bits (Terminal Controlled Carrier Option)  
- no delay (Permanent Carrier Option)

Received Line Signal Detector Turn on Time (During a Call) - 14 bits

Turn off Time (During a Call) - 21 bits

Turn off Time (To Enter Out-of-Service Mode)-Approx. 1 sec. for local loop failures, 300 ms for failure in high order digital facilities

AC Power Requirements:

105-129V, 60±3 Hz, uninterrupted power source

Weight: Approximately 17.3 lbs. (7.9 kg.)

Dimensions: Approximately 16" (40.7 cm.) wide, 11.4" (29 cm.) deep, 4.3" (10.9 cm.) high

## 1. INTRODUCTION

The purpose of this Technical Reference is to define the interface specifications associated with the Data Service Unit (501A-type DSU). DSUs\* are located at customers' premises as part of the Switched Digital Data System (SDDS), which is used to provide DATAPHONE Switched Digital Service. The SDDS is a common-user duplex\*\* switched digital data network, which accommodates the synchronous data transmission speed of 56 kb/s. The DSU provides equalization, remote and local testing capabilities and the logic and timing necessary to provide a standard CCITT V.35 type interface.‡ In addition to controlling the transfer of data, this Data Interchange Interface may be used by customer data terminal equipment for answering and terminating calls automatically. The DSU also provides an optional capability for automatic call origination through a standard EIA RS-366 type Automatic Calling Interface. In addition to this automatic call originating option, manual calling and answering is made available optionally by the Manual Call Controller (also referred to as the 821A-type Data Auxiliary Set). The Manual Call Controller has a key pad for addressing similar to a TOUCH-TONE® pad, and lights and a character display for call status indications. It also contains an audible alerting device to indicate an incoming call.

If manual control, timing recovery, data encoding and decoding and the standard interface circuitry are not

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\* In this Technical Reference, the term Data Service Unit (DSU) will be used exclusively in referring to the 501A-type Data Service Unit. This DSU is physically different from the 500A-type DSU, which is used in the Digital Data System (DDS) but not in the Switched Digital Data System (SDDS). The 500A-type DSU is discussed in the Technical Reference titled "Digital Data System Data Service Unit Interface Specifications" (PUB 41450).

\*\* Duplex operation, also called full-duplex operation, is the transmission of signals in both directions simultaneously.

‡ For ordering information on EIA and CCITT Standards, see Page 54.

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desired, a basic access line can be requested. A basic access line is terminated on the customer's premises by a Channel Service Unit (550A-type CSU) which provides only the minimum equipment required to produce a properly balanced and equalized loop termination and to permit rapid remote testing of the access line.\* Additional information on the CSU interface for SDDS may be found in the Technical Reference titled "DATAPHONE Switched Digital Service Channel Interface Specifications" (PUB 41023).

Section 2 provides an overview of the SDDS and the services offered. Sections 3 through 8 provide a more detailed description of the DSU and Manual Call Controller, system operation and maintenance, and the specific service objectives.

## 2. OVERVIEW OF THE SWITCHED DIGITAL DATA SYSTEM (SDDS)

### 2.1 DATAPHONE Switched Digital Service Capability

DATAPHONE Switched Digital Service, which will use only digital facilities from end to end,\*\* will be offered in selected geographical areas called Switched Digital Serving Areas (Switched DSAs) located in metropolitan areas throughout the United States. This duplex switched data transmission service will be offered on a common-user basis. Stations will be permitted to receive calls only from other SDDS stations that originate calls. During the data transfer phase of a call between two SDDS stations, the full 56 kb/s channel information capacity may be used, i.e., there are no restrictions on the bit patterns that may be transmitted.

Multiline hunting is available on an optional basis with DATAPHONE Switched Digital Service. Among a group of SDDS stations in a Switched DSA, which are designated by the customer to be in a multiline hunting group, the system hunts for an idle station in an attempt to complete an

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\* An access line is a dedicated duplex SDDS channel between an individual station and its associated switch.

\*\* No voice sharing or alternate voice/data capabilities are provided.

incoming call. Hunting takes place whenever some of the stations in the multiline hunting group are busy or signaling that they are not ready to receive calls. The type of multiline hunting provided is called terminal hunting. Terminal hunting is always carried out in a prescribed sequence, depending on the addresses of the stations in the hunting group and which station is being called. Stations having DSUs and stations having CSUs may belong to the same multiline hunting group. Further information on multiline hunting groups and their station addresses is provided in Sections 2.3, 5.1 and 6.2.

Service options are provided that permit SDDS stations having DSUs to originate and answer calls either manually or automatically. The capability to change between automatic and manual station control is also provided via a switch on the Manual Call Controller.

## 2.2 SDDS Description

The Switched Digital Data System (SDDS) is used to provide DATAPHONE Switched Digital Service. As shown in Figure 1, each SDDS station is connected to a switch by means of an access line. Switches are connected to other switches by means of digital trunks, so that any SDDS access line can be connected through switches and trunks to other SDDS access lines. The number of trunks and amount of switching equipment provided is sufficiently large so that call attempts will seldom be blocked, due to busy trunks or switching equipment. Automatic alternate routing is also provided, so that an alternate path may be used, in the event that all trunks along some given path are busy. Specific service objectives concerning quality, access availability, "dial tone" delay, call setup time and call teardown time are provided in Section 7.

For an SDDS station equipped with a DSU, the procedures for originating calls, answering calls and terminating calls are analogous to the procedures used in telephone service; but, in SDDS only digital signals are transmitted and received at the stations (no voice communication or coordination is provided). Thus, the originating station first signals the switch that the customer wishes to originate a call (analogous to the off-hook condition). The switch then signals the originating station that it is ready to receive the number (address) of the station

to be called (analogous to dial tone). Then, in response to manual keying or under control of the Automatic Calling Interface, the station transmits this information to the switch. The switch receives the address of the called station, and proceeds to set up a connection between the two stations. During the call setup, certain digital "call progress" signals may be returned to the calling station indicating the status of the call (such as "Remote Ringing," which indicates to the calling station that the system is "ringing" the called station). After being alerted, the called station answers by transmitting another digital signal to the system. In telephone service, "cut-through" (completion of the connection) is signaled by removal of both ringing and remote ringing. Similarly, the SDDS signals cut-through by removal of the digital signals that the system had been transmitting to the stations. Once the cut-through indication is received at a station, all data transmitted by it will be delivered to the other station. Either station may terminate an SDDS call by appropriately signaling the system (analogous to on-hook). Before it can originate or receive other calls, a station must have terminated its previous call by appropriately notifying the system (analogous to on-hook).

### 2.3 Station Addresses

For each SDDS station, the Telephone Company will assign a 7 digit address NNX-XXXX, where N may be any digit 2-9 and X may be any digit 0-9. Some addresses are reserved for special SDDS purposes. The address assigned to a station must be used when placing a call to that station from any other SDDS station. As mentioned in Section 2.1, multiline hunting arrangements are provided, using terminal hunting. Each station in a terminal hunting group will be assigned an individual 7 digit address. Further information on multiline hunting groups and station addresses is provided in Sections 5.1 and 6.2.

## 3. DETAILED EQUIPMENT DESCRIPTION

This section provides general information about the DSU and the Manual Call Controller, including station arrangements, physical descriptions of the equipments and their interfaces, controls and lamp indications, power and grounding requirements and interface cable distance limitations.

### 3.1 Station Arrangements

Three basic station arrangements are available using the DSU and, where manual operation is employed, the Manual Call Controller. They are:

- Automatic Answer-Only
- Automatic Originate and Answer
- Automatic and Manual Originate and Answer

A customer may select any of these three arrangements for each of his stations, including stations that are members of multiline hunting groups.

With the Automatic Answer-Only arrangement, a DSU presents a standard Data Interchange Interface containing data, timing and control signals. Control of the call answering and terminating functions is handled through this interface, but no capabilities are provided for originating calls or for manual control.

The Automatic Originate and Answer arrangement provides the same standard Data Interchange Interface (as is used with the Automatic Answer-Only arrangement) for the call answering and terminating functions and for data transfer, timing and control. In addition, a standard Automatic Calling Interface is also provided as part of the DSU, permitting automatic origination of calls; however, no capability is provided for manual control.

The Automatic and Manual Originate and Answer arrangement includes both the standard Data Interchange Interface and the standard Automatic Calling Interface used in the Automatic Originate and Answer arrangement. In addition, a Manual Call Controller is provided, which has the necessary control switches and displays to manually originate, answer and terminate SDDS calls, and to visually monitor the progress of the calls.

### 3.2 Interfaces

The Data Interchange Interface uses a 34-pin connector, and the Automatic Calling Interface uses a 25-pin connector.

The Data Interchange Interface provides a set of data, timing and control signals, which are defined by EIA

Standard RS-232-C, except that timing and data electrical signal characteristics are as defined in CCITT Recommendation V.35, Appendix 4. The Automatic Calling Interface provides a set of signals, which are defined by EIA Standard RS-366. Section 4.4 contains a more detailed discussion of the electrical characteristics.

### 3.3 Physical Description

Figure 2 shows a DSU connected with a Manual Call Controller. The cable normally used to connect these two units is approximately 6 feet (1.8 meters) in length; however, longer cables can be provided in lengths up to 50 feet (15.2 meters) at the customer's request. Both the DSU and the Manual Call Controller will operate over a temperature range of +40° F to +120° F and with a relative humidity less than 95 percent.

#### 3.3.1 DSU

The DSU shown in Figure 2 measures approximately 16 in. (40.7 cm.) wide, 4.3 in. (10.9 cm.) high and 11.4 in. (29.0 cm.) deep. It weighs approximately 17.3 lb. (7.9 kg.). Mounting arrangements can provide for stacking up to three of these units, as shown in Figure 3.

#### 3.3.2 Manual Call Controller

The Manual Call Controller shown in Figures 2 and 4 is approximately 6.5 in. (16.5 cm.) wide, 2.3 in. (5.9 cm.) high and 4.1 in. (10.4 cm.) deep. It weighs approximately 1.9 lb. (.87 kg.). To permit manual operation, each DSU requires one Manual Call Controller.

### 3.4 DSU - Manual Controls and Lamp Indications

A Lamp and Switch Assembly is provided on the DSU. It can be located in either the front or rear panel as a station option (see Section 5.2.6).

#### 3.4.1 Switch for Testing

The switch on the Lamp and Switch Assembly is called the Test Switch. It is a 3-position slide switch, with the center position to be used during normal operation. When the Test Switch is placed in the left position, the DSU

is in the Local Line (LL) Test mode. When the Test Switch is in the right position, the DSU is in the Remote Terminal (RT) Test mode. Use of this switch for testing purposes is discussed in Section 8.

### 3.4.2 Indicator Lamps

Four indicator lamps are located on the Lamp and Switch Assembly. These lamps, which are listed below, indicate that certain operating states have been entered.

- (a) PWR: illuminated when power is on.
- (b) NS: illuminated when no signal is being received by the DSU from the network.
- (c) LL: illuminated when the DSU is in the Local Line (LL) Test mode for testing.
- (d) RT: illuminated when the DSU is in the Remote Terminal (RT) Test mode for testing.

### 3.5 Manual Call Controller - Manual Controls and Lamp Indications

The Manual Call Controller shown in Figures 2 and 4 provides control switches and indicator lamps that allow SDDS calls to be originated, answered, and terminated manually. A brief functional description of each switch and lamp is given below.

- (a) Manual Mode - MM - Switch and Lamp: The MM lamp is illuminated when the DSU is in the Manual Mode and extinguished when the DSU is in the Automatic Mode. Depressing the MM switch causes the DSU to exchange manual and automatic modes. When the DSU is in the Manual Mode, the Data Set Ready (CC) circuit at the Data Interchange Interface will be off.
- (b) Call Mode - CALL - Switch and Lamp: The function of the CALL switch in the SDDS is analogous to that of the switchhook on a telephone. The Call-On State is analogous to the off-hook state in telephone service. The CALL lamp is illuminated in this state. The Call-Off State is analogous

to on-hook in telephone service, in which case the CALL lamp is extinguished. SDDS calls are originated and answered by entering the Call-On State and terminated by entering the Call-Off State. When the DSU is in the Manual Mode, the CALL switch is active and by operating this switch the call state can be changed. In the Automatic Mode the CALL switch is capable of terminating a manually originated call origination attempt; however, once the call is established, the Call switch is disabled from terminating the call. The CALL lamp is also illuminated during the on intervals of the Ring Indicator lead (CE) to indicate an incoming call. The Ring Indicator (CE) lead is one of the Data Interchange Interface leads described in Section 4.1.

- (c) Proceed Lamp - PROCEED: Illumination of this lamp indicates that the called party address digits can be sent by the calling party's DSU. If a call is being originated manually, a seven digit number followed by # is entered from the key pad. The PROCEED lamp is extinguished upon receipt by the DSU of an acknowledgment (ACK) or negative acknowledgment (NAK) code sent from the SDDS switch.
- (d) Recall Lamp - RECALL: Illumination of this lamp indicates that the call attempt in progress cannot be completed successfully. The Two Digit Call Progress Display, described below, will be simultaneously illuminated, indicating the reason for the unsuccessful call attempt.
- (e) Two Digit Call Progress Display: Two digit Call Progress Codes, which are discussed further in Section 6.5, are sent by the SDDS switch to an originating station to indicate remote ring, called station busy, called station Not Ready, time-out, trunk busy or invalid address. Call Progress Codes corresponding to conditions in which the called station is not rung (i.e., all codes except the remote ring) are indicated on the Two Digit Call Progress Display, which then remains illuminated until the Call-Off State is entered.

- (f) Remote Ring Lamp - REMOTE RING: This lamp is illuminated when the originating DSU receives the Call Progress Code corresponding to remote ring. The REMOTE RING lamp remains illuminated until either (a) the DSU receives the cut-through signal, indicating that the call has been answered, or (b) the originating DSU goes to the Call-Off State, whichever occurs first.
- (g) Connect Lamp - CONNECT: This lamp is illuminated when the DSU receives a cut-through indication from the network, as a result of either answering or originating a successful SDDS call. The CONNECT lamp will remain illuminated until the call is terminated.
- (h) Not Ready Mode - Switch and Lamp: When the DSU is in the Manual Mode, the Not Ready Mode may be entered only by operating the NR switch, which will cause the NR lamp to illuminate. A second operation of the NR switch will then cancel the Not Ready condition, causing the NR lamp to extinguish. In the Automatic Mode the Not Ready condition may be achieved by operating the NR switch when the DSU is in the Call-Off State. In the Automatic Mode the Not Ready condition is also under control of the In Service (IS) interface lead. After operation of the NR switch, entering the Call-On State cancels the Not Ready condition. Hence, if the Not Ready condition is to be achieved via the NR switch, it must be operated after each call or call origination attempt.
- (i) Key Pad: A 3x4 array of pushbutton keys is located on the Manual Call Controller. Individual keys are labeled with numerals 0 through 9 plus the characters \* and # in the same pattern as TOUCHTONE key pads. When the PROCEED lamp is illuminated, pressing a key causes a single address character to be transmitted by the DSU. The character # is used as the end-of-address character, but the character \* is not currently assigned.
- (j) Tone Ringer and Level Control Switch: When the DSU is in the Manual Mode, an incoming call will cause an audible indication of nominally one second

on, followed by a nominally three second off interval, repeated. The first on interval during an incoming call alert is a short (approximately 1/4 second) ring. The on interval is coincident with the on state of the Ring Indicator (CE) circuit of the Data Interchange Interface. Section 6.6.1 contains a detailed description of the SDDS alerting signals. A three position slide switch located beneath the Manual Call Controller can be used to control the sound level output of the tone ringer.

### 3.6 Power Requirements

Each DSU, including a Manual Call Controller when used, requires one 105-129 volt, 60  $\pm$ 3 Hz, uninterrupted (see Section 6.3) power source. Total power consumption varies with the features provided, but is always less than 25 watts. A standard 5.5 foot 3-wire power cord equipped with a 3-prong plug is supplied with each DSU.

### 3.7 Grounding

Protective Ground is established for the DSU and Manual Call Controller through the ground wire of the power cord. The customer's terminal equipment Protective Ground should be connected to the same ground as the ground wire of the power cord, and should not rely on the Protective Ground circuit (AA) provided in the Data Interchange Interface. A signal ground circuit is provided to the customer as a common return for control and data interchange circuits. Protective Ground and Signal Ground are normally tied together by means of a strap in the DSU. The strap may be disconnected as a station option (see Section 5.2.1), subject to local noise conditions, ground potentials and local safety regulations.

### 3.8 Distance Limitations

The Data Interchange Interface cable should not exceed 100 feet in length.\* The customer provided Automatic Calling Interface cable should not exceed 50 feet in length. In all installations care must be exercised to assure that the DSU and Manual Call Controller are not subject to stray

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\* See Section 4.3 on Data Interchange Cable Requirements.

electromagnetic fields. In particular, the DSU and the Manual Call Controller must both be located at least one foot away from any substantial source of electromagnetic radiation.

#### 4. INTERFACE SPECIFICATIONS

##### 4.1 Functional Description of Interface Circuits

##### 4.1.1 Data Interchange Interface

The DSU uses a 34-pin connector. The timing and data signals (DB, DD, BA, and BB) are dc-coupled balanced signals, and conform to the standards of CCITT Recommendation V.35. The control signals conform to the electrical characteristics of EIA Standard RS-232-C.

A brief functional description of each SDDS Data Interchange Interface signal is given below, along with its EIA RS-232-C circuit designation, where appropriate. The electrical characteristics of the interface signals are provided in Section 4.4. Signal definitions are the same irrespective of the electrical characteristics of the interface circuit.

- (a) Protective Ground - AA: Connection through power cord to building ground.
- (b) Transmitted Data - BA - To the DSU: Each change in the state of BA should coincide (within  $\pm 10$  percent of the nominal duration of a signal element) with a transition of DB from a binary 1 to a binary 0. Data bits presented to the DSU by the data terminal are transmitted if the following control lead conditions are met: Data Set Ready (CC), on; Request to Send (CA), on; Clear to Send (CB), on; Data Terminal Ready (CD) on.
- (c) Received Data - BB - From the DSU: Each change in the state of BB will coincide (within  $\pm 10$  percent of the nominal duration of a signal element) with a transition of DD from a binary 1 to a binary 0. The data terminal equipment should sample each data bit presented on BB coincident with a transition of DD from a binary 0 to a binary 1.

BB will be held in the mark hold condition (steady 1s) when control signal Received Line Signal Detector (CF) is off.

- (d) Request to Send - CA - To the DSU: An on condition must be present on this circuit prior to transmission of customer data. The Permanent On Request-to-Send option (see Section 5.2) causes the DSU to operate as if CA were constantly on.
- (e) Clear to Send - CB - From the DSU: CB goes on in response to an on condition of CA and Data Terminal Ready (CD), and entry of the DSU into the Data Mode.\*
- (f) Data Set Ready - CC - From the DSU: An on condition on this circuit indicates that the DSU is powered, connected to an SDDS channel, has completed the call originating or call answer functions and is not in the manual or loopback mode.
- (g) Signal Ground - AB: Common signal return path.
- (h) Received Line Signal Detector - CF - From the DSU: An on condition on this circuit indicates that Data Mode signals are being received by the DSU from the network.
- (i) Transmitter Signal Element Timing - DB - From the DSU: Timing signal that defines transmitted data bit intervals.
- (j) Receiver Signal Element Timing - DD - From the DSU: Timing signal that defines received data bit intervals (identical to DB).
- (k) In Service - IS - To the DSU: When the DSU is in the Automatic Mode an off condition on this circuit places the DSU in the Not Ready mode when the DSU is on-hook. This lead is not defined by EIA RS-232-C, and the operation described above is

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\* Whenever a station is in the Automatic Mode (i.e., Manual Mode lamp off) and is connected to another station via the SDDS, it is said to be in the Data Mode.

available on an optional basis only (see Section 5.2.5).

- (l) Data Terminal Ready - CD - To the DSU: When the DSU is in the Automatic Mode of operation, an on condition on this circuit, after a ringing signal has been placed on the Ring Indicator (CE) circuit, causes the DSU to answer an incoming call. The data terminal may leave CD on in preparation to answer an incoming call. Turning CD off during an established call causes the DSU to go on-hook, thereby terminating the call. When the DSU is in the Manual Mode or a test mode, it disregards the CD circuit.
- (m) Ring Indicator - CE - From the DSU: An incoming call causes a ringing signal to appear on this lead. The ringing signal occurs for nominally one second, followed by a nominally three second off interval, repeated.
- (n) Local Loop - LL - To the DSU: When the DSU is in the Automatic Mode, an on condition on this circuit places the DSU in the LL test mode. This lead is not defined by EIA RS-232-C.

#### 4.1.2 Automatic Calling Interface

The Automatic Calling Interface uses a 25-pin customer interface connector. A brief functional description of each SDDS Automatic Calling Interface lead is given below, along with its EIA RS-366 circuit designation.

- (a) Protective Ground - AA: Connection is through the power cord to building ground.
- (b) Digit Present - DPR - To the DSU: The on condition on this lead indicates that a called party address digit is being presented by the customer equipment on leads NB1, NB2, NB4, and NB8. The Present Next Digit (PND) lead must be on prior to the turn on of DPR. DPR must then be held on until PND is turned off, at which time DPR must be turned off until the next address digit is to be presented. DPR must be held off subsequent to the final digit presented.

- (c) Abandon Call and Retry - ACR - From the DSU:  
An on condition on this lead indicates that successful completion of the current call attempt is very unlikely. Action should be taken to abort the call attempt either automatically, by turning off the Call Request (CRQ) lead, or manually, through the use of the Manual Call Controller. A default timer starts when CRQ turns on and restarts each time another digit or the end-of-address digit (#) is presented and when the Remote Ring Call Progress Code is received. If the timer times out (see Section 6.5.1.3) prior to successful completion of the call attempt, the ACR lead turns on.
- (d) Call Request - CRQ - To the DSU: A call origination attempt can be initiated by turning CRQ on, providing PWI is on, and DLO is off. CRQ must then remain on during call origination until Call Origination Status (COS) is turned on. Turning off CRQ before COS turns on will terminate an automatic call origination that has not already been completed. After COS has turned on, depending on which one of two options is selected by the customer (see Section 5.2.4), turning off CRQ can be used to terminate a call. Regardless of which option is selected, CRQ should not remain on after the call is terminated.
- (e) Present Next Digit - PND - From the DSU:  
An on condition on this lead indicates that the DSU is ready to accept the next called party address digit from the customer equipment. For each address digit, PND is held on until Digit Present (DPR) is turned on and the digit accepted, at which point PND is turned off. After the DSU transmits any digit to the network, and the Digit Present (DPR) circuit from the customer equipment has been turned off, PND is again turned on. After the DSU transmits the end-of-address digit (#) and the DPR circuit has been turned off, PND is turned on for the duration of the call.
- (f) Power Indication - PWI - From the DSU:  
An on condition on this lead indicates that power is applied to the DSU.

- (g) Signal Ground - AB: Common signal return path.
- (h) Call Origination Status - COS - From the DSU: An on signal on this lead indicates that the Automatic Calling Interface has completed its call originating function, and that control of the channel has been transferred to the Data Interchange Interface under control of the Data Terminal Ready (CD) circuit. After COS is turned on, CRQ may be turned off without terminating the call, except as provided by the Automatic Call Termination Via CRQ or CD option (see Section 5.2.4).
- (i) Digit Signal Circuits:
  - Low Order Binary Digit - NB1
  - Second Order Binary Digit - NB2
  - Third Order Binary Digit - NB4
  - High Order Binary Digit - NB8Called party address digits are presented to the DSU via the Automatic Calling Interface in binary coded decimal form as given in Table I. The customer must provide a # digit following the last address digit transmitted. He may, at his option, follow the # digit by an end-of-number (EON) digit as discussed in Section 6.5.1.1. Note that no SDDS use has yet been designated for \* or for the digits labeled "Unassigned" in Table I.
- (j) Data Line Occupied - DLO - From the DSU: An on condition on this lead indicates that the DSU is in either the Manual Mode, a test mode, or a call is in progress. DLO must be off prior to initiating a call attempt via the Automatic Calling Interface.

## 4.2 Interface Connectors

### 4.2.1 Data Interchange Interface Connector

The Data Interchange Interface is the point of connection for data transfers between the data terminal equipment and the DSU. Each DSU is equipped with one 34-pin (female) connector. The male 34-pin connector required for the data terminal equipment cable should be a Winchester MRA(C)-

34P-JTC6-H8\* or Burndy MS34PM-124 or AMP 5-202431-2 or equivalent. The pin assignments for this connector are given on page 17.

Note that Pin m (or MM) on the DSU is reserved for future test purposes. The data terminal equipment must not be connected to this pin.

#### 4.2.2. Automatic Calling Interface Connector

The Automatic Calling Interface is the point of connection for automatic calling information transfers between the data terminal equipment and the DSU. It is provided with the Automatic Originate and Answer station arrangement and the Automatic and Manual Originate and Answer station arrangement. Each DSU is equipped with one 25-pin (female) connector for this purpose. For the male 25-pin connector, a customer-provided plug such as the DB-19604-432 plug manufactured by Cannon or Cinch, or the AMP 205784-1 manufactured by AMP, Incorporated, or equivalent is required. This type of plug provides reliable, low-resistance contacts. In addition, a DB-51226-1 hood manufactured by Cinch (or equivalent) is recommended to protect the connections, anchor the cable to the plug, provide a finger grip for easy insertion or removal, and provide a positive screw-in locking arrangement to prevent the connector from being pulled out inadvertently. The pin assignments for the Automatic Calling Interface connector are given on page 18.

Note that pin assignments 9 and 10 on the DSU are reserved for future test purposes. The data terminal equipment must not be connected to these pins.

#### 4.3 Data Interchange Interface Cable Requirements

The characteristics of the interconnection cable between the data terminal equipment and the DSU are specified in this section. An interconnecting cable meeting these specifications will result in a transmission line with a characteristic impedance on the order of 100 ohms at frequencies where series inductance and shunt capacitance

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\* The (C) is specified for the Winchester connector if insertable pins are desired.

PIN ASSIGNMENTS FOR DATA INTERCHANGE INTERFACE CONNECTOR

<u>Connector Pins</u>		<u>Function</u>	<u>EIA RS-232-C Designation</u>	<u>CCITT Designation</u>
<u>Winchester</u>	<u>AMP and Burndy</u>			
A	A	Protective Ground	AA	101
B	B	Signal Ground	AB	102
C	C	Request to Send	CA	105
D	D	Clear to Send	CB	106
E	E	Data Set Ready	CC	107
F	F	Rec'd. Line Signal Detector	CF	109
H	H	Data Terminal Ready	CD	108.2
J	J	Ring Indicator	CE	125
R	R	Received Data*	BB(A)	104(A)
T	T	Received Data*	BB(B)	104(B)
V	V	Receiver Signal Element Timing*	DD(A)	115(A)
X	X	Receiver Signal Element Timing*	DD(B)	115(B)
P	P	Transmitted Data*	BA(A)	103(A)
S	S	Transmitted Data*	BA(B)	103(B)
Y	Y	Transmitter Signal Element Timing*	DB(A)	114(A)
a	AA	Transmitter Signal Element Timing*	DB(B)	114(B)
m	MM	Reserved for future testing	-	-
K	K	Local Loop (LL)	†	†
n	NN	In Service (IS)	†	†
L-N, U, W, Z		Not Used‡	-	-
b-d, f-k	BB-FF, HH, JJ-LL	Not Used‡	-	-

\* The signals on these leads are dc-coupled balanced.

† These leads are not defined by EIA RS-232-C or by the CCITT.

‡ Within the DSU, these pins are not electrically terminated.

PIN ASSIGNMENTS FOR  
AUTOMATIC CALLING INTERFACE CONNECTOR

<u>Pin No.</u>	<u>Description</u>	<u>EIA RS-366 Designation</u>	<u>CCITT Designation</u>
1	Protective Ground	AA	212
2	Digit Present	DPR	211
3	Abandon Call and Retry	ACR	205
4	Call Request	CRQ	202
5	Present Next Digit	PND	210
6	Power Indication	PWI	213
7	Signal Ground	AB	201
8	Not Used*	--	--
9-10	Reserved for future testing of automatic calling equipment.	--	--
11-12	Not Used*	--	--
13	Call Origination Status	COS	204
14	Digit Signal Circuit (Low Order Binary Digit)	NB1	206
15	Digit Signal Circuit (Second Order Binary Digit)	NB2	207
16	Digit Signal Circuit (Third Order Binary Digit)	NB4	208
17	Digit Signal Circuit (High Order Binary Digit)	NB8	209
18-21	Not Used*	--	--
22	Data Line Occupied	DLO	203
23-25	Not Used*	--	--

\* Within the DSU, these leads are not electrically terminated.

dominate (normally above 100 kHz). This characteristic should minimize pulse distortion between the nominally 100-ohm interface drivers and terminators. The cable may be composed of twisted pairs or untwisted pairs (flat cable) possessing the following characteristics uniformly over its length:

Conductor Size. The cable shall be composed of pairs of wires of 24 gauge, or larger, conductor for solid or stranded copper wires, or for non-copper conductors, a sufficient size to yield a dc wire resistance not to exceed 30 ohms per 1000 feet per conductor.

Cable Length. The business machine cable should be less than 100 feet in length.

Mutual Pair Capacitance. The capacitance between one wire in the pair to the other wire shall not exceed 20 picofarads per foot, and the value shall be reasonably uniform over the length of the cable.

Stray Capacitance. The capacitance between one wire in the cable to all others in the cable sheath, with all others connected to ground, shall not exceed 40 picofarads per foot and shall be reasonably uniform for a given conductor over the length of the cable.

Pair-to-Pair Balanced Crosstalk. The balanced crosstalk from one pair of wires to any other pair in the same cable sheath shall have a minimum value of 40 decibels of attenuation measured at 150 kilohertz. To reduce the possibility of crosstalk between the leads, the following recommendations are made regarding the cable pair assignments for twisted pair cable. The greatest potential crosstalk problems are between the control signal circuits. It is recommended that one twisted pair be used for each control signal with one lead of the pair tied to Signal Ground at both ends of the cable. The amount of crosstalk depends on the cable, the cable driver characteristics and the cable terminator input impedance. In order to minimize crosstalk, the balanced data and clock signals should be assigned to pairs in the center of the cable. The cable pairs around the outside of the cable should be assigned to the control signals. An extra twisted pair with both leads tied to signal ground at the connector of the

cable should be used between each control pair to provide isolation. This arrangement with the extra ground wires around the outside of the cable also provides some shielding from interfering signals in the outside environment.

#### 4.4 Electrical Characteristics

Two types of interface signals are used: (1) data and timing signals, and (2) control signals. The electrical characteristics of the control signals conform to EIA Standard RS-232-C. The data and timing signals meet the balanced interface standard of CCITT Recommendation V.35. The cable drivers produce a nominal 1.1 volt peak-to-peak direct coupled signal balanced with respect to ground into 100 ohms. Figure 5 shows a typical balanced cable driver and cable terminator. For a binary "0," line A is nominally +.55 volts with respect to line B, and for a binary "1" line A is nominally -.55 volts with respect to line B. In making the transition from a "0" to a "1," line A goes from +.55 volts to -.55 volts with respect to line B for a swing of 1.1 volts peak-to-peak.

The interface driver meets the following requirements:

1. Differential output impedance is 100 ohms  $\pm$  50 percent.
2. Output impedance to ground with output terminals shorted together is 150 ohms  $\pm$  10 percent.
3. When terminated in a 100-ohm resistive load, the driver delivers a signal level of 1.1 volts peak-to-peak,  $\pm$  20 percent, i.e., the voltage between the two output leads is 0.55 volts  $\pm$  20 percent with the polarity of the output voltage for a transmitted binary "0" being the opposite of that for a transmitted binary "1."
4. Maximum rise and fall time between the 10 percent and 90 percent levels is less than 1 percent of the nominal duration of a signal element.
5. The arithmetic mean of the voltage of each output with respect to ground (DC line offset) does not

exceed 0.6 volts when the driver is terminated in 100 ohms.

The interface terminator meets the following requirements:

1. Input impedance is  $100 \pm 10$  ohms.
2. Resistance to ground with the input terminals shorted together is  $150 \pm 15$  ohms.

An interface driver complying with the above requirements when connected to an interface terminator complying with the above requirements will operate satisfactorily with a maximum of  $\pm 4$  volts difference in ground potential or with a maximum of  $\pm 2$  volts (peak) longitudinal noise. If margin is to be allocated to ground potential offset and longitudinal noise simultaneously, the driver-terminator should operate satisfactorily if the following is satisfied:

$$\frac{\text{Ground Potential Offset}}{2} + \text{Longitudinal Noise Voltage} \leq 2 \text{ volts}$$

Any balanced driver or terminator circuit in the interface should not be damaged by:

1. Shorting to ground.
2. Crossing with any other interchange lead.

Loop repeaters may be used to regenerate signals transmitted on 56 kb/s loops. Use of loop repeaters results in an increase in very low frequency perturbations occurring in the phase of the timing and received data signals at 56 kb/s customer interfaces; however, neither the phase differences between timing and data signals nor the symmetry of the timing signals are affected. (The duty cycle for the timing signals is  $50 \pm 5$  percent.) The frequencies of these phase perturbations are nominally less than 0.007 percent of the signaling frequency

(i.e., less than 4 Hz at 56 kb/s). Including the increase in very low frequency jitter that is due to repeaters, when employed, the degree of isochronous distortion on the Received Data (BB) circuit is not expected to exceed 30 percent, and the peak individual distortion on each of the two timing circuits (DB and DD) is not expected to exceed 15 percent. If the customer, by use of a timing recovery circuit of sufficient bandwidth,\* tracks the low frequency jitter on the Received Signal Element Timing (DD) circuit, the degree of isochronous distortion on the Received Data (BB) circuit, measured with respect to the recovered timing signal, is not expected to exceed 11 percent.

## 5. CUSTOMER OPTIONS

### 5.1 Service Options

Two basic service options must be specified for each SDDS station; type of station equipment arrangement and whether the station will be part of a multiline hunting group. These service options, which are described in this section, should be specified at the time an order is placed.

#### 5.1.1 Station Equipment Arrangements

One of the following three basic station arrangements must be specified for each DSU station:

- Automatic Answer-Only
- Automatic Originate and Answer
- Automatic and Manual Originate and Answer

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\* Bandwidth recommendations for timing recovery are discussed in the Technical Reference "DATAPHONE Switched Digital Service Channel Interface Specifications" (PUB 41023).

With the Automatic Answer-Only arrangement, incoming calls can be answered and terminated automatically via the Data Interchange Interface of the DSU, but no calls can be originated.

The Automatic Originate and Answer arrangement provides for answering and terminating calls automatically, and also permits calls to be originated automatically via the Automatic Calling Interface of the DSU.

The Automatic and Manual Originate and Answer arrangement permits calls to be originated, answered and terminated automatically and, in addition, provides the capability to originate, answer and terminate calls via the Manual Call Controller. Further information on these station arrangements is included in Section 3.1.

#### 5.1.2 Multiline Hunting Groups

For each station, the customer may select the basic single line service, or, if he has more than one station in a Switched DSA, he may select multiline terminal hunting. Single line stations will each be assigned one 7-digit address by the Telephone Company. This number should be used when calling the station from any other station. Whenever a single line station is busy or is signaling to the network that it is not ready to receive incoming calls, no calls addressed to the station will be completed.

When multiline hunting is selected, the stations to be included in each hunting group must be located in the same Switched DSA. Up to 20 stations may belong to the same terminal hunting group. Each station in a terminal hunting group will be assigned a separate 7-digit address by the Telephone Company, but the numbers assigned will not necessarily be sequential. When one of the stations is called, but it is either busy or signaling that it is not ready to receive calls, the call attempt is automatically rerouted to the station in the same hunting group, which has the next higher 7-digit address. If that station is busy or signaling that it is not ready to receive calls, the call attempt is rerouted to the next higher numbered station, and so on, until an attempt is made to reach the highest numbered station in the hunting group.

If that station is busy or signaling that it is not ready to receive calls, a Call Progress Code corresponding to "called station busy" is returned to the calling station. It is important to note that no call attempts will ever be rerouted to the station having the lowest numbered address in a terminal hunting group, and that no calls initially directed to the station having the highest numbered address in a terminal hunting group will ever be rerouted to any other station.

## 5.2 Station Options

For compatibility with various customer equipment arrangements and modes of operation, the following station options are provided, and should be specified at the time an order is placed.

### 5.2.1 Signal and Frame Ground

Signal Ground to Frame Ground Option:

This station option internally connects Signal Ground to Protective Ground for the Data Interchange Interface and for the Automatic Calling Interface.

Signal Ground Disconnected from Protective Ground Option:

This station option will provide a DSU with the Signal Ground disconnected from the Protective Ground. The option is subject to local noise conditions, grounding potentials and local safety regulations.

### 5.2.2 Request to Send Circuit Control

The Request to Send circuit for the Data Interchange Interface must be specified either as Permanent On or Terminal Controlled.

Permanent On Request to Send Option:

For customer data terminals that are not equipped to turn on the Request to Send circuit, a DSU option is provided to hold Request to Send on continuously. This option matches the EIA Type E interface of RS-232-C.

### Terminal Controlled Request to Send Option:

This conforms to customer data terminals with an EIA RS-232-C Type D interface. Note that a customer data terminal with a Type D interface should not use the above Permanent On Request to Send Option. A data terminal with a Type D interface, following the recommendations of RS-232-C, shall not turn its Request to Send circuit on, unless the Clear to Send circuit from the data communication equipment is off. Since an operating DSU with the Permanent On Request to Send Option presents a permanent on condition to the Clear to Send circuit, a data terminal in strict compliance with a Type D interface could not turn its Request to Send circuit on again, once having turned it off. Thus, the terminal could not go back into the transmit mode of operation.

### 5.2.3 Carrier Control

For stations having the Terminal Controlled Request to Send Option (see Section 5.2.2), either Permanent Carrier or Terminal Controlled Carrier operation must be specified.

#### Permanent Carrier Option:

With this option, while a connection is established with another station, when the data terminal equipment turns off its Request to Send (CA) circuit, the DSU turns off the Clear to Send (CB) circuit. The output of the DSU is a continuous Data Mode marking signal when the CA circuit is off. When the CA circuit is turned on, the CB circuit goes on, and the DSU transmits whatever data is presented on the Transmitted Data (BA) circuit.

#### Terminal Controlled Carrier Option:

This option is designed to facilitate half duplex operation on the full duplex SDDS channels. With this option, while a connection is established with another station, when the data terminal equipment turns off its Request to Send (CA) circuit, the DSU turns off the Clear to Send (CB) circuit, and the DSU transmits the Data Mode Extension (DME) code, which is a special sequence of pulses used for station-to-station signaling in the SDDS. This code is in a modified bipolar format (see PUB 41023), which is distinct from any pattern associated with customer

data, and imposes no restrictions on the customer data sequences. When the DSU at an SDDS station receives the DME characters, its Received Line Signal Detector (CF) circuit turns off. When the CA circuit is turned on, the CB circuit goes on after a delay sufficient to allow the CF lead at the distant DSU to turn on. This delay is approximately 21 bits. When the CB circuit turns on, the DSU transmits whatever data is presented to the Transmitted Data (BA) circuit.

#### 5.2.4 Automatic Call Termination

For stations having the Automatic Calling Interface, one of the following two methods must be specified for terminating calls automatically while the Call Origination Status (COS) circuit is on at the Automatic Calling Interface. With either method, turning the Call Request (CRQ) circuit off before the COS circuit turns on will terminate an automatic call origination that has not yet been completed.

##### Automatic Call Termination Via CRQ or CD Option:

With this option, calls that are originated through the Automatic Calling Interface are terminated automatically by turning off either the Call Request (CRQ) circuit at the Automatic Calling Interface or the Data Terminal Ready (CD) circuit at the Data Interchange Interface. CD and CRQ must both be held on after COS goes on to maintain the Call-On State.

##### Automatic Call Termination Via CD Only Option:

With this option, turning off the CD circuit after COS has turned on will terminate a call automatically, but turning off the CRQ circuit will not. Only CD must be held on after COS goes on to maintain the Call-On State.

#### 5.2.5 Not Ready Control

One of the following two methods must be selected concerning control of the DSU's state of readiness to accept incoming calls when in the Automatic Mode and in the Call-Off State.

#### Enable Not Ready Option:

The In Service (IS) circuit is enabled when this option is installed. It is effective only when the DSU is in the Automatic Mode and in the Call-Off State. An off condition presented to the IS circuit causes the DSU to transmit Not Ready control codes to the switch when the DSU is in the Call-Off State (analogous to on-hook in telephone service). An on condition presented to the IS circuit causes the DSU in the Automatic Mode to signal the switch that it is ready for incoming calls.

#### Disable Not Ready Option:

With this option installed, the DSU operates as if the IS circuit were permanently on, i.e., the DSU signals the switch that it is ready for incoming calls when the DSU is in the Automatic Mode and in the Call-Off State. Operation of the NR switch of the Manual Call Controller is not affected.

### 5.2.6 Test Switch and Indicator Lamp Location

#### Front Face Plate Option:

Depending on customer operating convenience the Test Switch and indicator lamps may be located on the front face plate of the DSU. (See Figure 6.)

#### Rear Face Plate Option:

The Test Switch and indicator lamps may alternatively be located on the rear face plate. (See Figure 6.) This end plate also contains the interface and ac power connectors.

## 6. SYSTEM OPERATION

### 6.1 Customer Operating Information

The information concerning system operation that is needed by a station attendant for originating, answering and terminating calls is included in an operator's manual, which will be provided at the time of service installation. This manual also summarizes the information on customer testing, trouble indications and trouble reporting, which are discussed in this Technical Reference.

## 6.2 Station Addresses

As mentioned in Section 2.3, each SDDS station will be assigned a 7-digit address (NNX-XXXX, where N can be any digit 2-9 and X can be any digit 0-9) for use when placing calls to the station. Some addresses are reserved for special purposes within the SDDS. It is important to note that SDDS stations can only place calls to other SDDS stations, and that no voice capabilities are provided.

In addition to the single line station arrangements, a terminal hunting arrangement is provided. In a terminal hunting group of stations, each station is assigned a unique 7-digit address. When a called station is busy or signaling that it is not ready to receive calls, an incoming call to that station is rerouted to the station in the group with the next numerically higher address for completion. If that station is also busy or signaling that it is not ready to receive calls, the call is again rerouted, and so on, until the call is routed to the station in the group having the numerically highest address. If that station is busy or signaling that it is not ready to receive calls, the Call Progress Code corresponding to "called station busy" is returned to the calling station.

## 6.3 Not Ready Condition

When a station is prepared to receive incoming calls, the DSU is said to be in the Idle State. When the customer's data terminal equipment is not ready to receive incoming calls, the DSU may be placed in the Not Ready condition. While in this condition, the Not Ready (NR) lamp on the Manual Call Controller is on, and the DSU continually signals the network to block all incoming calls. When a call is placed to a station that is in the Not Ready condition, the Not Ready Call Progress Code is returned to the calling station, as described in Section 6.5.

A station may be placed in the Not Ready condition under manual control by use of the Not Ready (NR) key on the Manual Call Controller. Independently, a station may be placed in the Not Ready condition under automatic control by use of the In Service (IS) signal at the Data Interchange Interface. (Use of the IS interface signal

is optional, as described in Section 5.2.5). Either automatic or manual means may be used to maintain the Not Ready condition, until the terminal is ready to receive calls.

It is important to recognize that removing the power source for the DSU and Manual Call Controller does not cause the station to enter the Not Ready condition. Power to these units should not be interrupted. If power is removed, any call in progress will be disconnected, and the DSU will lose communication contact with the network. The station will not be able to originate calls, and it will not be able to answer incoming calls. However, other stations calling a station whose power is off will receive the Remote Ring Call Progress Code (see Section 6.5), which indicates that the called station is being alerted, but has not yet answered the call.

#### 6.3.1 Control By In Service (IS) Interface Signal

When all four of the following conditions are satisfied, a DSU provided with the Enable Not Ready option will be held in the Not Ready condition, under control of the IS interface signal.

- a. Power is on; and
- b. The IS interface signal is off; and
- c. The station is in the Automatic Mode (the Manual Call Controller MM lamp is off); and
- d. No call is in progress, and the station is not in any test mode.

While in the Not Ready condition under control of the IS interface signal, calls may be originated either automatically or manually. This interrupts the Not Ready condition for the duration of the call, but the station reverts to the Not Ready condition immediately following call termination, if the above listed conditions are all satisfied at that time. Also, regardless of the conditions at the beginning of a call, if all four of the above conditions are satisfied at call termination, the station will immediately enter the Not Ready condition.

When the Enable Not Ready Option is used with the Automatic Answer - Only station arrangement, the customer's data terminal equipment should keep the IS interface signal on throughout each call.

### 6.3.2 Control By Not Ready (NR) Key

Depressing the Not Ready (NR) key once, while a station is in the Idle state, will place the station in the Not Ready condition, whenever either of the following two conditions is satisfied:

- a. The station is in the Manual Mode (the Manual Call Controller MM lamp is ON), and the station is not in any test mode. If a call is in progress, depressing the NR key will also cause the call to be disconnected; or
- b. The station is in the Automatic Mode (the Manual Call Controller MM lamp is OFF), no call is in progress, and the station is not in any test mode. If a call is in progress, depressing the NR key will have no effect.

While in the Not Ready condition as a result of depressing the Not Ready (NR) key, any one of the following conditions will cause the Not Ready condition to be cancelled, unless the station is held in the Not Ready condition by means of the In Service (IS) interface signal, as described in Section 6.3.1:

- a. Depressing the NR key again; or
- b. Removal of power. Note: After power is reapplied, the NR key must be depressed to resume the Not Ready condition under control of the NR key; or
- c. Initiation of a call origination attempt, either manually by depressing the CALL key, or automatically by turning on the Call Request (CRQ) signal at the Automatic Calling Interface. Note: After each call is terminated, the NR key must be depressed to resume the Not Ready condition under control of the NR key; or
- d. Entering the test mode, which causes the station to appear busy, with respect to incoming calls. Note: Having the Test Switch in the LL position, while the station is in the Manual Mode, will not cause the NR lamp to extinguish. This permits the Local Line Manual Test (see Section 8.1.3)

to be conducted. Also, returning the Test Switch from the LL position to the center off position, while the station is in the Manual Mode with the NR lamp lit, will cause the station to enter the Not Ready condition. Following any station tests, of course, the NR lamp on the Manual Call Controller should be checked to assure that the station is in the desired operating state (Idle or Not Ready).

#### 6.4 Terminal Operation - Duplex or Half-Duplex

This section discusses terminal operation, with emphasis on the differences between duplex and half duplex operation. With duplex operation, also called full-duplex operation, customer data is transmitted in both directions simultaneously. With half-duplex operation, customer data is transmitted in both directions, but not at the same time. The Not Ready condition and the procedures for originating, answering and terminating calls are the same for duplex and half-duplex terminals, and are discussed in Sections 6.3, 6.5 and 6.6.

The SDDS provides for switched four-wire duplex digital data transmission. Although four-wire duplex service will be provided, customers may also conduct data transfers in one-way and half-duplex manners. Between calls, when a station is Idle or transmitting Not Ready signals to the network, it is said to be in the "call-off" condition or "on-hook." During an established call or while a station is in the process of originating a call, a station is said to be in the "call-on" or "off-hook" condition. Whenever a station is in the Automatic Mode and is connected to another station via the SDDS, it is said to be in the "Data Mode." While in the Data Mode, the Clear to Send (CB) circuit at the Data Interchange Interface turns on in response to an on signal on the Request to Send (CA) circuit. With Clear to Send on, all data presented on the Transmitted Data (BA) circuit is transmitted to the other station. Thus, it is during the Data Mode that the differences between duplex and half-duplex operation are important.

##### 6.4.1 Duplex Operation

Simultaneous transmission in both directions is provided by the SDDS. The DSU provides, in addition to terminal

control of the Request to Send circuit, a Permanent On Request to Send option that holds the Request to Send circuit continuously in the on condition. With this option the Clear to Send circuit is always on while the station is in the Data Mode, and the data terminal equipment should have an EIA RS-232-C Type E interface. (See Section 5.2.2). When the Request to Send circuit is under the control of the data terminal equipment, the DSU has an EIA RS-232-C Type D interface.

#### 6.4.2 Half-Duplex Operation

In half-duplex operation only one terminal transmits customer data at a time. While in the Data Mode, a data terminal desiring to transmit turns on its Request to Send circuit (see Terminal Controlled Request to Send option, Section 5.2.2). In response, the Clear to Send circuit turns on, and customer data may then be transmitted. To accommodate the "channel turn-around" type of half duplex operation commonly used in analog communication systems, the Terminal Controlled Carrier option is provided (see Section 5.2.3). With this option, Data Mode Extension (DME) characters, which are special sequences of pulses used for station-to-station signaling while in the Data Mode, are transmitted whenever the Request to Send circuit is off. When DME characters are received at any DSU that is in the Data Mode, the Received Line Signal Detector (CF) interface circuit turns off, indicating that no customer data is being received from the distant station. This signal can be used in controlling half duplex transmissions between stations. With the Terminal Controlled Carrier Option a delay is inserted after Request to Send turns on and before Clear to Send is turned on to allow sufficient time for the Received Line Signal Detector circuit at the distant station to turn on (see Section 5.2.3).

#### 6.5 Call Origination and Termination

In the Automatic Mode, calls may be originated automatically by means of the Automatic Calling Interface or manually by means of the Manual Call Controller. In the Manual Mode, calls may be originated only manually by means of the Manual Call Controller. In the Automatic Mode, calls in progress may only be terminated automatically; however, manually originated call attempts, while in the automatic mode, may be terminated manually at any time before the called station answers. In the Manual Mode, calls may be terminated only

manually by means of the Manual Call Controller. Procedures for originating and terminating calls are described in Sections 6.5.1 and 6.5.2. Attempt control, a system feature intended to limit the number of unsuccessful call attempts during unusually heavy traffic periods, is described in Section 6.5.3.

### 6.5.1 Automatic Call Origination

Calls may be originated automatically using the Automatic Calling Interface circuits, which are described in Section 4.1.2. Figure 7 illustrates the normal sequence for interface signaling during a call origination. To originate a call automatically, the Power Indication (PWI) circuit from the DSU must be on, and the Data Line Occupied (DLO) circuit from the DSU must be off.

#### 6.5.1.1 Automatic Calling Procedure

Automatic call origination attempts are initiated by turning on the Call Request (CRQ) circuit to the DSU. The DLO circuit then turns on, and the DSU signals the network that a call request has been made. The DLO circuit remains on during all calls and also whenever the station is in any test mode or the Manual Mode or when the NS lamp is illuminated. After a period called "dial tone" delay (although only digital signals are used), the network signals the DSU that it is ready to receive the address of the station to be called. The DSU then turns on the Present Next Digit (PND) circuit at the Automatic Calling Interface, indicating that the first called party address digit may be transmitted.

The first called party address digit is then placed on the Digit Signal Circuits (NB1, NB2, NB4 and NB8) in binary coded decimal form, as shown in Table I. Then the Digit Present (DPR) circuit to the DSU is turned on, and the digit presented on the Digit Signal Circuits is read by the DSU. Following this, the DSU turns off the PND circuit, indicating that the digit has been accepted. The DPR circuit to the DSU should then be turned off until PND is again turned on. PND will be turned on after the entire digit is transmitted to the network, but only after DPR has been turned off. The remaining six called party address digits, followed by the # digit shown in Table I, are then conveyed to the network in the same manner.

Following #, the EON digit may also be transmitted, although it is not required by the SDDS. When EON is transmitted, the DSU receives it according to the above procedure, then immediately turns on the Call Origination Status (COS) circuit, indicating that the call origination functions of the Automatic Calling Interface are completed. The Data Set Ready (CC) circuit at the Data Interchange Interface also turns on. If EON is not transmitted, the COS and CC circuits will turn on only after a complete connection has been established and the called station has answered. In either case, after receiving the last digit, the DSU will again turn on the PND circuit, after DPR is turned off and the final address information has been transmitted to the network. PND, COS and DLO will all remain on for the remainder of the call.

When the called station answers, and a complete connection is established, the DSU indicates this by turning on the Data Set Ready (CC) circuit at the Data Interchange Interface; however, if the EON digit is transmitted via the Automatic Calling Interface, the Data Set Ready circuit will turn on immediately, before the connection is established, as an indication that an automatic call origination attempt is in progress. When Data Set Ready is turned on early (before a complete connection is established) turning on the Request to Send (CA) circuit will not cause the Clear to Send (CB) circuit to turn on until a complete connection is established. Also, the Received Line Signal Detector (CF) circuit will be held off during the entire call origination attempt and will turn on only when a complete connection is established.

#### 6.5.1.2 Abandoning a Call Origination Automatically and Terminating a Call Automatically

If, for any reason, it is necessary for the customer terminal equipment to abandon a call origination attempt automatically before the COS circuit is turned on, this can be accomplished by turning off the CRQ circuit.

After COS has turned on, a call may be terminated automatically in either of two ways, depending on which one of two station options is provided (as described in Section 5.2.4). If the DSU has the Automatic Call Termination Via CRQ or CD option, turning off either CRQ at the Automatic Calling Interface or Data Terminal Ready

(CD) at the Data Interchange Interface, after COS has turned on, will cause the call to be terminated. If the DSU has the Automatic Call Termination via CD Only option, the only way a call may be terminated automatically after COS has turned on, is by turning off the Data Terminal Ready (CD) circuit at the Data Interchange Interface. Calls or call origination attempts may be terminated manually at any time, by means of the Manual Call Controller, as described in Section 6.5.2. Also, if the power source to the DSU is turned off, any call in progress will be disconnected, after the hold-over period of the station power supply is exceeded.

While a station is in the automatic mode during a call, its DSU will be notified by the network of any disconnection of the call and will automatically enter the call-off (on-hook) condition.

#### 6.5.1.3 Timeout Periods

The DSU has a timer, which is reset to zero when CRQ is turned on at the beginning of an automatic call origination, and again after each address digit and the # character is transmitted to the DSU via the Automatic Calling Interface. It is also reset after the remote ring signal is received from the network, indicating that the called station is receiving a ringing signal. This timing function is canceled only when the called station answers or the automatic call origination attempt is aborted. If the timer "times out",\* it causes the Abandon Call and Retry (ACR) circuit from the DSU to be turned on at the Automatic Calling Interface. This signal indicates that the probability of successful call completion is very small. However, if calls are originated automatically to stations that use manual answering, it must be recognized that the ACR circuit may turn on before the call is answered manually, even though no difficulties have been encountered. If a call is completed after ACR has turned on, ACR will then turn off.

The SDDS network has a timer that has a nominal "time out" value of 20 seconds. This timer is set at zero when

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\* The "time out" period is greater than 8 and less than 15 seconds.

the "dial tone" signal is first transmitted to an originating station, and again after each address digit is received from the station. When the network receives the # character from the originating station, which indicates that a complete address has been transmitted, this timing function is no longer active. If this timer "times out," it will cause the call origination attempt to be cancelled, and the Call Origination Status (COS) circuit from the DSU will not turn on. COS will not be turned off, however, if it has already been turned on, due to use of the EON signal (see Section 6.5.1.1). Furthermore, the timer in the DSU will have already caused the Abandon Call and Retry (ACR) circuit to turn on at the Automatic Calling Interface.

#### 6.5.2 Manual Call Origination and Termination

Calls may be originated manually using the Manual Call Controller. Figure 8 illustrates the normal sequence of events during a manual call origination. The functions of the individual keys and lamps on the Manual Call Controller are described in Section 3.5.

A manual call origination is initiated by depressing the CALL key on the Manual Call Controller (see Figure 4) while the station is either in the Idle condition or the Not Ready condition. This will cause the CALL lamp to light, and is analogous to going "off hook" in telephone service. While in the Idle condition, however, it is possible for an incoming call to arrive just before the CALL key is depressed. In this case, the call origination attempt is cancelled. Also, depressing the CALL key inadvertently answers the call, if the station is in the Manual Mode. This cannot happen if the station is in the Not Ready condition when the CALL key is depressed. When the station is in the Automatic Mode, it is also possible for an automatic call origination to be initiated just before the CALL key is depressed, thus causing the station to ignore the manual call origination attempt. This cannot happen if the station is in the Manual Mode when the CALL key is depressed.

After the CALL key is depressed once, and the CALL lamp is lit, it will remain lit throughout the duration of the call. It will also be lit during automatically originated calls. If the station is in the Automatic Mode, and a call or an automatically initiated call origination is

in progress, depressing the CALL key will have no effect. However, if the station is in the Manual Mode, and the CALL key is depressed while a call or manually initiated call origination attempt is in progress, the Call-On condition will be cancelled, and the station will immediately enter the Idle condition. Similarly, depressing the Not Ready (NR) key, while the station is busy and in the Automatic Mode, will have no effect. However, if the station is busy and in the Manual Mode, depressing the NR key will cause the Call-On condition to be cancelled, and the station will immediately enter the Not Ready (NR) condition. Calls and call origination attempts may be terminated manually by depressing either the CALL key or the NR key, while the station is in the Manual Mode. While the station is in the Automatic Mode, a manually initiated call origination may be terminated by depressing the CALL key at any time before the call is answered, but a call in progress may be terminated only automatically as described in Section 6.5.1.2.

Upon detection by the network of the call origination, the network transmits to the station the digital "dial tone" signal indicating that the network is ready to receive the address of the station to be called. Receipt of the digital "dial tone" signal causes the PROCEED light on the Manual Call Controller to turn on, indicating that the 7 digit address of the called station should be entered via the keys numbered 0-9. Then the # key should be depressed. Care should be taken to avoid long delays while entering the address and depressing the # key. Once the PROCEED lamp is lit, if (approximately) 20 seconds expires with no digit being entered, the network will cancel the call origination attempt. When this happens, the Two Digit Call Progress display will indicate the number 30, meaning "invalid address," and the call attempt must be terminated at the originating station before a new call attempt can be made.

When the 7 digit address has been entered and the # key depressed, the network signals the DSU to turn off the PROCEED lamp. When the called station receives the digital ringing signal, the originating station receives the digital signal corresponding to remote ringing, and the REMOTE RING lamp turns on. If it is not possible to ring the called station, the RECALL lamp will turn on, and one of the following two-digit displays will be provided on

the Two Digit Call Progress Display located to the right of the RECALL lamp.\*

<u>Call Progress Code</u>	<u>Meaning</u>
10	- Called station is busy.
11	- Called station is Not Ready.
20	- Time-out (switching equipment in network timed out due to network difficulties).
21	- Trunk busy (no idle transmission path available due to heavy traffic in the network).
30	- Invalid address (invalid address received, possibly due to certain transmission errors, or network timed out during call origination).

When any of these displays are received, the call attempt must be terminated at the originating station before a new call can be initiated. (Also see Section 6.5.3 on attempt control for unsuccessful call attempts during extremely heavy traffic periods.)

When the called station answers, the REMOTE RING lamp turns off and the CONNECT lamp turns on. While the station is in the Automatic Mode, the Call-On condition is maintained by holding the Data Terminal Ready (CD) circuit on at the Data Interchange Interface, and data transmissions may take place. While the station is in the Manual Mode, the Call-On condition is maintained unless either the NR key or the CALL key is depressed.

When depressing the MM key to transfer from the Automatic Mode to the Manual Mode, it is possible to interrupt an automatically originated call. The state of the automatically originated call will be indicated by the lamps on the Manual Call Controller. This can usually be avoided by verifying that the CALL lamp is off just before depressing the MM key. However, if an automatically originated call is inadvertently interrupted by depressing the MM key, the MM key may be depressed again to place the station back in the Automatic Mode or the automatically originated call may be terminated by depressing the CALL

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\* When an automatically originated call cannot be completed, the appropriate call progress code will also be displayed on the Manual Call Controller until the call attempt is terminated either by the automatic calling interface or by the Manual Call Controller.

key. It should be noted that the Data Set Ready (CC) circuit at the Data Interchange Interface will be off, while the station is in the Manual Mode. Also, if an automatic call origination is interrupted by depressing the MM key, depressing the MM key again will permit the automatic call origination to resume, if it has not been aborted due to a timeout and if the Call Request (CRQ) circuit at the Automatic Calling Interface is still on when automatic control is resumed.

### 6.5.3 Attempt Control

Attempt control is a system feature intended to limit the number of unsuccessful call attempts at a switch during periods of unusually high traffic. If the number of unsuccessful call attempts at a switch were not limited during such periods, a number of stations (especially those using automatic calling) could originate an extremely large number of unsuccessful call attempts to stations that are busy or Not Ready. This could cause the "dial tone" delay period to increase for all customers served by the switch, and unnecessarily decrease the traffic handling capability of the system.

The attempt control mode of operation is only used when an unusually large number of call attempts occur at a switch, and only affects an originating station for a period of 6 seconds immediately following termination of an unsuccessful call attempt. During the attempt control mode of operation at a switch, an interval of approximately 6 seconds is required after termination of an unsuccessful call attempt before the switch will act on a new call origination attempt from the same originating station. Also, during this 6 second interval, the station will appear busy, with respect to incoming calls. For example, assume that a call is originated manually to a busy station during the attempt control mode of operation. If the attendant at the originating station cancels that call by depressing either the CALL or NR key, then attempts to originate another call 4 seconds later by depressing the CALL key, the PROCEED lamp will be delayed in turning on for a period of approximately 2 seconds, in addition to the normal "dial tone" delay. (The service objective for "dial tone" delay is discussed in Section 7.3). For automatically originated calls the additional delay would occur after the Call Request (CRQ) circuit to the DSU

turns on and before the Present Next Digit (PND) circuit from the DSU turns on.

## 6.6 Call Answering

The conditions governing whether a station is Idle (available to receive calls) and a description of how the station is alerted by an incoming call are described in Section 6.6.1. If these conditions are satisfied at an SDDS station, calls may be answered either automatically by means of the Data Interchange Interface or manually by means of the Manual Call Controller. These answering procedures are described in Sections 6.6.2 and 6.6.3.

### 6.6.1 Idle Station Condition and Alerting

To be available to receive incoming calls a station must be in the Idle condition. A station is in the Idle condition when all of the following requirements are satisfied.

- a. Power is on; and
- b. The station is not in any test mode either by the Test Switch on the DSU or by the LL interface signal lead, and the Telephone Company is not testing the station; and
- c. The station is not in the Not Ready condition (see Section 6.3); and
- d. No call is in progress, nor is one being originated by the station. In this call-off condition the CALL lamp on the Manual Call Controller is off, the Data Line Occupied (DLO) circuit from the DSU at the Automatic Calling Interface is off and the Data Set Ready (CC) circuit at the Data Interchange Interface is off.

At an Idle station, alerting signals are given to indicate the presence of an incoming call. The Ring Indicator (CE) circuit is used at the Data Interchange Interface, and the CALL lamp and a tone ringer are used at the Manual Call Controller. The tone ringer is activated only if the station is in the Manual Mode, but the other two alerting signals occur for every incoming call. While active, each of the alerting signals turns on for nominally

1 second, then off for nominally 3 seconds repetitively, except that the initial on interval is approximately 1/4 second. The alerting signals all cease as soon as the call is abandoned by the originating station or answered by the called station. A three position slide switch located beneath the Manual Call Controller can be used to control the sound level output of the tone ringer. During alerting the Data Line Occupied (DLO) circuit from the DSU at the Automatic Calling Interface is turned on to prevent automatic call origination attempts.

### 6.6.2 Automatic Answering

Calls can be answered automatically only while a station is in the Automatic Mode (the Manual Call Controller MM lamp is off). If ringing commences while a station is in the Manual Mode, the station may be placed in the Automatic Mode by depressing the MM key on the Manual Call Controller to permit the call to be answered automatically.

While the station is in the Automatic Mode, an on condition on the Data Terminal Ready (CD) circuit to the DSU coincident with or following an on signal on the Ring Indicator (CE) circuit from the DSU causes the incoming call to be answered automatically. As a result of the CD circuit being turned on, the DSU signals the network that the call has been answered. At this time the complete switched connection is established. The DSU indicates this by turning on the Data Set Ready (CC) circuit at the Data Interchange Interface. At the Manual Call Controller the CALL lamp remains on (it had been turning on and off as an alerting signal), and the CONNECT lamp turns on. The CONNECT and CALL lamps remain on for the remainder of the call, but the Data Set Ready (CC) circuit is on during a call only while the station is in the Automatic Mode.

### 6.6.3 Manual Answering

Calls can be answered manually only while a station is in the Manual Mode (the Manual Call Controller MM lamp is on). If alerting commences while a station is in the Automatic Mode, but the call has not yet been answered automatically (see Section 6.6.2), the station may be placed in the Manual Mode by depressing the MM key on the Manual Call Controller to permit the call to be answered manually. At the Manual Call Controller, depressing the

CALL key while in the manual mode during alerting causes the DSU to signal the network that the call has been answered. Then the complete switched connection is established, and at the Manual Call Controller the CALL lamp remains on (it had been turning on and off as an alerting signal), the tone ringer stops ringing, and the CONNECT lamp turns on. The CONNECT and CALL lamps remain on for the remainder of the call.

### 6.7 Minimum Interface Requirements

The minimum Data Interchange Interface circuits necessary to provide service with the Permanent On Request to Send Option and the Disable Not Ready Option, where call originating and answering functions are performed manually by means of the Manual Call Controller, are listed below for duplex, half-duplex, transmit-only and receive-only operation.

#### Minimum Interface Circuits

<u>Operation</u>	<u>Data Interchange Interface Circuits</u>		
	<u>Signal Ground and Data Terminal Ready</u>	<u>Transmitted Data and Transmit Timing</u>	<u>Received Data and Receive Timing</u>
Duplex	X	X	X
Half-Duplex	X	X	X
Transmit-Only	X	X	
Receive-Only	X		X

With the circuits indicated by Xs it is possible to communicate. However, there is no information on the status of the associated equipment across the interface, not even by "fail safe" circuitry (see EIA RS-232-C, Section 2.5), nor is there any assurance of circuit continuity, except as indicated by the lamps on the Manual Call Controller. Calls can be answered automatically without using the Ring Indicator circuit, if the Data Terminal Ready circuit is turned on again after being

turned off to terminate each call; however, no indication of the call status is provided.

It is possible to originate calls automatically without using the Power Indicator or the Abandon Call and Retry circuits at the Automatic Calling Interface, but all of the other circuits are necessary. It should also be noted that automatic call origination without use of the Power Indicator circuit would violate standard RS-366.

## 6.8 System Parameters

The objectives for DATAPHONE Switched Digital Service are given in Section 7. However it is felt that two parameters of the SDDS, which are not specified, are also useful in aiding the customer in appropriately implementing software, administrative procedures, etc. These parameters, propagation delay and network blocking, are discussed in this section.

### 6.8.1 Propagation Delay

Propagation delay, the one-way time delay encountered when transmitting data between two stations, is not specified for the SDDS. Normal network reconfigurations, tolerances, and alternate routing during heavy traffic periods would make such a specification impractical. However, preliminary estimates, assuming the use of only terrestrial circuits, indicate that the propagation delay between stations in a mature SDDS network should seldom exceed 50 msec. A typical propagation delay between cities that are 1000 airline miles apart is expected to be approximately 15 msec.

### 6.8.2 Network Blocking

The SDDS network\* has been engineered to assure that the necessary switching equipment and trunk facilities, which are shared by many customers, will be available for use when a customer places a call. During very busy periods,

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\* The term "network" includes all parts of the SDDS except the access lines, which are dedicated full-duplex SDDS channels between the individual stations and their associated switches.

however, message traffic congestion can occur, and can occasionally prevent a call attempt from being successful. When this happens, the originating station will receive the appropriate Call Progress Code, as described in Section 6.5, which will be displayed on the Manual Call Controller for manually originated calls, or, for automatically originated calls, will cause the Abandon Call and Retry (ACR) circuit at the Automatic Calling Interface to turn on. It will then be necessary for the customer to terminate the first call attempt and to originate a second call attempt.

The probability that a call attempt between any two stations will succeed is not specified for the SDDS. Normal network reconfigurations, occasional unusually high traffic peaks and alternate routing during heavy traffic periods would make such a specification impractical. Preliminary estimates, however, indicate that no more than one percent of the SDDS calls should require a second attempt due to message traffic congestion.

## 7. DATAPHONE SWITCHED DIGITAL SERVICE OBJECTIVES

The Switched Digital Data System (SDDS) is intended to provide an excellent communications medium for the transfer and switching of digital data between customer terminals. This leads to a set of design objectives which are aimed at the primary concerns that a data customer has about the communication system which he uses.

Overall performance will depend on the characteristics of the data terminal equipment provided and maintained by the customer as well as the characteristics of the SDDS. The quantitative objectives listed below apply to the SDDS exclusively.

The following are Preliminary Design Objectives only and are not to be construed as performance guarantees. The objectives are subject to change as experience with the SDDS dictates.

### 7.1 Quality

The objective is to provide an average performance exceeding 99.5 percent error-free seconds. Quality is the fraction of one-second intervals that are error-free during transmission of customer data.

## 7.2 Access Availability

The objective is to provide at least 99.98 percent access availability, which translates to an average annual downtime of 105 minutes. Access availability is the ability of the system to provide a Proceed to Select\* signal to the station in response to a Call Request signal\* from the station, and to present an incoming call to the station. It should be noted that this average is that value which would be observed over a period of several years. Some of the causes of downtime are failures which occur infrequently but which may have long outages associated with them when they do occur. While these infrequent long outages represent small contributions to the long-term average, they may significantly affect the downtime seen in a shorter period of time (even as long as a year).

## 7.3 "Dial Tone" Delay

The objective is that at least 99 percent of the call attempts should experience a "dial tone" delay less than 3 seconds. "Dial tone" delay is defined as the time between a Call Request\* signal and a Proceed to Select\* signal at the originating station.

## 7.4 Call Setup Time

The objective is that the network average call setup time not exceed 3 seconds. The call setup time is defined as the time between transmission of the End of Address signal and establishment of a data connection (excluding customer delays in answering).

## 7.5 Call Teardown Time

The objective is that the call teardown time be less than 100 milliseconds. Call teardown time is defined as the

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\* The Call Request and Proceed to Select signals are analogous to going off-hook and receiving dial tone in telephone service.

time between a Clear Request\* signal and a Clear Confirmation\* signal at the station originating the Clear Request signal.

## 8. TESTING AND MAINTENANCE

### 8.1 Customer Testing and Trouble Reporting

In any system, outages will occasionally occur, and it is important for the customer and the Telephone Company that prompt and efficient corrective actions be taken in all such situations. A telephone number will be provided at the time of service installation for customer use in reporting troubles in his service. Telephone Company testing and repair can be accomplished most efficiently if a complete and accurate description of the difficulty is provided by the customer.

When operating difficulties are encountered by a customer, it is expected that he will check his terminal equipment for proper operation prior to reporting a trouble to the Telephone Company. Considerable expense can be saved by making a careful initial evaluation of a trouble condition. Such things as unplugged power cords, tripped circuit breakers and loose interface connectors can completely disable a customer's system, but may be corrected by customer personnel with little delay. For this reason, it is recommended that customer personnel be acquainted with the basic equipment layout and instructed in fundamental maintenance techniques.

SDDS station equipment contains certain built-in trouble isolation and testing features, which customers are encouraged to become familiar with and to utilize. Use of these features will aid the customer in verifying whether problems exist in SDDS station equipment, and can provide information useful to the Telephone Company in diagnosing problems more quickly. In addition to the basic checks for power and interface cable connections, the following observations and tests may be conducted by a customer to aid in identifying station problems prior to reporting a trouble condition to the Telephone Company.

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\* Either station may originate the Clear Request signal. It is analogous to going on-hook during a call in telephone service. The Clear Confirmation signal from the network indicates that the call has been disconnected and that the system is ready to process new call attempts from the station.

**CAUTION:** Customer tests should not be conducted after a station has been released for testing by the Telephone Company, except as described in Section 8.2. Such testing could interfere with Telephone Company tests and yield misleading results.

### 8.1.1 Monitoring Interface Circuits

If the customer's data terminal equipment provides interface trouble indications, these may be useful to the customer in determining the source of a difficulty. For example, knowledge of the point reached in the call setup procedure before an automatic call attempt was aborted might aid in determining the most likely cause. If a call attempt or data transfer is unsuccessful because the other station is busy, Not Ready or becomes disconnected before normal call completion etc., interface signals provided by the DSU and described in Section 4.1 will be generated as discussed in Section 6. Knowledge of which interface signals are being generated when a problem exists should be helpful in determining the trouble source. For stations having a Manual Call Controller, specific tests that check DSU and Manual Call Controller functions are discussed in Section 8.1.3.

### 8.1.2 Local Line (LL) Automatic Test

A Test Switch is provided on the DSU. It can be used by a customer for testing his station as described below, while the DSU is in the Automatic Mode. Alternatively, the Local Loop (LL) interface circuit may be used instead of the Test Switch, as described below. (Also see Figure 9.) Local Line testing while in the Manual Mode, with a Manual Call Controller, is discussed in Section 8.1.3, and use of the Remote Test (RT) position of the Test Switch is discussed in Section 8.1.4.

While the DSU is in the Automatic Mode, if the Test Switch is in the Local Line (LL) position or if the Local Loop (LL) interface circuit is on, the DSU is in the Local Line test mode. The LL test permits a customer with an appropriately designed duplex terminal to test the back-to-back performance of the data terminal equipment and DSU by connecting the transmitter section of the DSU to the receiver section. For this test the Data Set Ready circuit is off, but the other Data Interchange Interface

Control circuits, Request to Send, Clear to Send and Received Line Signal Detector operate as in the Data Mode. Thus, much of the transmit and receive logic in the DSU can be exercised through the Data Interchange Interface.

The following steps are suggested for the LL automatic test, which can be performed with any of the SDDS station arrangements, when no call is in progress. (A station will not be alerted for an incoming call while in the Local Line test mode.) Signals on the Automatic Calling Interface, if present, should be ignored for this test; the interface circuits used are all in the Data Interchange Interface.

1. Check the power and interface cable connections to assure that they are properly in place. Place the Test Switch in its center off position. The DSU PWR indicator should be lit, but the other three indicator lamps on the DSU (RT, LL and NS) should be off. The Telephone Company should be notified if any of those indicators are on at this point in the test. If the station arrangement includes a Manual Call Controller, put the unit in the Automatic Mode of operation by depressing the switch designated MM to extinguish the lamp.
2. Either place the Test Switch on the DSU in the LL position or turn on the Local Loop (LL) interface circuit. The LL indicator on the DSU and the CALL lamp on the Manual Call Controller should turn on. The NS and RT indicators on the DSU should remain off.
3. Turn on the Request to Send (CA) interface circuit. Interface circuits Clear to Send (CB) and Received Line Signal Detector (CF) should turn on. Transmit any desired data patterns on the Transmitted Data (BA) interface circuit. The DSU should loop back this data and transmit it error free to the data terminal equipment via the Received Data (BB) interface circuit.
4. Turn off the Request to Send (CA) interface circuit. If the station has the Permanent Request to Send Option, this should cause no changes to occur on other interface circuits. If, instead, the station has the Terminal Controlled Request to Send option the Clear to Send (CB) interface circuit should go off when CA is turned off and on when CA is

turned on. If, in addition to the Terminal Controlled Request to Send option, the station also has the Terminal Controlled Carrier option, then the Received Line Signal Detector (CF) interface circuit should also go off when CA is turned off and on when CA is turned on.

5. Restore the Test Switch to its center off position (or turn off the LL interface circuit) to return the station to its normal operating condition. The LL lamp and the CALL lamp should go off.

### 8.1.3 Local Line (LL) Manual Test

At stations having a Manual Call Controller, a Local Line (LL) test may be conducted manually. This test exercises all functions of the Manual Call Controller and many functions of the DSU, without requiring any special test equipment or calls to other stations. Specific procedures for this test are described below. (A station will not be alerted for an incoming call while in the Local Line test mode.)

1. Check the power and interface cable connections to assure that they are properly in place. Place the Test Switch on the DSU in its center off position. The DSU PWR indicator should be lit, but the other three indicator lamps on the DSU (RT, LL and NS) should be off. The Telephone Company should be notified if any of those indicators are on at this point in the test. Place the station in the Automatic Mode by depressing the switch designated MM on the Manual Call Controller until the lamp associated with it is extinguished. All indications on the Manual Call Controller should be off. Depress the MM switch again to place the station in the Manual Mode. The corresponding lamp should go on.
2. Place the Test Switch on the DSU in the LL position. The LL indicator should go on. The NS and RT indicators on the DSU should remain off.
3. Press the NR switch on the Manual Call Controller until the lamp associated with it is on. This causes the "Not Ready" code to be generated in the DSU by the transmit logic and looped back to the receive logic. The PROCEED lamp should also go on.

4. Digits can be generated and displayed as follows. Press any two digits to be displayed except 00, then press the # button twice. The two digits should be displayed, the RECALL lamp should go on, and the PROCEED lamp should go off.
5. Pressing the CALL switch once should cause the CALL and CONNECT lamps to go on and the NR, REMOTE RING, RECALL and digit displays to extinguish if illuminated.
6. A second operation of the CALL switch should cause the CALL and CONNECT lamps to go off.
7. Other digits may be displayed by repeating steps 3 through 6.
8. To illuminate the REMOTE RING lamp, repeat step 3, then press the digit 0 twice and # twice. This should cause the PROCEED lamp to go off and the REMOTE RING lamp to go on. Repeat steps 5 and 6 to clear the lamp indicators.
9. Pressing and holding the \* button should cause the CALL lamp to flash and the tone ringer to sound at intervals of approximately one second on and approximately three seconds off. The tone ringer level control can be tested by changing the three position switch on the bottom of the Manual Call Controller.
10. Restore the Test Switch to its center off position to return the station to its normal (Manual Mode) operating condition. The LL lamp should go off.

#### 8.1.4 Digital Test Line and Remote Terminal Loopback Tests

At the time of service installation a 7-digit address called a Digital Test Line number will be provided for customer use in testing between his station and its associated switching center on a loopback basis. Calls placed manually or automatically to this number will be answered automatically by a Digital Test Line circuit located at the switching center, thus permitting any customer to check out his own call originating procedures

and interfaces. Calls placed to a Digital Test Line will be treated by the network in the same manner as calls placed to other customer stations. After the call is answered, the Digital Test Line will provide a loopback, as shown in Figure 9, so that all data transmitted by the calling station will be looped back toward the calling station. This permits the customer to monitor the data transmission accuracy of the entire (two-way) connection between his station and the Digital Test Line. When testing is completed, the call should be terminated by the calling station in the same manner as for calls to another customer station.

Remote Terminal (RT) tests may be conducted in much the same manner as tests with a Digital Test Line, except that tests are conducted between two customer stations instead of between one station and a Digital Test Line. For this test, either station places a normal call to the other station. After the call is answered, either station attendant may place the test switch on his DSU in the Remote Terminal (RT) position.\* The RT lamp on that DSU should turn on. When the Test Switch is in the RT position at a station, and the station is in the Automatic Mode, the DSU provides a loopback for data received from the other station. This permits the other station to monitor the data transmission accuracy of the entire (two-way) connection between the Data Interchange Interfaces at the two stations. (Regardless of the position of the Test Switch, whenever the station is in the Manual Mode, the DSU transmits a data signal of all 1s to the distant station during a call.)

With the Test Switch in the RT position, the output of the Received Data (BB) interface circuit is connected to the input of the Transmitted Data (BA) interface circuit at the Data Interchange Interface of the DSU, as shown in Figure 9. When the station is in the Automatic Mode, this causes data signals received from the line to be regenerated and looped back to the line. With the Test Switch in the RT position, the Data Interchange Interface

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\* If a Data Interchange Interface problem is suspected, it is best to originate and answer test calls manually, and to set the test switch in the RT position before placing the station in the automatic mode.

circuit drivers to the data terminal equipment are turned off and the Transmitted Data and Received Data leads from and to the customer's terminal equipment are open circuited.

When testing is completed the Test Switch should be returned to its center off position. This returns the station to its normal operating condition. Further loopback testing may be conducted by placing the test switch at either station in the RT position, or the call may be terminated in the normal manner. It is important to note that a call may be terminated manually, but not automatically via the Data Terminal Ready (CD) interface signal, while the Test Switch is in the RT position. However, if the Test Switch is changed to the center off position while the station is in the Automatic Mode, the Data Terminal Ready (CD) signal must be on to avoid terminating the call. Also, a station will not be alerted for incoming calls while the Test Switch is in the RT position.

## 8.2 Telephone Company Testing and Repair

Most SDDS equipment malfunctions that can degrade system performance will be detected automatically, and standby equipment will be placed in service automatically. Consequently neither routine maintenance nor routine testing periods that would interrupt customer service are required by the Telephone Company to keep the SDDS operating properly. In the event of trouble, the Telephone Company will test the service. Of course, the Telephone Company will not intentionally disturb the service without first receiving permission from the user.

It is expected that the customer will check his terminal equipment for proper operation prior to reporting a trouble to the Telephone Company. When a customer experiences a trouble condition and his terminal equipment is operating properly, he should call the number for trouble reporting that is furnished when the service is installed. Testing and repair can be accomplished most efficiently if a complete and accurate description of the difficulty is provided by the customer. Results of any troubles detected while conducting the customer tests described in Section 8.1 will be helpful in diagnosing most types of trouble conditions. Also, if a station attendant is available to assist in performing tests, some trouble conditions

may be isolated quickly without requiring a service call by a Telephone Company representative. Once the trouble has been reported, the DSU should be placed in the Not Ready condition.

CAUTION: After a station is released for testing by the Telephone Company, the customer should not change the settings on the DSU or the Manual Call Controller, unless requested to do so by the Telephone Company test person. Otherwise the Telephone Company tests could yield misleading results.

When maintenance tests are conducted for a station from a Telephone Company test center, the functions of the Test Switch on the DSU - Remote Test (RT) and Local Loop (LL) - can be actuated by remote control, and the RT or LL indicator lamps will turn on during the tests.

STANDARDS INFORMATION

1. EIA RS-232-C  
EIA RS-366

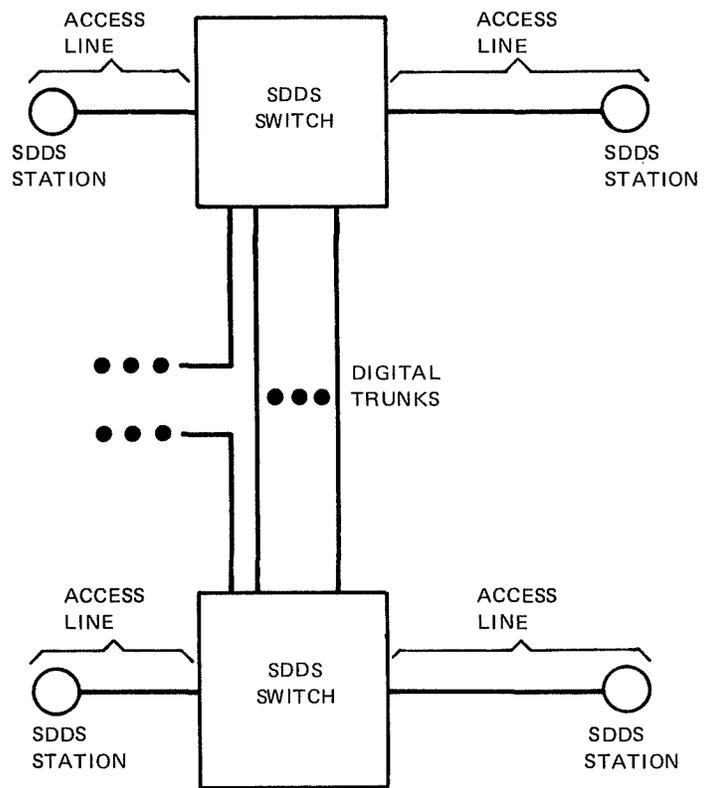
Electronic Industries Association (EIA)  
Engineering Department  
2001 Eye Street, N.W.  
Washington, D. C. 20006

2. The International Telegraph and Telephone  
Consultative Committee (CCITT)  
Vol. 8, Recommendation  
V.35, Appendix 4

United Nations Bookstore  
General Assembly Building  
United Nations, N. Y. 10017

TABLE I  
DIGIT SIGNAL CHARACTER SET  
REQUIRED BY THE  
AUTOMATIC CALLING INTERFACE

<u>Digit</u>	<u>Digit Signal States</u>			
	NB8	NB4	NB2	NB1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
*	1	0	1	0
#	1	0	1	1
EON	1	1	0	0
Unassigned	1	1	0	1
Unassigned	1	1	1	0
Unassigned	1	1	1	1



SWITCHED DIGITAL DATA SYSTEM  
FIGURE 1



501A DATA SERVICE UNIT  
AND MANUAL CALL CONTROLLER  
FIGURE 2

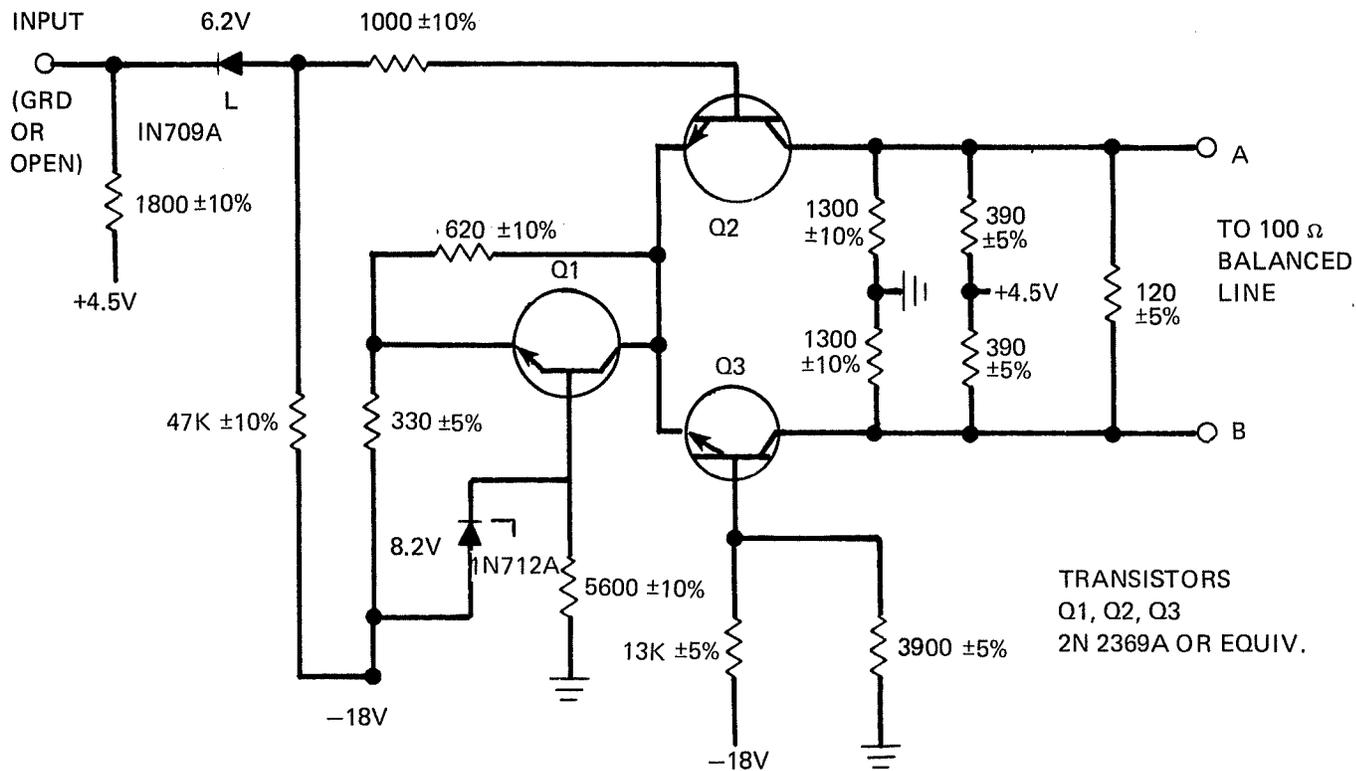


501A DATA SERVICE UNITS-STACKED  
ARRANGEMENT OF THREE  
FIGURE 3

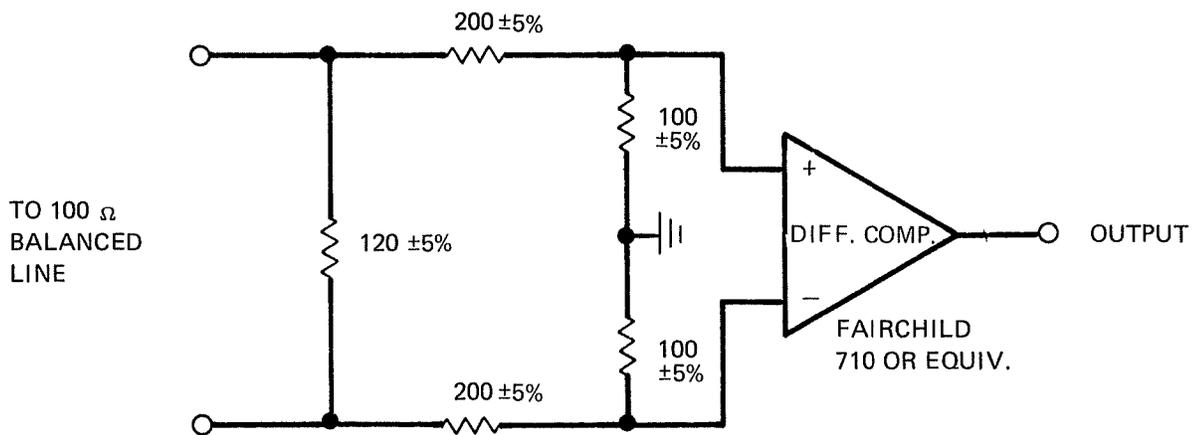


MANUAL CALL CONTROLLER  
(821A DATA AUXILIARY SET)  
FIGURE 4

**CABLE DRIVER**



**CABLE TERMINATOR**



NOTE:  
1. ALL RESISTANCE VALUES ARE IN OHMS

**TYPICAL 56 KB/S BALANCED INTERFACE  
CABLE DRIVER AND TERMINATOR CIRCUITS**

**FIGURE 5**

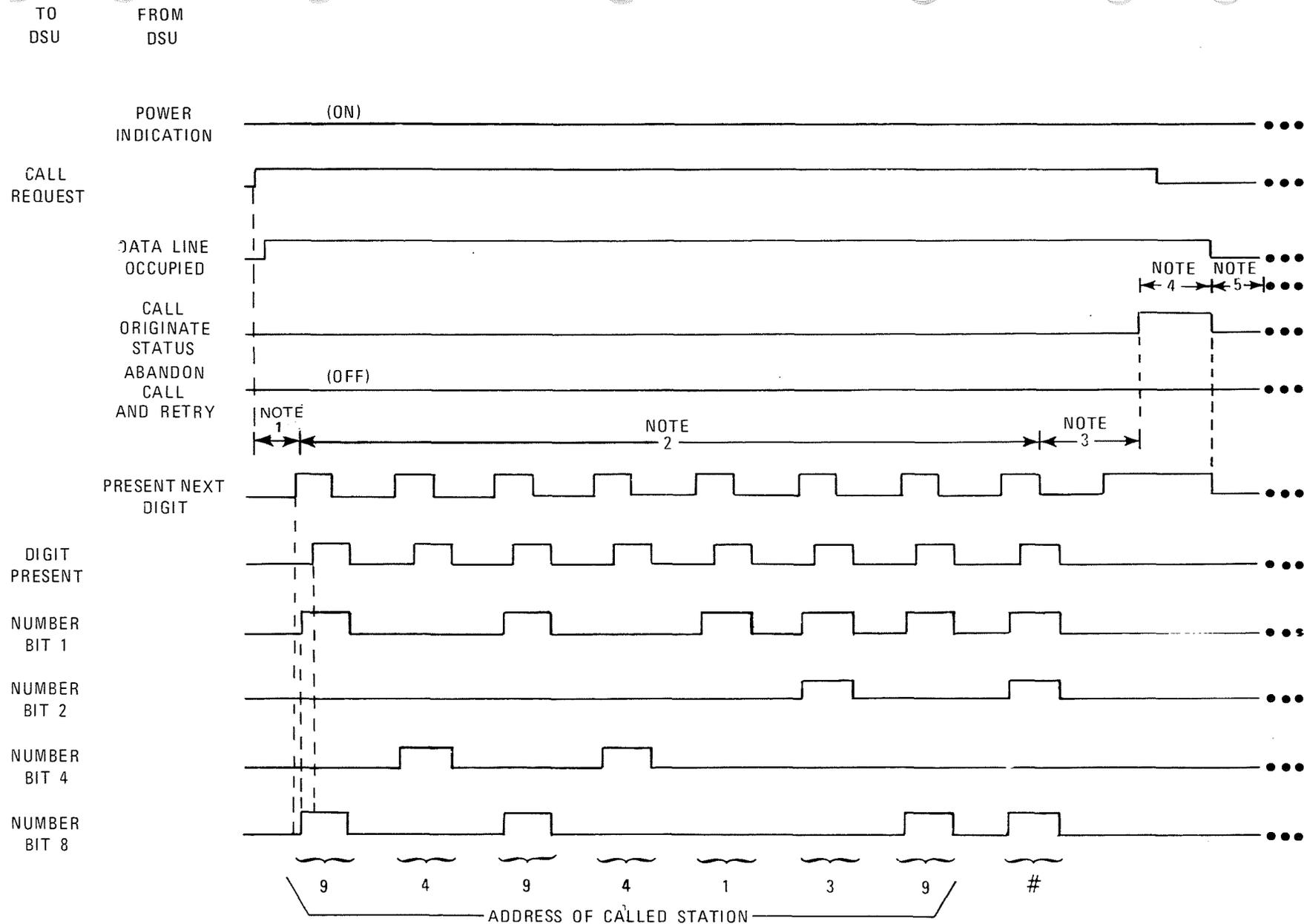
FRONT VIEW



REAR VIEW



501A DATA-SERVICE UNIT  
FIGURE 6

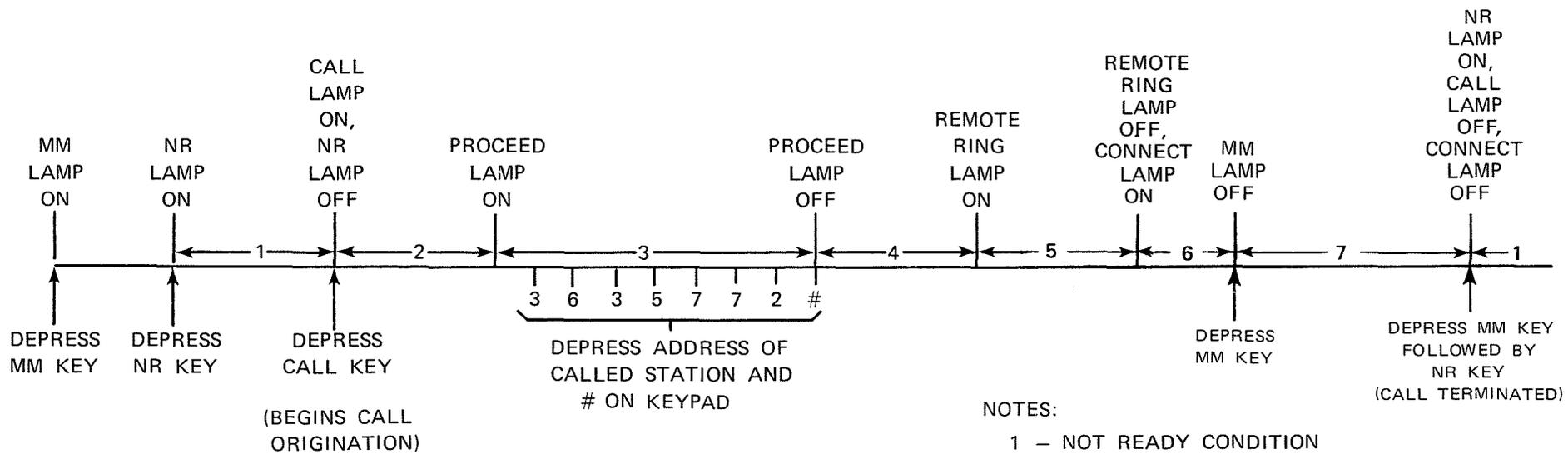


**AUTOMATIC CALL ORIGINATION  
INTERFACE SIGNALING**

**FIGURE 7**

**NOTES:**

- 1 - DIAL TONE DELAY
- 2 - DIALING
- 3 - CALL SETUP AND ALERTING
- 4 - CALL HOLDING AND TEARDOWN
- 5 - IDLE OR NOT READY CONDITION

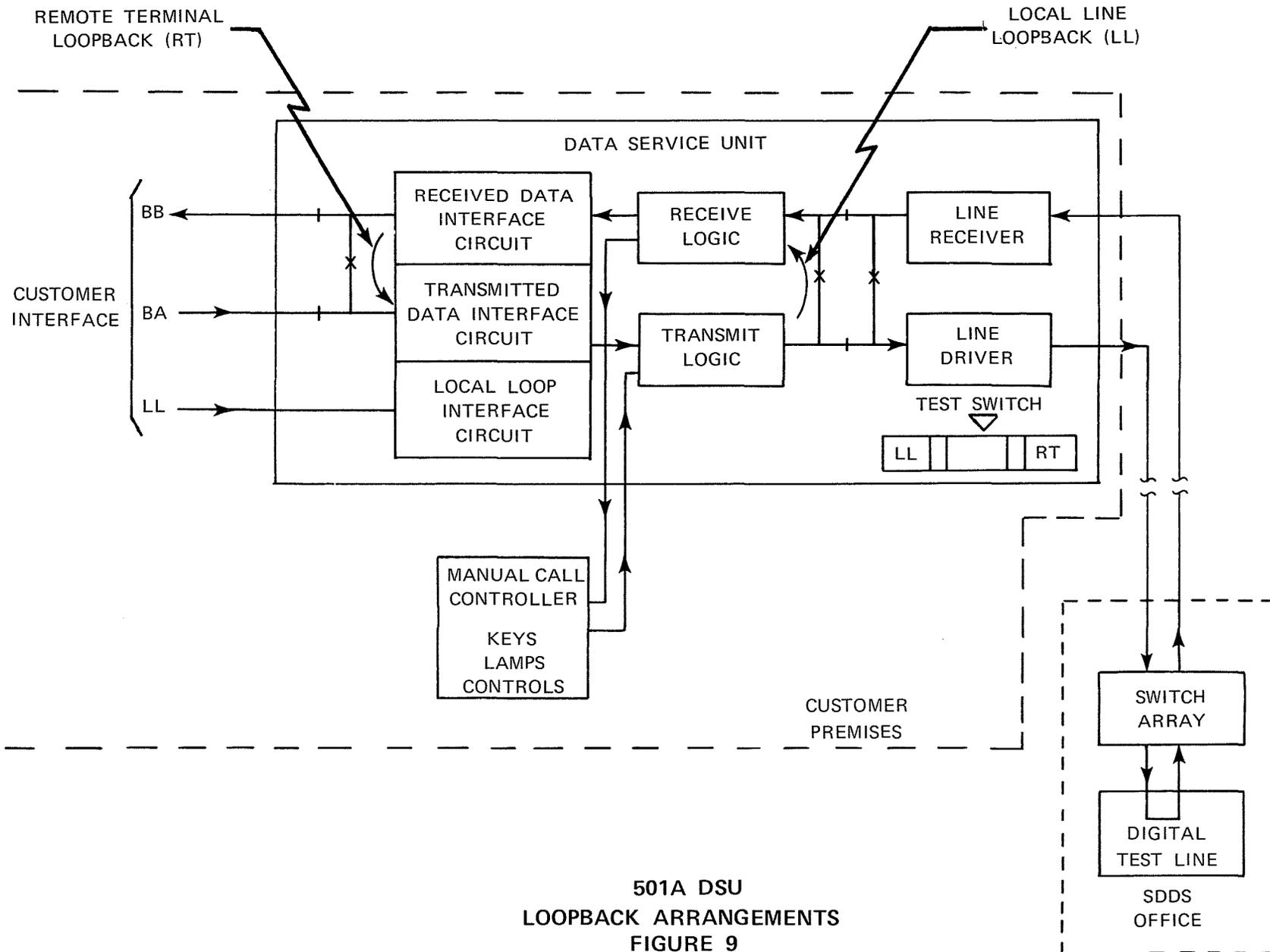


NOTES:

- 1 - NOT READY CONDITION
- 2 - DIAL TONE DELAY
- 3 - DIALING
- 4 - CALL SETUP
- 5 - ALERTING
- 6 - CALL HOLDING (MANUAL MODE)
- 7 - CALL HOLDING (AUTOMATIC MODE)

MANUAL CALL ORIGATION  
SEQUENCE OF EVENTS

FIGURE 8



501A DSU  
 LOOPBACK ARRANGEMENTS  
 FIGURE 9