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PRELIMINARY

Bell System Data Communications
TECHNICAL REFERENCE

DIGITAL DATA SYSTEM

DATA SERVICE UNIT

INTERFACE SPECIFICATIONS

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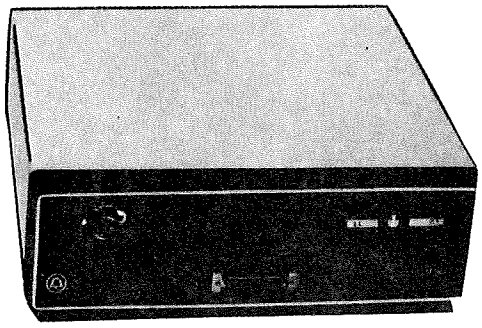


Rear View

DATA SERVICE UNIT

(Loopback switch and indicator lamps shown mounted on rear faceplate)

TECHNICAL SPECIFICATION SUMMARY

Data Rates:	2.4, 4.8, 9.6 or 56 kb/s
Operation:	Synchronous with timing control from Digital Data System (clock) at specified bit rate
Multiple Arrangements:	Stackable units (up to 3) Multi-Unit cabinet (up to 10)
Interface Signal Requirements:	2.4, 4.8, or 9.6 kb/s - EIA RS-232-C and RS-334 56 kb/s - EIA RS-232-C and CCITT Recommendation V.35
Principal Operating Mode:	Duplex (Half-Duplex and One-Way Operation Possible)
Data Terminal Connector:	2.4, 4.8, 9.6 kb/s - 25 pin Cinch or Cannon or equivalent Type DB-19604-432 plug with DB-51226-1 hood or equivalent 56 kb/s - 34 pin Winchester MRA-34 P-JTC6-H8 or equivalent
Environmental Requirements:	Ambient Temperature Range: 40° to 120°F Relative Humidity: Less than 95%
Dimensions:	Approximately 11-1/2" wide, 10-1/2" deep, 4" high
Control Functions:	Request to Send - Clear to Send Delay 2.4, 4.8, 9.6 kb/s - 19 to 20 bits 56 kb/s - 22 to 23 bits
	Receive Line Signal Detector Turn ON Time (Idle to Data Mode) 2.4, 4.8, 9.6 kb/s - 12 bits 56 kb/s - 14 bits
	Turn OFF Time (Data to Idle Mode) 2.4, 4.8, 9.6 kb/s - 18 bits 56 kb/s - 21 bits
	Turn OFF Time (Data to Out-of-Service Mode) Approx. 1 Sec. for local loop failure 300 ms for failure in high order digital facilities
AC Power Requirements:	105-129 V, 60 ± 3 Hz Power source. Three-wire outlet not under the control of switch.
Weight:	Approximately 10 lbs.

1. INTRODUCTION

The purpose of this Technical Reference is to define clearly the interface specifications associated with the Data Service Unit (DSU). The DSU is used only on data services provided via the Digital Data System (DDS) and only when a standard EIA* or CCITT* interface is desired. It provides equalization, remote and local testing capabilities and the logic and timing recovery necessary to provide a standard interface. If timing recovery, data encoding and decoding and the standard interface circuitry are not desired, a basic DDS channel can be requested. A basic DDS channel is terminated on the customer's premises by a Channel Service Unit (CSU) which provides only the minimum elements of plant required to produce a properly balanced and equalized loop termination and to permit rapid remote testing of the channel. Additional information on the CSU interface may be found in the Technical Reference titled -"Digital Data System Channel Interface Specifications" (PUB 41021).

The following section will briefly describe the Digital Data System and the type of service it offers. The remaining sections will concentrate on a description of the Data Service Unit and its interface characteristics.

2. OVERVIEW OF THE DIGITAL DATA SYSTEM

This section briefly discusses how the Data Service Unit fits into the overall Digital Data System. The overview is divided into two parts: The Service Capability and the System Description.

2.1 Service Capability

The Digital Data System (DDS) will provide a private line, two-point or multipoint** full duplex transmission capability at

* An EIA RS-232-C interface is available at the subrate speeds of 2.4, 4.8, and 9.6 kb/s. At 56 kb/s the interface conforms to CCITT recommendation V.35. For ordering information on EIA and CCITT Standards, see Page 28.

**The multipoint capability will not be available initially but will be added during the first year of service.

synchronous data rates of 2400, 4800, 9600 and 56,000 bits per second with no alternate voice or voice coordination provisions. The customer data is synchronized to a network clocking system. The channel imposes no restrictions on the format of the data to be transmitted.

Shortly after the above service capabilities are introduced, arrangements will be made available for interconnecting with off-net customers served via analog facilities in non-DDS locations.

A smooth conversion from present day analog channels and modems to the DDS is made possible by the new Data Service Unit (DSU) which was designed to provide plug-for-plug interchangeability with existing EIA type D or E interfaces at the subrate speeds of 2400, 4800 and 9600 bits per second. At 56,000 bits per second the DSU provides the standard CCITT balanced dc interface.

2.2 System Description

The Digital Data System (DDS), illustrated in Figure 1, is functionally discrete but physically integrated into the existing Bell System Network. It takes advantage of the existing and planned digital hierarchy, consisting of T1, T2, radio and coaxial transmission systems. At the T1 level and below, new arrangements are installed to provide service. These include data multiplexers to derive the 2.4, 4.8, 9.6 and 56 kb/s synchronous data channels from a T1 line. Transmission from the serving office to the customer's premises is accomplished using baseband transmission over 4-wire loops. Located on the customer's premises, the Data Service Unit (DSU) interfaces directly with the customer's data terminal equipment. Timing information required at the station is derived from the network through the DSU.

The DDS synchronous timing network is based on the use of one master clock with several subordinate clocks located at cities throughout the country. These clocks are configured such that all elements of the DDS including the DSU are maintained at the same time base.

On rare occasions, disruptions in the timing distribution system may isolate certain geographical segments. During these rare occasions the resulting subnetworks will run independently. This may result in the deletion or repetition of customer bits (a "slip") without any indication to the DSU. (In a multiple DSU installation, this effect may occur simultaneously to all DSUs). However, the accuracy and configuration of the clocks is such that the time between the occurrence of a disruption and the first "slip" between the subnetworks is on the order of several days.

3. GENERAL - DATA SERVICE UNIT

The Data Service Unit (DSU) consists of two basic sections, a channel terminator and an encoder-decoder. The function of the channel terminator is to provide basic loop equalization, network protection and a maintenance loopback. The encoder-decoder contains the transmitter, the receiver, the clock recovery circuitry, the interface loopback and the necessary EIA and CCITT drivers and terminators required to interface with the customer's data terminal equipment. The basic function of this unit is the conversion of EIA RS-232-C or CCITT V.35 interface signals to baseband bipolar line signals and vice versa.

3.1 Data Terminal Physical Interface

The Data Service Unit uses one of two interface connectors, depending on the service offering. A 25 pin connector is used for subrate (2.4 kb/s, 4.8 kb/s and 9.6 kb/s) services and a 34 pin connector is used for the 56 kb/s service.

3.2 Compatibility

The subrate Data Service Unit has an interface that conforms with the EIA Standard RS-232-C, interface type D or E. These units should, therefore, be directly compatible with any business machine which also conforms to this standard. The 56 kb/s Data Service Unit

interface differs from the subrate in that the clock and data signals are balanced, dc coupled as described in CCITT Recommendation V.35, Appendix 4. See Section 4.4 for a more detailed discussion of the electrical characteristics.

3.3 Physical Description

The DSU housing shown in Figure 2A measures approximately 11-1/2 inches wide, 4 inches high and 10-1/2 inches deep.

The DSU will operate over a temperature range of +40°F to +120°F and with a relative humidity less than 95 percent. The DSU weighs approximately 10 pounds. Mounting arrangements provide for stacking up to three of these units and a multiunit cabinet is available for housing up to 10 DSUs. (See Figures 2B and 2C.)

3.4 Manual Loopback Controls and Lamp Indications

3.4.1 Loopback Switch

A three position switch provides the capability of performing local or remote transmission tests. With the switch in the Local Line (LL) position, a two way loopback is provided. (See Figure 3.) The transmitter section of the DSU is connected to the receiver section and the receive line is connected to the transmit line through the loop terminating circuitry. With the switch in the Remote Terminal (RT) position, the output of the Received Data (BB) circuit is connected to the input of the Transmitted Data (BA) circuit at the data terminal interface. The BA and BB circuits are also disconnected from the customer terminal equipment. When the switch is in either Test position, an appropriate light indication is given. To avoid accidental interruption of service the manual operation of the Local Line loopback is inhibited in multipoint service applications. A detailed description of testing operations is given in Section 8.

3.4.2 Indicator Lamps

The following indicator lamps provide information on the status of the DSU.

a. Power On - This lamp (PWR) goes ON when AC power is supplied to the DSU.

b. Loopback Mode - Two loopback lamps are provided, one for the Local Line (LL) test and the other for the Remote Terminal (RT) test. The DSU can be placed in these loopback modes either locally by operating the loopback switch on the DSU (with the exception of the LL loopback in multipoint applications) or remotely by the Telephone Company from a Serving Test Center.

c. No Signal Indication - The No Signal lamp (NS) goes ON when no digital signals are received due to a failure on the receive leg of the 4-wire loop. The No Signal condition is detected approximately one second after a local loop failure.

   There may be instances when the Telephone Company is unaware of the trouble condition. Therefore, when the No Signal lamp goes ON, the customer should call the Repair Service telephone number given to him at the time the DSU is installed.

3.5 Power Requirements

Electric power is fed to the DSU from a customer-provided 105-129 volt 60 $\pm$ 3 Hz, nonswitched source. A standard ten foot 3-wire power cord equipped with a 3-prong plug is supplied with each DSU. The DSU consumes approximately 15 watts of AC power.

3.6 Grounding

Protective Ground is established for the DSU 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 terminal 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 on request of the customer, subject to local noise conditions, ground potentials, and local safety regulations.

3.7 Distance Limitations

For 2.4, 4.8, or 9.6 kb/s service, in accord with recommendations of EIA RS-232-C, the DSU should be located so that the customer provided interface cord to the data terminal will not exceed 50 feet in length, while for 56 kb/s service the interface cord should not exceed 100 feet in length. (See Section 4.3 on Interface Cable Requirements for 56 kb/s Service.) In all installations care must be exercised to insure that the DSU is not subject to stray fields which may emanate from the customer data terminal. In particular the DSU must be located at least one foot away from any source of electromagnetic radiation.

4. INTERFACE SPECIFICATIONS

4.1 Functional Description of Interface Circuits

A description of signals between the DSU and the data terminal equipment follows. The EIA RS-232-C abbreviation for the circuit is also shown.

4.1.1 Protective Ground (AA)

This conductor is electrically bonded to the equipment frame of the DSU. It is further connected to external grounds through the power cord.

4.1.2 Signal Ground (AB)

This circuit establishes the common ground reference potential for all interchange circuits except protective (frame) ground. It is normally connected to the Protective Ground Circuit to minimize the introduction of longitudinal power line noise into electronic circuitry through the power transformer. Depending on local regulations and conditions, this connection may be removed by the installer if the customer requests.

4.1.3 Transmitter Signal Element Timing (DB)

Direction: FROM DSU

Signals on this circuit are used to provide the data terminal equipment with transmit signal element timing information. The DSU provides continuous timing information. Since the transmitter timing is derived from the network, and is the same as the receiver timing, the peak individual distortion of the transmit clock is identical to that found on the Receiver Signal Element Timing circuit and is less than 5 percent.

For 56 kb/s service the DSU transmits a balanced clock signal to the data terminal equipment over the DB(A) and DB(B) circuits. The symmetry of the DB signal is determined by the zero crossings of the DB(A) minus the DB(B) signal. The time between zero crossings is between 0.45 and 0.55 of a clock period.

4.1.4 Receiver Signal Element Timing (DD)

Direction: FROM DSU

Signals on this circuit are used to provide the data terminal equipment with Receiver Signal Element Timing information. The DSU provides continuous timing information. Peak individual distortion on this circuit is less than 5 percent.

For 56 kb/s service the DSU transmits a balanced clock signal to the data terminal equipment over the DD(A) and DD(B) circuits.

The symmetry of the DD signal is defined by the zero crossings of the DD(A) minus DD(B) signal. The time between the zero crossings is between 0.45 and 0.55 of a clock period.

4.1.5 Transmitted Data (BA)

Direction: TO DSU

The Transmitted Data Circuit accepts serial binary data from the data terminal for transmission to the remote data terminal equipment. The data terminal equipment should not attempt to transmit data unless an ON condition is present on the Clear to Send Circuit. The DSU transmits a control idle signal when the Request to Send Circuit is OFF and a Steady MARK during the interval between Request to Send Circuit ON and Clear to Send ON independent of customer signals on the Transmitted Data Circuit. The DSU transmits a steady MARK when either a short or open circuit condition appears on circuit BA.

The BA signal must be properly aligned with the Transmitter Signal Element Timing (DB) signal. The state of the BA signal should be changed within $\pm$ 10 percent of a clock cycle of the positive going transition of the DB signal.

For 56 kb/s service, Circuit BA is a balanced signal transmitted to the DSU over the BA(A) and BA(B) circuits, and state changes should occur within $\pm$ 10 percent of a clock cycle on the positive going transition of the DB(A) minus the DB(B) signal. The Circuit BA(A) should be negative with respect to the Circuit BA(B) for a MARK or binary ONE condition.

The BA signal is sampled by the DSU coincident with the negative going zero crossing of the DB signal, or the DB(A) minus DB(B) signal for 56 kb/s service. The transmitted data signal should be maintained on the BA circuit for the full period of each signal element duration.

4.1.6 Received Data (BB)

Direction: FROM DSU

Signals on this circuit are generated by the receiving DSU in response to the data signal received from the network. The Received Data Circuit will be held in the "MARK HOLD" condition when the Received Line Signal Detector Circuit is OFF.

For 56 kb/s service, Received Data is a balanced signal delivered serially on the BB(A) and BB(B) circuits to the data terminal equipment. During the "MARK HOLD" condition, the BB(A) Circuit is negative with respect to the BB(B) Circuit which is equivalent to receiving a binary ONE.

The data on Circuit BB is changed coincident, within 10 percent of a clock cycle, with the positive going zero crossing of the Receiver Signal Element Timing (DD) signal or the DD(A) minus the DD(B) signal for 56 kb/s service. The data terminal equipment should sample the data received on the Circuit BB coincident with the negative going zero crossing of the DD signal, or the DD(A) minus the DD(B) for 56 kb/s service.

4.1.7 Data Set Ready (CC)

Direction: FROM DSU

Signals on this circuit are used to indicate the status of the local DSU. The ON condition on this circuit indicates that the local DSU is connected to ac power and is not in a Test (local or remote) mode. It should be noted that tests of the channel other than the DSU tests will not result in an OFF condition on Circuit CC. The ON condition should not be interpreted as either an indication that a communication channel exists to a remote data station or the status of any remote station equipment.

The OFF condition is an indication that the data terminal equipment should disregard signals appearing on any other interchange circuit.

With the System Status option, the Data Set Ready Circuit is OFF when no incoming signal is received or the Out of Service Code indication is given to the DSU (see Section 5.4 for additional details).

4.1.8 Request to Send (CA)

Direction: TO DSU

Signals on this circuit are generated by the data terminal equipment to condition the local DSU to enter transmit Data mode. The ON condition must be maintained whenever the data terminal equipment has information ready for transmission.

Data terminal equipment designed for either transmit-only or duplex operation may hold Request to Send in the ON condition all the time, or use the Permanent Request to Send Option in the DSU.

When the remote data terminal uses the Circuit Assurance Option, the local terminal must keep the Request to Send Circuit ON if the remote terminal is to get a Clear to Send indication. If the Request to Send Circuit is used for "interrupt" or "start" type signaling purposes, the minimum OFF interval that can be detected by the transmitting remote DSU is equal to 25 bits for 2.4, 4.8, or 9.6 kb/s service, or 29 bits for 56 kb/s service.

4.1.9 Clear to Send (CB)

Directions: FROM DSU

Signals on this circuit are generated by the DSU to indicate whether or not the DSU is ready to transmit data. The ON condition is a response to an ON condition

on interchange Circuit Request to Send delayed by a 19 to 20 bit interval for 2.4, 4.8, or 9.6 kb/s service and a 22 to 23 bit interval for 56 kb/s service. The Request to Send - Clear to Send timing delay for each of the data rates is given below.

Data Rate	Request to Send - Clear to Send Timing Delay
2.4 kb/s	8 ± 0.4 ms
4.8 kb/s	4 ± 0.2 ms
9.6 kb/s	2 ± 0.1 ms
56 kb/s	0.4 ± 0.02 ms

The OFF condition is an indication to the data terminal equipment that it should not attempt to transfer data on the Transmitted Data circuit. When Request to Send is turned OFF, Clear to Send is turned OFF within 1 bit interval. The Clear to Send Circuit must be ON before data can be transmitted (see Section 4.1.5).

With the Circuit Assurance Option, the Clear to Send indication is a result of an ON condition on both the Request to Send Circuit and the Received Line Signal Detector Circuit (CF) (see Section 5.3). With this option the Clear to Send Circuit is turned OFF if Circuit CF turns OFF in response to a system failure or if the remote data terminal turns Circuit CA OFF.

4.1.10 Received Line Signal Detector (CF)

Direction: FROM DSU

The ON condition on this circuit indicates that customer digital data signals (not the control-idle or Out-of-Service code) are being received and have been received for a 12 bit interval for 2.4, 4.8, or 9.6 kb/s service and for a 14 bit interval for 56 kb/s service due to an ON condition of the Request to Send circuit at the remote terminal.

The Received Line Signal Detector is turned OFF when:

1. An Out of Service condition exists due to a failure in the receive side of the local loop or a failure in the higher order digital facilities in the transmission path towards the local DSU.
2. The remote station's transmit pair to the DDS serving central office has failed.
3. The remote data terminal has turned its Request to Send Circuit OFF.
4. Data Set Ready Circuit is turned OFF except when the DSU is in the Local Line Test (see Section 8.1.1).
5. The DSU is in the Remote Terminal Test Mode.
6. The ac power is off.

The Received Line Signal Detector circuit turns OFF after customer data signals are no longer received. The turn OFF delay for 2.4, 4.8, or 9.6 kb/s service is 18 bits and for 56 kb/s service the turn OFF delay is 21 bits.

When this circuit is OFF, the Received Data Circuit is held in the "MARK HOLD" condition.

4.1.11 DSU Testing Circuits

Pin assignments 9 and 10 on the 25-pin connector and Pin m on the 34-pin connector are used on the DSU for test purposes by Telephone Company personnel. The data terminal equipment must not be connected to these pins.

4.2 Interface Connectors

The interface is the point of connection between the data terminal equipment and the Data Service Unit. Each DSU is equipped with one 25-pin (female) connector for 2.4, 4.8, or 9.6 kb/s

service or one 34-pin (female) connector for 56 kb/s service. 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.

For 56 kb/s service, the male 34-pin connector required for the data terminal equipment cable should be a Winchester MRA(C)-34P-JTC6-H8 or Burndy MS34TM-124 or AMP 5-202431-2 or equivalent. The (C) is specified for the Winchester connector if insertable pins are desired. The pin assignments for the 25- and 34-pin connectors are given below.

PIN ASSIGNMENTS FOR 25-PIN CONNECTOR
2.4, 4.8, 9.6 kb/s SERVICE

Pin Number	Function	EIA RS-232-C Designation	CCITT Designation
1	Protective Ground	AA	101
2	Transmitted Data	BA	103
3	Received Data	BB	104
4	Request to Send	CA	105
5	Clear to Send	CB	106
6	Data Set Ready	CC	107
7	Signal Ground	AB	102
8	Received Line Signal Detector	CF	109
9	Reserved for DSU Testing	-	-
10	Reserved for DSU Testing	-	-
11-14	Not Used	-	-
15	Transmitter Signal Element Timing	DB	114
16	Not Used	-	-
17	Receiver Signal Element Timing	DD	115
18-25	Not Used	-	-

PIN ASSIGNMENTS FOR 34-PIN CONNECTOR
56 kb/s SERVICE

Pin	Function	EIA RS-232-C Designation	CCITT Designation
A	Protective Ground	AA	101
B	Signal Ground	AB	102
C	Request to Send	CA	105
D	Clear to Send	CB	106
E	Data Set Ready	CC	107
F	Received Line Signal Detector	CF	109
R	Received Data	BB(A)	104
T	Received Data	BB(B)	104
V	Receiver Signal Element Timing	DD(A)	115
X	Receiver Signal Element Timing	DD(B)	115
P	Transmitted Data	BA(A)	103
S	Transmitted Data	BA(B)	103
Y	Transmitter Signal Element Timing	DB(A)	114
a	Transmitter Signal Element Timing	DB(B)	114
m	Reserved for DSU Testing	-	-
H, J, K, L, M, N	Not Used	-	-
U, W, Z, b, c, d, f, g,	Not Used	-	-
h, i, j, k, n	Not Used	-	-

4.3 Interface Cable Requirements for 56 kb/s Service

The cable from the data terminal equipment to the DSU should be a 24-gauge, 25- twisted pair cable. To reduce the possibility of crosstalk between the various leads and assure proper operation, the following recommendations are made regarding the cable parameters and cable pair assignments.

The business machine cable should have the following characteristics:

Gauge	24
Characteristics Impedance of Pair	120 ohms ± 10% at 150 kHz 100 ohms ± 10% above 400 kHz
Mutual Capacitance of Pair	1600 pF/100 feet ± 20%
Capacitance of Single Lead to Ground - all other leads grounded	4000 pF/100 feet maximum
Crosstalk Loss - pair-to-pair	40 dB minimum at 150 kHz

The greatest 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 the connector 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. The cable drivers and cable terminators will operate satisfactorily with up to 100 feet of 24 gauge cable.

4.4 Electrical Characteristics

4.4.1 2.4, 4.8, or 9.6 kb/s Service

For 2.4, 4.8, or 9.6 kb/s service the interface signals between the data terminal equipment and the DSU conform to the electrical characteristics of EIA Standard RS-232-C. In addition, the data and clock signals conform to EIA Standard RS-334 for synchronous channels except for the degree of peak individual distortion presented on the transmit clock. Since transmitter timing is derived from the network, the distortion of the transmit clock is identical to that found on the receive clock interface circuit. Consequently, the peak distortion of the transmit clock, as well as the receive clock, meets the 5 percent requirement imposed by RS-334 for synchronous data receivers. The duty cycle for both clocks is 50 $\pm$ 10 percent.

The degree of isochronous distortion of the signals on the Received Data Circuit as defined in RS-334 does not exceed 10 percent. The interval between any transition on the Received Data Circuit and any ON to OFF transitions on the Received Signal Element Timing Circuit is not less than 25 percent of the nominal unit interval of the data signal.

4.4.2 56 kb/s Service

For 56 kb/s service, two types of interface signals are used: (1) data and clock signals, and (2) control signals. The former 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 4 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 has gone 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 ± 50 percent.
2. Output impedance to ground with output terminals shorted together is 150 ohms ± 10 percent.
3. When terminated in a 100-ohm resistive load, the driver delivers a signal level of 1.1 volts peak-to-peak, ± 20 percent, i.e., the voltage between the two output leads is 0.55 volts ± 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 ± 10 ohms.
2. Resistance to ground with the input terminals shorted together is 150 ± 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 ± 4 volts difference in ground potential or with a maximum of ± 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.

5. CUSTOMER OPTIONS

For compatibility with existing services and customer convenience the following options are provided, and should be specified at the time an order is placed.

5.1 Request to Send

The Request to Send circuit must be specified either as Permanent On or Terminal Controlled.

Permanent On:

For customer data terminals that are not equipped to turn ON the Request to Send Circuit, an installer option is provided in the DSU to hold Request to Send ON permanently. This option is provided for all service offerings (2.4, 4.8, 9.6 or 56 kb/s) and matches the EIA Type E interface of RS-232-C for dedicated line service.

Terminal Controlled:

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, must turn OFF its Request to Send Circuit when the Clear to Send Circuit turns OFF and cannot turn its Request to Send Circuit on again until the data communications equipment turns its Clear to Send

Circuit OFF. Since an operating DSU with the Permanent Request to Send Option and without the Circuit Assurance Option (see Section 5.3) 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 Signal and Frame Grounding

Signal Ground to Frame Ground:

This installer's option internally connects signal ground to frame ground.

Signal Ground Disconnected from Frame Ground:

The Signal Ground may be disconnected from Frame Ground on customer request subject to local noise conditions, grounding potentials and local safety regulations.

5.3 Circuit Assurance

Circuit Assurance Indication from the Data Service Unit:

With this option, the ON condition of the Clear to Send circuit requires that both the clear to send timing delay (see Section 4.1.9) has expired and the Received Line Signal Detector circuit is ON. During operations, an OFF condition of the Received Line Signal Detector circuit will cause the Clear to Send circuit to turn OFF, but the DSU does not transmit the control idle code until the Request to Send circuit is turned OFF. If the Permanent Request to Send option is employed in combination with the Circuit Assurance option, the Clear to Send indications follow the Received Line Signal circuit conditions. (See Sections 6 and 6.2.1).

No Circuit Assurance Indication from the Data Service Unit:

If the Circuit Assurance option is not employed the Clear to Send indication is the result of an ON condition on the Request to Send circuit.

5.4 System Status

System Status Interface Indication:

With this option, the Data Set Ready circuit is turned OFF when the DSU receives the Out of Service code or when it receives no signals from the network. Loss of signals on a station's transmitting local loop will not be detected by this option. (See Sections 6 and 6.2.2).

No System Status Interface Indication:

If the System Status option is not employed, the OFF condition on the Data Set Ready circuit occurs only when the ac power is OFF or the DSU is in one of the two loopback test modes.

5.5 Loopback Switch and Indicator Lamp Location

Front Face Plate:

Depending on customer operating convenience the loopback switch and indicator lamps may be located in the upper right-hand corner of the front plate. See Figure 2A.

Rear Face Plate:

The loopback switch and indication lamps may alternately be located in the upper right-hand corner of the rear face plate. (See Figure 2A.) This end plate also contains the interface and ac power connectors. This configuration is always used when the units are housed in the multi-unit cabinet.

6. SYSTEM OPERATION

The DDS, as mentioned earlier, provides for two-point four-wire duplex private line digital data transmission. Although four-wire duplex service will be provided on DDS, customers may also operate in one-way and half-duplex manners. In describing the various DSU operations the DSU can be thought of as comprising separate transmitter and receiver portions. There are three modes of operation

which are common to both portions, they are Data, Idle and Test. A fourth mode, Out of Service, is applicable to the receiver portion. The Out-of-Service mode is the result of the DSU receiving the Out of Service control code or the loss of received line signals from the network. The transmitter of the DSU can attain the Data or Idle mode, independent of the state of the receiver. Similarly, the receiver can attain the Data, Idle, or Out-of-Service mode, independent of the state of the transmitter. The Test mode involves both the transmitter and receiver. (See Section 8.)

The transmitting Data mode is achieved by turning ON the Request to Send Circuit, after which the DSU responds by turning ON the Clear to Send Circuit. When the Request to Send Circuit is OFF, the transmitter is in the Idle mode and produces a control idle signal on the line. In the receiving Data mode, non-control data signals are being received and the Received Line Signal Detector Circuit is ON. In the receiving Idle mode, control idle signals are being received and CF is OFF. In the Out-of-Service mode, either control signals indicating a trouble condition are being received or no signals are being received; in both cases CF is OFF. (With the System Status Option, in the Out-of-Service mode the Data Set Ready circuit is OFF.) In the Remote Terminal (RT) Test mode, both CF and the Data Set Ready (CC) Circuits are OFF.

6.1 Duplex Operation

Simultaneous transmission in both directions is one of the basic premises around which the Digital Data System was designed. The DSU provides in addition to terminal control of the Request to Send circuit a Permanent ON option that holds the Request to Send circuit permanently in the ON condition. With this option the Clear to Send Circuit is always ON and the data terminal equipment should have an EIA RS-232-C Type E interface. (See Section 5.1). 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.

6.2 Half-Duplex Operation

In half-duplex operation only one terminal transmits at a time. The data terminal desiring to transmit turns ON its Request to Send Circuit. After a delay, (see Section 5.4.9) the Clear to Send Circuit turns ON, indicating that the data terminal may begin transmission. The receiving data terminal has its Request to Send Circuit OFF.

Figure 5 shows the signals on the interface circuits of the local and remote DSU during a turnaround sequence when the transmitting (local) DSU(A) enters the receive Data mode, and the remote DSU enters the transmit Data mode. To change directions of transmission, the transmitting data terminal equipment should turn its Request to Send Circuit OFF. The receiving data terminal equipment turns the Request to Send Circuit ON and after a short delay receives a Clear to Send ON signal. If the Permanent Request to Send Option is used, the receiving terminal may start transmitting immediately after an end of transmission code is received. The transmission delay between terminals consists of the propagation delay of the specific circuit and a fixed delay through the Data Service Units. The transmission delay for one-way transmission will generally be less than 50 milliseconds.

For Transmit-Only service, it is advisable that the Permanent Request to Send Option be used to avoid the Clear to Send delay.

6.2.1 Half-Duplex Operation with Circuit Assurance

Half-duplex data terminals that are not capable of monitoring the Received Line Signal Detector or the Received Data interface circuit when in the transmit mode can use the Circuit Assurance option. This option provides an indication that either the receiving terminal wishes to interrupt the transmission or that the transmission path from the receiving terminal has been interrupted.

Terminals using the Circuit Assurance option as a signaling scheme must have prearranged agreements on the meaning of the interrupt signal and the procedures to be followed. Figure 6 shows the interface signals when using this option.

6.2.2 Operation with the System Status Option

The System Status option permits the customer to distinguish between the control idle mode and a trouble condition as evidenced by receipt of the Out of Service code or by absence of digital signals on the receive loop. In each case the Received Line Signal Detector circuit will be turned OFF, but with the System Status option system trouble conditions will also cause the Data Set Ready circuit to be turned OFF.

6.3 Minimum Interface Requirement

The minimum interface circuits necessary to provide service with the Permanent Request to Send Option are listed below for duplex, half-duplex, transmit-only and receive-only operation.

Minimum Interface Circuits

Operation	Interface Circuits				
	Signal Ground	Transmitted Data	Received Data	Transmit Timing	Receive Timing
Duplex	X	X	X	X	X
Half-Duplex	X	X	X	X	X
Transmit-Only	X	X		X	
Receive-Only	X		X		X

With these circuits 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.

7. DIGITAL DATA SYSTEM OBJECTIVES

The Digital Data System is intended to provide an excellent communications medium for the transfer 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 communications channel which he uses.

Overall performance will depend on the characteristics of data communications equipment that is provided and maintained by the customer as well as those of the DDS. The quantitative objectives listed below apply to the DDS exclusively.

The following are preliminary design objectives only and are not to be construed as minimum performance guarantees. The objectives are subject to change as experience with the DDS dictates.

Quality -To average at least 99.5% error-free seconds at 56 kb/s and better performance at the lower rates of 9.6, 4.8, and 2.4 kb/s.

Availability -To average at least 99.96% channel availability, i.e., annual downtime less than 0.04%. 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.)

8. TESTING AND MAINTENANCE

The DSU contains two loopbacks. Both can be operated either manually at the station (with the exception of the Local Line Loopback in multipoint applications) or remotely from the Serving Test Center (STC). The first loopback shown in Figure 3 is

referred to as the Local Line (LL) loopback and provides a loopback both towards the line and towards the customer. If the customer experiences trouble and no network trouble indication is given the customer terminal equipment should be verified for proper operation prior to calling the Telephone Company. The terminal equipment should be designed to utilize the Local Line (LL) loopback for this verification as discussed in Section 8.1.1.

The second loopback is referred to as the Remote Terminal (RT) loopback. It disconnects the customer equipment and loops toward the line at the interface connector (see Figure 3). This loopback can also be utilized by the customer to verify that his remote terminal is operating properly. The Remote Terminal loopback together with the Local Line loopback permits the Serving Test Center to isolate trouble to either the DSU or the local line. The RT loopback also permits the Serving Test Center to verify whether the circuit meets the quality objectiye for the Digital Data System.

When the DSU is in either of the test modes a lamp and interface lead (CC) indication is given to the customer. When a steady No Signal lamp or interface lead indication is received, the customer should call the Repair Service telephone number given to him at the time of service installation. The user's permission will be obtained prior to Telephone Company testing.

No routine maintenance is required for the DSU.

8.1 Manual Control of Test Modes

A test switch provides the customer with the capability of performing a Local Line Test (LL) or a Remote Terminal Test (RT). To avoid accidental interruption of service the manual operation of the Local Line loopback is inhibited in multipoint service application. When the DSU is in either of the test modes the Data Set Ready circuit is OFF, therefore, the terminal should be designed to recognize this condition in order to utilize the DSUs test features.

8.1.1 Local Line (LL) Loopback (Two Point Service Only)

With the Test Switch in the LL position, the DSU is in the Local Line Test mode. The LL test permits the customer with a properly designed duplex terminal to test the back-to-back performance of his data terminal equipment and DSU by connecting the transmitter section of the DSU to the receiver section. In addition, the receive line is connected through terminating equipment to the transmit line to allow a signal to be maintained in both directions. For this test the Data Set Ready circuit is OFF, but the other control interface circuits, Request to Send, Clear to Send, and Received Line Signal Detector operate as in the control idle or data mode.

Figure 7 shows the signals on the interface circuits of the DSU when the DSU is placed in the LL Test mode. The delays between Request to Send (CA) turning ON and an ON condition on the Clear to Send (CB) and Received Line Signal Detector (CF) circuits are given below for the four service offerings. In addition, the received data is delayed by approximately 5 bits with respect to the transmitted data in passing through the transmitter and receiver sections.

Local Test Timing Delays

Data Rate	CA-CB Delay	CA-CF Delay
2.4 kb/s	8 ± 0.4 ms	4.8 ± 2 ms
4.8 kb/s	4 ± 0.2 ms	2.4 ± 1 ms
9.6 kb/s	2 ± 0.1 ms	1.2 ± .5 ms
56 kb/s	0.4 ± 0.02 ms	0.23 ± .1 ms

With the Permanent Request to Send Option the CB circuit is ON all the time.

8.1.2 Remote Terminal (RT) Loopback

With the Test switch in the RT position, the DSU is in the Remote Terminal Test mode. In this Test mode the output of the Received

Data Circuit is connected to the input of the Transmitted Data Circuit at the data terminal interface of the DSU as shown in Figure 3. For this test the control interface circuit drivers to the data terminal equipment are turned OFF and the Transmitted Data and Received Data Circuits from and to the customer are open circuited.

With the local DSU in the RT test mode, the properly designed remote data terminal has the capability of checking system operation exclusive of the local data terminal. This permits the customer to deduce whether the local data terminal is responsible for a system trouble condition. When the local DSU is in the RT test mode its Data Set Ready, Received Line Signal Detector and Clear to Send circuits are OFF.

8.2 Remote Control of Test Modes from the Serving Test Center

In addition to the manual control of the Test modes, the Telephone Company's Serving Test Center (STC) can place the DSU in either the Local Line or Remote Terminal Test mode in order to test the operations of the line and DSU. The state of the interface circuits in these test modes are the same as described in Sections 8.1.1 and 8.1.2. When the STC places the DSU in either of the Test modes, the appropriate Test lamp, LL or RT, will turn ON.

In the Remote Terminal (RT) Test mode the STC ascertains whether there are any defects in the transmitter, receiver, and interface circuits of the DSU and the transmission path to and from the customer. The STC does not ascertain whether the customer is putting proper signals on the interface circuits.

If the results of the Remote Terminal (RT) Test show that there is a trouble condition, then the STC can place the DSU in the Local Line (LL) Test mode to isolate the trouble condition between the DSU and the transmission facility.

The Test switch on the DSU must not be operated when the Telephone Company is performing its tests. If the DSU is placed manually in the Local Line (LL) Test mode, the STC cannot place the DSU in the Remote Terminal (RT) Test mode and, therefore, cannot determine if the DSU is defective. Before the Telephone Company performs any tests, customer clearance will be obtained.

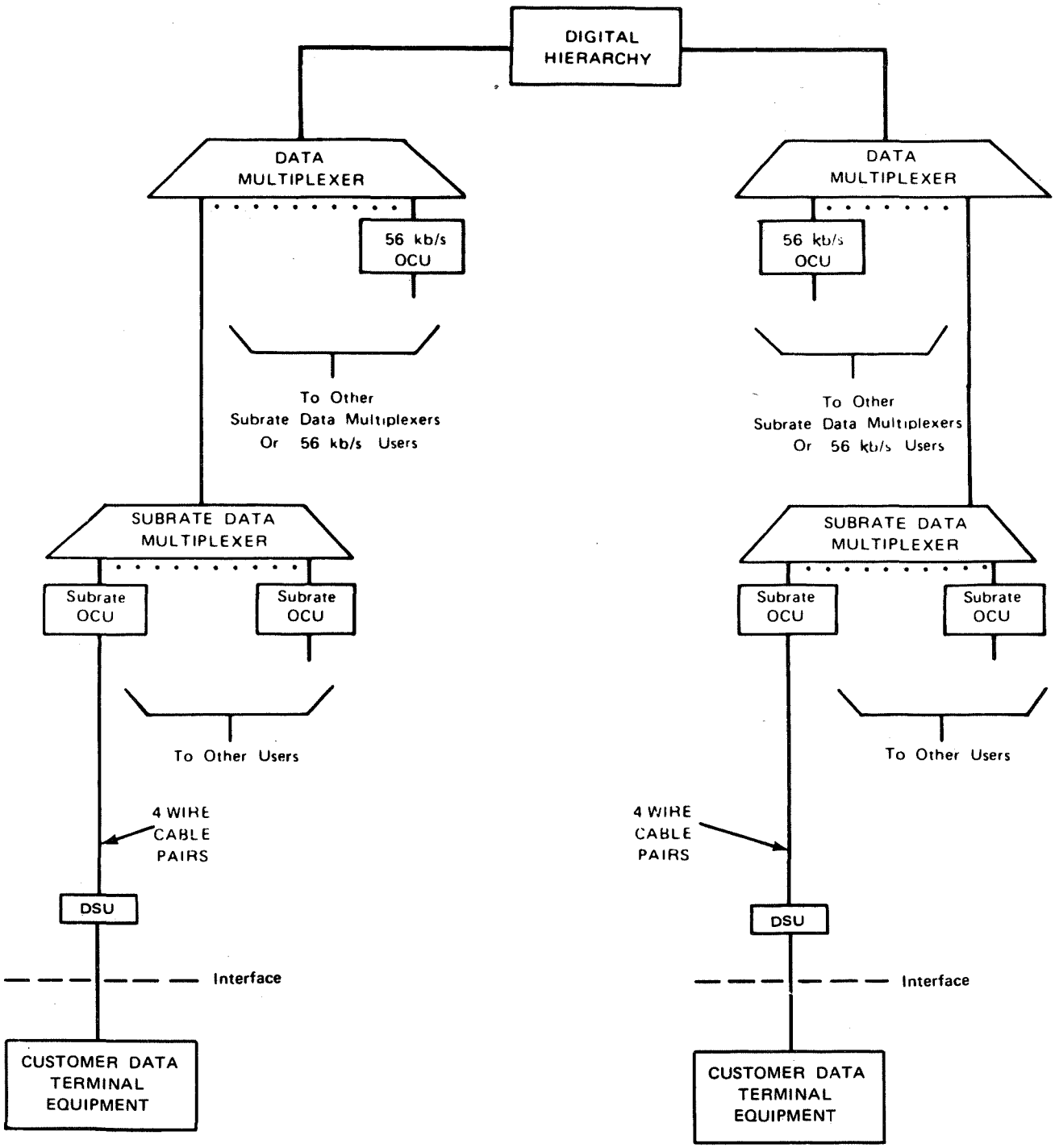
STANDARDS INFORMATION

1. EIA RS-232-C
   EIA RS-334

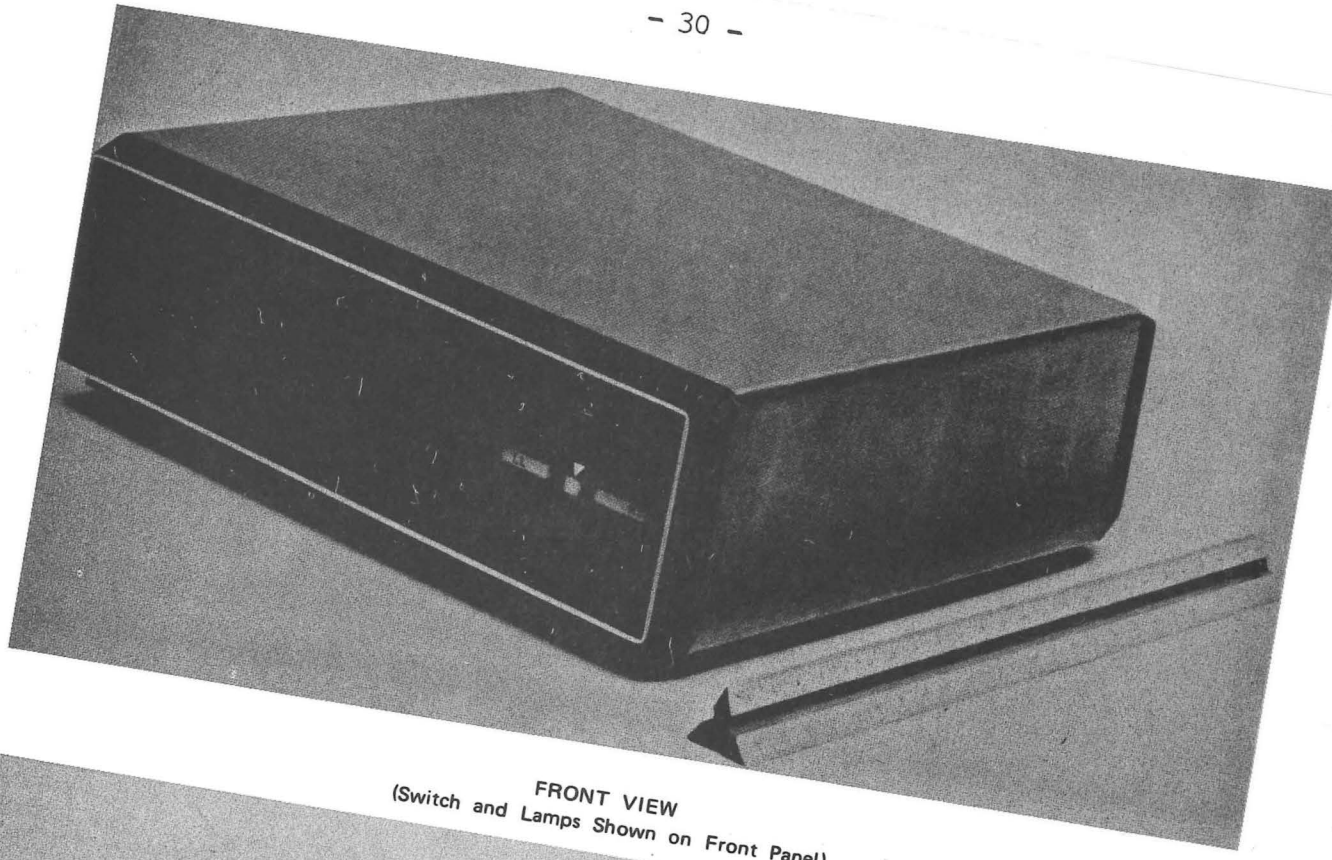
   Electronic Industries Association (EIA)
   Engineering Department
   2001 Eye Street, N.W.
   Washington, D. C. 20006

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

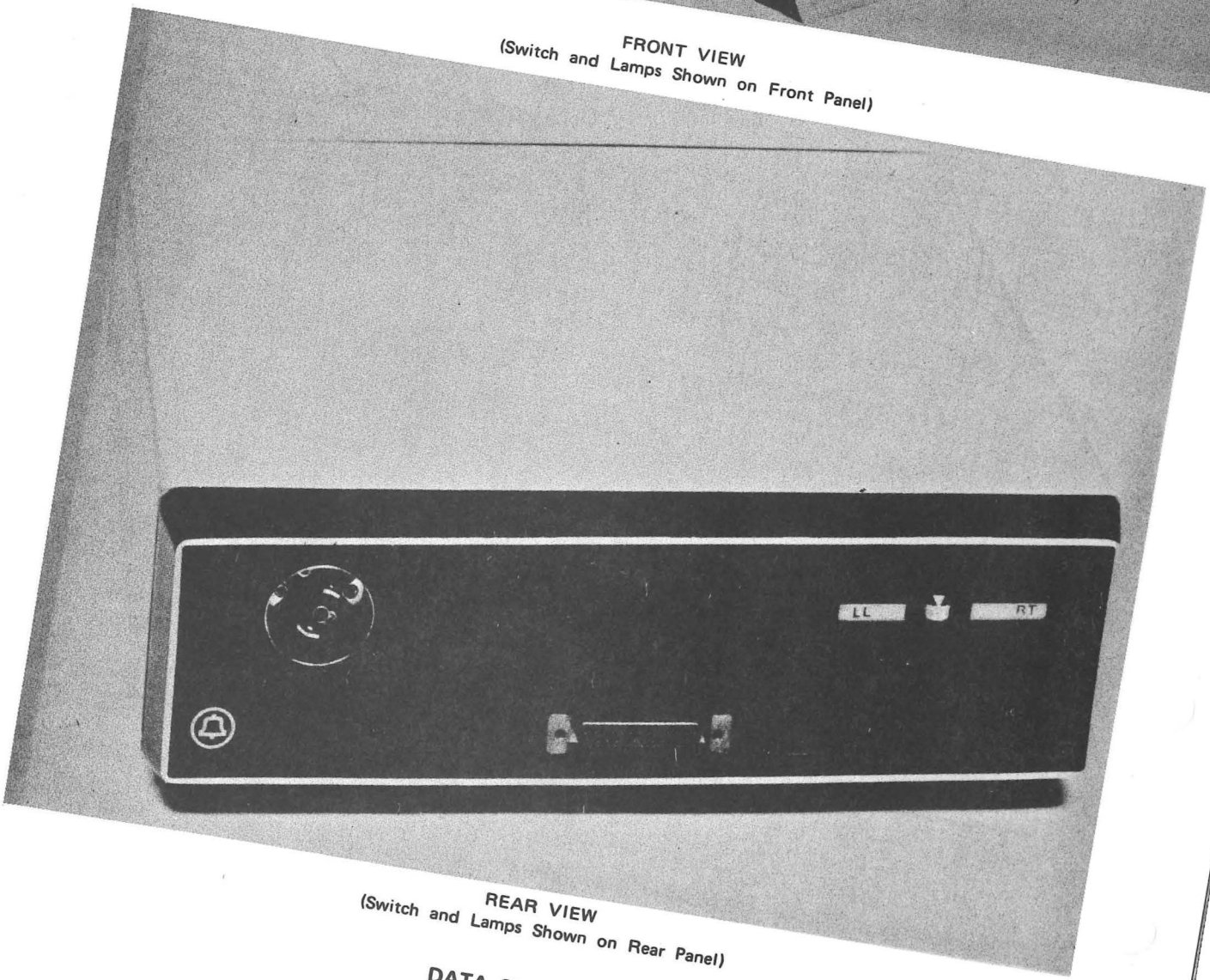
   United Nations Bookstore
   General Assembly Building
   United Nations, N. Y. 10017



DIGITAL DATA SYSTEM BLOCK DIAGRAM
FIGURE 1

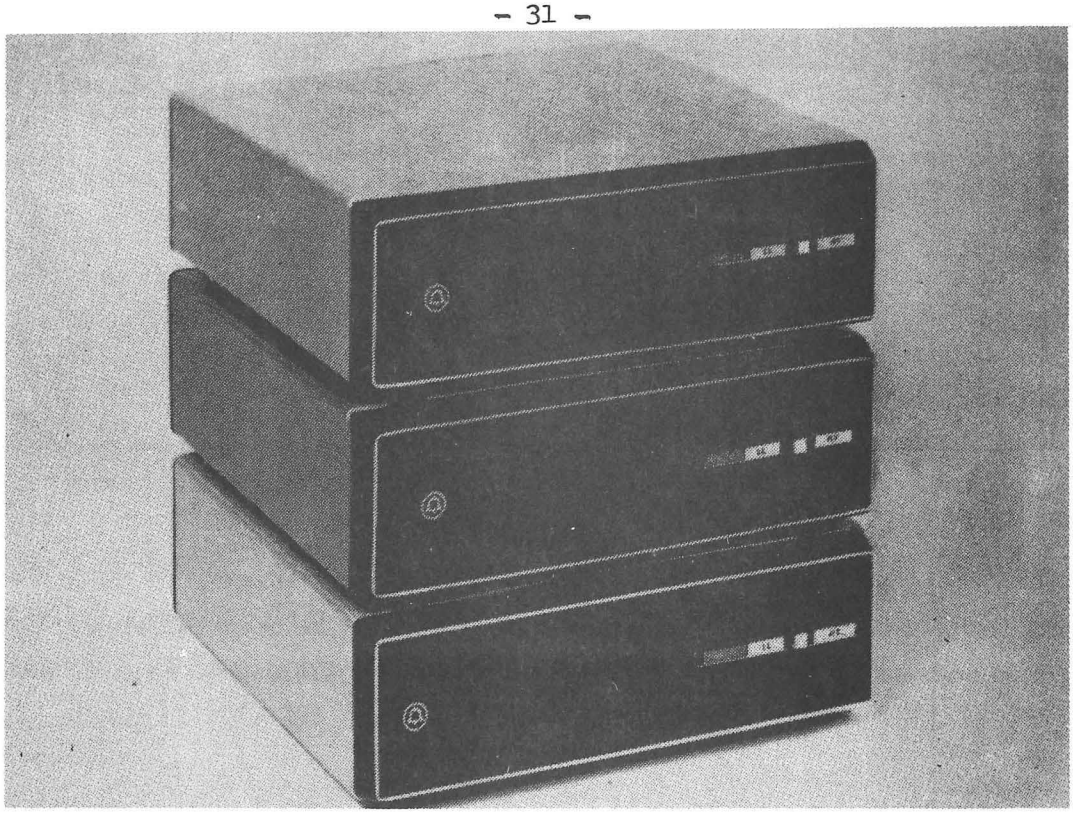


FRONT VIEW
(Switch and Lamps Shown on Front Panel)

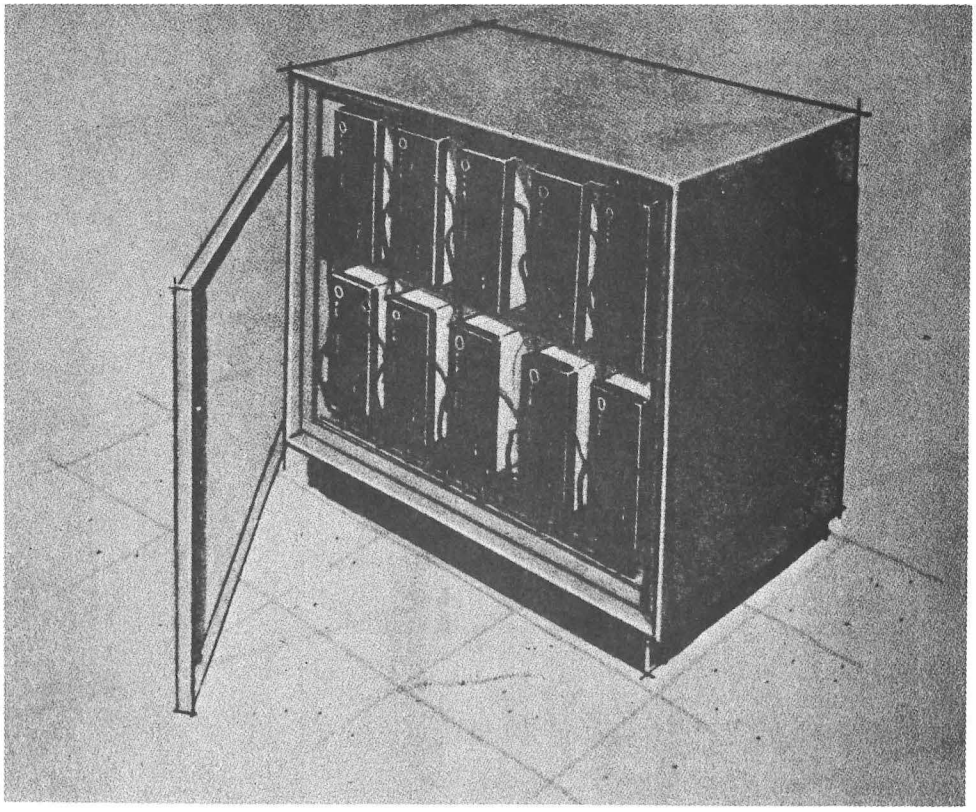


REAR VIEW
(Switch and Lamps Shown on Rear Panel)

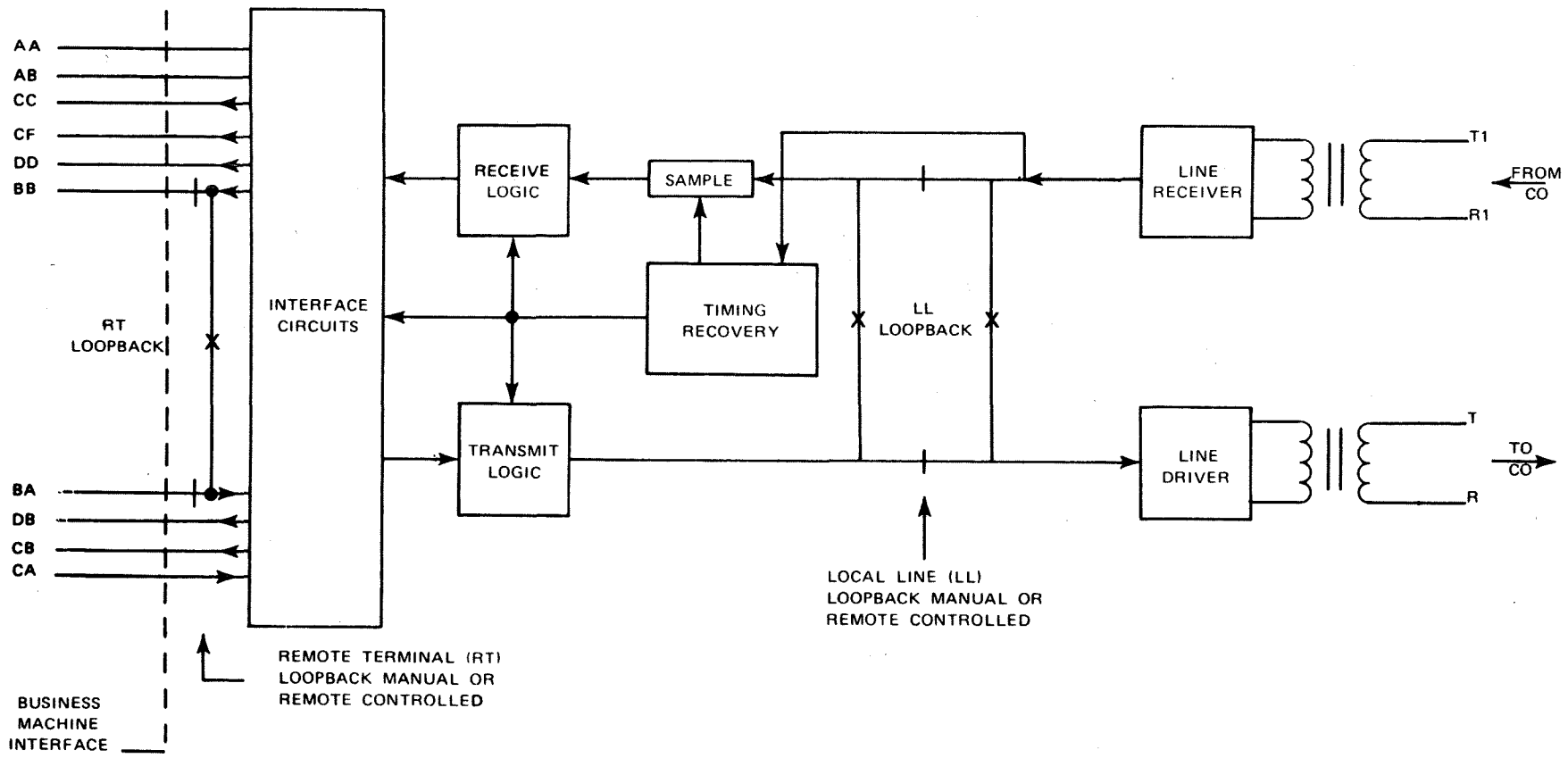
DATA SERVICE UNIT
SINGLE UNIT
FIGURE 2A



DATA SERVICE UNITS
THREE STACKED ARRANGEMENT
FIGURE 2B

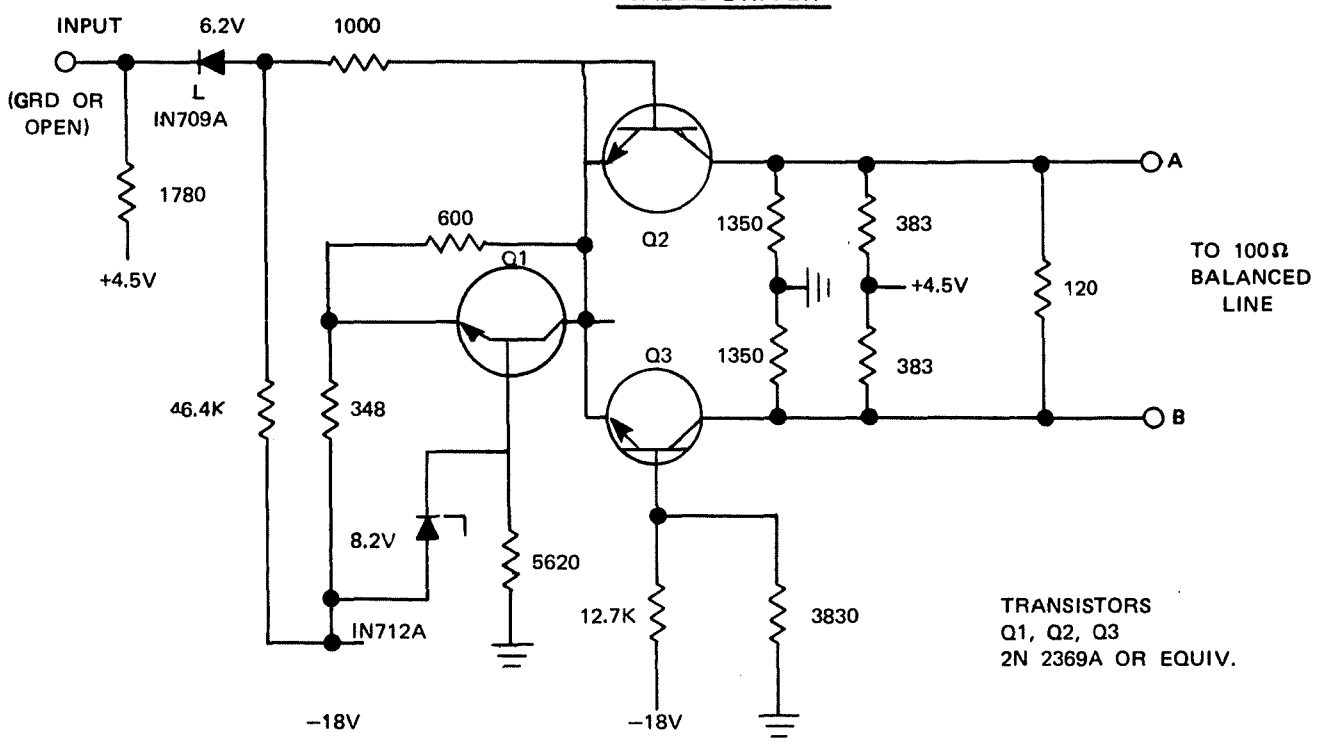


DATA SERVICE UNITS
MULTIUNIT CABINET ARRANGEMENT
FIGURE 2C

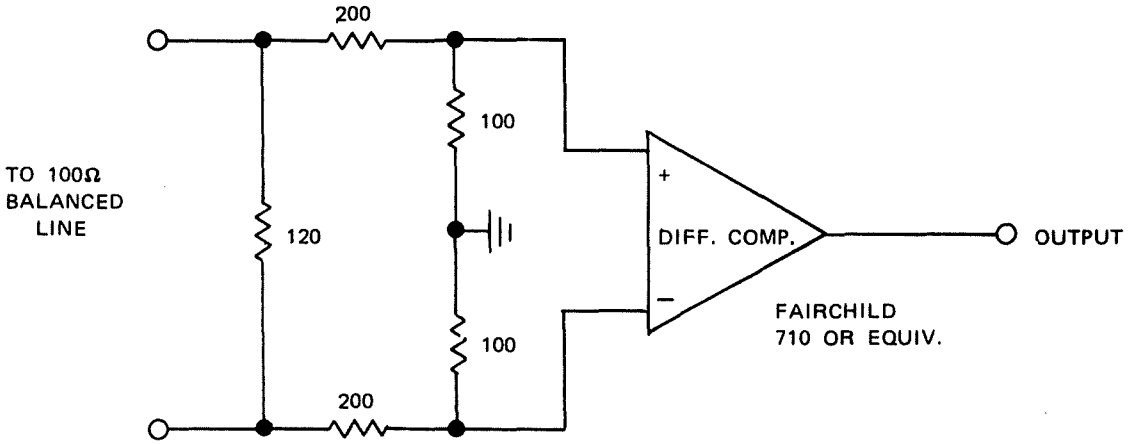


BLOCK DIAGRAM OF DATA SERVICE UNIT
FIGURE 3

CABLE DRIVER

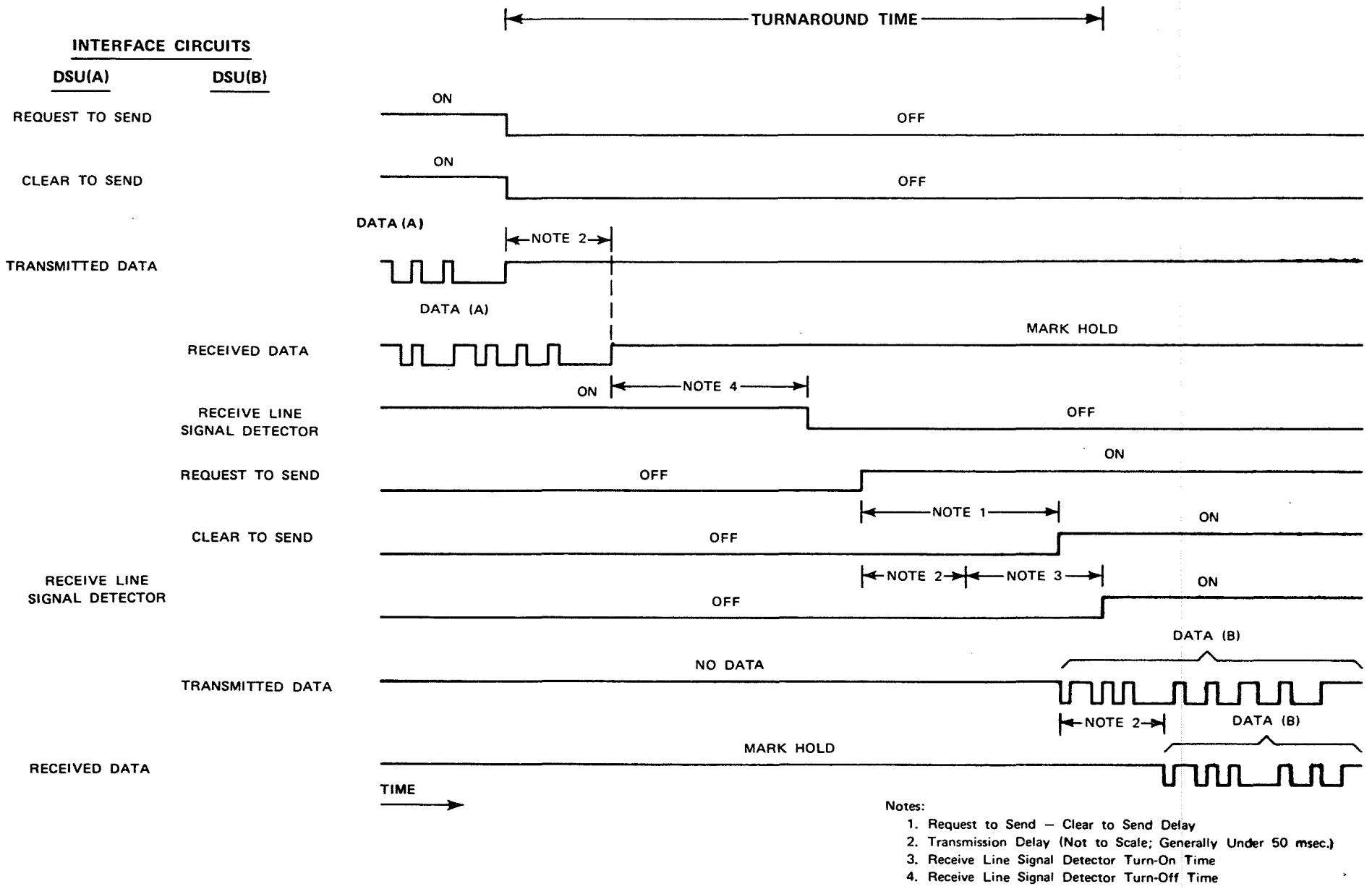


CABLE TERMINATOR



NOTE:
1. ALL RESISTANCE VALUES ARE IN OHMS

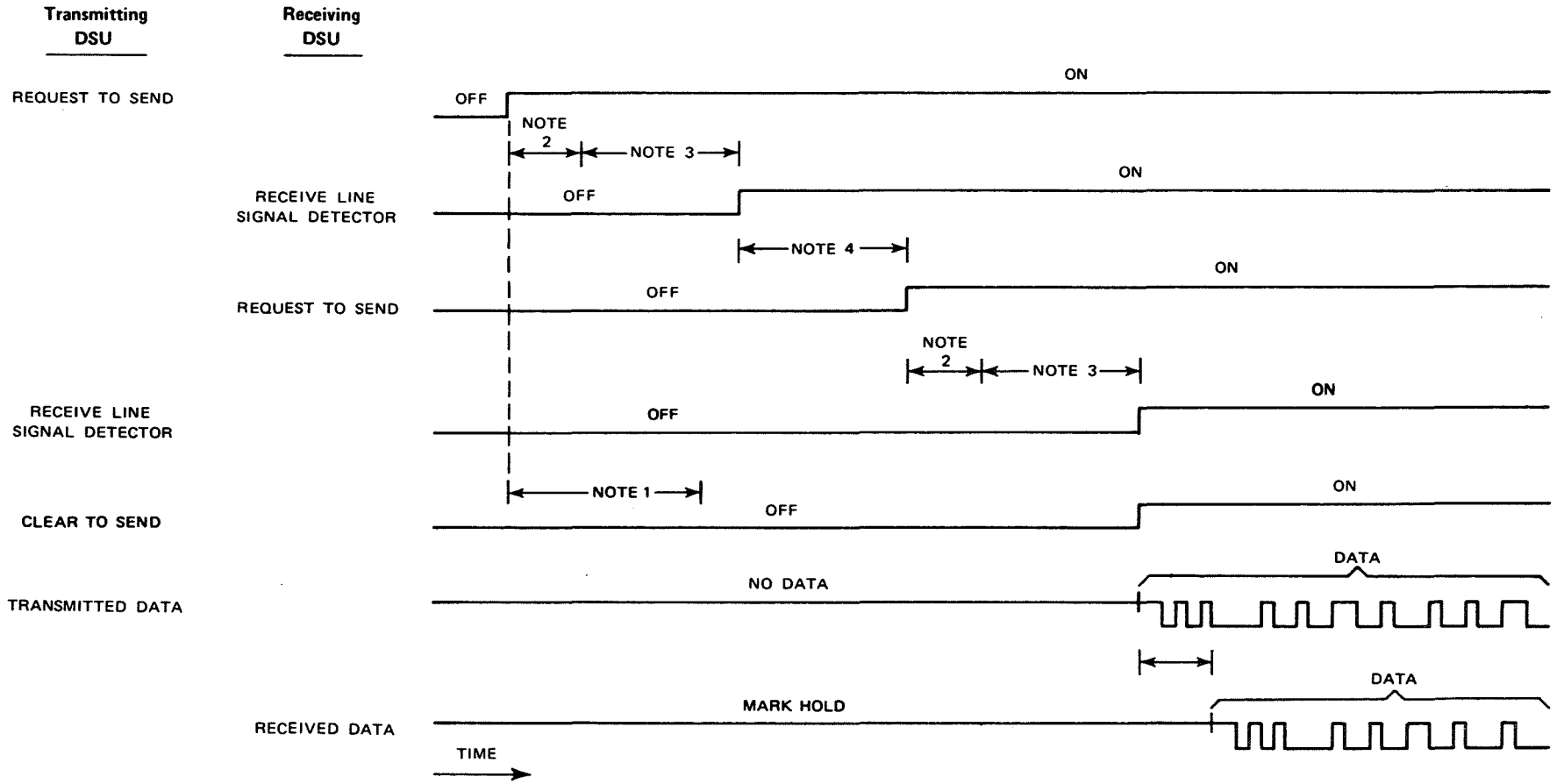
TYPICAL 56 KB/S BALANCED INTERFACE CABLE DRIVER AND TERMINATOR CIRCUITS
FIGURE 4



Notes:

1. Request to Send – Clear to Send Delay
2. Transmission Delay (Not to Scale; Generally Under 50 msec.)
3. Receive Line Signal Detector Turn-On Time
4. Receive Line Signal Detector Turn-Off Time

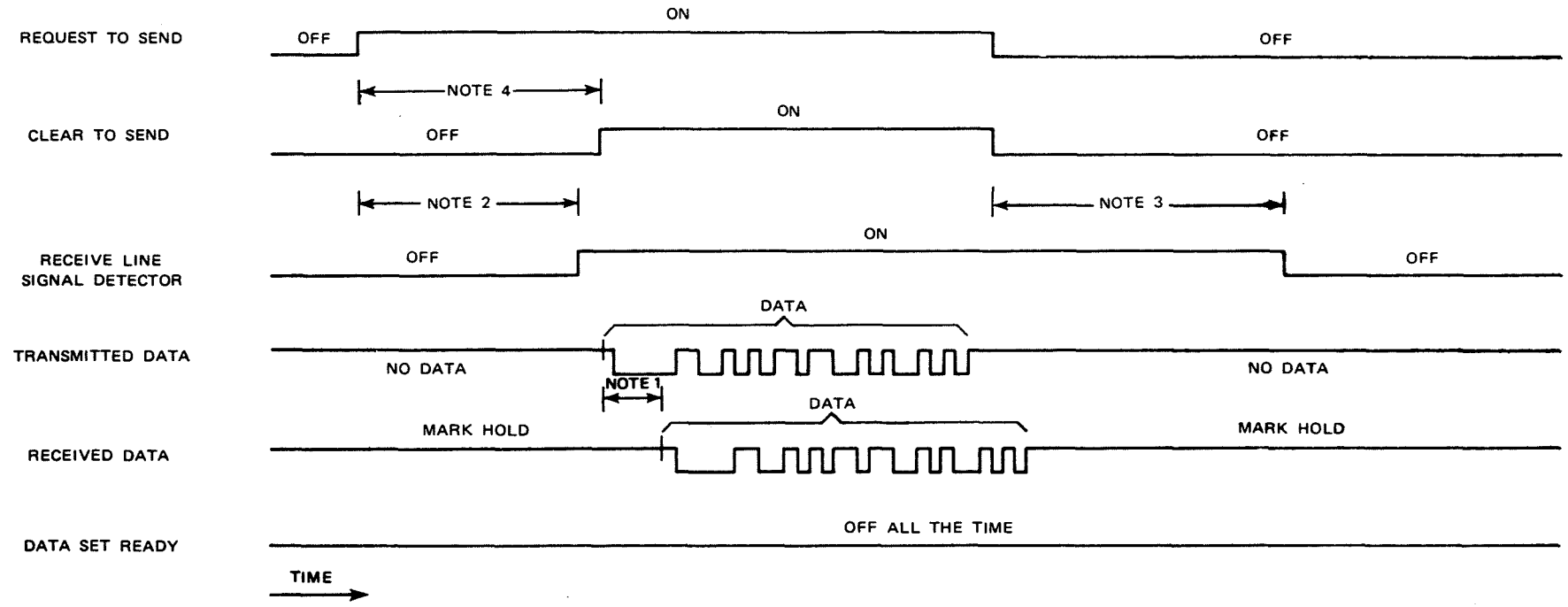
TURNAROUND SEQUENCE FOR HALF-DUPLEX OPERATION
FIGURE 5



NOTES:

1. Minimum Clear to Send Timing Delay (See Section 4.1.9)
2. Transmission Delay (Not to Scale, Generally under 50 msec.)
3. Receive Line Signal Detector Turn On Time
4. Customer Data Terminal Reaction Time

CIRCUIT ASSURANCE OPTION FOR HALF-DUPLEX OPERATION
FIGURE 6



Notes	DELAY (BITS) SUBRATE	56 kb/s
1. Transmission Delay through DSU	5	5
2. CA-CF Turn-on Time	8 to 15	10 to 17
3. CA-CF Turn-off Time	23	26
4. Request to Send–Clear to Send Delay	19 to 20	22 to 23

INTERFACE SIGNALS FOR LOCAL TEST OF DATA SERVICE UNIT FIGURE 7