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TECHNICAL REFERENCE

MULTISTATION DATAPHONE® DIGITAL SERVICE (USOC DDZ)

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If further information is required, please contact:

Engineering Manager - Data Network Services
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

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1. INTRODUCTION

This Technical Reference describes multistation DATAPHONE® Digital Service, which utilizes the Digital Data System (DDS). The DDS provides a private line, duplex[1] transmission capability at synchronous data rates of 2.4, 4.8, 9.6 and 56 kilobits per second (kb/s) with no alternate voice or voice coordination provisions. Two different service units are available for use at a customer's premises, the Data Service Unit (DSU) and the Channel Service Unit (CSU). The DSU is used 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, encoding and decoding of signals and the standard interface circuitry are not desired, the digital access line can be terminated on the customer's premises by a 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 DSU and CSU interfaces may be found in the Technical References titled - "Digital Data System, Data Service Unit Interface Specifications" (PUB 41450) and "Digital Data System, Channel Interface Specifications" (PUB 41021).

Multistation DATAPHONE Digital Service provides duplex communication between a control station[2] and two or more remote[3] stations. Throughout this Technical Reference the terms multistation and multipoint are used interchangeably to describe a configuration using duplex Multipoint Junction Units (MJUs) located at Telephone Company offices. As shown in Figure 1, all data transmitted by the control station is delivered to each of the remote stations. In the reverse direction, the MJUs combine bit streams transmitted by the remote stations into a single serial bit stream for delivery to the control station. Thus, to prevent errors in data transmitted toward the control station, only one remote station should transmit data at any given time. Direct data transmission between remote stations is not provided. Each control or remote station may have either a DSU or a CSU, but all stations on the same multipoint circuit[4] must operate at the same bit rate, which may be any one of the DDS customer service

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[1]Duplex operation, also called full-duplex operation, is the capability for transmission of signals in both directions simultaneously.

[2]The terms control station and master station are synonymous.

[3]The terms remote station and outlying station are synonymous.

[4]A multipoint circuit comprises one control station, all of its remote stations, and all of the channels, MJUs and digital access lines used to interconnect the stations.

rates. A typical configuration for multistation service is illustrated in Figure 2. Note that stations may be located in several different cities.

It is expected that many customers having multistation service will utilize polling techniques to maintain network discipline. Use of appropriate polling procedures assures that no more than one remote station transmits data at one time. These polling procedures can also be used to identify the remote stations to which each transmission from the control station is directed. When polling is used, polling messages transmitted from the control station direct individual remote stations to respond (one at a time), and to indicate whether they have data to transmit to the control station. Further information on polling and polling response delays is provided in Section 3. This information should be helpful in estimating the efficiency of various polling procedures and in determining appropriate timeout values to use when polling.

In addition to the polling information provided in Section 3, other sections discuss the station arrangements for multistation service, system operation, performance objectives and special features provided for testing and maintenance.

2. STATION ARRANGEMENTS

A user's interface with multistation service is the same as that for two station service. Ths DSU interface is described in PUB 41450, "Digital Data System, Data Service Unit Interface Specifications." The CSU interface is described in PUB 41021, "Digital Data System, Channel Interface Specifications." No other station equipment is necessary for multistation service.

3. SYSTEM DESCRIPTION

3.1 MJU Operation

Stations on a multipoint circuit are interconnected by means of duplex Multipoint Junction Units (MJUs) located at Telephone Company offices. Each MJU has one port for duplex data transmission with the control station and a number of ports for duplex transmission with the remote stations. The duplex data paths from an MJU toward remote stations are called branches. All data received at an MJU from the control station is delivered to all branches connected to the MJU. All data received at an MJU from its branches is combined in the MJU, and the resulting data is transmitted toward the control station. Hence, the functional operation of multipoint circuits in the DDS is like that of broadcast polling multipoint channels or "split bridge" operation used in analog data transmission systems.

As shown in Figure 2, MJUs may be cascaded to permit stations located in several different cities to be joined together in a multipoint circuit. MJUs may also be arranged to serve a number of stations within the same city. The MJU locations and configuration for each multipoint circuit will be assigned by the Telephone Company.

Logic in the MJUs allows two different polling disciplines. Properly utilized, an MJU can block many of the bit errors received from branches that are not in use, so that the performance quality for data transmitted from each remote station to the control station can be about as high as that for two station service. For this reason, the customer should take into account the manner in which an MJU combines data from its branches into a single data stream for transmission to the control station. When all stations have permanent Request to Send with idle stations in a mark-hold condition, performance is described in the following paragraph (a). When idle stations turn OFF their Request to Send (CA) interface circuit, performance is described in paragraph (b).

(a) Data bits received by an MJU from its branches are combined, such that a SPACE (0) bit is transmitted toward the control station whenever a SPACE (0) bit is received by the MJU from any one or more of its branches. If all branches transmit MARK (1) bits to the MJU, then the MJU transmits MARK (1) bits toward the control station. Thus, if one remote station transmits data (0 and 1 bits), and all of the other remote stations transmit only MARK (1) bits, only the data from the one active remote station is transmitted to the control station. With this arrangement, however, all bit errors received by an MJU from branches not carrying the data would be combined with the data, thus degrading the performance quality for all data received at the control station.

(b) Many errors of the type described above will be blocked by protective circuits in the MJUs if each remote station not transmitting data to the control station is held in the idle mode. For a CSU, this is accomplished by transmitting the idle sequence from the station having the CSU. The idle sequence is described in PUB 41021. For a DSU, the idle mode is maintained at the station having the DSU by holding the Request to Send (CA) interface circuit in the OFF state as described in PUB 41450. If one remote station transmits data, and all other remote stations remain in the idle mode, the data will be transmitted through the MJUs to the control station. Thus, to minimize the number of errors in the data received at the control station, it is recommended that each remote station be held in the idle mode, except while it is transmitting data to the control station.

When all of the remote stations on a multipoint circuit are in the idle mode, the idle sequence is transmitted to the control station. If the control station has a DSU, receipt of the idle sequence causes the Received Line Signal Detector (CF) interface circuit from the DSU to be placed in the OFF condition, following a turn-off delay. 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. Delays such as this have been included in the DSU logic circuitry to reduce the effect of short error bursts, which can simulate control code sequences.

3.2 Polling

In many multipoint circuits, it is expected that the control station will poll each remote station to determine if it has traffic to send. The time required to poll each remote station influences the efficiency of the data communications system. The steps in polling a remote station are illustrated in Figure 3 and may include the following:

1. A polling message is initiated at the control station.

2. The polling message is transmitted to the remote station.

3. A response message is initiated at the remote station.

4. The response message is transmitted to the control station.

Generally, some delay is associated with each of these steps due to such things as processing time, propagation delays, Request to Send - Clear to Send delays, etc. These delays limit the number of polling cycles that can be accomplished per unit time. The following discussion describes the amount of delay that may be expected from the DDS.

No delay (Request to Send - Clear to Send timing interval) need be encountered at the control station in Step 1. This is because the control station may remain on-line continuously (Request to Send ON) during all normal operations. Step 2 includes a one-way transmission delay between the control station and the remote station being polled. This delay consists of the propagation time through the various DDS equipment and facilities encountered in transmission from the control station to the remote station. Step 3 includes one turn-on period (Request to Send - Clear to Send timing interval) for equipment at the remote station. For the DSU, this timing delay is given below for each of the customer service rates.

Customer Service 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

Step 4 includes a one-way transmission delay for the response message from the remote station to the control station. All other delays (due to message lengths, processing times, etc.) depend upon the customer's procedures, and are not included in the polling response delay information provided herein; only the round trip transmission delay and one DSU turn-on delay are included.

It should be noted that the polling sequence for the next remote station to be polled may begin as soon as the last data bit from the previously polled remote station is recognized by the customer at the control location, providing that each remote station turns OFF its Request to Send interface signal immediately after transmitting the last data bit of each transmission. When this type of operation is used to minimize polling delays, it is possible that some remote stations located near the control station may respond to their polling messages so quickly that the Received Line Signal Detector interface signal at the control station may not go OFF between polling sequences. An alternative operating procedure would be to begin each polling sequence at the control station only if the Received Line Signal Detector interface signal is OFF, but the total time required to poll each remote station would then be increased by the turn-off delay of the Received Line Signal Detector interface signal.

Figure 4 provides information on estimated polling response delays for DDS multipoint circuits as a function of the total distance in airline miles from the control station to the remote station being polled. These curves result from a computer simulation of multipoint circuits. The individual polling response delays for any particular multipoint circuit may be larger or smaller than the values shown.

Maximum polling response delays cannot be specified, because circuit rearrangements and emergency measures to restore service if failures occur make such a specification impractical. However, polling response delays greater than 150 ms should seldom be experienced, even on the longest connections.

3.3 CSU/DSU Operation

The information in Figure 4 is based on use of DSUs at the remote stations being polled. If a remote station has a CSU, the time required to respond to a polling message depends to some extent upon the customer's procedures, because there is no Request to Send - Clear to Send delay in a CSU. However, at any station having a CSU, a minimum delay interval (five bits for 2.4, 4.8, and 9.6 kb/s service and six bits for 56 kb/s service) must be inserted by the customer immediately following transmission of the last bit of idle sequence, before transmitting data. This allows time for completion of the idle sequence transmission in progress to the other station(s) and assures that all data bits will be delivered to the other station(s). An additional delay (twelve bits for 2.4, 4.8, and 9.6 kb/s service and fourteen bits for 56 kb/s service) must be inserted if the CSU is transmitting to a DSU at the control station. This delay allows for the turn-on interval for the Received Line Signal Detector interface circuit at the DSU.

3.4 Example

To illustrate use of the polling response delay information provided in Figure 4, refer to Figure 2, and assume that the distance between City "A" and City "B" is 500 airline miles, and that the distance between City "A" and City "C" is 1,000 airline miles. Also assume that the stations operate at 4.8 kb/s and have DSUs. A reasonable estimate for the polling response delay for each station, based on the information in Figure 4, is shown below.

Remote Station	Airline Miles	Polling Response Delay at 4.8 kb/s*
1	0	18 ms
2	500	37 ms
3	1000	53 ms
4	1000	53 ms

*A polling response delay comprises one round trip transmission delay plus one DSU turn-on delay at the remote station.

4. PERFORMANCE OBJECTIVES

DDS performance objectives are stated below in terms of the goals that were established during the system design. These goals are not to be construed as minimum performance guarantees.

Quality - To average at least 99.5 percent 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 percent channel availability, i.e., annual downtime less than 0.04 percent. 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).

For multistation service, these goals apply for communication between the control station and each remote station, while all inactive remote stations are maintained in the idle mode, as described in Section 3.

5. TESTING AND MAINTENANCE

5.1 Trouble Reporting

Most equipment malfunctions that can degrade the performance of multistation service will be detected automatically, and standby equipment will be placed in service automatically. Consequently neither routine maintenance nor routine testing periods are required to keep multistation service 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 to test from the user.

It is expected that the customer will check his terminal equipment for proper operation prior to reporting trouble to the Telephone Company. When the customer suspects a trouble condition in his service, 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. In the case of multistation service, the most important information required is the location of the stations that are experiencing problems. Different maintenance procedures are followed depending on whether these station locations are identified when a user reports trouble.

1. If the locations are reported by the customer, it will usually by possible to isolate those stations, then diagnose and repair the fault without disrupting service for the unaffected stations.

2. When the identity of the affected locations is not provided to our maintenance forces, one-person diagnostic procedures permit each part of an entire multipoint circuit to be tested from the Telephone Company test center associated with the control station. Such tests require the removal of customer data. It is essential to good service that the user be willing to release his channel when such testing is required. The channel, digital access line or station having a failure can be identified during these tests. Once this identification is made, it will usually be possible to restore operation to the unaffected stations while the faults are being diagnosed and repaired.

Trouble indications for multistation service are the same as those for two station service and are described in PUB 41021 and PUB 41450.

5.2 <u>Loopback Testing</u>

A test switch is provided on DSUs, which can be used by a customer for testing his multipoint circuit as described below. Also see Figure 5.

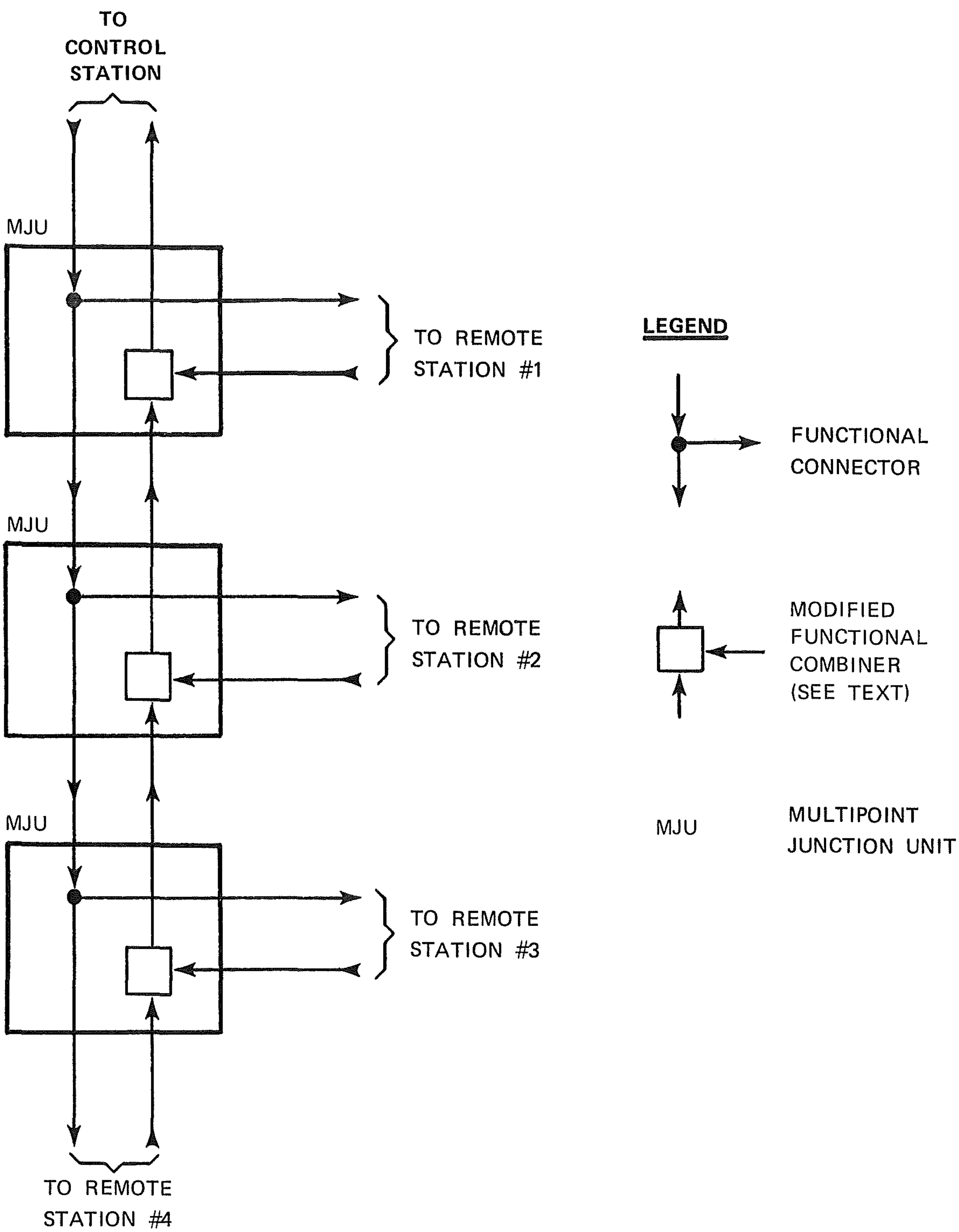
1. With the test switch in the Local Line (LL) position, the DSU is in the Local Line test mode. The LL test permits a customer with an appropriately designed duplex terminal at his control station to test the back-to-back performance of the data terminal equipment and DSU by connecting the transmitter section of the DSU to the receiver section. In addition, the receive line is connected through terminating equipment to the transmit line to allow a signal to be maintained in both directions on the loop. 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.

   To avoid accidental interruption of service, manual operation of the Local Line loopback is inhibited at remote stations. Its use at a remote station would loop all data signals from the control station back to the control station, and could cause garbling of data being transmitted from some other remote station to the control station. Loopback testing by customers at remote stations must be coordinated through the control station, as described in (2) below.

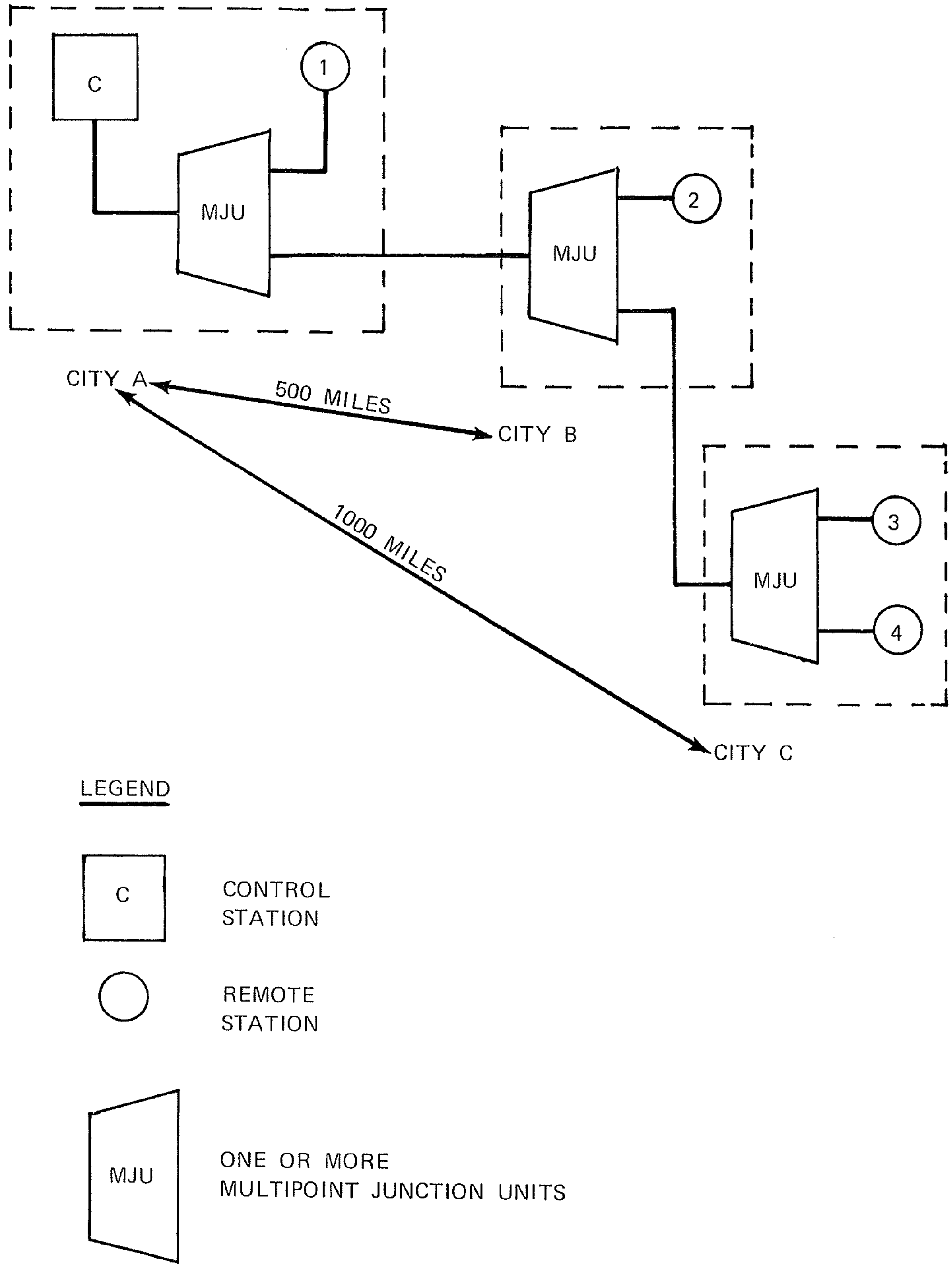
2. With the test switch in the Remote Terminal (RT) position, which is permitted at a control station or a remote station, the DSU is in the Remote Terminal test mode. In this test mode the output of the Received Data interface circuit is connected to the input of the Transmitted Data interface circuit at the data terminal interface of the DSU, causing data signals received from the line to be looped back to the line. (If the idle sequence or the out-of-service sequence is being received, a data signal of all 1's will be looped back to the line.) For this test the control interface 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.

   With the DSU at any one remote station in the RT test mode, an appropriately designed data terminal at the control station has the capability of testing system operation with that one remote station (exclusive of the data terminal at the remote station) by transmitting test sequences to the remote station, and checking the sequences after they are received back at the control station. With the DSU at the control station in the RT test mode, an appropriately designed data terminal at any one of the remote stations has the capability of checking system operation with the control station (exclusive of the data terminal at the control station) by transmitting test sequences to the control station, and checking the sequences after they are received back at the remote station. To prevent garbling of test data, only one station should be in the RT test mode at a time, and only one station should transmit test data at a time. Remote stations not participating in a test should remain in the idle mode, and should not respond to the test sequences received from the control station. RT tests permit the customer to verify circuit operation and to deduce whether any data terminal is responsible for a system trouble condition. Caution: Operation of the test switch to the RT position could cause garbling of data being transmitted from some remote station to the control station. When a DSU is in the RT test mode, its Data Set Ready, Received Line Signal Detector and Clear to Send circuits are OFF.

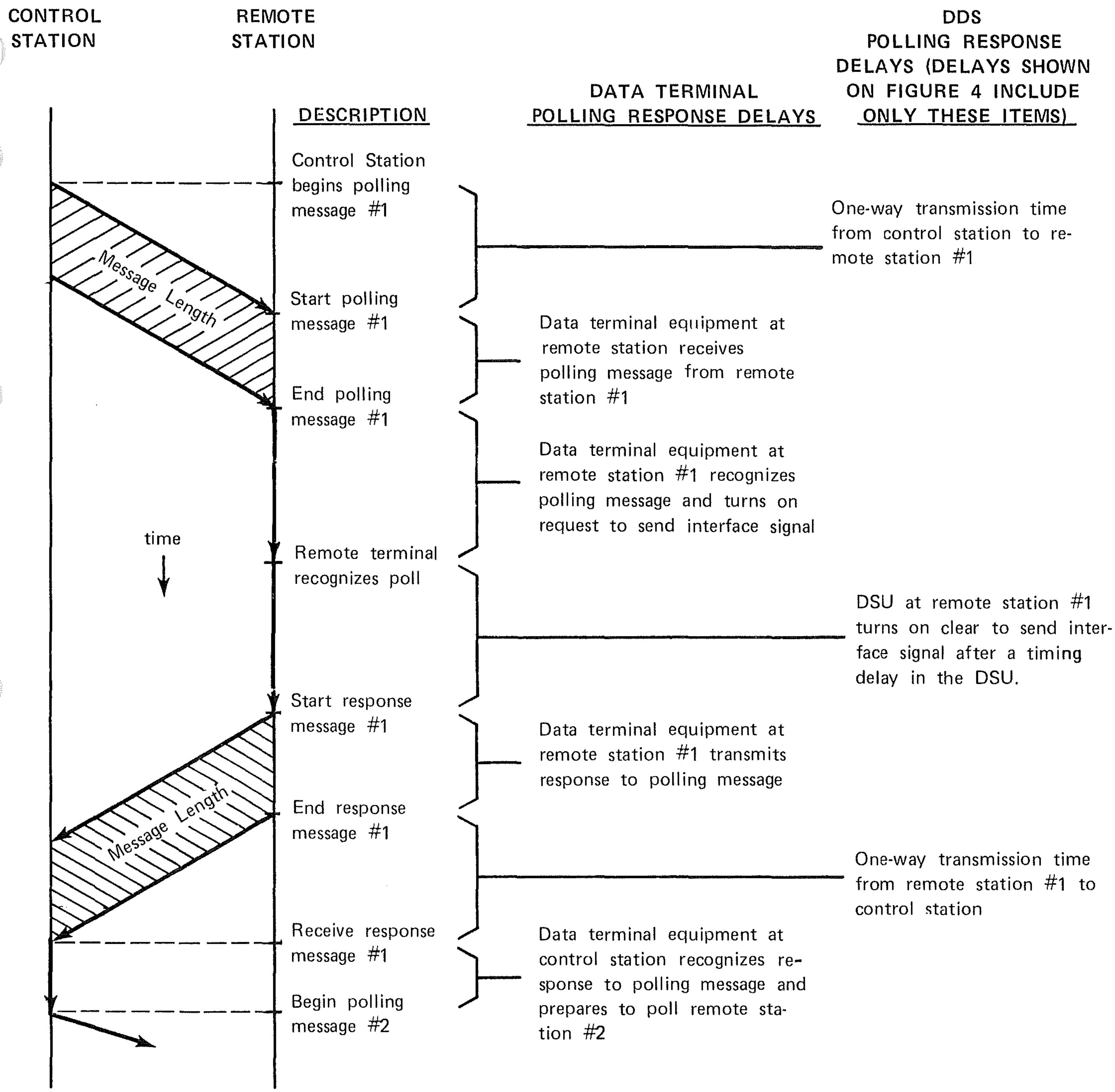
When maintenance tests are conducted from the Telephone Company's test center, the RT or LL switch function at a DSU is actuated by remote control, and the RT or LL Test lamp will turn ON. Similarly, a station having a CSU can be tested from the test center, but no test switches are provided with a CSU. When a CSU is being tested, its Status Indicator (SI) interface signal will be OFF, and its test (TST) lamp will be ON.



FUNCTIONAL REPRESENTATION OF MULTIPOINT JUNCTION UNITS (MJUs)
FIGURE 1

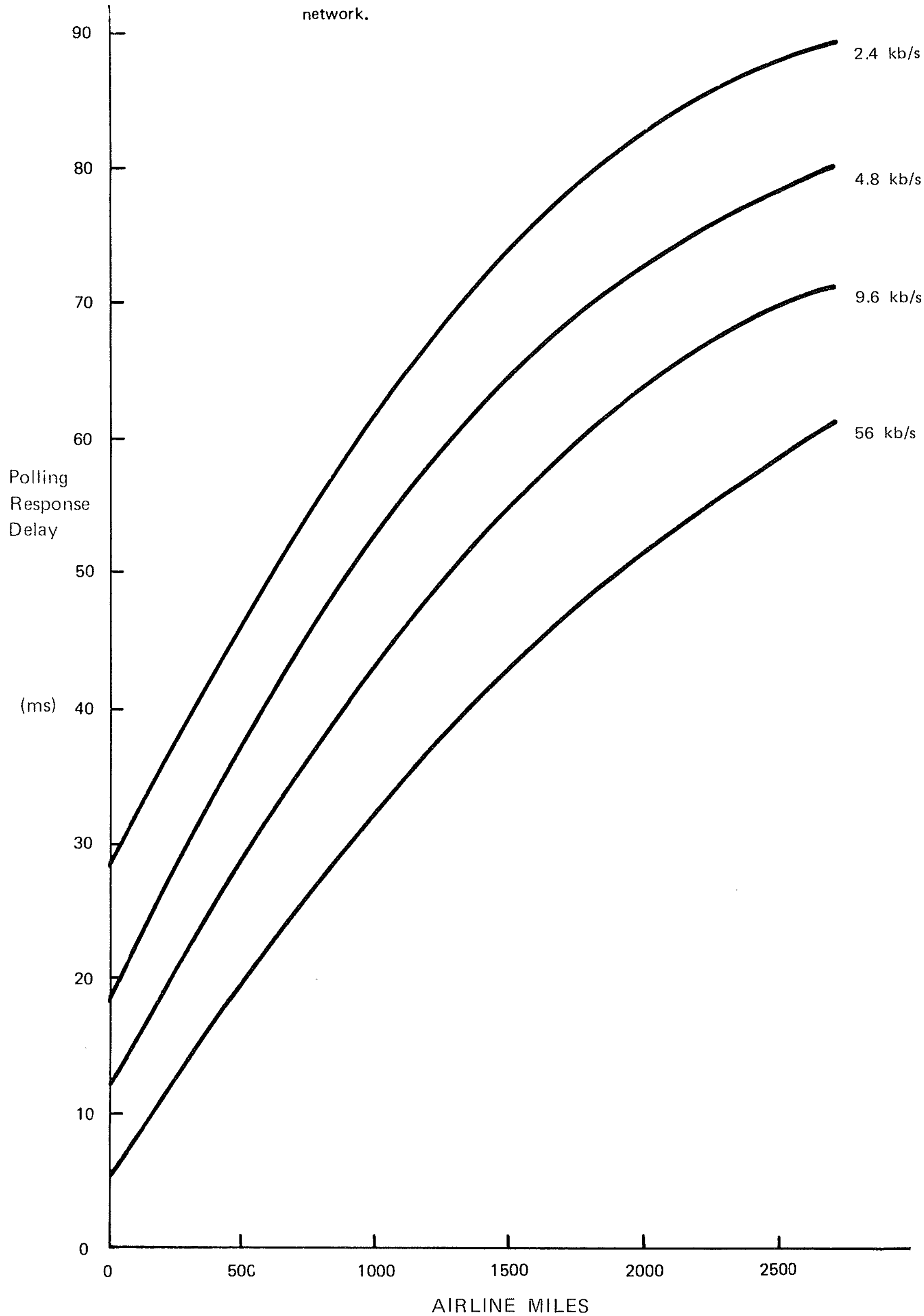


BLOCK DIAGRAM OF A TYPICAL MULTIPOINT CIRCUIT
FIGURE 2



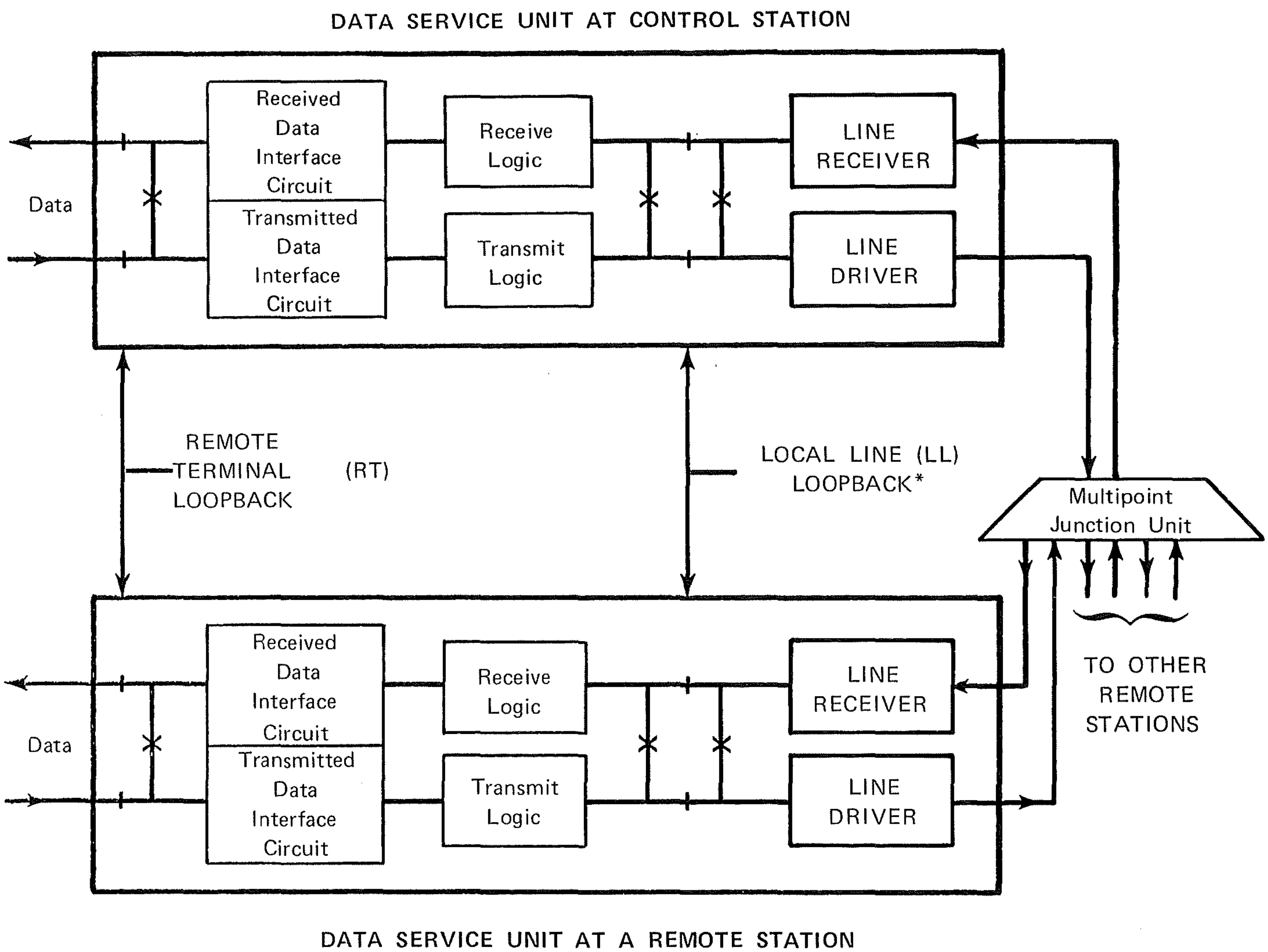
POLLING SEQUENCE DIAGRAM
FIGURE 3

NOTE: The polling response delay time between any two stations may occasionally change by a few milliseconds to a new fixed value, should a multiplexer reframe, causing a different number of customer bits to be stored in the network.



ESTIMATED POLLING RESPONSE DELAY

FIGURE 4



*Manual control of the Local Line (LL) loopback is available only at the control station. The LL switch is mechanically blocked at all remote stations.

DATA SERVICE UNIT
LOOPBACK ARRANGEMENTS
FIGURE 5