

# PRELIMINARY

**Bell System Data Communications  
TECHNICAL REFERENCE**

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**DATA SET 209A  
INTERFACE SPECIFICATION**

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**May 1974**

**Engineering Manager - Data Systems**



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## TABLE OF CONTENTS

	<u>PAGE</u>
0. TECHNICAL SPECIFICATION SUMMARY	1
1. GENERAL	3
1.1 Data Set 209A Type	3
1.2 Basic System Configurations	4
1.3 Physical Description	6
1.4 Power Requirements	6
1.5 Interface Compatibility	7
1.6 Test Switches and Testing Features	7
1.6.1 Basic Data Set Testing Modes	9
1.7 Status Lamp Indications	10
1.8 Automatic Retraining Feature	13
1.9 Location and Mounting of the Data Set	14
1.10 Alternate-Voice Service	14
2. OPTIONAL CUSTOMER FEATURES	15
2.1 Multiplex Options	15
2.2 Transmitter Timing Provided by Data Terminal Equipment	15
2.3 Continuous or Switched Carrier Operation	16
2.4 Switched or Continuous Request-to-Send Operation	17
2.5 Elastic Store Option to Work Through Digital Interface with Another Data Set	18
2.6 Slaved Transmitter Timing by Receiver	18
2.7 Data Set Ready Option for Analog Loopback Testing by Data Terminals	19
2.8 Grounding	20
3. CUSTOMER INTERFACE	21
3.1 Interface Connectors and Special Cords	21
3.2 Electrical Interface Circuit Considerations	22
3.2.1 Signal States on Active Connectors	22
3.2.2 Signal States on Circuits of Inactive Connectors	22
3.3 Interface Circuit Operation	23
3.3.1 Protective Ground	24
3.3.2 Transmitted Data	24
3.3.3 Received Data	24
3.3.4 Request-to-Send	25
3.3.5 Clear-to-Send	26
3.3.6 Data Set Ready	27
3.3.7 Signal Ground	28
3.3.8 Received Line Signal Detector	28
3.3.9 Circuits 9 and 10 (Connector No. 1 only)	30
3.3.10 Equalizer Mode (Connector No. 1 only)	30

3.3.11	Transmitter Signal Element Timing	30
3.3.12	Divided Clock Transmitter (Connector No. 1 only)	31
3.3.13	Receiver Signal Element Timing	32
3.3.14	Divided Clock Receiver (Connector No. 1 only)	32
3.3.15	Signal Quality Detector	32
3.3.16	Transmitter Signal Element Timing External (Connector No. 1 only)	33
3.3.17	Circuit 25 (Connector No. 1 only)	34
4.	OPERATION WITH DATA TERMINAL EQUIPMENT	34
4.1	System Configurations of Data Set 209A	34
4.1.1	Point-to-Point 9600 bps Service	34
4.1.2	Point-to-Point Multiplexing Service	35
4.1.3	Many Point Multiplexing Service	35
4.1.4	One-to-Many Multiplexing Service	37
4.2	Half-Duplex or Duplex Data Terminal Operation	38
5.	TESTING	38
5.1	Testing Single Link 209A Services	39
5.1.1	Data Set Self Test Procedures	39
5.1.2	Test Procedures Using the Data Terminal or External Test Equipment	42
5.1.3	Telephone Company Test Procedures	43
5.2	Testing of Multiplex Extension Services	44
5.2.1	Loop Tests Not Permitted	45
5.2.2	Availability of Self Test Capabilities in Data Set 208A	46
5.2.3	Restriction on the Use of TEST 5	47
6.	PERFORMANCE	47
7.	REFERENCES	48

## LIST OF FIGURES

- Fig. 1 - Front View of Data Set 209A
- Fig. 2 - Rear View of Data Set 209A
- Fig. 3 - Optional Customer-Specified Features of Data Set 209A
- Fig. 4 - Basic System Configurations and Data Set Options
  - (a) Point-to-Point 9600 bps Operation
  - (b) Point-to-Point Multiplexing
  - (c) Many Point Multiplexing
  - (d) One-to-Many Multiplexing
- Fig. 5 - Pin Assignments on Customer Interface Connector(s)
- Fig. 6 - Interface Operation During an Automatic Retraining Sequence
- Fig. 7 - Synchronization Arrangement for a Many Point Multiplexing System
- Fig. 8 - Timing Diagram for One-to-Many Multiplexing Operation
  - (a) 96 to 72/24 Operation
  - (b) 96 to 48/48 Operation
  - (c) 96 to 48/24/24 Operation
  - (d) 96 to 4-24 Operation
- Fig. 9 - Interface Circuit Turnaround Sequence for Half-Duplex Operation
- Fig. 10 - Self Test Arrangements
  - (a) Analog Loopback Self Test
  - (b) Digital Loopback Self Test
  - (c) End-to-End Self Test
- Fig. 11 - Tests Made by the Data Terminal or External Test Equipment Through Data Set Interface
  - (a) Analog Loopback Test
  - (b) Digital Loopback Test
- Fig. 12 - Telephone Company Remote Test
- Fig. 13 - Permissible and Prohibited Signal Looping Tests for Use in Extension Service System Testing
- Fig. 14 - Procedures to Systematically Isolate Problems on Extension Service Systems

## LIST OF TABLES

- Table 1 - Switch Positions and Lamp Status for Self Tests and Tests with External Test Equipment or a Data Terminal
- Table 2 - Special Connecting Cables for Many Point and One-to-Many Multiplexing Configurations When Extension Service is Involved
- Table 3 - Request-to-Send, Clear-to-Send Delays in Switched Carrier Operation
- Table 4 - References to Test Procedures and Acceptability Criteria for Customer Performed Loop Tests of Extension Channel Systems

0. TECHNICAL SPECIFICATION SUMMARY

Data Rates: 9600 bps from a single data source  
or one of several multiplexing arrangements:  
One 7200 bps and one 2400 bps data channel  
Two 4800 bps data channels  
One 4800 bps and two 2400 bps data channels  
Four 2400 bps data channels

Operation: Synchronous, binary, serial

Operating Modes: Half-duplex or duplex according to data terminal operation

Channel Requirement: 3002-type 4-wire private line channel with High Performance Data Conditioning (D1-type) and no C-type conditioning

Interface Voltages: Per EIA Standard RS-232-C

Interface Control Functions (applies to all connectors):

Request to Send - Clear to Send delay:

Continuous carrier operation with switched Request-to-Send:  
8 ± 1 milliseconds on any of the connectors that are used

Continuous carrier with continuous Request-to-Send:  
no delay, i.e., Clear-to-Send is ON all the time on any of the connectors that are used

Switched carrier operation:  
147 ± 1 milliseconds on connector No. 1 when multiplexing is not used. When multiplexing is used it will vary between 8 and 200 milliseconds on any of the connectors that are used

Received Line Signal Detector Operation:

Turn ON: 127 ± 2 milliseconds after Signal Quality Detector turns ON

Turn OFF: less than 1 millisecond after Signal Quality Detector turns OFF when working with a remote data set optioned for switched carrier, or approximately one second when working with a data set optioned for continuous carrier

Signal Quality Detector Operation:

Turn ON: approximately 20 milliseconds after data signal is present on line

Turn OFF: approximately 20 milliseconds after data signal is absent on line

Interface Connector(s) and Cable(s) :

Direct Data Terminal Connection:

Data Terminal connecting cord must provide a 25-pin Cinch or Cannon Type DB-19604-432 (male) plug with Cinch Type DB-51226-1 Hood (or equivalents) for each connector which is used. Interface cable provided by customer is recommended to be no more than 50 feet long (or no greater than 2500 picofarads shunt capacitance) in conformance with EIA Standard RS-232-C.

Connection to Data Set for Extension Service:

With many point or one-to-many multiplexing arrangements (see Section 1.2), interconnection of the 209A with a lower speed Telephone Company provided synchronous data set will be connected using a special interface cord provided by the Telephone Company. In addition, the remote data terminal will interface with the remote lower speed data set at the far end of the extension channel through another special Telephone Company provided interface cord terminated in a 25-pin (female) connector similar to that on the data set (see Table 2). Interconnection of a customer provided data set to the 209A will require that the customer provide the functionally equivalent special cords or circuitry.

AC Power Required:

117 volt  $\pm$  10 percent ac, 60 Hz  $\pm$  5 percent. Data set consumes about 95 watts. Power cord is furnished with data set. Power outlet should be a conventional 3-wire type not under switch control.

Environmental Requirements:

Ambient temperature range: 40° - 120°F  
Relative Humidity: from 20 to 95 percent up to 75°F  
from 20 to 40 percent at 120°F

Dimensions: 20-1/2 inches wide, 5-1/8 inches high, and 13-1/2 inches deep

Weight: Approximately 42 pounds

## 1. GENERAL

### 1.1 Data\_Set\_209A\_Type

Data Set 209A is designed for transmission and reception of synchronous 9600 bps serial, binary data on 3002-type 4-wire private line channels ordered with High Performance Data Conditioning (D1-type) but no C-type conditioning. The data set also provides time division multiplexing options for a) one 7200 bps and one 2400 bps serial bit streams, b) two 4800 bps serial bit streams, c) one 4800 bps and two 2400 bps serial bit streams, or d) four 2400 bps serial bit streams.\* The selection of the multiplexing option is under customer control via a selector switch shown in Figure 1. The selected multiplexing option is indicated by illumination of a combination of four LED lamps on the front of the data set. The data set features an 8 millisecond startup delay with continuous carrier and switched Request-to-Send operation, which is recommended for each basic system configuration, or no delay if used with the continuous carrier and continuous Request-to-Send options. Should the data terminal require switched carrier operation the startup delay is approximately 150 milliseconds, but in multiplexing applications can be between 8 and 200 milliseconds depending on when the data terminals use their Request-to-Send circuits. The data set uses automatic adaptive equalization and places no restriction on the coding of customer data as the transmitter contains a scrambler circuit to randomize the signal applied to the channel. The data set incorporates an automatic retraining feature which is described in Section 1.8. The data set provides seven LED status lamps which monitor four interface circuits, the automatic equalizer, test mode status, and the power supply. These status lamps and the four push-button test switches on the front of the data set permit fault isolation of problems to the data set, the channel, or the data terminal. System testing procedures are given in Section 5.

Data Set 209A can be interfaced with either data terminal equipment or other lower speed synchronous data sets operating at 7200, 4800, or 2400 bps for extension of the data streams from the multiplexing location to a remotely located data terminal. Lower speed Telephone Company provided data sets are available for 4800 and 2400 bps extension service (they must be ordered separately).

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\* For convenience these multiplexing options will be abbreviated throughout the remainder of this document as 96, 72/24, 48/48, 48/24/24, and 4-24.

Data Set 209A is line signal compatible only with another 209A. It provides 9600 bps duplex service which, depending upon the requirements of the data terminal(s) connected, can be operated to yield one-way, two-way nonsimultaneous (half-duplex) or two-way simultaneous (duplex) transmission for point-to-point private line applications. A discussion of basic system configurations is given in Section 1.2 with further details in Section 4.1. A description of optional customer specified features provided by the data set is presented in Section 2.

## 1.2 Basic System Configurations

There are four basic system configurations for Data Set 209A. These are not meant to represent all possible configurations, but to show the basic set of permissible configurations in which the 209A can be used. Each configuration is described in detail in Sections 4.1.1 to 4.1.4, following the sections describing the optional data set features (Section 2) and the operation of the interface circuits (Section 3). These latter two sections describe how the interfaces of the data set function. The customer must specify the system configuration in which the 209A will be used in order for the Telephone Company to appropriately engineer each data set in the system. There are seven optional features on the 209A which must be specified by the customer according to data terminal operation and system layout. Options must also be specified for other Bell System data sets used. Data Set 209A options are described in Section 2 and are listed in Figure 3. Figures 4(a) to 4(d) show the required options in each Bell System data set in the four basic system configurations. Options that are not denoted as required are only recommended. They need not be used if data terminal incompatibility results. The four basic configurations are described below.

### 1. Point-to-Point 9600 Service (Figure 4(a), Section 4.1.1)

Data is exchanged between two locations, each with a data terminal which is capable of 9600 bps data transfer rates located within 50 feet of the data set.

2. Point-to-Point Multiplexing Service (Figure 4(b), Section 4.1.2)

The data set provides time division multiplexing options for a) one 7200 bps and one 2400 bps data channel, or b) two 4800 bps data channels, or c) one 4800 bps and two 2400 bps data channels, or d) four 2400 bps data channels. For this configuration all data terminal equipment must be within 50 feet of the 209A data sets at each end of the private line channel.

3. Many Point Multiplexing Service (Figure 4(c), Section 4.1.3)

With any of the multiplexing options if any data terminal is farther than 50 feet from the 209A either in another location or within the same building, it may be connected to the 209A via an extension channel provided by a separate lower speed synchronous data set with a data rate compatible with the multiplexed data channel rate of the 209A (i.e., 7200, 4800, or 2400 bps). \* Up to four such extension channels may be provided from either one or both 209As depending on the multiplex option selected and the system layout. In this way the lower rate data channel can be extended via other private line facilities to remotely located data terminals. The extension channels may be point-to-point or multipoint depending on the application. There are restrictions on how multipoint extension channels may be configured. These are discussed in Section 4.1.3. The extension data sets and extension private line channel(s) must be ordered separately.

4. One-to-Many Multiplexing Service (Figure 4(d), Section 4.1.4)

A one-to-many multiplexing arrangement differs from the previous two multiplexing arrangements simply by the fact that one "central" data terminal does

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\* Only 4800 bps and 2400 bps extension service is available with Bell System data sets 208A and 201C, respectively. A Bell System 7200 bps extension service offering is not available.

the multiplexing of the 9600 bps data stream in place of the 209A at that location. This will save ports on the central data terminal. At the far-end 209A, the customer selects one of the four multiplexing options to provide two or more lower speed data streams for use by separate data terminals which may be collocated or accessed over extension channel(s) (ordered separately). The only advantage of using this arrangement is when the customer wants to use only one communications port on his data terminal at the central site. If this is advantageous compared to using the 209A for multiplexing as described for the point-to-point or many point multiplexing arrangements, then one-to-many multiplexing should be used. To perform the proper multiplexing of the 9600 bps data stream, the central data terminal must provide multiplexing software or hardware equivalent to that in the 209A. Synchronizing signals are supplied by the central 209A data set to allow identification of the time division multiplexed 9600 bps data sent to and received from the far-end. Sections 3.3.12 and 3.3.14 describe these synchronizing signals.

It should be noted that the multiplexing bit sequence of the 9600 bps data stream at the central 209A is rather complex when either the 72/24 or the 48/24/24 option is selected in the far-end 209A. Therefore, these two multiplexing options are not recommended for customer terminal multiplexing, but may be used if desired. See Section 4.1.4 for more information.

### 1.3 Physical Description

The housing of Data Set 209A, shown in Figures 1 and 2, measures 20-1/2 inches wide, 5-1/8 inches high, and 13-1/2 inches deep. The data set will operate normally over a temperature range from 40° to 120°F and with a relative humidity from 20 to 95 percent up to 75°F and from 20 to 40 percent at 120°F. The data set contains a small exhaust fan to aid in heat dissipation within the housing. The data set weighs approximately 42 pounds. Mounting arrangements are discussed in Section 1.9.

### 1.4 Power Requirements

Power is supplied through a 3-wire power cord attached via a twist lock connector on the back of the data set. The cord should be connected to a conventional 3-wire, 117 volt  $\pm 10$  percent, 60 Hz  $\pm 5$  percent, nonswitched ac outlet. The data set consumes approximately 95 watts of ac power typically and up to 100 watts maximum. Data set circuitry

is protected from over voltages from the power supply by a circuit breaker built into the power supply. Should this circuit breaker trip, the ON lamp (see Section 1.7) will go out and the data set will become inoperable. The Telephone Company should be notified if this occurs.

### 1.5 Interface Compatibility

The interface signals exchanged between Data Set 209A and any data terminal equipment on any of the four interface connectors of the data set conform electrically to the Electronics Industries Association (EIA) Standard RS-232-C. Most of the interface circuits on the four connectors of the 209A, listed in Figure 5, also conform functionally to those defined by RS-232-C with the exception of four interface circuits on connector No. 1 which are not defined by that standard (QM, DCT, DCR, and Circuit 25). These additional circuits are denoted by "ncn-EIA" in Figure 5 and in the circuit descriptions in Section 3.3. Section 3 provides details of the function and operation of all the interface circuits.

### 1.6 Test Switches and Testing Features

Data Set 209A has four push-button test switches accessible on the right side of the front cover. The test switches permit local and remote testing of the 209A data sets with the private line channel and with data sets on extension channels. Section 1.6.1 discusses the various test modes, referred to in this document as TEST 1 to TEST 6. These tests are intended for testing the 209A link alone. Test procedures are covered in Section 5.1. Testing of entire system configurations when they involve extension channels are discussed in Section 5.2. System testing of all data sets in a many point or one-to-many multiplexing configuration with extension channels will involve the use of test features in other Bell System data sets as well as those in the 209A. Test procedures are covered in Section 5.2.

It should be noted that the use of any of the test switches on the 209A (except LP) will affect all data set interfaces and will interrupt normal operation of the data set. Individual interfaces cannot be tested separately using the self-test circuitry or the AL and DL switches described below.

All of Data Set 209A's test switches, shown in Figure 1, are a push-to-operate and push-to-release type with the exception of the LP switch which is nonlocking. The four switches are identified as follows with their respective functions:

- 1) IP (Lamp Test): This is a nonlocking switch which when held depressed will light all of the data set mode and multiplex status lamps (see Section 1.7) except the ON lamp (which is lit whenever the data set is powered) to check that they are working. Depressing this switch does not affect data set operation in either the data or the test mode (i.e., when the AL, ST, or DL switches are depressed).
- 2) AL (Analog Loopback): This switch is used to connect the transmitter output to the receiver input through an internal attenuator network. This permits the testing of the local data set with either self-contained test circuitry activated by the ST switch or with external test equipment or the data terminal equipment through any of the data set interface connectors when the connector is activated. Depressing the AL switch will light the TM lamp, will disable the slaved transmitter timing option (see Section 2.6), will turn out the MR lamp and turn all Data Set Ready (CC) circuits OFF. If the Data Set Ready in AL mode ON option is installed (see Section 2.5) and the ST switch is not depressed, the MR lamp will be lit and the Data Set Ready (CC) circuit(s) will stay ON so that a data terminal on any connector can operate with the data set during an analog loopback test of the local data set (see TEST 4 in Section 1.6.1).
- 3) ST (Self Test): This switch is used to condition the data set to operate with a built-in test word generator and word comparator to check for errors. Internally it turns all Request-to-Send signals ON and causes the separate internal Received Data circuits to be monitored for errors. When the ST and AL switches are depressed to perform a self test of the local data set (see TEST 1 in Section 1.6.1), the ER lamp will blink if a bit error occurs in this test mode. Depressing the ST switch alone will light the TM lamp, will disable the slaved transmitter timing option (see Section 2.6), will disable the the external transmitter timing option (see Section 2.2), and will turn out the MR lamp and turn OFF the Data Set Ready (CC) circuit on all connectors (i.e., it overrides the Data Set Ready ON in AL mode option, see Section 2.5). When the ST switch on the local data set is depressed and the DL switch on the far-end data set is depressed, a test signal is sent to the far-end and returned to the local data set where it is checked for errors (see TEST 2 in Section 1.6.1). If a bit error occurs in the received signal, the ER lamp on the

local data set will flash momentarily when in this test mode.

- 4) DL (Digital Loopback): This switch is used to connect the Received Data (BB) circuit to the Transmitted Data (BA) circuit and the Receiver Signal Element Timing (DD) circuit to the Transmitter Signal Element Timing External (DA) circuit on each of the four interface connectors. It also connects together the Signal Quality Detector (CG) and Request-to-Send (CA) circuits on connector No. 1 which enables transmission on all the multiplexed data circuits. As a result of these loopback connections, these interface circuits are electrically opened circuited toward the data terminal on those connectors. The DL switch permits the data set to act as a regenerator of received signals to send them back to the far-end. This enables a test to be made of the private line and the near and far-end data sets. Test signals are generated at the far-end data set using either the self test circuitry activated by the ST switch or with external test equipment or the data terminal equipment through any one of the far-end data set interfaces. The test is monitored at the far-end data set. The DL switch also permits a remote loopback test of the local data set to be made with another 209A at a Telephone Company test center. Depressing the DL switch will light the TM lamp, turn out the MR lamp, and turn OFF the Data Set Ready interface circuit on all interface connectors.

#### 1.6.1 Basic Data Set Testing Modes

The AL, ST, and DL test switches permit the following types of tests to be made. Associated with each group of tests is a descriptive figure and a section reference which describes the test procedures in more detail. The tests are referred to in this document as TEST 1 through TEST 6.

##### Self Tests (Fig. 10, Section 5.1.1)

- TEST 1) Analog loopback self test: tests the local data set apart from the data terminal and private line.
- TEST 2) Digital loopback self test: tests both data sets plus both sides of the 4-wire private line channel as one assemblage with test status monitored at only one data set.

- TEST 3) End-to-end self test: tests each data set transmitter and receiver pair plus each side of the 4-wire private line independently; requires test status monitoring at each data set.

Tests Through Data Set Interface (Fig. 11, Section 5.1.2)

- TEST 4) Analog loopback test: uses the data terminal equipment or external test equipment to test with the local data set; requires duplex operation of test equipment or the data terminal.
- TEST 5) Digital loopback test: permits the data terminal equipment or external test equipment to perform TEST 2 by signaling through the interface of the local data set over the 4-wire private line channel and back through the digitally looped far-end data set. This requires simultaneous transmission and reception of data signals by the test equipment or data terminal.

Test From Telephone Company Test Center (Fig. 12, Section 5.1.3)

- TEST 6) Telephone Company remote test: tests the local data set in the digital loopback mode and both sides of the 4-wire private line channel between the data station and the Telephone Company test center.

The first three self tests can be made by the customer's operating personnel without any auxiliary test equipment. TESTS 4 and 5 can be run either with external test equipment or with the data terminal if it is appropriately arranged to make such a test. Procedures for these tests are covered in Section 5 of this document. Status lamp indications for these tests are summarized in Table 1. If trouble is isolated to the data set or private line channel, the customer should call the Telephone Company repair service.

1.7 Status Lamp Indications

Eleven LED status lamps are provided on the front of the data set. These are divided into two vertical groupings. The left grouping (4 lamps) indicates multiplex option status. The right grouping (7 lamps) indicates the status of four interface circuits and three other data set functions. The following is the list of lamp indications giving their abbreviated designations and corresponding

function as they appear on the right side of the data set's front cover. The left column appears as follows:

- 96 - corresponds to 9600 bps operation on connector No. 1
- 72 - corresponds to 7200 bps operation on connector No. 1
- 48 - corresponds to 4800 bps operation on connector No. 1 or on both connectors No. 1 and 2
- 24 - corresponds to 2400 bps operation on some or all connectors

The relation of these lamp indications to the selected multiplex option is shown in the following table:

<u>Lamps</u> <u>Lit</u>	<u>Multiplex</u> <u>Option</u>	<u>Active Connectors</u> <u>and Bit Rates (bps)</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
96	96	9600	*	*	*
72, 24	72/24	7200	2400	*	*
48	48/48	4800	4800	*	*
48, 24	48/24/24	4800	2400	2400	*
24	4-24	2400	2400	2400	2400
None	Test position				

\* = not operational (except as indicated in Section 3.2.2)

The right hand column of lamps is as follows:

- ON - Power Indication
- MR - Data Set Ready (Modem Ready)
- RS - Request to Send
- CS - Clear to Send
- CO - Received Line Signal Detector (Carrier On)
- ER - Equalizer retrain in data mode or error indication in self test mode
- TM - Test Mode

#### ON Lamp

The power indicator lamp (ON) is lit whenever the data set is powered. The ON lamp will go out if there is an over voltage on the power line which trips the power supply circuit breaker, or if the thermal cutout switch in the power supply opens to protect the data set from overheating. The thermal cutout switch is self-resetting, but the circuit breaker is not. If the ON lamp will not light while the data set is plugged in and the power outlet serving the

data set has been checked to verify that power is present, the Telephone Company should be called.

#### MR, RS, CS, CC Lamps

When in the data mode, the MR, RS, CS, and CO lamps light in accordance with the ON condition of the respective interface circuits Data Set Ready (CC), Request-to-Send (CA), Clear-to-Send (CB), and Received Line Signal Detector (CF). These indications are combined for all active connectors so that an ON condition on a given interface circuit of any connector lights the corresponding lamp. See Section 3.3 for a description of the operation of these circuits. Operation of these lamps in the various test modes is covered in Section 5 and is summarized in Table 1.

#### ER Lamp

The ER lamp indicates the mode of the adaptive equalizer when the data set is in the data mode (MR lamp is lit and no test switches are depressed, i.e., TM lamp is out). ER follows the operation of the QM circuit (which appears only on connector No. 1) but in the opposite sense, i.e., ER is lit when QM is OFF and is extinguished when QM is ON. ER is normally lit when the CO lamp is out (i.e., no signal is being received). In each of the four basic configurations given in Section 1.2 continuous carrier operation is recommended. As a result the CO lamp should be lit and ER should be out. However, if switched carrier is used, CO will be out when no carrier is received (i.e., between transmissions) and ER will be lit until the time a startup sequence is received. With continuous carrier operation or during transmission with switched carrier, the ER lamp will light while CO is lit when automatic retraining is taking place in the adaptive equalizer of the local data set. If ER should continuously flash or stay lit when carrier is being received (CO lamp is lit), marginal performance is indicated due to channel impairments, inability to retrain, or some other fault on the channel or in the data set. If this latter condition should arise, it is recommended that the testing procedures discussed in section 5 be employed to isolate the cause of the trouble indication.

The ER lamp will indicate data errors if one of the three self test modes is used (see Section 1.6.1, TESTS 1 to 3). The ER lamp is conditioned to flash momentarily if a bit error is detected in the received data test signal when the ST switch is depressed on the local data set. Flashing of the ER lamp when the data set is in the data mode or when only the AL or DL switch on the local data set is depressed does not indicate errors. In these cases ER

indicates only the state of the adaptive equalizer in the data set as explained above.

### TM Lamp

The TM lamp lights whenever the AL, DL, or ST switches are depressed to indicate that the data set is in a test mode, and when the LP switch is depressed. Selection of the test position of the rotary multiplex selector switch will not light the TM lamp (see Section 2.1).

### Use of Status Lamps for Test Monitoring

Section 5 outlines the test procedures used to isolate problems to the data terminal, data set, or transmission channel. Verification of proper data set operation using the self-contained test circuitry is by means of this right-hand vertical column of status lamps.

#### 1.8 Automatic Retraining Feature

The adaptive equalizer in a 209A receiver is trained by transmission of a special training sequence from the far-end transmitter. When operating either continuous or switched carrier this sequence is sent when power is applied to the data set. When operating switched carrier, the sequence is also transmitted under control of the Request-to-Send (CA) circuits on each connector. When the data set goes from a state where all CA circuits are OFF, the first CA circuit which turns CN initiates the sequence.

During transmission the receiver may require retraining due to interfering phenomena on the channel or when signal interruptions occur due to dropouts exceeding one second with continuous carrier operation or 20 milliseconds with switched carrier operation. If any momentary interference causes equalizer misadjustment, a retraining sequence sent from the far-end data set will correct this problem. If the interference is persistent, several retraining attempts may be necessary to correct the misadjustment. The automatic retraining feature permits the 209A receiver's adaptive equalizer to be automatically retrained when the equalizer has become misadjusted without the data terminal equipment(s) taking any action. The automatic retraining feature causes the Clear-to-Send (CB), Received Line Signal Detector (CF) and Signal Quality Detector (CG) circuits to go OFF on all active connectors of the data set requiring re-equalization. The Equalizer Mode (QM) circuit on connector No. 1 will also go OFF. On the far-end data set only the Clear-to-Send circuit(s) will be forced OFF upon receipt of a signal requesting retraining. An illustrative

diagram showing the interface operation of both data sets during a retraining sequence for one data set is shown in Figure 6.

Although automatic retraining interrupts customer data signals in both directions on all active connectors, the retraining interval is brief and the resulting improvement in error performance will reduce the need for numerous block retransmissions if the adaptive equalizer has become misadjusted.

### 1.9 Location and Mounting of the Data Set

The data set should be located in the vicinity of the data terminal equipment on a nearby desk, table, stand, or for multiple arrangements in Bell System\*provided data set cabinets or equipment racks (23 inch wide equipment racks are required for rack mounting). The customer should consult with the local Telephone Company on available mounting arrangements and specify the mounting arrangement that he requires (desk or rack mounting). At least two inches of space must be left at the rear of the data set in any mounting arrangement to permit circulating air to exhaust from the housing. Care should also be taken not to block the louvers in the front cover.

The customer provided interface cable(s) from the data terminal(s) should not exceed 50 feet in length in accordance with recommendations in EIA Standard RS-232-C. This recommendation is intended to minimize cross-talk coupling among the unbalanced interface circuits and reduce the chance of noise pickup from outside sources. The data set will be installed in a location to permit compliance with this recommendation.

### 1.10 Alternate-Voice Service

A private line channel equipped with a pair of Data Set 209As can be provided with telephone sets for alternate-voice private line service. When this service is ordered, the telephones will be connected to the line through the channel terminating equipment. Alternate-voice is an option of the private line channel and not of the data set. Speech may sound somewhat noisy on some private line channels equipped with high performance data conditioning. This is a result of the special engineering (replacing compandors with VF amplifiers) required on certain carrier systems to improve the nonlinear distortion characteristics.

\*Customer provided cabinets can be used, however, they must provide equivalent environmental (ventilation) characteristics.

## 2. OPTIONAL CUSTOMER FEATURES

Data Set 209A is provided with seven optional features which must be specified when the data set is ordered so they may be permanently installed. There is also a multiplex selector switch under customer control which may be changed as the customer requires. Of the seven customer-specified options all but the elastic store option affect operation of the entire data set. The elastic store option must be specified separately for each connector as is appropriate. A description of each of these options is provided in this section. Figure 3 provides a listing of these options and the choices which can be made.

### 2.1 Multiplex Options

The customer has control of the multiplexer option via a six-position continuous rotary switch located under the front of the data set (see Figure 1). The consecutive ordering of the switch positions is as follows: 1) 9600 bps operation on interface connector No. 1, 2) 7200 bps operation on connector No. 1 and 2400 bps on connector No. 2, 3) 4800 bps operation on connectors No. 1 and 2, 4) 4800 bps operation on connector No. 1 and 2400 bps on No. 2 and 3, 5) 2400 bps operation on each of the four interface connectors (No. 1 to 4), and 6) a switch position used for factory test purposes. The switch position is indicated by a column of status lamps as described in Section 1.7. The switch can be rotated continuously in either direction to arrive at the desired position. The customer may select any one of the five normal positions depending on the multiplexing arrangement of his system. The customer should not select the test position (no numeric lamps will light when the switch is in this position). Basic system configurations to guide in the use of this switch are described in Sections 1.2 and 4.1.1 to 4.1.4.

### 2.2 Transmitter Timing Provided by Data Terminal Equipment

The data set transmitter provides a transmit clock signal on circuit 15 (DB) on those active interface connectors, depending on the multiplex option used. This allows the data terminal equipment to properly transfer the transmitted data at either 9600 bps, 7200 bps, 4800 bps, or 2400 bps. As an option, one of the customer's data terminals can provide an EIA compatible transmit clock signal on circuit 24 (DA) of connector No. 1 to provide transmitter timing for the data set. It has been our experience that most data terminals designed to operate with synchronous data sets use the data set as the timing source (internal timing) rather than provide timing themselves (external timing). If, however, the data terminal provides transmitter timing,

the 209A will provide a transmit clock on circuit 15 (DB) of each active connector which is phase locked to the external clock on circuit 24 (DA) of connector No. 1. The external timing signal from the data terminal on circuit 24 (DA) of connector No. 1 must conform to the distortion accuracy of EIA Standard RS-334, which requires peak individual distortion of no more than 0.5 percent. The frequency accuracy must be within  $\pm 0.0025$  percent of the bit rate which can be 9600, 7200, 4800, or 2400 Hz depending on the multiplex speed chosen for connector No. 1.

If a data terminal on connector No. 2 to 4 provides an external timing signal on its DA circuit, the data set must be optioned with an elastic store on the particular connector(s) so used. The phase of these timing signals need not be locked to the phase of the timing signal provided by the data terminal on circuit DA of connector No. 1. However, the frequency of these clock signals must be locked to that provided on circuit DB of the same connector. The timing signal on the DA circuit of connector No. 2 to 4 is used only for data transfer to the multiplex logic, not for data set transmitter timing. The DA circuit and elastic stores are also used in extension service when interfaced with a lower speed data set (see Section 2.5).

### 2.3 Continuous or Switched Carrier Operation

In each of the four basic system configurations described in Section 1.2, it is recommended that both data sets send a carrier signal all the time to eliminate the need for sending the training sequence every time the data terminal(s) transmit a new data message. The training sequence is required at the beginning of carrier signal reception for detecting carrier and training the adaptive equalizer. An optional feature, called continuous carrier, is available which will keep the transmitter on permanently when the data set is powered. This maintains the adaptive equalizer in the far-end data set receiver in an active mode. When this option is employed, the Request-to-Send circuit of each connector may be used in one of two ways as described in Section 2.4.

The alternative option, switched carrier, causes the data set transmitter to turn on and off under control of the Request-to-Send (CA) circuits. Thus, each time all CA circuits turn OFF, the carrier signal disappears and the far-end data set receiver assumes an idle state. The receiver can be reactivated for further data transmission only by receiving a new training sequence from the near-end transmitter before accepting the customer data message. The training sequence which lasts about 150 milliseconds is not as efficient from a throughput standpoint as is

continuous carrier. The CA-CB delay for switched carrier can vary between 8 and 200 milliseconds depending on when the data terminal(s) turns the CA circuit OFF and ON (see Table 3). With the continuous carrier option, the CA-CB delay can be either 0 or 8 milliseconds depending on the Request-to-Send option chosen (see Section 2.4).

When using the continuous carrier option in any application or if the switched carrier option should be used in a multiplexing application, it should be noted that operation of the Received Line Signal Detector (CF) circuit at the receiving data set will not correspond to the presence of data messages. With continuous carrier the CF circuits of the receiving data set should be ON continuously because carrier is being received continuously. With switched carrier operation in a multiplex application, CF may be ON due to a transmission on any one of the active connectors, i.e., it does not correspond to the presence of data on individual connectors, but rather the presence of valid carrier at the receiver. It is advisable, therefore, for data terminals using the 209A to format separate data messages using control characters at the start and end of messages.

When using the continuous carrier option, disconnection of all interface plugs from the data set will not turn the transmitter off. Neither will a power failure in the data terminal(s), should this occur, causing the interface circuit voltages to go to zero potential. Thus, to a far-end data terminal the near-end data set will appear to be operational with MARK signals being sent. With switched carrier, however, disconnection of the interface connectors or a power failure in the data terminal(s) causes each Request-to-Send Circuit to go OFF, thereby turning the transmitter off.

#### 2.4 Switched or Continuous Request-to-Send Operation

When the continuous carrier option is selected, the Request-to-Send circuit can be optioned in one of two ways. This option is not available when switched carrier is used. With the switched Request-to-Send option, the data terminal on each connector may turn ON the Request-to-Send (CA) circuit and receive an ON condition on the Clear-to-Send (CB) circuit delayed by 8 milliseconds.

If switched Request-to-Send control is not required by the data terminal(s), the Request-to-Send circuit on all connectors can be held ON permanently within the data set, and the Clear-to-Send circuit(s) will be kept ON continuously except during an automatic retrain (see Section 1.8). This type of operation, called continuous Request-to-Send, eliminates the need for a Request-to-Send driver

circuit from the data terminal equipment on each of the connectors.

#### 2.5 Elastic Store Option To Work Through Digital Interface with Another Data Set

An elastic store option is associated separately with each of the four interface connectors. The option must be enabled (put IN) on those connectors of Data Set 209A which interface with lower speed data sets when many point or one-to-many multiplexing extension service is involved. An elastic store must also be enabled if an external timing signal is provided by the data terminal on circuit DA of connector No. 2, 3, or 4. In all other cases the options should be disabled.

An elastic store must be enabled if the customer anticipates alternate use of an extension service and an on-premises data terminal on a given connector. In such a case the on-premises data terminal must provide a transmit clock signal on circuit 24 (DA) of the particular connector which is frequency locked to the signal of circuit DB. This will substitute for the timing signal provided by the extension data set used in the extension service.

The elastic store option for connector No. 1 will disable the external timing option if this option has also been installed. Enabling an elastic store option on a particular connector activates the elastic store buffer on the Transmitted Data circuit of the selected connector so that data signals can be properly transferred from the Received Data (BB) circuit of the other data set to the Transmitted Data (EA) circuit of the 209A. This compensates for any timing phase difference between the transmitter timing of the 209A and the timing signal provided by the receiver of the other data set or data terminal on the DA circuit of the 209A. No buffer storage is required in the lower speed data set.

#### 2.6 Slaved Transmitter Timing by Receiver

The slaved timing option is required in one 209A in many point or one-to-many multiplexing configurations involving extension service on either data set. This option allows the designated slaved 209A transmitter to be timed by its receiver timing based on signals from a far-end 209A which serves as the master timing source for the system. Typical arrangements are shown in Figure 7. The choice of which 209A will serve as the slaved data set is arbitrary except for one consideration explained below.

If the customer anticipates using a data terminal or external test equipment to perform trouble isolation testing from one of the 209As in a many point or one-to-many multiplex configuration with extension service, the 209A serving as the master timing source should be located where the customer's technical operations personnel will perform these tests. This restriction comes about due to the fact that phase instability will occur in the slaved 209A if the master 209A is put in the digital loopback test mode (TEST 5). This will result in invalid test results. However, if the digital loopback self test is used instead (TEST 2), this restriction does not apply since the slaved timing option is disabled when the ST switch is depressed.

With extension service (many point or one-to-many multiplexing), the lower speed data sets connected to both the master and slaved 209A must derive their transmitter timing from their associated 209A, i.e., they must be optioned for external transmitter timing. Lower speed Telephone Company provided data sets are connected to the 209A via a data set interconnecting cord (also called "extension service" cord). The remote Telephone Company provided data set is provided with a data set - business machine multiplexing cord (also called a "timing" cord) on its customer interface connector to connect the DCR circuit to the DA circuit. See a description of these cords in Table 2. These special cords ensure that both lower speed data sets on the extension channel will receive the proper timing frequency and be phase-synchronized to the clock generated by the master 209A. If customer-provided data sets are interconnected with the 209A, the customer must provide an equivalent "extension service" cord to interface his data set with the 209A and a functionally equivalent clock looping arrangement (equivalent to the "timing" cord) on the remote data set.

#### 2.7 Data Set Ready Circuit Option for Analog Loopback Testing by Data Terminals

EIA Standard RS-232-C, which defines operation of the data terminal/data set interface, requires the data set to place the Data Set Ready (CC) circuit in the OFF condition when the data set is in the test mode or other non-data mode. When this occurs the data terminal, by hardware or software design, ignores any signals on all of the other interface circuits. If the 209A is placed in the analog loopback test mode, the CC circuit(s) will normally turn OFF (see Sections 3.3.6 and 5.1.2). Since the analog loopback test is intended to permit the data terminal to verify transmission through the local data set interface connectors, the normal operation of CC will defeat this test feature.

If the data terminal equipment manufacturer provides the hardware and software capability in the terminal to perform an analog loopback test (TEST 4 - see Sections 1.6.1 and 5.1.2) with the local data set and recommends such a test be used to isolate transmission problems with the local data set, the data terminal may require the CC circuit to be held ON during this test. An option is provided in the 209A to permit this condition of Data Set Ready (CC). Although this option is in conflict with the current RS-232-C standard, the analog loopback test is among several fault isolation tests defined in a recently published document by EIA on fault isolation between data sets and data terminals\* (see Section 3.3.2, Local Line Test, in that document). Without specific knowledge of the test capability and requirements of the data terminal, the Data Set Ready circuit in AI mode option should be set OFF (CC will be OFF in the analog loopback test mode). This does not, however, prohibit the use of external test equipment to make an analog loopback test through any of the data set interface connectors.

## 2.8 Grounding

The Protective Ground (AA) circuits on the interface connectors of Data Set 209A are established through the ground wire of the power cord. This also provides grounding of the data set housing and chassis to the local building power ground. It is recommended that the data terminal equipment be tied to the same building power ground as the data set to avoid differences in ground potentials which may affect data performance or damage electronic circuitry. The Signal Ground (AB) circuit on each of the interface connectors is the common reference potential for all the other circuits on the interface. The Protective and Signal Ground circuits are tied together by means of a strap in the data set as provided from the factory. This is intended to provide additional margin to longitudinal power line noise. The strap may, however, be disconnected at the request of the customer with due consideration given to possible noise conditions, ground potential differences, safety conditions, local electrical codes, and data terminal manufacturer recommendations.

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\* "Fault Isolation Methods for Data Communications Systems," Industrial Electronics Bulletin No. 11, November 1972. Available from Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006.

### 3. CUSTOMER INTERFACE

#### 3.1 Interface Connectors and Special Cords

The interface of Data Set 209A consists of four 25 pin (female) connectors numbered 1 to 4 to permit as many as four data terminal devices to be multiplexed through the data set. The choice of multiplex option will determine which interface connectors are used (see Section 2.1). In addition to direct connection to data terminal equipment, other Telephone Company or customer provided data sets may be connected to an appropriate 209A interface connector if the interface extension service is ordered for one or more of the lower speed data streams. The interfaces of other Bell System data sets for this extension service are described in appropriate Technical Reference documents for those sets. Refer to Section 7 for the title and document ordering numbers for Technical References on Data Sets 201C and 208A.

The customer must supply the plug and necessary cable to connect his data terminal equipment to the 209A. A male connector plug such as the DE-19604-432 Plug manufactured by Cannon\* or Cinch† is required on the customer provided cord. This type of plug provides a reliable, low-resistance contact. 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 plug from being pulled out inadvertently.

If lower speed Telephone Company provided data sets are used, they will be interconnected with the 209A using a special "extension service" cord provided by the Telephone Company. The remote Bell System data set will be provided with a special "timing" cord which provides a female connector to interface with data terminal equipment. For interconnection of customer provided data sets with the 209A, an equivalent "extension service" cord, described in Table 2, must be provided by the customer. Also the customer provided data set at the far-end of the extended channel must be configured to loop the receiver timing (DD) signal to the external transmit timing (DA) signal in some fashion while also providing the DD circuit to the

\* ITT-Cannon Electric, Division of IT&T Corp., 3208  
Humboldt St., Los Angeles, California 90031.

† Cinch Manufacturing Co., 1026 S. Homan Avenue, Chicago,  
Illinois 60624.

data terminal equipment. In addition the collocated data set must be optioned for external timing.

### 3.2 Electrical Interface Circuit Considerations

Data Set 209A is equipped to follow the recommendations of Electronic Industries Association Standard RS-232-C with regard to the electrical characteristics of all interface circuits on all of the connectors. In addition, the peak individual distortion and frequency accuracy of the signal element timing circuits on all interface connectors are in conformance with EIA Standard RS-334.

#### 3.2.1 Signal States on Active Connectors

For the Transmitted and Received Data circuits, data signals are considered in the MARK condition when the voltage on the circuit is more negative than -3 volts with respect to Signal Ground, and in the SPACE condition when the voltage on the circuit is more positive than +3 volts with respect to Signal Ground. When no voltage is applied to a Transmitted Data circuit, it will be held to the MARK condition.

For all control circuits, the control function is considered ON when the voltage on the circuit is more positive than +3 volts with respect to Signal Ground, and is considered OFF when the voltage on the circuit is more negative than -3 volts with respect to Signal Ground. These signal states are summarized in the table below.

#### Summary of Data and Control Circuit Interface Terminology

Voltage	Negative	Positive
Binary State	ONE	ZERO
Signal Condition	MARK	SPACE
Control Function	OFF	ON

When no voltage is applied to a Request-to-Send (CA) circuit, it will be held to the OFF state (fail safe).

#### 3.2.2 Signal States on Circuits of Inactive Connectors

When a given connector is not in use by virtue of selecting a multiplexing option which excludes it, the circuits on the inactive connector(s) may or may not appear functional according to the multiplex option chosen. Signal states of circuits on any of these inactive connectors are summarized below.

<u>Mux Option</u>	<u>Inactive Connectors</u>	<u>State of Circuits on Inactive Connectors</u>
96	2,3,4	All circuit drivers held OFF. No terminators respond.
72/24	3,4	CB,CC,CF,CG,DB,DD active; EB=random data; BA ignored; CA responsive.
48/48	3,4	All circuit drivers held OFF. No terminators respond.
48/24/24	4	CB,CC,CF,CG,DB,DD active; EB=random data; BA ignored; CA responsive.
4-24	None	Not Applicable

With the 72/24 and 48/24/24 multiplexing options certain circuits on inactive connectors appear to be functional. Therefore, any data terminal left connected to one of these connectors should be placed in an out of service mode to prevent false operation. If a data terminal on an inactive connector attempts to send data on circuit BA by turning ON circuit CA (CB will respond by turning ON), BA will be ignored and will not interfere with transmission on the active connectors. In addition, a data terminal on an inactive connector will observe random data on its BB circuit when the active connectors are operating. If the data set is optioned for switched carrier, turning ON circuit CA on an inactive connector will turn on the transmitter causing the CG and CF circuits of the far-end data set to go ON and MARK signals to appear on all active Received Data (BB) circuits at the far-end data set.

With the 96 or 48/48 multiplex options, all circuits on inactive connectors will be inoperable. This means no circuits will respond to signals from a data terminal and all driver circuits from the data set will be held in the OFF (MARK) state.

### 3.3 Interface Circuit Operation

Data Set 209A is provided with 15 interface circuits on connector No. 1 for connection to the customer's data terminal equipment and three additional circuits for connection to Telephone Company test equipment. On the other three connectors (No. 2 to 4) 6 of these 18 circuits do not appear, as shown in Figure 5. The Data Set Ready (CC), Received Line Signal Detector (CF), and Signal Quality Detector (CG) circuits on each active connector are operated

in unison. All other data and control interface circuits on separate connectors operate independently. A description of the operation of each circuit and the signals which appear on them follows. Circuit names and the mnemonics are in accordance with EIA Standard RS-232-C, except as noted. Circuit numbers correspond to pin assignments on each of the 25-pin connectors. Circuits which appear only on connector No. 1 are also noted.

### 3.3.1 Protective Ground (AA) - Circuit 1

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

### 3.3.2 Transmitted Data (BA) - Circuit 2

Direction: TO Data Set

Signals on this circuit are generated by the data terminal equipment and are sent to the data set for transmission to remote data terminal equipment. A positive polarity signal is a binary "0" or SPACE, and a negative polarity signal is a binary "1" or MARK.

The data terminal should not transmit data on this circuit unless an ON condition is present on the Clear-to-Send (CB) and Data Set Ready (CC) interface circuits from the data set. When the continuous Request-to-Send option is used, the transmitting data terminal equipment may keep this circuit in the MARK condition (idle code) when no data is to be transmitted.

At the start of transmission with switched carrier or with switched Request-to-Send operation, the first bit should be presented on this circuit coincident with the first positive transition (OFF to ON) of the Transmitter Signal Element Timing (DB) signal after Clear-to-Send turns ON. The data set will sample the signal state on this circuit on the negative transition (CN to OFF) of DB derived either from the data set's internal clock or from the data terminal clock on circuit DA if external timing is used.

### 3.3.3 Received Data (BB) - Circuit 3

Direction: FROM Data Set

Signals on this circuit are generated by the receiving data set in response to data signals received from a remote transmitting data set. The data terminal equipment should sample the Received Data signal on the negative transition of the Receiver Signal Element Timing (DD) signal. A

positive polarity represents a binary "0" or SPACE, and a negative polarity is a binary "1" or MARK.

This circuit is always held in the MARK ("1") condition when the Received Line Signal Detector circuit (CF) is OFF.

### 3.3.4 Request-to-Send (CA) - Circuit 4

Direction: TO Data Set

With continuous carrier operation, which is recommended for all system configurations, the 209A's transmitter is kept on at all times while the data set is powered. Some data terminal(s) may require that the CA circuit be used to control timing functions in the data terminal in which the CB circuit must respond to CA (switched Request-to-Send). When so optioned the data set will provide on each separate connector a delay of approximately 8 milliseconds between the ON condition of CA and the ON condition of CB. Circuit CB will turn OFF when CA is turned OFF. If the data terminal does not require switched Request-to-Send, the customer may specify continuous Request-to-Send when ordering 209A service. When so optioned the Request-to-Send logic will be held in the ON condition within the data set at all times (for all connectors except during automatic retrain sequences) and will not be under the control of the data terminal.

If the switched carrier option is installed, an ON condition on the CA circuit will turn on the data set transmitter and cause the data set to send a training sequence in preparation for transmission of customer data. After turning this circuit ON, the data terminal should wait for an ON condition on the Clear-to-Send (CB) circuit before starting transmission. When the CA circuit is turned OFF at the end of a message, the data set transmitter remains on about another 3 milliseconds (assuming all CA circuits are OFF) to clear the last few data bits from the transmitter. Reoperation of circuit CA to the ON condition on any connector following its being turned OFF or in a multiplex application having one data terminal turn circuit CA ON immediately or shortly after all CA circuits have been OFF, will cause the data set to operate as follows (see Table 3 for a summarized explanation). When any CA circuit is turned ON within about 3 milliseconds after all CA circuits are OFF, the transmitter is kept on and carrier will not be interrupted. As a result, the CF and CG circuits at the far-end data set will stay ON and indicate no signal interruption. The CB circuit on the particular connector involved will come ON after an 8 millisecond delay. When any CA circuit is turned on within about 3 to 50

milliseconds after all CA circuits are OFF, the CB circuit for that connector will be delayed in coming ON by a variable amount of up to 200 milliseconds. Actually, the time between the OFF state of the last CA circuit which was ON and the ON condition of the particular CB circuit is always about 200 milliseconds. The CF and CG circuits of the far-end data set will go OFF momentarily in this case. If any CA circuit is turned ON after at least 50 milliseconds elapses following all CA circuits being turned OFF, an ON condition of the CB circuit of that connector will be given after a delay of about 150 milliseconds.

In summary, when the 209A uses the switched carrier option, a data terminal may encounter CA-CB delays from 8 to 200 milliseconds when multiplexing is used or about 150 to 200 milliseconds when the 96 option is used. In addition, there is no assurance in a multiplexing application that the CF and CG circuits will turn OFF at the far-end data set to indicate the end of a previous message since other connectors may be operating. This factor should be taken into account in those data terminals which monitor the CF or CG circuit to detect an end of message.

Also note that if the switched carrier option is installed, the CA circuit will go OFF within the data set if the connection to the interface connector is broken. With the continuous carrier option (regardless of the Request-to-Send option), the transmitter remains ON (sending steady MARK signals) even though the interface connection is broken.

### 3.3.5 Clear-to-Send (CB) - Circuit 5

Direction: FROM Data Set

This circuit on any interface connector indicates whether or not the data set is ready to accept data on the Transmitted Data (BA) circuit of that connector for transmission to the private line channel. The ON condition of a given the Clear-to-Send circuit means that signals presented on the Transmitted Data (BA) circuit of that particular connector will be transmitted to the channel. The OFF condition of CB is an indication to the data terminal equipment that it should not transfer data on the BA circuit. Circuit CB turns ON in response to an ON condition on the circuit CA and turns OFF when CA is turned OFF.

In continuous carrier operation (which is recommended for all system configurations) with the switched Request-to-Send option installed, the CB circuit of a given active

connector turns CN approximately 8 milliseconds after the CA circuit on the same connector is turned ON. The 8 millisecond delay was selected to conform to other Bell System synchronous data sets. If the data terminal equipment does not require switched Request-to-Send control, the continuous Request-to-Send option should be specified. In this case the CB circuits of all active connectors will be kept ON (except during automatic retraining sequences - see Section 1.8) indicating availability of the data set to transmit data on those connectors.

In switched carrier operation, CB is turned ON in response to an CN condition of the Request-to-Send (CA) circuit on the same connector, delayed by an interval between 8 and 200 milliseconds depending on the activity of the CA circuits on the other interfaces if multiplexing is used or between about 150 and 200 milliseconds if multiplexing is not used (see Section 3.3.4 and Table 3 for a complete explanation of the CA-CB delay). With switched carrier operation, any of the Request-to-Send circuits on active connectors can turn on the data set transmitter to initiate the startup sequence prior to data transfer. If another data terminal on a different connector turns on Request-to-Send before this sequence is complete, it will incur a shorter CA-CB delay because the training sequence is in progress. The delay will always be at least 8 milliseconds.

### 3.3.6 Data Set Ready (CC) - Circuit 6

Direction: FROM Data Set

This circuit on each connector indicates the status of the local data set as far as readiness to initiate data transmission. The signal state of this circuit will be present simultaneously on all active connectors (and certain inactive ones depending on the multiplex option - see Section 3.2.2). The ON condition indicates that the local data set is capable of transmitting and receiving data signals. However, the ON condition of this circuit alone should not be interpreted that the private line channel is available or that the remote 209A is ready to receive or transmit. This circuit should be ON in addition to the Request-to-Send (CA) and Clear-to-Send (CB) circuits when transmitting data on circuit BA of any of the connectors. Circuit CC can be OFF during an analog loopback test (TEST 4) and still permit circuits CA and CB to be used during testing.

The OFF condition of this circuit indicates that the local data set is in a test mode (with the possible exception of the CC circuit ON option for analog loopback testing

- see Section 2.5) or that the channel is in the talk mode (if alternate-voice is used) or the local channel is electrically looped back for testing by the Telephone Company and is unavailable for use by the customer.

### 3.3.7 Signal Ground (AB) - Circuit 7

This circuit establishes the common ground reference potential for all interface circuits on each connector except Protective Ground (AA). This circuit 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 procedures and conditions, this connection to Protective Ground can be removed by the Telephone Company installer (see Section 2.8).

### 3.3.8 Received Line Signal Detector (CF) - Circuit 8

Direction: FROM Data Set

This circuit operates simultaneously on all active connectors when carrier is detected or is lost even though only one connector out of several is receiving data. The circuit indicates the presence of 9600 bps data carrier and not the presence of individual multiplexed data streams. CF will be ON continuously if the associated far-end 209A data set is optioned for continuous carrier (except during automatic retraining intervals or in case of line signal dropouts). It will also be ON if the far-end data set is optioned for switched carrier when at least one data terminal has its CA circuit ON at the far-end data set. Consequently, the presence of data on the Received Data (BB) circuit of all connectors will not be indicated by monitoring the ON condition of CF (except for the 96 option with switched carrier where only one data terminal is involved). Data terminals should instead use appropriate control characters to indicate the beginning and end of a message.

With continuous carrier operation, the CF circuit on all active connectors will go OFF only if data carrier signal is lost due to a dropout of the line signal exceeding one second or other interruption on the channel. There will be a lag of about one second between actual carrier loss and operation of CF to the OFF condition. The carrier loss will initially be indicated when circuit CG goes OFF (see Section 3.3.15). During this one second, the Received Data circuit(s) will not be clamped to MARK. Instead, the Received Data circuit(s) will pass all signals to the data terminal equipment(s) that are demodulated in this one-second interval even though they will not be valid. Also

the DD circuit will continue to provide receiver timing based on the receiver timing memorized from before the dropout.

In switched carrier operation, the ON condition of this circuit appears when valid data carrier signal has been received for 140 milliseconds or more. This circuit is timed to turn ON on all active connectors approximately 127 milliseconds after the Signal Quality Detector (CG) circuit turns ON. The Received Data circuit (BB) on the particular connector in use will provide data immediately after CF goes ON. Normal levels of message circuit noise, impulse noise, and out-of-band signals as prescribed for private line channels\* will not falsely turn ON this circuit.

With switched carrier operation, the CF circuit will go OFF simultaneously on all active connectors at the same time that the CG circuits go OFF. This occurs when the line signal disappears for more than 20 milliseconds due to the end of transmission from the last working data terminal or due to a transmission line dropout if one should occur during data transfer. The OFF condition of CF causes the Received Data (BB) circuit of each active connector to be clamped to the MARK condition. It also causes the Receiver Signal Element Timing (DD) signal to be replaced by the Transmitter Signal Element Timing (DB) signal and, on connector No. 1 the DCT signal replaces the DCR signal.

Also to be considered when either continuous or switched carrier operation is used is that if the an automatic retraining sequence occurs in the receiving 209A, CF will be turned OFF on all connectors of that 209A for a period of at least 200 milliseconds until retraining has been completed (see Figure 6). During this interval circuit BB is held to MARK, the timing signal on DB replaces the DD signal on each active connector, and the signal on DCT replaces the regular DCR signal on connector No. 1.

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\* See Technical Reference "Data Communications Using Voiceband Private Line Channels" - October, 1973, PUB 41004.

### 3.3.9 Circuits 9 and 10 (Connector No. 1 only)

These circuits which appear only on connector No. 1 are used for the purpose of testing by Telephone Company personnel. The data terminal must not connect to them.

### 3.3.10 Equalizer Mode (QM, non-EIA) - Circuit 11 (Connector No. 1 only)

Direction: FROM Data Set

This circuit, appearing only on connector No. 1, is used to indicate to the data terminal equipment on that connector whether or not the adaptive equalizer in the receiver is in need of retraining. QM is normally ON when the equalizer is properly adjusted. When operating in the continuous carrier mode QM will go OFF if retraining is required, and when operating in the switched carrier mode QM will go OFF if no carrier signal is received for 20 milliseconds. If both 209As are operated continuous carrier, QM may go OFF, indicating that the adaptive equalizer has requested an automatic retrain sequence (see Figure 6) from the far-end transmitter. QM in this case will stay OFF for at least 240 milliseconds. All Received Data (BB) circuits are held to MARK for at least 200 milliseconds while circuit CF is OFF during the retraining sequence. The only way that data terminals on connector No. 2 to 4 will know the retraining sequence is occurring is when the CF and CG circuits go OFF in the middle of a message. If QM is ON, the equalizer is in a trained adaptive mode and data reception will occur since circuit CF will also be ON.

If switched carrier operation is used in both 209As, the QM circuit will turn ON at the receiving data set when the startup training sequence has been completed and will stay ON during the reception of data carrier line signal. QM will turn OFF at the end of a message after all the far-end data terminals turn their CA circuits OFF and line signal disappears. If QM should go OFF during data transfer, this indicates that the automatic retraining sequence has been invoked or that a line dropout has occurred.

### 3.3.11 Transmitter Signal Element Timing (DB) - Circuit 15

Direction: FROM Data Set

For internally timed data sets, square-wave signals on this circuit of specific connectors at a nominal 9600, 7200, 4800, or 2400 Hz rate (depending on multiplex option selected) are used to provide the data terminal equipment with signal element timing information for the associated

Transmitted Data (BA) circuit. The clock frequencies available on each connector, depending on the selected multiplex option, are shown in the table in Section 1.7. A clock signal will be present on the DB circuit of each connector in use at all times when power is ON in the data set. When starting data transfer, the first signal element of the Transmitted Data (BA) signal should be presented by the data terminal equipment on the first positive (OFF to ON) transition of the clock signal DB which occurs after the ON condition of the Clear-to-Send (CB) signal. BA is sampled by the data set on negative transitions of DB.

When the 209A is timed externally by data terminal equipment on connector No. 1 (see Section 2.2), circuit DB on all connectors will provide a timing signal at the appropriate frequency which is phase-locked to the signal on the Transmitter Signal Element Timing External (DA) circuit of connector No. 1. Timing provided on the DA circuit of connector No. 1 by the data terminal controls the timing of the 209A transmitter in this manner only when the external timing option is installed and the elastic store associated with connector No. 1 is not installed. When the elastic store associated with connector No. 1 is installed, the data set automatically uses internal timing.

When data terminals provide external clocks on circuit DA of connectors No. 2 to 4, those signals must be frequency locked to the DB signal on those connectors. However, they need not be phase locked to the DB signal.

### 3.3.12 Divided Clock Transmitter (DCT, non-EIA) - Circuit 16 (Connector No. 1 only)

Direction: FROM Data Set

This circuit, appearing only on connector No. 1, provides a square-wave signal at 2400 Hz whenever power is on in the data set regardless of the multiplexing speed option selected. This circuit must be used in one-to-many multiplexing applications by the master data terminal to properly synchronize the 4-bit pattern of multiplexed data signals on circuit BA of connector No. 1 operating at 9600 bps. The 4-bit time division multiplexed data pattern consists of the separate data streams sent to the remote 209A which interfaces with the remote data terminals. The relationship of this timing signal (DCT) to the Transmitter Signal Element Timing (DB) signal on circuit 15 of connector No. 1 is shown in Figures 8(a) to 8(d). These figures also illustrate the bit pattern relationship at both data sets with each of the four multiplex options.

### 3.3.13 Receiver Signal Element Timing (DD) - Circuit 17

Direction: FROM Data Set

The square-wave signal on this circuit of a given connector appears at one of the nominal clock rates (9600, 7200, 4800, or 2400 Hz) depending on the selected multiplexing option. It is used to provide the data terminal equipment on that connector with receiver timing information for the associated Received Data (BB) circuit. For each active connector, the signal transition from ON to OFF on this circuit nominally indicates the center of each signal element on the BB circuit of that connector for sampling the received data.

The DD signal is always provided. It is derived from the received signal when the Received Line Signal Detector (CF) circuit is ON. When CF is OFF the signal on circuit DD is replaced by that on circuit DB. This may occur during signal dropouts or between transmissions if switched carrier is used. Thus, a timing waveform will appear on circuit DD as long as the data set is powered and the data set is not in digital loopback test mode.

### 3.3.14 Divided Clock Receiver (DCR, non-EIA) Circuit 18 (Connector No. 1 only)

Direction: FROM Data Set

This circuit, appearing only on connector No. 1, provides a square-wave signal at 2400 Hz for multiplexer timing information used to synchronize the received time division multiplexed 9600 bps data on the Received Data (BB) circuit of connector No. 1 in one-to-many multiplexing applications. This signal is provided when circuit CF is ON. When circuit CF is OFF, this signal is identical to that on circuit DCT. Figures 8(a) to 8(d) show the relationship of the bit timing signal on this circuit to the timing signal on circuit DD of connector No. 1 for demultiplexing data on circuit BE of connector No. 1.

### 3.3.15 Signal Quality Detector (CG) - Circuit 21

Direction: FROM Data Set

This circuit is used to give a carrier present/absent indication similar to that on the Received Line Signal Detector (CF) circuit but faster responding. Circuit CG will go ON simultaneously on each active connector approximately 20 milliseconds after data carrier signal is received by the data set. The CG circuit(s) will go OFF on all active connectors if there is a loss of data carrier signal for 20 milliseconds or longer. After Signal

Quality Detector goes ON, there is a delay of about 127 milliseconds until all CF circuits go ON on each connector in use, indicating that the Received Data (BB) signal can be monitored. Circuit CG will stay ON continuously (except during automatic retraining sequences or due to a line signal dropout greater than 20 milliseconds) on all active connectors when the far-end data set is operated with continuous carrier. Data terminals on connector No. 2 to 4 have no CM circuit to indicate when a retraining sequence occurs. Therefore, they could monitor either circuit CF or CG to determine when retraining occurs (ie, when these circuits go OFF). In switched carrier operation, the CG circuit(s) normally goes OFF at the end of data messages when all data terminals at the far-end transmitter turn their CA circuits OFF.

### 3.3.16 Transmitter Signal Element Timing External (DA) -- Circuit 24

Direction: TO Data Set

This circuit is used to provide transmitter timing on connector No. 1 when the external timing option is selected. It is also used on any of the connectors (No. 1 to 4) when the elastic store for the particular connector is enabled to permit operation with another data set in many point and one-to-many multiplexing extension service configurations. Additionally, it is used when the data terminal provides a transmit clock on any connector in any system configuration if the customer's data terminal is so equipped. The ON to OFF transition of signals on this circuit provided by the data terminal should nominally indicate the center of each signal element on the Transmitted Data (BA) circuit of the same connector.

When the external timing option is installed (see Section 2.2), the data terminal on connector No. 1 must provide a timing signal on the DA circuit of connector No. 1 at 9600, 7200, 4800, or 2400 Hz as appropriate with a frequency accuracy of  $\pm .0025$  percent, and a peak individual distortion on negative transitions of no greater than 0.5 percent per EIA Standard RS-334. The Transmitter Signal Element Timing (DB) circuits on each connector will be phase-locked to this DA signal, as will the Divided Clock Transmitter (DCT) signal. Signals should be available on the DA circuit of connector No. 1 at all times when external timing is used except when the data set is not in service.

When the elastic store option is enabled on any of the connectors for operation with another data set or for data terminals to provide an external clock on DA, the frequency of the signal provided on circuit DA must be locked to the

timing signal on circuit DB of the same connector although the phase may be arbitrary.

Clock signals provided by a data terminal on the DA circuit of connectors No. 2 to 4 are used to clock data into the elastic store buffer associated with the connector and do not affect the timing of the data set. When the elastic store for connector No. 1 is enabled to connect to another data set, the external timing option is automatically disabled in the 209A (i.e., internal timing is used) and the DA circuit serves only to clock data into the elastic store buffer.

### 3.3.17 Circuit 25 (non-EIA) (Connector No. 1 only)

This circuit, appearing only on connector No. 1, is used for testing purposes by Telephone Company personnel. The data terminal equipment must not connect to it.

## 4. OPERATION WITH DATA TERMINAL EQUIPMENT

### 4.1 System Configurations of Data Set 209A

The basic configurations of the 209A, presented in Section 1.2, are described below. The customer should determine from these configurations how his system will be arranged and indicate this to the Telephone Company when the service is ordered. Data set options for the 209A and other Bell System data sets (when extension service is used) are presented in Figures 4(a) to 4(d). Care should be observed in distinguishing required options from recommended options in these figures. The customer must specify those options indicated as required, but need not specify the other options which are only recommended if data terminal compatibility is affected.

#### 4.1.1 Point-to-Point 9600 bps Service (Fig. 4(a))

In this configuration data is exchanged between two data terminals capable of a 9600 bps data transfer rate. It is recommended that both 209A data sets operate with continuous carrier. This option permits a short CA-CB delay (8 milliseconds or no delay depending on the Request-to-Send option selected). In addition, both data set receivers will hold the CF and CG circuits ON continuously since a line signal is sent continuously.

If a polling type line protocol is used by the data terminal (this is not to be confused with a multipoint polling channel) which requires circuit CF to go ON and OFF in response to the presence and absence of data messages,

then one or both 209A data sets should be optioned for switched carrier. The CA-CB delay will be about 150 milliseconds in this case. Other data set options are given in Figure 4(a).

#### 4.1.2 Point-to-Point Multiplexing Service (Fig. 4(b))

In this arrangement Data Set 209A provides any one of four time division multiplexing combinations: a) one 7200 bps and one 2400 bps data channel, b) two 4800 bps data channels, c) one 4800 bps and two 2400 bps data channels, or d) four 2400 bps data channels. The data terminals must be located within 50 feet of the data set at each end of the channel. The multiplex selector switch on the 209As may be set in any position according to the data rates of the connected data terminals. The selector switch can be changed on both data sets to reconfigure multiplexing operation as desired assuming the data terminals can adapt to different data rates or the arrangement involves reconfiguration of several data terminals with different fixed data rates.

As long as both 209As are optioned for continuous carrier operation, the separate data terminals may transmit on each active connector without timing variability in CA-CB delays due to operation on other connectors. Timing variability will occur with switched carrier operation as described in Section 2.3 and Table 3. In addition, with switched carrier the CF circuit operates simultaneously on each active connector. Consequently, even if CF goes ON it may not indicate that data is available on the Received Data (BB) circuit if the indication is due to transmission on another interface. As noted earlier continuous carrier operation causes the CF circuit of each active connector to stay ON at all times since carrier will be present on the channel continuously. Therefore the data terminals must be able to note the beginning and end of transmission within the line protocol. This will assure that the data terminal recognizes the presence of data messages without regard to an indication on the CF circuit which could be erroneous as discussed above. Other data set options for this application are given in Figure 4(b). These are generally the same as for point-to-point 9600 bps service except for the multiplexing option.

#### 4.1.3 Many Point Multiplexing Service (Fig. 4(c))

Many point multiplexing service is exactly like point-to-point multiplexing service except that one or more data terminals are farther from the 209A than approximately 50

feet. The remotely located data terminals are connected to the 209A via a pair of lower speed data sets on a private line extension channel. Extension channels may be used on as many of the connectors of either 209A as needed. The Telephone Company will provide data sets operating at 2400 and 4800 bps for these extension channels (both of which must be ordered separately). Extension service at 7200 bps is generally uneconomical compared to collocating the 209A with the 7200 bps data terminal.

Extension channels may be either point-to-point or multipoint private line channels. Point-to-point extension channels may be used on one or both 209As on corresponding connectors. This will create either a two or three link configuration. Multipoint extension channels can only be provided on those connectors of a 209A which provide extension service to polled stations of a multipoint layout. The corresponding connector of the other 209A serving the central polling data terminal can have either no extension channel or a point-to-point extension channel. The reason for this restriction is the use of split bridges in multipoint polled systems which do not allow polled stations to communicate with each other. As shown in Figure 4(c), if a central terminal were on the multipoint circuit in place of one of the polled stations, it could not transmit to the other polled stations on that multipoint.

In arranging a many point multiplexing system, one 209A is arranged as a master timing source for the entire system, as illustrated in Figure 7. The timing of the other 209A and of the data sets on the extension channels are slaved to the master 209A. The choice of which 209A is to have the slaved timing option in this arrangement is basically arbitrary although there is a restriction on the use of TEST 5 when a data set has the slaved option (see discussion in Sections 2.6 and 5.2.3).

Lower speed Bell System data sets will be connected to the 209As through a Telephone Company provided "extension service" cord which transfers appropriate control, timing, and data circuits between the 209A and the other data set and causes the lower speed data set transmitter to be timed by the master 209A. On the remote lower speed Bell System data set which interfaces with the remotely located data terminal, a "timing" cord will be provided. This cord connects the Divided Clock Receiver (DCR) circuit to the

Transmitter Signal Element Timing External (DA) circuit.\*  
A many point multiplexing configuration using all Bell  
System data sets and channels will be maintained and tested  
as a system by the Telephone Company.

The customer must specify on which connectors of the 209A  
the elastic store will be installed for use by the  
collocated extension service data set. When installed the  
elastic store buffer permits the transfer of data from the  
Received Data circuit of the lower speed data set to the  
Transmitted Data circuit of the appropriate 209A connector.  
Customer options for Bell System Data Set 208A (4800 bps)  
and Data Set 201C (2400 bps) are given in Figure 4(c).

Customer provided data sets equivalent to Data Sets 208A  
or 201C can be utilized at the discretion of the customer  
on any extension channel. The Bell System's responsibility  
for maintenance and testing of this assembly involving  
customer-provided data sets terminates at the interface  
connector of the 209A. The customer must also provide an  
equivalent "extension service" cord in this case (see Table  
2). For the remote customer provided data set(s) a  
capability of looping receiver to transmitter timing must  
be provided. This should be functionally equivalent to  
that of Bell System data sets which use the "timing" cord.  
If the customer-provided data set loops the receiver timing  
(DD) signal to the external transmitter timing (DA) signal,  
it should be noted that the DD circuit must also be provided  
to the data terminal with an appropriate EIA compatible  
driver.

#### 4.1.4 One-to-Many Multiplexing Service (Fig. 4(d))

As noted in Section 1.2, a one-to-many multiplexing  
configuration is similar to point-to-point or many point  
multiplexing arrangements except that the data terminal  
at one 209A location provides the equivalent multiplexing  
function in place of the 209A. This data terminal must  
operate at 9600 bps on connector No. 1 of the 209A. The  
9600 bps data stream is sent to the far-end 209A which  
demultiplexes it into two or more lower speed data channels  
for separate data terminals. Extension service can also  
be used from the far-end 209A if the data terminals are  
remotely located. An example is shown in Figure 4(d).

\* With the "timing" cord the data terminal does not have  
access to either the DCR or DA circuits of the 208A or  
201C data set that is used. Access is provided to the  
DD circuit for receiver timing and the DB circuit for  
transmitter timing.

In order for the multiplexing data terminal to properly synchronize the 4-bit data patterns in the 9600 bps bit stream, framing signals are provided on the DCT and DCR circuits on connector No. 1 for the transmitted and received multiplexed data, respectively. The relationship of DCT and DCR to the 4-bit multiplexed data pattern of the lower speed data channels on the far-end data set is shown in Figures 8(a) to 8(d) for each of the four possible multiplex speed options. As seen in Figures 8(a) and 8(c), the multiplexed bit ordering at the 9600 bps 209A when the 72/24 and 48/24/24 multiplex options are used in the far-end 209A is not simple compared to the 48/48 and 4-24 options. Consequently, these options are not recommended for use in this configuration. Customer options for data sets in a one-to-many multiplexing configuration with or without extension data sets are shown in Figure 4(d). As with many point multiplexing if customer-provided data sets are used in place of Data Sets 208A or 201C, the Telephone Company is responsible for maintenance and testing of the assembly no farther than the 209A interface.

#### 4.2 Half-Duplex or Duplex Data Terminal Operation

Data Set 209A can be operated half-duplex or duplex by any data terminal directly connected to any of the four interfaces or connected via an extension channel. The line control protocol of any data terminal should not be restricted by the 209A or Bell System extension data sets.

For illustrative purposes Figure 9 depicts the operation of the interface control circuits of corresponding connectors of two 209A data sets involved in half-duplex operation. Duplex operation would be similar to this except that transmission would occur simultaneously in both directions.

When one of the four multiplex options is selected, the 209A will accept separate data streams on certain connectors. To assure essentially independent operation on each connector, it is recommended that continuous carrier rather than switched carrier be used in multiplexing configurations.

#### 5. TESTING

As indicated in Section 1.6, Data Set 209A has a built-in self test capability which can readily be used by customer personnel to isolate transmission problems to either the data set, transmission facilities or data terminal equipment. The use of the test switches and circuit status lamps on the 209A is described in this section. Section 5.1 is devoted to testing procedures for configurations

without extension channels. Section 5.2 is devoted to testing procedures for configurations with extension channels. Under Section 5.1 are three subsections: Section 5.1.1 deals with procedures for using self test circuitry of the 209As; Section 5.1.2 indicates how similar tests can be made using the data terminal or external test equipment to generate and check a test word sent through the 209A; and Section 5.1.3 indicates the type of remote test that a Telephone Company Test Center will use if it is attempting to clear a problem on the 209A link. Table 1 provides a summary of the lamp indications and switch positions on the 209A for all of the tests in Section 5.1.

It should be noted that the use of any of the test switches on the 209A (except LP) for any of the tests in this section will affect all data set interfaces and will interrupt normal operation of the data set.

## 5.1 Testing Single Link 209A Services

### 5.1.1 Data Set Self Test Procedures

TESTS 1, 2 and 3 described below are three self tests which can be conducted by customer personnel to isolate a transmission problem to the data set, transmission facilities, or data terminal equipment. The testing arrangements for these tests are depicted in Figures 10(a), (b) and (c), respectively. TEST 1 provides a quick test of each data set independent of the customer's data terminal and the channel. TESTS 2 and 3 involve testing of the transmission facilities and both the remote and local data sets in a looped or an end-to-end test arrangement. If TEST 2 or 3 should indicate a failure to reliably transmit and receive data, then the data sets or transmission facilities are suspect.

Initially the status lamps on the suspect data set(s) should be checked by holding the LP switch depressed to see that all lamps are working. Once it is confirmed that all lamps are working, the LP switch can be released. If the ON lamp should go off at any time, refer to Section 1.7 for information about possible causes.

The data terminal equipment associated with the data set under test should be placed in an idle mode so that data transmission is not interrupted during the following tests. Operations personnel conducting these tests should also note that any flashes occurring on the ER lamp at the time the test switches are operated should be ignored since they may be the result of transient behavior in transferring to the self test mode.

TEST 1 - Analog Loopback Self Test

- Step 1 - Depress the AL switch. The TM lamp should light.
- Step 2 - Depress the ST switch to place the data set in self test mode.
- Step 3 - At this point the MR and ER lamps should be off and all other lamps should be on.
- Step 4 - If the ER lamp flashes one or more times or remains lit or if any of the other lamps do not agree with the conditions in Step 3, the data set is defective. The lamps should be observed for at least 30 seconds to be confident that the data set is or is not working.
- Step 5 - To return the data set to normal operation, release the ST and AL switches.

TEST 2 - Digital Loopback Self Test

Either TEST 5 or TEST 6, described below in sections 5.1.2 and 5.1.3, respectively, provides a more complete test than TEST 2 for many point multiplexing arrangements since the self test circuitry in the 209A does not check the interface circuits, the phase synchronization, the elastic stores, or the timing synchronization as is done in TEST 5 or 6. TEST 2 should however be sufficient to detect most serious faults in the data sets or on the channel. When using TEST 2 as described below, it does not matter at which data set the signal is looped (i.e., it does not matter which is the remote or local data set as designated below).

- Step 1 - After assuring that the AL and ST switches are released, depress the DL switch on the remote data set. The TM lamp should light on that data set.
- Step 2 - Depress the ST switch on the local data set to place it in the self test mode. The TM lamp should light on the local data set. The test is controlled from this data set.
- Step 3 - At this point the MR and ER lamps on the local data set should be out and the remaining lamps should be lit. On the remote data set, the lamps should be in the same states except it should be noted that the ER lamp indicates equalizer retrain

periods and not errors. Lamp indications other than these denote data set malfunction or transmission problems on the channel.

Step 4 - At the local data set the ER lamp will flash if errors occur. Five one minute observations should be made. If the number of flashes of ER over these 5 minutes exceeds 30, the error performance objective is not being met by the data sets and the channel.

Step 5 - To return to normal operation, release the ST switch on the local data set and the DL switch on the remote data set.

The results of TEST 2 combined with those of TEST 1 made on both data sets should be sufficient to isolate a trouble to the transmission facilities or to one of the data sets. TEST 3 allows further isolation of the trouble to the receive or transmit side of the private line. Problems with telephone equipment or facilities should be reported to the local Telephone Company. The Telephone Company Test Center may decide to check the telephone facilities and perform a Remote Test of the data set as described in Section 5.1.3.

### TEST 3 - End-to-End Self Test

Step 1 - With an attendant at each station, manually establish a voice link between stations by means of a separate voice channel. If alternate voice service is provided, the private line to be tested can serve as the initial voice link as long as no voice communication is desired during the test interval.

Step 2 - Have the attendants agree on when to start the test and when to end it.

Step 3 - Depress the ST switch on both data sets. Note that the data set whose ST switch is depressed first may show error indications until the ST switch on the other set is depressed.

Step 4 - After a few seconds have the attendant at each data set check that the MR and ER lamps are out and that the rest of of the lamps are lit. Lamp indications other than these denote data set malfunction or transmission problems on the channel.

Step 5 - The ER lamp at each data set will flash if errors occur in this self test mode. Five one minute observations should be made. If the number of flashes of ER over these 5 minutes exceeds 6 per minute on the average, then the receiver, the receive half of the private line, or the transmitter of the other data set is not providing an error rate better than the objective.

Step 6 - To return the data sets to normal operation, release the ST switch on each data set to release them from the self test mode.

#### 5.1.2 Test Procedures Using the Data Terminal or External Test Equipment

In addition to the self test capability of Data Set 209A, it is possible to test the data terminal and the data set together in an analog loopback mode similar to TEST 1 on any active connector, or to have the data terminal test both data sets and the transmission facilities together in a digital loopback mode similar to TEST 2 above. Testing with external test equipment is also possible through any active connector of the 209A. As mentioned in Section 2.7, if the data terminal manufacturer provides the hardware and software capability to allow for simultaneous transmission and reception in an analog loopback test through the data set interface and the data terminal requires the Data Set Ready (CC) circuit to be ON, the CC lead should be optioned at initial installation of the 209A for the ON condition when the AL switch is depressed. Then TEST 4, depicted in Figure 11(a), can be made through any or all active connectors. TEST 5 does not require special optioning of the CC circuit in the data set from which the data terminal will run the digital loopback test. TEST 5 is depicted in Figure 11(b).

#### TEST 4 - Analog Loopback Test Using the Data Terminal

Step 1 - Depress the AL switch. The TM lamp should light.

Step 2 - Condition the data terminal to simultaneously transmit and receive from the local data set through any connector (depending on multiplex option). A delay of about 13 milliseconds occurs between signals on the Transmitted Data circuit and the Received Data circuit of any connector because of propagation delays in the data set circuitry. A steady MARK or SPACE signal is sufficient for a test signal since the data set has a built-in scrambler circuit to randomize the

data before modulation. If errors should occur, either the data set or data terminal may be in trouble. To isolate the problem, an analog loopback self test (TEST 1) should be made (if not already done) to check the data set by itself.

Step 3 - To return the data set to normal operation, release the AI switch.

#### TEST 5 - Digital Loopback Test Using the Data Terminal or Test Equipment

If one of the data sets is using the 72/24 or 48/24/24 multiplexing option, or if one or more elastic stores are being used on either 209A, then the far-end data set must be placed in the same multiplexing mode as the local data set for this test.

Step 1 - After ensuring that the AL and ST switches are released, depress the DL switch at the remote data set. The TM lamp should light. The MR lamp should be out.

Step 2 - Condition the data terminal to simultaneously transmit and receive a test signal through any connector of the local data set in the manner described in Step 2 of TEST 4 above. If the average block error rate over the test period is greater than 1 block error per 100 blocks for block lengths of 1000 bits, either the data terminal, the transmission facilities, or one of the data sets may be in trouble. Longer or shorter block lengths will result in a proportionally higher or lower block error rate, respectively. Further isolation can be accomplished by performing TEST 1, TEST 2, or TEST 3 as described previously.

Step 3 - To return to normal operation, release the DL switch on the remote data set.

The above two tests can also be performed by connecting suitable test equipment in place of the data terminal to the appropriate connectors of the 209A (depending on the multiplex option selected). The same procedures apply when using test equipment.

#### 5.1.3 Telephone Company Remote Test Procedures

For the Telephone Company to isolate problems on a 209A link, a digital loopback test of both 209As can be made from the Telephone Company Test Center (if available) with

the assistance of customer personnel at the data set location. The Telephone Company Repair Service should be notified of any problems which have been isolated to the data set or private line channel. When the Test Center calls in response to a trouble report, the customer's operations personnel may be requested to assist with the test features of the data set. They may also ask these personnel to make self tests of the data set. The digital loopback remote test arrangement is depicted in Figure 12.

#### TEST 6 - Digital Loopback Remote Test

Before initiating this test the data terminal should be placed in an idle mode. When instructed by the Test Center personnel, the DL switch should be depressed on the data set. The TM lamp should light and the MR lamp should be out. All other switches should be in their normal out position.

The Test Center will make a series of programmed transmissions with the local data set. After completing these test transmissions, the Test Center will call the customer location and ask that the data set be removed from the test mode by releasing the DL switch. Results of the test and any further action by the Telephone Company will be indicated by Test Center personnel.

#### 5.2 Testing of Multiplex Extension Services

This section covers aspects of testing of extension service configurations by customer personnel. For the customer's personnel to proceed with any fault location testing of a many point or one-to-many multiplexing system with extension channels, it should first be determined among the individual locations on the system whether the trouble is occurring in a few or in all of the channels. If only part of the system is affected, say on one set of extension channels, then only that portion of the system need be tested using self test circuitry available in Bell System data sets (except for 208A-I1, as indicated in section 5.2.2). The avoidance of placing the 209As in a test mode will permit the working extension channels to operate normally while testing the other extension channels separately. If, however, the trouble is common to all extension channels and all data terminal equipments connected to the system are affected, the entire system must be taken out of service and tests of the 209As should be made per the procedures in Section 5.1.1. Tests should also be made on the individual extension channels to verify their proper operation.

Consider for illustrative purposes the testing of the system in Figure 13. This figure depicts a many point multiplexing system with extension channels from both 209As. The case of a one-to-many multiplexing extension channel system or a many point system with extension channels on only one 209A would be similar to the layout in Figure 13 except that the extension channels on one 209A would be replaced by one or more collocated data terminals. For the many point multiplexing system in Figure 13, assume that a problem is noted at data terminal #1 (CPE#1) which is communicating with data terminal #2 (CPE#2). If the customer can ascertain that CPE#3 and CPE#4 are operating properly, then it can be assumed that the 209A link is operating properly. The customer at Location 1 (CPE#1) or Location 4 (CPE#2) can undertake testing on the DS1 to DS2 and DS5 to DS6 extension channel links with assistance from other personnel at locations 2, 3, and 4. A process for systematically testing a system and determining which link is in trouble is shown in Figure 14. Test procedures for the indicated loop tests are covered in this document and in other data set Technical References listed in Section 7. Table 4 outlines the appropriate testing criteria for use in each case.

When using the self test feature on Bell System data sets, some way of introducing errors into the looped signal is desirable to assure circuit continuity on extension channel systems. This can be accomplished with LOOP 4 and LOOP 6 by momentarily depressing and releasing the AL switch on the digitally looped data set and monitoring the ER lamp of the local data set for an indication of errors during that interval. With LOOPS 5 and 7 this can be accomplished by momentarily releasing and depressing the AL switch on the appropriate data set. If no errors are indicated when the test signal is interrupted at the far data set, one or more of the transmission links over which the test is conducted are definitely open. If the customer determines by using the loop test prescribed in Figure 14 that error performance is unsatisfactory on a particular extension channel or on the 209A link which is not attributable to the data terminal equipments, the Telephone Company repair service should be notified. They should be told of the suspected channels and data sets involved. The Telephone Company may ask for assistance with the data set and channel tests by depressing certain test switches on the data sets in the system.

#### 5.2.1 Loop Tests Not Permitted

Several loop tests, shown in Figure 13, are not permissible. These include LOOPS 8, 9, 10, and 11. In addition, analog

loopback tests of data sets DS1, DS6, DS7, and DS10 are not permissible. Reasons for these restrictions are discussed below.

LOOPS 8 and 9 are not permissible because a digital or analog loopback, respectively, of all extension data sets attached to the right hand 209A in Figure 13 would be necessary to produce valid results. Instead, LOOPS 6 and 7 should be used since they can be applied from individual remote extension data sets (DS1, DS6, DS7, or DS10) on either 209A to test each extension service separately.

With LOOPS 10 and 11 and the analog loopback tests on DS1, DS6, DS7, and DS10, the restriction applies because the remote data sets (DS1, DS6, DS7, and DS10) use the "timing" cord which loops receiver timing circuit DCR to circuit DA (external transmitter timing). Thus, if DS2, DS5, DS8, or DS9 are digitally looped as per LOOP 10 or 11, this would loop timing signals from the respective data sets DS1, DS6, DS7, or DS10 back to themselves. This creates an unbroken timing loop for each pair of data sets (DS1 to DS2, DS7 to DS8, DS5 to DS6, and DS9 to DS10) and results in phase instability of the sampling clock of the data set placed in self test mode. As a result error indications will occur as the data sets lose phase integrity when in fact the data sets and channel may be working satisfactorily. The same problem occurs with analog loopback tests (self test or otherwise) of data sets DS1, DS6, DS7 and DS10. For this reason these tests should not be made.

#### 5.2.2 Availability of Self Test Capabilities in Data Set 208A

The system tests described in Section 5.2 have assumed that self test circuitry is available in each Bell System data set in the system. Self test circuitry is available in the later version of Data Set 208A (208A-L1A) as well as in Data Set 201C. However, this is not true with Data Set 208A-L1 which may be provided when a 4800 bps extension channel is ordered. Consequently, certain loop tests cannot be made such as LOCP 1 and 2. However, at the remote extension data sets (DS1, DS6, DS7, and DS10) external test equipment may be attached to the outlier cord of the 208A-L1. This will enable the customer to perform LOOPS 4, 5, 6, and 7. Such test equipment should be able to generate a test pattern and check for block errors in the returned received data signal. Criteria for acceptable data performance is given in Table 4.

### 5.2.3 Restriction on the Use of TEST 5

When a many point or one-to-many multiplexing configuration is used which involves extension channels, one 209A is required to be optioned for slaved timing. This leads to a restriction on the use of TEST 5 from that data set. If the master 209A were digitally looped per TEST 5 in Section 5.1.2, this would establish an unbroken timing loop involving both the slaved and master 209A. This results in phase instability in the slaved 209A which will cause errors to occur in the Received Data (BB) signal which are not due to channel impairments or data set malfunction. No restriction applies when using TEST 1, 2, 3 or 4 in extension configurations because the ST switch and the AL switch disable the slaved timing option if it is installed in the 209A.

## 6. PERFORMANCE

The performance of Data Set 209A is specified in terms of block error performance because this measure is more meaningful than the conventional bit error rate specification for most users. Many data communications systems send data in a blocked format and consequently block error rate can be related to throughput, an important measure of system performance. A "block error" is defined as a block of data which contains one or more bit errors. A block transmission system generally forms data into blocks of a specific number of bits. This block of data usually contains redundant bits for the purpose of error detection at the receiving terminal. If one or more bit errors are detected in a received block of data, a message requesting retransmission of the entire block is returned to the source. In this sense, the block error rate is the ratio of the number of retransmissions required to the total number of blocks received.

Data Set 209A is designed to operate at 9600 bps over 4-wire 3002-Type private line channels with D1-type High Performance Data Conditioning (but no C-type conditioning) which will ensure that such channels meet stricter limits for signal-to-noise ratio and nonlinear distortion than specified for the basic 3002-type private line channels alone. Under these circumstances the objective is to realize a long-term average block error rate of  $10^{-2}$  or better for blocks 1000 bits long. The block size selected as part of the error performance objective is not meant to imply that customer systems should employ this size block. The block error rate statement applies to a continuous stream of data that is divided into blocks of 1000 bits. On the average, 99 of 100 blocks will be delivered error free; the remainder may include one or

more bit errors. Our experience indicates that block error rate will be approximately proportional to block size in the range from 500 to 10,000 bits. Thus, performance for other block sizes can be estimated from performance measured at the 1000 bit block size.

The performance objective for Data Set 209A applies literally to the point-to-point operation at 9600 bps, illustrated in Figure 4(a). It is also applicable to each of the lower rate streams in the point-to-point multiplexing configuration, illustrated in Figure 4(b). The many point multiplexing configuration, illustrated in Figure 4(c), amounts to operating several data services in tandem, and the performance objective applies to each data service individually. For data that traverses more than one service involving Data Set 209A and either Data Set 208A or 201C the 1000 bit block error rate objective is  $N \times 10^{-2}$  where N represents the number of Bell System data services traversed. It is expected that block error rate will be substantially better than the objective most of the time. For example, experience indicates that the probability of meeting 1000 bit block error rate of  $10^{-2}$  in tandem operation of three data services is greater than 95 percent and for two data services in tandem is greater than 97.5 percent. No overall performance objective will be supported on those assemblies involving channel extensions provided by customer-provided data sets in conjunction with the 209A. The Bell system's responsibility for such assemblies ends at the interface of the 209A which connects to customer-provided equipment.

The one-to-many multiplexing configuration, illustrated in Figure 4(d), will be maintained to meet the performance objective for each of the lower rates in the same way as for the point-to-point multiplexing, illustrated in Figure 4(b). Service in the one-to-many multiplexing configuration should be satisfactory when the software multiplexing within the data terminal is equivalent to the hardware multiplexing within Data Set 209A.

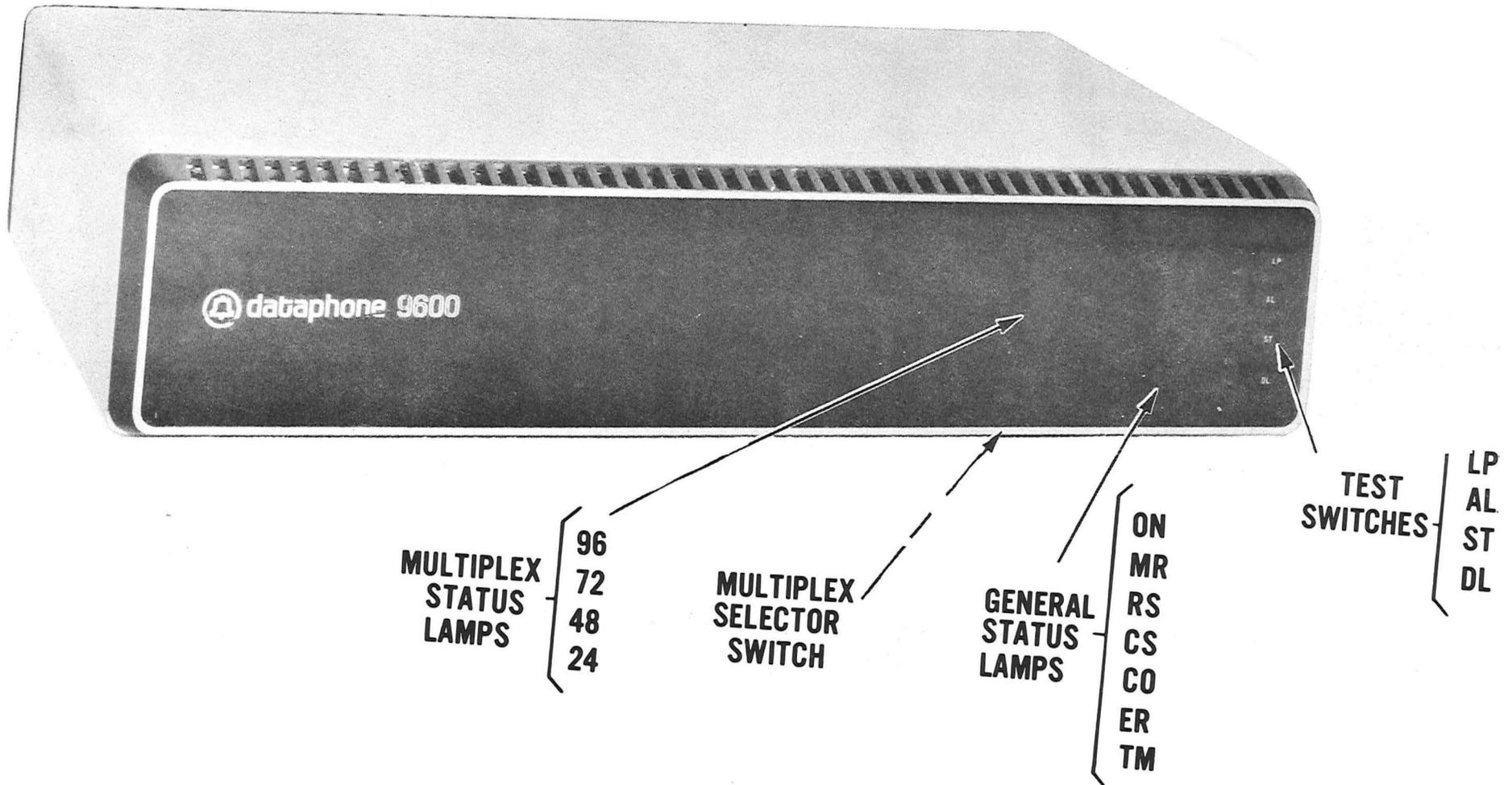
## 7. REFERENCES

Bell System Data Communications Technical Reference, "Data Communications Using Voiceband Private Line Channels," October 1973 - PUB 41004

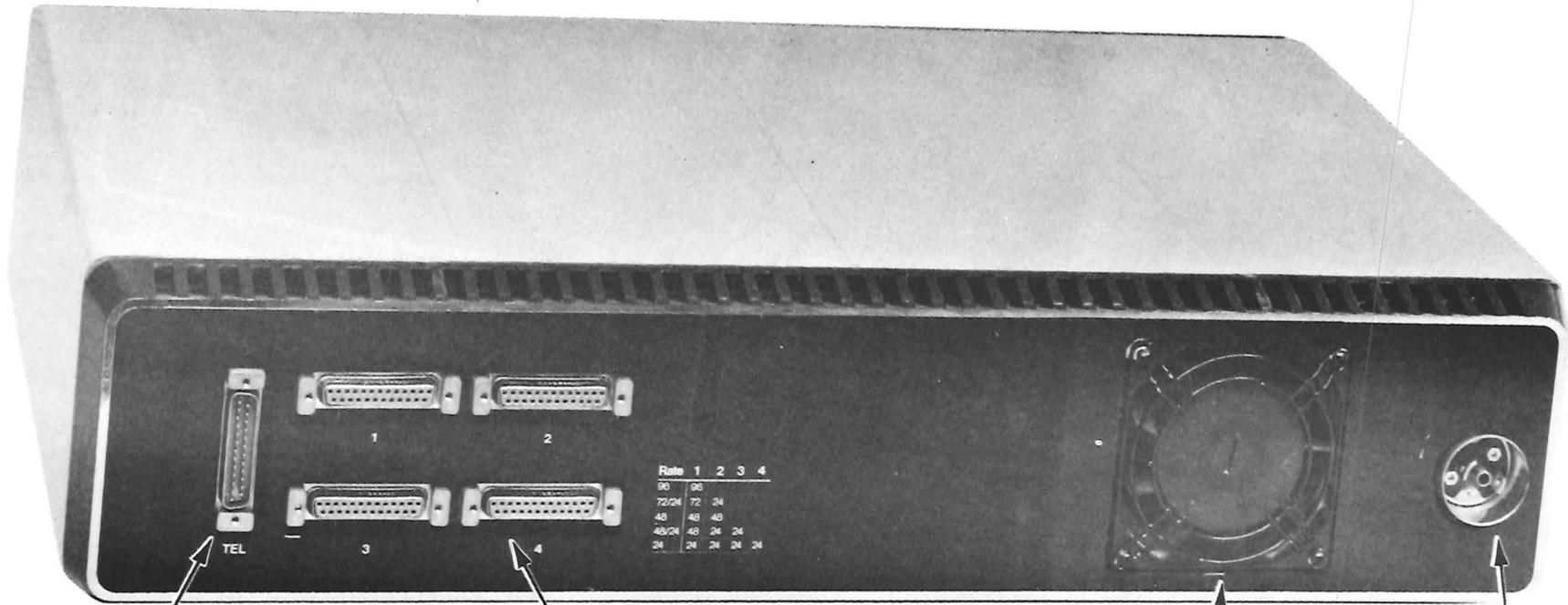
Bell System Data Communications Technical Reference, "Data Set 208A Interface Specification," November 1973 - PUB 41209

Bell System Data Communication Technical Reference, "Data Set 201C Interface Specification," April 1973 - PUB 41210

**FIGURE 1**  
**FRONT VIEW OF DATA SET 209A**



**FIGURE 2**  
**REAR VIEW OF DATA SET 209A**



**PRIVATE LINE  
CHANNEL  
CONNECTOR**

**DATA TERMINAL  
INTERFACE  
CONNECTORS**

**EXHAUST FAN**

**POWER CORD  
RECEPTACLE**

FIGURE 3

Optional Customer-Specified Features of Data Set 209A

Option Name	Choices	Section Reference
Multiplex Option (Under customer control)	96	2.1
	72/24	
	48/48	
	48/24/24	
	4-24	
Transmitter Timing Provided <sup>†</sup>	Data Set (internal)	2.2
	Data Terminal (external via connector No. 1)	
Carrier Control <sup>†</sup>	Continuous Carrier	2.3
	Switched Carrier*	
Request-to-Send Control <sup>†</sup>	Continuous (CB held ON)	2.4
	Switched (8 ms CA-CB delay)	
Elastic Store (one per connector)	IN (specify connector(s))	2.5
	OUT (specify connector(s))	
Slaved Transmitter Timing <sup>†</sup>	OUT	2.6
	IN (one 209A only)	
Data Set Ready (CC) condition in AL mode <sup>†</sup> (for use in TEST 4)	CC OFF when AL switch is depressed	2.7
	CC ON when AL switch is depressed	
Grounding <sup>†</sup> (Protective Ground (AA) to Signal Ground (AB))	AA connected to AB (Factory wired)	2.8
	AA disconnected from AB (specify)	

\* Request-to-Send Control need not be specified when Switched Carrier is selected.

† Option affects all interfaces.

FIGURE 4(a)

Basic System Configurations and Data Set Options

Point-to-Point 9600 bps Operation



Data Set 209A Options

Select		Select
96	Multiplex Option	96
Internal	Transmitter Timing	Internal
Continuous	Carrier Control	Continuous
per CPE <sup>†</sup>	Request-to-Send Control	per CPE <sup>†</sup>
All Out*	Elastic Stores	All Out*
Out*	Slaved Timing	Out*
per CPE <sup>†</sup>	Data Set Ready condition in AL mode	per CPE <sup>†</sup>
per CPE or local practice <sup>†</sup>	Grounding	per CPE or local practice <sup>†</sup>

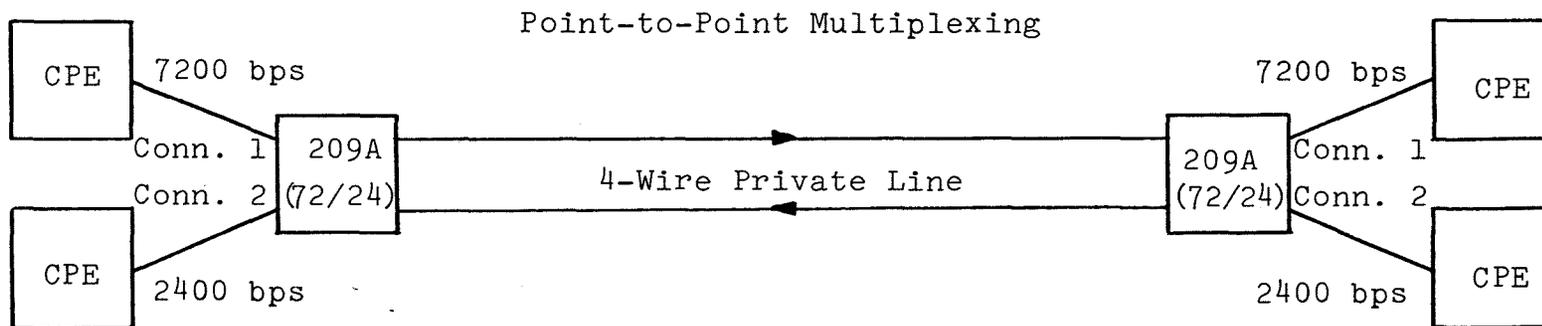
\* Required option.

<sup>†</sup>See Figure 3 for possible choices.

Legend: CPE = Customer Provided Equipment

FIGURE 4(b)

Basic System Configurations and Data Set Options



Data Set 209A Options

Select		Select
* 72/24, 48/48 48/24/24 or 4-24	Multiplex Option	* 72/24, 48/48 48/24/24, or 4-24
Internal	Transmitter Timing	Internal
Continuous per CPEs <sup>†</sup>	Carrier Control	Continuous per CPEs <sup>†</sup>
All Out <sup>‡</sup>	Request-to-Send Control	All Out <sup>‡</sup>
Out <sup>‡</sup>	Elastic Stores	Out <sup>‡</sup>
per CPEs <sup>†</sup>	Slaved Timing	per CPEs <sup>†</sup>
per CPEs or local practice <sup>†</sup>	Data Set Ready condition in AL mode	per CPEs or local practice <sup>†</sup>
	Grounding	

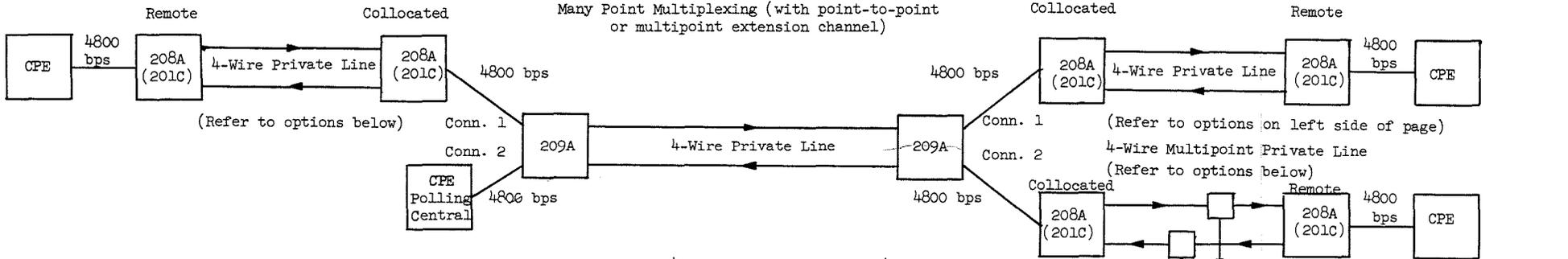
<sup>‡</sup>Required option.

\*The multiplex option must be the same for both data sets.

<sup>†</sup>See Figure 3 for possible choices.

Legend: CPE = Customer Provided Equipment.

FIGURE 4(c)  
Basic System Configurations and Data Set Options



(Remote) Select	Data Set 208A Options on Pt-to-Pt Extension Channel	(Collocated) Select
External§	Transmitter Timing	External§
Continuous**	Carrier Control	Switched§
0 or 8 ms per CPE*	Request-to-Send Operation	Not Applicable
Provided	One Second Holdover	Provided**
Not Used§	New Sync	Not Used§
CC ON or CC OFF per CPE*	Data Set Ready condition in AL test mode	CC OFF in AL test mode§
per CPE or local practice*	Grounding	AA connected to AB§

(Remote) Select	Data Set 201C Options on Pt-to-Pt Extension Channel	(Collocated) Select
External§	Transmitter Timing	External§
Continuous	Carrier Control	Switched§
0 or 7 ms per CPE*	Request to Send Clear-to-Send Delay	7 ms§
Not Used§	New Sync	Not Used§
per CPE or local practice*	Grounding	AA connected to AB§

Select	Data Set 209A Options	Select
Any but 96 (48/48 for example shown)	Multiplex Option	Any but 96 (48/48 for example shown)
Internal§	Transmitter Timing	Internal§
Continuous§	Carrier Control	Continuous§
Continuous	Request-to-Send Control	Continuous§
IN Conn. 1 OUT Conn. 2-4 (for example shown)§	Elastic Stores	IN Conn. 1 & 2 OUT Conn. 3 & 4 (for example shown)§
OUT§ (IN)§	Slaved Timing†	IN§ (OUT)§
per CPE at polling central (for example shown)†	Data Set Ready condition in AL test mode	CC OFF in AL test mode§
AA connected to AB§	Grounding	AA connected to AB§

(Collocated) Select	Data Set 208A Options on Multipoint Extension Channel	(Remote) Select
External§	Transmitter Timing	External§
Switched§	Carrier Control	Switched§
Not Applicable	Request-to-Send Operation	Not Applicable
Not Provided§	One Second Holdover	Provided§
Not Used§	New Sync	Not Used§
CC OFF in AL test mode§	Data Set Ready condition in AL test mode	CC ON or CC OFF per CPE*
AA connected to AB§	Grounding	per CPE or local practice*

\*See Technical References on Data Sets 208A or 201C for explanation.

†See Figure 3 for possible choices.

‡Slave timing option must be in one 209A or the other but not both. Selection of slaved 209A is arbitrary except for testing situations involving TEST 5. (See Sections 2.6 and 5.1.2).

§Required option.

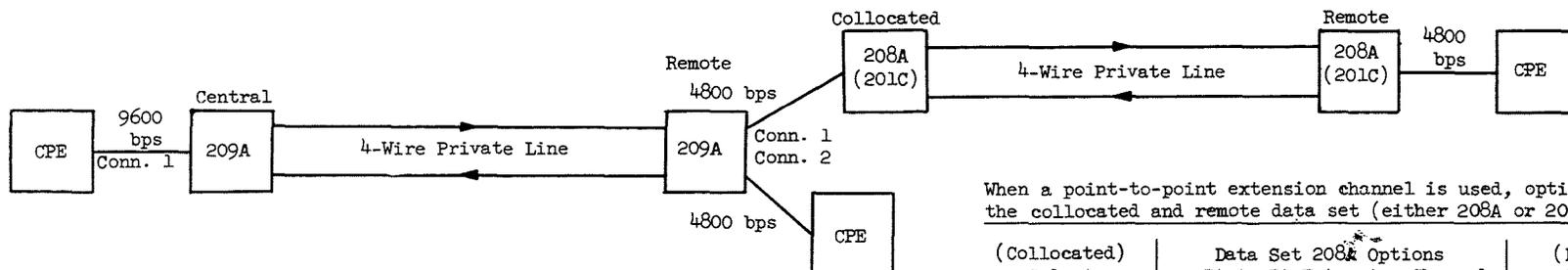
\*\*When Continuous Carrier Control is selected the One Second Holdover must be provided and when Switched Carrier Control is selected the One Second Holdover must be OUT.

Legend: CPE = Customer Provided Equipment.

(Collocated) Select	Data Set 201C Options on Multipoint Extension Channel	(Remote) Select
External§	Transmitter Timing	External§
Switched§	Carrier Control	Switched§
7 ms§	Request-to-Send Clear-to-Send Delay	7 ms§
Not Used§	New Sync	Not Used§
AA connected to AB§	Grounding	per CPE or local practice*

FIGURE 4(d)

Basic System Configurations and Data Set Options  
One-to-Many Multiplexing (with or without an extension channel)



When a point-to-point extension channel is used, options must be selected in the collocated and remote data set (either 208A or 201C).

(Central) Select	Data Set 209A Options	(Remote) Select
96§	Multiplex Option	Any multiplex option†
Internal§	Transmitter Timing	Internal (required when extension channel is connected on Connector 1.)
Continuous per CPE†	Carrier Control	Continuous§
	Request-to-Send Control	Continuous with exten. channel (Cont. or Swit. without exten. channel)
All OUT§	Elastic Stores	IN Conn. 1 OUT Conn. 2-4 (for example shown)§
OUT§	Slaved Timing	IN (with ext. channel)§ OUT (without ext. channel)§
per CPE†	Data Set Ready condition in AL test mode	CC OFF in AL test mode
per CPE or local practice†	Grounding	per CPE or local practice† (without ext. channel) AA connected to AB (with ext. channel)§

(Collocated) Select	Data Set 208* Options on Pt-to-Pt Extension Channel	(Remote) Select
External§	Transmitter Timing	External§
Switched§	Carrier Control	Continuous**
Not applicable	Request-to-Send Operation	0 or 8 ms per CPE*
Provided **	One Second Holdover	Provided
Not Used§	New Sync	Not Used§
CC OFF in AL test mode§	Data Set Ready (CC) condition in AL test mode	CC ON or CC OFF per CPE*
AA connected to AB§	Grounding	per CPE or local practice*

(Collocated) Select	Data Set 201C Options on Pt-to-Pt Extension Channel	(Remote) Select
External§	Transmitter Timing	External§
Switched§	Carrier Control	Continuous
7 ms§	Request-to-Send Clear-to-Send Delay	0 or 7 ms per CPE*
Not Used§	New Sync	Not Used§
AA connected to AB§	Grounding	per CPE or local practice*

§ Required option. Assume customer will control maintenance actions from here.  
\*See Technical References on Data Sets 208A and 201C for explanation.

†See Figure 3 for possible choices.  
‡The 72/24 and 48/24/24 options are not recommended (See Sections 1.2 and 4.1.4).

\*\*When Continuous Carrier Control is selected the One Second Holdover option must be provided and when Switched Carrier Control is selected the One Second Holdover must be OUT.

Legend: CPE = Customer Provided Equipment.

When a multipoint extension channel is used, refer to Figure 4(c) for data set options.

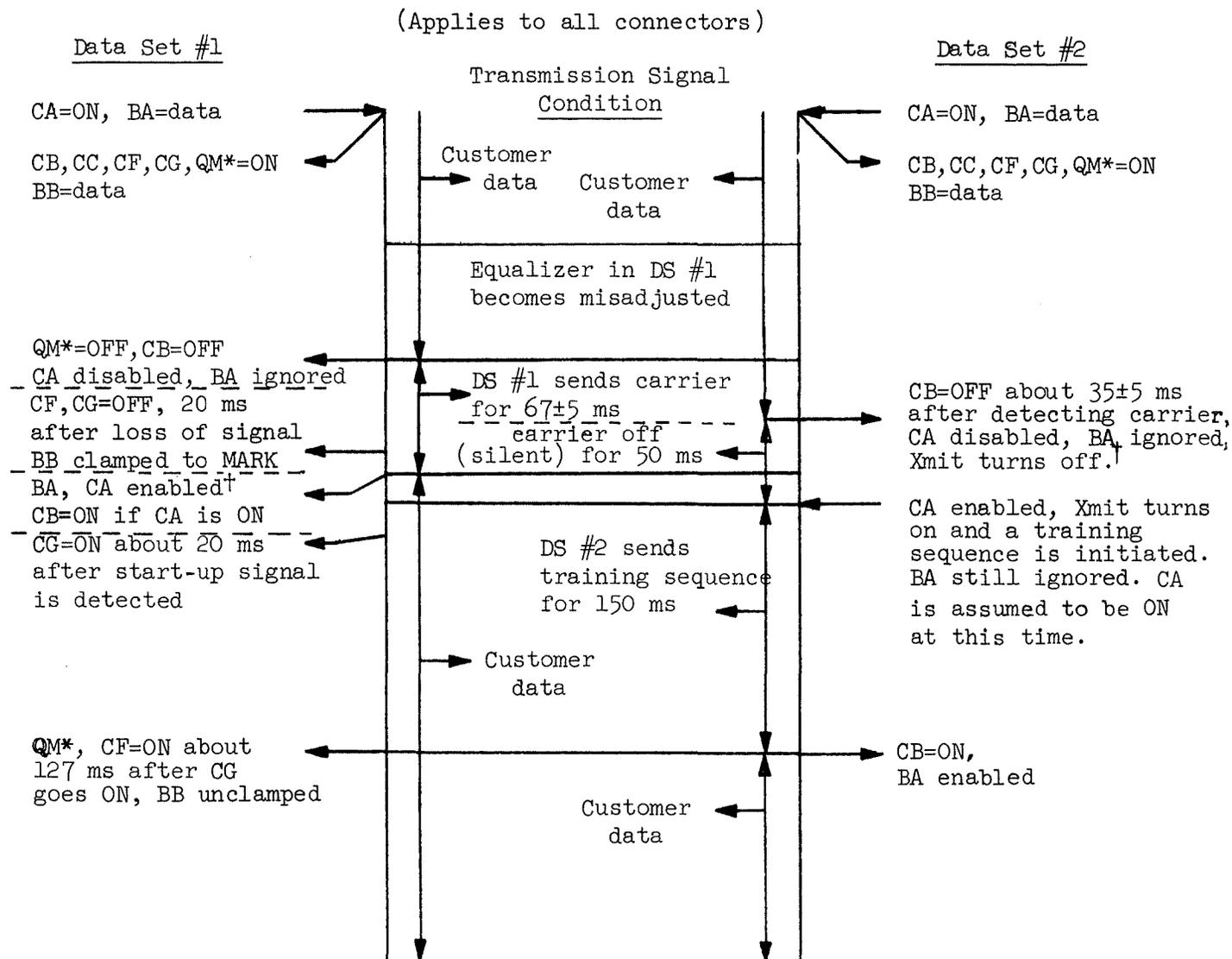
FIGURE 5

Pin Assignments on Customer Interface Connector(s)

<u>Pin No.</u>	<u>EIA RS-232-C Nomenclature</u>
1	Protective Ground (AA)
2	Transmitted Data (BA)
3	Received Data (BB)
4	Request-to-Send (CA)
5	Clear-to-Send (CB)
6	Data Set Ready (CC)
7	Signal Ground (AB)
8	Received Line Signal Detector (CF)
9	Reserved for Data Set Testing (Connector No. 1 only)
10	Reserved for Data Set Testing (Connector No. 1 only)
11	Equalizer Mode (QM, non-EIA, Connector No. 1 only)
12-14	Not Used
15	Transmitter Signal Element Timing (DB)
16	Divided Clock Transmitter (DCT, non-EIA, Connector No. 1 only)
17	Receiver Signal Element Timing (DD)
18	Divided Clock Receiver (DCR, non-EIA, Connector No. 1 only)
19-20	Not Used
21	Signal Quality Detector (CG)
22-23	Not Used
24	Transmitter Signal Element Timing External (DA)
25	Reserved for Data Set Testing (non-EIA, Connector No. 1 only)

FIGURE 6

INTERFACE OPERATION DURING AN AUTOMATIC RETRAINING SEQUENCE



NOTE: This illustration assumes no propagation delay in the channel.

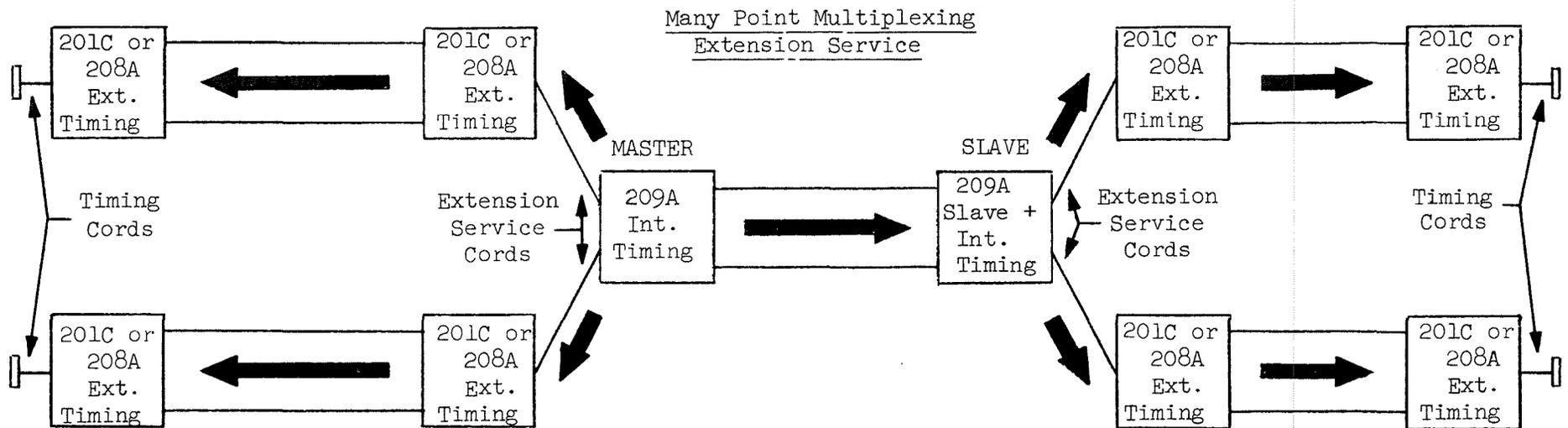
Summary

<u>Data Set #1</u>		<u>Data Set #2</u>	
<u>Circuits turned OFF or disabled</u>	<u>Duration</u>	<u>Circuits turned OFF or disabled</u>	<u>Duration</u>
CA disabled	67±5 ms	CA disabled	50 ms
CB OFF	67±5 ms	CB OFF	200 ms
CF OFF	180±5 ms	BA disabled	200 ms
CG OFF	53±5 ms		
QM* OFF	240±5 ms +		
	roundtrip delay		
BA disabled	67±5 ms		

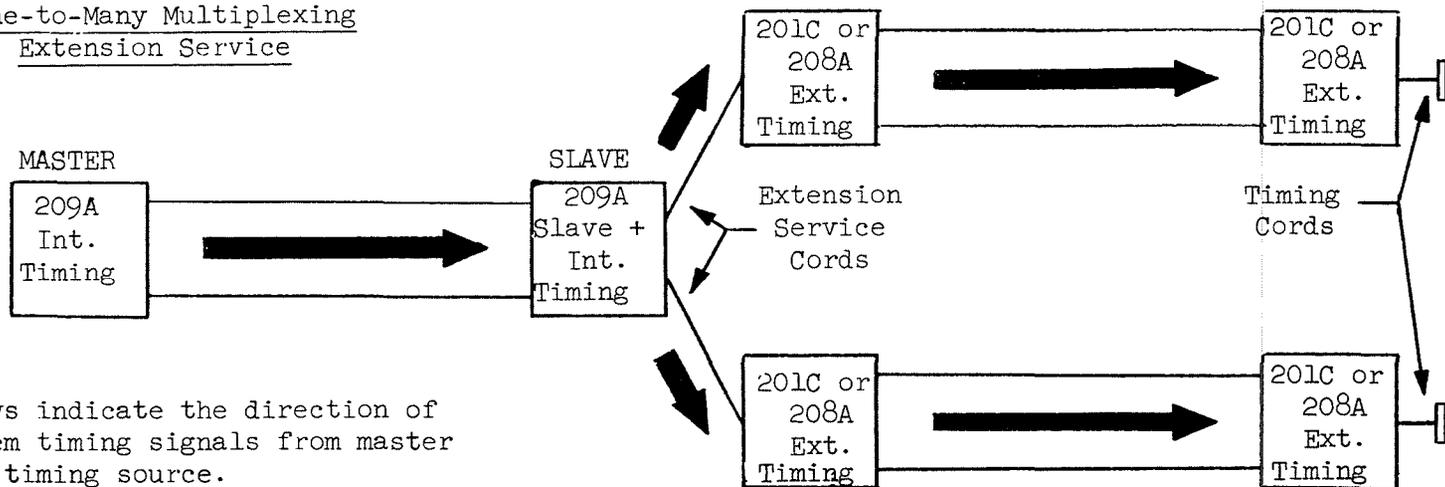
\*The QM circuit appears only on connector No. 1. All other circuits described appear on each connector.

†If the data sets are optioned for switched carrier and the CPE turns CA OFF after CB is turned OFF by the data sets, the transmitter will turn off at this point. Then it is up to the data terminals to reinitiate operation in each direction by turning their CA circuits ON again.

FIGURE 7  
Timing Synchronization Arrangements for Extension Service Configurations



One-to-Many Multiplexing  
Extension Service

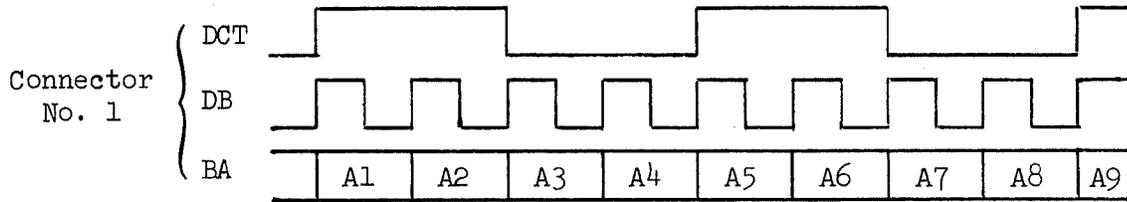


NOTE: Arrows indicate the direction of system timing signals from master 209A timing source.

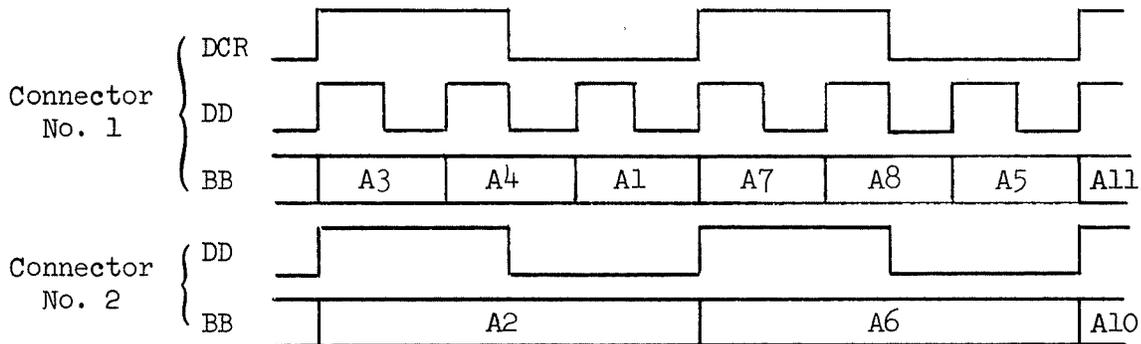
FIGURE 8 (a)

Timing Diagram for One-to-Many Multiplexing  
96 to 72/24

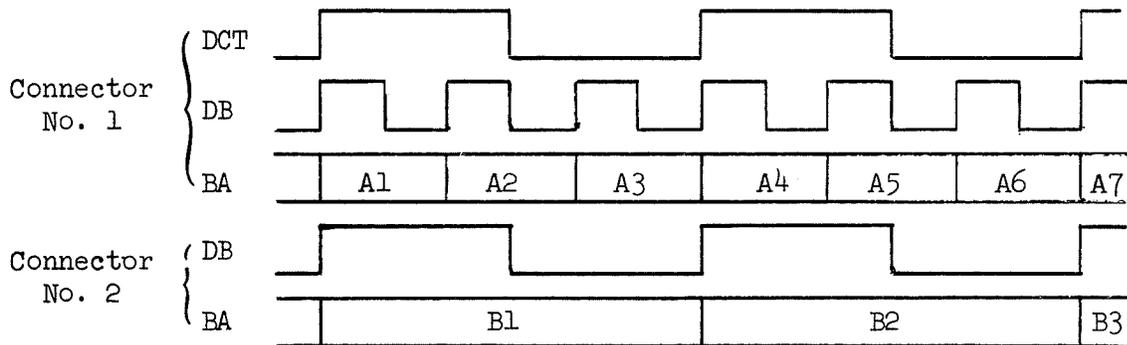
Transmit order at the master 209A with the 96 option:



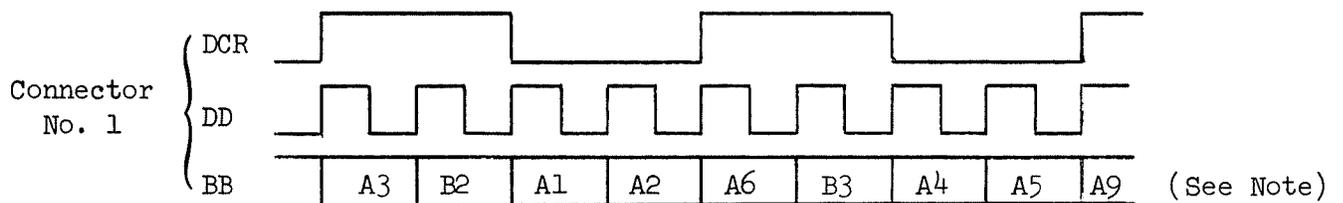
Resulting receive order at far-end 209A with the 72/24 option:



Transmit order at the far-end 209A with the 72/24 option:



Resulting receive order at master 209A with the 96 option:



NOTE: See attached sheet.

Figure 8(a)

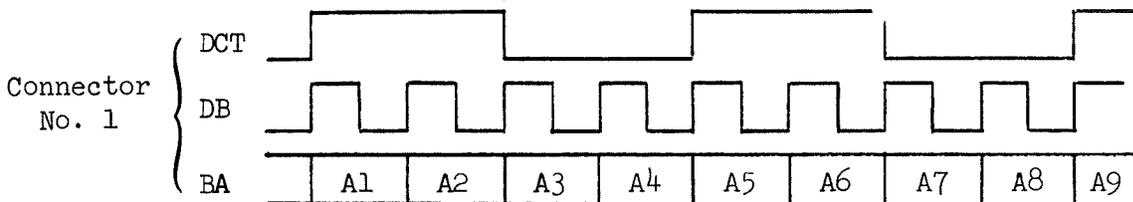
Note: The 209A with the 72/24 option processes the data on the BA circuits of connector Nos. 1 and 2 by delaying the 7200 bps channel (A bits) with respect to the 2400 bps channel (B bits) by one symbol interval (one cycle of DCT). Consequently, the data appearing on the BB circuit of connector No. 1 of the 209A with the 96 option is such that the B1 bit occurs in the previous cycle of DCR with the three previous bits of the 7200 bps channel (A bits: A-2, A-1, and A0).

FIGURE 8 (b)

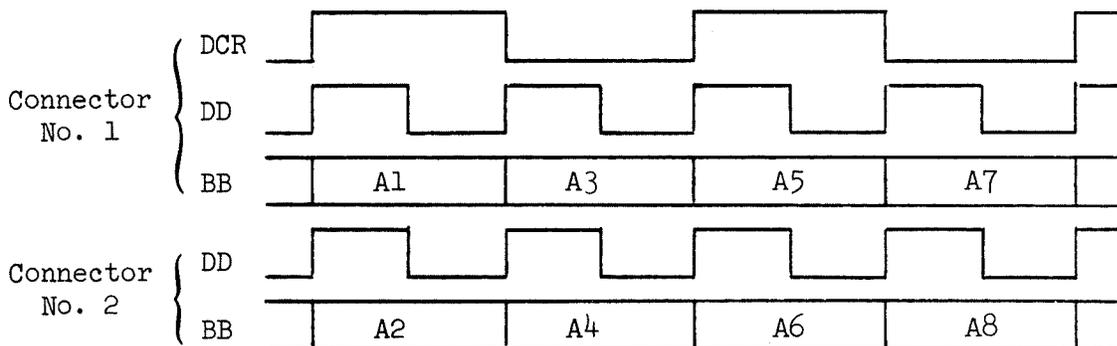
Timing Diagram for One-to-Many Multiplexing

96 to 48/48

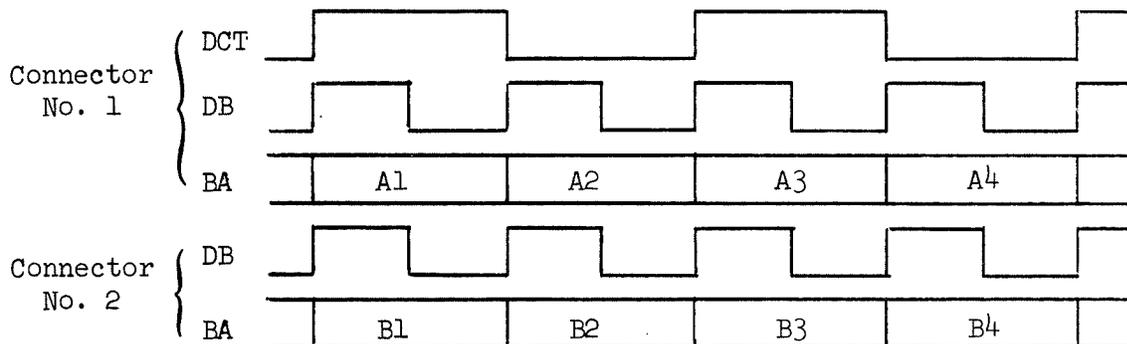
Transmit order at the master 209A with the 96 option:



Resulting receive order at far-end 209A with the 48/48 option:



Transmit order at the far-end 209A with the 48/48 option:



Resulting receive order at master 209A with the 96 option:

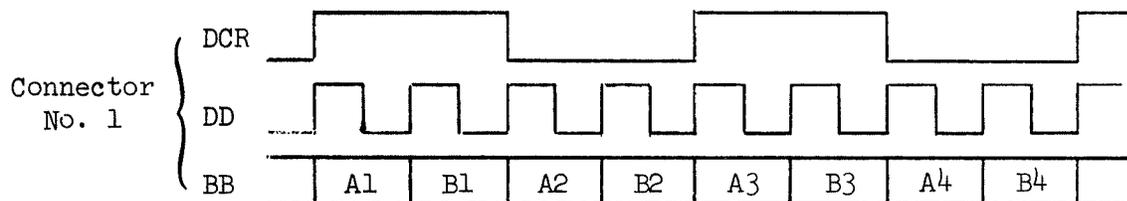
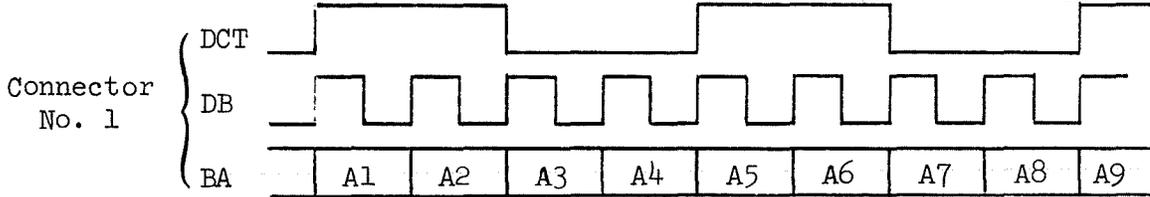


FIGURE 8 (c)

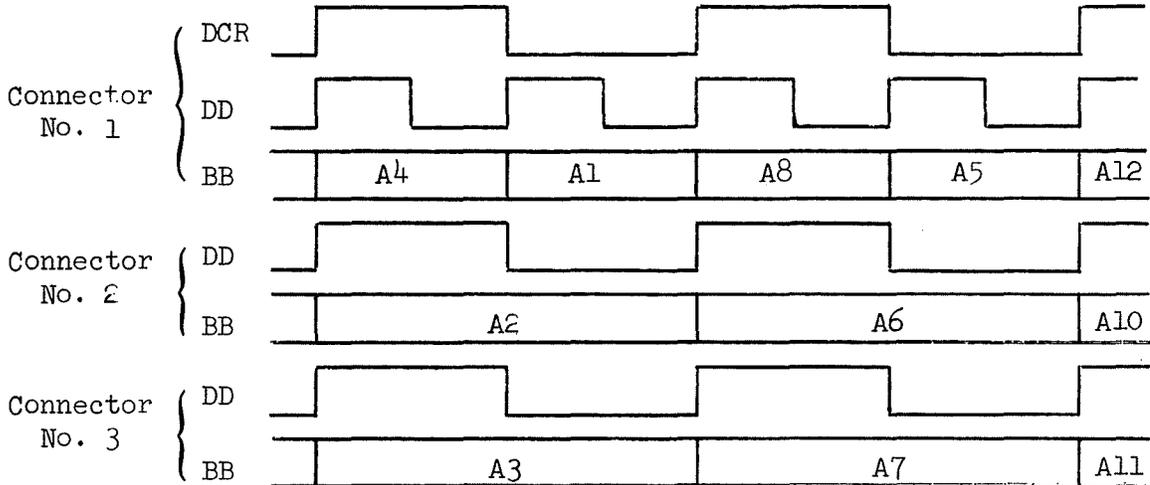
Timing Diagram for One-to-Many Multiplexing

96 to 48/24/24

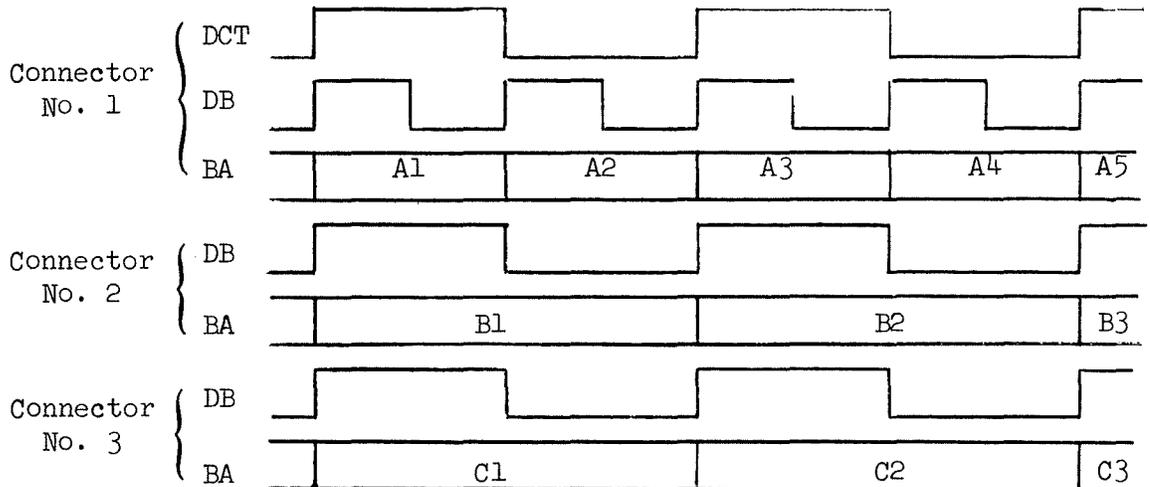
Transmit order at the master 209A with the 96 option:



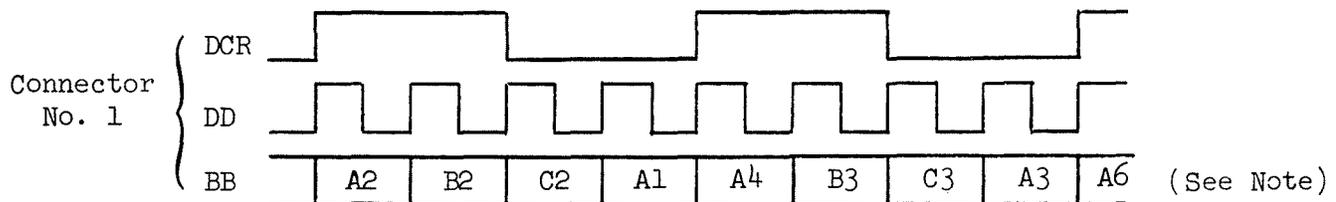
Resulting receive order at far-end 209A with the 48/24/24 option:



Transmit order at the far-end 209A with the 48/24/24 option:



Resulting receive order at master 209A with the 96 option:



NOTE: See attached Sheet.

Figure 8(c)

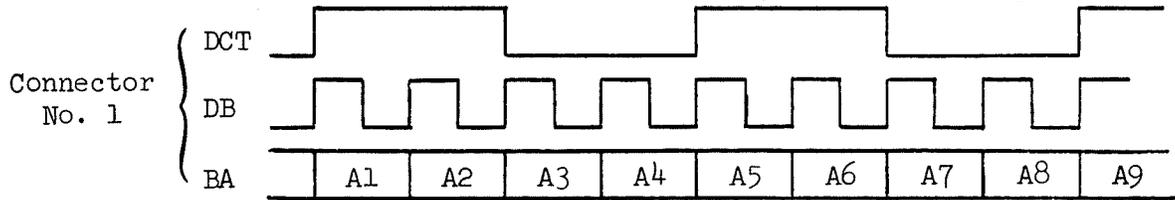
Note: The 209A with the 48/24/24 option processes the data on the BA circuits of connector Nos. 1 and 2 by delaying the 4800 bps channel (A bits) with respect to the two 2400 bps data channels (B bits and C bits) by one symbol interval (one cycle of DCT). Consequently, the data appearing on the BB circuit of connector No. 1 of the 209A with the 96 option is such that the B1 and C1 bits occur in the previous cycle of DCR with the two previous bits of the 4800 bps channel (A bits: A-1 and A0).

FIGURE 8 (d)

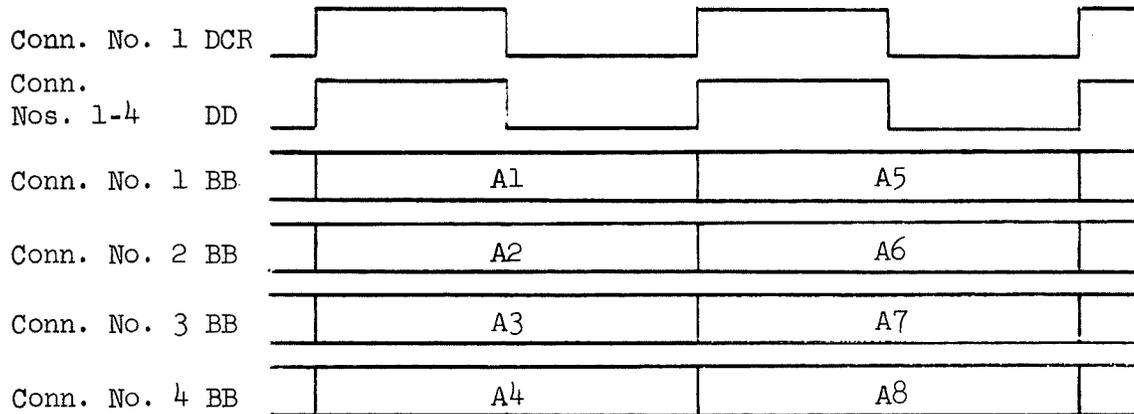
Timing Diagram for One-to-Many Multiplexing

96 to 4-24

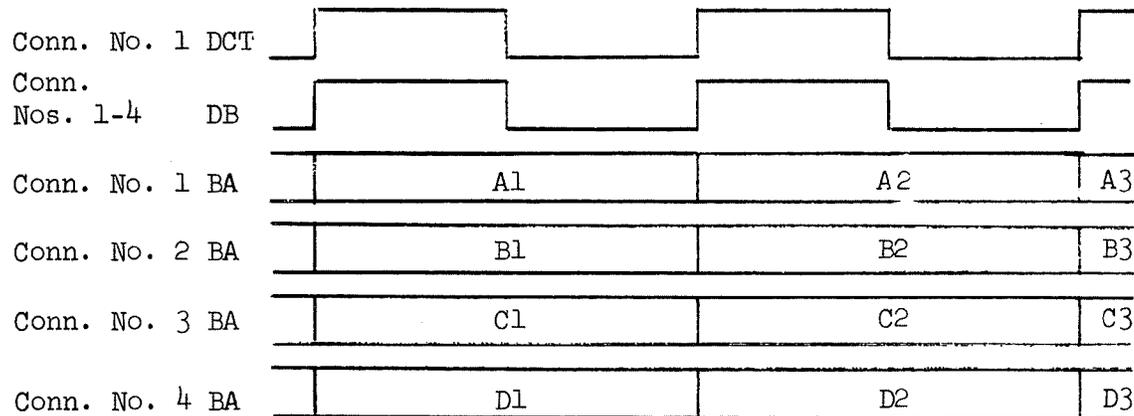
Transmit order at the master 209A with the 96 option:



Resulting receive order at far-end 209A with the 4-24 option:



Transmit order at the far-end 209A with the 4-24 option:



Resulting receive order at the master 209A with the 96 option:

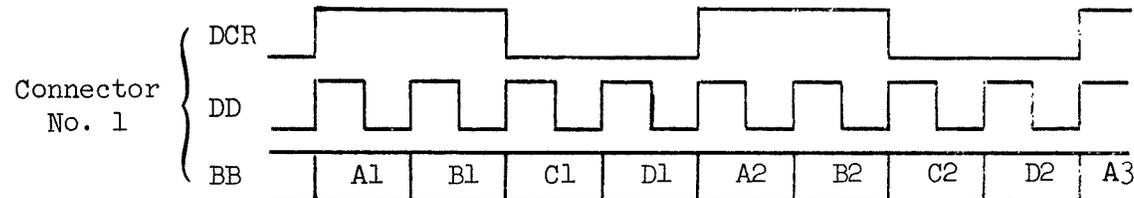
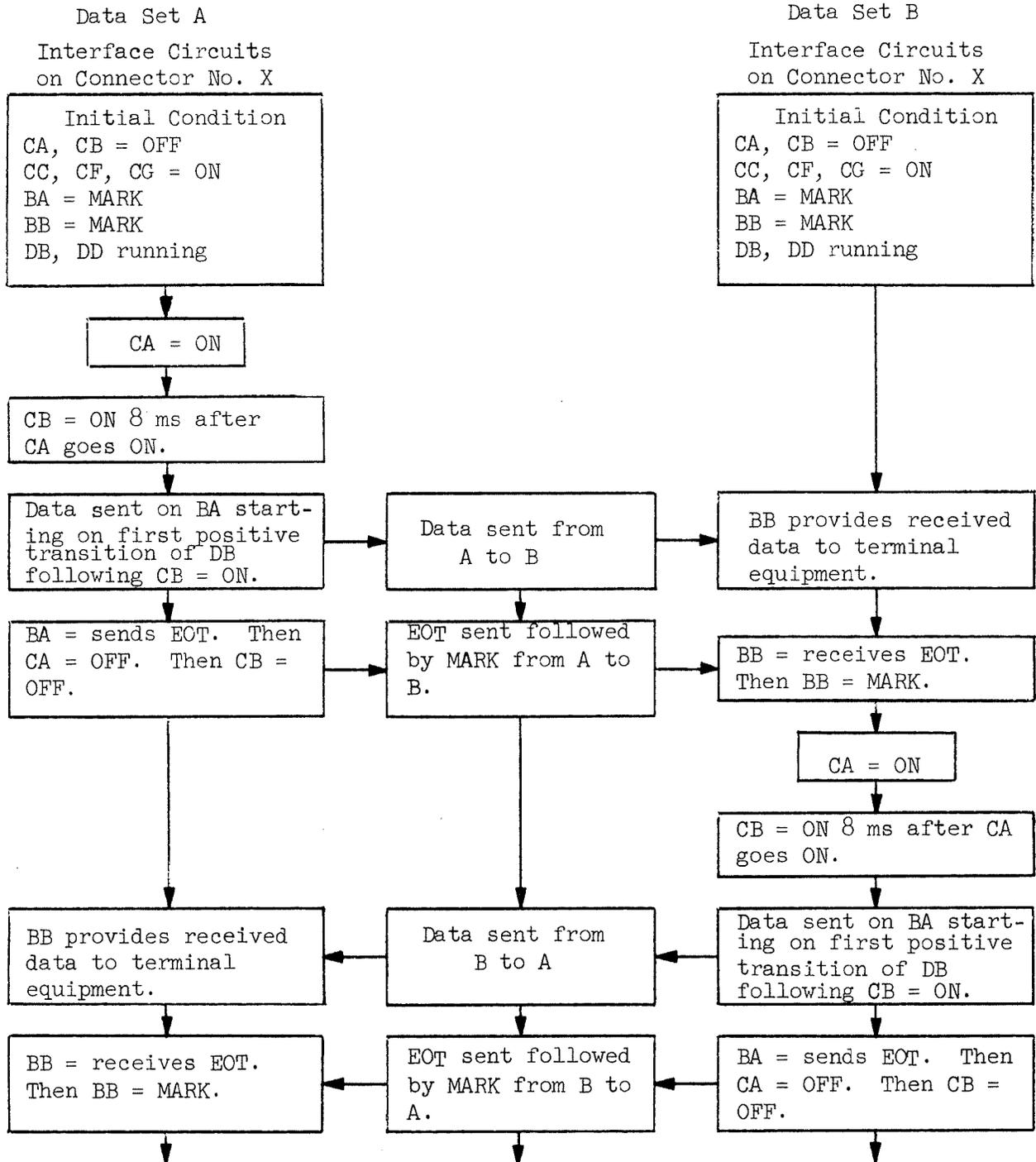


FIGURE 9

Half-Duplex Interface Circuit Operation  
(Illustrative example - see Notes below)



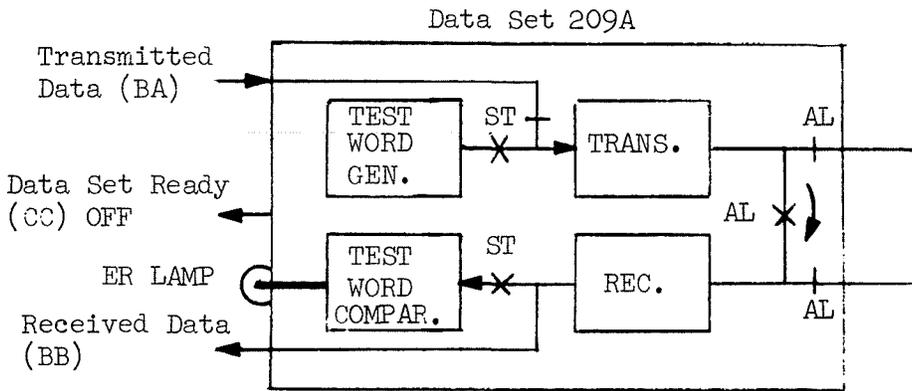
- Note 1: This diagram applies to operation on any given connector with the associated connector of the far-end data set for a point-to-point configuration.
- Note 2: Operation in either direction of transmission can occur simultaneously on each associated connector of each 209A independent of that on other connectors when continuous carrier is used in both data sets.
- Note 3: This illustrative example assumes continuous carrier is used in both data sets. As a result circuits CF and CG are always ON. Only in case of a line signal interruption or during automatic retraining will they go OFF. It is imperative that an end of transmission code be used to signal to the other terminal that all data has ended rather than waiting for circuit CF to go OFF.
- Note 4: Switched request-to-send operation is assumed in this example. If continuous request-to-send operation is selected, all references to the CA and CB circuits can be omitted and CB will be ON at all times.

FIGURE 10

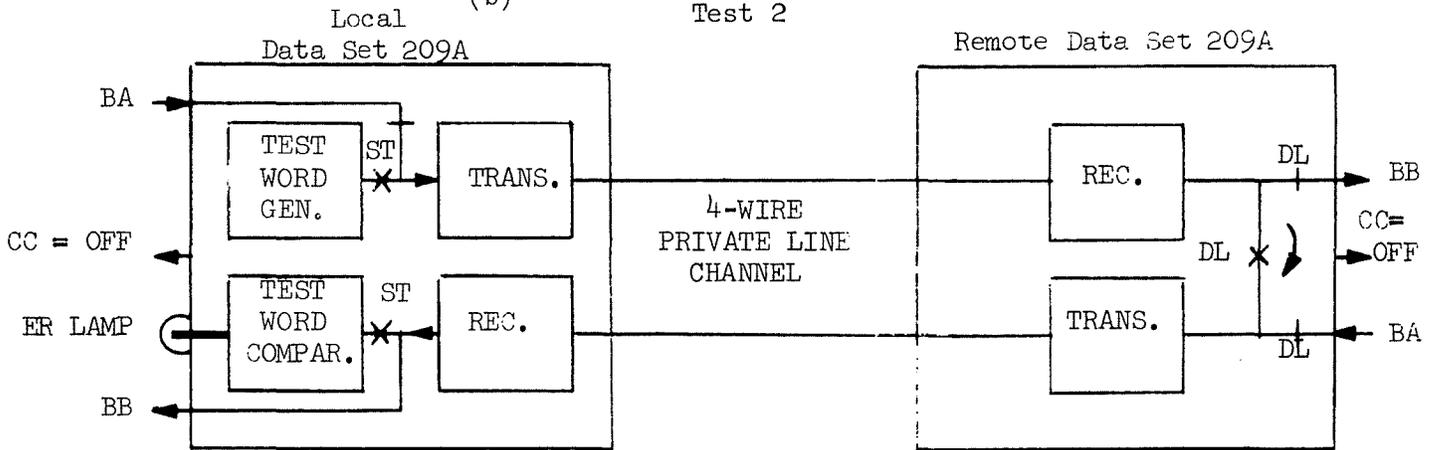
Self Test Arrangements  
of Data Set 209A

(a) Analog Loopback Self Test

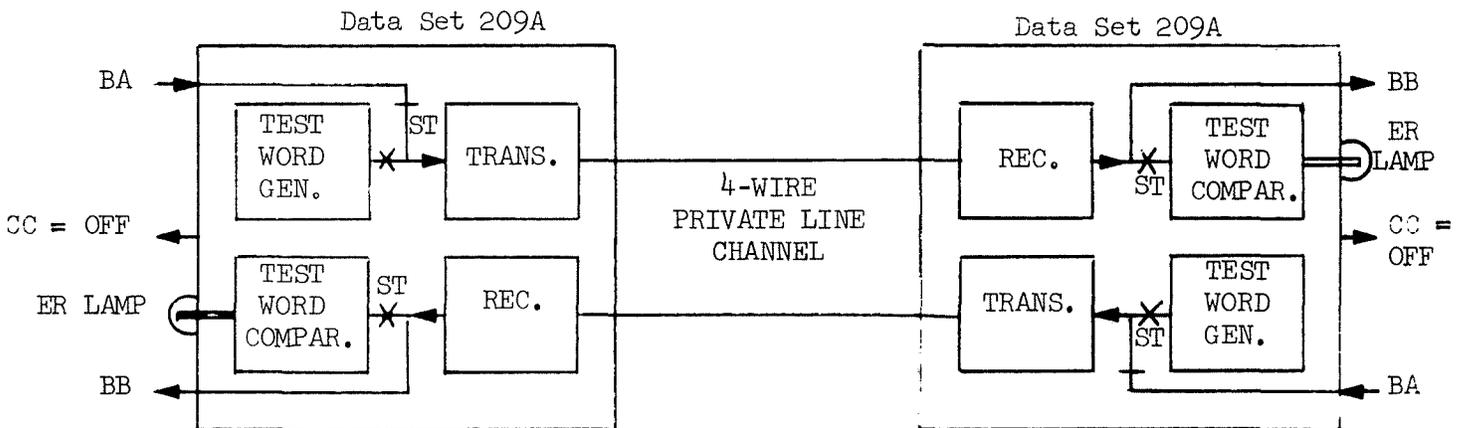
Test 1



(b) Digital Loopback Self Test  
Test 2



(c) End-to-End Self Test  
Test 3



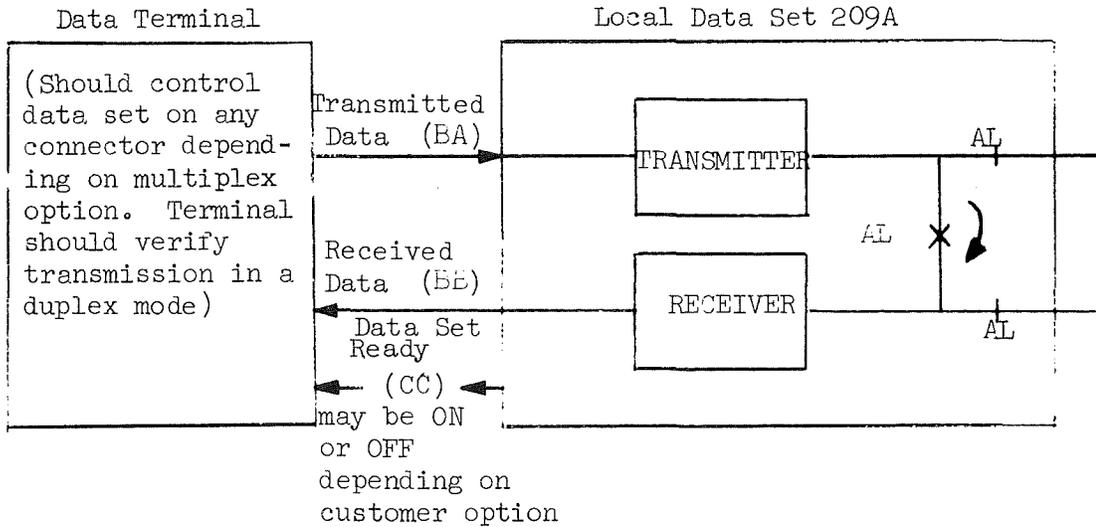
—|— = Normally closed (open when switch is operated)

—X— = Normally open (closed when switch is operated)

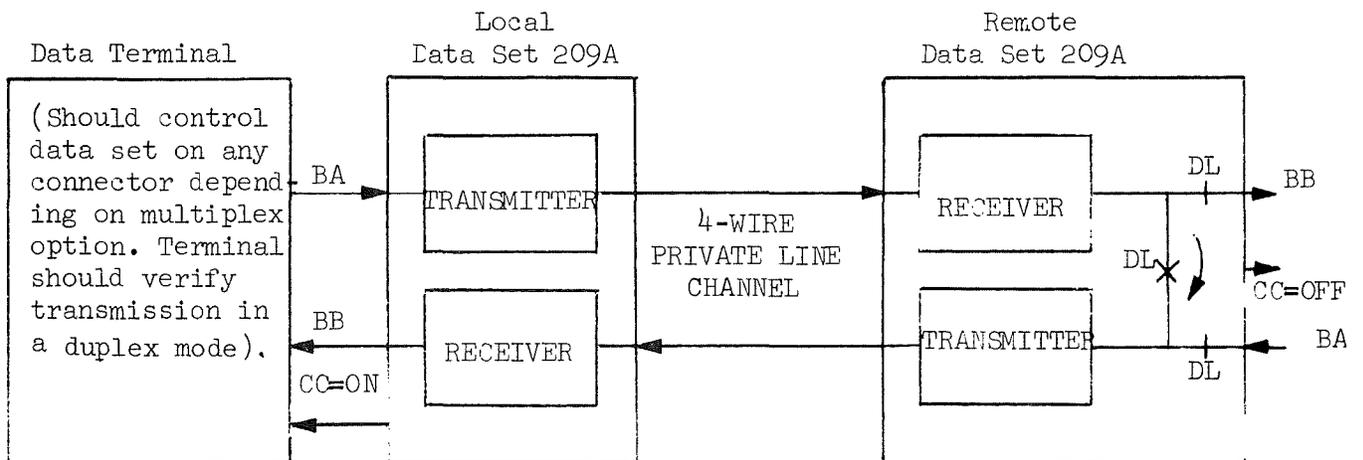
FIGURE 11

Tests made by the Data Terminal or External Test Equipment Through the Data Set 209A Interface

(a) Analog Loopback Test  
Test 4



(b) Digital Loopback Test  
Test 5  
(See Note below)



—+— = Normally closed (open when switch is operated)

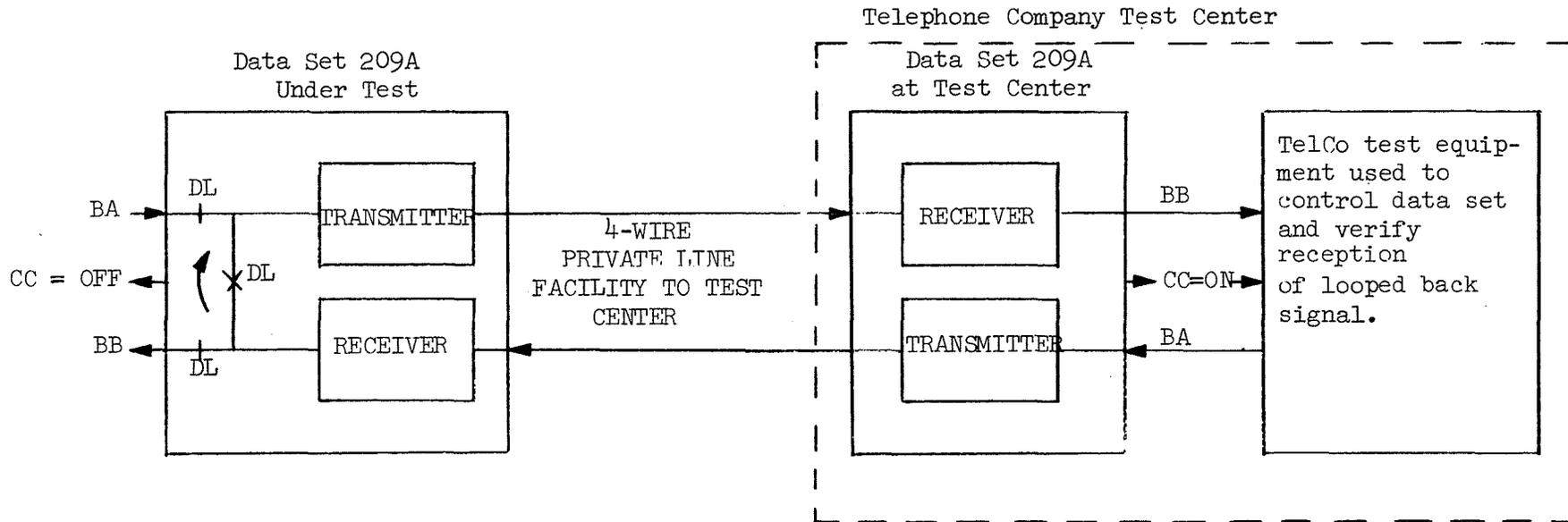
—X— = Normally open (closed when switch is operated)

Note: Test 5 cannot be made if the local 209A has the slaved timing option installed.

FIGURE 12

Telephone Company Remote Test  
of Data Set 209A

Test 6

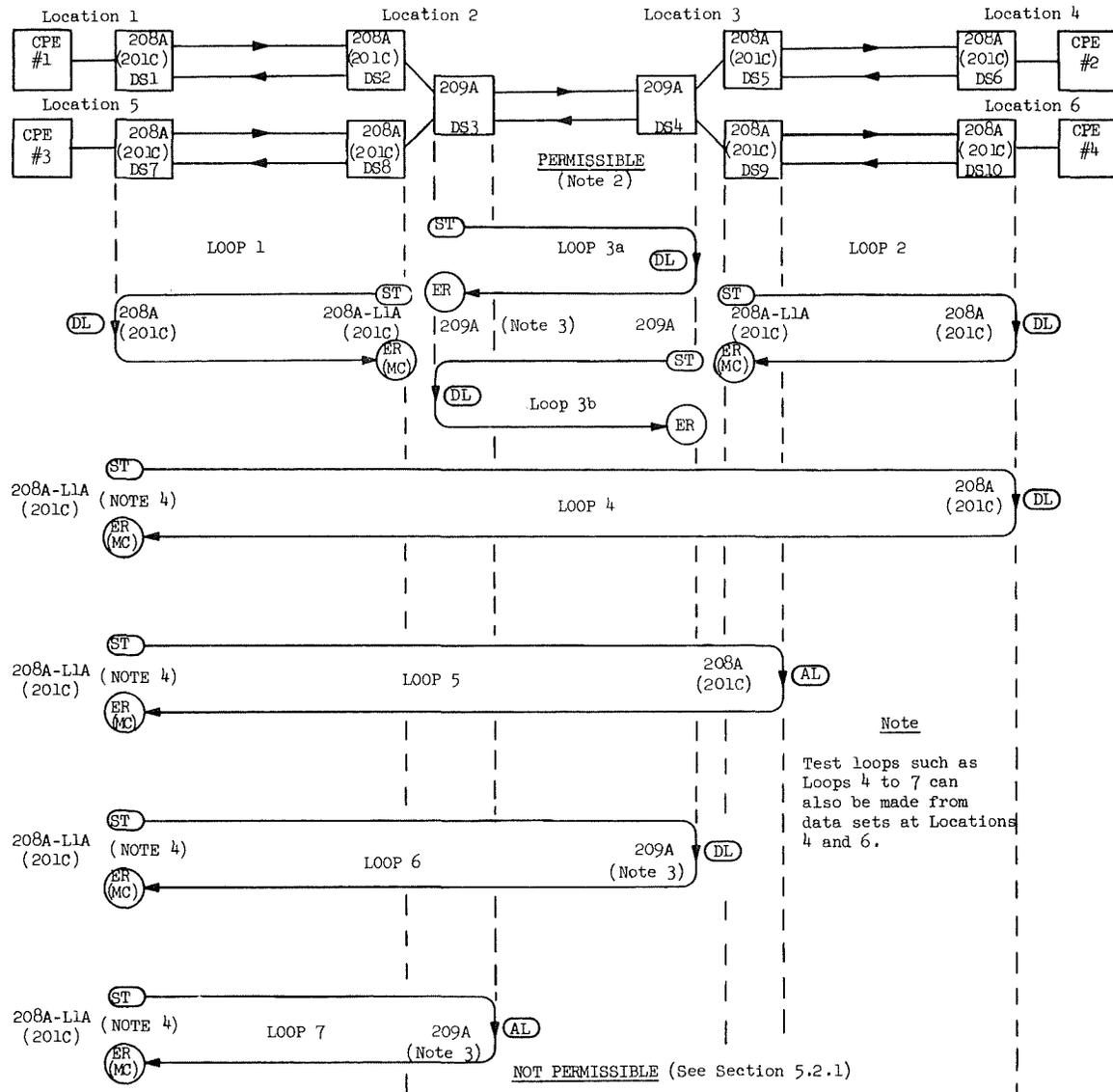


—|— = Normally closed (open when switch is operated)

—X— = Normally open (closed when switch is operated)

FIGURE 13

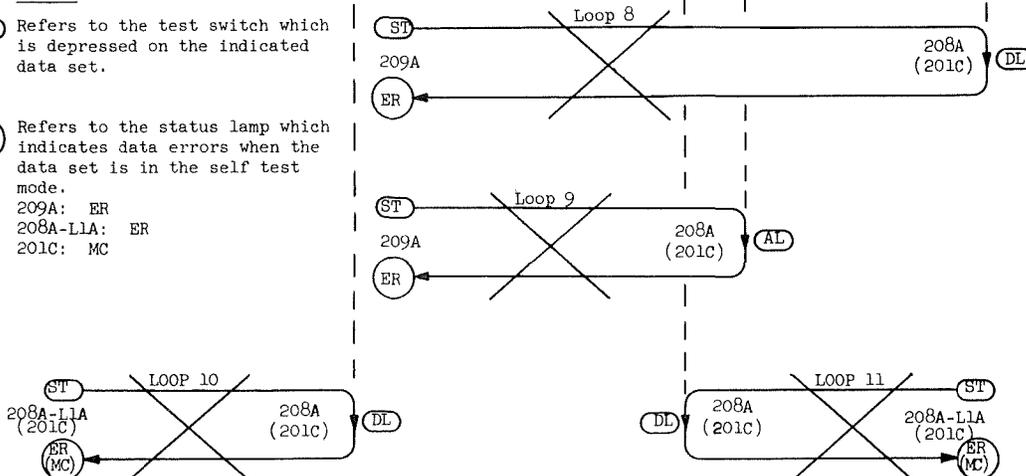
Permissible and Prohibited Signal Looping Tests for Use in  
Extension Service System Testing



(Note: Analog loopback tests of DS1, DS6, DS7, and DS10 are prohibited.)

LEGEND

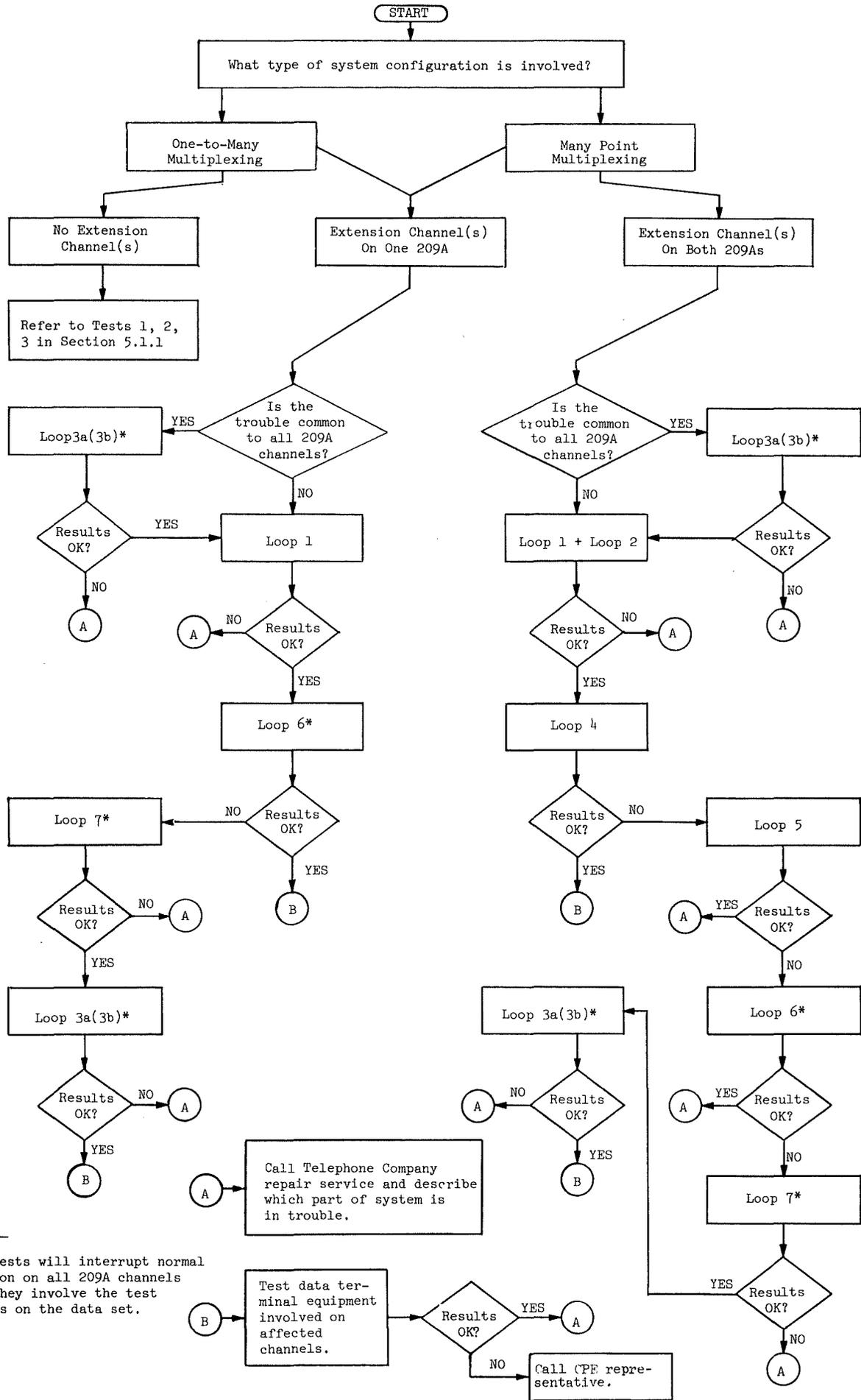
- Refers to the test switch which is depressed on the indicated data set.
- Refers to the status lamp which indicates data errors when the data set is in the self test mode.  
209A: ER  
208A-L1A: ER  
201C: MC



NOTE 1: Coordination of testing will be required between locations under control of the customer's personnel. A designated control location should be used.  
NOTE 2: Analog loopback self tests of data sets DS2, DS3, DS4, DS5, DS8, and DS9 are permissible.

NOTE 3: Any tests using the ST, AL, or DL switches on the 209As will affect operation on all connectors and will interrupt normal data transmission through the 209A link in the system.  
NOTE 4: The 208A-L1 data set has no self test capability. If this data set is used, external test equipment must be plugged into the outlier cord of that data set to generate test patterns and to check for errors.

**FIGURE 14**  
**Procedures to Systematically Isolate Problems**  
**on Extension Service Systems**



\* These tests will interrupt normal operation on all 209A channels since they involve the test switches on the data set.

TABLE 1

SWITCH POSITIONS AND LAMP STATUS FOR SELF TESTS AND TESTS WITH EXTERNAL TEST EQUIPMENT OR DATA TERMINAL

SWITCH OR LAMP STATUS	TEST 1	TEST 2		TEST 3	TEST 4	TEST 5 <sup>†</sup>		TEST 6	
	ANALOG LOOPBACK SELF TEST	DIGITAL LOOPBACK SELF TEST	LOCAL	FAR-END	END-TO-END SELF TEST (BOTH SETS)	ANALOG LOOPBACK TEST	DIGITAL LOOPBACK AT FAR-END	TELCO REMOTE TEST LOCAL SET	
							LOCAL	FAR-END	
SWITCHES*									
MUX SELECTOR	NOTE 1	NOTE 1	NOTE 1		NOTE 1	NOTE 1	NOTE 1	NOTE 1	NOTE 1
LP	NOTE 2	NOTE 2	NOTE 2		NOTE 2	NOTE 2	NOTE 2	NOTE 2	NOTE 2
AL	X					X			
ST	X	X			X				
DL				X				X	X
* X = SWITCH DEPRESSED, BLANK = SWITCH NOT DEPRESSED						† This test cannot be performed from a local 209A if it has the slaved timing option IN.			
LAMPS <sup>†</sup>									
ON	0	0	0	0	0	0	0	0	0
MR						NOTE 3	0		
RS	0	0	0	0	0	NOTE 4	NOTE 4	NOTE 9	NOTE 9
CS	0	0	0	0	0	NOTE 5	NOTE 5	NOTE 5	NOTE 5
CO	0	0	0	0	0	NOTE 6	NOTE 6	NOTE 6	NOTE 6
ER	NOTE 10	NOTE 7	NOTE 8		NOTE 7	NOTE 8	NOTE 8	NOTE 8	NOTE 8
TM	0	0	0	0	0	0	0	0	0

<sup>†</sup>0 = LAMP IS LIT, BLANK = LAMP IS NOT LIT

- Note 1: Position can be in any of the five regular multiplex positions as required by customer's arrangement.
- Note 2: LP should be depressed to check operation of status lamps prior to testing. LP is nonlocking.
- Note 3: MR lamp will be lit if the Data Set Ready in AL mode option is installed with CC in ON condition. Otherwise, MR will be out.
- Note 4: RS will light when test set or data terminal turns Request-to-Send ON or if continuous Request-to-Send option is used.
- Note 5: CS will light when data is being transmitted. CS will be out when RS is out.
- Note 6: CO will light when line signal is detected. Otherwise, CO is not lit. CO should always be lit when continuous carrier is installed in far-end data set. CO lights only when far-end data set transmits if switched carrier is installed.
- Note 7: Satisfactory performance is indicated by 6 flashes/minute or less averaged over 5 minutes.
- Note 8: ER will light during retraining (briefly) and will be out during remainder of time.
- Note 9: RS will light if CO lamp lights or if continuous Request-to-Send option is installed.
- Note 10: ER lamp should not light during this test.

TABLE 2

Special Connecting Cables for Many Point  
and One-to-Many Multiplexing Configurations  
When Extension Service is Involved

Extension Service Cord

Timing Cord

(On the collocated lower speed data set connected to Data Set 209A)

(On the remote lower speed data set)

Data Set 209A End			Interfacing Data Set End	
<u>Circuit</u>	<u>Pin</u>	to	<u>Circuit</u>	<u>Pin</u>
BA	2	to	BB	3
BB	3	to	BA	2
CA	4	to	CF	8
CF	8	to	CA	4
DD	17	to	DA	24
DA	24	to	DD	17
AA	1	to	AA	1
AB	7	to	AB	7

(no other conductors used)

For Bell System Data Sets 201C  
and 208A:

The timing cord provides 25-conductor cable in which pin 18 (DCR) is wired to pin 24 (DA). These two pins are not continuous to the customer interface connector. The end of this short cord appears in a regular 25-pin female connector compatible with the customer provided plug from the data terminal.

For Customer-Provided Data Sets:

An equivalent customer-provided cord may be used if there is a DCR circuit provided on pin 18 of the customer-provided data set. Otherwise, a functionally equivalent connection of the receiver timing to the DA circuit inside the customer-provided data set must be used. Note, however, that the receiver timing signal (DD) must be provided to the data terminal on pin 15 as well.

Each end of cord must be terminated in a male plug to permit connection to a data set (female) connector.

TABLE 3

Request-to-Send Clear-to-Send Delays  
in Switched Carrier Operation

Nonmultiplexing (applies to CA, CB circuits on connector No. 1)

Data Terminal Turns CA Circuit ON  
Within X ms of Turning CA OFF

0 < X < 3 ms

3 < X < 50 ms

X > 50 ms

Data Set Turns CB Circuit  
ON After a Delay of

8 ms

(200 - X) ms  
(at least 150 ms)

150 ms

Multiplexing (applies to CA, CB circuits on all active connectors)

First Data Terminal  
Turns CA ON Within  
X ms of All CA OFF

0 < X < 3 ms

3 < X < 50 ms

X > 50 ms

Resulting CA-CB  
Delay to First  
Data Terminal

8 ms

(200 - X) ms  
(at least 150 ms)

150 ms

Second (and Later)  
Data Terminal  
Turns CA ON Within  
Y ms of All CA OFF

0 < Y < 3 ms

Y > X  
3 < Y < 50 ms

Y > X  
Y > 50 ms

Resulting CA-CB  
Delay to Second  
(and Later)  
Data Terminal

8 ms

(200 - Y) ms  
(at least 150 ms)

[150 - (Y - X)]ms  
(at least 8 ms)

TABLE 4

References to Test Procedures and Acceptability Criteria  
for Customer Performed Loop Tests of Extension Channel Systems

<u>Loop Test No.</u> (See Figure 13)	<u>See Test Procedures In</u> (document title)	<u>Acceptability Criteria</u> (Maximum Average Error Indications per Minute)
Loop 1, Loop 2	Data Set 208A (201C) Technical Reference - TEST 3	3(2)* (1X10 <sup>-2</sup> ) <sup>†</sup>
Loop 3 (a,b)	TEST 2 in this document (Section 5.1.1)	6 (1X10 <sup>-2</sup> ) <sup>†</sup>
Loop 4	Data Set 208A (201C) Technical Reference - TEST 3	12(10)* (3X10 <sup>-2</sup> ) <sup>†</sup>
Loop 5	Data Set 208A (201C) Technical Reference - TEST 3 (depress AL switch at far-end 208A (201C))	9 ( 8)* (2X10 <sup>-2</sup> ) <sup>†</sup>
Loop 6	Data Set 208A (201C) Technical Reference - TEST 3 (depress DL switch on 209A at far-end)	9(8)* (2X10 <sup>-2</sup> ) <sup>†</sup>
Loop 7	Data Set 208A (201C) Technical Reference - TEST 3 (depress AL switch on 209A at near-end)	3(2)* (1X10 <sup>-2</sup> ) <sup>†</sup>

\* Numbers in parentheses refer to acceptability criteria for Data Set 201C with self-test circuitry. The other number refers to criteria for Data Set 208A-L1A with self-test circuitry.

<sup>†</sup> These numbers are the supported error criteria for the various loop arrangements expressed in terms of 1000 bit block error rate if the loop tests were made with test equipment which measured this parameter.