Bell System Data Communications

TECHNICAL REFERENCE

DATA SETS 202C and 202D INTERFACE SPECIFICATION

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May 1964

American Telephone & Telegraph Company

Engineering Director Data Communications

Bell System Data Communications

TECHNICAL REFERENCE MANUAL

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Data Sets

202C and 202D

Interface Specification

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May 1964

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DATA AND TELETYPEWRITER PLANNING ENGINEER

PREFACE

This specification is specifically intended for designers of business machine equipment to be used with Bell System Data Sets 202C and 202D in DATA-PHONE and similar services.

If additional details on the interface and its operation are needed, please contact:

Data and Teletypewriter Planning Engineer
American Telephone and Telegraph Company
195 Broadway
New York, N.Y., 10007

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DATA SET 202C AND 202D – INTERFACE SPECIFICATION

1. GENERAL

Data Sets 202C and 202D supersede Data Sets 202A and 202B. The new models meet new interface standard EIA RS-232-A of October 1963, have additional features, rearranged packaging, and improved performance. The intended field of use of the data sets is as follows:

Data Set	Use
202C	DATA-PHONE Service where an integrated equipment arrangement is desired and alternate voice-data private line service.
202D	Data only private line service.
202D with Data Auxiliary Set 804A1	DATA-PHONE Service and alternate voice-data private line service where a separate equipment arrangement is desired.
	Alternate 2-wire private line – 1 line DATA-PHONE Service.
202D with Data Auxiliary Set 804A2	Alternate 4-wire private line – one line DATA-PHONE Service and alternate 4-wire private line – 2 line DATA-PHONE Service.

2. COMPARISON WITH EARLIER MODELS

Data Sets 202C and 202D differ from Data Sets 202A and 202B in the ways described in the following sub-paragraphs.

2.1 Interface

The interface will conform to EIA RS-232-A in that voltage levels will be used for communication on all leads. A lead by lead discussion of the interface is contained in Part 4.2.

2.2 Reverse Channel

An optional reverse channel will be available. This feature is intended to provide a break feature, circuit assurance, and some forms of feedback for error detection and correction systems. More information about this feature is contained in Part 5.4.

2.3 Compatibility with Automatic Calling Systems

The new data sets are compatible with the standard version of automatic calling units (ACU). Data Sets 202A and 202B were compatible with model shop versions of ACU's, but not with the standard ACU's. ACU applications are expected to be limited to systems employing the unattended answering feature. The reason for this is that the standard ACU requires the receipt of a 2025 cps tone (except in the end of number mode) before turning the circuit over to the data set. Data Sets 202C and 202D (Data Auxiliary Set 804A is required to provide this capability with Data Sets 202D) provide this tone.

For information about ACU's please refer to:

Bell System Data Communications

Technical Reference

Automatic Calling Unit 801A

which is available from:

Data and Teletypewriter Planning Engineer
American Telephone and Telegraph Co.
195 Broadway
New York, New York 10007

2.4 Alternate Private Line – DATA-PHONE Service

Data Set 202D when connected to Data Auxiliary Sets 804A can provide an alternate Private Line – DATA-PHONE Service. More about this feature is contained in Parts 4.14 and 6.2.

2.5 Packaging

Packaging has been rearranged to provide a data set (202D) that can be applied to data only private lines without limiting the required features. This was done by providing the line control in a separate package with a telephone (804A). Contents of the line control are outlined in Part 4.13.

The data sets have been packaged in modular form employing replaceable cards to facilitate manufacturing and repair.

A connector has been added to the mounting cord and special connecting blocks have been developed to permit quicker installation.

2.6 Improved Performance

The modulator has been given more line output levels to permit better matching with its loop facility. The demodulator has been given greater sensitivity and the ability to withstand greater attenuation distortion.

2.7 Improved Request-to-Send Circuit

The Request to Send (CA) circuit has been revised so that there is no limitation on the time required to switch Request to Send from OFF to ON. The likelihood of receiving false spacing signals at the end of a message has been materially reduced. The transient which caused the false signals has been reduced by having the oscillator shifted out-of-band instead of OFF when Request to Send is turned OFF and when Transmitted Data is held marking. It is necessary to turn Request to Send OFF at the end of a message to take advantage of this feature, i.e., turning Data Terminal Ready OFF and thereby dropping the call will not minimize the transient.

2.8 Improved Carrier Detector

The carrier detector of the earlier model data sets measures the received energy across the voice band and when a certain level is exceeded for 50 ±10 milliseconds the carrier detector lead is turned ON. In this arrangement voice signals from a telephone transmitter can turn the carrier detector ON. In Data Sets 202C and 202D the carrier detector measures the energy within the data band (approx. 1000 to 2300 cps), see Fig. 11, and also the energy in the circuit outside of this band. If the energy within the data band is above a certain level and the energy outside the data band is below a certain level and this condition has existed for 40 ± 10 milliseconds the Data Carrier Detector (CF) lead will be turned ON. This arrangement minimizes the likelihood of Data Carrier Detector being turned ON by noise or voice signals.

2.9 Operating Change

Manual Operation of Data Sets 202C and 202D with Data Auxiliary Set 804A has been changed from that used with Data Sets 202A and 202B to permit echo suppressors to be disabled. This is discussed in Part 6.1.

3. THE SYSTEM

The Data Sets 202 provide a medium speed, binary, serial data transmission system for use in DATA-PHONE Service or in private line service.

Data Sets 202 accept and deliver binary DC data pulses at rates up to 1200 bits per second for DATA-PHONE Service and at rates up to 1800 bits per second for service on appropriately conditioned private line facilities (see Part 5.3). The accepted pulses are converted into FM signals suitable for transmission over voice band telephone facilities. The data sets receive and restore these FM signals to their original DC form for delivery to the receiving business machine.

The interface signals exchanged between the business machines and data sets are in bipolar voltage form and conform to the Electronics Industries Association Standard RS-232-A of October 1963.

The data sets place no restriction as to the code used or the number of consecutive marks and spaces. No synchronization system (timing) is provided by the data set. AIEE Paper No. 58-300 titled Synchronized Clocks For Data Transmission by Edson, Flavin, and Perry can be used as a reference by designers of receiver synchronization circuits.

4. DATA SETS 202C AND 202D AND DATA AUXILIARY SET 804A

4.1 Physical Characteristics

4.11 Data Set 202C

The Data Set 202C shown in Figure 1 consists of a six button key unit, a telephone handset, a dial, an FM modulator and demodulator with line coils for either 2-wire or 4-wire telephone line, a power supply, a remote test circuit and line control circuit. The overall dimensions of the data set are approximately 11 inches wide, 5½ inches high, and 14½ inches

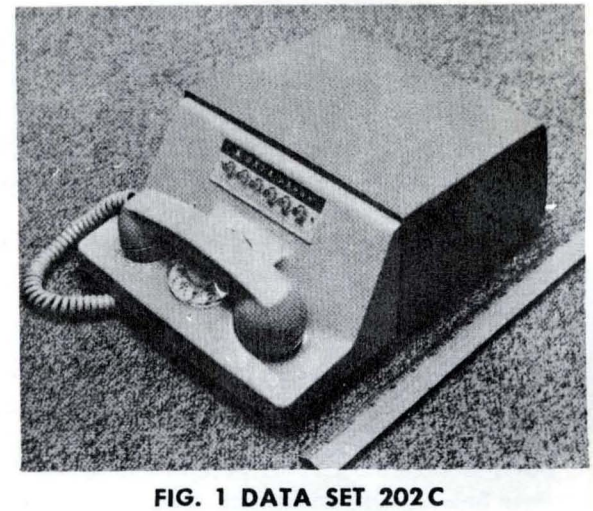


FIG. 1 DATA SET 202C

deep. The keys located on the data set may be used to select Talk, Data, Test and Auto (optional for unattended answering of data calls) conditions. The data set will operate satisfactorily over a temperature range of +50° to +120°F and a relative humidity range of 20% to 95%. The data set weighs approximately 15 pounds.

4.12 Data Set 202D

The Data Set 202D shown in Figure 2 is essentially the same as the Data Set 202C without a built-in telephone or line control. The Data Set 202D contains an FM modulator and demodulator, two line coils for terminating either 2-wire or 4-wire lines, and a remote testing circuit. The overall dimensions are approximately 11 inches wide, 5½ inches high, and 10¼ inches deep. The data set will operate satisfactorily over the same temperature and relative humidity ranges as the Data Set 202C. It weighs approximately 14 pounds. It can be used in one-way, two-way non-simultaneous, and two-way simultaneous applications (on 4-wire lines).

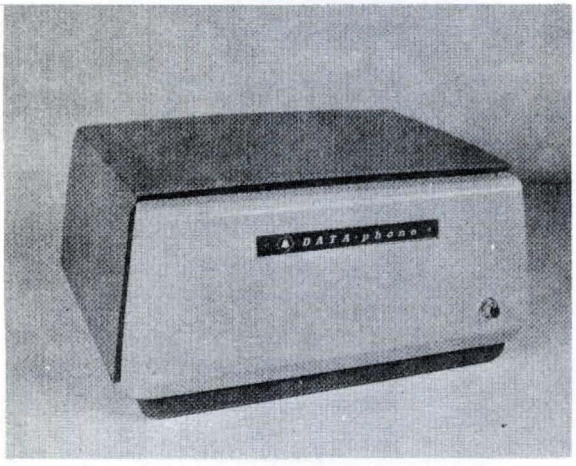


FIG. 2 DATA SET 202D

4.13 Data Auxiliary Sets 804A

Data Auxiliary Set 804A1 shown in Figure 3 consists of a telephone, a six button key unit, a dial, and a line control. The line control contains the logic for transfer between TALK and DATA, unattended answering, disabling echo suppressors, and working with ACU's. The overall dimensions are approximately 4¼ inches high, 9 inches wide, and 9 inches deep. The Data Auxiliary Set will operate satisfactorily over the same temperature and relative humidity ranges as Data Sets 202. It weighs approximately 8 pounds. It is intended for use with Data Set 202D in alternate voice-data private line and DATA-PHONE Service where a separate equipment arrangement is desired.

FIG. 3 DATA AUXILIARY SET 804A

The controls and some of the logic for an alternate private line – DATA PHONE Service feature is provided. This feature is intended for predominantly private line users who want to back-up their private line links with DATA-PHONE Service and for users that have private line systems but the traffic density to some prospective stations is too light to make extension of the private line circuits economically attractive. The DATA-PHONE Service available for this feature is limited to manual establishment of calls. The alternate service is provided in three possible ways:

Two-wire private line to one line DDD (804A1)

Four-wire private line to one line DDD (804A2)

Four-wire private line to two line DDD (804A2)

The third way requires that two calls be established and permits full duplex DATA-PHONE Service, but unattended answering is not available. The operator controls the selection of these options through the six button key unit located on the Data Auxiliary Set 804A2. Operation of the alternate private line – DATA-PHONE Service is discussed in Part 6.2. Data Auxiliary Set 804A2 is identical in all respects to Data Auxiliary Set 804A1 except that a transfer relay is provided for 4-wire to 2-wire option changes.

4.2 Interface

The interfaces of the Data Sets 202C and 202D discussed in the following paragraphs

conform with EIA Standard RS-232-A of October 1963. The data sets have identical interfaces.

4.21 Connector

The customer's data equipment should be equipped with a cable terminating in a Cinch or Cannon DB-19604-432 plug mounted in a Cinch DB-51226-1 hood assembly or equivalent. The receptacle on the data set is equivalent to a Cinch or Cannon DB-19604-433, and is equipped with threaded retaining spacers. The DB-51226-1 hood assembly includes retaining screws which enter these spacers, retaining the plug against accidental disengagement.

The cable should not exceed 50 feet in length.

A detailed discussion of the characteristics of the interface connector are covered in:

Bell System Data Communications
TECHNICAL REFERENCE
INTERFACE CONNECTORS

LEAD	STANDARD RS-232-A	TEMPORARY OPTIONAL DATA SET 202A AND 202B
1	Protective Ground (AA)	Frame Ground
2	Transmitted Data (BA)	Send Data (SD)
3	Received Data (BB)	Received Data (RD)
4	Request to Send (CA)	Request-to-Send (RS)
5	Clear to Send (CB)	Clear-to-Send (CS)
6	Data Set Ready (CC)	Interlock (INT)
7	Signal Ground (AB)	Signal Ground
8	Data Carrier Detector (CF)	Carrier ON-OFF
9	Reserved for Testing*	Positive Power*
10	Reserved for Testing*	Negative Power*
11	Supervisory Transmitted Data (SA)	-
12	Supervisory Received Data (SB)	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	Remote Releaseϕ (RR)
20	Data Terminal Ready (CD)	Remote Controlϕ (RC)
21	-	Ready ϕ (RY)
22	Ring Indicator (CE)	Ring Indicator 1ϕ (RI)
23	-	Ring Indicator 2ϕ (RI)
24	-	-
25	-	-

* Business Machine not to be connected to this lead

ϕ Contact Closure Lead

Fig. 4 Data Set 202C & 202D Interface Connections

The allocation of the leads in the connector is shown in Figures 4 and 5. The data set interface connector is located at the rear of the cabinet.

4.22 Standard Interface Lead Definitions

Circuit AA – Protective Ground – Lead 1

This conductor is electrically bonded to

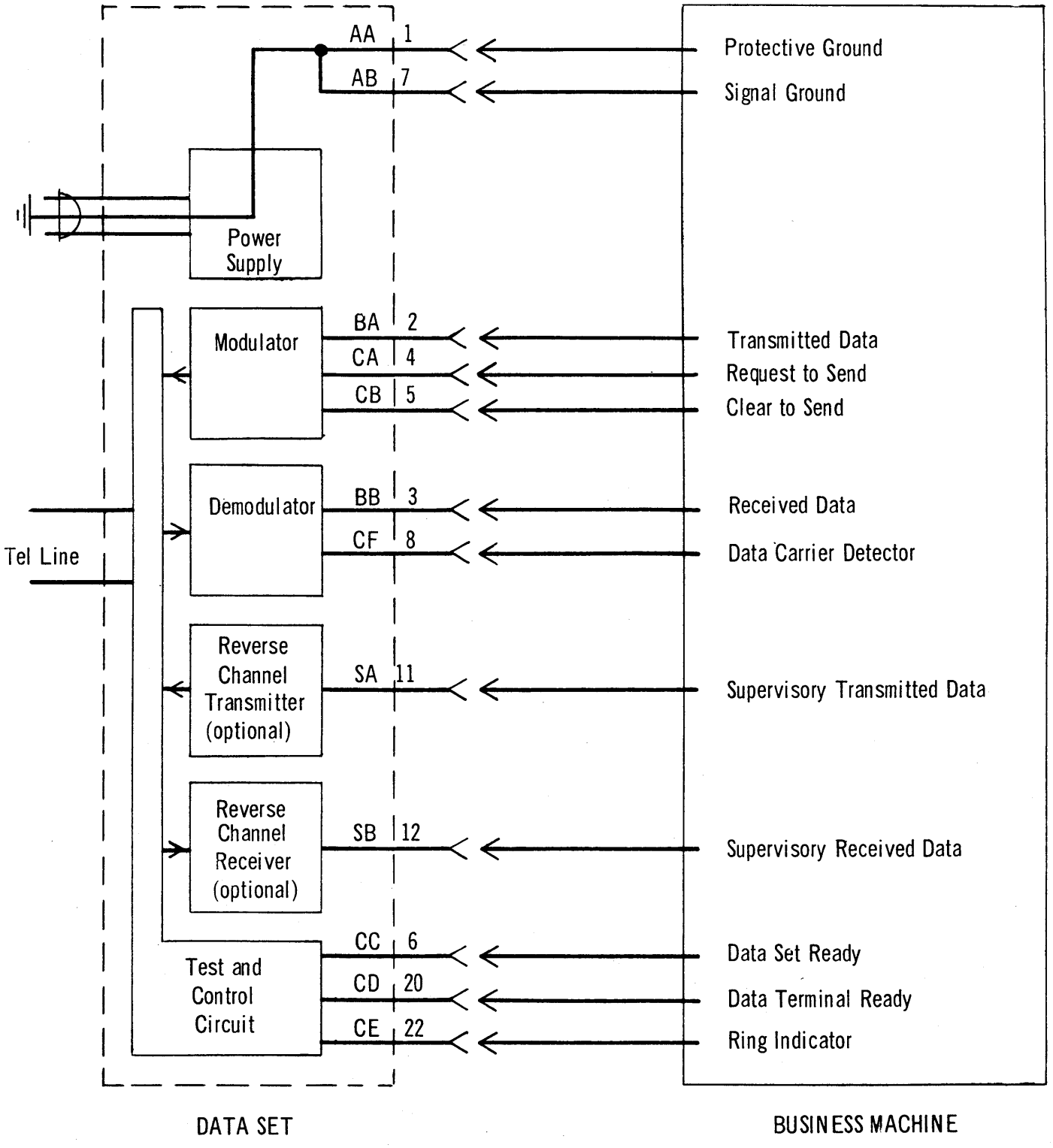


Fig. 5 Simplified Interface Block Diagram

the equipment frame. It is further connected to external grounds through the power cord.

Circuit AB – Signal Ground – Lead 7

This conductor establishes the common ground reference potential for all interchange circuits except Protective Ground.

It is connected to the frame and to Protective Ground, to minimize the introduction of noise into electronic circuitry.

Circuit BA – Transmitted Data – Lead 2

Direction: TO data set

Signals on this circuit are generated by the transmitting business machines and are connected to the transmitting data set for transmission to remote business machine equipment.

The transmitting business machine equipment must hold Transmitted Data in the OFF condition when no signals are to be transmitted.

Business Machine equipment designed for Receive-Only service must hold this circuit OFF at all times.

The OFF or ON signal condition shall be held for the total duration of each signal element.

Circuit BB – Received Data – Lead 3

Direction: FROM data set

Signals on this circuit are generated by the receiving data set in response to data signals received from remote business machine equipment.

In half-duplex service, the receiving data set holds OFF condition on Received Data when both data processing terminals have their Request to Send in the OFF condition. In half-duplex service, the Received Data Circuit follows the Local Transmitted Data Circuit and may be used to monitor transmitted signals (e.g., for local copy).

The OFF or ON signal condition is held for the total duration of each signal element.

Circuit CA – Request to Send – Lead 4

Direction: TO data set

Signals on this circuit are generated by the business machine equipment to condition the local data set to transmit. The carrier signal is transmitted during the ON condition of Request to Send.

The ON condition must be maintained whenever the business machine equipment has information ready for transmission or being transmitted. The data set transmits all data on Transmitted Data, while the ON condition is maintained on Request to Send, Clear to Send, and Data Set Ready. The Request to Send lead must not be turned OFF for at least 1 millisecond after the end of the last bit that is applied to the Transmitted Data lead. This is to insure that the last bit clears the modulator before carrier is turned OFF. If local copy is being received on 2-wire circuits from the demodulator of the set that is transmitting, it will be necessary to delay the OFF signal on the Request to Send lead four milliseconds instead of one millisecond. This is to allow the last bit to clear the demodulator before the squelch circuit clamps the output of the demodulator.

In half-duplex service, the OFF condition holds the data set in the receive-data condition, and the ON condition holds the data set in the transmit-data condition. The above conditions are established without regard to signals on Transmitted Data and Received Data.

Business machine equipment designed for Receive-Only service must hold Request to Send in the OFF condition at all times.

Business machine equipment designed for either Transmit-Only or Full-Duplex service may hold Request to Send in the ON condition at all times.

On a multipoint communication channel which may successively carry data signals transmitted by several data communication equipment stations, Request to Send must be used by each data processing terminal equipment to condition its local data set to transmit.

Circuit CB – Clear to Send – Lead 5

Direction: FROM data set

Signals on this circuit are generated by the transmitting data set to indicate that it is prepared to transmit data. The ON condition is a response to the ON condition on Request to Send delayed 200 ±20 milliseconds (except when Request to Send is turned ON during handshaking) to permit the data communication equipment to

establish a communication channel to a remote data processing terminal. When Request to Send is turned OFF, Clear to Send is also turned OFF.

In Receive-Only service, the data set holds Clear to Send OFF at all times.

Circuit CC – Data Set Ready – Lead 6

Direction: FROM data set

Signals on this circuit are generated by the local data set to indicate that it is ready to operate.

The OFF condition indicates either:

A. Any abnormal or test condition which disables or impairs the service furnished.

B. That the communication channel is switched to the voice mode.

C. That the local data set is not connected to a communication channel (i.e., the data set is on hook).

The ON condition appears at all her times.

This circuit indicates the status of the local data set. The ON condition should not be interpreted either as an indication that a communication channel has been established to a remote station or the status of any remote station or equipment.

Circuit CD – Data Terminal Ready – Lead 20

Direction: TO data set

Signals on this circuit are used to control switching the data set to the communication channel. The ON condition permits the data set to be connected to the communication channel. However, if the station is equipped only for call origination by means external to this interface (e.g., manually or an automatic call origination unit), then the ON condition serves only to maintain the connection established by these external means. When the station is wired for automatic answering of received calls, connection to the line is arranged to occur in response to a ringing signal.

The OFF condition removes the data set from the communication channel, for such reasons as:

A. Freeing the line for alternate use (e.g., voice or use by other stations).

B. Permitting use of the business machine equipment for an alternate function.

C. Terminating a call (i.e., going on hook).

The OFF condition does not disable the operation of Circuit CE (Ring Indicator).

It should be noted that in stations wired for unattended answering (not using the AUTO key option) when it is desired to answer manually, Data Terminal Ready will be held OFF. Once the operator answers manually and decides to go to the data mode, the call will fall down if Data Terminal Ready is OFF when the DATA key is pushed.

Circuit CE – Ring Indicator – Lead 22

Direction: FROM data set

Signals on this circuit indicate that a ringing signal is being received from a remote station. This circuit is used for automatic answering of received calls.

The ON condition indicates that a ringing signal is being received. The OFF condition is maintained at all other times.

Operation of this circuit is not disabled by an OFF condition on Data Terminal Ready.

Circuit CF – Data Carrier Detector – Lead 8

Direction: FROM data set

Signals on this circuit are used to provide an indication that the data carrier is being received and has been received for at least 40 ±10 milliseconds. When the data carrier is lost because the transmitting data set is turned OFF or because of a fault condition, the OFF condition follows after a 15 millisecond guard time delay.

In half-duplex service the Data Carrier Detector responds to carrier signals from either the local or remote transmitting data set.

The ON condition indicates reception of the data carrier. The OFF condition provides an indication of the end of present transmission activity or a fault condition.

Circuit SA – Supervisory Transmitted Data – Lead 11

Direction: TO data set

Signals on this circuit are used for com-

munication from the receiving data set to the transmitting data set simultaneous with the normal data channel. This channel can only be used when Request to Send is OFF. This lead is provided only on data sets equipped with reverse channels.

Circuit SB – Supervisory Received Data – Lead 12

Direction: FROM data set

Signals on this circuit are used to inform the transmitting data set of conditions at the receiving data set simultaneous with the normal data channel. This lead is provided only on data sets equipped with reverse channels.

4.23 Interface Electrical Characteristics

Data Sets 202C and 202D conform to the electrical characteristics contained in RS-232-A and will work with business machines that also conform to that specification. These characteristics are briefly outlined in the following paragraphs.

4.231 The maximum open-circuit voltage to either Protective Ground on any interchange circuit does not exceed 25 volts, and the maximum short-circuit current flow between any two conductors (including grounds) does not exceed one-half ampere.

4.232 All circuitry used to generate signal voltages on interchange circuits are designed so that no damage will be caused by either an open circuit condition or a short-circuit to either Protective Ground or Signal Ground. All circuitry used to receive signals from interchange circuits is designed for continuous operation with any input signal within the maximum voltage limits.

4.233 For Transmitted Data and Received Data, the signal is considered in the marking condition when the voltage on the circuit is more negative than minus three volts with respect to Signal Ground, and the signal is considered in the spacing condition when the voltage is more positive than plus three volts with respect to Signal Ground. During transmission of data, the marking condition is used to denote the binary state ONE (e.g., hole punched in paper tape), and the spacing condition is used to denote the binary state ZERO. Note that marking is the normal condition on a data circuit when no signals are present.

Summary of Data Circuit Interface Terms

Binary State	ONE	ZERO
Signal Condition	Marking	Spacing
Voltage	Negative	Positive
Paper Tape	Hole	No Hole

For all control circuits the control function is considered ON when the voltage on the circuit is more positive than plus three volts with respect to Signal Ground, and is considered OFF when the voltage on the circuit is more negative than minus three volts with respect to Signal Ground.

Summary of Control Circuit Interface Terms

Control Function	OFF	ON
Voltage	Negative	Positive

4.234 The operation of the circuitry that receives signals from an interchange circuit is dependent only on the signal voltage, and is, therefore, insensitive to the rise time, fall time, presence of signal overshoot, etc. The design of this circuitry minimizes the effects of any circuit time constants which would delay the circuit response, thus introducing time distortion in the signals.

4.235 The terminating impedance of the receiving end of interchange circuits has a d-c resistance of not less than 3000 ohms, and the voltage in open-circuited condition does not exceed two volts.

4.236 The source impedence of the sending end of interchange circuits is not specified.

4.237 For data circuits (Transmitted Data and Received Data), neither the rise time nor the fall time, through the six volt range in which the signal condition is not defined, exceeds three per cent of the nominal duration of a signal element. The circuitry used to generate a signal voltage on an interchange circuit meets this specification with any receiving termination which complies with Section 4.235.

4.238 In some applications, it may be necessary for fail-safe operation to detect either the power-off condition in the data set or the disconnection of the interconnecting cable.

Request to Send, and Data Set Ready may be used for this purpose. The power-off source impedance of the sending end of these circuits is not less than 300 ohms, measured at an applied voltage not greater than plus of minus two volts referenced to Signal Ground.

4.24 Optional Interface

For an indefinite period an interface of the Data Sets 202A and 202B type (see Fig. 4) will be made available with Data Sets 202C and 202D to facilitate interchangeability during the period of conversion to the new models. Business machine designers are encouraged to provide the new standard interface on all equipment designed to be placed in service after the second quarter of 1964.

Operation of the optional interface is described in:

Bell System Data Communications
Technical Reference
Data Sets 202A and 202B
July 1963

4.25 Power Leads

The positive and negative DC voltages which appear on leads 9 and 10 of the interface are provided to supply power to Bell System test equipment. The business machine should not connect to these leads.

4.3 Sequence of Manipulations for Data Communication

4.31 Background

To facilitate an understanding of the reasoning behind the sequence of operations in this system the purpose of the clamp and the requirements for echo suppressor disabling are briefly discussed. The clamp circuit is a means of protecting the demodulator against circuit noise. It requires a signal above a certain level and in the data band for a period of 40 ± 10 milliseconds before the demodulator is allowed to deliver a signal to the Received Data lead. If there is no signal, noise will not operate the carrier detector and clamp unless it is exclusively in the data spectrum (such as cross-talk tones might yield). If there is a signal, a high level of noise can cause the carrier detector to give an erroneous signal in 10 to 20 milliseconds and can possibly cause the carrier detector to go OFF completely. When a two-wire station that has been transmitting has its Request to Send lead turned OFF the line may reflect signals back to that station for up to the round trip delay of the circuit. To protect the demodulator of the station that has been transmitting from recovering these reflections as data, the clamp circuit causes the demodulator to be squelched against all signals for a period of 150 ± 25 milliseconds.

Echo suppressors are generally found in voice circuits that have two-wire segments and are of 1000 miles or more in overall length. They are designed to keep talker echo from disturbing the talker on a circuit being used for voice communications. The echo suppressor solves this problem by effectively opening the echo path thereby making the circuit temporarily one-way. The data set is not subject to this form of disturbance, hence the echo suppressor does not normally serve a purpose on circuits that are exclusively used for data communication. When the reverse channel is to be employed a two-way facility is required, therefore, any echo suppressors that are in the circuit must be disabled. Echo suppressors are disabled by the application of 300 ± 50 milliseconds of 2025 cps signal at a time when all other voice frequencies are quiet. This requirement is met by the automatic calling sequence under control of the ACU and by the operating technique discussed in Part 6. Echo suppressors will become enabled again if there is any period as long as 100 milliseconds without any signal on the line. In a system employing the reverse channel this last requirement must be met by the business machine terminals. This can be done by insuring that either the reverse channel transmitter or data transmitter is ON at all times after echo suppressors are disabled.

4.32 Establishing a Data-Phone Call

If a call is to be placed and answered manually it is established by the operators in the same way as any ordinary telephone call. Information about the procedure to be used when dialing a call with an ACU is contained in the material referred to in Part 2.3. If the call is to be answered unattended the RING INDICATOR (CE) lead will be turned ON for a period of approximately 1.7 seconds for each ring of the telephone line (typically, once per six seconds) the CE lead follows the rings of the telephone line to permit the answering data terminal to prepare itself, (such as getting a motor up to a stable speed) if necessary, before it answers the call by turning DATA TERMINAL READY (CD) ON. When CD is turned ON the call will be answered and DATA SET READY (CC) will be turned ON. If the answering station is to transmit first (as shown in Fig. 6) REQUEST TO SEND (CA) should be turned ON when the data set turns CC ON and CLEAR TO SEND (CB) will be turned ON after a delay of approximately 4 seconds. As soon as CB is ON the business machine can transmit unless the sending function is under control of the optional SUPERVISORY RECEIVED DATA (SB) lead. If the sending function is under control of the

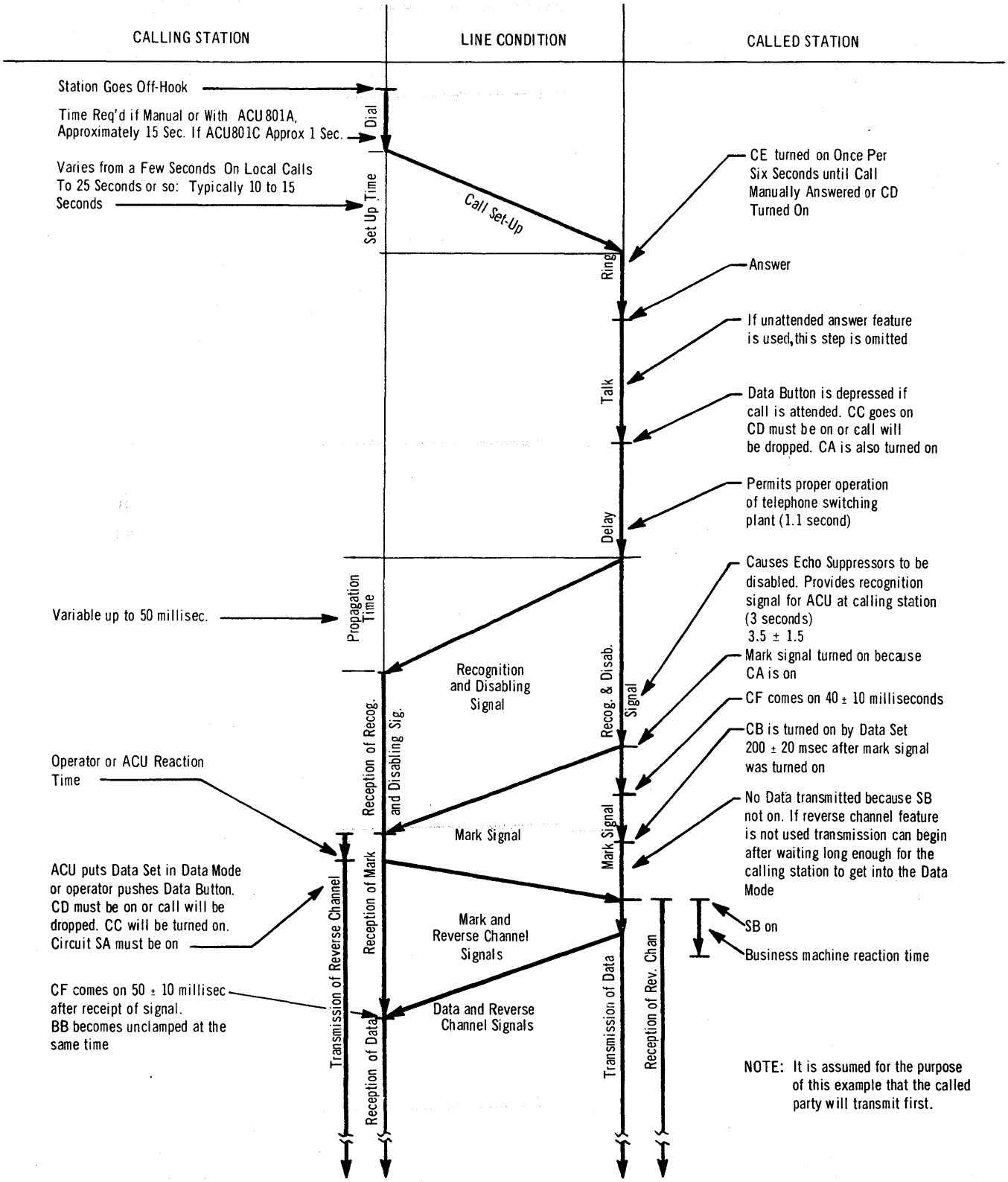


Fig. 6 Establishment of a Data-Phone Call

SB lead the transmission can start as soon as the reverse channel signal is received from the calling station.

In some arrangements a switched telephone connection will not be released until the called party hangs up. If a subscriber dials an unattended answering station in one of these situations, the connection will stay up until the business machine releases the call by turning Data Terminal Ready OFF. To avoid problems in this area, business machines arranged for unattended answering should be designed to turn Data Terminal Ready OFF whenever Data Set Ready is turned ON but Data Carrier Detector is OFF for a period of 30 seconds and has not been ON for this particular call.

4.33 Turning A Data-Phone Call Around

Once a call is established and data are being transmitted in one direction it may be desirable to turn the system around (transmit from the end that had been receiving and vice versa). At the end of a data message it is recommended that an end-of-message (EOM) code be transmitted so that the receiving business machine can be blinded against any line transients that may occur when Request to Send is turned OFF at the transmitting station (see Fig. 7). When Request to Send is turned OFF at the transmitting station the receiver (at the transmitting station) will be squelched off for a period of 150 ± 25 milliseconds to protect against reflections of the just transmitted data from the line. When the receiving station has received EOM it can bring Request to Send ON. The CB lead will be turned ON 200 ± 25 milliseconds after Request to Send has been turned ON to allow time for echo suppressors to be turned around (where the reverse channel is not being used) and for the clamp to be removed from the prospective receiver. Theoretically, the 200 ± 25 milliseconds figure in the turn around sequence of systems with echo suppressors disabled could be minimized if the business machine ignores Clear to Send and provides its own timing. The minimum delay after Request to Send is turned ON is the receiver squelch time, minus twice the propagation time of the system. Generally, in DATA-PHONE Service it is considered to be impractical to attempt to optimize the turn around time by ignoring the Clear to Send ON signal because the propagation time is widely variable. It may even vary significantly between two calls between the same points because of the alternate routing capability and the mix of facilities in the switched telephone network. The Carrier Detector (CF) lead at the prospective receiving station will come on 40 ± 10 milliseconds after data carrier is received. Data will begin to be received one propagation time and one echo suppressor turn around time (if they are not disabled) after Request to Send is ON at the prospective sending station. Business machine designers are encouraged to use a start of message (SOM) code to unblind receivers at the beginning of a message so that they can be blind to any noise conditions that may occur otherwise. Once the SOM signal is sent, the sending station can proceed to transmit data.

4.34 Terminating A Data-Phone Call

If a business machine turns a modulator OFF at the conclusion of a call by simply turning Data Terminal Ready OFF, transients will likely result which may cause spurious spacing signals to be received at the distant station. These transients can be avoided by having the business machine in the marking condition and then turning Request to Send OFF 15 milliseconds before turning Data Terminal Ready OFF. This permits the gradual removal of the oscillator from the line which minimizes the likelihood of spurious spacing signals.

After Request to Send is turned OFF at the station that transmits last and after the last EOM is received by the station that receives last, each of the business machines should cause the data sets to be disconnected from their lines by turning Data Terminal Ready OFF or by having the operators push the TALK key, lift the handset off-hook, and then go on-hook.

4.35 Data Only, Private Line Service

In point-to-point, data only, four-wire, private line service Request to Send can be held ON at both ends of the circuit. If the service is two-wire the Request to Send lead can be turned ON by the station desiring to transmit. Rarely, it may be advantageous for the business machine to supply its own clear-to-send timing and ignore Clear to Send. Since this is a two-wire facility and is still subject to reflections but since echo suppressors are not required (no voice) the minimum business machine generated clear-to-send signal is controlled by the maximum squelch time of the receiver which is 175 milliseconds less the business machine reaction time and twice the circuit propagation time.

In multipoint, data only, four-wire private line service there are two bridging techniques that may be employed. It should be kept in mind

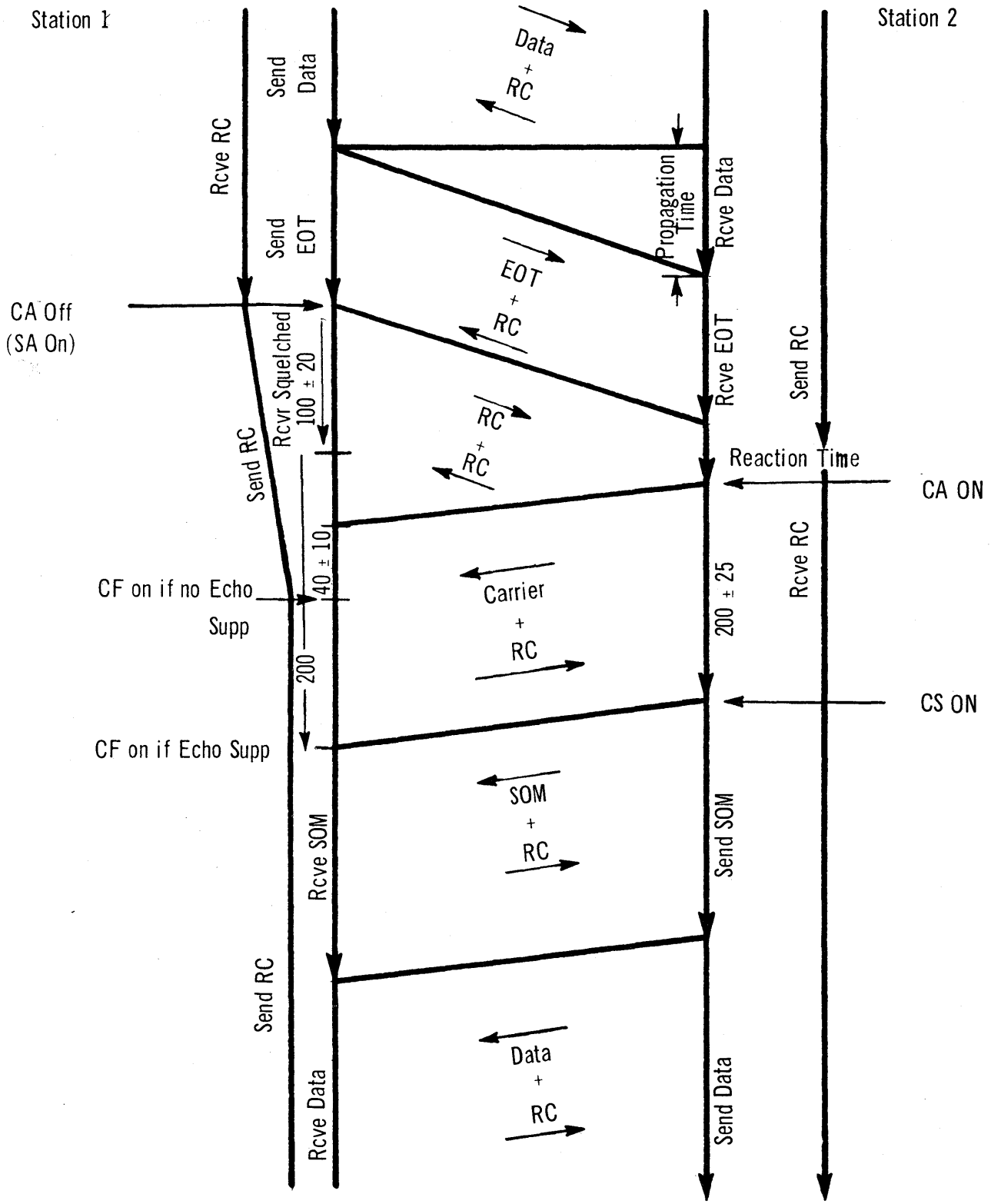


Fig. 7 Turn Around In Data-Phone Service

that the reverse channel feature discussed in Part 5.4 is not available for this four-wire service. The bridge itself is arranged such that an input from any station on the bridge is transmitted to as many as 3 or 5 other stations that are connected to the bridge but is not transmitted back to itself. Where the customer desires to obtain local copy through the receive leg, a talk-back feature may be added to the bridge.

One multipoint private line arrangement shown in Figure 8-A permits any station to transmit and receive from any other station non-simultaneously. It is also possible when the talk-back feature is not employed for any two stations to transmit and receive from each other simultaneously but systems rarely operate this way because all of the stations not engaged in the communication receive an unintelligible combination of both transmitted singals. Since this is data only service echo suppressors would not be employed. When the talk-back feature is not employed, the need for the squelch feature in the data set is eliminated because there is no path for reflections to get into the receiver. This permits reduction of the turn around time which is then controlled by the time required to remove the clamp (40 ± 10 milliseconds). If turn-around time is critical, it may be desirable to use some means other than clamp removal to protect the system against noise. The business machine may perform this function by using a multibit start of message (SOM) sequence. Some eight or greater bit character should be used in this method. A leader of at least 10 milliseconds should be transmitted before the SOM character to permit stabilization of any compandors that may be present in the circuits. A system employing this method of protection against noise may be improved (by the telephone companies) through the judicious use of pads at the input to the data set. If either of these techniques of minimizing the turn-around time are to be used it is necessary for the business machine to provide its own clear to send signal because clear to send in the data set does not have an adjustable delay.

Figure 8-B shows another multipoint private line arrangement that may be attractive where all transmissions are between a master station and a remote station (i.e., remote stations cannot intercommunicate directly). This system permits the master station to keep its Request to Send ON at all times thereby reducing the turn-around time from that possible in the system discussed above.

Figure 9 gives a comparison of the possible arrangements discussed in this section.

It should be noted that it is possible to have the data sets wired for clamp and squelch, clamp and no squelch, and neither clamp nor squelch; but it is not possible to arrange for squelch and no clamp.

In data only, private line service it is not necessary for the business machines to hold the Data Terminal Ready lead ON. For those customers desiring to minimize the number of conductors in the interface cable, the service can operate with only the Request-to-Send, Send Data, and Receive Data leads, if the informamation of the others leads is ignored.

Because of the number of variables involved in specific systems, it is strongly recommended that discussions be held at the earliest practical time between the interested parties of the telephone and business machine companies.

Two-wire multipoint private line service has not been discussed because it is not normally considered suitable for data service due to transmission considerations.

4.4 Power Requirements

Earlier models of Data Sets 202 contained a conventional full wave rectifier power supply with a moderate tolerance to the frequency of the AC supply, Data Sets 202C and D have ferromagnetic power supplies which are most sensitive to the frequency of the AC supply.

Electric power is fed to the set through a 10 foot detachable 3 wire power cord connected to the back of the set. The cord has a 3 wire plug for connection to a customer-provided 105–129 volt, 60 ± 0.6 cycle source not under switch control and on the same a.c. circuit which serves the associated business machine (to minimize noise causing impulse potentials by using the same ground bus for both machines). Data Sets 202 consume approximately 11 watts of a.c. power.

Data Sets 202C and 202D require power supplies with capacity for 145 to 220 milliamps of positive 18 ± .5 volts dc and 110 to 190 milliamps of negative 18 ± .5 volts dc.

5. APPLICATIONS

5.1 Locations

Data Sets 202 should be located so that the interface cord supplied by the business

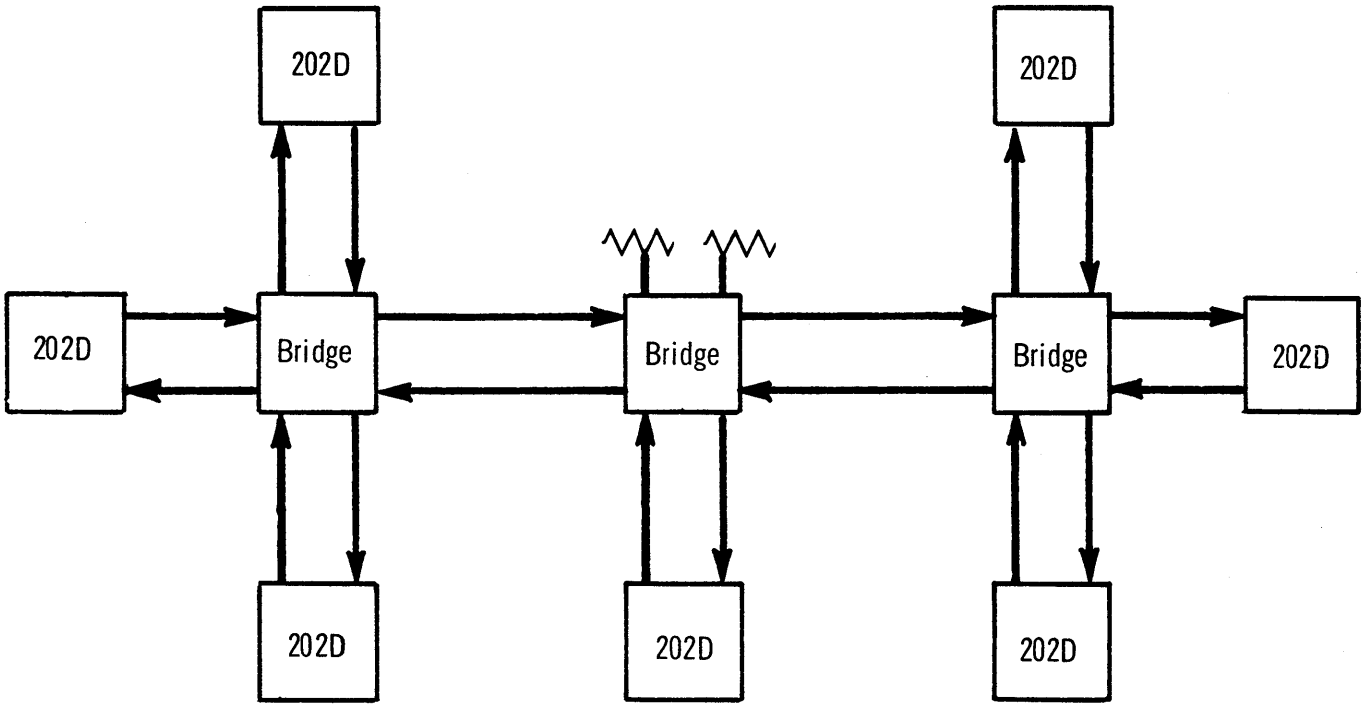


Fig. 8-A Multipoint Private Line Service Arrangement

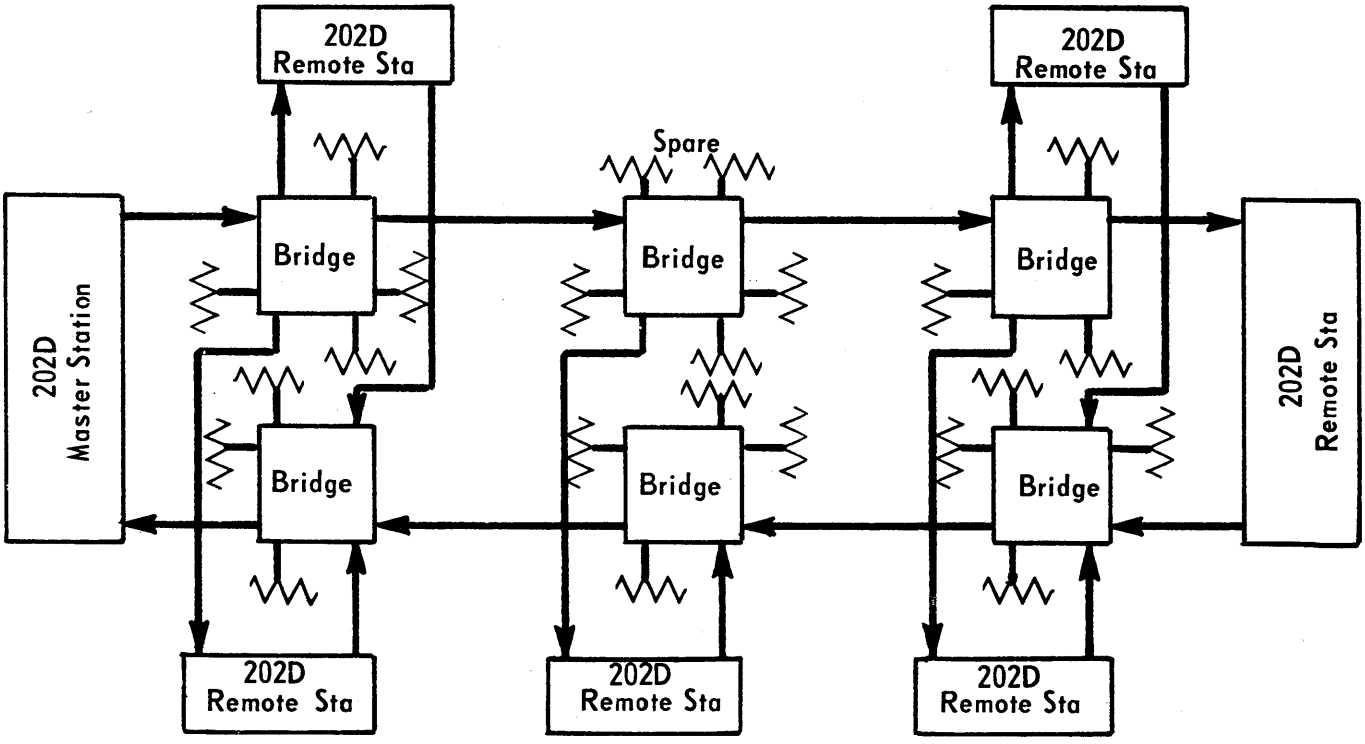
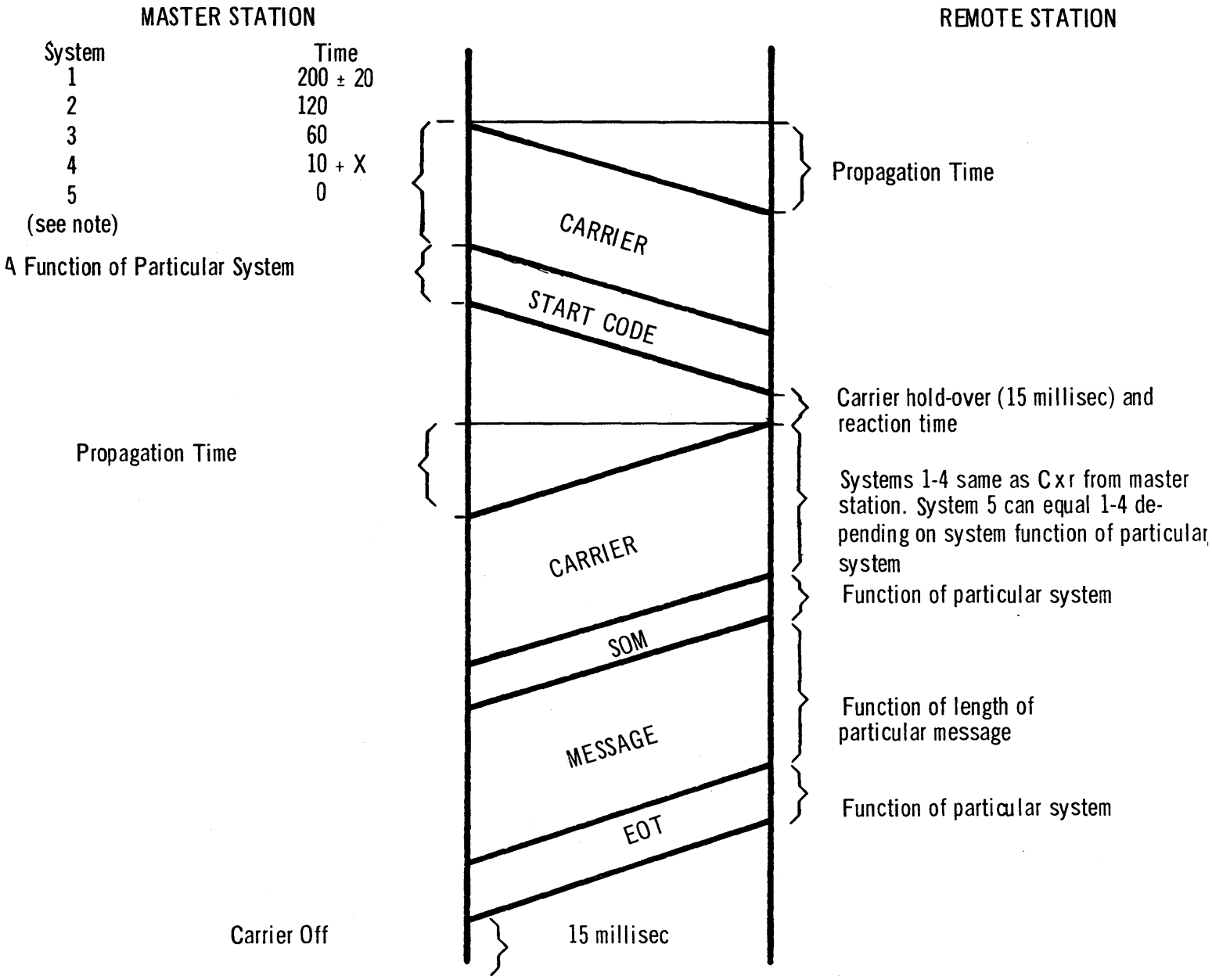


Fig. 8-B Multipoint Private Line Service Arrangement



NOTE: Systems 1-4 use circuit layout as shown in fig.8A. System 5 uses circuit layout as shown in fig 8B. System 1 uses data set CB to establish timing, clamp to protect against noise, and squelch to protect against reflections if talk-back is provided. System 2 uses clear to send timing provided by business machine, clamp to protect against noise, and squelch to protect against reflections if talk-back is provided. System 3 uses clear to send timing provided by business machine, clamp to protect against noise, and does not use talk-back or squelch. System 4 the business machine provides both timing and protection from noise – the x in the statement above allows time for transmission of any code that may be used for noise protection – the 10 milliseconds of carrier are required to insure stabilization of any compandors that may be in the circuit. For System 5 the timing requirements on the remote to master station are the same as systems 1-4 depending upon which system is used.

Fig. 9 Comparison of Times Required To Collect Messages in Multi-Point Data Only Private Line Service

machine manufacturer will not exceed 50 feet in length (to reduce stray capacitance). On all installations the housings should be left on the data sets.

The preferred installation locates the data set separate from the business machine equipment – on a nearby desk, table, stand or in Bell System provided equipment cabinets or racks (separations not to exceed prescribed limits).

Customers desiring to minimize the volume of visible space occupied by Data Sets 202 can have Data Set 202D mounted on the wall of a closet or other out-of-the-way place (within 50 feet of the business machine terminal) and Data Auxiliary Set 804A located on a desk, table, etc. where it can be operated.

5.2 Telephone Lines

In order to maintain high quality service and to minimize interference from related devices, it is preferable to use data sets on individual lines that do not have extensions. Data Set 202C can be installed on conventional key telephone systems but the hold feature can not be provided. When the Data Set 202 is used on a 4-wire private line, a line and test key is installed to permit back-to-back testing and to provide uninterrupted termination to multipoint private lines when the data set is disconnected for maintenance or testing.

5.3 Bit Rates

The maximum bit rate at which the Data Sets 202 will perform satisfactorily on the DDD network is 1200 bits per second. This limit is not a function of the data set alone but takes into consideration the nature of the network over which the sets will work. In private line service where the parameters of the transmission facility are known the maximum recommended bit rates for Schedule 4 data channels are as follows:

Conditioning Arrangement	Maximum Recommended Bit Rate
Type 4	1000 b/sec
4A	1400 b/sec
4B	1800 b/sec

The bit rates obtainable on private line facilities are based on limiting channel characteristics. The maximum bit rate possible on a given channel is also a function of how well the receiving business machine can recover synchronization in the presence of distortions.

5.4 Reverse Channel

The reverse channel was designed to provide a means of simultaneous communication from the receiver to the transmitter of two-wire data transmission systems. This optional feature is intended as a means of circuit assurance, for a break signal, and to facilitate certain forms of error control. The circuitry for providing this feature is located on a plug-in unit within the data set. The maximum signaling rate of the reverse channel is 5 bauds. In calls where line distortions result in marginal conditions, keying the reverse channel may cause interference in in the normal data channel.

6. OPERATION

6.1 Data-Phone Service and Alternate Voice-Data Private Line Service

The operation of Data Sets 202C and 202D (Data Auxiliary Set 804A is necessary with Data Set 202D) has been changed from that used in earlier models so that echo suppressors can be disabled. The operation is consistent for all Data Sets 202C and 202D (whether they have reverse channels or not). Services installed on data only private lines and those used with Automatic Calling Units do not require operator attention.

6.11 Originating Data Calls

The operator depresses the TALK key and places a telephone call to the distant terminal in the normal telephone manner. After the distant terminal answers:

Manually verbal agreement is reached as to when data is to be sent. A lamp is lighted under the TALK key of the called party. The called party pushes the DATA key first, the calling (or originating) party listens for a high pitched (2025 cps) tone, when that tone changes to a lower pitch (1200 cps – lead Request to Send ON or 387 cps – Request to Send OFF, Supervisory Transmitted Data ON, on station with reverse channel) and he then pushes the DATA key down until the associated lamp lights.

Automatically the high pitched tone will be heard for a few seconds. When that changes to a lower tone or goes OFF the DATA key (at the calling station) should be depressed until the associated lamp lights.

Noises that may get into the telephone transmitter while the operator is listening for the change in tone could keep the echo suppressor disabling circuit from functioning

properly. To minimize this possibility, the operator should not talk during this interval.

When calling a station equipped with an earlier model data set (202A or 202B) it is not necessary to wait for the change in tone (sometimes there won't be any) before going to the data mode.

6.12 Answering Data Calls

A data call can be answered manually or automatically. If the call is answered manually, the operator should insure that the TALK key is depressed and answer in the normal manner. The lamp will light under the TALK key at the called station. When verbal agreement is reached as to when transmission of data is to begin, the operator should depress the DATA key until its associated lamp lights. The set is now in the data mode and transmission can begin. If the call is answered automatically, no operation is required. The optional AUTO key can be used where it is desirable to answer in the unattended mode sometimes and the manual mode at other times. The operator depresses the AUTO key to permit the station to answer unattended.

6.13 Terminating Data Calls

A data call can be terminated in two ways; the operator can depress the TALK key, lift the handset, and hang up, or the business machines can be arranged to use Data Terminal Ready to terminate the call as described in Part 4.34.

6.14 Test

The customer may be requested by Data Test Center personnel to depress the TEST key. This will facilitate the tests mentioned in Part 9. Customer depresses the key and then places the handset in the cradle. A lamp will light under the TEST key for the duration of the tests. When the testing is completed the data set will be restored to normal and the Test lamp will go out.

6.2 Alternate DATA-PHONE – Private Line Service

Data sets equipped for alternate DATA-PHONE–Private Line Service are normally connected to the private line. When the operator wants to connect the data set to a single DATA-PHONE line the Line 1 key (second from the left and designated by the assigned telephone number) and the TALK key must be depressed. This will cause the data set to be switched from the private line and dial tone will be heard in the handset of the data set. The DATA-PHONE call should then be placed the same way as any ordinary manually placed and manually answered call. When the call is terminated the data set will be switched back to the private line.

In the case where two DATA-PHONE lines are being used to back-up a four-wire private line the first call can be established as discussed above. That call should then be held using the AUX key (first key on left), and the Line 2 key (third from the left and designated by the assigned telephone number) should be depressed and the second call established in a similar manner. The calling station Line 1 should be used to call the Line 2 of the answering station and Line 2 of the calling station should be used to call Line 1 of the answering station to insure that the transmitter at one end is connected to the receiver at the other end and vice versa. When both calls are established the customer can switch to the data mode. When these two calls are terminated, the data set will return to the four-wire private line.

The DATA-PHONE portion of stations equipped with this alternate service can be used to communicate with any other DATA—PHONE station equipped with Data Sets 202 or 3A.

When an alternate DATA-PHONE – private line station is communicating on the private line and it is called on the DDD line, the station will appear idle, i.e., the calling party will hear an audible ring but the called party will not answer.

7. GROUNDING

Ground is established for the Data Sets 202 through the ground wire of the power cord. Both frame ground and signal ground are connected to this ground.

It is expected that the customers' data equipment, if powered from commercial power, will be grounded in an appropriate manner.

A Signal ground is provided as a return for certain control or data circuits. If necessary, the signal ground lead may be connected to the ground frame of the customers' equipment. It is not proper to derive the main ground for the customers' data equipment through a ground lead from the data set.

In general, it is desirable that circuits in the customers' data equipment which connect to the data set have some path to ground. A direct or resistance ground on one side of the power supply would be an example of such a path. This practice avoids the possibility of the entire circuit involved being at an indeterminate

potential with respect to ground. Such a potential) perhaps a result of electrostatic induction, could result in insulation breakdown in the data set or the interface connector.

At the time of installation a measurement is made to determine if there are any impulsive differences of potential in the nominal voice band exceeding 2.2 volts peak to peak between the grounds of the business machine and data set. This measurement may also be taken when troubles occur.

8. COMPATIBILITY

8.1 Interface

Data Sets 202C and 202D have an interface that is compatible with any business machine that conforms with EIA Standard RS-232-A of October 1963. They also have an interface that is compatible with business machines that were designed to conform with earlier data sets 202 and 3A. The older type interface will be provided for an indefinite period. Manufacturers designing terminals are encouraged to use the RS-232-A interface.

8.2 Line Signals

Data Sets 202C and 202D can communicate with earlier Data Sets 202 except that the earlier models can not provide the reverse channel feature. This should be considered when plans are made to prevent transmission by business machine terminals unless Supervisory Received Data is ON. Earlier models of Data Sets 202 do not provide the proper answering tones for working with ACU's, so systems employing ACU's should have Data Sets 202C or 202D exclusively or should use the ACU end of number mode. Operators calling from stations equipped with a Data Set 202C or 202D to an older (202A or 202B) station will not get a change in tone if the answering station answers manually.

9. TESTING

The Data Sets 202 are equipped with a remote test feature which permits a test from a centralized Data Test Center. The test checks the following items:

1. Modulator marking frequency
2. Modulator spacing frequency
3. Demodulator output and slicing level
4. Operation of carrier detector circuit
5. Operation of the Request to Send circuit
6. Operation of the Clear to Send circuit
7. Operation of the receive data circuit
8. Operation of the send data circuit
9. In some cases, transmitting level and receiver sensitivity
10. Parts of the line control
11. Reverse Channel (if provided)

Remote testing is done at a central testing location in the telephone plant by means of tones sent over the telephone line. To check the Data Set 202, the attendant at the test center first makes telephone contact with someone at the data terminal. He then asks the customer to push the Test key and place the terminal in the test mode. In this mode, all important interface leads to the data processing equipment are disconnected from the data set with all output leads given negative or idle mode potentials. At the same time, suitable interconnections are made between receiver output, transmitter input and certain control functions in the line control unit. Maximum load is placed on all output leads and minimum input is applied to all input leads.

The data set is now in the automatic answering mode. The tester hangs up and calls the data station again which then answers automatically with the 2025 cps cycle tone. Following this tester begins testing.

Tones from the test center are derived from a calibrated oscillator. The tester listens for the transmitted tone as well as for the tone coming back from the data terminal. To ascertain whether there are any defects in most of the interface inputs and outputs as well as to determine the receiver slicing and the accuracy of the mark and space frequencies coming from the data set, the tester slides the oscillator frequency up and down in prescribed sequences between mark and space frequencies. The tester may also estimate transmitter send level and receiver sensitivity if he knows the line loss. By suitable filtering and test tone offset, he may select the specific tone from the data set and measure its level. Similarly, he may measure the oscillator level at which the data set drops off the line (it is held on line through the carrier-on-indicator).

During the testing, the tones from the data set are interrupted internally by means of a circuit which switches the tones ON and OFF to prevent the data set from locking itself into one state during testing.

In addition to these tests, equipment is available such that the transmitting and receiving business machines may be replaced by Bell System test sets and end-to-end tests can be made to give an indication of the performance

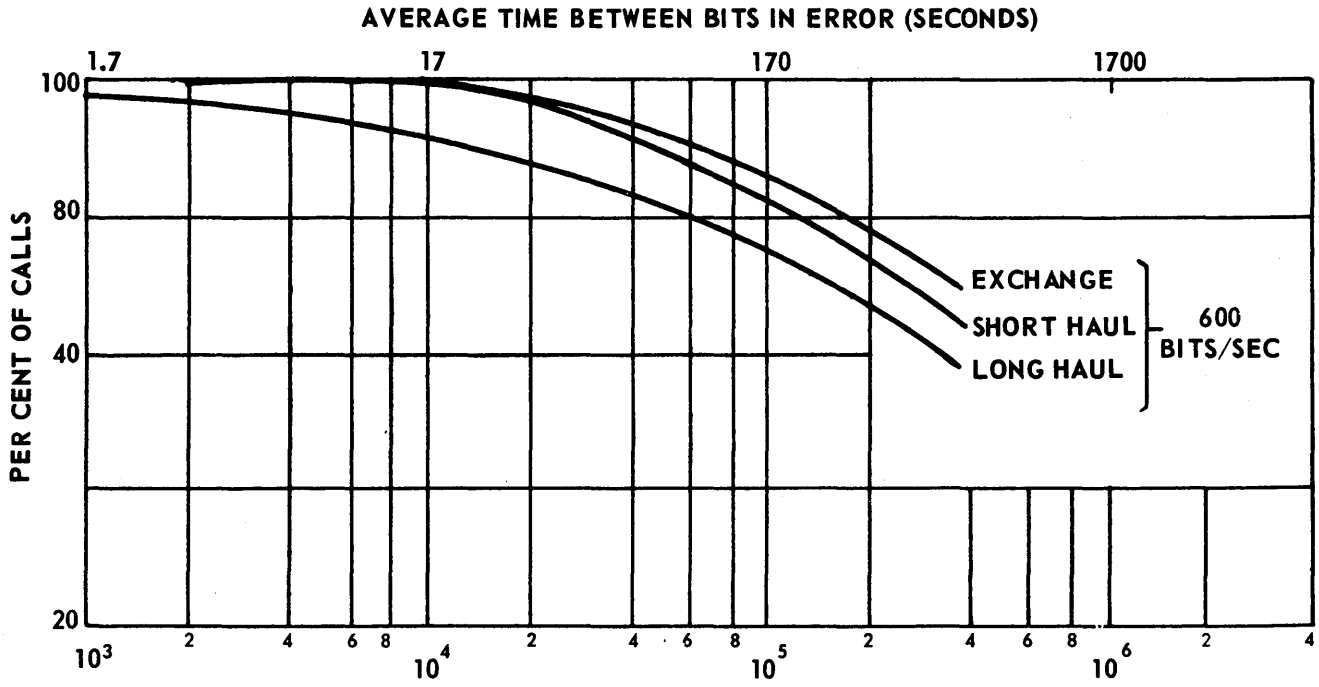


FIG. 10-A

– Error-rate distribution by class of call, 600 bits per second – percentage of calls with average error rate equal to or better than that shown on abscissa.

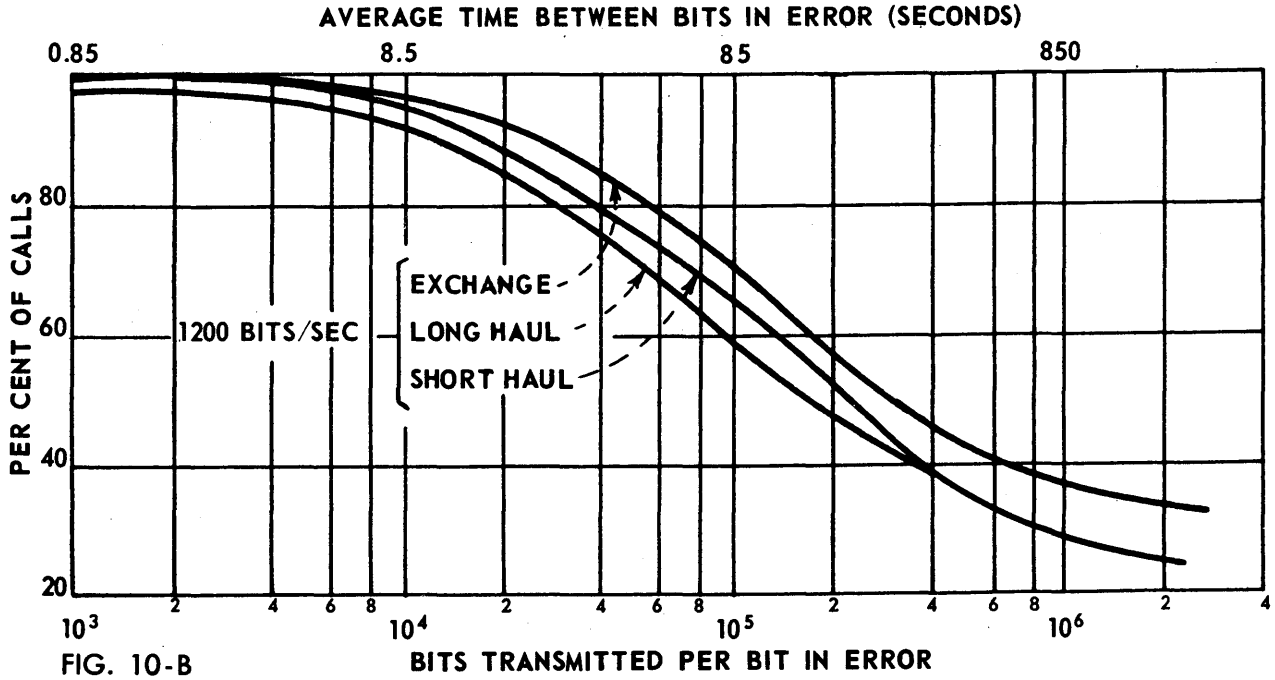
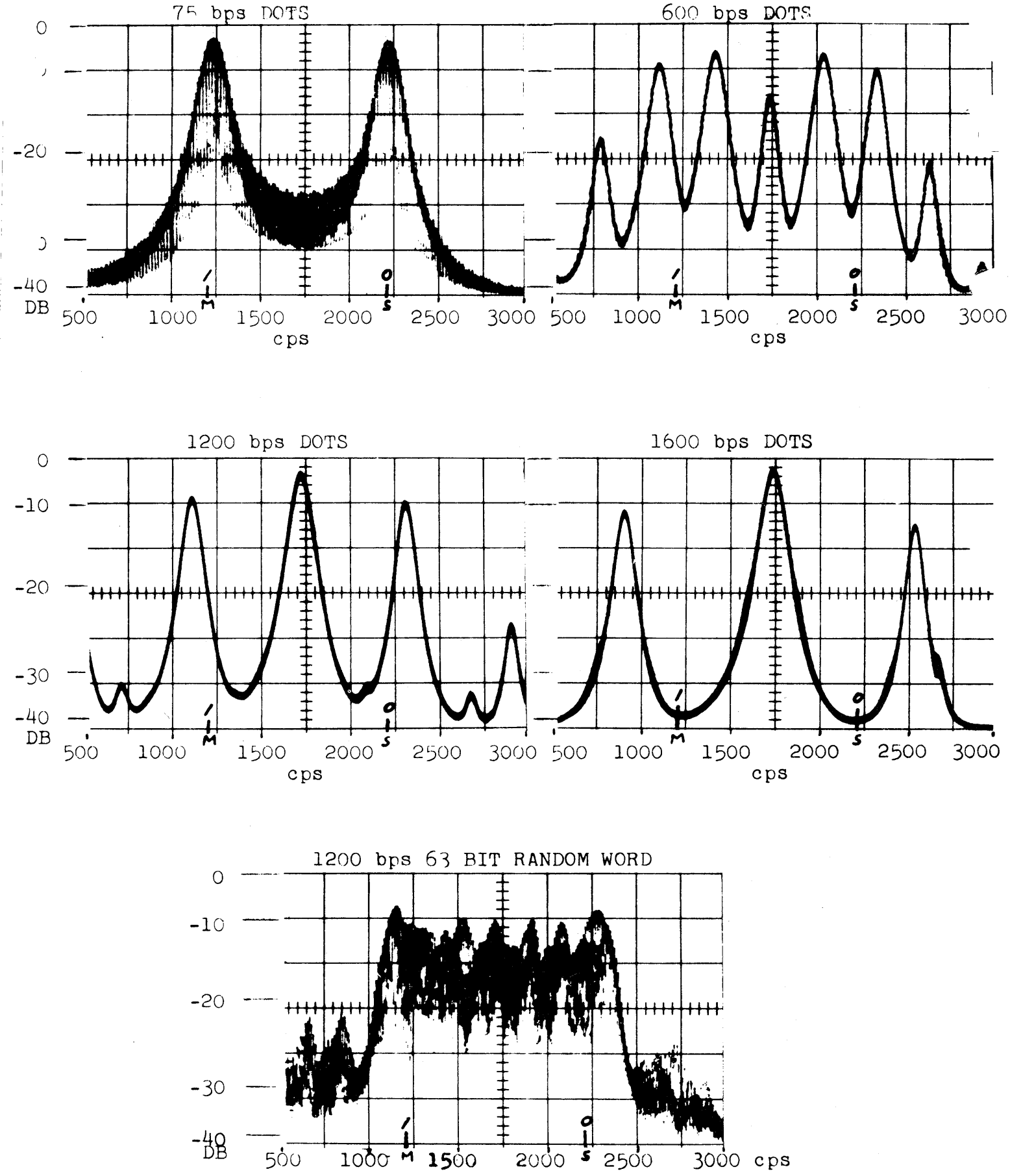


FIG. 10-B

Error-rate distribution by class of call, 1200 bits per second – percentage of calls with average error rate better than that shown on abscissa.

FIG. 11 SPECTRUM ANALYSIS OF OUTPUT OF DATA SETS 202



of the whole system as provided by the telephone companies.

10. ADDITIONAL INFORMATION

The absolute delay of a signal through a Data Set 202 modulator and demodulator is approximately 4 milliseconds.

The rates charged by telephone companies for data service employing Data Sets 202 vary from location to location. For this reason, the Telephone Company operating in a specific location should be contacted to obtain rate information.

11. PERFORMANCE

This section is included to provide the business machine designer with some insight into the performance that can be expected from systems employing the Data Sets 202. A much more complete discussion of this subject is contained in the Bell System Technical Journal, Vol. 39 pp 431-476 of May 1960, commonly referred to as the "Alexander, Gryb, Nast Report."

11.1 Data-Phone Service

Figures 10A and 10B are taken from the "Alexander, Gryb, Nast Report" and reflect data taken with FM data sets on the switched network. Note that this data is a summation of a number of calls from a number of locations. Performance from any one location may deviate substantially from that shown in the figures.

11.2 Private Line Service

A long term average of 1 bit in error per 100,000 bits transmitted or better on working circuits would be expected, but not guaranteed, if data sets are associated with the type of Schedule 4 private line channels recommended in Part 5.3.

11.3 Peak Distortion

The objective for peak distortion on systems employing Data Sets 202 is 20% or less. Peak distortion is defined as the summation of peak jitter and bias distortion. Bias distortion is defined as marks or spaces consistently too long or too short. Peak jitter is defined as distortion caused by the maximum instantaneous time displacement of a transition. This is calculated by the time displacement divided by the bit interval.

12. FUNCTIONAL DESCRIPTION

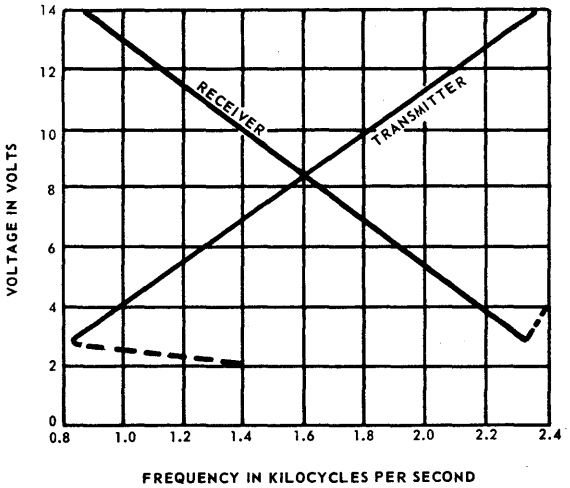
This portion is intended to provide a somewhat deeper understanding of the Data Set 202 interface by describing some of the circuitry contained in the data sets.

Frequency modulation is used in the Data Sets 202 because it allows signals to be correctly recovered despite sudden amplitude changes of the carrier during transmission. Any signal-to-noise advantage resulting from the use of FM in this application is small because of the character of line noise and because of the small deviation ratio usually used to obtain the utmost in transmission speed. A spectrum analysis of the modulator output is shown in Fig. 11. The transmitter and receiver are transistorized and use voltage control of a multivibrator frequency at the transmitter and zero crossing detection at the receiver. The control circuitry is composed mostly of relays. When it is used with suitable strapping arrangements or with keys associated with the telephone, it allows for changing the modes of terminal operation. The data set operates on plus and minus dc voltages derived from a ferroresonant power supply.

Figure 12 shows the data set in the two-wire configuration. The four-wire configuration is obtained by rearranging certain connections in the control circuit and splitting the line connections between the transmitter and receiver to allow independent transmit and receive paths.

The transmitter circuitry is shown in block form at the top of Fig. 12. The request to send control in the data set is a transistor-switch which brings the multivibrator in band and the clear to send circuit consists of a two-stage transistor amplifier and a resistor-capacitor timing network.

The multivibrator uses two transistors and precision resistor-capacitor cross-coupling



Curves show linearity of the modulation and demodulation process in terms of voltage input at modulator and voltage output at demodulator.

Fig. 13

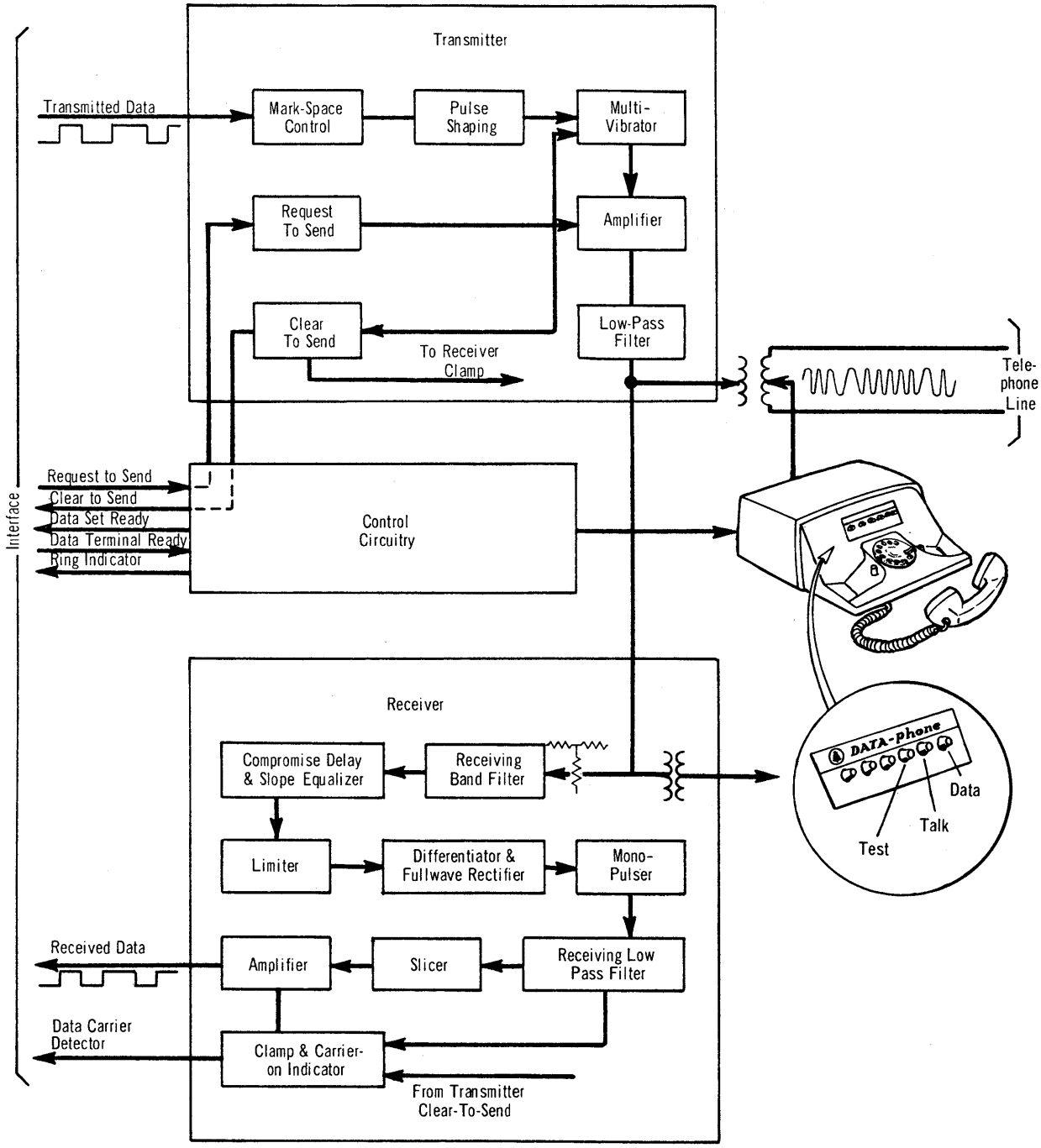


Fig. 12 Over-all block diagram of the Data Set 202

networks. Its frequency depends on the voltage applied at the junction of the two network resistors leading to the transistor bases. A typical range of frequency variation versus voltage input is shown in Fig. 13.

To shift the frequency of the multivibrator precisely between mark and space frequencies, a mark-to-space control is interposed between the send-data input and the voltage input to the multivibrator. This control circuit consists of a two-stage transistor gate in which a send-data input voltage of at least -3 volts and +3 volts causes the gate output to go from a low to a high impedance condition. This causes precise changes in output voltage of a resistance-divider network at the input to the multivibrator.

To make frequency control independent of supply voltage changes, the divider network is placed across ground and the power supply to the multivibrator. A resistance-capacitor pulse-shaping network is interposed between the divider and the multivibrator. This network limits higher data-pulse frequency components thereby reducing certain disturbing effects of the corresponding lower sideband frequency components appearing in the carrier band.

The multivibrator output is isolated from the transmission line by two transistor amplifiers. The first amplifier is followed by a low-pass filter having sufficient attenuation to suppress harmonics of the carrier to tolerable levels for the telephone line. The second amplifier permits selection of one of four possible line output levels.

The receiving circuit is shown in block form in the lower part of Fig. 12. The FM signal received from the line passes through a repeating coil, a pad which provides a proper termination toward the line, and a receiving band filter with a pass-band characteristic centered around the mean of the mark and space frequencies. The signal then passes through an optional line-delay equalizer and slope equalizer circuit to the input of the limiter.

The remainder of the receiving circuit consists of the following components: a limiter, (essentially, a three stage amplifier with non-linear feedback provided by a pair of oppositely poled silicon diodes) which converts the received sinusoidal input to a corresponding square-wave output; a differentiator, (consisting of an RL differentiator and a four diode full wave rectifier) which provides output pulses only at the transitions of the square wave; a monopulser, (standard one shot multivibrator) which measures out a fixed amount of energy for each output pulse of the differentiator; a low pass filter, which clears away all unwanted frequency components leaving an average voltage output which varies in proportion to the received frequency input; an output slicer-amplifier which makes a decision at a specific value of the average filter output voltage to indicate mark or space and then saturates correspondingly to give, at the Received Data output -8 volts for mark and +8 volts for space.

The carrier detector, clamp and squelch circuit is a five stage circuit which operates on the output of the receiving low pass filter. It requires signals within the data band (which can be determined by the voltage of the signal at the output of the filter) to be present for 40 ± 10 milliseconds before the Carrier Detector lead is turned ON. If the receiver clamp option is used the BB lead is clamped OFF until Carrier Detector comes ON. The squelch operates such that when the transmitting customer cuts Request to Send OFF, by turning a transistor switch OFF, outputs on Received Data are inhibited for 150 ±25 milliseconds. The squelch timing is controlled by an RC circuit connected between the squelching lead and the clear to send output.

When a call is received in the unattended mode, the received ringing current pumps the resistance capacitor tank circuit until enough current is available to operate a ringing relay. The pumping is required to insure against operation of this relay on unwanted interference. The operation of this relay provides, among other things, the closure on the ring-indicator leads.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