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IBM 2701 Data Adapter Unit

Principles of Operation

This manual provides information concerning the operation of the IBM 2701 Data Adapter Unit. The manual is divided into three sections.

The first section gives a general description of the 2701, including: the terminals operating with the 2701, the functional organization of the 2701, the special features on the 2701, and various configurations of the 2701.

The second section describes the operation of the 2701 with the System/360. Subjects discussed here include communication line addressing, multiplexor and selector channel operation, and I/O instructions concerning the 2701.

The third section covers the 2701's transmission adapters. A complete description on the operation of each adapter is made here. This description includes transmit and receive operation sequences, status and sense bytes, and the polling and addressing of the terminals.

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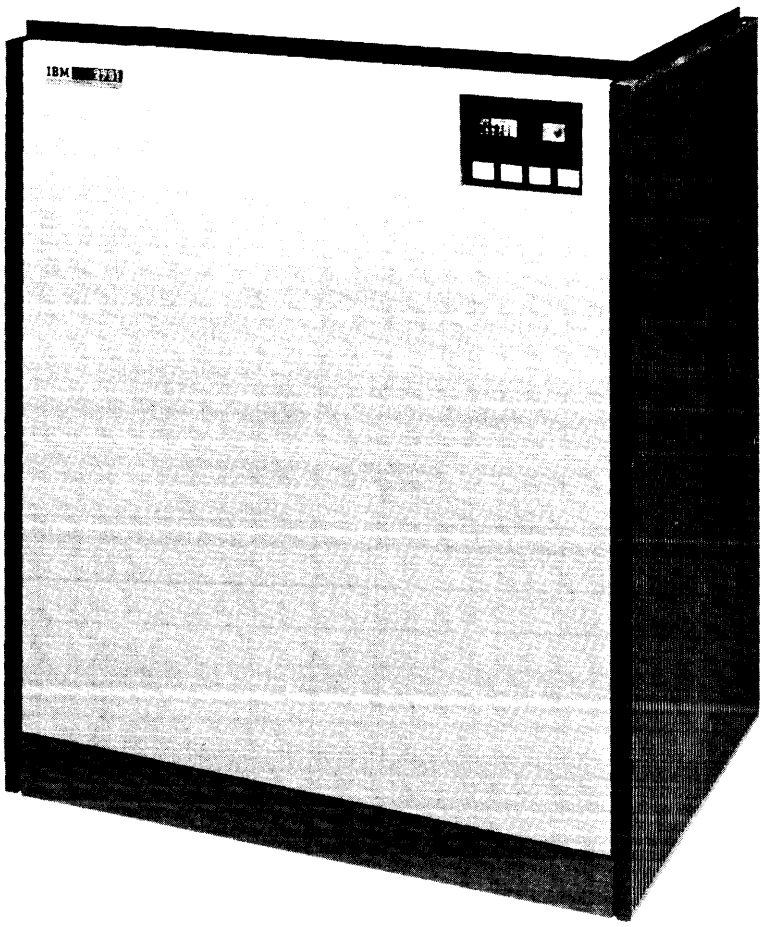


IBM 2701 Data Adapter Unit

Introduction

The IBM 2701 Data Adapter Unit greatly expands the input/output capabilities of the IBM System/360 (frontispiece). The 2701 provides for the connection and control of the information flow of a variety of remote and local external devices with an IBM System/360 (Figure 1). These devices are divided into three types:

COMMUNICATIONS — START/STOP

IBM 1030 Data Collection System
IBM 1050 Data Communication System
IBM 1060 Data Communication System
IBM 1070 Process Communication System
AT&T 83B2/83B3 Type Selective Calling Terminals
Western Union Plan 115A Terminals
Common Carrier TWX Stations (8-level code)
European Teleprinters (WT attachment)
2848 Display Controls with 2260 Display Stations.
2740 or 2741 (without interrupt feature) Communications Terminal

COMMUNICATIONS — SYNCHRONOUS

IBM 1009 Data Transmission Unit
IBM 1013 Card Transmission Terminal
IBM 7701 Magnetic Tape Transmission Terminal
IBM 7702 Magnetic Tape Transmission Terminal
IBM 7710 Data Communication Unit
IBM 7711 Data Communication Unit
IBM 7740 Communication Control System
IBM 7750 Programmed Transmission Control
IBM System/360 with similarly equipped 2701's

DATA ACQUISITION AND CONTROL

Parallel Data Devices
Contact Sense Terminals
Contact Operate Terminals
Serial Synchronous Terminals

The IBM 2701 can be attached to either the multiplexor or selector channel of the System/360. With the second channel interface feature, the 2701 can be attached to another channel on the same processor (multiplexor or selector) or to a channel on another processor. This means that different terminal devices on the 2701 can operate via the multiplexor channel or the selector channel. However, once a terminal device is assigned to a channel, it will operate only via this channel.

Functional Sections

The 2701 Data Adapter Unit provides for the on-line attachment of various input/output devices to any of the System/360 processors. All necessary bit-byte, word-byte conversion, data control, and interface matching is accomplished by the two functional sections of the 2701: the transmission interface converter (XIC) and the transmission adapter (XA).

The XIC and XA operate as a couple which provides a single complete path for the operation of the terminal devices with the channel (Figure 2). In a 2701 which has more than one XIC-XA couple, the XIC is logically the same for each couple; the XA changes, according to the type of terminal devices attached. A minimum 2701 configuration contains one XIC-XA couple. With the use of special features, the 2701 can have up to three more XIC-XA couples. See "2701 Configuration" section and Figure 3.

Transmission Interface Converter (XIC)

The XIC operates with the I/O interface; stores the status, sense, and command bytes; decodes the transmission adapter I/O address; develops and checks the parity of the data transfers with the I/O channel; responds to specific control unit commands; and operates with the transmission adapter.

Transmission Adapter (XA)

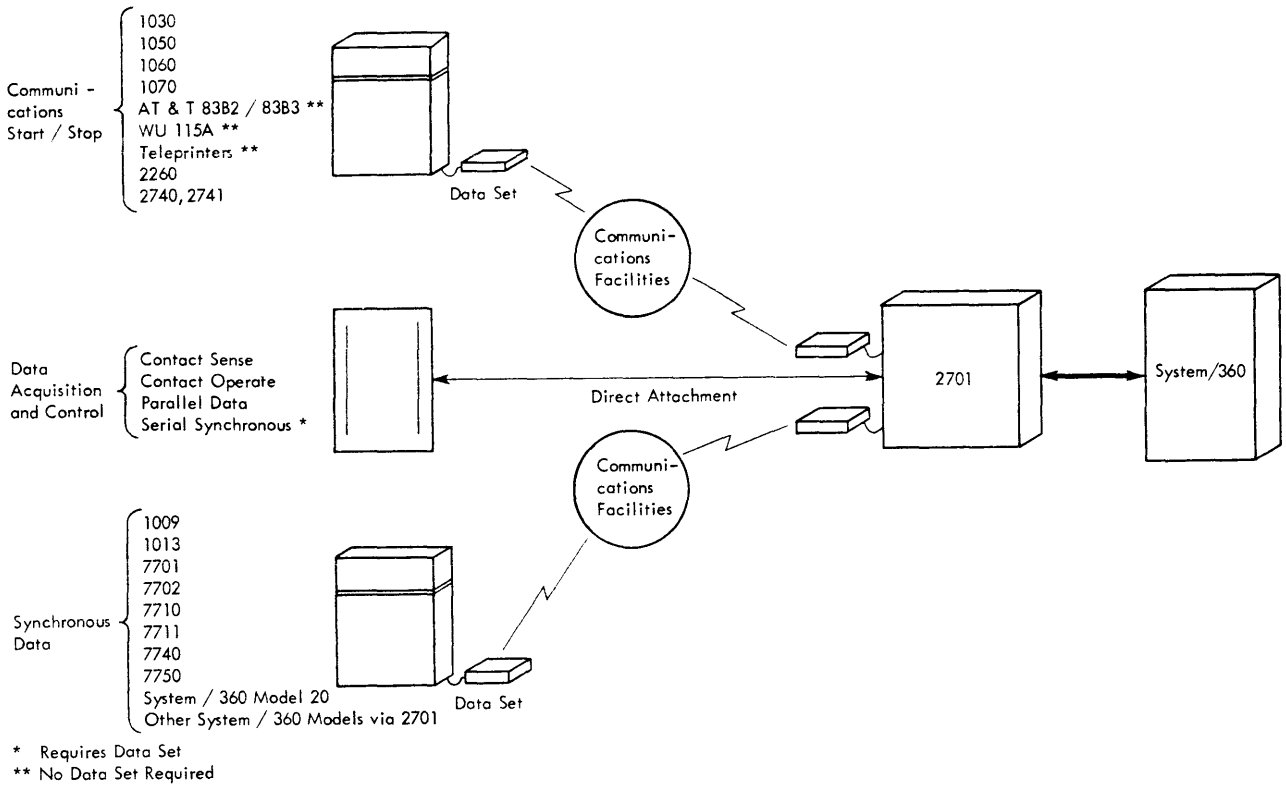
The transmission adapter contains the circuits necessary to perform the functions associated with a given external device or class of terminal devices, such as interface control, parity decoding, character and character sequence recognition, data buffering and byte conversion, and status and sense byte generation.

Special Features

The special features fall into two major classifications. There are some special features on the 2701 which affect all the transmission adapters, whereas others are on a particular transmission adapter and affect only that adapter. Only the former will be discussed in this section. The special features for the transmission adapter will be found in the following sections, in which the various transmission adapters are discussed.

Expansion Feature

This feature provides an additional XIC function for the attachment of another XIC-XA couple. The only circuitry in common with the first XIC-XA couple is the power supplies and the I/O channel interface drivers, terminators, and receivers. This sharing of the interface circuitry allows additional XIC-XA couples to



● Figure 1. 2701 in a System Environment

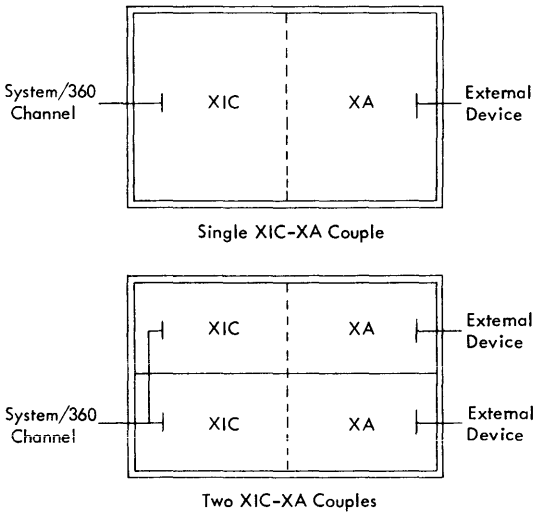


Figure 2. 2701 Functional Sections

be added without decreasing the total number of additional control units allowable on the I/O channel. With the expanded capability feature, up to three expansion features are available in the same 2701.

Expanded Capability Feature

The expanded capability feature provides for additional XIC-XA couples within the 2701. The expanded capability feature doubles the capability of the 2701. For example, with the use of an expansion feature, two communication start/stop transmission adapters may be housed within the 2701. The expanded capability feature allows for two additional communication start /stop transmission adapters with their respective expansion features to be housed within the same 2701.

Second Channel Interface Feature

The second channel interface feature allows for one or more of the XIC-XA couples to be operated on a second channel from the other couple in the 2701. This second channel may be another channel on the same processor (for example, the 2701 basic unit connected to the multiplexor channel and the second channel interface feature connected to the selector channel) or to a channel on a second processor. The extreme would be to connect the second channel interface feature to the same channel as the 2701 basic unit, but this would serve no useful purpose and would unnecessarily reduce the number of additional control units on that channel from seven to six. Once an XIC-XA couple is assigned to one or the other channel, it will operate only on that channel; there is no capability to switch from one to the other.

Automatic Call Feature (ACF)

The automatic call feature is valid only with some of the communications start/stop adapters. This feature

allows the terminal device to be dialed, under program control over common carrier switched dial networks. The ACF almost falls into the category of special features which affect only the particular transmission adapter; however, the automatic call feature affects the total number of XIC-XA couples allowable in the 2701 and is, therefore, discussed here. See the configuration section for further details.

2701 Configuration

The 2701 configuration is made up of the following units and features:

2701 basic unit
Transmission adapter
Expansion feature
Expanded capability feature
Second channel interface feature

Figure 3 shows the maximum 2701 configuration, using all of the above units and features. This configuration has four transmission adapters, two per gate. As will be shown below, this configuration is not possible with every transmission adapter.

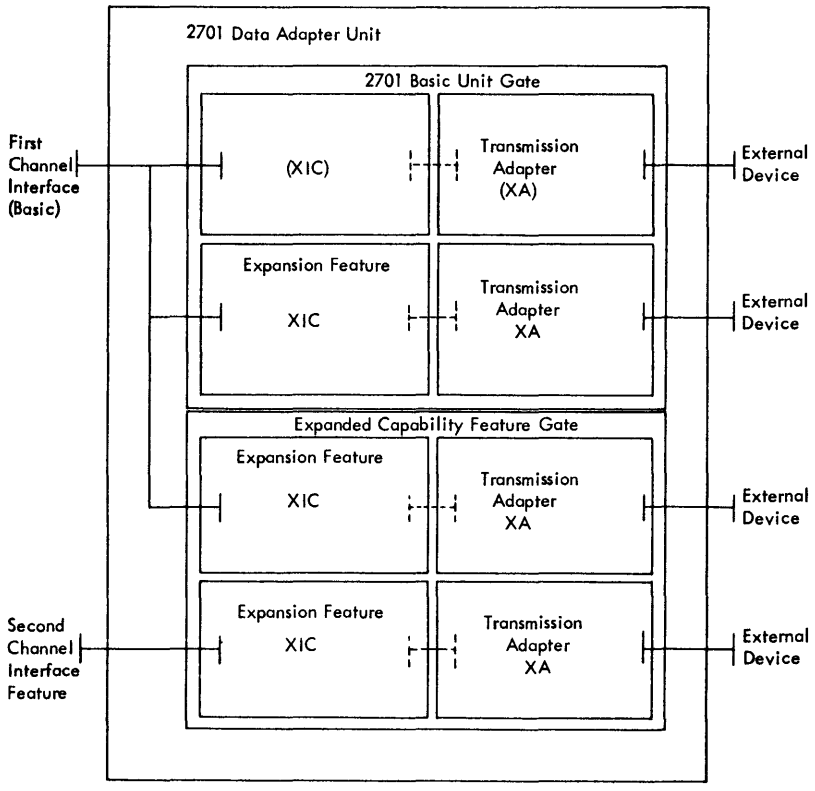
The 2701 basic unit supplies the frame, covers, power, a logic gate, and a transmission interface converter (XIC). To complete the XIC-XA couple, a transmission adapter must be obtained. The other units and features are described in the transmission adapter and the special features sections.

Some 2701 transmission adapters require more physical space than others in the 2701 frame. The use of these adapters restricts the number of the other XIC-XA couples housed within the same 2701. As an aid in specifying the configuration capabilities of the 2701, the transmission adapters have been grouped into three categories (Figure 4).

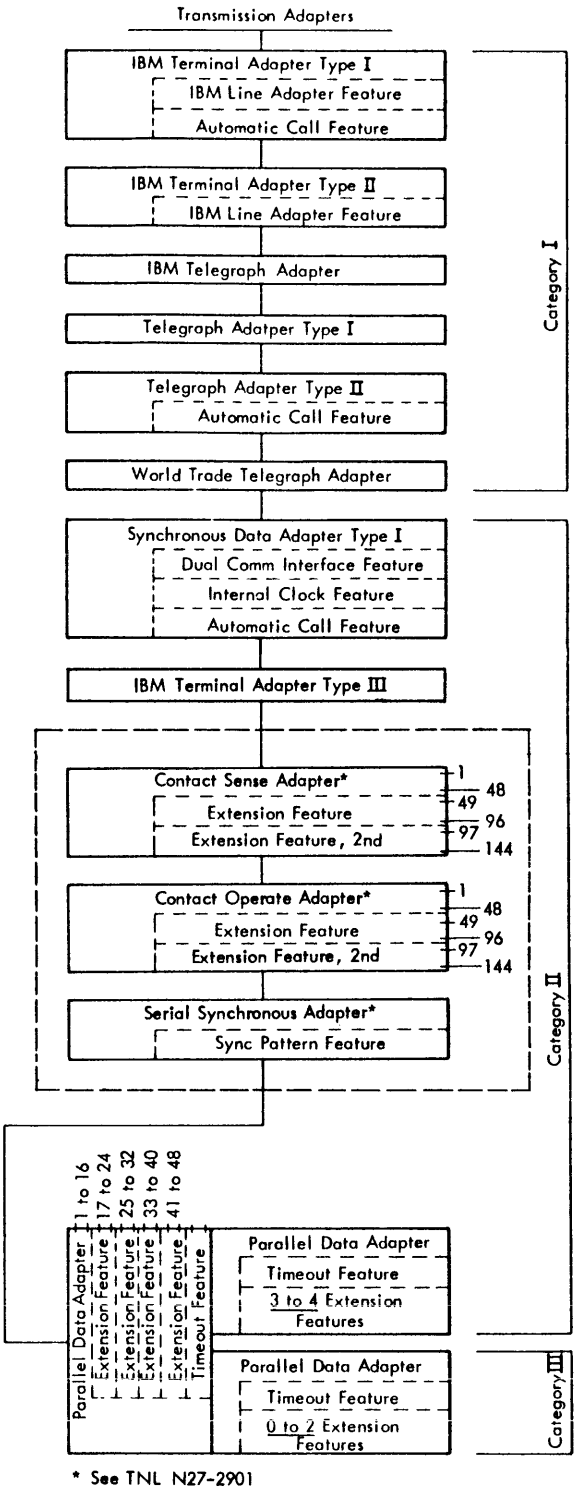
The 2701 basic unit gate can accommodate up to two category I adapters, one category II adapter, or up to two category III adapters. Adapters from different categories cannot be housed on the same gate.

The use of the expanded capability feature gate doubles the number of transmission adapters the 2701 can accommodate. Again, up to two category I adapters, one category II adapter, or up to two category III adapters can be accommodated on this gate. The transmission adapters on the expanded capability feature gate can be from the same or a different category as the adapters on the 2701 basic unit gate.

Expansion features must be obtained for each transmission adapter after the first. As mentioned earlier, the automatic call feature, when ordered on the communications start/stop adapters, reduces by one the allowable number of category I adapters. The automatic call feature, when ordered with the communica-



● Figure 3. Maximum 2701 Configuration



● Figure 4. Categories of 2701 Transmission Adapters

tion synchronous adapter, does not have this restriction.

When more than one automatic call feature are required, this restriction applies only with the first.

For example, the first communication – start/stop adapter (category I) with an automatic call feature completes a gate. The expanded capability feature must be obtained in order to add more adapters. With the expanded capability feature, in this case, two additional adapters from catgory I can be attached, and both adapters can also have the ACF. (The example could just as well have shown one category II or two category III adapters on the expanded capability gate.

The second channel interface feature connects an XIC-XA couple on the expanded capability feature gate to a second channel. When more than one XIC-XA couple are ordered on this gate, one or both couples can be connected to the second channel. For example, refer back to Figure 3. In the figure one XIC-XA couple on the expanded capability feature gate is shown connected to the second channel, and the other is shown connected to the same channel as the XIC-XA couples on the 2701 basic unit gate. Both XIC-XA couples on the expanded capability feature gate could just as well have been shown connected to the second channel. When the second channel interface feature is not obtained, all the XIC-XA couples housed within the 2701 are connected to the same channel. For further details on the configuration of the 2701, see the *IBM System/360 Data Communications and Acquisition Configurator*, Form A22-6824.

Line Addressing

To the IBM System/360, the 2701 appears as a control unit. Each 2701 may house up to four XIC-XA couples. Up to eight 2701's can be attached to each I/O channel, with each 2701 taking the place of one control unit otherwise attachable to that I/O interface. Each XIC-XA couple within a 2701 is identified by a unique I/O address that is specified by an 11-bit binary number. This number is specified by the address field of the start I/O instruction; the three high-order bits of the field specify the channel; the next eight bits specify the terminal device attached to the 2701. For more information concerning I/O unit addressing, see "Input/Output Operation," *IBM System/360 Principles of Operation,* Form A22-6821.

NOTE: Even when more than one terminal device is connected to an XIC-XA couple, only one I/O address exists. Addressing beyond this must be accomplished by other means. See transmission adapter section for specific details.

2701—Channel Operation

The 2701 connects to and operates with the multiplexor or selector channel via the I/O interface. This interface consists of byte-buses for commands, addresses, data, or status; channel interlock controls; and interface scanning signals. The scanning signals and interlocks establish priorities among the different 2701's and other control units attached to the I/O channel and among the XIC-XA couples within each 2701.

On either the multiplexor or selector channel, an I/O operation is initiated by a program command given by the channel and accepted by the control unit. The I/O device addressed cannot be addressed again until the 2701 presents the terminating status to the channel.

The 2701 operation on the multiplexor channel differs slightly from its operation on the selector channel. Each type of channel operation is discussed below.

Multiplexor Channel Operation

When connected to a multiplexor channel, the 2701 can operate in one of three modes: byte, multiple byte, or burst.

Byte Mode: The 2701 releases the I/O channel after initial selection, after transferring each byte of data, and prior to presenting the terminating status.

Multiple Byte: The 2701 releases the I/O channel after initial selection and after each data word is transferred. (A data word is defined here as the number of bytes buffered in the transmission adapter.) The data word length varies, for different transmission adapters, from two to eighteen bytes. The channel is also released after the transfer of the last data word and prior to the presentation of the terminating status. See "System Considerations" for details.

Burst Mode: The 2701 maintains control of the multiplexor channel from initial selection until after the presentation of terminating status. Burst mode may be obtained as a wiring option on the XIC. Neither the transmission adapter nor the channel has any control over the selection of one or the other modes of operation once the XIC is so wired.

If the XIC is wired for burst mode, the mode of operation is the burst mode. If the XIC is not so wired, the transmission adapter has the ability to force the operation to be in the multiple byte mode. The capability to force multiple byte mode is designed into only those adapters that have registers to buffer multiple bytes of data. If the transmission adapter is so designed, operation will be in the byte mode. See below.

ADAPTER MODE	WIRE OPTION	RESULTING MODE
Byte	Normal	Byte
Multiple byte	Normal	Multiple byte
Byte	Burst	Burst
Multiple byte	Burst	Burst

Selector Channel Operation

The selector channel always operates in burst mode. This mode is forced by the selector channel itself, and the 2701 has no control over it. In burst mode, the 2701 will not release the channel from initial command selection until the entire operation is completed and the terminating status is presented.

System Considerations

The meaning and usage of the byte, multiple byte, and burst modes for multiplexor channel operations are explained here. The system designer can specify the operation to be either burst mode or normal (non-burst) mode. The system designer has no way of specifying between byte and burst mode. While on the multiplexor channel, with the XIC set for normal mode, the transmission adapter determines whether the operation will be in byte or multiple byte mode. A buffered transmission adapter, that is, an adapter which can immediately transfer multiple bytes of data with the

channel, operates in the multiple byte mode on the multiplexor channel. Adapters which are not buffered and must obtain each byte of data from the terminal device operate in byte mode.

The main difference among the three modes of operation is the amount of interference the program and the channel encounter. Multiple byte mode increases the length of the program and the channel interference per data transfer over the byte mode, but significantly decreases the over-all program and channel interference by decreasing the number of selections required per message. For operations on the multiplexor channel, each time the channel performs a data transfer with a control unit, it must access the subchannel control word of the particular I/O adapter from storage; therefore, each access interferes with the program. The interference due to the actual data transfer is minimal compared to the access interference. It can be seen, therefore, that by reducing the number of accesses required per message, the processor interference can also be reduced. As an example, the processor interference for a six-byte burst on the multiplexor channel of the Model 30 is about one fourth the interference that would occur from transferring six bytes in the byte mode. The channel is unavailable to other devices for a longer time period when operating in the multiple byte mode than in the byte mode. However, the total over-all interference is less. The longer time period of unavailability may be intolerable for real-time device requirements. Therefore, channel interference must be considered. Channel interference is measured from a control unit standpoint. The system designer has to know the maximum length of time that the control unit must wait between two successive data transfers. For proper operation of the control unit, the maximum time should be such that the probability of losing data is minimal. When determining the maximum channel interference caused by any control unit, the time to do command chaining with a transfer in channel operation must be compared to the time required to perform the longest data or status transfer. The longer of the two is the maximum interference.

For 2701 XIC-XA couples which operates in byte mode, the time needed to perform the command chaining operation will be longer than the time required for a data transfer. For XIC-XA couples that operate in the multiple byte on burst mode, the time required for the data transfer may exceed the time required to command chain. This time should be calculated for each case.

The multiple byte mode, as opposed to the burst mode, reduces the maximum channel interference by releasing the channel after accepting the initial status and prior to presenting the terminating status. To further reduce channel interference, transmission adapters which have data word lengths greater than six bytes have the capability of being started at six-byte intervals. For example, a transmission adapter with 18 bytes in its data word can, under program command, be started at the first byte, the 7th byte, or the 13th byte. In this manner, if an 18-byte transmission presents too great an interference to the other control units on the channel, the programmer can limit the length of the multiple byte operation by the byte count in the channel command word. As a further example, consider a command with a byte count equal to six. When the 2701 attempts the transfer of the 7th byte, the channel will reject the transfer and signal the control unit to stop the operation. The 2701 will release the channel and at its next opportunity present the terminating status. The program can now cause a new command to restart the data transfer at the 7th byte (and later at the 13th byte).

The burst mode of operation has the 2701 maintain control of the multiplexor channel from initial selection until after the presentation of the terminating status. When operating on the multiplexor channel, burst mode should be used with the greatest of caution because it presents the greatest channel interference. It should only be used with transmission adapters which end after presenting each data word. When burst mode is used with transmission adapters, which present several data words prior to ending or when it is used with unbuffered adapters, processor interference must also be studied; for example, on the multiplexor channels of Models 30 and 40, there is 100 percent processor interference when the data transfer is in the burst mode.

I/O Instructions

The System/360 operates with the 2701 through the start I/O, test I/O, and halt I/O instructions.

An I/O instruction executed by the CPU causes initial command selection and the transfer of a command byte to the addressed XIC-XA couple of the 2701. Command chaining within the channel also causes selection and transfer of a command byte.

The command byte is decoded by both the XIC and the XA. A command which is successfully decoded by the XIC is operated on independent of the XA. An XA-decoded command is operated on by both the XIC and XA. A command which is not successfully decoded by either the XIC or XA is rejected by the unit check bit being presented in the status byte.

The status byte returned to the channel in response to a command selection indicates the 2701's condition

and acceptance or rejection of the command. Figure 5 presents the meaning of each possible status response for each of the I/O instructions.

Start I/O

There are many commands which may be issued with the start I/O instruction or as a result of command chaining. Where the XIC-XA couple has neither a previous command nor has outstanding status (status bits which have been set by either the XIC or the XA, but have not yet been accepted by the channel), and a valid start I/O command is decoded, all zero status will be returned to the channel. This indicates that the command has been accepted.

The sense and I/O no-op commands are the only commands resulting from a start I/O instruction or a command chain that is decoded and operated on by the XIC. (The other valid commands are decoded within the XA.) Each XA type accepts a different set of commands. Commands with the same bit structure may be defined differently for each type of adapter; therefore, only the sense command will be discussed here. The other commands will be discussed in later sections.

After completing transfer of the all-zero status byte, which indicates the 2701's acceptance of the sense command, the XIC transfers the sense byte to the channel and then presents terminating status with the device end and channel end bits on.

The definition of the bits within the sense byte depends upon which adapter is being used with the XIC. The sense bits are defined in the following sections, which cover the various adapters; however, bits 0 and 2 are reserved for the XIC:

Bit 0 – Command Reject.
This bit is set during an initial selection or command chain sequence when a command byte is not successfully decoded by either the XIC or the XA.

Bit 2 – Bus Out Check.
This bit is set whenever the XIC detects a parity error on the transfer of a byte from the channel over the bus-out lines.

The register within the XIC that holds the sense byte is reset by the XIC-XA couple's acceptance of a start I/O command other than sense and I/O No-Op.

Test I/O

Through the test I/O instruction, the CPU can addressably obtain the current status byte from any XIC-XA couple.

Upon decoding the test I/O command, the XIC presents the contents of the status register. The test I/O command ends with this status transfer. The acceptance of this command does not reset the sense register in the XIC.

Halt I/O

When operating on a command and upon detection of a halt I/O, the XIC-XA couple will not transfer any further data, and will be "busy" to any further com-

Instructions and Commands / Status Response	Start I/O: I/O No-Op	Start I/O: Other	Test I/O
All Zeros	4	1	1, 3, 6
Busy	2, 5, 6, 10 or 2, 9	2, 5, 6, 10 or 2, 9	2, 5, 6, 10 or 2, 9
Busy and Status Register*	2	2	4
Status Register*	7, 1, 3	4	1, 3
Unit Check	4	2, 8	4

1. Command accepted
2. Command rejected
3. Command successfully terminated with status response
4. Status response invalid for this command
5. Previous command outstanding
6. No outstanding status
7. This status response is valid when the "Status Register" contains only the device end and channel end status
8. Invalid command
9. A reset is being performed
10. This command should not have gotten past channel

* The "Status Register" is defined here as an outstanding status within a control unit excluding the busy bit (that is, up to 7 bits).

Figure 5. Status Responses to Instructions and Commands

mands until terminating status is accepted by the channel. Terminating status is presented to the channel as soon as possible; otherwise the XIC-XA couple will be immediately available.

Programming Considerations

From a programming standpoint, the 2701 appears as a number of individual devices (one to four). When an operation or a sequence of operations is to be performed, the programmer prepares a list of one or more channel command words (channel program) in main storage. The channel command word signifies:

1. The command (operation) to be performed: write, dial, read, etc.
2. The number of bytes in the record.
3. The initial address in main storage where the data should be placed when receiving, or the address of the first byte to be transmitted when sending.
4. Channel flag information indicating that another channel command word is to be executed when the current operation is terminated.

When the channel command words have been formed, the programmer specifies the channel and address of the XIC-XA couple. The execution of a start I/O instruction causes the command, count, data address, and control information to be stored in a specified subchannel in the multiplexor channel or in the register in the selector channel. The channel then selects the 2701's XIC-XA couple, and presents the command to it. The 2701 accepts the command if valid. The channel then indicates successful or unsuccessful execution of the start I/O instruction to the programmer. Once the command has been accepted by the channel and the 2701, the CPU program is unaware of the continuance of the operation until all the data has been received or transmitted, or until the channel needs program intervention to perform functions such as dynamic storage allocation. Because the channel contains all the necessary information pertaining to the current operation, data transfer between main storage and the XIC-XA couple can be overlapped with CPU processing. The extent of the overlap varies, depending on the type of channel (multiplexor or selector) and the processor model (30, 40, 50, 60, or 70) of the System/360.

Transmission Adapters

The transmission adapter (XA) provides for the connection and operation of remote and local devices with the System/360. The 2701 obtains its personality from the transmission adapter it houses. Each transmission adapter provides for the attachment and operation of a particular device or class of devices with the 2701. The transmission adapter contains the circuitry and logic for the control of a terminal device, the buffering of the data flow, the decoding of the program commands, and the connection to and operation with the XIC and the I/O channel.

Transmission adapters used in the 2701 are classified into one of three types: communications-start/stop adapters, communications synchronous adapters, and data acquisition and control adapters.

Communication-Start/Stop Adapters

Start/stop adapters for the 2701 include the following: IBM Terminal Adapter-Type I, IBM Terminal Adapter-Type II, IBM Terminal Adapter-Type III, Telegraph Adapter-Type I, Telegraph Adapter-Type II, IBM Telegraph Adapter, and the World Trade Telegraph Adapter. The operation of the 2701 start/stop adapters with the remote terminals requires various types of communications facilities and data sets (Figure 6). Figures 7 and 8 list the 2701 start/stop adapters and the terminals that may be operated with each. Also listed are the communications facilities and data sets required for the operation.

Programming Considerations

For those communication-start/stop terminals (1030, 1050, 1060, 1070, etc.) which can operate with both the 2701 and 2702, the operation programs used are identical. However, this compatibility does NOT extend to diagnostic programs.

Commands

The communications-start/stop adapters decode and execute the commands listed below. Some commands, such as read, write, and inhibit, are valid for all adapters; other commands, such as dial and search, are valid only for certain ones. The commands used by each type of adapter are listed in the section for that adapter. Binary representation of each command is given in Figure 9.

Read: This command causes bytes to be transferred from the communication line to the channel at a data rate equal to that of the communication line.

Write: This command causes bytes to be transferred from the channel to the communication line at a data rate equal to that of the communication line.

Inhibit: This command performs the read operation but inhibits the time-out function. Otherwise, the operation proceeds as if a read command had been issued.

Break: This command causes the 2701 to transmit continuous space signals to the line. Bytes transferred from the channel to the addressed unit must all be zeros. To provide control over the length of a space signal, a byte count must be specified by the program.

Prepare: This command can be used in a contention type communications system to indicate (to the CPU) that data are arriving. When a valid start bit is detected while the XIC-XA couple is operating upon a prepare command, the command is terminated with a device end, channel end status. Prepare can be command-chained to a normal read command. No data transfer occurs with this command, and timeout is not active during its execution.

Search: This command causes the 2701 to react as though a read command has been issued, but data are not transferred to the channel. The data line is monitored for an EOT (end of transmission). Line timeout is active during the execution of this command. This command is valid only for the Telegraph Adapter-Type I.

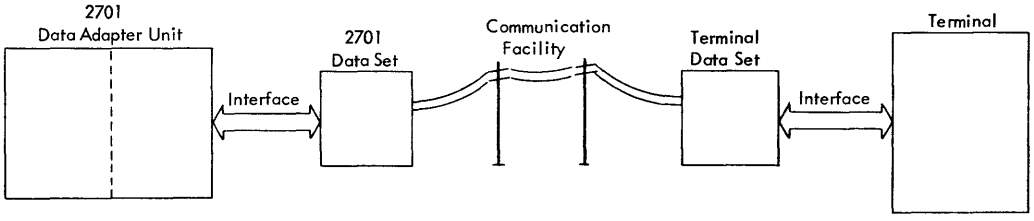


Figure 6. Terminal Connection via Data Sets and Communications Facilities

Terminal	Communication Facility	Terminal Data Set *	2701 Data Set *	Speed	2701 Adapters
1050 Data Communication System					
1051 Control Unit Model 1 or 2	Common Carrier Switched Telephone Network	Western Electric 103A2	Western Electric 103A2	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Common Carrier Switched (150 Baud) Teletypewriter Exchange (TWX) Network	Western Electric 103A1	Western Electric 103A1		
	Common Carrier Leased Private Line Telephone Service	Western Electric 103F2	Western Electric 103F2		
	Western Union Class D (180 Baud) Channel	Western Union Data Set 11725A	Western Union Data Set 11725A		
	Telephone Company Schedule 3A Data Channels (150 Baud)	An appropriate channel termination provided by the Telephone Company			
1051 Control Unit Model 1 or 2 with Telegraph Attachment #7873	Telephone Company Schedule 3 or Western Union Class C Channels (62.5 ma Neutral Signal)	Not Required	Not Required	75.0 Baud 8.33 Char/Sec	IBM Telegraph Adapter
1051 Control Unit Model 1 or 2 with Line Adapter #4790	**	Not Required	Not Required	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1060 Data Communication System					
1061 Control Unit Model 1 or 2	Common Carrier Leased Private Telephone Service	Western Electric 103F2	Western Electric 103F2	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 Baud) Channel	Western Union Data Set 11725A	Western Union Data Set 11725A		
	Telephone Company Schedule 3A Data Channels (150 Baud)	An appropriate channel termination provided by the Telephone Company			
1061 Control Unit Model 1 or 2 with Line Adapter #4790	**	Not Required	Not Required	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1030 Data Collection System					
1031A Input Station	**	Not Required	Not Required	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648 IBM Line Adapter #4637
1031A Input Station with Common Carrier Adapter #2068	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202D1	Western Electric 202D1	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648
	Western Union Class E Channel	Western Union 1601 A	Western Union 1601 A		
1070 Process Communications System					
1071 Control Unit Model 1	Common Carrier Leased Private Line Telephone Service	Western Electric 103F	Western Electric 103F	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 Baud) Channel	Western Union Data Set 11725A	Western Union Data Set 11725A		
1071 Control Unit Model 1 with Line Adapter #4792	**	Not Required	Not Required	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1071 Control Unit Model 2	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202D1	Western Electric 202D1	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646
	Western Union Class E Channel	Western Union 1601 A	Western Union 1601 A		
1071 Control Unit Model 2 with Line Adapter #4793	**	Not Required	Not Required	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646 IBM Line Adapter #4637
2740, 2741 Communications Terminal	Common Carrier Switched Telephone Network	Western Electric 103A2	Western Electric 103A2	134.49 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Common Carrier Switched TWX Network (150 Baud)	Western Electric 103A1	Western Electric 103A1		
	Western Union Class D Data Channels (150 Baud)	Western Union 11725A	Western Union 11725A		
	Telephone Company Schedule 3A Channels (150 Baud)	An appropriate channel termination provided by the Telephone Company			
	Common Carrier Leased Private Line Telephone Service	Western Electric 103F2	Western Electric 103F2		
	Western Union Class E Channels	Western Union 1601A	Western Union 1601A		
2740/2741 with IBM Line Adapter	Privately Owned Communication Facilities	Not Required	Not Required		

● Figure 7. Attachable Terminals and Communications Facilities for Domestic Use (Communications-Start/Stop Adapters)

Terminal	Communication Facility	Terminal Data Set *	2701 Data Set *	Speed	2701 Adapters
2848 Control Unit 2260 Display Station	Common Carrier Leased Private Line Telephone Service	Western Electric 202D1	Western Electric 202D1	1200 Baud 120 Char/Sec	IBM Terminal Adapter Type III #4656
		Western Electric 201B1	Western Electric 201B1	2400 Baud 240 Char/Sec	IBM Terminal Adapter Type III #4657
	Western Union Class E Data Channels	2121A	2121A	1200 Baud 120 Char/Sec	IBM Terminal Adapter Type III #4656
TWX (Teletypewriter Exchange)					
Models 33 and 35 TWX Terminals	Common Carrier Switched 150 bps TWX Networks	Western Electric 103A1	Western Electric 103A1	8-Level Code at 110 Baud Only	Telegraph Adapter Type II #7885
Other Terminals					
AT&T 83B2/83B3 Terminals	Telephone Company Schedule 1 Channels (45 Baud)	Not Required. 62.5 ma Neutral dc Loop: Tip Negative, Ring Positive	Not Required. 62.5 ma Neutral dc Loop: Tip Negative, Ring Positive	45.5 Baud	Telegraph Adapter Type I #7860
	Telephone Company Schedule 2 Channels (57 Baud)			56.9 Baud	Telegraph Adapter Type I #7861
	Telephone Company Schedule 3 Channels (75 Baud)			74.2 Baud	Telegraph Adapter Type I #7862
Western Union Plan 115A Terminals	Western Union Class A Channel	Not Required. 62.5 ma Neutral dc Loop: Tip Negative, Ring Positive	Not Required. 62.5 ma Neutral dc Loop: Tip Negative, Ring Positive	45.5 Baud	Telegraph Adapter Type I #7860
	Western Union Class B Channels (57 Baud)			56.9 Baud	Telegraph Adapter Type I #7861
	Western Union Class C Channels (75 Baud)			74.2 Baud	Telegraph Adapter Type I #7862

*Data Sets are those indicated or their equivalent.

** Common Carrier Leased Private Line Telephone or Privately Owned Two Wire Communication Facilities conforming to SRL Manual A24-3435 for Limited Distance Line Adapter II.

●Figure 7. Attachable Terminals and Communications Facilities for Domestic Use (Communications – Start/Stop Adapters) (continued)

Terminal	Communication Facility	Terminal Data Set	2701 Data Set	Speed	2701 Adapters
1050 and 1060 Data Communication Systems and 2740/2741 Communications Terminals					
1051 Control Unit Model 1 or 2 1061 Control Unit Model 1 or 2 2740/2741 Communications Terminal	Common Carrier Leased Private Line Telephone Service	IBM 3976	IBM 3976	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
1051 Control Unit Model 1 or 2 1061 Control Unit Model 1 or 2 2740/2741 Communications Terminal with Line Adapter #4790	**	Not Required	Not Required		IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1070 Process Communication System					
1071 Control Unit Model 1	Common Carrier Leased Private Line Telephone Service	IBM 3976	IBM 3976	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
1071 Control Unit Model 1 with Line Adapter #4792	**	Not Required	Not Required		IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1071 Control Unit Model 2	Common Carrier Leased Four-Wire Private Line Telephone Service	IBM 3977 Model 1	IBM 3977 Model 1	600.0 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646
1071 Control Unit Model 2 with Line Adapter #4793	**	Not Required	Not Required		IBM Terminal Adapter Type I #4646 IBM Line Adapter #4637
1030 Data Collection System					
1031A Input Station	**	Not Required	Not Required	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648 IBM Line Adapter #4637
1031A Input Station with Common Carrier Adapter #2068	Common Carrier Leased Four-Wire Private Line Telephone Service	IBM 3977 Model 1	IBM 3977 Model 1		IBM Terminal Adapter Type II #4648
2848 Display Control 2260 Display Station	Common Carrier Leased Private Line Telephone Service	IBM 3977 Model 1	IBM 3977 Model 1	1200 Baud 120 Char/Sec	IBM Terminal Adapter Type III #4656
World Trade Teleprinters					
W T Teleprinter	Common Carrier Private Line Telegraph Circuits (Double-Current Telegraph Lines)	Not Required	IBM 3945 Model 11	50 Baud	W T Telegraph Adapter
				75 Baud	W T Telegraph Adapter
W T Teleprinter	Common Carrier Private Line Telegraph Circuits (Single-Current Telegraph Lines)	Not Required	IBM 3945 Model 12	50 Baud	W T Telegraph Adapter
				75 Baud	W T Telegraph Adapter

** Common Carrier Leased Private Line Telephone or Privately Owned Two Wire Communication Facilities conforming to SRL Manual A24-3435 for Limited Distance Line Adapter II.

● Figure 8. Attachable Terminals and Communications Facilities for WT Use (Communications - Start/Stop Adapters)

Enable: This command conditions the 2701 to automatically answer incoming calls. This has meaning only when operating on a dial network.

Disable: This command deconditions the effect of the enable command. The 2701 will disconnect a call (if one is in operation) and will not answer any further incoming calls. This condition exists until an enable command is given.

Dial: This command will be accepted by the 2701 only when it has the automatic call feature. This command enables the automatic call feature to obtain dial digits from the processor. The dial command is ended when the call is either successfully completed or abandoned.

Diagnostic Write: This command sends data to a diagnostic register. If more than one byte are transferred, only the last byte remains stored. The communication line is isolated and does not receive this data. This command is ended either by the XA recognizing a terminating sequence of data or by a stop signal issued by the channel.

Diagnostic Read: This command presents the byte of data stored in the diagnostic register to the channel. The comunication line is isolated and no data occuring on the line will be recognized by the XIC-XA couple.

Adapter Operation

Receive Operation

The receive operation is initiated when the XIC-XA couple accepts a read type command (read, inhibit, search) from the channel. Upon detection of a start bit, the XA prepares to receive a character. The character, which is received one bit at a time, is assembled in a data register. When a full character has been as-

Commands	Bit Configurations P	0	1	2	3	4	5	6	7
Read	0	0	0	0	0	0	0	1	0
Write	0	0	0	0	0	0	0	0	1
Dial	0	0	0	1	0	1	0	0	1
Break	0	0	0	0	0	1	1	0	1
Prepare	1	0	0	0	0	0	1	1	0
Inhibit	1	0	0	0	0	1	0	1	0
Search	0	0	0	0	0	1	1	1	0
Enable	1	0	0	1	0	0	1	1	1
Disable	0	0	0	1	0	1	1	1	1
Diagnostic Read	0	0	0	0	0	0	1	0	1
Diagnostic Write	0	0	0	0	1	0	1	1	0

Note: Byte positions 0 and 1 must contain zeros; however, these positions are ignored by the basic 2701 Data Adapter Unit.

Figure 9. Communications – Start/Stop Adapter Commands

sembled, the XA checks for special characters, checks for VRC, assembles the LRC (where applicable), and requests a data transfer to the channel. The channel has a minimum 2.1 bit time, which prevents losing a character. This response time is determined with the worst possible receive distortion. The stop bit is checked for, and, unless some terminating status condition occurs, the XA prepares to receive the next character.

Line Time-Out

A 28-second timeout between data characters is performed when the XA is operating on a read type command other than inhibit. The timeout is used to prevent a communication line or terminal failure from going undetected. The timeout is started when the stop bit is received, and terminated when the next start is detected. If the timeout elapses, the command is terminated, and the channel is notified of this occurrence through the status and sense bytes. Some transmission adapters also require a short timeout.

Transmit Operation

The transmit operation is initiated by the acceptance of a write command by a XIC-XA couple. The XA accepts a character from the channel and transmits it a bit at a time over the communications facilities. The XA inserts the start and stop bits, checks for special characters, accumulates and transmits the LRC character (where applicable) and inserts shift characters (where applicable).

Unless some terminating condition has occurred, the XIC-XA couple will request a data transfer after the last data bit is sent to the communications line. When the data code requires one stop bit, there are 1.3 bit times for the channel to respond without elongating the stop bit time. When the data code requires two stop bits, the time is a 2.3 bit time. Although it decreases the overall data rate, an elongated stop bit is a normal occurrence for start/stop transmission schemes.

Status Byte

The following terminating statuses may be presented by the communications-start/stop adapter to the channel:

Device End, Channel End Status: Indicates that the current command has been brought to a normal end and the unit is free to accept another command.

Device End, Channel End, and Unit Exception Status: Indicates that the current command has been brought to a successful conclusion and EOT (end of transmission) has been received, or a no response to a poll has been detected.

Device End, Channel End, and Unit Check Status: Indicates that the current command has been ended with an unusual condition. A sense command must be issued to the addressed unit to further define these conditions.

Device End, Channel End, Unit Exception, and Unit Check Status: Indicates that the current command has been ended by unusual conditions and an EOT or a no response to a poll has been received. A sense command must be issued to the addressed unit to further define these conditions.

Sense Byte Definition

The sense byte is transferred to the channel during the sense operation; definition of the bits as they are sent to System/360 storage is given below:

0 Command reject*
1 Intervention required
2 Bus out check*
3 Equipment check
4 Data check
5 Overrun
6 Receiving
7 Timeout

Intervention Required is set when the following conditions exist:

1. The attached data set, where applicable, has power off or is in test mode.
2. An attached automatic calling unit, where applicable, has power off.
3. Continuous space signal has been received on a given communications line for more than one character.

Equipment Check is set when a halt I/O is detected during a service cycle.

Data Check is set during receive operations if:

1. At stop time, the receive data sample is a space signal.

*These bits are set by the XIC and are not discussed here.

2. If a parity or cyclic check error is detected. (During transmit operations, this bit is set if an echo check is detected at the relay interface of a telegraph line adapter.)

Overrun is set during receive operations if a byte is lost because data service could not be obtained in time.

Receiving is set whenever the addressed unit is engaged in receiving data. The automatic call feature sets this bit when a dial command is issued to a line that is currently "off-hook."

Timeout is set when the communications line timeout has elapsed. The automatic call feature sets this bit to indicate that the dial operation has not been successfully completed.

Special Features

Automatic Call Feature

This feature enables the 2701 to originate calls on a switched dial network by dialing through a Western Electric Automatic Calling Unit, or equivalent. This feature is not needed or used for handling the automatic answering of calls on a switched network. The automatic call feature can operate with only certain types of transmission adapters and certain types of terminals attached to those adapters. Therefore, the capability for the automatic call feature will be discussed in the sections covering the specific transmission adapters and the terminals.

To perform a dial operation, the programmer sets up the dialing number, one digit per byte, in an outgoing message. The digit is represented in binary code in bits 4, 5, 6, and 7 of the byte. He then issues a dial command (a bit configuration is shown in Figure 9), with a byte count equal to the number of digits to be dialed. The 2701, when it accepts the dial command, presents the digits to the automatic calling unit for dialing. When the call has been answered, the 2701 presents the device end, channel end status to the channel. Command chaining then occurs to a read or write command, depending upon the operation. If, for some reason, the call cannot be completed, the 2701 presents the device end, channel end, and unit check status with the timeout bit set in the sense byte.

IBM Line Adapter Feature

The IBM Line Adapter Feature is available with only certain communications-start/stop adapters, and with only some of the terminals that operate with these adapters. The capability to operate with the IBM Line Adapter is stated in the sections covering the specific transmission adapters. The IBM Line Adapter is a modem that provides for the attachment of the 2701 transmission adapter to customer-owned private telephone lines for distances up to 8 wire miles, conforming to *IBM 1030 Data Collection System Physical Planning*, Form A24-3021.

Diagnostics

2701 start/stop adapters each have a diagnostic register located on the 2701's side of the line drivers or relays that operate with the communication facilities. Through a diagnostic write command, data can be sent through the 2701's XIC-XA couple to the diagnostic register. The diagnostic register holds the start bit, the data bits, and the stop bit(s). If multiple bytes are transmitted under this command, only the last byte will remain stored in the register. Through a diagnostic read command, the contents of this register are sent back to storage for checking. The 2701 operates on this byte as though it were being received from the communication line. The start bit is checked; the data character is checked for special character; the shift bit, if applicable, is added; the stop bit is checked; and the character is transferred to the channel.

The use of the diagnostic commands allows a major portion of the 2701 circuitry to be checked out. The clocks, counters, registers, serializers, deserializers, etc. can be checked. Some of the decoding capabilities can be checked and the LRC generation circuitry can be checked. For example, with an IBM Terminal Adapter-Type I, the diagnostic write command can be used to transmit multiple bytes of data, the last byte being the EOB character. As will be explained in the section describing the IBM Terminal Adapter-Type I, the recognition of the EOB character causes the transmission adapter to transmit the EOB followed by the LRC character and then presents terminating status to the channel. The last character transmitted is the LRC character, which will reside in the diagnostic register. A diagnostic read command can then be given to bring the LRC character to storage for checking. On both a diagnostic read and diagnostic write operation, the communication lines are degated. In this manner, no data will be transferred to or from the communication lines. There are other techniques peculiar to each type of adapter, such as special character generation, which is not discussed.

Automatic Answering

Automatic answering of incoming calls, a standard feature on the IBM Terminal Adapter-Type I and the Telegraph Adapter-Type II, allows the programmer to control the answering of incoming calls. When the programmer desires to allow the answering of incoming calls, he issues an enable command to the 2701. The SLI (suppress length indication) flag is set in the associated channel command word. When a

call is answered, the enable command is ended, with the XIC-XA couple setting the device end, channel end status. Command chaining may be applied to either a write or a read command, depending upon the application. When conditions change and the programmer no longer desires to accept incoming calls, a halt I/O command is given to the XIC-XA couple which causes the device end, channel end status to be presented and the data set prevented from answering any further incoming calls. Once an enable command is given, the data set remains conditioned to answer calls until either a halt I/O or disable command is issued.

IBM Terminal Adapter-Type I

The IBM Terminal Adapter-Type I enables the 2701 to control data transfer between an IBM System/360 and the following terminals: IBM 1050, 1060, 1070, 2740, and 2741 (without interrupt feature) terminals at 14.8 characters per second (134.49 bps) or the IBM 1070 at 66.6 characters per second (600 bps.) Figures 7 and 8 illustrates the data sets and communications facilities required for each of the above terminals operating at different speeds. The IBM Terminal Adapter-Type I matches the line control required for terminal operation with the I/O channel using System/360 programming capabilities. Polling and addressing responses, VRC (vertical redundancy checking) and LRC (longitudinal redundancy check), special character recognition, and shifted character operations are all handled by the XA to minimize system interference.

Commands

The IBM Terminal Adapter-Type I decodes and excutes the following commands: read, write, inhibit, enable, disable, prepare, diagnostic read, and diagnostic write. The dial command is also valid for this adapter when it has the automatic call feature. The functions of these commands are explained under the communication-start/stop adapters.

Special Features

Two special features are available for the IBM Terminal Adapter-Type I:

The automatic call feature is obtainable with the IBM Terminal Adapter-Type I only when operating with the IBM 1050 Terminal.

The IBM Line Adapter Feature is obtainable with the IBM Terminal Adapter-Type I only when operating with the 1050 or 1070 terminals.

Adapter Operation

Character Set: The transmission code between the 2701 and the 1050, 1060, 1070, 2740, and 2741 terminals is six-bit BCD. The relationship between the 2701 and the I/O interface is illustrated in Figures 10, 11, and 12. One start bit and a minimum of one stop bit are added to a character when the XA is transmitting, and they are deleted from a character when the XA is receiving.

0	1	2	3	4	5	6	7
shift S	B	A	8	4	2	1	check C

System/360 Byte

6 Bit BCD

In the six-bit BCD transmission code, S represents the shift bit. A logical 1 identifies the upper case; a logical 0 represents the lower case. The B bit is the first bit transmitted and received following the start bit. An odd parity (check) bit follows the 1 bit. Each received character is checked for odd vertical parity.

On incoming data, the shifted character set conversion (a standard feature) automatically deletes the up shift and down shift characters from the received data stream, notes the last shift character received, and inserts the eighth bit S to indicate the case to System/360. On outgoing data, the S bit is removed and noted. A change in this S bit automatically causes insertion of the appropriate shift character (up shift or down shift) into the outgoing data stream before sending the data character.

START	B	A	8	4	2	1	check C	STOP

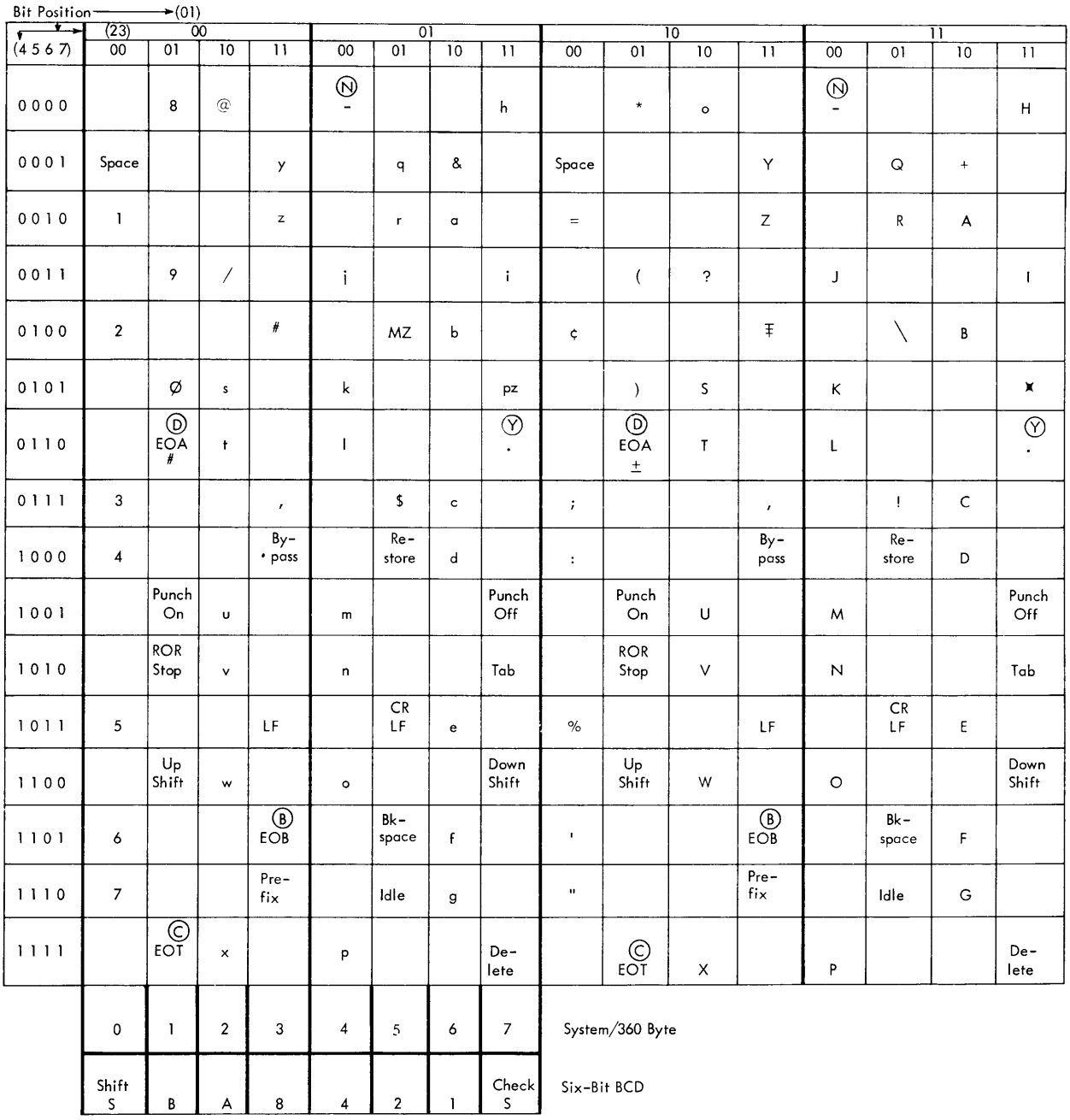
Outgoing Data Character

The C (check) bit in the character indicates the correct odd parity count; a logical 1 if the bit count of the character is even, or a logical 0 if the bit count of the character is odd.

VRC and LRC are provided, with any detected error setting the data check bit within the sense byte.

Polling and Addressing: When polling, a write command is initiated by a start I/O instruction which causes the polling character to be transmitted on the communications line. Command chaining to a read command should be used so that the 2701 has a valid command for receiving the incoming data.

Upon receiving a read command, the 2701 will initiate a 28-second timeout. When polling, this timeout is pre-empted by a 2-second short timeout. The 2701 will set the device end, channel end, and unit exception status when an Ⓝ character is received. Ⓝ indicates the terminal has no data to send. The device end, channel end and unit check status is set in the status byte when a timeout occurs; the timeout sense bit will also be set. When the first character received is a Ⓓ, it indicates that the polling was suc-



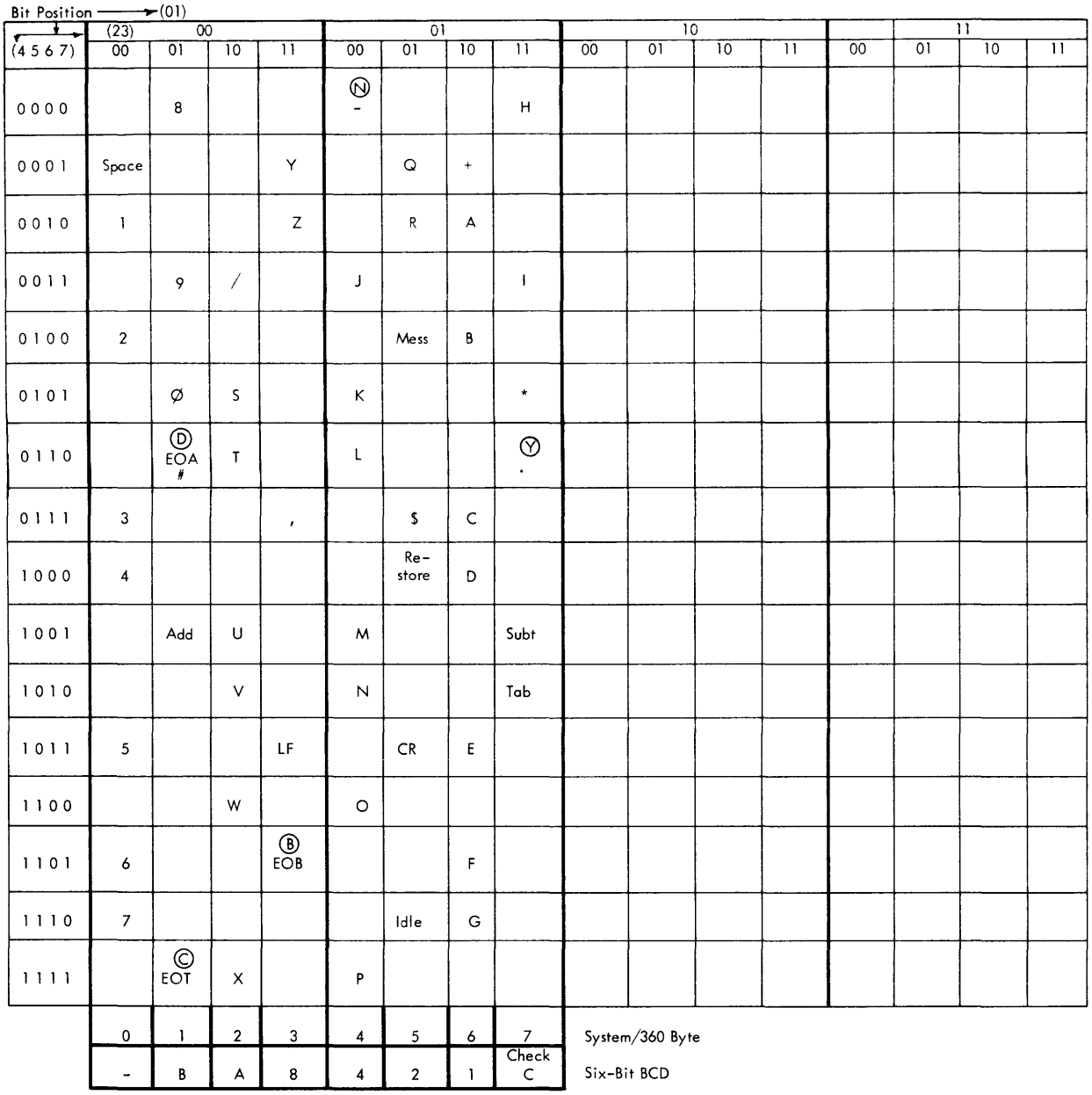
Bit Position → (01)																
(23)	00				01				10				11			
(4 5 6 7)	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0		8	@		Ⓝ -			h		*	o		Ⓝ -			H
0 0 0 1	Space			y		q	&		Space			Y		Q	+	
0 0 1 0	1			z		r	a		=			Z		R	A	
0 0 1 1		9	/		¡			i		(	?		J			I
0 1 0 0	2			#		MZ	b		ç			∓		\	B	
0 1 0 1		Ø	s		k			pz		)	S		K			✖
0 1 1 0		Ⓓ EOA #	t		l			Ⓨ .		Ⓓ EOA ±	T		L			Ⓨ .
0 1 1 1	3			,		$	c		;			,		!	C	
1 0 0 0	4			By- pass		Re- store	d		:			By- pass		Re- store	D	
1 0 0 1		Punch On	u		m			Punch Off		Punch On	U		M			Punch Off
1 0 1 0		ROR Stop	v		n			Tab		ROR Stop	V		N			Tab
1 0 1 1	5			LF		CR LF	e		%			LF		CR LF	E	
1 1 0 0		Up Shift	w		o			Down Shift		Up Shift	W		O			Down Shift
1 1 0 1	6			Ⓑ EOB		Bk- space	f		'			Ⓑ EOB		Bk- space	F	
1 1 1 0	7			Pre- fix		Idle	g		"			Pre- fix		Idle	G	
1 1 1 1		Ⓒ EOT	x		p			De- lete		Ⓒ EOT	X		P			De- lete
	0	1	2	3	4	5	6	7	System/360 Byte							
	Shift S	B	A	8	4	2	1	Check S	Six-Bit BCD							

Figure 10. Code Structure for 1050 Data Communication System

cessful. If the first character is not a Ⓓ, the message will be received without LRC accumulation. The read command continues with characters being transferred to the CPU as they are received. When addressing, the write command causes the addressing character to be transmitted on the communications line. When the write command ends, command chaining to a read command should be used to provide for receiving the Ⓝ or Ⓨ character. Ⓝ, which indicates that the addressed terminal is not prepared to receive data, will cause the device end, channel end, and unit exception status to be set as in polling. Ⓨ, which indicates the terminal is available, will cause the device end, channel end status to be set, which allows for command chaining to the output message.

Character Recognition: The following characters are recognized by the 2701 during write commands.

Ⓑ End of Block (EOB) indicates the end of a block of text. The LRC character, developed by the XA, will be transmitted after the Ⓑ. After transmitting the LRC character, the device end, channel end status will be set. Command chaining to a read command should be used to prepare the XA to receive the answer-back character from the terminal.



Bit Position → (01)																
(23)	00				01				10					11		
(4 5 6 7)	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0		8			Ⓝ -			H								
0 0 0 1	Space			Y		Q	+									
0 0 1 0	1			Z		R	A									
0 0 1 1		9	/		J			I								
0 1 0 0	2					Mess	B									
0 1 0 1		Ø	S		K			*								
0 1 1 0		Ⓓ EOA #	T		L			Ⓨ .								
0 1 1 1	3			,		$	C									
1 0 0 0	4					Re-store	D									
1 0 0 1		Add	U		M			Subt								
1 0 1 0			V		N			Tab								
1 0 1 1	5			LF		CR	E									
1 1 0 0			W		O											
1 1 0 1	6			Ⓑ EOB			F									
1 1 1 0	7					Idle	G									
1 1 1 1		Ⓒ EOT	X		P											
	0	1	2	3	4	5	6	7	System/360 Byte							
	-	B	A	8	4	2	1	Check C	Six-Bit BCD							

Figure 11. Code Structure for 1060 Data Communication System

Ⓒ End of Transmission (EOT) indicates the end of a transmission. This puts the XIC-XA couple into the control mode.

Ⓓ End of Address (EOA) indicates the end of address and is normally followed by text. The XA begins the LRC accumulation with the character which follows the Ⓓ character.

The following characters are recognized during read commands:

Ⓑ End of Block (EOB) indicates the end of a block of text. The next received character will be the LRC character, which will be checked against the LRC character accumulated in the XA. The device end, channel end status will be set with a compare. A non-compare will cause the device end, channel end, and unit check status to be set with the data check bit on the sense byte. The answer-back character Ⓨ or Ⓝ must be transmitted by the program by means of a write command.

Ⓒ End of Transmission (EOT) indicates the end of the transmission. The device end, channel end, unit exception status will be set.

Ⓓ End of Address (EOA) indicates that the following characters will be text. The LRC accumulation begins with the next character.

Ⓝ Negative Response indicates that the addressed terminal is not ready to receive data or that the text was received by the remote terminal with a detectable

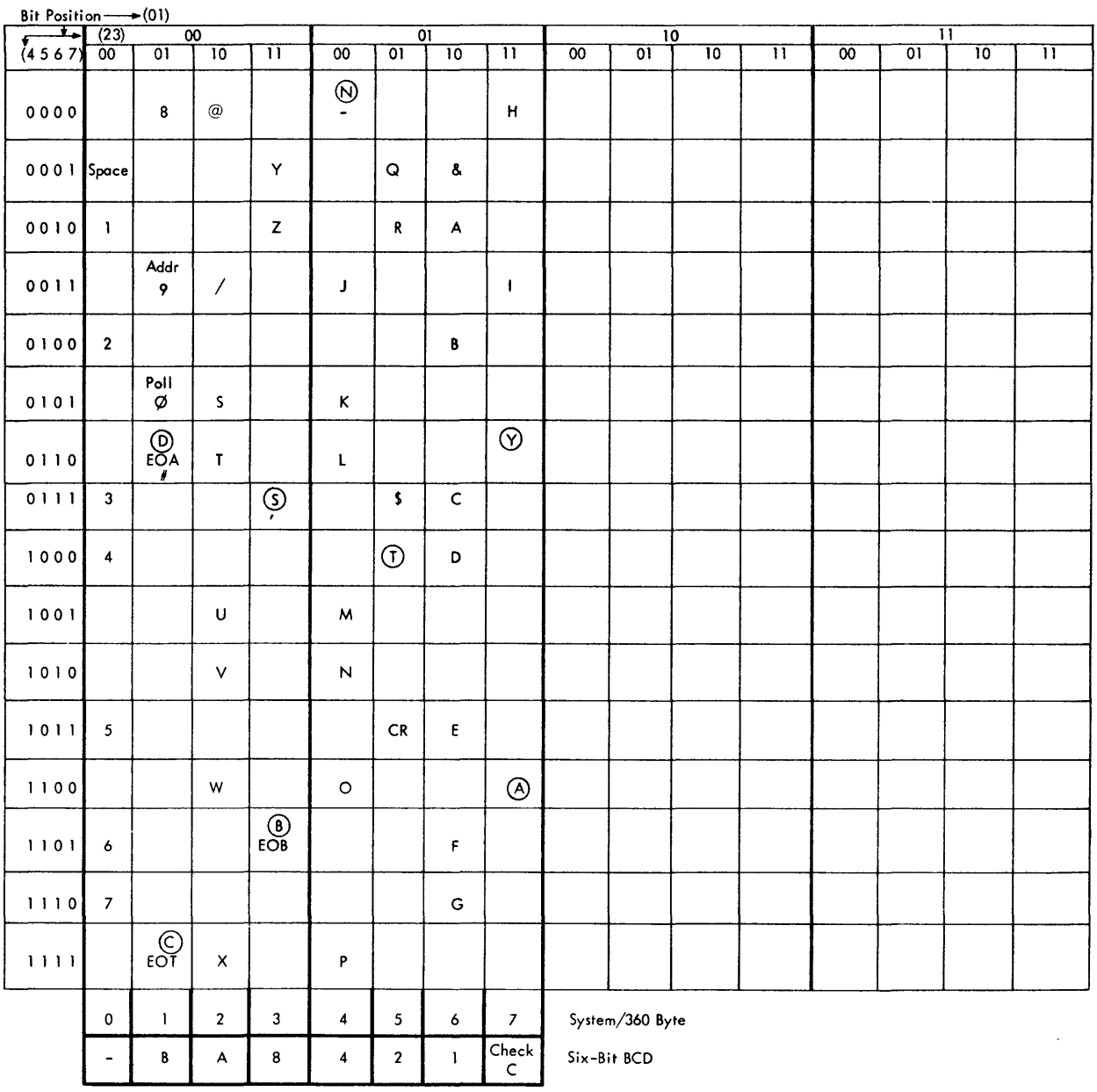


Figure 12. Code Structure for 1070 Process Communication System

error. The XA logically determines which of the above is valid and takes the following action:

Not Ready: The device end, channel end, unit exception status is set.

Error: The device end, channel end, unit check status is set with the data check bit set in the sense byte.

Ⓨ Positive Response indicates that the text received was correct or the addressed system is ready to receive data. In either case, the XA sets the device end, channel end status.

The IBM Terminal Adapter-Type I recognizes the delete and idle characters and includes them in the accumulated LRC but inhibits the transfer of these characters to the CPU.

1033 Operation — Message Restriction: The IBM 1070 Process Communication System uses the IBM 1033 Printer. When the IBM Terminal Adapter-Type I is used with the 600 bps line speed, a problem arises.

The 1033 Printer operates at 15 cps. The transmission line operates at 600 bps (or a comparable rate of 67 cps). A four-character delay time is required between output printing characters. This is effected by using the write command with three special characters (DF in Hexadecimal Representation), inserted between every printing character. The CPU program must take into account the difference in operating speed between the transmission line and the printer

and provide the necessary delays for printing the output, via the insertion of these write mark characters. Delays can also be effected in this manner to carriage returns, tabs, line feeds and so on.

IBM Terminal Adapter-Type II

IBM Terminal Adapter-Type II provides the 2701 with the controls for operation with the IBM 1030 Data Collection System at 600 bits per second.

Commands

The IBM Terminal Adapter-Type II decodes and executes the following commands: read, write, inhibit, prepare, enable, disable, diagnostic read, and diagnostic write. The functions of the command are explained in the start/stop adapter section.

Special Features

The IBM Line Adapter may be obtained with this adapter.

Adapter Operation

Character Set: The transmission code between the 2701 and the terminals is six bits plus parity. The relationship between the 2701 and the I/O Interface is illustrated in Figure 13. One start bit and a minimum of two stop bits are added to a character when the XA is transmitting to the terminal and deleted when the XA is receiving from the terminal.

0	1	2	3	4	5	6	7	System/360 Byte
-	B	A	8	4	2	1	check C	6 Bit BCD

The bit B is the first bit transmitted and received on the communications line following the start bit. The C bit in the character indicates the correct odd parity count: a logical 1 if the bit count of the character is even or a logical 0 if the bit count of the character is odd.

START	B	A	8	4	2	1	check C	STOP	STOP	Outgoing Data Character

Each received character is checked for odd vertical parity; a parity check causes the unit check bit to be set with the terminating status. The parity check does not cause the termination of the command.

Polling and Addressing: When polling, a write command is issued through a start I/O instruction which causes the polling character to be transmitted on the communication line. At the end of the write command, command chaining to a read command should be performed so that a read command, with its allocated storage, is ready for the incoming data. Upon receiving the read command, the 2701 will initiate a timeout. When polling, the IBM Terminal Adapter-Type II preempts the 28-second timeout with a 500-millisecond short timeout. When an (N) is received, the device end, channel end, and unit exception status is set. The device end, channel end, and unit check is set in the status byte when a timeout occurs; the timeout bit is also set in the sense field.

When addressing, a write command is issued through a start I/O instruction that causes the addressing character to be transmitted on the communication line. An (S) character (provided by the program) is transmitted before the addressing characters. At the end of the write command, command chaining to a read command is used to receive the (N) or (Y) character. (N) will set the device end, channel end, and unit exception status as in polling. (Y) will set the device end, channel end, which allows command chaining to the output message.

Character Recognition: The following characters are recognized during write command:

(C) End of Transmission (EOT) indicates the end of transmission and places the 2701 in a control mode. It is normally followed by polling or addressing.

(D) End of Address (EOA) indicates the end of address (start of message).

The following characters are recognized during read commands:

(B) End of Block (EOB) indicates the end of a block of text. If a VRC error is detected in the block of data, the device end, channel end, and unit check status will be set with the data check bit set in the sense byte. Otherwise, the device end, channel end status is set.

(D) End of Address (EOA) indicates that the following characters will be text.

(N) Negative response indicates that the addressed terminal is not ready to receive data or that the text received by the terminal is incorrect. The device end, channel end, and unit exception status is set for not ready condition, and the device end, channel end, and unit check status is set with the data check bit set in the sense byte for a text error.

(Y) Positive Response indicates that the addressed system is available or that the text received was correct. The device end, channel end status will be set.

1033 Operation – Message Restriction: The 1033 Printer operates at 15 characters per second, and the transmission line operates at 600 bps (or a comparable rate of 60 cps). A three-character delay time is required between output printing characters. This is effected by using the write command with three special characters (DF in hexadecimal representation) inserted between every printing character. The CPU program must consider the difference in operating speeds

Bit Position → (01)																
(23)	00				01				10				11			
(4 5 6 7)	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0		8			Ⓝ -			H								
0 0 0 1	Space			Y		Q	&									
0 0 1 0	1			Z		R	A									
0 0 1 1		9	/		J			I								
0 1 0 0	2						B									
0 1 0 1		Ø	S		K			?								
0 1 1 0		Ⓓ EOA #	T		L			Ⓨ								
0 1 1 1	3					$	C									
1 0 0 0	4						D									
1 0 0 1			U		M											
1 0 1 0			V		N			Tab								
1 0 1 1	5			LF		CR	E									
1 1 0 0			W		O											
1 1 0 1	6			Ⓑ EOB			F									
1 1 1 0	7					Idle	G									
1 1 1 1		Ⓒ EOT	X		P											
	0	1	2	3	4	5	6	7	System/360 Byte							
		B	A	8	4	2	1	Check C	Six-Bit BCD							

Figure 13. Code Structure for 1030 Data Collection System

between the transmission line and the printer and provide the necessary delays for printing the output by insertion of write mark characters. Delays can also be effected in this manner to carriage returns, tabs, line feeds, and so on.

IBM Terminal Adapter-Type III

The IBM Terminal Adapter-Type III allows the 2701 to operate in half duplex start-stop mode between a System/360 and the IBM 2848 Display Control – 2260 Display Station complex. The adapter enables the 2701 to interface with either a Western Electric 202D1 data set (or equivalent) at 1200 baud (120 cps) over a common carrier Schedule 4A line, or with a 201B1 (or equivalent) at 2400 baud (240 cps) over a common carrier Schedule 4B line. Operation at the latter rate employs the data set synchronous clock to perform the bit sampling function.

Both data and line control use the ASCII code set.

Commands

The IBM Terminal Adapter-Type III decodes and executes the following commands: read, write, diagnostic read, and diagnostic write. The function of each command is explained in the start/stop adapter section.

Special Features

There are no special features for this adapter.

Adapter Operation

Character set, polling and addressing, and character-recognition information will be published in a later revision of this manual.

IBM Telegraph Adapter

The IBM Telegraph Adapter is identical to the IBM Terminal Adapter-Type I with the exception of the communication medium. The IBM Telegraph Adapter operates over a telegraph network, through telegraph relays, at telegraph speeds. It also performs an echo check on the transmitted data. Factors such as commands decoded and executed, polling and addressing, character recognition, and other operating functions are the same as those for the IBM Terminal Adapter-Type I. The status and sense bytes are defined exactly as for the IBM Terminal Adapter-Type I except for the added echo check. When an echo check error is discovered, the unit check bit is set in the status byte and the data check bit is set in the sense byte. The command is not ended because of an echo check.

Telegraph Adapter-Type I

The Telegraph Adapter-Type I enables the 2701 to control data transfer between an IBM System/360

and the AT&T 83B2/83B3 or Western Union Plan 115A Terminals. The speed of transmission is 45.57, 56.9, or 75 bps.

Commands

The Telegraph Adapter-Type 1 decodes and executes the following commands: read, write, inhibit, search, prepare, diagnostic read, and diagnostic write. The functions of these commands are explained in the start/stop adapter section.

Special Features

There are no special features for this adapter.

Adapter Operation

Character Set: The transmission code between the 2701 and the terminals is Baudot. The relationship between the 2701 and the I/O interface is illustrated in Figures 14 and 15.

0	1	2	3	4	5	6	7	System/360 Byte
-	-	case S	1	2	3	4	5	Shifted Baudot Code

In the above figure, S represents the case. A logical 1 identifies upper case; a logical 0 identifies lower case. The 1 bit is the first bit transmitted following the start bit.

The shift character set conversion, a standard feature, automatically deletes LTRS and FIGS characters from the received data stream and denotes the case. A

Bit Position ——→ (01)

(4 5 6 7) ↓	(23) → 00				01				10				11			
	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0	Blank	E	Blank	3												
0 0 0 1	T	Z	5	"												
0 0 1 0	CR	D	CR	$												
0 0 1 1	0	B	9	?												
0 1 0 0	Space ✖	S	Space ✖	Bell												
0 1 0 1	H	Y	#	6												
0 1 1 0	N	F	,	!												
0 1 1 1	M	X	'	/												
1 0 0 0	LF	A	LF	-												
1 0 0 1	L	W	)	2												
1 0 1 0	R	J	4	'												
1 0 1 1	G	Figs ↑	∝	Figs ↑												
1 1 0 0	I	U	8	7												
1 1 0 1	P	Q	Ø	1												
1 1 1 0	C	K	:	(												
1 1 1 1	V	Ltrs ↓	;	Ltrs ↓												
	0	1	2	3	4	5	6	7	System/360 Byte							
			Shift S	1	2	3	4	5	Shifted Baudot Code							

Figure 14. Code Structure for AT&T 83B2/83B3, Western Union Plan 115A, and World Trade Teleprinter Terminals (C Keyboard)

Bit Position → (01)

(4 5 6 7) \ (23)	00				01				10				11			
	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0	Blank	E	Blank	3												
0 0 0 1	T	Z	5	"												
0 0 1 0	CR <	D	CR <	$												
0 0 1 1	O	B	9	5/8												
0 1 0 0	Space ✖	S	Space ✖	Bell												
0 1 0 1	H	Y		6												
0 1 1 0	N	F	7/8	1/4												
0 1 1 1	M	X	o	/												
1 0 0 0	LF	A	LF	-												
1 0 0 1	L	W	3/4	2												
1 0 1 0	R	J	4	'												
1 0 1 1	G	Figs ↑	∝	Figs ↑												
1 1 0 0	I	U	8	7												
1 1 0 1	P	Q	Ø	1												
1 1 1 0	C	K	1/8	1/2												
1 1 1 1	V	Ltrs ↓	3/8	Ltrs ↓												
	0	1	2	3	4	5	6	7	System/360 Byte							
			Shift S	1	2	3	4	5	Shifted Baudot Code							

Figure 15. Code Structure for AT&T 83B2/83B3, Western Union Plan 115A, and World Trade Teleprinter Terminals (A Keyboard)

sixth bit is added to the code set by the adapter; it indicates case to the processor. Data bytes transferred from the channel are in six-bit form. The adapter will remove the sixth bit and note the case. A change in case automatically causes the insertion of the proper shift character (LTRS or FIGS) into the outgoing data stream. The adapter will send two stop bits and check for the presence of one stop bit on receive.

Polling and Addressing: When polling, a write command is issued through a start I/O instruction, which causes the polling character to be transmitted on the communication line. At the end of the write command, command chaining to a read command should be used so that a read command with its allocated storage is ready for incoming data. Upon receiving the read command, the 2701 will initiate a timeout. When polling, the Telegraph Adapter-Type I pre-empts the 28-second timeout with a 2-second short timeout. The CPU program will be interrupted if V or M is received (which is a negative response to a poll). The device end, channel end status is set. Unit check will be set in the status byte if a timeout occurs; the timeout bit will be set in the sense field. The positive response to a poll is the message itself.

When addressing, a write command is issued through a start I/O instruction, which causes the addressing characters to be transmitted on the communication line. At the end of the write command, command chaining to a read command is used to receive the V or M response (which is the positive response). A V or M will cause a normal device end and channel end status which can be command-chained to the output message. A timeout will set unit check in the status byte and timeout within the sense field, as in polling, to interrupt the CPU program.

When operation on the multidrop line allows terminal to terminal traffic, different line control is required. In response to a polling message, the positive response is a CDC (Call Directing Code) or SSC (Station Selection Code). If the CPU or a terminal on another line is addressed, the CDC or SSC of the CPU must be the first address sent by the terminal. The character AZ is assigned to the CPU in all systems. If AZ is detected, a device end and channel end status will be set, thus ending the polling read command. The V answer-back must be sent by the program through a write command, and a chained read command must be provided for receiving the text. If the terminal has no message to send, it will respond with a V. The V will cause termination of the read command via channel end and device end status. If some sequence other than AZ or V is received, a stop signal is given by the channel when the byte count in the CCW (set to two by the program) is exceeded. In this case, a search command can be issued to monitor the line for end of transmission (EOT), if the program does not want to receive the message. Text messages must begin with EOA (End Of Address). For AT&T 83B2 and 83B3 Terminals, EOA is CR, LF, LTRS; for Western Union Plan 115A Terminals, EOA is the space character.

Character Recognition: The following characters are recognized during read commands:

1. A V or M received as the first character sets channel end and device end status.
2. FIGS H and LTRS are received as EOT and set channel end, device end and unit exception status.
3. The two-character sequence AZ is received as the first two characters of a message and the address of the CPU. The device and channel end status will be set.

Message Restrictions for Telegraph Adapter-Type I:

Terminal to Processor

1. All messages transmitted by a Western Union Plan 115A Terminal from its paper tape reader must be preceded with the sequence A, V, space.
2. A space character received by the 2701 will not downshift (FIGS to LTRS).
3. Text immediately following the sequence FIGS, H, LTRS (EOT) will be lost; EOT must not be sent between blocks of data.

Processor to Terminal

1. When transmitted, the characters (CR, LF, space and blank) must be in the same case as the preceding character.
2. The terminal control automatically inserts the proper shift character in outgoing data when a change of case is encountered.

Terminal to Terminal

1. AZ is the address assigned to the CPU and recognized by the 2701.
2. End of Address (EOA) must precede the transmission of text: EOA for AT&T 83B2 and 83B3 — CR, LF, LTRS; EOA for WU 115A — Space.

Telegraph Adapter-Type II

The Telegraph Adapter-Type II provides the necessary controls for the attachment of telephone company teletypewriter exchange (TWX) stations to the 2701. Control is point-to-point and is on common-carrier switched 150-bps TWX service. Transmission speed is 110 bps.

Commands

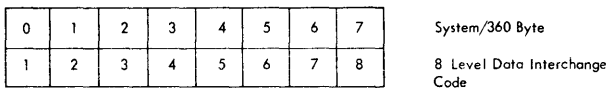
The Telegraph Adapter-Type II decodes and executes the following commands: read, write, inhibit, enable, disable, prepare, diagnostic read, and diagnostic write. The dial command is also valid when the automatic call feature is obtained. The functions of these commands are explained in the section "Start/Stop Adapters."

Special Feature

The automatic call feature is obtainable with the Telegraph Adapter-Type II.

Adapter Operation

Character Set: The transmission code used is the eight-bit Data Interchange Code (ASCII). The relationship of the 2701 with the I/O interface is illustrated in Figure 16.



One start bit and two stop bits are added to a character when the XA is transmitting to the terminal and are deleted when the XA is receiving from the terminal.

Line Control: Identification type of answer-back is handled by the 2701 and the System/360. Output

Bit Position → (01)																
(4 5 6 7) ↓ (23) →	00				01				10				11			
	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0																
0 0 0 1	Null		EOT	Form	EOA	Line Feed		SO	SOM	Hor TAB	WRU	Return	EOM	Vert Tab	Bell	SI
0 0 1 0																
0 0 1 1	@	H	D	L	B	J	F	N	A	I	E	M	C	K	G	O
0 1 0 0																
0 1 0 1	SP	(	$	,	"	*	&	.	!	)	%	-	#	+	'	/
0 1 1 0																
0 1 1 1																
1 0 0 0																
1 0 0 1	DCo		Tape Aux Off		Tape Aux On				X-on				X-off		LEM	
1 0 1 0																
1 0 1 1	P	X	T	\	R	Z	V	↑	Q	Y	U	]	S	[	W	←
1 1 0 0																
1 1 0 1	O	8	4	<	2	:	6	>	1	9	5	=	3	;	7	?
1 1 1 0																
1 1 1 1																
	0	1	2	3	4	5	6	7	System/360 Byte							
	1	2	3	4	5	6	7	8	Eight-Bit Data Interchange Code							

Figure 16. Eight-Bit Data Interchange Code

messages can be of any length or format. Input messages can be of any length; however, certain format restrictions are imposed because of the line control used by these terminals. On input, or during read operations, the following characters are recognized by the 2701:

WRU (Who are you?) This character causes device end, channel end status to be set.

XON (Transmitter on) This character causes channel end, device end status to be set.

XOFF (Transmitter off) This character causes device end, channel end status to be set.

EOT (End of transmission) This character causes the device end, channel end, and unit exception status to be set.

Message Restrictions for Telegraph Adapter-Type II:

Terminal to Processor

1. Delete characters are recognized, and the 2701 deletes them from the input message stream.

2. WRU, XON, XOFF, and EOT terminates receive operations.

World Trade Telegraph Adapter

World Trade telegraph adapter enables the 2701 to control data transfer between the IBM System/360 and various European telegraph printers over selectively single current or double current telegraph lines at either 50 bits per second or 75 bits per second.

Commands

The World Trade telegraph adapter decodes and executes the following commands: read, write, inhibit, prepare, search, break, diagnostic read, and diagnostic write. The functions of these commands are explained in the section "Start/Stop Adapters."

Special Features

There are no special features that operate with the adapter.

Adapter Operation

Character Set: The transmission code used between the 2701 and the terminals is the Baudot Code. The relationship between the 2701 and the I/O interface is illustrated in Figures 14 and 15.

0	1	2	3	4	5	6	7	System/360 Byte
-	-	S	1	2	3	4	5	Shifted Baudot Code

S represents the case. A logical one identifies the uppercase; logical zero, the lower case. The 1 bit is the first bit transmitted following the start bit. Shifted character set conversion, a standard feature, automatically deletes LTRS and FIGS characters from the received data stream, notes the last shift character received, and inserts a sixth bit (5) in the code set to indicate the case to the processor. On outgoing data, the S bit is removed and noted. A change in the S bit automatically causes the insertion of the appropriate shift character in the outgoing data stream before sending the data character.

Attachment to the World Trade telegraph adapter is point-to-point; thus, the line control method used is contention rather than polling.

When the terminal is transmitting, the programmer must insert from 4 to 20 LTR characters before inserting the start of message character (line feed) to ensure that the terminal is receiving properly. Should the terminal bid for the line simultaneously with the processor, an echo check will occur, terminating the write operation at the CPU.

When the terminal is receiving, the prepare command is issued to the World Trade telegraph adapter to wait for the completion of the first space condition from the terminal. The prepare command may be terminated in one of three ways:

1. A true start bit is detected. This is recognized by the line going to the space condition for one bit time and then returning to the mark condition. The device end, channel end status is set. Command chaining to a read command can be used to receive the incoming message.

2. The line goes to space and does not return to mark within 28 seconds. The device end, channel end, and unit check status is set with the timeout bit set in the sense byte.

3. A halt I/O or a reset is received from the channel. If a true start bit (as in 1 above) is detected and the halt I/O is received prior to the status being presented, the unit check status is also set. The receiving bit will be on in the sense byte. Otherwise, the device end, channel end status byte. Otherwise, the device end, channel end status is set.

Character Recognition:

1. EOT (End of Transmission) — format is FIGS, CHARACTER, LTRS with the character assigned on a per system basis. EOT sets channel end, device end, and unit exception status.

2. EOB (End of Block) — format is FIGS, CHARACTER with the character assigned on a per system basis. EOB sets channel end, device end status.

3. A V or M received as the first character sets channel end, device end status.

Message Restriction for World Trade Telegraph:

Terminal to Processor

1. The characters used in EOB and EOT must not be the same.

2. A space character received by the 2701 will not downshift (FIGS to LTRS).

3. Text immediately following FIGS, CHARACTER, LTRS will be lost. EOT must not be sent between blocks of data.

Processor to Terminal

1. When transmitted, the characters (CR, LF, space, and blank) must be in the same case as the preceding character.

2. The terminal control automatically inserts the proper shift character in outgoing data when a change of case is encountered.

Communications—Synchronous Adapter

The Synchronous Data Adapter-Type 1 (SDA-1) provides for point-to-point, half-duplex synchronous data transmission as a synchronous transmitter-receiver (STR) device in 4-out-of-8 code at speeds up to 5100 characters per second. The speed depends on the remote terminal, the communication facility, and the data set.

The SDA-1 can communicate with remote STR devices over private line or switched communication networks with voice grade or broad-band communication channels. In switched network operation, the SDA-1 can originate calls by dialing remote STR stations (via the auto call feature) and can automatically answer calls originated by such remote stations. The SDA-1 can be attached to two communication lines via the dual communication interface feature, providing operation over one line at a time. Selection of each line is under program control.

Since the SDA-1 is a category II adapter, a maximum of two SDA-1's can be installed in a single 2701 equipped with the expanded capability and expansion features.

The Synchronous Data Adapter-Type 1 enables the 2701 to control data transfers in half-duplex synchronous mode between an IBM System/360 computer and the following synchronous transmitter receiver (STR) terminals and devices:

1. IBM 1009 Data Transmission Unit, IBM 1013 Card Transmission Terminal, IBM 7702 Magnetic Tape Transmission Terminal, IBM 7740 Communication Control System, or System/360 2020 Processing Units equipped with communications adapter feature (#2073) at the following rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
2. IBM 7701 Magnetic Tape Transmission Terminal or the 7750 Programmed Transmission Control at 1,200 bits per second (150 characters per second).
3. IBM 7710 Data Communication Unit, IBM 7711 Data Communication Unit, or another IBM System/360 equipped with a 2701 Data Adapter Unit with the Synchronous Data Adapter-Type 1 at the following data rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
   19,200 baud (2400 character per second)
   40,800 bits per second (5,100 characters per second)

Refer to Figure 17 for the required communications facilities and data sets for each of the speeds described in items 1, 2, and 3.

Three features are obtainable on the Synchronous Data Adapter-Type 1.

1. Internal clock feature (prerequisite: Synchronous Data Adapter-Type 1) provides the clocking pulses for transmission speeds of 1,200; 2,000; and 2,400 bits per second. These speeds are selected by program control. This feature is required when the data set does not provide the clocking pulses or when half-duplex lines are used.
2. Dual communication interface feature (prerequisite: Synchronous Data Adapter-Type 1) provides a

Speed \ Communications Facilities	Common Carrier Switched Telephone Networks	Common Carrier Leased Private Line Telephone Services	Common Carrier Broadband Communications Services	Customer Owned Communications Facilities
1200 bps (150 cps)	Western Electric Data Set 202A or equivalent. See note.	Western Electric Data Set 202A, 202D1, or Western Union Data Set 2121A or equivalent. See note	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2000 bps (250 cps)	Western Electric Data Set 201A or equivalent. See note.	Western Electric Data Set 201A or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2400 bps (300 cps)	Not Applicable	Western Electric Data Set 201B or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
19,200 bps (2400 cps)	Not Applicable	Not Applicable	Western Electric Data Set 303A10 or equivalent	Modem equipment (data set) having a proper interface must be used.
40,800 bps (5,100 cps)	Not Applicable	Not Applicable	Western Electric Data Set 301B or equivalent	Modem equipment (data set) having a proper interface must be used.

NOTE: The Internal Clock feature is required for operation at 1200 bits per second and on the Switched Telephone Networks.

●Figure 17. Communications Facilities and Transmission Speeds

second communication interface. One interface is operable at a time and is selected by the program.

3. Automatic call feature: Enables the 2701 to originate calls on a switched dial network by dialing through a Western Electric Automatic Calling Unit 801A1. This feature is not needed or used for handling the automatic answering of calls on a switched network. This feature is available for operation at 1200 and 2000 baud.

For this adapter, additional information concerning commands, status bytes, sense bits, and operational functions will be provided in later publications.

Data Acquisition and Control Adapters

Data acquisition and control adapters for the 2701 include the following: the Parallel Data Adapter, Contact Sense Adapter, Contact Operate Adapter, and Serial Synchronous Adapter.

Parallel Data Adapter

The Parallel Data Adapter allows for the connection and operation of external devices that transfer data, parallel by bit, serial by word, with the System/360 processor. The data word size is 16 bits, expandable in groups of eight up to 48 bits. The Parallel Data Adapter presents a demand response interface to the external device that allows for the half duplex transfer of parallel data words into and out of System/360 processor and the external device. The Parallel Data Adapter controls this interface, converts from data

word to byte and from byte to data word, develops and checks one bit of odd parity per data word, and transfers data to and from the I/O channel, parallel by bit, serial by byte. The Parallel Data Adapter forces the multiple byte mode of operation on the multiplexor channel. The number of bytes transferred in the multiple byte operation is dependent upon the size of the data word. This can vary from two to six bytes.

In addition to the parallel data operation, the PDA and the direct control feature (DCF) on a System/360 processor can simulate the direct data feature on the 704X (7040-7044) and 709X (7090, 7094, 7094 II) systems. The interface circuitry is different, but the logical operation is the same.

Commands

The Parallel Data Adapter decodes and executes the following commands. (See Figure 18 for the configuration.)

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Read	0	0	0	0	0	0	1	0
Read with Timeout	0	0	0	1	0	0	1	0
Write	0	0	0	0	0	0	0	1
Write with Timeout	0	0	0	1	0	0	0	1
Diagnostic Write	0	0	0	0	0	1	0	1
Diagnostic Read	0	0	0	0	0	1	1	0

Figure 18. Bit Configuration for Parallel Data Adapter Commands

Read: This command causes the Parallel Data Adapter to accept data words from the external device and present them a byte at a time to the System/360 channel.

Write: This command causes the Parallel Data Adapter to take bytes of data from the System/360 channel, assemble them into data words, and transfer them to the external device.

Read with Timeout: This command is the same as the read command described above, except that a 2-second timeout is performed on the response of the external device to a request for data transfer made by the Parallel Data Adapter. This command is only valid when the timeout feature is obtained.

Write with Timeout: This command is the same as the write command described above, except that a 2-second timeout is performed on the response of the external device to a request for a data transfer made by the Parallel Data Adapter. This command is valid only when the timeout feature is obtained.

Diagnostic Write: The diagnostic write command operates as the normal write. However, the control and data transfer operations with the external device are inhibited. After one data word has been assembled in the Parallel Data Adapter, the device end, channel end status is presented, which terminates the command.

Diagnostic Read: This command operates like the normal read operation, except that the control and data transfer operations with the external device are inhibited. The data word stored in the Parallel Data Adapter's assembly register is transferred to the channel, and the device end status is presented, which terminates the command. This command should be preceded by the diagnostic write command.

Special Features

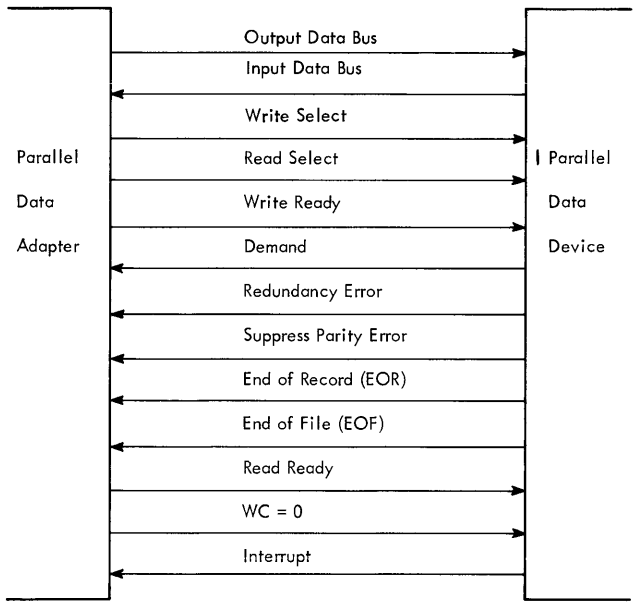
Extension Features: The Parallel Data Adapter provides a data word of 16 bits plus one bit of parity in each direction. Through the use of the extension features, the data word can be extended to 48 bits. One bit of parity is supplied for the data words regardless of the number of extension features used. Each extension feature adds eight input and eight output bits to the data word.

Timeout Feature: The timeout feature is used to recognize an external device failure. The timeout is initiated under program command. A 2-second timeout is performed from the time the Parallel Data Adapter notifies the external device that it is ready for a data transfer until the time that the external device responds. In detail, when the read ready or write ready line is raised, the timeout begins. The timeout is reset when the external device raises the demand line. The timeout will restart on the next occurrence of a read ready or write ready signal. If the demand response does not occur within the 2-second timeout period, the command will be ended with the device end, channel end and unit check status set and with the timeout bit set in the sense byte.

Adapter Operation

Operation between the Parallel Data Adapter and the external device is made through the Parallel Data Adapter interface. The interface consists of a set of lines that provide for control, signals and data paths (Figure 19). The name and functions of each line or lines of the interface are described below. Detailed information concerning timing and voltage levels will be published in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information* manual Form A22-6844.

Output Data Bus (PDA to External Device): The output data bus consists of 17 lines on the basic adapter. Sixteen lines are used to present data and one line is used to present the odd parity bit to the exter-



●Figure 19. Parallel Data Interface

nal device. With extension features, the number of lines can be increased to a maximum of 49 (48 data and one parity).

Input Data Bus (External Device to PDA): The input data bus consists of 17 lines on the basic adapter. Sixteen lines are used for input data and one line is used to obtain the odd parity from the external device. With extension features, the number of lines can be increased to a maximum of 49 (48 data and one parity).

Write Select (PDA to External Device): This line is used to notify the external device that it has been selected for a write operation. The line is raised because of the recognition of a write command from the channel, and it remains up until the end of the command.

Read Select (PDA to External Device): This line is used to notify the external device that it has been selected for a read operation. The line is raised because of the recognition of the read command from the channel, and it remains up until the end of the command.

Write Ready (PDA to External Device): This line notifies the external device that a word of data is on the output data bus. The data is stabilized and de-skewed before the raising of this line.

The occurrence of a demand, EOR, or EOF signal from the external device resets this line.

Read Ready (PDA to External Device): This line notifies the external device that the PDA is ready to accept the next word of data over the input bus.

The occurrence of a demand, EOR, or EOF signal from the external device resets this line.

Demand (External Device to PDA): The significance of the demand signal is dependent upon the command being executed.

1. Write Command – The demand signal signifies that the external device has accepted the data word on the output data bus.
2. Read Command – The demand signal signifies that the data on the input data bus is valid, stabilized, and de-skewed.

The demand signal must be present for at least 800 nanoseconds. The maximum length of the demand signal is dependent upon the external device and its desired data rate. Data must remain valid for the duration of the demand signal. A second read ready or write ready signal will not be given while the demand signal is still present.

Redundancy Error (External Device to PDA): This line indicates that the external device has a parity error.

Suppress Word Parity Error (External Device to PDA): This line from the external drive suppresses data word parity checks during read operations. It is used by devices which do not generate valid parity.

End of Record (EOR) (External Device to PDA): This line signifies that the external device has completed its operation and will not generate or accept any more data. Upon recognition, the PDA will present the device end, channel end status to the channel.

End of File (EOF) (External Device to PDA): This line signifies that the external device has completed its operation and will not generate or accept any more data. Upon recognition, the PDA will present the device end, channel end, and unit exception status to the channel. The unit exception status prevents command chaining.

Word Count Equals Zero ("WC=0") (PDA to External Device): This signal is generated by the PDA to inform the external device that the CPU has no more data to transfer or will not accept any more data depending upon the operation being a write or a read. An EOR or EOF should be presented by the external device.

Interrupt (External Device to PDA): The interrupt lines allow the external device to signal the CPU through a channel interrupt that it requires service.

The interrupt signal, when occurring in the absence of a read or write command, causes an attention status to be set. When the interrupt signal occurs during a read or write operation, device end, channel end and attention status is set.

Addressing

Up to eight external devices may be connected to the Parallel Data Adapter interface. There is almost an unlimited number of ways in which the external de-

vices can be connected to the Parallel Data Adapter to operate with it through this interface. The only restrictions are that the maximum number of connections be eight and that the control signals be valid with data transferred. There are two cases to be considered here. In the first, only one of the external devices is operating with the interface at any one time. The entire data word goes to and comes from that one external device. In the second, the data word is split up among various external devices. The former situation has the problem of addressing whichever external device will be operating with the interface at any one time. The latter has the problem of having the external devices respond properly to the interface control signals.

In this section, a few of the many possible addressing schemes will be outlined. First, consider the case in which only one of the external devices is operating with the interface at a time. The Parallel Data Adapter interface has two select lines, read select and write select, with no built-in capability for addressing the one device of the eight possibilities with which the Parallel Data Adapter can operate. There are several means available to the user to do the addressing. Listed below are three addressing schemes.

Manual Switching: This method of addressing sets a manually operated switch on one of the external devices to the ON position. Manual switching is used when ease of switching is a requirement but speed is not. It is simple and economical. For an example of its application, consider several "test cells" on the test floor when only one is scheduled to run at a time. The multi-drop capability allows relatively quick rotation of test cells without the necessity of cable pulling and equipment movement.

First Word Addressing: A more sophisticated approach is to have the first word of a write operation contain the addressing information. Only the device which recognizes its address will respond to further interface signals. The device, once selected, will remain so until a new write operation is initiated. To perform a write operation, the program need only ensure that the address code appears in the first word. To perform a read operation, the program must first perform a one-word write operation to address the device. When the write command ends, the program can command chain directly to the read command.

As implied earlier, the ending of the read command does not end the selection of the external device. Selection can be changed only by a new write operation. (The exception to this is the case in which the external device has been reset by an operator.) Additional read operations may thereby be performed with the same external device without the necessity of an addressing write operation.

Direct Control Feature: An even more sophisticated method of addressing is the use of the direct control feature (DCF) available on the System/360 processors. With this feature, the addressing can be accomplished through the sense or timing lines. The external devices may also indicate their need of service with the use of the interrupt lines of the DCF. This device-program communication is performed independent of the PDA operation, thereby allowing for greater versatility.

In addressing, the problem of interface control arises when the data word is split up for several external devices. The approach to this problem differs with each situation. Some typical questions a system designer might ask and the answers to these questions are given below.

Question: In a multiple-device attachment, which device responds to the control signal from the I/O interface?

Answer: One device may be given the logic to respond to the interface signals. If there are no more than seven external devices on one interface, the others can monitor the input signal lines (input to the 2701).

All devices can respond to the I/O interface control signals. The restriction here ensures that there are no more than seven external devices on the line. For example, consider the demand line. Once one of the external devices has presented the demand signal to the interface, any or all of the other external devices can present the same signal to the interface. However, once the demand line has fallen, no other external device can raise it until the next ready signal has ocurred. As stated above, when the number of external devices on the interface is seven or less, all the external devices can monitor the input lines.

Question: How does the external device know that the other units have stabilized the input data or sampled the output data?

Answer: A standard data rate may be set when the demand signal is given at a fixed period of time after the rise of the ready line.

Question: How would one handle the case in which a data transfer is intended for an needed by a specific external device, but any data transfer including all zeros is meaningful to another external device sharing the interface?

Answer: One bit in the record to or from each external device can be set aside as a validity indication. When this bit is on, the record is meaningful; when this bit is off, the record is to be ignored. This bit can be used on a read operation as well as a write. The program tests this bit; if on, it uses this record; if off, it ignores the record.

The addressing schemes do not require any modification of the 2701. The 2701 has no indication of the number of external devices that are on the interface nor of the means used to address them. The program, of course, must be aware of the external device addressing scheme.

Speed of Operation

The maximum over-all data rate possible for an external device is a complex function. It depends on parameters such as the processor, the channel, the other control units operating on the same and/or other channels, and the mode of operation (byte, multiple byte and burst). The Parallel Data Adapter transfers bytes with the channel at the maximum channel rate.

Read Operation

The read operation is initiated when the XIC-XA couple accepts a read command from the I/O channel. Upon the acceptance of this command, the read select and read ready lines are raised on the Parallel Data Adapter interface. The Parallel Data Adapter is then in a condition to accept the first word of data from the external device. When the input data is available, valid, and de-skewed on the input data bus, the external device will respond with the demand signal. The demand signal causes the dropping of the read ready line. The 2701 will then attempt to obtain channel selection in order to perform a data transfer. When selection has been successfully accomplished, the XIC-XA couple will transfer the received data word a byte at a time to the I/O channel. The mode of operation will be either multiple-byte or burst mode. After the full data word has been transferred to the channel, the Parallel Data Adapter will again raise the read ready line, thus informing the external device that the Parallel Data Adapter is ready to accept the next word of data. When data is again available, the external device will signal demand, and the data transfer operation will proceed as above.

The read operation may be ended in one of several ways:

1. An external device presents EOR or EOF. When the external device has determined that it has completed its data transfer with the System/360, it will signal either EOR or EOF. The EOR will cause the 2701 to present the device end and channel end status to the channel. The EOF signal will cause the 2701 to send the device end, channel end, and unit exception status to the channel. The unit exception status would prevent command chaining in the channel. To ensure the acceptance and transfer of the last word of data, the EOR or EOF signal should not occur until the demand signal has fallen. Once the Parallel Data Adapter has accepted the word of data, the terminating status will not be set until the final word has been transferred to the channel.

2. The channel can accept no more data. When the storage area allocated for the read operation has been filled and no other area is available, the channel can accept no more data. When the Parallel Data Adapter presents one more byte of data than the channel can accept, the channel will reject that byte and signal the 2701 to cease the operation. When the Parallel Data Adapter recognizes the stop signal from the channel, it signals WC=0 and read ready to the external device. The WC=0 line informs the external device that the Parallel Data Adapter will not transfer data to the System/360 channel. The read ready signal is available for external devices which cannot end until they have reached a physical position or have transferred all their data. The Parallel Data Adapter looks for either the EOR/EOF signals or the demand signal in response to the read ready/WC=0 signals. If the device can end immediately, it will present either EOR or EOF. When the Parallel Data Adapter recognizes these signals, it will set the terminating status as described above. If the external device cannot end immediately, it will signal demand. Upon recognizing the demand signal in response to the WC=0/read ready signals, the Parallel Data Adapter will drop the read ready line and set the channel end status. The setting of the channel end status has meaning when the XIC-XA couple is operating on the selector channel. The setting of this status will release the 2701 from the selector channel, thus allowing the channel to operate with other control units. This status being set when the 2701 is operating on a multiplexor channel, in the multiple byte mode, has little use, since the multiplexor channel has a capability of operating with all control units to which it is connected. When the external device drops the demand signal, the Parallel Data Adapter will again raise the read ready line. The data which is received by the Parallel Data Adapter is not transferred to the channel. This read ready-demand sequence continues until either the EOR/EOF or interrupt signals occur, whereupon the proper terminating status will be set.

3. Interrupts are set by the external device. An interrupt signal occurring on the Parallel Data Adapter interface while a read command is in progress causes the immediate setting of terminating status. The attention bit is also set in the status byte. An interrupt signal occurring while a a command is in operation must be used with the greatest caution. If an interrupt occurs during a demand signal, the deliverance of the last word of data to the channel is uncertain. If the interrupt signal is generated by other than the external device currently operating on the read command, this device either must be aware of the occurrence of the

interrupt, or must recognize its occurrence when the read select line drops prior to its setting the EOR or EOF signals.

4. A timeout elapses. During a read with timeout command (valid only when the timeout feature has been obtained), if a timeout does elapse, the device end, channel end, and unit check status will be set with the timeout bit set in the sense byte.

With every data word accepted by the Parallel Data Adapter, a check for correct odd parity is made. If a parity error check occurs, and the suppress parity error line is not signaled by the external device, then the unit check status bit will be set with the data check bit set in the sense byte. The command is not ended until the normal ending occurs.

When an ending does occur, normal or otherwise, the Parallel Data Adapter will drop the select out line when the device end status has been set.

Write Operation

The write operation is initiated upon the selection of either a write or a write with timeout command. The write select line is raised and an immediate request for data transfer made on the Parallel Data Adapter's recognition of a write command. On the multiplexor channel, the Parallel Data Adapter forces the multiplexor byte mode. When the number of bytes in the data word is obtained from the I/O channel to the Parallel Data Adapter, the adapter raises the write ready line and, when applicable, starts the timeout.

When the external device has accepted the data word, it responds with the demand signal. When the Parallel Data Adapter recognizes the demand signal, it will reset the data bus, terminate the timeout, and set up a request for another data transfer. With the transfer of each data word, the Parallel Data Adapter adds one bit of odd parity. If the external device checks this parity and determines there has been a parity error in the data transfer, it signals redundancy error. When the Parallel Data Adapter recognizes a redundancy error signal, it sets the data check bit of the sense byte and adds the unit check bit to the terminating status when delivered. The command is not ended by the occurrence of the redundancy error signal. The write operation continues until one of the ending conditions occurs:

1. The entire data message has been transferred from the I/O channel to the Parallel Data Adapter. This condition is recognized by a stop signal given by the channel when the Parallel Data Adapter requests the transfer of another byte of data. The Parallel Data Adapter will immediately set the WC=0 line unless a partial word of data has been accumulated prior to receiving the stop signal from the channel. If this is the case, the Parallel Data Adapter will go through one additional write ready demand sequence prior to signaling the WC=0. In this way, the partial word will be transferred to the external device. The WC=0 signal informs the external device that the I/O channel will not transfer any further valid data. The response of either EOR or EOF signals causes the device end, channel end status to be set and the operation ended. For the EOF, the unit exception status is also set. However, as in the read operation, the write ready signal is given with WC=0. If the external device cannot immediately end, it will respond with the demand signal to the WC=0/read ready signals. When the Parallel Data Adapter recognizes the demand response, it immediately sets the channel end status and, upon the dropping of the demand signal, again sets the write ready signal. The data transferred on this write ready-demand sequence will be all zeros with the proper parity. The write ready/demand sequence continues with write ready raised as soon as demand drops. When the external device sets either EOR, EOF or interrupt lines, the operation is ended with the proper terminating status.

2. Halt I/O is received from the channel. The operation for the halt I/O command is the same as though a data transfer stop signal were issued by the channel.

3. The external device issues EOR or EOF signals. When the Parallel Data Adapter recognizes an EOR/EOF signal, it sets the device end and channel end status. For the EOF, the unit exception status is also set. When the EOR/EOF signal occurs prior to the receipt of a stop signal or halt I/O from the channel, the Parallel Data Adapter determines whether the last word of data was successfully delivered to the external device. If it was not, the unit check status is also set with the overrun bit set in the sense byte.

4. The external device signals interrupt. When the Parallel Data Adapter recognizes an interrupt signal on the interface during a write operation, it sets device end, channel end, and attention status, terminating the command. The cautions stated for the interrupt termination during read operations also apply here.

5. Timeout elapses. During the execution of a write with timeout command, if the external device does not respond with the demand signal within 2 seconds of the occurrence of the write ready signal, the timeout elapses. This sets the device end, channel end, and unit check status with the timeout sense bit set.

Interrupts

The Parallel Data Adapter recognizes an interrupt signal whether or not it has a command. In fact, a command is usually not present. In either case, when an interrupt signal is recognized, the attention status will be set. As described under the read and write operations, if a read or write command is present, the ter-

minating status will also be presented. When operating without a command, the interrupt signal causes the attention status by itself to be presented to the channel.

Diagnostics

The Parallel Data Adapter operates under two diagnostic commands. Diagnostic write command presents one word of data to the Parallel Data Adapter. A diagnostic read operation causes the data stored in the Parallel Data Adapter's register to be read back to the channel. The diagnostic read operation will not cause the data register to be reset as is done with the normal read operation. With both the diagnostic read and diagnostic write operations, the control signals to the external device are inhibited. The external device will have no means of determining that a diagnostic read or a diagnostic write operation is occurring. If an interrupt signal occurs during a diagnostic operation, the Parallel Data Adapter responds as though a normal command were present by setting the device end, channel end, and attention status. The diagnostic operation checks the data path up to the external interface circuits.

Status Byte

The following statuses may be set by the Parallel Data Adapter.

Channel End: The channel end status appears by itself upon the refusal of the external device to respond to a WC=0 signal on either a read or write operation. The status indicates that the 2701 Parallel Data Adapter will transfer no additional bytes of data with the channel.

Device End: The device end status appears by itself only when it has been preceded by the channel end status. The device end status indicates that the external device and Parallel Data Adapter have completed their operations and are free to accept additional commands.

Device End, Channel End: The device end, channel end status indicates that the operation has been brought to a normal ending.

Device End, Channel End, Unit Check: This status indicates that an unusual ending condition has occurred. The sense byte should be obtained to determine which of the unusual ending conditions has occurred.

Device End, Channel End, Unit Exception: This status indicates that the external device has ended normally with the end of file signal.

Device End, Channel End, Unit Exception, Unit Check: This status indicates that an unusual ending has occurred with the external device signaling the end of file. The sense byte should be obtained to determine the cause for the unusual ending.

Device End, Channel End, Attention: The device end, channel end, attention status indicates that the operation has been ended in one of two ways: it has been ended by either the interrupt signal or the EOR signal, and prior to the status being delivered to the channel, an interrupt signal has occurred.

Device End, Channel End, Unit Exception, Attention: This status indicates that the operation has ended normally with the end of file signal and that prior to the status being delivered to the channel an interrupt signal has been received.

Device End, Channel End, Unit Check, Attention: This status indicates that the operation has ended abnormally in one of two ways:

1. The operation has been ended by an EOR signal with an unusual occurrence and an interrupt signal has been received prior to the status being delivered to the channel.
2. The operation has been ended by the interrupt signal, with an unusual condition having occurred prior to the appearance of the interrupt signal.

In either case, the sense byte contains information defining the cause of the unit check status.

Device End, Channel End, Unit Check, Unit Exception, Attention: This status indicates that the operation has not been successfully completed, that it has been ended by the EOF signal, and that an interrupt signal occurred prior to the status being delivered to the channel.

The sense byte contains the cause of the unit check status.

Sense Byte

Command Interrupt Bit 1: This bit is set when an interrupt signal is received while the Parallel Data Adapter is operating on a command. If the command has been normally ended and an interrupt condition occurs prior to the status being transferred to the channel, the sense bit will not be set. The condition of this sense bit enables the programmer to determine which of the two causes for ending occurred under the channel end, device end, attention status and the device end, channel end, unit check, attention status.

Data Check Bit 4: This bit is set when a parity check fails during a read operation and the suppress parity line is not signaled. This bit is also set when redundancy check is signaled.

Overrun Bit 5: This sense bit indicates that data has been lost. This occurs during a write operation when the EOR or EOF signal is set prior to the data in the Parallel Data Adapter being delivered in the external device. This bit will not be set during read operations. Data is lost when a stop is received from the channel when the Parallel Data Adapter is attempting to perform a data transfer. However, the channel has the ability to recognize this occurence. The Parallel Data Adapter will not cause a unit check interrupt.

Timeout Bit 7: This bit is set during a read with timeout or write with timeout operation when the external

device does not respond to a data transfer request within the 2-second timeout period.

Contact Sense Adapter

The contact sense adapter provides the System/360 with the capability of determining the condition of remotely set contacts and for binary voltage levels. The basic contact sense adapter has provisions for operating with 48 points and is expandable in two steps of 48 up to 144 points. The contact sense adapter recognizes either a contact closure or a binary voltage level. The selection between contact sensing or voltage level sensing is done on a per byte basis as an installation option. Each byte can be specified as to whether it is to be contact sensing or a voltage sensing. Under program command, the contact sense adapter samples and transfers to the channel from 1 to 18 bytes of sampling data. When operating on the multiplexor channel, the contact sense adapter operates in the word mode. In addition to transferring the contact conditions to the I/O channel under program command, the contact sense adapter, as an additional wire option, recognizes a contact closure or a binary voltage level going to 1 of any one of 8 points in the first contact sense byte as an interrupt condition.

The contact sense adapter also has the capability, under program command, of performing a timeout. This timeout is initially set to be from 30 microseconds to 4 seconds by the customer engineer at installation time. When performing this timeout, the contact sense adapter initially samples and delivers the number of bytes requested, presents the channel end status and then initiates the timeout. At the conclusion of the timeout period, the device end status is set.

Commands

The contact sense adapter recognizes and operates on the following commands (the bit configuration is shown in Figure 20).

Read A: On recognition of the read A command, the contact sense adapter samples the contact points starting with the first byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel.

Read B: On recognition of the read B command, the contact sense adapter samples the contact points starting with the seventh byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel (this command is valid only when the first extension feature is obtained).

Read C: On recognition of the read C command, the contact sense adapter samples the contact points starting with the 13th byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel (this command is valid only when the second extension feature is obtained).

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Read A	0	0	0	0	0	0	1	0
Read A with Timeout	0	0	0	1	0	0	1	0
Read B	0	0	0	0	0	1	1	0
Read B with Timeout	0	0	0	1	0	1	1	0
Read C	0	0	0	0	1	0	1	0
Read C with Timeout	0	0	0	1	1	0	1	0
Diagnostic Read Odd	0	1	1	0	0	0	1	0
Diagnostic Read Even	0	0	1	0	0	0	1	0

Figure 20. Bit Configuration for Contact Sense Adapter Commands

Read A with Timeout: This command is identical to the read A command except that at the end of the read A operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered (this command is valid only when the first extension feature is obtained).

Read B with Timeout: This command is identical to the read B command except that at the end of the read B operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered.

Read C with Timeout: This command is identical to the read C command except that at the end of the read C operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered (this command is valid only when the second extension feature is obtained).

Diagnostic Read Odd: With this command, the contact sense adapter circuitry sets the odd bytes to a logical 1 and the even bytes to a logical 0. A normal read A operation is then performed.

Diagnostic Read Even: With this command, the contact sense adapter circuitry sets the even bytes to a logical 1 and the odd bytes to a logical 0. A normal read A operation is then performed.

Extension Features

The contact sense adapter provides for the sampling of 48 external points. The two extension features allow the number of contact points to be expanded to 96 and 144. The first extension feature validates the read B and the read B with timeout commands, and the

second extension feature validates the read C and the read C with timeout commands.

Adapter Operation

The external contact or voltage points are connected to the contact sense adapter through a two-wire circuit. Detailed information concerning the line restrict, timing, and voltage levels for this connection is available in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information,* Form A22-6844.

The contact sense adapter has three wire options, which may be taken at installation time.

Interrupt Lines: The first byte in the contact sense adapter may be used as interrupt lines to the I/O channel. As a wire option, any one or all of the eight points in the first byte may be wired for the interrupt condition.

Contact Closure vs. Voltage Levels: As a wire option, any byte may be wired to recognize either a contact closure or a binary voltage level.

Length of Timeout: The timeout may be set from 30 microseconds to 4 seconds.

Read Operation: Read operation is initiated by the contact sense adapter accepting any one of the six read commands. On recognizing a read command, the contact sense adapter samples the first or seventh, thirteenth byte of contact points and presents it to the I/O channel. The operation of the multiplexor channel is in the multiple byte or burst mode. The contact sense adapter samples each byte in turn and transfers it to the channel until either the last byte in the contact sense adapter has been delivered to the channel or a stop has been received from the channel. The last byte of data is either the 6th, 12th or 18th byte, depending on the number of extension features acquired.

After transferring the last byte of data, the contact sense adapter sets the channel end and, if the command is not with timeout, sets the device end status to the channel, thereby ending the command. If the timeout was called for, the channel end status is set and the timeout initiated. At the completion of the timeout, the device end status is set.

The timeout may be used in conjunction with command chaining to additional read commands to allow successive samplings of the data prior to the program being called in to analyze the operation.

For example, consider the case where the timeout has been set to 1 second and it is desirable to have five samples of the data occur within a 5-second period prior to interrupting the program. To accomplish this, the programmer sets up five read commands. The first four commands are read with timeout commands with the command chain flag on. The fifth is a read command with no flag for command chaining.

After the first read command is accepted and operated on, the channel end status is delivered to the channel and the 1-second timeout is started. On completion of the timeout, the command is ended with the device end status. Command chaining then occurs to the second read with timeout command and the procedure repeats itself. After the fourth read with timeout command has been completed, command chaining occurs to the fifth and final read command. At the completion of the last data transfer, the channel end and device end status is set. This status causes a program interruption, thus notifying the program of the completion of the operation. The programmer now has five samples of the contact conditions as they existed at 1-second intervals.

Care should be exercised while operating on the selector channel when using command chaining. When command chaining is indicated, the channel is not released on the presentation of the channel end status. When the device end status is delivered, the channel performs the command chain operation without allowing selection of any of the other possible control units on the channel.

The timeout operation may also be used to perform contact sampling at a sufficiently high sampling rate to ensure the capture of any event. When multiple sampling rates are required, the timeout should be set to satisfy the highest sampling rate. The placement of the higher frequency response points in the lower byte positions of the contact sense adapter, allows the programmer to sample the higher sampling rate points without having to sample the lower sampling rate points.

For example, consider the case where one set of contacts must be sampled at a rate 5 times that of other contacts. The timeout must be set for a sampling rate at least as high as the contact requirement. The programmer then sets up five read with timeout commands with command chaining. The byte count for the first four commands should be just large enough to allow the sampling of the higher response points. The fifth command has a byte count large enough to allow the sampling of all the points. This example was for a condition where there were contacts with only two different response requirements. Outside of programming complications, there is no reason why this may not be expanded to an additional number of response requirements. In fact, the availability of the read A, B, and C commands, the timeout, and the interrupt lines allows the programmer or system designer to use his ingenuity to solve his operational problems in the most efficient manner.

Interrupts

As explained in the Wiring Option section, when one or more of the eight possible points in the first byte of the contact sense adapter closes or goes to a logical 1 an interrupt will be recognized. In all cases, the interrupt sets the attention status bit. When an interrupt is recognized during the operation of a command, the device end, channel end and attention status is set. If a timeout is in progress, it is terminated. When no command is present, the attention status causes an interrupt on the channel. A read A command must be given in order to determine the contact caused by the interrupt. The interrupt condition is not captured by the contact sense adapter. This means the read A command must be returned in sufficient time to allow the sampling of the first byte in the contact sense adapter prior to the stimulus of the interrupt condition disappearing.

Diagnostics

The diagnostic operation is initiated by either of the two diagnostic read commands, namely, diagnostic read odd or diagnostic read even. On the acceptance of the diagnostic read even command, the input circuits corresponding to the even bytes in the contact sense adapter are set to binary 0 and the odd bytes are set to binary 1. Likewise, the diagnostic read odd command sets the input circuits corresponding to the odd bytes to binary 1 and even bytes to binary 0.

After the conditioning of the interface circuitry, the contact sense adapter operates on the diagnostic command as though a read A command were given. That is, the bytes are sampled and delivered to the channel until either the last byte has been transferred or a STOP has been received from the channel or an interrupt has occurred. In either case, the device end, channel end status is given.

If any of the points in the first byte have been wired for interrupt, the attention status is also given in the diagnostic read odd command; however, the command is not terminated by this interrupt. In this manner, with the use of both diagnostic read commands, it can be determined whether the contact sense adapter can recognize both a zero and a one condition for each point and interrupt condition. This can be done without physically disconnecting the input cable; the only exception is where one or more bytes are wired for voltage sensing and any of these bytes are in a logical 1 condition. In this case, it is not possible for the diagnostic read commands to set these points to a logical 0 condition.

Speed of Operation

The speed of operation of a contact sense device is normally measured by the number of points per second which the device can sample. This is a difficult parameter to define for the general case; for the sampling rate is dependent on variables such as the model and channel of the System/360 that the 2701 is connected to, and the other devices operating on the same or other channels as the contact sense adapter. The speed of operation is also determined by the number of points that are read with each selection. Reading just one byte per selection results in a relatively low sampling rate; sampling 18 bytes per selection results in a relatively higher sampling rate. The contact sense adapter will transfer bytes to the channel at the maximum channel rate.

Status Byte

The contact sense adapter can present the following terminating status conditions:

Channel End: The channel end appearing by itself indicates that the data transfer is complete; however, the contact sense adapter is not prepared to accept additional commands. This is due to the contact sense adapter performing a timeout.

Device End Status: The device end status appears by itself only when the channel end status has previously been presented. The device end status indicates that the contact sense adapter is prepared to accept another command.

Device End Attention: This status appears when the channel end status has previously been given and an interrupt condition has occurred. This can occur for one of three reasons:

1. A timeout has been terminated by an interrupt.
2. A timeout has been completed, but the interrupt occurred prior to the device end signal being accepted by the channel.

Device End, Channel End: This status appears when a data operation has been successfully completed.

Device End, Channel End, Attention: This status appears when an interrupt condition has occurred either during a read operation or after the operation has been completed but not yet accepted by the channel.

Attention: The attention status appears by itself when a contact sense adapter is not operating on a command and an interrupt condition occurs.

Sense Byte

The contact sense adapter does not set any sense conditions.

Contact Operate Adapter

The Contact Operate Adapter provides contacts which are set on program command for external sampling. Each contact point set is held in the set (closed) condition until directed by an additional program instruction to release the contact point. The

program has the ability of picking and dropping each contact point without disturbing the condition of the other contacts. The basic Contact Operate Adapter comes with 48 contact points and is expandable in steps of 48 to 96 or 144 contact points. When operating on the multiplexor channel, the Contact Operate Adapter forces the multiple byte mode of operation. Momentary contact closures can be achieved through the use of the timeout operation and command chaining, as will be discussed in the following sections.

Commands

The Contact Operate Adapter decodes and executes the following commands. (See Figure 21 for bit configuration.)

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Write A	0	0	0	0	0	0	0	1
Write A with Timeout	0	0	0	1	0	0	0	1
Write B	0	0	0	0	0	1	0	1
Write B with Timeout	0	0	0	1	0	1	0	1
Write C	0	0	0	0	1	0	0	1
Write C with Timeout	0	0	0	1	1	0	0	1
Diagnostic Read	0	0	0	0	0	0	1	0

Figure 21. Bit Configuration for Contact Operate Adapter Commands

Write A Command: The write A command starts the data transfer to the first byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's registers. A 1 condition will cause a contact to set (close); a 0 condition will cause a contact to be reset (open); contacts which are not required to change condition by the write operation will not open or close, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition.

Write B Command: The Write B Command starts the data transfer to the seventh byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's register. A 1 condition will cause a contact to close; a 0 condition will cause a contact to open. Contacts which are not required to change condition by the write command will not close or open, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition. The operation will be terminated with the device end, channel end status after the last byte has been obtained or a stop signal received from the channel. (This command is valid only when the first or second extension feature is obtained.)

Write C Command: The write C command starts the data transfer from the 13th byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's registers. A 1 condition will cause a contact to set (close); a 0 condition will cause a contact to reset (open). Contacts which are not required to change condition by the write command will not experience any momentary opens or closures, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition. The operation will be terminated with the device end, channel end status after the last byte has been obtained or a stop signal received from the channel. (This command is valid only when the second extension feature is obtained.)

Write A with Timeout: This command is operated in the same manner as the write A command, except that after the last byte or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set.

Write B with Timeout: This command is operated in the same manner as the write B command, except that after the last byte has been received or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set. (This command is valid only when the first extension feature is obtained.)

Write C with Timeout: This command is operated in the same manner as the write C command, except that after the last byte has been received or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set. (This command is valid only when the second extension feature is obtained.)

Diagnostic Read: The diagnostic read operation causes one byte of data to be read to the I/O channel. The first bit in this byte is the OR'ed function of the contact conditions of the first bit position in each byte, that is, if the first, 13th, 20th, 27th, 34th, or 41st contact is closed, the first bit in the read byte will be a 1. If all are opened, the bit will be a 0. Likewise, the second bit position in the read byte is the OR'ed function of the second bit in each byte of the Contact Operate Adapter. This continues until the eighth bit in the read byte becomes the OR'ed function of the eighth

bit position in each byte of the Contact Operate Adapter.

Extension Features

The Contact Operate Adapter provides 48 contacts for external sampling. Through the use of the two extension features, the number of contacts can be extended to 96 and 144, respectively. The first extension feature validates the write B commands, and the second extension feature validates the write C commands.

Adapter Operation

The Contact Operate Adapter presents a two-wire per contact interface for external sampling. Detailed information concerning the timing and contact readings for this connection will be available in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information*, Form A22-6844.

The length of the timeout may be set at installation time to be anywhere from 30 microseconds to 4 seconds.

Write Operation: The write operation is initiated by the Contact Operate Adapter accepting any one of the six write commands. Upon recognizing a write command, the Contact Operator Adapter will accept the first byte of data from the I/O channel and place it in the contact operate register in the first, seventh, or 13th byte position, depending upon the command. The contact operate register maintains the current condition for each contact point. A logical 1 stored in a contact operate register position will cause the associated contact to be held closed (set). This register does not need to be cleared prior to loading in a new byte of data. This allows the contacts, once set, to remain set during loading operations on other contacts. As soon as a bit position in the contact operate register is loaded with a logical 1, the corresponding relay will commence the setting of the contact. The contact operate adapter uses reed relays and the set time is approximately 1 millisecond. When a bit position contains a 0, the corresponding relay will be reset (open). The reset time is in the order of several hundred microseconds.

Once the first byte of data has been loaded into the contact operate register the Contact Operate Adapter will request the next byte of data from the I/O channel. The operation is terminated when either the last byte of data has been loaded into the contact operate register, the last byte of data being either the sixth, 12th, or 18th byte, depending upon the number of extension features obtained, or a stop signal is received from the I/O channel. When the command is without a timeout, the device end, channel end status is set. When the command is with a timeout, the channel end status is set, and a timeout operation is initiated. At the completion of the timeout the device end status is set.

The programmer will find it most helpful to maintain a mirror of the contact operate register within core. With this, the programmer has an indication of the exact status of every contact in the Contact Operate Adapter. This also aids in the setting of the Write message. For example, when a contact point needs to be changed, the programmer need only change the bit position as it appears in core and perform a Write A, Write B, or Write C with the byte count just large enough to ensure that the bit change is transferred to the Contact Operate Adapter.

When the need exists for momentary contact closures, the contact operate timeout commands should be used. For example, consider the case where a contact needs to be closed for a period of 3 seconds and then opened, the timeout set to 1 second. To do this, the programmer sets up four write commands. The first three write commands are with timeout and command chaining. The fourth command is without a timeout. With the first write command, the programmer sets the contacts to the initial conditions. The second and third write commands can either rewrite the same data that was written with the first write command or rewrite just one byte. The latter can be done because the command does not change any contact conditions. The commands are needed only to initiate a timeout. This technique is used to reduce the system interference. The fourth write command causes the required contacts to be opened. The Contact Operate Adapter, when receiving the first write command, loads the contact operate register, thus setting the contacts in the initial condititons. After the last byte is transferred, the channel end status is presented and a timeout initiated. At the end of the 1-second timeout, the device end status is presented. Command chaining then occurs to the second write command. After the data transfer initiated by the second write command has been completed, the channel end status is presented and the timeout initiated. At the termination of the timeout, the device end status is set, and chaining occurs to the third write command. The third write command is operated on by the Contact Operate Adapter as is the second write command. After the third 1-second timeout is completed, the Contact Operate Adapter sets the device end status and the channel command chains to the final write operation. The data transfer in this write operation causes the applicable contacts to be reset. At the completion of the data transfer, the device end, channel end status is presented, and an interrupt occurs. The interrupt informs the program that the operation has been completed. This example would have been much simpler if the length of the timeout were 3 seconds rather than the 1 second specified. An example with the length of

timeout at 1 second was given, however, to illustrate the techniques that can be used to accomplish the momentary contact closures when the timeout period is less than that of the contact closure period. These techniques can be expanded to show contact closures of different periods. For instance, some of the contacts could have been closed for 1 second and 2 seconds as well as for 3 seconds. All that need be done to perform this operation is to put the proper data in the second and third write with timeout commands. When variable-length momentary contact closures are required in the system, the length of the timeout should be set to either the shortest contact closure or the lowest common denominator of the several momentary contact closures.

Diagnostics

The diagnostic operation is initiated through the diagnostic read command. In the contact operate adapter, the reed relays occur in pairs, one pair going to the external interface and the other being used for diagnostics. Both contacts are picked by the same relay coil and circuit. The byte of data received on a diagnostic read command is a composite of all the contacts in the Contact Operate Adapter. The diagostic contacts driven by the first bit in each byte of the Contact Operate Adapter are OR'ed to the first bit position in the diagnostic read byte. In the same manner, the diagnostic contacts from the second bit position in each byte of the contact operate adapter are OR'ed together to the second bit position in the diagnostic read byte. With the use of alternating diagnostic write and read commands, the operation of each relay coil can be checked. Such an operation might be as follows: First, to check the capability of each relay call to drop out, perform a write command which sets all the bit positions in every byte equal to 1. Command chaining is applied to a diagnostic write command which sets all the bit positions in every byte equal to logical 0's. Command chaining is then applied to a diagnostic read command. The diagnostic read byte should be all 0's. When this test is successfully completed, it is known that each contact which can be closed can also open. To determine whether the contacts can be closed, the following operations should be performed:

1. Issue a write command which sets all the bits in the first byte to logical 1's and all other bits in the other bytes to logical 0's.

2. Command chain to a diagnostic read command. The bits in the received byte should all be 1's. This shows that the contacts connected to the first byte can be closed.

3. Issue a write command which sets the bits in the first byte equal to logical 0's and all bits in the second byte equal to logical 1's. (All other bits in the contact operate register will be 0 from preceding commands.)

4. Command chain to a diagnostic read command. The diagnostic read byte should be all 1's. This shows that the contacts operated by the second byte can be closed.

5. Continue this procedure, alternating write operations with diagnostic read operations until it is verified that all the contacts can be closed.

The completion of this operation verifies that the relay coils in the Contact Operate Adapter can cause contacts to be closed and opened. The condition of the actual operate points has not been checked by this operation. However, when trouble occurs, the successful completion of the diagnostic operation verifies the operation of the Contact Operate Adapter up to the actual operate points.

Speed of Operation

The speed of operation of a contact operate device is normally measured in the time required for a point to be set or reset and the number of points per second which the device can set. The contact operate adapter points act within 1 millisecond and resets in hundreds of microseconds. The latter parameter is difficult to define for the general case, for the rate is dependent upon variables such as the model and channel of the System/360 which the 2701 is connected to and the other devices operating on the same or other channels as the Contact Sense Adapter. The speed of operation is also determined by the number of points which are set with each selection. Setting just one byte per selection results in a relatively low sampling rate while sampling 18 bytes per selection results in a relatively higher sampling rate. The Contact Operate Adapter will obtain bytes from the channel at the maximum channel rate.

Status Byte

The following statuses may be set by the Contact Operate Adapter.

Device End: The device end status appearing by itself indicates that the channel end status has been previously set and that the timeout operation has been completed.

Channel End: The channel end status appearing by itself indicates that the data transfer has been completed and a timeout is in progress.

Device End, Channel End: The device end, channel end status indicates that the write operation has been successfully completed.

Sense Byte

Contact Operate Adapter does not set any sense conditions.

Serial Synchronous Adapter (SSYA)

The Serial Synchronous Adapter (SSYA) sends and receives serial synchronous data at rates up to 2 million bits per second; no lower limit is imposed. When operating with a given system, this maximum data rate can be reduced by restrictions imposed by the processor, its programming requirements, I/O channel capacity, system configuration, and so forth. Operation may be on either the selector or multiplexor channel, various system requirements permitting. Connection is made to a bit reconstructor or synchronizer or to a communication channel (or medium) through modulation-demodulation equipment (a modem). The modem converts the 2701's binary DC signals into a form suitable for the communication channel, for example, a data set or radio receiver. The modem must be a type that provides clocking signals to the attached digital device (2701 in this case). The SSYA operates in byte or burst mode on the multiplexor channel.

An optional feature provides the SSYA with the capability of acquiring frame synchronization when receiving data. The adapter becomes synchronized when it recognizes the first frame sync pattern. The pattern may be from 10 to 32 bits long; it is set into the hardware at installation time. Once synchronized, it will check for a pattern at the beginning of each ensuing frame. The data portion of the frame (the record) may range from 8 to 4,096 bits in length. Records must be of fixed length in a single transmission, and each frame must follow immediately after the previous one. The record length for a particular transmission is set by the program before beginning to receive.

Functional Description

The basic adapter operates with the System/360 I/O channel through the XIC and is composed of three functional sections.

Data Section: This section provides the required data assembly and buffer registers, as well as data control logic. Data received serially by bit are assembled through a shift register into characters and then transferred to the I/O channel. Transmitted data are accepted from the I/O channel one character at a time and then shifted out one bit at a time.

Controls Section: This section of the adapter provides the logic for over-all control of the adapter, including its data and external device interface sections, and operation with the I/O channel and the XIC.

External Device Interface: This section provides the interface (data and control) between the attached modern and the adapter, including all line drivers and terminators. Timing and various control line requirements are accommodated here. The modern interface available provides for connection to the Western Electric Data Set 301B. A second type of interface is provided for connection to bit reconstructor and bit synchronizers.

Commands

The SSYA decodes and executes the following commands (see Figure 22 for bit configuration):

Commands	Bit Configuration							
Basic SSYA-Channel Commands								
	0	1	2	3	4	5	6	7
Write	0	0	0	0	0	0	0	1
Read	0	0	0	0	0	0	1	0
Disconnect	0	0	0	0	1	0	1	1
Synchronous Pattern Recognition Commands								
Lock-Read	0	0	0	0	0	1	1	0
Load-Count-Low	0	0	0	0	1	1	1	1
Load-Count-High	0	0	0	0	0	1	1	1
Diagnostic Commands								
	0	1	2	3	4	5	6	7
Read-Loop	0	0	0	0	1	1	1	0
Write-Loop	0	0	0	0	1	0	0	1

Figure 22. Bit Configuration for Serial Synchronous Adapter Commands

Read: This command causes the SSYA to accept serial data, shift the data through the assembly/disassembly register, and pass the assembled bytes to the channel at a data rate equal to that of the terminal device.

Write: This command causes bytes to be transferred from the channel to the SSYA assembly/disassembly register and be shifted out serially by bit to the terminal device at a data rate equal to that of the terminal device.

Disconnect: This command causes the SSYA to cease present operations and prevents further operations with the terminal device. This is done by turning off the processor ready signal on the external interface. The command then ends.

Load Count-Low: This is a one-byte control command used to specify the number of bits in a frame. The six low-order bits of the command byte are loaded into the six low-order positions of the count reset register. As explained in the following discussion, this register maintains the frame bit count.

Load Count-High: This is a one byte control command which completes the specification of the frame

length. The six low-order bits of the command byte are loaded into the six high-order positions of the count reset register.

Write-Loop: This is a diagnostic command that allows the program to test the operation of the adapter. It causes the high-order end of the assembly/disassembly register to be looped into its low-order end.

The adapter accepts this byte of data from the channel. The character received is placed in the assembly/disassembly register's high-order end and then shifted into the low-order end. When this operation is complete, the command ends.

Read-Loop: This diagnostic command should be issued after a write-loop command to retrieve the test character. When accepted, the character stored in the a/d register's low-order end is shifted into its high-order end and then transferred back to the I/O channel through the transfer register. The adapter then ends the command.

Special Features

Synchronous Pattern Feature: With this optional feature, the SSYA is capable of detecting one specified synchronization pattern appearing at fixed intervals in the received data stream. This feature operates only when the 2701 is receiving data. The pattern may be from 10 bits up to 32 bits in length (the length being a selective feature).

External Device Interface Feature: The external device interface is a selective feature; that is, when ordering, one of the following must be chosen:

Type A — Interface for Western Electric Data Sets 301B or their equivalent.

Type B — Interface for bit constructors and bit synchronizers.

Type A — This interface allows the SSYA to operate with the Western Electric Data Set 301B or its equivalent over a broadband communication channel such as Telpak A. The data rate is 40,800 bps with Data Set 301B. The data rate may be less for other data sets. The SSYA provides and operates with the following lines:

Receive Data (RD): The data is received serially by bit over this line. The data is clocked by the serial clock receiver line.

Send Data (SD): The SSYA places data to be transmitted on this line. The data is clocked out by the serial clock transmit line.

Serial Clock Receiver (SCR): When receiving, successive bits are sampled or strobed on the receive data line upon each on-to-off transition of this line.

Serial Transmit Clock (STC): When transmitting, the adapter gates successive bits out over the send data line with each off-to-on transition of this line.

Send Request (SR): This line is used to indicate to the data set that the data processing system desires to send data.

Clear to Send (CS): This signal is turned on by the data set in response to the request to send signal. The SSYA can transmit data only when this line is up.

Type B — This interface is provided for the connection and operation of various bit reconstructors and synchronizers. Not all of the signals provided by the SSYA need to be used by each and every device; however, those signals not used will be strapped to the proper condition at installation time. The function of the lines are described below. For further information concerning the signal levels refer to the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information,* Form A22-6844.

Data In: The data is received serially-by-bit over this line. The data is clocked in by the receiving clock.

Data Out: The SSYA places data to be transmitted on this line. The data is clocked out by the transmitting clock.

Transmitting Clock: This signal must be provided by the external device if the system is to transmit data. It is used as the adapter's prime clock signal in normal write operations. When sending, the adapter gates successive bits out over the data-out line with each off-to-on transition of the transmitting-clock control signal.

Receiving Clock: This signal must be provided by the external device if the system is to receive data. It is used as the adapter's prime clock signal in all normal read operations. When receiving, successive bits are sampled or strobed on the data-in line upon each on-to-off transition of the receiving-clock control line.

Request to Send: The request-to-send signal may be used to indicate to the external device that the data processing system desires to send a message. In certain situations, it can also be used as a start-of-message signal to indicate or tag the beginning of an outgoing (from the processor) message.

The signal is turned on when the write command is decoded by the SSYA, provided the receiving-interlock control line is off. It remains on until it is turned off by either of the following conditions:

1. The last character of a message has been transmitted when operating on the write command, that is, request to send is turned off as soon as the last character received from the I/O channel has been transmitted after receiving a stop signal from the I/O channel.

2. The reset signal from the XIC turns on.

If the receiving interlock (by being on) prevents the request to send from turning on, an interface error condition occurs. The current command will be ended

immediately with unit check status on and the timeout bit in the sense byte set.

Processor Receiving: This signal is on while the SSYA is accepting data from the external device over the data-in line. It is turned on if the following conditions occur:

1. A read command is decoded by the SSYA when receiver on is on and start of message is on.
2. The read command is being decoded by the SSYA when receiver on is on and start of message is off. Processor receiving will turn on when start of message turns on, provided clear to send is off.

The processor-receiving signal is turned off if one of the following conditions occurs:

1. The read operation ends.
2. Receiver on turns off before the current read command ends (an error condition).
3. A byte overrun occurs.

Processor Ready: The processor ready signal provides the processor and its program with a means of signaling its conditions for handling data with the external device. When on, it indicates that the system is ready to handle transmissions. This control signal is turned on by any valid read or write command except read-loop and write-loop. Processor ready will remain on until turned off by the processor via the disconnect command, or presence of a reset.

Interlock: This signal may be used by the external device to indicate its current status. When on, it indicates that the device is in operation with its power on and ready to send or receive data. When off, the device is considered to be inoperable, which is defined as a communication fault condition if a valid read or write command other than read-loop and write-loop is present. If this occurs, the SSYA ends the current command immediately with unit check status on and the intervention required sense bit set. The adapter is then reset. If interlock is off, attention status will not be signaled. If the external device does not supply an interlock signal, this line must be strapped on within the adapter.

Clear to Send: This signal is caused to turn on by the external device in response to the turning on of request to send; it is provided so that the external device can indicate its readiness to receive data (from the SSYA). The SSYA will send data only if this signal is on. The first data bit passing from the adapter to the external device is gated out upon the first off-to-on transition of the transmitting clock signal occurring after clear to send turns on.

This signal is turned off by the external device in response to the turning off of request to send.

When the attached device does not provide a clear-to-send signal, this line must be tied to the request-to-send signal.

If this signal turns off before request to send during the operation of the write command, the SSYA will end the command with unit check status on and the equipment check bit of the sense byte set.

Receiver On: This signal is turned on by the external device while it is transferring data to the SSYA over the data in line. The first valid data bit in a received transmission, which is accepted by the SSYA, is the one occurring with the next succeeding off-to-on transition of the receiving-clock control line. After receiver on once turns on, it should turn off while operating on a valid read command other than read-loop. The command will be ended immediately with unit check status on and the equipment check bit of the sense byte set. The processor-receiving signal is reset. If the start-of-message signal is on and receiver on is off when a valid read command other than read-loop is present, the command is ended immediately with unit check status on and the equipment check bit of the sense byte set.

If the attached device does not provide the receiver-on-signal, this control line must be strapped on.

Start of Message: This signal is not used by the adapter if the synchronization pattern recognition feature is installed; if such is the case, this signal is strapped on within the adapter.

The signal is available with the basic SSYA to provide the external device with the capability of interrupting the processor and to initiate a read operation. It also has the feature of synchronizing the received data with the rise of this signal; hence, the external device can act to synchronize the basic adapter with the data.

If this signal is initially off and turns on, attention status is signaled and the receiving bit of the sense byte is set, provided no command is present and receiver on and interlock are on.

If the read command is being decoded with receive and start of message on, then processor receiving is turned on and the adapter starts to accept data from the external device over the data-in line. If any command but read is present, the start-of-message signals are ignored by the adapter.

If the attached device does not supply this signal, this line must be strapped off.

Adapter Operation

The following operations are defined when the sync pattern feature is not obtained.

Data transfer between the Serial Synchronous Adapter and the terminal device is made through the external device interface. This interface consists of a

data-in line and a data-out line. Data from the external device to the SSYA are handled over the data-in line, while data from the SSYA to the external device are handled on the data-out line. Either or both of these lines may be utilized in operating with a particular terminal device, or in a given situation; however, the SSYA is not capable of handling data over both lines simultaneously.

The SSYA handles only binary non-return to zero coded (NRZC) bits; that is, it sends and receives binary non-return to zero signals. There is a signal transition every time the data changes state and there is no signal transition when the data does not change state.

Receive: The receive operation is initiated upon the receipt of a read command. Data are received serially by bit and character from the terminal device over the data-in line of the interface and are shifted into the low-order end of the assembly/disassembly register until a complete character is held in its high-order end. This character is transferred in parallel into a transfer register where it is held until accepted by the I/O channel. When accepted, the character is placed on the channel's data-in bus. The transfer register will not accept another character from the a/d register until the character currently stored is accepted by the channel. A byte overrun condition will occur if, while receiving data, a data character cannot enter the transfer register because the previous character has not been accepted by the I/O channel. If this condition occurs, the current command is ended with unit check status and the byte overrun bit of the sense byte set. The adapter is then reset. Normal ending status always includes device end and channel end. There are eight-bit times between each service request and the overrun condition. The read command is ended when one of the following conditions occurs:

1. Stop from the channel.
2. Loss of interlock on the interface.
3. Byte overrun.

Transmit: A transmit operation is initiated by the receipt of a write command. The request to send a signal is raised on the external device interface, and transmission starts upon receiving the response to the clear-to-send signal. Data to be transmitted are received one character at a time from the I/O channel. As soon as the entire preceding character has been shifted out of the assembly/disassembly register, the adapter obtains the next character from the channel. This shifting occurs in proper synchronism with the transmitting-clock signal supplied by the external device.

A byte overrun condition occurs when channel service cannot be obtained in time for a data character to be transmitted in sequence immediately following the previous character. If this occurs, the current command is ended immediately with unit check status and the byte overrun bit of the sense byte set. The adapter is then reset. There are eight-bit times between the request for the next character and an overrun condition. If a stop bit is received from the channel in lieu of another data character, this signals the end of transmission to the adapter; the command will end after all data characters held are transmitted.

The write command is ended by any of the following conditions:

1. Receipt of a stop signal from the channel.
2. Loss of interlock on the interface.
3. Byte overrun.

The following operations are defined when the sync pattern feature is obtained. The following discussion relates only to the receive operation. The transmit operation is independent of the sync pattern feature.

The SSYA operates under two modes: search and lock. The system as defined by the program can operate in three modes: search, verify and lock.

Search: The search mode is initiated by a read command. While in the search mode, the SSYA does not transfer any data to the channel. Instead, it examines the incoming data for the existence of the present sync pattern. This pattern is set at installation time and may be from 10 to 32 bits in length. As soon as the sync pattern is recognized, the SSYA enters the lock mode. The read command is not ended at this time.

Lock Mode: This mode is entered from the search mode when the adapter is operating on the read command and sync pattern is recognized. The data portion of the record following the sync pattern is transferred to the I/O channel. Sync patterns are not passed to the channel but are effectively deleted from the received data stream. The counter is started with the first data bit following the sync pattern. The counter indicates when the entire record has been received. While the counter is running, the sync pattern recognition circuit is blinded. The next sync pattern immediately follows the data portion of the previous record. At this point the recognition circuit is activated and the adapter determines whether or not the correct pattern is in this proper position. If a pattern is present, it is likely that the adapter is properly synchronized. If not, the adapter may be out of synchronism or noise on the communication channel may have altered the proper pattern. In any event, the current read command is ended; if no errors were found, the device end, channel end, and status modifier bits of the status byte are set. If an error was detected, the device

end, channel end status is set. The ending status is the means by which the adapter signals the state of the current sync pattern (proper or improper) to the I/O channel. The ending status allows command chaining, so command chain lists can be designed to control the adapter's operation.

The sync pattern is shifted out of the a/d register as new data bits (of the next record) are received. The next command must be issued before the first data byte of the next record is ready to be transferred to the I/O channel in order to avoid byte overrun. If the program desires to maintain synchronism (and the current lock mode) it must issue the lock-read command. When the entire sync pattern is shifted out of the a/d register, the bit and byte counters are again activated. They will determine when the data portion of the record being received ends and will then activate the pattern recognition circuit. The lock-read command will then be ended as before with the ending status depending upon whether or not the pattern was recognized.

If on the other hand, the program wishes to enter search mode, it issues the read command instead. This resets the counter and the data is continually scanned for a sync pattern as previously described.

The lock mode continues until either the command is ended (as in the normal read command) or the program causes the return to search mode.

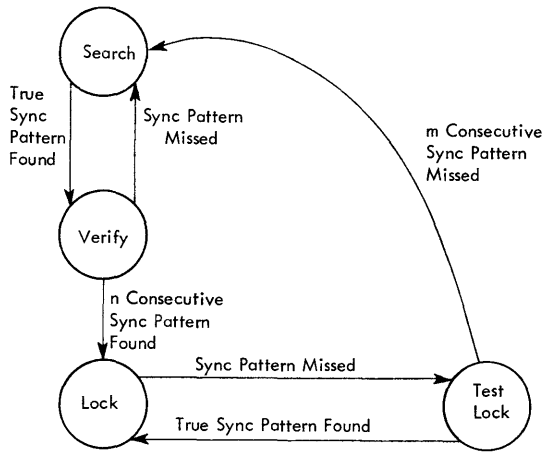
Programming Notes

System Modes of Operation: Whereas the SSYA only has defined a search and lock mode, a receiving serial synchronous PCM telemetry system normally operates in one of three modes: search, verify and lock. The commands and status bytes of the SSYA are defined so as to allow a chain of commands to control the adapter in such a way as to derive all three modes of system operation. The three modes of operation of the system are:

Search Mode: Upon starting operation or when re-synchronization is desired, the system operates in this mode. The SSYA tests for the sync pattern each time a new bit is received. The first pattern found causes the SSYA to enter the lock mode and the data transfer begins. This in effect causes the system to enter the verify mode.

Verify Mode: The system uses this mode for verification, to a degree, that true synchronism has been established. The possibility exists that a data sequence was identical to the sync pattern or errors made the data appear to be the pattern, that is, synchronism was initially established on a false pattern. In such cases, the system relies on the fact that data changes and will not appear as the sync pattern in the following records. While in this mode, the pattern is not found in the proper position, and the system re-enters search mode (issues a read command to the SSYA). Generally, a system will remain in verify mode for three or more records before it establishes true synchronism and enters lock mode.

Lock Mode: In lock mode, true synchronism has been established. However, erroneous patterns may be found. This may be due to noise on the communication channel or, perhaps, actual loss of synchronism. However, in most cases the system will not leave lock mode upon the first detected error. It generally will require five or more erroneous patterns in a row before the system re-enters search mode. If the system is in lock mode and one or more errors have occurred, the system is said to be in test lock mode; it will return to lock mode upon recognition of the first properly positioned correct sync pattern. Figure 23 shows a general logic flow for this operation, while Figure 24 gives a



n = the number of consecutive true sync patterns the system requires to enter the lock mode.

m = the number of consecutive missed sync patterns the system requires to accept the loss of synchronization and the return to the search mode.

Figure 23. Logic Flow for System Modes

sample command chain list which yields this type of operation. Dynamic core allocation is used extensively in this example. Because of the use of the status modifier status to depict a valid pattern, it is at times necessary to assign core to two channel commands at once. The notes in the figure refer to the assignment and release of core for these cases.

Other schemes may be used, such as the "ping-pong" technique where blocks of core are used alternately.

n=3, m=5	Commands	Notes	Modes
1	Read	Can release core assigned for 7	Search
2	Tic (to 1)		
3	Lock-Read	1st correct pattern must provide core for 5 and 1	Verify
4	Tic (to 1)		Verify
5	Lock-Read	2nd correct pattern	Verify
6	Tic (to 1)		Verify
7	Lock-Read	3rd correct pattern must provide core for 9 and a; can release core from 1	Lock
8	Tic (to a)		Lock
9	Lock-Read		Lock
10	Tic (to a)		Lock
11	Lock-Read		Lock
12	Tic (to a)		Lock
↓			↓
N	- - - - - -		Lock

	Commands	Notes	Modes
a	Lock-Read	1st bad pattern; must provide for 7 and c	Test Lock
b	Tic (to d)		Test Lock
c	Tic (to 7)		
d	Lock-Read	2nd bad pattern	
e	Tic (to 9)		
f	Tic (to 7)		
g	Lock-Read	3rd bad pattern	Test Lock
h	Tic to j		
i	Tic (to 7)		
j	Lock-Read	4th bad pattern; must provide core for 1	
k	Tic (to 1)		
l	Tic (to 7)		Test Lock

Figure 24. Channel Program for Sync Pattern Operation

System Notes: When the sync pattern feature is obtained, the maximum speed capability of the 2701 is not reduced. However, when receiving data, the technique of command chaining used to acquire and maintain synchronism in the adapter will generally reduce this maximum speed for a given I/O channel and model of System/360 (data transmission is not so affected). In this case, the main restriction is the amount of time required for the I/O channel to command chain to a transfer in channel (TIC) command, which, in turn, chains to another read command. The maximum speed is also dependent on the length of the sync pattern; the shorter the pattern, the slower the maximum possible rate. This is due to the reduction in the number of bit times available for the chaining and TIC operation. In a formula for calculating the maximum data rate:

T = The longest time for command chaining to complete, including one TIC in the worst case.

R = Maximum possible data rate.

L = Length of the sync pattern in bits.

The maximum possible data rate is then:

$$R = \frac{L}{T}$$

Status Byte

The following status conditions can be sent to the I/O channel by the SSYA adapter.

Device End, Channel End Status is the normal ending status for all of the basic SSYA commands. This status will be issued in ending the read and write commands when stop is signaled by the XIC if no unusual conditions are present.

When the sync pattern feature is obtained, device end, channel end status is the normal ending status for all valid commands except read and lock-read.

Read Status is signaled in ending the read or lock-read command to indicate that the adapter did not find the correct sync pattern in the proper position after a record was received.

Channel End, Device End, and Status Modifier Status is one that will be set only when the sync pattern feature is obtained. This is the normal ending status for the read and lock-read commands when the correct sync pattern was found in its proper position following the record.

Device End, Channel End, and Unit Check Status is signaled by the XIC if an unusual error condition has occurred. A sense byte will be set to further define the cause of the interrupt.

Attention status is signaled if the external device signals start of message while the adapter is not operating on a command. The receiving sense bit will be set when this condition occurs.

Sense Byte

The sense bits for the SSYA are defined as:

BUS IN POSITION AND NAME	CAUSE OF INDICATION
1 Not operational	External device not operational (interlock control line off).
3 Equipment check	a. Receiver-on control line off. b. Clear-to-send control line off.
5 Overrun	Data service could not be obtained within the byte interval of the communication line.
6 Receiving	Start-of-message control line turns on.
7 Timeout	Attempt to transmit to a half-duplex while it is in receiving mode (receiving interlock is on).

File No. S360-03
Form A22-6864-0

IBM Systems Reference Library

IBM 2701 Data Adapter Unit

Principles of Operation

This manual provides information concerning the operation of the IBM 2701 Data Adapter Unit. The manual is divided into three sections.

The first section gives a general description of the 2701, including: the terminals operating with the 2701, the functional organization of the 2701, the special features on the 2701, and various configurations of the 2701.

The second section describes the operation of the 2701 with the System/360. Subjects discussed here include communication line addressing, multiplexor and selector channel operation, and I/O instructions concerning the 2701.

The third section covers the 2701's transmission adapters. A complete description on the operation of each adapter is made here. This description includes transmit and receive operation sequences, status and sense bytes, and the polling and addressing of the terminals.

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Contents

The IBM 2701 Data Adapter Unit greatly expands the input/output capabilities of the IBM System/360 (frontispiece). The 2701 provides for the connection and control of the information flow of a variety of remote and local external devices with an IBM System/360 (Figure 1). These devices are divided into three types:

COMMUNICATIONS — START/STOP
- IBM 1030 Data Collection System
- IBM 1050 Data Communication System
- IBM 1060 Data Communication System
- IBM 1070 Process Communication System
- AT & T 83B2 Type Selective Calling Terminals
- Western Union Plan 115A Outstations
- Common Carrier TWX Stations (8-level code)
- European Teleprinters (WTC attachment)

COMMUNICATIONS — SYNCHRONOUS
- IBM 1009 Data Transmission Unit
- IBM 1013 Card Transmission Terminal
- IBM 7701 Magnetic Tape Transmission Terminal
- IBM 7702 Magnetic Tape Transmission Terminal
- IBM 7710 Data Communication Unit
- IBM 7711 Data Communication Unit
- IBM 7740 Communication Control System
- IBM 7750 Programmed Transmission Control
- IBM System/360 with similarly equipped 2701's

DATA ACQUISITION AND CONTROL
- Parallel Data Devices
- Contact Sense Terminals
- Contact Operate Terminals
- Serial Synchronous Terminals

The IBM 2701 can be attached to either the multiplexor or selector channel of the System/360. With the second channel interface feature, the 2701 can be attached to another channel on the same processor (multiplexor or selector) or to a channel on another processor. This means that different terminal devices on the 2701 can operate via the multiplexor channel or the selector channel. However, once a terminal device is assigned to a channel, it will operate only via this channel.

Functional Sections

The 2701 Data Adapter Unit provides for the on-line attachment of various input/output devices to any of the System/360 processors. All necessary bit-byte, word-byte conversion, data control, and interface matching is accomplished by the two functional sections of the 2701: the transmission interface converter (XIC) and the transmission adapter (XA).

The XIC and XA operate as a couple which provides a single complete path for the operation of the terminal devices with the channel (Figure 2). In a 2701 which has more than one XIC-XA couple, the XIC is logically the same for each couple; the XA changes, according to the type of terminal devices attached. A minimum 2701 configuration contains one XIC-XA couple. With the use of special features, the 2701 can have up to three more XIC-XA couples. See "2701 Configuration" section and Figure 3.

Transmission Interface Converter (XIC)

The XIC operates with the I/O interface; stores the status, sense, and command bytes; decodes the transmission adapter I/O address; developes and checks the parity of the data transfers with the I/O channel; responds to specific control unit commands; and operates with the transmission adapter.

Transmission Adapter (XA)

The transmission adapter contains the circuits necessary to perform the functions asociated with a given external device or class of terminal devices, such as interface control, parity decoding, character and character sequence recognition, data buffering and byte conversion, and status and sense byte generation.

Special Features

The special features fall into two major classifications. There are some special features on the 2701 which affect all the transmission adapters, whereas others are on a particular transmission adapter and affect only that adapter. Only the former will be discussed in this section. The special features for the transmission adapter will be found in the following sections, in which the various transmission adapters are discussed.

Expansion Feature

This features provides an additional XIC function for the attachment of another XIC-XA couple. The only circuitry in common with the first XIC-XA couple is the power supplies and the I/O channel interface drivers, terminators, and receivers. This sharing of the interface circuitry allows additional XIC-XA couples to be added without decreasing the total number of addi-

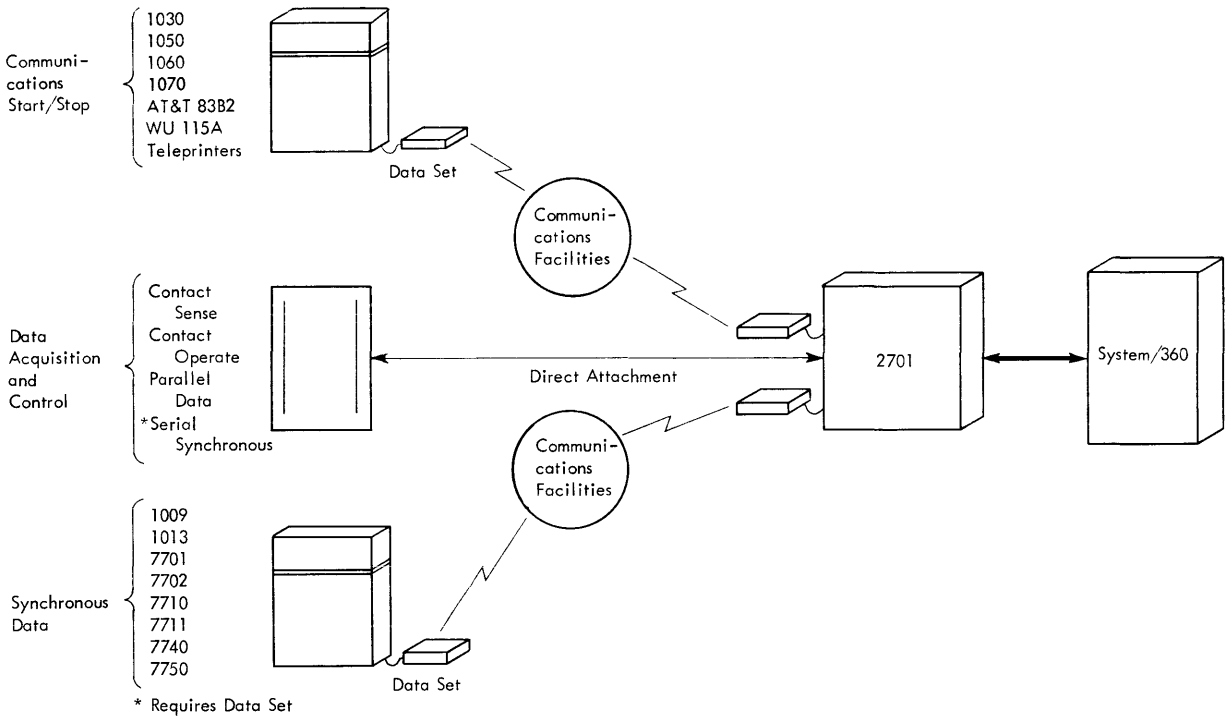


Figure 1. 2701 in a System Environment

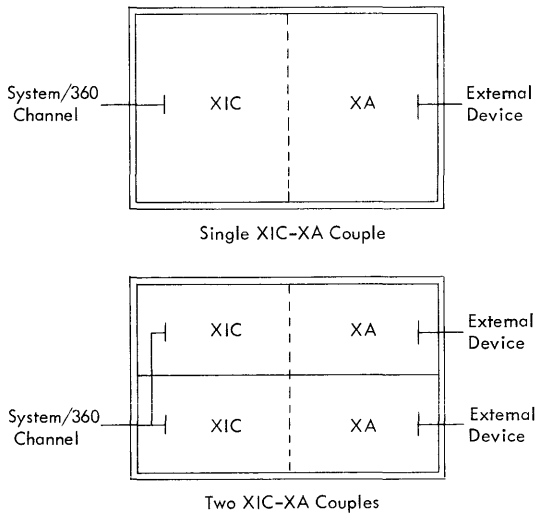


Figure 2. 2701 Functional Sections

tional control units allowable on the I/O channel. With the expanded capability feature, up to three expansion features are available in the same 2701.

Expanded Capability Feature

The expanded capability feature provides for additional XIC-XA couples within the 2701. The expanded capability feature doubles the capability of the 2701. For example, with the use of an expansion feature, two communication start/stop transmission adapters may be housed within the 2701. The expanded capability feature allows for two additional communication start /stop transmission adapters with their respective expansion features to be housed within the same 2701.

Second Channel Interface Feature

The second channel interface feature allows for one or more of the XIC-XA couples to be operated on a second channel from the other couple in the 2701. This second channel may be another channel on the same processor (for example, the 2701 basic unit connected to the multiplexor channel and the second channel interface feature connected to the selector channel) or to a channel on a second processor. The extreme would be to connect the second channel interface feature to the same channel as the 2701 basic unit, but this would serve no useful purpose and would unnecessarily reduce the number of additional control units on that channel from seven to six. Once an XIC-XA couple is assigned to one or the other channel, it will operate only on that channel; there is no capability to switch from one to the other.

Automatic Call Feature (ACF)

The automatic call feature is valid only with some of the communications start/stop adapters. This feature

allows the terminal device to be dialed, under program control over a common carrier switched network. The ACF almost falls into the category of special features which affect only the particular transmission adapter; however, the automatic call feature affects the total number of XIC-XA couples allowable in the 2701 and is, therefore, discussed here. See the configuration section for further details.

2701 Configuration

The 2701 configuration is made up of the following units and features:

2701 basic unit
Transmission adapter
Expansion feature
Expanded capability feature
Second channel interface feature

Figure 3 shows the maximum 2701 configuration, using all of the above units and features. This configuration has four transmission adapters, two per gate. As will be shown below, this configuration is not possible with every transmission adapter.

The 2701 basic unit supplies the frame, covers, power, a logic gate, and a transmission interface converter (XIC). To complete the XIC-XA couple, a transmission adapter must be obtained. The other units and features are described in the transmission adapter and the special features sections.

Some 2701 transmission adapters require more physical space than others in the 2701 frame. The use of these adapters restricts the number of the other XIC-XA couples housed within the same 2701. As an aid in specifying the configuration capabilities of the 2701, the transmission adapters have been grouped into three categories (Figure 4).

The 2701 basic unit gate can accommodate up to two category I adapters, one category II adapter, or up to two category III adapters. Adapters from different categories cannot be housed on the same gate.

The use of the expanded capability feature gate doubles the number of transmission adapters the 2701 can accommodate. Again, up to two category I adapters, one category II adapter, or up to two category III adapters can be accommodated on this gate. The transmission adapters on the expanded capability feature gate can be from the same or a different category as the adapters on the 2701 basic unit gate.

Expansion features must be obtained for each transmission adapter after the first. As mentioned earlier, the automatic call feature, when ordered on the communications start/stop adapters, reduces by one the allowable number of category I adapters. The automatic call feature, when ordered with the communica-

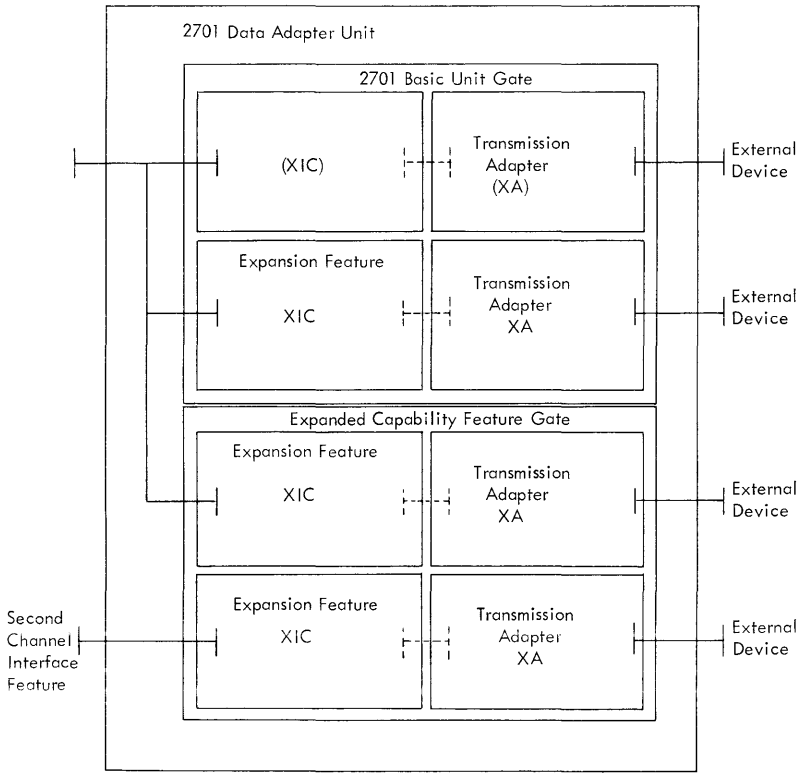


Figure 3. Maximum 2701 Configuration

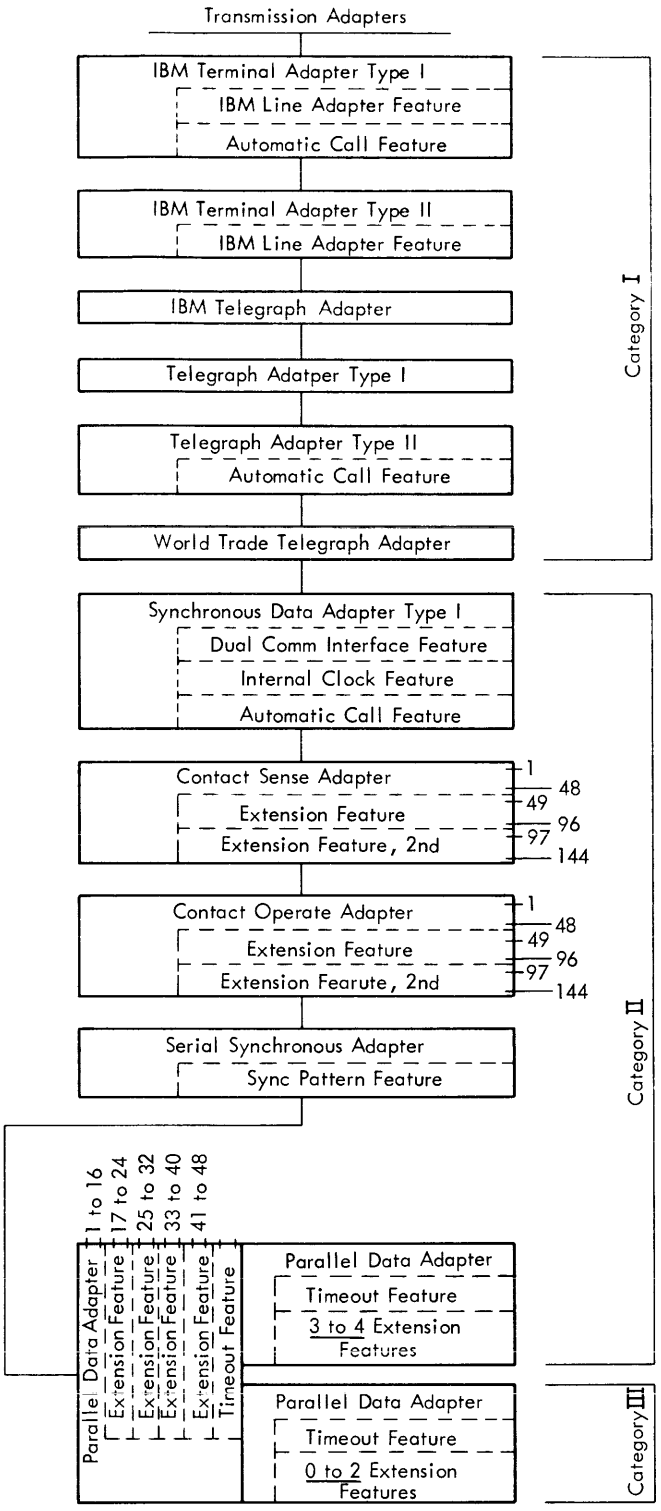


Figure 4. Categories of 2701 Transmission Adapters

tion synchronous adapter, does not have this restriction.

When more than one automatic call feature are required, this restriction applies only with the first.

For example, the first communication – start/stop adapter (category 1) with an automatic call feature completes a gate. The expanded capability feature must be obtained in order to add more adapters. With the expanded capability feature, in this case, two additional adapters from catgory 1 can be attached, and both adapters can also have the ACF. (The example could just as well have shown one category II or two category III adapters on the expanded capability gate.

The second channel interface feature connects an XIC-XA couple on the expanded capability feature gate to a second channel. When more than one XIC-XA couple are ordered on this gate, one or both couples can be connected to the second channel. For example, refer back to Figure 3. In the figure one XIC-XA couple on the expanded capability feature gate is shown connected to the second channel, and the other is shown connected to the same channel as the XIC-XA couples on the 2701 basic unit gate. Both XIC-XA couples on the expanded capability feature gate could just as well have been shown connected to the second channel. When the second channel interface feature is not obtained, all the XIC-XA couples housed within the 2701 are connected to the same channel. For further details on the configuration of the 2701, see the *IBM System/360 Data Communications and Acquisition Configurator*, Form A22-6824.

and acceptance or rejection of the command. Figure 5 presents the meaning of each possible status response for each of the I/O instructions.

Start I/O

There are many commands which may be issued with the start I/O instruction or as a result of command chaining. Where the XIC-XA couple has neither a previous command nor has outstanding status (status bits which have been set by either the XIC or the XA, but have not yet been accepted by the channel), and a valid start I/O command is decoded, all zero status will be returned to the channel. This indicates that the command has been accepted.

The sense and I/O no-op commands are the only commands resulting from a start I/O instruction or a command chain that is decoded and operated on by the XIC. (The other valid commands are decoded within the XA.) Each XA type accepts a different set of commands. Commands with the same bit structure may be defined differently for each type of adapter; therefore, only the sense command will be discussed here. The other commands will be discussed in later sections.

After completing transfer of the all-zero status byte, which indicates the 2701's acceptance of the sense command, the XIC transfers the sense byte to the channel and then presents terminating status with the device end and channel end bits on.

The definition of the bits within the sense byte depends upon which adapter is being used with the XIC. The sense bits are defined in the following sections, which cover the various adapters; however, bits 0 and 2 are reserved for the XIC:

Bit 0 – Command Reject.
This bit is set during an initial selection or command chain sequence when a command byte is not successfully decoded by either the XIC or the XA.

Bit 2 – Bus Out Check.
This bit is set whenever the XIC detects a parity error on the transfer of a byte from the channel over the bus-out lines.

The register within the XIC that holds the sense byte is reset by the XIC-XA couple's acceptance of any non-sense start I/O command.

Test I/O

Through the test I/O instruction, the CPU can addressably obtain the current status byte from any XIC-XA couple.

Upon decoding the test I/O command, the XIC presents the contents of the status register. The test I/O command ends with this status transfer.

Halt I/O

Upon detection of a halt I/O, the XIC-XA couple will not transfer any further data, and will be "busy" to any further commands until terminating status is accepted by the channel. Terminating status is presented to the channel as soon as possible.

Instructions and Commands / Status Response	Start I/O: I/O No-Op	Start I/O: Other	Test I/O
All Zeros	4	1	1, 3, 6
Busy	2, 5, 6, 10 or 2, 9	2, 5, 6, 10 or 2, 9	2, 5, 6, 10 or 2, 9
Busy and Status Register*	2	2	4
Status Register*	7, 1, 3	4	1, 3
Unit Check	4	2, 8	4

1. Command accepted
2. Command rejected
3. Command successfully terminated with status response
4. Status response invalid for this command
5. Previous command outstanding
6. No outstanding status
7. This status response is valid when the "Status Register" contains only the device end and channel end status
8. Invalid command
9. A reset is being performed
10. This command should not have gotten past channel

* The "Status Register" is defined here as an outstanding status within a control unit excluding the busy bit (that is, up to 7 bits).

Figure 5. Status Responses to Instructions and Commands

Programming Considerations

From a programming standpoint, the 2701 appears as a number of individual devices (one to four). When an operation or a sequence of operations is to be performed, the programmer prepares a list of one or more channel command words (channel program) in main storage. The channel command word signifies:

1. The command (operation) to be performed: write, dial, read, etc.
2. The number of bytes in the record.
3. The initial address in main storage where the data should be placed when receiving, or the address of the first byte to be transmitted when sending.
4. Channel flag information indicating that another channel command word is to be executed when the current operation is terminated.

When the channel command words have been formed, the programmer specifies the channel and address of the XIC-XA couple. The execution of a start I/O instruction causes the command, count, data address, and control information to be stored in a specified subchannel in the multiplexor channel or in the register in the selector channel. The channel then selects the 2701's XIC-XA couple, and presents the command to it. The 2701 accepts the command if valid. The channel then indicates successful or unsuccessful execution of the start I/O instruction to the programmer. Once the command has been accepted by the channel and the 2701, the CPU program is unaware of the continuance of the operation until all the data has been received or transmitted, or until the channel needs program intervention to perform functions such as dynamic storage allocation. Because the channel contains all the necessary information pertaining to the current operation, data transfer between main storage and the XIC-XA couple can be overlapped with CPU processing. The extent of the overlap varies, depending on the type of channel (multiplexor or selector) and the processor model (30, 40, 50, 60, or 70) of the System/360.

The transmission adapter (XA) provides for the connection and operation of remote and local devices with the System/360. The 2701 obtains its personality from the transmission adapter it houses. Each transmission adapter provides for the attachment and operation of a particular device or class of devices with the 2701. The transmission adapter contains the circuitry and logic for the control of a terminal device, the buffering of the data flow, the decoding of the program commands, and the connection to and operation with the XIC and the I/O channel.

Transmission adapters used in the 2701 are classified into one of three types: communications-start/stop adapters, communications synchronous adapters, and data acquisition and control adapters.

Communication-Start/Stop Adapters

Start/stop adapters for the 2701 include the following: IBM Terminal Adapter-Type I, IBM Terminal Adapter-Type II, Telegraph Adapter-Type I, Telegraph Adapter-Type II, IBM Telegraph Adapter, and the World Trade Telegraph Adapter. The operation of the 2701 start/stop adapters with the remote terminals requires various types of communications facilities and data sets (Figure 6). Figures 7 and 8 list the 2701 start/stop adapters and the terminals that may be operated with each. Also listed are the communications facilities and data sets required for the operation.

Programming Considerations

For those communication-start/stop terminals (1030, 1050, 1060, 1070, etc.) which can operate with both the 2701 and 2702, the operation programs used are identical. However, this compatibility does NOT extend to diagnostic programs.

Commands

The communications-start/stop adapters decode and execute the commands listed below. Some commands, such as read, write, and inhibit, are valid for all adapters; other commands, such as dial and search, are valid only for certain ones. The commands used by each type of adapter are listed in the section for that adapter. Binary representation of each command is given in Figure 9.

Read: This command causes bytes to be transferred from the communication line to the channel at a data rate equal to that of the communication line.

Write: This command causes bytes to be transferred from the channel to the communication line at a data rate equal to that of the communication line.

Inhibit: This command performs the read operation but inhibits the time-out function. Otherwise, the operation proceeds as if a read command had been issued.

Break: This command causes the 2701 to transmit continuous space signals to the line. Bytes transferred from the channel to the addressed unit must all be zeros. To provide control over the length of a space signal, a byte count must be specified by the program.

Prepare: This command can be used in a contention type communications system to indicate (to the CPU) that data are arriving. When a valid start bit is detected while the XIC-XA couple is operating upon a prepare command, the command is terminated with a device end, channel end status. Prepare can be command-chained to a normal read command. No data transfer occurs with this command, and timeout is not active during its execution.

Search: This command causes the 2701 to react as though a read command has been issued, but data are not transferred to the channel. The data line is monitored for an EOT (end of transmission). Line timeout is active during the execution of this command. This command is valid only for the Telegraph Adapter-Type I.

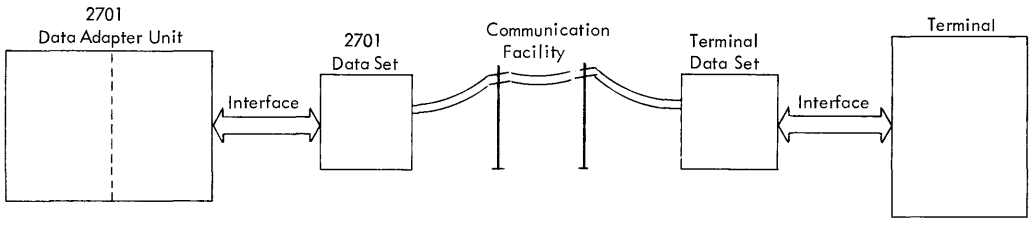


Figure 6. Terminal Connection via Data Sets and Communications Facilities

Terminal	Communication Facility	Terminal Data Set	2701 Data Set	Speed	2701 Adapters
1050 Data Communication System					
1051 Control Unit Model 1 or 2	Common Carrier Switched Telephone Network	Western Electric 103A	Western Electric 103A	134.4 Baud	IBM Terminal Adapter Type I #4645
	Common Carrier Switched (150 bps) Teletypewriter Exchange (TWX) Network				
	Common Carrier Leased Private Line Telephone Service	Western Electric 103B or F	Western Electric 103F	14.8 Char/Sec	
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1051 Control Unit Model 1 or 2 with Telegraph Attachment #7873	Telephone Company Schedule 3 or Western Union Class C Channels (62.5 ma Neutral Signal)	Not Required	Not Required	75.0 Baud 8.33 Char/Sec	IBM Terminal Adapter Type I #4645
1051 Control Unit Model 1 or 2 with Line Adapter #4790	Customer-Owned Two-Wire Networks Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1060 Data Communication System					
1061 Control Unit Model 1 or 2	Common Carrier Leased Private Telephone Service	Western Electric 103B	Western Electric 103F	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1061 Control Unit Model 1 or 2 with Line Adapter #4790	Customer-Owned Two-Wire Networks Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1030 Data Collection System					
1031A Input Station	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648 IBM Line Adapter #4637
1031A Input Station with Common Carrier Adapter #2068	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202B	Western Electric 202B	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648
	Western Union Class E (1200 bps) Channel	Western Union 1601-A	Western Union 1601-A		
1070 Process Communications System					
1071 Control Unit Model 1	Common Carrier Leased Private Line Telephone Service	Western Electric 103F	Western Electric 103F	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1071 Control Unit Model 1 with Line Adapter #4792	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1071 Control Unit Model 2	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202B	Western Electric 202B	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646
	Western Union Class E (1200 bps) Channel	Western Union 1601-A	Western Union 1601-A		
1071 Control Unit Model 2 with Line Adapter #4793	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646 IBM Line Adapter #4636
TWX (Teletypewriter Exchange)					
Teletypewriter Corporations Models 33 and 35 Teletypewriters	Common Carrier Switched Telephone Networks or Switched 150 bps TWX Networks	Western Electric 103A	Western Electric 103A	110 Baud	Telegraph Adapter Type II #7885
Other Terminals					
AT&T 83B2 Selective Calling Terminal	Telephone Company Schedule 1 Channels (45 bps)	Not Required	Not Required	45.5 Baud	Telegraph Adapter Type I #7860
	Telephone Company Schedule 2 Channels (57 bps)			56.9 Baud	Telegraph Adapter Type I #7861
	Telephone Company Schedule 3 Channels (75 bps)			74.2 Baud	Telegraph Adapter Type I #7862
Western Union Plan 115A Outstation	Western Union Class B Channels (57 bps)	Not Required	Not Required	56.9 Baud	Telegraph Adapter Type I #7861
	Western Union Class C Channels (75 bps)			74.2 Baud	Telegraph Adapter Type I #7862

Figure 7. Attachable Terminals and Communications Facilities for Domestic Use (Communications-Start/Stop Adapters)

Terminal	Communication Facility	Terminal Data Set	2701 Data Set	Speed	2701 Adapters
1050 and 1060 Data Communication Systems					
1051 Control Unit Model 1 or 2 or 1061 Control Unit Model 1 or 2	Common Carrier Leased Private Line Telephone Service	IBM 3976	IBM 3976	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
1051 Control Unit Model 1 or 2 or 1061 Control Unit Model 1 or 2 with Line Adapter #4790	Customer-Owned Communications Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required		IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1070 Process Communication System					
1071 Control Unit Model 1	Common Carrier Leased Private Line Telephone Service	IBM 3976	IBM 3976	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
1071 Control Unit Model 1 with Line Adapter #4792	Customer-Owned Communications Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required		IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1071 Control Unit Model 2	Common Carrier Leased Four-Wire Full Duplex Private Line Telephone Service	IBM 3977 Model 1	IBM 3977 Model 1	600.0 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646
1071 Control Unit Model 2 with Line Adapter #4793	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required		IBM Terminal Adapter Type I #4646 IBM Line Adapter #4637
1030 Data Collection System					
1031A Input Station	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648 IBM Line Adapter #4637
1031A Input Station with Common Carrier Adapter #2068	Common Carrier Leased Four-Wire Full Duplex Private Line Telephone Service	IBM 3977 Model 1	IBM 3977 Model 1		IBM Terminal Adapter Type II #4648
World Trade Teleprinters					
W T Teleprinter	Common Carrier Private Line Telegraph Circuits (Double-Current Telegraph Lines)	Not Required	IBM 3945 Model 11	50 Baud	W T Telegraph Adapter
				75 Baud	W T Telegraph Adapter
W T Teleprinter	Common Carrier Private Line Telegraph Circuits (Single-Current Telegraph Lines)	Not Required	IBM 3945 Model 12	50 Baud	W T Telegraph Adapter
				75 Baud	W T Telegraph Adapter

Figure 8. Attachable Terminals and Communications Facilities for WTC Use (Communications-Start/Stop Adapters)

Enable: This command conditions the 2701 to automatically answer incoming calls. This has meaning only when operating on a dial network.

Disable: This command deconditions the effect of the enable command. The 2701 will disconnect a call (if one is in operation) and will not answer any further incoming calls. This condition exists until an enable command is given.

Dial: This command will be accepted by the 2701 only when it has the automatic call feature. This command enables the automatic call feature to obtain dial digits from the processor. The dial command is ended when the call is either successfully completed or abandoned.

Diagnostic Write: This command sends data to a diagnostic register. If more than one byte are transferred, only the last byte remains stored. The communication line is isolated and does not receive this data. This command is ended either by the XA recognizing a terminating sequence of data or by a stop signal issued by the channel.

Diagnostic Read: This command presents the byte of data stored in the diagnostic register to the channel. The comunication line is isolated and no data occuring on the line will be recognized by the XIC-XA couple.

Adapter Operation

Receive Operation

The receive operation is initiated when the XIC-XA couple accepts a read type command (read, inhibit, search) from the channel. Upon detection of a start bit, the XA prepares to receive a character. The character, which is received one bit at a time, is assembled in a data register. When a full character has been as-

Commands	Bit Configurations P	0	1	2	3	4	5	6	7
Read	0	0	0	0	0	0	0	1	0
Write	0	0	0	0	0	0	0	0	1
Dial	0	0	0	1	0	1	0	0	1
Break	0	0	0	0	0	1	1	0	1
Prepare	1	0	0	0	0	0	1	1	0
Inhibit	1	0	0	0	0	1	0	1	0
Search	0	0	0	0	0	1	1	1	0
Enable	1	0	0	1	0	0	1	1	1
Disable	0	0	0	1	0	1	1	1	1
Diagnostic Read	0	0	0	0	0	0	1	0	1
Diagnostic Write	0	0	0	0	1	0	1	1	0

Note: Byte positions 0 and 1 must contain zeros; however, these positions are ignored by the basic 2701 Data Adapter Unit.

Figure 9. Communications – Start/Stop Adapter Commands

sembled, the XA checks for special characters, checks for VRC, assembles the LRC (where applicable), and requests a data transfer to the channel. The channel has a minimum 2.1 bit time, which prevents losing a character. This response time is determined with the worst possible receive distortion. The stop bit is checked for, and, unless some terminating status condition occurs, the XA prepares to receive the next character.

Line Time-Out

A 28-second timeout between data characters is performed when the XA is operating on a read type command other than inhibit. The timeout is used to prevent a communication line or terminal failure from going undetected. The timeout is started when the stop bit is received, and terminated when the next start is detected. If the timeout elapses, the command is terminated, and the channel is notified of this occurrence through the status and sense bytes. Some transmission adapters also require a short timeout.

Transmit Operation

The transmit operation is initiated by the acceptance of a write command by a XIC-XA couple. The XA accepts a character from the channel and transmits it a bit at a time over the communications facilities. The XA inserts the start and stop bits, checks for special characters, accumulates and transmits the LRC character (where applicable) and inserts shift characters (where applicable).

Unless some terminating condition has occurred, the XIC-XA couple will request a data transfer after the last data bit is sent to the communications line. When the data code requires one stop bit, there are 1.3 bit times for the channel to respond without elongating the stop bit time. When the data code requires two stop bits, the time is a 2.3 bit time. Although it decreases the overall data rate, an elongated stop bit is a normal occurrence for start/stop transmission schemes.

Status Byte

The following terminating statuses may be presented by the communications-start/stop adapter to the channel:

Device End, Channel End Status: Indicates that the current command has been brought to a normal end and the unit is free to accept another command.

Device End, Channel End, and Unit Exception Status: Indicates that the current command has been brought to a successful conclusion and EOT (end of transmission) has been received, or a no response to a poll has been detected.

Device End, Channel End, and Unit Check Status: Indicates that the current command has been ended with an unusual condition. A sense command must be issued to the addressed unit to further define these conditions.

Device End, Channel End, Unit Exception, and Unit Check Status: Indicates that the current command has been ended by unusual conditions and an EOT or a no response to a poll has been received. A sense command must be issued to the addressed unit to further define these conditions.

Sense Byte Definition

The sense byte is transferred to the channel during the sense operation; definition of the bits as they are sent to System/360 storage is given below:

0 Command reject*
1 Intervention required
2 Bus out check*
3 Equipment check
4 Data check
5 Overrun
6 Receiving
7 Timeout

Intervention Required is set when the following conditions exist:

1. The attached data set, where applicable, has power off or is in test mode.
2. An attached automatic calling unit, where applicable, has power off.
3. Continuous space signal has been received on a given communications line for more than one character.

Equipment Check is set when a halt I/O is detected during a service cycle.

Data Check is set during receive operations if:

1. At stop time, the receive data sample is a space signal.

*These bits are set by the XIC and are not discussed here.

2. If a parity or cyclic check error is detected. (During transmit operations, this bit is set if an echo check is detected at the relay interface of a telegraph line adapter.)

Overrun is set during receive operations if a byte is lost because data service could not be obtained in time.

Receiving is set whenever the addressed unit is engaged in receiving data. The automatic call feature sets this bit when a dial command is issued to a line that is currently "off-hook."

Timeout is set when the communications line timeout has elapsed. The automatic call feature sets this bit to indicate that the dial operation has not been successfully completed.

Special Features

Automatic Call Feature

This feature enables the 2701 to originate calls on a switched dial network by dialing through an AT&T 801A1 type auto dial unit. This feature is not needed or used for handling the automatic answering of calls on a switched network. The automatic call feature can operate with only certain types of transmission adapters and certain types of terminals attached to those adapters. Therefore, the capability for the automatic call feature will be discussed in the sections covering the specific transmission adapters and the terminals.

To perform a dial operation, the programmer sets up the dialing number, one digit per byte, in an outgoing message. The digit is represented in binary code in bits 4, 5, 6, and 7 of the byte. He then issues a dial command (a bit configuration is shown in Figure 9), with a byte count equal to the number of digits to be dialed. The 2701, when it accepts the dial command, presents the digits to the automatic dialing unit for dialing. When the call has been answered, the 2701 presents the device end, channel end status to the channel. Command chaining then occurs to a read or write command, depending upon the operation. If, for some reason, the call cannot be completed, the 2701 presents the device end, channel end, and unit check status with the timeout bit set in the sense byte.

IBM Line Adapter Feature

The IBM Line Adapter Feature is available with only certain communications-start/stop adapters, and with only some of the terminals that operate with these adapters. The capability to operate with the IBM Line Adapter is stated in the sections covering the specific transmission adapters. The IBM Line Adapter is a modem that provides for the attachment of the 2701 transmission adapter to customer-owned private telephone lines for distances up to 8 wire miles, conforming to *IBM 1030 Data Collection System Physical Planning*, Form A24-3021.

Diagnostics

2701 start/stop adapters each have a diagnostic register located on the 2701's side of the line drivers or relays that operate with the communication facilities. Through a diagnostic write command, data can be sent through the 2701's XIC-XA couple to the diagnostic register. The diagnostic register holds the start bit, the data bits, and the stop bit(s). If multiple bytes are transmitted under this command, only the last byte will remain stored in the register. Through a diagnostic read command, the contents of this register are sent back to storage for checking. The 2701 operates on this byte as though it were being received from the communication line. The start bit is checked; the data character is checked for special character; the shift bit, if applicable, is added; the stop bit is checked; and the character is transferred to the channel.

The use of the diagnostic commands allows a major portion of the 2701 circuitry to be checked out. The clocks, counters, registers, serializers, deserializers, etc. can be checked. Some of the decoding capabilities can be checked and the LRC generation circuitry can be checked. For example, with an IBM Terminal Adapter-Type I, the diagnostic write command can be used to transmit multiple bytes of data, the last byte being the EOB character. As will be explained in the section describing the IBM Terminal Adapter-Type I, the recognition of the EOB character causes the transmission adapter to transmit the EOB followed by the LRC character and then presents terminating status to the channel. The last character transmitted is the LRC character, which will reside in the diagnostic register. A diagnostic read command can then be given to bring the LRC character to storage for checking. On both a diagnostic read and diagnostic write operation, the communication lines are degated. In this manner, no data will be transferred to or from the communication lines. There are other techniques peculiar to each type of adapter, such as special character generation, which is not discussed.

Automatic Answering

Automatic answering of incoming calls, a standard feature on the IBM Terminal Adapter-Type I and the Telegraph Adapter-Type II, allows the programmer to control the answering of incoming calls. When the programmer desires to allow the answering of incoming calls, he issues an enable command to the 2701. The SLI (suppress length indication) flag is set in the associated channel command word. When a

call is answered, the enable command is ended, with the XIC-XA couple setting the device end, channel end status. Command chaining may be applied to either a write or a read command, depending upon the application. When conditions change and the programmer no longer desires to accept incoming calls, a halt I/O command is given to the XIC-XA couple which causes the device end, channel end status to be presented and the data set prevented from answering any further incoming calls. Once an enable command is given, the data set remains conditioned to answer calls until either a halt I/O or disable command is issued.

IBM Terminal Adapter-Type I

The IBM Terminal Adapter-Type I enables the 2701 to control data transfer between an IBM System/360 and the following terminals: IBM 1050, 1060, and 1070 terminals at 14.8 characters per second (134.49 bps) or the IBM 1070 at 66.6 characters per second (600 bps). Figures 7 and 8 illustrate the data sets and communications facilities required for each of the above terminals operating at different speeds. The IBM Terminal Adapter-Type I matches the line control required for terminal operation with the I/O channel using System/360 programming capabilities. Polling and addressing responses, VRC (vertical redundancy checking) and LRC (longitudinal redundancy check), special character recognition, and shifted character operations are all handled by the XA to minimize system interference.

Commands

The IBM Terminal Adapter-Type I decodes and excutes the following commands: read, write, inhibit, enable, disable, prepare, diagnostic read, and diagnostic write. The dial command is also valid for this adapter when it has the automatic call feature. The functions of these commands are explained under the communication-start/stop adapters.

Special Features

Two special features are available for the IBM Terminal Adapter-Type I:

The automatic call feature is obtainable with the IBM Terminal Adapter-Type I only when operating with the IBM 1050 Terminal.

The IBM Line Adapter Feature is obtainable with the IBM Terminal Adapter-Type I only when operating with the 1050 or 1070 terminals.

Adapter Operation

Character Set: The transmission code between the 2701 and the 1050, 1060, and 1070 terminals is six-bit BCD. The relationship between the 2701 and the I/O interface is illustrated in Figures 10, 11, and 12. One start bit and a minimum of one stop bit are added to a character when the XA is transmitting, and they are deleted from a character when the XA is receiving.

0	1	2	3	4	5	6	7	System/360 Byte
shift S	B	A	8	4	2	1	check C	6 Bit BCD

In the six-bit BCD transmission code, S represents the shift bit. A logical 1 identifies the upper case; a logical 0 represents the lower case. The B bit is the first bit transmitted and received following the start bit. An odd parity (check) bit follows the 1 bit. Each received character is checked for odd vertical parity.

On incoming data, the shifted character set conversion (a standard feature) automatically deletes the up shift and down shift characters from the received data stream, notes the last shift character received, and inserts the eighth bit S to indicate the case to System/360. On outgoing data, the S bit is removed and noted. A change in this S bit automatically causes insertion of the appropriate shift character (up shift or down shift) into the outgoing data stream before sending the data character.

START	B	A	8	4	2	1	check C	STOP	Outgoing Data Character

The C (check) bit in the character indicates the correct odd parity count; a logical 1 if the bit count of the character is even, or a logical 0 if the bit count of the character is odd.

VRC and LRC are provided, with any detected error setting the data check bit within the sense byte.

Polling and Addressing: When polling, a write command is initiated by a start I/O instruction which causes the polling character to be transmitted on the communications line. Command chaining to a read command should be used so that the 2701 has a valid command for receiving the incoming data.

Upon receiving a read command, the 2701 will initiate a 28-second timeout. When polling, this timeout is pre-empted by a 2-second short timeout. The 2701 will set the device end, channel end, and unit exception status when an Ⓝ character is received. Ⓝ indicates the terminal has no data to send. The device end, channel end and unit exception status is set in the status byte when a timeout occurs; the timeout sense bit will also be set. When the first character received is a Ⓓ, it indicates that the polling was suc-

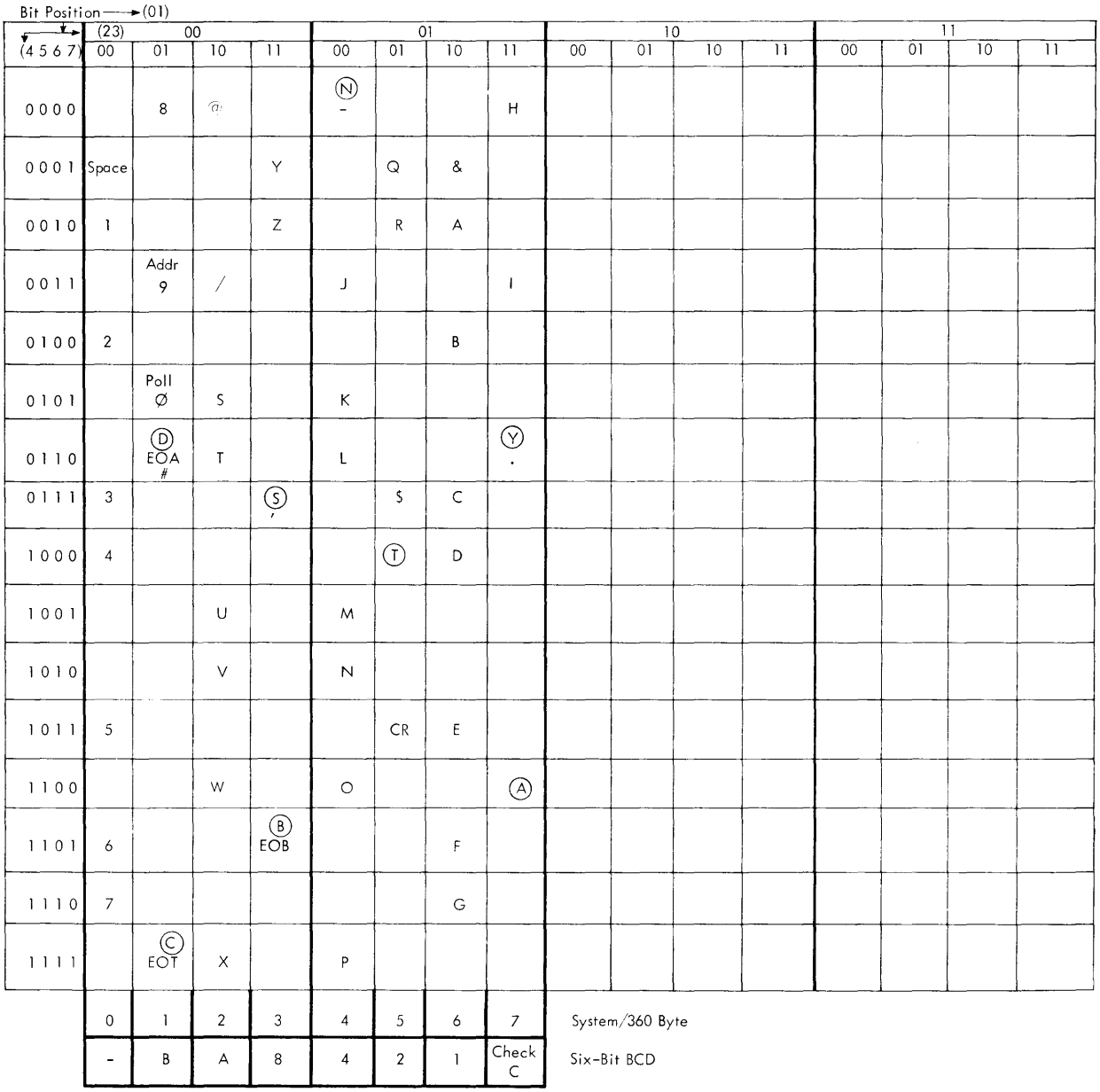


Figure 12. Code Structure for 1070 Process Communication System

error. The XA logically determines which of the above is valid and takes the following action:

Not Ready: The device end, channel end, unit exception status is set.

Error: The device end, channel end, unit check status is set with the data check bit set in the sense byte.

(Y) Positive Response indicates that the text received was correct or the addressed system is ready to receive data. In either case, the XA sets the device end, channel end status.

The IBM Terminal Adapter-Type I recognizes the delete and idle characters and includes them in the accumulated LRC but inhibits the transfer of these characters to the CPU.

1033 Operation — Message Restriction: The IBM 1070 Process Communication System uses the IBM 1033 Printer. When the IBM Terminal Adapter-Type I is used with the 600 bps line speed, a problem arises.

The 1033 Printer operates at 15 and the transmission line operates at 600 bps (or a comparable rate of 67 cps). A four-character delay time is required between output printing characters. This is effected by using the write command with three special characters (DF in Hexadecimal Representation), inserted between every printing character. The CPU program must take into account the difference in operating speed between the transmission line and the printer

and provide the necessary delays for printing the output, via the insertion of these write mark characters. Delays can also be effected in this manner to carriage returns, tabs, line feeds and so on.

IBM Terminal Adapter-Type II

IBM Terminal Adapter-Type II provides the 2701 with the controls for operation with the IBM 1030 Data Collection System at 600 bits per second.

Commands

The IBM Terminal Adapter-Type II decodes and executes the following commands: read, write, inhibit, prepare, diagnostic read, and diagnostic write. The functions of the commands are explained in the start/stop adapter section.

Special Features

The IBM Line Adapter may be obtained with this adapter.

Adapter Operation

Character Set: The transmission code between the 2701 and the terminals is six bits plus parity. The relationship between the 2701 and the I/O Interface is illustrated in Figure 13. One start bit and a minimum of two stop bits are added to a character when the XA is transmitting to the terminal and deleted when the XA is receiving from the terminal.

0	1	2	3	4	5	6	7	System/360 Byte
-	B	A	8	4	2	1	check C	6 Bit BCD

The bit B is the first bit transmitted and received on the communications line following the start bit. The C bit in the character indicates the correct odd parity count: a logical 1 if the bit count of the character is even or a logical 0 if the bit count of the character is odd.

START	B	A	8	4	2	1	check C	STOP	STOP	Outgoing Data Character

Each received character is checked for odd vertical parity; a parity check causes the unit check bit to be set with the terminating status. The parity check does not cause the termination of the command.

Polling and Addressing: When polling, a write command is issued through a start I/O instruction which causes the polling character to be transmitted on the communication line. At the end of the write command, command chaining to a read command should be performed so that a read command, with its allocated storage, is ready for the incoming data. Upon receiving the read command, the 2701 will initiate a timeout. When polling, the IBM Terminal Adapter-Type II preempts the 28-second timeout with a 500-millisecond short timeout. When an Ⓝ is received, the device end, channel end, and unit exception status is set. The device end, channel end, and unit check is set in the status byte when a timeout occurs; the timeout bit is also set in the sense field.

When addressing, a write command is issued through a start I/O instruction that causes the addressing character to be transmitted on the communication line. An Ⓢ character (provided by the program) is transmitted before the addressing characters. At the end of the write command, command chaining to a read command is used to receive the Ⓝ or Ⓨ character. Ⓝ will set the device end, channel end, and unit exception status as in polling. Ⓨ will set the device end, channel end, which allows command chaining to the output message.

Character Recognition: The following characters are recognized during write command:

Ⓒ End of Transmission (EOT) indicates the end of transmission and places the 2701 in a control mode. It is normally followed by polling or addressing.

Ⓓ End of Address (EOA) indicates the end of address (start of message).

The following characters are recognized during read commands:

Ⓑ End of Block (EOB) indicates the end of a block of text. If a VRC error is detected in the block of data, the device end, channel end, and unit check status will be set with the data check bit set in the sense byte. Otherwise, the device end, channel end status is set.

Ⓓ End of Address (EOA) indicates that the following characters will be text.

Ⓝ Negative response indicates that the addressed terminal is not ready to receive data or that the text received by the terminal is incorrect. The device end, channel end, and unit exception status is set for not ready condition, and the device end, channel end, and unit check status is set with the data check bit set in the sense byte for a text error.

Ⓨ Positive Response indicates that the addressed system is available or that the text received was correct. The device end, channel end status will be set.

1033 Operation — Message Restriction: The 1033 Printer operates at 15 characters per second, and the transmission line operates at 600 bps (or a comparable rate of 60 cps). A three-character delay time is required between output printing characters. This is effected by using the write command with three special characters (DF in hexadecimal representation) inserted between every printing character. The CPU program must consider the difference in operating speeds

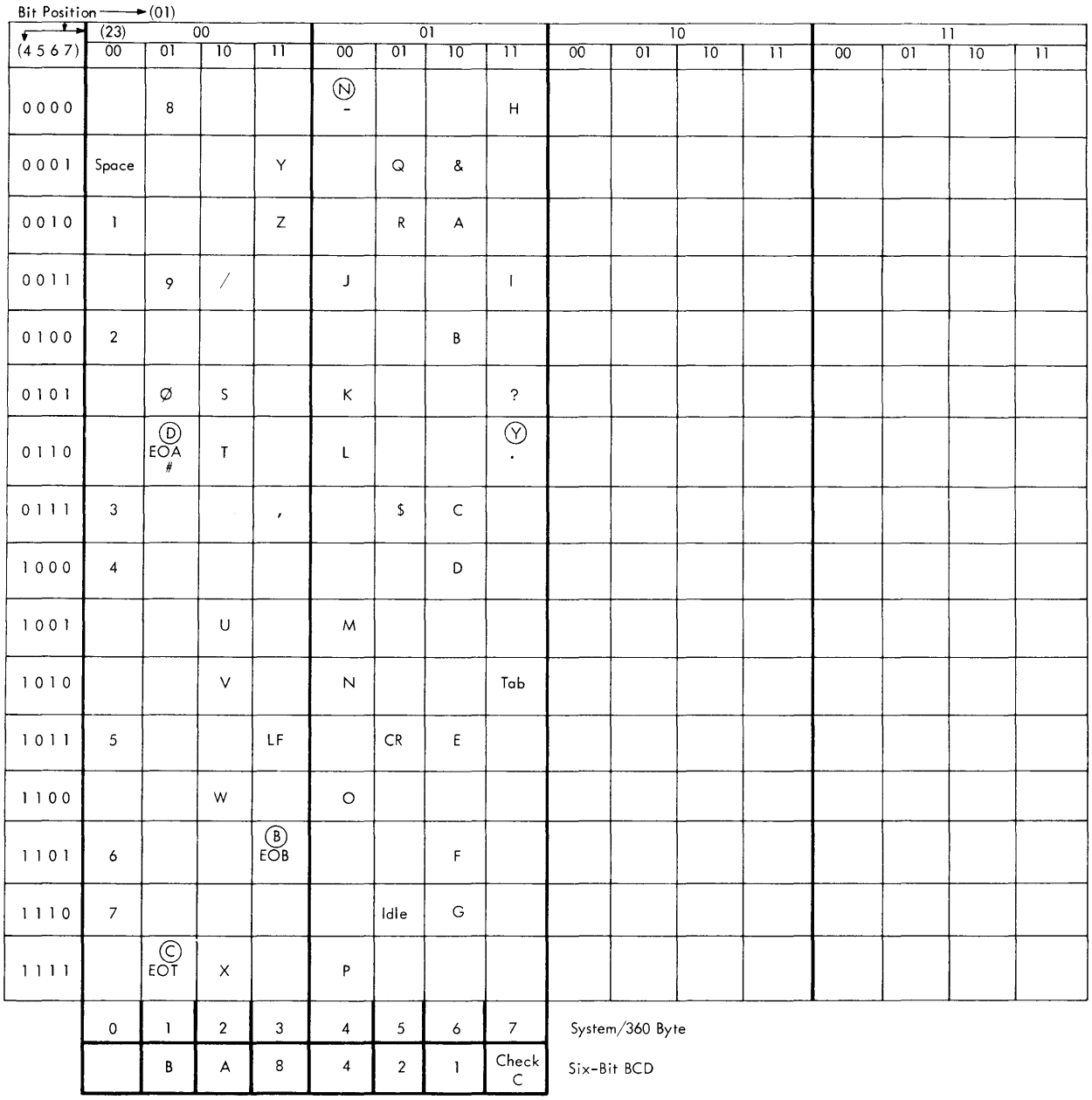


Figure 13. Code Structure for 1030 Data Collection System

between the transmission line and the printer and provide the necessary delays for printing the output by insertion of write mark characters. Delays can also be effected in this manner to carriage returns, tabs, line feeds, and so on.

IBM Telegraph Adapter

The IBM Telegraph Adapter is identical to the IBM Terminal Adapter-Type I with the exception of the communication medium. The IBM Telegraph Adapter operates over a telegraph network, through telegraph relays, at telegraph speeds. It also performs an echo check on the transmitted data. Factors such as commands decoded and executed, polling and addressing, character recognition, and other operating functions are the same as those for the IBM Terminal Adapter-Type I. The status and sense bytes are defined exactly as for the IBM Terminal Adapter-Type I except for the added echo check. When an echo check error is discovered, the unit check bit is set in the status byte and the data check bit is set in the sense byte. The command is not ended because of an echo check.

Telegraph Adapter-Type I

The Telegraph Adapter-Type I enables the 2701 to control data transfer between an IBM System/360

and the AT&83B2 or Western Union Plan 115A Outstations. The speed of transmission is 45.57 or 75 bps.

Commands

The Telegraph Adapter-Type I decodes and executes the following commands: read, write, inhibit, search, prepare, diagnostic read, and diagnostic write. The functions of these commands are explained in the start/stop adapter section.

Special Features

There are no special features for this adapter.

Adapter Operation

Character Set: The transmission code between the 2701 and the terminals is Baudot. The relationship between the 2701 and the I/O interface is illustrated in Figures 14 and 15.

0	1	2	3	4	5	6	7	System/360 Byte
-	-	case S	1	2	3	4	5	Shifted Baudot Code

In the above figure, S represents the case. A logical 1 identifies upper case; a logical 0 identifies lower case. The 1 bit is the first bit transmitted following the start bit.

The shift character set conversion, a standard feature, automatically deletes LTRS and FIGS characters from the received data stream and denotes the case. A

Bit Position ——→ (01)

↓ (23)	00				01				10				11			
(4 5 6 7) ↓	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0 0 0 0	Blank	E	Blank	3												
0 0 0 1	T	Z	5	"												
0 0 1 0	CR	D	CR	$												
0 0 1 1	0	B	9	?												
0 1 0 0	Space	S	Space	Bell												
0 1 0 1	H	Y	#	6												
0 1 1 0	N	F	,	!												
0 1 1 1	M	X	¢	/												
1 0 0 0	LF	A	LF	-												
1 0 0 1	L	W	)	2												
1 0 1 0	R	J	4	'												
1 0 1 1	G	Figs ↑	∝	Figs ↑												
1 1 0 0	I	U	8	7												
1 1 0 1	P	Q	Ø	1												
1 1 1 0	C	K	:	(												
1 1 1 1	V	Ltrs ↓	;	Ltrs ↓												
	0	1	2	3	4	5	6	7	System/360 Byte							
			Shift S	1	2	3	4	5	Shifted Baudot Code							

Figure 14. Code Structure for AT&T 83B2, Western Union Plan 115A, and World Trade Teleprinter Terminals (C Keyboard)

Bit Position → (01)																
(4567) ↓ / (23) →	00				01				10				11			
	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0000	Blank	E	Blank	3												
0001	T	Z	5	"												
0010	CR <	D	CR <	$												
0011	O	B	9	5/8												
0100	Space ✖	S	Space ✖	Bell												
0101	H	Y		6												
0110	N	F	7/8	1/4												
0111	M	X	o	/												
1000	LF	A	LF	-												
1001	L	W	3/4	2												
1010	R	J	4	'												
1011	G	Figs ↑	∝	Figs ↑												
1100	I	U	8	7												
1101	P	Q	Ø	1												
1110	C	K	1/8	1/2												
1111	V	Ltrs ↓	3/8	Ltrs ↓												
	0	1	2	3	4	5	6	7	System/360 Byte							
			Shift S	1	2	3	4	5	Shifted Baudot Code							

Figure 15. Code Structure for AT&T 83B2, Western Union Plan 115A, and World Trade Teleprinter Terminals (A Keyboard)

sixth bit is added to the code set by the adapter; it indicates case to the processor. Data bytes transferred from the channel are in six-bit form. The adapter will remove the sixth bit and note the case. A change in case automatically causes the insertion of the proper shift character (LTRS or FIGS) into the outgoing data stream. The adapter will send two stop bits and check for the presence of one stop bit on receive.

Polling and Addressing: When polling, a write command is issued through a start I/O instruction, which causes the polling character to be transmitted on the communication line. At the end of the write command, command chaining to a read command should be used so that a read command with its allocated storage is ready for incoming data. Upon receiving the read command, the 2701 will initiate a timeout. When polling, the Telegraph Adapter-Type I pre-empts the 28-second timeout with a 2-second short timeout. The CPU program will be interrupted if V or M is received (which is a negative response to a poll). The device end, channel end status is set. Unit check will be set in the status byte if a timeout occurs; the timeout bit will be set in the sense field. The positive response to a poll is the message itself.

When addressing, a write command is issued through a start I/O instruction, which causes the addressing characters to be transmitted on the communication line. At the end of the write command, command chaining to a read command is used to receive the V or M response (which is the positive response). A V or M will cause a normal device end and channel end status which can be command-chained to the output message. A timeout will set unit check in the status byte and timeout within the sense field, as in polling, to interrupt the CPU program.

When operation on the multidrop line allows terminal to terminal traffic, different line control is required. In response to a polling message, the positive response is a CDC (Call Directing Code) or SSC (Station Selection Code). If the CPU or a terminal on another line is addressed, the CDC or SSC of the CPU must be the first address sent by the terminal. The character AZ is assigned to the CPU in all systems. If AZ is detected, a device end and channel end status will be set, thus ending the polling read command. The V answer-back must be sent by the program through a write command, and a chained read command must be provided for receiving the text. If the terminal has no message to send, it will respond with a V. The V will cause termination of the read command via channel end and device end status. If some sequence other than AZ or V is received, a stop signal is given by the channel when the byte count in the CCW (set to two by the program) is exceeded. In this case, a search command can be issued to monitor the line for end of transmission (EOT), if the program does not want to receive the message. Text messages must begin with EOA (End Of Address). For the AT&T 83B2 Terminal, EOA is CR, LF, LTRS; for the Western Union Plan 115A Outstation, EOA is the space character.

Character Recognition: The following characters are recognized during read commands:

1. A V or M received as the first character sets channel end and device end status.
2. FIGS H and LTRS are received as EOT and set channel end, device end and unit exception status.
3. The two-character sequence AZ is received as the first two characters of a message and the address of the CPU. The device and channel end status will be set.

Message Restrictions for Telegraph Adapter-Type

Terminal to Processor

1. All messages transmitted by a Western Union Plan 115A Outstation from its paper tape reader must be preceded with the sequence A, V, space.
2. A space character received by the 2701 will not downshift (FIGS to LTRS).
3. Text immediately following the sequence FIGS, H, LTRS (EOT) will be lost; EOT must not be sent between blocks of data.

Processor to Terminal

1. When transmitted, the characters (CR, LF, space and blank) must be in the same case as the preceding character.
2. The terminal control automatically inserts the proper shift character in outgoing data when a change of case is encountered.

Terminal to Terminal

1. AZ is the address assigned to the CPU and recognized by the 2701.
2. End of Address (EOA) must precede the transmission of text: EOA for AT&T 83B2 – CR, LF, LTRS; EOA for WU 115A – Space.

Telegraph Adapter-Type II

The Telegraph Adapter-Type II provides the necessary controls for the attachment of telephone company teletypewriter exchange (TWX) stations to the 2701. Control is point-to-point and is on common-carrier switched 150-bps TWX service. Transmission speed is 110 bps.

Commands

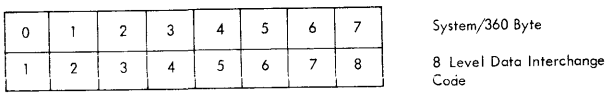
The Telegraph Adapter-Type II decodes and executes the following commands: read, write, inhibit, enable, disable, prepare, diagnostic read, and diagnostic write. The dial command is also valid when the automatic call feature is obtained. The functions of these commands are explained in the section "Start/Stop Adapters."

Special Feature

The automatic call feature is obtainable with the Telegraph Adapter-Type II.

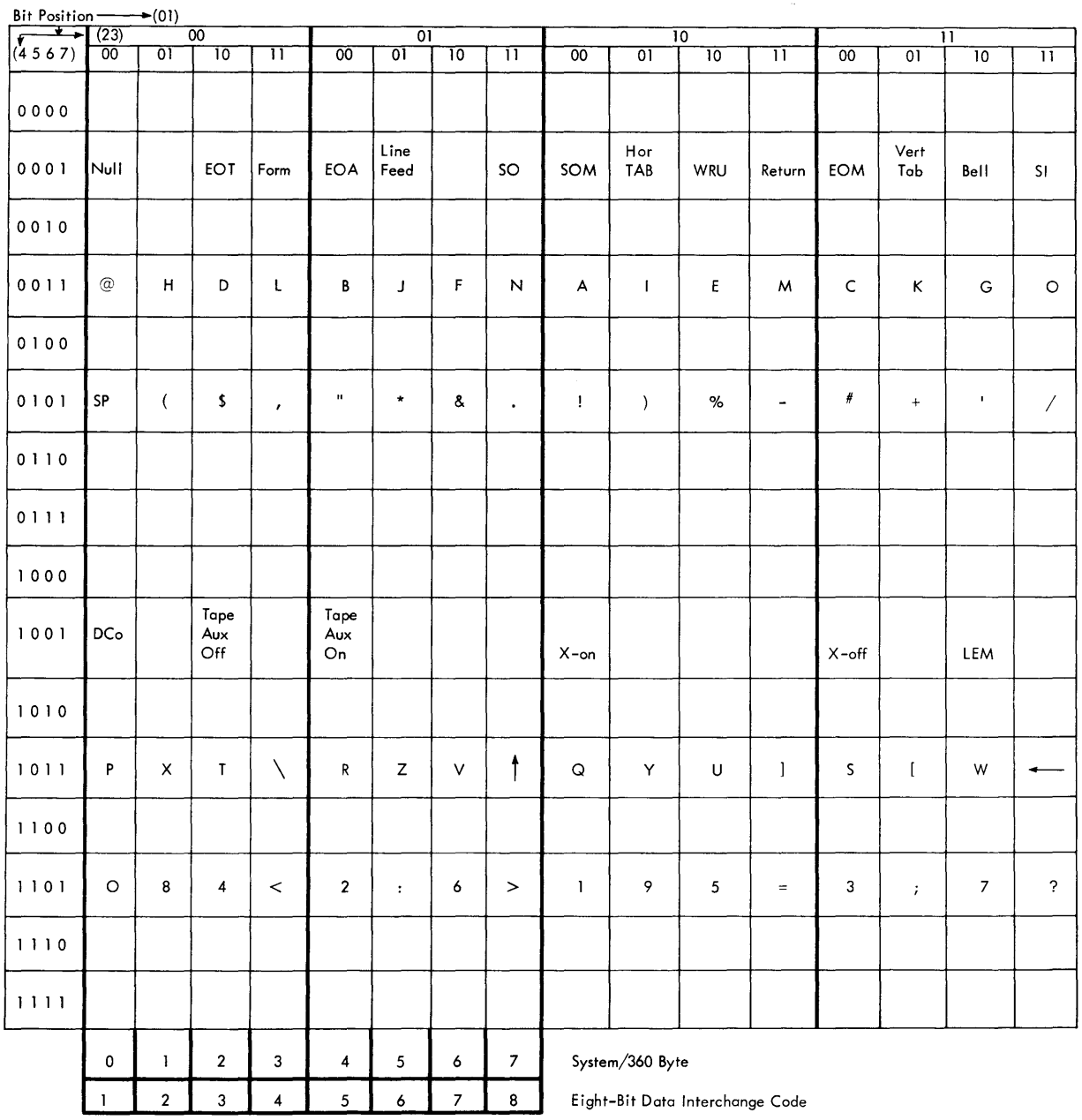
Adapter Operation

Character Set: The transmission code used is the eight-bit Data Interchange Code (ASCII). The relationship of the 2701 with the I/O interface is illustrated in Figure 16.



One start bit and two stop bits are added to a character when the XA is transmitting to the terminal and are deleted when the XA is receiving from the terminal.

Line Control: Identification type of answer-back is handled by the 2701 and the System/360. Output



Bit Position → (01)																
(4 5 6 7) ↓ (23) →	00				01				10				11			
	00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11
0000																
0001	Null		EOT	Form	EOA	Line Feed		SO	SOM	Hor TAB	WRU	Return	EOM	Vert Tab	Bell	SI
0010																
0011	@	H	D	L	B	J	F	N	A	I	E	M	C	K	G	O
0100																
0101	SP	(	$	,	"	*	&	.	!	)	%	-	#	+	'	/
0110																
0111																
1000																
1001	DCo		Tape Aux Off		Tape Aux On				X-on				X-off		LEM	
1010																
1011	P	X	T	\	R	Z	V	↑	Q	Y	U	]	S	[	W	←
1100																
1101	O	8	4	<	2	:	6	>	1	9	5	=	3	;	7	?
1110																
1111																
	0	1	2	3	4	5	6	7	System/360 Byte							
	1	2	3	4	5	6	7	8	Eight-Bit Data Interchange Code							

Figure 16. Eight-Bit Data Interchange Code

messages can be of any length or format. Input messages can be of any length; however, certain format restrictions are imposed because of the line control used by these terminals. On input, or during read operations, the following characters are recognized by the 2701:

WRU (Who are you?) This character causes device end, channel end status to be set.

xon (Transmitter on) This character causes channel end, device end status to be set.

xoff (Transmitter off) This character causes device end, channel end status to be set.

EOT (End of transmission) This character causes the device end, channel end, and unit exception status to be set.

Message Restrictions for Telegraph Adapter-Type II:

Terminal to Processor

1. Delete characters are recognized, and the 2701 deletes them from the input message stream.

2. WRU, XON, XOFF, and EOT terminates receive operations.

World Trade Telegraph Adapter

World Trade telegraph adapter enables the 2701 to control data transfer between the IBM System/360 and various European telegraph printers over selectively single current or double current telegraph lines at either 50 bits per second or 75 bits per second.

Commands

The IBM Terminal Adapter-Type II decodes and executes the following commands: read, write, inhibit, prepare, search, break, diagnostic read, and diagnostic write. The functions of these commands are explained in the section "Start/Stop Adapters."

Special Features

There are no special features that operate with the adapter.

Adapter Operation

Character Set: The transmission code used between the 2701 and the terminals is the Baudot Code. The relationship between the 2701 and the I/O interface is illustrated in Figures 14 and 15.

0	1	2	3	4	5	6	7	System/360 Byte
-	-	S	1	2	3	4	5	Shifted Baudot Code

S represents the case. A logical one identifies the uppercase; logical zero, the lower case. The 1 bit is the first bit transmitted following the start bit. Shifted character set conversion, a standard feature, automatically deletes LTRS and FIGS characters from the received data stream, notes the last shift character received, and inserts a sixth bit (5) in the code set to indicate the case to the processor. On outgoing data, the S bit is removed and noted. A change in the S bit automatically causes the insertion of the appropriate shift character in the outgoing data stream before sending the data character.

Attachment to the World Trade telegraph adapter is point-to-point; thus, the line control method used is contention rather than polling.

When the terminal is transmitting, the programmer must insert from 4 to 20 LTR characters before inserting the start of message character (line feed) to ensure that the terminal is receiving properly. Should the terminal bid for the line simultaneously with the processor, an echo check will occur, terminating the write operation at the CPU.

When the terminal is receiving, the prepare command is issued to the World Trade telegraph adapter to wait for the completion of the first space condition from the terminal. The prepare command may be terminated in one of three ways:

1. A true start bit is detected. This is recognized by the line going to the space condition for one bit time and then returning to the mark condition. The device end, channel end status is set. Command chaining to a read command can be used to receive the incoming message.

2. The line goes to space and does not return to mark within 28 seconds. The device end, channel end, and unit check status is set with the timeout bit set in the sense byte.

3. A halt I/O or a reset is received from the channel. If a true start bit (as in 1 above) is detected and the halt I/O is received prior to the status being presented, the unit check status is also set. The receiving bit will be on in the sense byte. Otherwise, the device end, channel end status byte. Otherwise, the device end, channel end status is set.

Character Recognition:

1. EOT (End of Transmission) — format is FIGS, CHARACTER, LTRS with the character assigned on a per system basis. EOT sets channel end, device end, and unit exception status.

2. EOB (End of Block) — format is FIGS, CHARACTER with the character assigned on a per system basis. EOB sets channel end, device end status.

3. A V or M received as the first character sets channel end, device end status.

Message Restriction for World Trade Telegraph:

Terminal to Processor

1. The characters used in EOB and EOT must not be the same.

2. A space character received by the 2701 will not downshift (FIGS to LTRS).

3. Text immediately following FIGS, CHARACTER, LTRS will be lost. EOT must not be sent between blocks of data.

Processor to Terminal

1. When transmitted, the characters (CR, LF, space, and blank) must be in the same case as the preceding character.

2. The terminal control automatically inserts the proper shift character in outgoing data when a change of case is encountered.

Communications—Synchronous Adapter

For the 2701, there is only one communications synchronous type adapter: the Synchronous Data Adapter-Type 1.

The Synchronous Data Adapter-Type 1 enables the 2701 to control data transfers in half-duplex synchronous mode between an IBM System/360 computer and the following synchronous transmitter receiver (STR) terminals and devices:

1. IBM 1009 Data Transmission Unit, IBM 1013 Card Transmission Terminal, IBM 7702 Magnetic Tape Transmission Terminal, or the IBM 7740 Communication Control System at the following rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
2. IBM 7701 Magnetic Tape Transmission Terminal or the 7750 Programmed Transmission Control at 1,200 bits per second (150 characters per second).
3. IBM 7710 Data Communication Unit, IBM 7711 Data Communication Unit, or another IBM System/360 equipped with a 2701 Data Adapter Unit with the Synchronous Data Adapter-Type 1 at the following data rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
   40,800 bits per second (5,100 characters per second)

Refer to Figure 17 for the required communications facilities and data sets for each of the speeds described in items 1, 2, and 3.

Two features are obtainable on the Synchronous Data Adapter-Type 1.

1. Internal clock feature (prerequisite: Synchronous Data Adapter-Type 1) provides the clocking pulses for transmission speeds of 1,200; 2,000; and 2,400 bits per second. This feature is required when the data set does not provide the clocking pulses.
2. Dual communication interface feature (prerequisite: Synchronous Data Adapter-Type 1) provides a second communication interface. Only one interface is operable at a time.

For this adapter, additional information concerning commands, status bytes, sense bits, and operational functions will be provided in later publications.

Data Acquisition and Control Adapters

Data acquisition and control adapters for the 2701 include the following: the Parallel Data Adapter, Contact Sense Adapter, Contact Operate Adapter, and Serial Synchronous Adapter.

Parallel Data Adapter

The Parallel Data Adapter allows for the connection and operation of external devices that transfer data, parallel by bit, serial by word, with the System/360 processor. The data word size is 16 bits, expandable in groups of eight up to 48 bits. The Parallel Data Adapter presents a demand response interface to the external device that allows for the half duplex transfer of parallel data words into and out of System/360 processor and the external device. The Parallel Data Adapter controls this interface, converts from data word to byte and from byte to data word, develops and checks one bit of odd parity per data word, and transfers data to and from the I/O channel, parallel by bit, serial by byte. The Parallel Data Adapter forces the multiple byte mode of operation on the multiplexor channel. The number of bytes transferred in the

Speed \ Communications Facilities	Common Carrier Switched Telephone Networks	Common Carrier Leased Private Line Telephone Services	Common Carrier Broadband Communications Services	Customer Owned Communications Facilities
1200 bps (150 cps)	Western Electric Data Set 202A or equivalent. See note.	Western Electric Data Set 202A, B, or Western Union Data Set 1601A or equivalent. See note.	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2000 bps (250 cps)	Western Electric Data Set 201A or equivalent. See note.	Western Electric Data Set 201A or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2400 bps (300 cps)	Not Applicable	Western Electric Data Set 201B or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
40,800 bps (5,100 cps)	Not Applicable	Not Applicable	Western Electric Data Set 301B	Modem equipment (data set) having a proper interface must be used.

NOTE: The Internal Clock feature is required for operation at 1200 bits per second and on the Switched Telephone Networks.

Figure 17. Communications Facilities and Transmission Speeds

multiple byte operation is dependent upon the size of the data word. This can vary from two to six bytes.

The speed of operation of the Parallel Data Adapter depends on the processor and channel to which the 2701 is connected and to the external device. Figures 20 and 21 show the maximum data rates obtainable for each model of the System /360 processor. These rates are shown for both the selector and multiplexor channels.

In addition to the parallel data operation, the PDA and the direct control feature (DCF) on a System/360 processor can simulate the direct data feature on the 704X (7040-7044) and 709X (7090, 7094, 7094 II) systems. The interface circuitry is different, but the logical operation is the same.

Commands

The Parallel Data Adapter decodes and executes the following commands. (See Figure 18 for the configuration.)

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Read	0	0	0	0	0	0	1	0
Read with Timeout	0	0	0	1	0	0	1	0
Write	0	0	0	0	0	0	0	1
Write with Timeout	0	0	0	1	0	0	0	1
Diagnostic Write	0	0	0	0	0	1	0	1
Diagnostic Read	0	0	0	0	0	1	1	0

Figure 18. Bit Configuration for Parallel Data Adapter Commands

Read: This command causes the Parallel Data Adapter to accept data words from the external device and present them a byte at a time to the System/360 channel.

Write: This command causes the Parallel Data Adapter to take bytes of data from the System/360 channel, assemble them into data words, and transfer them to the external device.

Read with Timeout: This command is the same as the read command described above, except that a 2-second timeout is performed on the response of the external device to a request for data transfer made by the Parallel Data Adapter. This command is only valid when the timeout feature is obtained.

Write with Timeout: This command is the same as the write command described above, except that a 2-second timeout is performed on the response of the external device to a request for a data transfer made by the Parallel Data Adapter. This command is valid only when the timeout feature is obtained.

Diagnostic Write: The diagnostic write command operates as the normal write. However, the control and data transfer operations with the external device are inhibited. After one data word has been assembled in the Parallel Data Adapter, the device end, channel end status is presented, which terminates the command.

Diagnostic Read: This command operates like the normal read operation, except that the control and data transfer operations with the external device are inhibited. The data word stored in the Parallel Data Adapter's assembly register is transferred to the channel, and the device end status is presented, which terminates the command. This command should be preceded by the diagnostic write command.

Special Features

Extension Features: The Parallel Data Adapter provides a data word of 16 bits plus one bit of parity in each direction. Through the use of the extension features, the data word can be extended to 48 bits. One bit of parity is supplied for the data words regardless of the number of extension features used. Each extension feature adds eight input and eight output bits to the data word.

Timeout Feature: The timeout feature is used to recognize an external device failure. The timeout is initiated under program command. A 2-second timeout is performed from the time the Parallel Data Adapter notifies the external device that it is ready for a data transfer until the time that the external device responds. In detail, when the read ready or write ready line is raised, the timeout begins. The timeout is reset when the external device raises the demand line. The timeout will restart on the next occurrence of a read ready or write ready signal. If the demand response does not occur within the 2-second timeout period, the command will be ended with the device end, channel end and unit check status set and with the timeout bit set in the sense byte.

Adapter Operation

Operation between the Parallel Data Adapter and the external device is made through the Parallel Data Adapter interface. The interface consists of a set of lines that provide for control, signals and data paths (Figure 19). The name and functions of each line or lines of the interface are described below. Detailed information concerning timing and voltage levels will be published in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information* manual Form A22-6844.

Output Data Bus (PDA to External Device): The output data bus consists of 17 lines on the basic adapter. Sixteen lines are used to present data and one line is used to present the odd parity bit to the exter-

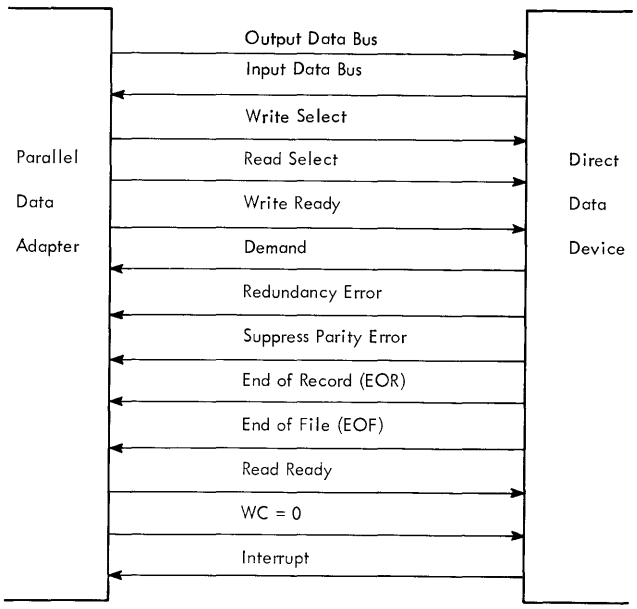


Figure 19. Parallel Data Interface

nal device. With extension features, the number of lines can be increased to a maximum of 49 (48 data and one parity).

Input Data Bus (External Device to PDA): The input data bus consists of 17 lines on the basic adapter. Sixteen lines are used for input data and one line is used to obtain the odd parity from the external device. With extension features, the number of lines can be increased to a maximum of 49 (48 data and one parity).

Write Select (DA to External Device): This line is used to notify the external device that it has been selected for a write operation. The line is raised because of the recognition of a write command from the channel, and it remains up until the end of the command.

Read Select (PDA to External Device): This line is used to notify the external device that it has been selected for a read operation. The line is raised because of the recognition of the read command from the channel, and it remains up until the end of the command.

Write Ready (PDA to External Device): This line notifies the external device that a word of data is on the output data bus. The data is stabilized and de-skewed before the raising of this line.

The occurrence of a demand, EOR, or EOF signal from the external device resets this line.

Read Ready (PDA to External Device): This line notifies the external device that the PDA is ready to accept the next word of data over the input bus.

The occurrence of a demand, EOR, or EOF signal from the external device resets this line.

Demand (External Device to PDA): The significance of the demand signal is dependent upon the command being executed.

1. Write Command – The demand signal signifies that the external device has accepted the data word on the output data bus.
2. Read Command – The demand signal signifies that the data on the input data bus is valid, stabilized, and de-skewed.

The demand signal must be present for at least 800 nanoseconds. The maximum length of the demand signal is dependent upon the external device and its desired data rate. Data must remain valid for the duration of the demand signal. A second read ready or write ready signal will not be given while the demand signal is still present.

Redundancy Error (External Device to PDA): This line indicates that the external device has a parity error.

Suppress Word Parity Error (External Device to PDA): This line from the external drive suppresses data word parity checks during read operations. It is used by devices which do not generate valid parity.

End of Record (EOR) (External Device to PDA): This line signifies that the external device has completed its operation and will not generate or accept any more data. Upon recognition, the PDA will present the device end, channel end status to the channel.

End of File (EOF) (External Device to PDA): This line signifies that the external device has completed its operation and will not generate or accept any more data. Upon recognition, the PDA will present the device end, channel end, and unit exception status to the channel. The unit exception status prevents command chaining.

Word Count Equals Zero ("WC=0") (PDA to External Device): This signal is generated by the PDA to inform the external device that the CPU has no more data to transfer or will not accept any more data depending upon the operation being a write or a read. An EOR or EOF should be presented by the external device.

Interrupt (External Device to PDA): The interrupt lines allow the external device to signal the CPU through a channel interrupt that it requires service.

The interrupt signal, when occurring in the absence of a read or write command, causes an attention status to be set. When the interrupt signal occurs during a read or write operation, device end, channel end and attention status is set.

Addressing

Up to eight external devices may be connected to the Parallel Data Adapter interface. There is almost an unlimited number of ways in which the external de-

vices can be connected to the Parallel Data Adapter to operate with it through this interface. The only restrictions are that the maximum number of connections be eight and that the control signals be valid with data transferred. There are two cases to be considered here. In the first, only one of the external devices is operating with the interface at any one time. The entire data word goes to and comes from that one external device. In the second, the data word is split up among various external devices. The former situation has the problem of addressing whichever external device will be operating with the interface at any one time. The latter has the problem of having the external devices respond properly to the interface control signals.

In this section, a few of the many possible addressing schemes will be outlined. First, consider the case in which only one of the external devices is operating with the interface at a time. The Parallel Data Adapter interface has two select lines, read select and write select, with no built-in capability for addressing the one device of the eight possibilities with which the Parallel Data Adapter can operate. There are several means available to the user to do the addressing. Listed below are three addressing schemes.

Manual Switching: This method of addressing sets a manually operated switch on one of the external devices to the ON position. Manual switching is used when ease of switching is a requirement but speed is not. It is simple and economical. For an example of its application, consider several "test cells" on the test floor when only one is scheduled to run at a time. The multi-drop capability allows relatively quick rotation of test cells without the necessity of cable pulling and equipment movement.

First Word Addressing: A more sophisticated approach is to have the first word of a write operation contain the addressing information. Only the device which recognizes its address will respond to further interface signals. The device, once selected, will remain so until a new write operation is initiated. To perform a write operation, the program need only ensure that the address code appears in the first word. To perform a read operation, the program must first perform a one-word write operation to address the device. When the write command ends, the program can command chain directly to the read command.

As implied earlier, the ending of the read command does not end the selection of the external device. Selection can be changed only by a new write operation. (The exception to this is the case in which the external device has been reset by an operator.) Additional read operations may thereby be performed with the same external device without the necessity of an addressing write operation.

Direct Control Feature: An even more sophisticated method of addressing is the use of the direct control feature (DCF) available on the System/360 processors. With this feature, the addressing can be accomplished through the sense or timing lines. The external devices may also indicate their need of service with the use of the interrupt lines of the DCF. This device-program communication is performed independent of the PDA operation, thereby allowing for greater versatility.

In addressing, the problem of interface control arises when the data word is split up for several external devices. The approach to this problem differs with each situation. Some typical questions a system designer might ask and the answers to these questions are given below.

Question: In a multiple-device attachment, which device responds to the control signal from the I/O interface?

Answer: One device may be given the logic to respond to the interface signals. If there are no more than seven external devices on one interface, the others can monitor the input signal lines (input to the 2701).

All devices can respond to the I/O interface control signals. The restriction here ensures that there are no more than seven external devices on the line. For example, consider the demand line. Once one of the external devices has presented the demand signal to the interface, any or all of the other external devices can present the same signal to the interface. However, once the demand line has fallen, no other external device can raise it until the next ready signal has ocurred. As stated above, when the number of external devices on the interface is seven or less, all the external devices can monitor the input lines.

Question: How does the external device know that the other units have stabilized the input data or sampled the output data?

Answer: A standard data rate may be set when the demand signal is given at a fixed period of time after the rise of the ready line.

Question: How would one handle the case in which a data transfer is intended for an needed by a specific external device, but any data transfer including all zeros is meaningful to another external device sharing the interface?

Answer: One bit in the record to or from each external device can be set aside as a validity indication. When this bit is on, the record is meaningful; when this bit is off, the record is to be ignored. This bit can be used on a read operation as well as a write. The program tests this bit; if on, it uses this record; if off, it ignores the record.

The addressing schemes do not require any modification of the 2701. The 2701 has no indication of the number of external devices that are on the interface nor of the means used to address them. The program, of course, must be aware of the external device addressing scheme.

Speed of Operation

The maximum over-all data rate possible for an external device is a complex function. It depends on parameters such as the processor, the channel, the other control units operating on the same and/or other channels, and the mode of operation (byte, multiple byte and burst). The Parallel Data Adapter transfers bytes with the channel at the maximum channel rate.

Read Operation

The read operation is initiated when the XIC-XA couple accepts a read command from the I/O channel. Upon the acceptance of this command, the read select and read ready lines are raised on the Parallel Data Adapter interface. The Parallel Data Adapter is then in a condition to accept the first word of data from the external device. When the input data is available, valid, and de-skewed on the input data bus, the external device will respond with the demand signal. The demand signal causes the dropping of the read ready line. The 2701 will then attempt to obtain channel selection in order to perform a data transfer. When selection has been successfully accomplished, the XIC-XA couple will transfer the received data word a byte at a time to the I/O channel. The mode of operation will be either multiple-byte or burst mode. After the full data word has been transferred to the channel, the Parallel Data Adapter will again raise the read ready line, thus informing the external device that the Parallel Data Adapter is ready to accept the next word of data. When data is again available, the external device will signal demand, and the data transfer operation will proceed as above.

The read operation may be ended in one of several ways:

1. An external device presents EOR or EOF. When the external device has determined that it has completed its data transfer with the System/360, it will signal either EOR or EOF. The EOR will cause the 2701 to present the device end and channel end status to the channel. The EOF signal will cause the 2701 to send the device end, channel end, and unit exception status to the channel. The unit exception status would prevent command chaining in the channel. To ensure the acceptance and transfer of the last word of data, the EOR or EOF signal should not occur until the demand signal has fallen. Once the Parallel Data Adapter has accepted the word of data, the terminating status will not be set until the final word has been transferred to the channel.

2. The channel can accept no more data. When the storage area allocated for the read operation has been filled and no other area is available, the channel can accept no more data. When the Parallel Data Adapter presents one more byte of data than the channel can accept, the channel will reject that byte and signal the 2701 to cease the operation. When the Parallel Data Adapter recognizes the stop signal from the channel, it signals WC=0 and read ready to the external device. The WC=0 line informs the external device that the Parallel Data Adapter will not transfer data to the System/360 channel. The read ready signal is available for external devices which cannot end until they have reached a physical position or have transferred all their data. The Parallel Data Adapter looks for either the EOR/EOF signals or the demand signal in response to the read ready/WC=0 signals. If the device can end immediately, it will present either EOR or EOF. When the Parallel Data Adapter recognizes these signals, it will set the terminating status as described above. If the external device cannot end immediately, it will signal demand. Upon recognizing the demand signal in response to the WC=0/read ready signals, the Parallel Data Adapter will drop the read ready line and set the channel end status. The setting of the channel end status has meaning when the XIC-XA couple is operating on the selector channel. The setting of this status will release the 2701 from the selector channel, thus allowing the channel to operate with other control units. This status being set when the 2701 is operating on a multiplexor channel, in the multiple byte mode, has little use, since the multiplexor channel has a capability of operating with all control units to which it is connected. When the external device drops the demand signal, the Parallel Data Adapter will again raise the read ready line. The data which is received by the Parallel Data Adapter is not transferred to the channel. This read ready-demand sequence continues until either the EOR/EOF or interrupt signals occur, whereupon the proper terminating status will be set.

3. Interrupts are set by the external device. An interrupt signal occurring on the Parallel Data Adapter interface while a read command is in progress causes the immediate setting of terminating status. The attention bit is also set in the status byte. An interrupt signal occurring while a a command is in operation must be used with the greatest caution. If an interrupt occurs during a demand signal, the deliverance of the last word of data to the channel is uncertain. If the interrupt signal is generated by other than the external device currently operating on the read command, this device either must be aware of the occurrence of the

interrupt, or must recognize its occurrence when the read select line drops prior to its setting the EOR or EOF signals.

4. A timeout elapses. During a read with timeout command (valid only when the timeout feature has been obtained), if a timeout does elapse, the device end, channel end, and unit check status will be set with the timeout bit set in the sense byte.

With every data word accepted by the Parallel Data Adapter, a check for correct odd parity is made. If a parity error check occurs, and the suppress parity error line is not signaled by the external device, then the unit check status bit will be set with the data check bit set in the sense byte. The command is not ended until the normal ending occurs.

When an ending does occur, normal or otherwise, the Parallel Data Adapter will drop the select out line when the device end status has been set.

Write Operation

The write operation is initiated upon the selection of either a write or a write with timeout command. The write select line is raised and an immediate request for data transfer made on the Parallel Data Adapter's recognition of a write command. On the multiplexor channel, the Parallel Data Adapter forces the multiplexor byte mode. When the number of bytes in the data word is obtained from the I/O channel to the Parallel Data Adapter, the adapter raises the write ready line and, when applicable, starts the timeout.

When the external device has accepted the data word, it responds with the demand signal. When the Parallel Data Adapter recognizes the demand signal, it will reset the data bus, terminate the timeout, and set up a request for another data transfer. With the transfer of each data word, the Parallel Data Adapter adds one bit of odd parity. If the external device checks this parity and determines there has been a parity error in the data transfer, it signals redundancy error. When the Parallel Data Adapter recognizes a redundancy error signal, it sets the timeout bit of the sense byte and adds the unit check bit to the terminating status when delivered. The command is not ended by the occurrence of the redundancy error signal. The write operation continues until one of the ending conditions occurs:

1. The entire data message has been transferred from the I/O channel to the Parallel Data Adapter. This condition is recognized by a stop signal given by the channel when the Parallel Data Adapter requests the transfer of another byte of data. The Parallel Data Adapter will immediately set the WC=0 line unless a partial word of data has been accumulated prior to receiving the stop signal from the channel. If this is the case, the Parallel Data Adapter will go through one additional write ready demand sequence prior to signaling the WC=0. In this way, the partial word will be transferred to the external device. The WC=0 signal informs the external device that the I/O channel will not transfer any further valid data. The response of either EOR or EOF signals causes the device end, channel end status to be set and the operation ended. However, as in the read operation, the write ready signal is given with WC=0. If the external device cannot immediately end, it will respond with the demand signal to the WC=0/read ready signals. When the Parallel Data Adapter recognizes the demand response, it immediately sets the channel end status and, upon the dropping of the demand signal, again sets the write ready signal. The data transferred on this write ready-demand sequence will be all zeros with the proper parity. The write ready/demand sequence continues with write ready raised as soon as demand drops. When the external device sets either EOR, EOF or interrupt lines, the operation is ended with the proper terminating status.

2. Halt I/O is received from the channel. The operation for the halt I/O command is the same as though a data transfer stop signal were issued by the channel.

3. The external device issues EOR or EOF signals. When the Parallel Data Adapter recognizes an EOR/EOF signal, it sets the device end and channel end status. When the EOR/EOF signal occurs prior to the receipt of a stop signal or halt I/O from the channel, the Parallel Data Adapter determines whether the last word of data was successfully delivered to the external device. If it was not, the unit check status is also set with the overrun bit set in the sense byte.

4. The external device signals interrupt. When the Parallel Data Adapter recognizes an interrupt signal on the interface during a write operation, it sets device end, channel end, and attention status, terminating the command. The cautions stated for the interrupt termination during read operations also apply here.

5. Timeout elapses. During the execution of a write with timeout command, if the external device does not respond with the demand signal within 2 seconds of the occurrence of the write ready signal, the timeout elapses. This sets the device end, channel end, and unit check status with the timeout sense bit set.

Interrupts

The Parallel Data Adapter recognizes an interrupt signal whether or not it has a command. In fact, a command is usually not present. In either case, when an interrupt signal is recognized, the attention status will be set. As described under the read and write operations, if a read or write command is present, the terminating status will also be presented. When operating without a command, the interrupt signal causes the attention status by itself to be presented to the channel.

Diagnostics

The Parallel Data Adapter operates under two diagnostic commands. Diagnostic write command presents one word of data to the Parallel Data Adapter. A diagnostic read operation causes the data stored in the Parallel Data Adapter's register to be read back to the channel. The diagnostic read operation will not cause the data register to be reset as is done with the normal read operation. With both the diagnostic read and diagnostic write operations, the control signals to the external device are inhibited. The external device will have no means of determining that a diagnostic read or a diagnostic write operation is occurring. If an interrupt signal occurs during a diagnostic operation, the Parallel Data Adapter responds as though a normal command were present by setting the device end, channel end, and attention status. The diagnostic operation checks the data path up to the external interface circuits.

Status Byte

The following statuses may be set by the Parallel Data Adapter.

Channel End: The channel end status appears by itself upon the refusal of the external device to respond to a WC=0 signal on either a read or write operation. The status indicates that the 2701 Parallel Data Adapter will transfer no additional bytes of data with the channel.

Device End: The device end status appears by itself only when it has been preceded by the channel end status. The device end status indicates that the external device and Parallel Data Adapter have completed their operations and are free to accept additional commands.

Device End, Channel End: The device end, channel end status indicates that the operation has been brought to a normal ending.

Device End, Channel End, Unit Check: This status indicates that an unusual ending condition has occurred. The sense byte should be obtained to determine which of the unusual ending conditions has occurred.

Device End, Channel End, Unit Exception: This status indicates that the external device has ended normally with the end of file signal.

Device End, Channel End, Unit Exception, Unit Check: This status indicates that an unusual ending has occurred with the external device signaling the end of file. The sense byte should be obtained to determine the cause for the unusual ending.

Device End, Channel End, Attention: The device end, channel end, attention status indicates that the operation has been ended in one of two ways: it has been ended by either the interrupt signal or the EOR signal, and prior to the status being delivered to the channel, an interrupt signal has occurred.

Device End, Channel End, Unit Exception, Attention: This status indicates that the operation has ended normally with the end of file signal and that prior to the status being delivered to the channel an interrupt signal has been received.

Device End, Channel End, Unit Check, Attention: This status indicates that the operation has ended abnormally in one of two ways:

1. The operation has been ended by an EOR signal with an unusual occurrence and an interrupt signal has been received prior to the status being delivered to the channel.
2. The operation has been ended by the interrupt signal, with an unusual condition having occurred prior to the appearance of the interrupt signal.

In either case, the sense byte contains information defining the cause of the unit check status.

Device End, Channel End, Unit Check, Unit Exception, Attention: This status indicates that the operation has not been successfully completed, that it has been ended by the EOF signal, and that an interrupt signal occurred prior to the status being delivered to the channel.

The sense byte contains the cause of the unit check status.

Sense Byte

Command Interrupt Bit 1: This bit is set when an interrupt signal is received while the Parallel Data Adapter is operating on a command. If the command has been normally ended and an interrupt condition occurs prior to the status being transferred to the channel, the sense bit will not be set. The condition of this sense bit enables the programmer to determine which of the two causes for ending occurred under the channel end, device end, attention status and the device end, channel end, unit check, attention status.

Data Check Bit 4: This bit is set when a parity check fails during a read operation and the suppress parity line is not signaled. This bit is also set when redundancy check is signaled.

Overrun Bit 5: This sense bit indicates that data has been lost. This occurs during a write operation when the EOR or EOF signal is set prior to the data in the Parallel Data Adapter being delivered in the external device. This bit will not be set during read operations. Data is lost when a stop is received from the channel when the Parallel Data Adapter is attempting to perform a data transfer. However, the channel has the ability to recognize this occurence. The Parallel Data Adapter will not cause a unit check interrupt.

Timeout Bit 7: This bit is set during a read with timeout or write with timeout operation when the external

device does not respond to a data transfer request within the 2-second timeout period.

Contact Sense Adapter

The contact sense adapter provides the System/360 with the capability of determining the condition of remotely set contacts and for binary voltage levels. The basic contact sense adapter has provisions for operating with 48 points and is expandable in two steps of 48 up to 144 points. The contact sense adapter recognizes either a contact closure or a binary voltage level. The selection between contact sensing or voltage level sensing is done on a per byte basis as an installation option. Each byte can be specified as to whether it is to be contact sensing or a voltage sensing. Under program command, the contact sense adapter samples and transfers to the channel from 1 to 18 bytes of sampling data. When operating on the multiplexor channel, the contact sense adapter operates in the word mode. In addition to transferring the contact conditions to the I/O channel under program command, the contact sense adapter, as an additional wire option, recognizes a contact closure or a binary voltage level going to 1 of any one of 8 points in the first contact sense byte as an interrupt condition.

The contact sense adapter also has the capability, under program command, of performing a timeout. This timeout is initially set to be from 30 microseconds to 4 seconds by the customer engineer at installation time. When performing this timeout, the contact sense adapter initially samples and delivers the number of bytes requested, presents the channel end status and then initiates the timeout. At the conclusion of the timeout period, the device end status is set.

Commands

The contact sense adapter recognizes and operates on the following commands (the bit configuration is shown in Figure 20).

Read A: On recognition of the read A command, the contact sense adapter samples the contact points starting with the first byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel.

Read B: On recognition of the read B command, the contact sense adapter samples the contact points starting with the seventh byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel (this command is valid only when the first extension feature is obtained).

Read C: On recognition of the read C command, the contact sense adapter samples the contact points starting with the 13th byte. Each byte of data is transferred in succession to the I/O channel until either the last byte in the adapter has been delivered or a STOP has been received from the channel (this command is valid only when the second extension feature is obtained).

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Read A	0	0	0	0	0	0	1	0
Read A with Timeout	0	0	0	1	0	0	1	0
Read B	0	0	0	0	0	1	1	0
Read B with Timeout	0	0	0	1	0	1	1	0
Read C	0	0	0	0	1	0	1	0
Read C with Timeout	0	0	0	1	1	0	1	0
Diagnostic Read Odd	0	1	1	0	0	0	1	0
Diagnostic Read Even	0	0	1	0	0	0	1	0

Figure 20. Bit Configuration for Contact Sense Adapter Commands

Read A with Timeout: This command is identical to the read A command except that at the end of the read A operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered (this command is valid only when the first extension feature is obtained).

Read B with Timeout: This command is identical to the read B command except that at the end of the read B operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered.

Read C with Timeout: This command is identical to the read C command except that at the end of the read C operation, the channel end status is presented and a timeout is initiated. At the completion of the timeout, the device end status is delivered (this command is valid only when the second extension feature is obtained).

Diagnostic Read Odd: With this command, the contact sense adapter circuitry sets the odd bytes to a logical 1 and the even bytes to a logical 0. A normal read A operation is then performed.

Diagnostic Read Even: With this command, the contact sense adapter circuitry sets the even bytes to a logical 1 and the odd bytes to a logical 0. A normal read A operation is then performed.

Extension Features

The contact sense adapter provides for the sampling of 48 external points. The two extension features allow the number of contact points to be expanded to 96 and 144. The first extension feature validates the read B and the read B with timeout commands, and the

program has the ability of picking and dropping each contact point without disturbing the condition of the other contacts. The basic Contact Operate Adapter comes with 48 contact points and is expandable in steps of 48 to 96 or 144 contact points. When operating on the multiplexor channel, the Contact Operate Adapter forces the multiple byte mode of operation. Momentary contact closures can be achieved through the use of the timeout operation and command chaining, as will be discussed in the following sections.

Commands

The Contact Operate Adapter decodes and executes the following commands. (See Figure 21 for bit configuration.)

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Write A	0	0	0	0	0	0	0	1
Write A with Timeout	0	0	0	1	0	0	0	1
Write B	0	0	0	0	0	1	0	1
Write B with Timeout	0	0	0	1	0	1	0	1
Write C	0	0	0	0	1	0	0	1
Write C with Timeout	0	0	0	1	1	0	0	1
Diagnostic Read	0	0	0	0	0	0	1	0

Figure 21. Bit Configuration for Contact Operate Adapter Commands

Write A Command: The write A command starts the data transfer to the first byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's registers. A 1 condition will cause a contact to set (close); a 0 condition will cause a contact to be reset (open); contacts which are not required to change condition by the write operation will not open or close, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition.

Write B Command: The Write B Command starts the data transfer to the seventh byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's register. A 1 condition will cause a contact to close; a 0 condition will cause a contact to open. Contacts which are not required to change condition by the write command will not close or open, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition. The operation will be terminated with the device end, channel end status after the last byte has been obtained or a stop signal received from the channel. (This command is valid only when the first or second extension feature is obtained.)

Write C Command: The write C command starts the data transfer from the 13th byte of the Contact Operate Adapter. The bytes are brought in one at a time from the channel to the Contact Operate Adapter's registers. A 1 condition will cause a contact to set (close); a 0 condition will cause a contact to reset (open). Contacts which are not required to change condition by the write command will not experience any momentary opens or closures, that is, a contact which is closed remains closed, and a contact which is open remains opened without any momentary changes in condition. The operation will be terminated with the device end, channel end status after the last byte has been obtained or a stop signal received from the channel. (This command is valid only when the second extension feature is obtained.)

Write A with Timeout: This command is operated in the same manner as the write A command, except that after the last byte or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set.

Write B with Timeout: This command is operated in the same manner as the write B command, except that after the last byte has been received or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set. (This command is valid only when the first extension feature is obtained.)

Write C with Timeout: This command is operated in the same manner as the write C command, except that after the last byte has been received or a stop signal has been received from the channel, the Contact Operate Adapter will set the channel end status and initiate a timeout. At the completion of the timeout, device end status will be set. (This command is valid only when the second extension feature is obtained.)

Diagnostic Read: The diagnostic read operation causes one byte of data to be read to the I/O channel. The first bit in this byte is the OR'ed function of the contact conditions of the first bit position in each byte, that is, if the first, 13th, 20th, 27th, 34th, or 41st contact is closed, the first bit in the read byte will be a 1. If all are opened, the bit will be a 0. Likewise, the second bit position in the read byte is the OR'ed function of the second bit in each byte of the Contact Operate Adapter. This continues until the eighth bit in the read byte becomes the OR'ed function of the eighth

bit position in each byte of the Contact Operate Adapter.

Extension Features

The Contact Operate Adapter provides 48 contacts for external sampling. Through the use of the two extension features, the number of contacts can be extended to 96 and 144, respectively. The first extension feature validates the write B commands, and the second extension feature validates the write C commands.

Adapter Operation

The Contact Operate Adapter presents a two-wire per contact interface for external sampling. Detailed information concerning the timing and contact readings for this connection will be available in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information*, Form A22-6844.

The length of the timeout may be set at installation time to be anywhere from 30 milliseconds to 4 seconds.

Write Operation: The write operation is initiated by the Contact Operate Adapter accepting any one of the six write commands. Upon recognizing a write command, the Contact Operator Adapter will accept the first byte of data from the I/O channel and place it in the contact operate register in the first, seventh, or 13th byte position, depending upon the command. The contact operate register maintains the current condition for each contact point. A logical 1 stored in a contact operate register position will cause the associated contact to be held closed (set). This register does not need to be cleared prior to loading in a new byte of data. This allows the contacts, once set, to remain set during loading operations on other contacts. As soon as a bit position in the contact operate register is loaded with a logical 1, the corresponding relay will commence the setting of the contact. The contact operate adapter uses reed relays and the set time is approximately 1 millisecond. When a bit position contains a 0, the corresponding relay will be reset (open). The reset time is in the order of several hundred microseconds.

Once the first byte of data has been loaded into the contact operate register the Contact Operate Adapter will request the next byte of data from the I/O channel. The operation is terminated when either the last byte of data has been loaded into the contact operate register, the last byte of data being either the sixth, 12th, or 18th byte, depending upon the number of extension features obtained, or a stop signal is received from the I/O channel. When the command is without a timeout, the device end, channel end status is set. When the command is with a timeout, the channel end status is set, and a timeout operation is initiated. At the completion of the timeout the device end status is set.

The programmer will find it most helpful to maintain a mirror of the contact operate register within core. With this, the programmer has an indication of the exact status of every contact in the Contact Operate Adapter. This also aids in the setting of the Write message. For example, when a contact point needs to be changed, the programmer need only change the bit position as it appears in core and perform a Write A, Write B, or Write C with the byte count just large enough to ensure that the bit change is transferred to the Contact Operate Adapter.

When the need exists for momentary contact closures, the contact operate timeout commands should be used. For example, consider the case where a contact needs to be closed for a period of 3 seconds and then opened, the timeout set to 1 second. To do this, the programmer sets up four write commands. The first three write commands are with timeout and command chaining. The fourth command is without a timeout. With the first write command, the programmer sets the contacts to the initial conditions. The second and third write commands can either rewrite the same data that was written with the first write command or rewrite just one byte. The latter can be done because the command does not change any contact conditions. The commands are needed only to initiate a timeout. This technique is used to reduce the system interference. The fourth write command causes the required contacts to be opened. The Contact Operate Adapter, when receiving the first write command, loads the contact operate register, thus setting the contacts in the initial condititons. After the last byte is transferred, the channel end status is presented and a timeout initiated. At the end of the 1-second timeout, the device end status is presented. Command chaining then occurs to the second write command. After the data transfer initiated by the second write command has been completed, the channel end status is presented and the timeout initiated. At the termination of the timeout, the device end status is set, and chaining occurs to the third write command. The third write command is operated on by the Contact Operate Adapter as is the second write command. After the third 1-second timeout is completed, the Contact Operate Adapter sets the device end status and the channel command chains to the final write operation. The data transfer in this write operation causes the applicable contacts to be reset. At the completion of the data transfer, the device end, channel end status is presented, and an interrupt occurs. The interrupt informs the program that the operation has been completed. This example would have been much simpler if the length of the timeout were 3 seconds rather than the 1 second specified. An example with the length of

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File Number S360-03

Re: Form No. A22-6864-0

This Newsletter No. N22-0160-0

Date October 29, 1964

Previous Newsletter Nos. None

CHANGES TO IBM 2701 DATA ADAPTER UNIT PRINCIPLES OF OPERATION, FORM A22-6864-0

Replace pages 11 through 14, 27 through 36, and 39 and 40 of Form A22-6864-0 with the attached sheets. Pages 13, 27, 32, 33, 35, 36, and 39 do not change.

Changes to Figure 7 on page 14 and Figure 19 on page 31 are indicated by a bullet to the left of the figure titles and by a vertical bar to the left of the changes. Changes on text pages are indicated by vertical bars placed to the left of the column containing the changes.

File this Newlsetter at the back of the bulletin. It will provide a reference to changes, a method of determining that all amendments have been received, and a check for determining if the bulletin contains the proper pages.

International Business Machines Corp., Product Publications Dept., Poughkeepsie, N. Y. 12602

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The transmission adapter (XA) provides for the connection and operation of remote and local devices with the System/360. The 2701 obtains its personality from the transmission adapter it houses. Each transmission adapter provides for the attachment and operation of a particular device or class of devices with the 2701. The transmission adapter contains the circuitry and logic for the control of a terminal device, the buffering of the data flow, the decoding of the program commands, and the connection to and operation with the XIC and the I/O channel.

Transmission adapters used in the 2701 are classified into one of three types: communications-start/stop adapters, communications synchronous adapters, and data acquisition and control adapters.

Communication-Start/Stop Adapters

Start/stop adapters for the 2701 include the following: IBM Terminal Adapter-Type I, IBM Terminal Adapter-Type II, Telegraph Adapter-Type I, Telegraph Adapter-Type II, IBM Telegraph Adapter, and the World Trade Telegraph Adapter. The operation of the 2701 start/stop adapters with the remote terminals requires various types of communications facilities and data sets (Figure 6). Figures 7 and 8 list the 2701 start/stop adapters and the terminals that may be operated with each. Also listed are the communications facilities and data sets required for the operation.

Programming Considerations

For those communication-start/stop terminals (1030, 1050, 1060, 1070, etc.) which can operate with both the 2701 and 2702, the operation programs used are identical. However, this compatibility does NOT extend to diagnostic programs.

Commands

The communications-start/stop adapters decode and execute the commands listed below. Some commands, such as read, write, and inhibit, are valid for all adapters; other commands, such as dial and search, are valid only for certain ones. The commands used by each type of adapter are listed in the section for that adapter. Binary representation of each command is given in Figure 9.

Read: This command causes bytes to be transferred from the communication line to the channel at a data rate equal to that of the communication line.

Write: This command causes bytes to be transferred from the channel to the communication line at a data rate equal to that of the communication line.

Inhibit: This command performs the read operation but inhibits the time-out function. Otherwise, the operation proceeds as if a read command had been issued.

Break: This command causes the 2701 to transmit continuous space signals to the line. Bytes transferred from the channel to the addressed unit must all be zeros. To provide control over the length of a space signal, a byte count must be specified by the program.

Prepare: This command can be used in a contention type communications system to indicate (to the CPU) that data are arriving. When a valid start bit is detected while the XIC-XA couple is operating upon a prepare command, the command is terminated with a device end, channel end status. Prepare can be command-chained to a normal read command. No data transfer occurs with this command, and timeout is not active during its execution.

Search: This command causes the 2701 to react as though a read command has been issued, but data are not transferred to the channel. The data line is monitored for an EOT (end of transmission). Line timeout is active during the execution of this command. This command is valid only for the Telegraph Adapter-Type I.

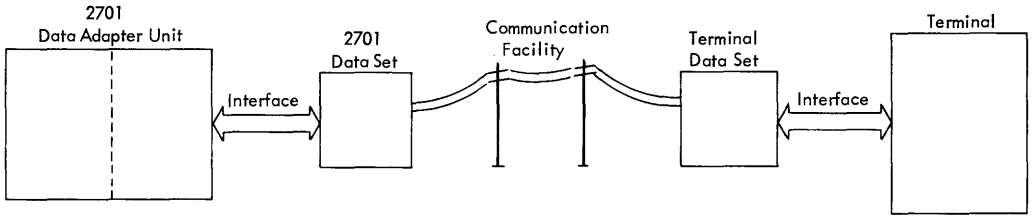

Figure 6. Terminal Connection via Data Sets and Communications Facilities

Terminal	Communication Facility	Terminal Data Set	2701 Data Set	Speed	2701 Adapters
1050 Data Communication System					
1051 Control Unit Model 1 or 2	Common Carrier Switched Telephone Network	Western Electric 103A	Western Electric 103A	134.4 Baud	IBM Terminal Adapter Type I #4645
	Common Carrier Switched (150 bps) Teletypewriter Exchange (TWX) Network				
	Common Carrier Leased Private Line Telephone Service	Western Electric 103B or F	Western Electric 103F	14.8 Char/Sec	
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1051 Control Unit Model 1 or 2 with Telegraph Attachment #7873	Telephone Company Schedule 3 or Western Union Class C Channels (62.5 ma Neutral Signal)	Not Required	Not Required	75.0 Baud 8.33 Char/Sec	IBM Telegraph Adapter
1051 Control Unit Model 1 or 2 with Line Adapter #4790	Customer-Owned Two-Wire Networks Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1060 Data Communication System					
1061 Control Unit Model 1 or 2	Common Carrier Leased Private Telephone Service	Western Electric 103B	Western Electric 103F	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1061 Control Unit Model 1 or 2 with Line Adapter #4790	Customer-Owned Two-Wire Networks Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1030 Data Collection System					
1031A Input Station	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648 IBM Line Adapter #4637
1031A Input Station with Common Carrier Adapter #2068	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202B	Western Electric 202B	600 Baud 60 Char/Sec	IBM Terminal Adapter Type II #4648
	Western Union Class E (1200 bps) Channel	Western Union 1601-A	Western Union 1601-A		
1070 Process Communications System					
1071 Control Unit Model 1	Common Carrier Leased Private Line Telephone Service	Western Electric 103F	Western Electric 103F	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645
	Western Union Class D (180 bps) Channel	Western Union Data Set 8500	Western Union Data Set 8500		
1071 Control Unit Model 1 with Line Adapter #4792	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	134.4 Baud 14.8 Char/Sec	IBM Terminal Adapter Type I #4645 IBM Line Adapter #4636
1071 Control Unit Model 2	Common Carrier Leased Four-Wire Full Duplex Private Telephone Service	Western Electric 202B	Western Electric 202B	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646
	Western Union Class E (1200 bps) Channel	Western Union 1601-A	Western Union 1601-A		
1071 Control Unit Model 2 with Line Adapter #4793	Customer-Owned Two-Wire Network Conforming to IBM 1030 Data Collection System Physical Planning, Form A24-3021	Not Required	Not Required	600 Baud 66.6 Char/Sec	IBM Terminal Adapter Type I #4646 IBM Line Adapter #4637
TWX (Teletypewriter Exchange)					
Teletypewriter Corporations Models 33 and 35 Teletypewriters	Common Carrier Switched Telephone Networks or Switched 150 bps TWX Networks	Western Electric 103A	Western Electric 103A	110 Baud	Telegraph Adapter Type II #7885
Other Terminals					
AT&T 83B2 Selective Calling Terminal	Telephone Company Schedule 1 Channels (45 bps)	Not Required	Not Required	45.5 Baud	Telegraph Adapter Type I #7860
	Telephone Company Schedule 2 Channels (57 bps)			56.9 Baud	Telegraph Adapter Type I #7861
	Telephone Company Schedule 3 Channels (75 bps)			74.2 Baud	Telegraph Adapter Type I #7862
Western Union Plan 115A Outstation	Western Union Class B Channels (57 bps)	Not Required	Not Required	56.9 Baud	Telegraph Adapter Type I #7861
	Western Union Class C Channels (75 bps)			74.2 Baud	Telegraph Adapter Type I #7862

● Figure 7. Attachable Terminals and Communications Facilities for Domestic Use (Communications-Start/Stop Adapters)

Communications—Synchronous Adapter

For the 2701, there is only one communications synchronous type adapter: the Synchronous Data Adapter-Type I.

The Synchronous Data Adapter-Type I enables the 2701 to control data transfers in half-duplex synchronous mode between an IBM System/360 computer and the following synchronous transmitter receiver (STR) terminals and devices:

1. IBM 1009 Data Transmission Unit, IBM 1013 Card Transmission Terminal, IBM 7702 Magnetic Tape Transmission Terminal, or the IBM 7740 Communication Control System at the following rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
2. IBM 7701 Magnetic Tape Transmission Terminal or the 7750 Programmed Transmission Control at 1,200 bits per second (150 characters per second).
3. IBM 7710 Data Communication Unit, IBM 7711 Data Communication Unit, or another IBM System/360 equipped with a 2701 Data Adapter Unit with the Synchronous Data Adapter-Type I at the following data rates:
   1,200 bits per second (150 characters per second)
   2,000 bits per second (250 characters per second)
   2,400 bits per second (300 characters per second)
   40,800 bits per second (5,100 characters per second)

Refer to Figure 17 for the required communications facilities and data sets for each of the speeds described in items 1, 2, and 3.

Three features are obtainable on the Synchronous Data Adapter-Type I.

1. Internal clock feature (prerequisite: Synchronous Data Adapter-Type I) provides the clocking pulses for transmission speeds of 1,200; 2,000; and 2,400 bits per second. This feature is required when the data set does not provide the clocking pulses.
2. Dual communication interface feature (prerequisite: Synchronous Data Adapter-Type I) provides a second communication interface. Only one interface is operable at a time.
3. Automatic call feature: Enables the 2701 to originate calls on a switched dial network by dialing through an AT & T 801A1 type auto dial unit. This feature is not needed or used for handling the automatic answering of calls on a switched network. This feature is available only for operation at 1,200 bps.

For this adapter, additional information concerning commands, status bytes, sense bits, and operational functions will be provided in later publications.

Data Acquisition and Control Adapters

Data acquisition and control adapters for the 2701 include the following: the Parallel Data Adapter, Contact Sense Adapter, Contact Operate Adapter, and Serial Synchronous Adapter.

Parallel Data Adapter

The Parallel Data Adapter allows for the connection and operation of external devices that transfer data, parallel by bit, serial by word, with the System/360 processor. The data word size is 16 bits, expandable in groups of eight up to 48 bits. The Parallel Data Adapter presents a demand response interface to the external device that allows for the half duplex transfer of parallel data words into and out of System/360 processor and the external device. The Parallel Data Adapter controls this interface, converts from data

Speed \ Communications Facilities	Common Carrier Switched Telephone Networks	Common Carrier Leased Private Line Telephone Services	Common Carrier Broadband Communications Services	Customer Owned Communications Facilities
1200 bps (150 cps)	Western Electric Data Set 202A or equivalent. See note.	Western Electric Data Set 202A, B, or Western Union Data Set 1601A or equivalent. See note.	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2000 bps (250 cps)	Western Electric Data Set 201A or equivalent. See note.	Western Electric Data Set 201A or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
2400 bps (300 cps)	Not Applicable	Western Electric Data Set 201B or equivalent	Not Applicable	Modem equipment (data set) having a proper interface must be used.
40,800 bps (5,100 cps)	Not Applicable	Not Applicable	Western Electric Data Set 301B	Modem equipment (data set) having a proper interface must be used.

NOTE: The Internal Clock feature is required for operation at 1200 bits per second and on the Switched Telephone Networks.

Figure 17. Communications Facilities and Transmission Speeds

word to byte and from byte to data word, develops and checks one bit of odd parity per data word, and transfers data to and from the I/O channel, parallel by bit, serial by byte. The Parallel Data Adapter forces the multiple byte mode of operation on the multiplexor channel. The number of bytes transferred in the multiple byte operation is dependent upon the size of the data word. This can vary from two to six bytes.

In addition to the parallel data operation, the PDA and the direct control feature (DCF) on a System/360 processor can simulate the direct data feature on the 704X (7040-7044) and 709X (7090, 7094, 7094 II) systems. The interface circuitry is different, but the logical operation is the same.

Commands

The Parallel Data Adapter decodes and executes the following commands. (See Figure 18 for the configuration.)

	Bit Configurations							
Commands	0	1	2	3	4	5	6	7
Read	0	0	0	0	0	0	1	0
Read with Timeout	0	0	0	1	0	0	1	0
Write	0	0	0	0	0	0	0	1
Write with Timeout	0	0	0	1	0	0	0	1
Diagnostic Write	0	0	0	0	0	1	0	1
Diagnostic Read	0	0	0	0	0	1	1	0

Figure 18. Bit Configuration for Parallel Data Adapter Commands

Read: This command causes the Parallel Data Adapter to accept data words from the external device and present them a byte at a time to the System/360 channel.

Write: This command causes the Parallel Data Adapter to take bytes of data from the System/360 channel, assemble them into data words, and transfer them to the external device.

Read with Timeout: This command is the same as the read command described above, except that a 2-second timeout is performed on the response of the external device to a request for data transfer made by the Parallel Data Adapter. This command is only valid when the timeout feature is obtained.

Write with Timeout: This command is the same as the write command described above, except that a 2-second timeout is performed on the response of the external device to a request for a data transfer made by the Parallel Data Adapter. This command is valid only when the timeout feature is obtained.

Diagnostic Write: The diagnostic write command operates as the normal write. However, the control and data transfer operations with the external device are inhibited. After one data word has been assembled in the Parallel Data Adapter, the device end, channel end status is presented, which terminates the command.

Diagnostic Read: This command operates like the normal read operation, except that the control and data transfer operations with the external device are inhibited. The data word stored in the Parallel Data Adapter's assembly register is transferred to the channel, and the device end status is presented, which terminates the command. This command should be preceded by the diagnostic write command.

Special Features

Extension Features: The Parallel Data Adapter provides a data word of 16 bits plus one bit of parity in each direction. Through the use of the extension features, the data word can be extended to 48 bits. One bit of parity is supplied for the data words regardless of the number of extension features used. Each extension feature adds eight input and eight output bits to the data word.

Timeout Feature: The timeout feature is used to recognize an external device failure. The timeout is initiated under program command. A 2-second timeout is performed from the time the Parallel Data Adapter notifies the external device that it is ready for a data transfer until the time that the external device responds. In detail, when the read ready or write ready line is raised, the timeout begins. The timeout is reset when the external device raises the demand line. The timeout will restart on the next occurrence of a read ready or write ready signal. If the demand response does not occur within the 2-second timeout period, the command will be ended with the device end, channel end and unit check status set and with the timeout bit set in the sense byte.

Adapter Operation

Operation between the Parallel Data Adapter and the external device is made through the Parallel Data Adapter interface. The interface consists of a set of lines that provide for control, signals and data paths (Figure 19). The name and functions of each line or lines of the interface are described below. Detailed information concerning timing and voltage levels will be published in the *IBM 2701 Data Adapter Unit Original Equipment Manufacturers Information* manual Form A22-6844.

Output Data Bus (PDA to External Device): The output data bus consists of 17 lines on the basic adapter. Sixteen lines are used to present data and one line is used to present the odd parity bit to the exter-

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CHANGES TO IBM 2701 DATA ADAPTER UNIT PRINCIPLES OF OPERATION, FORM A22-6864-0

Add or replace Title page, Contents page and pages 5 through 7, 13 through 18, 21 through 26, 29, and 29.1 of Form A22-6864-0 with the attached sheets.

Due to minimal demand, the following features previously announced for the 2701 Data Adapter Unit are being withdrawn:

	Feature Code
Contact Sense Adapter	#2255
Contact Sense Extension	#2256
Contact Sense Extension, 2nd	#2257
Contact Operate Adapter	#2268
Contact Operate Extension	#2269
Contact Operate Extension, 2nd	#2270
Serial Synchronous Adapter	#7095, 7096
Synchronous Pattern	#7700

Pages 36 through 47, which describe these features, may be deleted at the discretion of the user.

Changes to the following figures are indicated by a bullet to the left of the figure titles: 1, 3, 4, 7, 8, 14, 15, and 17.

File this cover page at the back of the publication. It will provide a reference to changes, a method of determining that all amendments have been received, and a check for determining if the publication contains the proper pages.

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