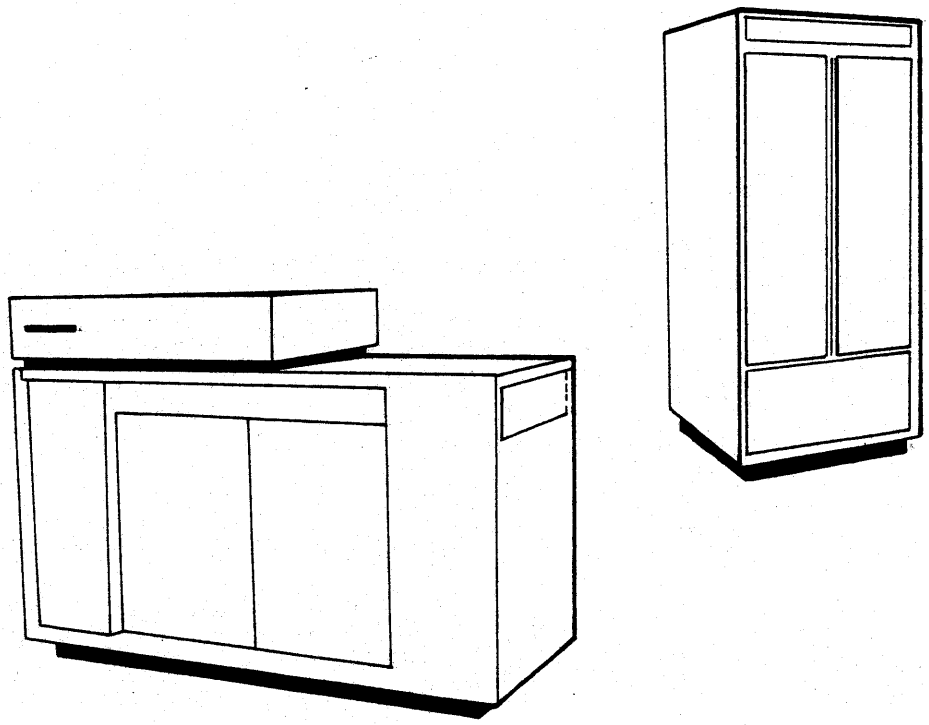
CONTROL DATA® 791

LOCAL COMMUNICATIONS CONTROLLER



CONTROL DATA

REFERENCE MANUAL

791
LOCAL COMMUNICATIONS CONTROLLER
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or use Comment Sheet in the back of this manual.

FOREWORD

This manual (formerly the CONTROL DATA® 791 Communications Subsystem Controller Functional Characteristics and Programming Manual) contains a general description of the equipment comprising the 791 Communications Subsystem Controller. Information is provided to enable configuring a terminal subsystem with communications adapters and modems that are appropriate to a given application. Also, processing time and memory capacity constraints are explained and equations for determining limiting factors on subsystem expansion are provided. Section 3 lists the commands that are issued by the higher level processor (HLP), describes information flow across the remote batch terminal interface, and describes the autoload operation. Sections 4 through 6 provide detailed descriptions of Mode 2 synchronous, Mode 3 asynchronous, and Mode 4 synchronous protocols, respectively.

The 791-1 Communications Subsystem Controller consists of a main cabinet with sufficient control hardware to service up to 48 communication lines; however, only 16 lines can be connected to the main cabinet. The 791-2 Communications Subsystem Module includes an expansion cabinet to which eight additional communication lines may be connected. The 791-3, -4, and -5 are additional modules which may be installed in the expansion cabinet to connect additional lines (eight lines per module) to the controller.

NOTE

Throughout this manual, the term "Local Communications Controller" or (abbreviated) "LCC" is used to refer to the 791 Communications Subsystem Controller.

Refer to the following Control Data Corporation publications for additional information concerning the controller operation and hardware:

Title	Publication No.
Local Communications Controller Customer Engineering Manual	60321800
Buffer Controller Reference Manual	60275000
18-Bit Word, 200-Nanosecond Memory Assemblies	60309700
7077-1 Communications Station Reference Manual	60364600

These publications can be ordered from:

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INTRODUCTION 1

This section contains a general description of the basic hardware in the CONTROL DATA® Local Communications Controller (LCC). Also included are brief descriptions of the application and driver software and the communications protocols supported by the LCC controlware.

LOCAL COMMUNICATIONS CONTROLLER

The LCC (figure 1-1) is an internally-programmed device which connects multiple communication lines of different types and speeds to a CDC 6000 or CYBER 72-74 Computer System (via a 7077-1 Communications Station). The LCC performs most of the control functions necessary for servicing up to 48 full- or half-duplex communication lines and transmit data to the computer system in a standard format ready for processing. By performing these functions, the LCC frees the central processing unit and central storage for more productive processing.

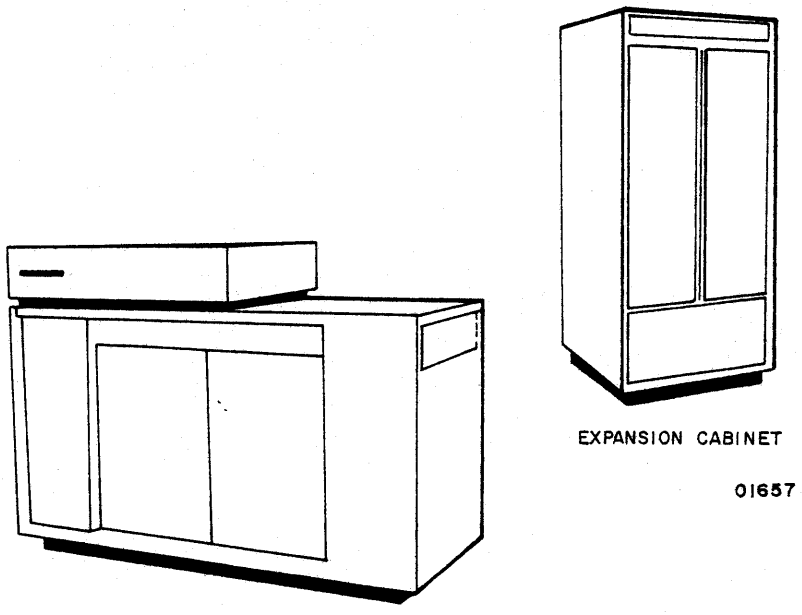


Figure 1-1. Local Communications Controller

BASIC AND EXPANDED LCC

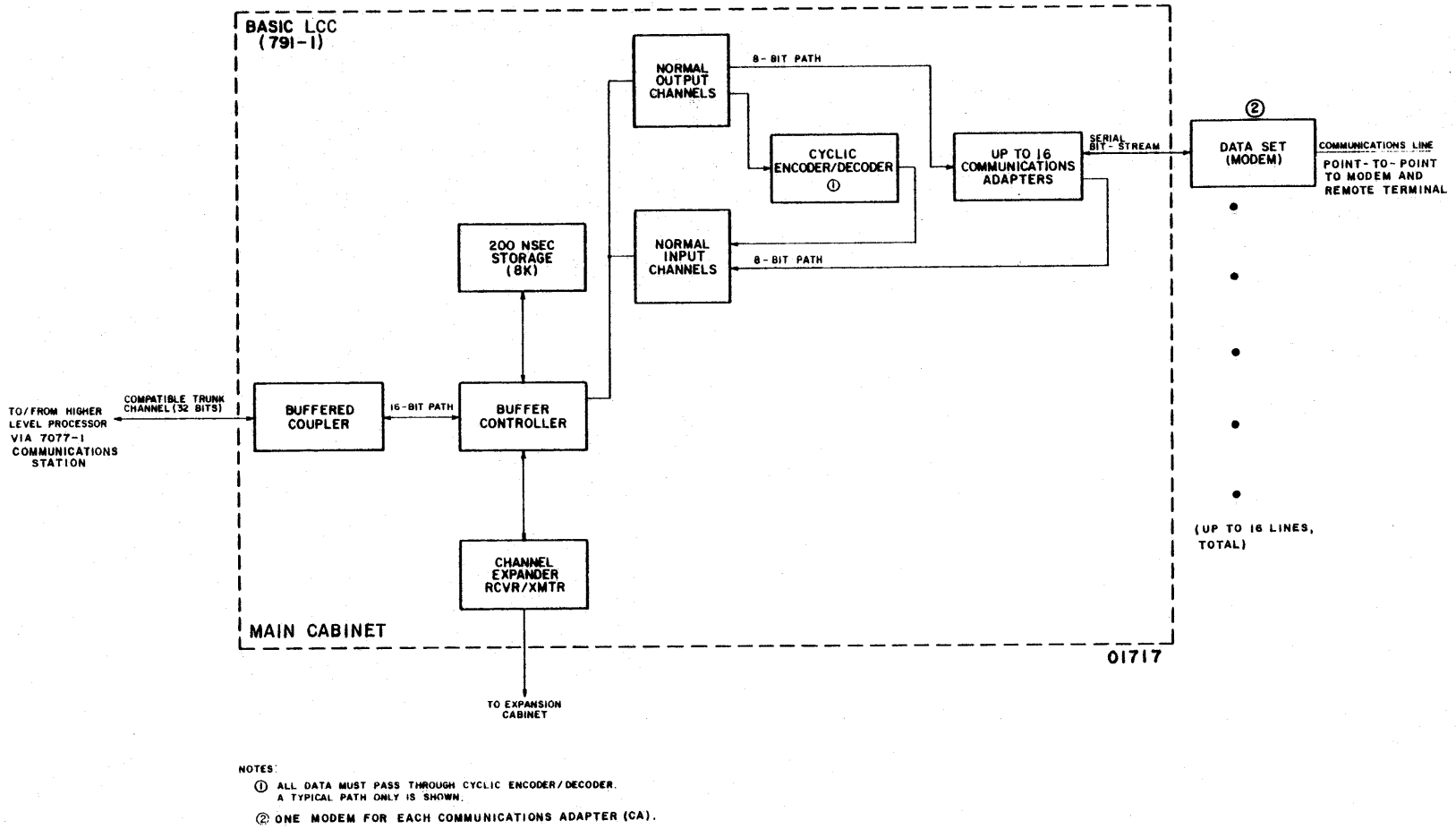
The basic LCC shown in block diagram form in figure 1-2 corresponds to the "Main Cabinet" in figure 1-1 and the "791-1" portion of table 1-1. This controller has a basic storage capacity of 8192 (16-bit) words of core storage with a cycle time of 200 nanoseconds. A cyclic encoder/decoder ensures communication accuracy. As shown in figure 1-2, up to 16 communication lines may be connected to the basic LCC via modems and CDC communications adapters. Mode 2 and Mode 3 communication lines are point-to-point to another modem and a remote terminal; however, Mode 4 terminals may use party lines.

Figure 1-3 shows a fully-expanded controller which includes an expansion cabinet (part of the 791-2 product) that can be used to interface up to 32 additional communication lines via CDC communications adapters and modems. Table 1-1 describes the expansion cabinet and additional channel capability under the 791-2 through 791-5 products. Information concerning communications adapters and modems suitable for use with specific types of communication lines and remote terminals is at the end of Section 2.

7077-1 COMMUNICATIONS STATION

The 7077-1 Communications Station provides the communications link between the LCC and the HLP. Core storage in the 7077-1 is used for data buffers and a table interface that enables the HLP to control the LCC and to status the LCC and the remote terminals. The 7077-1 consists of the following equipment:

- A Storage Access Controller (SAC) that regulates any entries into the 7077-1 memory.
- An SAC Coupler that interfaces the HLP input/output channel to port 3 of the 7077-1.
- A Central Storage Cabinet (CSC) with a minimum of 8K of 16-bit words with a memory access time of 1.1 microseconds. Additional 8K storage modules can be installed to increase the storage capacity to 32K and an additional 16K or 32K can be added by using an auxiliary memory cabinet.

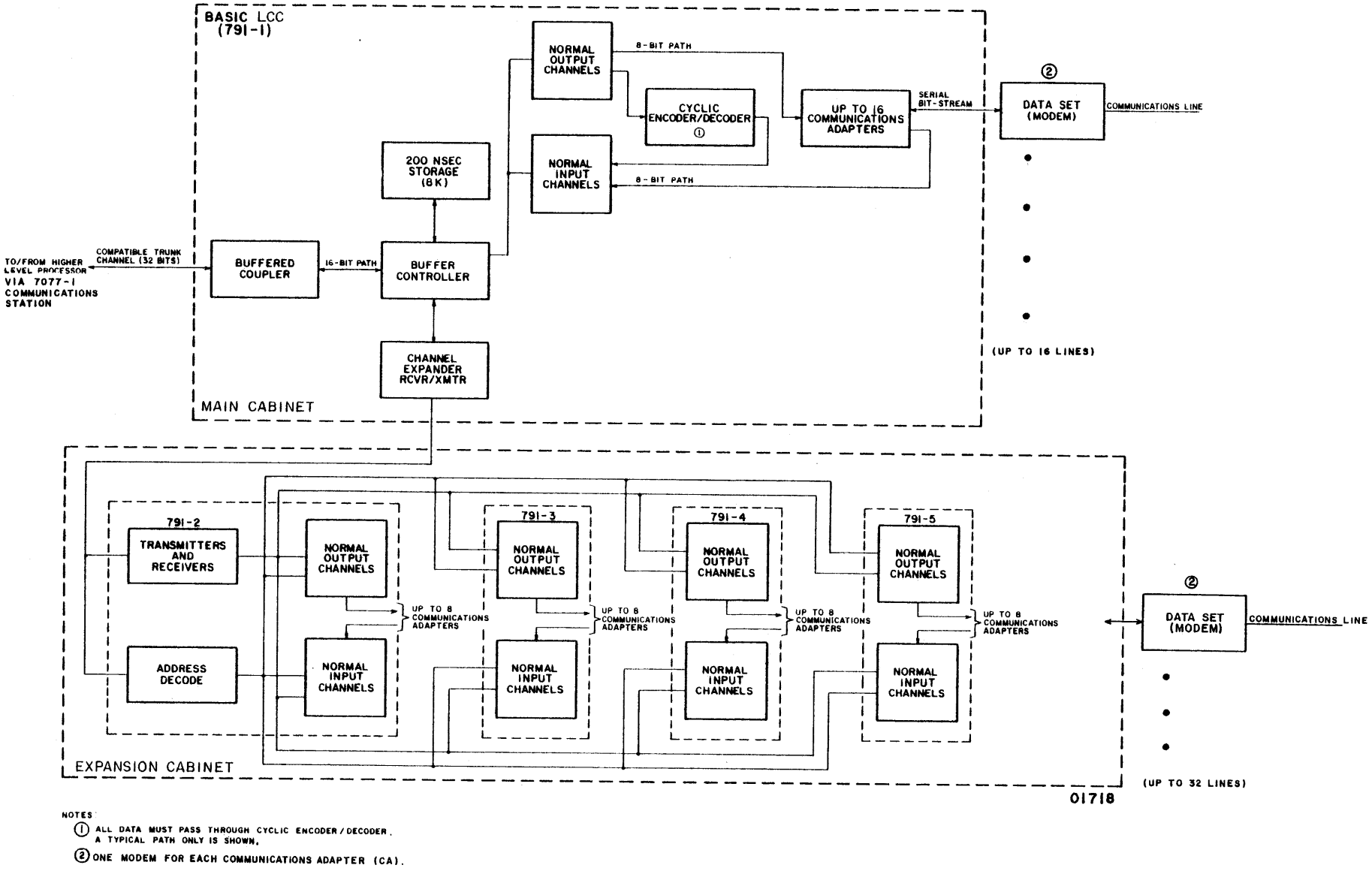


NOTES:

① ALL DATA MUST PASS THROUGH CYCLIC ENCODER/DECODER. A TYPICAL PATH ONLY IS SHOWN.

② ONE MODEM FOR EACH COMMUNICATIONS ADAPTER (CA).

Figure 1-2. Basic LCC



NOTES:

① ALL DATA MUST PASS THROUGH CYCLIC ENCODER/DECODER. A TYPICAL PATH ONLY IS SHOWN.

② ONE MODEM FOR EACH COMMUNICATIONS ADAPTER (CA).

Figure 1-3. Fully Expanded LCC

TABLE 1-1. MODULAR EXPANSION CAPABILITY

PRODUCT NUMBER	PRODUCT DESCRIPTION	COMMUNICATIONS ADAPTERS	LEVEL
791-1 (Basic LCC)	Main (SCU) cabinet Power supply Normal output half-channels 0-F, bits 00-15 Normal input channels 0-F, bits 00-15 Buffered coupler (32 bits) Station control board Cyclic encoder/decoder board Buffer controller 4K, 200-nsec storage module Wired and 4K expansion storage module back panel Connector and switch panel Channel expander receiver and transmitter boards	1 to 16	1
791-2	Expansion (62-inch Nu-line) cabinet Power supply Normal output half-channels X00-X03, X08, and X09, bits 00-15 Normal input channels X00-X03, X08, and X09, bits 00-15 Transmitter and receiver boards Address decode boards Set/clear boards Wired back panel Connector and switch panel	17 to 24	2
791-3	Normal output half-channels X04-X07, X10, X11, X18, and X19 Normal input channels X04-X07	25 to 32	3
791-4	Normal output half-channels X12, X13, X1A, X1B, and X14-X17 Normal input channels X10-X13, X18, X19, X1A, and X1B	33 to 40	4
791-5	Normal input channels X14-X17	41 to 48	5

COMMUNICATIONS SOFTWARE

Generally, two levels of software (the application software and the driver) are implemented within a communications subsystem. It is the responsibility of the application software to interpret and process data associated with the terminals. The communications driver maintains an orderly flow of data between the application software and the terminal network.

DRIVER FUNCTIONS

The higher level processor (HLP) and the LCC contain complementary levels of software drivers. Representative functions of a communications driver together with the separation of functions between the HLP and the LCC are as follows:

HLP — Performs device control functions such as code conversion, or terminal device error recovery (for example, the HLP informs the operator when a printer is not ready and examines the text portion of the message for special format or device control characters such as line feed, carriage return, etc.)

LCC — Performs line multiplexing (scan for assembled data)

— Adds/deletes communications control information to maintain the proper sequence of messages between the terminal and the LCC and to recover from communication line errors

— Polls remote synchronous terminals

A series of tables, maintained in the central storage cabinet of the 7077-1 Communications Station (the interface between the LCC and the HLP) coordinates these two driver elements.

COMMUNICATION PROTOCOLS

The three communication protocols supported by the LCC controlware are designated Mode 2, Mode 3, and Mode 4. Mode 2 protocol supports synchronous, nonswitched, full-duplex communication lines with line speeds of 2400 to 40,800 bits per second. Communication over Mode 2 lines is:

- Two-way simultaneous: the bidirectional information flow between the LCC and terminal occurs simultaneously
- Asymmetric: all communication activities are initiated by the LCC (the terminal is slaved to the controller)
- Noncontinuous: for each command issued by the LCC, a response is returned by the terminal on a one-for-one basis

The terminals supported by Mode 2 protocol include the CDC 731-10 and 732-10 Remote Batch Terminal which operate at line speeds of 2400 to 9600 bits per second and the CDC 733-10 High-Speed Batch Terminal which operates at line speeds of 19,200 to 40,800 bits per second.

Mode 3 protocol supports switched or nonswitched asynchronous lines with line speeds of 110 to 300 bits per second. Communication over Mode 3 lines is two-way alternate; that is, the bidirectional information flow between the LCC and the terminal cannot occur simultaneously. Terminals supported by Mode 3 protocol include Teletypewriter Models 33, 35, and 38 ASR or KSR (automatic send/receive or keyboard send/receive) and the CDC 713-10 Conversational Display Terminal.

Mode 4 protocol supports synchronous communication over the following types of lines:

- 2000 bps, point-to-point, half-duplex, switched lines.
- 1200 to 9600 bps, point-to-point, 2-wire or 4-wire, nonswitched lines.
- 1200 to 9600 bps, multidrop, 2-wire or 4-wire, dedicated, leased, or private lines.

Communication over Mode 4 lines is essentially two-way alternate, asymmetric. Terminals supported by Mode 4 protocol include the CDC 200 User Terminal (either ASCII or BCD); the 214-x Remote Single-Station Terminal; the 217-x CRT Display Station; the 711-10 CRT Display Terminal; the 714 Remote Multistation Terminal; and the 731-12, 732-12, and 734-1 Remote Batch Terminals (and any other terminals that are fully compatible with these terminals).

Mode 4 is the only protocol that permits the use of party lines as well as point-to-point connections to remote terminals. Mode 4 can be used with either Mode 2 or Mode 3 protocol, but not both, in a given LCC.

CONFIGURING THE LOCAL COMMUNICATIONS CONTROLLER 2

This section describes the terminal interface of the local communications controller (LCC) and lists some of the constraints that must be considered when configuring a communications subsystem.

The terminal interface of the fully-expanded LCC consists of 48 ports*, each of which may be used to communicate with a teletypewriter-type terminal. When fewer than the full 48 ports are used for TTY terminals, groups of the slower asynchronous TTY terminals may be replaced by a synchronous remote batch terminal. In fact, several batch-processing terminals may be used in a communications subsystem provided the processing time and memory capacity constraints (discussed in this section) are not exceeded.

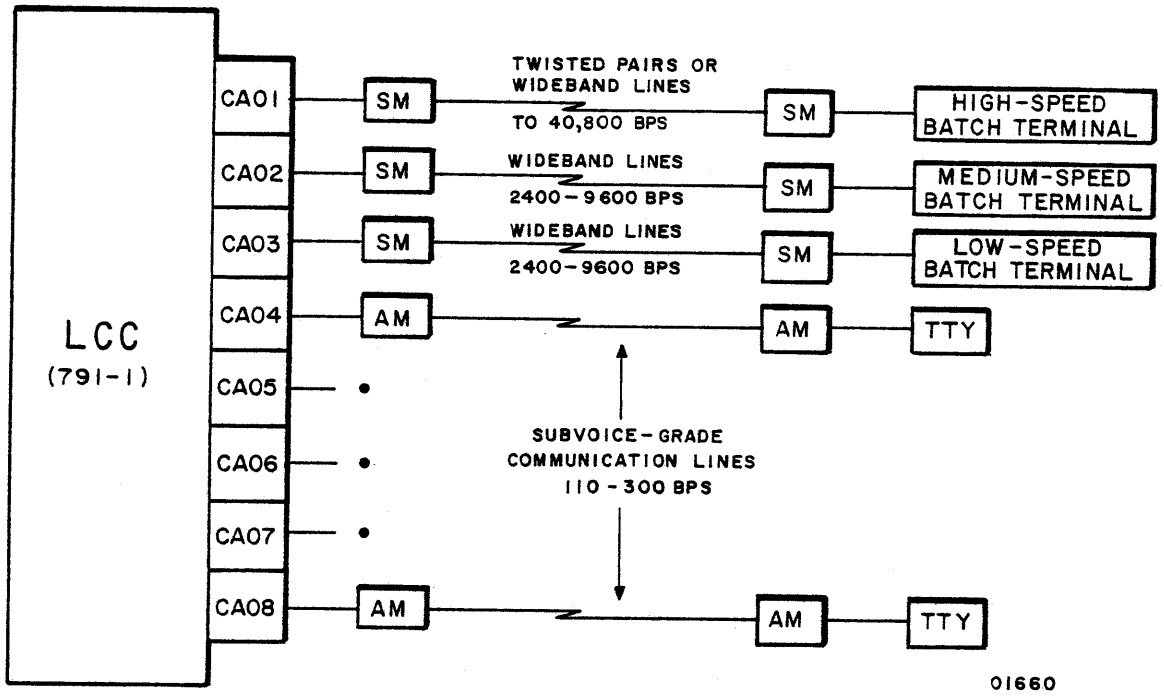
A CDC 792 Communications Adapter (CA) must be installed at each port of the LCC that is to be used to communicate with a remote terminal. The CA's are cabled directly to modems on the receiving end of the communication lines from the terminals.

A teletypewriter terminal consists of a keyboard and printer and can include a paper tape reader and punch. A batch terminal can include a crt display/keyboard, a card punch, one or more card readers, and several line printers.

LINE ASSIGNMENT

The lower-numbered communication ports of the LCC are serviced more often than are the higher-numbered ports and are, therefore, reserved for the faster terminals. The fastest batch terminals should be connected to the lowest-numbered ports. Other batch terminals should be connected to the next-higher series of ports and the slower TTY terminals should be connected to the highest-numbered ports used. The ports need not be assigned consecutively. Figure 2-1 shows how line assignments might be made for a subsystem consisting of three batch terminals and five TTY terminals. The types of CA's and modems that should be used with the various types of terminals are defined under Communications Adapters later in this section.

* Ports 1 through 48 correspond to lines 0 through 47, the term used in the LCC control program.



KEY: CA = COMMUNICATIONS ADAPTER
(SOMETIMES TERMED "DSA" – DATA SET ADAPTER)
SM = SYNCHRONOUS MODEM
AM = ASYNCHRONOUS MODEM
TTY = TELETYPEWRITER (ASR OR KSR)

Figure 2-1. Line Assignments (Example)

CONFIGURATION CONSTRAINTS

The final constraints affecting terminal configuration, throughput, etc., are memory space and processing time in the LCC. Equations in the following paragraphs may be used to determine throughput capacity and memory requirements.

The LCC can support any configuration of line speeds, mix of supported terminals, and mix of communication protocols up to and including the maximum configuration without performance degradation. The LCC is configured to the maximum extent when one or more of the following conditions are met:

- all 48 ports of the LCC are utilized, or
- insufficient memory space remains for the LCC to configure another line, or
- insufficient processing time remains for the LCC to service another line.

MEMORY REQUIREMENTS

The (core) memory requirements for the LCC controlware are as follows:

Core = Base + CAD + 5L + 8 + Mode 2 + Mode 3 + Mode 4 = 8192 16-bit words

Where:

Base = the executable resident controlware size. Values for Mode 2, for Mode 3, for Mode 4, or for allowable combinations (pairs) are:

Base Code Description	Base Code Size	INTERCOM Identifier (Reference Only)
Mode 2	3920	0ZD
Mode 3	3200	0ZF
Modes 2 and 3	5600	0ZJ
Mode 4	3600	0ZH
Modes 2 and 4	5930	0ZL
Modes 3 and 4	5280	0ZN

CAD = memory space required for communications adapter driver

Number of Lines	Code Size
1-4	0
5-8	51
8-16	117
17-24	271
25-32	337
33-40	411
41-48	430

L = total number of configured lines

Mode 2 = memory space required for Mode 2 line tables

Mode 2 table size = 51 (number of Mode 2 lines)
+16 (active lines + active streams)

(For computational purposes, all available lines are normally considered active, and the number of streams is considered to be 2 plus the number of Mode 2 terminal devices for each Mode 2 terminal.)

Mode 3 = memory space required for Mode 3 line tables

Mode 3 table size = 57 (number of Mode 3 lines)

Mode 4 = memory space required for Mode 4 line tables

Mode 4 table size = $29 (L_4) + 3 (BC_4) + A_4 + 104$

Where: L_4 = number of Mode 4 lines

BC_4 = number of Mode 4B and 4C terminals in system

A_4 = number of Mode 4A terminals in the system

Note: The "104" at the end of the equation comprises 80 words reserved for emergency situations and three 8-word buffers for the processing of requests.

THROUGHPUT CAPACITY

The formula expressed for throughput provides the throughput capacity of the LCC for a given number of configured lines. The following assumptions are made relative to this formula:

- LCC memory cycle time is 200 nanoseconds
- The LCC is connected to a CDC 6000 or CYBER 72-74 Computer System via a 7077-1 Communications Station

$$\text{Throughput maximum} = \frac{8}{s + n + p} \quad \text{bits per second}$$

Where:

s = controlware processing overhead = 24.5 μs

n = Additional overhead increment based on the total number of configured lines

n = 0 μs for 1-4 lines
= 4.40 μs for 5-8 lines
= 5.45 μs for 9-16 lines
= 5.85 μs for 17-24 lines
= 7.45 μs for 25-32 lines
= 12.25 μs for 33-40 lines
= 13.85 μs for 41-48 lines

p = 7077-1 access increment. In a 7077-1 Communications Station configuration consisting of two or more LCC's, this parameter must be added depending on the 7077-1 port occupied by the LCC.

p = 0 if the LCC is attached to port 0 of the 7077-1
= 1.1 μs if the LCC is attached to port 1

When three LCC's are connected to the 7077-1 Communications Station, the controller on port 2 should be used for Mode 3 communications only. This will reduce the likelihood of memory access conflicts in the 7077-1 which might result in excessive "lost data" conditions.

Table 2-1 indicates various LCC configurations which are obtained through the application of the preceding formulas.

TABLE 2-1. 8192-WORD LCC

MODE(S)	LINE SPEED (Bits per Second)	STREAMS/LINE	TOTAL LINES	CONSTRAINING FACTOR
2	2400	5	26	Memory space
	4800	5	26	Memory space
	9600	5	14	Processing time
	19,200	5	7	Processing time
	40,800	5	4	Processing time
3	300 or less	1	48	Number of ports
4	2400	1	48	Memory space
	4800	1	42	Processing time
	9600	1	24	Processing time
2	40,800	7	1	Memory space
4A	4800	1	29	
2	9600	6	12	Memory space
4A	9600	1	1	
3	300 or less	1	39	Memory space
4A	9600	1	1	
3	300 or less	1	1	Processing time
4A	9600	1	24	

COMMUNICATIONS ADAPTERS

The CDC 792 Communications Adapters (CA's) in the basic controller or expansion cabinet interface the LCC with the modem interface to the terminals. Functions of the CA's include:

Input operations — maintain synchronization with the transmitting terminal

— Assemble successive bits into 8-bit bytes

Output operations — disassemble successive 8-bit bytes into a serial bit stream

One CA is required for each port used in the LCC and three types of CA's are available for Mode 2, Mode 3, and Mode 4 applications (see table 2-2).

TABLE 2-2. EQUIPMENT SELECTION TABLE

CA	LINE SPEED (Bits per Second)	MODEMS	APPLICABLE TERMINALS
792-1	110-300* (asynchronous)	AT&T 103 Series, AT&T 202, or equivalent	Teletypewriter Models 33, 35, or 38 (ASR or KSR**) CDC 713-10 Conversational Display Terminal
792-2	2400-9600 (synchronous)	AT&T 201A, 201B, 203, or equivalent	CDC 200 User Terminal (either ASCII or BCD), 214-x Remote Terminal, 217-x CRT Display Station, 711-10 CRT Display Terminal, 714 Multistation Terminal, 731-10/12, 732-10/12, and 734-1 Remote Batch Terminals
792-3	19,200-40,800 (synchronous)	AT&T 300 Series, CDC 358-4 Transceiver, or equivalent	CDC 733-10 High-Speed Batch Terminal

* Although the 792-1 CA can operate at speeds of 75 to 1800 bits per second, the LCC controlware supports only the range from 110 to 300 bits per second.

** ASR = Automatic Send Receive
KSR = Keyboard Send Receive

Each of the CDC communications adapters connects directly to the normal input/output channels of the LCC. On output operations, the CA performs a parallel-to-serial conversion, disassembling 8-bit parallel characters into serial characters. The asynchronous 792-1 CA inserts start and stop bits around the serial characters before they are sent to the associated modem. For input operations, the CA performs a serial-to-parallel operation, assembling 8-bit parallel characters for input to the LCC. In this case, the 792-1 strips off the start and stop bits before sending the parallel character to the LCC.

The modem interface of each of these units conforms to EIA (Electronic Industries Association) Standard RS-232-C. Also, the 792-1 and 792-2 CA's have self-contained data set simulators for testing purposes.

MODEMS

Each communication line serviced by the LCC must be terminated by a modem (modulator/demodulator) that is compatible with the CA used at that specific port of the LCC. The modem's function is to convert a digital serial bit stream to an analog waveform that is suitable for transmission over the communications line. This process is termed "modulation" and the reverse operation, performed on information received over the line from the remote terminal, is termed "demodulation."

LOW-SPEED LINES (TELETYPEWRITER INTERFACE)

Modems must be chosen according to the line type and line speed of the associated communications lines (refer to table 2-2). Asynchronous modems with an RS-232-C interface must be used on all low-speed lines served by the LCC. An example of this class of modem is the AT&T 103 Series, which may be attached to either a switched or private line.

Modems at the local end of switched communication lines may or may not be strapped for automatic answering. If the automatic answering function is used, the LCC controlware automatically initiates the processing on that line whenever a call connection is detected. However, if automatic answering is not used, manual intervention is necessary to place the modem in data mode.

At the conclusion of processing, the LCC attempts to automatically disconnect the call. The user must check his communications facility to see whether it is possible for the callee to disconnect the line at the conclusion of a call. If this is not possible, the line must be disconnected manually at the point of origin of the call.

MEDIUM-SPEED LINES (REMOTE BATCH TERMINAL INTERFACE)

As shown in table 2-2, high-grade voice channels operating at rates of 2400 to 9600 bits per second must be terminated by a synchronous modem with an RS-232-C interface. An example of this class of modem is the AT&T 201B, which provides a transmission rate of 2400 bits per second on a full-duplex, private line.

HIGH-SPEED LINES (HIGH-SPEED BATCH TERMINAL INTERFACE)

Wideband lines operating at speeds of up to 40,800 bits per second must be terminated by a synchronous modem such as the AT&T 300 Series. Another example is the CDC 358-4 Transceiver which provides an identical capability over a customer-provided, twisted-pair line.

LCC OPERATING CHARACTERISTICS 3

This section contains a general description of the HLP-LCC interface and shows the relationship between the five basic HLP commands and the resultant actions taken by the LCC in response to these commands. Also included is a description of the autoload process.

HLP-LCC INTERFACE

The LCC is dominant over the communication lines to the terminals but is subordinate to the higher level processor (HLP) in the overall communications process. A table interface is established by the HLP (in the 7077-1 Communications Station) to permit the HLP to direct LCC actions and enable the LCC to report the status of each operation to the HLP. General characteristics of the HLP-LCC interface are explained in table 3-1 and details of this interface are provided in Section 4 through 6 of this manual.

Data flow between the LCC and a terminal occurs when the HLP issues a read or write command for a properly-activated (or opened) line. The exact sequence of events that follows the initiation of data transfers is dependent upon the particular terminal being addressed and thus the communications protocol used.

TABLE 3-1. HLP-LCC INTERFACE CHARACTERISTICS

FUNCTION TYPE	HLP COMMAND	RESULTING LCC ACTION
Logical HLP-LCC	Open	LCC logically activates the line in preparation for input/output activity.
	Close	LCC logically deactivates the line.
	Terminate	LCC abnormally terminates the associated input/output request.
Terminal I/O	Read	LCC inputs data from the selected terminal/device.
	Write	LCC outputs data to the selected terminal/device.

AUTOLOAD

To initiate the autoload process, the HLP places the 64-word autoload record (consisting of a 62-word autoload program and the first-word address of the autoload table, see figure 3-1) in the central storage cabinet of the 7077-1 Communications Station starting at address 0000 and sends an external flag to the LCC. Upon receiving the external flag, the LCC autoload hardware performs a master clear and then reads the 64-word autoload record and loads it in LCC storage beginning at address 0000. When the record is loaded, the LCC interrupts the HLP and awaits a channel flag from the HLP.

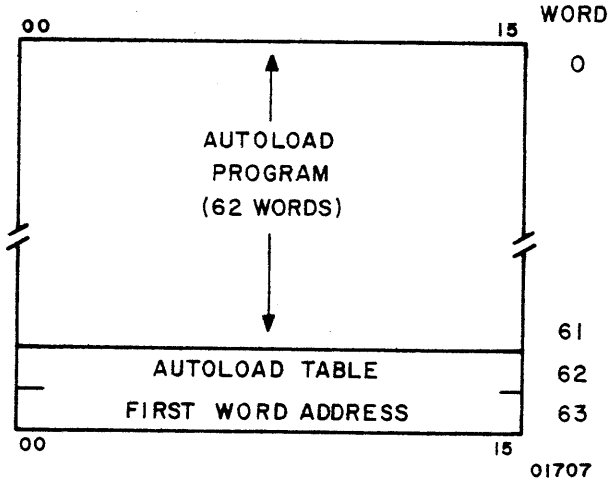
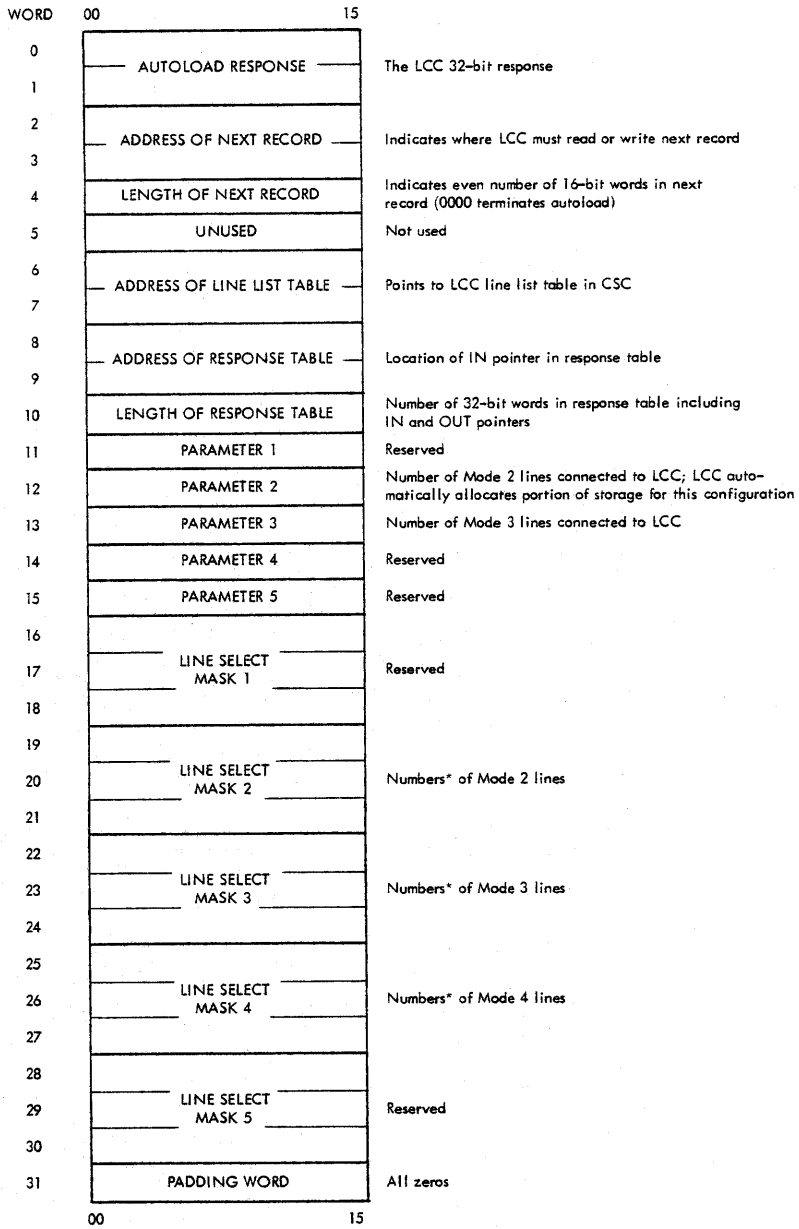


Figure 3-1. Autoload Record Format

NOTE

All autoload responses from the LCC to the HLP are accompanied by an interrupt. Absence of an LCC response during an autoload operation indicates that a record was transmitted in error and the HLP must time out for approximately one second and reinitiate autoload.

Upon receiving this initial interrupt from the LCC, the HLP interrogates the compatible trunk channel interface to ensure that no errors occurred. Then the HLP begins writing the autoload table (see figure 3-2) starting at address 0040 in the 7077-1 Communications Station and sends a channel flag to the LCC. The LCC then reads the autoload table into its memory and returns a "2" response (actually, hexadecimal 0000 0002, see table 3-2) accompanied by an interrupt to indicate that it is now ready to begin loading the controlware program.



* EACH BIT IN THIS 48-BIT PARAMETER CORRESPONDS TO A GIVEN LINE; E.G., BIT 0 CORRESPONDS TO LINE ZERO, BIT 1 CORRESPONDS TO LINE ONE, ETC. SET BITS INDICATE ACTIVE MODE-X LINES.

NOTE: WORDS 16 THROUGH 31 ARE INCLUDED IN THE AUTOLOAD TABLE ONLY WHEN MODE 4 TERMINALS ARE USED WITH THE LCC.

Figure 3-2. Autoload Table Format

TABLE 3-2. AUTOLOAD RESPONSE CODES

AUTOLOAD RESPONSE CODE (HEXADECIMAL)		DESCRIPTION
0000	0001	Error switch: Used if a local autoload occurs when a function (other than a local autoload) was requested.
0000	0002	Ready to read (load) another record: Used in autoload operations.
0000	0004	Autoload operation complete: The last segment is loaded. Used at the completion of autoload operations.
0000	0008	Ready to dialogue via software interface: Used after internal initialization following completion of autoload operations.
0000	0016	Error response: LCC aborted current operation and requires autoload to restart.

At this point the HLP obtains the first record of the LCC controlware from disc storage and loads it into the 7077-1 Communications Station starting at address 0000. The HLP then changes the next record address and next record length fields in the autoload table and sends a channel flag to the LCC. The LCC reads in the first segment of the controlware and sends a "2" accompanied by an interrupt. The HLP then loads the next program segment into the 7077-1, changes the autoload table "next record" fields, and sends a channel flag. The LCC reads in that segment of the program and sends another "2" reply and an interrupt. This sequence continues until the last of the controlware is loaded into the 7077-1, at which time the HLP inserts a next record length of zero into the autoload table. The LCC stores that segment of the controlware and replies with an interrupt and a "4" (or 0000 0004, see table 3-2) indicating that the autoload operation is complete.

INITIALIZATION AFTER AUTOLOAD

Upon receiving the "4" response from the LCC, the HLP inserts the following material into the autoload table:

- Line list table address (words 6 and 7)
- Response table address (words 8 and 9)
- Response table length (word 10)
- Control word (parameters 2 and 3, words 12 and 13, respectively)
- Line select data (words 16 through 31, only when Mode 4 terminals are used with the LCC)

The HLP then sends a channel flag to the LCC.

Upon receiving the channel flag, the LCC unconditionally initializes its internal tables using the values of parameters 1 through 5. If no Mode 4 terminals are used with this LCC, the sum of words 12 and 13 will equal the number of the highest-numbered CA port being used. (Note: this is equal to one more than the highest-numbered line used.)

Upon completing this initialization process, the LCC transmits an autoload response "8" indicating that it is ready to use the software interface. Then, upon receiving the next channel flag from the HLP, the LCC exits from the initialization program and enters its monitor routine.

MODE 2 CONTROLWARE 4

This section provides a detailed description of the Mode 2 synchronous communications protocol implemented in the Local Communications Controller (LCC).

Mode 2 protocol used for remote batch terminals supports synchronous full-duplex communication lines with speeds of 2400 to 40,800 bits per second. Communication on these lines is two-way simultaneous, asymmetric (that is, all communication activities are initiated by the LCC) and noncontinuous (or one-for-one). The communications discipline for the Mode 2 terminals is fairly rigorous. Messages that are longer than the HLP-designated buffer capacity must be divided into "blocks" of acceptable length, etc.

For Mode 2 operation, data is handled in several different streams that are time-multiplexed. This separate but virtually simultaneous communications approach allows several peripheral devices at a terminal to operate at the same time. The terminal controlware interprets all message formats, handles input and output data routing, and performs error reporting, error logging, data compression and decompression, and code-conversion functions.

INFORMATION FLOW

The LCC and the remote batch terminal interface communicate by trading blocks of information. The LCC initiates all information trades.

Two types of information trades are merged by the interface. These are designated alpha (α) and beta (β). During an α trade the LCC always sends a status block first, and the remote terminal responds by returning a data block. During a β trade the LCC always sends a data block first, and the remote terminal responds by returning a status block. A full-duplex communication channel connects the remote terminal with the LCC, allowing simultaneous, bidirectional information transfer. Thus, the information interface is a two-way simultaneous, noncontinuous link, as represented in figure 4-1.

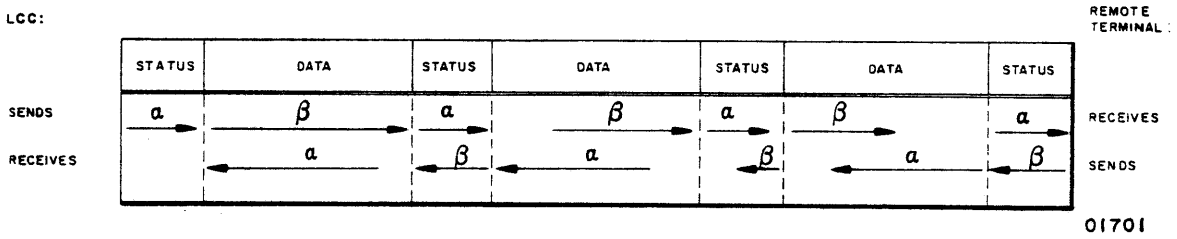


Figure 4-1. Two-Way Simultaneous, Noncontinuous Information Flow

A third type of information trade is the control block transmission. This is used to reestablish communication on a link. This is necessary if an equipment failure occurs or some other condition breaks the link.

ALPHA INFORMATION TRADE

Type α information trade consists of two information blocks. The LCC initiates the trade by transmitting a status block. After the complete block is received by the remote terminal, the terminal responds with a data block. An α status block contains stream control information which is used by the remote terminal to direct its activities. An α data block contains specific data (or text) associated with an input (odd-numbered) stream destined for the HLP.

See figure 4-2 for a graphic description of an α trade. An arrow denotes a block of information and its direction. Read the figure from left to right; i.e., the LCC sends an α status block, then receives an α data block, sends another α status block, receives another α data block, etc.

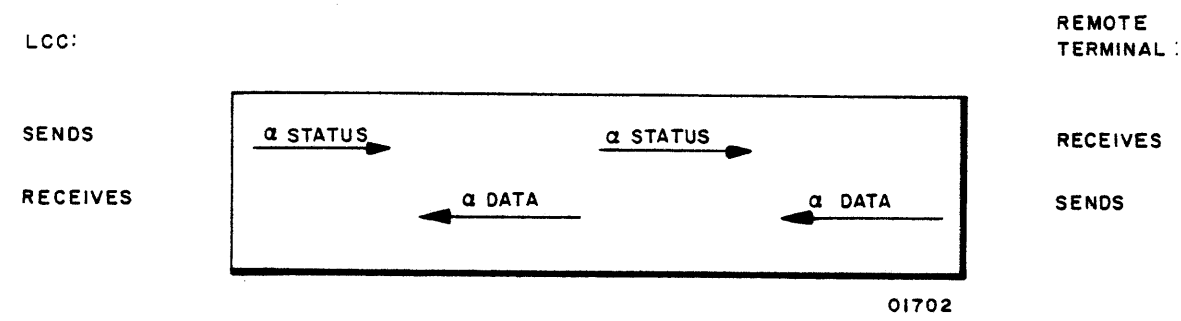


Figure 4-2. Alpha Block Trade

BETA INFORMATION TRADE

Type β information trade also consists of two information blocks. The LCC initiates the trade by transmitting a data block. After receiving the complete data block, the remote terminal responds with a status block. A β data block contains data (or text) associated with an output (even-numbered) stream destined for the remote terminal. A β status block contains the status of each of the streams in the remote terminal (they are busy, they can accept data, etc.).

See figure 4-3 for a graphic description of a β trade. An arrow denotes a block of information and its direction of flow. Read the figure from left to right.

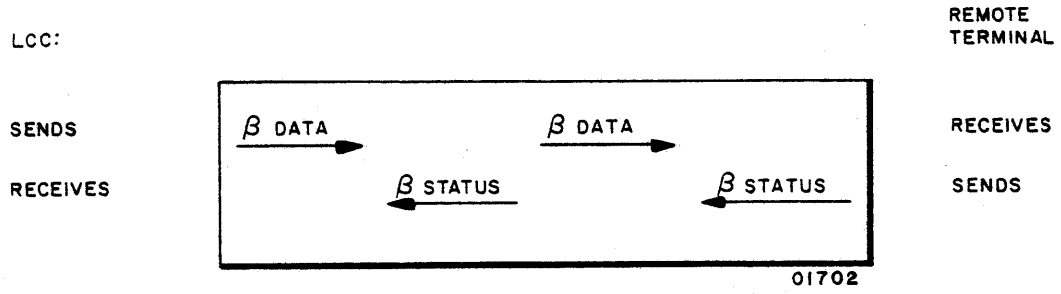


Figure 4-3. Beta Block Trade

If there is no information to trade, but communication is to be maintained, the remote terminal sends an idle block (a block with no data or status) in lieu of the data or status block. See figure 4-4.

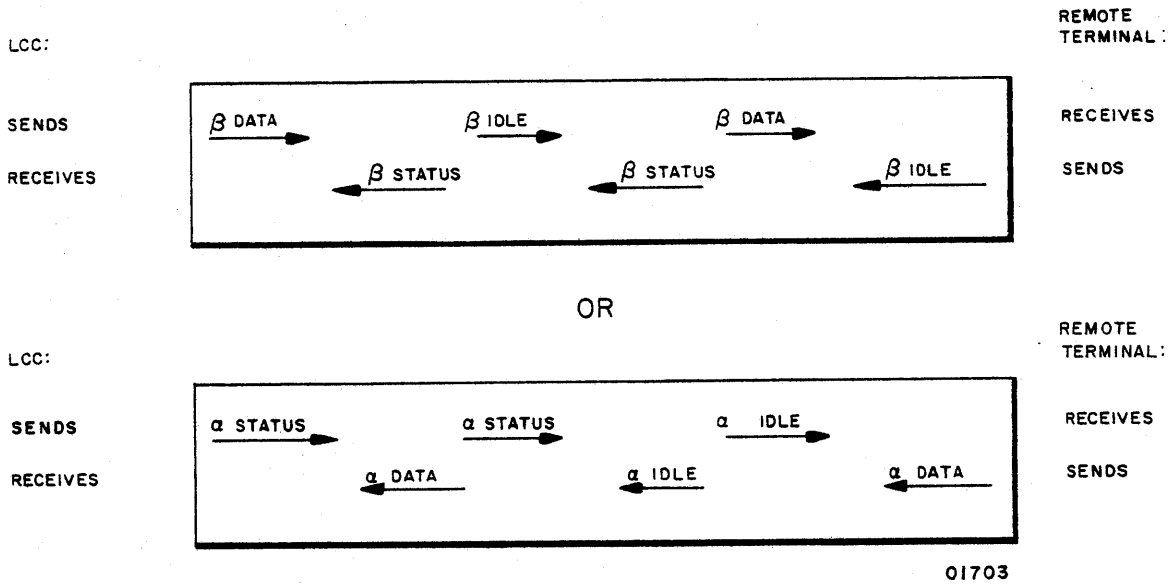


Figure 4-4. Idle Block Trade

CONTROL BLOCK TRANSMISSION

The control block reestablishes communication on a link. Either the LCC or the remote terminal may initiate the trade, but the remote terminal will always respond to a block sent by the LCC. If the remote terminal does not respond, the link will not be reestablished.

The control block may be sent before, during, or after an alpha/beta trade. In any case, it indicates that the communications link has been broken and that either the LCC or the remote terminal is attempting to reestablish communication.

If the remote terminal sends a control block during a normal alpha/beta trade, the LCC terminates all activity on the line until it can reply with a corresponding control block. The only control block code used in Mode 2 protocol is the restart function. Issurance of the restart code by either the LCC or the terminal indicates that the alpha/beta numbers are to be reset to an even state (see ASCII Graphic Characters Used As Sequence Numbers) and that any uncompleted data exchanges are to be voided.

If the LCC is reautoloaded during an exchange of data, the restart control block informs the remote terminal that the last data block was not accepted.

Graphic descriptions of restart control block trades are shown in figures 4-5, 4-6, and 4-7.

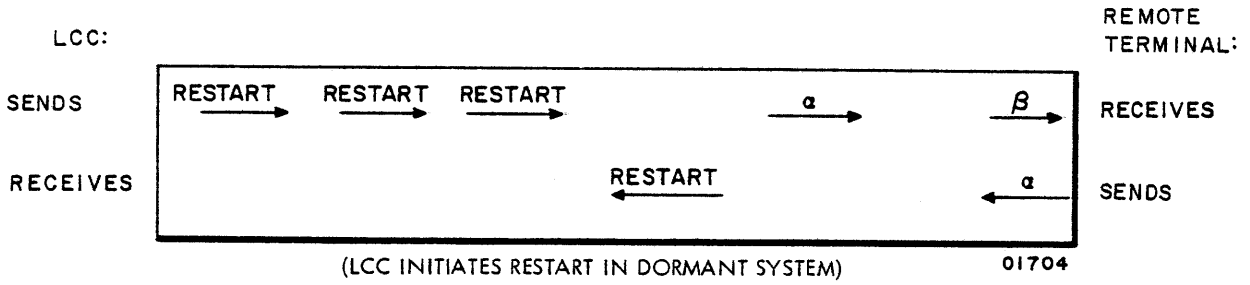


Figure 4-5. Idle Poll

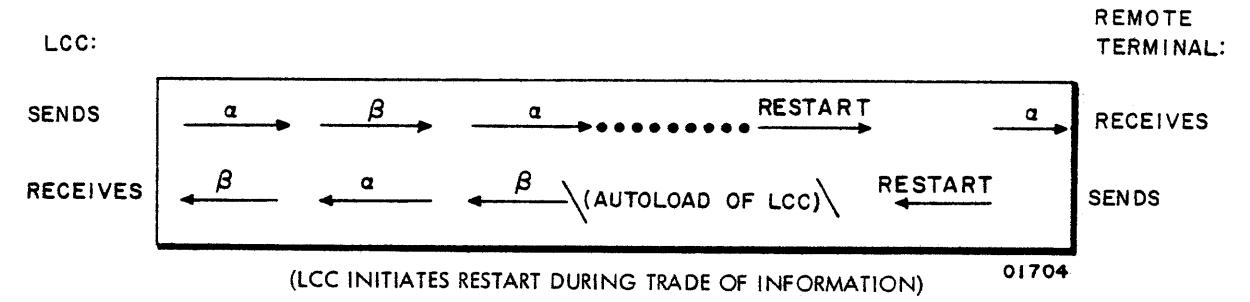


Figure 4-6. Restart (1)

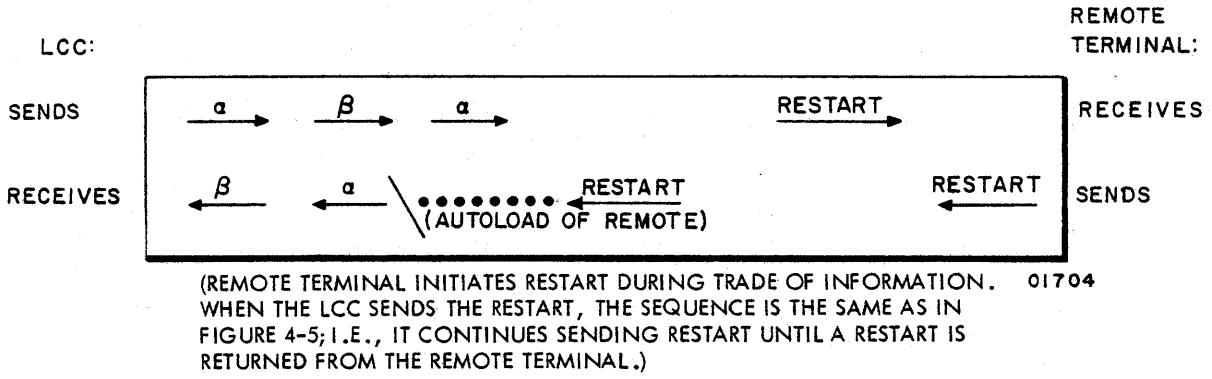


Figure 4-7. Restart (2)

ASCII GRAPHIC CHARACTERS (USED AS SEQUENCE NUMBERS)

Blocks are differentiated from each other by sequential numbers. Each transmitted block contains as even or odd sequence number. The even/odd numbers transmitted by the LCC for α information blocks are the ASCII graphic characters p and q, and for β information blocks are the ASCII graphics characters 0 and 1. The even/odd numbers anticipated by the LCC in the responding blocks sent by the remote terminal for α type information blocks are the ASCII characters 0 and 1, and for β type information blocks are the ASCII characters p and q. See figure 4-8 for a graphic description. If the responding block number is not correct, the LCC initiates line error-recovery procedures.

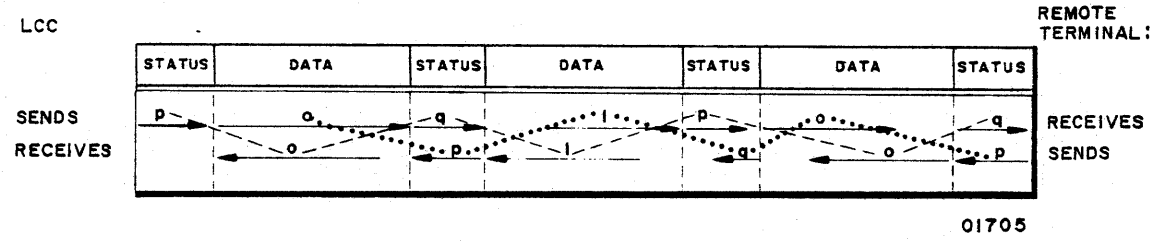


Figure 4-8. ASCII Even/Odd Character Sequence

TRANSMISSION BLOCKS

Following is a description of the two types of Mode 2 transmission blocks used by the LCC communications subsystem — information blocks and error information blocks. There are two types of information blocks: data information blocks and status information blocks. Data blocks contain data which is associated with streams destined for the HLP or remote terminal. Status information blocks contain stream information only, and are the conversation media used by the LCC and the remote terminal to coordinate their activities.

The two types of error information blocks are: REP (repeat) blocks and NEG (negative) response blocks. Repeat blocks are sent by the LCC to the remote terminal to inform the terminal that it must retransmit a block. The REP codes use ASCII lowercase characters x and y to specify repeat of α and β blocks respectively. The negative response block is sent by the remote terminal to the LCC to inform the LCC that the terminal could not accept the last information block sent by the LCC. The NEG code uses ASCII uppercase character N. See figure 4-9 and 4-10 for graphic representations of REP and NEG blocks.

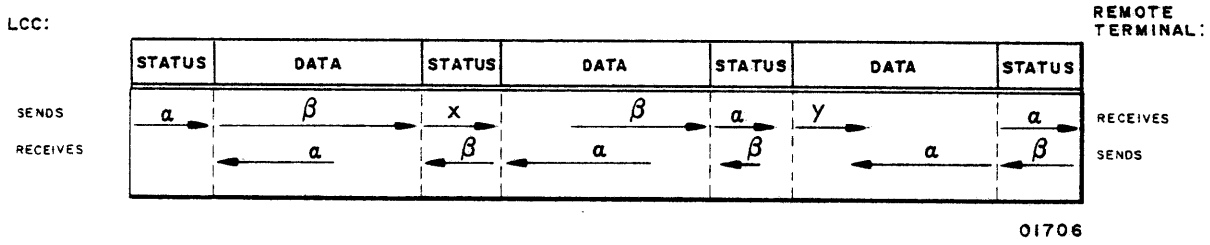


Figure 4-9. REP (Repeat) Response Sequence

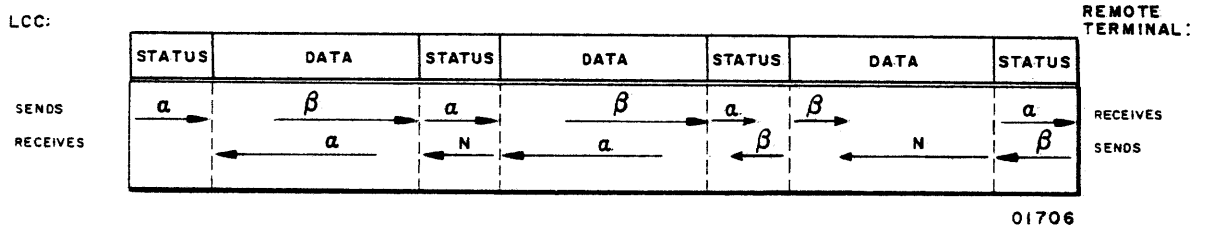


Figure 4-10. NEG (Negative) Response Sequence

FORMAT OF BLOCKS

Both types of blocks, information blocks and error information blocks, as well as the control block, are made up of a combination of the following fields: OD, CI, DF, ED, and CRC. In addition, a control block has an information code field designated CBC. Figure 4-11 shows, in train-graph form, how the fields are combined to form the various types of blocks. The following discussion of the formats of blocks is divided into two major subjects: characteristics of the block fields and composition of the blocks using these fields.

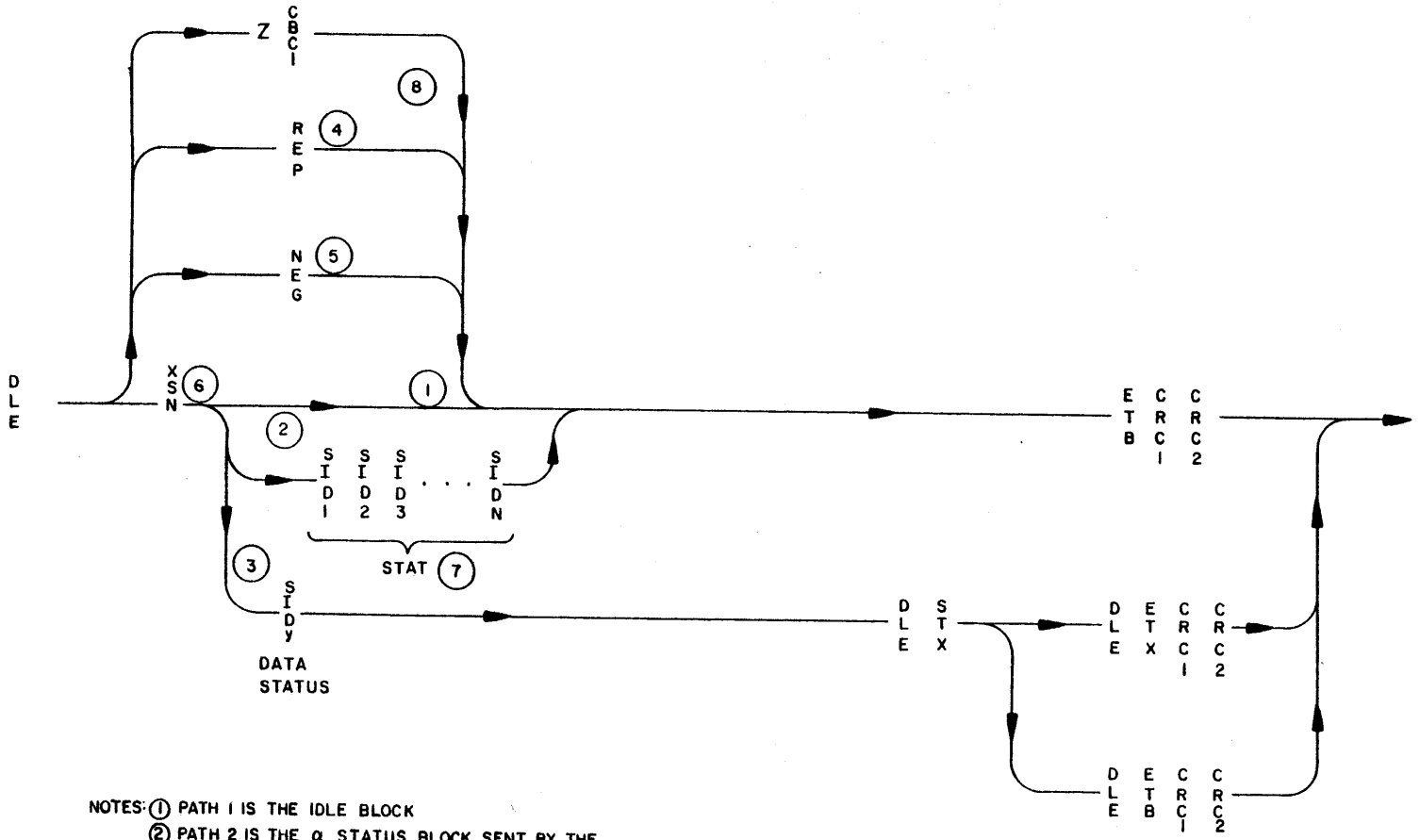
BLOCK FIELDS

This list briefly defines block fields; characteristics of the fields are described in the following paragraphs.

- OD — Opening delimiters. All blocks must have opening delimiters. This sequence of ASCII characters defines the beginning of a transmission block.
- CI — Control information. All information blocks contain control information. Control information is passed with stream identifiers (SID) and the current status of those streams.
- CBC — Control block information code.
- DF — Data framing control characters. All data information blocks have the data (text or routing information) framed with ASCII control characters.
- ED — Ending delimiter. All blocks must have an ending delimiter which signifies the end of a block.
- CRC — Cyclic redundancy check. All blocks must have a cyclic redundancy check character comprising two 8-bit bytes.

Opening Delimiters

Three types of opening delimiters are used for transmission blocks: There is a type for information blocks, a type for error information blocks, and one for control blocks.



NOTES:
① PATH 1 IS THE IDLE BLOCK
② PATH 2 IS THE α STATUS BLOCK SENT BY THE LCC TO THE REMOTE, OR IT IS THE β STATUS BLOCK RESPONSE SENT BY THE REMOTE TO THE LCC.
③ PATH 3 IS THE β DATA BLOCK SENT BY THE LCC TO THE REMOTE, OR IT IS THE α DATA BLOCK RESPONSE SENT BY THE REMOTE TO THE LCC
④ PATH 4 IS THE REPEAT BLOCK SENT BY THE LCC TO THE REMOTE (ASCII CHARACTER x OR y)
⑤ PATH 5 IS THE NEGATIVE RESPONSE BLOCK SENT BY THE REMOTE TO THE LCC
⑥ XSN= TRANSMISSION SEQUENCE NUMBER (α OR β)
⑦ STAT = STREAM STATUS yy
⑧ PATH 8 IS THE CONTROL BLOCK SENT BY EITHER THE REMOTE OR THE LCC (TWO-WAY ALTERNATE) Z IS THE CHARACTER WHICH DENOTES THIS BLOCK AS A CONTROL BLOCK AND CBCI IS THE RESTART FUNCTION

01708

Figure 4-11. Block Format Train-Graph

Information Block Opening Delimiters

Information block opening delimiters are: DLE, α or β XSN.

DLE — ASCII communication control character referred to as data link escape.

α XSN — Odd/even sequencing number for α type information trades. The LCC transmits the ASCII graphic characters p and q. The remote terminal responds with the ASCII graphics characters 0 and 1. (Refer to figure 4-8.)

β XSN — Odd/even sequencing number for β type information trades. The LCC transmits the ASCII graphic characters 0 and 1. The remote terminal responds with the ASCII graphic characters p and q. (Refer to figure 4-8.)

Error Information Block Opening Delimiters

There are two types of error information block opening delimiters: DLE, REP (α x/β y) and DLE, N.

DLE — ASCII communication control character referred to as data link escape.

REP — ASCII graphic character x in α type information trades and y in β type information trades. This opening delimiter indicates that this block is a repeat block. See line error recovery description.

N — ASCII communications control character referred to as negative acknowledge. This opening delimiter indicates that the last message was not received correctly. See line error recovery description.

Control Block Opening Delimiters

The control block opening delimiters are: DLE, z.

DLE — ASCII communication control character referred to as data link escape.

z — ASCII graphic character lowercase z, which identifies this block as a control block.

Control Information

Control information is comprised of 8-bit bytes referred to as SID (Stream IDentifiers). Each SID contains the current status of a stream, along with its identifier. A SID has the following 8-bit format: P1XXXXYY.

P — Parity of the SID (odd parity).

1 — A flag which indicates that this is a SID (or noncommuncation control character).

XXXX — Stream number of a source/sink path. Even-numbered streams refer to output simplex paths from a source (or buffer) in the HLP to a sink in the remote terminal. Odd-numbered streams refer to input simplex paths from a source in the remote terminal to a sink (or buffer) in the HLP. The maximum stream number is hexadecimal F and the minimum stream number is zero.

YY — Current status of this stream. See table 4-1.

TABLE 4-1. YY BIT ASSIGNMENTS (STREAM STATUS)

CONDITION OF LCC	INPUT STREAM (ODD NUMBER)	YY	OUTPUT STREAM (EVEN NUMBER)
Sending	CTS	00	RTS
	—	01	Data
	—	10	—
	AS	11	AS
Receiving	RTS	00	CTS
	Data	01	Busy
	Source idle	10	Normal termination
	NA	11	AS

CTS — Clear to send. The stream sink is conditioned and ready to receive data from the source.

RTS — Request to send. The stream source wants to send data to the sink.

Data — The stream source is delivering the data (which follows) to the sink.

Idle — The source/sink stream is idle (no activity) and is not yet prepared to send/receive data.

NA — Not available. The source/sink is not available for any activity. Example: Remote terminal sink (such as a printer) is down.

Busy — The stream sink is unable to receive data because it is currently occupied with previous data.

Normal termination — Normal termination of an output stream (ETX block processed). The sink in the remote terminal is prepared to receive more data.

AS — Abort stream. The LCC is terminating the current operations of this stream. Example: The HLP is down, or the HLP has terminated the stream. The remote terminal returns this response when it has terminated an output stream (output file).

Control Block Information Code

The control block information code is made up of 8-bit bytes. The code has the following 8-bit structure: P1XXXXXX.

P	—	Parity of the code
1	—	Indicates that it is a noncommunication control character.
XXXXXX	—	This is the code. (The only defined code is 000001, or restart).

Data Framing Control Character

Data information blocks alone contain a data framing character. This character precedes the data and defines the characteristics of the data characters which follow. The data framing character is the following ASCII control character.

TSTX (DLE, STX)	—	Start of transparent text. This character may denote the end of station control information. It also delimits the start of transparent text (data) in a block. The data characters which follow are 8-bit bytes with no parity.

Ending Delimiters

All blocks must have as an ending delimiter one of the following ASCII control characters:

ETB	—	End of this transmission block. This character, used only on status, idle, or control blocks, implies that additional information blocks or error blocks will follow.
TETB (DLE, ETB)	—	End of transparent text for this transmission block. Additional transparent text for this stream is pending.
TETX (DLE, ETX)	—	End of transparent text for this transmission block and for this stream of data. This sequence is used only on data blocks.

Cyclic Redundancy Check Character

Two cyclic redundancy check (CRC) bytes are accumulated at both the sending and receiving terminals during the transmission of a message to facilitate error detection. They are transmitted following the closing delimiters of blocks.

Following are the rules for determining the value of the accumulated CRC character:

1) The accumulation begins with the first opening delimiter character (DLE) of a block.

2) All characters from the beginning of accumulation through and including the ending delimiter (ETB or ETX) are included in the accumulation, with the exception of the characters listed in paragraph 4.

3) The CRC bytes are transmitted following the ETB or ETX delimiter; then the accumulation is reset and restarted when the opening delimiter of the following transmission block is detected.

4) The following characters are excluded from the accumulation:

   - SYN characters (synchronization characters detected after the opening delimiter and before the TSTX).
   - TSYN characters (DLE, SYN) detected after the opening delimiter.
   - One DLE character from the DLE sequences detected in the transparent text. All control characters use bit 8 for character parity. However, transparent text uses bit 8 for data, thus providing 256 possible bit-combinations in each byte. The data link escape (DLE) character introduces the transparent text transmission and subsequently distinguishes the control characters that are in the bit stream.

     Within the transparent text, control characters are recognized as such only when immediately preceded by a DLE character. The transmitting terminal monitors the data stream and inserts another DLE character immediately preceding each DLE character to be transmitted. The receiving terminal then interprets the DLE, DLE character as a single DLE character; i.e., the receiving terminal drops one DLE and looks for a control character immediately following the remaining DLE character.

BLOCK COMPOSITION

Each variation of block type has a unique combination of the previously specified fields. See figures 4-12, 4-13, and 4-14 for examples of these combinations in an information flow.

Information Blocks

Data Blocks: OD, CI, DF, (Data), ED, and CRC

OD — DLE, α or β XSN (0, 1, p, q)

CI — One SID only with YY status equal to data

DF — TSTX (DLE, STX)

ED — Ending delimiter characters (DLE, ETB) or (DLE, ETX)

CRC

Status Blocks: OD, CI, ED, and CRC

OD — DLE, α or β XSN

CI — A variable number of SIDs

Example:	S	S	S	S	S	S	S
	I	I	I	I	I	I	I
	D	D	D	D	D	D...	D
	0	1	3	4	5	8	N
	RTS	CTS	CTS	RTS	IDLE	RTS	-

ED — ETB

CRC

Idle Block: OD, ED, and CRC

OD — DLE, α or β XSN

ED — ETB

CRC

Control Block

Restart Block: OD, CBC, ED, CRC

OD — DLE, z

CBC — 11000001_2

ED — ETB

CRC

Error Information Blocks

Repeat Blocks: OD, ED, and CRC

OD — DLE, α REP (x) or DLE, β REP (y)

ED — ETB

CRC

Negative Response Blocks: OD, ED, and CRC

OD — DLE, N

ED — ETB

CRC

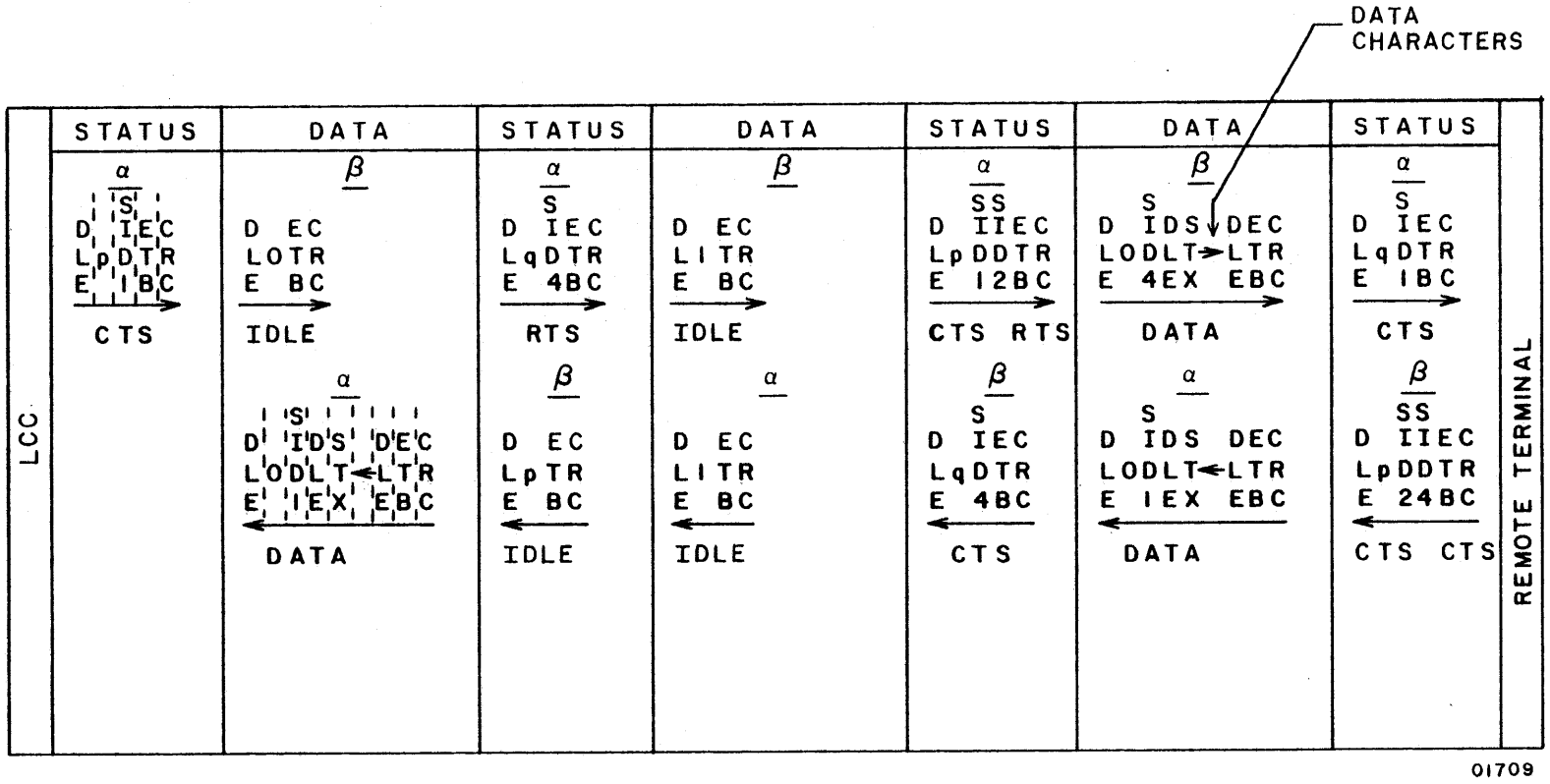


Figure 4-12. Data, Status, and Idle Blocks

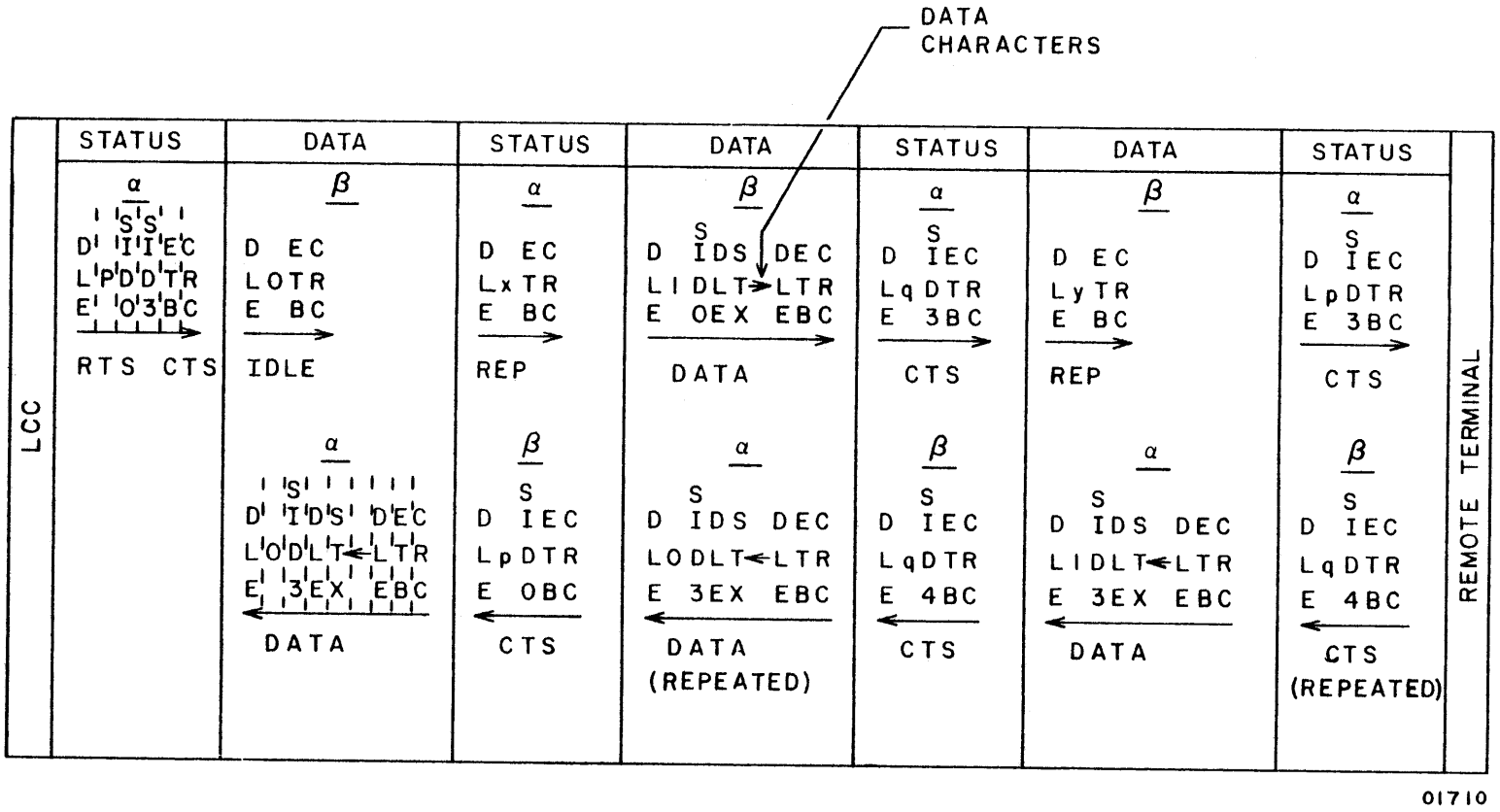


Figure 4-13. Data, Status, Idle, and REP Blocks

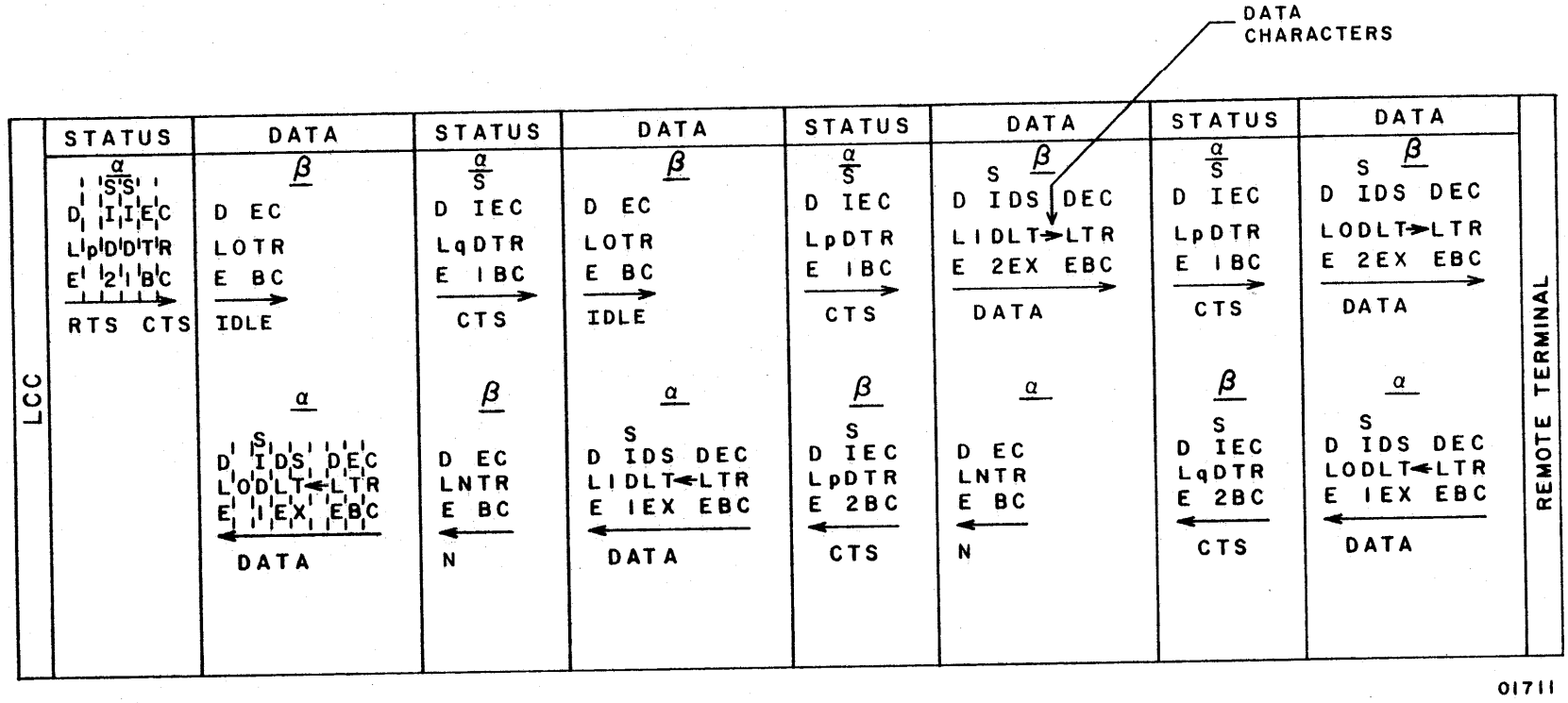


Figure 4-14. Data, Status, Idle, and NEG Blocks

ERROR RECOVERY

The next paragraphs describe the error-recovery procedures used by the LCC.

TRANSMISSION LINE ERROR RECOVERY

If the LCC detects an error condition in an α or β block, it initiates error-recovery procedures for that block a maximum of n times (n is defined at assembly time). When recovery procedures have been executed n times, the HLP exercises the DSA to determine whether the error was caused locally, etc. A nonrecoverable error causes the LCC to close the communication line and terminate all requests abnormally.

The conditions which initiate recovery procedures are listed in table 4-2.

TABLE 4-2. LINE ERROR-RECOVERY CONDITIONS AND ACTIONS

CONDITION CAUSING RECOVERY	RECOVERY ACTION
Timeout — LCC does not receive a valid response block for an α or β transmission within the allowed time frame.	The LCC retransmits the last α or β block.
Incorrect Parity — LCC receives a response block which has a control character parity error or CRC error.	LCC sends an α or β message which requests a repeat transmission of the last α or β block.
Negative Response (NAK) — The remote terminal sent a response to the LCC which indicates that it detected a control character parity error or CRC error.	LCC retransmits the last α or β block.
Improper Sequence — The LCC does not receive the expected α or β numbered response. However, parity and CRC are correct.	LCC retransmits the last α or β block.

BLOCK ERROR-RECOVERY RESPONSES

The LCC initiates a timeout feature of n milliseconds after a transmission block (the value n is set by the HLP at system initialization via a configuration definition request). If the value n is reached before a valid response is received from the remote terminal, the LCC initiates a line error-recovery procedure.

The remote terminal receives transmission blocks from the LCC in one of the following three conditions:

1) Valid and Correct. A valid and correct transmission block is one that has no character parity error or CRC error.

2) Valid and Incorrect. A valid and incorrect transmission block is one that has a character parity error or a CRC error.

3) Invalid. An invalid transmission block is one whose opening delimiter (DLE, α or β XSN) and closing delimiter (ETB/ETX) are not recognized as being in a proper format.

A response to a transmission block depends on the condition and content of the block as shown in table 4-3. Figures 4-15 through 4-20 show (graphically) information flow and line error recovery.

TABLE 4-3. RESPONSES TO TRANSMISSION BLOCKS

RECIPIENT	RECEIVES	RESPONDS WITH
Remote Terminal	1) Valid and correct block with:	
	a) Data or status block in proper sequence	a) A new data or status block with an updated sequence number; the responding block number is the expected block number
	b) Data or status block in improper sequence	b) A repetition of the last correct information block, if the corresponding block number is not correct
	c) Repeat request block (REP)	c) A repetition of the last correct information block
	2) Valid and incorrect block	2) DLE, NEG, ETB, CRC
	3) Invalid block	3) No response
LCC	1) Valid and correct block with:	
	a) Data or status block in proper sequence	a) A new data or status block with an updated sequence number
	b) Data or status block in improper sequence	b) A retransmission of the last correct information block
	c) Negative response (NEG)	c) A retransmission of the last correct information block
	2) Valid and incorrect block	2) A repeat block (DLE, REP, ETB, CRC)
	3) Invalid block or no response	3) A timeout and the last correct data or status block.

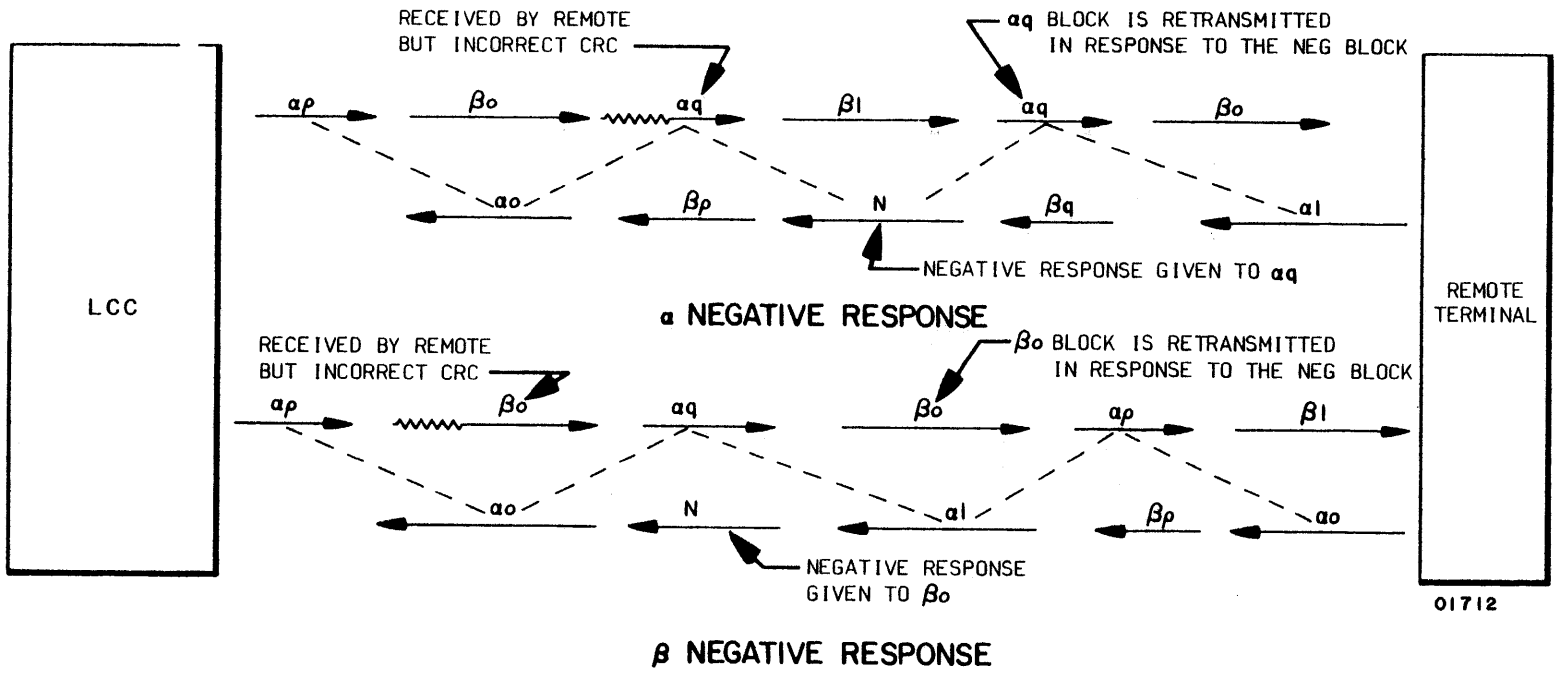


Figure 4-15. Error Recovery Information Flow
(α/β Valid and Incorrect Blocks with Negative Response)

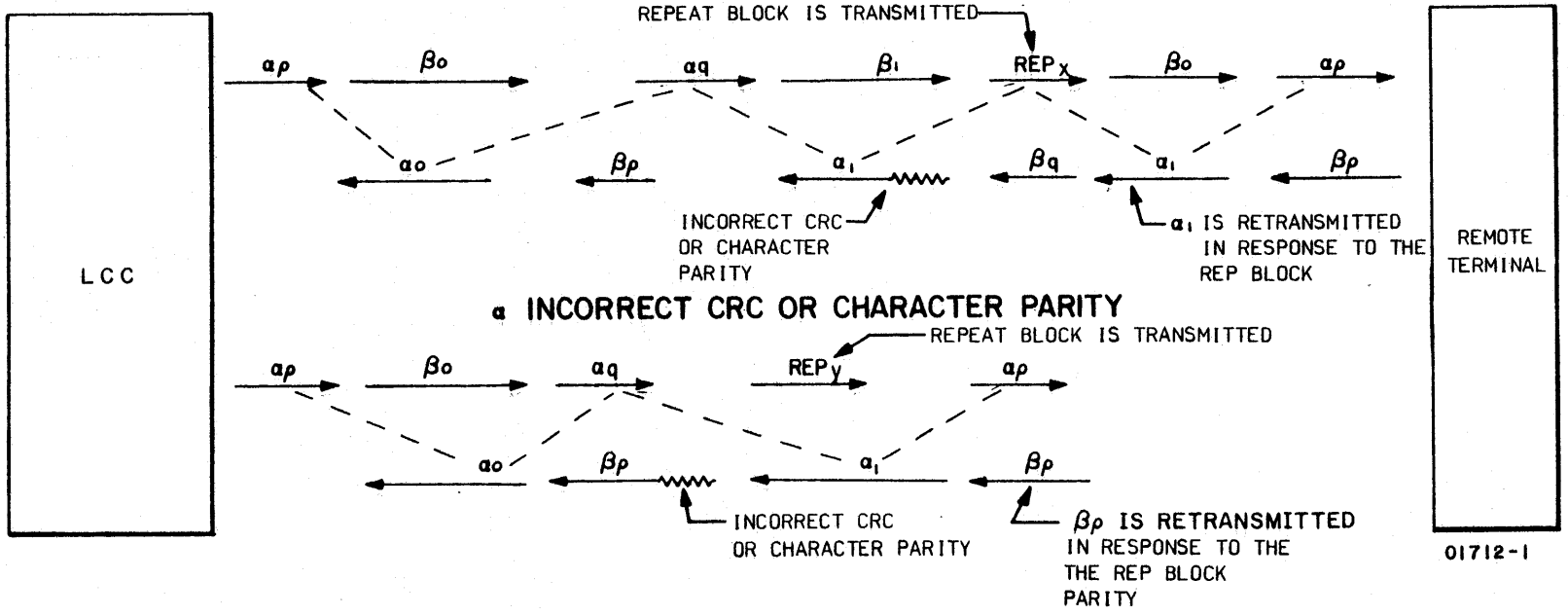


Figure 4-16. Error Recovery Information Flow
(α/β Valid and Incorrect Blocks with Repeat Response)

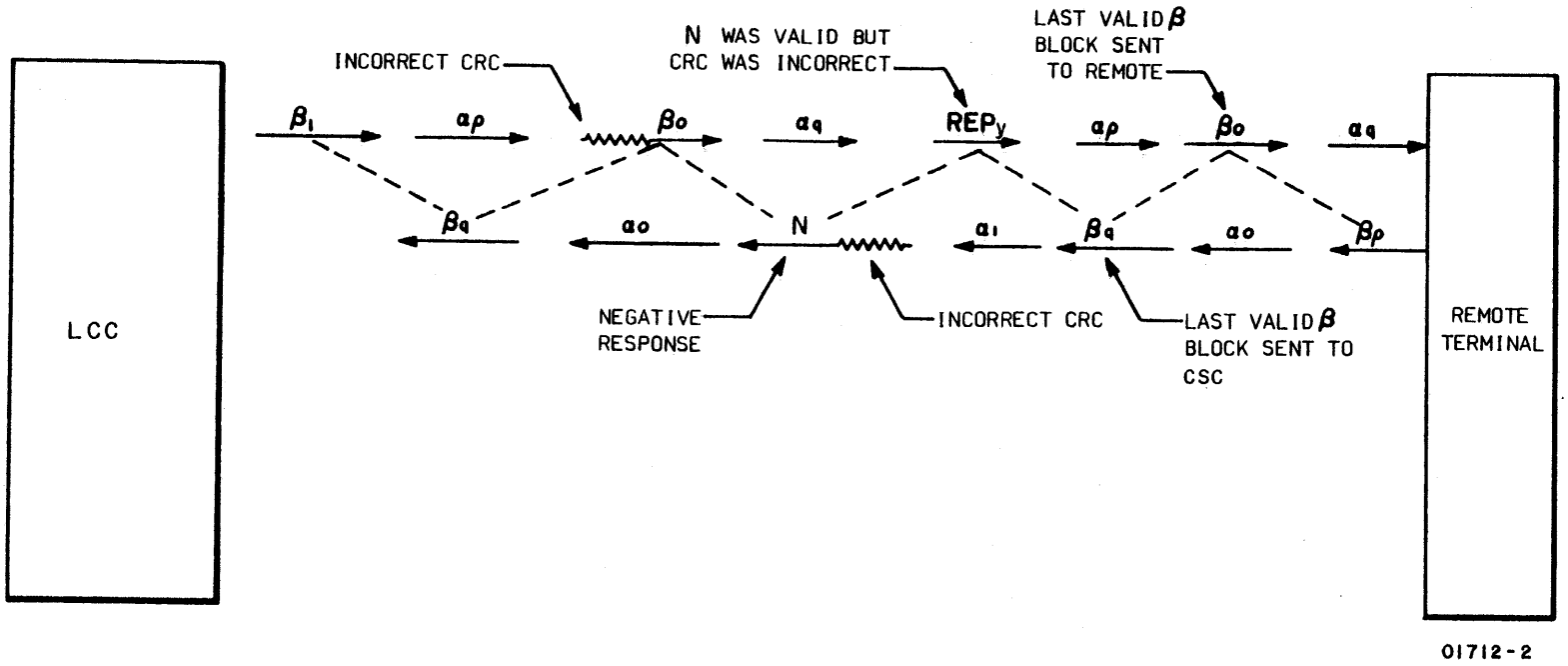


Figure 4-17. Error Recovery Information Flow
(Valid and Incorrect Blocks with Negative and Repeat Responses)

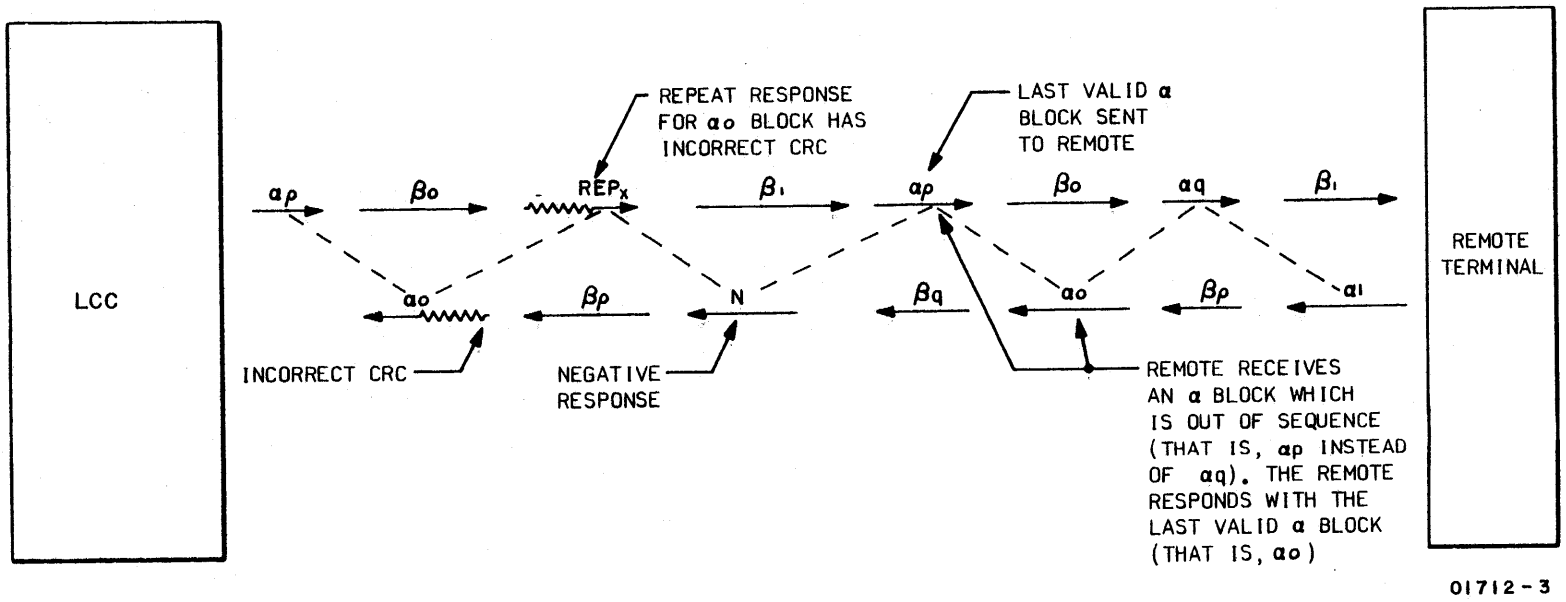


Figure 4-18. Error Recovery Information Flow
(Valid and Incorrect Block with Negative Response and Out of Sequence)

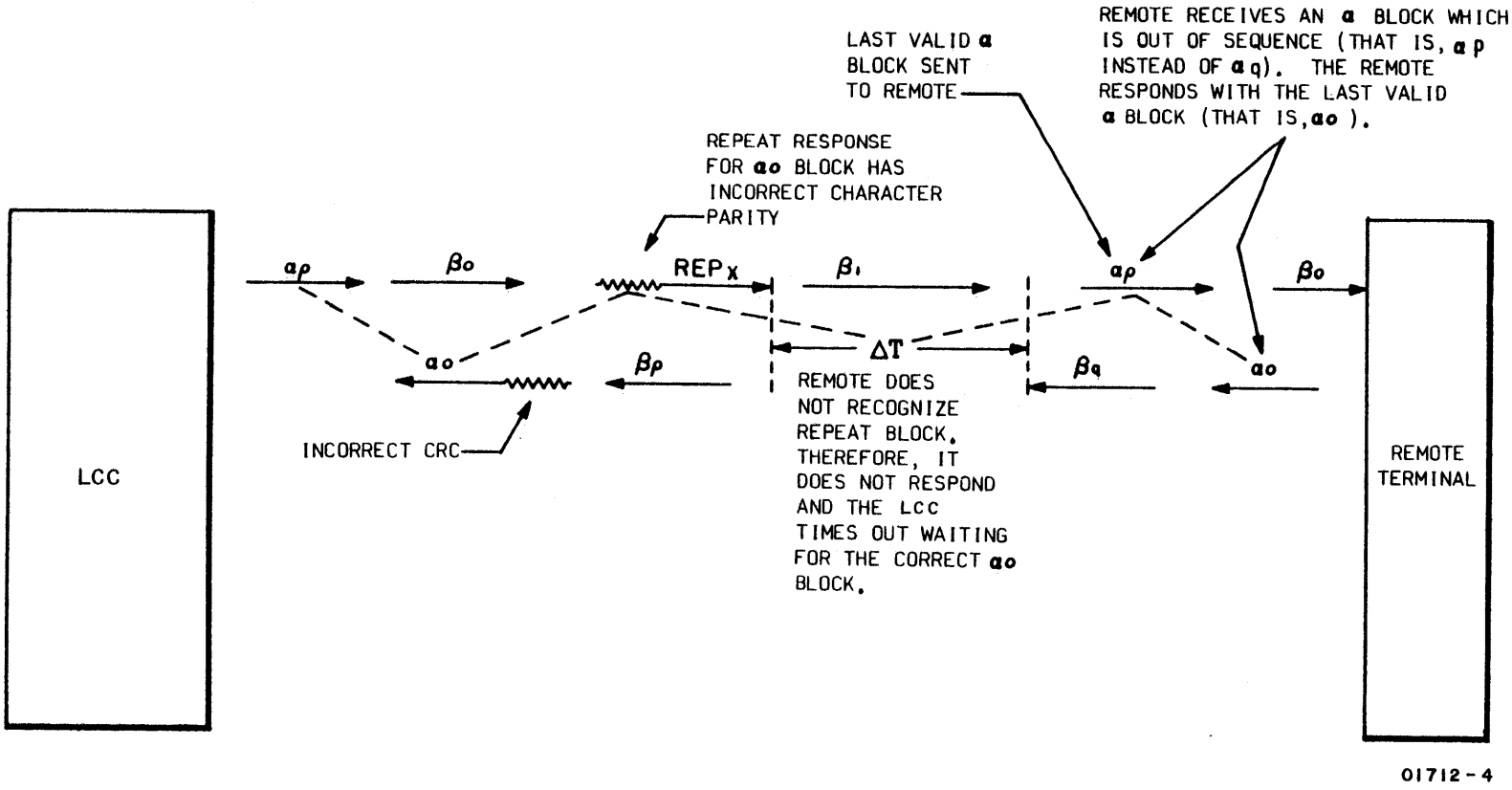
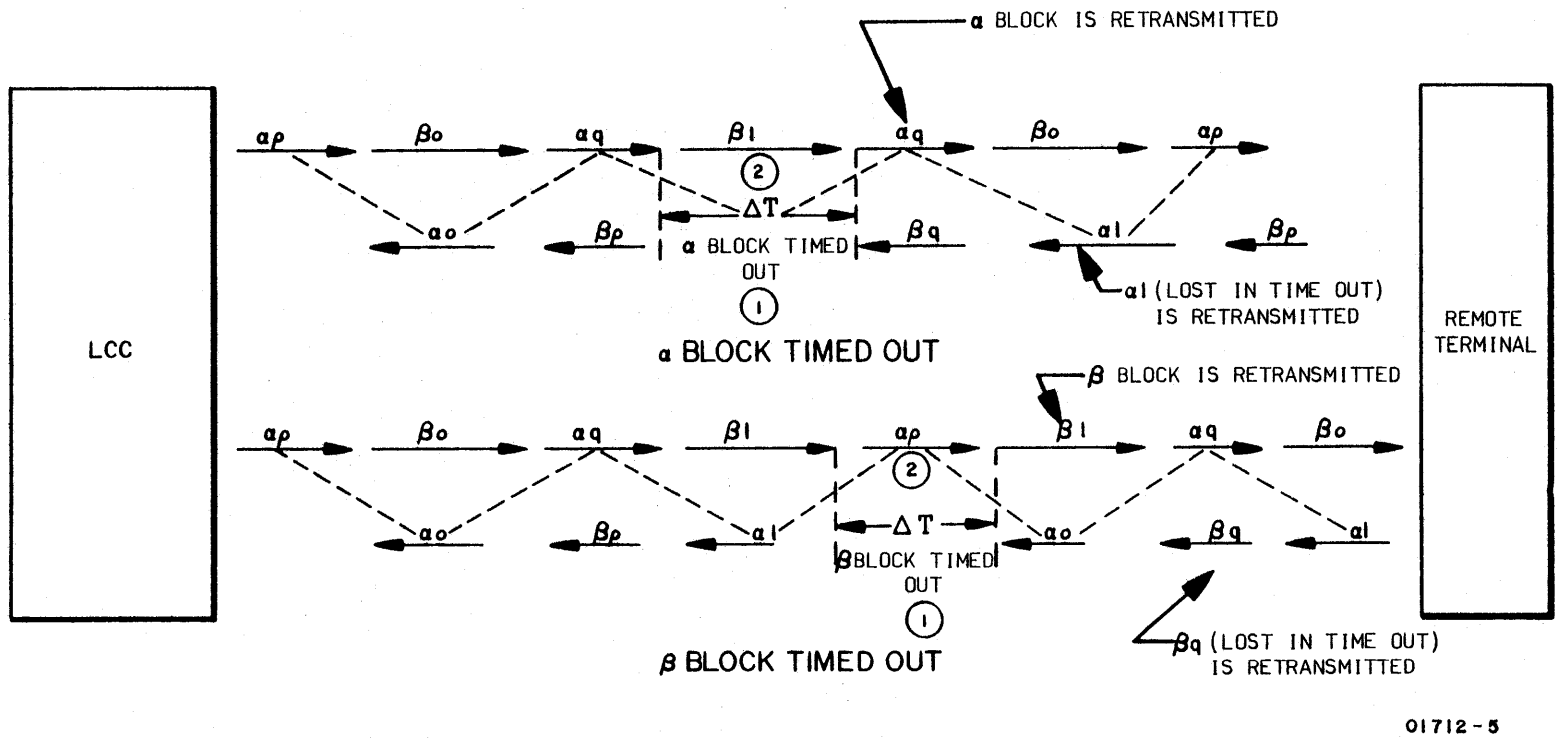


Figure 4-19. Error Recovery Information Flow
(Valid and Incorrect Block with Repeat Response and Invalid or No Response Block with Time Out)



NOTES: (1) "TIMED OUT" MEANS THAT THE TIME ALLOTTED TRANSMIT AN α/β BLOCK HAS ELAPSED AND A VALID TRANSMISSION HAS NOT OCCURRED
(2) THE VALUE OF ΔT IS ESTABLISHED AT ASSEMBLY TIME

Figure 4-20. Error Recovery Information Flow (α/β Invalid or No Response Blocks with Time Out)

MODE 2 INTERFACE LISTS

The remainder of this section provides details concerning the Mode 2 interface lists which reside in the HLP. (These are the tables through which the HLP and the LCC communicate.) Figure 4-21 provides an overview of this material.

CHANNEL FLAG

The channel flag is set by the HLP to inform the LCC to do one of the following functions:

- Activate one or more lines
- Close a line that is presently in an idle poll state

The LCC clears the channel flag, sends responses to the HLP indicating that the lines have been activated, etc., and sends a response notifying the HLP that the channel flag has been cleared.

LINE LIST

The line list, with an entry slot for every line in the system, resides in the HLP. Each line number corresponds to a particular CA port; that is, line 0 corresponds to port CA01, line 1 corresponds to port CA02, etc. When the channel flag is set by the HLP, the LCC reads entries from the line list for those lines that are currently inactive (closed). If the entry is negative, there is no new activity for the line; if the entry is positive, however, the line list contains a 32-bit base address of the request list for this line.

REQUEST LIST

Once the base address of the request list is read into the LCC, it remains there until the associated line is closed. Periodic references to the request lists are made by the LCC to determine whether a new request has been entered. As each request is completed (normally or abnormally), a response is sent to the HLP.

The request list for each Mode 2 line has two types of entry slots. The first entry slot of each list is dedicated to requests for communication between the HLP and the LCC. The second and all succeeding entry slots are dedicated to "streams." A "stream" is the simplex flow of data from one point to another, that is, from a source to a sink, and the request list must have as many stream entries as the maximum number of streams allocated for that line. The maximum number of streams that can be allocated for a given line is 16 (8 input streams and 8 output streams). Even-numbered streams, from 0 through 8 and hexadecimal A through E, are used for output data from the HLP. Odd-numbered streams, from 1 through 9 and hexadecimal B through F, are used for input data from sources at the remote terminal.

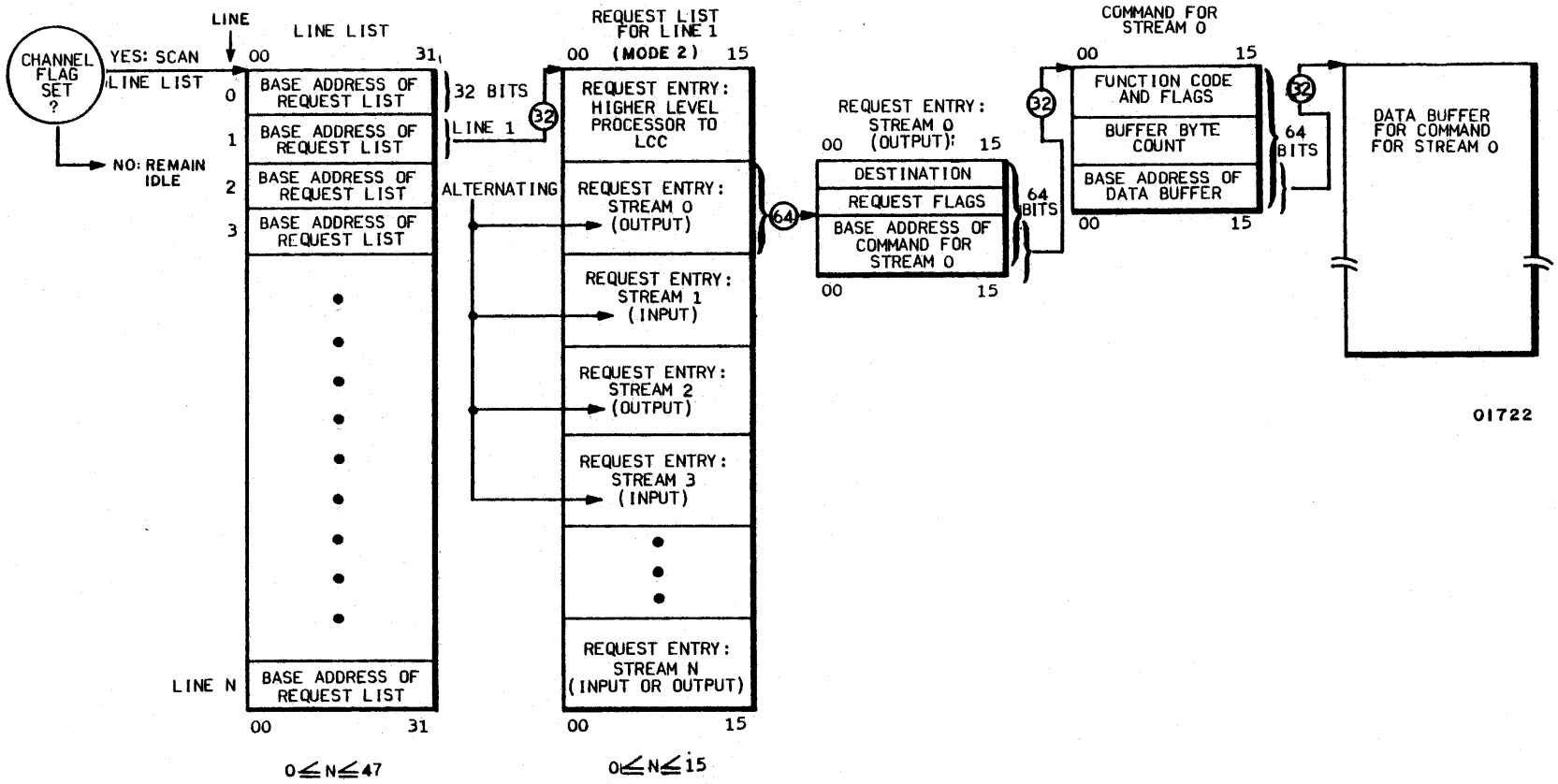


Figure 4-21. Interface Lists Resident in the Higher Level Processor

NOTE

Stream entries in the request list must be consecutive (see following example).

If the high-speed batch terminal on line 1 consists of a crt keyboard display, a card reader, a card punch, and three line printers, then a total of 10 streams would have to be allocated for that line although the terminal has no input devices (sources) corresponding to two of the odd-numbered streams (7 and 9). Note that streams 0 and 1 are used for station control.

Stream (Hex)	Device
0	Station Control
1	Station Control
2	CRT
3	Keyboard
4	Line Printer 1
5	Card Reader 1
6	Line Printer 2
7	--
8	Card Punch 1
9	--
A	Line Printer 3
B through F	--

MULTISTREAM ACTIVITY

For Mode 2 operation, the LCC monitors the transmission of several streams on a time-shared basis over a communication line to a remote terminal (see figure 4-22). The following example illustrates multistream activity: Assume that the HLP has a buffer of data ready for transmission to the device served by stream 2 and another buffer of data ready to be sent to the device served by stream 8. In the preceding example, stream 2 serves the crt, and stream 8 serves the card punch at the remote terminal. (The terminal defines which streams serve the various terminal devices.)

The HLP initiates the data output by placing the data for streams 2 and 8 in separate data buffers in the 7077-1 Communications Station (where the buffer sizes are specified by the HLP). If the associated devices at the remote terminal are ready to receive data, the LCC loads the first eight characters for each of these buffers into two "stream buffers" from which it will output the characters one at a time in designated

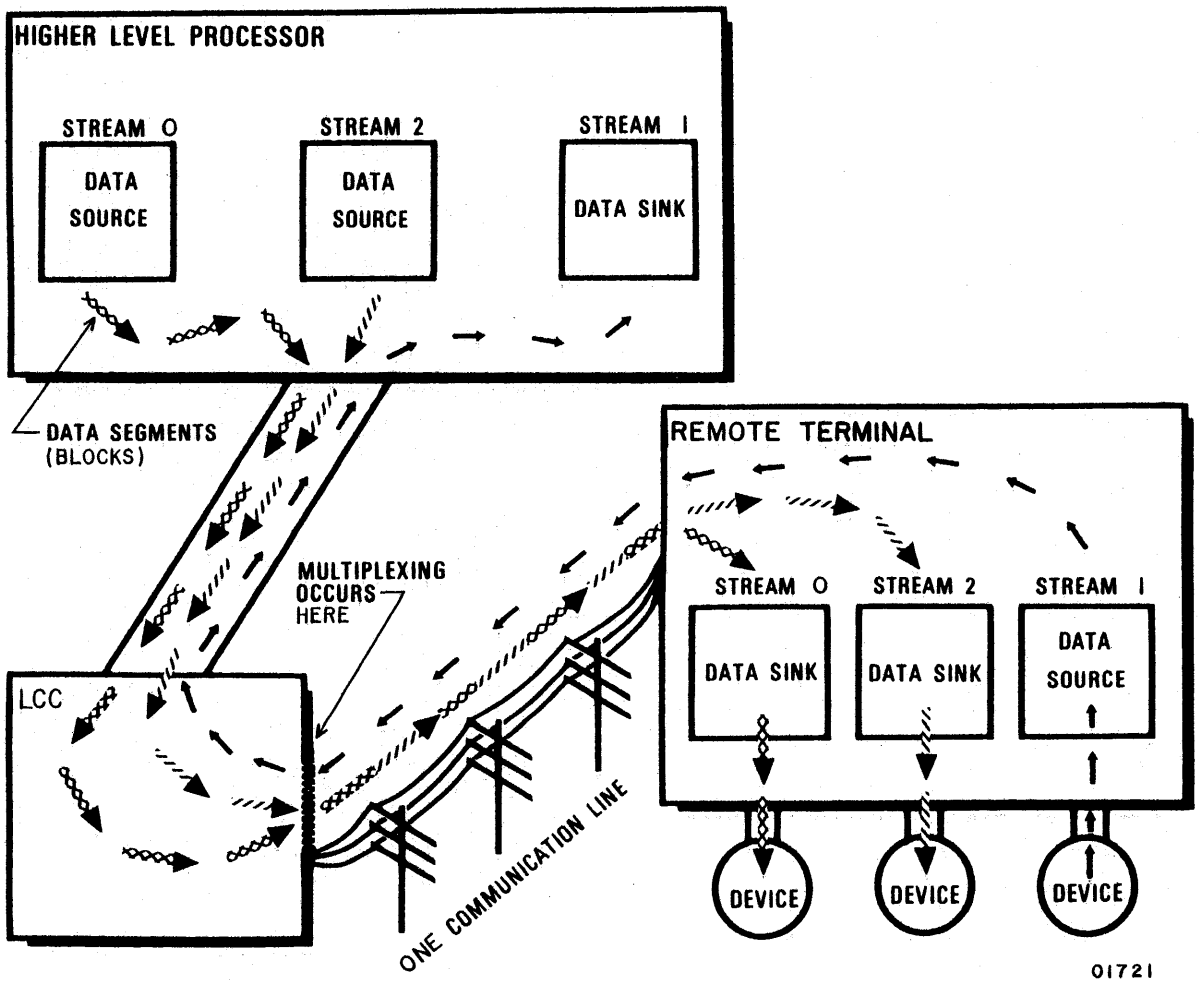


Figure 4-22. Multistream Activity

blocks (64-character blocks are commonly used for high-speed batch terminals) to the remote terminal. These are actually two-section buffers, and when the fourth character leaves a buffer, the LCC will begin to load the next four characters from the communications station. The blocks of data for streams 2 and 8 will be interleaved on the communications lines and will continue across the lines until either the message ends or the associated buffer at the remote terminal is filled. In the latter case, the LCC will await a CTS (clear to send) from the terminal before sending additional data for that stream. While these output operations are being performed, the LCC can also be receiving data from the terminal keyboard and card reader via odd-numbered streams 3 and 5.

Following is the format for the request entries used in Mode 2 protocol. Figure 4-23 and table 4-4 show and describe the fields in these two 32-bit words which are placed in the HLP-to-LCC and the HLP-to-Stream slots in the Mode 2 request table.

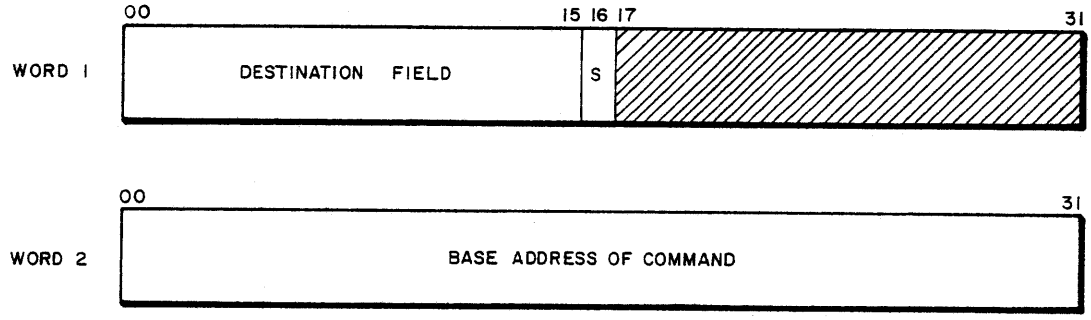


Figure 4-23. Request Entry Format

TABLE 4-4. REQUEST ENTRY FIELDS

WORD	BIT(S)	DESCRIPTION
1	00-15	Destination Field: Stream and line numbers; supplied by the HLP and returned in the solicited response.
1	16	S Field (status of this request slot): 1 - This request is ready for initiation. (The HLP sets this bit when it places the request on the request list.) 0 - The LCC clears this bit when it initiates this request; therefore, a 0 indicates that this request is either active or has been completed.
1	17-31	Filled with zeros.
2	00-31	Base Address of Command: Location of associated command in command list; supplied by HLP and returned in solicited response.

COMMANDS

Commands, 64 bits in length, supply the LCC with detailed information necessary for proper execution of a request. One command is issued by the HLP for each request.

Commands for streams direct two types of executable functions — read (or input data from the selected device), and write (or output data to the selected device). Odd-numbered streams always read data, and even-numbered streams always write data. Input stream read requests are not accepted by the LCC unless an unsolicited request to send (RTS) has been received from the remote terminal.

For Mode 2 operation, the data buffers should be some multiple of the transmission block size for a stream. (This is assured by keeping the transmission block size relatively small — commonly either 64 or 128 bytes.) Only the last block of an input/output message is permitted to be smaller than the stated block size. On receiving such a block, the LCC terminates the request and indicates the actual number of bytes received from the remote terminal.

NOTE

When the write function on an output stream reflects an end of message, or a received block on an input stream contains an ETX, the request is terminated as "correctly completed with ETX." Also, on input streams, if a buffer is filled and an ETB is received, the request is terminated and the HLP receives a response from the LCC with an implied unsolicited response which states that the remote terminal has additional data for this file.

HLP to LCC Commands

The format of commands from the HLP to the LCC is shown in figure 4-24; and the commands are defined in table 4-5.

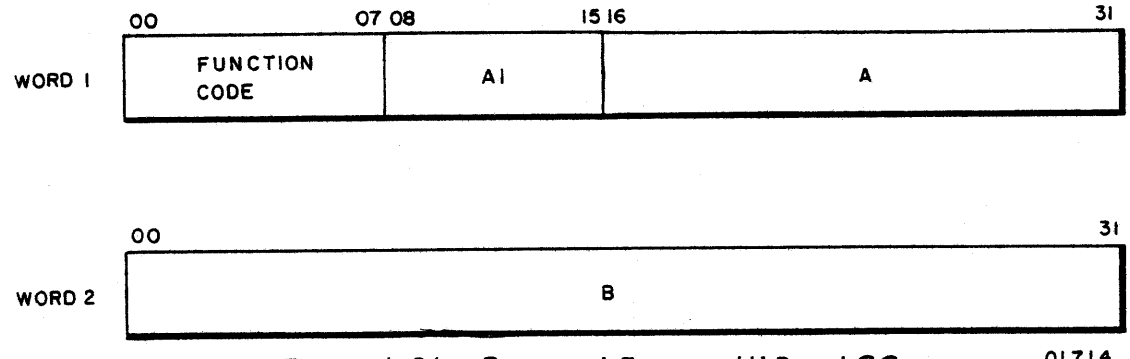


Figure 4-24. Command Format, HLP to LCC

TABLE 4-5. COMMANDS, HLP TO LCC

FUNCTION CODE (HEX)	DESCRIPTION
F1	Close Line: Terminate all outstanding stream requests to this line. Responses reflect an abnormal termination since this is a requested action. The LCC scans each entry in the line request queue before writing the completion response to this request. New requests are terminated abnormally. All references to this line are eliminated and the line is considered inactive when all entries are scanned.
F2	Terminate the Active Request on Stream x defined in Field A: Field A is the input or output stream number. The line returns to an idle state. A normal response is given for successful completion of this request. The LCC is in one of three states with the defined stream when a "terminate the active request on stream x" command is issued. 1) The LCC has processed and is executing a stream request for the defined stream. The LCC terminates that request and sends an abnormal termination response to the HLP. The byte count in the response reflects the number of bytes successfully received/transmitted. 2) The LCC does not have a stream request in storage for the defined stream. However, internal flags infer that implied RTS or CTS blocks have been traded with the remote terminal. The LCC clears all internal flags and sends an abnormal termination response to the HLP. 3) The LCC does not have a stream request in its storage area nor does it have internal flags for the defined stream. An abnormal termination response is sent to the HLP. The LCC transmits an abort stream SID to the remote terminal for all three states.
F5	Configuration Definition for Line x: This request should be issued at open-line time only. If it is issued at other times, the result cannot be determined. This request defines the Timeout Type (bits 13-15 of field B) and the maximum number of streams for this line (bits 27-31). The Timeout Type is an index that points to a table entry describing the timeout duration and implying the line speed and type of terminal supported on this line. The table entries are constant: Index 0 = 180-millisecond timeout (for high-speed line) Index 1 = 90-millisecond timeout (for low- or medium-speed line) Indexes 2 through 7 are not defined.

Stream Commands

The format of commands for streams is shown in figure 4-25; the commands are defined in table 4-6.

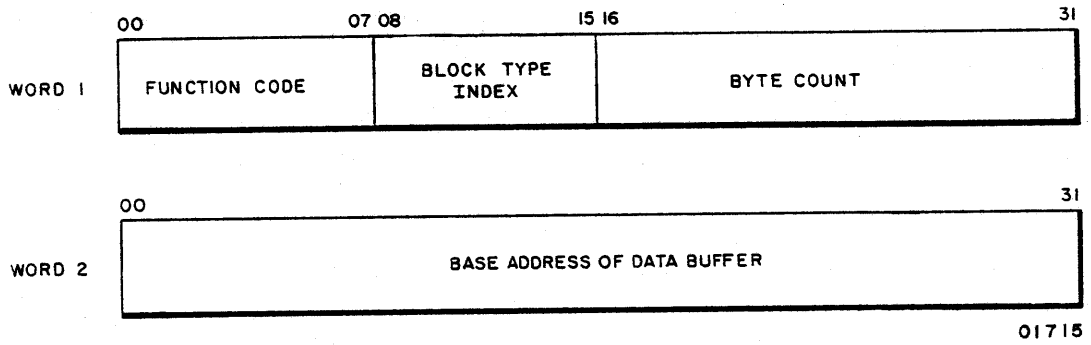


Figure 4-25. Command Format, Stream

TABLE 4-6. COMMANDS FOR STREAMS

WORD	BIT(S)	FUNCTION CODE (HEX)	DESCRIPTION
1	00-07	00	Read: The LCC stores, in the data buffer, the data it receives from the line and stream (defined in the request).
		80	Write transparent text with ETB (more data to follow).
		81	Write transparent text with ETX (end of message).
1	08-15		Block Type Index: An index (ranging from 00-07) for a table containing block byte counts (see following blocked data buffer example). The index points to the entry in the table depicting the block size for a particular stream. The entries in the table are constant.
			Index / Bytes/Block: 00 Byte Count; 01 64; 02 128; 03 256; 04 512; 05 640; 06 768; 07 996
1	16-31		Byte Count: This field specifies the total number of 8-bit bytes to be processed (read or write) from the data buffer (see following block data buffer example). Used by all function codes.
2	00-31		Base Address of Data Buffer: Used by all function codes — the source (for a write) or destination (for a read) of the data to be processed.

Figure 4-26 shows an example of a blocked data buffer designated by the block type index and byte count fields of word 1 of the commands for streams format. Assuming the block type index field equals hexadecimal 01 and the byte count field equals hexadecimal 00C8, each full block contains 64 bytes and a total of 200 bytes is to be processed.

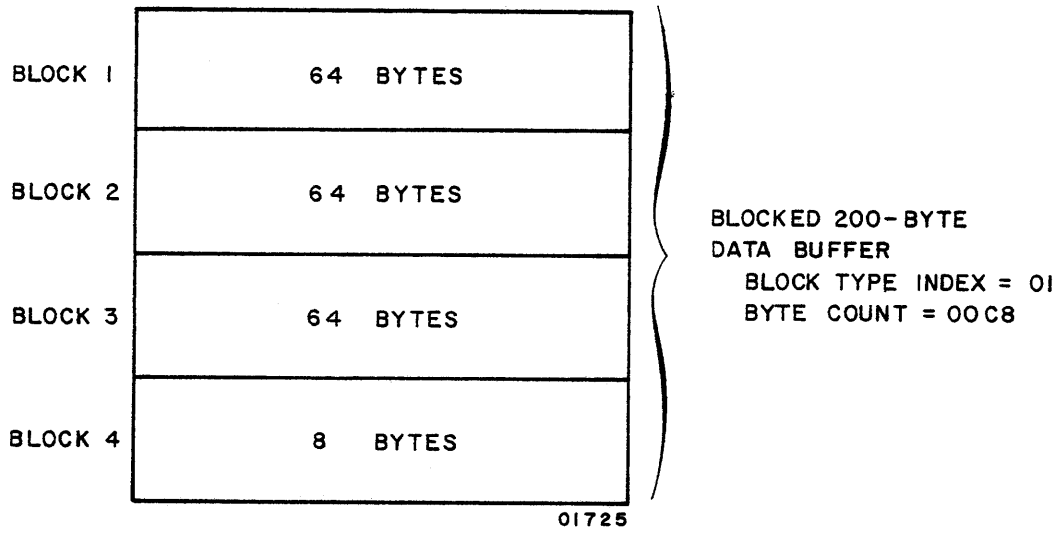


Figure 4-26. Blocked Data Buffer Example

RESPONSE LIST

The response list, shown in figure 4-27, is resident in the HLP memory. The LCC informs the HLP of current requests, commands, and the status of the system by updating the response list. There are two types of responses — solicited and unsolicited. Solicited responses are the result of an HLP request. Unsolicited responses are the result of unexpected stream or system condition(s). Examples of unsolicited responses are:

- The remote terminal input stream requests to send data to the LCC.
- The LCC storage threshold is exceeded.
- Unique stream status bits are received.
- The CA exerciser and its status are in this response.

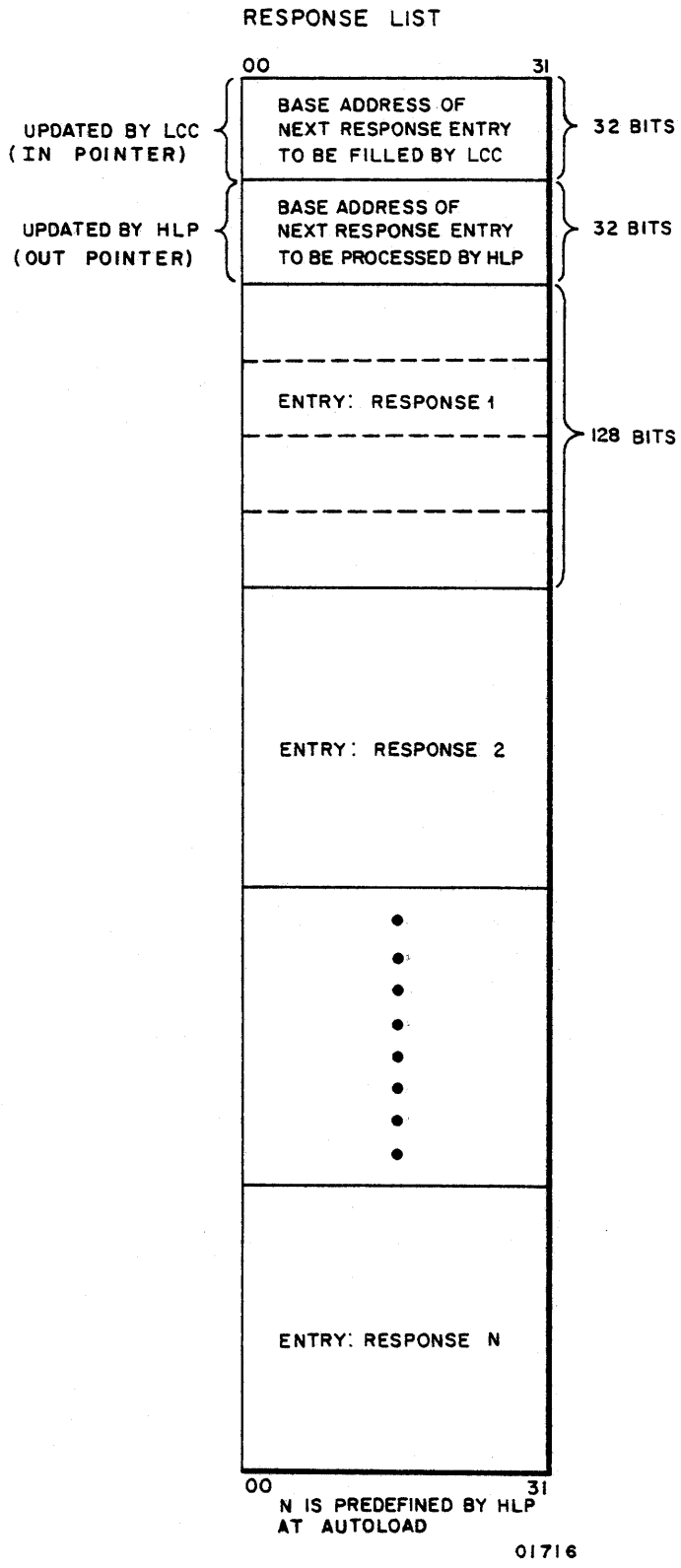


Figure 4-27. Response List in 7077-1 SAC CSM Memory

Response Entry Formats

All response entries from the LCC to the HLP are 128 bits in length (eight 16-bit words in the LCC, which are converted to four 32-bit words in the 7077-1 SAC CSM memory); refer to figure 4-27. Solicited responses provide the HLP with information concerning a previous HLP request, and unsolicited responses generally provide information upon which the HLP must take some necessary action. The four response entry formats are shown in figure 4-28 through 4-31, and the field definitions are listed in table 4-7.

Format 1

Response format 1, for normal unsolicited responses (figure 4-28), contains merely the response code, the number of the line (and, if necessary, also the number of the stream) from which the response originates. This response may also contain a log bit and/or an interrupt bit.

Format 2

Response format 2, for normal solicited responses (figure 4-29), contains the response code, a destination field supplied by the HLP, and the base address of the command (also supplied by the HLP). The destination field here is actually identical to the "stream/line" word used in response format 1. The command referenced here is in the command list in the SAC CSM memory.

Format 3

Response format 3, for normal solicited responses to stream requests (figure 4-30), is similar to response format 2. Also included in this response are the following fields:

- Retransmit Count field showing the number of error-recovery attempts on the last block
- Byte Count field showing the number of 8-bit bytes received/stored in the data buffer
- Line Status field (refer to Field B of format 4)

Format 4

Response format 4, for abnormal unsolicited responses (figure 4-31), contains the response code, the line number, four special fields (A through D), a log bit, and may contain an interrupt bit. Only the following two response codes use format 4:

- Code 44 — line errored out
- Code 45 — intermittent SAC problem

Of the four special fields, response code 45 uses only field A (number of intermittent SAC rejects in this pass) and response code 44 uses only fields B, C, and D. Definitions of these special fields follow:

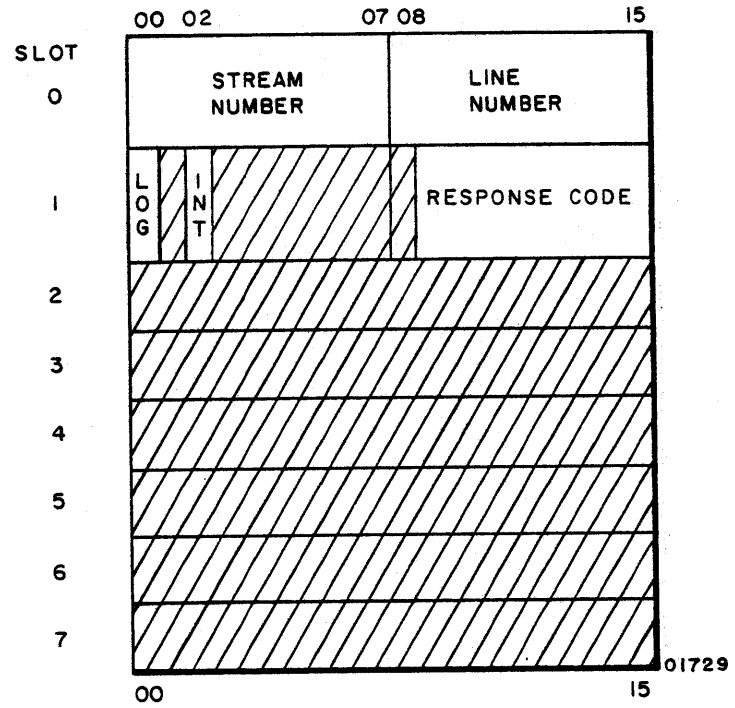


Figure 4-28. Normal Unsolicited Response - Format 1

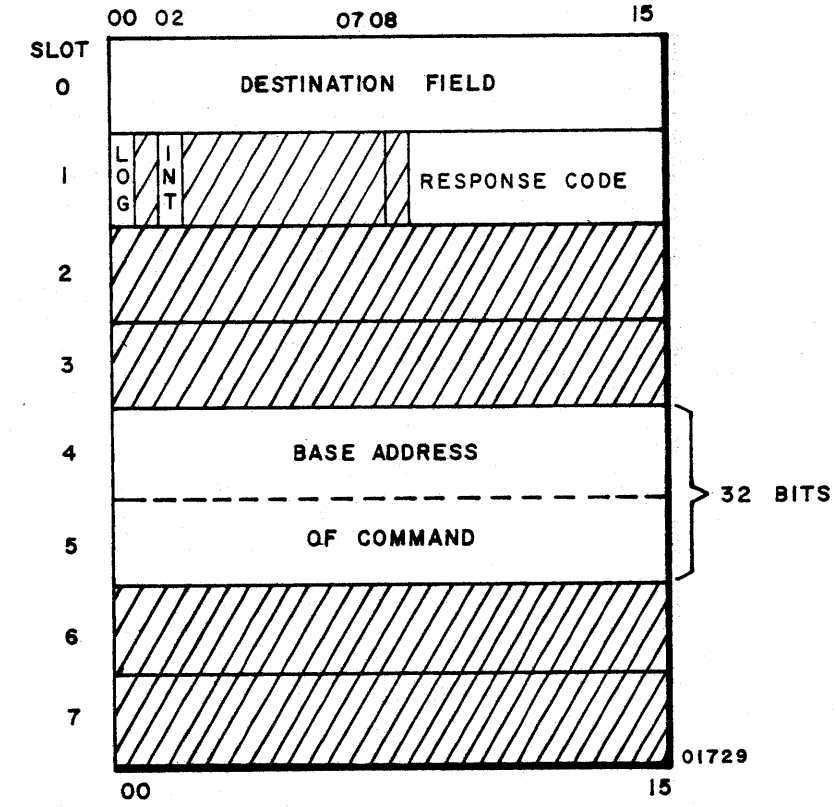


Figure 4-29. Normal Solicited Response to HLP/LCC Request and to Illegally Formatted Requests - Format 2

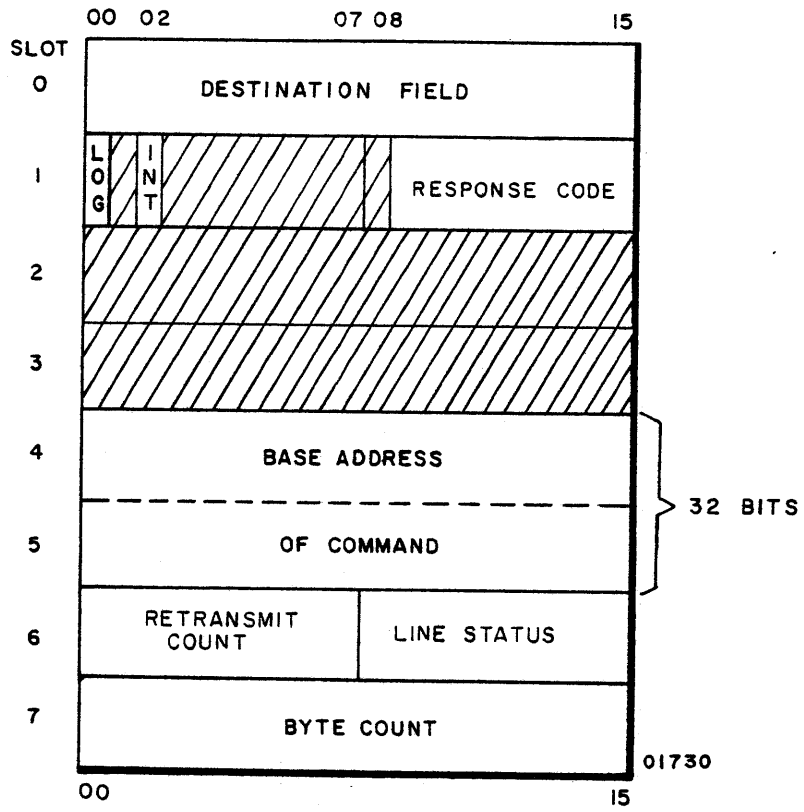


Figure 4-30. Normal Solicited Response to a Stream Request - Format 3

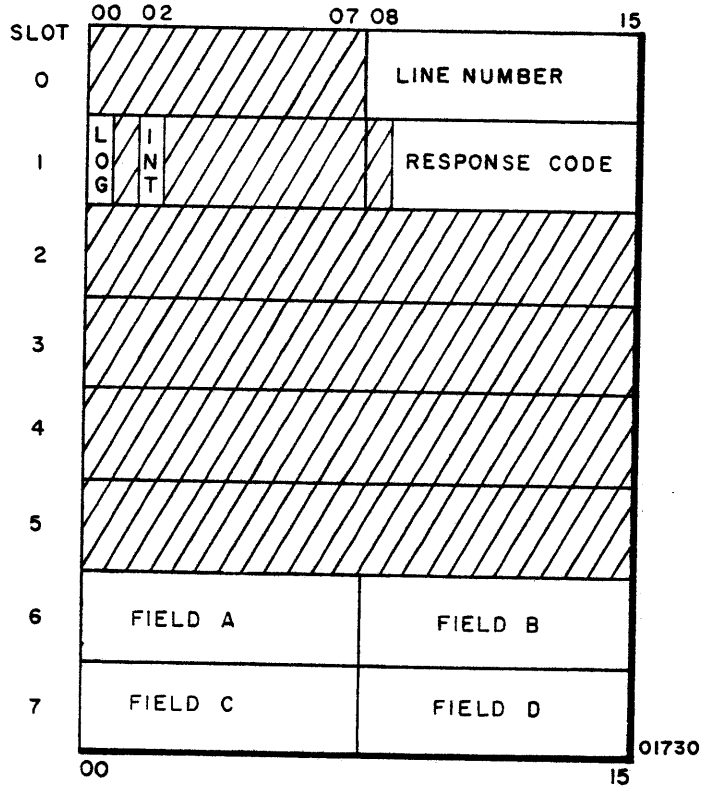


Figure 4-31. Abnormal Unsolicited Response - Format 4

TABLE 4-7. RESPONSE ENTRY FIELD DEFINITIONS

FIELD	FORMAT	DEFINITION
Stream Number	1	Source of unsolicited response
Line Number	1, 4	Vehicle for unsolicited response
Log	All	A flag indicating that specific conditions should be logged on an error file
Interrupt	All	Interrupt flag, active when a logical 1
Response Code	All	A 7-bit code indicating conditions at the LCC and/or action required
Base Address of Command	2, 3	Supplied by HLP in request entry for solicited response
Destination Field	2, 3	Supplied by HLP in request entry for solicited response
Retransmit Count	3	Number of error-recovery attempts on previous block
Line Status	3	An 8-bit field indicating line status
Byte Count	3	Number of 8-bit bytes received/stored in data buffer
Field A	4	Number of intermittent SAC rejects in this pass (used only in response code 45)
Field B	4	An 8-bit field indicating line status (same as Line Status field in format 3)
Field C	4	Results of CA exercise (data set loop results — used only in response code 44)
Field D	4	Carrier on/off status (used only in response code 44)

Field B: This field consists of eight bits designated B, S, C, NE, N, NA, SAC, and TO which describe line status as shown in figure 4-32. This field configuration also is used in format 3 where it is defined as the Line Status field.

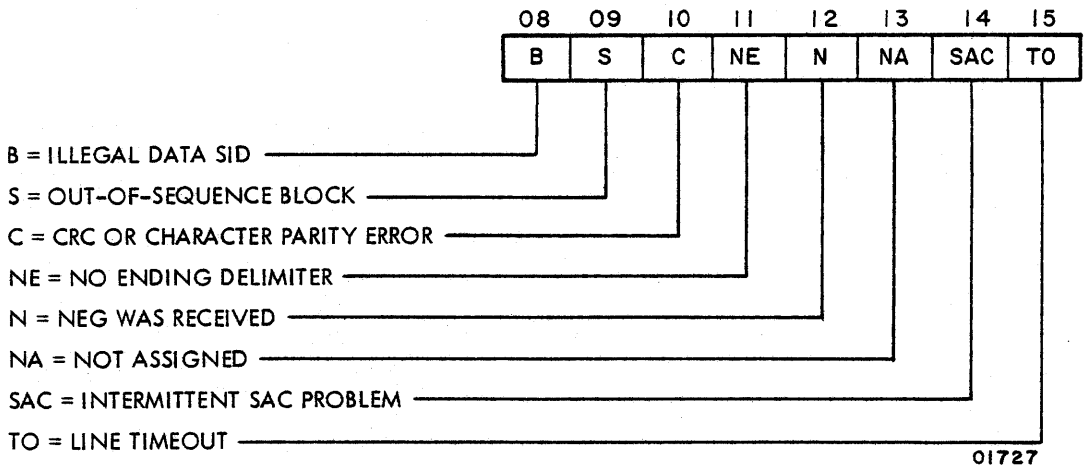


Figure 4-32. Line Status (Field B) Bit Assignments

Field C: This field provides results of the communications adapter loop test exercise. When this field is equal to zero, the loop test was successful. When this field is nonzero, it indicates the (binary) number of times the loop test was attempted.

Field D: This field provides carrier on/off status and data set ready/not ready status, as follows:

00 - Carrier is on and data set is ready
01 - Carrier is on but data set is not ready
02 - Carrier is not on and data set is ready
03 - Carrier is not on and data set is not ready

Response Code Word

The response code word (in slot 1 of the response entry format) is 16 bits in length as shown in figure 4-33. Bit 00 is used to flag any conditions that should be logged on an error file. Bit 02 is available for use as an LCC-to-HLP interrupt and bit 09 generally flags unsolicited responses. (The single exception is when bit 09 is set for a 61 response code, which can be either a solicited or an unsolicited response indicating that a read stream x request terminated normally with an unsolicited RTS — Request To Send.) Bits 09 through 15 in this word contain the response code itself. Bits 01 and 03 through 08 must be zeros.

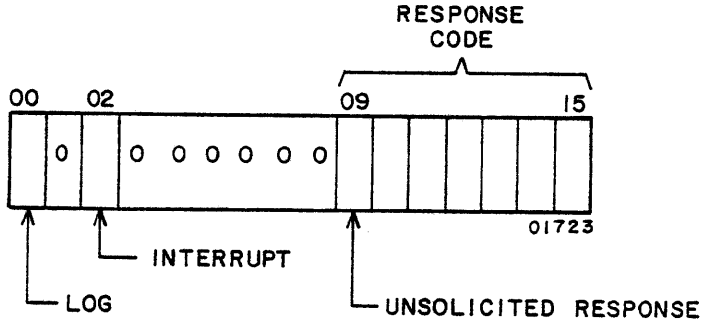


Figure 4-33. Response Code Word Bit Assignments

Solicited response codes and their definitions are listed in table 4-8. As indicated, solicited response codes are associated with commands (in the command list of the SAC CSN memory). These commands and the applicable response codes are cross-referenced in table 4-9. Unsolicited response codes and their definitions are listed in table 4-10.

TABLE 4-8. MODE 2 SOLICITED RESPONSE CODES AND DEFINITIONS

CODE	FORMAT	ASSOCIATED COMMAND	DEFINITION
21	3	80	When stream x request (function code = 80) terminated normally with an ETB. Another buffer of data is required.
22	3	00, 81	Read/write stream x request terminated normally with an ETX. This file is complete.
23	2	F5	HLP request to configure line x is complete.
24	2	F2	HLP request to terminate stream x is initiated. Response code 28 will be given for this stream.
28	3	00, 80, 81	Stream x request terminated abnormally.
29	2	All	Request rejected - illegal parameter.
2A	3	00, 80, 81	On threshold of buffer saturation. This request is rejected.
2D	2	All	Line not opened successfully. The first request read for line was not open line request.
61*	3	00	Read stream x request terminated normally with unsolicited RTS.

Note: Codes 00 through 20, 25, 26, 27, 2B, 2C, 2E, and 2F are not assigned.

* Solicited and unsolicited response.

TABLE 4-9. COMMANDS AND ASSOCIATED SOLICITED RESPONSES

COMMAND		SOLICITED RESPONSE	
F1	Close Line: terminate all outstanding stream requests to this line	24 29	Request initiated Request rejected - illegal parameter
F2	Terminate the active request on stream x (defined in field A)	24 28 29	Request initiated Stream x request terminated abnormally Request rejected - illegal parameter
F5	Configuration definition for line x	23 29	Request completed Request rejected - illegal parameter
00	Read	22 28 29 2A 61 2D	Request terminated normally with ETX; file complete Stream x request terminated abnormally Request rejected - illegal parameter Request rejected (on threshold of buffer saturation) Request terminated normally with unsolicited RTS Line not opened successfully
80	Write transparent text with ETB	21 28 29 2A 2D	Request terminated normally with ETB Request terminated abnormally Request rejected - illegal parameter Request rejected (on threshold of buffer saturation) Line not opened successfully
81	Write transparent text with EOM	22 28 29 2A	Request terminated normally with ETX Request terminated abnormally Request rejected - illegal parameter Request rejected (on threshold of buffer saturation)

TABLE 4-10. MODE 2 UNSOLICITED RESPONSE CODES AND DEFINITIONS

CODE	FORMAT	DEFINITION
40	1	Response from line x - stream y has RTS. Read command required.
41	1	Response from line x - stream y idle.
42	1	Response from line x - stream y not available.
43	1	Response from line x - stream y has busy status.
44*	4	Line x errored out and is closing. All outstanding requests are terminated abnormally. HLP must issue a close line request.
45*	4	System had intermittent SAC rejects. Field A of response contains the current count.
46*	1	Buffer saturation. Line x is closing. HLP must issue a close line request.
47	1	Illegal stream identifier (SID) in status block. HLP must issue a close line request.
48*	1	CA malfunction. Line x is closing. HLP must issue a close line request.
49	1	Channel flag cleared.
4A*	1	RTS/CTS is received when the RTS/CTS flag is set.
4C	1	Remote terminal has initiated restart (is rewinding its files). Line x is closing. HLP must issue a close line request.
4E	1	Line x is closed.
50	1	Terminal has established communication with LCC. This line is no longer in idle poll state.
61**	3	Read stream x request terminated normally with unsolicited RTS.

Note: Codes 4B, 4D, 4F, and 51 through 60 are not assigned.

* Logged on error file.
** Solicited and unsolicited response.

MODE 3 CONTROLWARE 5

This section provides a detailed description of the asynchronous communications protocol implemented in the Local Communications Controller (LCC).

Teletypewriters and similar asynchronous devices do not possess as rigorous a communications discipline as is found in terminals supporting Mode 2 protocol. Furthermore, the communications discipline for Mode 3 devices is defined by the implementation scheme employed in the host computer and this scheme may vary from one application to another within the host.

INFORMATION FLOW

An active Mode 3 line may exist in one of three operating states:

- Idle — There are no messages in the process of being input or output. Either HLP-initiated output or terminal-initiated output will be honored — whichever occurs first. The LCC controlware will inform the HLP of arriving input at which time the HLP must respond by establishing a buffer area for the data.
- Input — A message is in the process of being received. An outstanding request for output will not be initiated until the input message is complete and the line once again reverts to the idle state.
- Output — A message is in the process of being output. Any input which is received during the output operation is regarded as a terminal operator interrupt and results in cessation of the output.

DATA DEPENDENCIES

Certain characters in the input data stream are used for message control purposes as shown in table 5-1.

The LCC controlware does not inspect the TTY output data stream; therefore, the HLP controlware must insert all carriage return and line feed characters necessary for formatting output data.

TABLE 5-1. INPUT DATA STREAM CHARACTER RECOGNITION

CHARACTER DETECTED IN INPUT STREAM	OPERATION PERFORMED
LF (Line Feed)	When the LCC detects LF in the input stream, it sends a response to the HLP which indicates a termination with LF. This response is interpreted by the HLP. (For example, the LF may be used by the processing application to denote that a segment of a larger message has been entered, but that the message is not yet complete.) The LF is not placed in the HLP buffer. The LCC sends a CR to the TTY following a message that terminated with LF. The carriage is positioned and the operator of the TTY is informed that more data can be entered.
CR (Carriage Return)	When the LCC detects CR in the input stream, it sends a response to the HLP which indicates a termination with CR. This response is interpreted by the HLP. (For example, the CR may be used to indicate that the final segment of a message has been entered.) The CR is not placed in the HLP buffer. The LCC sends an LF to the TTY following a message that terminated with CR.
NUL or DEL	NUL and DEL characters in the input stream are deleted by the LCC; that is, they are not sent to the HLP buffer.
X-OFF or EOT	Keyboard Input Treated the same as CR except that no LF is sent to the TTY. Also, no timeout is set up as for paper tape. Paper Tape Input 1) Used as message delimiters. X-OFF, which turns the paper tape reader off, or end of transmission (EOT) terminates a message if either is encountered after a series of data characters with no intermediate LF or CR. The LCC sends a solicited response to the HLP which indicates termination with CR. This response is interpreted by the HLP. (For example, the X-OFF or EOT character is used to indicate that the final segment of a message has been received.) The X-OFF or EOT character is not placed in the HLP buffer. In addition to this processing, the LCC times out for 0.2 second when the X-OFF or EOT is encountered. If no input is received within 0.2 second, it is assumed that tape motion has stopped and an unsolicited response (which indicates X-OFF or EOT) is sent to the response list in the HLP storage. DEL/NUL characters received during the timeout interval reset the timeout. When tape motion has stopped, the LCC places the line in the idle state and is prepared to accept further input from the keyboard. A readTI command must be issued to restart the tape reader. 2) Used as single control characters. If X-OFF and EOT are not encountered after a series of data characters, they are assumed to be control characters. No response (indicating termination with CR) is sent to the HLP (that is, X-OFF and EOT are not put into the HLP buffer) but the remaining processing, including the timeout processing is the same as if X-OFF and EOT were message delimiters.
Any Input During an Output Operation	Whenever an input is detected during an output operation, the LCC sends a response to the HLP which indicates that the remote operator has interrupted the output cycle. The interrupted output is terminated by the LCC. This feature is useful when a long file is transmitted in relatively short segments. The "interrupt" is interpreted by the HLP as a request to discontinue or delay the present output.

ERROR RECOVERY

Mode 3 error recovery consists of monitoring the modem status and checking for "lost data" conditions.

For each character input or output, a timeout is set. Should the timeout expire before the next character is input or output, then the modem status conditions of Data Set Ready (DSR) and Carrier On (CO) are checked.

- If both DSR and CO remain on, the timeout is reset and processing continues.
- If either DSR or CO is off, the HLP is notified that a communications failure has occurred.

Each input message is subjected to a lost data check. Should a lost data condition occur, the contents of the input buffer is erased and the LCC sends the following message to the remote terminal:

(CR) (LF) (LF) (LF) REPEAT LINE (LF) (CR) (LF) (LF)

(CR) = Carriage Return

(LF) = Line Feed

If the REPEAT LINE message is sent to a remote terminal six times in succession without a correct message intervening, the HLP is notified of the abnormality.

MODE 3 INTERFACE LISTS

The next portion of this section provides details concerning the Mode 3 interface lists which reside in the high level processor (HLP). Figure 5-1 is an overview of this material.

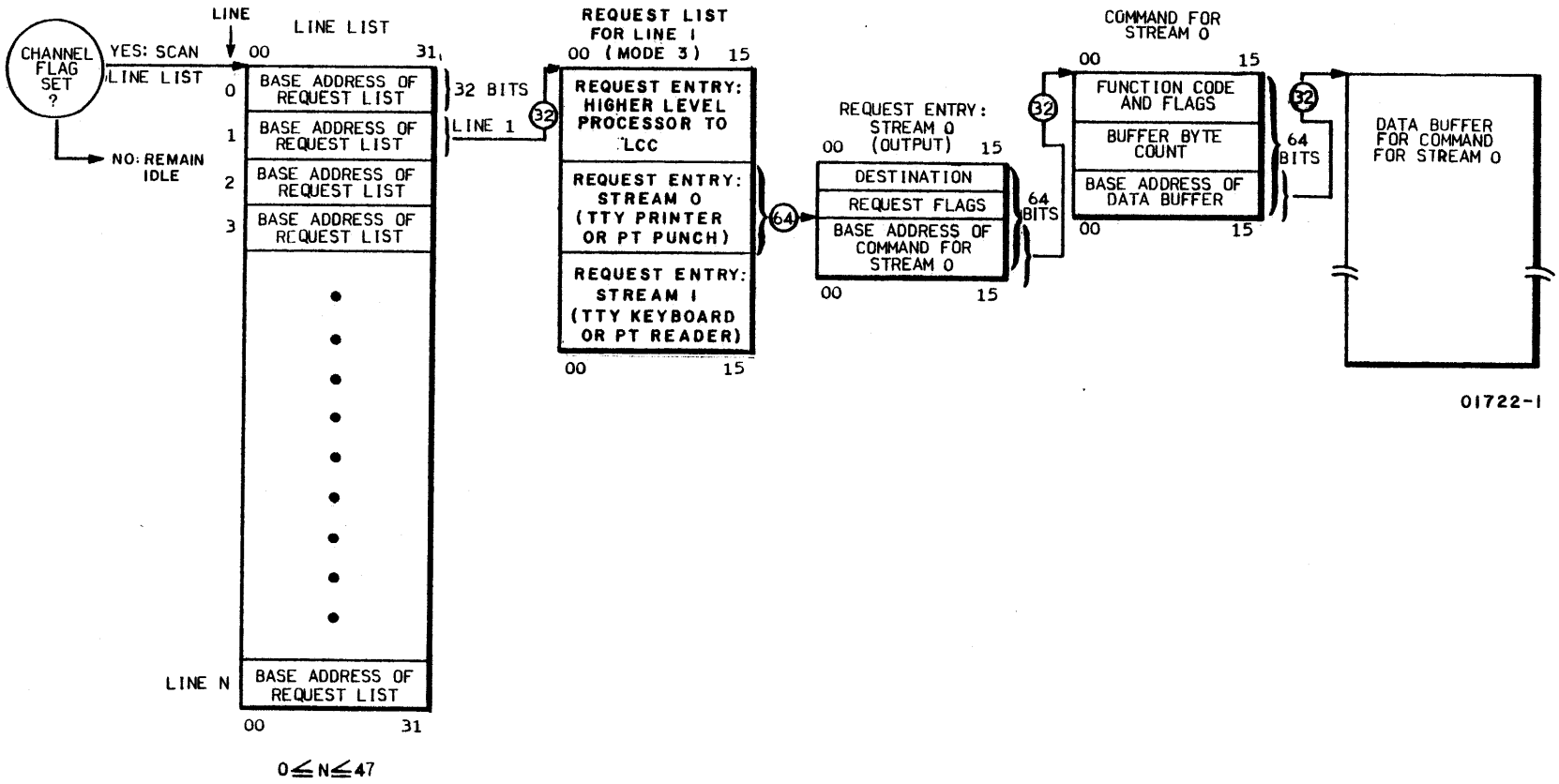


Figure 5-1. Interface Lists Resident in the Higher Level Processor

CHANNEL FLAG

The channel flag is set by the HLP to inform the LCC to do one of the following functions:

- Activate one or more lines
- Close a line that is presently in an idle poll state

The LCC clears the channel flag, sends responses to the HLP indicating that the lines have been activated, etc., and sends a response notifying the HLP that the channel flag has been cleared.

LINE LIST

The line list, with an entry slot for every line in the system, resides in the HLP. Each line number corresponds to a particular CA port; that is, line 0 corresponds to port CA01, line 1 corresponds to port CA02, etc. When the channel flag is set by the HLP, the LCC reads entries from the line list for those lines that are currently inactive (closed). If the entry is negative, there is no new activity for the line; if the entry is positive, however, the line list contains a 32-bit base address of the request list for this line.

REQUEST LIST

Once the base address of the request list is read into the LCC, it remains there until the line involved is closed. Periodic references to the request lists are made by the LCC to determine whether a new request has been entered. As each request is completed, a response is sent to the HLP.

The request list for each line has two types of entry slots. The first entry slot of each list is dedicated to requests for communication between the HLP and the LCC. The second and third entry slots are dedicated to streams. The request list may have no more than two stream entries — the maximum number of streams allocated for a Mode 3 line.

As shown in figures 5-1 and 5-2, the streams are numbered 0 and 1, with stream 0 dedicated to outputs to the TTY printer or paper tape punch. Stream 1 is dedicated to inputs from the TTY keyboard or paper tape reader. Mode 3 streams are two-way alternate in nature; that is, input or output operations cannot occur simultaneously.

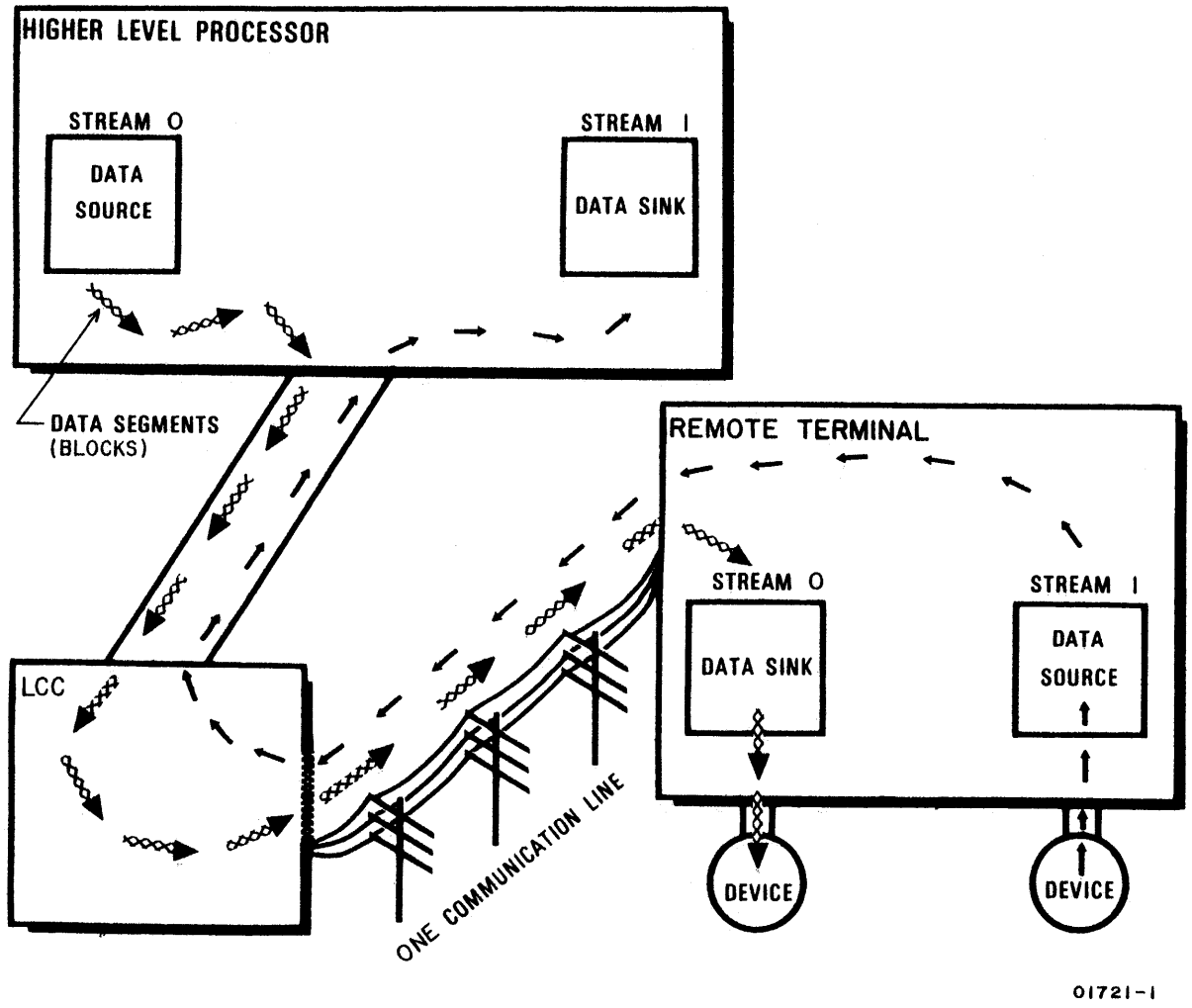


Figure 5-2. Mode 3 Activity (On One Line)

Following is the format for the request entries used in Mode 3 protocol. Figure 5-3 and table 5-2 show and describe the fields in these two 32-bit words which are placed in the HLP-to-LCC and the HLP-to-Stream slots in the Mode 3 request table.

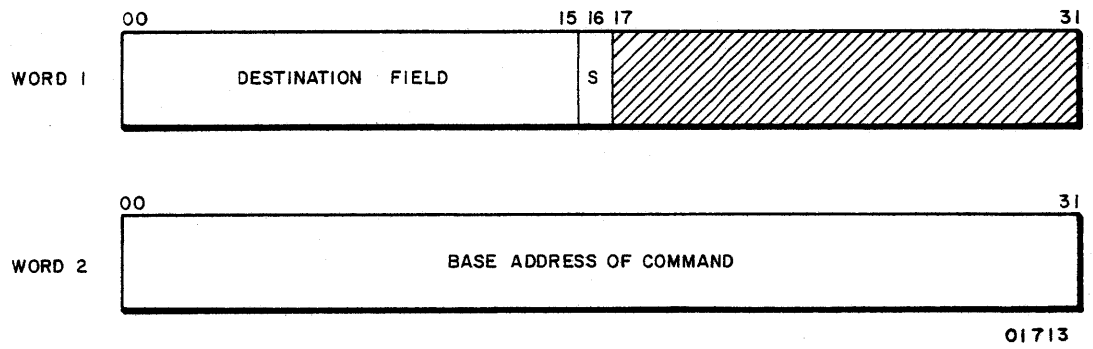


Figure 5-3. Request Entry Format

TABLE 5-2. REQUEST ENTRY FIELDS

WORD	BIT(S)	DESCRIPTION
1	00-15	Destination Field: Stream and line numbers; supplied by the HLP and returned in the solicited response.
1	16	S Field (status of this request slot): 1 - This request is ready for initiation. (The HLP sets this bit when it places the request on the request list.) 0 - The LCC clears this bit when it initiates this request; therefore, a 0 indicates that this request is either active or has been completed.
1	17-31	Filled with zeros.
2	00-31	Base Address of Command: Location of associated command in command list; supplied by HLP and returned in solicited response.

COMMANDS

Commands, 64 bits in length, supply the LCC with detailed information necessary for proper execution of a request. One command is issued by the HLP for each request.

Commands for streams direct two types of executable functions: an input (odd-numbered) stream reads data and an output (even-numbered) stream writes data.

HLP to LCC Commands

The command format for the HLP to the LCC is shown in figure 5-4; the commands are defined in table 5-3.

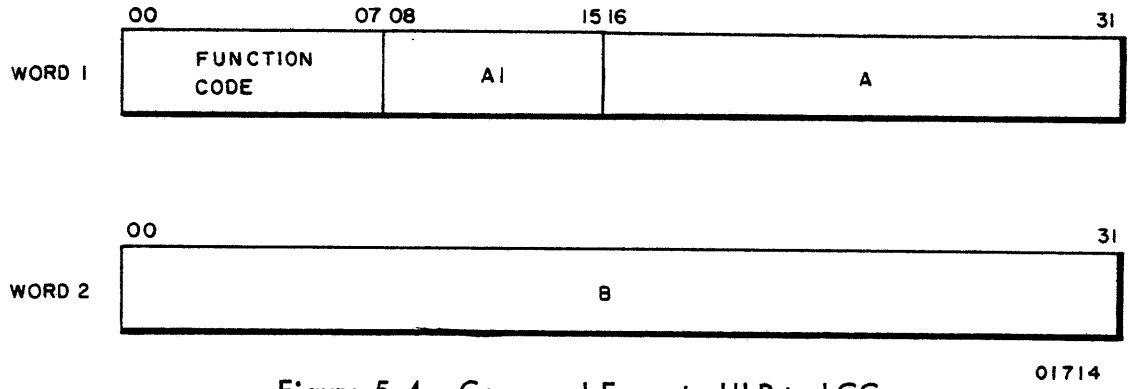


Figure 5-4. Command Format, HLP to LCC

TABLE 5-3. COMMANDS, HLP TO LCC

FUNCTION CODE (HEX)	DESCRIPTION
F1	Close Line: Terminate all outstanding stream requests to this line. Responses reflect an abnormal termination since this is a requested action. The LCC scans each entry in the line request queue before writing the completion response to this request. New requests are terminated abnormally. All references to this line are eliminated and the line is considered inactive when all entries are scanned.
F2	Terminate the Active Request on Stream x defined in Field A: Field A is the input or output stream number. The line returns to an idle state. A normal response is given for successful completion of this request. The LCC is in one of three states with the defined stream when a "terminate the active request on stream x" command is issued. 1) The LCC has processed and is executing a stream request for the defined stream. The LCC terminates that request and sends an abnormal termonation response to the HLP. The byte count in the response reflects the number of bytes successfully received/transmitted. 2) The LCC does not have a stream request in storage for the defined stream. However, internal flags infer that implied RTS or CTS blocks have been traded with the remote terminal. The LCC clears all internal flags and sends an abnormal termination response to the HLP. 3) The LCC does not have a stream request in its storage area nor does it have internal flags for the defined stream. An abnormal termination response is sent to the HLP. The LCC transmits an abort stream SID to the remote terminal for all three states.
F5	Open Line Request: This must be the first request received for a newly-opened line. It does not contain parameters (timeout, maximum number of streams, etc.) for Mode 3 as does the F5 configuration definition command for Mode 2.

Stream Commands

The format of commands for streams is shown in figure 5-5; the commands are defined in table 5-4.

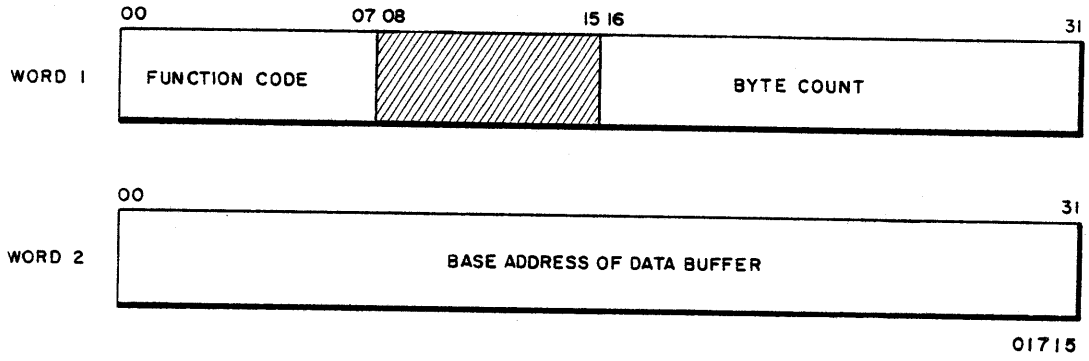


Figure 5-5. Command Format, Stream

TABLE 5-4. COMMANDS FOR STREAMS

WORD	BIT(S)	FUNCTION CODE (HEX)	DESCRIPTION
1	00-07	00	Read: The LCC stores in the data buffer the data it receives from the line and stream (defined in the request).
		01	ReadTI: The initial read command when input from a paper tape is expected.
		80	Write transparent text with ETB.
		81	Write transparent text with EOM.
1	08-15		Not used.
1	16-31		Byte Count: This field specifies the total number of 8-bit data bytes to be processed (read or write) from the data buffer. Used by all function codes.
2	00-31		Base Address of Data Buffer: Used by all function codes.

Input Stream Commands

There are two forms of input stream commands — those associated with keyboard input operations, and those associated with paper tape input operations. It is assumed by the LCC that the HLP knows which TTY device is sending data and is directing the LCC accordingly.

NOTE

1) All DEL and NUL characters that appear in the input stream from the TTY are discarded by the LCC.

2) There are two descriptions of the read command (function code 00). The first description covers the paper tape input operation, and the second one covers the keyboard input operation.

Read (Paper Tape), Function Code 00: This command is issued for all subsequent inputs from tape after readTI. Read, unlike readTI, does not send X-ON (which turns the paper tape reader on) prior to a data input.

The primary function of read is to define the location and length of the central storage cabinet buffer in which input data from the associated TTY line is to be placed. The read command may be issued either before or after the input flow begins. The input flow is defined as the first character encountered. Should the TTY input begin before the central storage cabinet buffer is defined, a response is sent to the HLP which demands read be issued promptly.

Buffer termination conditions are shown in figure 5-6. The buffer defined by read is terminated normally when the LCC encounters any of the following conditions:

- Line feed
- Carriage return
- X-OFF (if immediately preceded by data)
- EOT (if immediately preceded by data)

LF or CR is the first terminating character encountered in a message segment. This determines the response which is sent. The terminating character is not placed in the central storage cabinet buffer. Succeeding DEL characters are ignored as is the LF or CR which occurs after the initial LF or CR.

The characters X-OFF and EOT are used as message delimiters as well as control functions. X-OFF and EOT terminate a message if either is encountered after a series of data characters with no intermediate LF or CR. The message response indicates "termination with CR" when X-OFF and EOT terminate the message.

Message segments from paper tape may appear in any order on the tape insofar as the LCC is concerned.

	PASSED TO CENTRAL STORAGE CABINET BUFFER	NOT PASSED TO CENTRAL STORAGE CABINET BUFFER
1	[d] [d] • • • [d]	[LF] [CR] [DEL] [DEL] [DEL]
2	[d] [d] • • • [d]	[CR] [LF] [DEL] [DEL] [DEL]
3	[d] [d] • • • [d]	[X-OFF] [DEL] [DEL] [DEL]
4	[d] [d] • • • [d]	[EOT] [DEL] [DEL] [DEL]
5		[X-OFF]
6		[EOT]

[d] = 8-BIT DATA BYTE (MESSAGE SEGMENT) 01724

Figure 5-6. Message Buffer Termination

It is recommended that three or more DEL/NUL characters be sent to the LCC to provide adequate time delays in HLP-to-LCC communications.

The characters X-OFF and EOT are processed in a unique way by the LCC. When either of these characters is encountered in the input stream, a timeout of 0.2 second occurs. If no input is received within 0.2 second, it is assumed that tape motion has stopped and a response, which indicates X-OFF or EOT, is sent to the response list. DEL/NUL characters received during the timeout interval reset the timeout period. When it is determined that tape motion has stopped, the LCC places the line in the idle state and is prepared to accept further input from the keyboard. ReadTI must be issued to restart the tape reader. If, however, an input does occur before the expiration of the timeout, the response is cancelled and the input is accepted. It is assumed that this data originates from the paper tape reader.

Read (Keyboard), Function Code 00: This command is issued for all keyboard input operations. Read may be issued either before or after the input flow has begun. The input flow is defined as the first character encountered in a message. Should the input flow begin prior to the issuance of read, a response is sent to the HLP demanding that a read command be given to define the central storage cabinet input buffer.

The read command is terminated whenever one of the following characters is encountered:

- Line feed
- Carriage return
- EOT
- X-OFF

Treated as CR but timeouts are not set as with tape. LF is not returned as for CR.

The ending character determines which response is sent. If the message terminates with LF, the LCC automatically sends a CR to the TTY prior to expecting a subsequent message. Conversely, if the message terminates with CR, the LCC sends the TTY an LF.

ReadTI, Function Code 01: This command is issued only prior to the initial input from paper tape. Then, X-ON is sent to the TTY prior to a data input.

NOTE

The HLP is aware of a forthcoming paper tape input via either prior entry at the keyboard or another stimulus.

A tape input may occur before the LCC recognizes the readTI command. In this instance, the input is assumed to originate from the keyboard, X-ON is not sent, and any data received up to the time readTI is detected is treated as though it originated from the keyboard.

Should an entire tape message be received before readTI is detected, the message is treated as though it originated from the keyboard.

Output Stream Commands

Output stream commands are honored when a line is open and idle. The LCC initiates a write operation when a message is not presently being received. If an input operation is in process when the HLP issues a write, the LCC allows the input to continue to completion.

The write commands, function codes 80 and 81, output data to the TTY and operate with either the printer or paper tape. There is an output to paper tape only if the paper tape punch is manually turned on.

NOTE

The LCC does not distinguish between write, function code 80 and write, function code 81; the difference centers entirely around the response sent to the HLP. The HLP may find the distinct responses useful for its own control.

The LCC does not inspect the output stream for special characters as it does during an input operation. It is assumed that proper format codes are contained in the message and that the carriage is positioned for the subsequent input/output operation. The termination of write occurs when the previously-specified number of bytes has been transmitted.

RESPONSE LIST

The remainder of this section describes the response list which is resident in the HLP. The LCC informs the HLP of current requests, commands, and the status of the system by updating the response list. There are two types of responses — solicited and unsolicited. Solicited responses are the result of an HLP request. Unsolicited responses are the result of unexpected stream or system condition(s). Examples of unsolicited responses are:

- The remote terminal input stream requests to send data to the LCC.
- The LCC storage threshold is exceeded.
- Unique stream status bits are received.
- The CA exerciser and its status are in this response.

Response Entry Formats

Responses are 128 bits in length (eight 16-bit words in the LCC, which are converted to four 32-bit words in the 7077-1 SAC CSM memory), see figure 5-7. They provide the HLP either with information about a previous request or information which the HLP must act upon. The four response entry formats are shown in figures 5-8 through 5-11, and their fields are defined in table 5-5.

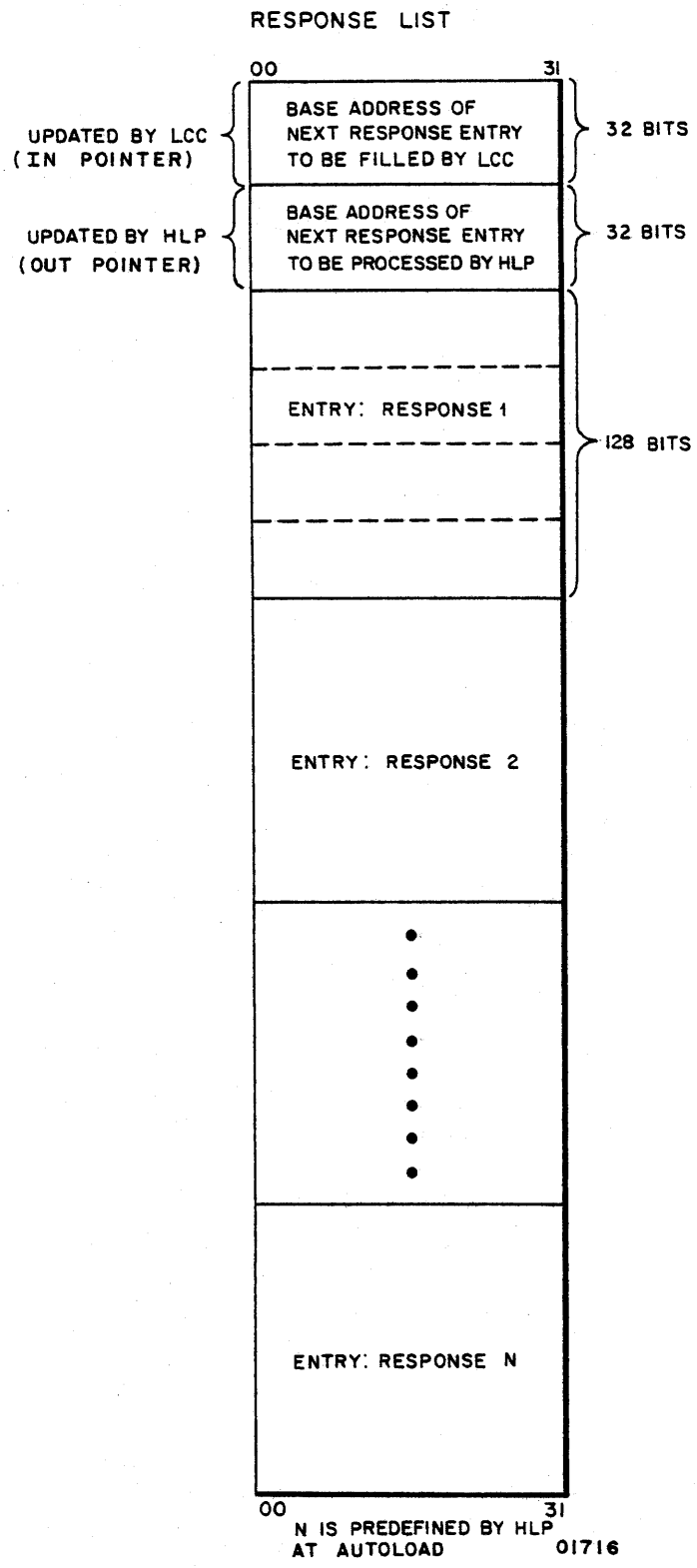


Figure 5-7. Response List in 7077-1 SAC CSM Memory

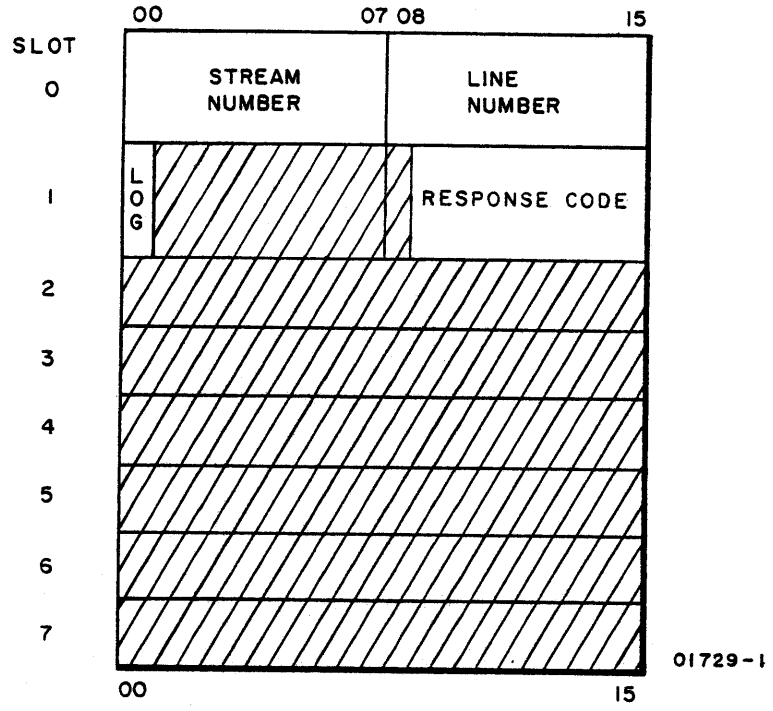


Figure 5-8. Normal Unsolicited Response - Format 1

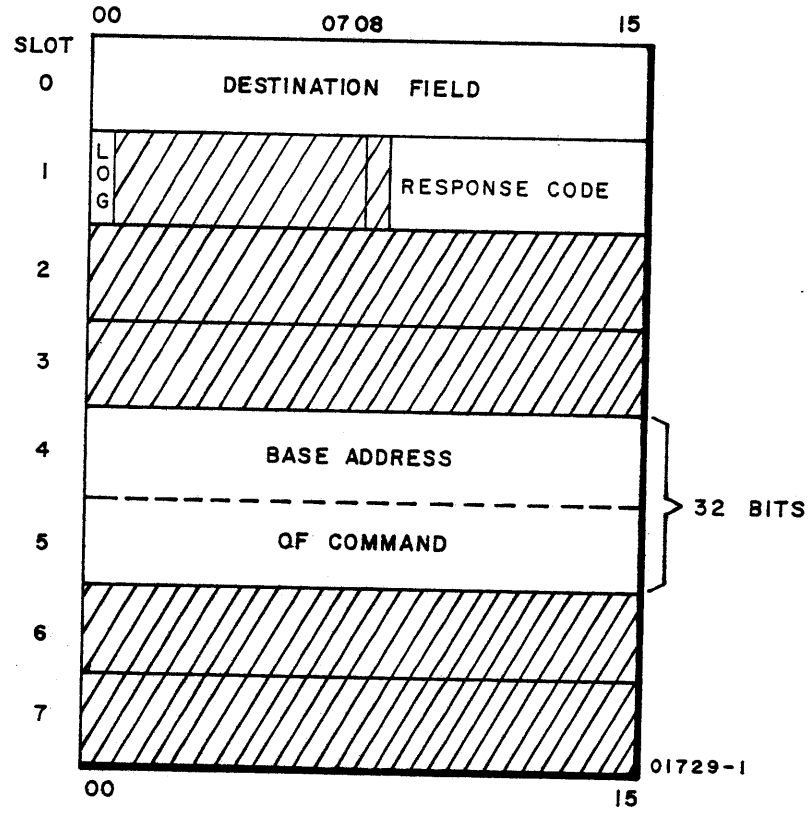


Figure 5-9. Normal Solicited Response to HLP/LCC Request and to Illegally Formatted Requests - Format 2

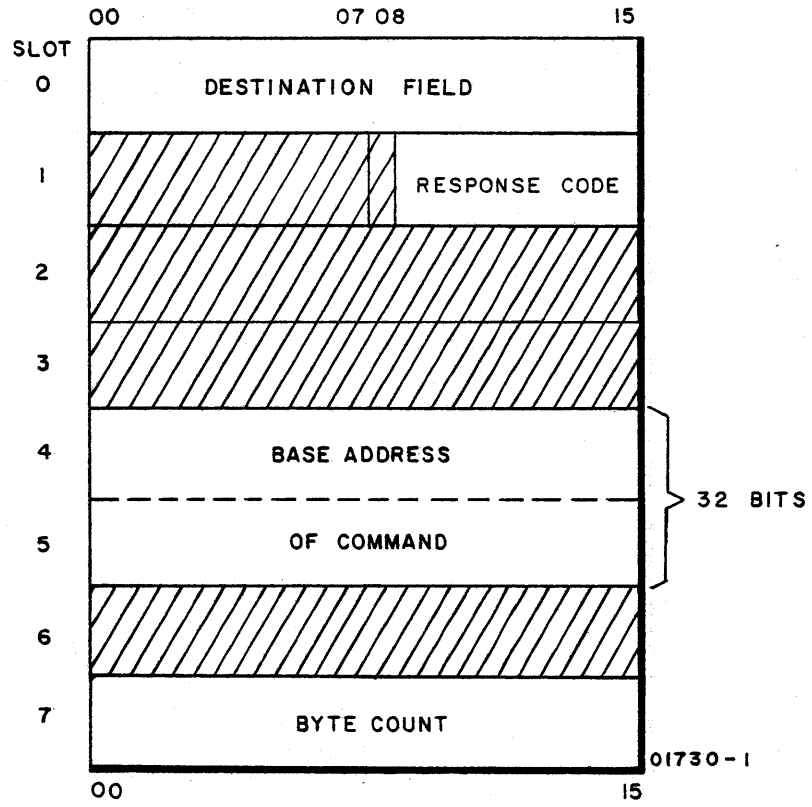


Figure 5-10. Normal Solicited Response to a Stream Request - Format 3

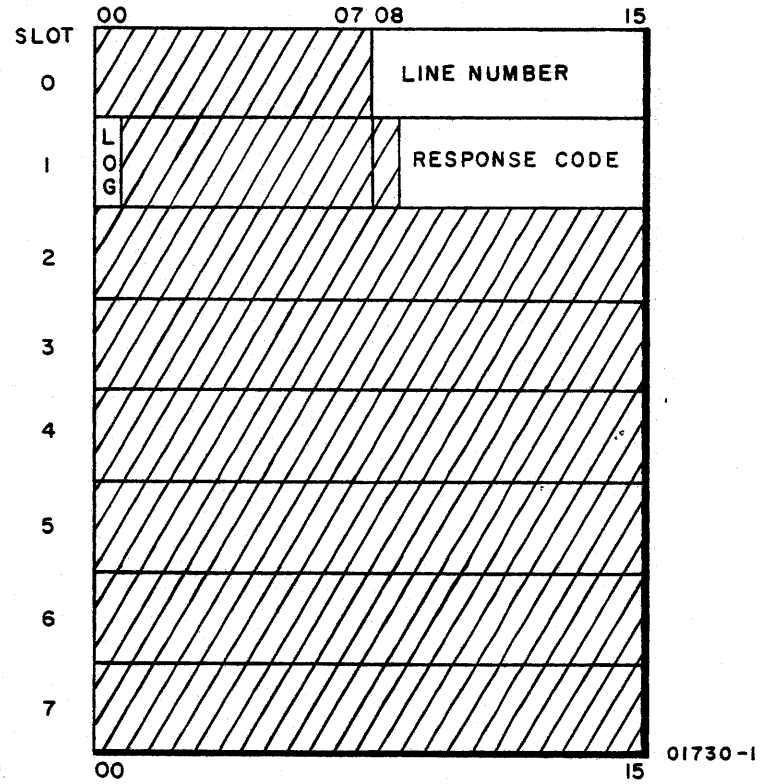


Figure 5-11. Abnormal Unsolicited Response - Format 4

TABLE 5-5. RESPONSE ENTRY FIELD DEFINITIONS

FIELD	FORMAT	DEFINITION
Stream Number	1	Source of unsolicited response
Line Number	1, 4	Vehicle for unsolicited response
Log	1, 2, 4	A flag indicating that specific conditions should be logged on an error file
Response Code	All	A 7-bit code indicating conditions at the LCC and/or action required
Destination Field	2, 3	Supplied by HLP in request entry for solicited response
Base Address of Command	2	Supplied by HLP in request entry for solicited response
Byte Count	3	Number of 8-bit bytes received/ stored in data buffer

Response Code Word

The response code word (in slot 1 of the response entry format) is 16 bits in length as shown in figure 5-12. Bit 00 is used to flag any conditions that should be logged on an error file. Bit 09 flags unsolicited responses and bits 01 through 08 must be zeros.

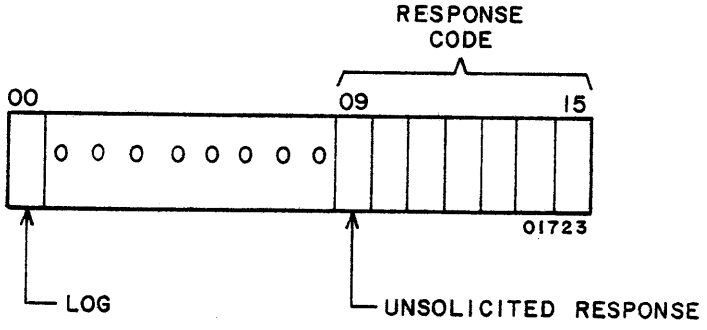


Figure 5-12. Response Code Word Bit Assignments

Solicted response codes and their definitions are listed in table 5-6. Unsolicited response codes and definitions are listed in table 5-7.

TABLE 5-6. MODE 3 SOLICITED RESPONSE CODES AND DEFINITION

CODE	FORMAT	ASSOCIATED COMMAND	DEFINITION
21	3	Write (function code 80)	The output is complete.
22	3	Write (function code 81)	The associated read or write command has terminated.
		ReadTI (function code 01)	This response has no inherent meaning to the LCC for subsequent input/output operations.
		Read (function code 00)	In the case of output operations, the response implies the entire buffer has been transmitted; in the case of input operations, the response implies the message terminated with carriage return.
23	2	F5	Line open. This response is sent to HLP upon receiving "Open Line Request" command.
28	3	Close	This response indicates that a stream is abnormally terminated. This results from a close command or from a forced closing of a line by the LCC.
29	3	All	This command is unrecognizable and/or the command contained illegal values.
2A	3	All	The internal buffer pool in the LCC has reached a threshold level. This request is rejected.
2D	2	All	Line failed to open. The first request for this line was not an open line request.
61*	3	Read (function code 00) and ReadTI (function code 01)	The TTY input stream terminated normally with LF as the last character.

Note: Codes 00 through 20, 24 through 27, 2B, 2C, 2E, and 2F through 3F are not assigned.

* Solicited and unsolicited response.

TABLE 5-7. MODE 3 UNSOLICITED RESPONSE CODES AND DEFINITIONS

CODE	FORMAT	ASSOCIATED COMMAND	DEFINITION
44*	4		Line x errored out and is closing because of lost data condition. Repeated efforts to input the line failed. Any outstanding request is abnormally terminated.
45*	4		The LCC experienced intermittent SAC rejects.
46*	4		System buffers are saturated. Line x is closing. HLP must issue a close line request.
48*	1		The communications adapter connected to this line is malfunctioning. Line x is closing. When closed, response code 4E is sent to the HLP. Response code 28 is also sent to the HLP if a stream command is terminated. HLP must issue a close line request.
49	1		The channel flag is cleared. This occurs when the scan of the line list is complete during the open procedure.
4E	1		Line x is closed. This response is returned following either a close command or forced line closing caused by an abnormal condition. If stream commands are active when line x is closing, they are terminated. Response code 28 is returned for each stream so terminated.
50	1		The LCC has answered a call on TTY line x. This response is sent when the data set ready (DSR) lead from the modem is on and occurs with either a switched or a dedicated line. The line is prepared for an unsolicited keyboard input operation.
51	1		X-OFF was received from the paper tape reader and then there was no input for 0.2 second. It is assumed that tape motion has stopped. If a read command is active and the X-OFF did not occur with data, the read command is not terminated and will be used for subsequent keyboard inputs.
52	1		EOT is detected; otherwise, it is assumed that tape motion has stopped (refer to X-OFF).
58	1		The carrier on (CO) lead from the modem indicates that a carrier signal is not being received. Line x is closing. When line x is closed, response code 4E is sent to the HLP. Response code 28 is also sent to the HLP if a stream command is terminated.
59	1		The DSR lead from the modem is off. The call has been disconnected and line x is closing. When line x is closed, response code 4E is sent to the HLP. Response code 28 is also sent to the HLP if a stream command is terminated.

TABLE 5-7. MODE 3 UNSOLICITED RESPONSE CODES AND DEFINITIONS (CONT)

CODE	FORMAT	ASSOCIATED COMMAND	DEFINITION
5A	1		One or more characters of the TTY message are lost because: 1) HLP did not supply an input buffer in time. 2) Internal LCC timing conflicts - the log flag is set in the response word. This is an informative response. No special recovery actions are required by the HLP because the LCC initiated retransmission of the message.
5B	1		An input is arriving on the indicated TTY line. The HLP must promptly issue a read command to define the receiving buffer.
5C	1	Write (function codes 80 and 81)	Input was received during output operation. The current output operation is terminated and the LCC prepares to receive data. Response code 28 is sent to the HLP for the terminated output command (same as for interrupt from remote operator).
5D	1		The TTY input buffer filled before a CR or LF was encountered. The LCC spaces to the end of the message segment, discarding the remaining characters of the segment. Response code 28 is sent to the HLP if an input stream command is present.
61**	3	Read (function code 00) and ReadTI (function code 01)	The TTY input stream terminated normally with LF as the last character.

Note: Codes 40 through 43, 47, 4A through 4D, 4F, 53 through 57, and 5E through 60 are not assigned.

* Logged on error file.
** Solicited and unsolicited response.

MODE 4 CONTROLWARE 6

This section provides a detailed description of the Mode 4 synchronous communications protocol implemented in the LCC Version 3.0 controlware. This protocol (which actually consists of two variants termed Mode 4A and Mode 4B supports the terminals listed in table 6-1 over synchronous communication lines with speeds of 1200 bps to 9600 bps. Mode 4A protocol is used with CDC 200 User (single-station-type) terminals, Mode 4B is a 216-multistation-type protocol that is also used in conjunction with the 714 multistation.

TABLE 6-1. TERMINALS SUPPORTED BY MODE 4 PROTOCOL

CDC TERMINAL*		PROTOCOL VARIANT
Standard Remote Terminal Products		
734-X	Batch	Mode 4A
714-10/714-20	Multistation	Mode 4B
711-10	Multistation	Mode 4B
Mature Remote Terminal Products		
200 UT	Batch	Mode 4A
217-X + 222-X + 224-X		
214-X	Single Station	Mode 4A
216-X	Multistation	Mode 4B
731-12	LSBT Batch	Mode 4A
732-12	MSBT Batch	Mode 4A

* In addition to the terminals listed here, the LCC version 3.0 controlware supports any other terminal that is fully compatible with these terminals.

LCC-TERMINAL INTERFACE

Mode 4 protocol supports communication over the following types of synchronous lines:

- 2000 bps, point-to-point, half-duplex, switched lines.

  (Automatic answer/disconnect service is provided for terminals on switched lines, allowing any Mode 4 terminal to dial into any available Mode 4 line.)

- 1200 to 9600 bps, point-to-point, 2-wire or 4-wire, nonswitched lines.
- 1200 to 9600 bps, point-to-point, 2-wire or 4-wire, dedicated, leased, or private lines.

  (Multidrop capability on dedicated, leased, or private lines reduces overall customer cost per line.)

Figure 6-1 shows how an LCC dedicated to Mode 4 operation might be configured. (Mode 4 operation can be combined with either Mode 2 synchronous protocol or Mode 3 asynchronous protocol, but not both, in a given LCC.) Terminals on dedicated lines must be completely specified by the HLP when the LCC is autoloaded. (See following description of Line Parameter Record.) Terminals on switched lines are identified whenever connection is made to the LCC. A variety of terminals may be used on either a direct or dialup line.

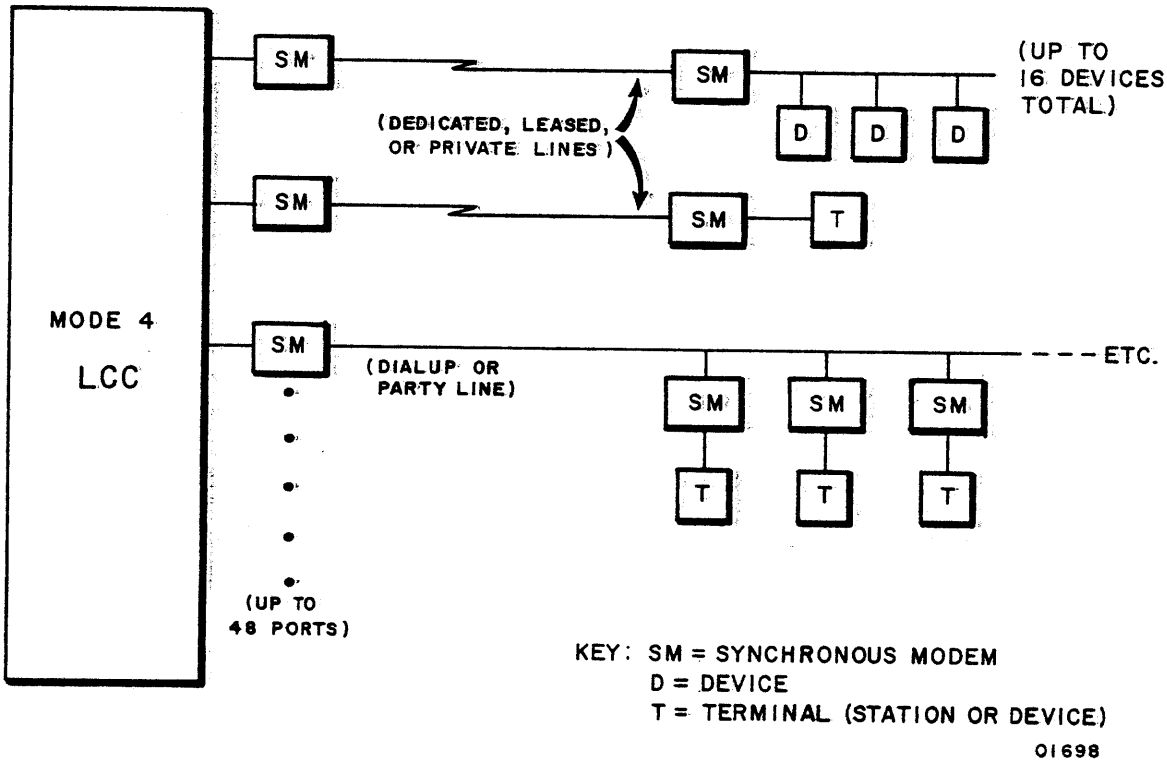


Figure 6-1. A Mode 4 LCC

LINE PARAMETER RECORD

The format of the line parameter record is shown in figure 6-2. Word zero (the line descriptor) is a 16-bit word giving the line number as well as the number of stations or terminals connected to the line. Also included in the line descriptor word is an indicator showing whether the line is direct or dialup.

Words 1 through N (where N represents the total number of stations connected to the line — a maximum of decimal 16) are "station descriptors" containing information concerning each station on the line. Each of these words shows the station code and contains a protocol indicator that shows whether the station uses the 4A "single-station" protocol or the 4B/4C "multistation" protocol. A mode ordinal, also related to the protocol, is included in each station descriptor word to facilitate the building of internal tables.

When N is an even number, an additional all-zero "padding" word must be included in the line parameter record to make the record length an even number. (Each line parameter record must be a multiple of 32 bits in length.)

For Mode 4 operation, the HLP may send the line parameter records to the LCC in a single buffer or in several buffers.

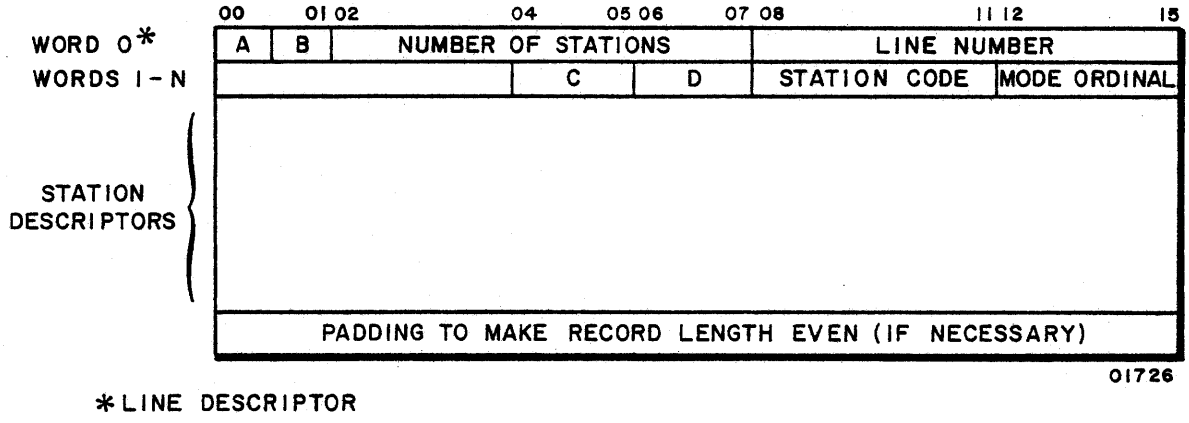


Figure 6-2. Line Parameter Record

Following is an explanation of the various fields in the line parameter record (figure 6-2):

Line Descriptor (Word 0)

Field A: Bit zero is always zero

Field B: (Bit 1, Dialup Indicator): 0 = Dialup Line
1 = Direct Line

Number of Stations: Bits 2-7 equal N, the total number of stations on the line (or the number of station descriptor words)

Line Number: Bits 8-15 contain a hexadecimal number from 0 to 2F (lines zero through decimal 47 correspond to CA ports CA01 through CA48 in the LCC.)

Station Descriptors (Words 1 through N)

Field C (Bits 4, 5, Protocol Indicator): 00 = Mode 4A
10 = Mode 4B/4C

Field D (Bits 6, 7, Code Set Indicator): 00 = ASCII
10 = External BCD

Station Code: Bits 8-11 contain the code (from 0 to F) assigned to the station or terminal (equals station address minus hexadecimal 70)

Mode Ordinal: (Bits 12-15): 1 = Mode 4A
2 = Mode 4B/4C

NOTE

Sixteen-bit padding word, when used, is all zeros.

Following are significant features of the LCC's interface with the remote terminals:

- The LCC performs all line-control procedures needed to communicate with the terminals, including line initialization, polling for input data, message-sequence control (as necessary to perform the operation specified by the HLP), and line disconnect.
- The LCC identifies (by means of poll messages sent to the terminal independent of HLP activity) terminals that dial into a switched line.

- The LCC adds necessary message-framing characters to output blocks of data and, after checking their validity, deletes the message-framing characters from input blocks of data received from the terminals (see figure 6-3).
- The LCC converts ASCII code to external BCD code, or vice versa, for those single-station devices that require code conversion.
- The LCC generates and checks character (byte) parity, and calculates and checks message (longitudinal) parity.
- The LCC attempts to recover from errors detected while communicating with remote terminals. Message blocks found to contain errors are retransmitted, based on a "retry count" that is included in the LCC Version 3.0 controlware, and error-status information is sent to the HLP for control and error-logging purposes.

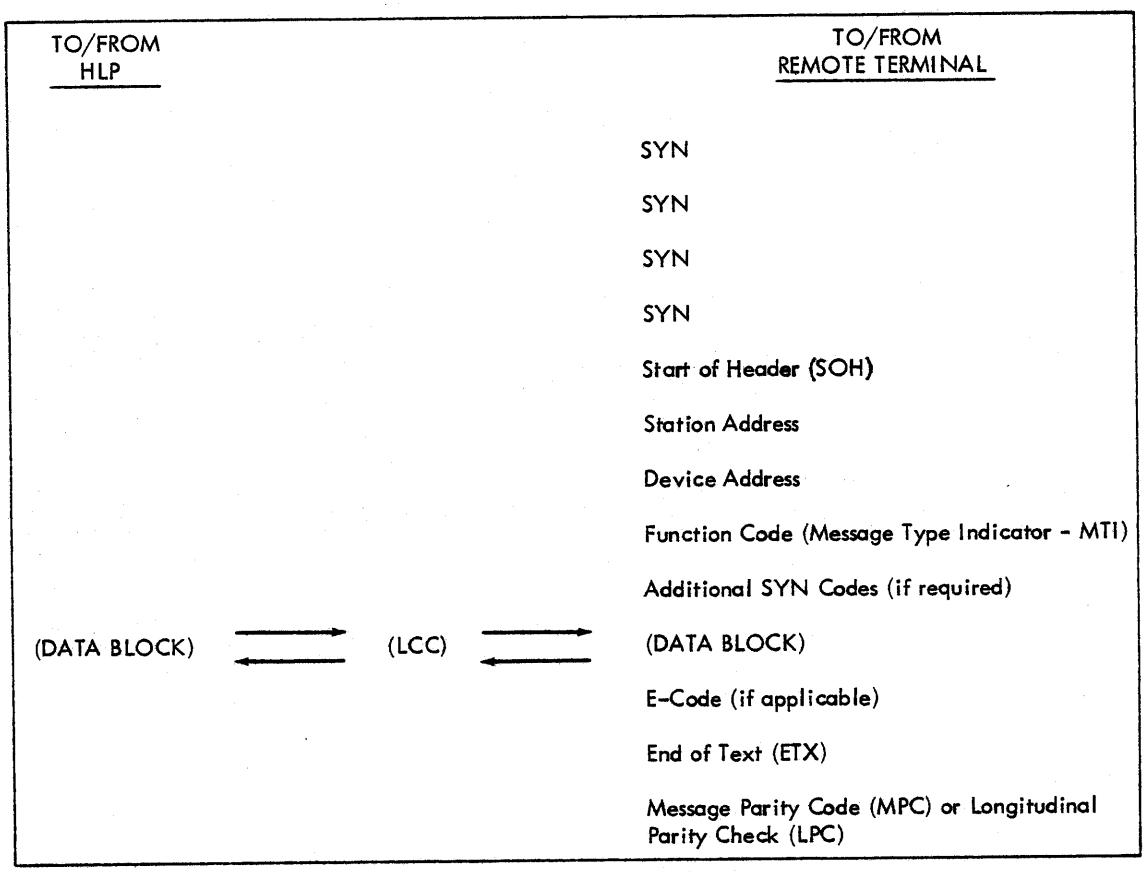


Figure 6-3. Data-Block Transfer Through LCC

COMMUNICATION WITH REMOTE TERMINALS

Information flow between the LCC and any Mode 4 terminal is essentially two-way alternate. The HLP initiates communication with a remote terminal by placing a request list address into the terminal's line slot in the line list and then issuing an Open Line command. (Line list and request list are explained under the heading Mode 4 Interface Lists.) To stop communicating with a terminal, the HLP can either issue a Close Line command or merely issue a Terminate Active Request command. This latter command will leave the line open for communication with other terminals on the line or for a resumption of communication with the same terminal.

Opening a Switched Line

When a Mode 4 switched line is opened, the LCC attempts to identify the calling terminal or device. When Data Set Ready is detected at the communications adapter, each terminal or device connected to the line is polled in succession. Upon receiving a Read, CAN, or NAK in response to the poll, the LCC sends the HLP a response identifying, by address code, the terminal that has dialed in. If the terminal cannot be identified in this manner, an error response is sent to the HLP and the line must be closed.

Opening a Direct Line

On direct lines, a similar response is sent to the HLP when the line is opened, but no address code is required because the HLP already knows what equipment is connected to the line.

Control Characters

The LCC frames all output data blocks to the remote terminals with a set of control characters as shown in figure 6-3. Leading control characters consist of four SYN characters, a start of header code (SOH), a station address (from 140 to 177 octal), a device address [either octal 141 for Mode 4A and 141-157 for Mode 4B, or 161 for Mode 4A and 161-177 for Mode 4B] , a function (message type indicator) code, and any SYN codes required after the function code.

As is indicated in the material on commands for streams, the HLP supplies a subfunction 32-bit word with each write message to specify either a normal write, a clear write, or a reset write message. As applied to a crt display at the remote terminal, these functions differ as follows:

- Normal Write — writes data beginning at the present cursor position.
- Clear Write — clears the screen, then moves the cursor to the top left corner of the screen and begins writing the data.
- Reset Write — moves the cursor to the top left corner of the screen (without removing old displayed data), then begins writing the data.

Following the write data, which might consist of up to 1040 data bytes (to completely fill an 80 by 13 display screen), the LCC supplies an end of text character and a message parity code.

Input data blocks from the remote terminals are enclosed in similar control characters which the LCC interprets, checks for validity, and strips off before transferring only the data block to the input buffer in the HLP memory.

LCC-HLP INTERFACE

The HLP communicates with the LCC (and, ultimately, the remote terminals) by issuing requests and commands. This interface enables the HLP to do the following:

- Send messages to a terminal.
- Receive messages from a terminal.
- Start and stop communication with a given terminal.
- Determine the cause of errors.

This interface enables the LCC to do the following:

- Notify the HLP of the end of an operation.
- Notify the HLP of LCC internal problems.
- Report errors to the HLP for logging and/or control purposes.

MODE 4 INTERFACE LISTS

The remainder of this section provides detailed information concerning the Mode 4 tables, resident in the 7077-1 SAC CSM memory (or HLP memory), through which the HLP and the LCC communicate. Figure 6-4 provides an overview of this material.

LINE LIST

The line list, whose address in HLP memory is passed to the LCC during autoload, contains a slot for every line in the system, from line zero to the highest-numbered line used. Each slot contains a 32-bit entry that is either negative or contains the non-negative address of the request list for that line.

When there is no new activity for a line, or the line is not configured, the HLP sets the corresponding slot in the line list negative. Prior to opening a line with an Open Line command, the HLP first places the request list address in the line list slot.

REQUEST LIST

After the address of the request list for a given line is read into the LCC, it remains there until that line is closed. Periodic references to the request list are made by the LCC to determine whether a new request has been entered. As each request is completed, a response is sent to the HLP.

The request list for Mode 4 lines contains only two entry slots as shown in figure 6-4. The first slot is reserved for communication between the HLP and the LCC. The second slot is used for input/output operations with specific terminals or devices on the line. An identical format is used in both of the request entry slots. The station and device codes are from 0 to F (hexadecimal), and the line number is expressed as a hexadecimal number of 0 to 2F.

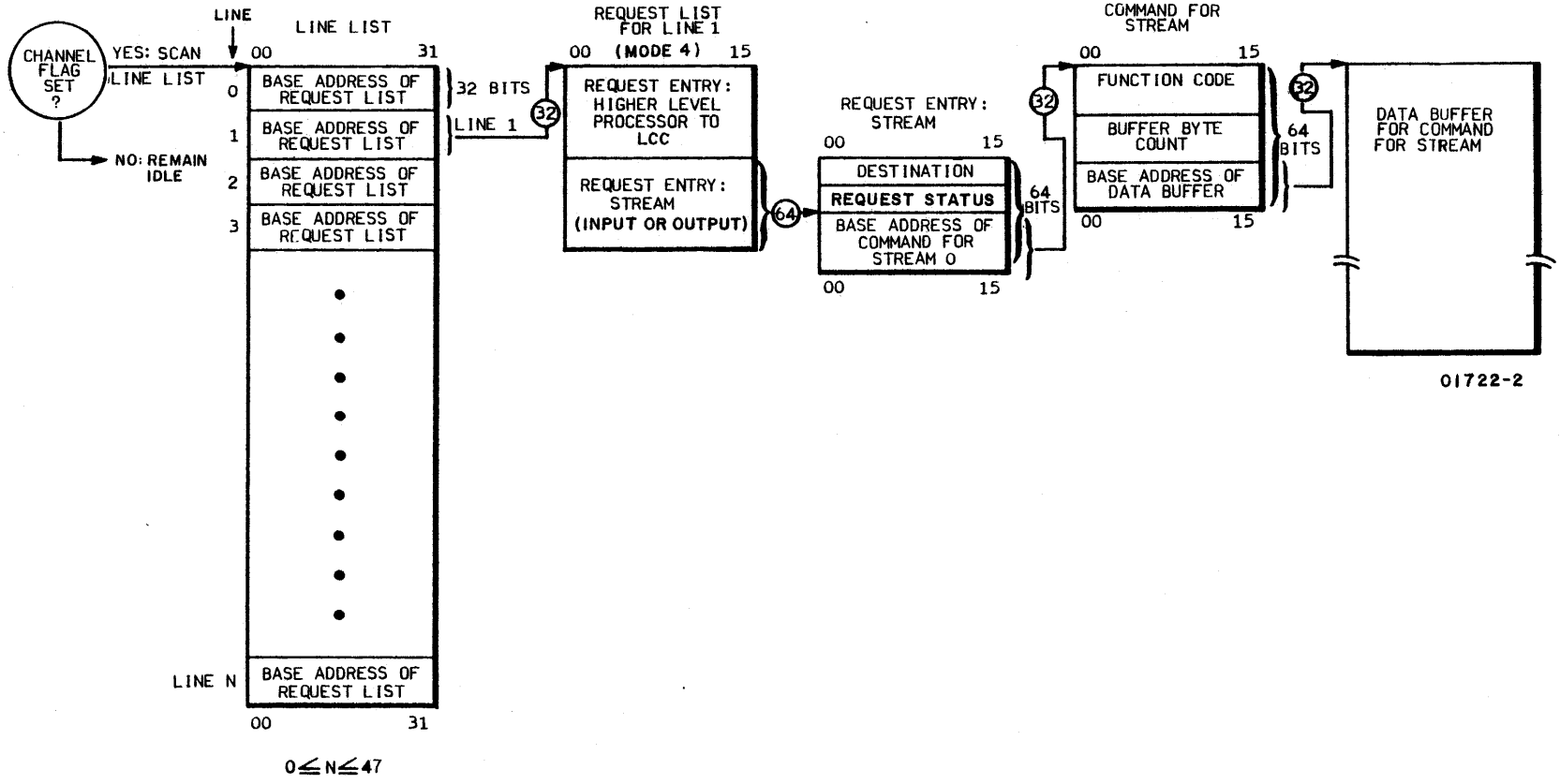


Figure 6-4. Interface Lists Resident in the Higher Level Processor

Following is the format for the request entries used in Mode 4 protocol. Figure 6-5 and table 6-2 show and describe the fields in these two 32-bit words which are placed in the HLP-to-LCC and the HLP-to-Stream slots in the Mode 4 request table.

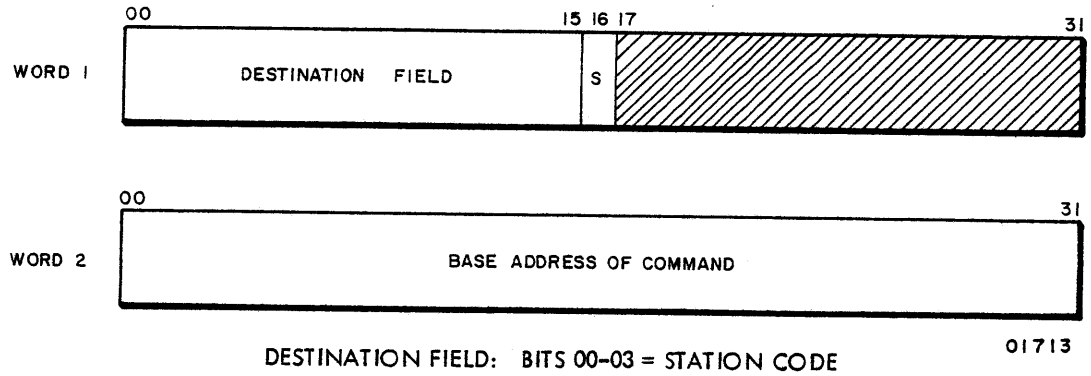


Figure 6-5. Request Entry Format

TABLE 6-2. REQUEST ENTRY FIELDS

WORD	BIT(S)	DESCRIPTION
1	00-15	Destination Field: Station/device/line number; supplied by the HLP and returned in the solicited response.
1	16	S Field (status of this request slot): 1 - This request is ready for initiation. (The HLP sets this bit when it places the request on the request list.) 0 - The LCC clears this bit when it initiates this request; therefore, a 0 indicates that this request is either active or has been completed.
1	17-31	Filled with zeros.
2	00-31	Base Address of Command: Location of associated command in command list; supplied by HLP and returned in solicited response.

COMMANDS

Commands, 64 bits in length, supply the LCC with detailed information necessary for the proper execution of a request. One command is issued by the HLP for each request. For an HLP-to-LCC request, the command is either a Close Line (hexadecimal F1) command, a Terminate Active Requests (F2) command, or an Open Line (F5) command. For details, see figure 6-6 and table 6-3. For Mode 4 operation, commands associated with stream requests are Poll (00), Enter Queue (02), Exit Queue (03), or Write (hexadecimal 81). For details refer to figure 6-7 and table 6-4.

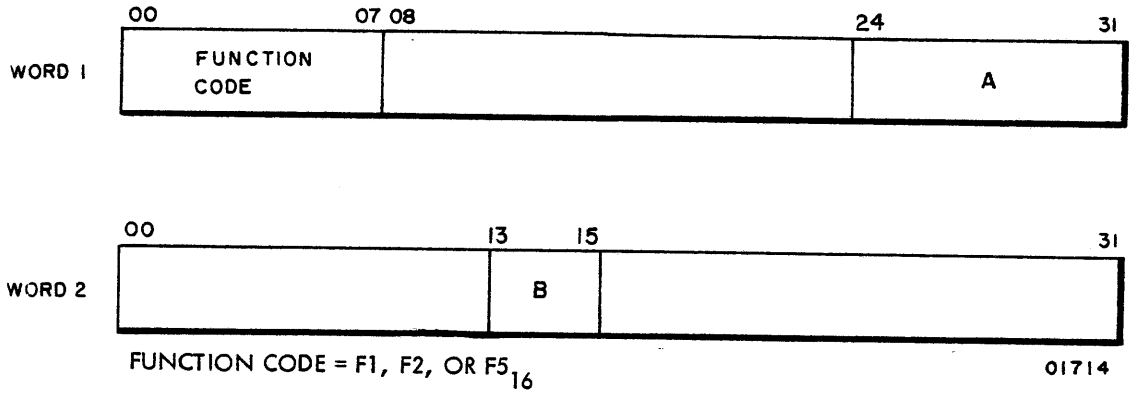
HLP-to-LCC command function code F2 enables the HLP to terminate all active requests on a given line while leaving the line open for additional communication activity. This function code enables the HLP to terminate any poll requests that are internally queued within the LCC. Also, F2 enables the HLP to terminate requests after previously-set timeouts occur.

Before reading any stream requests, the LCC always checks the HLP-to-LCC request slot; therefore, an F2 function code (Terminate Active Stream Requests) will take precedence over any active stream request. Upon reading an F2 function code, the LCC will do the following:

1) Return a solicited response code 24 to the HLP.

2) Abnormally terminate any poll request for that line and terminate any new stream request that appears in the request list for that line.

3) Return a solicited response code 28 when all requests have been terminated.



FUNCTION CODE = F1, F2, OR $F5_{16}$ 01714

F1 = CLOSE LINE

F2 = TERMINATE

F5 = OPEN LINE

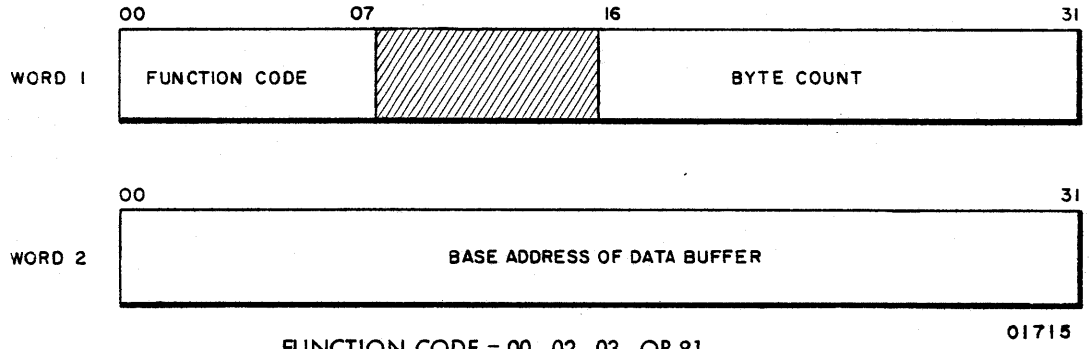
A = STATION/DEVICE IDENTIFIER, USED ONLY WITH FUNCTION F2.

B = TIMEOUT POINTER BASED ON LINE SPEED, USED ONLY WITH FUNCTION F5.

Figure 6-6. Command Format, HLP to LCC

TABLE 6-3. COMMANDS, HLP TO LCC

FUNCTION CODE (HEX)	DESCRIPTION
F1	Close Line: Terminate all outstanding stream requests to this line. For a switched line, the LCC will attempt to disconnect the terminal before closing the line.
F2	Terminate Active Requests: All active requests on this line terminated, line remains open.
F5	Open Line: This command, issued after placing the request list address in the line list, causes the line to be logically opened and allows input/output commands to be issued on the line. For a switched line, the LCC will attempt to identify the terminal that has dialed in. Field B contains a pointer to a table of timeout values that are associated with various line speeds. B = 1 for 9600 bps line = 2 for 4800 bps line = 3 for 2400/2000 bps line = 4 for 1200 bps line For any other line speeds, use the value for the next-lower line shown above; for example, for a 7200 bps line place a "2" in field B.



FUNCTION CODE = 00, 02, 03, OR 81_{16}

00 = POLL

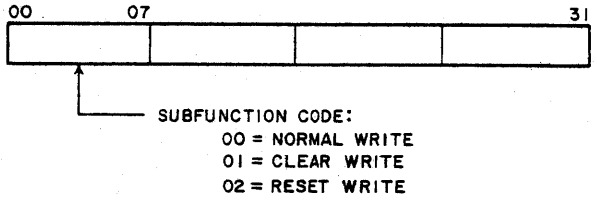
02 = ENTER QUEUE

03 = EXIT QUEUE

81 = WRITE

Figure 6-7. Command Format, Stream

TABLE 6-4. COMMANDS FOR STREAMS

FUNCTION CODE (HEX)	DESCRIPTION
00	Poll: The request associated with this command will be satisfied when a read response is received from any terminal or device in the poll queue of the given line. The station/device satisfying the request will be identified in the destination field of the response, and the data will be stored in an input buffer provided by the HLP.
02	Enter Queue: This command enables the HLP to return a terminal or device to the poll queue so it can be referenced in the next poll command. (Normally, the poll queue comprises only those terminals or devices to which a successful write command was previously issued.)
03	Exit Queue: This command enables the HLP to remove a given terminal or device from the poll queue.
81	Write: This command enables the HLP to write transparent text to the terminal. The destination field of the request contains the station code and device code of the addressed terminal/device. The byte count comprises the number of characters to be written plus four additional bytes for the word specifying the particular type of write operation to be performed. In the HLP buffer, this subfunction word precedes the data to be sent to the terminal. 

RESPONSE LIST

The next portion of this section describes the response list (see figure 6-8) which resides in the HLP memory. This is a circular list whose entries are responses to requests (primarily) and which is used by the LCC to inform the HLP of request status, errors, etc. Solicited responses are the result of an HLP request. Unsolicited responses are the result of unexpected stream or system conditions.

Response Entry Format

Responses are 128 bits in length with the format shown in figure 6-9.

Following is an explanation of the fields comprising the response entry:

- Destination field here is a reflection of the destination field that was received in the request from the HLP.

  Bits 00-03 = Station Code

  Bits 04-07 = Device Code

  Bits 08-15 = Line Number

- Log is a flag indicating that specific conditions should be logged on an error file.

- Response code is right-justified in the indicated field.

- Retransmit count field shows the number of error-recovery attempts made on the last block of data.

- Line status field (see figure 6-10).

- Byte count field indicates the number of 8-bit bytes of data transferred between the terminal and the LCC.

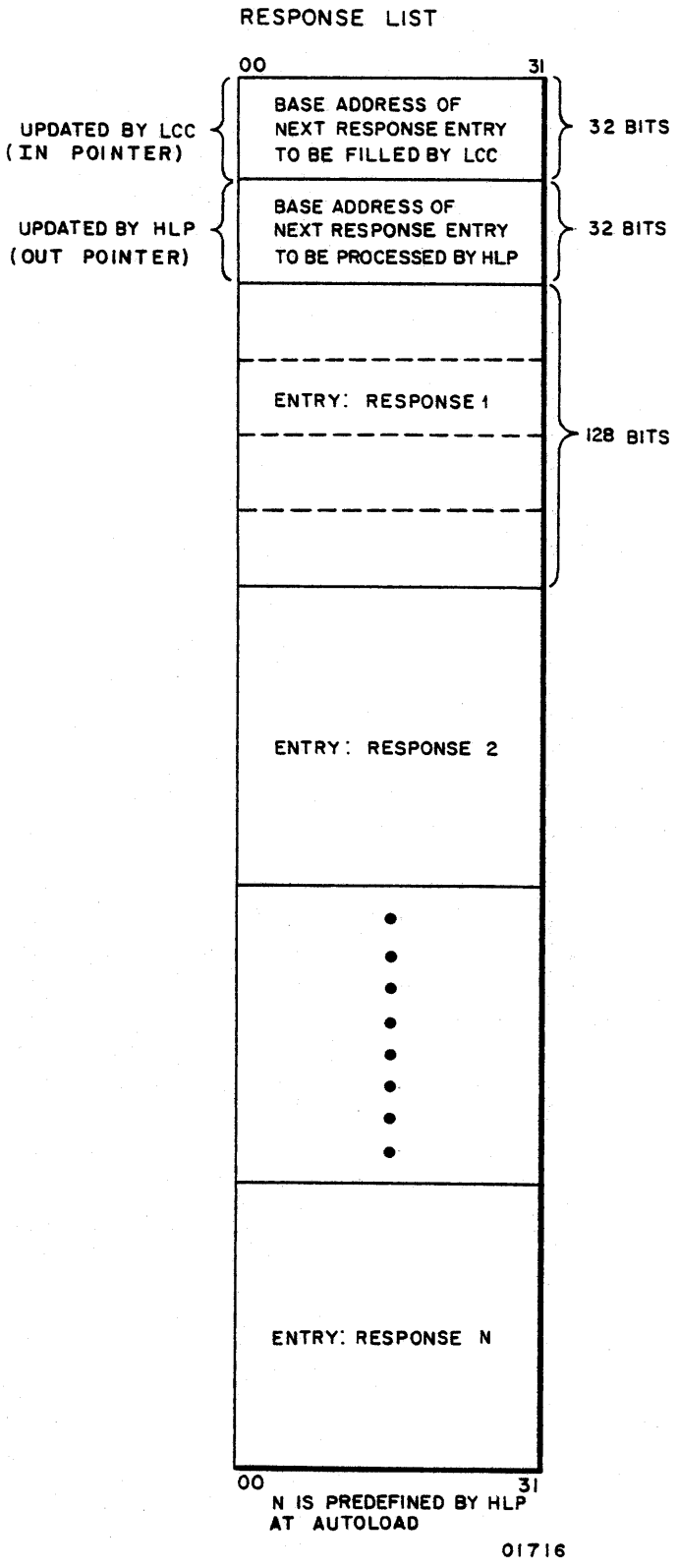


Figure 6-8. Response List in 7077-1 SAC CSM Memory

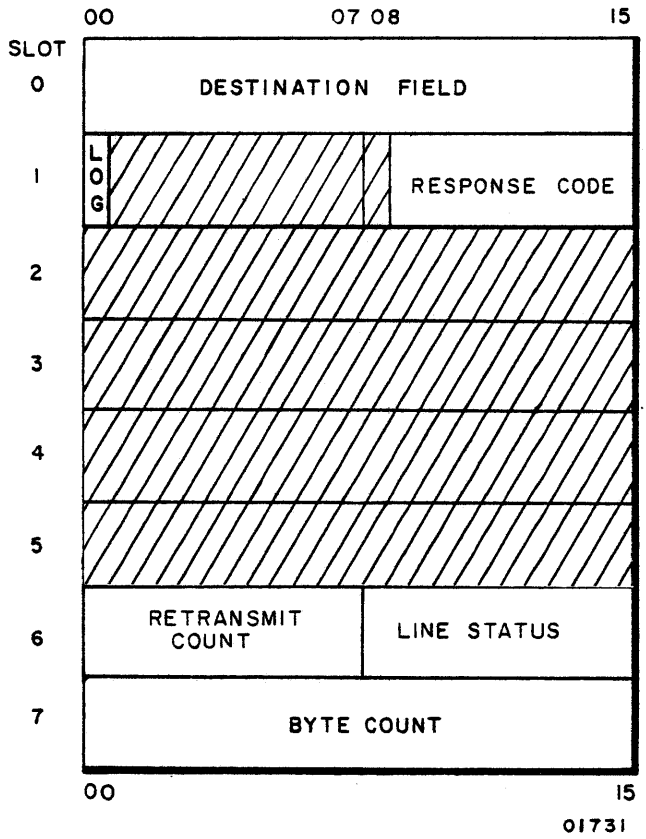


Figure 6-9. Mode 4 Response Entry Format

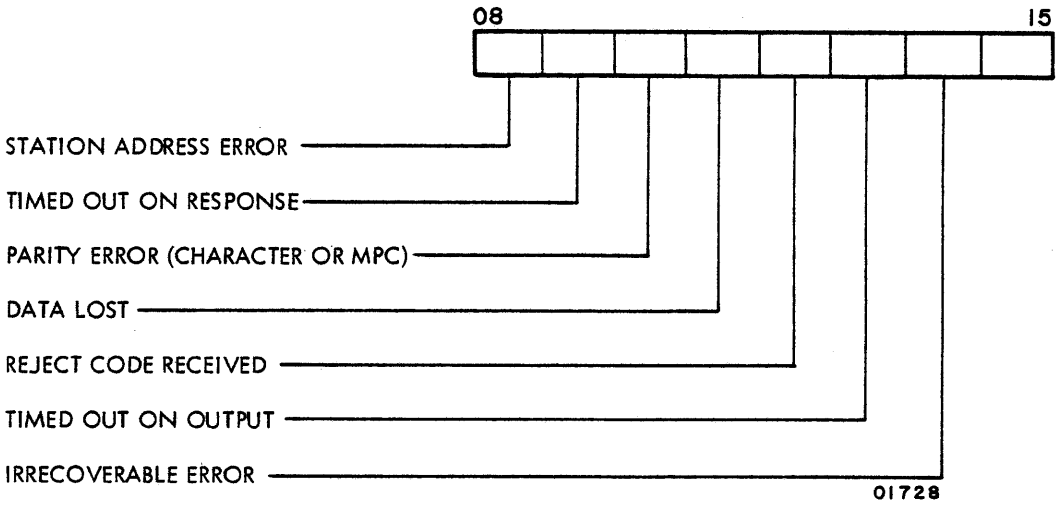


Figure 6-10. Line Status Field of Response Entry

Solicited Responses

By writing responses in the HLP's response list, the LCC notifies the HLP of completed requests. Associated with a particular request, such a response would be considered to be a solicited response. (See table 6-5 for the complete list of Mode 4 solicited responses.) In addition to flagging the end of an operation, the solicited response does the following:

- Indicates whether the operation was successfully completed or not.
- Shows the number of bytes of data that were processed.
- Shows whether any errors occurred as the operation was being performed.

TABLE 6-5. MODE 4 SOLICITED RESPONSE CODES AND DEFINITIONS

CODE	ASSOCIATED COMMAND	DEFINITION
20	All stream	Poll command resulted in a Read-E2 message from terminal: card reader or printer Not Ready. (E-code is returned in data buffer.)
21	All stream	Poll command resulted in a Read-E3 message from terminal: another buffer of data is required (printer is awaiting another buffer, or card reader has additional cards to be read into the input buffer).
22	All stream	Poll command resulted in a Read-E1 message from terminal: (poll message to display was received without error) or an ACK message was received in response to a Write command.
23	F5	HLP request to open line x is complete.
24	F2	HLP request to terminate active requests has been initiated. Response code 28 will be sent when the requests are terminated.
25	02	Enter Queue request completed normally.
26	03	Exit Queue request completed normally.
28	F1, F2	All requests have been terminated.
29	All	Request rejected: illegal parameters in request or command.
2A	All	Request rejected: internal buffer threshold has been reached; system is nearly saturated.
2D	All	Attempted an I/O request on a line that had not been opened.

Following are two representative internal (to the LCC) problems that can be reported using a solicited response:

- The LCC found an illegal parameter in the request or command it is processing and must reject this request.
- The LCC has reached the buffer saturation point and must reject the present request.

Unsolicited Responses

The following LCC internal problems are not associated with a particular request and are reported by unsolicited responses:

- Intermittent errors were detected on the data path between the HLP and the LCC.
- A fatal error has occurred on a communication line, and the line must now be closed because it is not possible to do any additional processing on it.
- A fatal error occurred in the communications adapter, and the HLP must close the line because processing cannot continue on the line.

Following are the errors that can be reported to the HLP via unsolicited responses from the LCC:

- A request was not successfully completed in the allowed number of retransmissions.
- A request was terminated by an HLP request before it was successfully completed.

See table 6-6 for the complete list of Mode 4 unsolicited responses.

TABLE 6-6. MODE 4 UNSOLICITED RESPONSE CODES AND DEFINITIONS

CODE	ASSOCIATED COMMAND	DEFINITION
44*	F5	Data Set Ready was detected on a dialup line, but then no terminal or device configured on that line responded to the poll message.
45*	—	System had intermittent SAC rejects.
46*	—	System buffers are saturated. Line x is closing. HLP must issue a close line request.
48*	—	The communications adapter connected to this line is malfunctioning, and the line is closing. HLP must issue a close line request.
49	—	The channel flag has been cleared.
4E	F1	Line x is closed. This response is returned following a close line command.
50	F5	Line x is open and communication has been established with a terminal. For a dialup line, the station code is returned in the destination field of the response.
53*	All stream	Parity error in last message (either character parity error or message parity error).
54*	All stream	An error function code was returned from the terminal.
55*	All stream	No response was received from the remote terminal.
56	All stream	Reject was returned from the terminal in response to a Write message.
57*	00	No E-code was returned in a Read message from the terminal.
59*	All stream	Data Set Ready status has dropped at the modem. The call has been disconnected and line x is closing.
5E*	00	The input message from the terminal was larger than the buffer that was provided for it.
5F*	81	Write toggle error.

* Logged on error file.

Exception Messages From Remote Terminal

In Mode 4 protocol, two types of messages returned by the terminal may be classed as exception responses.

- NAK (error) message generally indicates that the terminal did not receive the previous output message correctly.
- CAN (reject) message indicates that either the terminal controller was busy, or (for a poll message) the terminal had no data to send.

In addition to these two responses, the terminal may return an E-code indicating some specific condition (E-code meanings vary depending on the type of device from which they are received).

Should a terminal send no response at all, the LCC will return an unsolicited, logged response code (hexadecimal 55) to the HLP. See tables 6-7 and 6-8 for additional information concerning the processing and interpretation of responses.

TABLE 6-7. WRITE-COMMAND RESPONSES

MESSAGE RETURNED BY TERMINAL	LCC ACTION	MEANING OF RESPONSE RETURNED TO HLP
ACK (Acknowledge)	LCC sends a 22 response code indicating no errors and places the addressed terminal/device in the Poll Queue.	The remote terminal received the output message correctly (without error).
CAN (Reject)	LCC sends an appropriate response. The Poll Queue is not modified.	Terminal controller was busy.
NAK (Error)	LCC tries to retransmit the Write message N* times, then sends a response indicating whether this was accomplished successfully; if not, the LCC removes the terminal/device from the Poll Queue.	The remote terminal did not receive the Write message without errors.
No response, or errors in input message (parity, etc.)	LCC polls the terminal to determine whether Write message was received correctly; if necessary, repeats Write and Poll messages up to a total of N* times, depending on the responses obtained. The Poll Queue is not modified.	Write message was not received correctly by the remote terminal, or the message was received correctly but the LCC did not receive a response from the terminal.

* N is a number assembled into the controlware (currently 5).

TABLE 6-8. POLL-COMMAND RESPONSES

MESSAGE RETURNED BY TERMINAL	LCC ACTION	MEANING OF RESPONSE RETURNED TO HLP
Read-E1	LCC terminates Poll command and sends a 22 response code to the HLP, then removes addressed terminal/device from the Poll Queue.	Poll message to display was received without error.
Read-E2	LCC terminates Poll command and sends a 20 response code to the HLP, then removes addressed terminal/device from the Poll Queue.	Card reader or printer was not ready.
Read-E3	LCC terminates Poll command and sends a 21 response code to the HLP, then removes addressed terminal/device from the Poll Queue.	Card reader is ready to input additional card data, or printer is awaiting another buffer of data.
CAN (Reject)	LCC ignores this terminal/device and continues to look for a Read message.	— (No response is returned to the HLP.)
NAK (Error)	LCC repeats the Poll command and removes the addressed terminal/device from the Poll Queue if message is not successfully transmitted in N* retries.	Poll message was not received correctly by the remote terminal.
No response, errors in message, etc.	LCC repeats the Poll command and removes the addressed terminal/device from the Poll Queue if message is not successfully transmitted in N* retries.	Response from terminal was not correctly received by LCC.

*N is a number assembled into the controlware (currently 5).

DATA BUFFERS

The data buffers used by the HLP for communication with the remote terminals are physically located in the 7077-1 Communications Station and are sized and formatted by the HLP. Mode 4 data buffers have the following characteristics:

1) All input and output buffers are multiples of 4 bytes in length. Data bytes have eight bits, and there are two bytes per 16-bit word.

2) Input buffers must be large enough to allow an entire message to be read in from a terminal. If an input buffer is too small, data will be lost and an error response will be returned to the HLP.

3) Output buffers must be large enough to allow an entire message to be read to a terminal. Furthermore, all output buffers must contain a subfunction sequence in the first four 8-bit bytes (see Write function code for format). These bytes are included in the data buffer byte count. Any time an illegal subfunction sequence appears, the request will be rejected with an error response.

4) Output escape codes and E-code sequences must be embedded in the data block. Input E-codes are passed to the HLP in the data buffer provided.

5) Format control characters for 200 User Terminal printers must be embedded in the data and are assumed to be convertible if the message is addressed to a BCD terminal.

6) The character following an escape code is not converted.

7) Within an input or output data buffer, only one data mode can be used. (A data mode is considered to be the combination of the code set, the byte size, and the arrangement of bytes within a 16-bit word.)

GLOSSARY

The definitions of terms in this glossary are general and are specifically oriented to their application to the local communications controller and should not be taken as absolute or applicable to all CDC products.

ACTIVE LINE —
A communications line having an area in the higher level processor's storage dedicated to requests.

ACTIVE STREAM —
A stream which has a valid request in a request list.

ALPHA DATA TRADE —
See Contents for specific section of manual.

ASCII —
American Standard Code for Information Interchange, X3.4-1968. Usually pronounced ask'ee. The set of 128 control and graphic characters defined as a standard data communications code by ANSI to achieve compatibility between data devices. The code uses 7 bits to represent each character or control function. Synonymous with USASCII.

ASYNCHRONOUS —
Having no fixed time base within or between signaling elements.

BETA DATA TRADE —
See Contents for specific section of manual.

BLOCK —
A transmission block is a group of bits, characters, or bytes that are transmitted on a line as an entity via line control.

BUFFER —
A storage device used to compensate for a difference in the rate of flow of information or the time of occurrence of events.

BYTE —

8 bits.

CHANNEL FLAG —

Communication between the higher level processor and the local communications controller is initiated when the higher level processor sends a signal to the LCC via the truck channel and a channel flag control code on the control lines. The channel flag indicates that the higher level processor requests that one or more lines be activated.

CHARACTER —

An 8-bit byte. A member of a coded character set, the binary representation of such a member, and its graphic symbol or control function.

CLOSING DELIMITER —

A character sequence which defines the end of a transmission block.

COMMAND —

A command supplies detailed information to a station for proper execution of a request.

COMMUNICATIONS ADAPTER —

A hardware module that interfaces a modem with the terminal interface of the LCC. During input operations, the communications adapter assembles the serial bit stream (from the modem) into 8-bit characters. During output operations, it disassembles 8-bit characters for serial bit stream transmission.

COMPATIBLE TRUNK CHANNEL —

(LCC-to-HLP interface.) A 32-bit major communications artery carrying messages simultaneously by means of time or frequency interface techniques.

CORRECT TRANSMISSION —

A transmission whose opening delimiter and closing delimiter are recognizable (i.e., valid) and whose cycle redundancy check is errorless.

CYCLIC REDUNDANCY CHECK —

A method of error control employing a series of encodings and accumulations made in hardware encoder/decoders in both the LCC and the remote terminal, one check per transmission block.

DATA —

Those characters which comprise a message.

DATA FRAMING CHARACTER —

An ASCII control character which delimits the data and indicates its transmitted mode (TSTX).

DATA LINK ESCAPE —

An ASCII communications control character which introduces the transparent text transmission and distinguishes control character bit configurations which are present in the data stream.

DATA/STATUS BLOCK —

A transmission block which contains only stream identifiers and their respective status.

DEMODULATOR —

A signal converter which accepts analog signals and converts them to digital signals.

DOMINANT —

Designation given to stations which initiate all activity on a line. A subordinate station must always reply to the dominant station, but the converse is not always true. The LCC is dominant over the remote terminals but is subordinate to the higher level processor.

ENTRY SLOT —

A dedicated area within a list where information is stored and used. For example, the first entry slot of each request list (bits 00–31) is dedicated to requests for communication between the higher level processor and the LCC; the remaining entry slots are dedicated to streams.

EXERCISER —

A pseudo-diagnostic program which causes the communications adapter to loop as part of an error-recovery procedure to determine whether an error condition is caused locally.

FRAMING CHARACTERS —

Characters which bind a data block on both ends and define characteristics about the block.

FULL DUPLEX —

A hardware capability of transmitting and receiving simultaneously on a communications line.

FULL-DUPLEX CHANNELS —

A pair of channels, one operating in each direction, allowing simultaneous information transmission in both directions.

INPUT STREAM —

Input streams are those simplex flows of data which are received by the local communications controller; that is, the local communications controller inputs the block of data.

INTERPRETABLE RESPONSE —

A response which has valid opening and closing delimiters; that is, ones which can be translated.

LINE —

A data communication channel, including its control logic which is connected directly to a station or a remote terminal.

MESSAGE —

A logically-related group of characters or bits which must be switched or processed as an entity by the data communications subsystem. A message consisting of a group of noncoded bits (binary) is a transparent message.

MESSAGE TRANSMIT TIME —

The time required for transmitting a message from its point of origin to its point of destination in a system.

MODEM —

A contraction of modulator/demodulator. A unit containing both a modulator and a demodulator.

MODULATOR —

A device which changes the frequency of electrical waves by imposing upon them others of another, usually a lower, frequency. A signal converter which accepts digital signals and converts them into analog signals by modulating a carrier signal. The modulated analog signal must be suitable for transmission on a given circuit.

MULTIPLEXING —

The simultaneous transmission of two or more messages on a single channel during a given time interval.

MULTIPOINT LINE —

A communications line interconnecting several stations.

NONCONTINUOUS —

Every block that is transmitted (in one direction) must have a response before another block is transmitted in the same direction. The response temporarily discontinues the transmission.

NON-SWITCHED LINE —

A communications line which has both ends connected point-to-point (the line does not go through a telephone switching network).

OFFLINE —

A remote terminal is offline when it does not service a communcations line but performs some external function.

OPENING DELIMITER —

A sequence of characters which defines the beginning of a transmission block.

OUTPUT STREAM —

Output streams are those simplex flows of data which are transmitted by the local communications controller to the remote terminal; that is, the local communications controller outputs a block of data.

POLL —

A poll is a signal from the local communications controller to the remote terminal which quizzes the remote terminal for activity.

POINT-TO-POINT —

Two modems only are connected on a communications line.

PREEMPTIVE PRIORITY —

A request which is processed prior to all others, regardless of the time it enters a system.

REMOTE TERMINAL STATION —

A subsystem that provides a user interface to a system for the purpose of entering and obtaining information. It contains data and control logic, communication control elements, local storage, and input/output remote terminals.

REQUEST —

A request is the leading part of a message sent to a station. The request contains a command which specifies the detailed information to be carried out by the station.

RESPONSE —

A response is a message sent from a station to the operating system (higher level processor), usually in answer to a request. It provides information about a previous request to the higher level processor, or it notifies the higher level processor that an area needs attention.

ROTATE INTERNAL BUFFERS —
Buffers are dynamically assigned from a "pool" of buffers; that is, from a group of buffers sharing or allocated to a common interest.

SCAN —
A search for the highest priority function to be performed.

SERIAL-BIT TRANSFER —
A system of data transmission in which characters are sent bit-by-bit, in sequential order, over a single path.

SIMPLEX —
Simple or uncompounded. Unidirectional, as in a communications line in which data flows in only one direction, irreversibly.

SINK —
The receiver of data.

SOURCE —
The sender of data.

STATION CONTROL INFORMATION —
Information about the status or activity of a stream.

STREAM —
A simplex flow of data.

STRIPPING —
Framing characters are removed or stripped off the data block before the data block is recorded in the higher level processor's data buffer.

SUBORDINATE —
A station on a line which responds to communications but does not initiate communications.

SYNCHRONIZE —
To get in step with another unit or a bit, element, character, or word.

SYNCHRONOUS —
Operating in isochronous harmony with connected devices; that is, an event recurring at regular intervals of equal time.

TEXT —
That portion of a message which contains user data.

TRANSMISSION BLOCK KEY —

A code (0-7) which indicates the size of the data block requested. The transmission block key is bits 08-15 of the command format stream. The size of the block, corresponding to the code, is an assembly parameter.

TRANSPARENT DATA OR TEXT —

Data which uses all 8 bits of a byte. There is no character parity.

TWO-WAY ALTERNATE —

A mode of operation in which bidirectional information flow is accepted, but cannot occur simultaneously.

TWO-WAY SIMULTANEOUS —

A mode of operation supporting both an outgoing transmission and an incoming transmission simultaneously. A full-duplex channel is required for two-way simultaneous operations.

VALID TRANSMISSION —

A transmission whose opening delimiter and closing delimiter are recognizable.

VOICE GRADE —

A grade of communication line which has the same bandwidth as normal voice circuits and which is a part of the common carrier switched telephone network.

WORD —

16 bits of data, or two 8-bit bytes.

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