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1. NETWORK DESCRIPTION

The Power Line Network (PLN) provides for the interconnection and communication between devices via a standard installed ac wiring network. Its primary characteristics are:

MEDIUM:
The already installed 110/220 volt ac wiring system, standard in all residential, business, and industrial structures.

NUMBER OF STATIONS:
254 maximum.

DATA ENCODING:
Synchronous serial data transmissions. Transmitted data is spread-spectrum encoded. The encoded signal then modulates a high frequency carrier signal which is injected onto the transmission medium.

DATA RATE:
15,300 bits per second.

NETWORK ACCESS:
Communication links are time division multiplexed (only one transmitter active at any time) and controlled by a network Arbitrator, eliminating the need for 'carrier sense' and 'collision detection'.

PACKET FORMAT:
Each communication packet begins and ends with an 8-bit flag byte. The packet includes fields for destination address, status, control, user supplied message, and CRC.

MAXIMUM MESSAGE LENGTH:
256 8-bit bytes.

COMMUNICATION PROTOCOL:
At its allocated time slot, station "A" sends a packet addressed to station "B". Station "B", at its time slot, sends an acknowledgement to station "A". Failure of station "B" to acknowledge will cause station "A" to retransmit the packet.

NETWORK CONFIGURATION:
User supplied configuration information resides in the network Arbitrator. The Arbitrator communicates with and provides each network station with the address of its 'connected' station(s).

2. NETWORK COMPONENTS

Since the transmission medium of the power line network (PLN) is already in place, the components needed to implement the network are:

(1)A device to physically interface to user-supplied equipment and to the network medium (the ac power line). This device constitutes the network station or node. In the PLN, this device is called the NETWORK INTERFACE MODULE (NIM).

(2)A device to cyclically poll each network station to determine if that station desires network access. This device is the network's 'traffic cop', allocating time-slots to each of the network's stations and directing each station's output to the correct destination. In the PLN, this device is called the ARBITRATOR.

(3)A means of operator-communications with the network for the purpose of 'connecting' and 'disconnecting' network stations and making inquiries about network status. This function is provided by appropriate user-supplied equipment (such as a terminal or computer), connected to the network via a NIM and communicating with the Arbitrator. When the user-supplied equipment and its interface to the network are functioning in this fashion, this network station is called a 'COMMAND DEVICE'.

(4)Appropriate user-supplied equipment. Although not part of the network mechanism, the user-supplied equipment is of course a necessary component of the network. It is assumed that the user will connect data-processing type equipment (terminals,computers,printers), communications-type equipment (modems), more rudimentary equipment intended to implement such functions as remote control, remote status monitoring, energy management, security control, or a combination of all these types of equipment.

2.1 NETWORK INTERFACE MODULE (NIM)

The function of the NIM is, first, to provide an interface into the network from the user-supplied equipment. Data from the user-supplied equipment is formatted into a data packet to be transmitted onto the network. The NIM adds to the packet: the address of the destination station, the required control bytes, and a 16-bit cyclical-redundancy-code (CRC) for error checking at the receiver. When the NIM is polled by the Arbitrator, indicating that the network is available, the complete data packet , properly encoded for insertion onto the ac power line, is serially transmitted.

The NIM at each station of the network decodes the transmitted packet and determines if the destination address of the packet matches its own station address. The addressed NIM accepts the packet, verifies that no errors occurred during transmission (CRC check), interprets and verifies that the control bytes are correct, and

presents the original message to the user-supplied equipment to which it is connected.

A second function of the NIM is to allow operator communications with the network from certain user-supplied equipment. To allow this function, the NIM is placed in the 'COMMAND' mode by the operator. This is usually accomplished by the operator pressing the 'BREAK' key on a terminal keyboard. In the command mode, the NIM receives messages from the user-supplied equipment, reformats the message, and when the network is available, transmits the message to the Arbitrator. As long as the NIM is in the command mode, all network communication is between the NIM and the Arbitrator. The responses from the Arbitrator are passed on to the user-supplied equipment. This dialogue between the operator and the Arbitrator accomplishes the connections and disconnections between the various stations of the network.

Figure 2-1 illustrates the functional divisions of the network interface module. A typical implementation to provide these functions is illustrated in Figure 2-2. Although the user interface shown in Figure 2-2 specifies the familiar RS232, the interface to the user equipment may be any standard interface. Those NIMS interfacing the network to more rudimentary user-supplied equipment, such as for remote control, will provide a basic interface of 16 parallel output lines and 16 parallel input lines.

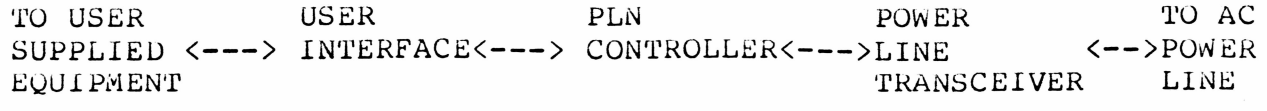

FIGURE 2-1. NETWORK INTERFACE MODULE FUNCTIONAL DESCRIPTION.

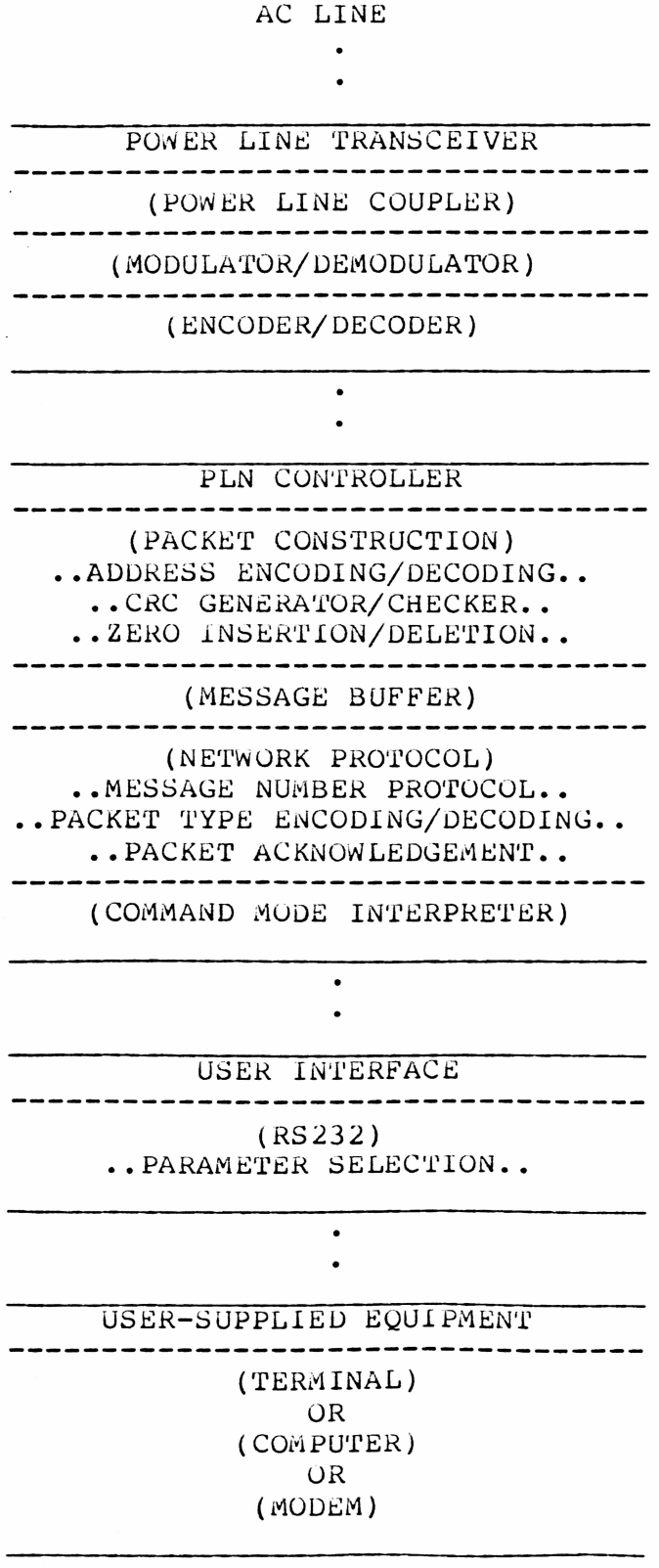

FIGURE 2-2. TYPICAL IMPLEMENTATION OF NETWORK INTERFACE MODULE

2.2 ARBITRATOR

The primary function of the Arbitrator is to allocate time-slots on the network to the various network stations desiring access to the network. After the network's configuration is known to the Arbitrator, it cyclically polls each 'connected' network station by transmitting a packet to each station implying that the network is available. The polled station may respond in one of four ways.

(1)If the station has data to be transmitted to another station, it immediately places a properly addressed packet onto the network. The Arbitrator monitors the transaction and at the conclusion of the transmission, polls the next station on the network.

(2)If the polled station does not desire access to the network, it immediately transmits a packet to the Arbitrator declining the network. The Arbitrator then polls the next station on the network.

(3)If the polled station has certain status conditions to report, a packet containing that status is immediately transmitted to the Arbitrator. The Arbitrator acts immediately on the reported status and then polls the next station on the network.

(4)If the polled station is in the COMMAND mode (that is, performing as a Command Device), a packet containing a reformatted message from the user-supplied equipment is transmitted to the Arbitrator. The Arbitrator interprets the command message, performs the requested service, and communicates the results to the user-supplied equipment by transmitting an appropriate packet to the polled station. After this entire transaction is completed, the Arbitrator then polls the next station on the network.

The Arbitrator maintains a network configuration table that specifies the connections between and the status of all the network stations. This information is derived from station responses during the normal polling cycle and from operator inputs (via Command Devices). The Arbitrator cyclically polls each station that is currently 'connected' to another station. At the conclusion of this cycle, the Arbitrator then polls one station that is not currently 'connected'. This procedure is explained in more detail in Section 3 (NETWORK INITIALIZATION). This method of selectively polling only 'connected' devices reduces the time between network accesses for the stations using the network.

When a 'connection' is requested to be made between network stations, the Arbitrator immediately communicates with the subject stations providing them with the appropriate destination addresses for their outgoing packets. During the polling cycle, the Arbitrator never sequentially polls two stations which are 'connected' to each other. This is to allow the unpolled station, which may have just received a packet, adequate time to prepare an acknowledgement.

The Arbitrator continuously generates and places on the network certain required timing signals. In addition to the normal packet communications between stations or between the Arbitrator and a station, this timing information is always present on the network. It provides for synchronization of all the power line tranceivers on the network.

Figure 2-3 illustrates the functional divisions of the Arbitrator. A typical implementation to provide the non-timing functions is illustrated in Figure 2-4.

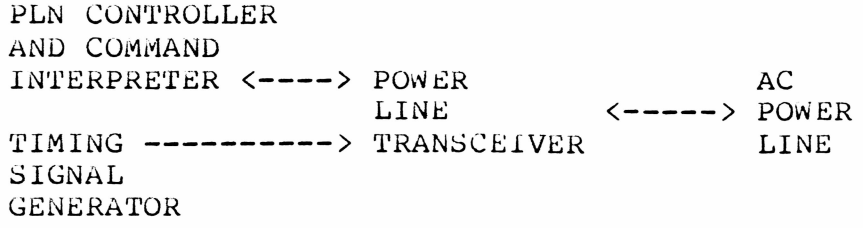

FIGURE 2-3. NETWORK ARBITRATOR FUNCTIONAL DESCRIPTION

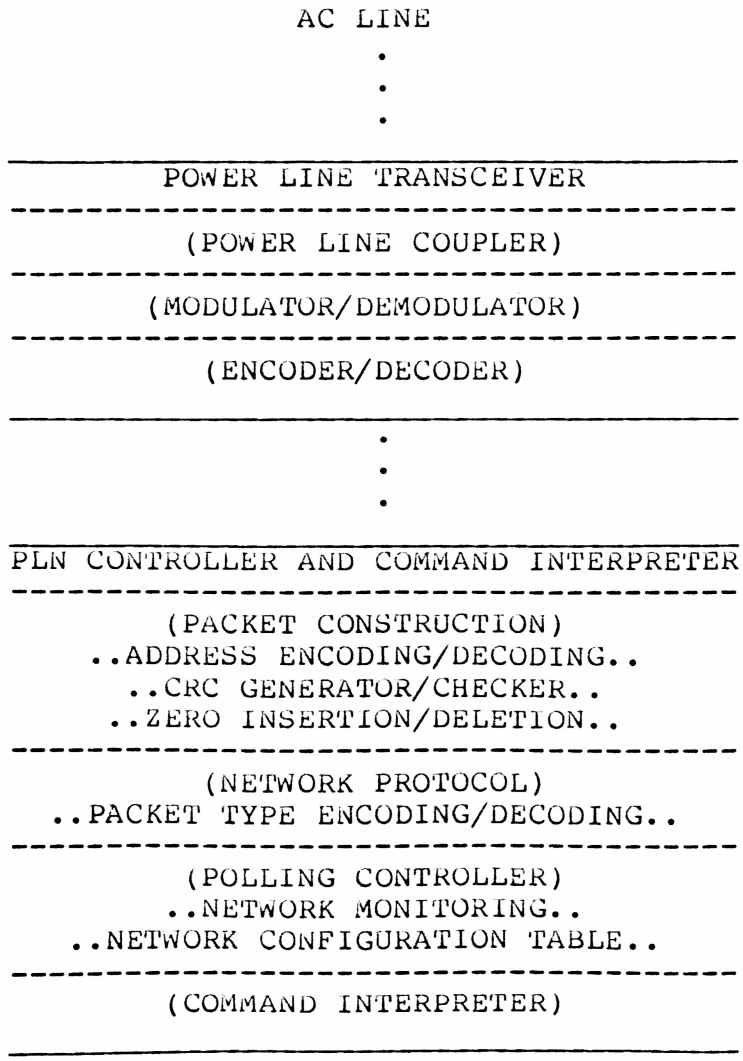

FIGURE 2-4. TYPICAL IMPLEMENTATION OF NETWORK ARBITRATOR

3. NETWORK INITIALIZATION

This section describes the procedure which the Arbitrator follows at RESET in order to initialize conditions at all stations and allow network configuration. It is assumed, for this description, that some of the network stations are already physically connected to the network medium (the ac power line), although that fact isn't necessary. This procedure will also describe how stations may be added to the active network.

The Arbitrator contains a battery back-up which ensures the integrity of the contents of its memory during the absence of ac power. Therefore, once the Arbitrator memory contains configuration information, it will not be destroyed by a power loss.

3.1 CONFIGURATION TABLE INITIALIZATION

At 'RESET' the Arbitrator executes the following procedure:

(1)A table containing the list of 'connected' stations is cleared. This table will eventually contain the address of every station which has been 'connected' to another station. Initially, this table will be capable of containing information for 254 stations. An operator at a Command Device may request that the Arbitrator limit the number of possible network stations to a number less than 254. This reduction in the 'maximum nodes' value will improve the efficiency of the polling cycle.

(2)A table containing the list of 'not connected' stations is filled with all valid station addresses up to the 'maximum nodes' value.

3.2 INITIALIZATION OF ALL NETWORK STATIONS

It is assumed that each NIM connected to the power line, and therefore representing a network station, will have a valid and unique 8-bit address selected. This is accomplished with pencil switches physically located on the NIM.

After table initialization, the Arbitrator executes the following procedure:

(1)Each station whose address is in the 'not connected' table, in sequence, is sent a 'disconnect' packet by the Arbitrator (a type >c0 packet, described in Section 4.4.1.2). The Arbitrator expects, but doesn't require, a response to each of these packets.

(a)If a station with this address is not currently connected to the network medium, of course there will be no response. The Arbitrator

then addresses the next station.

(b)The addressed station may respond by sending an 'acknowledge' packet to the Arbitrator. This 'acknowledge' packet contains the addressed station's status. During this first cycle the Arbitrator ignores the station's reported status. The Arbitrator then addresses the next station.

(c)The addressed station may respond by sending a command to the Arbitrator. This response results from the station having been placed in the command mode and a command message prepared for the Arbitrator. during this first cycle the Arbitrator ignores any received command messages. The Arbitrator then addresses the next station.

This sequence continues until the Arbitrator has addressed each of the 'not connected' stations one time. In this way, the Arbitrator causes each station to initially be 'disconnected'.

(2)The Arbitrator then repeats the cycle by sending each station, in sequence, a 'disconnect' packet. During this cycle the Arbitrator evaluates each station's response.

(a)If a station with this address is not currently connected to the network medium, there will be no response. The Arbitrator then addresses the next station.

(b)The addressed station may respond by sending an 'acknowledge' packet to the Arbitrator. This 'acknowledge' packet contains the addressed station's status. The Arbitrator evaluates and records the status and attempts to correct certain error conditions. The Arbitrator then addresses the next station.

(c)The addressed station may respond by sending a command to the Arbitrator. This response results from the station having been placed in the command mode and a command message prepared for the Arbitrator. The Arbitrator interprets and executes the command and sends a response back to the addressed station. The Arbitrator then addresses the next station.

This sequence continues, and this cycle is repeated, until two or more stations are caused to be 'connected' as described below.

3.3 DETERMINATION OF 'CONNECTED' STATIONS

If, at some time during the second cycle described above, a command from an addressed station requests that two (or more) stations be 'connected', the Arbitrator removes those requested addresses from the 'not connected' table and places them in the 'connected' table. The Arbitrator also communicates with the subject stations providing them with the appropriate destination addresses for their outgoing packets.

When the 'connected' table contains station addresses, the Arbitrator 'polls' each station whose address is in the 'connected' table (a type >80 packet), allowing access to the network by those stations. When all 'connected' stations have been 'polled', one 'not connected' station is sent a 'disconnect' packet (a type >C0 packet). This polling technique assures the 'connected' stations maximum access to the network, while continuing to address all other valid station addresses at a less frequent rate. this final polling sequence continues to be executed during the normal network operation.

At any time, an additional station may be physically connected to the network medium and be placed in the 'connected' table by a request from a Command Device; or may itself become a Command Device and communicate with the Arbitrator upon receiving the 'disconnect' packet ultimately sent to all 'not connected' station addresses.

4. NETWORK COMMUNICATIONS

This section describes the protocol sequences which occur during the communications transactions on the Power Line Network. This section contains a detailed description of the packet fields, packet types, and additional description of the polling process.

4.1. NIM TO USER-SUPPLIED EQUIPMENT COMMUNICATIONS

The NIM continuously monitors the interface to the user-supplied equipment. Once the NIM is 'connected', any data supplied at this interface is accepted and placed in the NIM'S transmit buffer. When the NIM gains access to the network, any data in the transmit buffer is placed in a packet and transmitted onto the network. If the amount of data exceeds 256 bytes, only the first 256 bytes are transmitted. This data, just transmitted, is retained by the NIM until the receiving station has acknowledged the transmission. Failure to receive a proper acknowledgement results in the same data being retransmitted when network access is again granted to this station.

If the NIM is not 'connected' (unless the NIM is in the Command Mode), any data received from the user-interface is ignored.

The NIM also continuously monitors the interface to the network medium (the output from the power line transceiver). The address field of each incoming packet is examined and a 'match' causes the entire packet to be accepted by the NIM. If the NIM is 'connected', the packet contains a message field, and no errors have occurred, the message data is placed in the NIM'S receive buffer. The data from the receive buffer is then presented to the user-supplied equipment interface. If the incoming packet was correctly received and contained a message field, the NIM prepares an 'acknowledge' packet to be sent to the sending station. When network access is granted to the NIM, the 'acknowledge' packet is transmitted.

If the NIM is not 'connected', all incoming packets from other network stations are ignored.

4.2 PACKET DESCRIPTION

Each time the Arbitrator polls a network station, the NIM at that station responds by transmitting a data packet. The contents of the packet will vary depending upon the conditions at the NIM.

(1)If data from the user-supplied equipment at the NIM has been placed in the NIM'S transmit buffer, a packet with that data in the message field is transmitted. The packet is addressed to the station's 'connected' station.

(2)If, since the last poll, a message has been received by the NIM, an

'acknowledge' packet is transmitted. The packet is addressed to the station's 'connected' station.

(3)If conditions described in both (1) and (2) exist, a packet containing both message data and an 'acknowledge' is transmitted. The packet is addressed to the station's 'connected' station.

(4)If neither condition described in (1) and (2) exists, and no error conditions exist, a packet is transmitted indicating that network access is not required. This packet is addressed to the Arbitrator.

(5)If the polled station is in the command mode and a command message has been prepared, a packet with that command in the message field is transmitted to the Arbitrator.

(6)Regardless of all other conditions, if error conditions exist, a packet is transmitted reporting the error conditions. This packet is addressed to the Arbitrator.

4.3 PACKET FIELD DESCRIPTION

The network packet consists of a sequential combination of fields, each field being one or more 8-bit bytes: (1)Flag, (2)Destination Address, (3)Packet Type, (4)Message Number, (5)Message, (6)CRC, and (7)Flag. All fields except the Message field and Message Number field are present in every packet. All fields except the Flag fields are processed for serial transmission by inserting a 'ZERO' following five consecutive 'ONES'. The inserted 'ZEROS' are removed at the receiving station.

4.3.1 FLAG

The Flag field at the beginning of the packet consists of two 'FLAG' bytes. The bit combination of a Flag byte is '01111110'. The Flag byte is recognized by all receiving stations as the beginning or end of a packet. The Flag byte represents a unique combination of bits because, in all other packet fields, 'ZEROS' are inserted following five consecutive 'ONES'. Two 'Flag' bytes are placed at the beginning of the packet to permit synchronization of the network receivers. During the first byte, receiver synchronization takes place assuring proper reception of the second byte.

4.3.2 DESTINATION ADDRESS

The Destination Address field is a one byte field representing the 8-bit address of the station to receive the packet. An all-zeros value in this field addresses the Arbitrator. An all-ones value in this field addresses all network stations. The remaining bit

combinations represent the 254 possible station addresses.

The Destination Address value is provided to a station by the Arbitrator when the station has been requested to be 'connected'.

4.3.3 PACKET type

The field indicating the packet type is one byte in length. The defined packet types are listed below and discussed in more detail in Section 4.4 (PACKET TYPE PROTOCOL).

PACKET TYPE >00
No message field; sending station is ready to resume receiving data. (this packet type is sent after sending a type >06 or >46 packet).

PACKET TYPE >04
No message field; acknowledgement of last received message.

PACKET TYPE >06
No message field; acknowledgement of last received message, but receive buffer is now full. Send no more data until receipt of a type >00 or >40 packet.

PACKET TYPE >40
Packet contains message field.

PACKET TYPE >44
Packet contains message field; acknowledgement of last received message. (If sent to the Arbitrator, implies status in message field).

PACKET TYPE >46
Packet contains message field; acknowledgement of last received message, but receive buffer is now full. Send no more data until receipt of a type >00 or >40 packet.

PACKET TYPE >60
Packet contains message field. This type packet is sent only to special NIMS.

PACKET TYPE >80
This packet type is sent only by the Arbitrator. There is no message field. This packet type is sent by the Arbitrator to inform the station that network access is available.

PACKET TYPE >C0
This packet type is sent only by the Arbitrator. The message field of the packet contains a one byte value to be used as the destination address of outgoing packets. (This packet type is sent by the Arbitrator to perform a 'connection' between stations).

PACKET TYPE >C4
This type packet is sent only by the Arbitrator. The message field of the packet contains the response to a command from a Command Device.

4.3.4 MESSAGE NUMBER

This field is present in all packets transferred between network stations. The message number field is one byte in length and indicates the message number of the message being transmitted.

4.3.5 MESSAGE

The message field is an optional field in the packet. If a message field is contained in the packet, its length will be from one to 256 bytes. Generally, the data in the message field originates at the user-supplied equipment; however, the NIM or Arbitrator may generate the contents of this field for certain packet types.

4.3.6 CRC

The CRC field is two bytes in length. The 16-bit CRC value is calculated over all the packet fields except the flag fields.

4.3.7 FLAG

The final Flag field of the packet is one byte containing the value '01111110'.

4.4 PACKET TYPE PROTOCOL

The different packet types were listed in Section 4.3.3. This section describes in more detail the meanings and uses of the packet type values. Table 4-1 illustrates the meanings of each of the bits in the packet type field.

BIT NUMBER	MEANING
(LSB)0	THIS BIT IS RESERVED FOR FUTURE USE.
1	1=RECEIVE BUFFER IS FULL. DISCONTINUE TRANSMISSION
2	1=ACKNOWLEDGEMENT OF RECEIPT OF MESSAGE.
3	RESERVED
4	RESERVED
5	1=THE DESTINATION OF THIS PACKET IS A SPECIAL NIM. ALL OTHERS DISREGARD.
6	1=THIS PACKET CONTAINS A MESSAGE FIELD.
(MSB)7	1=THIS PACKET ORIGINATED AT THE ARBITRATOR.

TABLE 4-1. PACKET TYPE FIELD BIT MEANINGS.

4.4.1 PACKET TYPES ORIGINATING AT THE ARBITRATOR

Only certain packet types may originate at the Arbitrator: >80, >C0, >C4. The rationale and protocol associated with each of these packet types are described in Sections 4.4.1.1 through 4.4.1.3 and in Table 4-2.

4.4.1.1 PACKET TYPE >80 (bit 7=1)

This packet type is generated only by the Arbitrator and is the 'polling' packet. This packet type is sent to each 'connected' station to advise that network access is available. The responses the Arbitrator expects from this packet type are:

(1)No response. this action may occur either because of random errors on the network medium or because the network station is no longer functioning. If a station fails to respond to 15 consecutive 'polls', the Arbitrator records this status for future reporting to a Command Device.

(2)A type >00 packet from the polled station, addressed to the Arbitrator, indicates that the station does not require network access. This is a normal response and requires no special action by the Arbitrator.

(3)A type >40 packet from the polled station, addressed to the Arbitrator, indicates that the station is in the command mode. The message field of the packet contains a formatted command from an operator. The Arbitrator immediately interprets this command and sends a response as described in Section 4.4.1.3.

(4)A type >44 packet from the polled station, addressed to the Arbitrator, indicates that the station is reporting an error status condition. The message field of this packet contains two bytes of status. The first byte contains the station's error status. The status conditions reported are:

(a)Station has not received a 'connect' (or 'disconnect') directive since being powered up. The Arbitrator attempts to correct this condition by immediately sending a type >C0 packet to the station.

(b)The station's user interface indicates 'no-connection' to user-supplied equipment. The Arbitrator records and subsequently reports this status to any Command Device attempting to 'connect' this station to another station.

(c)The station has observed excessive 'lost packet' indications following recent outgoing packets. This is recorded in the status of the station 'connected' to this station, for future reporting to a Command Device.

(d)The station is a special NIM. If this is the only status reported, the Arbitrator treats this response the same as a type >00 response. The Arbitrator modifies this station's status to indicate it is a special NIM.

The second byte of the message contains the present destination address of the station's outgoing packets.

(5)A packet addressed to another network station. The Arbitrator monitors this transaction to determine the end of the transmitted packet. None of the packet information is evaluated by the Arbitrator.

4.4.1.2 PACKET TYPE >C0 (bits 7,6=1)

This packet type is generated only by the Arbitrator and is sent to a network station to provide it 'connection' information. The message field of the packet contains a one-byte destination address for the station's outgoing packets. An 'all-zeros' value in this field instructs the station to become 'disconnected'. An 'all-ones' value in this field informs the station that it is being 'connected' to a special NIM (or NIMS), and to follow a special addressing protocol. This special addressing protocol is discussed in Section 6 (SPECIAL NIMS).

Successful reception of this type packet by a receiving station is acknowledged by sending either a type >40 or a type >44 packet back to the Arbitrator. As described earlier, a type >40 packet from the addressed station, sent to the Arbitrator, indicates that the station is in the command mode. A type >44 packet from the addressed station, sent to the Arbitrator, is the normal response to the 'connect' directive. The message field of this packet contains two bytes of status. The first byte contains the station's status; the second byte contains the station's 'connect' address.

If this packet contains a 'connect' directive and the Arbitrator fails to receive an acknowledgement, the message is immediately retransmitted. Four attempts at retransmission without the required acknowledgement cause the station to be remain 'not connected' and no other station will be 'connected' to it.

If this packet contains a 'disconnect' directive and the Arbitrator fails to receive an acknowledgement, the Arbitrator declares the station 'disconnected' and 'disconnects' any other station 'connected' to it.

4.4.1.3 PACKET TYPE >C4 (bits 7,6,2=1)

This packet type, when transmitted by the Arbitrator, implies the acknowledgement of a 'command' message from a Command Device and that the message field of this packet is the response to that 'command'. The message content of these 'response' packets are described in Section 7.2 and Table 7-4. The Arbitrator expects no acknowledgement to this type packet.

<--*

ARBITRATOR SENDS	MEANING	RESPONSE	MEANING
Adr,80,xx	Poll	00,00,xx	Time slot declined
		00,40,msg...	Sending command message
		00,44,msg...	Sending status message
		Adr,.....	NIM to NIM transaction
		No response	???
Adr,C0,Dest	Connect	00,40,msg...	Sending command message
		00,44,msg...	Sending status message
		No response	???
Adr,C4,msg...	Response to Command	No response expected	

Adr = a network station address
Dest = Destination address directive
msg.. = message field
xx = ignored by receiving station

TABLE 4-2. ARBITRATOR PACKETS AND RESPONSES

4.4.2 PACKET TYPES ORIGINATING AT NETWORK STATIONS

All packet types except >80,>C0, and >C4 may originate at the network station. Packets are sent by the network stations only upon receiving a type >80, >C0, or >C4 packet from the Arbitrator. Packets may be sent to other network stations only upon receipt of a type >80 packet from the Arbitrator. The rationale and protocol associated with each packet type are described in Sections 4.4.2.1 through 4.4.2.7 and in Table 4-3.

4.4.2.1 PACKET TYPE >00

If the station has no message information in its transmit buffer, and only wishes to inform its 'connected' station that incoming messages will again be accepted, this packet type is sent. This packet type is sent following a type >06 or >46 which had halted incoming messages. No acknowledgement is expected for this packet type; however, once sent, this packet type (or a type >40 will continue to be sent to the 'connected' station' at each time slot (instead of declining network access) until some type packet is received from the 'connected' station.

This packet type may be sent by a station to the Arbitrator to indicate that network access is not required. As above, no acknowledgement is expected.

4.4.2.2 PACKET TYPE >04 (bit 2=1)

This packet type is sent when the station has no message data in its transmit buffer, and only wishes to acknowledge the successful reception of an incoming message (since last being polled). No acknowledgement is expected for this type packet.

4.4.2.3 PACKET TYPE >06 (bits 2,1=1)

This packet type is sent when the station has no message data in its transmit buffer, and only wishes to inform its 'connected' station that the last incoming message was accepted but no more messages should be sent until receipt of a packet indicating 'resume transmissions' (packet type >00 or >40). No acknowledgement is expected for this type packet.

4.4.2.4 PACKET TYPE >40

If the station has message information in its transmit buffer,

and wishes to inform its 'connected' station that incoming messages will be accepted, this packet type is sent. An acknowledgement is expected for this packet type.

This packet type is sent to the Arbitrator when the station is in the command mode and is communicating operator commands to the Arbitrator. In this mode, an acknowledgement is expected in the form of a packet type >C4 containing the Arbitrator's response to the command. The message content of this 'command' type packet is described in Section 7.1 and Table 7-3.

4.4.2.5 PACKET TYPE >44 (bits 6,2=1)

This packet type is sent when the station has message data in its transmit buffer, and wisnes to acknowledge the successful reception of an incoming message (since last being polled). An acknowledgement is expected for this type packet.

This packet type is sent, as a status report, to the Arbitrator, either in response to a 'connect' directive from the Arbitrator or if the station has error status to report. The status information is contained in the two-byte message field of the packet. When sent to the Arbitrator, no acknowledgement is expected for this type packet. The message content of this type packet, when sent as a status report, is described in Section 5.2 and Table 5-1.

4.4.2.6 PACKET TYPE >46 (bits 6,2,1=1)

This packet type is sent when the station has message data in its transmit buffer, and wisnes to inform its 'connected' station that the last incoming message was accepted but no more messages should be sent until receipt of a packet indicating 'resume transmissions' (packet type >00 or >40). An acknowledgement is expected for this type packet.

4.4.2.7 PACKET TYPE >60 (bits 6,5=1)

This packet type implies that a 3-byte message field is contained in the packet and that this packet is to be received only by special NIMS. No acknowledgement is expected to this type packet. This packet type is discussed furtner in Section 6 (SPECIAL NIMS).

PACKET FORMAT	REASON FOR SENDING (SENDING STATION)	ACTION UPON RECEIVING (RECEIVING STATION)
Adr,00,xx	OK to receive msgs.	OK to transmit msgs.
00,00,xx	Decline network access.	***Received by Arbitrator
Adr,04,xx	Rec'd last msg. OK.	Send next message.
Adr,06,xx	Rec'd last msg. OK, but buffer full.	wait for 00 or 40, then send next message.
Adr,40,MN,msg..	Sending msg.	Receive msg and prepare ack.
00,40,msg..	Sending Cmnd msg.	***Received by Arbitrator
Adr,44,MN,msg..	Rec'd last msg OK, and sending msg.	Receive msg, prepare ack, and send next message.
00,44,msg..	Sending Status msg	***Received by Arbitrator
Adr,46,MN,msg..	Rec'd last msg OK, but buffer full, and sending msg.	Receive msg, prepare ack, wait for 00 or 40 then send next message.
Adr,60,xx,msg..	Sending msg to Special NIM.	Received by Special NIM only.

Adr = a network station address
MN = Message Number
msg.. = message field
xx = ignored by receiving station

TABLE 4-3. PACKET TYPES ORIGINATING AT NETWORK STATIONS.

4.5 MESSAGE NUMBER PROTOCOL

The message number field of the network packet provides the two communicating stations a means of message resynchronization in the case of a lost message. This field contains the number of the message being transmitted if there is a message field. If the packet contains no message field, the message number field is ignored by receiving stations.

This message number protocol applies only to communications between network stations. Packets transmitted between the Arbitrator and network stations do not contain message number fields.

4.5.1 INITIALIZATION OF MESSAGE NUMBERS

Upon receipt of a type >C0 packet from the Arbitrator (a 'connect' command), the transmitted and received message number values at a NIM are set to zero.

4.5.2 TRANSMITTED MESSAGE NUMBER

This message number is directly associated with a block of message data, taken from the transmit buffer, and being sent in the message field of the packet. When this message has been acknowledged, the NIM increments the message number (the value 255 increments to zero). Until acknowledgement of a successful transmission, the message number retains its association with the same block of message data in the transmit buffer. This value is placed in the message number field of outgoing packets which are sent to other network stations.

Packets sent to the Arbitrator, even packets containing message fields, have no effect on the transmitted message number, nor on the association between the message number and its message data block.

4.5.3 RECEIVED MESSAGE NUMBER

Each successfully received message results in this value being incremented (the value 255 increments to zero). This parameter is never transmitted but is maintained at the NIM for comparison to incoming message numbers.

4.5.4 NON-MESSAGE PACKETS

Transmitted packets which do not contain a message field, do not cause the transmitted message number to be incremented, nor do they affect the association between the transmitted message number and the data block in the transmit buffer. Upon receiving these 'non-message' packets, receiving stations ignore the transmitted message number.

4.5.5 MESSAGE NUMBER PROTOCOL AND THE ARBITRATOR

Packets transmitted to the Arbitrator, even those containing a message field (packet types >40 and >44), do not cause the transmitted message number to be incremented. Packets transmitted to the Arbitrator do not contain a message number field.

Packets originating at the Arbitrator have no message number field. Messages incoming to a station from the Arbitrator do not cause the received message number to increment.

4.5.6 NON-AGREEMENT OF MESSAGE NUMBERS

An incoming packet, containing a message field and therefore a valid transmitted message number, should indicate a message number equal to the last received message number. If so, the incoming message is retained and an acknowledgement is subsequently sent. If not, an acknowledge packet is transmitted to the sending station but the message data is discarded.

The occurrance of a non-agreement in message numbers may be caused by the failure of a sending station to receive the acknowledgement for a successfully transmitted message, causing the station to 're-send' the same message with the same transmitted message number. The difference between one station's transmitted message number and its 'connected' station's received message number can never be greater than one.

5. NETWORK ERROR CONDITIONS

This section describes the type of errors that may occur in the network and the action taken for each type. The error types are divided into two categories: communication errors and station errors.

5.1 COMMUNICATION ERRORS

One type of communication error occurs when the received data packet contains the wrong message number or contains message data which fills (or almost fills) the receiving station's receive buffer. The cause and recovery procedure for incorrect message numbers are described in Section 4.5.6.

A station's receive buffer may become full if the incoming data from another station is arriving at a higher rate than the connected user-supplied equipment can receive it. An incoming message which depletes the receive buffer's free space to less than 256 bytes causes the receiving station to send a message acknowledgement to the sending station directing it to discontinue transmissions. When adequate free space again exists in the receive buffer, a packet is sent to the sending station directing it to resume transmissions.

Another type of communication error is that which occurs because of random signal interference during packet transmission, resulting in the unsuccessful reception of the packet at its intended destination. Errors of this type appear in two forms:

(1)The errors are such that the intended receiving station is unaware that it is being addressed. These are called 'lost packets'.

(2)The receiving station accepts the packet but the CRC check indicates that errors are present in the packet. These packets are ignored by the receiving station since none of the packet fields may be reliably interpreted.

Since both of these conditions result in the packet being lost, they are both considered 'lost packets'.

5.1.1 'LOST PACKETS'

Usually, the intended receiving station is unaware of this condition and can take no direct corrective action. The recovery to this condition is built into the message acknowledgement protocol of the network.

If the transmitted packet contained a message field, the

transmitting station never receives the expected acknowledgement, and consequently re-transmits the packet.

If the transmitted packet contained an acknowledgement to a successfully received message, the subsequent retransmission of the message results in a message number error. Recovery of message numbers errors has been described.

If the transmitted packet was of a type containing neither message nor acknowledgement, the network mechanism that originally generated the packet either re-generates it in due time or the network tolerates its loss. Those specific cases are:

(a)Packet type >60, sent by a station to a Special NIM: Incoming messages from the Special NIM contains an echo of its last message received. It is the responsibility of the user-supplied equipment to verify receipt of the last message and re-transmit, if necessary.

(b)Packet type >00, sent by a station to decline network access: This condition is tolerated by the Arbitrator, and the station will be polled again during the next polling cycle.

(c)Packet type >00, sent by a station to indicate that message data will now be accepted: This station will continue to indicate this condition, and continue to send a packet conveying this condition, until a 'message' is received.

(d)Packet type >80, sent by the Arbitrator to indicate that network access is available: The destination station loses its opportunity to gain access to the network for this polling cycle, but will be polled again during the next polling cycle.

5.2 STATION ERRORS

Station errors are those error conditions that may exist at a network station and are reported in a packet type >44 to the Arbitrator. As long as station errors exist, all outgoing packets are packet type >44 addressed to the Arbitrator. The error conditions, the cause of these conditions, and the procedures for correction are:

(1) DESTINATION ADDRESS UNKNOWN
Until a station has been initially 'connected' to another station or 'disconnected', by receiving a packet type >C0 from the Arbitrator, this condition will exist. This condition is corrected by the reception of a type >C0 packet. When power is first applied to the NIM, or if power is interrupted during operation, this reported condition informs the Arbitrator that a 'connection' (or

'disconnection') packet is required by this station.

(2) USER-SUPPLIED EQUIPMENT DISCONNECTED
If the NIM's inteface to the user-supplied equipment indicates that there is no connected equipment, or that the equipment is not 'powered-up', this condition is reported to the Arbitrator. The Arbitrator subsequently reports this condition to a Command Device for operator action. The Arbitrator will not permit 'connections' to this station.

(3) EXCESSIVE LOST PACKETS
An acknowledgement packet is expected in response to each outgoing packet which contains a message field. If a station fails to receive an acknowledgement for 15 consecutive message transmissions (to another station), this condition is reported to the Arbitrator. The Arbitrator records this condition in the station's status. Upon reporting this status, this condition is 'cleared' at the NIM until another 15 messages fail to be acknowledged. This condition is also 'cleared' by a 'connect' or 'disconnect' command from the Arbitrator.

(3) SPECIAL NIM
Some NIMS are configured as SPECIAL NIMS, and although not an error condition, this special configuration is reported to the Arbitrator as long as the station is 'disconnected'. A packet type >44 reporting only this condition is treated by the Arbitrator as if it were a type >00 packet declining network access. In the status table, the Arbitrator records this station as a SPECIAL NIM.

The message field of a type >44 packet sent to the Arbitrator is two bytes in length. The first byte indicates the station's error status. Table 5-1 illustrates the meaning of each of the bits of this status word. The second byte indicates the destination address of the station's outgoing network packets.

BIT NUMBER	MEANING
(LSB)0	1=EXCESSIVE LOST PACKETS
1	1=USER-SUPPLIED EQUIPMENT DISCONNECTED
2	1=DESTINATION ADDRESS UNKNOWN
3	1=SPECIAL NIM
4	UNDEFINED
.	.
.	.
7	UNDEFINED

TABLE 5-1. STATION STATUS WORD BIT MEANINGS

6. SPECIAL NIMS

The NIM at some network stations may be a special configuration NIM called a SPECIAL NIM. Functionally, it is the same as the NIM described in Section 2.1. Its principal differences lie in its user-interface and its 'connection' to and communication with other network stations.

The special NIM's interface to the user-supplied equipment consists of 16-bits of parallel output and 16-bits of parallel input. This NIM is the network's interface to the more rudimentary user-supplied equipment intended to implement such functions as remote control, remote status monitoring, energy management, or security control. Further refinements to this interface may be implemented to provide relay contacts, analog input/output, or other specific functions, but the basic interface is as described.

6.1 'CONNECTION' TO SPECIAL NIMS

Multiple network stations with Special NIMS may be 'connected' to other stations with standard NIMS. These multiple 'connections' require a special adressing protocol.

An operator at a Command Device requests that 'connections' be made between one standard network station and multiple stations with Special NIMS. In executing this 'connection', the Arbitrator:

(1) Sends the standard station a type >C0 packet containing a destination address of 255. The receiving station interprets this destination address as follows:

(a) All outgoing packets from this station will contain this station's address as the destination address (except, of course, packets sent to the Arbitrator).

(b) All outgoing packets, except those sent to the Arbitrator, will be packet type >60.

(c) All outgoing packets, except those sent to the Arbitrator, will contain a three-byte message field. The NIM waits until the user-supplied equipment has placed at least three bytes of data in the transmit buffer before sending a packet.

(d) No acknowledgement will be sent for any incoming message packets (except those from the Arbitrator).

(2) Sends each of the requested stations, with Special NIMS, a type >C0 packet containing the address of the standard station as a destination address. To implement the 'connection' to the standard station, each of these receiving stations:

(a) Place the standard station's address in the destination-address field of all outgoing packets. Place their own station address in the first byte of the message field of the outgoing packet. This establishes their connection 'to' the standard station.

(b) Accept only type >60 packets addressed to the station to which they are 'connected'. This establishes their connection 'from' the standard station.

(c) Ignore any incoming type >60 packet which does not have the receiving station's normal address, or the value 255, as the first byte of the message field. This provides their 'selective' addressing by the standard station. The value 255 in the first byte of the message field allows the transmitting station to address all 'connected' stations simultaneously.

(d) Accept all types of incoming packets (except type >60) addressed to their normal station address. This maintains their communication with the Arbitrator.

(e) Expect no acknowledgement packets for any message packets sent.

6.2 COMMUNICATIONS WITH SPECIAL NIMS

Packets sent to stations with Special NIM always contain a 3-byte message field. It is the responsibility of the user-supplied equipment at the sending station to provide the data in 3-byte blocks, with the first byte containing the target station's destination address. Upon being polled by the Arbitrator, the NIM at this sending station transmits a packet only if at least three bytes of data reside in the transmit buffer.

Packets sent to Special NIMS contain a message number field but the message number value in this field is meaningless. Outgoing packets do not cause the transmitted message number to increment. Incoming packets do not cause the received message number to increment.

Packets received from Special NIMS always contain a 5-byte message field. The packet is ignored only if there are CRC errors; no checks are made for receive buffer overflow or incorrect message number. The NIM makes no attempt to analyze the message contents; it is the responsibility of the user-supplied equipment to examine the first byte of each 5-byte data block in the receive buffer, to determine the message source.

Type >60 packets received at the Special NIM are ignored unless the first byte of the 3-byte message field is the station address.

Otherwise, incoming packets are ignored only if CRC errors exist. No checks are made for receive buffer overflow or incorrect message numbers. The second and third bytes of the message field provide the 16-bits of parallel output at the user-interface.

Once 'connected', each time it is 'polled', the Special NIM transmits a type >40 packet containing a 5-byte message field. The first byte of the message field contains this station's address. The second and third bytes echo the last received message (and provide a means of verifying the last communications); the fourth and fifth bytes reflect the 16-bits of parallel input from the user-interface. The message number field of these packets contain a zero value.

7. NETWORK CONFIGURATION

The configuration of the network, that is: which stations are connected to each other, is provided by an operator at a Command Device, communicating with the Command Interpreter in the Arbitrator. Any network station connected to appropriate user-supplied equipment may become a Command Device.

7.1 COMMAND DEVICE

The NIM at a network station continuously monitors the user-interface. The reception of a 'BREAK' signal at this interface causes the station to go into the 'command' mode. While in the 'command' mode, this station functions as a COMMAND DEVICE.

Once in the command mode, the NIM evaluates each character received from the user-supplied equipment. Until receipt of an EOL character, each input character is echoed to the user interface and stored in a special buffer. Upon receiving the EOL, the received message is interpreted and re-formatted for transmission to the Arbitrator. The received message must be one of the ten formats illustrated in Table 7-1. Table 7-2 describes the meaning of the messages. If the received message is incorrectly formatted the NIM ignores the message and sends an error message to the user-supplied equipment. While in the Command Mode, all normal message data transfers between the NIM and the user-supplied equipment are suspended.

Upon receipt of a correctly formatted command message, the NIM re-formats the message for transmission to the Arbitrator. The format of the converted command message is illustrated in Table 7-3. After re-formatting the command message the NIM sends a type >40 packet containing the message to the Arbitrator.

MSG	FORMAT
1	H EOL
2	Q EOL
3	R EOL
4	S EOL
5	E space <value> EOL
6	I space <value> EOL
7	L space <value> EOL
8	C space <value1> space <value2> EOL
9	M space <value1> space <value2> space <value3>... ...space <valueX> EOL
10	D space <value1> space <value2> space <value3>... ...space <valueX> EOL or D space <value1> space ALL EOL

TABLE 7-1. COMMAND MESSAGE FORMATS

MSG	MEANING
1	HELP (Send a command menu to the operator).
2	QUIT (Terminate Command Mode).
3	REPORT all network error status.
4	Report general network STATUS.
5	Clear ERROR status of station whose address is <value>.
6	INQUIRY about station whose address is <value>.
7	LIMIT the number of nodes to <value>.
8	CONNECT stations whose addresses are <value1> and <value2>. (Both addresses must represent standard #nims)
9	Connnect the station whose address is <value1> to all of the stations whose addresses are listed (MULTIPLE connections). All of the addresses except the first one must be for SPECIAL NIMS, but need not be in numerical order.
10	DISCONNECT the stations whose addresses are supplied. If more than two addresses are supplied (implying SPECIAL NIMS), <valuei> may not be a SPECIAL NIM address. If the word ALL is entered instead of a second address value, <value1> may not be a SPECIAL NIM address.

TABLE 7-2. COMMAND MESSAGE MEANINGS

BYTE VALUE	MEANING
00	REQUEST FOR NETWORK ERROR STATUS. (MESSAGE LENGTH=1 BYTE)
02	REQUEST FOR GENERAL NETWORK STATUS (MESSAGE LENGTH=1 BYTE)
08	SET 'MAXIMUM NODES' VALUE: VALUE IN SECOND BYTE. (MESSAGE LENGTH=2 BYTES)
06	INQUIRY: STATION ADDRESS IN SECOND BYTE. (MESSAGE LENGTH=2 BYTES)
04	CLEAR STATION ERROR STATUS: STATION ADDRESS IN SECOND BYTE (MESSAGE LENGTH=2 BYTES)
0A	CONNECT: STATION ADDRESSES IN SECOND AND THIRD BYTES. BOTH ADDRESSES ARE STANDARD NIMS. (MESSAGE LENGTH=3 BYTES)
0C	MULTIPLE CONNECT: PRIMARY ADDRESS (STANDARD NIM) IN SECOND BYTE, OTHER ADDRESSES (SPECIAL NIMS) IN REMAINING BYTES. (MESSAGE LENGTH UNSPECIFIED)
0E	DISCONNECT: PRIMARY ADDRESS (STANDARD NIM) IN SECOND BYTE, OTHER ADDRESSES IN REMAINING BYTES. (MESSAGE LENGTH UNSPECIFIED)
10	DISCONNECT ALL: PRIMARY ADDRESS (STANDARD NIM) IN SECOND BYTE. (MESSAGE LENGTH=2 BYTES)

TABLE 7-3. BYTE DEFINITION: FIRST BYTE OF COMMAND MESSAGE

After acting upon the command the Arbitrator sends a response to the command device. The Command Device receives a type >C4 packet containing the response message. The format of the message is illustrated in Table 7-4. In those responses reporting station status, the second byte of the message is a station address and the third and fourth bytes represent the status of that station. If appropriate, the fifth byte is a station address, the sixth and seventh represent its status, etc. The format of the two bytes representing a station's status is illustrated in Table 7-5.

If the Command Device receives a 'polling' packet (a type >80 from the Arbitrator) before a response from the command, indicating a 'lost packet', the command is again transmitted.

The NIM re-formats the Arbitrator's response and presents it, in a meaningful form, to the user-interface. The response appears at the user-supplied equipment for verification by the operator or computer program.

The station remains in the command mode until receipt of a 'QUIT' command from the user interface. After the one command-then-response transaction between the station and the Arbitrator, the station must wait for its next time slot in the polling cycle to again access the network.

7.2 COMMAND INTERPRETER

Upon receipt of a type >40 packet from a Command Device, the Arbitrator interprets the received commands and executes the following sequences:

REQUEST FOR ERROR STATUS
Prepares, as a response message, a list of all station addresses whose status indicates:
(a) Excessive lost packets,
(b) User-interface errors, or
(c) Any other error status.
Each station address in the list is followed by the status byte for that station and one byte indicating either the station address to which the station is 'connected' or a byte of 'zeros' if not 'connected'. If there is no error status to report, the second byte of the response message is set to all 'zeros'.

REQUEST FOR NETWORK STATUS
Prepares, as a response message, a list consisting of:
(a) Value of 'maximum nodes',
(b) Total number of station addresses in 'connected' table,

STATUS CLEAR
Clears the status indicators representing: excessive crc errors, user interface errors, and other error status, for the station address specified.
Prepares a response message echoing the requested station address.

STATION INQUIRY
Prepares, as a response message, a list consisting of:
(a) The requested station's address,
(b) The status byte for that station, and
(c) Either the station address to which the station is 'connected' or a byte of 'zeros' if not 'connected'.

SET 'MAXIMUM NODES' VALUE
Changes the 'maximum nodes' value to the received value and echos that value in in the response message.

CONNECT TWO STATIONS
(1) If both station's status indicates 'not connected', standard NIMS, and no user-equipment errors, sends a type >C0 packet with destination address to each station. If both packets are successfully acknowledged,
(a) Changes status of both stations to 'connected'.
(b) Prepares response for Command Device containing both station addresses.

(2) If both station's status indicates that a 'connection' already exists as requested, prepares a response for the Command Device containing both station addresses.

(3) If either station's status indicates a 'connection' to another address, that it is a Special NIM, or indicates a user-equipment error, prepares a response for the Command Device containing address of failing station, followed by the status byte for that station and one byte indicating the station to which it is 'connected' (or ZEROS if not 'connected').

MULTIPLE CONNECTIONS
(1) Verifies that primary address (standard nim) is 'not connected', or already 'connected' to special NIM(s). Verifies that primary station's status indicates no user-equipment errors. Verifies that all other addresses are special NIMS.

(2) If the special NIMS' status indicate that a 'connection' already exists, but to the address requested, or indicates 'not connected':
(a) Sends type >C0 packet with destination address to each station.
(b) Changes status of all stations to 'connected'.
(c) Prepares response for Command Device containing all station addresses.

(3) If the primary address is 'connected' to another address, or indicates user-equipment errors, or if one of the special NIM addresses indicates 'connection' to anotner address, prepares a response for the Command Device containing address of failing station,

followed by the status byte for that station and one byte indicating the station to which it is 'connected' (or ZEROS if 'not connected').

DISCONNECT STATIONS (STATION ADDRESSES ITEMIZED)
(1) Examines each address specified. Each address which is already 'not connected' is ignored. For those addresses which are 'connected', verifies the following:

(a) That the primary address is a standard NIM and if more than two address are specified, all others are special NIMS.

(b) That all the special NIM addresses are 'connected' to the standard NIM, or if special NIMS are not involved, that the two addresses are 'connected' to each other.

(2) If these 'disconnect' criteria are met:
(a) If special NIMS are involved, sends a type >C0 packet with 'ZERO' destination address to each special NIM. If no other stations remain 'connected' to the standard station, sends a packet of the same type and contents to the standard station.
If special NIMS are not involved, sends a type >C0 packet with ZERO destination address to each of the two stations.

(b) Prepares response for Command Device containing all specified station addresses (including those already 'disconnected').

(3) if 'disconnect' criteria are not met:
Prepares response for Command Device containing address of failing station, followed by the status byte for that station, and the address to which the station is 'connected'.

DISCONNECT STATIONS (ALL)
(1) Verifies that the single address is not a special NIM.

(2) If 'disconnect' criteria are met:
(a) If the station is 'connected', sends type >C0 packet with 'ZERO' destination address to the specified station and to each station 'connected' to it. If not 'connected', sends no 'disconnect' packets.

(b) Prepares response for Command Device containing the specified station's address and all station addresses which were 'connected' to it.

(c) If the specified station was already 'disconnected' prepares response for Command Device containing only the specified address.

(3) If the specified address is 'connected', but is a special NIM, prepares a response for the Command Device containing this address, followed by one status byte and the address to which the station is 'connected'.

BYTE VALUE	MEANING
00	RESPONSE TO ERROR STATUS REQUEST: SECOND BYTE CONTAINS STATION ADDRESS, THIRD & FOURTH BYTE CONTAIN ITS STATUS, FIFTH BYTE CONTAINS STATION ADDRESS, ETC. (MESSAGE LENGTH UNSPECIFIED)
02	RESPONSE TO GENERAL STATUS REQUEST: SECOND BYTE 'MAXIMUM NODES' VALUE, THIRD BYTE CONTAINS TOTAL 'CONNECTED' STATIONS (MESSAGE LENGTH=3 BYTES)
06	RESPONSE TO STATION INQUIRY: SECOND BYTE CONTAINS STATION ADDRESS, THIRD & FOURTH BYTE CONTAIN ITS STATUS. (MESSAGE LENGTH=4 BYTES)
04	RESPONSE TO STATUS CLEAR: SECOND BYTE CONTAINS STATION ADDRESS. (MESSAGE LENGTH=2 BYTES)
08	RESPONSE TO 'MAXIMUM NODES' VALUE SECOND BYTE 'MAXIMUM NODES' VALUE. (MESSAGE LENGTH=2 BYTES)
0A	POSITIVE RESPONSE TO CONNECT REQUEST: SECOND ,THIRD, AND REMAINING BYTES CONTAIN STATION ADDRESSES. (MESSAGE LENGTH UNSPECIFIED)
0C	NEGATIVE RESPONSE TO CONNECT REQUEST: SECOND BYTE CONTAINS FAULTY STATION ADDRESS, THIRD & FOURTH BYTES CONTAIN STATUS. (MESSAGE LENGTH=4 BYTES)
0E	POSITIVE RESPONSE TO DISCONNECT REQUEST: SECOND ,THIRD, AND REMAINING BYTES CONTAIN STATION ADDRESSES. (MESSAGE LENGTH UNSPECIFIED)
10	NEGATIVE RESPONSE TO DISCONNECT REQUEST: SECOND BYTE CONTAINS FAULTY STATION ADDRESS, THIRD & FOURTH BYTES CONTAIN STATUS. (MESSAGE LENGTH=4 BYTES)

TABLE 7-4. BYTE DEFINITION: FIRST BYTE OF RESPONSE MESSAGE

BIT	MEANING
(LSB)0	1=ERROR STATUS: EXCESSIVE LOST PACKETS.
1	1=ERROR STATUS: USER-INTERFACE ERRORS.
2	1=POWER FAILURE INDICATED
3	1=SPECIAL NIM
4	UNDEFINED
5	UNDEFINED
6	UNDEFINED
(MSB)7	1=CONNECTED

TABLE 7-5. BIT DEFINITIONS: STATION STATUS FROM ARBITRATOR