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National Electrical Manufacturers Association
2101 L Street, N.W. Suite 300
Washington, D.C. 20037 (202) 457-8400

PROPOSED, NEW AND REVISED STANDARDS

TO: VOTING REPRESENTATIVES OF THE
DIAGNOSTIC IMAGING AND THERAPY
SYSTEMS DIVISION

Subject: Editorial Revision No. **1** to the ACR-NEMA Standard Publication for *Digital Imaging and Communications*, NEMA Pub. No. **300-1985.**

Dear Representative:

Editorial Revision No. **1** is enclosed as an errata sheet for correction of the subject publication. Please make the necessary changes to your text as the enclosed copy indicates.

Be sure to make these corrections carefully as extra copies of this revision are not available.

Sincerely,

Krystyna Bagnato

Krystyna Bagnato
Standards Publications Editor

Encl: Editorial Revision No. 1 to 300-1985
Copies to: All known Holders of 300-1985

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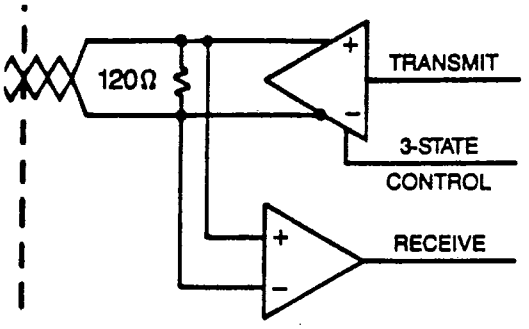
ERRATA SHEET FOR
ACR-NEMA DIGITAL IMAGING AND COMMUNICATIONS
ACR-NEMA STANDARDS PUBLICATION NO. 300-1985

Page 3
Section 2.2.1
Replace micro-type in line 6 of the first paragraph.

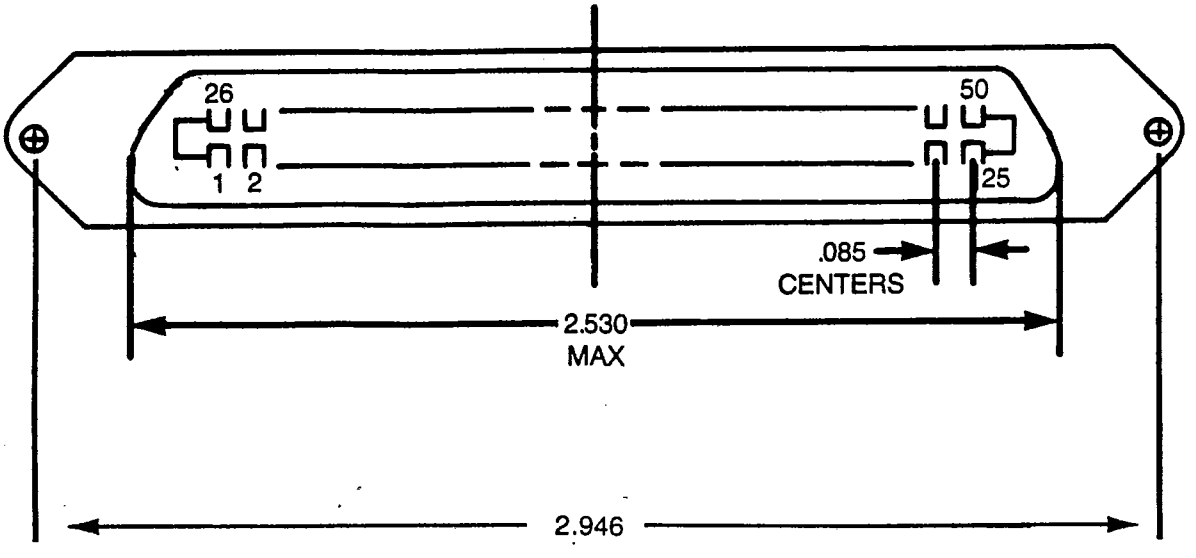
Page 9
Section 3.5
Replace micro-type in line 2 of the last paragraph.

Page 13
Section 4.7.1
Replace the first word of line 2 in the second paragraph with characters.

Page 30
Figure 7-3, Typical Interface Circuit
Replace the right hand side of the Data and Parity Circuits with the following.



Page 31
Figure 7-4, Connector -- 50 Pin Female Receptacle Front View
Replace with the following figure.



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Page 33
Figure 7-6, Physical Protocol State Diagram
Label the line coming out of TX_DAK STBO = 0.

Pages 40 and 41
Replace the first paragraph of 8.4.3 with the following.

Control packets which contain Connect Request and Connect Indication words shall contain source and destination data in the format specified in Figure 8-7. The format of the source and destination field shall be as follows: Destination Logical Address, Destination Network Address, Source Logical Address, and Source Network Address. Each set of addresses is eight (8) words long.

The Source Logical Address is required to contain the pertinent information. The other three addresses (Destination Logical, Destination Network, and Source Network) must contain either spaces (i.e., defaulted) or pertinent information.

Page 48
Figure 8-7, Connection Control Packet Format
Place "Source Logical Address Word 5" on line 21 of the figure.

Page 50
Table 8-3, Frame Status Parameters
Replace the last line of the table with the following.

X X 1 X X X X X X X X X Interface not serviced.

Add the following as the last line of the table.

0 0 0 0 0 0 0 0 0 0 0 0 No errors; interface available.

Page 51
Table 8-4, Packet Type Codes and Definitions
Replace the code for Open Channel Indication with 0100.
Replace the last line of Pause Request with "Resume Request is received for that channel."

Page 66
Replace the values after Patient's Mother's Maiden Name with "AT FF S 3".

Page 70
Replace the values after Termination time with "AT DF S".

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Page 71
Replace the third and fourth lines of the definition of Image Orientation with "respect to the equipment coordinate axes x,y,z, followed by".

Replace the values in the default column with "1\0\0\0\1\0".

Page 75
Replace "Hounsfield" in the definition of Rescale Intercept.

Replace the values after Window Center, Window Width, Rescale Intercept, and Rescale Slope with "AN FF M".

Page 77
Replace the values after Origin with "BI HX M".

Page 79
Table 10-2, Group 0000 Data Element Types by Command
Replace the fourth title under Data Element with "Number of Matches".

Page 88
In example 3, replace performed in the first sentence.

Page 89
In example 4, replace recorded in the last sentence.

Page 104
Add the following line before the last line on the page.

0000,0850	1	Only one match

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ACR-NEMA STANDARDS PUBLICATION/ NO. 300-1985

nema

Digital Imaging and Communications

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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FOREWORD

With the introduction of computed tomography (CT) followed by other digital diagnostic imaging modalities in the 1970's, and the increasing use of computers in clinical applications, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) recognized the emerging need for a standard method for transferring images and associated information between devices manufactured by various vendors. These devices produce a variety of digital image formats. With a standard for data exchange, it becomes possible to connect a system of such devices to other sources of hospital information, which might include clinical labs, medical records, and various financial and management systems. Such a system could facilitate efficient management and operation of a diagnostic imaging department.

In the preparation of this Standards Publication, input of users and other interested parties has been sought and evaluated. Inquiries, comments and proposed or recommended revisions should be submitted to the Diagnostic Imaging and Therapy Systems Division by contacting:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

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SCOPE

This Standards Publication specifies a minimum set of necessary attributes for an imaging device interface to communicate successfully with other devices that also meet the specifications of this Standards Publication. The Standards Publication is not intended to be an overall picture archiving and communications system (PACS) or workstation specification, nor an archive or magnetic tape transfer standard, nor a network standard. Imaging devices include CT scanners, MR imaging systems, nuclear cameras, ultrasound systems, and x-ray film digitizers.

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HISTORY

PURPOSE

The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee to develop a standard that should:

1) promote communication of digital image information, regardless of source format or device manufacturer;
2) facilitate the development and expansion of picture archiving and communication systems (PACS) that can also interface with other systems of hospital information; and
3) allow the creation of diagnostic information data bases that can be interrogated by a wide variety of devices distributed geographically.

This Standards Publication (hereinafter called the ACR-NEMA Standard) specifies the hardware interface, a minimum set of software commands, and a consistent set of data formats for communication across an interface between an imaging device and a network interface unit or another imaging device. Figure 1-1 depicts a typical PACS network configuration and the location of the ACR-NEMA Standard interface. Figure 1-2 depicts the use of the ACR-NEMA Standard interface without a network to connect an imaging device with a supporting device, such as a workstation or printer.

The ACR-NEMA Standard should help to assure that a hospital or imaging center can add new equipment that may communicate with existing equipment or systems meeting this standard.

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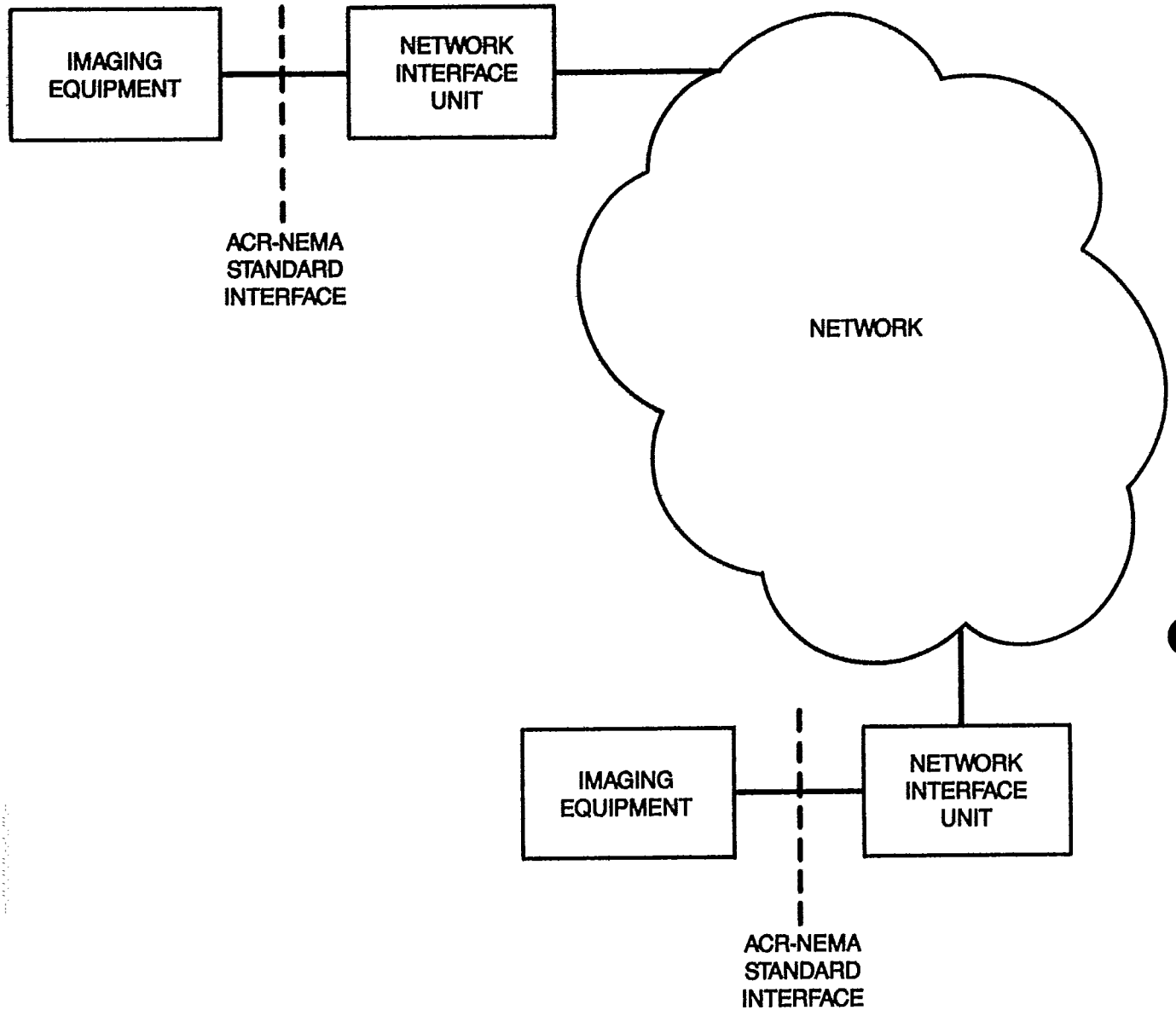

Figure 1-1
LOCATION OF ACR-NEMA STANDARD INTERFACE WITH A NETWORK

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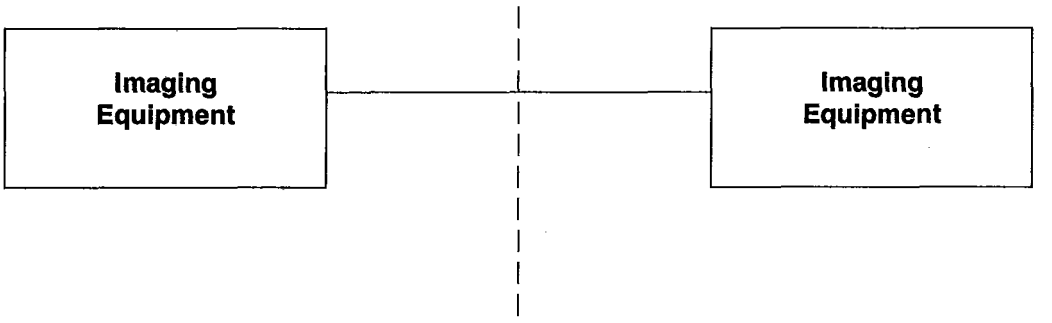

Figure 1-2
LOCATION OF ACR-NEMA STANDARD INTERFACE WITHOUT A NETWORK

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RATIONALE

The medical imaging community has expressed several needs. First, newly acquired data, whether from imaging modalities or other clinical sources, should be brought to central or distributed viewing or interpretation locations. Second, all clinically relevant information for a patient, such as historical images or laboratory data, should be accessible from these viewing locations. Third, image and data transfer should be accomplished without corruption. Fourth, information should be available at more than one location simultaneously. Fifth, addition of another piece of equipment to a communicating group of devices should be easily possible.

The ACR-NEMA Standard is created so that a group of devices, each of which meets this standard, may be organized into a system to meet the above user needs, a potential especially important in a multivendor environment.

VALIDATION

The ACR-NEMA Standard does not contain a validation procedure. A working group of the ACR-NEMA Standards Committee has been established to address this issue. It is recognized that a validation procedure would be very useful in demonstrating interoperability.

EVOLUTION OF THE ACR-NEMA STANDARD

It is anticipated that the ACR-NEMA Standard would be an evolving standard and that periodic enhancements should be forthcoming from the member organizations and input from users of the standard. A continuing requirement for these updates should be compatibility with the previous versions of the ACR-NEMA Standard. ACR and NEMA will continue to support the activities of the joint committee to clarify and update the ACR-NEMA Standard.

OVERVIEW OF THIS DOCUMENT

This document is organized in several sections. Section 1 provides referenced standards and definitions. Section 2 provides a technical review of the ACR-NEMA Standard, including a description of the relationship of the ACR-NEMA Standard to the ISO-OSI reference model. Section 3 describes the performance specifications around which the ACR-NEMA Standard was designed. Section 4 contains the design philosophy and explanatory details of the structure of a message. A detailed description of the specific data elements is in Section 10. Section 5 details the representation of images, text and other data. Section 6 provides definitions and explanatory details of the commands defined to permit transfer of images from one device to another. Section7 describes design philosophy and details of the electrical signals and the physical layer protocol. Section 8 defines the data transfer protocols for establishing end-to-end connections and for exchanging messages. Section 9 gives examples of formats and protocols for sending and receiving messages. Section 10 contains the format data dictionary specifying the required and optional data elements for the messages.

The appendices provide examples of message exchange, further descriptions of the hierarchichal grouping of images, and the coordinate system designation.

Each section provides explanatory information (Authorized Engineering Information) in addition to the requirements.

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Section 1

REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

The following publications are adopted, in whole or in part as indicated, by reference in this standards publication. Mailing address of each referenced organization is also provided.

American National Standards Institute
1430 Broadway
New York, New York 10018

ANSI X3.4-1977 *Codes for Information Interchange*
ANSI X3.9-1978 *FORTRAN*

Electronic Industries Association
2001 Eye Street, N.W.
Washington, D.C. 20026

EIA 485 *Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

Institute for Electrical and Electronic Engineers
345 East 47th Street
New York, New York 10017

IEEE 488 *Standard Digital Interface for Programmable Instrumentation*

International Organization for Standardization
1 Rue de Varembe
Geneva, Switzerland

ISO 7498-1983 *Information Processing Systems—Open Systems Interconnection—Basic Reference Model*

Prentice-Hall, Inc.
Englewood Cliffs, New Jersey

Andrew S. Tanenbaum, *Computer Networks*, 1981, p. 16.

1.2 DEFINITIONS

ASCII. American National Standard Code for Information Interchange.

Bit. A unit of information represented by either a zero or a one.

Byte. A group of eight (8) adjacent bits operated on as a unit.

Command Group. The group containing instructions concerning the intended use of the data set.

Data Element. Individual segments of information.

Data Set. The collection of all groups in a message except the command group.

Double Word. Two adjacent words operated on as a unit.

Group. A collection of data elements which contain information of a similar nature.

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Imaging Equipment (IE). A device which assembles and sends, or receives and disassembles ACR-NEMA messages.

Message. The entity of information transmitted across the interface consisting of one command group and one data set.

Network Interface Units (NIUs). Devices which operate in pairs to relay ACR-NEMA messages across an intervening data communications network.

Sink. A piece of imaging equipment which receives an image across the interface.

Source. A piece of imaging equipment which transmits an image across the interface.

TTL. Transistor-transistor logic.

Twos Complement (2's complement). A true complement with a base of two.

Word. A sixteen (16) bit entity.

NEMA Standard 10-16-1985.

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Section 2

TECHNICAL OVERVIEW OF THE STANDARD

2.1 INTRODUCTION

This section provides a brief introduction to the technical aspects of the ACR-NEMA Standard. The hardware and software specifications and protocols are summarized, and correspondences between the ACR-NEMA Standard with the International Standards Organization Open Systems Interconnection (ISO-OSI) reference model for networks is illustrated. There are differences in terminology as well as scope between the ACR-NEMA Standard and the ISO-OSI model.

Authorized Engineering Information 10-16-1985.

2.2 FUNCTIONAL DESCRIPTION

The ACR-NEMA Standard interface is intended to provide manufacturers of medical imaging equipment (including image sources, archive devices, and viewing systems) with a means by which data may be interchanged between these devices. For the benefit of the institutions using these devices, the ACR-NEMA Standard interface can support mixed-vendor system interconnections. The specification of the ACR-NEMA Standard interface includes both hardware definitions and software protocols and formats.

Authorized Engineering Information 10-16-1985.

2.2.1 Hardware

A complete description of the hardware and lower layer software protocols can be found in Sections 7 and 8 of this document. Hardware specifications include a connector and pinout assignment, cabling, timing and the electronic devices to support the interface signals. A 50 pin microtype connector should be specified. It can support 16 data circuits, one parity circuit, and six control circuits, which are all differential pair circuits. Circuit ground lines are also included.

In order to allow any device connected via the ACR-NEMA Standard interface to operate within its data rate capability and to function as a peer, the data exchange should be asynchronous and the cabling provide crossed control lines as illustrated in Section 7.

No minimum operating speed is specified, although an effective lower limit of two bytes/second exists because of interface timeout limits. The target rate should be 8 Megabytes per second. Any cable length is allowed. However, use of longer cable lengths may result in lower data rates. Data should be transferred in parallel as sixteen-bit words with parity.

Authorized Engineering Information 10-16-1985.

2.2.2 Protocol Elements

The physical protocol, which handles control signal handshakes and interrupts, supports the transfer of data using the electrical lines of the interface. It is defined by a description, a state diagram, and a timing diagram in Section 7.

Data flow should be supported by the use of a frame protocol at the Data Link Layer. A packet protocol at the Transport/Network Layer supports virtual channels and conveys segments of a message across the interface. End-to-end message delivery should be supported by the Session Layer protocol. These protocols are defined in Section 8.

Messages should contain data and commands directing use of the data. The structure of messages is detailed in Section 4. The content of messages is discussed in Sections 5 and 10. The use of commands is detailed in Section 6. Figures 2-1 and 2-2 summarize the data transfer protocols.

The specifics of a protocol implementation in an IE are not detailed in the ACR-NEMA Standard. While the internal design details may differ from manufacturer to manufacturer, the protocol formats and sequences conveyed across an interface should be standardized to allow different implementations to communicate.

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2.2.3 Interface Location

The interface plane across which the data moves should be located between the imaging equipment (IE) and a second device, as shown in Figure 1-2. In more complex systems, the second device could be a network interface unit (NIU) to provide access to an interconnecting network, as shown in Figure 1-1. The ACR-NEMA Standard imposes no specifications on such external networks except those implied by the Session Layer connection service.

Authorized Engineering Information 10-16-1985.

2.3 COMPARISON WITH THE ISO-OSI MODEL

In the design of the ACR-NEMA Standard interface, an effort was made to adhere to the ISO-OSI reference model. This Open Systems Interconnect (OSI) model

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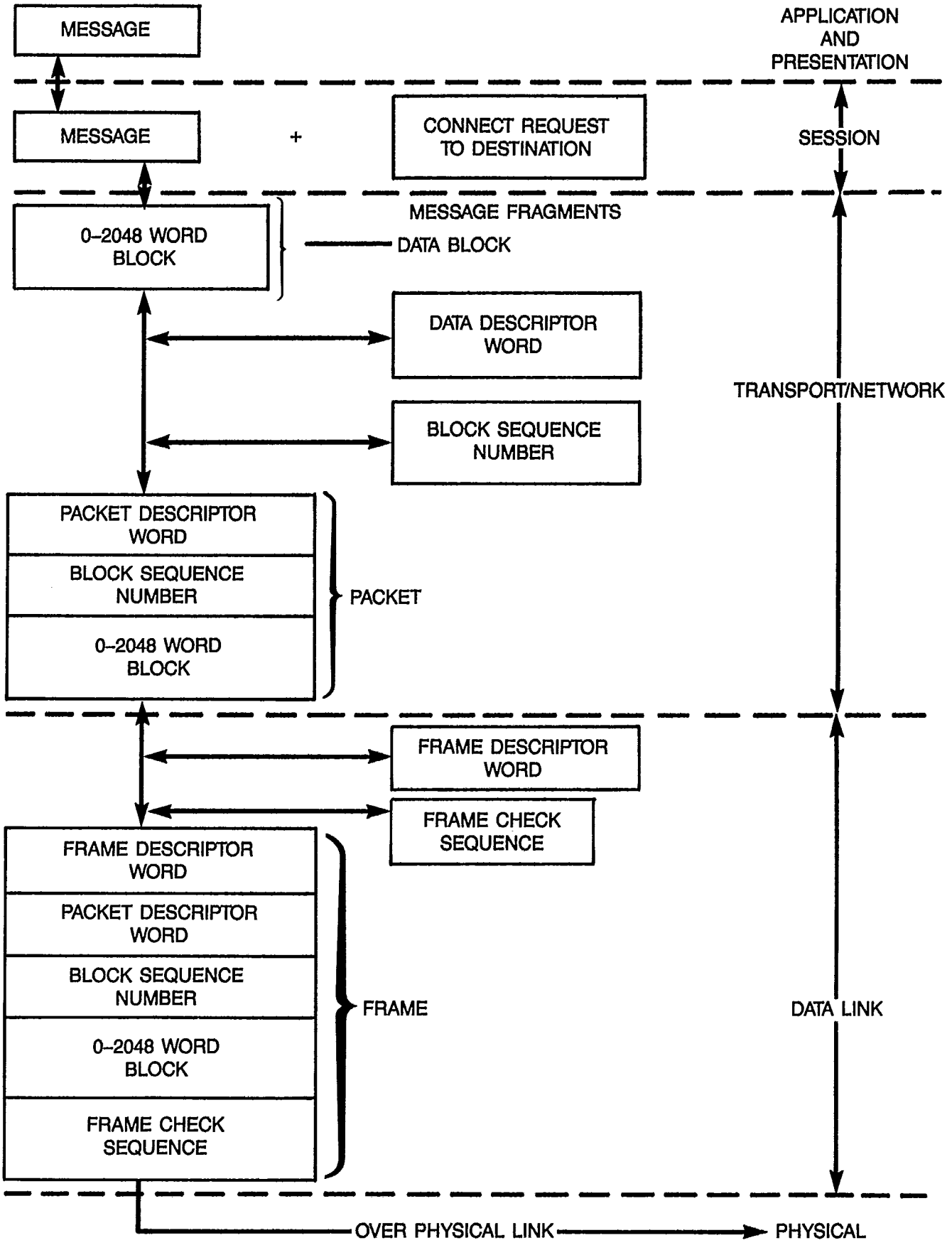

Figure 2-1
MESSAGE FRAGMENTATION

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separates the functions of device-to-device communication into well-defined layers. Much as in other structured systems, each layer is self-contained, and the data which move into and out of these layers are defined. This allows software and/or hardware in any layer to be modified without necessarily altering other layers. Also, compatibility of different systems should be enhanced since the data requirements are known for each layer.

The idea of a layered structure should be particularly applicable to the ACR-NEMA Standard because the functions of the layers are defined without specifying a particular implementation.

For reference, the ISO-OSI model is illustrated in Figure 2-3. The hierarchy starts at the Physical Layer and extends upward to the Application Layer. Data move both up and down through the layers, depending on whether the device supporting the layers is receiving or sending a message. For full explanations of the ISO-OSI model, refer to ISO 7498-1983.

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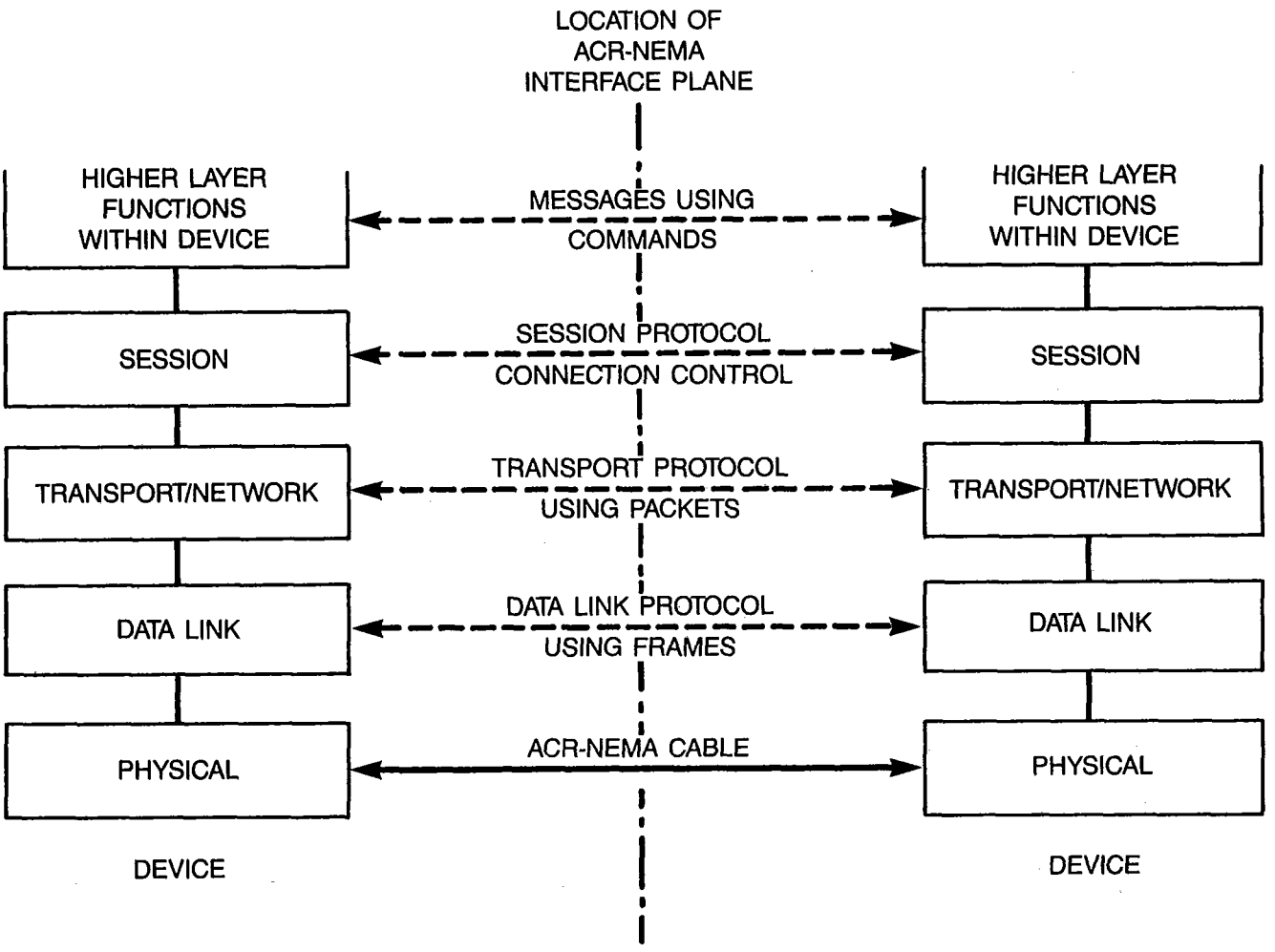

Figure 2-2
PROTOCOL LAYERS SUMMARY

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2.3.1 Corresponding Layers

A correspondence between the ISO-OSI layers and those of the ACR-NEMA Standard is illustrated in Figure 2-4.

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2.3.1.1 PHYSICAL LAYER

This layer should be completely described by the hardware specifications and by interface access and word exchange protocols. It should define interlocked signal sequences to provide high speed data transmission across the interface and be used by the Data Link Layer to send data and to provide flow control and error detection.

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2.3.1.2 DATA LINK LAYER

The ACR-NEMA Data Link Layer corresponds to the ISO-OSI Data Link Layer. This layer should frame data from the Transport/Network Layer with control words and send it out via the Physical Layer. This should be accomplished through the protocol detailed in Section 8.2. During the receipt of data from the Physical Layer it should remove the framing words, check for transmission errors, and deliver the data to the Transport/Network Layer.

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2.3.1.3 TRANSPORT/NETWORK LAYER

In the ACR-NEMA Standard, functions similar to those found in the ISO-OSI Network Layer and Transport Layer are combined in a Transport/Network Layer. Because the ACR-NEMA Standard defines a point to point interface across a plane, a Network Layer, with all of its routing-control parts, should not be necessary. In the ACR-NEMA Standard, the fragmenting of the message into blocks (up to 2048 words), and the subsequent packetization (with added packet sequencing and description headers), should be performed at this Transport/Network Layer. Section 8.3 describes the protocol in further detail.

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2.3.1.4 SESSION LAYER

The Session Layer in the ISO-OSI model is an interface layer between application programs and the communication protocols. The ACR-NEMA Session Layer defines the protocol for establishing and breaking end to end connections to applications in another device.

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2.3.1.5 PRESENTATION AND APPLICATION LAYERS

The uppermost two layers, presentation and application, are addressed by the ACR-NEMA Standard at the level of the message format. Building the message (completing the groups and organizing them) should be a Presentation Layer function. Given the data entered at the equipment via Application Layer programs, the Presentation Layer should serve to reorganize the data into the groups and elements defined by the ACR-NEMA Standard. The ACR-NEMA Standard provides commands (see Section 6) to invoke certain operations which should require connection with a second device.

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2.4 SUMMARY OF PROTOCOL AND DATA STRUCTURES

Figure 2-1 illustrates the fragmenting of a message into data blocks and combining channel control words to make packets. The packets should be passed to the Data Link Layer where they should be combined with control words to make frames. The frames should be passed to the Physical Layer for transmission across the interface.

Figure 2-2 summarizes the protocol layers specified in this ACR-NEMA Standard and the peer to peer communications supported. The figure again emphasizes that the protocols define data exchange across a plane between two pieces of equipment which comply with this standard.

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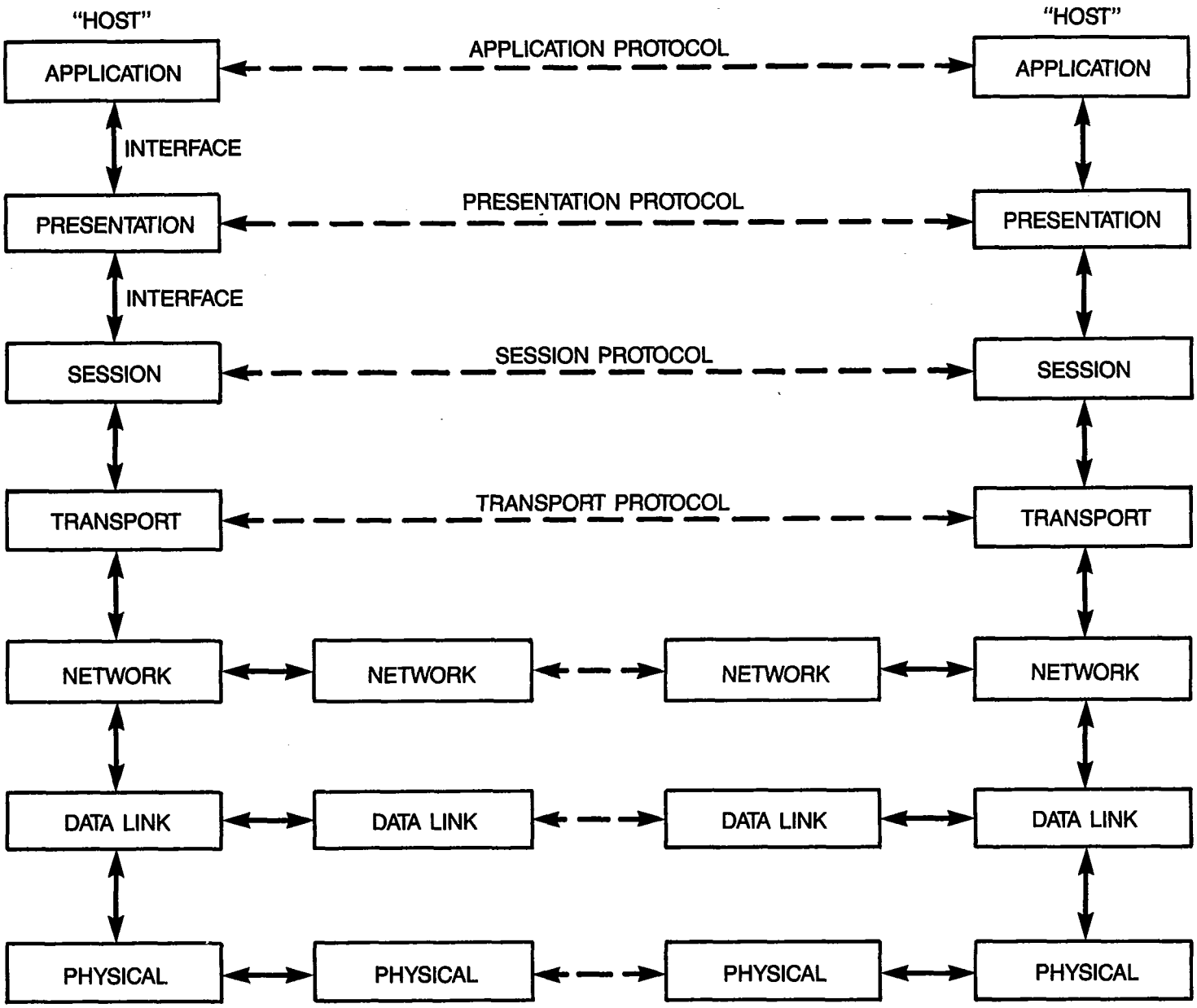

Adapted from Andrew S. Tanenbaum, *Computer Networks*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, I981, p. 16.

Figure 2-3
ISO-OSI MODEL

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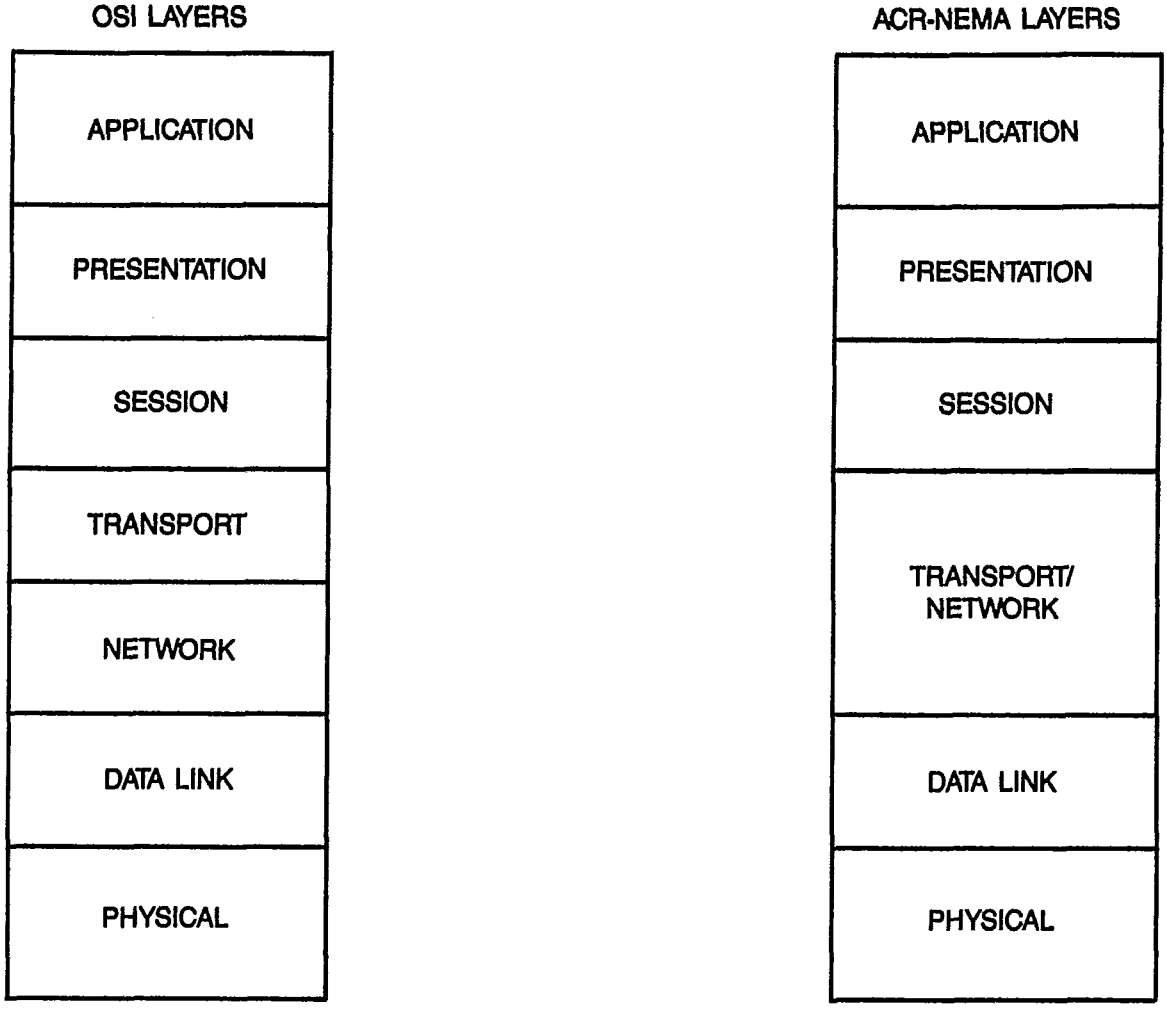

Figure 2-4
COMPARISON OF OSI LAYERS AND ACR-NEMA LAYERS

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Section 3

PERFORMANCE SPECIFICATIONS

3.1 INTRODUCTION

This section discusses the performance requirements for compatiblity with the ACR-NEMA Standard interface. The specific functions to be implemented in hardware and software are described in Sections 4 to 8 of this document.

Authorized Engineering Information 10-16-1985.

3.2 ERROR RATES

The sum of the individual error rates on the 17 parallel lines in the interface shall be no greater than 17×10^{-9}, prior to any correction. Error correction algorithms are not specified in the ACR-NEMA Standard.

NEMA Standard 10-16-1985.

3.3 RATE OF DATA TRANSFER

The target data rate should be 8 Megabytes/second. The hardware interface may be capable of successfully operating at rates faster than the target rate. Asynchronous handshake protocols should be used, thereby permitting devices to successfully connect to this interface and operate at slower data rates.

A standard test for measuring actual data rate for a cable length of zero meters is defined in Appendix A.

Authorized Engineering Information 10-16-1985.

3.4 ENVIRONMENTAL SPECIFICATIONS

Environmental considerations should be left to the individual manufacturers.

Authorized Engineering Information 10-16-1985.

3.5 MINIMUM NECESSARY FUNCTIONS FOR COMPATIBILITY

To be ACR-NEMA compatible, a piece of imaging equipment has certain minimum functions which it utilizes the ACR-NEMA interface to perform. In the simplest cases, the imaging device may be either an image source or image sink; some devices may be both source and sink devices or neither (see Table 3-1 for examples).

Authorized Engineering Information 10-16-1985.

For every command, a response is defined. Any ACR-NEMA compatible device must recognize all commands, and must send a response. An acceptable command response has a status code indicating "refused." This negative response is required to inform the requestor that the target device is not equipped or is otherwise unable to respond to that command.

NEMA Standard 10-16-1985.

An ACR-NEMA device must support at least one channel which is then called channel 0. (See Section 8)

NEMA Standard 10-16-1985.

The physical interface presented on an ACR-NEMA compatible device must use the specified 50 pin microtype connector and associated signal levels and timing. Messages must include all required information as defined in Section 4.

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Table 3-1
EXAMPLES OF SOURCE, SINK, AND SOURCE/SINK DEVICES *

DEVICE	IMAGE SOURCE	IMAGE SINK	IMAGE SOURCE/SINK	NEITHER
Film Digitizer	X			
Digital Radiography Unit	X			
Ultrasound System	X			
Densitometer	X			
Thermographic System	X			
Electrocardiograph	X			
Gamma Camera	X			
Multiformat Camera		X		
Printer		X		
Workstation		X	X	
Archive			X	
Management Terminal				X
CT Systems	X		X	
MR Systems	X		X	
PET Systems	X		X	
Digital Subtraction Angiographic System	X		X	

* The devices listed are felt to be representative of equipment found in many imaging departments; the list is not meant to be exhaustive. The designation as source or sink or both is based on the most common modes of operation, not on specialized ones. Management terminals are listed as an example of a non-image data device likely to be found in an imaging department.

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Section 4

MESSAGE FORMAT

4.1 INTRODUCTION

In order for images to be interpreted, a minimum amount of information should be available with the images. This information can be divided into general categories of: identifying, patient, acquisition, relationship, image presentation, overlay and image pixel data.

The image or other data, its associated information, and its associated instructions should be contained within a message. This message should be organized into groups representing the general categories of information. Each group may be further subdivided into related data elements.

Within each group there may be data elements which are mandatory and optional. The mandatory items should provide data necessary to display an image and to interpret it. Optional data elements may be included to provide supplemental information.

Twenty-four (24) groups which have been defined are listed in Table 4-1 and they should adhere to the specifications in 4.3. Group 0000H, which gives information necessary for commands, is described in Section 6 and detailed in Section 10. Other groups, which may be associated with images or other information, are described in this and the following section, and detailed in Section 10. Some groups have been reserved for manufacturer or user specific information. All other groups are reserved for future expansion of the ACR-NEMA Standard.

Authorized Engineering Information 10-16-1985.

4.2 MESSAGE

Except for the DIALOG command, all information to be transmitted across the interface between two pieces of equipment shall be contained within an entity called a message. Messages shall be exchanged between devices to provide user or system functions or services. All messages shall consist of two parts: a command group and a data set (see 4.4).

NEMA Standard 10-16-1985.

4.3 GROUPS

Each message shall be organized in groups.

NEMA Standard 10-16-1985.

All groups shall be formatted in the same way.

NEMA Standard 10-16-1985.

Each group shall appear at most once within a message.

NEMA Standard 10-16-1985.

Groups shall appear in the resulting message in numeric order, with group 0000H first.

NEMA Standard 10-16-1985.

A group number is a word interpreted as an unsigned integer.

NEMA Standard 10-16-1985.

Every even numbered group shall be reserved for use in the ACR-NEMA Standard. Certain of these groups, standard groups, are defined and listed in Table 4-1.

NEMA Standard 10-16-1985.

All odd numbered groups shall be available for use by manufacturers or users, with the requirement only that group structure conventions as described in 4.5 must be followed.

NEMA Standard 10-16-1985.

The ACR-NEMA Standard does not contain a method to resolve any conflicts arising from such use.

Authorized Engineering Information 10-16-1985.

Odd numbered groups with a group number which is one greater than a standard group number are called shadow groups. These shadow groups shall be reserved for users and manufacturers to place data elements with information of the same category as that in the standard group. The use of certain data element numbers in these groups is restricted as described in 4.5. If a data element is defined as mandatory in a standard group, putting it in some form in a shadow group shall not eliminate the requirement for it to be present in the standard group.

NEMA Standard 10-16-1985.

It is expected that shadow groups should be used to transmit information omitted by the standard or to supplement data that is specified by the standard. The meanings of these elements may be made public. A continuing ACR-NEMA Committee may also choose to recommend elements to be included in these groups between revisions of the ACR-NEMA Standard.

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Group 0000H is defined as the command group, and contains information relating to the intended use of the data contained in the message.

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Group 0001H is the shadow group of group 0000H.

Authorized Engineering Information 10-16-1985.

All other groups are defined as data groups and the data groups collectively are defined as the data set.

NEMA Standard 10-16-1985.

4.4 DATA SET TYPES

Various data set types should be defined by the groups they contain. For a given data set type, groups should be classified as either required, optional or not allowed. The classification of each group within the defined data set types is given by Table 4-2. See 4.8 for further description of groups in optional data sets.

Authorized Engineering Information 10-16-1985.

In addition to the data sets shown in Table 4-2, three additional data set types shall be defined by the standard. The shadow data sets of IMAGE, TEXT, and GRAPHICS shall be PRIVATE IMAGE, PRIVATE TEXT, and PRIVATE GRAPHICS. Classification of groups in these shadow data sets must be the same as for the standard data sets except that one or more of the required groups is a shadow (manufacturer or user specific) group and not present as the required group.

NEMA Standard 10-16-1985.

Any data set containing group 7FE0H is by definition a data set of type IMAGE; thus, group 7FE0H shall not be used in any other data set type.

NEMA Standard 10-16-1985.

Data sets of type TEXT shall always contain group 4000H.

NEMA Standard 10-16-1985.

Data sets of type GRAPHICS shall always contain at least one of the groups 6000H-601EH (even).

NEMA Standard 10-16-1985.

Data sets of type OTHER shall be used for data sets which cannot be classified as IMAGE, TEXT, or GRAPHICS.

NEMA Standard 10-16-1985.

IDENTIFIER is a special case of data sets of type OTHER. If this data set type is used, then it shall be used as the type for the data groups associated with FIND_REQUEST, FIND_RESPONSE, GET_REQUEST, and MOVE_REQUEST.

NEMA Standard 10-16-1985.

A data set of type NULL is a special case of data set type OTHER which contains no groups. It shall be used when the command group (group 0000H) is the only group in the message.

NEMA Standard 10-16-1985.

4.5 DATA ELEMENTS

Each group is subdivided into data elements which contain individual segments of information. The components of the data element are contained in four fields: a group number; a data element number; a length; and a value. These components shall be present in the order stated. In the ACR-NEMA Standard, a specific data element within a specific group is referred to as element name (group number, data element number).

A data element number is a word interpreted as an unsigned integer.

A particular combination of group number and data element number shall appear at most once within a message.

Data element number 0000H of all groups shall be the first data element. Its value shall be the number of bytes expressed in binary from the end of its own value field to the beginning of the next group. All groups, whether standard, shadow, user, or manufacturer-specific, must have this element.

All data elements with the same group number must be grouped together and shall be ordered sequentially according to data element number.

Data element numbers within defined groups which are not identified in Section 10 shall be reserved for future use.

In a shadow group, element numbers 0001H through 7FFFH shall be reserved for manufacturers. Element numbers 8000H through FFFFH shall be reserved for users.

NEMA Standard 10-16-1985.

4.6 LENGTH

The length field is a double word (32 bits) interpreted as an unsigned integer representing the number of bytes from the end of the length field to the beginning of the next data element, or to the next potential element if the element is the last element. This binary number must be even.

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4.7 VALUE

The value of the data element shall be an even number of bytes. The value shall be an ASCII string unless otherwise specified in Section 10.

The combination of group number and data element number shall determine the unique representation of the associated value. Section 10 contains this representation for all defined elements. The multiplicity of values permitted for a particular data element is specified in Section 10. There are certain data elements for which only specific entries within the value field (enumerated values) are allowed. These are specified in Section 10.

NEMA Standard 10-16-1985.

4.7.1 ASCII Values

Values represented in ASCII shall use the character set as defined in ANSI X3.4-1977.

If an element is represented with an ASCII value, character defined as part of the graphic character set (20H to 7EH) of the ANSI standard shall be used. The control characters carriage return (0DH) and line feed (0AH) shall be permitted also. The characters * (2AH) and @ (40H) shall have special meanings when present in the value fields associated with the FIND_REQUEST (See 6.2.2). The character \ (5CH) is the delimiter (see 4.7.3).

An integer number, represented by ASCII numeric, shall contain only the characters 0 through 9, +, and −.

A fixed point number, represented by ASCII numeric, shall contain only the characters 0 through 9, +, −, and an explicit decimal point marker (.). Implied decimal points shall not be permitted.

A floating point number, represented by ASCII numeric, shall be as defined in ANSI X3.9-1978. Character E shall be the valid character to indicate the start of the exponent.

Where a word consists of two ASCII characters, the first character shall appear in the least significant byte.

All ASCII fields shall be padded if necessary to produce an even number of bytes. ASCII alphanumeric text shall be left justified. ASCII numeric text shall be right justified. The padding character for ASCII strings shall be the space (20H).

NEMA Standard 10-16-1985.

4.7.2 Binary Values

Binary values shall be represented in 2's complement form, except for pixel values which shall be represented in a form specified by Pixel Representation (0028H,0103H).

In a double precision 32-bit binary integer, the least significant word shall be transmitted first across the interface. Such an integer must be used in the value field of a data element which represents a length to the end of a group or a message.

NEMA Standard 10-16-1985.

4.7.3 Multiple Values

Multiple values shall be allowed in designated value fields. For ASCII values, only the backslash (\ ) shall be used as a delimiter. Multiple binary values shall be a sequence of 16 bit 2's complement words unless otherwise specified (i.e., for pixels or overlays).

NEMA Standard 10-16-1985.

4.8 DATA ELEMENT TYPES

Data elements are classified into three types:

Type 1—necessary for storage or display of the data
Type 2—primary items used for interpretation
Type 3—secondary items used for interpretation

Types 1 and 2 are subdivided into default and nondefault types.

NEMA Standard 10-16-1985.

4.8.1 Type 1 Data Elements

Type 1 data elements shall contain meaningful values and shall be sent with every message. The value field shall contain valid data.

NEMA Standard 10-16-1985.

4.8.2 Type 1D (Default) Data Elements

If type 1D data elements are not sent with a message, the receiver shall assume the default value(s) as defined in the standard. If the default value is not to be used, then these elements shall be sent with the message and the value field shall contain valid data.

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4.8.3 Type 2 Data Elements

Type 2 data elements shall be sent with every message (except as noted in 4.8.6). If the value for a data element is not known, that data element must be sent with the length set to zero and with no value (i.e., value field does not exist).

NEMA Standard 10-16-1985.

4.8.4 Type 2D (Default) Data Elements

If type 2D data elements are not sent with a message, the receiver shall assume the default values as defined in the standard (except as noted in 4.8.6). If the default value is not to be used, then these elements must be sent with the message. If the value for a data element is not known, that data element shall be sent with the length set to zero and with no value (i.e., value field does not exist).

NEMA Standard 10-16-1985.

4.8.5 Type 3 Data Elements

Senders shall not be required to send type 3 data elements. If they are sent, they must be sent with a value field. Receivers shall not be required to interpret type 3 data elements.

NEMA Standard 10-16-1985.

The difference between type 1 and type 2 elements is that all type 1 elements must be known before a valid message can be sent, while type 2 elements may be unknown but must still be sent as zero length elements. Type 3 elements are meant for additional useful information and are optional.

NEMA Standard 10-16-1985.

4.8.6 Data Elements In Optional Groups

Depending on the data set type, groups are classified as required, optional, or not allowed as defined in Table 4-2.

If a group is required by its particular data set type, then the definitions of type 1 and type 2 data elements require that these elements must be present in this group. The definitions of type 1D and type 2D data elements require that their defaults be assumed if these elements are not present in a required group.

If an optional group is sent, all type 1 data elements must be sent and all type 1D defaults shall be assumed if the element is not sent. If type 2 data elements are contained in optional groups, senders are not required to send them. In optional groups defaults shall not be assumed for type 2D data elements.

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4.9 EXAMPLES

Examples of typical messages can be found in Appendix B.

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Table 4-1
IDENTIFICATION AND DESCRIPTION OF STANDARD GROUPS

Group Number (Hex)	Type of Information	Description of Group Content
0000	Command	Information which provides for end to end communication capability between two pieces of imaging equipment
0008	Identifying	Information which provides unique image identification parameters to the user
0010	Patient	Information related to the patient
0018	Acquisition	Information related to the image acquisition device and imaging procedure
0020	Relationship	Information relating the image to the location within the patient and to other associated images
0028	Image Presentation	Information related to the manner in which the image can be presented or displayed in a consistent and reproducible manner
4000	Text	ASCII text
Even 6000-601E	Overlay	Information related to overlay pixel data associated with the image
7FE0	Pixel Data	Image pixel data

Table 4-2
CLASSIFICATION OF GROUPS FOR EACH DATA SET TYPE

DATA SET	GROUPS				
	0008H, 0010H, 0018H, 0020H, 0028H	4000H	EVEN 6000H-601EH	7FE0H	PRIVATE
IMAGE	R	O	O	R	O
TEXT	O	R	N	N	O
GRAPHICS	O	O	R	N	O
OTHER	O	N	N	N	O
IDENTIFIER	O	N	N	N	N
NULL	N	N	N	N	N

R = required
O = optional
N = not allowed

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Section 5

MESSAGE CONTENT

5.1 INTRODUCTION AND OVERVIEW

A message should contain a single data set. Four types of data sets which are contained in messages are discussed in this section: images, overlays, text, and other.

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In addition to the medical content of a particular image, information may contain the temporal sequencing of images (e.g., the growth of a lung tumor on two chest films 3 months apart; the distinction of arterial and venous supply to a tumor on images taken every second for 30 seconds).

Authorized Engineering Information 10-16-1985.

The relationship between the data contained in an image and the location of that image in the patient may also be important. On occasion, an additional relationship should also be specified; e.g., that between the patient (or image) and the geometrical configuration of the imaging device.

Authorized Engineering Information 10-16-1985.

Images shall be arranged and identified in a hierarchical grouping containing four levels: study (most inclusive); series; acquisition; and image (least inclusive).

NEMA Standard 10-16-1985.

The orientation of the image relative to the patient shall be specified and a means of specifying the relation of an image to an equipment coordinate frame is provided.

NEMA Standard 10-16-1985.

The bit fields containing pixel data shall be explicitly specified. If overlays are associated with an image they shall be stored one bit with each pixel or in a separate data element as indicated in (X,2000H).

NEMA Standard 10-16-1985.

If special display characteristics are necessary for images or overlays, then these characteristics shall be defined in lookup tables or parameters defining linear transformations.

NEMA Standard 10-16-1985.

5.2 IMAGES

5.2.1 Hierarchical Relationships of Sets of Images

No more than one image is contained in a message. Relationships to other images shall be described in four levels: image, acquisition, series, study. The image is the lowest level. One or more images may be derived from a single acquisition which is a single continuous gathering of raw data. Related acquisitions form a series and related series form a study. Data elements representing these four levels shall be included with an image. If any of these data elements for a given modality is not used, its value shall be set equal to one.

NEMA Standard 10-16-1985.

When associating one image with another, the data elements: study(0020H,0010H)\series(0020H,0011H)\ acquisition (0020H,0012H)\image(0020H,0013H) shall be used.

NEMA Standard 10-16-1985.

Some hospitals and departments may have their own study number, computed, for example, by an information management system. In any given case, the meaning of these terms should depend upon the particular modality and implementation. Some possible implementations and examples are shown in Appendix C. Depending on the implementation it may be necessary to use additional data elements to guarantee unique identification of an image.

Authorized Engineering Information 10-16-1985.

5.2.2 Image Identification

For the purpose of image identification, three types of images are defined:

1. Original image—pixel values represent original, non-transformed data.
2. Modified image—pixel values have been modified.
3. Composite image—two or more images (from the same study) have been combined into one image for display or storage.

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Composite images composed of images from different studies are not supported by this version of the standard. They may be handled using private groups.

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5.2.2.1 ORIGINAL IMAGE IDENTIFICATION

There are many ways to uniquely identify images. For the examples given in this document it is assumed that devices generating images assign a study number which does not repeat during a single day. Thus an original image may be uniquely identified by:

Station ID	Element	(0008H,1010H)
Study Date		(0008H,0020H)
Study		(0020H,0010H)
Series		(0020H,0011H)
Acquisition		(0020H,0012H)
Image		(0020H,0013H)

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5.2.2.2 MODIFIED IMAGE IDENTIFICATION

Modified images must contain the following three data elements which shall be supplied by the modifying device:

Modifying Device ID	(0020H,3401H)
Modified Image ID	(0020H,3402H)
Modified Image Date	(0020H,3403H)

The data elements used to identify the original image shall not be changed in the modified image. For subtraction images the series, acquisition, and image numbers of the mask image must be given in Masking Image (0020H,0080H).

NEMA Standard 10-16-1985.

An example of a modified image is one which has been changed by picture processing or subtraction.

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5.2.2.3 COMPOSITE IMAGE IDENTIFICATION

For composite images, the Station ID, Study Date, and Study Number data elements must refer to the original images. The original Series, Acquisition and Image data element values have no meaning for the composite image and they must be set to 1. In addition, composite images must contain the following elements:

Modifying Device ID	(0020H,3401H)
Modified Image ID	(0020H,3402H)
Modified Image Date	(0020H,3403H)

NEMA Standard 10-16-1985.

References to the images used to generate the composite image shall be contained in Source Image IDs (0020H,3100H) to (0020H,31FFH) with one data element per reference image. The value field of each of these elements shall contain: "Series \ Acquisition \ Image \ Modifying Device ID \ Modified Image ID \ Modified Image Date." If the reference image is an original image, only the first three identifiers shall be required. In that case, the last three identifiers are sent as *null* (i.e., "Series \ Acquisition \ Image \ \ \ "). If the reference image is a modified image, only the last three identifiers shall be required (i.e., " \ \ \ Modifying Device ID \ Modified Image ID \ Modified Image Date").

NEMA Standard 10-16-1985.

Examples of composite images include: sagittal and coronal reconstructions, perspective views of three dimensional images, and collages.

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5.2.3 Image Coordinate System

The image coordinate system shall be implicitly defined by the order of pixel transmission. Image pixel data is transmitted in rows. The positive row axis (R) is in the direction from the first to last pixel of any row containing two or more pixels. The positive column axis (C) is perpendicular to the row axis in the direction of successively transmitted rows. The origin is located at the first pixel transmitted.

NEMA Standard 10-16-1985.

5.2.4 Patient Orientation

The patient orientation relative to the image shall be specified by a two valued data element Patient Orientation (0020H,0020H) that designates the anatomical direction of the positive row axis and positive column axis (see Figure 5-1).

NEMA Standard 10-16-1985.

Anatomical directions shall be designated by the capital characters: A (anterior), P (posterior), R (right), L (left), H (head), F (foot). Each value of the orientation element shall contain at least one of these characters. If refinements in the orientation descriptions are to be specified, then they shall be designated by additional letters in each value. Within each value the letters will be ordered with the principal orientation designated in the first character. See Appendix D for examples.

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Some combinations of characters are clearly nonsensical (e.g., HF \ AP or H \ F). The orientation is expected to be meaningfully constructed.

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5.2.5 Coordinate Systems

5.2.5.1 INTRODUCTION

Image locations and orientations are specified with respect to equipment based coordinate systems. If two images from the same image source have the same study and series identifier number (see 5.2.2.1) then they shall be referred to by the same coordinate system.

NEMA Standard 10-16-1985.

The definitions of coordinate frames should be based on CT and MR modalities.

Authorized Engineering Information 10-16-1985.

5.2.5.2 AXIS DEFINITION

An imaging device shall have a manufacturer-defined front and back identified for its gantry. When facing the front of the gantry, and with the gantry in a neutral (untilted) position, the x-axis shall be increasing to the right; the y-axis shall be increasing down (defined by gravitational attraction); and the z-axis shall be defined as the line orthogonal to x and y, with increasing values from the front to the back of the gantry.

NEMA Standard 10-16-1985.

5.2.5.3 ORIGIN DEFINITION

An origin is defined as a point fixed with respect to the pallet.

NEMA Standard 10-16-1985.

The purpose of a fixed origin is to allow images with the same series and study number to be spatially related. The result of this is an equipment based coordinate frame fixed to the patient during a series.

Authorized Engineering Information 10-16-1985.

5.2.5.4 IMAGE LOCATION AND ORIENTATION

If required for a modality, an image shall include Image Position (0020H,0030H) specifying the x, y and z coordinates of the first pixel in the image relative to the equipment related axes. Similarly, an image shall also include Image Orientation (0020H,0035H) specifying the direction cosines of the first row and column of the image with respect to the equipment related axes.

NEMA Standard 10-16-1985.

5.2.5.5 LOCALIZER IMAGES

A projection image, such as a localizer scan in CT and MR, shall be treated as a plane described in the same coordinate system as any cross sectional images associated with it in the same study.

NEMA Standard 10-16-1985.

The coordinates of the first pixel in Image Position (0020H,0030H) and the orientation of this localizer image plane in Image Orientation (0020H,0035H), compared to the values of the same elements for cross sectional images, give sufficient information to show the location of the cross sectional images on the localizer.

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5.2.5.6 OTHER LOCATION INFORMATION

If the Slice Location (0020H,1041H) is specified, then it shall be the distance of the slice image plane from the anatomical reference marker in Position Reference Indicator (0020H,1040H). If both the Slice Location (0020H,1041H) and the Image Location (0020H,0050H) and Image Orientation (0020H,0035H) are present then the combination of Image Location and Image Orientation shall have precedence over Slice Location in determining relative location of slices.

NEMA Standard 10-16-1985.

5.2.6 Pixel Bit Fields

Pixels of various bit depths shall be accommodated. The data elements for Bits Allocated (0028H,0100H), Bits Stored (0028H,0101H), and High Bit (0028H,0102H) shall define the pixel structure. Designation of bits allocated shall determine packing of the data.

NEMA Standard 10-16-1985.

For example, in pixel data with 12 bits allocated, 12 bits stored and bit 11 designated as the high bit, four pixels should be transmitted in three words. For additional examples of various packing schemes, see Appendix E.

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The field of bits representing the value of a pixel shall be a binary 2's complement integer or unsigned integer as specified by the Pixel Representation (0028H,0103H). These values shall be directly usable for physically meaningful quantitative calculation.

NEMA Standard 10-16-1985.

If the pixel value range is limited, then Smallest Pixel Value (0028H,0104H) and Largest Pixel Value (0028H,0105H) shall be used to specify these elements.

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Some CT scanners incorporate text, annotation and region of interest into the pixel value field with, for example, all numbers greater than 1000 or less than −1000 annotation values. ACR-NEMA compatibility requires that all such information should be placed in an overlay plane; no way of specifying overlay like information in this way is included.

Authorized Engineering Information 10-16-1985.

5.2.7 Image Geometry

The image geometry specified in the Image Format data element (0028H,0040H) shall be rectangular.

NEMA Standard 10-16-1985.

The spacing of pixel centers along rows and columns shall be specified by the values of Pixel Size (0028H,0030H).

NEMA Standard 10-16-1985.

The image aspect ratio can be calculated from the number of Rows (0028H,0010H), number of Columns (0028H,0011H), and Pixel Size (0028H,0030H).

Authorized Engineering Information 10-16-1985.

5.2.8 Image Display

If a transformation of pixel values to a gray scale display is specified, it shall be contained in Lookup Table Descriptors—Gray (0028H,1100H) and Lookup Data—Gray (0028H,1200H) and Window Center (0028H,1050H) and Window Width (0028H,1051H), or a Rescale Intercept (0028H,1052H) and Rescale Slope (0028H,1053H). The window transformation shall be applied to the result of the rescale or lookup table transformations. If both the rescale and lookup table transformations are present the lookup table transformation shall be applied to the result of the rescale transformation.

If there are multiple window or rescale transformations, then these shall be stored as multiple values of the elements.

If a transform of pixel values to a red, green or blue display is specified, it shall be contained in the corresponding lookup table elements.

An example of a lookup table is contained in Appendix F. In the table data, all 0's correspond to black; all 1's correspond to white. Pixel values smaller than the smallest number transformed by the table are transformed by the first entry of the table. Pixel values larger than the largest number transformed by the table are transformed by the last entry of the table.

NEMA Standard 10-16-1985.

5.3 OVERLAYS AND GRAPHICS

5.3.1 Definitions

An overlay plane shall contain graphics or text which is coincident with the image and is used to indicate such items as regions of interest, reference marks, and annotation. Sufficient information shall be available to allow an overlay to be presented at a display station superimposed on a particular image with which it is associated.

NEMA Standard 10-16-1985.

5.3.2 Overlay Representations

Each overlay plane shall be assigned one bit. When there are one or more overlay planes they shall be described by using groups 6000H to 601EH (even). Each group contains a pointer, Overlay Location (X,0200H), which shall point to the location of the overlay data. Its default is the current group.

NEMA Standard 10-16-1985.

Origin (X,0050H) shall be the row and column coordinates of the first overlaid image point; its default shall map the overlay origin into the image origin.

NEMA Standard 10-16-1985.

The display levels of an overlay plane are defined by a set of elements specifying two entry lookup tables, (X,1100-1103H) and (X,1200-1203H). The first and second entries of each overlay display table shall correspond to overlay bit values 0 and 1 respectively.

NEMA Standard 10-16-1985.

The values contained in these elements are similar to the values found in the lookup tables for image pixel values.

Authorized Engineering Information 10-16-1985.

Overlays may be stored: with the image in group 7FE0H and still be interpreted, using Overlay Location (X,0200H); with different numbers of rows and columns than those comprising the image; or without image pixel data, thus allowing a representation of pure graphics.

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5.3.3 Regions of Interest

A region of interest (ROI) is a specific use of an overlay. The overlay bits corresponding to the pixels included in the region of interest shall be set to 1. All other bits are set to 0.

NEMA Standard 10-16-1985.

If statistical parameters of the ROI are to be transmitted with it, then the ROI Area (X,1301H), the ROI Mean (X,1302H), and the ROI Standard Deviation (X,1303H) shall be used.

NEMA Standard 10-16-1985.

Boundaries of the regions may also be shown as overlays. However, ROI Area (X,1301H), ROI Mean (X,1302H), and ROI Standard Deviation (X,1303H), if used, should then only refer to the pixels under the boundaries, not those in the included regions.

Authorized Engineering Information 10-16-1985.

5.4 TEXT

If narrative text information is to be included in a message, then this type of data is carried in group 4000H.

NEMA Standard 10-16-1985.

A short report, explanatory information, or other text messages may be included in this group. A comment data element which exists in most groups provides a location for brief explanatory text.

Authorized Engineering Information 10-16-1985.

5.5 OTHER

Any medical data which is not image, graphics, or text, shall be data type Other.

NEMA Standard 10-16-1985.

Raw data or spectroscopic data carried in a private group is an example of the data type Other.

Authorized Engineering Information 10-16-1985.

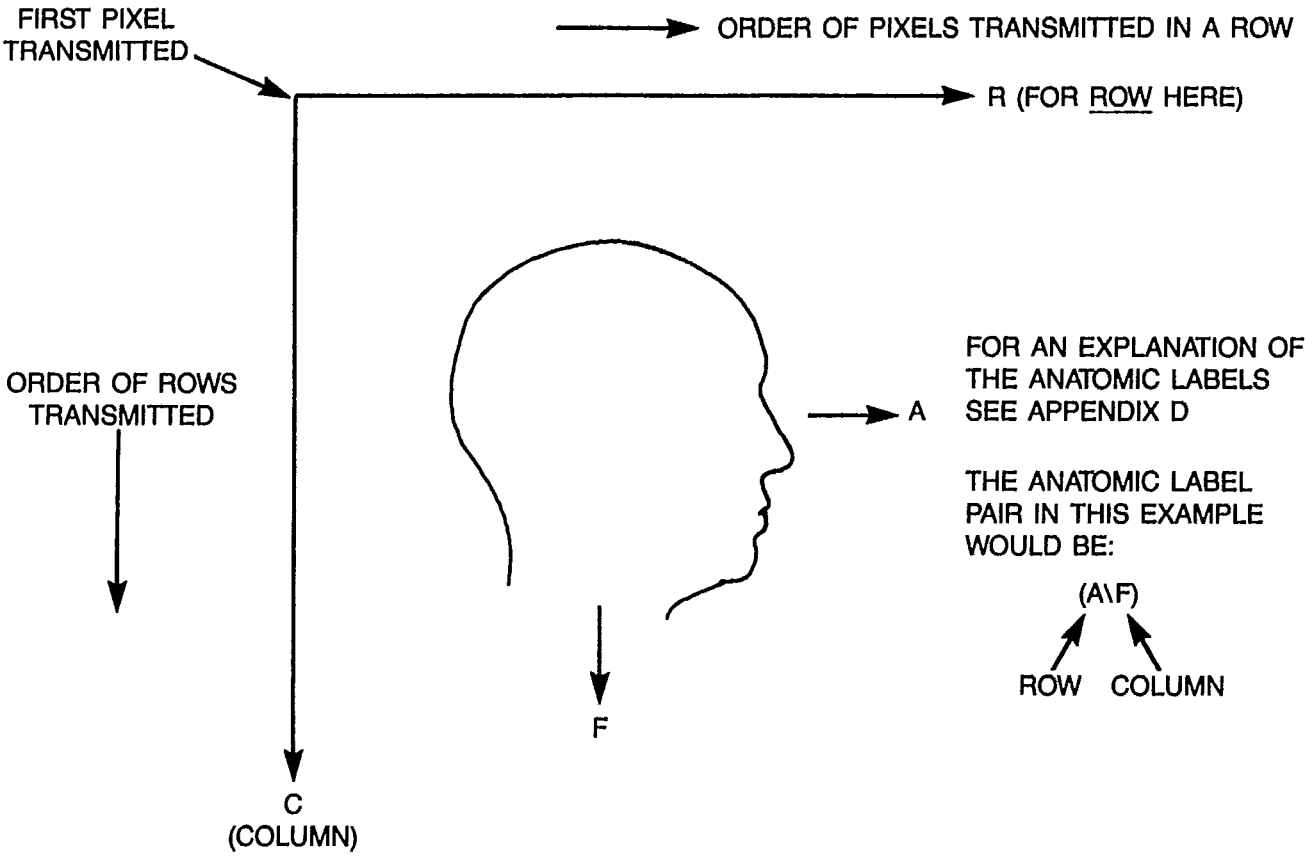

Figure 5-1
IMAGE COORDINATES

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Section 6

COMMAND STRUCTURE

6.1 INTRODUCTION

A minimum set of commands is defined in this section. The commands, parameters and data elements defined in Section 10 are imbedded in the data structure defined in Section 4.

Three types of commands are defined: one type for normal processing (SEND, GET, MOVE, FIND, and DIALOG); one for exceptions (CANCEL); one for verification (ECHO).

Commands shall be initiated by imaging equipment. The initiator, receiver, FIND Location and MOVE Destination fields in the command shall always describe imaging equipment defined by its logical address. The command response shall always be initiated by the receiver whose logical address was specified in the original command request. The command response must be sent back to the initiator of the command request.

Imaging equipment that is a source of data must be able to initiate a SEND__REQUEST and must be able to receive SEND__RESPONSE. Imaging equipment that is a sink must be able to receive a SEND__REQUEST and must be able to initiate a SEND__RESPONSE. All imaging equipment must be able to recognize an ECHO__REQUEST and respond with an ECHO__RESPONSE. The ability to initiate all other commands shall be optional. The minimum command handling required for compatibility is discussed in Section 3.

Associated with commands are parameters which are defined in Section 10, Tables 10-1 and 10-2. Group 0000H contains all command information.

Examples of commands are found in Appendix G.

NEMA Standard 10-16-1985.

6.1.1 Status

The status referred to in the remainder of this section is always indicated in data element (0000H,0900H). Message status codes shall be one word. The most significant byte of the word shall be generated and interpreted according to the meanings listed in Tables 10-3 and 10-4. All other codes are reserved for future use by the ACR-NEMA Standard. The least significant byte of the word shall contain either 1) a zero value indicating no specific additional status information, or 2) a non-zero value containing more detailed status information.

NEMA Standard 10-16-1985.

An implementation may always put zeros in the least significant byte of the status. When enumerated codes are available it may use one of them. When the code in the high order byte implies that the specific status is not specified (e.g., AFxxH or CFxxH), the implementation specific codes may be placed in the least significant byte.

Authorized Engineering Information 10-16-1985.

6.2 COMMANDS FOR NORMAL PROCESSING

6.2.1 SEND Commands

The SEND__REQUEST command is used to transfer data to a receiver. The SEND__RESPONSE command acknowledges the receipt of the data.

NEMA Standard 10-16-1985.

The data source (the device that has the data) shall initiate the SEND__REQUEST and must receive an indication of the successful data transfer (Status = Success) or an error message (Status = Failed) via the SEND__RESPONSE. The SEND__RESPONSE is a distinct command issued by the SEND__REQUEST receiver. A successful response shall indicate that the message was successfully received by an imaging device. The interpretation of a successful response is implementation specific.

NEMA Standard 10-16-1985.

A successful response should be interpreted by the original data source as an indication that the data transfer was successful. Depending on the pieces of equipment involved, this may have different meanings. For instance, an imaging device sending an image to an archive may have a protocol that a successful response is the indication that the archive is assuming responsibility for the integrity of the image and that the imaging equipment can purge its disk of the image data. On the other hand, an archive sending an image to a printer may have a protocol that would not purge the image data from the archive. In this case the successful response may indicate that the image was successfully printed or may indicate only that the image was received by the printer.

Authorized Engineering Information 10-16-1985.

6.2.2 FIND Commands

The FIND__REQUEST is used to query a device to determine if the requested data exists. This command shall contain elements describing the data sought. The device receiving the FIND__REQUEST replies with FIND__RESPONSEs which shall contain any matches found.

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In order to describe the data which is desired from the FIND__REQUEST receiver, group 0000H shall be followed by data groups containing data elements whose value fields indicate the known and sought data. All data groups are optional.

NEMA Standard 10-16-1985.

A datum on the receiver shall be matched to the FIND__REQUEST when every element (other than element numbers 0000H and 0001H) of the FIND__REQUEST matches its corresponding element in that datum. When its corresponding element is multivalued, that element must be matched if any of its values match.

NEMA Standard 10-16-1985.

The characters * and @ shall be used as special characters representing the sought data, and shall be allowed to be used in any element whose value is ASCII. The * shall mean that some number of characters are unknown and shall allow no (0) characters to be present. The * used alone in a value field shall mean all possible values for that data element are desired. The @ shall mean that the single character represented by @ in the FIND__REQUEST is unknown. The FIND__RESPONSE shall replace the @ with the single character that is part of the match, and shall replace the * with the characters that are part of the match.

NEMA Standard 10-16-1985.

As examples, the patient name SMITH would be returned for values in element (0010H,0010H) of *, S*, *I*, *IT@, and S@@@@, but not S@@@ or S*T. A value of A*B would return matches of AB,ABB, and ACBDB.

Authorized Engineering Information 10-16-1985.

If a FIND__REQUEST contains type 3 elements with known values or partial sought values (an * with another character or at least one @) then only data sets wich contain that element with the sought values shall cause a match.

NEMA Standard 10-16-1985.

If a FIND__REQUEST contains a type 3 element with only an * as its value, then a match shall be caused by data sets which match the other elements specified whether the type 3 element is present or not in that data set. A set with the type 3 element present and one with it not present shall give separate matches.

NEMA Standard 10-16-1985.

In many cases the same information may be stored in different formats; for example, patient name. The same name may be stored as:

(1) Smith, James C. Jr.;
(2) Smith Jr., J.C.;
(3) Smith, J.;
(4) James C. Smith.

It is not the intent of this standard to require any given name format; the implementation should carry the reponsibility for standardization. Initiators of FIND__REQUESTs should anticipate various formats. For example:

SMITH*J*C will return the first two names above;
SMITH*J* will return the first three names; and
SMITH will return all four names.

Whether the receiver treats upper and lower case characters as equivalent is also implementation specific.

Authorized Engineering Information 10-16-1985.

If an element with binary values is sent in a FIND__REQUEST, then, if the length of the value field is zero, all values of this element shall be returned in the responses. If the length of the value field is not zero, then only values that match shall be returned. This shall allow binary fields to be searched in a manner similar to ASCII fields. Matches shall not be made against elements describing group length or message length.

NEMA Standard 10-16-1985.

Multiple responses to a FIND__REQUEST shall be permitted. Each FIND__RESPONSE shall contain group 0000H followed by the same groups and data elements contained in the FIND__REQUEST, with the * and @ replaced by the value or values found. In the response, only the element numbers provided with known values or values sought (or both) in the request shall be returned. Each unique matched value set shall provide a separate response. In the FIND__RESPONSE, data element (000H,0850H) shall contain the number of data sets which give an identical FIND__RESPONSE. If the length of (000H,0850H) is set to zero, there can be other identical FIND__RESPONSEs. Status shall be set to Pending in all responses except the last, in which it shall be set to Success. In order to allow these responses to arrive in a different order than they are generated, data element (0000H,0860H), Sequence Number, shall be set to 1 for the first response, which can indicate multiple images, and shall be incremented by 1 for each succeeding response. Indication that no matching data was found shall be receipt of a response with the Status=Success and Sequence Number=0.

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The location of the matched data set is indicated through the FIND Location (0000H,0400H).

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6.2.3 GET COMMANDS

The GET__REQUEST asks the request receiver to SEND a data set back to the request initiator. A GET__RESPONSE indicates that the request has been received.

NEMA Standard 10-16-1985.

In order to describe the data which is desired from the GET__REQUEST receiver, group 0000H shall be followed by data groups containing data elements whose value fields indicate the known data. All data groups are optional.

NEMA Standard 10-16-1985.

This set of data elements shall be a specification which defines a data set to be transmitted in response to the GET__REQUEST. Each value shall be treated as an exact match requirement. The symbols used as special characters in the FIND command shall not be treated as such in the GET command; instead they shall represent themselves.

NEMA Standard 10-16-1985.

The receiver of a GET command shall search for images that have group element values that exactly match the elements in the GET__REQUEST message. However, matches shall not be made against elements describing group length or message length. The GET__REQUEST receiver shall respond with two GET__RESPONSE messages. The first shall indicate the status of the received GET__REQUEST message. The second shall indicate the number of matches found in element (0000H,0850H) if the device is capable of determining this information; otherwise (0000H,0850H) shall be set to zero. Even if there is more than one match, only one match shall be returned by the subsequent SEND command, which is implementation specific.

NEMA Standard 10-16-1985.

If the data set is available, then the receiver of the GET__REQUEST command shall use the SEND__REQUEST command to send the data set to the initiator of the GET__REQUEST command. This SEND__REQUEST (and the subsequent SEND__RESPONSE) shall be identical to normal SEND command, except that this SEND command shall include Message ID Being Responded To (0000H,0120H) field which shall contain the message ID of the original GET__REQUEST command.

NEMA Standard 10-16-1985.

The GET command initiator should be expected to know enough to uniquely specify data sets. The GET command should not be intended for use as a network or system search command. It should be used to fetch a specific, known and existing data set.

Authorized Engineering Information 10-16-1985.

6.2.4 MOVE Commands

The MOVE__REQUEST initiator sends to the MOVE__REQUEST receiver a message which directs that receiver to SEND the specified data set to a third party; i.e., that receiver becomes the initiator of a SEND__REQUEST.

NEMA Standard 10-16-1985.

The MOVE__REQUEST receiver shall respond with two MOVE__RESPONSE messages. The first MOVE__RESPONSE shall indicate successful receipt of the MOVE__REQUEST message by having Status=Pending. The Status contained in the second MOVE__RESPONSE shall indicate the result of the MOVE__REQUEST.

NEMA Standard 10-16-1985.

In the case that the SEND__REQUEST initiated by the MOVE__REQUEST failed, the status code returned in the SEND__RESPONSE shall be transmitted to the MOVE__REQUEST initiator in the second MOVE__RESPONSE.

NEMA Standard 10-16-1985.

A data set is described in a MOVE__REQUEST in a manner identical to the GET__REQUEST. Any of the reasons why a GET can fail shall be a reason for a MOVE to fail. Unlike GET, the MOVE__REQUEST shall fail if there is more than one data set found by its receiver.

NEMA Standard 10-16-1985.

If any status other than pending is returned in the first MOVE__RESPONSE message, then it must be a failure response, and no second MOVE__RESPONSE shall be transmitted or expected.

NEMA Standard 10-16-1985.

Although MOVE is similar to GET, success for a MOVE command is more restrictive than success for a GET command (GET succeeds if there are multiple matches; MOVE does not) due to the effect on a third party. The MOVE command may be allowed to specify the data destination to be the same as the initiator, in which case the MOVE command has the effect of a GET command, except that only a single match is allowed for the MOVE command.

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6.2.5 DIALOG Commands

The DIALOG command shall provide the means for exchanging unformatted and interactive information between entities (operators or programs) in imaging equipment.

NEMA Standard 10-16-1985.

The request initiator shall send a DIALOG_REQUEST message requesting that an interactive connection be established with the DIALOG_REQUEST receiver's program or service identified in data element (0000H,4000H) (see Section 10) which must be operating in the equipment specified as receiver in data element (0000H,0300H). The request receiver must respond with a DIALOG_RESPONSE command which contains Status (0000H,0900H) indicating Success or Failed for the specified reason code (see Section 10).

NEMA Standard 10-16-1985.

If the response indicates Success, then the program or service requested shall be available to the initiator via further message segments sent across the interface in Command packets (see 9.5 for details).

NEMA Standard 10-16-1985.

Since the DIALOG_REQUEST receiver is an unspecified program, the details of the exchange cannot be specified, but two examples are shown in Appendix H.

Authorized Engineering Information 10-16-1985.

The connection shall be considered to be established when the DIALOG_RESPONSE with Status=Success has been received from the DIALOG_REQUEST receiver by the DIALOG_REQUEST initiator. The connection shall remain until the DIALOG_REQUEST initiator or the DIALOG_REQUEST receiver terminates it.

NEMA Standard 10-16-1985.

Group 0000H has a data element in which a description of the Terminal Type (0000H,4010H) may be included. The value of this data element is expected to be understood by the receiver.

Authorized Engineering Information 10-16-1985.

The default type shall be a standard console device which accepts ASCII text in 80 character lines with no screen control except carriage return and line feed.

NEMA Standard 10-16-1985.

All equipment which supports DIALOG shall include a default DIALOG receiver which shall be called "SYSTEM." It shall accept DIALOG messages and route them for presentation on the equipment console device. No return stream need be generated and sent. The initiator shall be responsible for disconnection, but the receiver can initiate a disconnect after an implementation-specific timeout.

NEMA Standard 10-16-1985.

The terminating equipment should be responsible for performing the Session Layer Disconnect and closing the channel. The protocols of the connection are those of a user at a terminal running a program in an attached computer. The DIALOG_REQUEST receiver may require log in and a password before allowing access. The receiver may send prompts for service choices. The initiator responds with information. If the initiator is an operator at the equipment console, the DIALOG service software may send a message segment after each carriage return. The receiver software delivers these segments to the DIALOG receiver. The DIALOG receiver responds with prompts or data which its service software sends to the initiator using the protocols defined in Section 9.

Authorized Engineering Information 10-16-1985.

Among the uses of this command should be to make connection to a database of patient studies kept by other equipment, to run a statistics program, to send patient or schedule data to an information system, to exchange data in a different format, etc. The DIALOG receiver still has full access control, and an initiator should provide any passwords, etc.

Authorized Engineering Information 10-16-1985.

6.3 COMMAND FOR EXCEPTION PROCESSING—CANCEL

6.3.1. CANCEL as Applicable to Commands in General

The ability to generate a CANCEL_REQUEST shall be optional for all devices except as noted in this section. The ability to react to a CANCEL_REQUEST shall be mandatory for devices which implement the ability to generate FIND_RESPONSEs. If a device implements the ability to perform a MOVE_REQUEST and implements the ability to respond to a CANCEL, it must be able to generate a CANCEL_REQUEST. The ability to react to a CANCEL_REQUEST shall be optional for all other devices.

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A CANCEL__REQUEST shall have meaning only when initiated by a device which has previously transmitted a command request. The CANCEL__REQUEST shall reference the message ID number of that command request in Message ID Being Responded To (0000H,0120H).

If a command request has been completely transmitted then a CANCEL__REQUEST message shall be sent in order to cancel the command request.

If a command request has been partially transmitted, then the channel on which the message is being transmitted shall be closed or reset to cancel the command request.

If a CANCEL__REQUEST is successful, all devices must return to the state they would have been in if the original command request had not been transmitted.

If a CANCEL__REQUEST is not successful, all devices must be in the state they would have been if no CANCEL__REQUEST had been invoked.

A receiving device shall return a CANCEL__RESPONSE only to indicate to the initiating device that it does not support the CANCEL__REQUEST.

A receiving device shall indicate to the transmitting device that a CANCEL__REQUEST has been successful by returning the appropriate command response with Status=Cancelled.

A receiving device shall indicate that a CANCEL__REQUEST was not successful by returning a command response with the status equal to the value it would have been if no CANCEL__REQUEST had been invoked.

If a device does not support CANCEL, it shall return a CANCEL__RESPONSE indicating it does not support CANCEL and it shall ignore the CANCEL__REQUEST and continue processing the command request as if no CANCEL__REQUEST had been transmitted. This shall be the only use of the CANCEL__RESPONSE.

NEMA Standard 10-16-1985.

6.3.2 CANCEL as Applicable to Specific Commands

6.3.2.1 INTRODUCTION

Each command follows the general rules described in the previous section. Special actions for specific commands are described in the following sections. Device A transmits the command request and implements the CANCEL__REQUEST. Device B responds to the CANCEL__REQUEST and transmits the command response. In all cases it is assumed that device A has completed transmitting the command request across the interface.

NEMA Standard 10-16-1985.

6.3.2.2 SEND

There are no special considerations for a CANCEL of a SEND command.

NEMA Standard 10-16-1985.

6.3.2.3 GET

If device A has received a SEND__REQUEST from device B, a SEND__RESPONSE shall be returned with Status=Cancelled.

If device A has not received a SEND__REQUEST from device B, device A shall send a CANCEL__REQUEST to device B.

If device B has not sent the SEND__REQUEST when it receives a CANCEL__REQUEST from device A, device B shall send a second GET__RESPONSE with Status=Cancelled and does not send a SEND__REQUEST.

NEMA Standard 10-16-1985.

6.3.2.4 FIND

If device B has not yet transmitted the first FIND__RESPONSE when it recognizes the CANCEL__REQUEST, it shall then transmit a single FIND__RESPONSE with Status=Cancelled.

If device B has begun transmitting responses when it recognizes the CANCEL__REQUEST, it shall terminate transmission of the normal FIND__RESPONSEs and it shall transmit a single additional FIND__RESPONSE with Status=Cancelled.

If device B has begun transmitting the final FIND__RESPONSE when it recognizes the CANCEL__REQUEST, it shall continue the final response with Status = Success indicating to device B that the CANCEL__REQUEST was not successful.

NEMA Standard 10-16-1985.

6.3.2.5 MOVE

Device A requests Device B to send image to Device C. If device B has not yet transmitted the first MOVE__RESPONSE to device A when it recognizes the CANCEL__REQUEST, it shall transmit a MOVE__RESPONSE to device A with Status=Cancelled and shall not transmit the SEND__REQUEST to device C.

If device B has transmitted the first MOVE__RESPONSE to device A, but not yet transmitted the SEND__REQUEST to device C when it recognizes the CANCEL__REQUEST, it shall transmit the second MOVE__RESPONSE to device A with Status=Cancelled and shall not transmit the SEND__REQUEST to device C.

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If device B has not received the SEND__RESPONSE from device C, it shall transmit a CANCEL__REQUEST to device C. This shall result in device B receiving an indication from device C that the CANCEL__REQUEST was either successful or not successful as for the SEND command. If device B receives an indication of a successful CANCEL from device C, it shall transmit the second MOVE__RESPONSE to device A with Status= Cancelled. If device B receives an indication of an unsuccessful CANCEL from device C, it shall transmit the second MOVE__RESPONSE to device A with status equal to the value it would have been if no CANCEL__REQUEST had been transmitted by device A.

If device B has already received the SEND__RE PONSE from device C, it shall transmit the second MOVE__RESPONSE to device A with status equal to the value it would have been if no CANCEL__REQUEST had been transmitted by device A.

NEMA Standard 10-16-1985.

6.4 COMMAND FOR VERIFICATION—ECHO

This command shall allow an initiator to test and verify the end to end connection to a receiver. The ECHO__REQUEST transmitted by an initiator shall require that the receiver retransmit an ECHO__RESPONSE message. This ECHO__RESPONSE message shall contain the same group 0000H data elements that were contained in the ECHO__REQUEST message. The Initiator (0000H,0200H), Receiver (0000H,0300H), and Message ID Being Responded To (0000H,0120H) value fields shall be the same as in any other command response. This message shall contain only the command group.

In particular, the Message ID Being Responded To (0000H,0120H) in the ECHO__RESPONSE shall have the same value as the Message ID (0000H,0110H) in the ECHO__REQUEST.

The status returned in the ECHO__RESPONSE shall indicate one of the following conditions:

- refused—the command request receiver does not presently have the resources to complete the function implied by the command request; or
- success.

NEMA Standard 10-16-1985.

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Section 7

HARDWARE AND PROTOCOLS

7.1 INTRODUCTION

The purpose of this section is to define the interface across the plane between two devices to support high speed transfers of blocked data including digital image data. Some conditions and desirable features which shaped this section were that the interface:

- be simple enough to be retrofitted into existing equipment,
- use a single connector of readily available style,
- carry 16-bit parallel data with parity,
- use differential circuits to ease ground and noise problems,
- use circuitry to not limit data rate below 8 Mbytes per second,
- use asynchronous "handshake" word transfer protocol so all types of devices can be supported, and,
- use identical interface symmetry so any two devices can be connected as equals or peers (i.e., no master slave relationship).

Authorized Engineering Information 10-16-1985.

These features ruled out use of an existing interface standard (e.g., IEEE 488) since those available are either too slow or have bus oriented master-slave operation and/or complex extra features that are not required for image transfer.

Authorized Engineering Information 10-16-1985.

The hardware defined for this interface provides signal ground and 24 differential circuits; 16 for data, 1 for parity, 6 for control, and 1 reserved for future use. Using presently available logic devices, the interface circuitry should allow data rates in excess of 8 Mbytes per second. The cable propagation time and data handling in the host equipment will constrain the actual interface data rate.

Authorized Engineering Information 10-16-1985.

The cable must be terminated with a 50 pin micro-type connector. Six circuits are crossed in the cable between ends so the control lines are each driven by one side of the interface. However, the hardware, connector and software functions for each device are equivalent.

NEMA Standard 10-16-1985.

The protocols defined follow the layered model as described in Section 2. They include the Physical, Data Link, Transport/Network Layers and some features of the Session Layer.

Authorized Engineering Information 10-16-1985.

Required peer-to-peer (horizontal) formats and transactions are specified, but the implementation of inter-layer (vertical) communications internal to each device may be designed by the vendor. The specified protocols support the transmission of messages from the Application Layer with virtual connections at the Session Layer and virtual

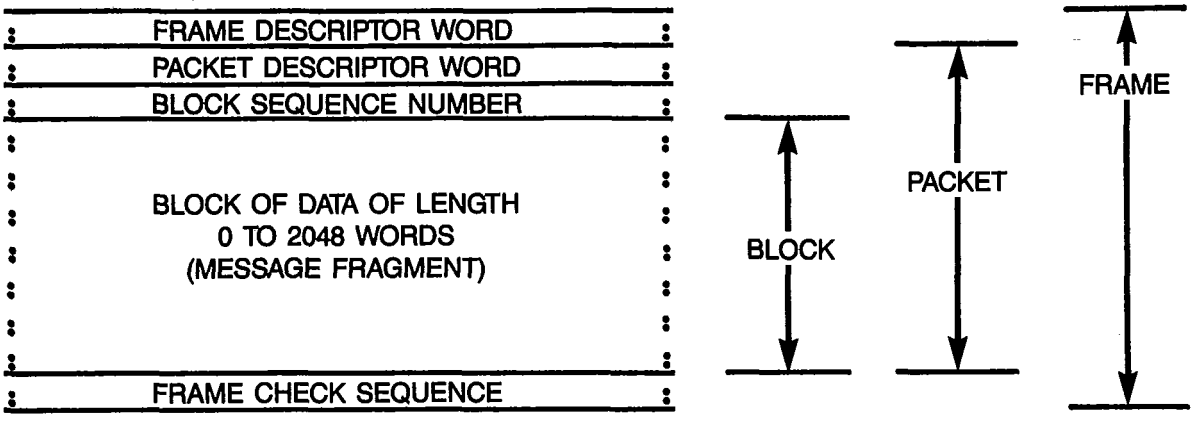

Figure 7-1
GENERAL FRAME STRUCTURE

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channels at the Transport/Network Layer. These channels can be opened and closed to support connections with specified services. The message is fragmented into blocks of up to 2048 words and combined with a channel identification number and a block sequence number to make data packets. The packets are delivered to the Data Link Layer where they are framed by a frame descriptor word and frame check sequence. The Data Link Layer also handles interface status and error reporting. The frames are sent to the Physical Layer for transmission across the physical interface. This layer handles the hardware interface access handshake and data word flow control. Timeouts and interrupt circuits should be specified to allow orderly recovery from errors.

Authorized Engineering Information 10-16-1985.

Each frame of a message should have the form shown in Figure 7-1, where the components of a frame, packet and message fragment called data block are illustrated. The frame, packet and data block structures are defined in Section 8.

Authorized Engineering Information 10-16-1985.

7.2 PHYSICAL LAYER ELECTRICAL SPECIFICATIONS

7.2.1 Definitions

The terms asserted, released, and non-asserted are used to signify the state of a given line. For equivalence to TTL, Logical, Differential, and EIA 485 specification, see Table 7-1.

A plus (+) following a signal name indicates the non-inverting element of a differential pair and the "B" terminal from the EIA 485 specification.

A minus (-) following a signal name indicates the inverting element of a differential pair and the "A" terminal from the EIA 485 specification.

The initial state is defined as having all bi-directional signals in the released state and Request Out (REQO), Interrupt Out (INTO), and Strobe Out (STBO) non-asserted.

NEMA Standard 10-16-1985.

7.2.2 Signal Definitions

The physical ACR-NEMA interface and the logical interface plane between the two connected devices is shown in Figure 7-2. The three pairs of control signals are crossed so that any device handles the signals in the same manner. The signals, their function and protocol are defined in Tables 7-2 and 7-3. The parity signal shall be asserted if and only if an even number of data signal lines are asserted, thus providing odd parity.

NEMA Standard 10-16-1985.

7.2.3 Signal Electrical Characteristics

7.2.3.1 DRIVER AND RECEIVER CHARACTERISTICS

The electrical characteristics of the signals are specified in EIA 485, which allows for multiple generators and receivers to be attached to a common interconnecting cable. The specification of the generators are structured so that more than one generator driving a line at once will not cause damage. Application of EIA 485, therefore, allows implementation of balanced bi-directional data and parity signals across the ACR-NEMA interface plane.

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7.2.3.2 CABLING AND TERMINATION

Each circuit will have a 120 ohm termination resistor connected between the + and − inputs of the receiver. These resistors shall be located as close as possible to the reciever input terminals. The cables shall have a nominal impedence of 120 ohms.

The EIA 485 specification further describes cable and ground considerations. Figure 7-3 shows typical circuits.

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7.2.3.3 PHYSICAL CONNECTORS

The connector on the equipment shall be a 50 pin female micro-type receptacle. Tables 7-2 and 7-3 show the pin definitions for the interface circuits. Figure 7-4 shows the mechanical characteristics of the connector.

The cable shall have a mating male micro-type plug connector on each end. The three pairs of control circuits will be crossed between the two connectors as illustrated in Figure 7-2.

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7.2.3.4 SIGNAL TIMING SPECIFICATIONS

The timing to be used for sending data is shown in Figure 7-5, where time intervals t_1 to t_6 are defined and minimum and maximum times are specified. These times define the handshake cycle of the STBO and STBI circuits that provides an unambiguous sequence of states for each word transfer. A minimum data circuit set-up time of 70 nanoseconds before assertion of STBO is specified. The maximum times of 1 second define a physical layer "inactivity" timeout, beyond which successful transmission is not assured.

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7.3 PHYSICAL LAYER AND PHYSICAL PROTOCOL

7.3.1 Introduction

The physical interface should consist of sixteen (16) bi-directional data lines plus one (1) bi-directional parity line, and six (6) uni-directional control lines as described in 7.2. These control circuits provide for interface access and data flow control, and provide hardware interrupt service. The Physical Layer data transfer protocol should be described in terms of a transition sequences state model which uses the control circuit states to specify the protocol states.

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7.3.2 Physical Protocol State Model

The states are defined in Table 7-4, and Figure 7-6 shows the diagram of allowed state transition sequences. The binary state values assigned to the states represent the states of the control signals in the order INTO, INTI, REQO, REQI, STBO, STBI. The values for INTI, REQI, and STBI are the signal values seen by the device receivers. The values for INTO, REQO, and STBO are the signal values output. These values are either asserted (1) or non-asserted (0). For example, RX-INT, 0110XX means INTO is non-asserted, INTI and REQO are asserted, REQI is non-asserted, and STBO, STBI are in

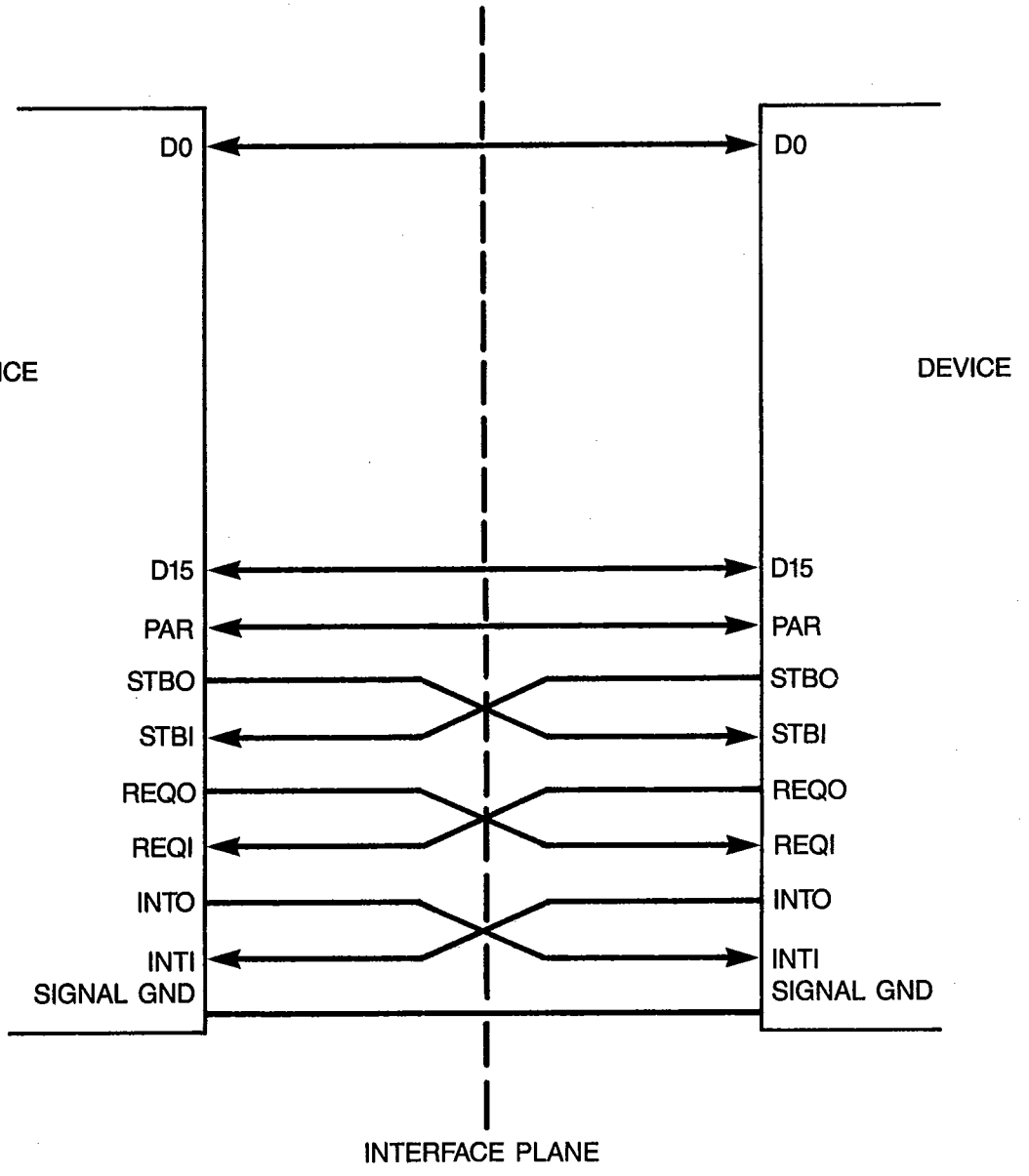

Figure 7-2
PHYSICAL AND LOGICAL INTERFACE

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either state. The state diagram shown in Figure 7-6 defines all functions of the interface since the circuitry on both sides of the interface is functionally equivalent. The initial state is the IDLE state and is defined as having all bi-directional signals in the released state and REQO, INTO, and STBO non-asserted.

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7.3.2.1 Interface Arbitration for Data Transmission

The arbitration for permission to send data is described by the state diagram (Figure 7-6). The bi-directional data signals (D0 to D15 and PAR) must be left in the Released state until permission is granted to send data as defined by entering the TX_READY state. When a collision occurs (entering the collision state), the device detecting the collision must delay for a collision wait time before trying to gain control of the interface again. This collision wait time shall be a uniformly distributed random time between 0 and 15 microseconds or an implementation-specific fixed time greater than 7.5 microseconds. During the delay, the interface shall pass through the RX_READY state before data is to be received.

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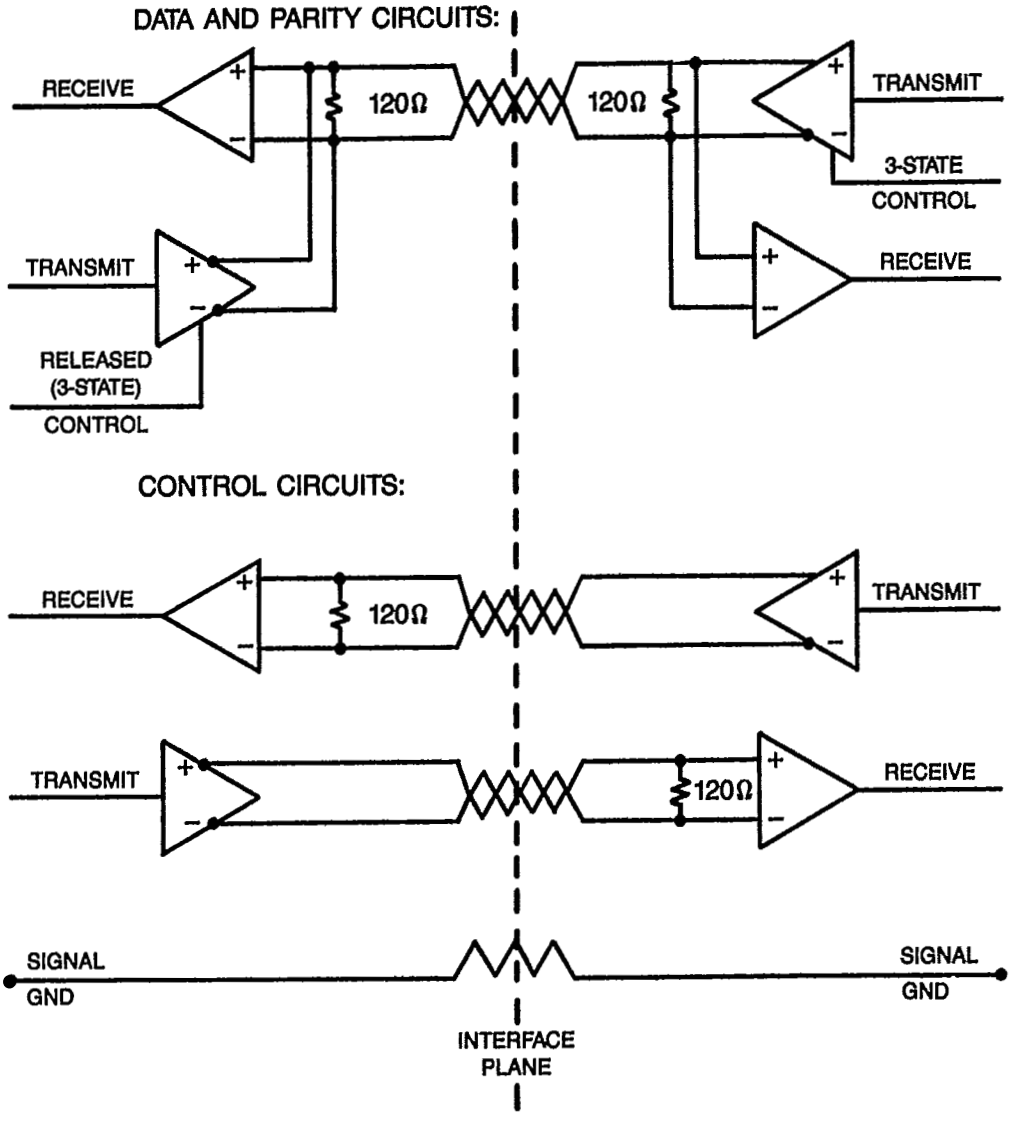

Figure 7-3
TYPICAL INTERFACE CIRCUIT

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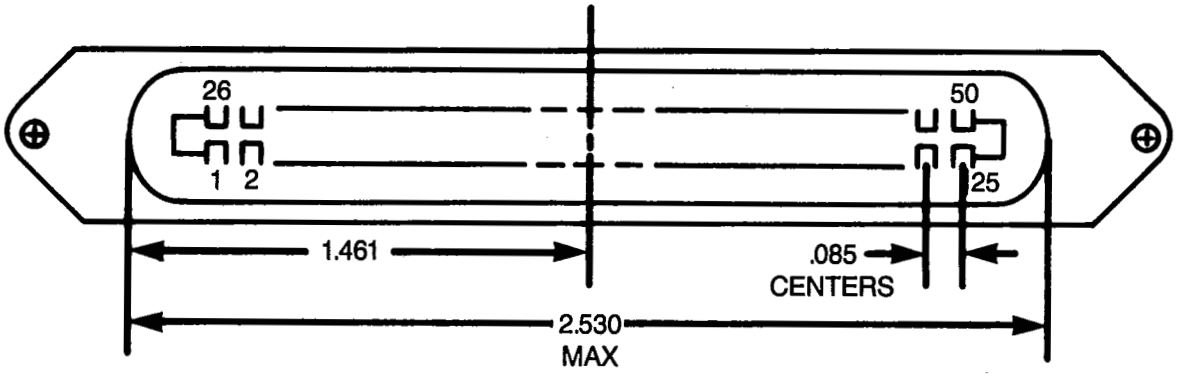

Figure 7-4
CONNECTOR—50 PIN FEMALE RECEPTACLE FRONT VIEW

Table 7-1
SIGNAL STATE DEFINITIONS

STATE	LOGICAL	TTL	DIFFERENTIAL	EIA 485
Asserted	True	High	Positive	Off
Non-asserted	False	Low	Negative	On
Released	Don't Care	Three-state	Not Defined	Passive

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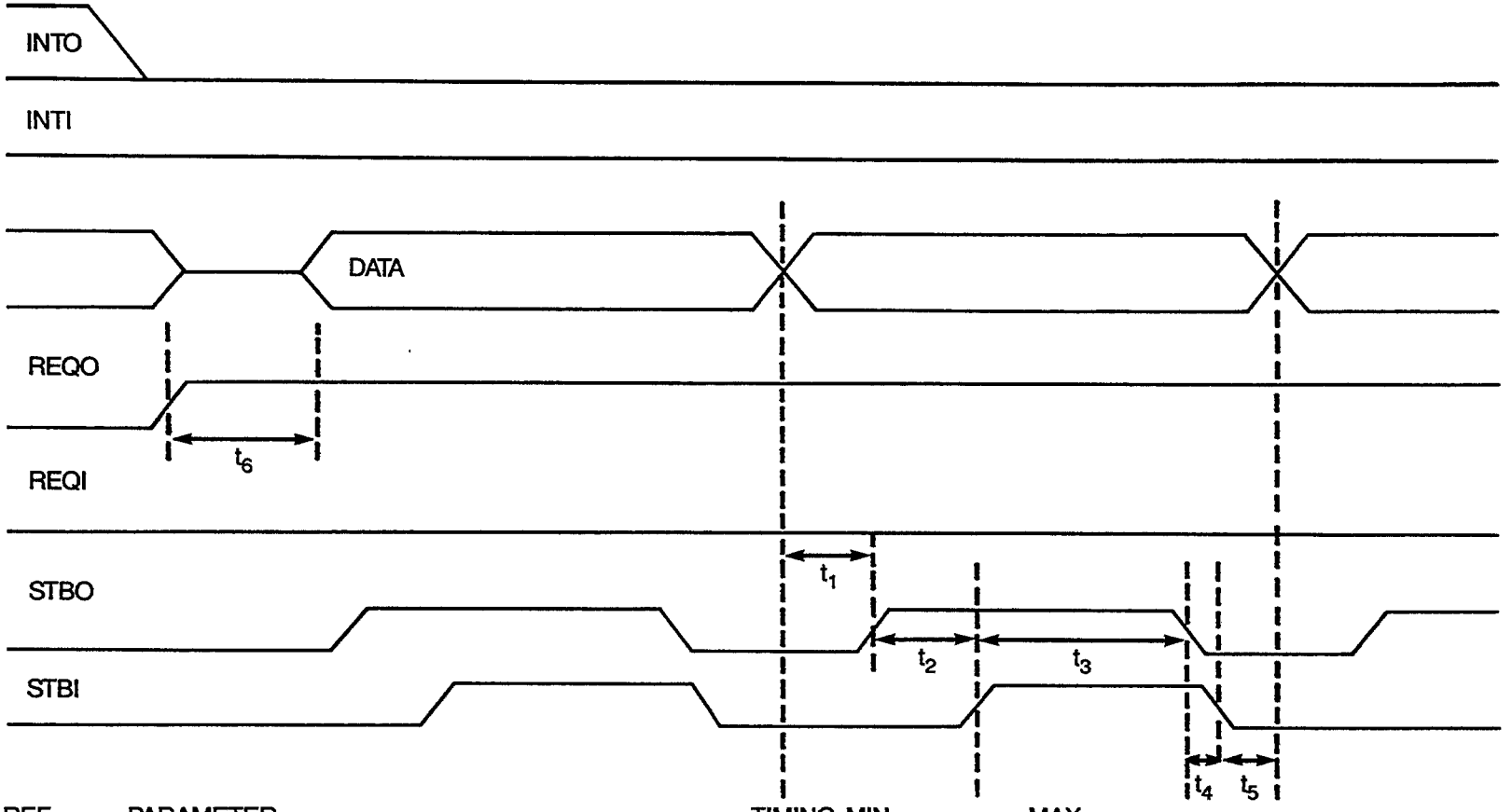

REF	PARAMETER	TIMING MIN	MAX
t_1	DATA SET UP TO LEADING EDGE OF STBO	70 ns	1 sec
t_2	LEADING EDGE OF STBO TO LEADING EDGE OF STBI	0 ns	1 sec
t_3	LEADING EDGE OF STBI TO TRAILING EDGE OF STBO	0 ns	1 sec
t_4	TRAILING EDGE OF STBO TO TRAILING EDGE OF STBI	0 ns	1 sec
t_5	TRAILING EDGE OF STBI TO DATA CHANGING	0 ns	1 sec
t_6	COLLISION ARBITRATION WINDOW	750 ns	1250 ns

Figure 7-5
TIMING DIAGRAM FOR SENDING DATA

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300-85 6470247 0000210 1

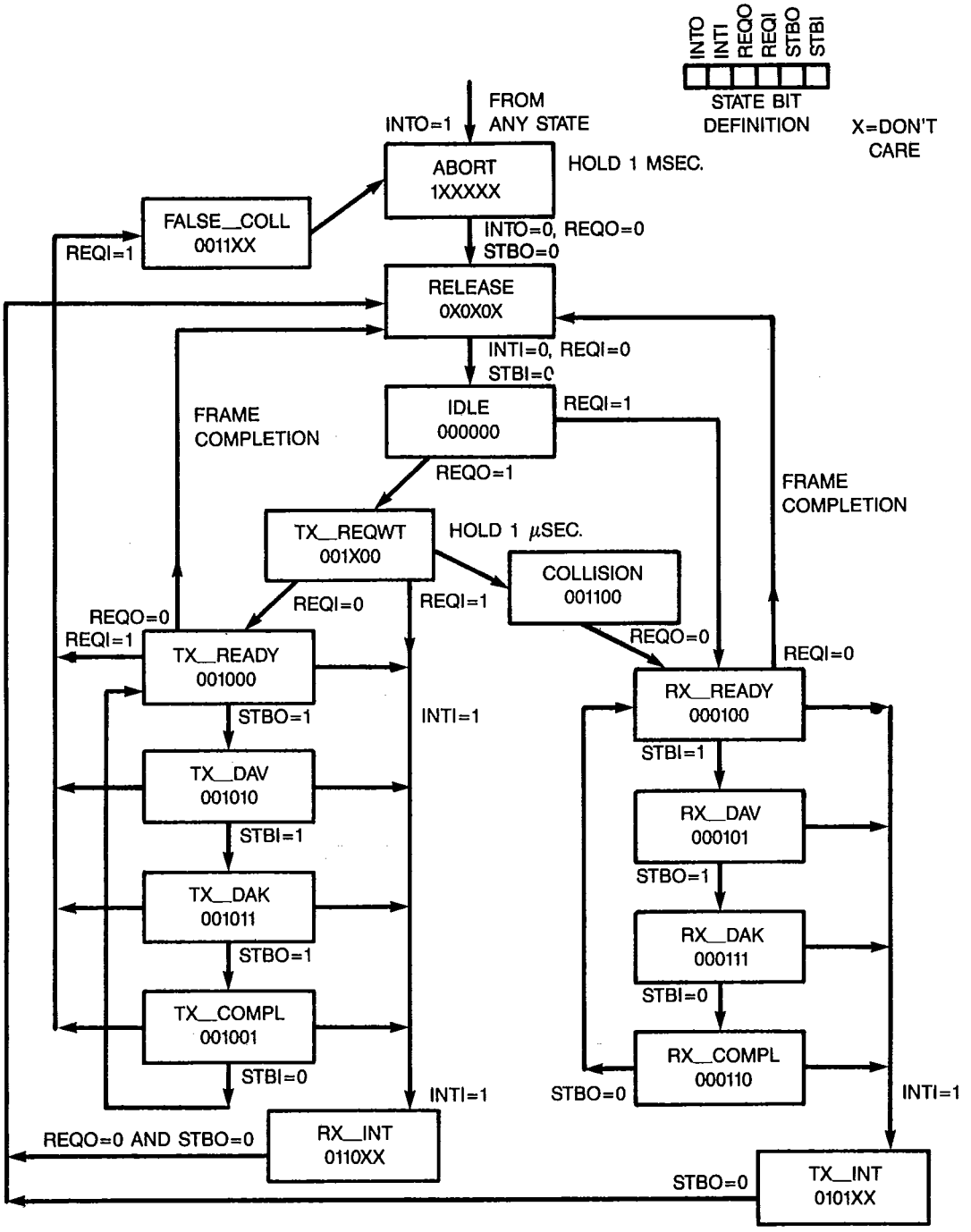

Figure 7-6

PHYSICAL PROTOCOL STATE DIAGRAM

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Table 7-2
ELECTRICAL CONNECTIONS

PIN	FUNCTION	PIN	FUNCTION
1	Signal Gnd	26	Signal Gnd
2	D 0+	27	D 0−
3	D 1+	28	D 1−
4	D 2+	29	D 2−
5	D 3+	30	D 3−
6	D 4+	31	D 4−
7	D 5+	32	D 5−
8	D 6+	33	D 6−
9	D 7+	34	D 7−
10	D 8+	35	D 8−
11	D 9+	36	D 9−
12	D10+	37	D10−
13	D11+	38	D11−
14	D12+	39	D12−
15	D13+	40	D13−
16	D14+	41	D14−
17	D15+	42	D15−
18	PAR+	43	PAR−
19	Reserved	44	Reserved
20	STBO+	45	STBO−
21	STBI+	46	STBI−
22	REQO+	47	REQO−
23	REQI+	48	REQI−
24	INTO+	49	INTO−
25	INTI+	50	INTI−

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Table 7-3
SIGNAL FUNCTIONS AND PROTOCOLS

NAME	FUNCTION
SIGNAL GROUND	Signal return path between the circuit grounds.
D0 to D15	Bi-directional data. D0 will carry the least significant bit of a transferred word.
PAR	Parity. Bi-directional signal which will be asserted if the number of asserted signals in D0 to D15 is even, thus producing odd parity.
STBO	Data Strobe Out. Output signal driven by the equipment interface. When transmitting data, the asserted state will signify that the data lines are stable and the receiver can now accept the data. When receiving data, assertion will signify that the data have been accepted.
STBI	Data Strobe In. A flow control input signal which is connected to the STBO signal from the equipment across the interface as seen in Figure 7-2. When transmitting data, detecting assertion of this signal means the data are accepted. When receiving data, assertion means new data are available.
REQO	Request to Send Out. An asynchronous output signal asserted by the equipment requesting to send data. The requestor must wait the arbitration time of one (1 ± 0.25) microseconds before assuming control. If REQI is asserted at the end of the arbitration wait time, a collision has occurred. REQO must be non-asserted for a collision wait time specified in Section 7.3.2.1.
REQI	Request to Send In. An asynchronous input signal connected to the REQO of the equipment on the other side of the interface. Detecting the assertion of this signal signifies that equipment wants to send data. If detected at the end of the arbitration wait time after asserting REQO, a collision has occurred.
INTO	Interrupt Out. An asynchronous output signal used to abort data transfer. It shall be asserted for one (1) millisecond, then non-asserted. STBO and REQO shall be non-asserted. STBO and REQO shall be non-asserted during INTO assertion.
INTI	Interrupt In. An input signal which is connected to INTO of the equipment on the other side of the interface. Detecting the assertion of this signal signifies the interruption of the data transfer. INTO, REQO, and STBO shall be non-asserted.

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Table 7-4
DESCRIPTION OF PHYSICAL PROTOCOL STATES

STATE NAME	CODE	DEFINITION
IDLE	000000	The IDLE state is the normal quiescent state of no data transfer. PAR and Data signals are in the Released state.
RX__READY	000100	The other equipment is asserting its REQO resulting in REQI being asserted. Prepare to receive data.
RX__DAV	000101	Data are available on the data circuits, as signaled by STBI asserted.
RX__ACK	000111	STBO is asserted to acknowledge receipt of data. The current transfer is complete, and the data shall be changed, if desired.
RX__COMPL	000110	STBI non-asserted. Data are no longer valid. Non-assert STBO to return to RX__READY.
TX__REQWT	001X00	REQO is asserted from IDLE state to request permission to send, but not during collision wait time. Hold for 1 microsecond.
COLLISION	001100	REQO and REQI asserted, resulting in a collision for interface transmission. De-assert REQO, start collision wait timer, enter RX__ READY state.
TX__READY	001000	Interface is ready for transmission of data. Place next word on data circuits.
TX__DAV	001010	Assert STBO to signal data are stable at least 70 nanoseconds after asserting data on D0-D15 and PAR.
TX__DAK	001011	STBI asserted, acknowledging receipt of data.
TX__COMPL	001001	Non-assert STBO to signal data no longer stable. Prepare next word for transmission. Return to TX__READY when STBI is non-asserted.
RX__INT TX__INT	0110XX 0101XX	Device on other side has interrupted the data transfer. De-assert STBO, REQO.
ABORT	10XXXX	Assert INTO to abort data transfer. This shall be done if an undefined or out-of-sequence state is detected which interferes with the specified protocol for data transfer. Hold 1 millisecond.
RELEASE	0X0X0X	INTO, REQO, STBO are de-asserted. Any of INTI, REQI, STBI can be asserted. This state is a transition state to IDLE. The device can assert INTO after 1 second if these circuits remain asserted and are preventing desired activity.
FALSE__COLL	0011XX	FALSE COLLISION—REQI is asserted during TX__cycle. This is an error state.

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Section 8

DATA EXCHANGE PROTOCOL

8.1 INTRODUCTION

The protocols defined in this section provide for transmission of messages across the interface by encapsulating message fragments of manageable size. The protocol layers include Data Link, Transport/Network, and Session Layers.

Required peer-to-peer (horizontal) formats and transactions are specified, leaving the implementation of the interlayer (vertical) communications internal to each device up to each vendor. The specified protocols support the transmission of messages from the Application Layer with virtual connections at the Session Layer and virtual channels at the Transport/Network Layer. These channels may be opened and closed to support connections with specified services. The message is fragmented into blocks of up to 2048 words and combined with channel identification number and block sequence number to make data packets. The packets are delivered to the Data Link Layer where they are framed by a frame descriptor word and frame check sequence. The Data Link Layer also handles interface status and error reporting. The frames are sent to the Physical Layer for transmission across the physical interface.

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Unless otherwise specified in the standard, response timeouts within the protocol layers shall not be less than one second in duration.

NEMA Standard 10-16-1985.

8.2 DATA LINK PROTOCOL

All data sent across the interface is enclosed by a frame descriptor word as the first word in a frame and a frame check sequence as the last word. The frame structure from the standpoint of the protocol in the Data Link Layer is shown in Figure 8-1. The protocol for frame sequencing is shown in Figure 8-3. Flow control and exception handling are specified in 8.6.2 and 8.7.2, respectively.

NEMA Standard 10-16-1985.

The Data Link Layer must allow for interface arbitration after transmission of each frame. Specifically, the Physical Layer must be returned to the release state shown in Figure 7-6.

NEMA Standard 10-16-1985.

8.2.1 Frame Descriptor Word Fields

The frame descriptor word contains a frame type field and a parameter field, as shown in Figure 8-2. The frame type names and parameters are summarized in Table 8-1.

NEMA Standard 10-16-1985.

8.2.1.1 FRAME TYPE FIELD

The frame types and field codes are defined in Table 8-2. All implementations of the interface must support all defined frame types. Data link frames are used to communicate information across the interface. Figure 8-3 contains a data link state diagram showing all allowed frame sequences. The status request and indication frame types are used to communicate interface condition or resolve problems relevant to data link activity. Specifically, if a data transfer is interrupted by the hardware interrupt circuits (INTO, INTI; see 7.4), then the interrupted device shall send a Status Request frame (i.e., asking what went wrong) including its status, and the interrupting device must respond with a Status Indication frame including the status conditions pertinent to the interrupt (i.e., here is the problem). If the interrupting device does not respond to the Status Request frame in an implementation specific timeout, not less than one second, it is assumed to be non-operational.

If an ECHO Request frame arrives, the Data Link Layer will replace the frame type with ECHO Indication, recompute the frame check sequence and send the frame back.

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8.2.1.2 FRAME DESCRIPTOR PARAMETER FIELD

There shall be two forms of the parameter field:

1. Frame word count—used for DATA and Data/ACK frames. The field shall contain the total number of words in the frame expressed as a 12-bit binary number.
2. Status—used for control frames. The field shall contain twelve bits to denote specific error and interface conditions as shown in Figure 8-2 and defined in Table 8-3. Multiple bits shall be asserted, if necessary.

NEMA Standard 10-16-1985.

The physical protocol (see Section 7.3) should specify a wait time of 1 millisecond for the transition from ABORT to RELEASE (to allow the other side to detect the interrupt) and a timeout of 1 second as a general physical layer "inactivity" timeout. These timeouts may be handled in software or hardware, and may be longer than 1 second.

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The physical layer timeout should be reported across the interface via a status bit which is defined in Table 8-3. The number of retries for various activities is not specified since this is implementation-specific. Another status bit is defined for reporting too many retries, however, since it may be useful for upper layer reporting purposes. Status bits are defined to report that a receive buffer is unavailable, and to report that the interface is not being serviced by upper layer software. The action to be taken upon receiving these error and status codes is implementation-specific. See the general outline of exception handling in 8.6.

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All bits in the frame descriptor parameter field not explicitly defined in this standard are reserved for use and definition in future versions of the standard.

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Based on emerging packet technology and determinations of transmission efficiency, it is likely that future versions of this standard should implement the ability to use packets containing a maximum other than 2048 data words. In any such future revision, the ability to implement the current packet size of 2048 words should remain as the default method required of all implementors. Accordingly, the frame descriptor word and additional words may be used to implement this revision.

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8.2.2 Frame Check Sequence

The frame check sequence (FCS) is used to test the validity of the received data. This word will be the one's complement of the truncated binary sum of all the words received in the frame excluding the FCS word itself. This FCS word is what is commonly referred to as the check sum. For a two word status frame, for example, it will be the one's complement of the frame descriptor word.

The combination of the FCS and word parity values allows for correction of single-bit errors in received frames. This standard only requires error detection.

NEMA Standard 10-16-1985.

8.3 TRANSPORT/NETWORK PROTOCOL

8.3.1 Introduction

The purpose of the transport and network protocols is to provide the means for sending messages across the interface. The implementation of these protocols must fragment messages from higher layers into blocks, form packets, and send them via the Data Link Layer, or get packets from the Data Link Layer, reconstruct the messages and deliver them to the higher layer.

The peer-to-peer protocols specified here use numbered packets as the means of supporting the fragmentation and reconstruction of messages. Virtual channels shall allow the possibility of multiple simultaneous messages.

A device which uses this interface to provide connections via an external network will require explicit source and destination addresses. These parameters are provided by the Session Layer (see 8.4) when setting up the channel. This explicit address information must be associated with the virtual channel number and saved to support the virtual channel service. Block sequence numbers are specified as the means for ensuring that blocks within a message can be acccurately reconstructed.

The data packet structure is shown in Figure 8-4. It starts with a packet descriptor word consisting of a channel number, a packet type, and a service class field as indicated in Figure 8-5. The second word is a required data block sequence number containing a last block flag (bit 15) and a 15-bit binary number. The appropriate block (fragment) of message data follows these two words, and has a length of from 0 to 2048 words.

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8.3.2 Packet Descriptor Word

8.3.2.1 CHANNEL NUMBER FIELD

All packets have an 8-bit channel number. Channels must be opened for (bi-directional) data flow across the interface. They are opened by using an Open Channel Request (OCR) packet and acknowledged by the addressed peer with an Open Channel Indication (OCI) packet. Numbered channels remain open as virtual connections to the specified destination until closed with a Close Channel Request (CCR) from either side and a Close Channel Indication (CCI) from the peer. The channel number chosen by a device is an arbitrary 8-bit binary number not currently in use by the peers across the interface.

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8.3.2.2 DEFAULT CHANNEL NUMBERS

All implementations of this interface shall support channel number 0 (zero) for exchanging packets.

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8.3.2.3 PACKET TYPE FIELD

The type field is used to specify packets as Data, Command or Transport Control for ease of transport layer routing. Ten types of packets are specified as listed in Table 8-4. Six Control packets are used to provide request and acknowledgement of transport/network services and functions. The Data type packet carries data on an established channel. The Command type packet carries the message group 0000H command information specified in Section 6, and facilitates appropriate rapid routing of this information to the proper intelligence in the receiving device. Two packet types are provided for transport level flow control. They permit pause and resume requests for data flow on a specific channel. A state diagram showing allowed previous packet type and next packet type sequences is shown in Figure 8-6. It specifies sequences on a single established channel.

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8.3.2.4 SERVICE CLASS FIELD

The service class field is provided to permit the requesting device to select the type of service to be used by the assigned virtual channel. Table 8-5 lists the available service class options. The unassigned bits are reserved for future considerations.Open Channel Request and Reset Channel Request packets must always configure the service class field of the packet descriptor word. Open Channel Indication and Reset Channel Indication packets must confirm the service for the channel by returning the requested service class.

If an Open Channel Request or Reset Channel Request is refused with a Close Channel Request, then the Close Channel Request must specify a service class supported by the destination device.

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8.3.3 Block Sequence Number

This field shall be used to sequence a series of Data or Command packets in a message. Channel Control (Open Channel Request, etc.) packets shall be numbered 0. The block sequence number shall be a 15-bit binary number and shall be incremented by one (1) for each succeeding block (fragment) of the message segment.

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The most significant bit of the block sequence word shall be reserved as a flag bit. It shall be asserted (set) only for the last block of a message segment. The first block of the command segment of a message shall be numbered zero, and the last block shall have the flag bit set. If the command is only one block in length, then only the flag bit shall be set. If the data groups follow the command segment of the message, then the first data block shall again be numbered zero and the last block shall have the flag bit set.

NEMA Standard 10-16-1985.

8.3.4 Establishing Channels

The Open Channel Request and Indication sequence shall be the protocol which provides an initial handshake to establish virtual channels across the interface. It shall also provide the means for passing installation-specific addresses as needed by a system implementation so that virtual channels are associated from end to end to establish connections. This shall be done by including in these packets the Session Layer data as described in 8.4. The channel number used with Open Channel Request packets shall be a number assigned by the originating device and used by subsequent message packets.

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The Reset Channel Request and Reset Channel Indication control packets shall be used to stop transmission or to request a change in channel parameters or both. The channel will remain open to the same destination and can be used for subsequent messages, but the block number counters shall be reset. The reset is not accomplished until the Reset Channel Indication is returned.

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The Close Channel Request shall be used to close a virtual channel after communication is complete or to prematurely terminate a message transfer. It shall also contain the Session Layer Disconnect Request. If a message has been received (including the last block) when a Close Channel Request is received, then the message transfer shall be assumed to be complete. Close Channel Request shall also be used to refuse a requested channel service. The channel is not closed and is not available for subsequent re-opening until the Close Channel Indication is received.

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Devices on both sides of the ACR-NEMA interface could each attempt to close or reset the same channel

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simultaneously. A sender of a Close Channel Request or Reset Channel Request should be prepared to receive either a Close Channel Request or Reset Channel Request on the same channel while awaiting a response.

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If a Reset Channel Request is sent in each direction, both devices should respond and the channel is reset. One or both devices may then receive a Reset Channel Indication on the channel after the reset is effected.

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If a Close Channel Request is sent in each direction, both devices should respond and the channel is closed. One or both devices may then receive a Close Channel Indication on the channel after the close is effected.

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If a Close Channel Request is sent in one direction and a Reset Channel Request is sent in the other direction, the Close Channel Request should be responded to with a Close Channel Indication.

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Likewise, devices on both sides of the ACR-NEMA interface could each attempt to open the same channel number simultaneously. A sender of an Open Channel Request should be prepared to receive an Open Channel Request with the same channel number while awaiting a response. If this occurs, both devices should respond with a Close Channel Request. Both devices may again attempt the Open Channel Request with either the same channel number as before or another channel number.

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8.4 SESSION LAYER PROTOCOL

8.4.1 Introduction

The protocols defined previously provide for access to the physical interface, frame error control and establishment of virtual channels across the defined interface plane. Since a device which uses this interface may be performing multiple tasks, and an external network may be involved, a protocol should be needed to establish end-to-end message connections using virtual channels. This connection function is handled by the partial Session Layer protocol defined in this section. Connection control words and message source and destination field formats to be included in Transport Layer channel control packets are specified. These fields provide instructions for associating the channels opened with the connection.

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8.4.2 Connection Control Word

All transport/network channel control packets (Open, Reset, Close Channel packets as described in 8.3.4) shall contain a connection control word. This word and associated source and destination data shall provide the means for requesting and acknowledging end-to-end Connect and Disconnect service and shall be delivered to the destination Session Layer. Tables 8-6 and 8-7 and Figure 8-7 specify the types and format of the connection control word.

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The connection control word usage should be via transport/network channel control packet types, which are Open, Close, or Reset Channel. A connection may only be made using the the Open Channel Request packet type. A connection may be disconnected using Close Channel Request packet type. The resultant transport/network indication packet type should convey the required connection control word indication response when appropriate. The destination Session Layer should respond to an initiator's connect request control word with a connect indication to complete the connection, or disconnect request to refuse the connection. The Transport/Network Layer protocol should convey this connection control word to the initiator in the appropriate channel control packet type.

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Open, Close and Reset Channel Control packets shall always contain a connection control word. Reset Channel control packets will use the Continue connection control word when the other choices are not required.

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Tables 8-6 and 8-7 describe the connection control word types and their identification codes. Figure 8-7 illustrates the source and destination address pair assignments established for a particular connection. Section 9 further illustrates the flow control requirement.

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8.4.3 Destination/Source Fields

Control packets which contain Connect Request and Connect Indication words shall contain source and destination data in the format specified in Figure 8-7. The format of the source and destination fields shall be as follows. The eight words (16 bytes) following the Connect Request Word will contain the logical name of the connection destination (receiver). The next eight (8) words will contain the installation-specific destination network physical address field. The next eight (8) words will contain the

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logical name of the connection destination (receiver). The next eight (8) words will contain the installation-specific destination network physical address field. The next eight (8) words will contain the logical name of the source (sender or initiator) and the next eight (8) words will contain the source physical network address field.

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It is recommended that the logical addresses used in these fields be the same as those used at the application layer.

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The specific physical address can be installed into imaging equipment at the installation and can be an arbitrary string of bytes which is used by the network. Any piece of imaging equipment may insert installation-specific default numbers for these addresses if there is a network which interprets the default numbers or names.

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This data may be maintained in a table in the equipment which can be configured by an engineer at the installation site. The table may contain two fields for each installation destination, including its own. The first field could contain the user-understood logical names of destination equipment, such as "CT107". The associated second field could contain an external-network-understood destination name, such as "17" corresponding to node 17. This table would allow for logical names of up to 16 ASCII characters, and physical destination identifiers of up to 16 bytes.

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As another example, these fields might contain "AR59" as the logical destination name, and "0" as the physical destination field. In this case it is assumed that the external network should perform the translation from logical destination name to physical destination field. Entries in both fields may be the same, and more than one logical name may have the same destination identifier.

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If default destination fields are used, the logical destination should contain 16 bytes of ASCII space (20H), and the network destination should contain 16 null bytes (0H). Examples of fields and message are shown in Section 9.2.

Authorized Engineering Information 10-16-1985.

8.4.4 Channel 0

Channel 0 is a reserved channel in the Transport/Network Layer function that is dedicated to providing a connection for handling ACR-NEMA messages between two end-to-end application processes in order to avoid the need for a full multi-channel service (see 9.4). Channel 0 and the connection it serves would presumably be established whenever the system is initialized or whenever the two end-to-end processes come on line.

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8.4.5 Additional Services of Session Protocol

There are anticipated to be three classes of equipment which would use this interface: primary imaging equipment, dedicated imaging equipment and network interface units. Each would need to handle data differently as it moves to and from the Transport/Network Layer.

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8.4.5.1 Primary Imaging Equipment

Primary imaging equipment will need Session Layer through Application Layer software to originate and receive a variety of messages and commands. Primary imaging equipment must compose messages, choose destinations, and deliver this information in the specified format and structure to the sending Transport/Network Layer. The format of messages including command (group 0000H) and data segments is described in Sections 4 and 6. In addition to supporting the message structure, the Session Layer must monitor connections, open channels, and provide for handling of exceptions (see 8.6). The Session Layer and application services must also determine the disposition of received messages and compose command responses. Also, either these services or the Transport/Network Layer must be responsible for sequencing the blocks. The packet block sequence number provides the means; the implementation is not specified.

NEMA Standard 10-16-1985.

8.4.5.2 Dedicated Imaging Equipment

Equipment in this class (for example, printers or digitizers, etc.) can originate or receive (or both) image data and perform specific operations on that data. Data receivers will need specialized Session Layer services to route data arriving on the default channel 0 to the dedicated application. It must recognize Open Channel

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but can refuse them with a Close Channel Request. The Session Layer of data generating equipment will make a connection (it can use the default destination). SEND or other commands and the necessary message groups will be sent on the channel. If this type of equipment is installed in a system which has an external network, then the network interface unit connected to it will need to be supplied with the destination to be used as the default destination for routing the message.

NEMA Standard 10-16-1985.

8.4.5.3 NETWORK INTERFACE UNITS

This class of equipment connects to an imaging device and has a primary function of interfacing such equipment to an external network or data path. It shall not be necessary for this device to provide Session Layer to Application Layer services, since it provides a translation and relay service. This device must support the interface protocols specified for the Physical to Transport/Network Layer, including the flow control packets and the channel control packets. It (or a central server) must also interpret the connection control data and the destination address enclosed, pass it to the destination, and keep the association of channel number and destination until the channel is closed. The interface equipment and external network must provide apparent virtual channel service across the interface, connection service to the destination, and be "transparent" to the end-to-end message delivery and response. If the NIU supports an imaging device that uses default destinations, then it must be able to accept the default identification and the corresponding network address to use in making connections.

NEMA Standard 10-16-1985.

8.5 FLOW CONTROL

This section summarizes the flow control provided at the various protocol levels and its interaction with exception handling protocols.

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8.5.1 Physical Layer

The primary flow control mechanism at the Physical Layer for interface access and word transfer is the interlocked handshake cycle of STBO and STBI.

NEMA Standard 10-16-1985.

8.5.2 Data Link Layer

This protocol layer can exert flow control on data sent in (the default) Data/ACK frames. When a Data/ACK frame is sent, the receipt of an Acknowledge or Not Acknowledge frame is always the expected response. There should be no timeout interval for the receipt of these response frames. Therefore, the sending of another frame may be controlled by the receiver by delaying the response frame. The receipt of an Acknowledge or Not Acknowledge frame should be the signal that the other side is prepared to accept another frame.

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Both devices must be able to receive the two-word Status Request, Status Indication, Acknowledge, and Not Acknowledge frames at all times. DATA, Data/ACK and ECHO Request frames can also arrive at any time (except as noted above for Data/ACK). These shall only be refused by interrupting at the Physical Layer.

NEMA Standard 10-16-1985.

If a sender waiting for an Acknowledge frame has reached an (internal-specific) timeout and needs to determine status (flow control is being exerted, the frame was lost or the interface is dead), it can inquire by sending a Status Request frame.

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Flow control for DATA frames can be accomplished as follows. The receiver can interrupt the sender. The sender may then request status. The receiver may respond with status indicating a buffer full condition. To resume transmission the receiver should send a status request indicating normal condition. If the interrupt occurs during transmission of a DATA frame, that frame should be retransmitted upon resuming data flow as specified in 8.6.2.

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8.5.3 Transport/Network Layer

Flow control shall be maintained by the receiver by sending a Pause Request packet to request the sender to stop sending packets, and a Resume Request packet to request that packets be sent again. A sender which "gets tired of waiting" shall prematurely terminate the message transmission by sending a Close Channel Request.

NEMA Standard 10-16-1985.

8.5.4 Session Layer and Message Level

When an Open, Reset, or Close Request packet is sent, the receipt of the appropriate acknowledgment is expected. No subsequent packets should be sent until the expected indication packet is received. There is no specified timeout interval for the receipt of a response. Therefore, the sending of messages may be delayed by the other side by withholding these expected packets.

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The Connect Indication for a Connect Request can also be delayed for flow control at the Session Layer. If the originator "times out", it shall initiate a Disconnect Request within a Close Channel Request Packet.

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Message level flow control is provided by using the group 0000H command responses described in Section 6.

NEMA Standard 10-16-1985.

8.6 EXCEPTION HANDLING

This section summarizes the protocols to be used when error conditions occur. The implementation of error reporting between layers is not specified, but the function should be required.

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8.6.1 Physical Layer

The primary protocol for stopping data flow is the INTO interrupt signal of the interface hardware. This layer will initiate the interrupt if the physical state sequence protocol is violated. This action will be reported to the Data Link Layer (unspecified data link error) for inclusion in the status field. The protocol specifies that the interrupted equipment will send a (data link) Status Request frame. The Physical Layer can also be instructed by upper layers to create an interrupt. When an interrupt is received (INTI asserted), it will be reported to the Data Link Layer for resolution.

NEMA Standard 10-16-1985.

8.6.2 Data Link Layer

This layer must handle data errors as determined by the parity and frame check sequence fields. The Not Acknowledge frame reports these errors and elicits a retransmission. A Status Request frame can be received if the sender retry count has been exceeded. This layer also enforces the specified frame sequence protocol (Figure 8-3). If a frame type is received which cannot be interpreted, the receiver will send a Status Request frame so indicating. If an Acknowledge frame was expected, the returned Status Indication will contain the needed previous frame error status. Problems at this layer and those reported from other layers will be exchanged across the interface via Status Request and Status Indication frames, and will be reported to higher layers if not resolved.

If an interrupt occurs (via INTO or INTI) during the transfer of a frame, the receiver will discard the frame fragment and the sender is expected to resend the total frame. The retransmission will occur after resolution of the interrupt condition.

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8.6.3 Transport/Network Layer

This layer controls the virtual channel via the control packets. Unresolved errors in packet sequences and problems reported from lower layers are handled at this layer by sending a Reset Channel Request or Close Channel Request if appropriate, and reporting the problems and actions to higher layers. The extent of authority given to this layer is implementation specific. Upper layers will also instruct that actions be initiated at this or lower layers.

NEMA Standard 10-16-1985.

8.6.4 Session Layer and Message Level

The Session Layer can abort a non-reconstructable or an uninterpretable message by sending a Disconnect Request via a Close or Reset Channel Request. If a connection or channel is closed before the last block of a message was received or sent, the sender shall assume that no portion of the message was received.

Problems reported from lower layers need to be interpreted at the message level to determine their effect on message transfer. The command responses (group 0000H) provide means for reporting errors at this level. Final resolution of errors reported from the lower layers must be made here, possibly with operator assistance.

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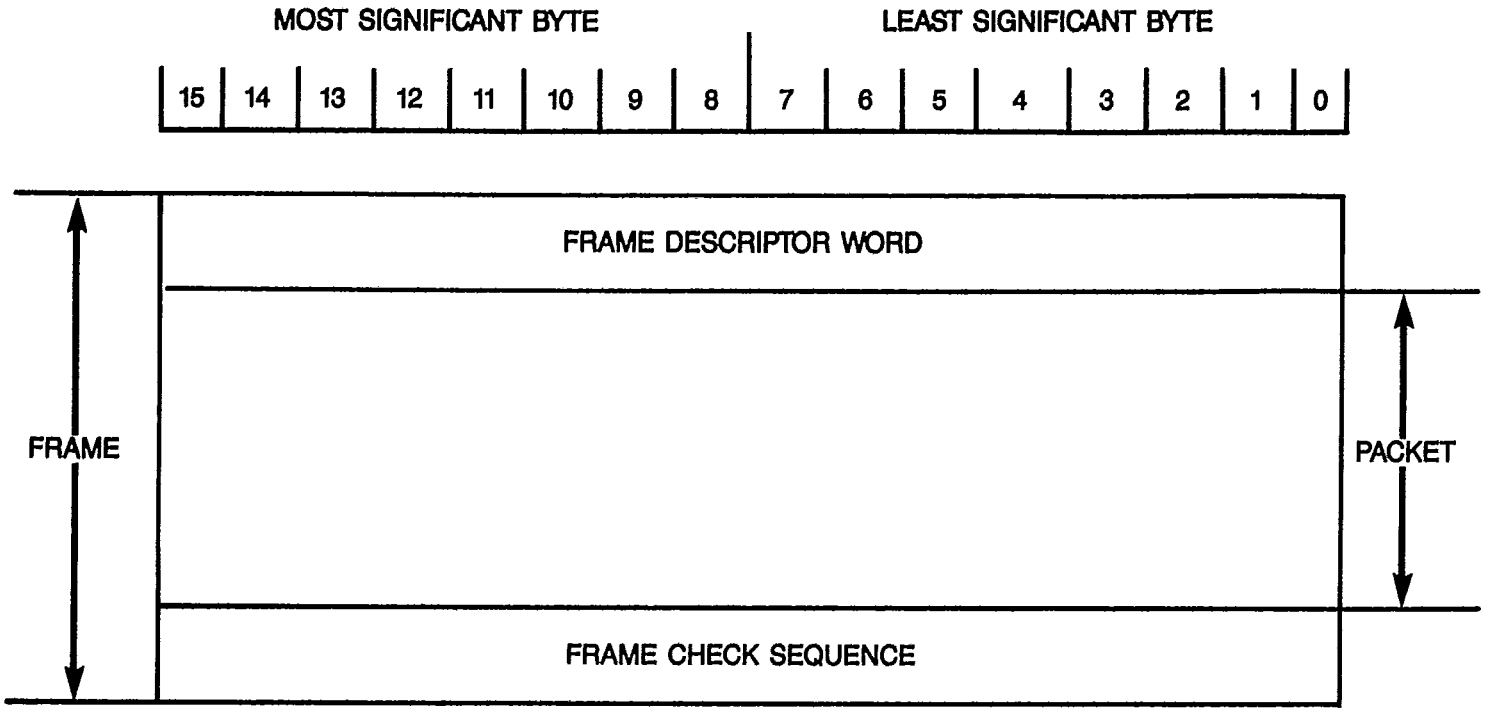

Figure 8-1
FRAME STRUCTURE

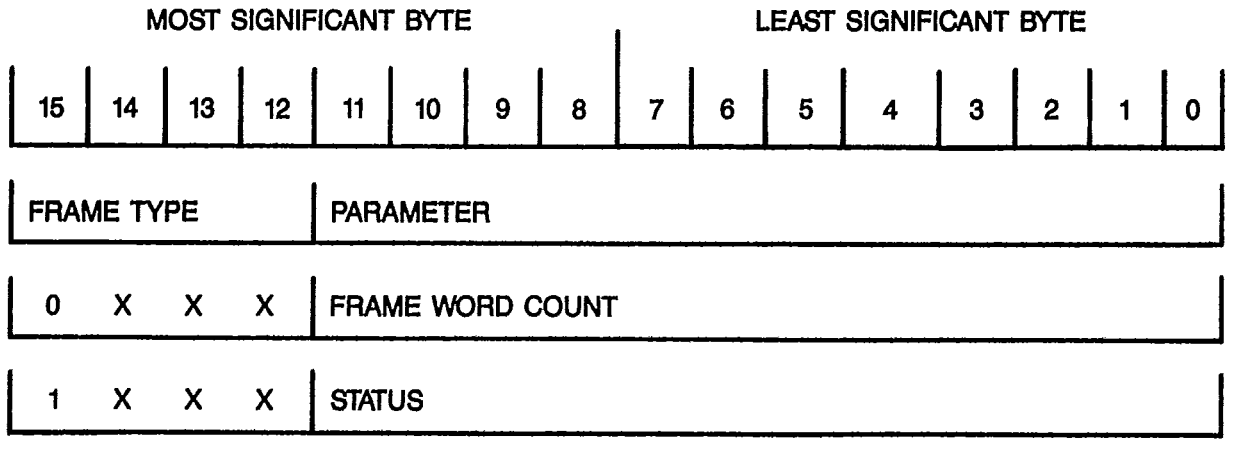

Figure 8-2
FRAME DESCRIPTOR WORD

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FRAME SEQUENCES UNDER NORMAL CONDITIONS

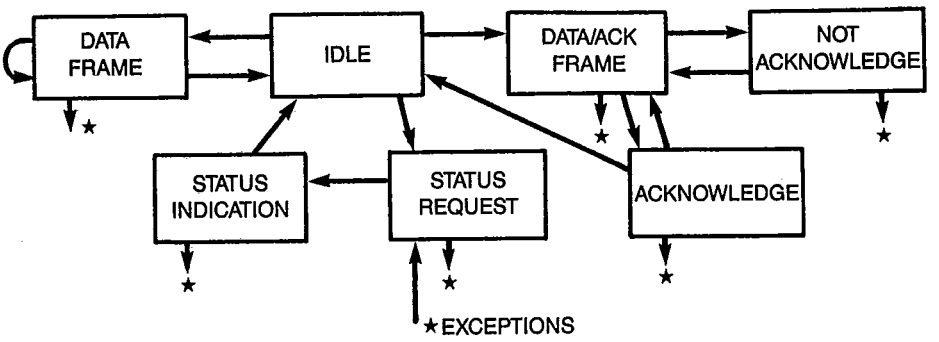

DIAGRAM OF ALLOWED STATE SEQUENCES

PREVIOUS FRAME \ NEXT FRAME	DATA	DATA/ACK	ACK	N.ACK	STATUS REQ	STATUS IND	IDLE	ECHO REQ	ECHO IND
DATA	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	
DATA/ACK			ACK	N. ACK	STATUS REQ				
ACK	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	
N. ACK	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	
STATUS REQ					STATUS REQ	STATUS IND	IDLE		
STATUS IND	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	
IDLE	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	
ECHO REQ					STATUS REQ				ECHO IND
ECHO IND	DATA	DATA/ACK			STATUS REQ		IDLE	ECHO REQ	

Figure 8-3
PHYSICAL PROTOCOL STATE DIAGRAMS

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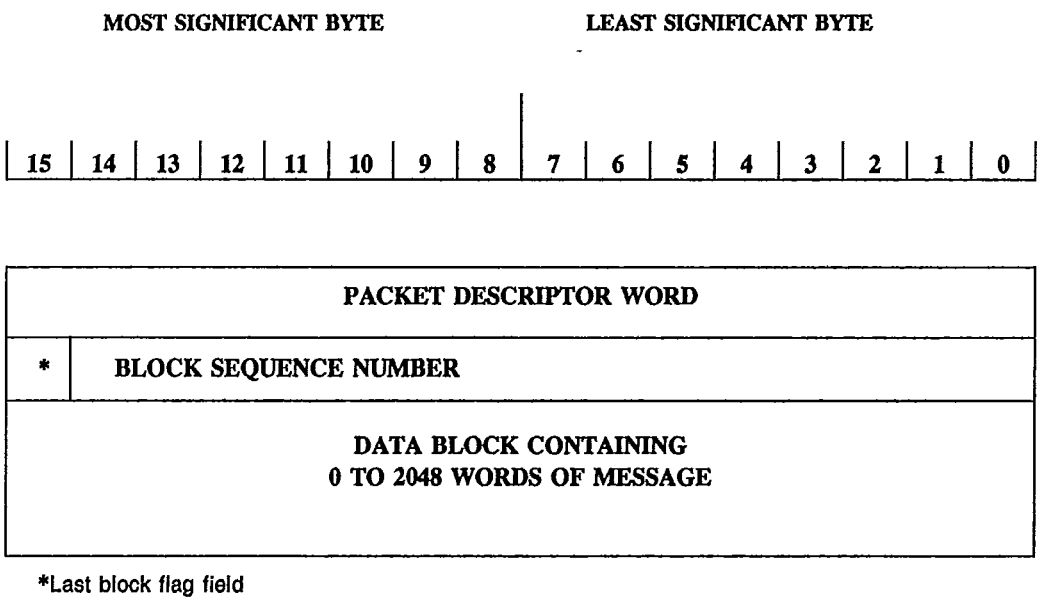

Figure 8-4
DATA PACKET STRUCTURE

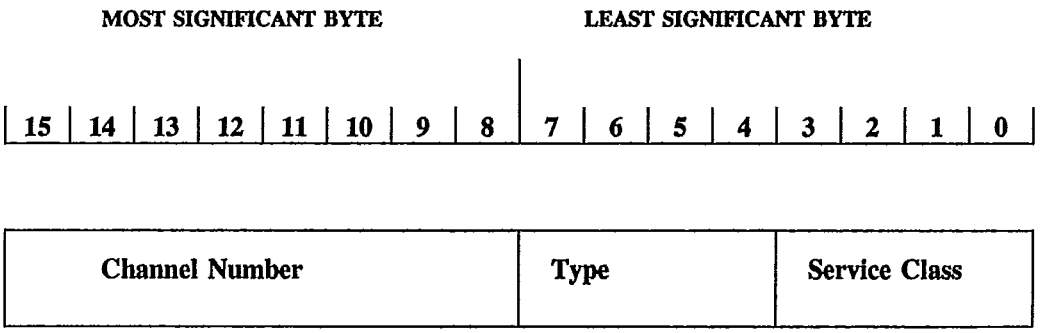

Figure 8-5
PACKET DESCRIPTOR WORD FIELDS

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NEXT PACKET SENT ON CHANNEL *

PREVIOUS FRAME	RCR	RCI	CCR	CCI	OCR	OCI	CMD	DATA	PAUSE	RESUME
RCR		Honor RCR	Refuse RCR							
RCI	Request RCR		Close Channel Request				*Send* CMD Packet	*Send* DATA Packet		
CCR			Refuse CCR	Honor CCR						
CCI			Refuse CCI		Open Channel Request					
OCR			Refuse OCR			Honor OCR				
OCI	Reset Channel Request		Close Channel Request				Send CMD Packet	Send DATA Packet		
CMD	Reset Channel Request		Close Channel Request				Send CMD Packet	Send DATA Packet	Request PAUSE	
DATA	Reset Channel Request		Close Channel Request				Send CMD Packet	Send DATA Packet	Request PAUSE	
PAUSE	Reset Channel Request		Close Channel Request							Request RESUME
RESUME	Reset Channel Request		Close Channel Request				Send CMD Packet	Send DATA Packet	Request PAUSE	

*THIS STATE DIAGRAM REPRESENTS ACTIVITY ON A SINGLE CHANNEL. MULTIPLE CHANNEL ACTIVITY MAY BE INTERLEAVED.

Figure 8-6
STATE DIAGRAM FOR PACKET EXCHANGE

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CONNECTION HEADER
Connection Control Word
Destination Logical Address Word 1
Destination Logical Address Word 2
Destination Logical Address Word 3
Destination Logical Address Word 4
Destination Logical Address Word 5
Destination Logical Address Word 6
Destination Logical Address Word 7
Destination Logical Address Word 8
Destination Network Address Word 1
Destination Network Address Word 2
Destination Network Address Word 3
Destination Network Address Word 4
Destination Network Address Word 5
Destination Network Address Word 6
Destination Network Address Word 7
Destination Network Address Word 8
Source Logical Address Word 1
Source Logical Address Word 2
Source Logical Address Word 3
Source Logical Address Word 4
Source Logical Addres Word 5
Source Logical Address Word 6
Source Logical Address Word 7
Source Logical Address Word 8
Source Network Address Word 1
Source Network Address Word 2
Source Network Address Word 3
Source Network Address Word 4
Source Network Address Word 5
Source Network Address Word 6
Source Network Address Word 7
Source Network Address Word 8

Figure 8-7
CONNECTION CONTROL PACKET FORMAT

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Table 8-1
FRAME DESCRIPTOR WORD SUMMARY

FRAME TYPE	CODE	PARAMETER FIELD CONTENTS
DATA Frame	0000	Frame Word Count
Data/ACK Frame	0100	Frame Word Count
Acknowledge	1000	Status field
Not-Acknowledge	1001	Status field
Status Request	1101	Status field
Status Indication	1100	Status field
ECHO Request	0011	Frame Word Count
ECHO Indication	0010	Frame Word Count
Reserved	All other codes	

Table 8-2
FRAME TYPES, CODES, AND DEFINITIONS

NAME	CODE	DESCRIPTION
DATA	0000	A frame which shall contain a packet. These frames shall not be acknowledged or not acknowledged. The parameter field must contain the total frame word count.
Data/ACK	0100	A frame which shall contain a packet. The receiving data link must respond with an Acknowledge frame or a Not Acknowledge frame. The parameter field must contain the frame word count.
Acknowledge	1000	A two-word frame which shall be sent to indicate successful receipt of the previous frame. Successful receipt will mean that no parity errors were detected and the frame check sequence computed by the receiving data link is the same as that contained in the received frame. It shall contain the current status as defined in Table 8-3.
Not Acknowledge	1001	A two-word frame which shall be sent to indicate unsuccessful receipt of the previous frame. It shall contain the current status. The previous frame shall be retransmitted unless the sender's retry count has been exceeded, in which case a Status Request frame shall be sent.
Status Request	1101	A two-word frame sent to request a Status Indication frame. It shall contain the current status. The receiving data link must respond with a Status Indication frame.

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Table 8-2
FRAME TYPES, CODES AND DEFINITIONS (Continued)

NAME	CODE	DESCRIPTION
Status Indication	1100	A two-word frame sent in response to a Status Request frame. It shall contain the current status as defined in Table 8-3.
ECHO Request	0011	A frame which may contain a packet. The Parameter field shall contain the total word count. The receiving Data Link will not send an Acknowledge or Not Acknowledge frame, but will return the packet in an ECHO Indication frame.
ECHO Indication	0010	A frame which contains a packet which was received in an ECHO request frame. The parameter field shall contain the total word count.

Table 8-3
FRAME STATUS PARAMETERS

PARTIAL CODE	CONDITION INDICATED
bit 11 0	
X X X X X X X X X X X 1	Parity error
X X X X X X X X X X 1 X	Frame Check Sequence error
X X X X X X X X X 1 X X	Previous frame unrecognized
X X X X X X X X 1 X X X	Frame incomplete
X X X X X X X 1 X X X X	Physical Layer protocol timeout
X X X X X X 1 X X X X X	Data Link retry count exceeded
X X X X X 1 X X X X X X	Acknowledge pending
X X X X 1 X X X X X X X	Unspecified error (at Data Link)
X X X 1 X X X X X X X X	Receive buffer unavailable
X X 1 X X X X X X X X X	No errors, interface available

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Table 8-4
PACKET TYPE CODES AND DEFINITIONS

CODE	NAME AND DESCRIPTION
1110	Reset Channel Request (RCR). This is used to stop a data transfer without closing the channel, to indicate that what follows will be a new message (and reset the block number counter), or to change the service class by sending by new parameters.
1100	Reset Channel Indication (RCI). This acknowledges successful response to Reset Channel Request.
1010	Close Channel Request (CCR). This requests release of a channel with abandonment of any pending data, or refusal to accept an Open Channel Request or other Packet Type.
1000	Close Channel Indication (CCI). This acknowledges the Close Channel Request.
0110	Open Channel Request (OCR). This requests that a virtual channel be established. The service class field specifies the requested service class. Session Layer information containing installation-specific addresses are included in the data field.
1011	Open Channel Indication (OCI). This is the acknowledge response for an Open Channel Request. The parameter field should agree.
0010	Command (CMD).These packets contain message command or message response (group 0) information.
0000	Data (DATA). These packets contain from 0 to 2048 words of message data.
1001	Pause Request (PAUSE). This request can be sent by the receiver to the sender to halt data transmission on the specified channel until a Resume Request is recieved for that channel.
0101	Resume Request (RESUME). This request is sent by the receiver to the sender indicating that message packets on the specified channel can resume again.

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Table 8-5
SERVICE CLASS FIELD PARAMETERS

PARTIAL CODE	SERVICE REQUESTED
bit 3 0	
X X X 1	No data link acknowledgements. Data packets will be sent in DATA frames.
X X X 0	Data link acknowledgements required. Data packets will be sent in Data/ACK frames.
0 0 0 0	Default service class.
Bits 3, 2, 1	Reserved for future use.

Table 8-6
CONNECTION CONTROL WORD

RESERVED	CODE	DESCRIPTION
XXXX XXXX XXXX	0000	Continue
XXXX XXXX XXXX	0110	Connect Request
XXXX XXXX XXXX	1010	Disconnect Request
XXXX XXXX XXXX	0100	Connect Indication
XXXX XXXX XXXX	1000	Disconnect Indication
XXXX XXXX XXXX	0011	Reserved
XXXX XXXX XXXX	0001	Reserved
XXXX XXXX XXXX	0111	Reserved
XXXX XXXX XXXX	1XXX	Reserved

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Table 8-7
CONNECTION CONTROL WORD DEFINITION

CODE	NAME AND DESCRIPTION
0110	Connect Request. This is used to request an end-to-end connection for sending a message to a specified destination. It will be contained in Open or Reset Channel Requests along with the destination and source data as defined in Section 8.4.2.
0100	Connect Indication. This will be the acknowledgement of a Connect Request. It will be contained in an Open or Reset Channel Indication packet or in a DATA packet. The packet will also contain the destination and source data from the Connect Request packet (with source and destination interchanged).
1010	Disconnect Request. This will be used to break a connection. It will be contained in a Reset or Close Channel Request packet. No additional data are needed.
1000	Disconnect Indication. This is the acknowledgement of a Disconnect Request. It will be contained in a Reset or Close Channel Indication packet. Note that it must be sent before or with the CCI packet since the CCI terminates the virtual channels.
0000	Continue. This Connection type is defined to be sent with Channel Control packets when no change in Connection service is needed.

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Section 9

EXAMPLES OF SENDING AND RECEIVING MESSAGES

9.1 INTRODUCTION

The purpose of this section is to describe message flow between two pieces of imaging equipment. Several examples are included to illustrate the different types of data and control flow. Included are:

- sending messages via a network
- receiving messages via a network
- using channel 0 (zero)
- using the DIALOG command

Figure 9-1 shows an interfacing model which is used in describing the different flows. Imaging Equipment-Reference A (IE-A), is connected to a Network Interface Unit-Reference B (NIU-B). NIU-B communicates through a network to NIU-Reference C. NIU-C is connected to IE-Reference D. The end-to-end communication path is IE-A to IE-D.

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9.2 SENDING MESSAGES

This section describes the steps of sending a message from an IE to another IE. It is described from the viewpoint of the IE-A, (see Figure 9-1), sending the message (see Section 4 for message content) to IE-D. One or more messages may be sent to the same destination using the following procedure. Only one message transaction can be active on a specified channel at a time. The following procedure assumes that an active connection is not initially in place between the two IE's.

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9.2.1 Opening a Channel and Establishing a Connection

The Session Layer services in IE-A deliver message segments and instructions to open a channel to a destination (in this case IE-D). A vacant channel number should be selected, along with the connect Request, Open Channel Request, and the Source and Destination logical table information. The frame sent to NIU-B is:

FDW= DATA + Frame Length (37)
PDW= Channel Number + Open Channel Request + DATA
BSN = Last Flag Set + Count (0)
DATA = Connection Control Word = Connection Request
Data + 1 = Destination Logical Address Word 1
Data + 2 = Destination Logical Address Word 2
Data + 3 = Destination Logical Address Word 3
Data + 4 = Destination Logical Address Word 4
Data + 5 = Destination Logical Address Word 5
Data + 6 = Destination Logical Address Word 6
Data + 7 = Destination Logical Address Word 7
Data + 8 = Destination Logical Address Word 8
Data + 9 = Destination Network Address Word 1
Data + 10 = Destination Network Address Word 2
Data + 11 = Destination Network Address Word 3
Data + 12 = Destination Network Address Word 4
Data + 13 = Destination Network Address Word 5
Data + 14 = Destination Network Address Word 6
Data + 15 = Destination Network Address Word 7
Data + 16 = Destination Network Address Word 8
Data + 17 = Source Logical Address Word 1
Data + 18 = Source Logical Address Word 2
Data + 19 = Source Logical Address Word 3
Data + 20 = Source Logical Address Word 4
Data + 21 = Source Logical Address Word 5
Data + 22 = Source Logical Address Word 6
Data + 23 = Source Logical Address Word 7
Data + 24 = Source Logical Address Word 8
Data + 25 = Source Network Address Word 1
Data + 26 = Source Network Address Word 2
Data + 27 = Source Network Address Word 3
Data + 28 = Source Network Address Word 4
Data + 29 = Source Network Address Word 5
Data + 30 = Source Network Address Word 6
Data + 31 = Source Network Address Word 7
Data + 32 = Source Network Address Word 8
FCS

IE-A waits for a Connection Indication and an Open Channel Indication packet. When the indication returns, the virtual channel should be established to NIU-B, and a virtual connection should be established between IE-A and IE-D. The returning packet has the form:

FDW = DATA + Frame length (37)
PDW = Channel Number + Open Channel Indication + DATA
BSN = Last Flag Set + Count (0)
Data = Connection Indication plus 32 destination and source words
FCS

The Open Channel Indication came from NIU-B and the Connection Indication came from IE-D.

If a Close Channel Request is returned, the Open Channel Request has been denied. IE-A responds with a Close Channel Indication.

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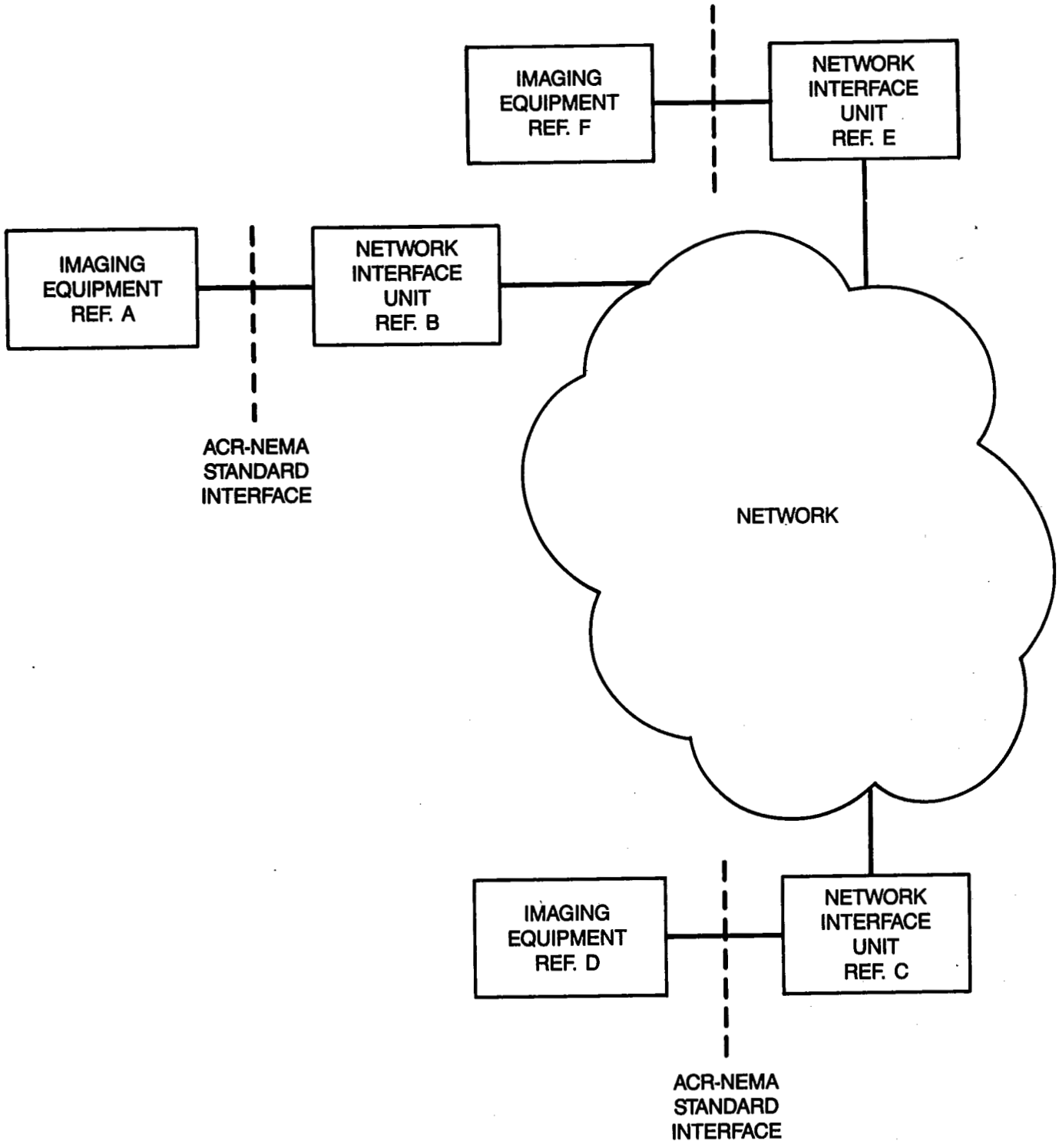

Figure 9-1

INTERFACE MODEL

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If a timeout (implementation specific) occurs while waiting for the indication, IE-A should send a Close Channel Request and wait for the Close Channel Indication. The timeout interval should accomodate the many steps required to establish a "virtual connection" across the network. It may be desirable for the timeout interval to be a parameter which can be set at the installation.

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9.2.2 Sending Command Packets

IE-A sends the group 0000H segment of the message as a Command packet of 2048 words or less. Depending on the message command type, the entire message may be sent in the Command packets (see the description of the commands in Section 6). An ACK packet is sent from NIU-B if it receives the correct Command packet. The Command packet sent from IE-A should be as follows:

FDW = Data/ACK + Frame length (4 + n)
PDW = Channel Number + CMD + Data/ACK Service
BSN = Last Flag Set + Count (0)
Data = Group 0000H part of message (length = n)
FCS

The ACK packet from NIU-B should be as follows:

FDW = Acknowledge + Interface is Idle and Available + No Error
FCS = FDW (one's complement)

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9.2.3 Sending Data Packets

IE-A sends the rest of the message data segments in 2048 word (or less) blocks contained in Data packets. IE-A should be ready to receive control packets (especially Pause and Resume packets) or Command and Data packets as described in 9.3. The Data frame should have the form:

FDW = Data/ACK + Frame length (4 + n)
PDW = Channel Number + Data + Data/ACK
BSN = Last Flag Set + Count (0)
Data = Group 0008 + ...part of message (length = n)
FCS

The ACK packets are sent from NIU-B, as described in 9.2.2.

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9.2.4 Message Response

After the entire message has been sent, the application software should wait for the message response from the destination indicating success or failure. The destination (IE-D) may choose to return the response on the open connection, or it may choose to close the connection after receiving the message and open another connection at a later time to send the message response. The Session Layer protocol should be able to handle this delayed response. The Session Layer software in IE-A may close the connection or send another message. If closing, it should proceed as described in 9.2.5.

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9.2.5 Closing a Channel and Dissolving a Connection

IE-A sends a Disconnect Request in a Close Channel Request packet. The packet format should be as follows:

FDW = DATA + Frame length (5)
PDW = Channel Number + Close Channel Request + DATA Service
BSN = Last Flag Set + Count (0)
Data = Disconnect Request
FCS

NIU-B responds with a Close Channel Indication and IE-D should respond with a Disconnect Indication forming the following packet:

FDW = DATA + Frame length (5)
PDW = Channel Number + Close Channel Indication + DATA
BSN = Last Flag Set + Count (0)
Data = Disconnect Indication
FCS

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9.3 RECEIVING MESSAGES

The protocol for receiving messages follows that for sending messages (see 9.2). One or more messages may be sequentially received from a source on an established virtual connection for delivery to the Session Layer services. IE-D is receiving a message from IE-A in Figure 9-1. The following procedure assumes that an active connection is not in place between the two IEs.

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9.3.1 Receiving an Open Channel Request and Connect Request

The receiving Session Layer services in IE-D receives a Connect Request, an Open Channel Request, and the source-destination logical table information. If the requested channel or connection request is not supported, a Close Channel Request should be returned containing a Disconnect Request, using the same channel number as in the Open Channel Request.

If the connection is to be supported a Connection Indication and an Open Channel Indication is sent to establish the connection (IE-D to IE-A) and the channel (NIU-C to IE-D). The channel number from the Open Channel Request should be used for all subsequent packets associated with this message.

The packet received may be the same format as the one shown in 9.2.1. The channel number may be different than the one used for communication between IE-A, and NIU-B. The receiving NIU-C should map the incoming message channel numbers to a different channel. This would happen when the channel number selected by IE-A to communicate with NIU-B is already in use between NIU-C and IE-D. Similarly, NIU-C should map the channel numbers back on message replies being sent from IE-D to IE-A.

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9.3.2 Receiving Command Packets

A Command packet is received from the source (IE-A) containing the group 0000H information describing the message content and processing desired. This packet should be delivered to the Session Layer services for interpretation. More than one packet may be required, and the last block of the command should be flagged.

If the command cannot be performed, then the higher layer should compose a message response block with the proper Status code. This message should be sent back (on the same channel) in a Command packet. A Close Channel Request and a Disconnect Request packet is sent to dissolve the connection and channel. A Disconnect Indication and Close Channel Response is received before the channel and connection are disconnected.

If the message's command is accepted, IE-D should prepare to accommodate it. If data follow the command, then the data should be received as a series of Data packets, which should be numbered, with the last packet having the last block flag set. The data is routed to the internal Session Layer. Flow control can be maintained by sending Pause and Resume Packets.

If a condition requires that data flow be aborted, two methods can be used; normal and abrupt. The normal method means the Session Layer should send a Reset Channel Request or a Close Channel Request packet. A Reset Channel Indication or a Close Channel Indication should be received before the channel is reset or closed. The abrupt method means a lower layer (i.e., Transport/Network Layer) should issue the Close Channel Request, and then notify the Session Layer services that a close process is now in motion. Closing a channel also should disconnect the connection.

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9.3.3 Message Response

If a full message has been received, the source (IE-A) should expect a message response packet. The Session Layer composes and delivers the message for sending as a Command packet.

Note that connections open between IEs are bi-directional. The IE should be prepared to receive a message at any time on a connection.

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9.4 SENDING FROM DEDICATED EQUIPMENT USING MINIMUM PROTOCOL

As specified in Section 3, a piece of equipment which sends a message, including those described as dedicated imaging equipment in 8.4.5.2, must support a minimum set of protocols described in the ACR-NEMA Standard. Those include the physical, data link, transport/network and session protocols of Sections 7 and 8, at least one channel (zero), and the SEND command. It must recognize the other commands but need not support them (''unable to respond'' response). All required message groups and elements (types 1 and 2) must be sent, as described in Sections 4 and 10.

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As an example of such a minimum implementation, consider an IE, reference F (IE-F), attached to an NIU, reference E (NIU-E), which can communicate with other NIUs as shown in Figure 9-1. IE-F is a simple image generating device, and the outside network and NIU-E allows the use of default destinations. This implies that NIU-E should be able to substitute the installation-specific default destination for the default destination field in the Connect Request format.

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IE-F should send the following Open Channel Request:

FDW = DATA + Frame Count (37)
PDW = Channel (0) + Open Channel Request + Data/ACK Service (0)
BSN = Last Flag Set + Count (0)
DATA = Connect Request (1)
DATA + 1 – DATA + 8 = Destination Logical Address (Default = blanks)
DATA + 9 – DATA + 16 = Destination Network Address (Default = nulls)
DATA + 17 – DATA + 24 = Source Logical Address (NI)
DATA + 25 – DATA + 32 = Source Network Address (Default = nulls)
FCS

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NIU-E receives this frame, substitutes the network addresses from its installation-specified default values, and sends the Connect Request to that destination, for example "Archive 3" at node 31. That destination accepts the Connect Request and returns a Connect Indication in an Open Channel Indication which NIU-E, node 5, returns to IE-F. This transaction should follow:

FDW = DATA + Frame Count (37)
PDW = Channel (0) + Open Channel Indication + Service (0)
BSN = Last Flag Set + Count (0)
DATA + 1 – DATA +8 = Destination Logical Address (Archive 3)
DATA + 9 – DATA +16 = Destination Network Address (31)
DATA + 17 – DATA + 24 = Source Logical Address (NI)
DATA + 25 – DATA + 32 = Source Network Address
FCS

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IE-F can now send the group 0000H command portion of the message.

FDW = Data/ACK + Frame Count
PDW = Channel (0) + CMD + Service (0)
BSN = Last Flag Set + Count (0)
DATA
Minimum group 0 data elements for SEND command
DATA
FCS

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NIU-E sends an acknowledge frame to IE-F, and then delivers the command to NIU (31) and hence to IE (Archive 3). IE-F sends the remaining groups in successive blocks of 2048 words each with data elements present as may be required. When the last Data packet of the message has been sent and acknowledged, IE-F should wait for a SEND_RESPONSE. After Archive 3 sends this in a Command packet, IE-F should send a Close Channel Request and Disconnect Request. Archive 3 sends the indication:

FDW = DATA + Frame Count (5)
PDW = Channel (0) + Close Channel Indication + Service
BSN = Last Flag Set + Count (0)
DATA = Disconnect Indication (6)
FCS

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The message should now be satisfactorily sent and acknowledged, the connection to the default destination should be disconnected and the channel should be closed.

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9.5 USING THE DIALOG COMMAND

The DIALOG command specified in Section 6 is unique in that it is not the "preface" to a fixed-length one-way message. Since the command requests two-way dialog, the total message length is not known. The protocol specifies that the command request should be sent and should include the DIALOG receiver program or service and a terminal type. The destination equipment (if it can support the request) should establish an internal link between the interface connection (which should already exist between the two devices) and the program specified as DIALOG receiver. The initiator of the request should have a similar link with the operator terminal or an initiating program.

Examples of DIALOG message segment exchanges are shown in Appendix H. All message segments which are exchanged on an established DIALOG link should be sent as Transport/Network Layer CMD packets. Each new segment should be given a block number starting with 0 (zero). If the segment contains more than 4096 bytes the following packets should be numbered in ascending order, with the last block flagged. The size of a message segment should be determined by the software serving the initiator and receiver programs, but the default should be a text line terminator (carriage return-line feed) marking the end of a segment. Such a segment should be sent to the other entity. The entities (or the serving software)

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should be responsible for determining when to initiate a Session Layer Disconnect Request. This should be done when the initiator or receiver program terminates.

The DIALOG_REQUEST command should contain a field to specify the terminal type of the initiator. This information may be made available to the receiver or its serving software. As specified in the command description in 6.2.5, the default is a simple console mode of ASCII text strings with line length of 80 characters and carriage control terminators. Handling of these formats should be a function for the Presentation Layer in the specific equipment.

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Section 10

DESCRIPTION OF DATA ELEMENTS

10.1 INTRODUCTION

This section contains a description of the data elements that shall be used. Table 10-1 is an abbreviated data dictionary. Table 10-2 lists the types of different group 0000H data elements that shall be used according to command type. Tables 10-3 and 10-4 list status codes and an expansion of those codes to describe format and content errors, respectively.

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LEGEND FOR TABLE 10-1

DEFINITIONS FOR MODALITY SYMBOLS

CT Computed Tomography
NM Nuclear Medicine
MR Magnetic Resonance
US Ultrasound
DS Digital Subtraction Angiography
DR Digital Radiography
OT Other

DEFINITIONS FOR VALUE REPRESENTATIONS (VR)

BI 16 bit binary (2's complement, except for pixels which are separately labeled)
BD 32 bit binary, used for group lengths
AN ASCII numeric
AT ASCII text

DEFINITIONS FOR VALUE TYPES (VT)

EV Enumerated value for which a list of appropriate entries are given in the dictionary.
DF Defined format (AN or AT)
FF Free form (AN or AT)
HX Any hexadecimal number (BI or BD)

DEFINITIONS FOR VALUE MULTIPLICITY (VM)

S Single
M Multiple

DEFINITIONS FOR DATA ELEMENT TYPES (See 4.7)

1 Type 1
1D Type 1D
2 Type 2
2D Type 2D
3 Type 3

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Note that when the data type is not listed under the type column, the data type is modality specific and listed under symbols for the modality. If a data element type is modality dependent and not defined for a given modality, it is type 3 for that modality if used.

NOTES:

All group and data element numbers are in Hex.

All dates are given yyyy.mm.dd; for example 1984.11.01 with the decimal points explicitly present.

Unless explicitly stated otherwise, all times are given hh:mm:ss.frac (24-hour time) with the colons and . explicitly present.

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Table 10-1
ABBREVIATED DATA DICTIONARY

GROUP 0000
COMMAND INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	DEFINITION
0000	0000	Group Length	BD	HX	S	1		An even number of bytes from the end of the value field to the beginning of the next group.
0000	0001	Length to End	BD	HX	S	1		An even number of bytes from the end of the value field to the end of the message. For DIALOG = 0
0000	0010	Recognition Code	AT	EV	S	1		ACR-NEMA 1.0
0000	0100	Command Field	BI	EV	S	1		SEND_REQUEST = 0001 SEND_RESPONSE = 8001 GET_REQUEST = 0010 GET_RESPONSE = 8010 FIND_REQUEST = 0020 FIND_RESPONSE = 8020 MOVE_REQUEST = 0021 MOVE_RESPONSE = 8021 ECHO_REQUEST = 0030 ECHO_RESPONSE = 8030 CANCEL_REQUEST= 0FFF CANCEL_RESPONSE= 8FFF DIALOG_REQUEST = 0080 DIALOG_RESPONSE = 8080
0000	0110	Message ID	BI	HX	S	1		Code which differentiates messages generated by a device.
0000	0120	Message ID Being Responded to	BI	HX	S	*		(0000,0110) from command request.
0000	0200	Initiator	AT	FF	S	1		Logical address of sender, assigned by site.
0000	0300	Receiver	AT	FF	S	1D	Installation Specific Address	Logical address of receiver, assigned by site. For messages on channel 0, an installation specific default address.
0000	0400	FIND Location	AT	FF	S	*	Receiver of FIND_REQUEST	Logical address of location, assigned by site.
0000	0600	MOVE	AT	FF	S	*		Logical address being sent to, assigned Destination by site.
0000	0700	Priority	BI	HX	S	1D	Normal	NORMAL = 0000 Other values are implementation specific.

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GROUP 0000
COMMAND INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	DEFINITION
0000	0800	Data Set Type	BI	EV	S	1D	101	Data type of this message. IMAGE = 0 GRAPHICS= 2 TEXT = 3 OTHER = 100 NULL = 101 IDENTIFIER = 102 PRIVATE IMAGE = 8000 PRIVATE GRAPHICS = 8002 PRIVATE TEXT = 8003
0000	0850	Number of Matches	BI	HX	S	*	1	Number of matches found.
0000	0860	Response Sequence Number	BI	HX	S	*	0	Number which is incremented as part of a FIND__ RESPONSE.
0000	0900	Status	BI	EV	S	*		See Tables 10-3 and 10-4.
0000	4000	DIALOG Receiver	AT	FF	S	*	SYSTEM	Name of program connected to.
0000	4010	Terminal Type	AT	FF	S	*	TTY	Initiator's type of terminal, e.g., "VT100".

*See Table 10-2.

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GROUP 0008
IDENTIFYING INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT NM MR DS US DR	DEFINITION
0008	0000	Group Length	BD	HX	S	1			An even number of bytes from the end of the value field to the beginning of the next group.
0008	0001	Length to End	BD	HX	S	1			An even number of bytes from the end of the value field to the end of the data set.
0008	0010	Recognition Code	AT	EV	S	1			ACR-NEMA 1.0
0008	0020	Study Date	AT	DF	S	2			The date of the study. The format is yyyy.mm.dd; e.g., 1984.07.18
0008	0030	Study Time	AT	DF	S	2			The time the study started. The format is hh:mm:ss.frac; e.g., 10:05:03.0001 (24 hour time)
0008	0040	Data Set Type	BI	HX	S	1			The data set type being sought or transmitted. Enumerated values listed in (0000,0800).
0008	0041	Data Set Subtype	AT	FF	S	3			Further description of data set type.
0008	0060	Modality	AT	EV	S	2			Source equipment for the image. Values are CT, NM, MR, DS, DR, US, OT.
0008	0070	Manufacturer	AT	FF	S	2			Manufacturer of the equipment that produced the digital image. In the case of digitized film, the manufacturer of the digitizer.
0008	0080	Institution ID	AT	FF	S	2			Institution at which the digital image originated.
0008	0090	Referring Physician	AT	FF	M	2			Patient's primary referring physician.
0008	1000	Network ID	AT	FF	S	3			Network on which the digital image originated.
0008	1010	Station ID	AT	FF	S	2			Label identifying the machine which generated the digital image.
0008	1030	Procedure Description	AT	FF	S	3			Description of the study, e.g., CPT terminology or code.

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GROUP 0008
IDENTIFYING INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0008	1040	Institutional Department	AT	FF	S	3								For example: radiology, cardiology, nuclear medicine, medical imaging, radiation therapy, etc.
0008	1050	Attending Physician	AT	FF	M	3								Physician administering the examination.
0008	1060	Radiologist	AT	FF	M	3								Radiologist interpreting the examination.
0008	1070	Operator Identification	AT	FF	M	3								Technologist supporting the examination.
0008	1080	Admitting Diagnosis	AT	FF	M	3								Description of admitting diagnosis.
0008	1090	Manufacturer Model	AT	FF	S	3								Model number of imaging device for manufacturers with more than one device in a given modality.
0008	4000	Comments	AT	FF	M	3								

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GROUP 0010
PATIENT INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0010	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
0010	0010	Patient Name	AT	FF	S	2								Patient's legal name.
0010	0020	Patient ID	AT	FF	S	2								Primary hospital identification number or code for the patient.
0010	0030	Patient Birthdate	AT	DF	S	2								Date of birth of the named patient. The format is year. mm.dd. For example: 1984. 11.01
0010	0040	Patient Sex	AT	EV	S	2								Sex of the named patient; M, F, or O for Other.
0010	1000	Other Patient ID's	AT	FF	M	3								Other identification numbers or codes used to identify the patient.
0010	1001	Other Patient Names	AT	FF	M	3								Other names used to identify patient.
0010	1005	Patient's Maiden Name	AT	FF	S	3								Patient's maiden name.
0010	1010	Patient Age	AT	DF	S	3								Patient age given as xxxD, xxxW, xxxM, or xxxY, for day, week, month, or year.
0010	1020	Patient Size	AN	FF	S	3								Patient height or length information in meters.
0010	1030	Patient Weight	AN	FF	S	3								Weight of the patient in kilograms.
0010	1040	Patient Address	AT	FF	S	3								Legal address of the named patient. Carriage return and line feed should be used for clarification.
0010	1050	Insurance Plan ID	AT	FF	M	3								Insurance plan ID numbers and/or names used by the patient.
0010	1060	Patient's Mother's Maiden Name	AT	F	S	3								Maiden name of the patient's mother.
0010	4000	Comments	AT	FF	M	3								

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GROUP 0018
ACQUISITION INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0018	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
0018	0010	Contrast/ Bolus Agent	AT	FF	M	2D	NONE							Contrast or bolus agent; NONE means none used. Multiple entries refer to multiple injections. See (0018, 1040-1044) for optional further descriptions.
0018	0020	Scanning Sequence	AT	FF	M		Not Applicable	2	2	2	2	2D	2D	Description of the type of data taken. For MR—IR, SE, PS, etc.;for CT—dual energy, cardiac gated, etc.
0018	0030	Radionuclide	AT	FF	M				2					Name of isotope administered. See (0018,1070-1075). If multiple isotopes, all elements have values in corresponding order.
0018	0040	Cine Rate	AN	FF	S	2D	Not Applicable							Number of images per second.
0018	0050	Slice Thickness	AN	FF	S			2	2	2		3	3	Nominal slice thickness in mm.
0018	0060	KVP	AN	FF	M			2			3		3	KV output of the x-ray generator used.
0018	0070	Counts Accumulated	AN	FF	S				2					Sum of all gamma events.
0018	0080	Repetition Time	AN	FF	S					2				The period of time in msec between the beginning of a pulse sequence and the beginning of the succeeding (essentially identical) pulse sequence.
0018	0081	Echo Time	AN	FF	S					2				Time in msec between the middle of 90 degree pulse and middle of spin echo production.
0018	0082	Inversion Time	AN	FF	S					2				Time in msec after the middle of inverting RF pulse to middle of 90 degree pulse to detect amount of longitudinal magnetization.
0018	0083	Number of Averages	AN	FF	S					2				Number of times a given pulse sequence is repeated before any parameter is changed.

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GROUP 0018
ACQUISITION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0018	0084	Imaging Frequency	AN	FF	S				2					Precession frequency in MHz of the nucleus being addressed.
0018	0085	Imaged Nucleus	AT	FF	S				2					Nucleus which is resonant at the imaging frequency; e.g. P31, H1.
0018	1000	Device Serial Number	AT	FF	S	3								Serial number of image acquisition equipment supplied by manufacturer.
0018	1010	Film Scanner ID	AT	FF	S	3								ID of machine which created image by digitizing film.
0018	1020	Software Version	AT	FF	S	3								Alphabetic and numeric representation of software which generated the image.
0018	1030	Protocol	AT	FF	S	3								Any identifier specific to the device or user which describes the condition under which the image was acquired.
0018	1040	Contrast/bolus Route	AT	FF	M	3								Administration route of contrast agent.
0018	1041	Contrast/bolus Volume	AN	FF	M	3								Volume of contrast agent in cubic centimeters.
0018	1042	Contrast/bolus Start Time	AT	DF	M	3								Time of start of injection.
0018	1043	Contrast/bolus Stop Time	AT	DF	M	3								Time of end of injection.
0018	1044	Contrast/bolus Total Dose	AN	FF	M	3								Total amount of the active in injection.
0018	1050	Spatial Resolution	AN	FF	M	3								The inherent limiting resolution in mm of the equipment for high contrast objects for the data gathering and reconstruction technique chosen. If variable across the image, use the value at the image center.
0018	1060	Trigger Time	AN	FF	S	3								Time measured in milliseconds from the start of the R-wave to the beginning of data taking.
0018	1070	Radionuclide Route	AT	FF	M	3								Route of injection.
0018	1071	Radionuclide Volume	AN	FF	M	3								Volume of injection in cubic cm.

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GROUP 0018
ACQUISITION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0018	1072	Radionuclide Start Time	AT	DF	M	3								Time of start of injection.
0018	1073	Radionuclide Stop Time	AT	DF	M	3								Time of end of injection.
0018	1074	Radionuclide Total Dose	AN	FF	M	3								Total amount of radionuclide injected.
0018	1100	Reconstruction Diameter	AN	FF	S			3	3	3				Diameter in mm of the region from within which data were used in creating the reconstruction of the image. Data can exist outside this region and portions of the patient can exist outside this region.
0018	1110	Distance Source to Detector	AN	FF	S			3	3		3		3	Distance in mm from source to detector center.
0018	1111	Distance Source to Patient	AN	FF	S			3	3		3			Distance in mm from source to isocenter (center of field of view).
0018	1120	Gantry Tilt	AN	FF	S			3						Angle of tilt in degrees of the scanning gantry as normally given by this device. Angles for use in relating to space are the direction cosines of the image in (0020,0035).
0018	1130	Table Height	AN	FF	S			3						The distance in mm of the top of the patient table to the center of rotation; below the center is positive.
0018	1140	Rotation Direction	AT	EV	S			3						Direction of rotation of the source when relevant. cw or cc, about nearest principal axis of equipment.
0018	1150	Exposure Time	AN	FF	S			3			3		3	Length of time the x-ray tube in in milliseconds.
0018	1151	Exposure Rate	AN	FF	S			3			3		3	Tube current in mA.
0018	1152	Exposure	AN	FF	S			3			3		3	The product of exposure time and exposure rate expressed in mAs.
0018	1160	Filter Type	AT	FF	M			3			3		3	Label for the type of x-ray filter inserted into the beam prepatient.

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GROUP 0018
ACQUISITION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0018	1170	Generator Power	AN	FF	S			3		3	3		3	Power in kW to the x-ray or RF generator.
0018	1180	Collimator/ grid	AT	FF	M			3	3		3		3	Label describing any collimator or grid inserted.
0018	1190	Focal Spot	AN	FF	M			3			3		3	Size of the focal spot in mm for units with variable focal spot or multiple focal spots. Small dimension followed by large dimension.
0018	1200	Date of Last Calibration	AT	DF	M			3		3				Date when the image acquisition device calibration was last changed in any way. Multiple entries can be used for additional calibrations at other times. An example of a calibration is a CT air scan.
0018	1201	Time of Last Calibration	AT	DF	M			3		3				Time when the image device was last changed in any way. Multiple entries can be used.
0018	1210	Convolution Kernel	AT	FF	M			3						A label describing the convolution kernel or special algorithm used to reconstruct the data.
0018	1240	Upper/Lower Pixel Values	AN	FF	M				3					Maximum and minimum gamma counts in any pixel.
0018	1242	Termination Time	AN	DF	S				3					Time in msec at which data gathering terminated.
0018	1243	Count Rate	AN	FF	S				3					Maximum number of counts achieved in any one second interval during the acquisition.
0018	1250	Receiving Coil	AT	FF	S					3				Receiving coil used for image.
0018	1251	Transmitting Coil	AT	FF	S					3				Transmitting coil used for image.
0018	1260	Screen Type	AT	FF	S						3		3	Label of detector screen.
0018	1261	Phosphor Type	AT	FF	S						3		3	Label of type of phosphor on screen.
0018	4000	Comments	AT	FF	M	3								

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GROUP 0020
RELATIONSHIP INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0020	0000	Group Length	BDHX	S	1									An even number of bytes from the end of the value field to the beginning of the next group.
0020	0010	Study	ANFF	S	2									Sequential study number assigned by the imaging device which is used in labeling an image. (See Section 5.2.2).
0020	0011	Series	ANFF	S	2D	1								Part of a study; a set of logically related acquisitions.
0020	0012	Acquisition	ANFF	S	2D	1								A single continuous gathering of data over a period of time.
0020	0013	Image	ANFF	S	2D	1								The number of an image, which is the outcome of an acquisition; more than one image per acquisition is allowed.
0020	0020	Patient Orientation	ATEV	M	2									Patient direction of the first row and column of the images. The first entry is the direction of the rows, given by the direction of the last pixel in the first row from the first pixel in that row. The second entry is the direction of the columns, given by the direction of the last pixel in the first column from the first pixel in that column. L=left, R=right, H=head, F=feet, A=anterior, P=posterior. Up to 3 letters can be used in combination to indicate oblique planes. See Section 5.2.
0020	0030	Image Position	ANFF	M				2	2	2				x,y,z coordinates in mm of the first pixel in the image. See coordinate system definition in Section 5.2.5.
0020	0035	Image Orientation	ANFF	M			1,0,0;0,1,0	2D	2D	2D				Direction cosines of the R axis of the image system with respect to the patient coordinate axes x,y,z, followed by direction cosines of the C axis of the image system with respect to the same axes.

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GROUP 0020
RELATIONSHIP INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0020	0050	Location	AN	FF	S			2	2	2		2		A location reference, standard for the modality (such as CT bed position), used to indicate position. Calculation of position for other purposes is only from (0020,0030) and (0020, 0035).
0020	0060	Laterality	AT	EV	S	2D	Not paired Structure							Laterality of (paired) part examined, e.g., foot. R=right, L=left. See Appendix D.
0020	0070	Image Geometry Type	AT	FF	S	2D	Planar							Used for images which are not Typeplanes, such as an unravel image.
0020	0080	Masking Image	AT	DF	M	2D	Not subtraction image							ID of the image used as a mask for this image. Format is "series \ acquisition \ image".
0020	1000	Series in Study	AN	FF	S	3								The number of series in this study.
0020	1001	Acquisitions in Series	AN	FF	S	3								The number of acquisitions in this series.
0020	1002	Images in Acquisition	AN	FF	S	3								The number of images from this acquisition.
0020	1020	Reference	AT	DF	M			3	3					Reference to a previous image which was used to define where or how this image was made, e.g., a localizer scan. See (0020,0030) and (0020, 0035). See Section 5.2.2.
0020	1040	Position Reference Indicator	AT	FF	S			3						Part of the patient's anatomy used as a reference, such as the iliac crest, orbital-meatal, sternal notch, symphysis pubis, xiphoid, lower coastal margin, external auditory meatus.
0020	1041	Slice Location	AN	FF	S			3						Relative position of exposure expressed in mm from position reference indicator (0020, 1040). It can be signed.
0020	1070	Other Study Numbers	AN	FF	M	3								Other study numbers assigned.
0020 to	3100 31FF	Source Image ID's	AT	DF	M	2D	No Composite							ID's of images which entered the composite. See Section 5.2 for explanation of format.

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GROUP 0020
RELATIONSHIP INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0020	3401	Modifying Device ID	AT	FF	M	2D	Not Composite							ID of device which modified image. See Section 5.2.
0020	3402	Modified Image ID	AT	FF	M	2D	Not Composite							ID of modified image supplied by modifying device.
0020	3403	Modified Image Date	AT	DF	M	2D	Not Composite							Date of image modification.
0020	3404	Modifying Device Manufacturer	AT	FF	M	2D	Not Composite							Manufacturer of device which modified image.
0020	3405	Modified Image Time	AT	DF	M	2D	Not Composite							Time image modified.
0020	3406	Modified Image Description	AT	FF		2D	Not Composite.							Description of image modification.
0020	4000	Comments	AT	FF	M	3								

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GROUP 0028
IMAGE PRESENTATION INFORMATION

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0028	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
0028	0005	Image Dimensions	BI	HX	S	1D	2							Number of dimensions. Greater than two not supported.
0028	0010	Rows	BI	HX	S	1								Number of rows in the image.
0028	0011	Columns	BI	HX	S	1								Number of columns in the image.
0028	0030	Pixel Size	AN	FF	M			2	2	2	3	2	3	The real world spacing of the pixels in the image, specified by a numeric pair—row value (delimiter) column value in mm.
0028	0040	Image Format	AT	EV	S	1D	RECT							Description of image format. Formats other than rectangular not supported.
0028	0050	Manipulated Image	AT	FF	M	2D	Not altered							Pixel data have been altered. Description of algorithm if present. Multiple values can be used to keep a history of the transformations that have been made.
0028	0060	Compression Code	AT	EV	S	1D	NONE							Compression not supported.
0028	0100	Bits Allocated	BI	HX	S	1D	16							Maximum number of bits allocated for any pixel. See Section 5.2.6.
0028	0101	Bits Stored	BI	HX	S	1D	Bits allocated							Number of bits stored for each pixel.
0028	0102	High Bit	BI	HX	S	1D	Number of bits stored—1							Most significant bit for pixel data.
0028	0103	Pixel Representation	BI	EV	S	1D	1							Data representation of the pixels. 1 is 2's complement; 0 is unsigned integer.
0028	0104	Smallest Pixel Value	BI	HX	S	2D	Smallest value allowed by (0028,0101) and (0028,0103)							Smallest valid pixel value. Section 5.2.6.
0028	0105	Largest Pixel Value	BI	HX	S	2D	Largest pixel value allowed by (0028,0101) and (0028,0103)							Largest valid pixel value.
0028	0200	Image Location	BI	DF	S	1D	7FE0							Group containing pixel data. If not 7FE0, must be a private or shadow group.

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GROUP 0028
IMAGE PRESENTATION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0028	1050	Window Center		ANDF	M	3								The level to which a gray scale mapping algorithm might set the window center level. Multiple values indicate that the recommended viewing is more than one window. Applied after transform in (0028, 1052) and (0028, 1053).
0028	1051	Window Width		ANDF	M	3								The value to which a gray scale mapping algorithm can set the window width if no other is specified. Multiple values indicate that the recommended viewing is with more than one window. The corresponding width goes with the corresponding center (0028, 1050).
0028	1052	Rescale Intercept		ANDF	M	3								The number DV to be displayed or used for standardized units (Hounds-field numbers, for example) is linearly related to the stored value SV by DV= m*SV + b. b is specified here and m in (0028, 1053).
0028	1053	Rescale Slope		ANDF	M	3								m in the above equation.
0028	1080	Gray Scale		ATEV	S	3								A gray scale bar is stored as part of the image (Y or N).
0028	1100	Lookup Table Descriptors—Gray	BI	HX	M	2D	No lookup table							The number of entries in the lookup table, followed by the pixel value mapped by the first entry (which is the smallest pixel value being mapped), followed by the number of bits in each entry. See Appendix F.
0028	1101	Lookup Table Descriptors—Red	BI	HX	M	2D	No lookup table							Same as 1100 for red.
0028	1102	Lookup Table Descriptors—Green	BI	HX	M	2D	No lookup table							Same as 1100 for green.

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GROUP 0028
IMAGE PRESENTATION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0028	1103	Lookup Table Descriptors—Blue	BI	HX	M	2D	No lookup table							Same as 1100 for blue.
0028	1200	Lookup Data —Gray	B1	DF	M	2D	No lookup table							Lookup data as described by data element 1100. A value in the table of 0 represents black; a value of all 1s represents white.
0028	1201	Lookup Data —Red	BI	DF	M	2D	No lookup table							Same as for element 1200 for red.
0028	1202	Lookup Data —Green	BI	DF	M	2D	No lookup table							Same as for element 1200 for green.
0028	1203	Lookup Data —Blue	BI	DF	M	2D	No lookup table							Same as for element 1200 for blue.
0028	4000	Comments	AT	FF	M	3								

GROUP 4000
TEXT

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
4000	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
4000	0010	Arbitrary	AT	FF	M	1								Text containing any valid ASCII characters.
4000	4000	Comments	AT	FF	M	3								

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GROUPS 6000-601E (EVEN)
OVERLAY

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
X	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
X	0010	Rows	BI	HX	S	1D	Same as image in Group 0028							Number of rows in overlay.
X	0011	Columns	BI	HX	S	1D	Same as image in Group 0028							Number of columns in overlay.
X	0040	ROI	AT	EV	S	1D	R							G=Graphics, R=ROI.
X	0050	Origin	BI	HX	S	1D	1,1							Location of first overlay point with respect to pixels in the image, given as row and column.
X	0060	Compression Code	AT	EV	S	1D	None							See (0028,0060).
X	0100	Bits Allocated	BI	HX	S	1D	Number of bits allocated for the pixel data in (0028,0100)							Number of bits allocated in the overlay.
X	0102	Bit Position	BI	HX	S	1D	Number of bits stored for the pixel data in (0028,0101)							Bit in which overlay is stored.
X	0110	Overlay Format	AT	EV	S	1D	Same as (0028,0040)							Description of format.
X	0200	Overlay Location	BI	HX	S	1D	This group (X,3000)							Group containing the overlay plane.
X	1100	Overlay Descriptor —Gray	BI	HX	S	2D	0							The number of bits in each entry of (X,1200).
X	1101	Overlay Descriptor —Red	BI	HX	S	2D	0							The number of bits in each entry of (X,1201).
X	1102	Overlay Descriptor —Green	BI	HX	S	2D	0							The number of bits in each entry of (X,1202).
X	1103	Overlay Descriptor —Blue	BI	HX	S	2D	0							The number of bits in each entry of (X,1203).
X	1200	Overlays —Gray	BI	HX	M	2D	No table							Overlay bits equal to 0 and 1. A value of zero in the table represents black. A value of all 1s represents white.

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GROUPS 6000-601E (EVEN)
OVERLAY (continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
X	1201	Overlays —Red	BI	HX	M	2D	No table							
X	1202	Overlays —Green	BI	HX	M	2D	No table							
X	1203	Overlays —Blue	BI	HX	M	2D	No table							
X	1301	ROI Area	AN	FF	S	3								ROI area in pixels.
X	1302	ROI Mean	AN	FF	S	3								ROI mean.
X	1303	ROI Standard Deviation	AN	FF	S	3								ROI standard deviation.
X	3000	Overlay Data	BI	DF	M	1D	Data not in this group							Overlay data.
X	4000	Comments	AT	FF	M	3								

X = number of specific overlay group

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GROUP 7FE0
PIXEL DATA

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
7FE0	0000	Group Length	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
7FE0	0010	Pixel Data	BI	DF	M	1								Data as described in group 28, Row 1, followed by Row 2, etc. Data type given by element (0028,0103), each with the number of bits given in elements (0028,0100) and (0028,0101). Bits not used for pixels can be used for overlay planes described in Groups 6000-601E (even).

Table 10-2
GROUP 0000 DATA ELEMENT TYPES BY COMMAND

COMMAND	DATA ELEMENT							
	Message ID Being Responded to	FIND Location	MOVE Destination Matches	Number of Number	Response Sequence	Status	DIALOG Receiver	Terminal Type
	0120	0400	0600	0850	0860	0900	4000	4010
SEND__RESPONSE	1					1		
GET__RESPONSE	1			2		1		
MOVE__REQUEST			1					
MOVE__RESPONSE	1		1			1		
FIND__RESPONSE	1	1		2	1D	1		
DIALOG__REQUEST							1D	1D
DIALOG__RESPONSE	1					1	1D	1D
ECHO__RESPONSE	1					1		
CANCEL__RESPONSE	1					1		

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Table 10-3
STATUS CODES

NAME	CODE	DESCRIPTION
Success	0000	The command request receiver properly completed the function implied by the command request.
Pending	FF00	The command request receiver will attempt to complete the function implied by the command request.
Cancelled	FE00	A cancel message was received and the receiver is now in a condition equivalent to having never received the cancelled command request.
Refused		The function implied by the command request is not completed because:
	A000	The receiver does not support the command.
	A100	The information requested by a GET, MOVE or FIND is not available at the receiver.
	A200	The information requested by the MOVE is not uniquely specified.
	A300	The data destination of the MOVE is not known to the receiver.
	A400	The receiver does not support image compression.
	A500	No DIALOG receiver is available.
	AFxx	No specified standard reason, i.e., none of the above.
Failed	C000	The command request receiver did not understand the command request because:
	C0bb	It did not have an ACR-NEMA structure.
	C100	It was not completely received (missing segments).
	C2dd	An event in the receiver disrupted the process of receiving the message.
	CFxx	No specified standard reason, i.e., none of the above.

Legend

bb—See Table 10-4
dd—network failures:
  01—line problem
  02—frame problem
  03—packet problem
  04—software problem
  FF—none of the above
xx—Manufacturer specific

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Table 10-4
STATUS CODES FOR FORMAT AND CONTENT ERRORS

NAME	CODE	DESCRIPTION
Missing Last Segment	01	The receiver has ceased waiting for the last segment of a message to be received.
Missing Segment	02	The last segment of a message has been received and an earlier segment of the message is missing.
Duplicate Segment	03	Two copies of one segment of a message have been received and the copies are not identical.
Mixed Message Length	04	Message lengths in command and identifying groups are inconsistent.
Group Length	05	Length of a group points beyond end of message.
Last Group Length	06	Length of last group does not point to end of message.
Element Length	07	Length of an element points beyond end of group.
Last Element Length	08	Length of last element does not point to end of group.
Group Order	09	The number of a group is not higher than the number of the preceding group, if any.
No Zero Element	0A	The first element in a group is not the element numbered zero.
Element Order	0B	The number of an element is not higher than the number of the preceding element of the same group.
Mixed Elements	0C	An element of a group does not have the same group number as the previous element zero has.
Unknown Value	41	The value of an element with enumerated values is not one of the enumerated values. If the command field element of the command group has an unknown value, then the command value in the command response must be the value in the command request plus 8000.
Unaccepted Value	42	The value of an element with enumerated values is one of the enumerated values and the receiver does not support the specific value. Note that an unaccepted value for the command field is reported with the "command not supported" code.
Wrong Representation	43	The value of an element does not adhere to its specified value representation.
Wrong Type	44	The value of an element does not adhere to its specified value type.
Wrong Multiplicity	45	The value of an element doe not adhere to its specified value multiplicity.
Missing Element	46	A required element (type 1 or 2) is missing.
Missing Group	47	A group which is required is missing.
Nonstandard Element	48	A nonstandard element is contained within a standard group.
Wrong Receiver	49	Device receiving is not the device specified in the receiver data element.

Table 10-4 (continued)

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Table 10-4
STATUS CODES FOR FORMAT AND CONTENT ERRORS (continued)

NAME	CODE	DESCRIPTION
Truncated Image	4A	The size of the image element is less than that implied by rows, columns, and bits allocated per pixel.
Overlay Missing	4B	The overlay group has an overlay pointer that references a non-existent element.
Truncated Overlay	4C	The size of an overlay element is less than that implied by the rows and columns.

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Appendix A

MAXIMUM TRANSFER RATE MEASUREMENT

The test circuit shown in Figure A-1 can be used to measure the maximum transfer rate of the ACR-NEMA interface. The circuit should be constructed as close as possible to the connector to minimize cable delays. The minus reference of the +5V. supply used to power the pullup resistors R_1 and R_2 should be connected to the connector ground pins 1 or 26 as shown in Figure A-1. The capacitor C_2 should have good high frequency characteristics.

The test should be performed by instructing the interface to be tested to send frames of 2052 words across the interface. These frames should be sent as Data frames since the incomplete interface cannot supply an acknowledge. It should also be noted that any frame type requiring a response such as Status Request will not receive a response.

The data transfer rate should be computed by measuring the time t_1, as shown in Figure A-2, with an oscilloscope or other suitable measuring instrument at test point TP1, as shown in Figure A-1. Time t_1 should be the time from the output of the first word of the first frame to the first word of the second frame. The number of bytes (4104) should be divided by the time t_1 obtained in the previous step to obtain the maximum transfer rate in bytes/second.

As an example, if the time t_1 measured using the above procedure was determined to be 5.1×10^{-4} seconds the maximum transfer rate would be computed as:

$$\text{TRANSFER RATE} = \frac{4104 \text{ BYTES}}{5.1 \times 10^{-4} \text{ SEC}} = 8.039 \times 10^{6} \frac{\text{BYTES}}{\text{SEC}}$$

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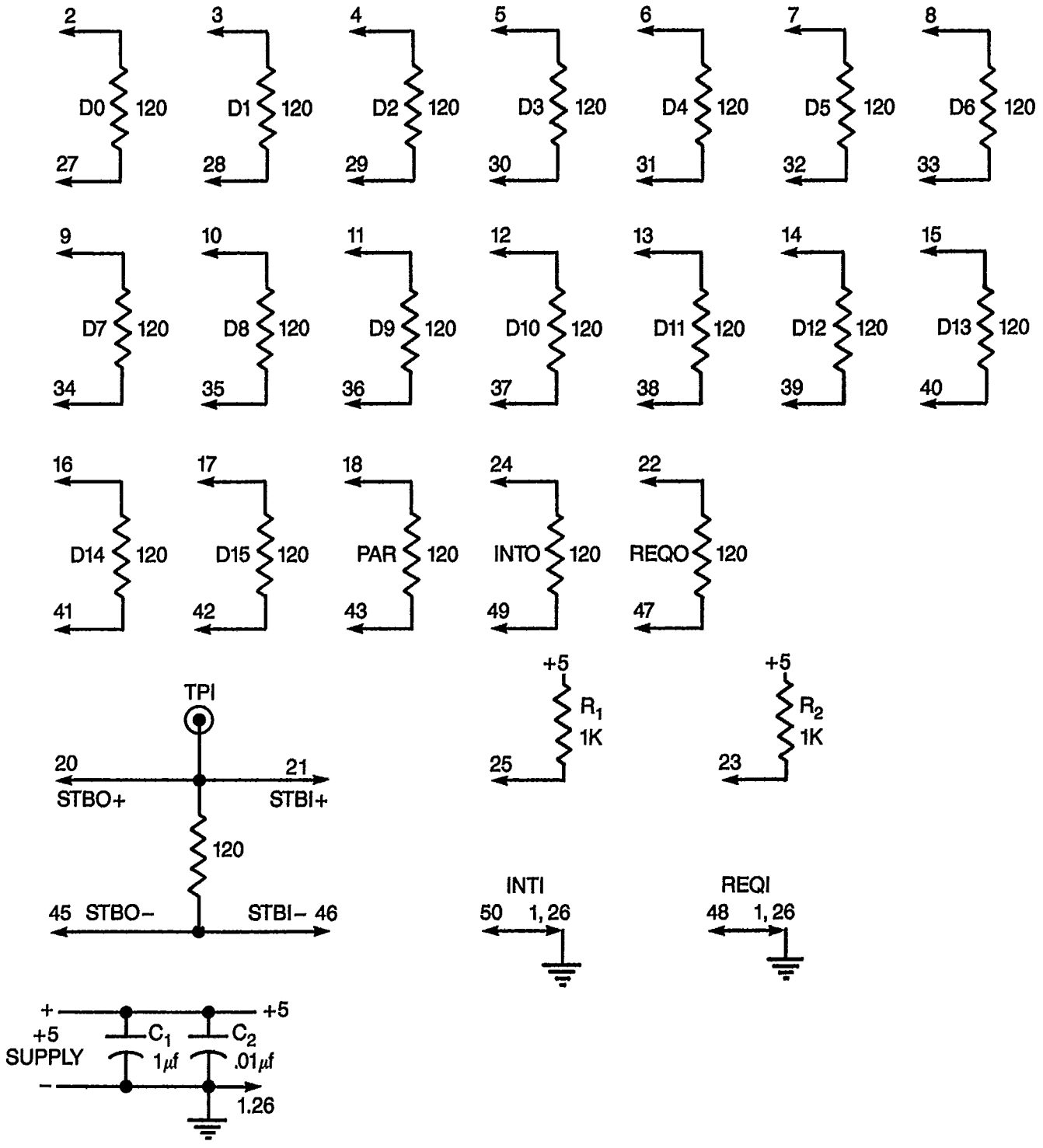

Figure A-1
TEST CIRCUIT

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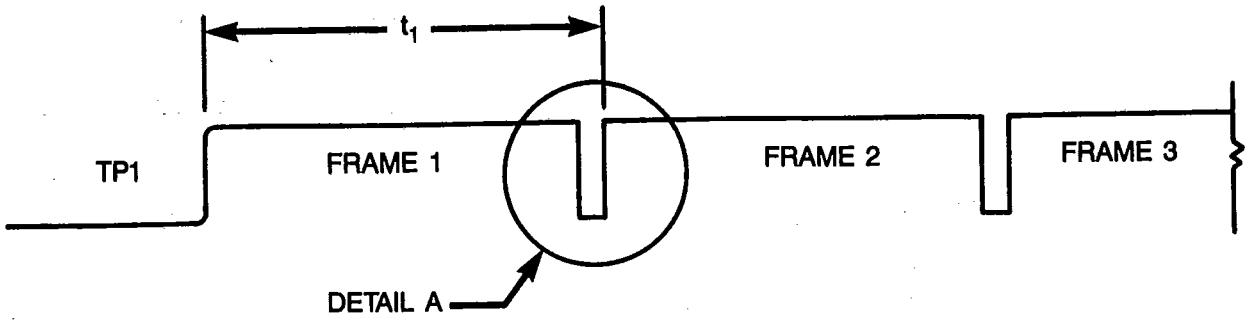

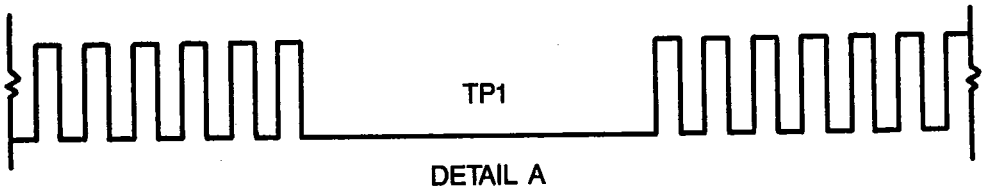

Figure A-2

TRANSFER TIME MEASUREMENT

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Appendix B

EXAMPLES OF TYPICAL MESSAGES

A typical message containing a SEND_REQUEST follows. Words are shown from left to right in the order transmitted.

MESSAGE STRUCTURE
SEND_REQUEST

GROUP	ELEMENT	LENGTH	VALUE	MEANING	DESCRIPTION
0000	0000	0004 0000	0044 0000		Even number of bytes from the end of this field to the beginning of the next group
0000	0001	0004 0000	0190 0010		Even number of bytes from the end of this field to the end of the message
0000	0100	0002 0000	0001	"0001"	Command field = SEND_REQUEST
0000	0110	0004 0000	3231 4133	"123A"	Device generated message ID
0000	0200	0004 0000	4344 3148	"DCH1"	Logical address of sender
0000	0300	0004 0000	4341 3148	"ACH1"	Logical address of receiver
0000	0800	0002 0000	0000	"0000"	Data type = image
0008	0000	0004 0000	0084 0000		Group length
0008	0001	0004 0000	0140 0010		Message length
0008	0010	000C 0000	4341 2D52 454E 414D 3120 302E	"ACR-NEMA 1.0"	Recognition code
0008	0020	000A 0000	3931 3538 312E 2E31 3532	"1985.11.25"	Study date
0008	0030	0008 0000	3231 303A 3A35 3935	"12:05:59"	Study time
0008	0040	0006 0000	4D49 4741 2045	"Image"	Data set type
0008	0060	0002 0000	5244	"DR"	Modality
0008	0070	0004 0000	4241 4443	"ABCD"	Manufacturer
0008	0080	000E 0000	454D 4352 2059 4F48 5053 5449 4C41	"Mercy Hospital"	Institution ID
0008	0090	0000 0000			Referring physician not known
0010	0000	0004 0000	0042 0000		Group length

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GROUP	ELEMENT	LENGTH	VALUE	MEANING	DESCRIPTION
0010	0010	000E 0000	4F4A 454E 2C53 4A20 4D49 4320 202E	"Jones, Jim C."	Patient name
0010	0020	0080 0000	3031 2D32 3033 2034	"102-304__"	Patient ID
0010	0030	000A 0000	3931 3632 312E 2E31 3532	"1926.11.25"	Patient birthdate
0010	0040	0002 0000	204D	"M"	Patient sex = male
0018	0000	0004 0000	0000 0000		Group length equals zero—no other elements are being transmitted
0020	0000	0004 0000	0016 0000		Group length
0020	0010	0004 0000	3932 3330	"2903"	Study number
0020	0020	0002 0000	2052	"R"	Patient orientation
0028	0000	0004 0000	002C 0000		Group length
0028	0010	0002 0000	0400	"0400"	Number of rows = 1024
0028	0011	0002 0000	0400	"0400"	Number of columns = 1024
0028	0030	0004 0000	332E 2E5C 2033	".3 \ .3__"	Real world size of pixels = .3 × .3 mm
0028	1000	0002 0000	0008	"0008"	Bits allocated per pixel = 8
7FE0	0000	0004 0000	0008 0010		Group length
7FE0	0010	XXXX XXXX 0000 0010	...XXXX XXXX		Pixel data (524,288 words)

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Appendix C

Hierarchical Grouping of Images

The standard provides a hierarchical four-level scheme for identifying related groups of images. A study may be defined as all images obtained by examining a region of a patient at some well-defined time. A study often corresponds to a single examination that is reported as an entity by the radiologist. A study may be composed of related groups of images defined as series. For example, in angiography it is often the case that a rapid sequence of images will be taken to visualize the flow of a bolus of contrast material through vessels in a given part of the patient. Such a "run" of images is a series. This concept can be generalized to describe sequences of images of parallel planes through a patient obtained by CT or ultrasound. In all of these cases, the series requires multiple acquisitions of data; e.g., multiple exposures in angiography, multiple collections of raw data in CT and multiple orientations of the transducer plane in ultrasound. The term acquisition refers to the collection of related physical data from which an image may be produced. In certain situations, more than one image may be produced from a single acquisition. For example, a single set of raw data in CT may be used to reconstruct many images at different magnifications or using different reconstruction kernels. In summary, several images may be produced from a single data acquisition; several acquisitions may be grouped as a temporal or spatial series; and several series may be performed as part of a single study.

The definitions of these terms are not precise. The conventions for their use should be left to the discretion of the vendor or the user. The following examples illustrate some uses of the terminology. In these examples, images are identified by a quadruplet of numbers which represent the study, series, acquisition and image, respectively. For brevity in the examples, ranges of values for any parameter are given as two numbers separated by a hyphen.

Example 1—PA and lateral projections of the chest are obtained with a digital chest unit. The images are labeled as follows:

(257,1,1,1)—PA projection
(257,1,2,1)—Lateral projection

Example 2—A PA projection of the chest is obtained by a dual energy digital chest unit. The images are labeled as follows:

(258,1,1,1)—low energy image
(258,1,1,2)—high energy image
(258,1,1,3)—low Z (soft tissue) image
(258,1,1,4)—high Z (bone) image

In this instance, the assumption is that all four images are produced as a unit; i.e., by a single acquisition.

Example 3—A CT examination of the chest is perfomred on a patient with a lung mass. Ten slices beginning at the apex are performed without difficulty, but then the patient becomes ill. When the patient again feels well, an additional fifteen scans are performed through the remainder of the chest. Finally, the stored raw data from scans 3-8 (before the incident) are used to produce magnified images of the mass.

(259,1,1-10,1)—pre-incident images of the chest
(259,2,1-15,1)—post-incident images
(259,1,3-8,2)—magnified images of the mass

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Here, two series are used to indicate the possible differences in positioning of the patient in the gantry before and after the incident. The magnification images were made from data acquired in the first series. If the mass had been rescanned to produce the magnified images they could have been numbered (259,3,1-6,1).

Example 4—An obstetrical ultrasound examination begins by collecting five longitudinal and ten transverse B-mode scans of the uterus followed by an M-mode image through the fetal head and two of the fetal abdomen to check for intrauterine growth retardation. This device allows the operator to superimpose ellipses on the fetal head and abdomen images and reports diameters, circumferences and areas for those ellipses.

(260,1,1-5,1)—longitudinal B-mode scans
(260,2,1-10,1)—transverse B-mode scans
(260,3,1,1)—M-mode for fetal heart motion
(260,4,1-4,1)—real-time fetal head and abdomen
(260,4,1-4,2)—real-time images with superimposed ellipses and values

A reasonable alternative might have been to record the real-time fetal head and abdomen images as separate series; i.e., (260,4,1-2,1) and (260,5,1-2,1). In that case, the processed images (those with superimposed ellipses) would be rocorded as (260,4,1-2,2) and (260,5,1-2,1).

Example 5—A volume-imaging study of a patient's head is performed by a magnetic resonance imaging device. The data are used to produce 15 transverse, 15 coronal, and 15 sagittal sections through the brain.

(261,1,1,1-15)—transverse images
(261,1,1,16-30)—coronal images
(261,1,1,31-45)—sagittal images

It is tempting to record these as three series of images. However, because of the hierarchical meaning of the nomenclature, using the sequence (261,2,1,1-15) to denote the coronal images would imply a second acquisition of data and would therefore be inappropriate.

Example 6—An intravenous carotid angiogram is performed by acquiring thirty images of the neck following injection of contrast. A "mask" image created by averaging the first three images is subtracted from images 25 through 30.

(262,1,1-30,1)—original images
(262,1,25-30,2)—subtraction images

The subtraction image headers will reflect the composition of the mask. A second injection with the patient in a different position might be recorded as a second series. Similarly, a second set of projections acquired simultaneously with the first (e.g., biplane technique) should also be recorded as a second series.

Note that a hospital may have established a system to allocate a single study number to several exams of one patient. This is acceptable provided that unique series, acquisition and image numbers were also assigned.

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Appendix D

EXPLANATION OF PATIENT ORIENTATION

The figures in this appendix provide an explanation of how to use the patient orientation data elements.

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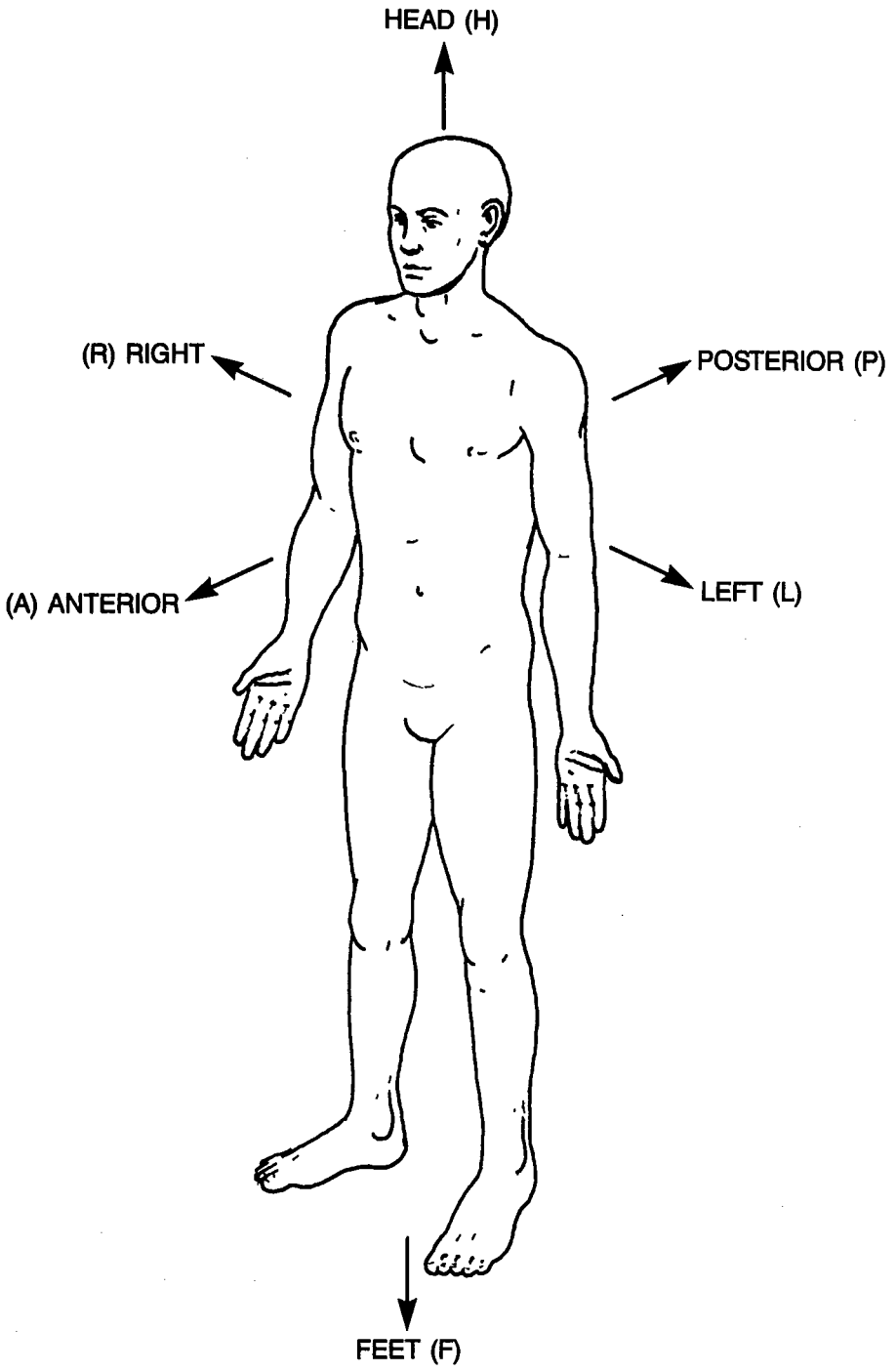

The standard anatomic position is standing erect with the palms facing anterior. This position is used to define a label for the direction of the fingers and toes (toward the FEET (F)) while the direction of the wrist and ankle is towards the HEAD (H). This labeling is retained despite changes in the position of the extremities. For bilaterally symmetric body parts, a laterality indicator (R or L) should be used.

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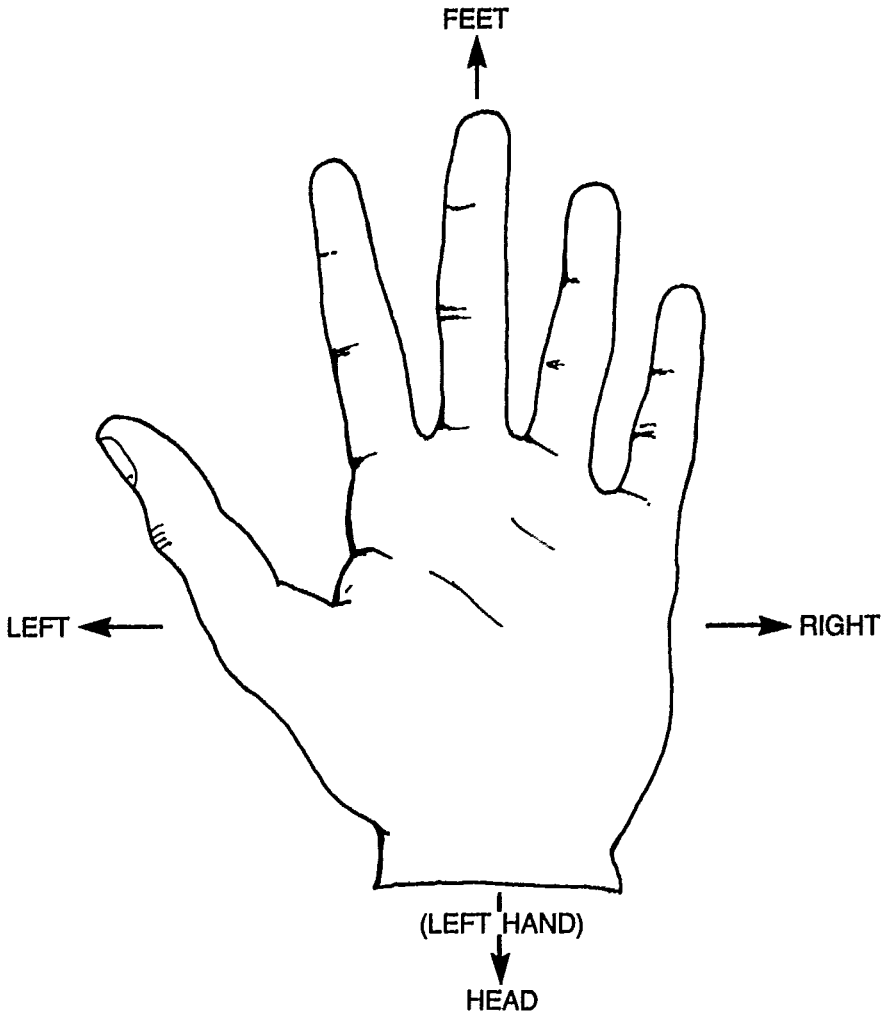

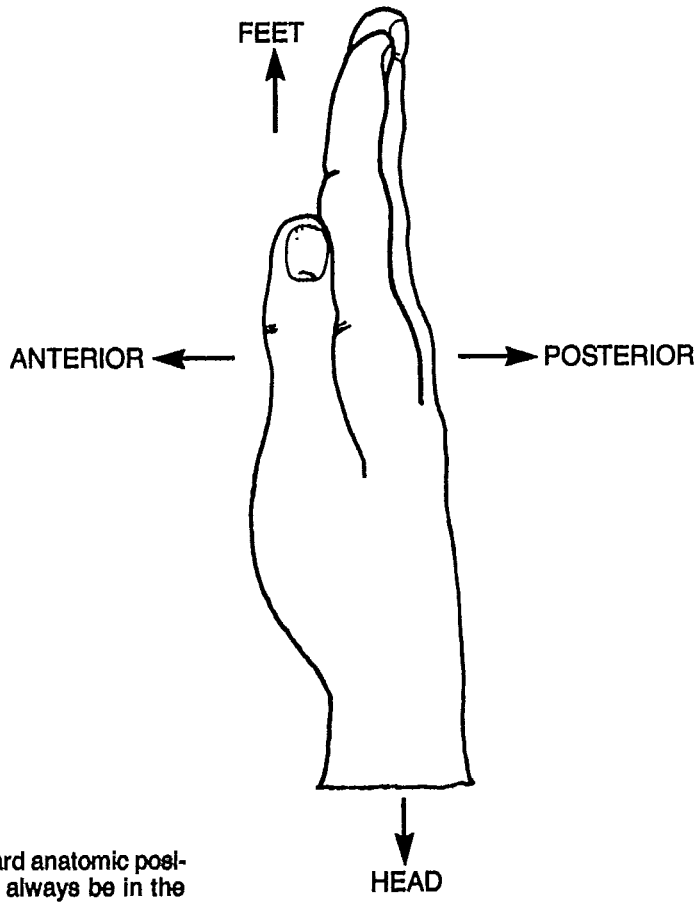

For the hands, the direction labels are based on the standard anatomic position. For the left hand illustrated, for example, LEFT will always be in the direction of the thumb, irrespective of position changes.

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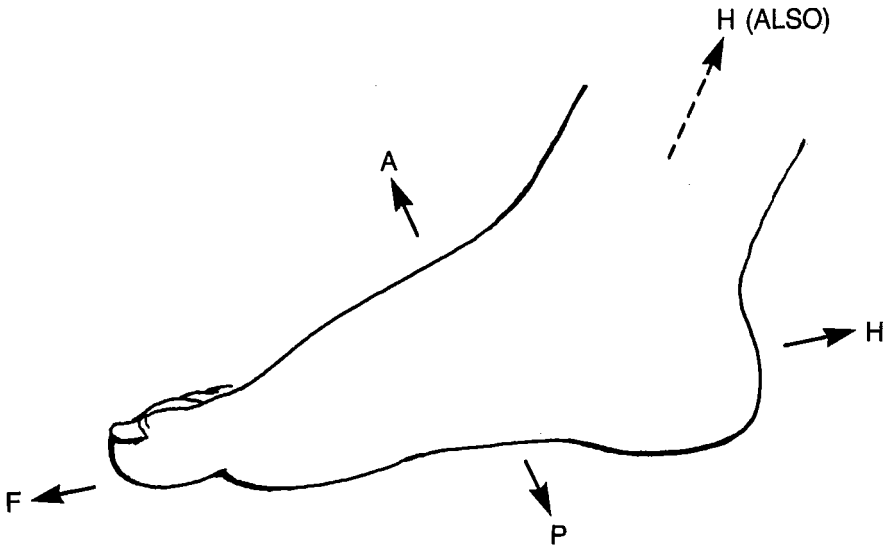
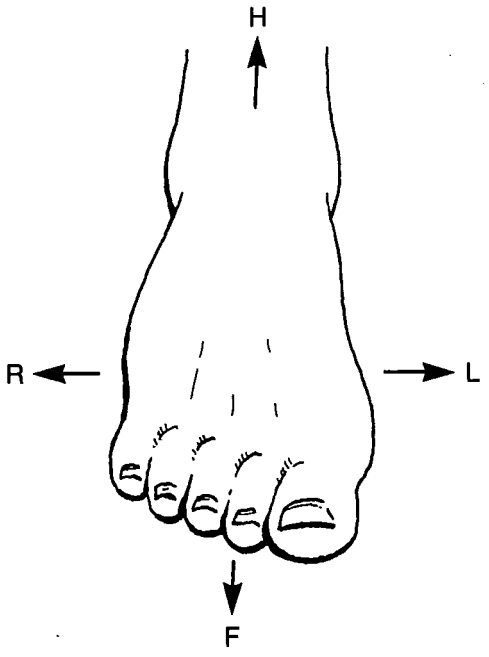


RIGHT FOOT



RIGHT FOOT—ANTERIOR VIEW

As for the hand, the direction labels are based on the foot in the standard anatomic position. For the right foot, for example, RIGHT will be in the direction of the 5th toe. This assignment will remain constant through movement or positioning of the extremity. This is also true of the HEAD and FOOT directions.

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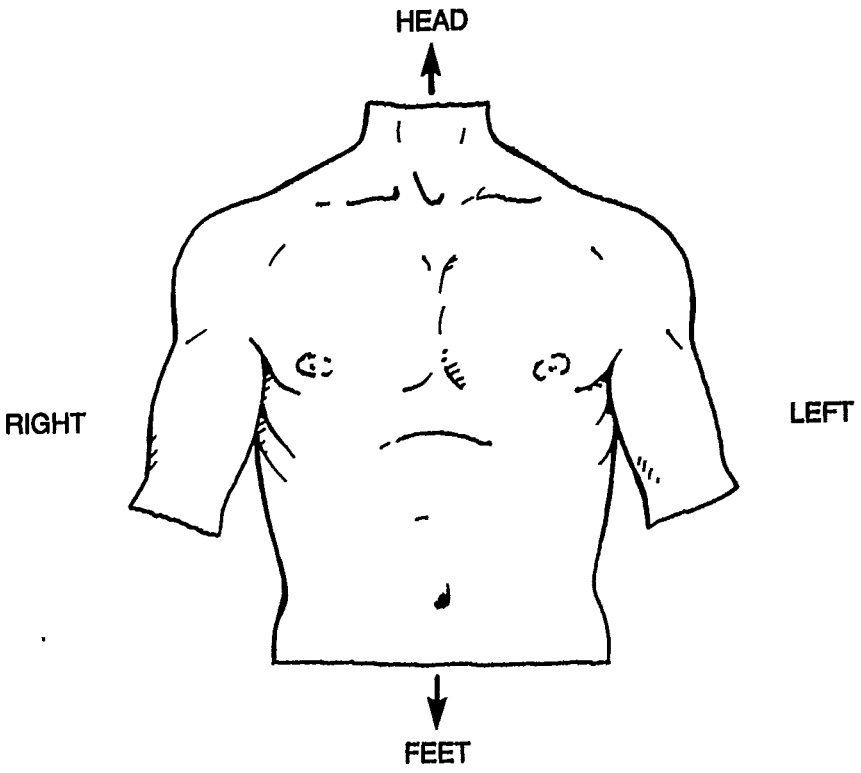
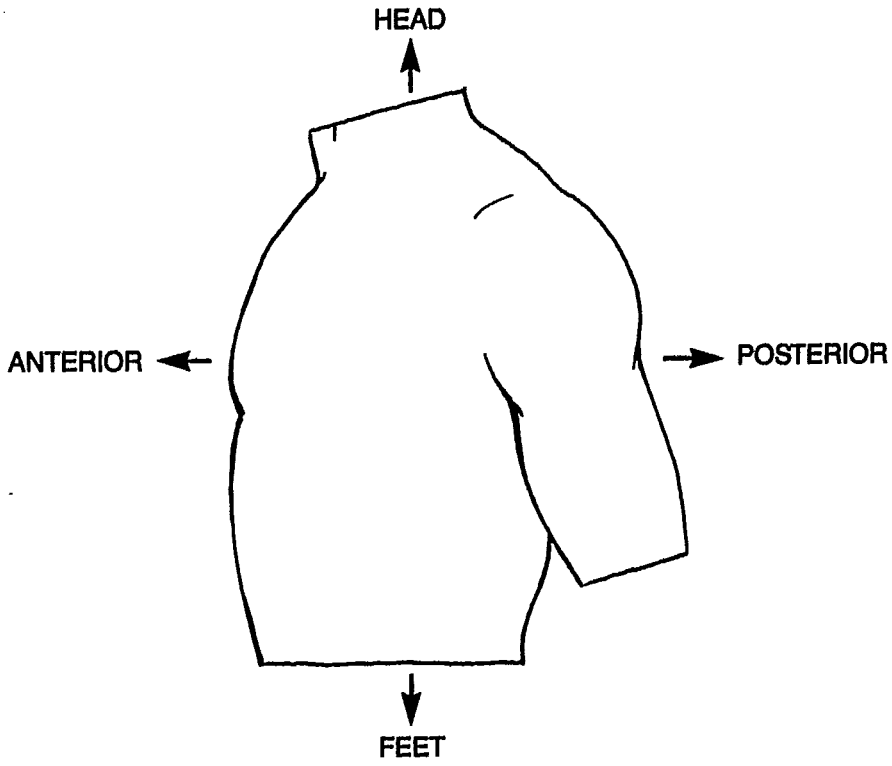


VIEWING THE FRONT OF THE PATIENT



Anterior and left lateral views of the patient. In the view of the left side (bottom illustration) the left arm has been drawn posteriorly.

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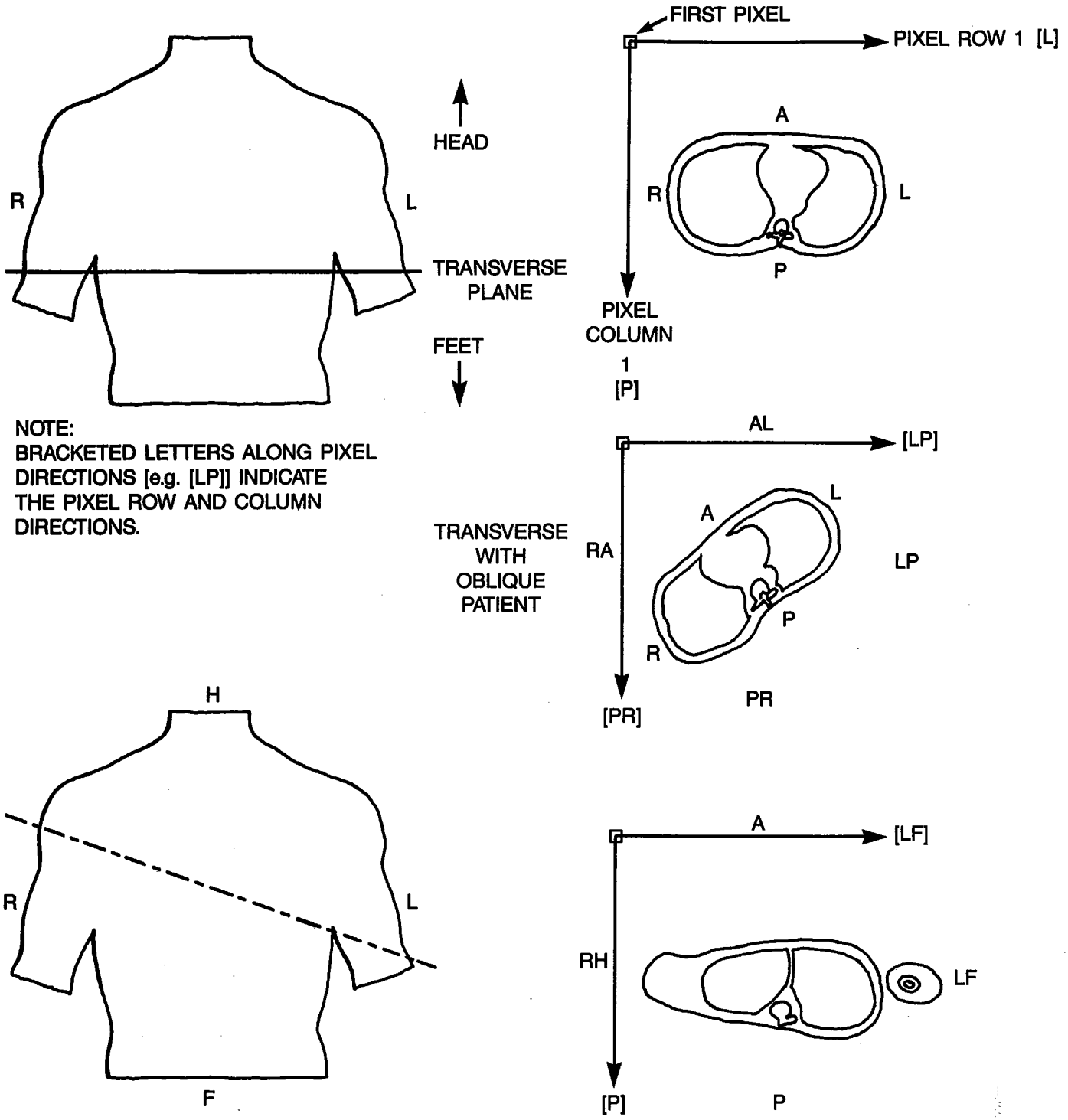

OBLIQUE TRANSVERSE PLANE

Since the major direction of the transverse plane is right-to-left (or anterior-to-posterior), the first letter of the combined direction will indicate this. For example, RH—moving right also moves towards the head.

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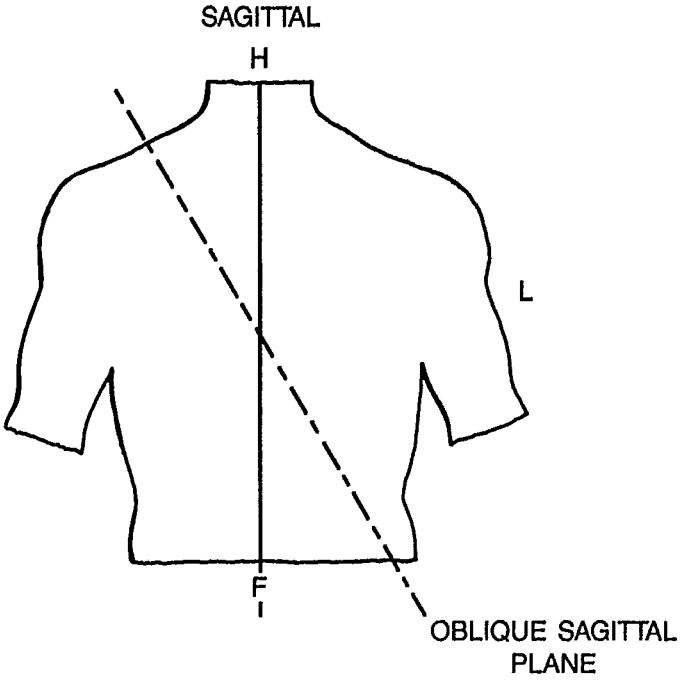

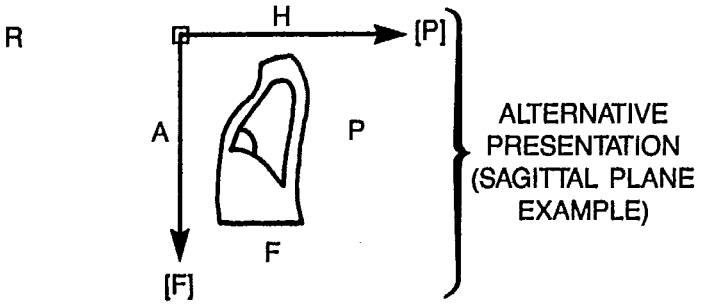

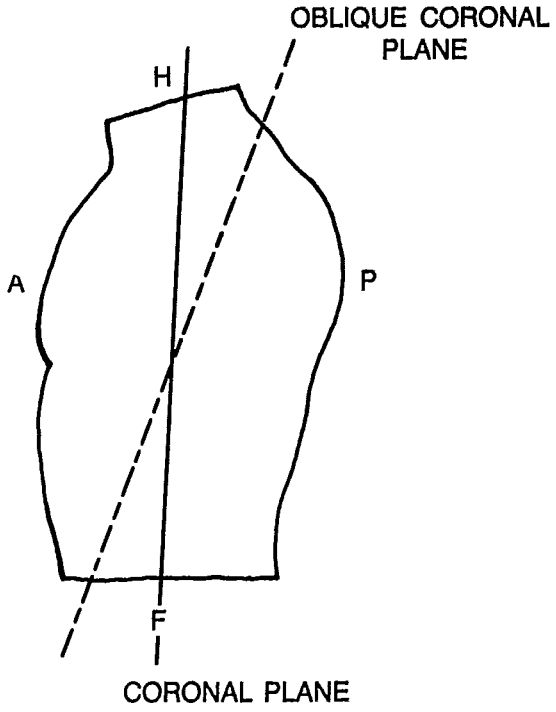

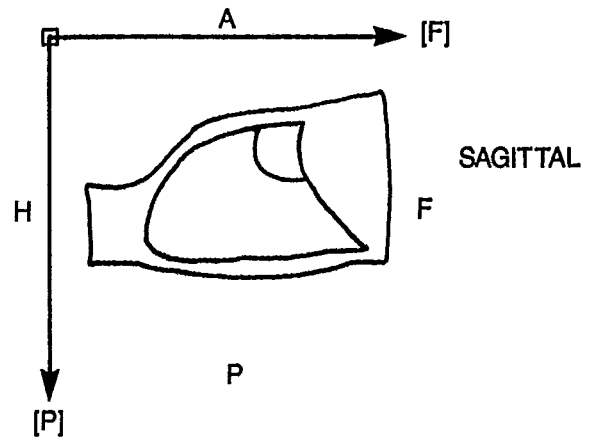

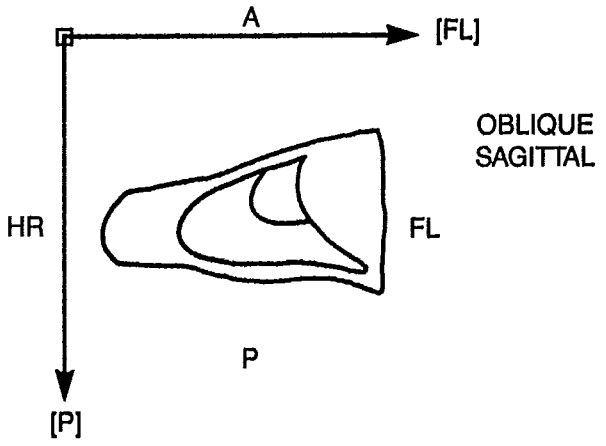

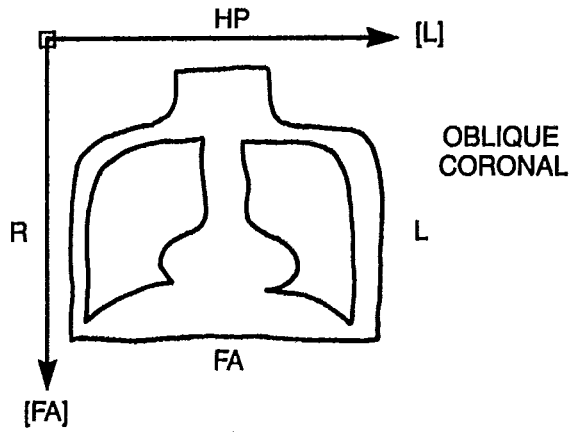

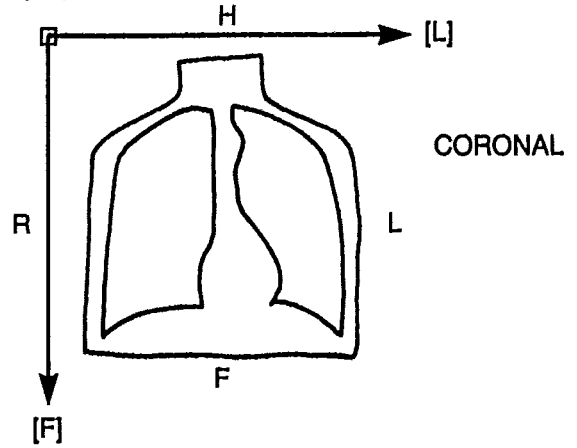

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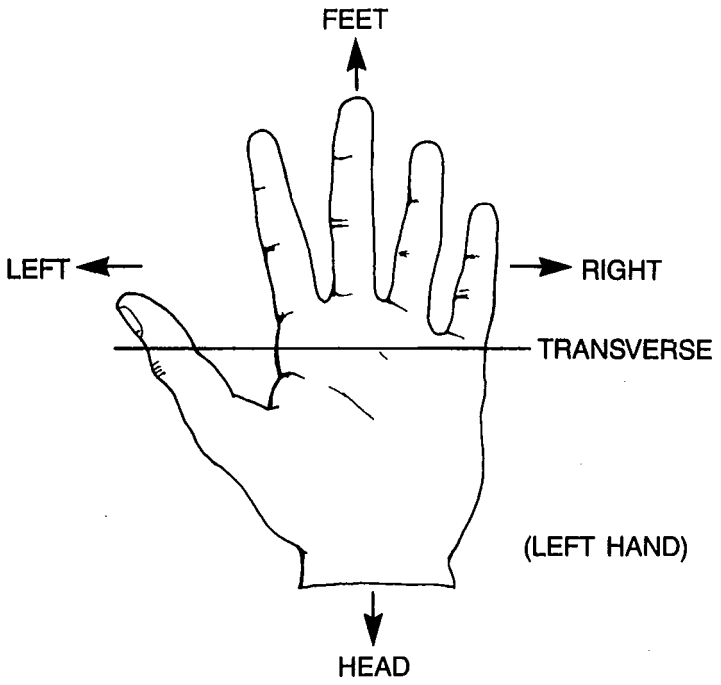

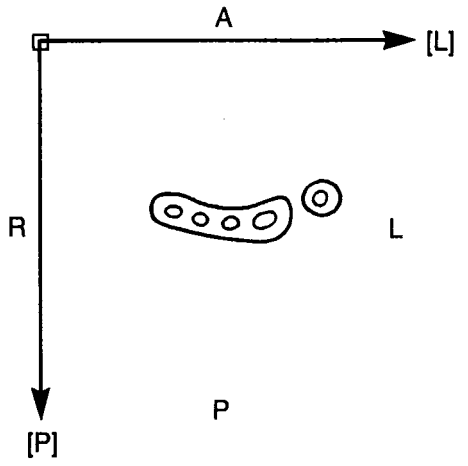



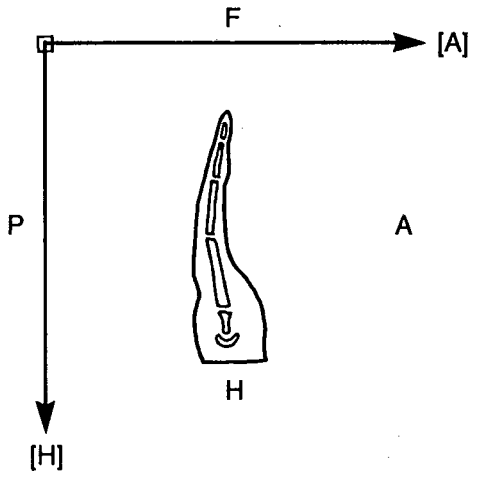

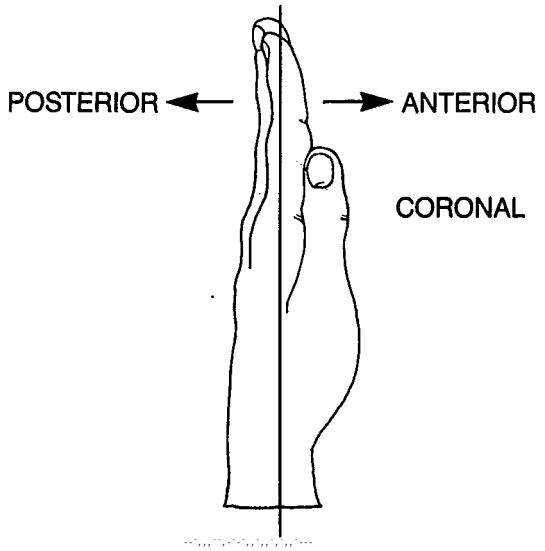

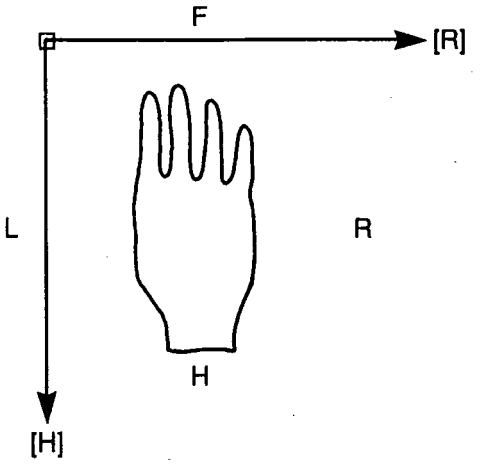

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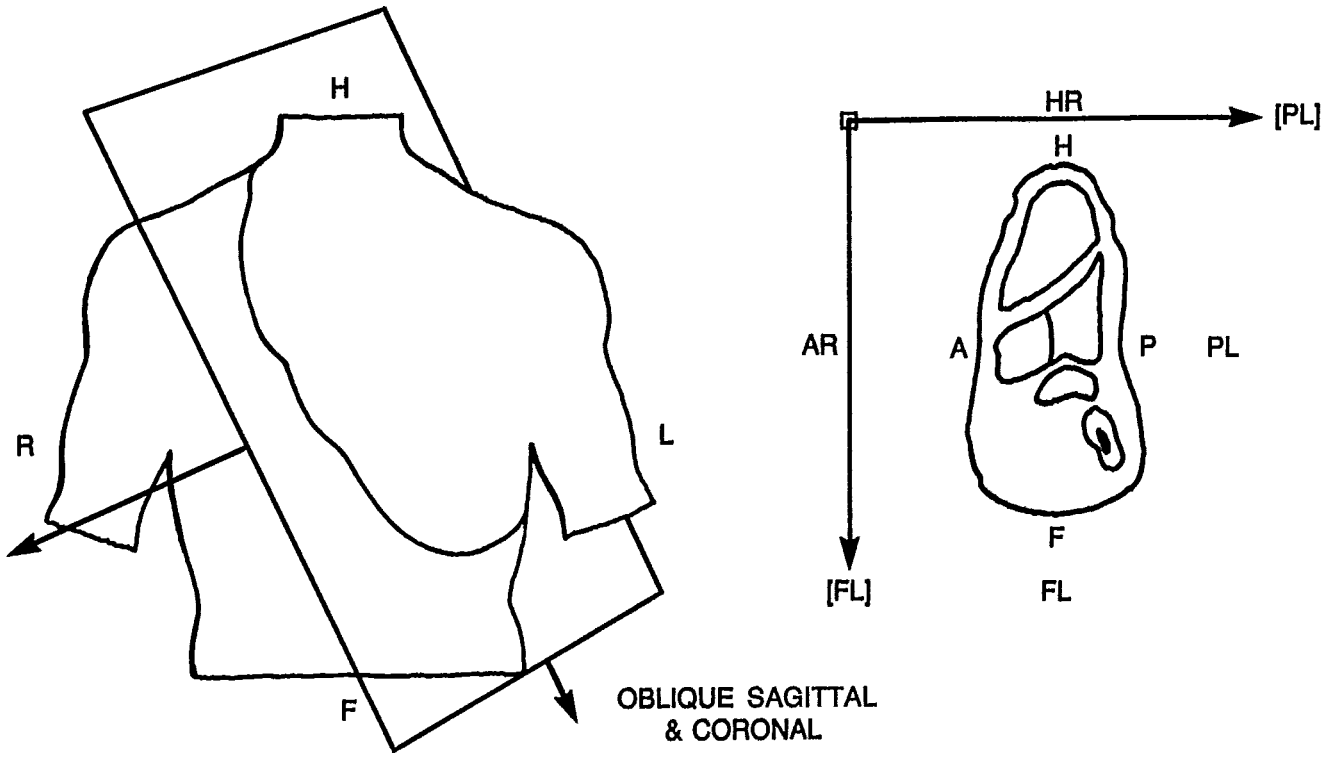
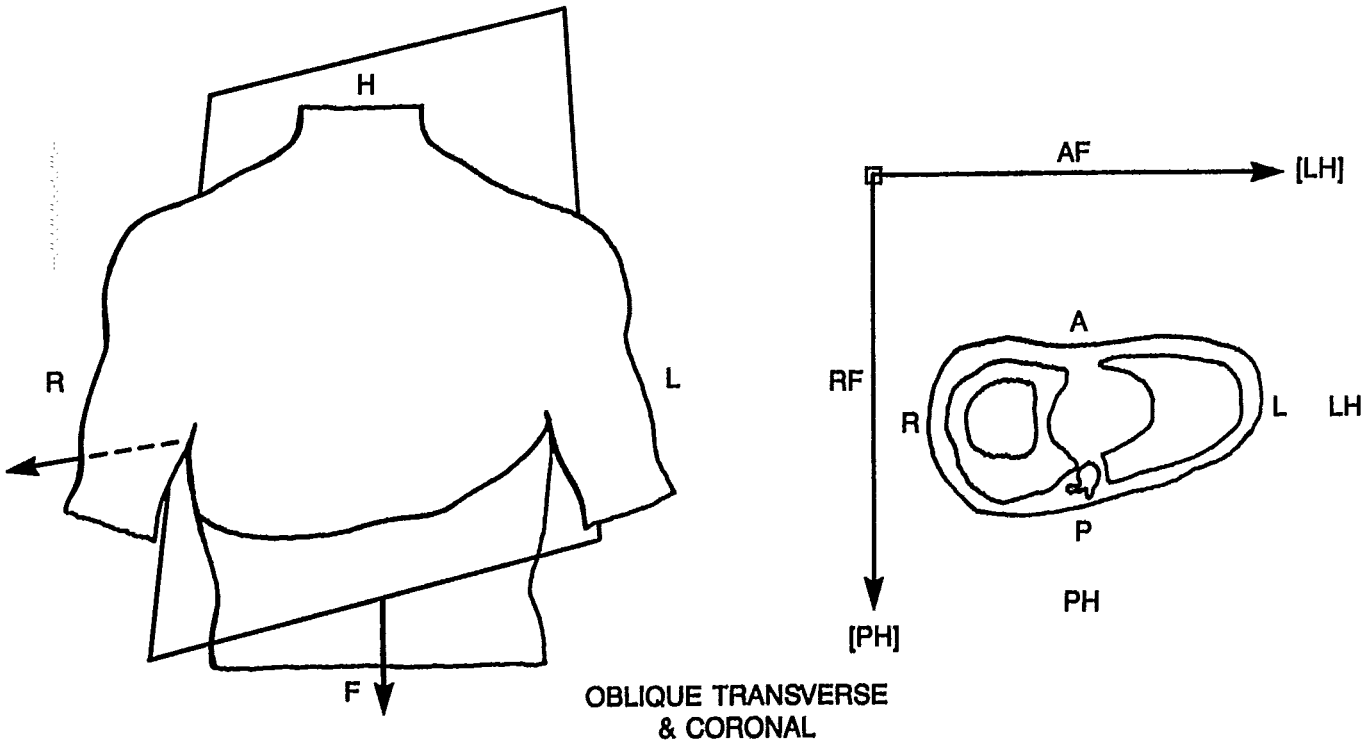


OBLIQUE SAGITTAL
& CORONAL



OBLIQUE TRANSVERSE
& CORONAL

Combined tilt planes and possible labels are based on major plane directions.

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Appendix E

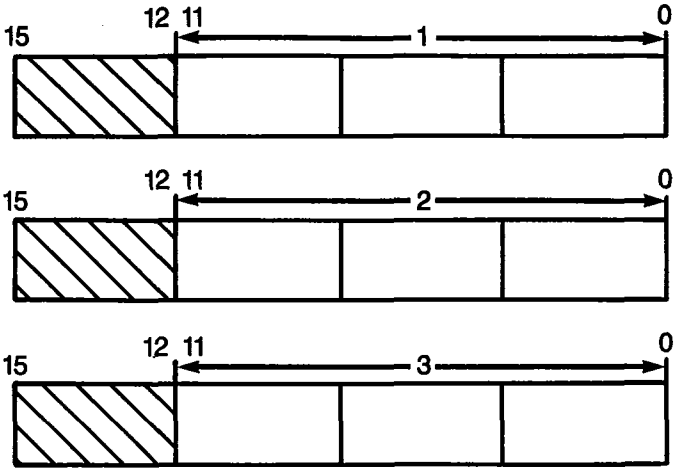
EXPLANATION OF PACKING OPTIONS

The following examples further illustrate the use of the data elements for Bits Allocated, Bits Stored, and High Bit.

BITS ALLOCATED = 16

BITS STORED = 12

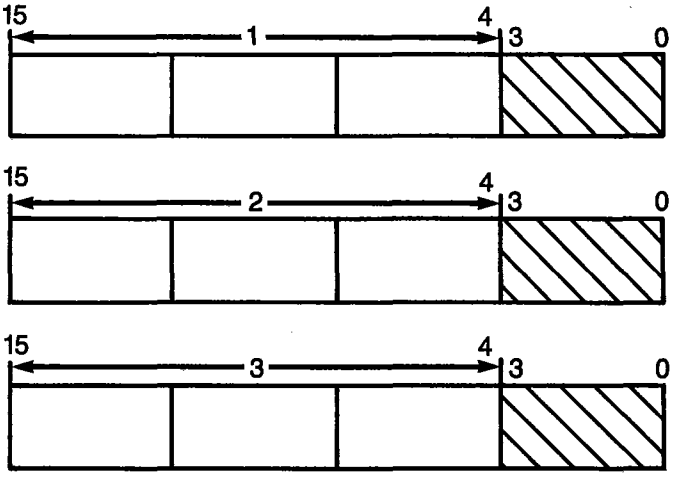
HIGH BIT = 11



BITS ALLOCATED = 16

BITS STORED = 12

HIGH BIT = 15



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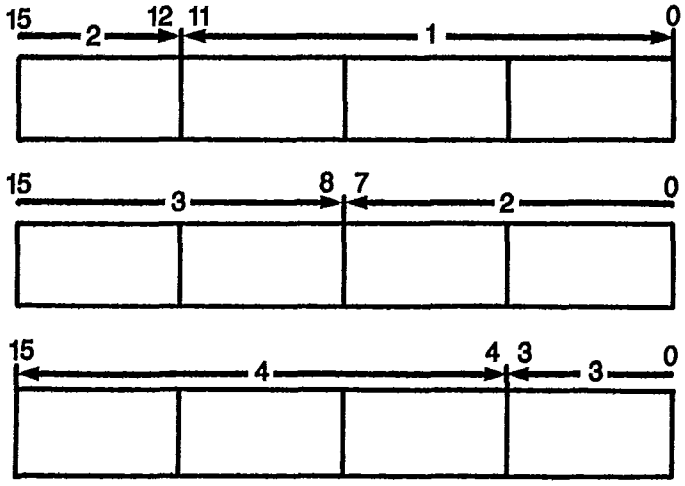
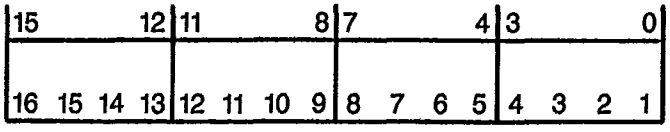


BITS ALLOCATED = 12

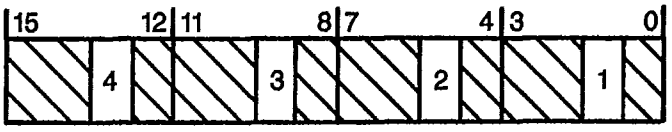
BITS STORED = 12

HIGH BIT = 11

BITS ALLOCATED = 1
BITS STORED = 1
HIGH BIT = 0

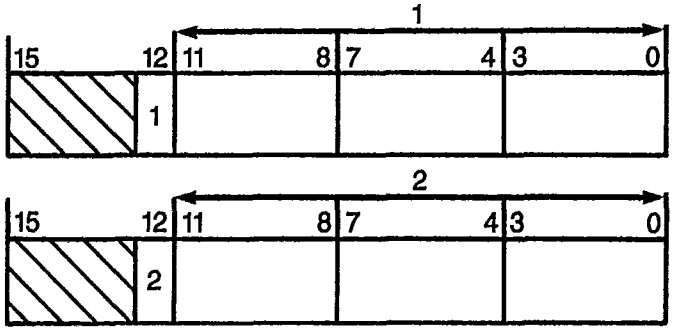


BITS ALLOCATED = 4
BITS STORED = 1
HIGH BIT = 1



PIXEL
BITS ALLOCATED = 16
BITS STORED = 12
HIGH BIT 11

OVERLAY
BITS ALLOCATED = 16
BIT POSITION = 12



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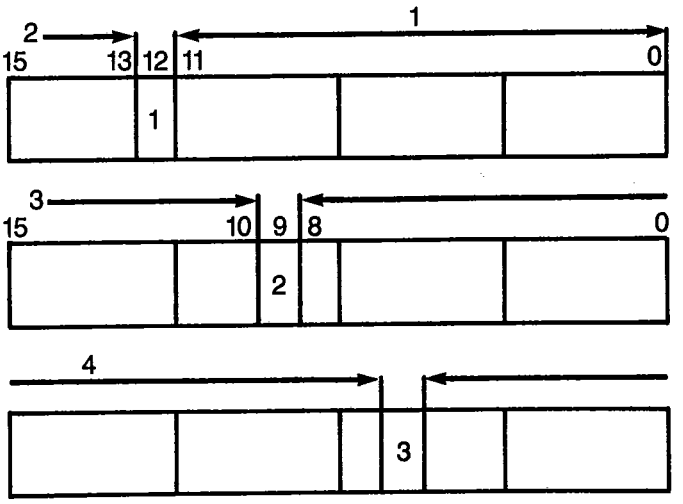
PIXEL
BITS ALLOCATED = 13
BITS STORED = 12
HIGH BIT = 11

OVERLAY
BITS ALLOCATED = 13
BIT POSITION = 12



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Appendix F

LOOKUP TABLE EXAMPLE

Problem: Pixel values 0 to 1F (5 bits) are mapped in a non-linear way to gray scales 0 to F (4 bits). All pixel values 8 or less are mapped to 0. All numbers are in hexadecimal.

ELEMENT	VALUE	EXPLANATION
(0028,1100)	16	Number of entries
	8	First value mapped
	4	Bits per entry
(0028,1200)	0	Table
	1	
	2	
	3	First full word 3210
	4	
	5	
	6	
	7	Second full word 7654
	8	
	9	
	9	Note nonlinearity
	A	Third full word A998
	A	
	B	
	B	
	C	Fourth full word CBBA
	C	
	D	
	D	
	E	Fifth full word EDDC
	F	
	F	
	0	Padding
	0	Padding, Fifth Word 00FF

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Appendix G

COMMAND EXAMPLES

Following are descriptions of the flow of messages for SEND, GET, and MOVE commands. Each example shows the series of messages sent to complete the command. Only those data elements required to illustrate the basic structures of the message are shown. Group and element numbers are shown in hex, other numbers are decimal unless followed by H which indicates hex.

SEND

A CAT scanner (CAT1) may send an image to an archive (ACH1):

GROUP,ELEMENT	VALUE	MEANING
CAT1 TRANSMITS:		
0000,0100	0001H	this is a SEND_REQUEST
0000,0110	1234	this is message # 1234
0000,0200	CAT1	message being sent by CAT1
0000,0300	ACH1	message being sent to ACH1
0000,0800	0000H	an image is being sent
ACH1 TRANSMITS:		
0000,0100	8001H	this is a SEND_RESPONSE
0000,0110	A23	this is message # A23
0000,0120	1234	responding to message # 1234
0000,0200	ACH1	message being sent by ACH1
0000,0300	CAT1	message being sent to CAT1
0000,0800	0102H	data set type = IDENTIFIER
0000,0900	0000H	status = success

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GET

A workstation WKS2 may request from an archive ACH1 an ultrasound image on Mary Young. The image should be specified by STUDY # 246, SERIES # 1, ACQUISITION # 3, and IMAGE # 8.

GROUP,ELEMENT	VALUE	MEANING
WKS2 TRANSMITS:		
0000,0100	0010H	this is a GET__REQUEST
0000,0110	23	this is message # 23
0000,0200	WKS2	message being sent by WKS2
0000,0300	ACH1	message being sent to ACH1
0000,0800	0103H	data set type = IDENTIFIER
0008,0040	0000H	an image is being requested
0008,0060	US	the modality is ultrasound
0010,0010	Young, Mary	the patient is Mary Young
0018,0010	246	study # 246
0018,0011	1	series # 1
0018,0012	3	acquisition # 3
0018,0013	8	image # 8
ACH1 TRANSMITS:		
0000,0100	8010H	this is a GET__RESPONSE
0000,0120	23	responding to message # 23
0000,0200	ACH1	message being sent by ACH1
0000,0300	WKS2	message being sent to WKS2
0000,0900	FFOOH	status = pending
ACH1 TRANSMITS:		
000,0100	0001H	this is a SEND__REQUEST
0000,0110	455	this is message # 455
0000,0120	23	responding to message # 23
0000,0200	ACH1	message being sent by ACH1
0000,0300	WKS2	message being sent to WKS2
WKS2 TRANSMITS:		
0000,0100	8001H	this is a SEND__RESPONSE
0000,0120	455	responding to message # 455
0000,0300	ACH1	message being sent to ACH1
0000,0900	0000H	status = success
ACH1 TRANSMITS:		
0000,0100	8010H	this is a GET__RESPONSE
0000,0120	23	responding to message #23
0000,0200	ACH1	message being sent by ACH1
0000,0300	WKS2	message being sent to WKS2
0000,0900	0000H	status = success

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MOVE

A workstation (WKS1) may request that an image be sent from an archive (ACH2) to a printer (PNT3).

GROUP,ELEMENT	VALUE	MEANING
WKS1 TRANSMITS:		
0000,0100	0021H	this is a MOVE__REQUEST
0000,0110	12	this is message # 12
0000,0200	WKS1	message being sent by WKS1
0000,0300	ACH2	message being sent to ACH2
0000,0600	PNT3	destination is PNT3
ACH2 TRANSMITS:		
0000,0100	8021H	this is a MOVE__RESPONSE
0000,0120	12	responding to message # 12
0000,0200	ACH2	message being sent to ACH2
0000,0300	WKS1	message being sent to WKS1
0000,0900	FFOOH	status = pending
ACH2 TRANSMITS:		
0000,0100	0001H	this is a SEND__REQUEST
0000,0110	55	this is message # 55
0000,0200	ACH2	message being sent by ACH2
0000,0300	PNT3	message being sent to PNT3
PNT3 TRANSMITS:		
0000,0100	8001H	this is a SEND__RESPONSE
0000,0120	55	responding to message # 55
0000,0200	PNT3	message being sent by PNT3
0000,0300	ACH2	message being sent to ACH2
0000,0900	0000H	status = success
ACH2 TRANSMITS:		
0000,0100	8021H	this is a MOVE__RESPONSE
0000,0120	12	responding to message # 12
0000,0200	ACH2	message being sent by ACH2
0000,0300	WKS1	message being sent to WKS1
0000,0900	0000H	status = success

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FIND

Two detailed examples of the use of the FIND command are presented. The first is an example showing the contents of the FIND__REQUEST and several FIND__RESPONSEs. The second illustrates the case when the receiver of the FIND__REQUEST is a data base, but is not the storage location of the actual images.

A. FIND__REQUEST RECEIVER IS THE LOCATION OF THE IMAGES:

An operator at a work station (WKS1) wishes to obtain enough information to later issue GET__REQUESTS for images froma CT series done on a patient whose last name is Snyder. The exam was done during March, 1985, but the exact date is not known. The operator does not know the patient's first name, but does remember that he was male and about 50 years old.

This example shows a FIND__REQUEST and a possible series of FIND__RESPONSEs which provide data needed to specify the desired images.

Recognition Code and Group and Message Length data elements are not shown, but all other required data elements are given. Group and element numbers are in hex. Other numbers are in decimal unless followed by H for hex.

The original FIND__REQUEST:

GROUP,ELEMENT	VALUE	MEANING
0000,0100	0020H	This is a FIND__REQUEST.
0000,0110	455	Message number 455.
0000,0200	WKS1	Sent by Work Station 1 (WKS1).
0000,0300	ACH1	Sent to archive 1 (ACH1).
0000,0800	0102H	Data set type is IDENTIFIER.
0008,0020	1985.03.*	Study date with day unknown.
0008,0040	000H	An IMAGE is requested.
0008,0060	CT	Looking for CT exam.
0008,1010	*	Station ID is unknown.
0010,0010	Snyder,*	Patient name with first name unknown.
0010,0030	*	Birthdate unknown.
0010,0040	M	Sex is male.
0020,0010	*	Study number is unknown.
0020,0011	*	Series number is unknown.

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This FIND__REQUEST could generate 14 FIND__RESPONSEs from the data base. The first two and the last one are shown:

GROUP,ELEMENT	VALUE	MEANING
0000,0100	8020H	This is a FIND__RESPONSE.
0000,0110	1256	This is message number 1256.
0000,0120	455	Responding to message number 455.
0000,0200	ACH1	Sent by archive 1.
0000,0300	WKS1	Sent to Work Station 1.
0000,0400	ACH1	Data are in Archive 1.
0000,0800	0102H	Data set type is IDENTIFIER.
0000,0850	32	there are 32 data sets in the archive which match the set of values in this FIND__RESPONSE.
0000,0860	1	This is the first response.
0000,0900	FFOOH	STATUS=PENDING, more responses will follow.
0008,0020	1985.03.02	Study date is March 2, 1985.
0008,0040	0000H	Data set type is IMAGE.
0008,0060	CT	Modality is CT.
0008,1010	CT1	Station CT1 generated the image.
0010,0010	SNYDER, JAMES	Patient's name is James Snyder.
0010,0040	M	Sex is male.
0010,1010	1934.11.23	Patient was born in 1934.
0020,0010	234	Study number is 234.
0020,0011	1	Series number is 1.

This response has returned all the missing information for one study and series on James Snyder and has indicated that there are 32 images in the archive from this series.

The second response could be:

0000,0100	8020H	This is a FIND__RESPONSE.
0000,0110	1257	This is message number 1257.
0000,0120	455	Responding to message number 455.
0000,0200	ACH1	Sent by Archive 1.
0000,0300	WKS1	Sent to Work Station 1.
0000,0400	ACH1	Data are in Archive 1.
0000,0800	0102H	Data type is IDENTIFIER.
0000,0850	24	There are 24 data sets in the archive which match the set of values in this FIND__RESPONSE.

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GROUP,ELEMENT	VALUE	MEANING
0000,0860	2	This is the second response.
0000,0900	FFOOH	STATUS=PENDING, more responses will follow.
0008,0020	1985.03.02	Study date is March 2, 1985.
0008,0040	0000H	Data set type is IMAGE.
0008,0060	CT	Modality is CT.
0008,1010	CT1	Station CT1 generated the image.
0010,0010	SNYDER, JAMES	Patient's name is James Snyder.
0010,0040	M	Sex is male.
0010,1010	1934.11.23	Patient was born in 1934.
0020,0010	234	Study number is 234.
0020,0011	2	Series number is 2.

This response indicated that there was a second series done on James Snyder in the same study. There are 24 images in this series.

The final response could be:

0000,0100	8020H	This is a FIND__RESPONSE.
0000,0110	1300	This is message number 1300.
0000,0120	455	Responding to message number 455.
0000,0200	ACH1	Sent by Archive 1.
0000,0300	WKS1	Sent to Work Station 1.
0000,0400	ACH1	Data are in Archive 1.
0000,0800	0102H	Data type is IDENTIFIER.
0000,0850	16	There are 16 data sets in the archive which match the set of values in this FIND__RESPONSE.
0000,0860	14	This is the 14th response.
0000,0900	0000H	STATUS=SUCCESS, this is the final response.
0008,0020	1985.03.12	Study date is March 12, 1985.
0008,0040	0000H	Data set type is IMAGE.
0008,0060	CT	Modality is CT.
0008,1010	CT2	Station CT2 generated the image.
0010,0010	SNYDER, STEPHEN	Patient's name is Stephen Snyder.
0010,0040	M	Sex is male.
0010,1010		Patient birthdate is not known—it was not stored in the original data set.
0020,0010	332	Study number is 332.
0020,0011	1	Series number is 1.

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Note that element (0010,1010) has no value in the value field. This indicates that although the FIND__REQUEST asked for these data, they do not exist in the data set stored for these images.

The workstation now has the requested information on 14 different studies done on patients with the last name Snyder who received CT scans during the month of March, 1985. From these data, the operator can either request more specific information on a specific patient or exam by generating another FIND__REQUEST; or request a specific image with a GET__REQUEST.

B. FIND__REQUEST RECEIVER IS NOT THE LOCATION OF THE IMAGES:

In this example, the receiver of the FIND__REQUEST is a data base (DB) which contains data on all images on the network, but images are actually stored at dispersed archives on the network.

The details of this example are the same as the one in section A, except that the FIND__REQUEST is sent to DB instead of the archive.

Recognition Code and Group and Message Length data elements are not shown, but all other required data elements are given. Group and element numbers are in hex. Other numbers are in decimal unless followed by H for hex.

The original FIND__REQUEST:

GROUP,ELEMENT	VALUE	MEANING
0000,0100	0020H	This is a FIND__REQUEST.
0000,0110	455	Message number 455.
0000,0200	WKS1	Sent by Work Station 1 (WKS1).
0000,0300	DB	Sent to data base (DB).
0000,0800	0102H	Data set type is IDENTIFIER.
0008,0020	1985.03.*	Study date with day unknown.
0008,0040	0000H	An IMAGE is requested.
0008,0060	CT	Looking for CT exam.
0008,1010	*	Station ID is unknown.
0010,0010	Snyder, *	Patient name with first name unknown.
0010,0030	*	Birthdate unknown.
0010,0040	M	Sex is male.
0020,0010	*	Study number is unknown.
0020,0011	*	Series number is unknown.

This FIND__REQUEST could generate 14 FIND__RESPONSEs from the date base. Only the first one is shown:

0000,0100	8020H	This is a FIND__RESPONSE.
0000,0110	1256	This is message number 1256.
0000,0120	455	Responding to message number 455.
0000,0200	DB	Sent by data base.

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GROUP,ELEMENT	VALUE	MEANING
0000,0300	WKS1	Sent to Work Station 1.
0000,0400	ACH1	Data are in Archive 1.
0000,0800	0102H	Data set type is IDENTIFIER.
0000,0850	32	There are 32 data sets in the archive which match the set of values in this FIND__RESPONSE.
0000,0860	1	This is the first response.
0000,0900	FFOOH	STATUS=PENDING, more responses will follow.
0008,0200	1985.03.02	Study date is March 2, 1985.
0008,0040	0000H	Date set type is IMAGE.
0008,0060	CT	Modality is CT.
0008,1010	CT1	Station CT1 generated the image.
0010,0010	SNYDER,JAMES	Patient's name is James Snyder.
0010,0040	M	Sex is male.
0010,1010	1934.11.23	Patient was born in 1934.
0020,0010	234	Study number is 234.
0020,0011	1	Series number is 1.

This response has returned all the missing information for one study and series on James Snyder and has indicated that there are 32 images in the archive from this series.

The work station operator could now request the second image from the tenth acquisition with the following GET__REQUEST.

0000,0100	0010H	This is a GET__REQUEST.
0000,0110	45	This is message # 45.
0000,0200	WKS1	Message being sent by WKS1.
0000,0300	ACH1	Message being sent to ACH1.
0000,0800	0102H	Data set type is IDENTIFIER
0008,0020	1985.03.02	Study date is March 2, 1985.
0008,0040	0000H	An IMAGE is requested.
0008,1010	CT1	Station ID is CT1.
0010,0010	SNYDER,JAMES	Patient is James Snyder.
0020,0010	234	Study number is 234.
0020,0011	1	Series number is 1.
0020,0012	10	Acquisition number is 10.
0020,0013	2	Image number is 2.

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Appendix H

EXAMPLES OF THE DIALOG COMMAND

These examples represent remote services that could be available through the use of the DIALOG commands. Some design choices are implicit in these examples. It is the responsibility of the managers of systems able to accept a DIALOG__REQUEST to clearly document the nature of the service provided, its name (value accepted in DIALOG receiver element), the terminals supported, (values accepted in terminal type element), and the protocols used to communicate with the service once the DIALOG commands have been exchanged.

All examples assume that the dialog would be successfully established. If the dialog cannot be established, failure should be indicated in the status element of the DIALOG__RESPONSE command.

Report ENTRY

The manager of a system (R) advertises that it supports a medical report editing service named "REPORTS". A user at another system (A) desires to enter a diagnostic report. The user sits at an ANSI terminal on system A and makes a request to have a connection to the REPORTS service of the R system.

System A establishes a connection to system R and then transmits the message: (in all examples below: values for lengths are required in the message but omitted from these tables, the message length always equals the group length—8, lower case entries are symbols for binary values listed in Section 10)

group length:	
message length:	
recognition:	ACR-NEMA 1.0
command:	DIALOG__REQUEST
message ID:	273
receiver:	R
initiator:	A
data type	null
dialog receiver:	REPORTS
terminal type:	ANSI

System R receives the message. If it is currently able to provide the REPORTS service and support an ANSI terminal (one that uses ANSI standard screen control sequences), then on the previously establshed session it transmits:

group length:	
message length:	
recognition:	ACR-NEMA 1.0
command:	DIALOG__RESPONSE
message ID:	445
message resp to:	A
initiator:	R
data type	null
status:	success

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After system A receives the response command, the user is informed that he is now in remote interaction with the REPORTS service on system R. Any characters typed by the user at the system A terminal are now sent in command packets over the established session to system R where they are routed to the REPORTS service. Any character responses (including echoes) of the REPORTS service in system R are sent to system A in command packets over the established session where they are printed on the user's terminal.

Each side has a stream of characters to send and groups these characters into packets. The packetizing rule could be to send a packet at least every quarter second in order to give the user a moderately good sense of interactive control. However, no characters are added, removed or modified between the user's terminal and the REPORTS service since the ACR-NEMA interface is merely providing transparent connection.

The communication protocol should be defined as the set of keyboard character sequences acceptable to the process providing the REPORTS service.

When the user is done, he indicates this to the REPORTS service by typing its termination character sequence. The service on the system R then disconnects the session to system A. When system A detects the disconnection, it informs the user that a disconnection has occurred and that his terminal is now returned to local interaction with system A.

Operator Conversation

The manager of an archive system (ARCHIVE) advertises that users on other systems can "CONVERSE" with the operator of the archive system by using the DIALOG commands. A user at a review station system (REVIEW) wants to ask the archive operator if a repair to a disk subsystem is complete. The user sits at a terminal on the REVIEW system and makes a request to have a conversation with the operator at the ARCHIVE system.

The REVIEW system establishes a connection with the ARCHIVE system and then sends the message:

group length:	
message length:	
recognition:	ACR-NEMA 1.0
command:	DIALOG_REQUEST
message ID:	2166
receiver:	ARCHIVE
initiator:	REVIEW
data type	null
dialog receiver:	CONVERSE
terminal type:	TTY

The ARCHIVE system receives the message, notes that it can support a TTY terminal (a terminal using only the line feed and carriage return control chracters), and pages the operator. When the operator indicates a willingness to converse, the ARCHIVE system uses the previously established session to transmit the message:

group length:	
message length:	
recognition:	ACR-NEMA 1.0
command:	DIALOG_RESPONSE
message ID:	1723
message ID resp to:	2166
receiver:	REVIEW
initiator:	ARCHIVE
data type	null
status:	success
terminal type:	TTY

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Bylaw—Art. V, Sec. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Bylaw—Art. V, Sec. 2, Subsection A)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

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