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ACR/NEMA STANDARDS PUBLICATION NO. 300

nema

Digital Imaging and Communications

NEMA

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

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ACR-NEMA 300

DIGITAL IMAGING AND COMMUNICATIONS

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FOREWORD

With the introduction of computed tomography (CT) followed by other digital diagnostic imaging modalities in the 1970s, 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, inputs 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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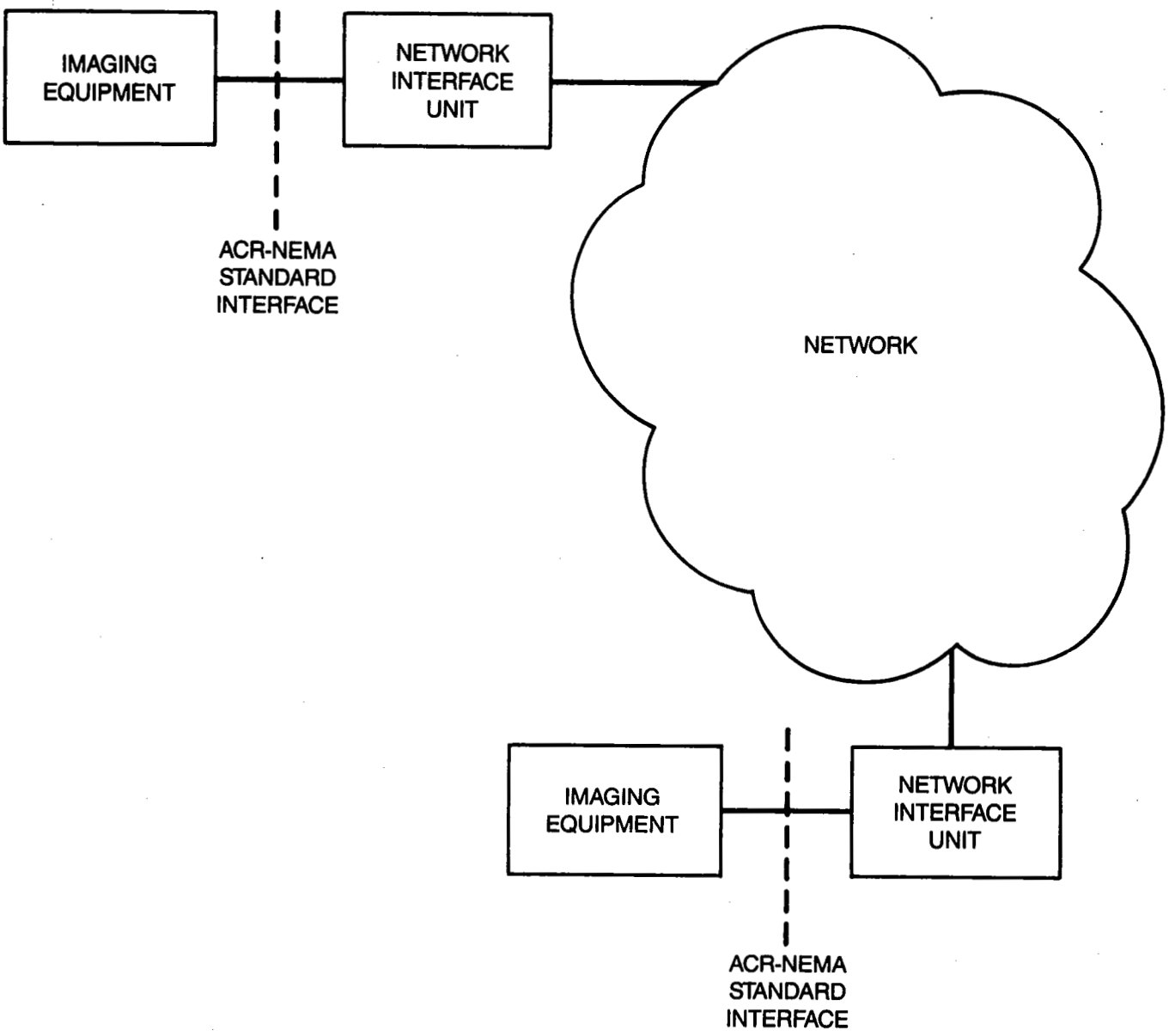

Figure 1-1
LOCATION OF ACR-NEMA STANDARD INTERFACE WITH A NETWORK

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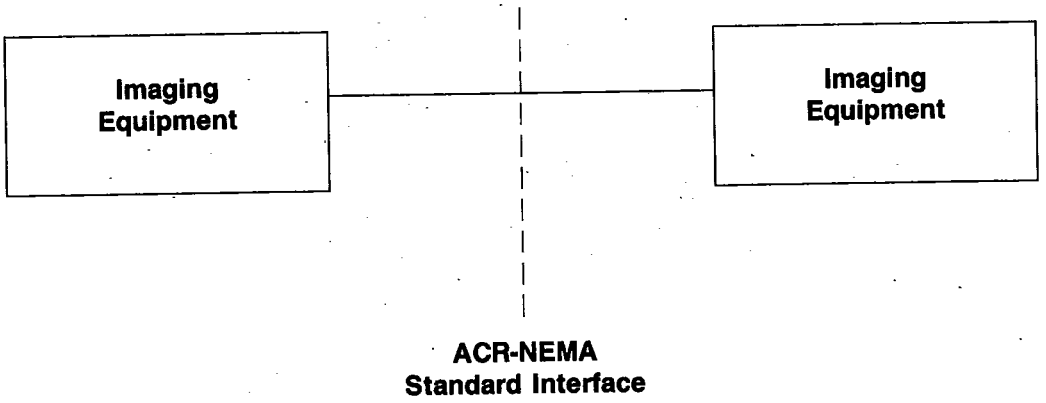

Figure 1-2
LOCATION OF ACR-NEMA STANDARD INTERFACE WITHOUT A NETWORK

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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 will be an evolving standard and that periodic enhancements will 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.

ACR-NEMA Standards Publication No. 300-1985, published in 1985 was designated version 1.0. The Standard was followed by two revisions, No. 1 dated October 1986 and No. 2 dated January 1988.

This publication designated version 2.0 includes version 1.0, the published revisions, and additional revisions. It also includes new material to provide command support for laser cameras and other display devices, to introduce a new hierarchy scheme to identify an image, and to add data elements for increased specificity when describing an image. Those paragraphs that have been added or revised are designated with a 1988 date rather than 1985.

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. Section 7 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 messages.

The appendices provide examples of message exchange, further descriptions of the hierarchical 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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COMPATIBILITY OF VERSIONS OF THE ACR-NEMA DIGITAL IMAGING AND COMMUNICATIONS STANDARDS

The ACR-NEMA Digital Imaging and Communications Standards Committee anticipated that ACR-NEMA 300-1985 would evolve, and so established a requirement that revisions of the standard be compatible with earlier versions.

Two elements named "Recognition Code" are provided in the Standard. One is sent in Group 0 (0000H,0010H) and a second in Group 8 (0008H,0010H). These elements are mandatory. The present revision carries "ACR-NEMA 2.0" in Group 0. The value carried in Group 8 will depend on the revision of the software that generated the data set.

These elements are intended for use by system software and will identify the revision level of Group 0 and the data set.

The actions taken by software when receiving a message are defined by the figure below.

REVISION LEVEL (RECOGNITION CODE) OF RECEIVER

REVISION LEVEL OF MESSAGE	1.0	2.0
1.0	Full Compatibility	Upwards Compatibility Software interprets as if it were running V1.0
2.0	Downwards Compatibility A. All required V1.0 elements are present and the message is interpretable without new elements. B. Receiver understands as if a V1.0 message had been sent. C. Extra elements are ignored. D. New Commands will not be executed. Defaulted new elements will be ignored.	Full Compatibility

Note that if the message and receiving software revision levels match, the receiver will properly interpret all required parts of the message.

If the receiving software is a higher revision level than that of the message, it will interpret that message as if the software itself were the lower revision level version. The software will not expect any new commands, groups, elements, or error codes to be present in this message.

This is not felt to be a burden to the user since (with one exception discussed below) no definitions of ACR-NEMA 1.0 commands, groups, elements, or error codes were changed.

If the receiver software is a lower revision level than that of the message, the software will follow the principles shown above.

Note that such lower revision level software will reply that it does not support new commands and will ignore new groups, elements, and error codes.

Despite the effors of the ACR-NEMA Digital Imaging and Communications Standards Committee to retain the group and element definitions of ACR-NEMA 300-1985, one element has been changed. Group 0020, Element 0010 had its value representation changed from ASCII numeric (AN) to ASCII text (AT). This decision was made because a number of information systems, which will use this element, will need to place non-numeric data in it. The value type, value multiplicity, type, and definition are unchanged.

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Users should note that this change in (0020,0010) only affects downwards compatibility (message revision level higher than receiving software revision level) for receiving software (i.e., image sink) which rejects non-numeric data in this field. If the receiving software accepts all ASCII characters in the field, there will be no compatibility problem for this element. As AN is a subset of AT, there is no problem with upwards compatibility.

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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.

American National Standards Institute
1430 Broadway
New York, NY 10018

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

Electronic Industries Association
2001 Eye Street, N.W.
Washington, DC 20006

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, NY 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 adjacent bits operated on as a unit.

Command Groups. The group (and optional shadow 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 groups.

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

Group. A collection of data elements that contains information of a similar nature.

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Imaging Equipment (IE). A device that 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 that operate in pairs to relay ACR-NEMA messages across an intervening data communications network.

Private Groups. All odd numbered groups. These are reserved for manufacturers and users.

Shadow Groups. Private groups with a group number one greater than a standard group. Used for information of the same category as that in the corresponding standard group.

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

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

TTL. Transistor-transistor logic.

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

Word. A sixteen 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 correspondence 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 micro-type connector is specified. It supports 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 is asynchronous and the cabling provides 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 is 8 Megabytes per second. Any cable length is allowed. However, use of longer cable lengths may result in lower data rates. Data is 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 is 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 is supported by the Session Layer protocol. These protocols are defined in Section 8.

Messages 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 are standardized to allow different implementations to communicate.

Authorized Engineering Information 10-16-1985.

2.2.3 Interface Location

The interface plane across which the data moves is 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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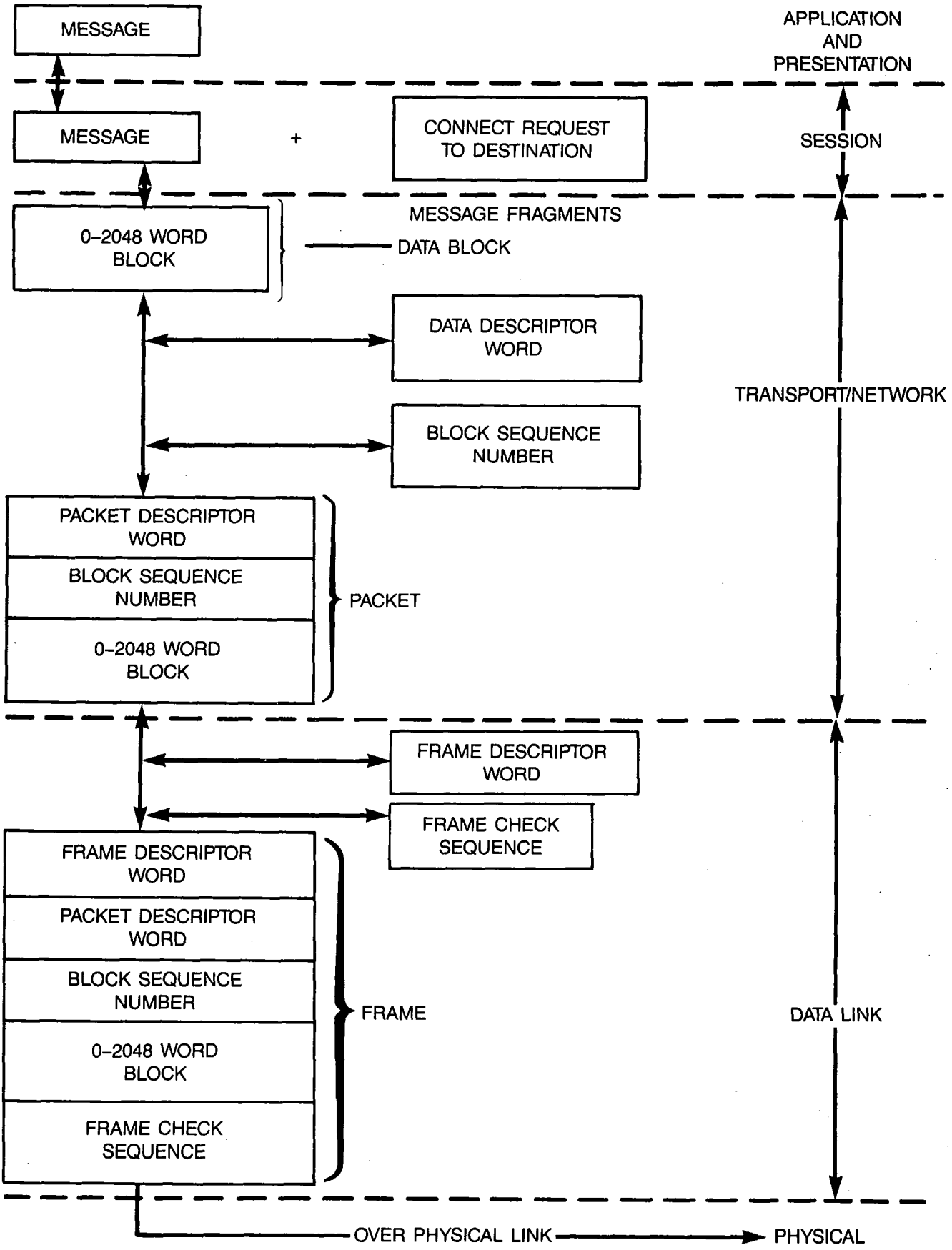

Figure 2-1
MESSAGE FRAGMENTATION

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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 that 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 is enhanced since the data requirements are known for each layer.

The idea of a layered structure is 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.

Authorized Engineering Information 10-16-1985.

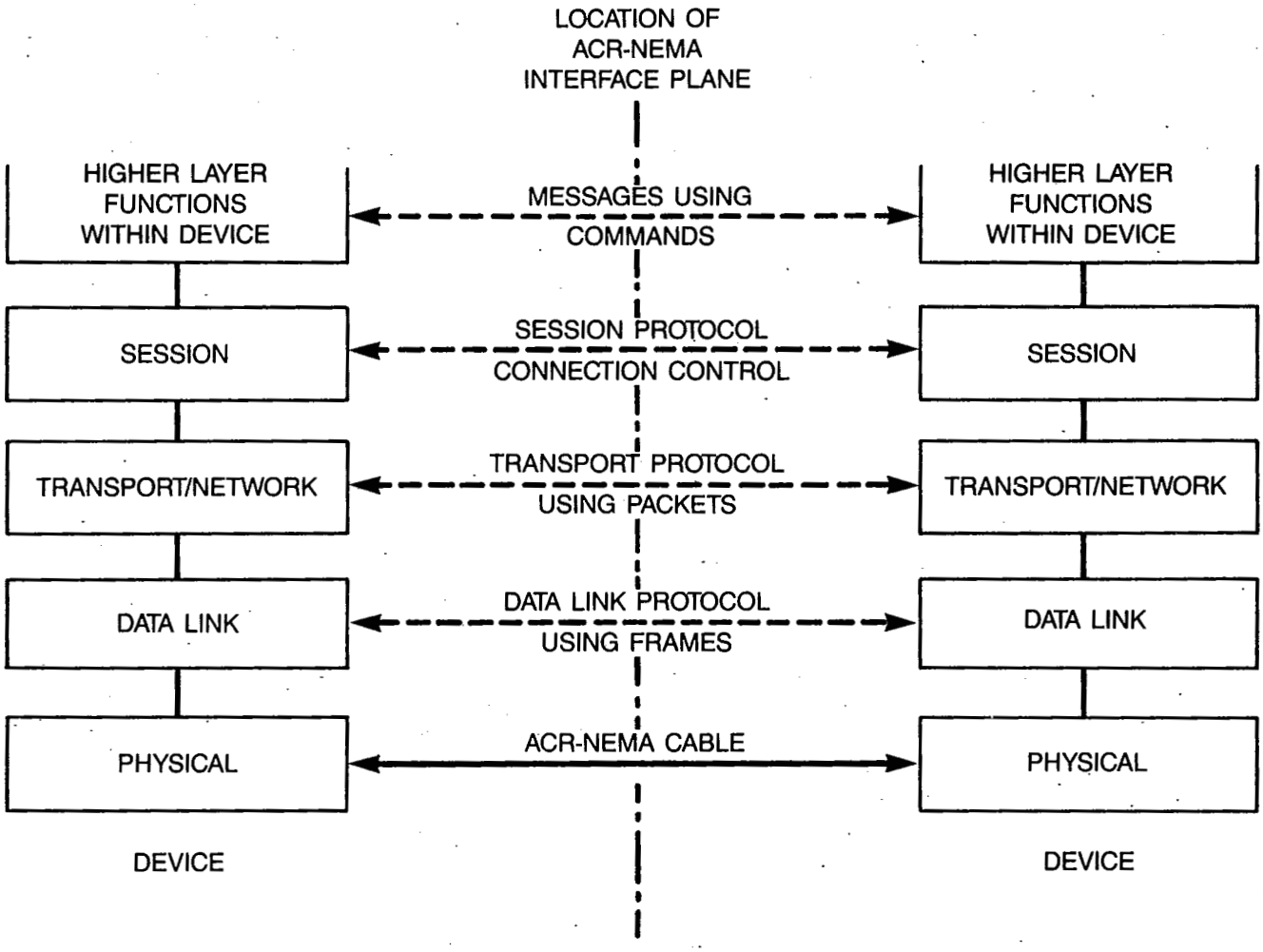

Figure 2-2
PROTOCOL LAYERS SUMMARY

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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 is completely described by the hardware specifications and by interface access and word exchange protocols. It defines 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 frames data from the Transport/Network Layer with control words and sends it out via the Physical Layer. This is accomplished through the protocol detailed in 8.2. During the receipt of data from the Physical Layer it removes the framing words, checks for transmission errors, and delivers 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), is performed at this Transport/Network Layer. The protocol is described in further detail in 8.3.

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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 that 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 are passed to the Data Link Layer where they are combined with control words to make frames. The frames are 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 that comply with this standard.

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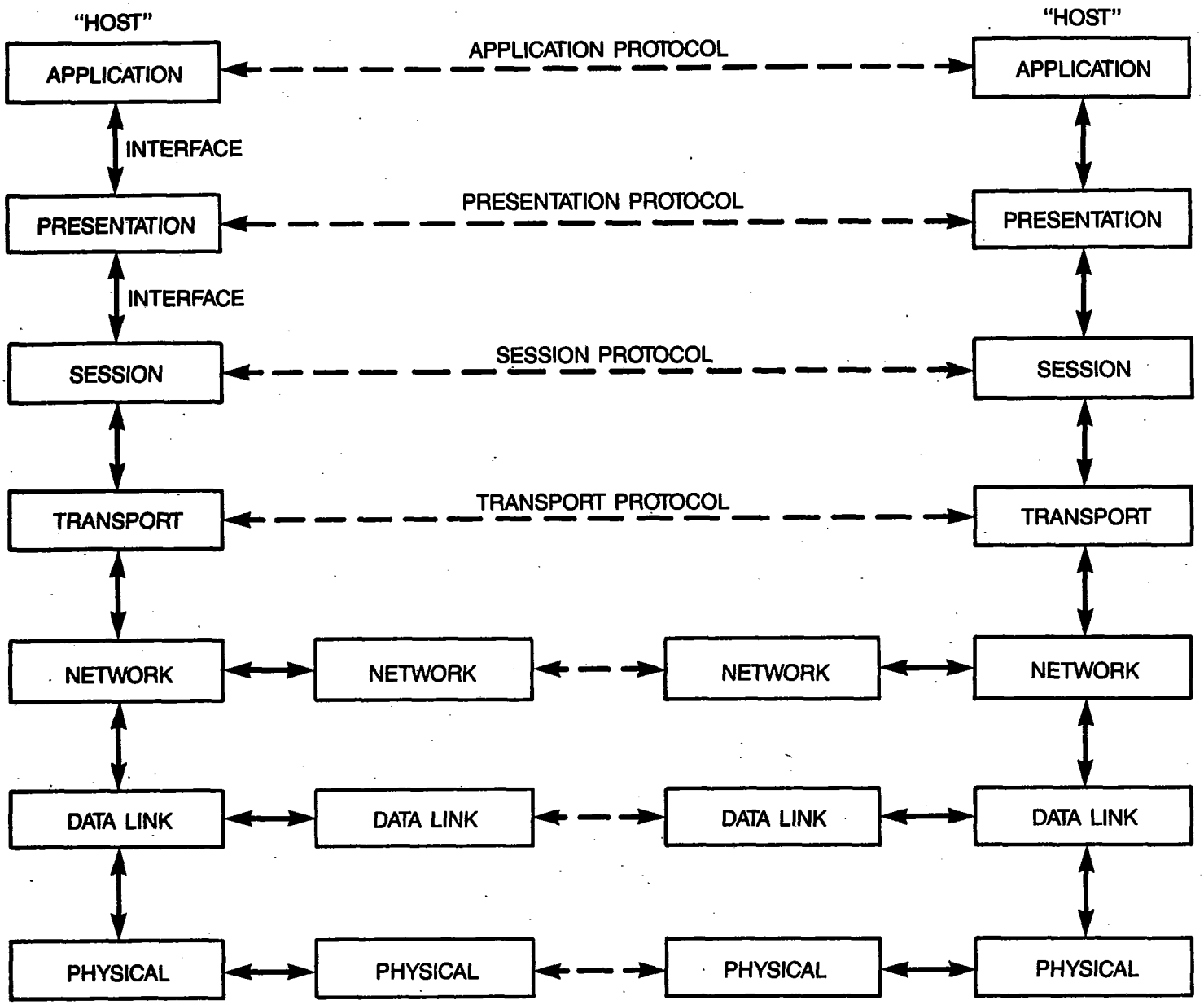

Adapted from Andrew S. Tanenbaum, *Computer Networks*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981, p. 16.

Figure 2-3
ISO-OSI MODEL

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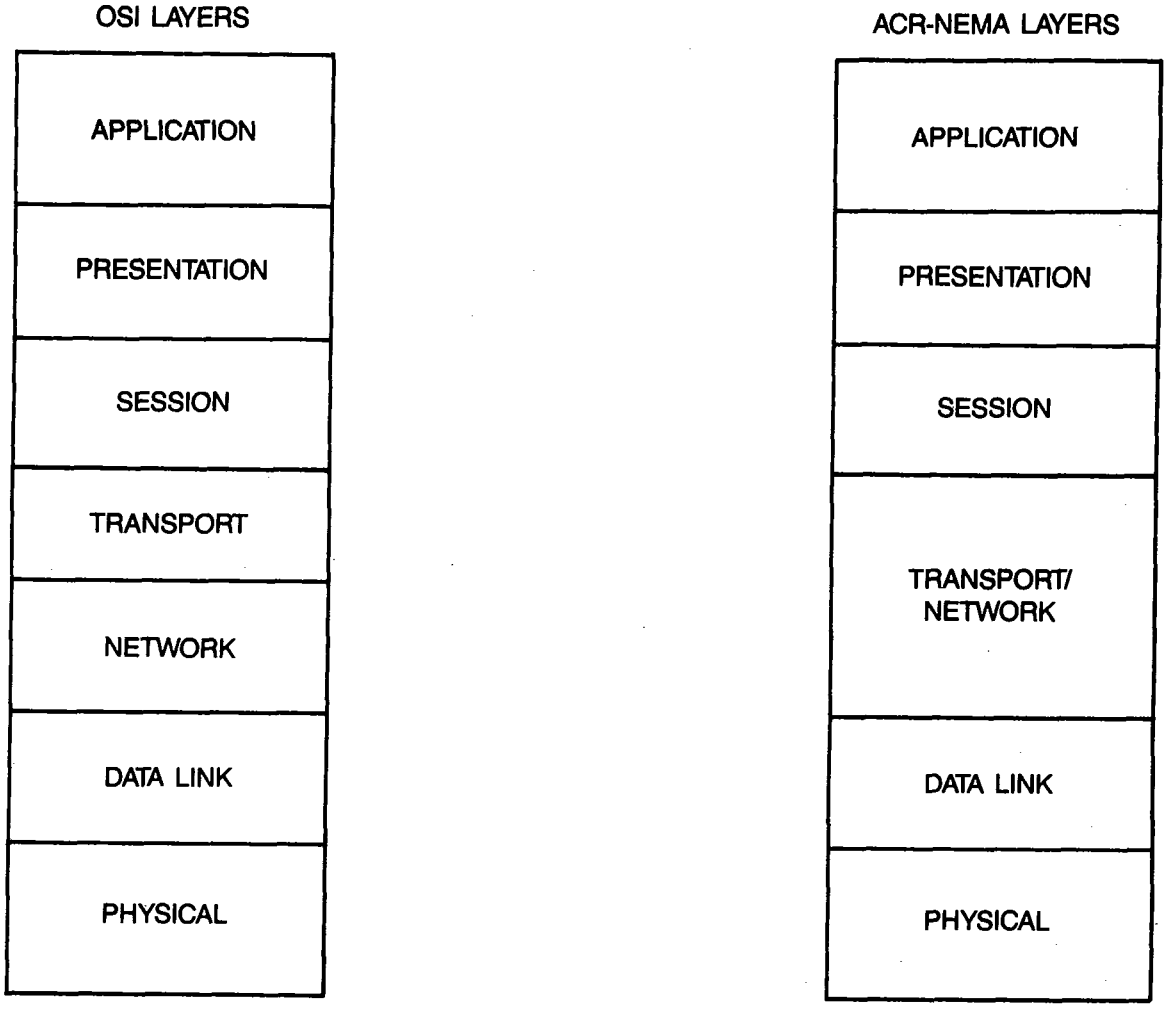

Figure 2-4
COMPARISON OF OSI LAYERS AND ACR-NEMA LAYERS

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Section 3
PERFORMANCE SPECIFICATIONS

3.1 INTRODUCTION

This section discusses the performance requirements for compatibility with the ACR-NEMA Standard interface. The specific functions to be implemented in hardware and software are described in Sections 4 through 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 7×10^{-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 is 8 Megabytes/second. The hardware interface may be capable of successfully operating at rates faster than the target rate. Asynchronous handshake protocols are 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.

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3.4 ENVIRONMENTAL SPECIFICATIONS

Environmental considerations are left to the individual manufacturers.

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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).

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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.

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

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 are contained within a message. This message is organized into groups representing the general categories of information. Each group is further subdivided into related data elements.

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

Twenty-four groups that have been defined are listed in Table 4-1, and they 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.

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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.

All groups shall be formatted in the same way.

Each group shall appear at most once within a message.

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

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

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.

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

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Please see 4.9.

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Odd numbered groups with a group number that 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 4.9. 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.

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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.

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All groups other than 0000H and 0001H are defined as data groups and the data groups collectively are defined as the data set.

NEMA Standard 7-13-1988.

4.4 DATA SET TYPES

Various data set types are defined by the groups they contain. For a given data set type, groups are 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.

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In addition to the data sets shown in Table 4-2, three additional data set types are 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.

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.

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

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

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

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. It shall be used when the command group (group 0000H) and its shadow group, if present, are the only groups in the message.

NEMA Standard 7-13-1988.

4.5 DATA ELEMENTS

Each group is subdivided into data elements that 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 that are not identified in Section 10 shall be reserved for future use.

NEMA Standard 10-16-1985.

In group 000H, data elements numbered from 5000H-5FFFH are reserved for device control data. These have special meaning when received as part of a MOVE Command. See 6.2.1.1.

NEMA Standard 9-27-1988.

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.

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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.

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4.7.1 ASCII Values

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

If an element is represented with an ASCII value, characters 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. 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 that 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).

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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.

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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.

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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).

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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).

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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.

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.

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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 SHADOW GROUPS

It is possible that several manufacturers and users may define elements within the same odd numbered group. To avoid conflicts when data sets are shared, a scheme for allocating sets of elements within each odd numbered group shall be used.

In each odd numbered group except the Command Information Shadow Group (Group 1), a fixed block of data element numbers (0010H–00FFH) shall be reserved to identify the ownership of sets of data elements within that group. Each identifier element shall be a type 1 free format (FF) single (S) ASCII string (AT) that contains a manufacturer or user defined identification code.

By inserting an identification code in the first available identifier element, a manufacturer or user, shall reserve a set of data elements within the specified group. The following reservation rules shall apply.

- Element 0010H identifies the manufacturer reserving elements 1000H–10FFH, Element 0011H identifies the manufacturer reserving elements 1100H–11FFH, and so on until element 007FH that identifies the manufacturer reserving elements 7F00H–7FFFH.
- Element 0080H identifies the user reserving elements 8000H–80FFH, Element 0081H identifies the user reserving elements 8100H–81FFH, and so on until element 00FFH, which identifies the user reserving elements FF00H–FFFFH.
- Elements within a set shall be numbered sequentially from xx00H–xxFFH. The actual element number in the message shall be determined by mapping the element number of the identifier to replace xx.

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- For odd numbered groups the combination of group number, data element number, and manufacturer or user identification code determine the unique representation of the associated value.

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4.10 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 that provides for end-to-end communication capability between two pieces of imaging equipment
0008	Identifying	Information that 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 (odd numbered)
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

*At least one of these groups must be present.

Refer to 4.4 for description of private data set types.

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Section 5
MESSAGE CONTENT

5.1 INTRODUCTION AND OVERVIEW

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

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).

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.

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Images shall be arranged and identified in a hierarchical grouping as specified in data element Original Image Identification (0020H,5000H).

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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.

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,0200H).

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 levels as specified in data element Original Image Identification (0020H,5000H). This element contains an ordered list of group and element numbers. These group and element numbers specify the data element used to identify the image. The choice of elements used is implementation specific. This is a Type 2D data element. The default is to identify images in a six level hierarchy: Station ID (0008H,1010H) (most inclusive), Study Date (0008H, 0020H), Study (0020H,0010H), Series (0020H,0020H), Acquisition (0020H,5000H), and Image (0020H,5000H) (least inclusive). If an implementation chooses to use other data elements or a different number of levels, they must be specified in data element (0020H,5000H). All data elements used to identify an image must be included with the image. If, for a particular image, any of these data elements is not used, its value shall be set equal to 1.

Since specific implementations may label the hierarchical levels differently than given in this standard, a means is included to indicate the labels used by the device that generated the original image. The data element Original Image Identification Nomenclature (0020H, 5002H) is used for this. This element contains an ordered list of ASCII strings identifying the names associated with the elements in (0020H,5000H).

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Two related problems are addressed by the hierarchical level specification: description of the sender's directory structure and unique identification of the image. The set of elements included in the relationship descriptor, when considered in the specific order, should provide sufficient information to permit the receiver to resolve these two problems.

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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 depends 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.

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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 have been combined into one image.

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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 standard it is assumed that the default hierarchy given in data element Original Image Identification (0020H,5000H) is used. It is further assumed that devices generating images assign a study number that does not repeat during a single day. Thus an original image may be uniquely identified by:

Station ID	(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 identifying information of the mask image shall be given in Masking Image (0020H,0080H). The contents of this field shall be an ordered list of the values of the data elements specified in Original Image Identification (0020H,5000H). These values shall be separated by the character \ .

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

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5.2.2.3 COMPOSITE IMAGE IDENTIFICATION

Composite images must contain the following elements, which shall be supplied by the device forming the composite:

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

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 the values of the data elements specified in Original Image Identification (0020H,5000H) followed by Modifying Device ID \ Modified Image ID \ Modified Image Date. If the reference image is an original image, only the values specified by Original Image Identification (0020H,5000) shall be required. In that case the last three identifiers are sent as null (i.e., "Station ID \ Study Date \ Study \ Series \ Aquisition \ Image \ \ \ \". If the referenced image is a modified image, only the last three identifiers shall be required (i.e., "\ \ \ \ \ \ Modifying Device ID \ Modified Image ID \ Modified Image Date").

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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).

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 are 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.

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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.

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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.

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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.

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For example, in pixel data with 12 bits allocated, 12 bits stored and bit 11 designated as the high bit, four pixels are 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.

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 be placed in an overlay plane; no way of specifying overlay like information in this way is included.

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5.2.7 Image Geometry

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

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

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

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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.

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5.2.9 Display Devices

Two data elements that are intended to be used for control of images being sent to a display device such as a work station or laser camera are defined in Chapter 10. These data elements are Message Set ID (0000H, 5010H) and End Message Set (0000H,5020H).

Display devices often work with multiple images. These data elements allow individual images to be grouped together, allowing display devices to associate multiple images with each other. A typical use of these elements would be to specify a group of images that are to be printed on a single film by a laser camera. Examples of using these data elements are given in Appendix I.

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5.3 OVERLAYS AND GRAPHICS

5.3.1 Definitions

An overlay plane shall contain graphics or text that 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.

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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.

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.

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 of 0 and 1 respectively.

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

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.

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

Please see 4.4 and Table 4-2.

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5.6 DISPLAY DEVICES

This standard contains elements to facilitate communication with display devices such as work stations and laser cameras.

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5.6.1 Message Set ID

Each message contains, at most, one image. Display devices often handle images in groups or sets. For example, a laser camera usually will print more than one image on each sheet of film.

The data element, Message Set ID, provides a means for the source of the images to indicate to the receiver that the image is part of a group of images. This is an optional element. However, if the element is used to identify one image as part of a group, the Standard requires that all images in that group be identified with the same Message Set ID.

It is expected that display devices will have a default protocol to handle images where Message Set ID is not present. One such protocol could be to assume that all images received from the same source, without an explicit Message Set ID, are part of the same group. Other default protocols are possible.

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5.6.2 Text Format ID

Printing text on an image is often necessary for proper interpretation. In the general case, it is complicated for a display device to extract text from the image header and display it on the image in the manner desired by the originator of the image or the user who must interpret the image. The data element Text Format ID provides a means for the source device to communicate the text format to the receiver. This element contains a label that specifies the format of the text for the image. In the general case, one or more specific text formats must be defined for both the source and receiver.

In cases where text formats have not been defined for both the source and receiver, three specific values for Text Format ID have been defined in the Standard. A value of "NONE" instructs the reciever to display the image without any additional text.

This would be used in the case where the source has already placed the text in the image or when no text is desired on the image.

In some implementations, full identifying text may be desired with each image. In this case, the source could specify "FULL" as the value of this data element. It is assumed that the display device will have some default rules for extracting information from the image header and displaying it on the image.

In other implementations, information that is common to all images on the page may be displayed only once. Examples of this information are patient name and patient ID. The source could insert "ABBREVIATED" as the value of Text Format ID to instruct the display device to extract only variable information and display it with each image. In this case, the display device would have a default protocol to extract the desired variable information and display it on each image. To display the common text information, the source could send an image that contains only the common text as a bit map.

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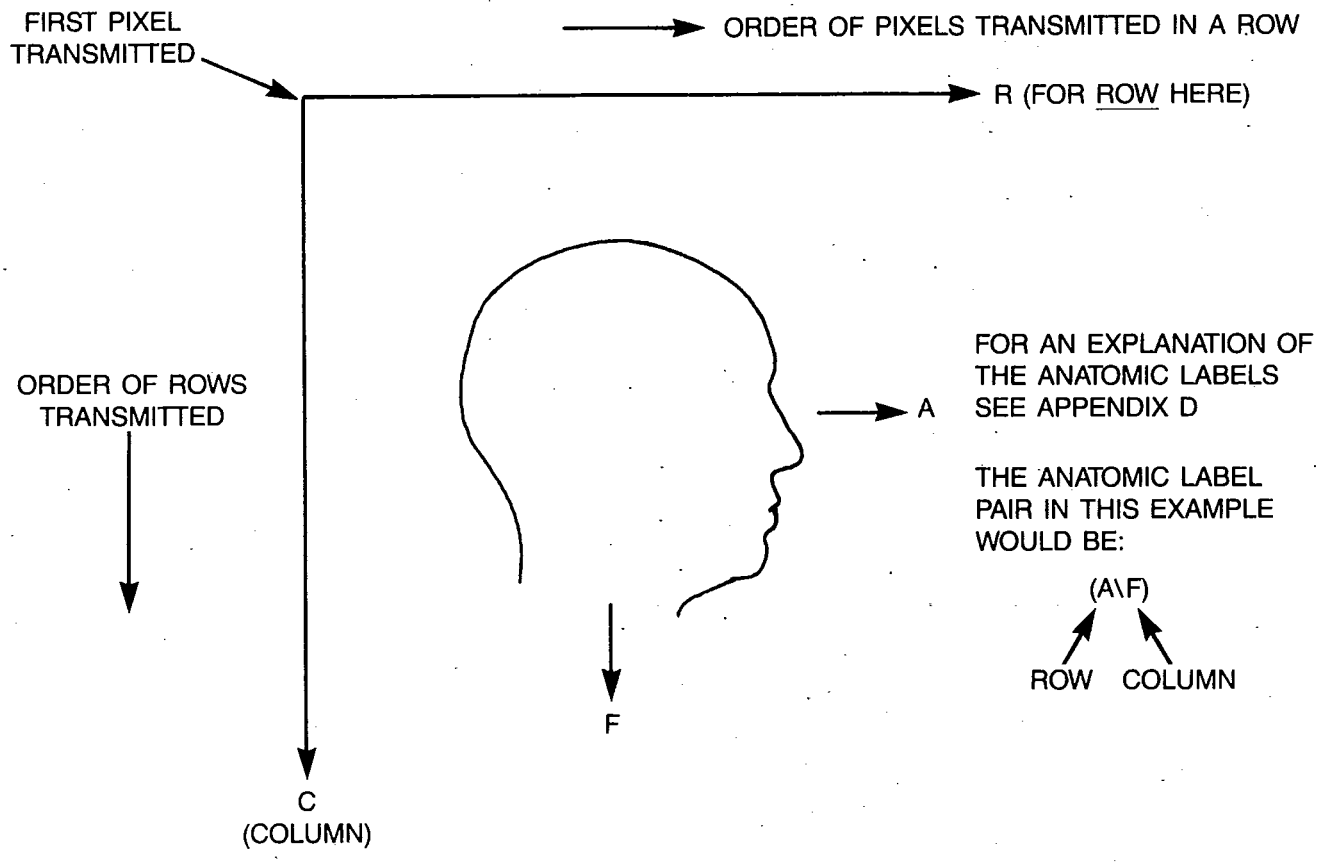

Figure 5-1
IMAGE COORDINATES

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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 Appendices B, G, H, and I.

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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 a zero value indicating no specific additional status information or a non-zero value containing more detailed status information.

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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.

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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.

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The data source (the device that has the data) shall initiate the SEND_REQUEST and must receive an indication of the results of the request. The SEND_RESPONSE is a distinct command issued by the SEND_REQUEST receiver. The SEND_RESPONSE must contain one of the status words as described in Tables 10-3 and 10-4. A successful response shall indicate that the message was successfully received by an imaging device. The interpretation of a successful response is implementation specific.

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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.

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6.2.1.1 SEND COMMAND TO DISPLAY DEVICES

The Data Dictionary (Section 10) contains several data elements intended to be used to send control information to a laser camera or other display device. Examples of using these data elements are given in Appendix I. All but one of these data elements are Type 3 (see 4.8). It is expected that at the time of installation, the display device will be set up with default values for its control features. For example, a data element (0000H,5160H) is provided to instruct to camera to print either clear or black borders between individual images on a page. A laser camera

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may be set up to print black borders as the default condition. If this data element is not present in any of the images to be printed on a page, the camera will print the page with black borders.

Implementation of display devices using this standard should provide a default value for the display device of each of the printer control data elements (0000H, 5110H–51B0H). It is expected that a SEND_REQUEST received by a display device will be able to be interpreted and displayed using defaults, even if none of the printer control data elements are contained in the message.

In the case that the display device receives control data elements, but cannot perform the function specified, the device should display the image using its default value for that function. The appropriate status code (Table 10-3) should be included in data element (0000H,0900H) of the SEND_RESPONSE. For example, if data element ADD GRAY SCALE (0000H,5150H) is received with an image, and the device does not have the capability to generate a gray scale as part of the image, the device should display the image without a gray scale and return status code B001 (Camera cannot respond to that command—print made using camera defaults) in the SEND_RESPONSE.

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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 that shall contain any matches found.

In order to describe the data that 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.

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.

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.

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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.

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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 that contain that element with the sought values shall cause a match.

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If a FIND_REQUEST contains a Type 3 element with only an * as its value, then a match shall be caused by data sets that 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.

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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., and
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.

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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.

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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 that 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.

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 single data set back to the request initiator. Two GET__RESPONSE messages are required. In the following description, device A initiates the GET__REQUEST and device B is the receiver of the GET__REQUEST.

In order to describe the data which are desired from device B (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. This set of data elements 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. Matches shall not be made against elements describing group length or message length.

After receiving the GET__REQUEST, device B shall respond with the first GET__RESPONSE. This GET__RESPONSE indicates successful receipt of the GET__REQUEST message by having Status = Pending. Device B shall search for data sets that have group element values that exactly match the elements in the GET__REQUEST message. If no exact matches are found, device B shall send the second GET__RESPONSE with status FAILURE.

The result of a successful GET__REQUEST command is SEND__REQUEST command from device B to device A. Even in the case that device B has more than one data set that matches the data in the GET__REQUEST, only one SEND__REQUEST is generated. It is the option of device B to choose which data set of multiple matches is sent. It is the option of device B to determine whether multiple matches exist or not.

Device B is permitted to send the first match found and discontinue the search.

The SEND__REQUEST resulting from a successful GET__REQUEST is the same as described in 6.2.1 except that it shall contain Message ID Being Responded To (0000H,0120H) field that shall contain the message ID of the original GET__REQUEST command. The SEND__RESPONSE is the same as described in 6.2.1.

After receiving the SEND__RESPONSE from device A, device B shall send the second GET__RESPONSE. This response indicates the status of the entire transaction.

NEMA Standard 7-13-1988.

Device A should know enough to uniquely specify a known, existing data set. The GET__REQUEST command should not be used as a network or system search command. The FIND__REQUEST command is provided for that purpose.

If device B provides information on the total number of matches found, it should be done using data element Number of Matches (0000H,0850H) in one or both of the GET__RESPONSE messages.

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6.2.4 MOVE Commands

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

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.

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.

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.

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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.

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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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6.2.4.1 MOVE COMMAND TO A DISPLAY DEVICE

When a MOVE command is received and the message contains any of the device control data elements (0000H, 5000H−5FFFH), these data elements shall be copied into the resulting SEND__REQUEST. If these data elements are present, it is assumed that the receiver of the SEND__REQUEST is a display device that will use these data elements for control or formatting of the images.

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Display device control elements are contained in Group 0000H. This is appropriate most of the time, since these elements are transitory and normally would not be stored with an image, say in an archive. In the case when the image is later MOVEd to a display device, new control elements may be desired. They are provided by placing them in Group 0000H of the MOVE__REQUEST.

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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.

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) that must be operating in the equipment specified as receiver in data element (0000H,0300H). The request receiver must respond with a DIALOG__RESPONSE command that contains Status (0000H,0900H) indicating Success or Failed for the specified reason code (see Section 10).

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).

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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.

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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.

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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.

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

All equipment that supports DIALOG shall include a default DIALOG receiver that 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.

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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 that its service software sends to the initiator using the protocols defined in Section 9.

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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.

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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 that 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.

A CANCEL__REQUEST shall have meaning only when initiated by a device that 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 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.

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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.

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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.

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__REPONSE 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.

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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 currently have the resources to complete the function implied by the command request; or
- success.

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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).

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.

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 currently 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.

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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.

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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.

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

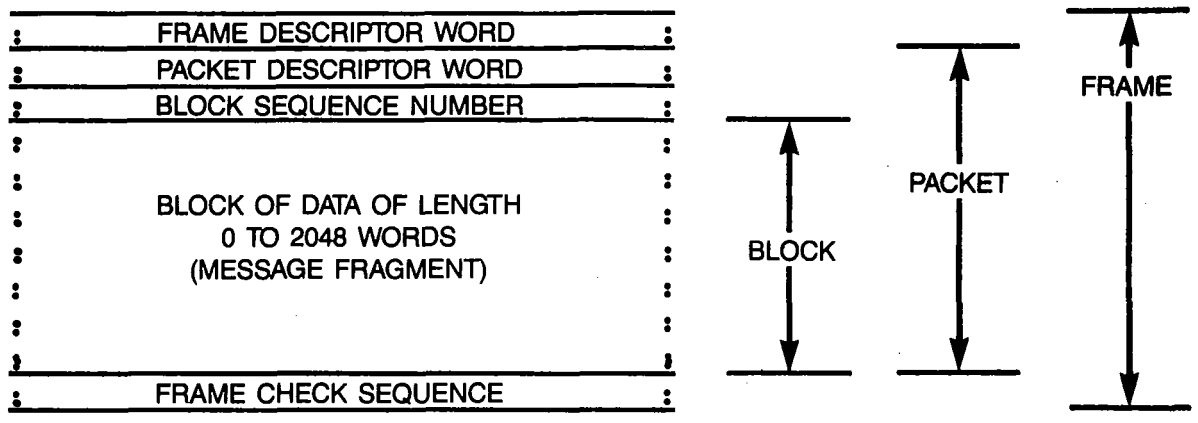

Figure 7-1
GENERAL FRAME STRUCTURE

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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.

Each frame of a message has 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.

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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.

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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 7-4. The parity signal shall be asserted if and only if an even number of data signal lines are asserted, thus providing odd parity.

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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 specifications 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 receiver 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 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 consists of sixteen bi-directional data lines plus one bi-directional parity line, and six 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 is described in terms of a transition sequences state model that uses the control circuit states to specify the protocol states (i.e., the transition labels from state to state are not events that a state machine must sense to move from state to state). The states as defined by the control circuits refer to the states of these lines at the interface connector to a cable, and not to states in a state machine implementation of the protocol. Thus the state sequence could be verified by a logic analyzer attached to the connector.

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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

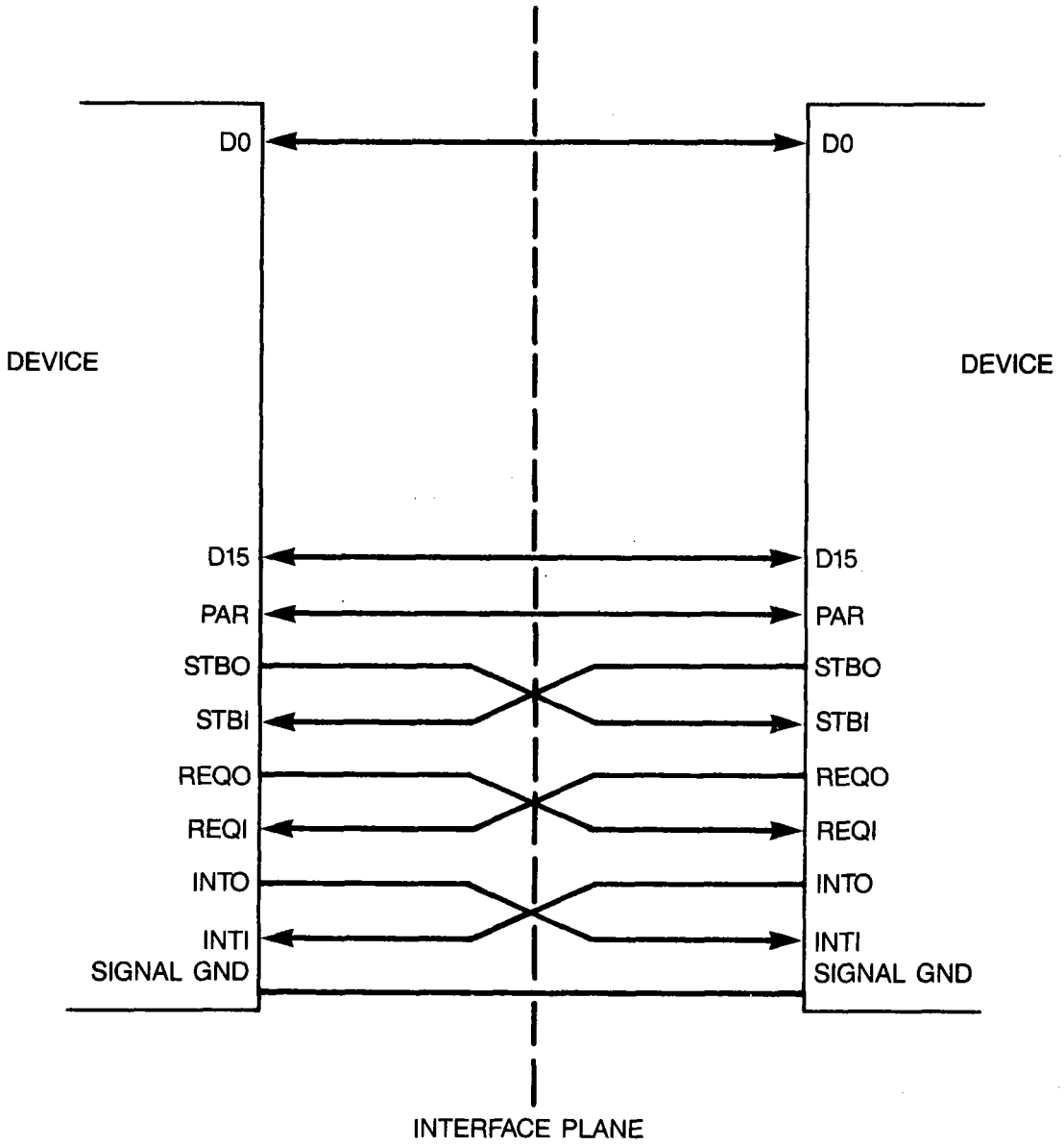

Figure 7-2
PHYSICAL AND LOGICAL INTERFACE

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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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The state diagram for signals at the connector should be interpreted with reference to the timing diagram of Figure 7-5. Both timing and control signal states are referenced to the interface connector. Signal delays from long connecting cables will cause slower traversal of protocol state sequences. The timing diagram specifies a minimum delay of ten microseconds between the non-assertion of REQO by a sender and the re-assertion of REQO for a next frame to allow reaction and arbitration time for the receiver. The receiver need not wait this interval to arbitrate for the interface.

The RELEASE state of Figure 7-6 is a transition state in which one device has released its control signals and the other side has not. The second device will pass directly to IDLE when its control signals are released.

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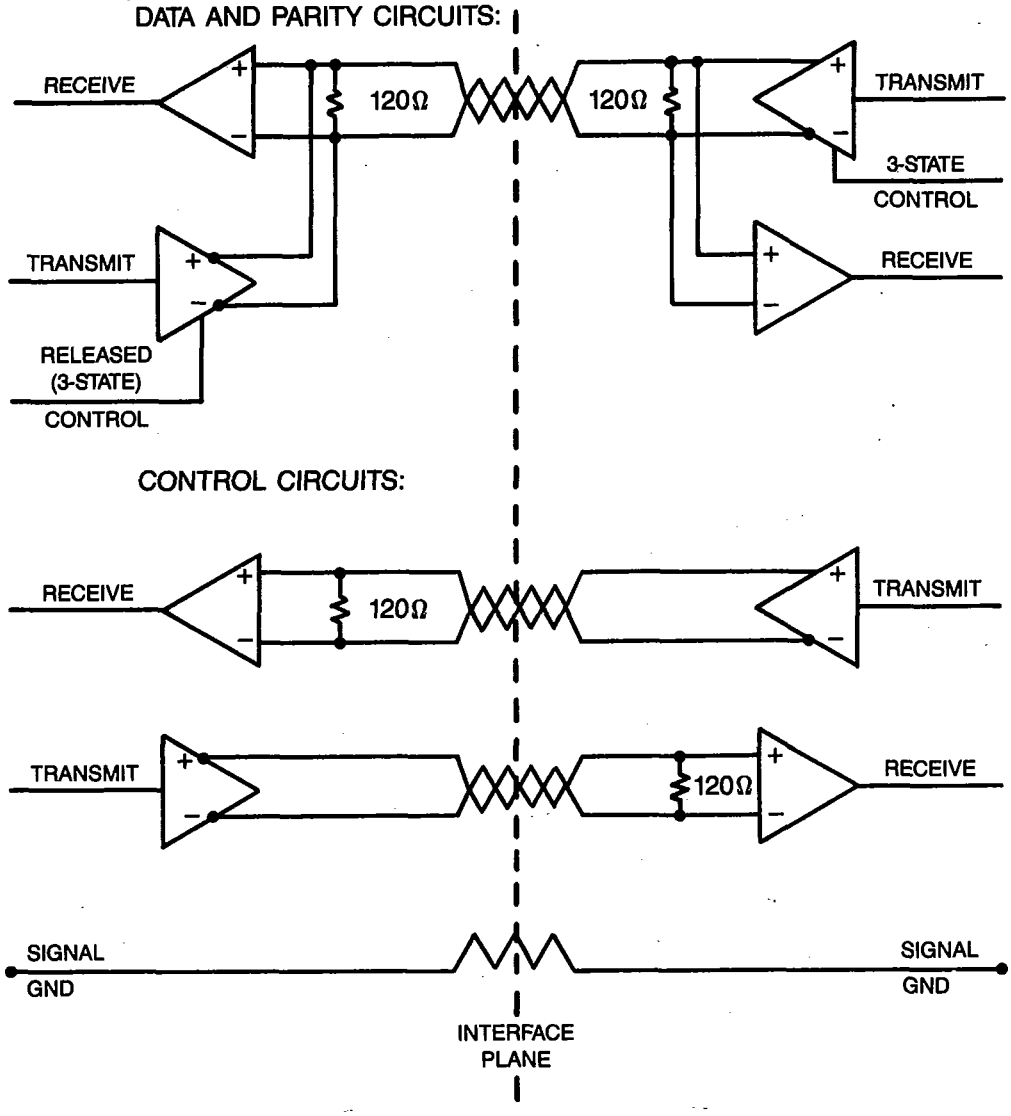

Figure 7-3
TYPICAL INTERFACE CIRCUIT

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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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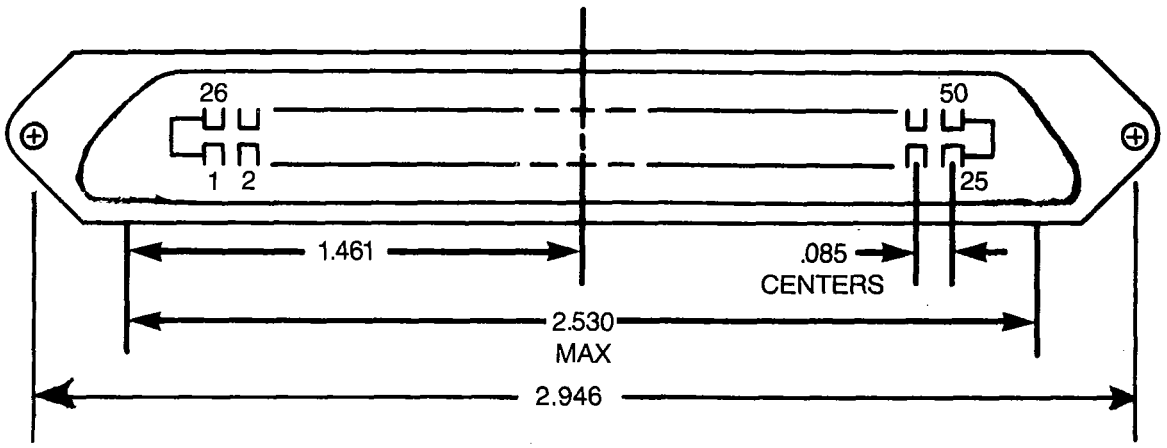

Figure 7-4

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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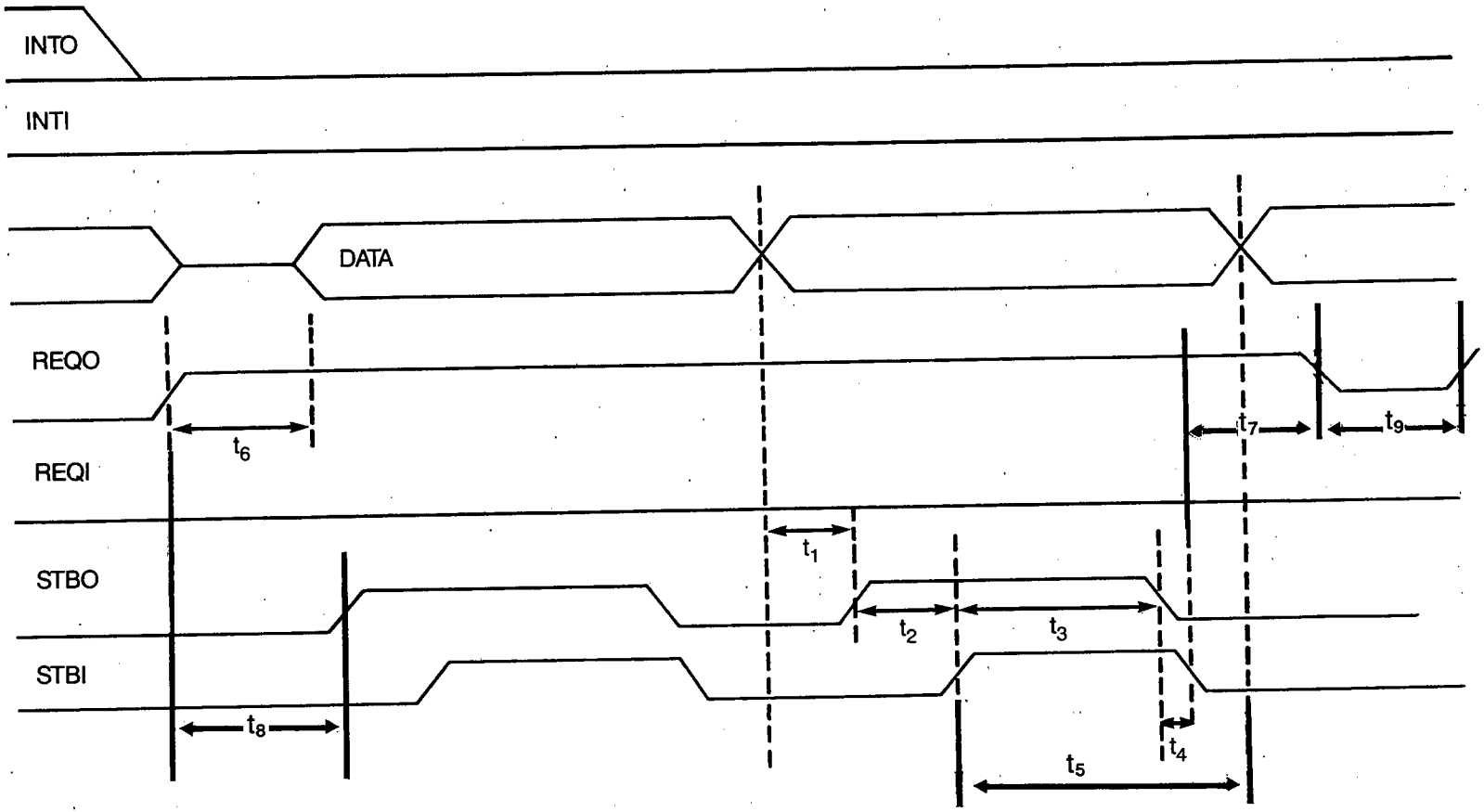
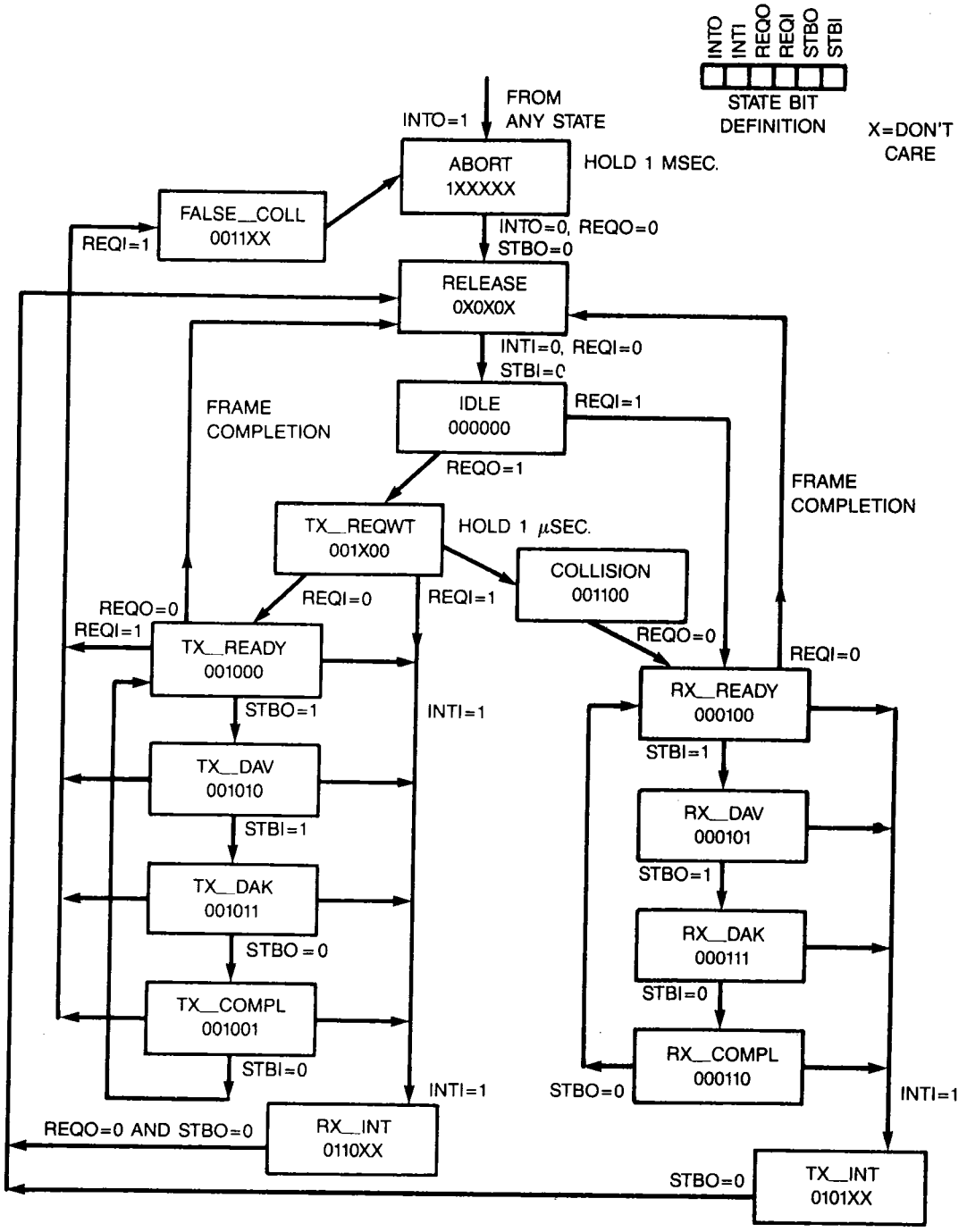


REF	PARAMETER	TIMING MIN	MAX
t_1	DATA SET UP TO LEADING EDGE OF STBO	70 nanoseconds	1 second
t_2	LEADING EDGE OF STBO TO LEADING EDGE OF STBI	0 nanoseconds	1 second
t_3	LEADING EDGE OF STBI TO TRAILING EDGE OF STBO	0 nanoseconds	1 second
t_4	TRAILING EDGE OF STBO TO TRAILING EDGE OF STBI	0 nanoseconds	1 second
t_5	LEADING EDGE OF STBI TO DATA CHANGING	0 nanoseconds	
t_6	COLLISION ARBITRATION WINDOW	750 nanoseconds	1250 nanoseconds
t_7	TRAILING EDGE OF STBI TO TRAILING EDGE OF REQO	0 nanoseconds	1 second
t_8	LEADING EDGE OF REQO TO LEADING EDGE OF STBO	t_6 ns + 70 nanoseconds	1 second
t_9	TRAILING EDGE OF REQO TO LEADING EDGE OF REQO	10 microseconds	

Figure 7-5

TIMING DIAGRAM FOR SENDING DATA (revised illustration)



(revised illustration)

Figure 7-6
PHYSICAL PROTOCAL 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 that 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 that 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 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 millisecond, then non-asserted. STBO and REQO shall be non-asserted during INTO assertion.
INTI	Interrupt In. An input signal that 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 that 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 inter-layer (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.

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8.2 DATA LINK PROTOCOL

All data sent across the interface are 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

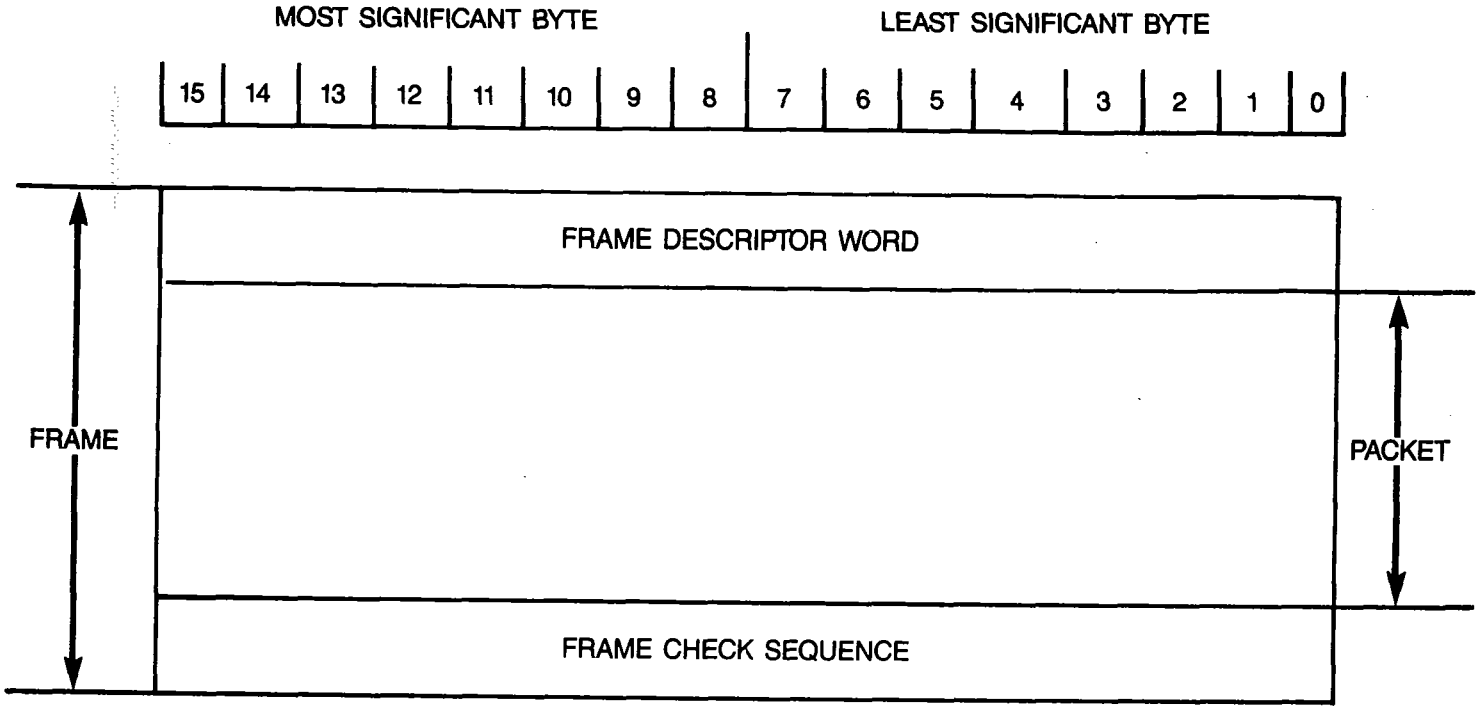

Figure 8-1
FRAME STRUCTURE

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is shown in Figure 8-3. Flow control and exception handling are specified in 8.6.2 and 8.7.2, respectively.
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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.
NEMA Standard 10-16-1985.

Table 8-1
FRAME DESCRIPTOR WORD SUMMARY

NAME	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	

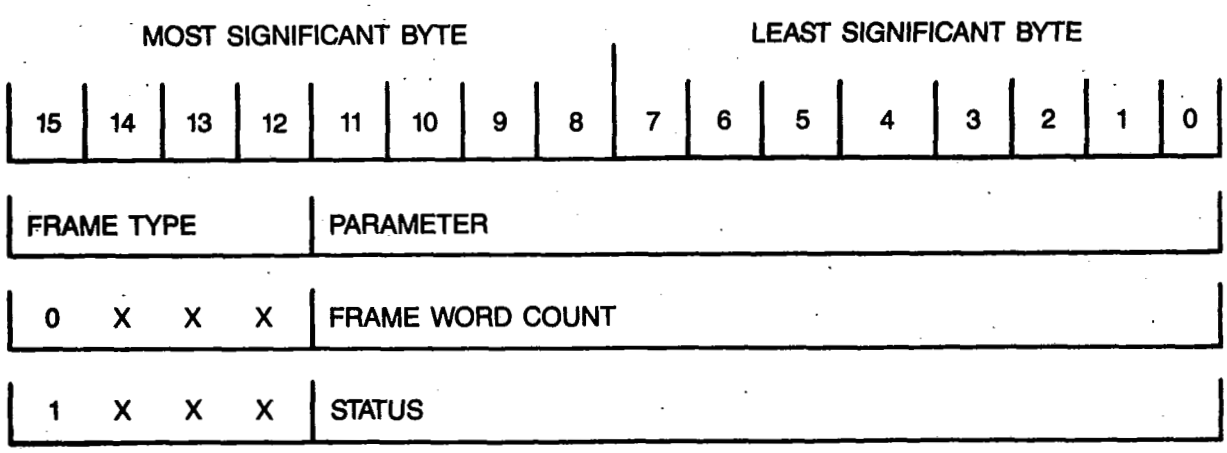

Figure 8-2
FRAME DESCRIPTOR WORD

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Table 8-2
FRAME TYPES, CODES, AND DEFINITIONS

NAME	CODE	DESCRIPTION
DATA	0000	A frame that 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 that 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 that 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 that 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.
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 that 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 that contains a packet that was received in an ECHO request frame. The parameter field shall contain the total word count.

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FRAME SEQUENCES UNDER NORMAL CONDITIONS

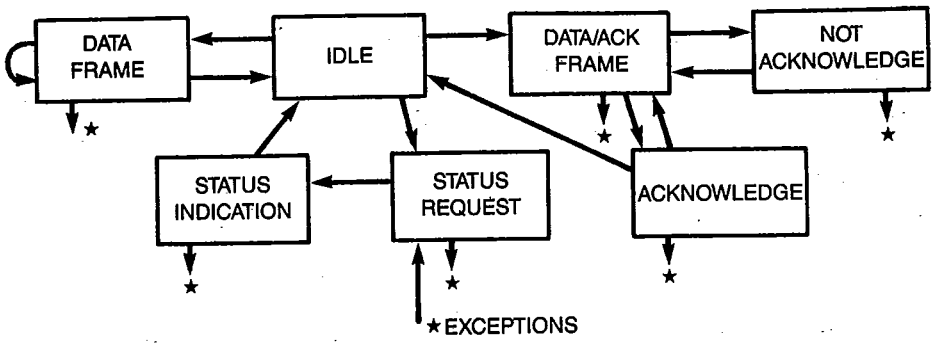

DIAGRAM OF ALLOWED STATE SEQUENCES

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
DATA LINK PROTOCOL STATE DIAGRAMS

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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.

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The physical protocol (see 7.3) specifies 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.

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 with 2048 data 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.

Authorized Engineering Information 10-16-1985.

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.

This standard only requires error detection.

NEMA Standard 10-16-1985.

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; waiting for ACK
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	Interface not serviced
0 0 0 0 0 0 0 0 0 0 0 0	No errors, interface available

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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 that 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 accurately 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 0 to 2048 words.

NEMA Standard 10-16-1985.

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.

NEMA Standard 10-16-1985.

8.3.2.2 DEFAULT CHANNEL NUMBERS

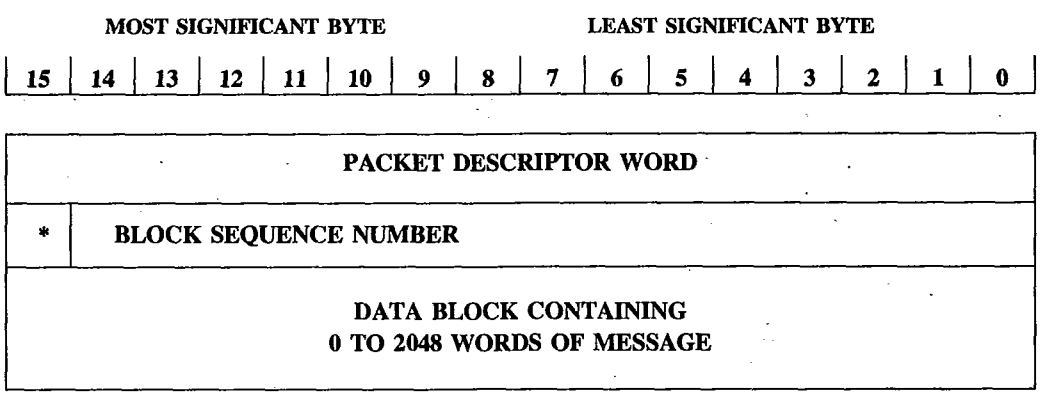
All implementations of this interface shall support channel number 0 (zero) for exchanging packets.

NEMA Standard 10-16-1985.

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.

PREVIOUS PACKET SENT ON CHANNEL



*Last block flag field

Figure 8-4
DATA PACKET STRUCTURE

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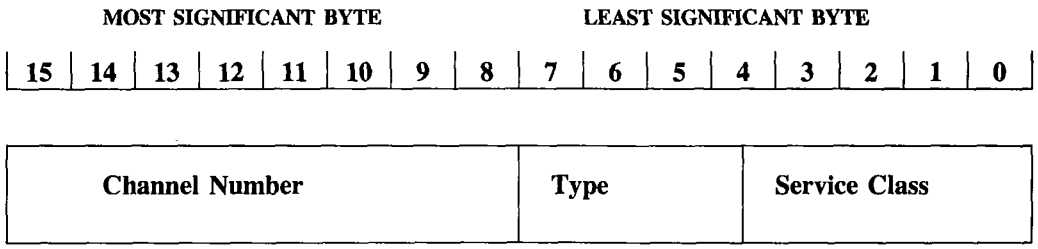

Figure 8-5
PACKET DESCRIPTOR WORD FIELDS

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.
0100	Open Channel Indication (OCI). This is the acknewledge 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 be sent by the receiver to the sender to halt data transmission on the specfied channel until a Resume Request is received 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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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.

NEMA Standard 10-16-1985.

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.

NEXT PACKET SENT ON CHANNEL*

PREVIOUS PACKET SENT ON CHANNEL*	RCR	RCI	CCR	CCI	OCR	OCI	CMD	DATA	PAUSE	RESUME
RCR		Honor RCR	Refuse RCR							
RCI	Send RCR		Send CCR				Send CMD Packet	Send DATA Packet		
CCR			CCR (exception)	Honor CCR						
CCI			CCR (exception)		Send OCR					
OCR			Refuse OCR			Honor OCR				
OCI	Send RCR		Send CCR				Send CMD Packet	Send DATA Packet		
CMD	Send RCR		Send CCR				Send CMD Packet	Send DATA Packet	Request PAUSE	
DATA	Send RCR		Send CCR				Send CMD Packet	Send DATA Packet	Request PAUSE	
PAUSE	Send RCR		Send CCR							Request RESUME
RESUME	Send RCR		Send CCR				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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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 for each succeeding block (fragment) of the message segment.

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 that 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.

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.

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.

NEMA Standard 10-16-1985.

Table 8-5
SERVICE CLASS 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.

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

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.

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.

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.

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 that uses this interface may be performing multiple tasks, and an external network may be involved, a protocol is needed to establish end-to-end message connections using virtual channels. This connection function is handled by the rudimentary 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 is 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 responds 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 conveys 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.

NEMA Standard 10-16-1985.

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: Destination Logical Address, Destination Network Address, Source Logical Address, and Source Network Address. Each set of addresses is eight 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.

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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

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 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. The packet will also contain the destination and source data from the Connect Request packet (with source and destination interchanged).
1010	Disconnnect 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 set 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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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 Address 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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The destination fields will always refer to the receiver of the packet, and the source fields to the sender. This means that the source fields of a Connect Request packet will be used as the destination fields of the answering Connect Indication packet, and the source fields of the Connect Indication packet will be those of the sender.

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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.

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

This data may be maintained in a table in the equipment that 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.

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.

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 9.2.

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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 that 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.

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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 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 that 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.

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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.

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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.

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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 is 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.

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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.

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 that "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.

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

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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 also can 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.

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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 also will instruct that actions be initiated at this or lower layers.

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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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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 IEs.

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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/ACK service
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

Note that the channel control packets can be sent as DATA frames while requesting that the service class used for the message will be Data/ACK service. The channel control packets establish a connection on virtual channels and are not part of the messages that will be carried on it.

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/ACK service
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.

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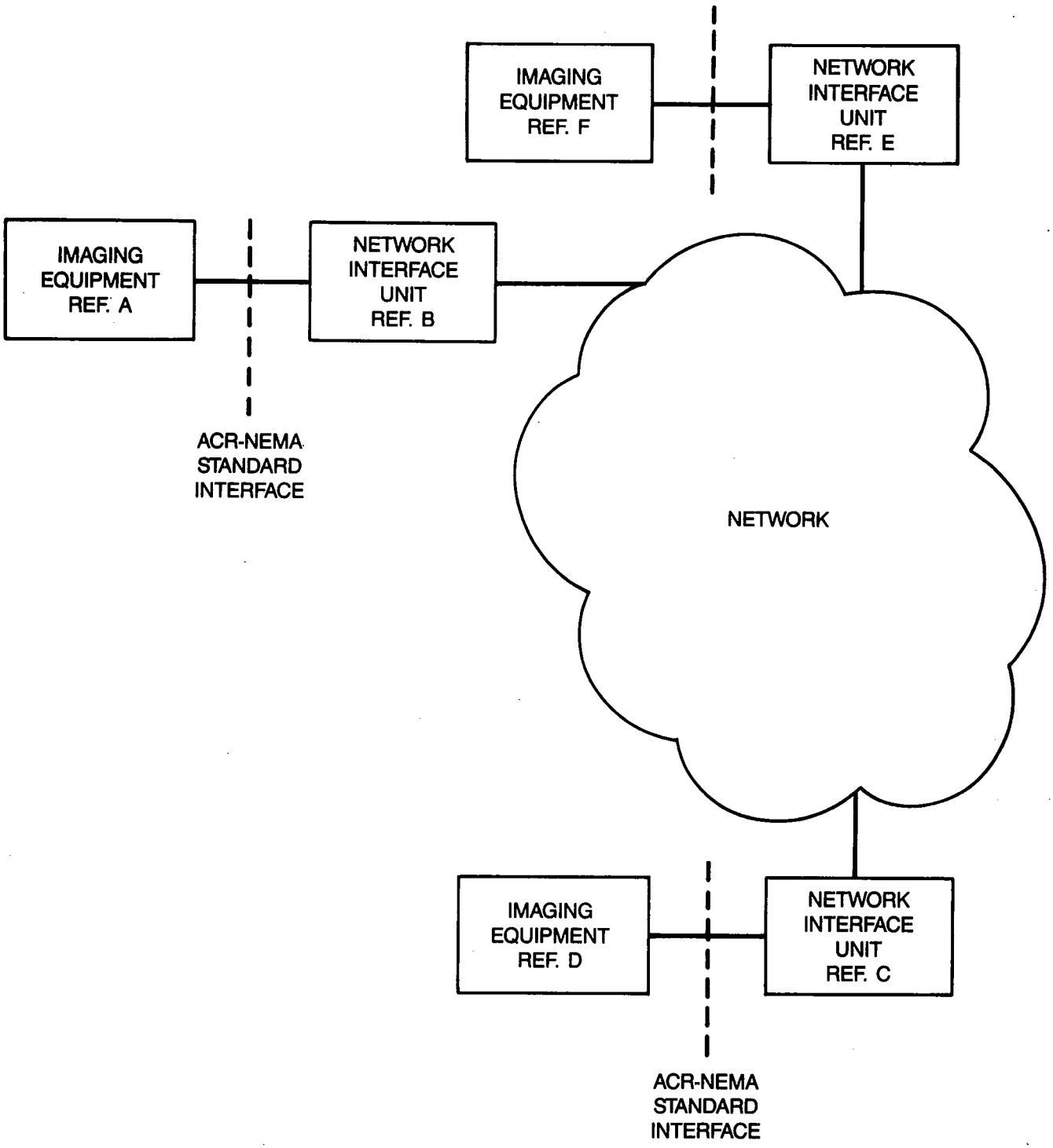

Figure 9-1
INTERFACE MODEL

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

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 accommodate the many steps required to establish a "virtual connection" across the network. It may be desirable for the timeout interval to be a parameter that 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 frame 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 frame 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 frames 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/ACK 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/ACK service
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 in 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 is 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 are 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 is 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 is delivered through 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 are sent to dissolve the connection and channel. A Disconnect Indication and Close Channel Response are 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 are received as a series of Data packets, which are numbered, with the last packet having the last block flag set. The data are routed to the 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 sends a Reset Channel Request or a Close Channel Request packet. A Reset Channel Indication or a Close Channel Indication is received before the channel is reset or closed. The abrupt method means a lower layer (i.e., Transport/Network Layer) issues the Close Channel Request and then notifies the Session Layer services that a close process is now in motion. Closing a channel disconnects 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. The Session Layer 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 that 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
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 =Connect Indication
DATA + 1 - DATA + 8 = Destination Logical Address (NI)
DATA + 9 - DATA + 16 = Destination Network Address (5)
DATA + 17 - DATA + 24 = Source Logical Address (Archive 3)
DATA + 25 - DATA + 32 = Source Network Address (31)
FCS

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

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

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 name of 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 that 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. 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) should

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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 ELEMENTS (See 4.8)

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

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 decimal point explicitly present.

When ASCII enumerated values (EV), defined format values (DF), or defaults are shown in the element descriptions, padding spaces (if needed) are not shown. However, any necessary padding shall be included in actual messages and datasets.

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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 2.0
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 that 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 Destination	AT	FF	S	*		Logical address being sent to, assigned by site.
0000	0700	Priority	BI	HX	S	1D	Normal	NORMAL = 0000 Other values are implementation specific.

(Continued)

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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	0101	Data type of this message. IMAGE = 0000 GRAPHICS= 0002 TEXT = 0003 OTHER = 0100 NULL = 0101 IDENTIFIER = 0102 PRIVATE IMAGE = 8000 PRIVATE GRAPHICS = 8002 PRIVATE TEXT = 8003
0000	0850	Number of Matches	BI	HX	S	*	0001	Number of matches found.
0000	0860	Response Sequence Number	BI	HX	S	*	0000	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."
0000	5010	Message Set ID	AT	FF	S	3		A label that identifies each image that is a part of a group of images. Since devices may support multiple sets simultaneously, this label must be unique. It is recommended that INITIATOR (0000,0200) be included as part of this label. If an image set is open all images sent for that set must contain the appropriate ID. If an ID is not present, device defaults will be used. One use of this data element is to identify images being sent to a laser camera or other display device.

*See Table 10-2.

(Continued)

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GROUP 0000
COMMAND INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	DEFINITION
0000	5020	End Message ID	AT	EV	S	3		"NORMAL" instructs the receiver to end the current MESSAGE SET. When this element is sent to a display device such as a laser camera, it will indicate that the camera is to print any images on a partial page including the image contained in this message, if any. "ABORT", when used with a laser camera, instructs the device to close the current MESSAGE SET, not to print any partial page and abort any pages now being printed after the current page is completed. With other devices, the use of ABORT in this data element is implementation specific.
0000	5110	Display Format	AT	FF	S	3		A label that defines the page format. All devices using this element shall support integer values that specify the number of equal size images per page. Values other than integers shall specify special formats predefined for both sender and receiver. If multiple page sizes are supported by the device, this ID will be used to identify the desired page size. Integer values will use the camera default page size.
0000	5120	Page Position ID	AT	FF	S	3		A label that identifies the position of the image within the format. Integer values shall specifiy the order of images from left to right, then top to bottom when associated with integer values of element (0000H,5110H). Other special formats must be predefined for both sender and receiver.

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GROUP 0000
COMMAND INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VM	VT	TYPE	DEFAULT	DEFINITION
0000	5130	Text Format ID	AT	FF	S	3		A label that defines the format for printing text on the image. The meaning of this element must be predefined for both the sender and receiver. A value of "NONE" will indicate that no text is to be added to the printed image. A value of "FULL" will indicate the use of full text with the image. A value of "ABBREVIATED" will indicate minimum text. The meaning of "FULL" and "ABBREVIATED" shall be implementation specific.
0000	5140	Nor/Rev	AT	EV	S	3		"NORMAL" instructs the device to print the image in the normal tone scale as determined by the window/level values or the lookup table transmitted with the image. "REVERSE" instructs the device to print the image with reverse tone scale.
0000	5150	Add Gray Scale	AT	EV	S	3		"Y" instructs the device to add a gray scale to the image. "N" instructs the device not to add a gray scale to the image.
0000	5160	Borders	AT	EV	S	3		"BLACK" instructs the device to print the borders between images at maximum density. "CLEAR" instructs the device to print borders at minimum density. "OTHER" instructs the device to print borders at all intermediate density which must be defined for the device.
0000	5170	Copies	AN	DF	S	3		The number (integer) in the value field indicates the number of copies to be made for the current page.

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GROUP 0000
COMMAND INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	DEFINITION
0000	5180	Magnification Type	AT	FF	S	3		In many cases, a laser camera will increase the number of pixels in the image before printing to make the printed image the desired size. The value in this element will indicate the type of magnification that is to be used. Two specific values are defined. Others are permitted and are implementation specific. "NEIGHBOR" instructs the camera to increase the number of pixels by calculating new pixel values based on more than one neighboring original pixel. "REPLICATE" instructs the camera to increase the number of pixels based on a single original pixel.
0000	5190	Erase	AT	FF	M	3		A list of PAGE POSITION IDs. Instructs the printer to "erase" the images in these positions. A value of "ALL" instructs the device to "erase" the entire current page. A value of "LAST" instructs the device to erase the most recently stored image.
0000	51A0	Print	AT	EV	S	3		Instructs a laser camera to print the current page of images. The message set remains open. After printing, the camera shall be permitted to delete the images from its memory. The single allowed enumerated value is "PRINT".
0000	51B0	Overlays	BI	EV	M	2D	No Overlays	A list of group members (which are present in this message) that describe overlay planes that are to be printed on the image. See 5.3

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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 2.0
0008	0020	Study Date	AT	DF	S	2								The date on which the study started. The format is yyyy.mm.dd; e.g., 1984.07.18
0008	0021	Series Date	AT	DF	S	3								The date on which the series started. The format is yyyy.mm.dd.
0008	0022	Acquisition Date	AT	DF	S	3								The date on which the acquisition started. The format is yyyy.mm.dd.
0008	0023	Image Date	AT	DF	S	3								The date on which reconstruction of this image started. The format is yyyy.mm.dd.
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	0031	Series Time	AT	DF	S	3								The time the series started. The format is hh:mm:ss.frac (24 hour time).
0008	0032	Aquisition Time	AT	DF	S	3								The time the acquisition started. The format is hh:mm:ss.frac (24 hour time).
0008	0033	Image Time	AT	DF	S	3								The time at which reconstruction of this image started. The format is hh:mm:ss.frac (24 hour time)
0008	0040	Data Set Type	BI	EV	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.

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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	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 that generated the digital image.
0008	1030	Procedure Description	AT	FF	S	3								Description of the study, e.g., CPT terminology or code.
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 IDs	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	FF	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	BDHX	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	3								Number of times a given pulse sequence is repeated before any parameter is changed. Number of frames averaged in Ultrasound.
0018	0084	Imaging Frequency	AN	FF	S					2				Precession frequency in MHz of the nucleus being addressed.

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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	0085	Imaged Nucleus	AT	FF	S				2					Nucleus that is resonant at the imaging frequency; e.g. P31, H1.
0018	0086	Echo Number	AN	FF	M	3								The echo number used in generating this image.
0018	0090	Data Collection Diameter	AN	FF	S	3								The diameter in mm of the region over which data were collected.
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 that created image by digitizing film.
0018	1020	Software Version	AT	FF	S	3								Alphabetic and numeric representation of software that generated the image.
0018	1030	Protocol	AT	FF	S	3								Any identifier specific to the device or user that 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 ingredient 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			Time of x-ray exposure 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	Data Acquisition Duration	AN	FF	S				3					Elapsed time of data acquisition in minutes.
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 0018
AQUISITION INFORMATION (Continued)

GROUP #	ELEMENT #	NAME	VR	VT	VM	TYPE	DEFAULT	CT	NM	MR	DS	US	DR	DEFINITION
0018	5000	Output Power	AN	FF	S								3	Ultrasound output power (in dB).
0018	5010	Transducer Data	AT	FF	M								3	Used to describe ultrasound transducer used. Sent as type \ frequency \ focal length (e.g. Sector \ 3 MHz \ long).
0018	5020	Preprocessing Function	AT	FF	S								3	Code or description of preprocessing function used (if any).
0018	5021	Postprocessing Function	AT	FF	S								3	Code or description of postprocessing function used (if any).
0018	5030	Dynamic Range	AN	FF	S								3	The dynamic range used for the image, in dB.
0018	5040	Total Gain	AN	FF	S								3	The overall system gain used for the image.
0018	5050	Depth of Scan Field	AN	FF	S								3	The depth, in cm, from the transducer face to the deepest point included in the scan field.
0018	5100	Patient Position	AT	FF	S	3								Technique position descriptor (e.g., for radiography: prone, supine, right posterior oblique, etc.

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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	BD	HX	S	1								An even number of bytes from the end of the value field to the beginning of the next group.
0020	0010	Study	AT	FF	S	2								Study indentification that is used in labeling the image. May be assigned by the imaging device, generated by an external information system, or derived by some other means.
0020	0011	Series	AN	FF	S	2D	1							Part of a study; a set of logically related acquisitions.
0020	0012	Acquisition	AN	FF	S	2D	1							A single continuous gathering of data over a period of time.
0020	0013	Image	AN	FF	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	AT	EV	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 5.2 and appendix D.
0020	0030	Image Position	AN	FF	M			2	2	2				x,y,z coordinates in mm of the first pixel in the image. See coordinate system definition in 5.2.5.
0020	0035	Image Orientation	AN	FF	M		1\0\0\0\1\0	2D	2D	2D				Direction cosines of the R axis of the image system with respect to the equipment 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		An image 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 that are not planes, 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. Copy from (0020,5002).
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 that was used to define where or how this image was made, e.g., a localizer scan. See (0020,0030) and (0020, 0035). See 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 IDs	AT	DF	M	2D	No Composite							IDs of images that entered the composite. See 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	S	2D	Not a Modified Image							ID of device that modified image. See 5.2.
0020	3402	Modified Image ID	AT	FF	S	2D	Not a Modified Image							ID of modified image supplied by modifying device.
0020	3403	Modified Image Date	AT	DF	S	2D	Not a Modified Image							Date of image modification.
0020	3404	Modifying Device Manufacturer	AT	FF	S	2D	Not a Modified Image							Manufacturer of device that modified image.
0020	3405	Modified Image Time	AT	DF	S	2D	Not a Modified Image							Time image modified.
0020	3406	Modified Image Description	AT	FF	S	2D	Not a Modified Image							Description of image modification.
0020	4000	Comments	AT	FF	M	3								
0020	5000	Original Image Identification	BI	HX	M	2D	0008 1010 0008 0020 0020 0010 0020 0011 0020 0012 0020 0013							The ordered sets of Groups, that specify the structure used to uniquely identify the image.
0020	5002	Original Image Identification Nomenclature	AT	FF	M	2D	Station ID\ Study Date \ Study \ Series \ Aquisition \ Image							The ordered naming sets (follows 0020,5000) that specify the naming structure used to uniquely identify the image.

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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	0002							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	0016							Maximum number of bits allocated for any pixel. See 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	0001							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. See 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	AN	FF	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	AN	FF	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	AN	FF	M	3								The number DV to be displayed or used for standardized units (Hounsfield 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	AN	FF	M	3								m in the above equation.
0028	1080	Gray Scale	AT	EV	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	BI	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	M	1D	0001,0001							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	0000							The number of bits in each entry of (X,1200).
X	1101	Overlay Descriptor —Red	BI	HX	S	2D	0000							The number of bits in each entry of (X,1201).
X	1102	Overlay Descriptor —Green	BI	HX	S	2D	0000							The number of bits in each entry of (X,1202).
X	1103	Overlay Descriptor —Blue	BI	HX	S	2D	0000							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.
X	1201	Overlays —Red	BI	HX	M	2D	No table							
X	1202	Overlays —Green	BI	HX	M	2D	No table							

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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	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	VMTYPE	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	Number of Matches	Response Sequence Number	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.
	FF01	Camera out of film.
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.
	A600	Camera out of film.
	AFxx	No specified standard reason, i.e., none of the above.
Failed		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.
Warning	B000	The command was executed, despite an error being detected.
	B001	Camera cannot respond to that command—print made using camera defaults.
	B002	DISPLAY FORMAT ID not valid—image stored using last valid ID.
	B003	TEXT FORMAT ID not valid—image stored using last valid ID.
	B004	Page position already occupied—image stored in next default position.
	B005	Page position already occupied—previous image was deleted and the new image stored.
	BFxx	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
No Specific Reason	00	Unable to give specific reason.
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 does not adhere to its specified value multiplicity.
Missing Element	46	A required element (type 1 or 2) is missing.
Missing Group	47	A group that is required is missing.
Nonstandard Element	48	A nonstandard element is contained within a standard group.

(Continued)

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

NAME	CODE	DESCRIPTION
Wrong Receiver	49	Device receiving is not the device specified in the receiver data element.
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 Figures A-1A and A-1B can be used to measure the maximum transfer rate of the ACR-NEMA interface. The circuit should be constructed as close as possible to its male connector to minimize circuit 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-1A and A-1B. The capacitor C_2 should have good high frequency characteristics.

The test circuit shown in Figure A-1B can be used to measure the transfer rate of an ACR-NEMA interface with an attached cable. The control circuit connections are adjusted to reflect the crossed signal lines in the cable (See 7.2.3.3). This test circuit should have a female connector and may be used to test transfer rates with various cable lengths.

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 also should 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-1A and A-1B. 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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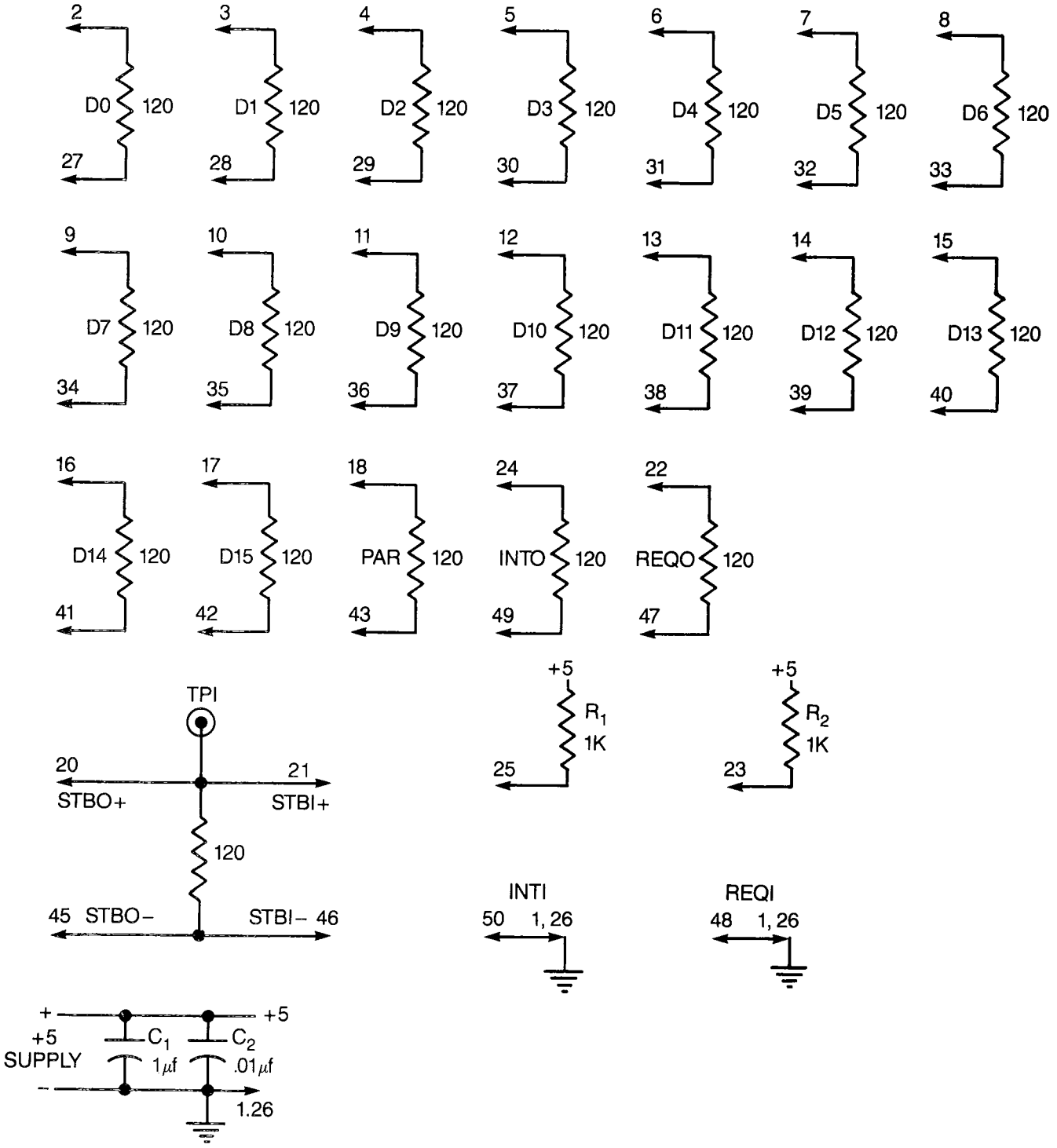

Figure A-1A
TEST CIRCUIT FOR NO CABLE WITH MALE CONNECTOR

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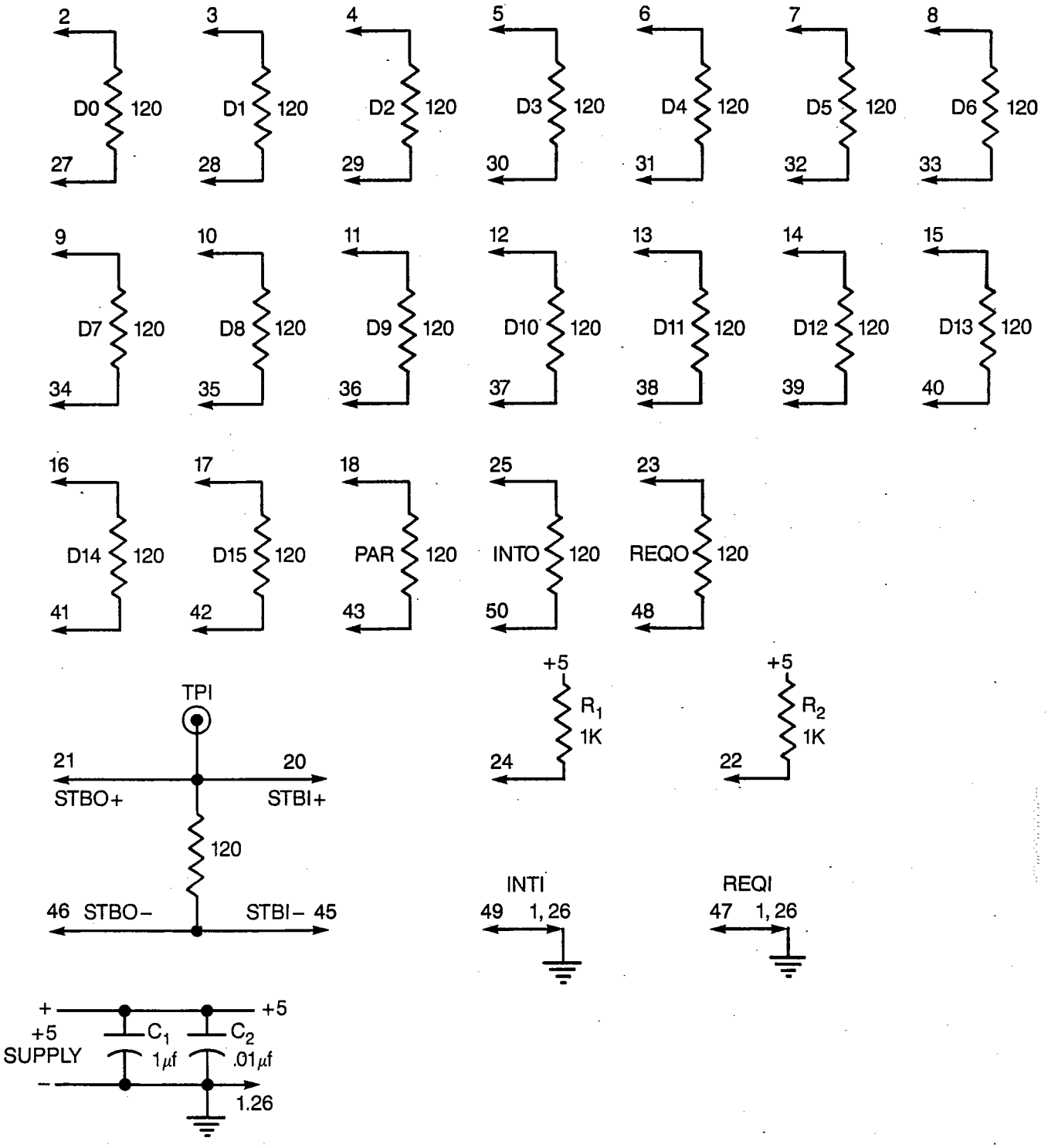

Figure A-1B
TEST CIRCUIT FOR CABLE WITH FEMALE CONNECTOR

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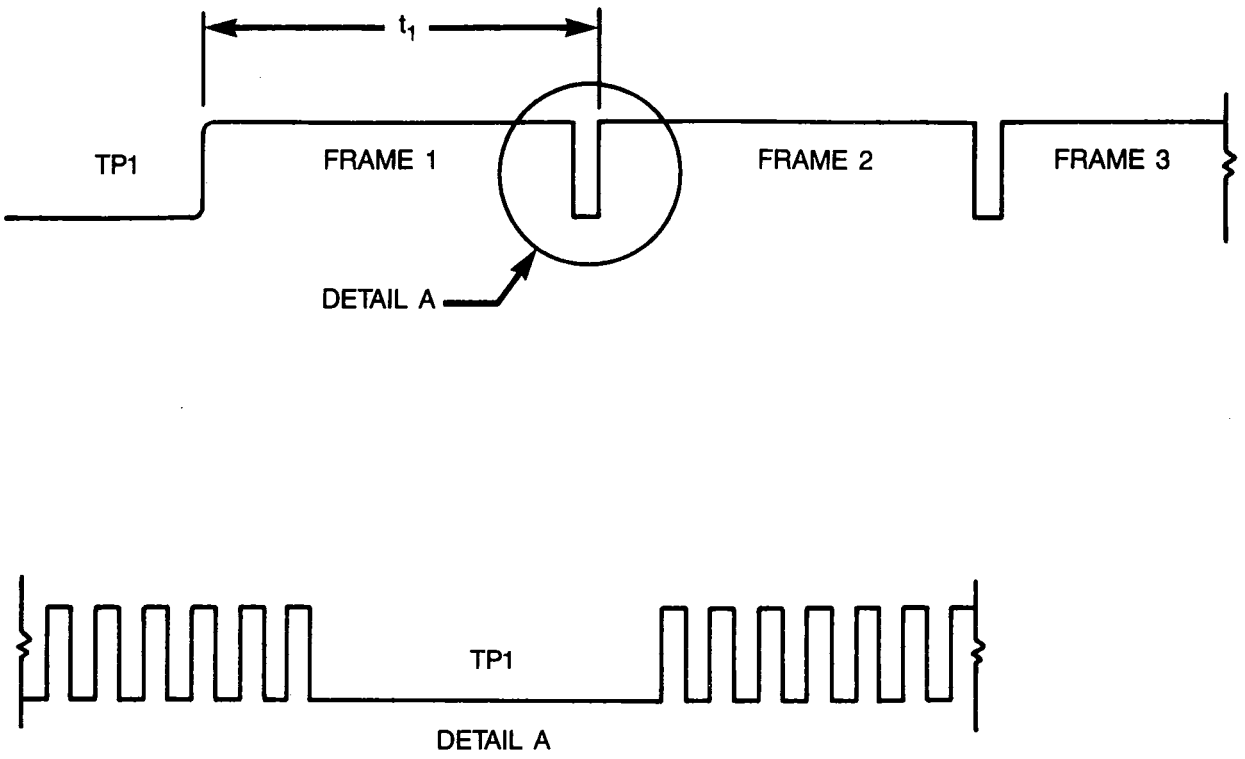

Figure A-2
TRANSFER TIME MEASUREMENT

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Appendix B

EXAMPLE OF A TYPICAL MESSAGE

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	0056 0000		Even number of bytes from the end of this field to the beginning of the next group
0000	0001	0004 0000	01A0 0010		Even number of bytes from the end of this field to the end of the message
0000	0010	000C 0000	4341 2D52 454E 414D 3120 302E	"ACR-NEMA 1.0"	Recognition Code
0000	0100	0002 0000	0001	0001H	Command field = SEND__REQUEST
0000	0110	0002 0000	123A	123AH	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	0000H	Data type = image
0008	0000	0004 0000	0080 0000		Group length
0008	0001	0004 0000	013E 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	0002 0000	0000	0000H	Data set type = image
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
0010	0010	000E 0000	4F4A 454E 2C53 4A20 4D49 4320 202E	"JONES, JIM C.__"	Patient Name
0010	0020	0008 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	0018 0000		Group length
0020	0010	0004 0000	3932 3330	"2903"	Study number
0020	0020	0004 0000	5C52 2046	"R/F__"	Patient Orientation
0028	0000	0004 0000	002C 0000		Group length
0028	0010	0002 0000	0400	0400H	Number of rows = 1024
0028	0011	0002 0000	0400	0400H	Number of columns = 1024
0028	0030	0006 0000	2E20 5C33 332E	"__.3 \ .3"	Real word size of pixels = .3 × .3 mm
0028	0100	0002 0000	0008	0008H	Bits allocated per pixel = 8
7FE0	0000	0004 0000	0008 0010		Group length
7FE0	0010	0000 0010	xxxx xxxx .... xxxx xxxx		Pixel data (524,288 words)

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APPENDIX C

Hierarchical Grouping of Images

The standard provides a hierarchical scheme for identifying related groups of images. The default scheme uses six levels. The bottom four levels are Study, Series, Acquisition, and Image. 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 that 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 performed 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 recorded 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) also should 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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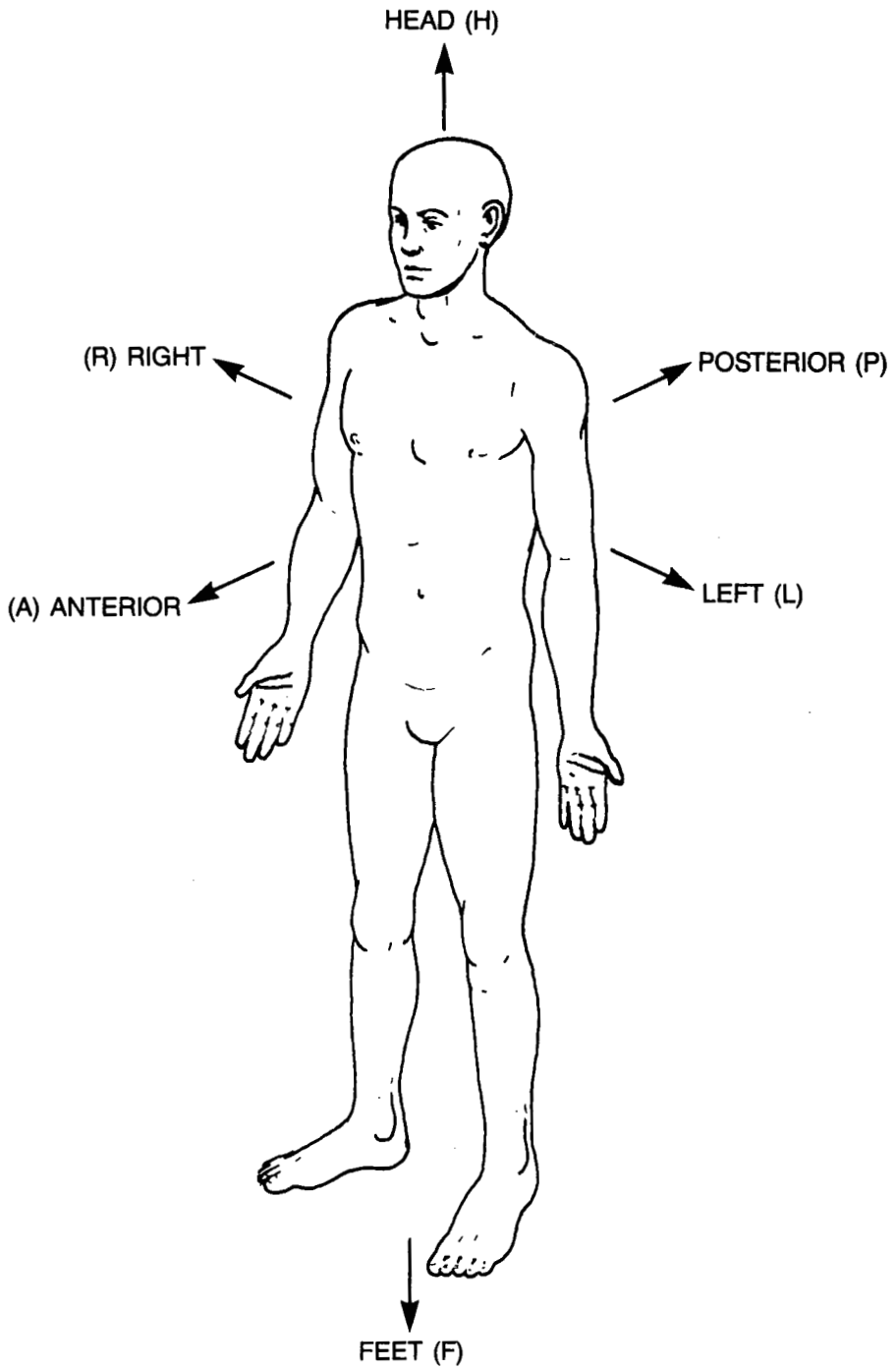
Appendix D
EXPLANATION OF PATIENT ORIENTATION

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



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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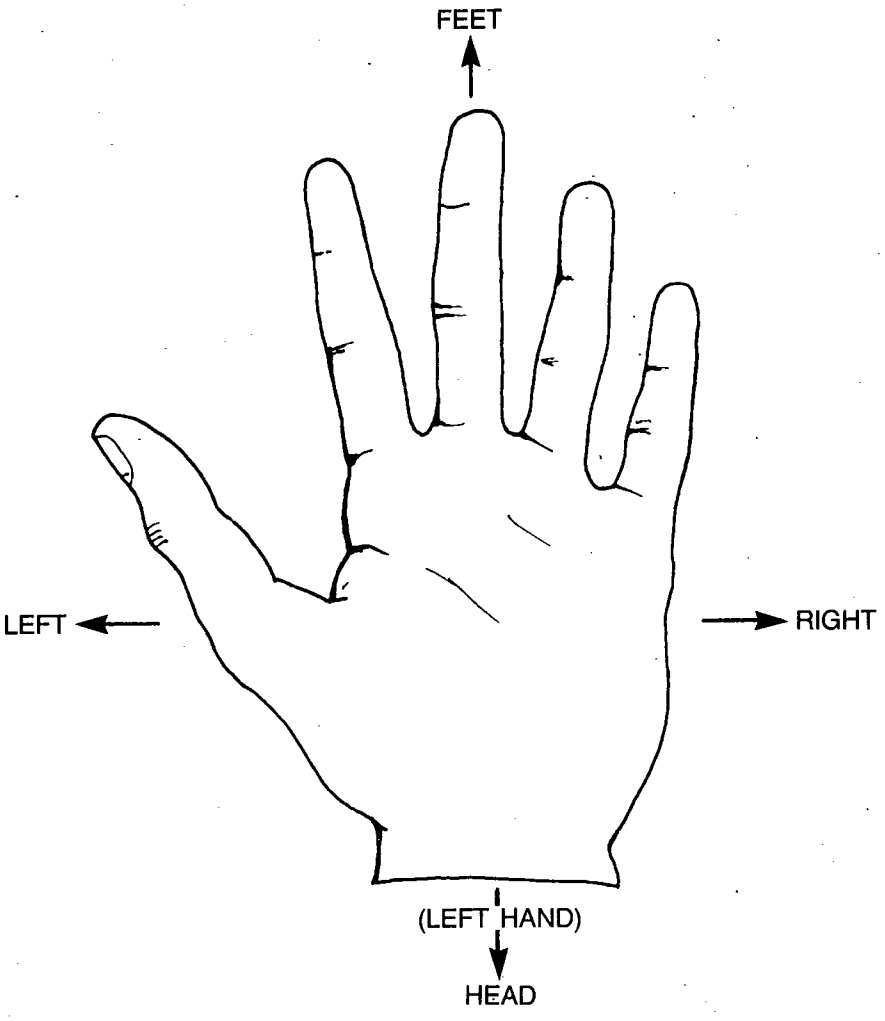

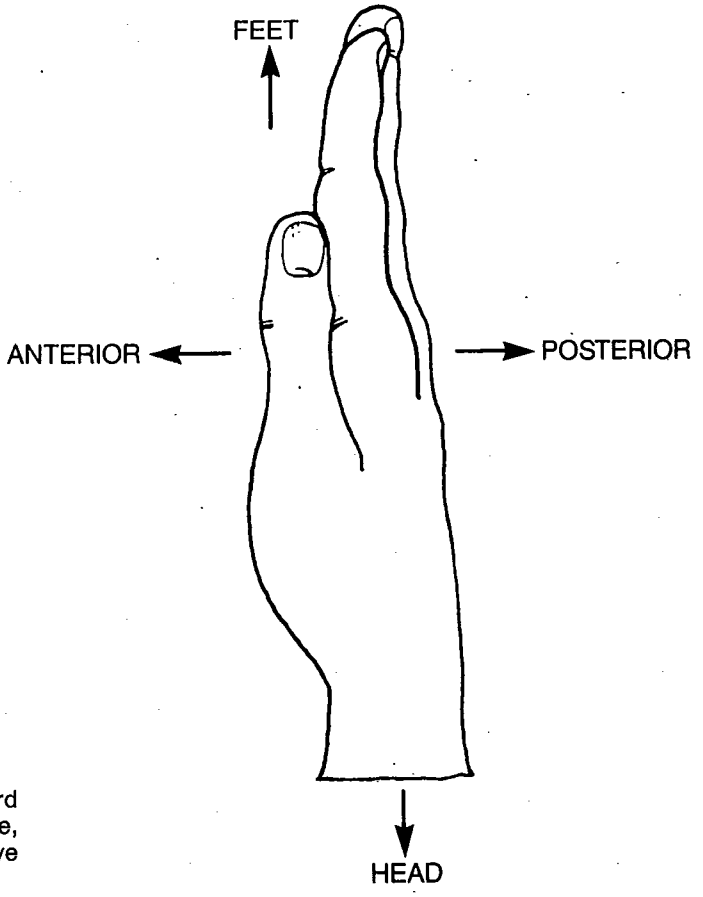

For the hands, the direction labels are based on the standard anatomic position. For the left hand illustrated, for example, LEFT will always be in the direction of the thumb, irrespective of position changes.

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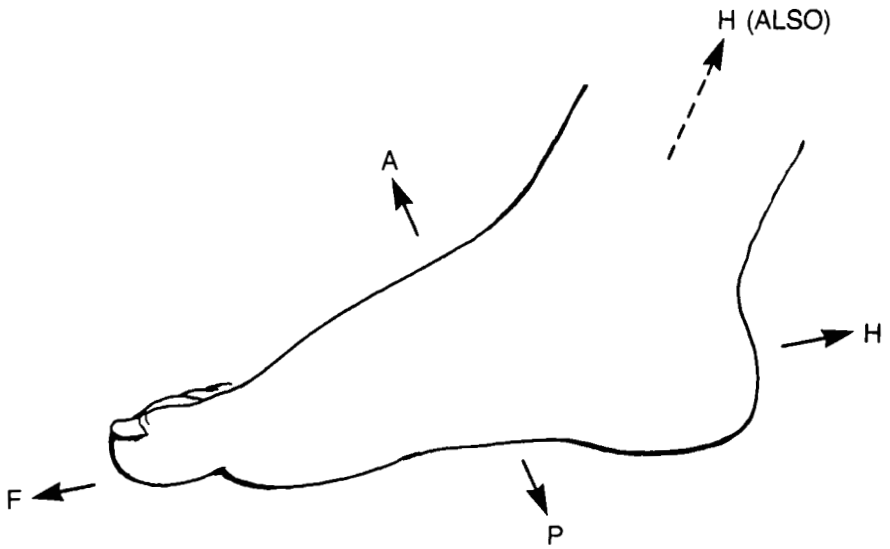
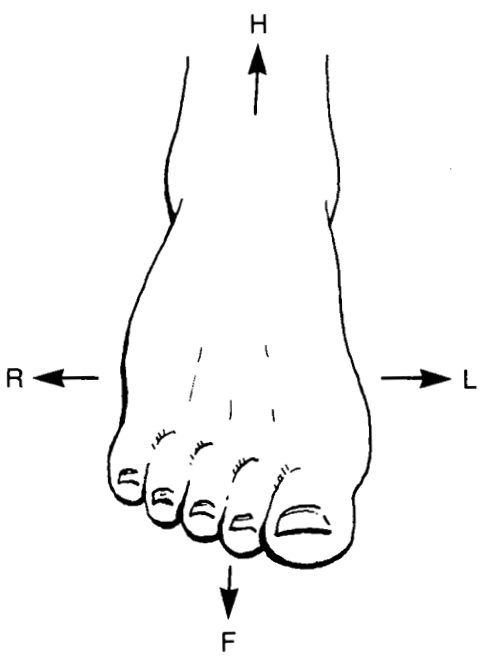


RIGHT FOOT



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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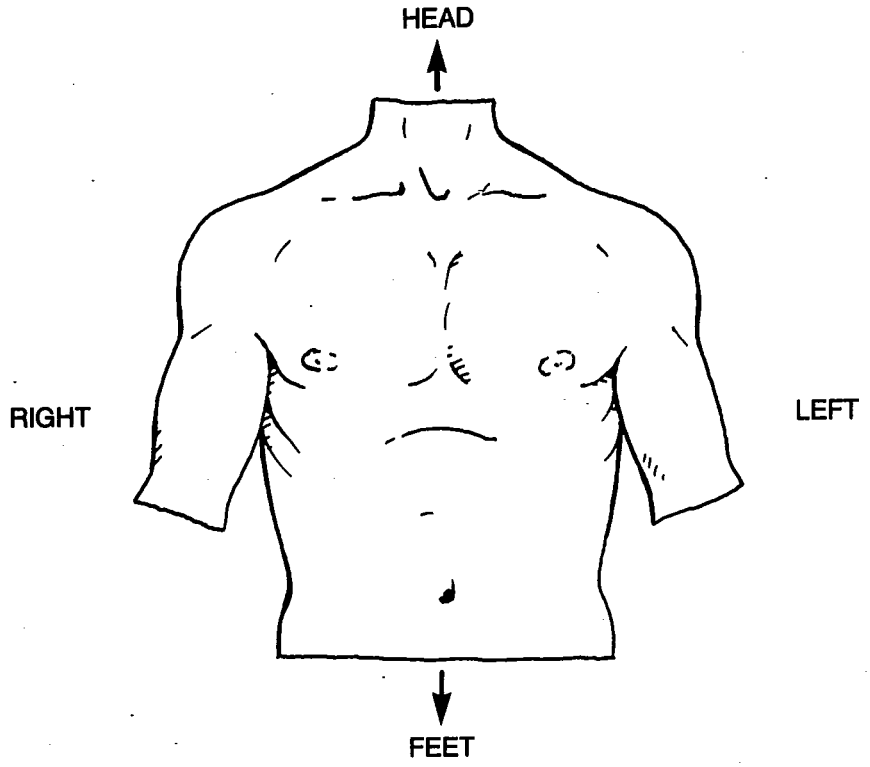
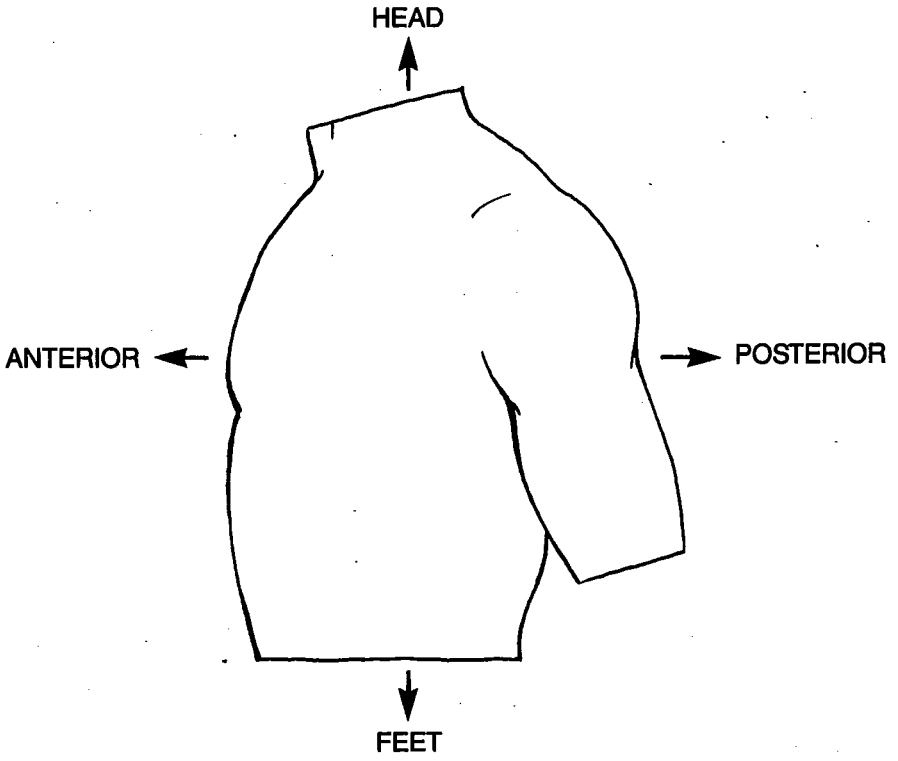


VIEWING THE FRONT OF THE PATIENT



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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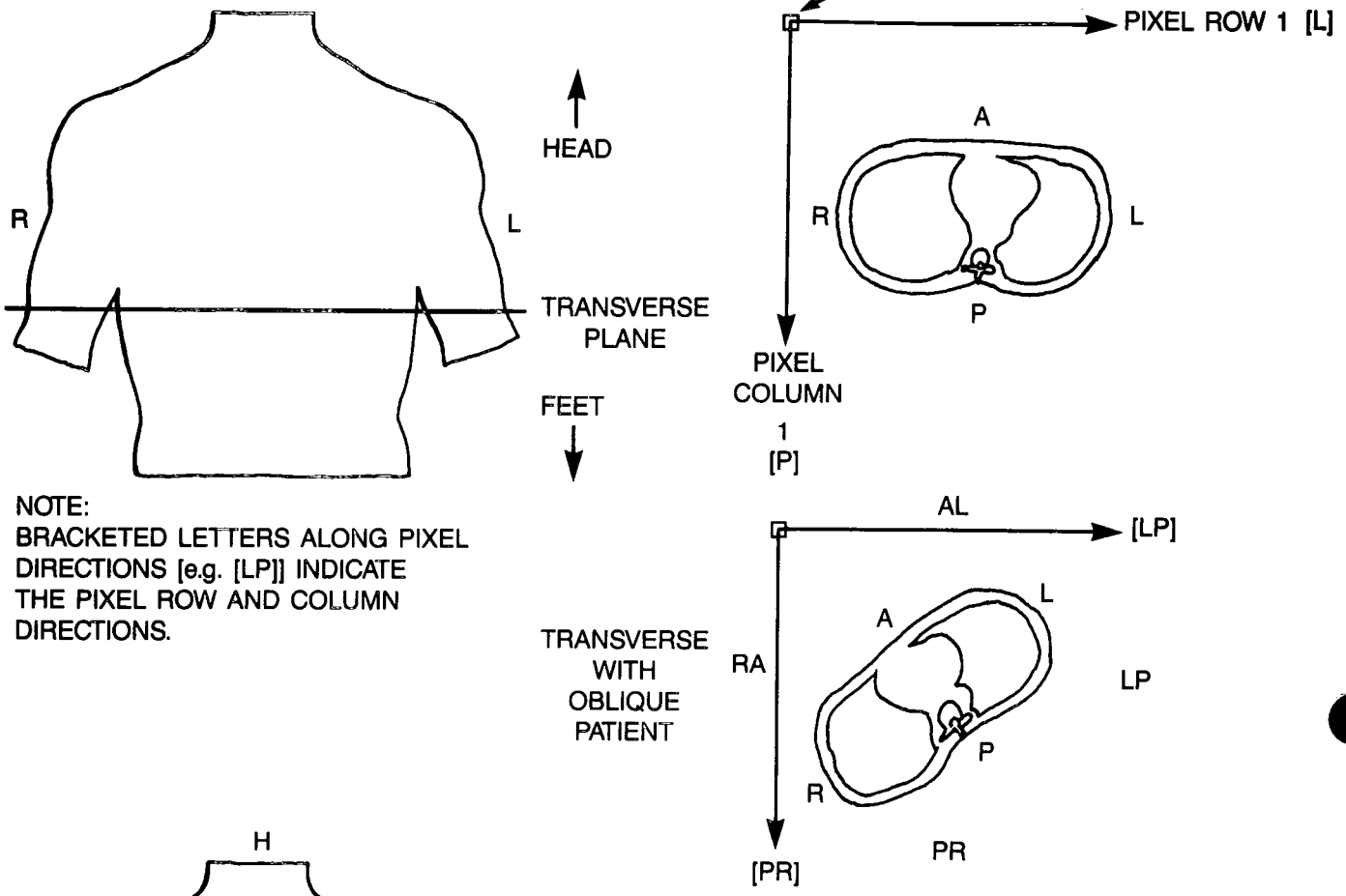

NOTE:
BRACKETED LETTERS ALONG PIXEL DIRECTIONS [e.g. [LP]] INDICATE THE PIXEL ROW AND COLUMN DIRECTIONS.

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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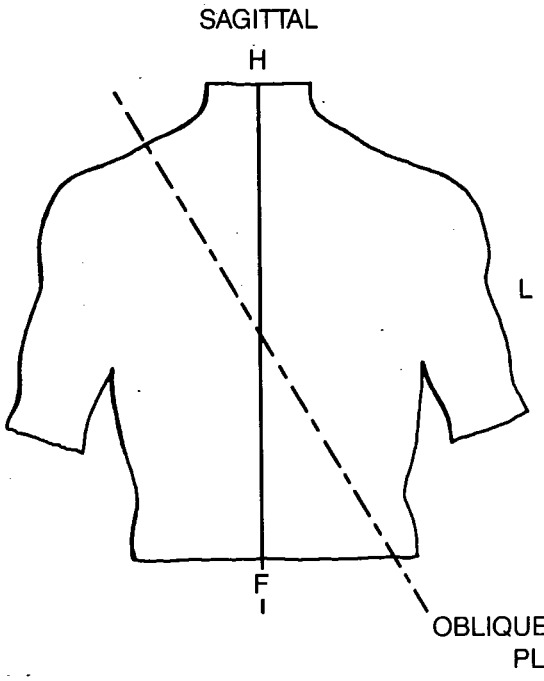

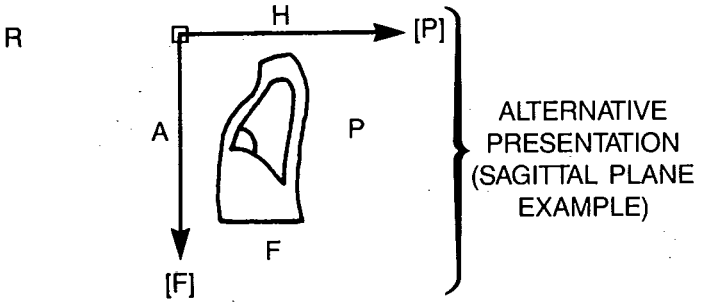

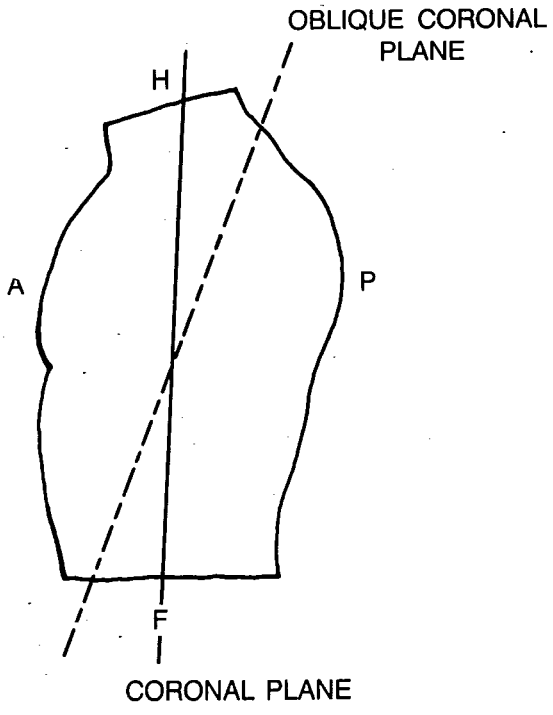

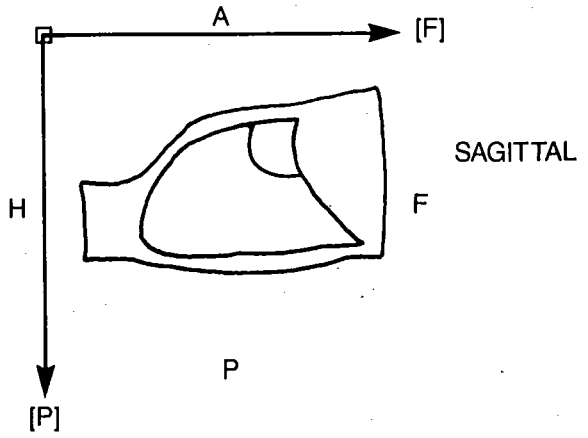

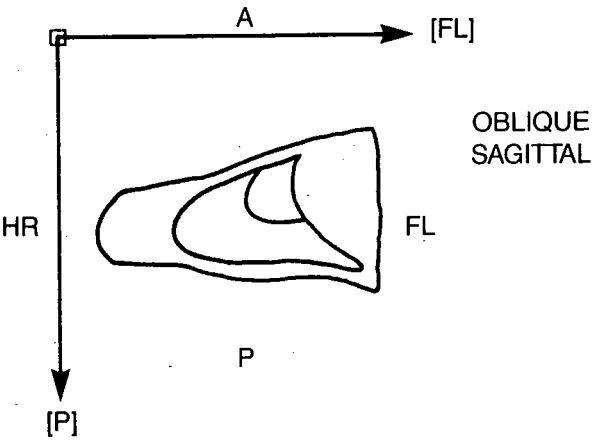

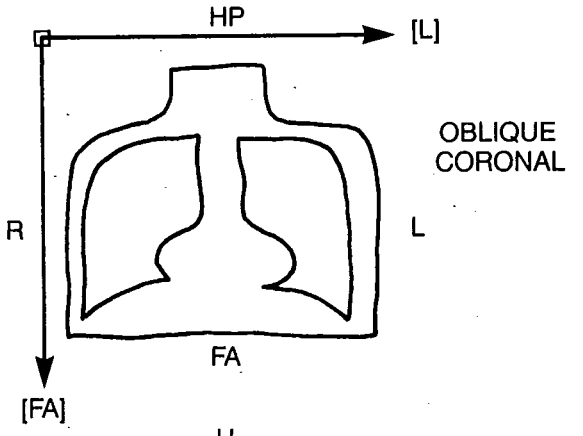

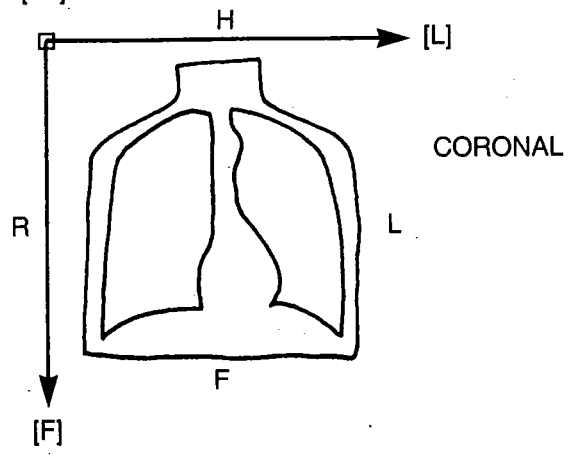

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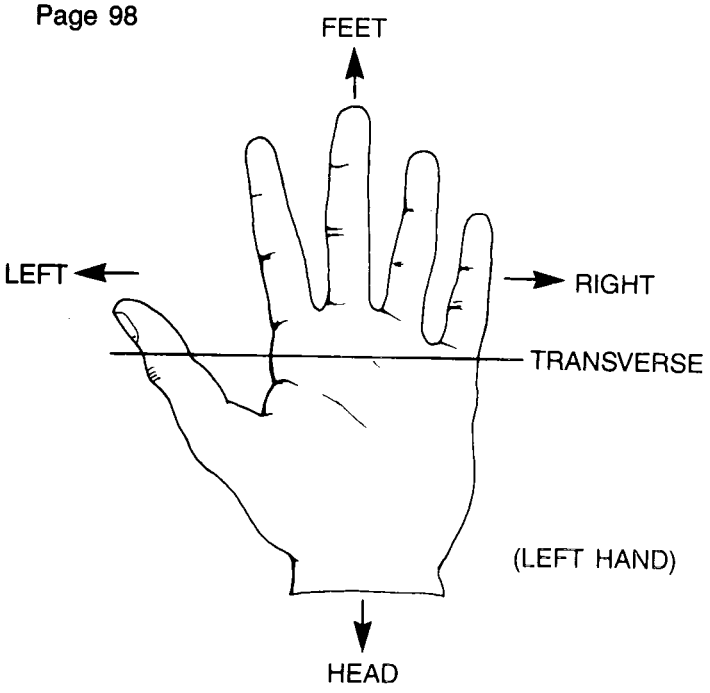

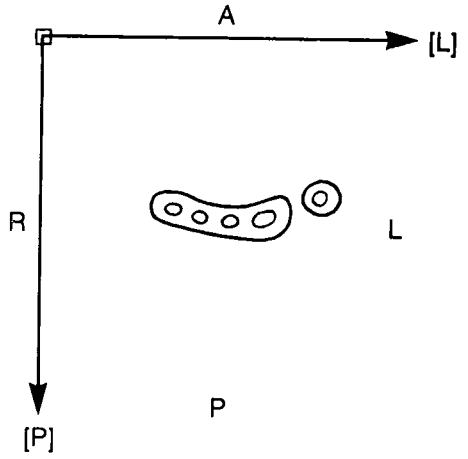



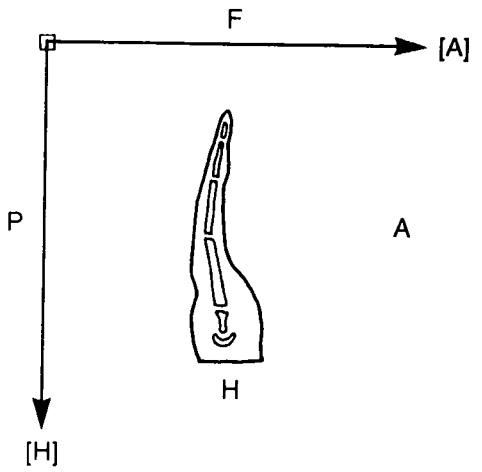

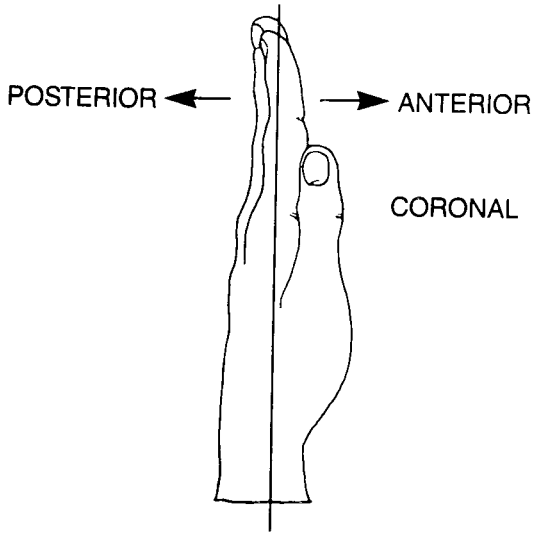

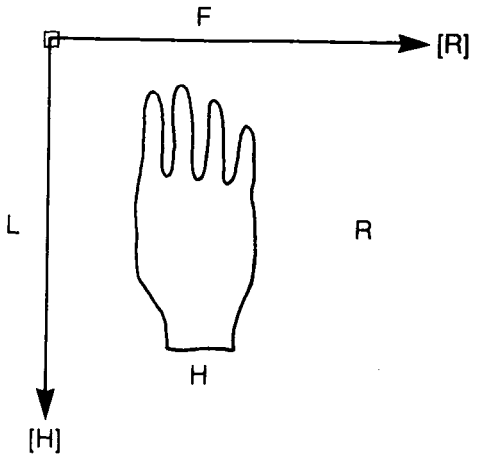

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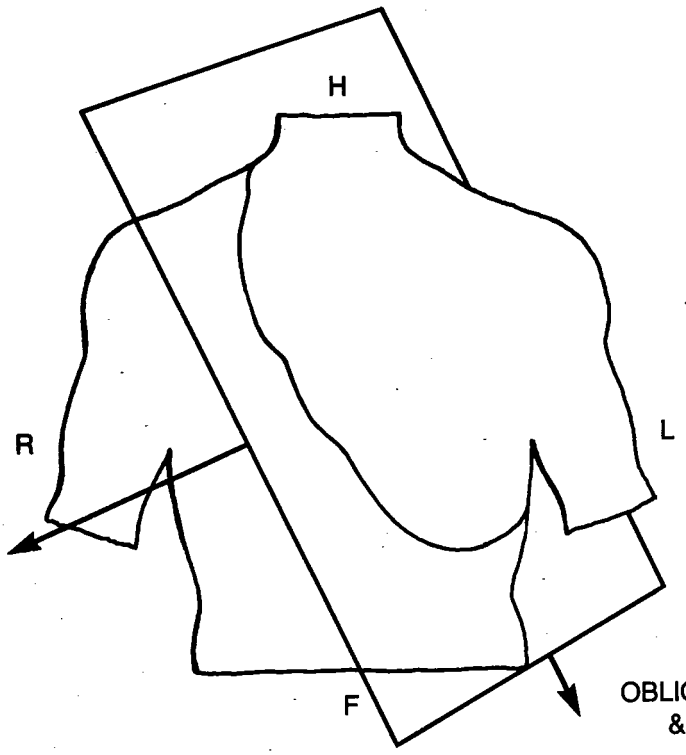
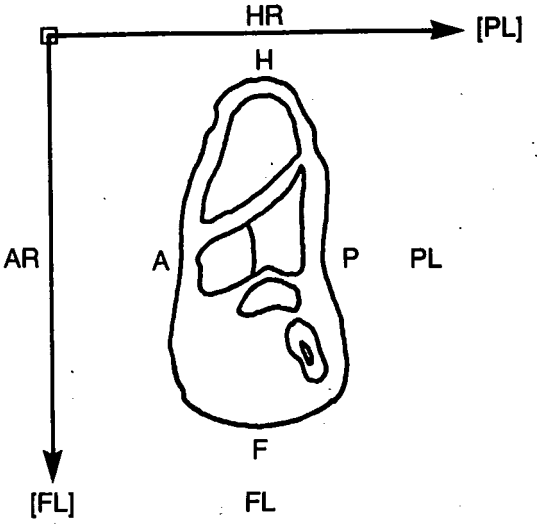
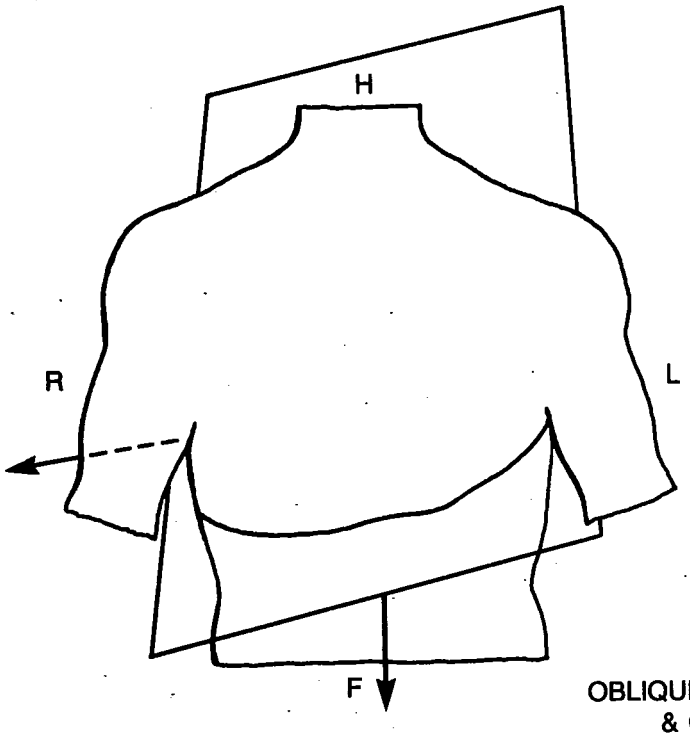
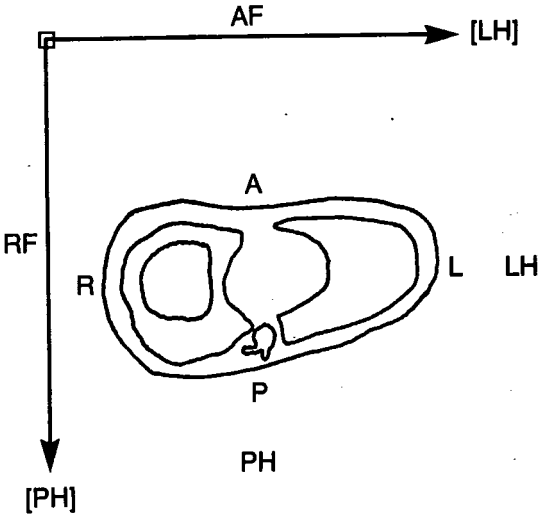




OBLIQUE SAGITTAL
& CORONAL





OBLIQUE TRANSVERSE
& CORONAL

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

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Appendix E

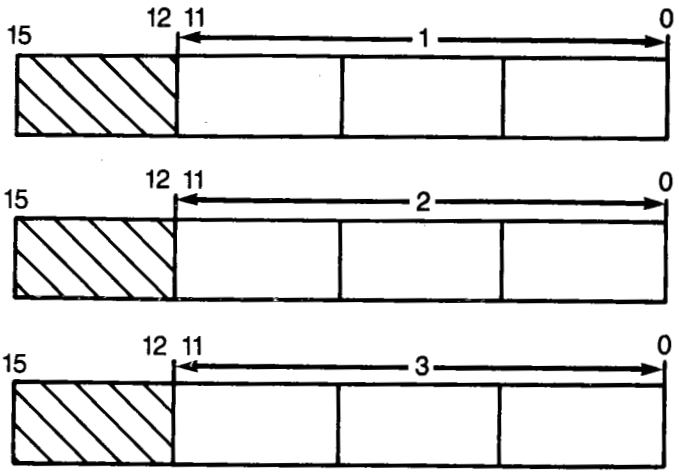
EXPLANATION OF PACKING OPTIONS

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

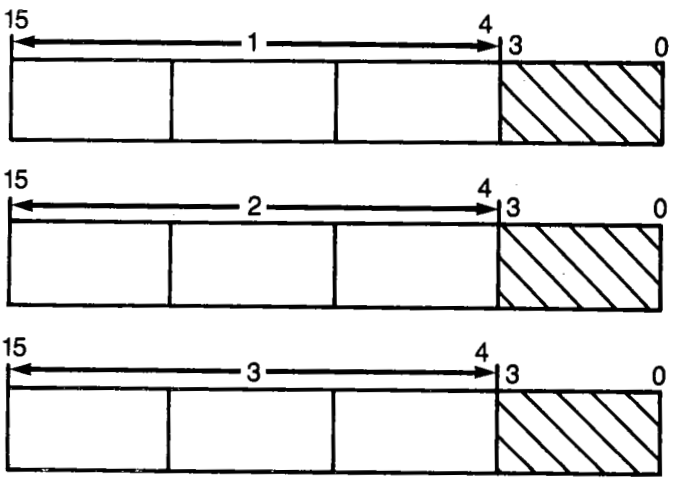
HIGH BIT = 11



BITS ALLOCATED = 16

BITS STORED = 12

HIGH BIT = 15



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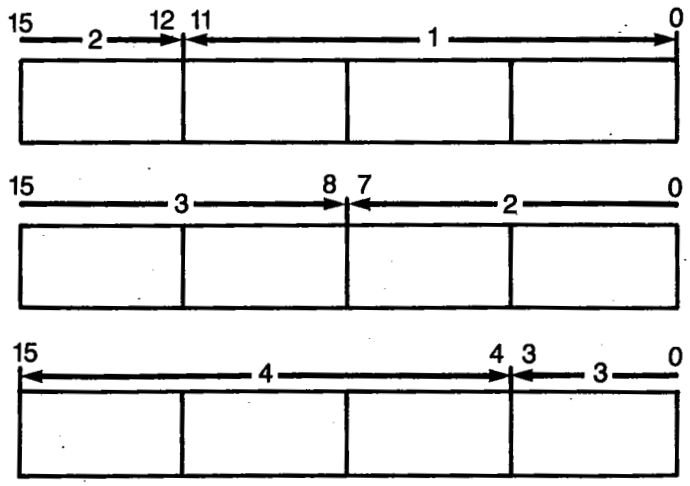
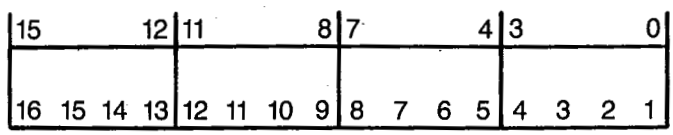
BITS ALLOCATED = 12

BITS STORED = 12

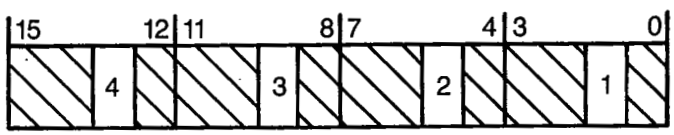
HIGH BIT = 11



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

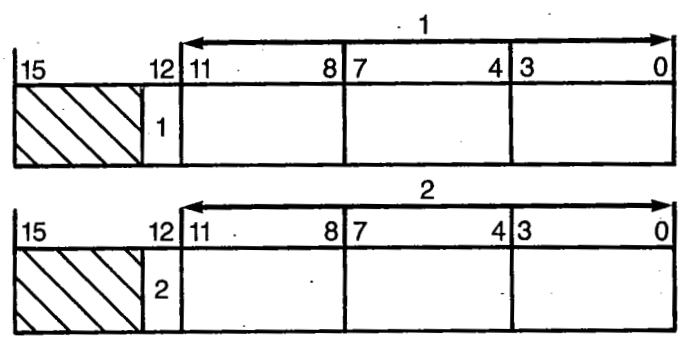


BITS ALLOCATED = 4
BITS STORED = 1
HIGH BIT = 1



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

OVERLAY
BITS ALLOCATED = 16
BIT POSITION = 12



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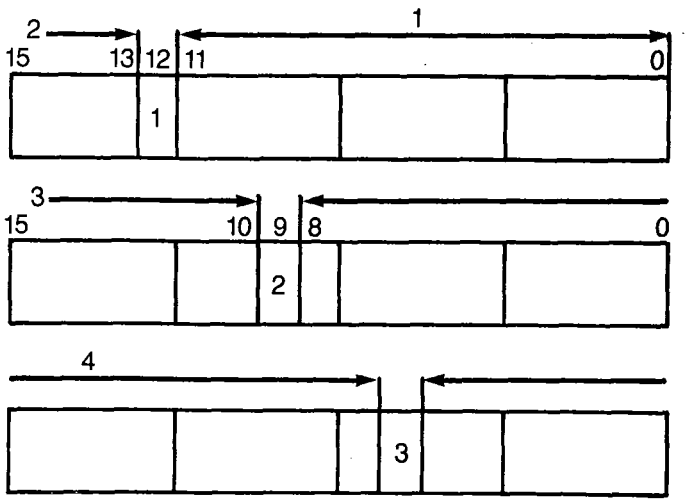
PIXEL
BITS ALLOCATED = 13
BITS STORED = 12
HIGH BIT = 11

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 = NULL
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	0102H	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
0020,0010	246	study # 246
0020,0011	1	series # 1
0020,0012	3	acquisition # 3
0020,0013	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	FF00H	status = pending
ACH1 TRANSMITS:		
0000,0100	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
0000,0800	0000H	data set type = IMAGE
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
0000,0850	1	only one match
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
0000,0800	0102H	data set type = IDENTIFIER
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	FF00H	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 from a 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	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

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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 that match the set of values in this FIND__RESPONSE
0000,0860	1	This is the first response
0000,0900	FF00H	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
0010,0030	1934.11.23	Patient was born Nov. 23, 1934
0010,0040	M	Sex is male
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	FF00H	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
0010,0030	1934.11.23	Patient was born Nov. 23, 1934
0010,0040	M	Sex is male
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:

GROUP,ELEMENT	VALUE	MEANING
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
0010,0030		Patient birthdate unknown
0010,0040	M	Sex is male
0020,0010	332	Study number is 332
0020,0011	1	Series number is 1

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Note that element (0010,0030) 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 data 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
0000,0300	WKS1	Sent to Work Station 1

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GROUP,ELEMENT	VALUE	MEANING
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	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
0010,0030	1934.11.23	Patient was born Nov. 11, 1934
0010,0040	M	Sex is male
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.

GROUP,ELEMENT	VALUE	MEANING
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 established 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 characters), 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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Appendix I

EXAMPLES OF USING DISPLAY DEVICE DATA ELEMENTS FOR CONTROL OF A LASER CAMERA

EXAMPLE 1 (SIMPLE CASE)—

Sender does not perform formatting function. The only device control data element required is Print (0000H,51A0H). The sender relies on default formats at the camera. All camera control functions are controlled at the camera. The sender does not have to keep track of the images sent, it only needs to send the Print (0000H,51A0H) data element when last image is sent.

1. The sender transmits SEND__REQUESTs. No display device specific data elements are sent, except with the last image. As each page is filled with images, the camera will print the page and start a new page with the next image sent. Any number of images may be sent. The sender will receive a SEND__RESPONSE from the camera for each SEND__REQUEST transmitted.
2. After the sender has sent all images to be printed, it transmits a SEND__REQUEST containing the Print (0000H,51A0H) data element. The SEND__REQUEST may be Data Set Type IMAGE in which case, this is the last image. The SEND__REQUEST may be Data Set Type NULL indicating that no more images will be sent. The presence of this data element instructs the camera to print any images on a partial page.

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EXAMPLE 2—
Sender is a work station (with logical name WS2) that will perform the formatting functions. Sender wishes to print two copies of each image with a format of 12 images per page. There will be a total of 15 images printed. A brief summary of the message sent follows. All display device specific data elements are shown.

MESSAGE –	ELEMENT	VALUE	MEANING
1st	Message Set ID	WS2-1	Begins print session
	Display Format ID	12	12 images per page
	Page Position ID	1	Store this image in position 1
	Text Format ID	2	Text format 2, which is a predefined format for extracting information from the image header and printing it on the film
	Borders	BLACK	Print black borders between images
	Copies	2	Two copies are to be made of each page
2nd	Message Set ID	WS2-1	
	Page Position	3	Store this image in position 3
3rd	Message Set ID	WS2-1	
	Page Position	2	Store this image in position 2
⋮			
12th	Message Set ID	WS2-1	Since this is the 12th image,
	Page Position	12	the camera will make two copies of the page after receiving this message
13th	Message Set ID	WS2-1	
	Page Position	4	
14th	Message Set ID	WS2-1	This message does not contain an image
	Erase	4	"Erase" the image stored in position 4
15th	Message Set ID	WS2-1	
	Page Position	4	Store this new image in position 4
16th	Message Set ID	WS2-1	
	Page Position	5	Store image in position 5
17th	Message Set ID	WS2-1	
	Page Position	6	Store image in position 6
	Overlays	6000	Print the overlay in group 6000 on this image
	End Message Set	NORMAL	End the print session and print two copies of the partial page

The result of this print session is to produce two prints each of two pages. The first page contains 12 images each in the position specified. The second page contains 3 images in positions 4, 5, and 6. The image sent in message #13 is not printed. The image printed in position 6 contains an overlay plane printed on the image.

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EXAMPLE 3—

The following are examples of the Group 0000H (Command) part of a series of messages sent from imaging equipment CT3 to Laser Imager LI2. This set of messages defines a session ID, requests a format of four images on a film, black borders, neighbor interpolation (for example, cubic spline), normal tone scale, no gray scale, and (by omission) no text. Images are sent with the first four messages and placed in format locations 2, 3, 4, and 1. The fourth message also requests 2 copies printed. The fifth message erases image 1 (the last sent), and requests a change to reverse tone scale. The last message requests normal end set (with one print of images 2, 3, and 4, in reverse tone). The ability for a specific laser camera to support all the functions in this example is implementation-specific. See the explanation at the end of the example.

MESSAGE -	ELEMENT -	NAME	VALUE	MEANING
1st	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0001	first message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0000	image data
	5010	Message Set ID	CT3/87.7.24	label for session
	5110	Display format ID	4	use 4-up format
	5120	Page position ID	2	put this image in position 2
	5140	NOR/REV	NORMAL	use normal tone scale
	5150	Add gray scale	N	don't add gray scale
	5160	Borders	BLACK	use black borders
	5180	Magnification	NEIGHBOR	use neighbor interpolation
... Groups 0008H−7FE0H for image follow.				
2nd	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0002	second message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0000	image data
	5010	Message Set ID	CT3/87.7.24	label for session
	5120	Page position ID	3	put this image in position 3
... Image follows.				
3rd	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0003	third message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0000	image data
	5010	Message Set ID	CT3/87.7.24	label for session
	5120	Page position ID	4	put this image in position 4
... Image follows.				

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MESSAGE –	ELEMENT –	NAME	VALUE	MEANING
4th	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0004	fourth message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0000	image data
	5010	Message Set ID	CT3/87.7.24	label for session
	5120	Page position ID	1	put this image in position 1
	5170	Copies	2	print 2 copies
	51A0	Print	PRINT	print page
....Image follows.				
5th	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0005	fifth message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0100	"other"—command to LI2
	5010	Message Set ID	CT3/87.7.24	label for session
	5140	NOR/REV	REVERSE	request (change) reverse tone
	5190	Erase	LAST	erase last image (position 1)
... No image follows this command.				
6th	0000	Group length	00xx 0000	length to end of Group 0000
	0001	Length to end	xxxx xxxx	length to end of message
	0010	Recognition code	ACR-NEMA 2.0	
	0100	Command field	0001	SEND__REQUEST
	0110	Message ID	0006	sixth message this session
	0200	Initiator	CT3	
	0300	Receiver	LI2	
	0800	Data Set type	0100	"other"—command to LI2
	5010	Message Set ID	CT3/87.7.24	label for session
	5020	End message set	NORMAL	print page and end set
	5170	Copies	1	print 1 copy
... No image follows this command.				

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After each message a SEND__RESPONSE message should return from LI2 of the form below:

0000	Group length	00xx 0000	length to end of Group 0000H
0001	Length to end	00xx 0000	length to end of message
0010	Recognition code	ACR-NEMA 2.0	
0100	Command field	8001	SEND__RESPONSE
0110	Message ID	0006	Response sequence number
0120	Message responded	000x	Request message number
0200	Initiator	LI2	
0300	Receiver	CT3	
0800	Data Set type	0101	"Null"—command to CT3
0900	Status	0000	Success
5010	Message Set ID	CT3/87.7.24	(optional)

If a problem occurred at LI2, the Status field would contain another value.

For example, after the print command is issued in message #4, the laser camera is permitted to delete all the Image data. Thus it could not act on message #5 or #6. In this case, the camera would send a Status of REFUSED as the response to message #5. Other implementations may not delete the image data until the first store image command for the next page is received. Thus, the actions requested in this message could be performed.

As a second example, if LI2 could not change the tone scale from normal to reverse after accepting the images (message #5), a warning or failure status would be returned.

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EXAMPLE 4—
EXAMPLE OF CAMERA INTERFACE INVOLVING THE MOVE COMMAND

The Sender is a work station (with logical name WS1) that will perform formatting functions and control the transfer of images from archive devices (logical names ARC4 and ARC2) to a camera (logical name PR1). Only the relevant group 0000H elements are listed and only request commands. All responses are assumed to have status values that indicate success.

MESSAGE #	ELEMENT	VALUE	MEANING
1st	Command	SEND__REQUEST	Send request from
	Initiator	WS1	Workstation 1 to
	Receiver	PR1	Print Station 1
	Message Set ID	WS1__1	Image Set ID = WS1__1
	Display Format ID	12	Defined format (12/page)
	Page Position ID	1	First image, position 1
	Text Format ID	4	DEFINED TEXT FORMAT 4
2nd	Command	MOVE__REQUEST	Move image 2 from
	Initiator	WS1	
	Receiver	ARC4	Archive 4 to
	Move Location	PR1	Print Station 1
	Message Set ID	WS1__1	Part of Set WS1__1
	Page Position ID	2	Image for position 2
3rd	Command	SEND__REQUEST	Send image from
	Initiator	ARC4	Archive 4 to
	Receiver	PR1	Print Station 1
	Message Set ID	WS1__1	SET ID and PAGE POSITION ID
	Page Position ID	2	Fields copied from MOVE__REQUEST
4th	Command	MOVE__REQUEST	Repeat for image for position 3
	Initiator	WS1	
	Receiver	ARC2	Source is ARC2
	Message Set ID	WS1__1	
	Page Position ID	3	
5th	Command	SEND__REQUEST	
	Initiator	ARC2	
	Receiver	PR1	
	Message Set ID	WS1__1	
	Page Position ID	3	
. . . . .			

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MESSAGE -	ELEMENT	VALUE	MEANING
	•		
	•		
	•		
22nd	Command	MOVE__REQUEST	Repeat for image 12
	Initiator	WS1	
	Receiver	ARC2	
	Move Location	PR1	
	Message Set ID	WS1__1	
	End Message Set	NORMAL	Normal end of set
	Page Position ID	12	
	Print	PRINT	Optional, automatic print should occur on end of set
23rd	Command	SEND__REQUEST	
	Initiator	ARC2	
	Receiver	PR1	
	Message Set ID	WS1__1	
	End Message Set	NORMAL	Normal end of set
	Page Position ID	12	
	Print	PRINT	Optional, automatic print should occur on end of set

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status, are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced 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.

(Standardization Policies and Procedures, p. 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.

(Standardization Policies and Procedures, p. 2)

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.

(Standardization Policies and Procedures, p. 9)

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.

(Standardization Policies and Procedures, pp. 8 & 17)

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, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 8 & 17)

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, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

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.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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