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American National Standard

ANSI C12.18-1996

Protocol Specification for ANSI Type 2 Optical Port

National Electrical Manufacturers Association

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American National Standard

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ANSI C12.18-1996

AMERICAN NATIONAL STANDARD

Protocol Specification For ANSI Type 2 Optical Port

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Foreword (This foreword is not part of American National Standard for Protocol Specification for ANSI Type 2 Optical Port, ANSI C12.18-1995.)

This American National Standard provides an open platform communications protocol for two-way communication with an electronic metering device or an electromechanical metering device with an added electronic board. The communications is specified to pass through an ANSI Type 2 Optical Port. The protocol is written to conform to the OSI seven layer stack.

Suggestions for improvement to this standard are welcome. They should be sent to:

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AMERICAN NATIONAL STANDARD **C12.18-1996**

Protocol Specification for ANSI Type 2 Optical Port

1 Scope

This document details the criteria required for communications with an electric power metering device by another device via an optical port. The other device could be a handheld reader, a laptop or portable computer, a master station system, a power metering device, or some other electronic communications device.

This document provides details for a complete implementation of an OSI 7-layer model.

The protocol specified in this document was designed to transport data in table format. The table definitions are referenced in Clause 2.

2 References

ISO 7498/1, *OSI Reference Model*

ISO 3309-1991: *Information technology–Telecommunications and information exchange between systems - High-level data link control (HDLC) procecdures*

3 Definitions

For the purposes of this document, the following definitions are made for terms and syntax used throughout this document.

3.1 Point-to-point communications

Point-to-point communications is defined as communication between two devices through a single optical interface.

3.2 Table

Functionally related data elements, grouped together into a single data structure for transport

3.3 Document syntax

Describing data definitions is usually accomplished within the confines of a given language and the grammar rules of that language. Since the data definitions embodied within this document are meant to be independent of a specific language and, hopefully, capable of being implemented within the confines of any language, a method for describing the data definitions must be developed. A modified form of the Backus-Naur Format (BNF) will serve as the basis for building the descriptions used to construct the data definitions.

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The modified form of BNF has the following definitions:

Symbol	Meaning
< >	A string contained inside angle brackets is called a non-terminal. That is, while it may be viewed as a single unit it can and should be redefined as consisting of one or more simpler elements.
::=	This symbol is read as "is defined as." The non-terminal which occurs on the left hand side (LHS) of this symbol consists of the elements (non-terminals, terminals, or a combination of the two) found on the right hand side (RHS). A line containing an LHS, ::=, and an RHS is known as a production rule.
|	The vertical bar is an "OR" symbol. The OR symbol always occurs on the right hand side of a production where the left hand side can be defined in more than one way. The OR bar separates valid alternative right hand sides.
[ ]	A symbol enclosed in square brackets is optional. The production is valid whether or not it is included.
*	The superscript asterisk is known as the Kleene star. A symbol followed by the Kleene star may occur zero or more times without violating the grammar.
+	The superscript plus sign is known as the Kleene cross. A symbol followed by the Kleene cross must occur one or more times.
+n	A symbol followed by the Kleene cross and any number "n" represents "n" occurences of the symbol.
{ }	The curly braces are used to enclose comments within the descriptions. Comments have no impact on the productions.

4 Protocol details

Following the guidelines established by the OSI seven layer model, the protocol described in this document provides three functions. These are:

1) modification of the communication channel

2) transport of information to and from the metering device

3) orderly closure of the communication channel when communications are complete

Three layers are used to provide these communication capabilities. These are the Physical, Data Link and Application layers.

With the default conditions established by this document, the communication channel is considered available once the physical connection has been completed. The identification service is required to establish the protocol version and revision in use. Certain communication parameters may be modified through the use of the negotiate service in the Application layer. This service is optional and if not implemented in the metering device or not used during actual communications, the communication channel parameters will remain at the default settings specified by this document. Device implementors are strongly encouraged to implement this optional Application service.

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Once the data link is established, the application layer provides logon, security and logoff services for session activation, access control and deactivation; read and write services for issuing data transmission requests; terminate service for shutdown of the communication channel; and a response structure that provides information regarding the success or failure of the service requests.

An example of a typical communications session would consist of the following services with appropriate responses, in the order listed: identification; negotiate; logon; security; read (zero or more); write (zero or more); and terminate. Note that this brief example does not detail the packet structure nor other aspects of the protocol. For a more detailed example of a typical communications session reference Annex B, Communication example.

4.1 Order of transmission

Within the syntax definitions, multiple parameters shall be transmitted in the order as shown, from left to right.

Parameters in all layers within the protocol definition are transmitted most significant byte first. The order of transmission of data field parameters within tables are dictated by the table structure.

Bytes are transmitted in frames. Each frame consists of a start bit, followed by a <byte>, and ending with a stop bit. The start bit is transmitted first.

Bits within each byte are transmitted least significant bit first with the least significant bit identified as bit 0 and most significant bit as bit 7.

<word24> ::= <msbyte> <byte> <lsbyte>
<word16> ::= <msbyte> <lsbyte>

<msbyte> ::= <byte> {most significant byte}
<lsbyte> ::= <byte> {least significant byte}

<byte> ::= <bit0> <bit1> <bit2> <bit3> <bit4> <bit5> <bit6> <bit7>

4.2 Layer 7—application layer

The application layer provides a minimal set of services and data structures required to support electronic metering devices for purposes of configuration, programming and information retrieval.

4.2.1 Data structure

This protocol shall transport table structures. The table specifications this standard was designed to transport are referenced in Clause 2.

4.2.2 Language—protocol specifications for electric metering ("PSEM")

The language PSEM has been designed to provide an interface between the metering device and any other device over a point-to-point communication medium. The PSEM language consists of 9 services. Each service consists of a request and a response. Each of these requests and responses is described in following service clauses.

<requests> ::= <ident> | { Identification request }
<read> | { Read request }
<write> | { Write request }
<logon> | { Logon request }
<security> | { Security request }

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		<logoff> |	{ Logoff request }
		<negotiate> |	{ Negotiate request }
		<wait> |	{ Wait request }
		<terminate>	{ Terminate request }
<responses>	::=	<ident_r> |	{ Identification response }
		<read_r > |	{ Read response }
		<write_r > |	{ Write response }
		<logon_r > |	{ Logon response }
		<security_r> |	{ Security response }
		<logoff_r > |	{ Logoff response }
		<negotiate_r > |	{ Negotiate response }
		<wait_r > |	{ Wait response }
		<terminate_r >	{ Terminate response }

4.2.2.1 Request codes

PSEM requests always include a one byte request code. Code numbers are assigned as follows:

00_H–$1F_H$	Codes shall not be used to avoid confusion with response codes
20_H–$7F_H$	Codes are available for use within optical port protocol
80_H–FF_H	Codes shall be reserved for protocol extensions

4.2.2.2 Response codes

PSEM responses always include a one byte response code. These codes are defined as follows:

<nok>	::=	<err>|<sns>|<isc>|<onp>|<iar>|<bsy>|<dnr>|<dlk>|<rno>|<isss>	
<ok>	::=	00_H	{Acknowledge—No problems, request accepted.}
<err>	::=	01_H	{Error—This code is used to indicate rejection of the received service request. The reason for the rejection is not provided.}
<sns>	::=	02_H	{Service Not Supported—This application level error response will be sent to the device when the requested service is not supported. This error indicates that the message was valid, but the request could not be honored.}
<isc>	::=	03_H	{Insufficient Security Clearance—This application level error indicates that the current authorization level is insufficient to complete the request.}
<onp>	::=	04_H	{Operation Not Possible—This application level error will be sent to the device which requested an action that is not possible. This error indicates that the message was valid, but the message could not be processed. Covers

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			conditions such as: Invalid Length, Invalid Offset}
<iar>	::=	05_H	{Inappropriate Action Requested—This application level error indicates that the action requested was inappropriate. Covers conditions such as write request to a read only table or an invalid table id.}
<bsy>	::=	06_H	{Device Busy—This application level error indicates that the request was not acted upon because the device was busy doing something else.}
<dnr>	::=	07_H	{Data Not Ready—This application level error indicates that request was unsuccessful because the requested data is not ready to be accessed.}
<dlk>	::=	08_H	{Data Locked—This application level error indicates that the request was unsuccessful because the data cannot be accessed.}
<rno>	::=	09_H	{Renegotiate Request—This application level error indicates that the responding device wishes to return to the ID or base state and re-negotiate communication parameters.}
<isss>	::=	$0A_H$	{Invalid Service Sequence State—This application level error indicates that the request is not accepted at the current service sequence state. For more information on service sequence states, see Annex D.}
		$0B_H$–$1F_H$	{Codes are currently undefined, but are available for use within optical port protocol}
		20_H–$7F_H$	{Codes shall not be used to avoid confusion with request codes}
		80_H–FF_H	{Codes shall be reserved for protocol extensions}

4.2.2.3 Identification service

This service shall be the first service issued once the physical connection is established. The service returns the version and revision of the protocol. The version is positioned left of the decimal indicating a major change. The revision is positioned right of the decimal indicating a minor change.

Request:

<ident>	::=	20_H

Response:

The responses <err>, <bsy>, and <isss> indicate a problem with the received service request.

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The response <ok> indicates the identification service request was accepted and the version and revision are included in the response.

<ident_r>	::=	<err> | <bsy> | <isss> | <ok> <std> <ver> <rev> <rsvd>	
<std>	::=	<byte>	{Code identifying reference standard. The codes are defined as follows: 00_H = ANSI C12.18 01_H = For use by Industry Canada 02_H-FF_H = Reserved }
<ver>	::=	<byte>	{Referenced standard version number}
<rev>	::=	<byte>	{Referenced standard revision number}
<rsvd>	::=	<byte>	{Reserved for future use. This byte shall be set to 00_H until further defined.}

4.2.2.4 Read service

The read service is used to cause a transfer of table data to the requesting device.

Request:

The read request allows both complete and partial table transfers. The retrieval of a portion of a table is possible through the use of both offset-count and index-count methods.

Request codes 30–39, 3E and 3F give access to all possible methods used for table transfer. Request code 30 specifies a complete table transfer. Request codes 31 through 39 specify a partial table transfer using 1 to 9 indices. Request code 3E specifies a default table transfer. Request code 3F specifies a partial table transfer using the offset-count method.

<read>	::=	<full_read> | <pread_index> | <pread_offset> | <pread_default>	
<full_read>	::=	30_H <tableid>	
<pread_index>	::=	<$3j_H$> <tableid> <index>+ <count>	
<$3j_H$>	::=	31_H |	{ 1 <index> included in request }
		32_H |	{ 2 <index> included in request }
		33_H |	{ 3 <index> included in request }
		34_H |	{ 4 <index> included in request }
		35_H |	{ 5 <index> included in request }
		36_H |	{ 6 <index> included in request }
		37_H |	{ 7 <index> included in request }
		38_H |	{ 8 <index> included in request }
		39_H	{ 9 <index> included in request }
<pread_default>	::=	$3E_H$	{ Transfer default table }
<pread_offset>	::=	$3F_H$ <tableid> <offset> <count>	
<tableid>	::=	<word16>	{ Table identifier }

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<offset>	::=	<word24>	{ Offset into data table in bytes }
<index>	::=	<word16>	{ Index value used to locate start of data }
<count>	::=	<word16>	{ Length of table data requested, in bytes }

Response:

Responses of type <nok> indicate a problem with the received service request.

The response <ok> indicates the read service was accepted and the data is part of the response.

<read_r>	::=	<nok> | <ok> <table_data>	
<table_data>	::=	<count> <data> <cksum>	
<count>	::=	<word16>	{ Length of <data> returned, in bytes }
<data>	::=	<byte>+	
<cksum>	::=	<byte>	{ 2's compliment checksum computed only on the <data> portion of <table_data>. The checksum is computed by summing the bytes (ignoring overflow) and negating the result. }

4.2.2.5 Write service

The write service is issued to transfer table data to the target device.

Request:

The write request allows both complete and partial table transfers. The modification of a portion of a table is possible through the use of both offset-count and index-count methods.

Request codes 40–49 and 4F give access to all possible methods used for table transfer. Request code 40 specifies a complete table transfer. Request codes 41 through 49 specify a partial table transfer using 1 to 9 indices. Request code 4F specifies a partial table transfer using the offset-count method.

<write>	::=	<full_write> | <pwrite_index> | <pwrite_offset>	
<full_write>	::=	40_H <tableid> <table_data>	
<pwrite_index>	::=	<4j$_H$> <tableid> <index>+ <table_data>	
<4j$_H$>	::=	41_H |	{ 1 <index> included in request }
		42_H |	{ 2 <index> included in request }
		43_H |	{ 3 <index> included in request }
		44_H |	{ 4 <index> included in request }
		45_H |	{ 5 <index> included in request }
		46_H |	{ 6 <index> included in request }
		47_H |	{ 7 <index> included in request }
		48_H |	{ 8 <index> included in request }
		49_H	{ 9 <index> included in request }
<pwrite_offset>	::=	$4F_H$ <tableid> <offset> <table_data>	
<tableid>	::=	<word16>	{ Table identifier }

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<offset>	::=	<word24>	{ Offset into data table in bytes }
<index>	::=	<word16>	{ Index value used to locate start of data }
<table_data>	::=	<count> <data> <cksum>	
<count>	::=	<word16>	{ Length of <data> to be written, in bytes }
<data>	::=	<byte>+	
<cksum>	::=	<byte>	{ 2's compliment checksum computed only on the <data> portion of <table_data>. The checksum is computed by summing the bytes (ignoring overflow) and negating the result. }

Response:

Responses of type <nok> indicate a problem with the received service request.

The response <ok> indicates the write service was successfully completed and the data was successfully transmitted to the device.

<write_r> ::= <nok> | <ok>

4.2.2.6 Logon service

Logon service establishes a session without establishing access permissions.

Request:

The <user_id> parameter is a code, optionally stored by the metering device, indicating a utility supplied identity of the operator requesting the creation of a session. The <user_id> would be inserted in the Event and History Logs of the tables specification referenced in Clause 2, References, if the logs are supported by the metering device. The <user> field provides a utility supplied name of the operator requesting the access to the device. The logon service is required.

The logon service has the following format:

<logon>	::=	50_H <user_id> <user>	
<user_id>	::=	<word16>	{User identification code}
<user>	::=	<byte>+10	{10 bytes containing user identification}

Response:

The responses <err>, <bsy>, <iar>, and <isss> indicate a problem with the received service request.

The response <ok> indicates the logon service was successfully completed and the session was established.

<logon_r> ::= <err> | <bsy> | <iar> | <isss> | <ok>

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4.2.2.7 Security service

The security service is provided for setting access permissions.

Request:

A password is used as a means to select access permissions. This service request may only be sent during a session. The <password> field will be compared with those in the password table of the table specifications referenced in Clause 2, References, if the password tables are supported by the metering device.

<security> ::= 51_H <password>

<password> ::= <byte>$^{+20}$ {20 byte field containing password}

Response:

The responses <err> <bsy>, and <isss> indicate a problem with the received service request.

The response <ok> indicates the security service was successfully completed and the access permissions associated with the password were granted.

<security_r> ::= <err> | <bsy> | <isss> | <ok>

4.2.2.8 Logoff service

The logoff service provides for an orderly shutdown of the session established by the logon service.

Request:

Following a logoff service request the communication channel will retain the parameters previously established. The communication channel is terminated by either physical disruption of the channel or by the terminate service.

<logoff> ::= 52_H

Response:

The responses <err> <bsy>, and <isss> indicate a problem with the received service request.

The response <ok> indicates the acceptance of the logoff service and the cessation of the session established by the logon service. Prior to further data transfers with the metering device, the logon service must be reissued.

<logoff_r> ::= <err> | <bsy> | <isss> | <ok>

4.2.2.9 Negotiate service

The negotiate service provides the mechanism for reconfiguring the communication channel for communication parameters differing from the default values specified in this document.

Request:

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This service is initiated by the device communicating with the metering device. It is optional and, if not used, the communication channel operates with the default parameters established by this document. Device implementers are strongly encouraged to provide this service.

<negotiate>	::=	<6j$_H$> <packet_size> <nbr_packet> <baud_rate>*	
<6j$_H$>	::=	60$_H$ |	{ No <baud rate> included in request. Stay at default baud rate }
		61$_H$ |	{ 1 <baud rate> included in request }
		62$_H$ |	{ 2 <baud rate> included in request }
		63$_H$ |	{ 3 <baud rate> included in request }
		64$_H$ |	{ 4 <baud rate> included in request }
		65$_H$ |	{ 5 <baud rate> included in request }
		66$_H$ |	{ 6 <baud rate> included in request }
		67$_H$ |	{ 7 <baud rate> included in request }
		68$_H$ |	{ 8 <baud rate> included in request }
		69$_H$ |	{ 9 <baud rate> included in request }
		6A$_H$ |	{10 <baud rate> included in request }
		6B$_H$	{11 <baud rate> included in request }
<packet_size>	::=	<word16>	{ Maximum packet size supported, in bytes. This value shall not be greater than 8192 bytes.}
<nbr_packet>	::=	<byte>	{ Maximum number of packets this layer is able to reassemble into an upper layer data structure at one time. }
<baud_rate>	::=	00$_H$ |	{ Externally defined }
		01$_H$ |	{ 300 baud }
		02$_H$ |	{ 600 baud }
		03$_H$ |	{ 1200 baud }
		04$_H$ |	{ 2400 baud }
		05$_H$ |	{ 4800 baud }
		06$_H$ |	{ 9600 baud }
		07$_H$ |	{ 14400 baud }
		08$_H$ |	{ 19200 baud }
		09$_H$ |	{ 28800 baud }
		0A$_H$	{ 57600baud }
			{ 0B$_H$ -FF$_H$ reserved }

Response:

The responses <err>, <sns>, <bsy>, and <isss> indicate a problem with the received service request and that the communication channel will maintain its current settings.

The response <ok> indicates the service request was accepted and the new settings now apply. The data following the <ok> indicates the setting that will apply upon positive acknowledgement. If the target cannot accept the negotiate request baud rates, the original baud rate will be echoed in the response.

<negotiate_r> ::= <err> | <sns> | <bsy> | <isss> | <ok> <packet_size> <nbr_packet> <baud_rate>

4.2.2.10 Wait service

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The wait service is used by the communicating devices to maintain an established communication channel during idle periods thus preventing automatic termination. This temporarily extends the channel traffic time-out to the <time> specified in the request upon acknowledgement of the wait service request. The channel traffic time-out will be reset to the default value once the next valid packet is received by the target.

Request:

<wait> ::= 70_H <time>

<time> ::= <byte> { Suggested wait period in seconds. }

Response:

The responses <err>, <sns>, <bsy>, and <isss> indicate a problem with the received service request and time-out is not extended.

The response <ok> indicates the service request was accepted and the time-out is extended to the value requested.

<wait_r> ::= <err> | <sns> | <bsy> | <isss> | <ok>

4.2.2.11 Terminate service

The terminate service provides for an immediate cessation of the communication channel.

Request:

This service should be used to terminate either partially or fully established communication channels for reasons such as excessive errors, security issues, internal error conditions, end of session, or other reasons as set by the device manufacturer.

<terminate> ::= 21_H

Response:

The response <err> indicates a problem with the received service request and the channel remains open.

The response <ok> indicates the service request was accepted and the channel will return to default settings as stated in Clause 4.7.1.1, Default Settings, upon receipt of a positive acknowledgment.

<terminate_r> ::= <err> | <ok>

4.3 Layer 6—presentation layer

4.3.1 Null layer

The end device will not provide queuing capabilities for service requests.

4.4 Layer 5—session layer

4.4.1 Null layer

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Communications with the end device over the optical port communications path will be connection oriented and consist of a single session. The session is defined to begin with the acceptance of the logon service and terminates with the acceptance of either the logoff service or the terminate service.

4.5 Layer 4—transport

4.5.1 Null layer

4.6 Layer 3—network layer

4.6.1 Null layer

4.7 Layer 2—data link

Services of upper layers are transported in one or many packets. Each packet is variable in length but cannot exceed a maximum packet size. The maximum packet size has a default value when the communication channel is opened. The maximum packet size can be changed through the use of the negotiate service.

For each packet received, a positive or negative acknowledgment is sent by the target. This acknowledgment consists of a single byte transmitted outside of the packet structure. If the requester does not receive an acknowledgment before the Response Time-Out, or a negative acknowledgment is received, the same packet is re-transmitted up to 3 times. After the 3rd retry attempt, the requester should assume termination has occurred.

4.7.1 Basic data

Communication channel settings are specified below. The baud rate, number of packets, and packet size each has a default setting which applies at the initiation of communication. These settings may be changed through the negotiate service. Negotiated channel settings will return to defaults as a result of the terminate service or channel traffic time-out.

DATA TYPE: Asynchronous, serial bit (start - stop), half duplex
DATA FORMAT: 8 data bits, 1 start bit, 1 stop bit, no parity
DATA POLARITY: LED on, start bit, space, logical 0
LED off, stop bit, mark, logical 1, quiescent state
DATA RATE: The maximum transmitting speed shall be at least 9600 baud. Selection codes have been arranged for the following baud rates: 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 56200, or externally defined. Additional selection codes have been reserved for future assignment.
NUMBER OF PACKETS: At least one (1) packet is required although more are negotiable.
PACKET SIZE: Default packet size is 64 bytes, although a larger size can be negotiated.
CHANNEL TRAFFIC TIME-OUT: 6 seconds
INTER-CHARACTER TIME-OUT: 500 milliseconds
RESPONSE TIME-OUT: 2 seconds
TURN-AROUND DELAY: 175 microseconds

In the event of a collision (communicating device and meter are transmitting at the same time), the meter shall cease transmission and wait for the transmission from the communicating device.

4.7.1.1 Default settings

DATA RATE: 9600 baud
NUMBER OF PACKETS: 1
PACKET SIZE: 64 bytes

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4.7.2 Packet

<packet>	::=	<stp> <reserved> <ctrl> <seq_nbr> <length> <data> <crc>	
<stp>	::=	EE_H	{ Start of packet character. }
<reserved>	::=	<byte>	{ This field reserved for manufacturer or utility use. Value of the byte should be zero (00_H) if the field is not used. }
<ctrl>	::=	<byte>	{ Control field. Bit 7. If true (1_H) then this packet is part of a multiple packet transmission. Bit 6. If true (1_H) then this packet is the first packet of a multiple packet transmission. Bit 5. Represents a toggle bit to reject duplicate packets. This bit is toggled for each new packet sent. Retransmitted packets keep the same state as the original packet sent. Bits 0 to 4, Reserved.}
<seq_nbr>	::=	<byte>	{Number that is decremented by one for each new packet sent. The first packet in a multiple packet transmission shall have a <seq_nbr> equal to the total number of packets minus one. A value of zero in this field indicates that this packet is the last packet of a multiple packet transmission. If only one packet in a transmission, this field shall be set to zero.}
<length>	::=	<word16>	{ Number of bytes of data in packet. }
<data>	::=	<byte>+	{ <length> number of bytes of actual packet data. This value is limited by the maximum packet size minus the packet overhead of 8 bytes. This value can never exceed 8183. }
<crc>	::=	<word16>	{ CCITT CRC standard polynomial $X^{16} + X^{12} + X^5 + 1$ }

4.7.3 CRC selection

The CRC selected for implementation is the CCITT CRC standard polynomial $X^{16} + X^{12} + X^5 + 1$. The method for calculation and insertion is the HDLC standard per ISO 3309-1979(E) Annex A.

In the PSEM frame, there is no opening flag as referenced in ISO 3309-1979 Annex A. The PSEM start of packet character EE is included in the CRC calculation. The result of the CRC calculation shall be transmitted least significant byte first per the ISO 3309 Annex.

4.7.4 Acknowledgment

A positive or negative acknowledgment is used by the communicating devices to indicate either acceptance or rejection of a packet.

An <ack> is issued by the receiving device to the transmitting device for each packet received that meets the constraints established by this clause.

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<ack> ::= 06_H

A <nak> is issued by the receiving device to the transmitting device for each packet received that does not meet the constraints established by this clause. Examples of problems with received packets indicated by a <nak> response include CRC errors, packet structure errors, incorrect bit patterns and missing characters.

<nak> ::= 15_H

4.7.5 Retransmission

The same packet shall be transmitted if a <nak> is received, an invalid character is received, or the acknowledge time-out elapses. After 3 consecutive negative acknowledgments, automatic termination shall occur.

If a duplicate packet is received by the target, the target should disregard the duplicate packet and return an <ack>.

4.7.6 Time-out

4.7.6.1 Channel traffic time-out

The metering device will terminate communications after waiting some period of time for a valid packet or acknowledgement. This period of time, defined as the channel traffic timeout, shall be 6 seconds.

4.7.6.2 Inter-character time-out

The recipient of the packet must handle the case when the end of a packet is lost. Inter-character time-out is defined as the minimum amount of time the recipient shall wait between characters within a packet when receiving data over the communication channel. The recipient shall wait at least this amount of time before it ceases to wait for the remaining packet and sends a <nak>. The inter-character time-out shall be 500 milliseconds.

4.7.6.3 Response time-out

The sender of the packet must handle the case when the acknowledgment is lost. Response time-out is defined as the minimum amount of time the sender shall wait after a packet is sent to receive an acknowledgment over the communication channel. If this amount of time elapses, the sender will send the packet again. The response time-out shall be 2 seconds.

4.7.7 Delays

4.7.7.1 Turn around delay

The turn around delay is the minimum delay the recipient must wait after receiving a packet and before sending a positive or negative acknowledge. The turn around delay shall be 175 microseconds.

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4.8 Layer 1—physical

4.8.1 Physical

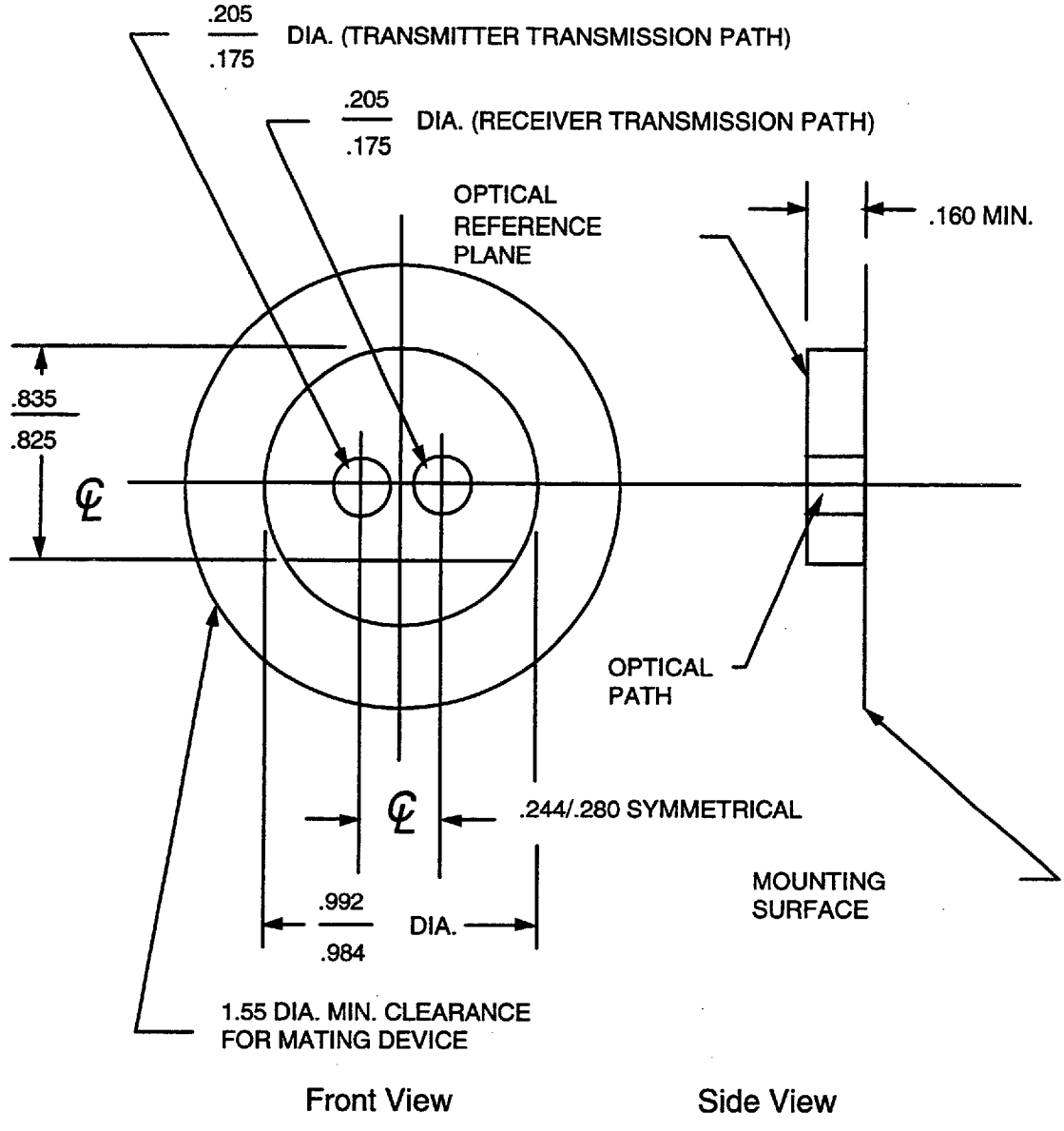


Figure 4-1–External view of port optical port—ANSI type

NOTE: All dimensions are in inches.

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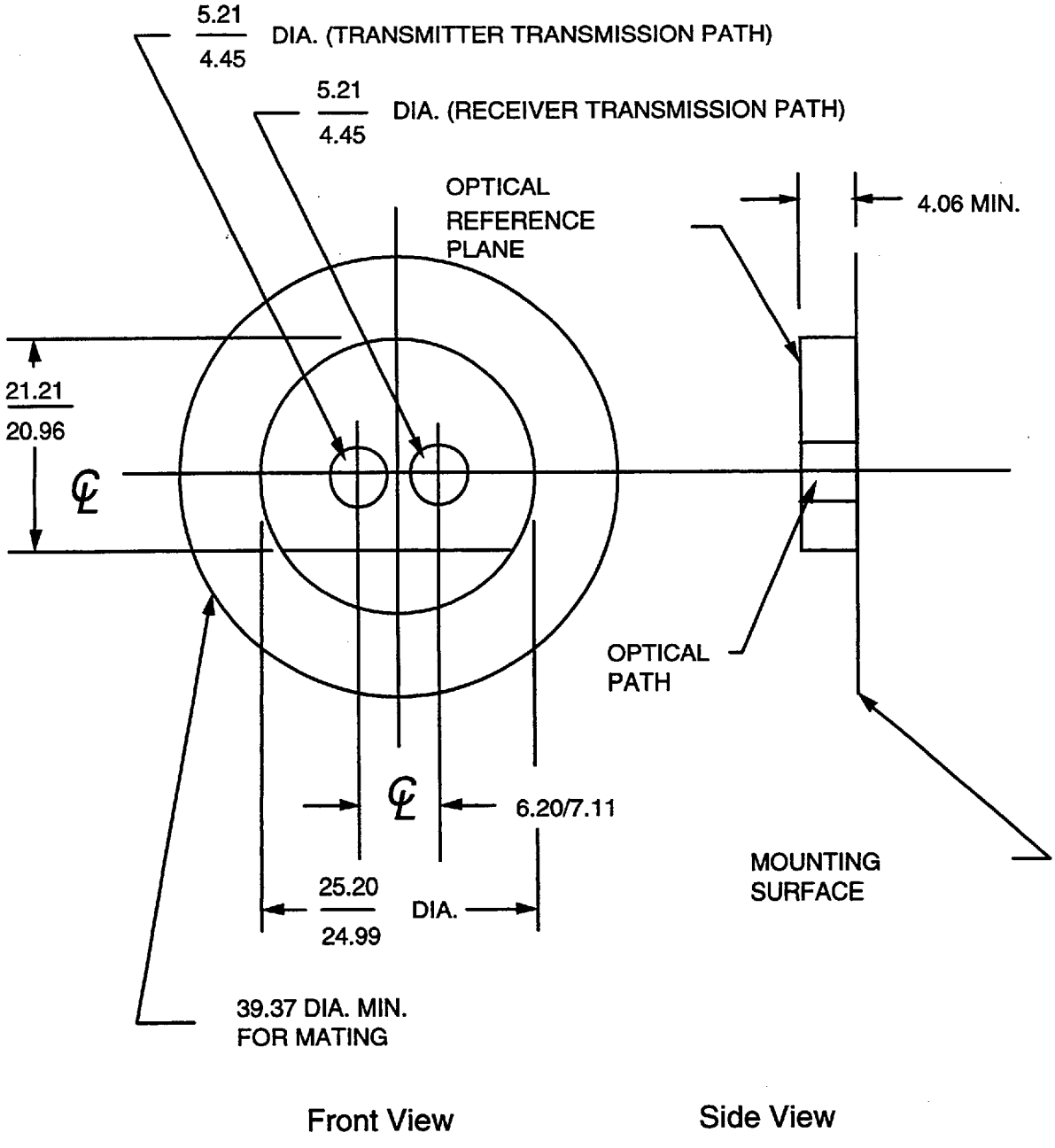


Figure 4-2–External view of port optical port—ANSI type 2

NOTE: All dimensions are in mm.

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4.8.2 Basic data

The physical layer data setting is specified below.

DATA POLARITY: LED on, start bit, space, logical 0
LED off, stop bit, mark, logical 1, quiescent state

4.8.3 Light levels

4.8.3.1 Optical characteristics

The wavelength of the radiated signals in both directions is between 800 nm and 1,000 nm (infrared).

4.8.3.2 Transmitter characteristics

With reference to figure 4-3, the transmitter in the metering device generates a signal with a radiation strength $E_{ø/T}$ over a defined circular reference surface (optically active area) of diameter d_1. The test receiver is on the optical axis of the transmiter at a distance d_2 from the optical reference plane on the metering device.

The following limiting values apply:

The reference temperature is 23°C (± 2°C).

d1 = 5 mm (± 1 mm)

Both conditions shall be met:

	ON-condition	OFF-condition
d2 = 10 mm (± 1 mm)	$250 < E_{ø/T} < 7500\ \mu W/cm^2$	$E_{ø/T} < 10\ \mu W/cm^2$
d2 = 25 mm (± 1 mm)	$85 < E_{ø/T} < 7500\ \mu W/cm^2$	$E_{ø/T} < 10\ \mu W/cm^2$

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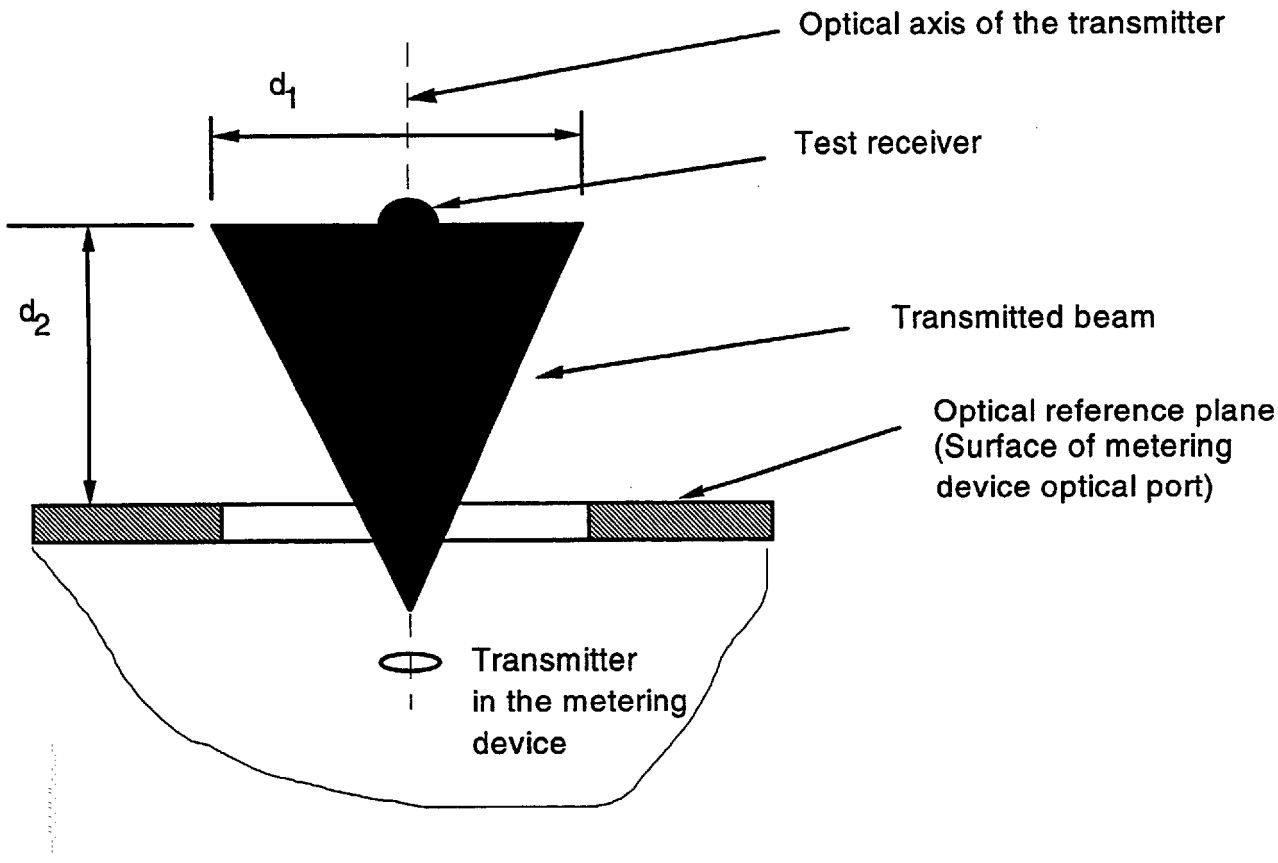


Figure 4-3–Test arrangement for the transmitter

4.8.3.3 Receiver characteristics

With reference to figure 4-4, a test transmitter, located on the optical axis, and positioned at a distance d_2 from the optical reference plane of the metering device, generates a signal with a radiation strength $E_{ø/R}$ over a defined circular reference surface (optically active area) with a diameter d_1 at the optical reference plane. The receiver shall respond to test signals as follows:

The following limiting values apply:

The reference temperature is 23°C (± 2°C).

d1 = 5 mm (± 1 mm)

Both conditions shall be met:

	ON-condition	**OFF-condition**
d2 = 10 mm (± 1 mm)	$1000 < E_{ø/R} < 7500$ µW/cm^2	$E_{ø/T} < 10$ µW/cm^2
d2 = 25 mm (± 1 mm)	$1000 < E_{ø/R} < 7500$ µW/cm^2	$E_{ø/T} < 10$ µW/cm^2

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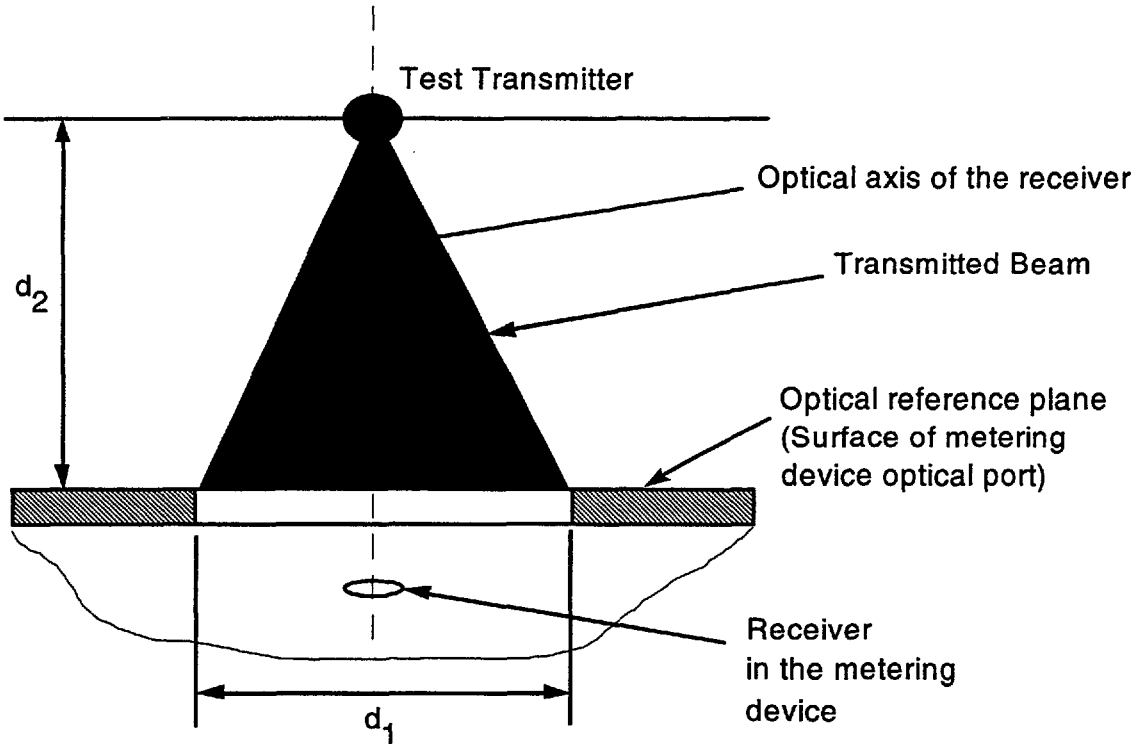


Figure 4-4–Test arrangement for the receiver

4.8.3.4 Environmental lighting condition

The optical path (data transmission) shall not be affected by surrounding light with an intensity of up to 16,000 lux (light composition comparable with daylight, including fluorescent light).

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ANNEX A
(Informative)
Protocol syntax

A.1 Order of transmission syntax

<bit 0>	::=	Least significant bit
<bit 1>	::=	Second least significant bit
<bit 2>	::=	Third least significant bit
<bit 3>	::=	Fourth least significant bit
<bit 4>	::=	Fourth most significant bit
<bit 5>	::=	Third most significant bit
<bit 6>	::=	Second most significant bit
<bit 7>	::=	Most significant bit
<byte>	::=	<bit0> <bit1> <bit2> <bit3> <bit4> <bit5> <bit6> <bit7>
<lsbyte>	::=	<byte> {least significant byte}
<msbyte>	::=	<byte> {most significant byte}
<word16>	::=	<msbyte> <lsbyte>
<word24>	::=	<msbyte> <byte> <lsbyte>

A.2 Layer 7 syntax

<3j$_H$>	::=	31_H |	{ 1 <index> included in request }
		32_H |	{ 2 <index> included in request }
		33_H |	{ 3 <index> included in request }
		34_H |	{ 4 <index> included in request }
		35_H |	{ 5 <index> included in request }
		36_H |	{ 6 <index> included in request }
		37_H |	{ 7 <index> included in request }
		38_H |	{ 8 <index> included in request }
		39_H	{ 9 <index> included in request }
<4j$_H$>	::=	41_H |	{ 1 <index> included in request }
		42_H |	{ 2 <index> included in request }
		43_H |	{ 3 <index> included in request }
		44_H |	{ 4 <index> included in request }
		45_H |	{ 5 <index> included in request }
		46_H |	{ 6 <index> included in request }
		47_H |	{ 7 <index> included in request }
		48_H |	{ 8 <index> included in request }
		49_H	{ 9 <index> included in request }
<6j$_H$>	::=	60_H |	{ No <baud rate> included in request. Stay at default baud rate }
		61_H |	{ 1 <baud rate> included in request }
		62_H |	{ 2 <baud rate> included in request }
		63_H |	{ 3 <baud rate> included in request }
		64_H |	{ 4 <baud rate> included in request }
		65_H |	{ 5 <baud rate> included in request }

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		66_H |	{ 6 <baud rate> included in request }
		67_H |	{ 7 <baud rate> included in request }
		68_H |	{ 8 <baud rate> included in request }
		69_H |	{ 9 <baud rate> included in request }
		$6A_H$ |	{10 <baud rate> included in request }
		$6B_H$	{11 <baud rate> included in request }
<baud_rate>	::=	00_H |	{ Externally defined }
		01_H |	{ 300 baud }
		02_H |	{ 600 baud }
		03_H |	{ 1200 baud }
		04_H |	{ 2400 baud }
		05_H |	{ 4800 baud }
		06_H |	{ 9600 baud }
		07_H |	{ 14400 baud }
		08_H |	{ 19200 baud }
		09_H |	{ 28800 baud }
		$0A_H$	{ 57600 baud }
<bsy>	::=	06_H	{Device Busy—This application level error indicates that the request was not acted upon because the device was busy doing something else.}
<cksum>	::=	<byte>	{ 2's compliment checksum computed only on the <data> portion of <table_data>. The checksum is computed by summing the bytes (ignoring overflow) and negating the result. }
<count>	::=	<word16>	{Length of table data in bytes}
<data>	::=	<byte>+	
<dlk>	::=	08_H	{Data Locked—This application level error indicates that the request was unsuccessful because the data cannot be accessed.}
<dnr>	::=	07_H	{Data Not Ready—This application level error indicates that request was unsuccessful because the requested data is not ready to be accessed.}
<err>	::=	01_H	{Error—This code is used to indicate rejection of the received service request. The reason for the rejection is NOT provided.}
<full_read>	::=	30_H <tableid>	
<full_write>	::=	40_H <tableid> <table_data>	

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<iar>	::=	05_H	{Inappropriate Action Requested—This application level error indicates that the action requested was inappropriate. Covers conditions such as write request to a read only table or an invalid table id.}
<ident>	::=	20_H	
<ident_r>	::=	<err> | <bsy> | <isss> | <ok> <std> <ver> <rev> <rsvd>	
<index>	::=	<word16>	{Index value used to locate start of data}
<isc>	::=	03_H	{Insufficient Security Clearance—This application level error indicates that the current authorization level is insufficient to complete the request.}
<isss>	::=	$0A_H$	{Invalid Service Sequence State—This application level error indicates that the request is not accepted at the current service sequence state. For more information on service sequence states, see Annex D.}
<logoff>	::=	52_H	
<logoff_r>	::=	<err> | <bsy> | <isss> | <ok>	
<logon>	::=	50_H <user_id> <user>	
<logon_r>	::=	<err> | <bsy> | <iar> | <isss> | <ok>	
<negotiate>	::=	<6j$_H$> <packet_size> <nbr_packet> <baud rate>*	
<negotiate_r>	::=	<err> | <sns> | <bsy> | <isss> | <ok> <packet_size> <nbr_packet> <baud_rate>	
<nbr_packet>	::=	<byte>	{Maximum number of packets that this layer is able to reassemble into an upper layer data structure at one time.}
<nok>	::=	<err>|<sns>|<isc>|<onp>|<iar>|<bsy>|<dnr>|<dlk>| <rno>|<isss>	
<offset>	::=	<word24>	{Offset into data table in bytes }
<ok>	::=	00_H	{Acknowledge—No problems, request accepted.}
<onp>	::=	04_H	{Operation Not Possible—This application level error will be sent to the device which requested an action that is not possible. This error indicates that the message was valid, but the message could not be processed. Covers conditions such as: Invalid Length, Invalid Offset}
<packet_size>	::=	<word16>	{ Maximum packet size supported, in bytes. This value shall not be greater than 8192 bytes.}

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<password>	::=	<byte>+	{20 byte field containing password}
<pread_default>	::=	$3E_H$	{ Transfer default table }
<pread_index>	::=	<3j$_H$> <tableid> <index>+ <count>	
<pread_offset>	::=	$3F_H$ <tableid> <offset> <count>	
<pwrite_index>	::=	<4j$_H$> <tableid> <index>+ <table_data>	
<pwrite_offset>	::=	$4F_H$ <tableid> <offset> <table_data>	
<read>	::=	<full_read> | <pread_index> | <pread_offset> | <pread_default>	
<read_r>	::=	<nok> | <ok> <table_data>	
<responses>	::=	<ident_r> |	{ Identification response }
		<read_r > |	{ Read response }
		<write_r > |	{ Write response }
		<logon_r > |	{ Logon response }
		<security_r> |	{ Security response }
		<logoff_r > |	{ Logoff response }
		<negotiate_r > |	{ Negotiate response }
		<wait_r > |	{ Wait response }
		<terminate_r >	{ Terminate response }
<requests>	::=	<ident> |	{ Identification request }
		<read> |	{ Read request }
		<write> |	{ Write request }
		<logon> |	{ Logon request }
		<security> |	{ Security request }
		<logoff> |	{ Logoff request }
		<negotiate> |	{ Negotiate request }
		<wait> |	{ Wait request }
		<terminate>	{ Terminate request }
<rev>	::=	<byte>	{Referenced standard revision number}
<rno>	::=	09_H	{Renegotiate request—This application level error indicates that the responding device wishes to return to the ID or base state and re-negotiate communication parameters.}
<rsvd>	::=	<byte>	{Reserved for future use. This byte shall be set to 00_H until further defined.}
<security>	::=	51_H <password>	
<security_r>	::=	<err> | <bsy> | <isss> | <ok>	
<sns>	::=	02_H	{Service Not Supported—This application level error response will be sent to the device when the requested service is not supported. This

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			error indicates that the message was valid, but the request could not be honored.}
<std>	::=	<byte>	{Code identifying reference standard. The codes are defined as follows: 00_H = ANSI C12.18 01_H = Industry Canada 02_H-FF_H = Reserved }
<tableid>	::=	<word16>	{Table identifier}
<table_data>	::=	<count> <data> <cksum>	
<terminate>	::=	21_H	
<terminate_r>	::=	<err> | <ok>	
<time>	::=	<byte>	{Suggested wait period in seconds}
<user_id>	::=	<word16>	{User identification code}
<user>	::=	<byte>+	{10 bytes containing user identification}
<ver>	::=	<byte>	{Referenced standard version number}
<wait>	::=	70_H <time>	
<wait_r>	::=	<err> | <sns> | <bsy> | <isss> | <ok>	
<write>	::=	<full_write> | <pwrite_index> | <pwrite_offset>	
<write_r>	::=	<nok> | <ok>	

A.3 Layer 2 syntax

<ack>	::=	06_H	
<crc>	::=	<word16>	{ CCITT CRC standard polynomial $X^{16} + X^{12} + X^5 + 1$ }
<ctrl>	::=	<byte>	{ Control field. Bit 7. If true (1_H) then this packet is part of a multiple packet transmission. Bit 6. If true (1_H) then this packet is the first packet of a multiple packet transmission. Bit 5. Represents a toggle bit to reject duplicate packets. This bit is toggled for each new packet sent. Retransmitted packets keep the same state as the original packet sent. Bits 0 to 4, Reserved.
<data>	::=	<byte>+	{ <length> number of bytes of actual packet data. This value is limited by the maximum packet size minus the packet overhead of 8 bytes. This value can never exceed 8183. }

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<length>	::=	<word16>	{ Number of bytes of data in packet. }
<nak>	::=	15_H	
<packet>	::=	<stp> <reserved> <ctrl> <seq_nbr> <length> <data> <crc>	
<reserved>	::=	<byte>	{ This field reserved for manufacturer or utility use. Value of the byte should be zero (00_H) if the field is not used. }
<seq_nbr>	::=	<byte>	{Number that is decremented by one for each new packet sent. The first packet in a multiple packet transmission shall have a <seq_nbr> equal to the total number of packets minus one. A value of zero in this field indicates that this packet is the last packet of a multiple packet transmission.}
<stp>	::=	EE_H	{ Start of packet character. }

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ANNEX B
(Informative)
Communication example (layer 7 and layer 2)

Figures B-1 and B-2 show an example of a communications session between a handheld and a meter in which a table is read. Annex C, figure C-1 shows the actual packet data transmission of this example.

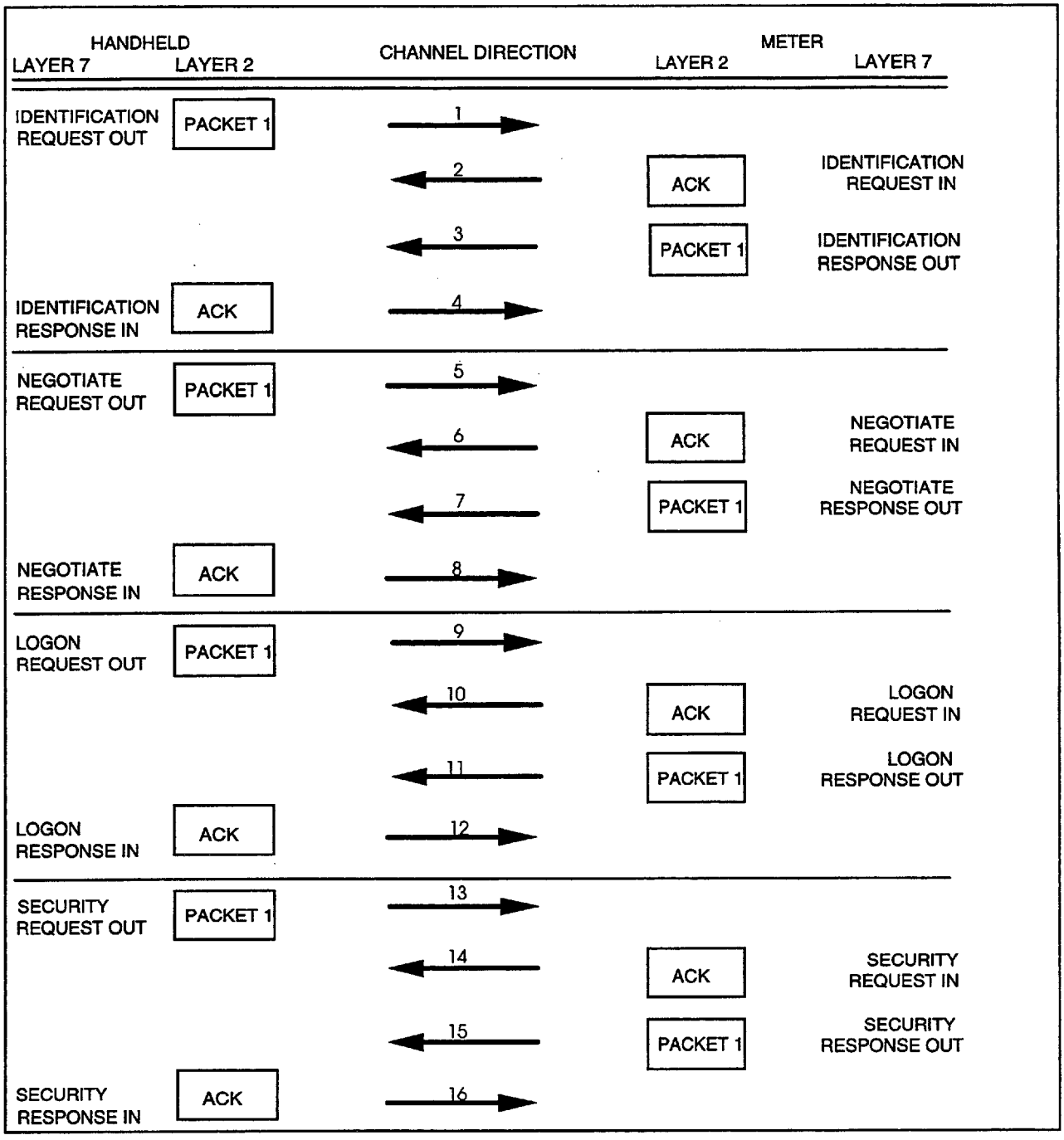


Figure B-1–Communication example

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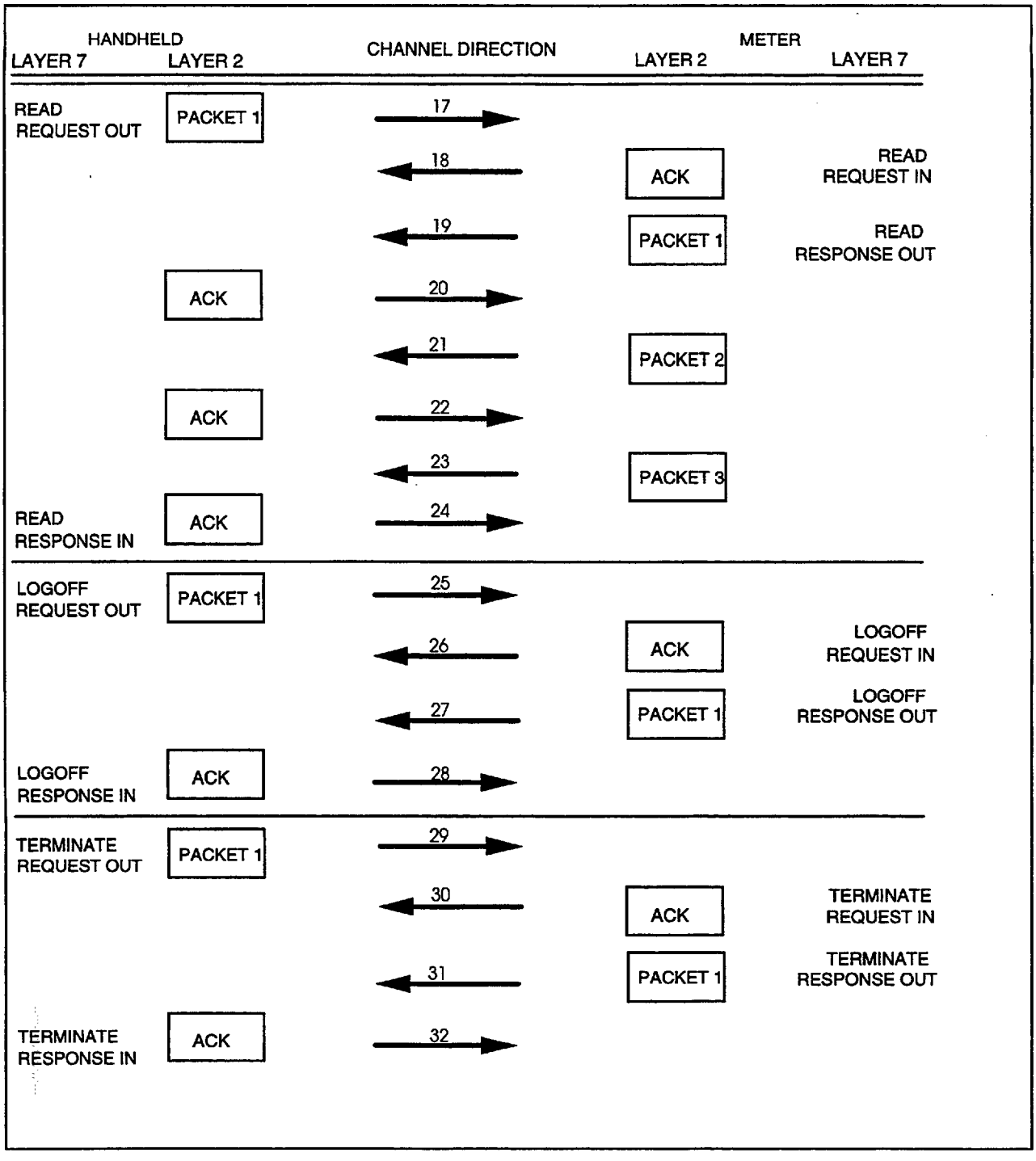


Figure B-2–Communication example continued

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ANNEX C
(Informative)
Packet transmission example

Figure C-1 shows the actual packet data being transmitted in figures B-1 and B-2 in Annex B. Numbers 1)–32) refer to the numbers in figures B-1 and B-2. All values are specified in hexadecimal format. The following arbitrary information was used.

<std>	=	00
<ver>	=	01
<rev>	=	00
<packet_size>	=	0040 (64 bytes)
<nbr_packet>	=	04 (4 packets)
<baud_rate>	=	08 (19200 baud)
<user_id>	=	1111
<username>	=	01 02 03 04 05 06 07 08 09 0A
<password>	=	01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12 13 14
<table_id>	=	0000
<offset>	=	000010
<count>	=	0096 (150 bytes)
<data>	=	01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

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```
1) → EE 00 00 00 0001 20 13 10
2) ← 06
3) ← EE 00 00 00 0005 00 00 01 00 00 C6 B5
4) → 06
5) → EE 00 20 00 0005 61 0040 04 08 8A 5F
6) ← 06
7) ← EE 00 20 00 0005 00 0040 04 08 7D F5
8) → 06
9) → EE 00 00 00 000D 50 1111 0102030405060708090A CA 33
10) ← 06
11) ← EE 00 00 00 0001 00 11 31
12) → 06
13) → EE 00 20 00 0015 51 0102030405060708090A0B0C0D0E0F1011121314 86 27
14) ← 06
15) ← EE 00 20 00 0001 00 80 51
16) → 06
17) → EE 00 00 00 0008 3F 0000 000010 0096 B0 7F
18) ← 06
19) ← EE 00 C0 02 0038 00 0096 0102030405060708090A0B0C0D0E0F1011121314151617
    18191A1B1C1D1E1F202122232425262728292A2B2C2D2E2F303132333435 BA 8E
20) → 06
21) ← EE 00 A0 01 0038 363738393A3B3C3D3E3F404142434445464748494A4B4C4D4E4F50
    515253545556575859 5A5B5C5D5E5F606162636465666768696A6B6C6D F0 47
22) → 06
23) ← EE 00 80 00 002A 6E6F707172737475767778797A7B7C7D7E7F80818283848586
    8788898A8B8C8D8E8F90919293949596 C3 BD B1
24) → 06
25) → EE 00 20 00 0001 52 17 20
26) ← 06
27) ← EE 00 20 00 0001 00 80 51
28) → 06
29) → EE 00 00 00 0001 21 9A 01
30) ← 06
31) ← EE 00 00 00 0001 00 11 31
32) → 06
```

Figure C-1–Packet transmission example

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ANNEX D
(Informative)
Service sequence state control

The period of PSEM communications is defined in a series of "Service Sequence States." The use of each service may be restricted to one or more states. Specific services also cause transitions between states. The transition is implemented upon positive acknowledgement of the service. The recognized states include:

a) Base State—This is the state at which communication begins. At this point the default data transmission parameters apply.

b) ID State—Once the metering device has been identified, this is the state that is entered.

c) Session State—When a successful logon has been completed, this is the state achieved.

The relationship between PSEM services and service sequence states is:

Identification service requests are accepted at the base state only. Acceptance of an identification service request, <ok> transitions communications to the ID state. This service cannot originate from the metering device.

Wait service requests are accepted in the ID and session states. Acceptance of these requests do not result in any sequence state changes. This service can originate from either end of the communication channel.

Negotiate service requests are accepted in the ID state only. Acceptance of these requests do not result in any sequence state changes. Negotiated services are not implemented until after acceptance. This service cannot originate from the metering device.

Logon service requests are accepted at the ID state only. Acceptance of a logon service request, <ok> transitions communications to the session state. This service cannot originate from the metering device.

Security service requests are accepted at the session state only. Acceptance of these requests do not result in any sequence state changes. This service cannot originate from the metering device.

Read and write service requests are accepted in the session state only. Acceptance of these requests do not result in any sequence state changes. These services can originate from either end of the communication channel.

Logoff service requests are accepted at the session state only. Acceptance of a logoff service request, <ok> transitions communications to the ID state. This service can originate from either end of the communication channel.

Terminate service requests are accepted at the ID and session states. Acceptance of a terminate service request, <ok> transitions communications to the base state. This service can originate from either end of the communication channel.

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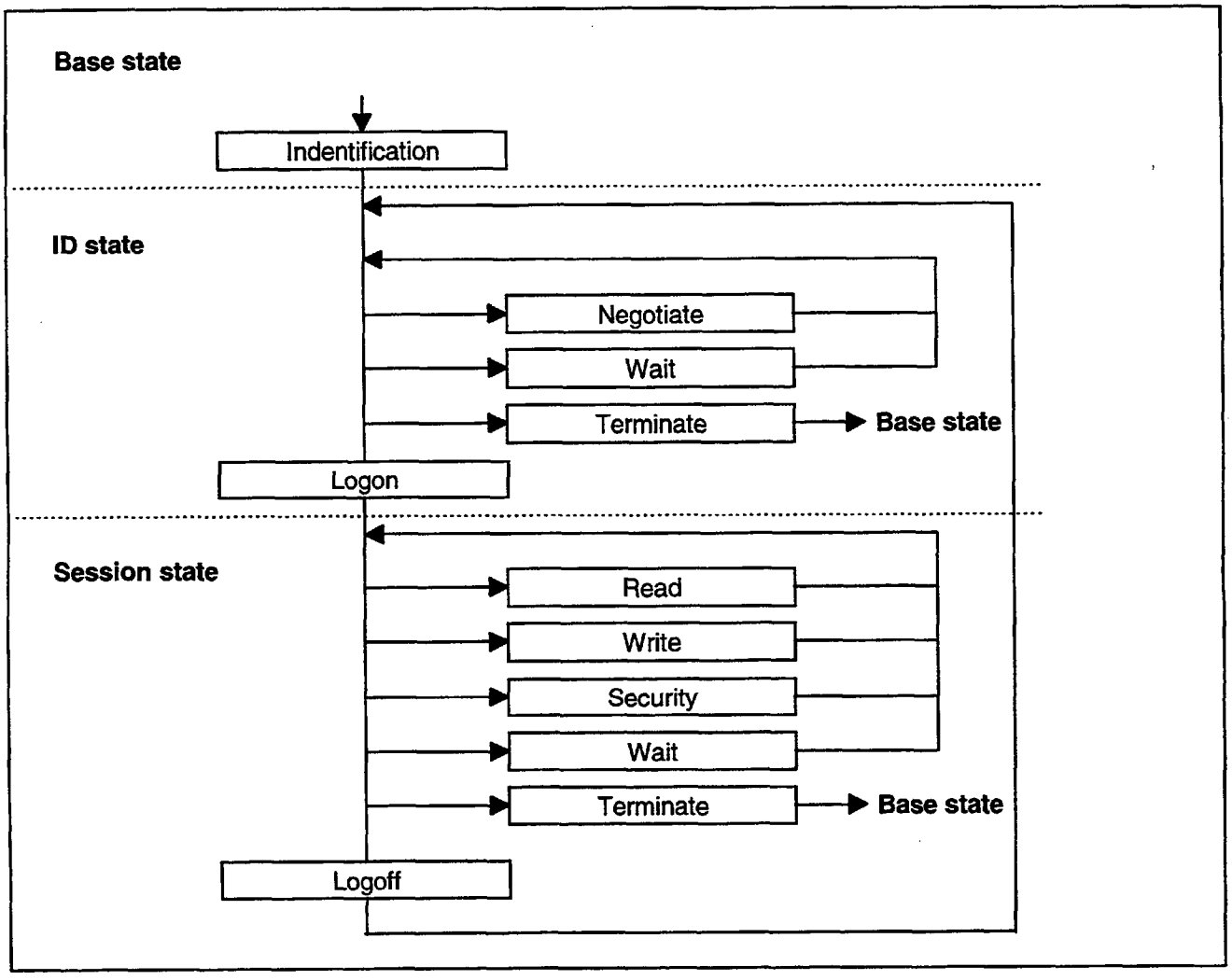


Figure D-1–Communication state diagram

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