AMETEK®

POWER INSTRUMENTS

DIGITAL POLYPHASE METER COMMUNICATIONS PROTOCOL REFERENCE MANUAL

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1. Ci20 Communications Protocol Reference Manual

Introduction: Ci20 Communication Structures

This manual describes the protocol layers defined for the *Ci20* meter serial communication ports. It is intended for use by design engineers to design the communications functions for external programs that communicate with the *Ci20* meter.

Discussions in this section include:

- ”Protocol Layers”
- ”Physical Layer” on page 1-2
- ”Transport Layer” on page 1-2
- ”Notation used in this document” on page 1-6
- ”Definitions” on page 1-10
- ”Introduction to Passwords and Privileges” on page 1-11
- ”Hardware Security Key” on page 1-13

Protocol Layers

The *Ci20* serial communication protocols have three distinct layers, similar to the layered-protocol model described in the Open Systems Interconnect (OSI) model of the International Standards Organization (ISO). The layers defined for *Ci20* are physical, transport, and application (i.e., commands and responses):

Physical layer	Defines the hardware media and byte framing used for serial communications. The specifications of the *Ci20* physical-layer protocol are outlined in the *Ci20 User Manual* (1086-381). See ”Physical Layer” on page 1-2.

Transport layer	Guarantees delivery of the application layer data between the meter and an external computer. The *Ci20*'s transport protocol allows for fragmentation of the communications between the meter and computer, detects data corruption due to noise and/or breaks on the physical link, and allows for a multidrop communications mode. See "Transport Layer" on page 1-2.
Application layer	Configures how an external computer instructs the meter to perform various functions, including configuring the meter, reading the configuration from the meter, reading the registers and history buffers, reading status information, writing registers, reading and setting time, and performing control functions, such as Demand Reset. See "Commands and Responses" on page 1-14.

Physical Layer

The *Ci20* has several options in the physical layer: Optical, RS-232, RS-485, and Modem. Each uses *universal asynchronous* byte framing with eight data bits, no parity, and one stop bit. The meters are individually addressable; more than one meter can share a common node. The meter is addressed within the transport layer of the protocol, allowing more than one meter to share a modem or an RS-232 connection, with proper equipment.

Transport Layer

The transport layer packages the commands and responses, as described in "Commands and Responses" on page 1-14. Both commands and responses from the meter abide by this transport-layer format.

Transport layer discussions include:

- "Format"
- "Other Transport Layer Transmission" on page 1-5

Format

Table 1.1 shows the transport protocol lay out.

Table 1.1 Transport Protocol Layout

DLE	SOH	ADR	CMD	EXT	DLE	STX	TXT	DLE	ETX	CRCL	CRCH

DLE – Data Link Escape character (0x10)

Used before every control character, such as SOH, STX, ETX, or ETB.

SOH – Start of Header (0x01)

Indicates the beginning of a command or response.

ADR

Use any hexadecimal number between 0x00 and 0xff corresponding to the meter's communications address. This allows individual meter addressing when multiple meters are connected on a common node (modem or RS-485). All meters respond to a global address of 0xfe.

A broadcast address of 0xff is also available to which the meters perform the function of the command, if any, but do not respond to it. This is used to prevent data contention on the communications line where multiple meters are installed. This broadcast address is useful for broadcasting a freeze or a time set to multiple meters simultaneously.

The default addresses for the comm port and optical port are 0x02 and 0x05, respectively.

CMD – Command byte

Indicates a particular command grouping. The combination of the CMD and the EXT determines the specific command.

EXT – Command extension byte

Indicates the specific command within a particular command group. The combination of the CMD and the EXT determines the command.

STX – Start of Text (0x02)

Indicates the beginning of text associated with the specified command.

TXT – Protocol Text Area

Represents the data part of a command or response.

ETX – End of Text (0x03)

Indicates the end of text associated with the specified command. In a multiple-packet transmission, the ETX indicates that the last text packet has been transmitted. Otherwise, an ETB is sent.

ETB – End of Transmission Block (0x17)

Indicates the end of text within a given packet for a multiple-packet transmission. This indicates that another transmission packet is sent with additional text associated with the same command.

CRCn — Sets a two-byte cyclic redundancy check for the particular transmission packet, least-significant byte sent first. The CRC-16 polynomial is $x^{16}+x^{15}+x^{2}+1$.

The initial CRC for a packet is 0x0000.

NOTE

STX and ETX bytes with preceding DLEs are required whether or not text is associated with the command.

Double DLEs — Send a (0x10) byte outside the standard DLEs used in the transport layer and the *Ci20* precedes the (0x10) character with a DLE character, indicating that the following character is a 0x10 (not a control character). This rule applies if a 0x10 appears in the meter's communication address, command or extension, and data. A 0x10 CRC byte high or low order is not doubled.

Other Transport Layer Transmission

ACK

A lone ACK (0x06) is sent to acknowledge that a packet has been received correctly and that the next one, if any, can be sent.

No additional control characters are sent.

NAK-in-a-box

Represents one method for sending a negative acknowledgment. If a command is improperly sent, or if an attempt is made to activate an invalid password, the meter responds with a NAK-in-a-box. This response abides by the transport layer vehicle. The address, command, and extension are the same as the command that is negatively acknowledged. The text contains a time stamp in a packed BCD in the format *MM DD YY HH MM SS Day-of-Week* and then a NAK (0x15).

EOT – End of Transmission (0x04)

Sent by the meter if it receives more than 15 bad packets of information or receives 15 consecutive NAKs in response to a transmission packet that the meter is attempting to send. The meter awaits a new command after the EOT is sent.

NAK

Sent in response to a packet if the data is improperly received due to a bad CRC. A lone Nak prompts the computer or meter to retransmit the last packet of information. No additional control characters are sent.

Notation used in this document

This manual describes, for the most part, commands and data formats used in communicating with the *Ci20* Digital Power Meter. For a description of the Binary Transport Protocol, see the *JEM10 Polyphase Meter Technical Reference Manual: JEM10 Communications Protocol, chapter 2 (Transport Layer*).

Numeric-only constants are assumed to be decimal. Hexadecimal constants are prefixed with *0x* as in the C programming language.

Data types are modeled on those found in C (Table 1.2).

Table 1.2 Data Types

Manual Notation	C Language Equivalent	Comments
U8	unsigned char	
S8	signed char	
U16	unsigned short	Beware of using *int* - it is 16 bits on some platforms and 32 bits on others. *short* is always 16 bits.
S16	signed short	Beware of using *int* - it is 16 bits on some platforms and 32 bits on others. *short* is always 16 bits.
U32	unsigned long	
S32	signed long	
F32	single precision float (IEEE 754 single-precision format)	
F64	double precision float (IEEE 754 double-precision format)	

Arrays are indicated by adding the dimension of the array in square brackets after the *type* rather than the *name*. For example, a 50-character string is described as:

U8[50] string name (ASCII string, null terminated)

Structures and arrays of structures are indicated by this text construction:

begin structure(description of structure and rationale for number of structures in an array)

type1(description of first element)

type2(description of second element)

end structure [dim] (dim gives number of structures in array - omitted if single structure)

The types within a structure can be any of the previously described types, including other structures.

The description of any variable usually gives the allowed range of values. Some variables are used to store an enumeration. In that case, the variable description lists all possible enumeration values. In a few cases, a variable description can list an enumeration, but limit the allowed values to a subset. This allows use of a common enumerated type for multiple variables.

All multi-byte types, except for structures as a whole and arrays of U8 or S8, are transmitted least-significant-byte first, according to the Binary Transport Protocol. For structures and arrays of multi-byte data types, the elements are transmitted in the order they are declared, but each individual element is transmitted LSB-first.

Bit fields (e.g. *U16 timeOfDay:12*) are ordered in memory according to the convention used by the Toshiba 900-family C compiler used to build the *Ci20* Register firmware. The Toshiba 900-family C compiler encodes the first-declared fields in the upper (more significant) bits of the word.

Bit field example 1:

```
struct U8FIELD
  { unsigned char  firstU8field:2;
    unsigned char  secondU8field:2;
    unsigned char  thirdU8field:2;
    unsigned char  fourthU8field:2;
  } const fieldU8 = {0,1,2,3};
```

This yields an 8-bit storage location containing the value 1B hex (Table 1.3).

Table 1.3 8-Bit Storage Location

firstU8field	secondU8field	thirdU8field	fourthU8field
00 (bin)	01 (bin)	10 (bin)	11 (bin)
0 (dec)	1 (dec)	2 (dec)	3 (dec)

Bit field example 2:

```
struct U16FIELD
{ unsigned short firstU16field:4;
  unsigned short secondU16field:4;
  unsigned short thirdU16field:4;
  unsigned short fourthU16field:4;
} const fieldU16 = {0,1,2,3};
```

This yields a 16-bit storage location containing the value 0123 hex (Table 1.4).

Table 1.4 16-Bit Storage Location

firstU16field	secondU16field	thirdU16field	fourthU16field
0000 (bin)	0001 (bin)	0010 (bin)	0011 (bin)
0 (dec)	1 (dec)	2 (dec)	3 (dec)

Bit field example 3:

```
struct U32FIELD
  {
    unsigned long firstU32field:8;
    unsigned long secondU32field:8;
    unsigned long thirdU32field:8;
    unsigned long fourthU32field:8;
  } const fieldU32 = {0,1,2,3};
```

This yields a 32-bit storage location containing the value 00010203 hex (Table 1.5).

Table 1.5 32-Bit Storage Location

FirstU32field	SecondU32field	ThirdU32field	FourthU32field
0000 0000 (bin)	0000 0001 (bin)	0000 0010 (bin)	0000 0011 (bin)
0 (dec)	1 (dec)	2 (dec)	3 (dec)

Definitions

Working (register)	The displayed numeric value that is regularly updated as part of the meter's operation.
BPR, Storage (register)	A snapshot of the Working register taken when a Billing Period Reset is performed. Commonly, a meter reader performs a BPR on a meter, then reads and records the Storage registers. This ensures that the readings taken are simultaneous.
Freeze (register)	A snapshot of the Working register taken in response to a communications Freeze command. Used to ensure that serial register readings are simultaneous.
Season (register)	A snapshot of the Working register taken when a Time of Use season changes. Used to obtain a *final reading* at the end of a season.
Thermal (register)	A register in which instantaneous changes in input are reflected slowly in a displayed register to simulate a thermal response to an increased load. For example, suddenly increasing the load on a transformer from 100 W to 100 kW does not cause the transformer's temperature to increase immediately. The thermal register increases gradually from 100 W to 100 kW over a user-defined time period to simulate the thermal time characteristic of the transformer.

Introduction to Passwords and Privileges

The *Ci20* meter uses a set of four passwords to give user programs access to internal data. Each password is six characters in length. The first password is the master password, which always gives access to all internal data. Three user passwords have assignable *privileges* that enable various read or write ability for meter data items (Table 1.6).

Table 1.6 Password/Privileges Codes

Name	Value	Description
PR_NORM_REG	0x00000001	Read Normal register list
PR_ALT_REG	0x00000002	Read Alternate register list
PR_DISP_QUAN	0x00000004	Read any displayable quantity
PR_SET_TIME	0x00000008	Set time
PR_BPR	0x00000010	Perform billing reset
PR_TESTMODE	0x00000020	Enter test, site diagnostic, or calibration mode
PR_PRESET	0x00000040	Preset registers
PR_CONF_ID	0x00000080	Configure meter identity (ID strings, CT/PT ratios, etc.) and comm parameters
PR_CONF_TOU	0x00000100	Configure TOU schedule
PR_CONF_MISC	0x00000200	Configure miscellaneous.
PR_CHANGE_PW	0x00000400	Change Password
PR_READ_CONFIG	0x00000800	Read all configuration data
PR_MASTER	0xFFFFFFFF	All privileges enabled

Use the Password Change command (0x50,0x03) or the *JEMWARE* software's Change Meter Password feature to set the password strings.

Use *JEMWARE* software to configure privilege levels for all passwords, except the Master Password. The Master Password is required to use this command.

The *Ci20* keeps two counters to track password attempts:

- One increments every time there's a successful password activation,
- One increments whenever there is an unsuccessful attempt.

The contents of these counters are reported in the Query *Ci20* Status command response. The *Ci20* also keeps a log of the last five password attempts, their source (Optical, RS-232, or modem port), and whether or not they were successful.

Hardware Security Key

Commands that can modify or corrupt the meter's ability to measure correctly are protected by a hardware jumper inside the meter. See the *Ci20 User's Manual 1086-381, Security Keys*.

Commands listed in this manual marked with *Hardware Key Required: Yes* are *disabled* if the Configuration jumper is *removed.* Install the key to configure any of these operations via serial command:

- Timekeeping (clock reference)
- Interval Timing (Demand or Load Profile intervals, automatic events)
- Demand Parameters (subinterval length, outage deferral)
- Load Profile (quantities, pulse constants)
- Pulse I/O (channel assignments)
- Analog Outputs (channel assignments)
- Primary Scaling (VT ratio, CT ratio, Units of Measure)
- Normal, Alternate, or Test display lists (register assignments)
- Time of Use (rate schedule, holiday list, season schedule)
- Line / Transformer Loss Compensation
- Reactive Selection (VAR or Q)
- Thermal Demand Time Characteristic
- Threshold Alarms
- Site Monitor Alarms
- Daylight Saving Time Schedule
- Energy Pulses (quantities, pulse constants)
- Enter Test Mode
- Preset Registers
- Load firmware into FLASH memory
- Modify permanent FLASH data (calibration, factory data, or software options).

Commands and Responses

MV-90 I Command

Cmd, Ext:

I (not part of Binary Transport Protocol)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description	This command informs the MV-90 retrieval system of the meter's type
Command data	A single ASCII *I* (0x49)
Response Data	An array of 15 bytes followed by an ASCII LF character
	JEM CI <9 padded spaces>
	Not sent as part of a Binary Transport Protocol packet. Not null terminated.

Query Ci20 Status (0x06, 0x01)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command is used to query *JCi20*-specific information regarding the hardware, firmware revisions, and other miscellaneous information.

Command Data None

Response Data

Table 1.7 Query Ci20 Status Response Data

Data Format	Field Description
U8	Meter type (0x09)
U8	Meter sub-type (0x01)
U8	Transport Protocol Revision Level
U8	Commands & Responses Revision Level
U8[9]	Register firmware version (string, null terminated)
U8[9]	Metrology firmware version (string, null terminated)

U8	Time-related status
	(Bit field: struct{
	U8 In Daylight Saving Time: 1; //1 = meter presently in DST period
	U8 spare: 3;
	U8 TOU Rate In Effect: 4; //Present TOU rate 0-8. 0=Total only (no rate in effect)
	} timeStatus;

U8	Meter form (enum 2 EL 3 WIRE DELTA (Form 5), 3 EL 4 WIRE WYE (Form 9), 2.5 EL 4 WIRE WYE (Form 6), 2.5 EL 4 WIRE DELTA (Form 8))
U8	Meter voltage range (enum 69-480, 69-277, 120-480)

Table 1.7 Query Ci20 Status Response Data (Continued)

Data Format	Field Description
U8	Meter current range (enum CLASS 20)

U8	Installed Communication Options
	(Bit field: struct{
	U8 RS232 installed:1;
	U8 RS485 installed:1;
	U8 Comm Repeater installed:1;
	U8 Modem installed: 1;
	U8 Power Fail Notification installed: 1;
	U8 secondary RS232 installed:1;
	U8 secondary RS485 installed:1;
	U8 Ethernet installed:1;
	} commOptions; //1 = option is installed)

U8	Other Installed Options
	(Bit field: struct{
	U8 4 Channel Load Profile installed:1;
	U8 12 Channel Load Profile installed:1;
	U8 Contact Output Option installed: 1;
	U8 Contact Input Option installed: 1;
	U8 spare: 3;
	U8 Extended Query Command (0x06, 0x03) available:1;
	} otherOptions; //1 = option is installed)

Query JEM C&I Extended Status (0x06, 0x03)

Privilege Required: None

Commands and Responses Rev. Level: 2

Hardware Key Required: No

Description This command is used to query extended *JEM C&I*-specific information regarding the hardware, firmware revisions, and other miscellaneous information.

Command Data None

Response Data

Table 1.8 Query JEM C&I Extended Status Response Data

Data Format	Field Description

U8	Communication Hardware Options 1
	(Bit field: struct{
	U8 RS232:1;
	U8 RS485:1;
	U8 Comm Repeater:1;
	U8 Modem: 1;
	U8 Power Fail Notification: 1;
	U8 secondary RS232:1;
	U8 secondary RS485:1;
	U8 Ethernet installed: 1
	} CommOptions1; //1 = option is installed)

U8	Communication Hardware Options 2
	(Bit field: struct{
	U8 Contact Wetting option installed
	U8 spare:7;
	} CommOptions2; //1 = option is installed)

U8	Communication Hardware Options 3
	(Bit field: struct{
	U8 spare:8;
	} CommOptions3; //1 = option is installed)

U8	Communication Hardware Options 4
	(Bit field: struct{
	U8 spare:8;
	} CommOptions4; //1 = option is installed)

Table 1.8 Query JEM C&I Extended Status Response Data (Continued)

Data Format	Field Description

U8	Protocol Options 1
	(Bit field: struct{
	U8 JEM10 Binary installed: 1;
	U8 DNP installed: 1;
	U8 Modbus installed: 1;
	U8 ANSI Data Tables installed: 1;
	U8 IEC 60870-102 installed:1: (not used in Ci20 meter)
	U8 reserved: 1;
	U8 Web Server installed: 1;
	U8 spare: 1;
	} ProtOptions1; //1 = option is installed)

U8	Protocol Options 2
	(Bit field: struct{
	U8 spare:8;
	} ProtOptions2; //1 = option is installed)

U8	Protocol Options 3
	(Bit field: struct{
	U8 spare:8;
	} ProtOptions3; //1 = option is installed)

U8	Protocol Options 4
	(Bit field: struct{
	U8 spare:8;
	} ProtOptions4; //1 = option is installed)

U8	I/O Options 1
	(Bit field: struct{
	U8 Contact Output Option installed: 1;
	U8 Contact Input Option installed: 1;
	U8 0-1 mA Analog Output Option installed: 1; (not used in Ci20 meter)
	U8 4-20 mA Analog Output Option installed: 1; (not used in Ci20 meter)
	U8 Extended Contact Output (JEM2) Option installed: 1;
	U8 6-channel DI/DO Option installed: 1;
	U8 Contact Input Wetting Source installed: 1;
	U8 spare: 1
	} IoOptions1; //1 = option is installed)

Table 1.8 Query JEM C&I Extended Status Response Data (Continued)

Data Format	Field Description

U8	I/O Options 2
	(Bit field: struct{
	U8 spare:8;
	} IoOptions2; //1 = option is installed)

U8	I/O Options 3
	(Bit field: struct{
	U8 spare:8;
	} IoOptions3; //1 = option is installed)

U8	I/O Options 4
	(Bit field: struct{
	U8 spare:8;
	} IoOptions4; //1 = option is installed)

U8	Miscellaneous Options 1
	(Bit field: struct{
	U8 4 Channel Load Profile installed:1;
	U8 12 Channel Load Profile installed:1;
	U8 Demand Prediction installed:1;
	U8 Pulsed Load Mode enabled:1; (not used in Ci20 meter)
	U8 Compensated / Uncompensated installed:1; (not used in Ci20 meter)
	U8 Totalization installed:1
	U8 Power Quality Monitoring installed: 1
	U8 Time of Use installed: 1
	} MiscOptions1; //1 = option is installed)

Table 1.8 Query JEM C&I Extended Status Response Data (Continued)

Data Format	Field Description

U8	Miscellaneous Options 2
	(Bit field: struct{
	U8 Per-Phase Measurements installed: 1;
	U8 Threshold Alarms installed: 1;
	U8 Site Monitoring installed: 1;
	U8 Thermal Registers installed: 1;
	U8 Loss Compensation installed: 1;
	U8 spare:3;
	} MiscOptions2; //1 = option is installed)

U8	Miscellaneous Options 3
	(Bit field: struct{
	U8 spare:8;
	} MiscOptions3; //1 = option is installed)

U8	Miscellaneous Options 4 U8 Max Available Display Registers (0xff=minimum)

NOTE

All spare and unused bits are set to zero.

Read Power Outage Events (0x41, 0x02)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Power Outage Event Log.

Command Data None

Response Data

Table 1.9 Read Power Outage Events Response Data

Data Format	Field Description
begin structure	One for each of five events
U32	Time of power loss (seconds since midnight 1/1/70)
U32	Meter status at power loss
U32	Time of power restoration (seconds since midnight 1/1/70)
end structure[5]	

Read Time Change Events (0x41, 0x03)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Time Change Event Log.

Command Data None

Response Data

Table 1.10 Read Time Change Events Response Data

Data Format	Field Description
begin structure	one for each of five Time Change events
U32	Time of change (seconds since midnight 1/1/70)
U32	Time after change (seconds since midnight 1/1/70)
U8	Source of change (enum SERIAL, UI, ENTER DST, EXIT DST)
U8[3]	spare
end structure[5]	

Read Register Freeze Events (0x41, 0x04)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Register Freeze Event Log.

Command Data None

Response Data

Table 1.11 Read Register Freeze Events Data Response

Data Format	Field Description
begin structure	One for each of five Freeze events
U32	Time of Freeze event (seconds since midnight 1/1/70)
U8	Source of Freeze (enum SERIAL, AUTO, BPR)
U8[3]	Spare
end structure[5]	

Read Register Preset Events (0x41, 0x05)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Register Preset Event Log.

Command Data None

Response Data

Table 1.12 Read Register Preset Events Response Data

Data Format	Field Description
U32	Time of Preset event (seconds since midnight 1/1/70)

Read Test Mode Events (0x41, 0x06)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Test Mode Event Log.

Command Data None

Response Data

Table 1.13 Read Test Mode Events Response Data

Data Format	Field Description
U32	Time of last entry into Test Mode (seconds since midnight 1/1/70)
U32	Time of last exit from Test Mode (seconds since midnight 1/1/70)

Read Calibration Events (0x41, 0x07)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Calibration Event Log.

Command Data None

Response Data

Table 1.14 Read Calibration Events Response Data

Data Format	Field Description
U32	Time of last Calibration event (seconds since midnight 1/1/70)

Read Register Threshold Events (0x41, 0x08)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Register Threshold Event Log.

Command Data None

Response Data

Table 1.15 Read Register Threshold Events Response Data

Data Format	Field Description
begin structure	One for each of 20 Threshold events
U32	Time of Threshold event (seconds since midnight 1/1/70)
U8	Threshold channel causing event (1-4)
U8[3]	Spare
end structure[20]	

Read Site Monitor Events (0x41, 0x09)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Site Monitor Event Log.

Command Data None

Response Data

Table 1.16 Read Site Monitor Events Response Data

Data Format	Field Description
begin structure	One for each of 20 Site Monitor events
U32	Time of Site Monitor event (seconds since midnight 1/1/70)

Table 1.16 Read Site Monitor Events Response Data (Continued)

Data Format	Field Description

U32	Site Monitor event condition (bit field: struct{
	U32 Phase A over voltage:1;
	U32 Phase A voltage swell:1;
	U32 Phase A under voltage:1;
	U32 Phase A voltage sag:1;
	U32 Phase A PF low: 1;
	U32 Phase A PF high: 1;
	U32 Phase A power reversed:1;
	U32 Phase A over current: 1;
	U32 Phase A under current: 1;
	U32 Phase B over voltage:1;
	U32 Phase B voltage swell:1;
	U32 Phase B under voltage:1;
	U32 Phase B voltage sag:1;
	U32 Phase B PF low: 1;
	U32 Phase B PF high: 1;
	U32 Phase B power reversed:1;
	U32 Phase B over current: 1;
	U32 Phase B under current: 1;
	U32 Phase C over voltage:1;
	U32 Phase C voltage swell:1;
	U32 Phase C under voltage:1;
	U32 Phase C voltage sag:1;
	U32 Phase C PF low: 1;
	U32 Phase C PF high: 1;
	U32 Phase C power reversed:1;
	U32 Phase C over current: 1;
	U32 Phase C under current: 1;
	U32 Neutral current swell: 1;
	U32 Neutral over current: 1;
	U32 Voltages out of sequence: 1;
	U32 Voltage Imbalance: 1;
	U32 Current Imbalance: 1;
	} siteMonitorCondition; //1 = condition detected

end structure[20]	

Read Billing Period Reset Events (0x41, 0x0A)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Billing Period Reset Event Log.

Command Data None

Response Data

Table 1.17 Read Billing Period Reset Events Response Data

Data Format	Field Description
begin structure	One for each of 5 BPR events
U32	Time of BPR event (seconds since midnight 1/1/70)
U8	Source of BPR (enum SERIAL, UI, AUTO, SEASON)
U8[3]	Spare
end structure[5]	

Read Configuration Events (0x41, 0x0B)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the contents of the Configuration Event Log.

Command Data None

Response Data

Table 1.18 Read Configuration Events Response Data

Data Format	Field Description
begin structure	One for each of three events
U32	Time of Configuration event (Seconds since midnight 1/1/70)
U8	Origin of Configuration event (enum SERIAL, UI)
U8[3]	Spare
end structure[3]	

Read Password Attempt Log (0x41, 0x0C)

Privilege Required: PR_DISP_QUAN

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads a log of the last five Password Activate attempts.

Command Data None

Response Data

Table 1.19 Read Password Attempt Log Response Data

Data Format	Field Description
Begin structure	One for each of five Password Activate attempt events
U32	Time of Password Activate attempt (seconds since midnight 1/1/70)
U8	Source of attempt (enum OPTICAL, RS-232, MODEM)
U8	Result (enum SUCCESSFUL, FAILED)
U8[2]	Spare
end structure[5]	

Read Voltage Sag/Swell Events (0x41, 0x10)

Privilege Required: None

Commands and Responses Rev. Level: 6

Hardware Key Required: No

Description This command reads the contents of the Sag / Swell Event Log.

Command Data None

Response Data

Table 1.20 Read Voltage Sag/Swell Events Response Data

Data Format	Field Description
Begin structure	One for each of up to 100 Sag / Swell events
U32	Time of beginning of event (seconds since midnight 1/1/70)
F32 [3]	Minimum primary voltage during event (one for each of Phase A, B, and C)
F32 [3]	Minimum primary current during event (one for each of Phase A, B, and C)
F32 [3]	Maximum primary voltage during event (one for each of Phase A, B, and C)
F32 [3]	Maximum primary current during event (one for each of Phase A, B, and C)
F32 [3]	Average primary voltage during event (one for each of Phase A, B, and C)
F32 [3]	Average primary current during event (one for each of Phase A, B, and C)
F32 [3]	Average PF during event (one for each of Phase A, B, and C)
U16	Status (signal that caused event). See ”Status Enumeration” on page 1-32.
U16	Duration of event in line cycles

Status Enumeration

The status enumeration is one of the following values:

Value	Status
0	Phase A voltage sag
1	Phase B voltage sag
2	Phase C voltage sag
3	Phase A voltage swell
4	Phase B voltage swell
5	Phase C voltage swell
6	Phase A voltage long sag (> 600 cycles)
7	Phase B voltage long sag (> 600 cycles)
8	Phase C voltage long sag (> 600 cycles)
9	Phase A voltage long swell (> 600 cycles)
10	Phase B voltage long swell (> 600 cycles)
11	Phase C voltage long swell (> 600 cycles)
12	End of previous Phase A voltage long sag
13	End of previous Phase B voltage long sag
14	End of previous Phase C voltage long sag
15	End of previous Phase A voltage long swell
16	End of previous Phase B voltage long swell
17	End of previous Phase C voltage long swell

Billing Period Reset (0x42, 0x01)

Privilege Required: PR_BPR

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description	This command performs a Billing Period Reset on the meter.
Command Data	None
Response Data	A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Read Load Profile (0x44, 0x01)

Privilege Required: PR_DISP_QUAN

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description — This command reads the data recorded in the optional Load Profile memory. Load Profile records are returned oldest first. You can request data by number of days, up to 45. Any request greater than 45 causes the meter to return all records in storage. If the meter does not contain enough Load Profile data to fulfill the request, it returns all records currently stored.

Command Data

Table 1.21 Read Load Profile Command Data

Data Format	Field Description
U8	Number of days to read, 0-255: • 0 = read all today's records since most recent midnight, • 1 = read all of yesterday's records plus all today's records since midnight, etc.

Response Data

Table 1.22 Read Load Profile Response Data

Data Format	Field Description
U32	Time of beginning of retrieval. (Seconds since midnight 1/1/70)
U16	Number of pulse channels per record (1-12)
U16	Load Profile Interval Length (1-60 minutes)
begin structure	one for each of 12 channels
F32	Pulse constant for channel, in secondary units
U8	Channel measurement type (enum Instantaneous, Integrated)
U8	Channel quantity (enum W, VAR, VA, A, Q, PF, V, FREQ, VTHD, ATHD, EXTERNAL COUNT, EXTERNAL STATUS, VOLT SQUARED, AMP SQUARED)
U8	Channel direction (enum NO_DIR, DEL, REC, Q1, Q2, Q3, Q4)
U8	Channel phase or element (enum NO_PHASE, POLYPHASE, PHASE A, PHASE B, PHASE C, NEUTRAL)
end structure [12]	
U16[]	A stream of words that is the requested Load Profile data. The length cannot be determined ahead of time. See Appendix B ”Load Profile Response Data Format” for details on parsing the stream into Load Profile records.

Read Load Profile – with Event First (0x44, 0x02)

Privilege Required: PR_DISP_QUAN

Commands and Responses Rev. Level: 3

Hardware Key Required: No

Description This command reads the data recorded in the optional Load Profile memory. Load Profile records are returned oldest first. You can request data by number of days, up to 60. Any request greater than 60 causes the meter to return all records in storage. If the meter does not contain enough Load Profile data to fulfill the request, it returns all records currently stored.

NOTE

The first Load Profile record returned (after the preamble) is guaranteed to start with a time-stamped Special Event record, which can be used to determine the time of all subsequent interval records. The meter can skip old intervals for which no time can be determined.

Command Data

Table 1.23 Read Load Profile – with Event First Command Data

Data Format	Field Description
U8	Number of days to read, 0-255: • 0 = read all today's records since most recent midnight • 1 = read all of yesterday's records plus all today's records since midnight, etc.

Response Data

Table 1.24 Read Load Profile – with Event First Response Data

Data Format	Field Description
U32	Time of beginning of retrieval. (Seconds since midnight 1/1/70)
U16	Number of pulse channels per record (1-12)
U16	Load Profile Interval Length (1-60 minutes)
begin structure	One for each of 12 channels
F32	Pulse constant for channel, in secondary units

Table 1.24 Read Load Profile – with Event First Response Data

Data Format	Field Description
U8	Channel measurement type (enum Instantaneous, Integrated)
U8	Channel quantity (enum W, VAR, VA, A, Q, PF, V, FREQ, VTHD, ATHD, EXTERNAL COUNT, EXTERNAL STATUS, AMP SQUARED, VOLT SQUARED)
U8	Channel direction (enum NO_DIR, DEL, REC, Q1, Q2, Q3, Q4)
U8	Channel phase or element (enum NO_PHASE, POLYPHASE, PHASE A, PHASE B, PHASE C, NEUTRAL)
end structure [12]	
U16[]	A stream of words that is the requested Load Profile data. The length cannot be determined ahead of time. See Appendix B ”Load Profile Response Data Format” for details on parsing the stream into Load Profile records.

Freeze Registers (0x4C, 0x01)

Privilege Required: PR_DISP_QUAN

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description	This command saves a snapshot of all internal registers.
Command Data	None
Response Data	A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Enter Test Mode (0x4D, 0x01)

Privilege Required: PR_TESTMODE

Commands and Responses Rev. Level: 1

Hardware Key Required: Yes

Description	This command causes the meter to enter Test Mode.
Command Data	None
Response Data	A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Exit Test Mode (0x4D, 0x02)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description	This command causes the meter to exit Test Mode.
Command data	None
Response Data	A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Select Test Register (0x4D, 0x03)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command causes the meter to display the selected Test Register and, if appropriate, output a Test Pulse for the displayed quantity.

Command Data

Table 1.25 Select Test Register Command Data

Data Format	Field Description
U8	Test Register to display; 0-50, index into Test Register List. See ”Read Test Registers (0x52, 0x04)” on page 1-48.

Response Data A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if the register selected does not exist.

Password Activate (0x50, 0x01)

Once activated, a password remains active until a Password Deactivate command is received or until the configured *password timeout* elapses on the active serial channel.

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command activates the supplied password. This allows execution of commands whose privileges match those associated with the supplied password.

Command Data

Table 1.26 Password Activate Command Data

Data Format	Field Description
U8[6]	The password to activate. Six ASCII characters, no null termination.

Response Data A transport layer ACK is returned if the supplied password was activated. Otherwise, a NAK-in-a-box is returned.

Password Deactivate (0x50, 0x02)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command deactivates the currently active password.

Command Data None.

Response Data This command returns a transport layer ACK.

Password Change (0x50, 0x03)

The master password must be active in order to change the master password.

A password user, other than the Master Password, must activate his password, include his current password in the *current password* field, AND have PR_CHANGE _PW privilege in order to change his password.

PR_MASTER is required to set the privileges for a user password.

Privilege Required: PR_CONF_MISC or PR_MASTER

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command changes a given password and/or its associated privileges.

Command Data

Table 1.27 Password Change Command Data

Data Format	Field Description
U16	The password number to change: • 0 is the master password • 1 is user password #1, etc.
U8[6]	The current value for this password. Any 6 characters can occupy this field if PR_MASTER is set on the active channel. (6 ASCII characters, no null termination)
U8[6]	The new value for this password (can be the same as the old value) (6 ASCII characters, no null termination)

Response Data A transport layer ACK is returned if the supplied password was changed. Otherwise, a NAK-in-a-box is returned.

Read Site Diagnostic Data (0x52, 0x01)

Electrical measurement variables reflect unfiltered instantaneous (i.e. taken over approximately 50 ms) measurements, and are not guaranteed to meet stated accuracy specifications. They are provided only to give a rough idea of present operating conditions.

For each voltage pair, real and imaginary for a given phase, the numbers given are the rectangular representation of a voltage vector. The units are mV, and the maximum full-scale value is 150.000. The largest value that can appear in a voltage component is 150,000, which corresponds to 530 V at the meter terminals. Phase angles derived from these measurements are referenced to a sampling signal inside the meter, and unavailable to the user. Traditionally, Volts phase A is the reference against which all other voltage and current phase angles are measured.

For each current pair, real and imaginary for a given phase, the numbers given are the rectangular representation of a current vector. The units are milliamps, and the maximum full-scale value is 10.000. The largest value that can appear in a voltage component is 10,000,(which corresponds to Class Amps at the meter terminals. Phase angles derived from these measurements are referenced to a sampling signal inside the meter, and unavailable to the user. Traditionally, Volts phase A is the reference against which all other voltage and current phase angles are measured.

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads Site Diagnostic, voltage and current phasors, and other data.

Command Data None

Response Data

Table 1.28 Read Site Diagnostic Data Response Data

Data Format	Field Description
S32	Volts phase A real component
S32	Volts phase A imaginary component
S32	Amps phase A real component
S32	Amps phase A imaginary component

Table 1.28 Read Site Diagnostic Data Response Data (Continued)

Data Format	Field Description
S32	Volts phase B real component
S32	Volts phase B imaginary component
S32	Amps phase B real component
S32	Amps phase B imaginary component
S32	Volts phase C real component
S32	Volts phase C imaginary component
S32	Amps phase C real component
S32	Amps phase C imaginary component
S32	Watts Polyphase
S32	VA Polyphase
S32	System Power Factor

Read Normal Registers (0x52, 0x02)

Requests for identification numbers that do not exist in the Normal display list returns a structure containing nulls.

If an identification number is duplicated in the Normal display list, the display item with the first occurrence of that number is retrieved.

Privilege Required: PR_NORM_REG

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads registers from the Normal display list.

Command Data

Table 1.29 Read Normal Registers Command Data

Data Format	Field Description
U8	Number of registers (N) to read, 1-50, or 255 for all Normal registers.
U8	Spare - can be omitted if requesting all registers
U16[N]	List of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.30 Read Normal Registers Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned
U32 or F32	Register data (depending on Data Type and Data Selector)
U32	Data Selector (see Appendix A: Register and Display Selectors)
U16	Register number (000-999)
U8	Data Type (see Appendix A: Register and Display Selectors)
U8	Number of digits (3-6)

Table 1.30 Read Normal Registers Response Data (Continued)

Data Format	Field Description
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float . . . . . floating point number with # digits and decimal places above Time . . . . . seconds since midnight 1/1/70, display time of day part Date . . . . . seconds since midnight 1/1/70, display date part String . . . . . ignore Register data, select string from ID Strings config data based on Data Selector above. Status . . . . . 32-bit status field Blank . . . . . ignore Register data, blank display Segment . . . . . ignore Register data, turn on all display segments
U8[20]	description (string, null-terminated)
end structure[N]	

Read Alternate Registers (0x52, 0x03)

Requests for identification numbers that do not exist in the Alternate display list returns a structure containing nulls.

If an identification number is duplicated in the Alternate display list, the display item with the first occurrence of that number is retrieved.

Privilege Required: PR_ALT_REG

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads registers from the Alternate display list.

Command Data

Table 1.31 Read Alternate Registers Command Data

Data Format	Field Description
U8	Spare - Can be omitted if requesting all registers.
U16[N]	List of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.32 Read Alternate Registers Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned
U32 or F32	Register data (depending on Data Type and Data Selector)
U32	Data Selector. See Appendix A ”Register and Display Selectors”.
U16	Register number (000-999)
U8	Data Type. See Appendix A ”Register and Display Selectors”.
U8	Number of digits (3-6)
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)

Table 1.32 Read Alternate Registers Response Data (Continued)

Data Format	Field Description
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float . . . . . floating point number with # digits and decimal places above Time . . . . . seconds since midnight 1/1/70, display time of day part Date . . . . . seconds since midnight 1/1/70, display date part String . . . . . ignore Register data, select string from ID Strings config data based on Data Selector above. Status . . . . . 32-bit status field Blank . . . . . ignore Register data, blank display Segment . . . . . ignore Register data, turn on all display segments
U8[20]	Description (string, null-terminated)
end structure[N]	

Read Test Registers (0x52, 0x04)

Requests for identification numbers that do not exist in the Test display list returns a structure containing nulls.

If an identification number is duplicated in the Test display list, the display item with the first occurrence of that number is retrieved.

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads registers from the Test Display List.

Command Data

Table 1.33 Read Test Registers Command Data

Data Format	Field Description
U8	Number of registers (N) to read: 1-30, or 255 for all Test registers.
U8	Spare - Can be omitted if requesting all registers.
U16[N]	list of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.34 Read Test Registers Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned
U32 or F32	Register data, depending on Data Type and Data Selector.
U32	Data Selector (see Appendix A: Register and Display Selectors)
U16	Register number (000-999)
U8	Data Type. See Appendix A ”Register and Display Selectors”.
U8	Number of digits (3-6)

Table 1.34 Read Test Registers Response Data (Continued)

Data Format	Field Description
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float. . . . . floating point number with # digits and decimal places above Time. . . . . seconds since midnight 1/1/70, display time of day part Date. . . . . .seconds since midnight 1/1/70, display date part String . . . . . ignore Register data, select string from ID Strings config data . . . . . .based on Data Selector above. Status. . . . . .32-bit status field Blank. . . . . .ignore Register data, blank display Segment. . . . . .ignore Register data, turn on all display segments
U8[20]	Description (string, null-terminated)
end structure[N]	

Read Normal Registers - Double Precision (0x52, 0x12)

Requests for identification numbers that do not exist in the Normal display list returns a structure containing nulls.

If an identification number is duplicated in the Normal display list, the display item with the first occurrence of that number is retrieved.

For a register whose Translation Indicator is Float, the F64 field and the F32 field contain the same value (within the limits of precision of the respective fields). When displaying the retrieved value, use the F64 field.

For registers whose Translation Indicator is other than Float, use the U32 field. (The F64 field contains 0 in this case.)

Privilege Required: PR_NORM_REG

Commands and Responses Rev. Level: 5

Hardware Key Required: No

Description This command reads registers from the Normal display list, with double-precision floating point values for applicable registers.

Command Data

Table 1.35 Read Normal Registers - Double Precision Command Data

Data Format	Field Description
U8	Number of registers (N) to read, 1-50, or 255 for all Normal registers.
U8	Spare - Can be omitted if requesting all registers.
U16[N]	list of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.36 Read Normal Registers - Double Precision Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned

Table 1.36 Read Normal Registers - Double Precision Response Data

Data Format	Field Description
F64	Double-precision Register data - for numeric registers only
U32 or F32	Register data - depending on Data Type and Data Selector
U32	Data Selector. See Appendix A ”Register and Display Selectors”
U16	Register number (000-999)
U8	Data Type. See Appendix A ”Register and Display Selectors”
U8	Number of digits (3-6)
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float . . . . . floating point number with # digits and decimal places above Time . . . . . seconds since midnight 1/1/70, display time of day part Date . . . . . seconds since midnight 1/1/70, display date part String . . . . . ignore Register data, select string from ID Strings config data based on Data Selector above. Status . . . . . 32-bit status field Blank . . . . . ignore Register data, blank display Segment. . . . . ignore Register data, turn on all display segments
U8[20]	Description (string, null-terminated)
end structure[N]	

Read Alternate Registers - Double Precision (0x52, 0x13)

Requests for identification numbers that do not exist in the Alternate display list returns a structure containing nulls.

If an identification number is duplicated in the Alternate display list, the display item with the first occurrence of that number is retrieved.

For a register whose Translation Indicator is Float, the F64 field and the F32 field contain the same value (within the limits of precision of the respective fields). When displaying the retrieved value, use the F64 field.

For registers whose Translation Indicator is other than Float, use the U32 field. (The F64 field contains 0 in this case.)

Privilege Required: PR_ALT_REG

Commands and Responses Rev. Level: 5

Hardware Key Required: No

Description This command reads registers from the Alternate display list, with double-precision floating point values for applicable registers.

Command Data

Table 1.37 Read Alternate Registers - Double Precision Command Data

Data Format	Field Description
U8	Number of registers (N) to read - 1-50, or 255 for all Alternate registers
U8	Spare - Can be omitted if requesting all registers
U16[N]	List of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.38 Read Alternate Registers - Double Precision Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned

Table 1.38 Read Alternate Registers - Double Precision Response Data (Continued)

Data Format	Field Description
F64	Double-precision Register data - for numeric registers only
U32 or F32	Register data - depending on Data Type and Data Selector
U32	Data Selector. See Appendix A ”Register and Display Selectors”
U16	Register number (000-999)
U8	Data Type - See Appendix A ”Register and Display Selectors”
U8	Number of digits (3-6)
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float . . . . . floating point number with # digits and decimal places above Time . . . . . seconds since midnight 1/1/70, display time of day part Date. . . . . seconds since midnight 1/1/70, display date part String. . . . . ignore Register data, select string from ID Strings config data based on Data Selector above. Status. . . . . 32-bit status field Blank. . . . . ignore Register data, blank display Segment. . . . . ignore Register data, turn on all display segments
U8[20]	Description (string, null-terminated)
end structure[N]	

Read Test Registers - Double Precision (0x52, 0x14)

Requests for identification numbers that do not exist in the Test display list returns a structure containing nulls.

If an identification number is duplicated in the Test display list, the display item with the first occurrence of that number is retrieved.

For a register whose Translation Indicator is Float, the F64 field and the F32 field contain the same value. Within the limits of precision of the respective fields. When displaying the retrieved value, use the F64 field.

For registers whose Translation Indicator is other than Float, use the U32 field. The F64 field contains 0 in this case.)

Privilege Required: None

Commands and Responses Rev. Level: 5

Hardware Key Required: No

Description This command reads registers from the Test display list, with double-precision floating point values for applicable registers.

Command Data

Table 1.39 Read Test Registers - Double Precision Command Data

Data Format	Field Description
U8	Number of registers (N) to read, 1-50, or 255 for all Test registers
U8	Spare - Can be omitted if requesting all registers
U16[N]	list of register identification numbers (0 - 999). Can be omitted if requesting all registers.

Response Data

Table 1.40 Read Test Registers - Double Precision Response Data

Data Format	Field Description
U8	Number of registers returned.
U8[3]	Spare
begin structure	One for each of N registers returned

Table 1.40 Read Test Registers - Double Precision Response Data (Continued)

Data Format	Field Description
F64	Double-precision Register data
U32 or F32	Register data - depending on Data Type and Data Selector
U32	Data Selector - See Appendix A ”Register and Display Selectors”
U16	Register number (000-999)
U8	Data Type - See Appendix A ”Register and Display Selectors”
U8	Number of digits (3-6)
U8	Decimal position (enum NONE, PLACE 0, PLACE 1, PLACE 2, PLACE 3)
U8	Translation Indicator (enum Float, Time, Date, String, Status, Blank, Segment) If Indicator is: Present Register Data as: Float. . . . . floating point number with # digits and decimal places above Time. . . . . seconds since midnight 1/1/70, display time of day part Date. . . . . .seconds since midnight 1/1/70, display date part String . . . . . ignore Register data, select string from ID Strings config data . . . . . .based on Data Selector above. Status. . . . . .32-bit status field Blank. . . . . .ignore Register data, blank display Segment. . . . . .ignore Register data, turn on all display segments
U8[20]	Description (string, null-terminated)
end structure[N]	

Read Health and Status (0x53, 0x01)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command reads the current and latched status flags of the meter, as well as meter health data.

Command Data None

Response Data

Table 1.41 Read Health and Status Response Data

Data Format	Field Description

U16	Present system status word (bit field: struct{
	U16 battery warning: 1; //1 = accumulated time on battery approaching 2 years
	U16 config default: 1; //1 = config error, default config used
	U16 Site Monitor alarm event: 1; //1 = a Site Monitor alarm event has occurred
	U16 External Status: 1; //reflects state of External Status Input 1 = On
	U16 Threshold Alarm 1: 1; //1 = a Reg. Threshold 1 Alarm event has occurred
	U16 Threshold Alarm 2: 1; //1 = a Reg. Threshold 2 Alarm event has occurred
	U16 Threshold Alarm 3: 1; //1 = a Reg. Threshold 3 Alarm event has occurred
	U16 Threshold Alarm 4: 1; //1 = a Reg. Threshold 4 Alarm event has occurred
	U16 spare: 5; //unused
	U16 Phase C Potential: 1; //1 = potential active
	U16 Phase B Potential: 1; //1 = potential active
	U16 Phase A Potential: 1; //1 = potential active} presentSystemStatus;)

U16	Latched system status word (bit field: struct{
	U16 battery warning: 1; //1 = accumulated time on battery approaching 2 years
	U16 config default: 1; //1 = config error, default config used
	U16 Site Monitor alarm event: 1; //1 = a Site Monitor alarm event has occurred
	U16 External Status: 1; //reflects state of External Status Input 1 = On
	U16 Threshold Alarm 1: 1; //1 = a Reg. Threshold 1 Alarm event has occurred
	U16 Threshold Alarm 2: 1; //1 = a Reg. Threshold 2 Alarm event has occurred
	U16 Threshold Alarm 3: 1; //1 = a Reg. Threshold 3 Alarm event has occurred
	U16 Threshold Alarm 4: 1; //1 = a Reg. Threshold 4 Alarm event has occurred
	U16 spare: 5; //unused
	U16 Phase C Potential: 1; //1 = potential active
	U16 Phase B Potential: 1; //1 = potential active
	U16 Phase A Potential: 1; //1 = potential active} latchedSystemStatus;)

Clear Latched Status (0x53, 0x02)

Privilege Required: PR_BPR

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description	This command clears any latched status flags and alarm indicators.
Command Data	None
Response Data	A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Read Site Monitor Status (0x53, 0x03)

Privilege Required: PR_NONE

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command returns the status of the individual Site Monitor detectors.

Command Data None

Response Data

Table 1.42 Read Site Monitor Status Response Data

Data Format	Field Description
U32	Present Site Monitor status flags (bit field: for each bit 1 = condition is TRUE Bits are numbered 31 (MSB) to 0 (LSB) Bit Condition 31 Phase A over voltage 30 Phase A voltage swell 29 Phase A under voltage 28 Phase A voltage sag 27 Phase A PF low 26 Phase A PF high 25 Phase A power reversed 24 Phase A over current: 23 Phase A under current: 22 Phase B over voltage 21 Phase B voltage swell 20 Phase B under voltage 19 Phase B voltage sag 18 Phase B PF low 17 Phase B PF high 16 Phase B power reversed 15 Phase B over current 14 Phase B under current 13 Phase C over voltage 12 Phase C voltage swell 11 Phase C under voltage 10 Phase C voltage sag 9 Phase C PF low 8 Phase C PF high 7 Phase C power reversed 6 Phase C over current 5 Phase C under current 4 Neutral current swell 3 Neutral over current 2 Voltages out of sequence 1 Voltage Imbalance 0 Current Imbalance
U32	Latched Site Monitor status flags. Bit field: same definitions as Present Site Monitor status flags above, but TRUE bits persist until cleared by Billing Period Reset or Clear Latched Status command.

Time Verify – Current Time (0x54, 0x02)

Privilege Required: None

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command verifies the present time in the meter.

Command Data None

Response Data

Table 1.43 Time Verify – Current Time response Data

Data Format	Field Description
U8[13]	BCD date & time string: YYMMDDHHMMSSW: Where YY = 2 digit year (00-99) MM = 2 digit month (01-12) DD = 2 digit date (01-31) HH = 2 digit hour (00-23) MM = 2 digit minute (00-59) SS = 2 digit second (00-59) W = 1 digit weekday (0 (Sunday) – 6 (Saturday))

Time Set – Current Time (0x54, 0x05)

Privilege Required: PR_TIMESET

Commands and Responses Rev. Level: 1

Hardware Key Required: No

Description This command sets the time on the meter, to the second.

Command Data

Table 1.44 Time Set – Current Time Command Data

Data Format	Field Description
U8[13]	BCD date & time string: YYMMDDHHMMSSW: Where YY = 2 digit year (00-99) MM = 2 digit month (01-12) DD = 2 digit date (01-31) HH = 2 digit hour (00-23) MM = 2 digit minute (00-59) SS = 2 digit second (00-59) W = 1 digit weekday (0 (Sunday) – 6 (Saturday))

Response Data A transport layer ACK is returned if the PR_TIMESET privilege is activated and the desired time and date are valid. Otherwise, a NAK-in-a-box is returned.

Preset Normal Registers (0x57, 0x01)

Privilege Required: PR_PRESET

Commands and Responses Rev. Level: 1

Hardware Key Required: Yes

Only registers calculated from power measurements can be preset. This includes:

- Consumption and Average Power Factor registers; including Working, Billing Period Reset, and Season Change storage registers. (Data type F32)
- Peak Demand, Coincident Demand, and Coincident Power Factor; including Working, Billing Period Reset, Season Change, Cumulative, and Continuous Cumulative storage registers. (Date type F32)
- Time of Peak; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32)
- Peak Thermal; including Working, Billing Period Reset, and Season Change storage registers. (Data type F32)
- Instantaneous, Thermal, Predicted Demand; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32) Note that Working registers of these types is overwritten almost immediately with newly calculated readings.

Totalization registers

These register types cannot be preset:

- Date and time - other than Time of Peak Demand.
- Health, status and alarm displays.
- Identification and message displays.

Privilege Required: PR_PRESET

Commands and Responses Rev. Level: 1

Hardware Key Required: Yes

Description This command allows you to set values into the registers in the meter's Normal register display list.

Command Data

Table 1.45 Preset Normal Registers Command Data

Data Format	Field Description
(U32 or F32)[50]	Values for each register in the Normal Register List

Response Data A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Preset Alternate Registers (0x57, 0x02)

Privilege Required: PR_PRESET

Commands and Responses Rev. Level: 1

Hardware Key Required: Yes

Only registers calculated from power measurements can be preset. This includes:

- Consumption and Average Power Factor registers; including Working, Billing Period Reset, and Season Change storage registers. (Data type F32)
- Peak Demand, Coincident Demand, and Coincident Power Factor; including Working, Billing Period Reset, Season Change, Cumulative, and Continuous Cumulative storage registers. (Date type F32)
- Time of Peak; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32)
- Peak Thermal; including Working, Billing Period Reset, and Season Change storage registers. (Data type F32)
- Instantaneous, Thermal, Predicted Demand; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32) Note that Working registers of these types is overwritten almost immediately with newly calculated readings.

Totalization registers

These register types cannot be preset:

- Date and time - other than Time of Peak Demand.
- Health, status and alarm displays.
- Identification and message displays.

Hardware Key Required: Yes

Description This command allows you to set values into the registers in the meter's Alternate register display list.

Command Data

Table 1.46 Preset Alternate Registers Command Data

Data Format	Field Description
(U32 or F32)[50]	Values for each register in the Alternate Register List

Response Data

A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Preset Normal Registers - Double Precision (0x57, 0x03)

Privilege Required: PR_PRESET

Commands and Responses Rev. Level: 5

Hardware Key Required: Yes

Only registers calculated from power measurements can be preset. This includes:

- Consumption and Average Power Factor registers; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64)
- Peak Demand, Coincident Demand, and Coincident Power Factor; including Working, Billing Period Reset, Season Change, Cumulative, and Continuous Cumulative storage registers. (Date type F64)
- Time of Peak; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32)
- Peak Thermal; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64)
- Instantaneous, Thermal, Predicted Demand; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64) Note that Working registers of these types is overwritten almost immediately with newly calculated readings.

Totalization registers

These register types cannot be preset:

- Date and time - other than Time of Peak Demand.
- Health, status and alarm displays.
- Identification and message displays.

For each register in the list:

- If it is a Consumption, Cumulative Peak, Continuous Cumulative Peak, or Totalization register, send an F64.
- If it is a Time of Peak or Date of Peak, send a U32 in the first 32 bits of the 64-bit data field.
- If it is any other register, send an F32 in the first 32 bits of the 64-bit data field.

Description This command allows you to set values into the registers in the meter's Normal register display list, in double-precision floating point format.

Command Data

Table 1.47 Preset Normal Registers - Double Precision Command Data

Data Format	Field Description
begin union	One for each of 50 registers
F64	Double-precision float
U32[2]	Long integer (first is register value, second is spare)
End union[50]	One for each of 50 registers

Response Data

A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Preset Alternate Registers - Double Precision (0x57, 0x04)

Privilege Required: PR_PRESET

Commands and Responses Rev. Level: 5

Hardware Key Required: Yes

Only registers calculated from power measurements can be preset. This includes:

- Consumption and Average Power Factor registers; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64)
- Peak Demand, Coincident Demand, and Coincident Power Factor; including Working, Billing Period Reset, Season Change, Cumulative, and Continuous Cumulative storage registers. (Date type F64)
- Time of Peak; including Working, Billing Period Reset, and Season Change storage registers. (Data type U32)
- Peak Thermal; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64)
- Instantaneous, Thermal, Predicted Demand; including Working, Billing Period Reset, and Season Change storage registers. (Data type F64) Note that Working registers of these types is overwritten almost immediately with newly calculated readings.

Totalization registers

These register types cannot be preset:

- Date and time (other than Time of Peak Demand).
- Health, status and alarm displays.
- Identification and message displays.

For each register in the list:

- If it is a Consumption, Cumulative Peak, Continuous Cumulative Peak, or Totalization register, send an F64.
- If it is a Time of Peak or Date of Peak, send a U32 in the first 32 bits of the 64-bit data field.
- If it is any other register, send an F32 in the first 32 bits of the 64-bit data field.

Description This command allows you to set values into the registers in the meter's Alternate register display list in double-precision floating point format.

Command Data

Table 1.48 Preset Alternate Registers - Double Precision Command Data

Data Format	Field Description
begin union	One for each of 50 registers
F64	Double-precision float
U32[2]	Long integer (first is register value, second is spare)
End union[50]	One for each of 50 registers

Response Data

A transport layer ACK is returned if the command was successful. Otherwise, a NAK-in-a-box is returned. For example, if your password privilege is insufficient.

Appendix A. Register and Display Selectors

This chapter discusses data formats for:

- ”Display Selector”
- ”Register Selector” on page A-1
- ”Time Selector” on page A-3
- ”Status Selector” on page A-3
- ”ID Selector” on page A-3
- ”Totalization Selector” on page A-4
- ”Enumerations” on page A-4

Display Selector

Table A.1 Display Selector

Data Format	Field Description
U8	Data type (enum REGISTER, TIME, STATUS, ID, NOT USED, TOTALIZATION)
U32	Data selector (format depends on data type - see below)

Register Selector

Data Type = REGISTERBit field: struct REG_SELECTOR

{

U32 alg:3; //algorithm selector from Register Algorithms enumeration

U32 qty:4; //quantity selector from Measurement Quantity enumeration

U32 dir:3; //direction selector from Power Direction enumeration

U32 elm:3; //element selectorfrom Meter Element enumeration

U32 disp:3; //display type selector from Display Type enumeration

U32 rate:4; //TOU rate selector from TOU Rate enumeration

```
U32 dmdalg:2        //demand algorithm selector from Peak Demand Algorithm
                    enumeration if
                    //alg == Peak Demand  or Present Demand Algorithm
                    enumeration if
                    //alg == Present Demand
U32 dmdqty:4        //coincident demand quantity selector from Measurement
                    Quantity enumeration
U32 dmddir:3        //coincident demand direction selector from Power Direction
                    enumeration
U32 dmdelm:3        //coincident demand element selector from Meter Element
                    enumeration
} reg_selector;
```

Table A.2 Register Selector

Data Format	Field Description
alg	See Table A.10, “Register Algorithms,” on page A-6
qty	See Table A.9, “Measurement Quantities,” on page A-5
dir	See Table A.11, “Power Direction,” on page A-6
elm	See Table A.12, “Meter Element,” on page A-7
disp	See Table A.13, “Display Type,” on page A-7
rate	See Table A.14, “TOU Rate,” on page A-7
dmdalg	If alg field is: • REG_PKDMD see Table A.15, “Peak Demand Algorithm,” on page A-8 • REG_DMD see Table A.16, “Present Demand Algorithm,” on page A-8
dmdqty	See Table A.9, “Measurement Quantities,” on page A-5
dmddir	See Table A.11, “Power Direction,” on page A-6
dmdelm	See Table A.12, “Meter Element,” on page A-7

Time Selector

Data Type = TIME

Table A.3 Time Selector

Data Format	Field Description
U32	See Table A.17, “Time Register Types,” on page A-9

Status Selector

For serial retrieval (i.e. Register Read), the Register F/W (firmware) Version and Metrology F/W Version is sent as null-terminated strings in the Description field of the response structure. All other status words are sent as a U32 in the Register data field.

Data Type = STATUS

Table A.4 Status Selector

Data Format	Field Description
U32	See Table A.18, “Status Register Types,” on page A-9

ID Selector

For serial retrieval (i.e. Register Read command), each of these items is returned as null-terminated strings in the Description field of the response structure.

Data Type = ID

Table A.5 ID Selector

Data Format	Field Description
U32	See Table A.19, “ID Register Types,” on page A-10

Totalization Selector

For serial retrieval (i.e. Register Read command), each of these items are returned as a Consumption register.

Data Type = TOTALIZATION

Table A.6 Totalization Selector

Data Format	Field Description
U32	Totalization channel (0-11)

Enumerations

Table A.7 Data Type

Description	Numeric Value	Notes
Instantaneous	0	Non-integrated measurements
Integrated	1	Integrated (x-hour) measurements
Totalization	2	Sum of integrated quantities from multiple sources

Table A.8 Register Type

Description	Numeric Value	Notes
REGISTER	0	Power-related measurement
TIME	1	Time-related data
STATUS	2	Status data
ID	3	Identification data
NOT USED	4	Unused register
TOTALIZATION	5	Totalization register

Table A.9 Measurement Quantities

Description	Numeric Value	Notes
WATT	0	Real power
VAR	1	Reactive power
VA	2	Apparent power
A	3	Current
Q	4	Pseudo-reactive power
PF	5	Power Factor
V	6	Volts
FREQ	7	Frequency
VTHD	8	Volts Harmonic Distortion
ATHD	9	Amps Harmonic Distortion
EXTERN_COUNT_ ANY	10	Any external counter input (Load Profile)
EXTERN_STATUS	11	Any external status input (Load Profile)
AMP2	12	Current squared
VOLT2	13	Volts squared
RVOLT	14	Fundamental Volts (real)
IVOLT	15	Fundamental Volts (imaginary)
RAMP	16	Fundamental current (real)
IAMP	17	Fundamental current (imaginary)

Table A.10 Register Algorithms

Description	Numeric Value	Notes
REG_DMD	0	Demand
REG_CONS	1	Consumption
REG_AVGPF	2	Average PF
REG_PKDMD	3	Peak Demand
REG_INST	4	Instantaneous
REG_THERM	5	Thermal
REG_PKTHERM	6	Peak Thermal
REG_PRED	7	Predicted Demand

Table A.11 Power Direction

Description	Numeric Value	Notes
NO_DIR	0	Directionless
DEL	1	Delivered
REC	2	Received
Q1	3	Quadrant 1
Q2	4	Quadrant 2
Q3	5	Quadrant 3
Q4	6	Quadrant 4
BIPOLAR	7	Bidirectional (signed)

Table A.12 Meter Element

Description	Numeric Value	Notes
NO_PHASE	0	Unrelated to any element
POLYPHASE	1	Sum of all elements
PHASE_A	2	Element A
PHASE_B	3	Element B
PHASE_C	4	Element C
NEUTRAL	5	Neutral
PHASE_AVG	6	Average of all elements

Table A.13 Display Type

Description	Numeric Value	Notes
DISP_WORK	0	Working register
DISP_FREEZE	1	Register value at last Freeze
DISP_SEASON	2	Register value at last Season Change
DISP_BPR	3	Register value at last Billing Period Reset
DISP_CUML	4	Cumulative Peak/Coincident Demand
DISP_CONT	5	Continuous Cumulative Peak/Coincident Demand

Table A.14 TOU Rate

Description	Numeric Value	Notes
TOTAL	0	No rate - always active
RATE 1	1	Rate Period A
RATE 2	2	Rate Period B
RATE 3	3	Rate Period C

Table A.14 TOU Rate (Continued)

Description	Numeric Value	Notes
RATE 4	4	Rate Period D
RATE 5	5	Rate Period E
RATE 6	6	Rate Period F
RATE 7	7	Rate Period G
RATE 8	8	Rate Period H

Table A.15 Peak Demand Algorithm

Description	Numeric Value	Notes
PEAK	0	Peak Demand
TIME_OF_PEAK	1	Time of Peak Demand
COINCIDENT	2	Coincident Demand
DATE_OF_PEAK	3	Date of Peak Demand

Table A.16 Present Demand Algorithm

Description	Numeric Value	Notes
NOT_USED	0	No demand
PAST_INTERVAL	1	Demand for interval just ended
PRESENT_INTERVAL	2	Demand so far in present interval

Table A.17 Time Register Types

Description	Numeric Value	Notes
PRESENT_TIME	0	Present Time
LAST_BPR_TIME	1	Time of last Billing Period Reset
LAST_FREEZE_TIME	2	Time of last Freeze
LAST_SEASON_TIME	3	Time of last Season Change
NEXT_DST_TIME	4	Time of next Daylight Saving Time change
PRESENT_DATE	5	Present Date
LAST_BPR_DATE	6	Date of last Billing Period Reset
LAST_FREEZE_DATE	7	Date of last Freeze
LAST_SEASON_DATE	8	Date of last Season Change
NEXT_DST_DATE	9	Date of next Daylight Saving Time change
TEST_TIME_REMAINING	10	Time remaining in Test Mode
DEMAND_TIME_REMAINING	11	Time remaining in Demand Interval
DAYS_ON_BATTERY	12	Days on battery backup

Table A.18 Status Register Types

Description	Numeric Value	Notes
PRESENT_STATUS	0	Present Status
LATCHED_STATUS	1	Present Status - persistent report
LAST_BPR_STATUS	2	Status at last Billing Period Reset

Table A.18 Status Register Types

Description	Numeric Value	Notes
LAST_FREEZE_STATUS	3	Status at last Freeze
LAST_SEASON_STATUS	4	Status at last Season Change
REGISTER_FW_VERSION	5	Register Firmware Version
METROLOGY_FW_VERSION	6	Metrology Firmware Version
BLANK	7	Blank display
SEGMENT_CHECK	8	Display segment check
PHASOR_V	9	All Volts phase diagram
PHASOR_A	10	All Currents phase diagram
PHASOR_VAIA	11	Element A phase diagram
PHASOR_VBIB	12	Element V phase diagram
PHASOR_VCIC	13	Element C phase diagram
BPR_COUNT	14	Billing Period Reset counter
OUTAGE_COUNT	15	Power Outage counter

Table A.19 ID Register Types

Description	Numeric Value	Notes
LABEL_1	0	Identification label 1 *Meter Name*
STRING_1	1	User ID string 1
LABEL_2	2	Identification label 2 *Administrator*
STRING_2	3	User ID string 2
LABEL_3	4	Identification label 3 *Location*
STRING_3	5	User ID string 3
LABEL_4	6	Identification label 4 *Configuration ID*

Table A.19 ID Register Types

Description	Numeric Value	Notes
STRING_4	7	User ID string 4
LABEL_5	8	Identification label 5 *Account Number*
STRING_5	9	User ID string 5

Appendix B. Load Profile Response Data Format

Ci20 Load Profile is capable of storing up to 12 channels of measurement data per interval. Each channel can be one of the following:

- For consumption quantities (e.g. Watthours delivered), the accumulation of the selected consumption quantity over the Load Profile interval, divided by the virtual pulse constant (in unit-hours per count). The channel count multiplied by the virtual pulse constant gives the consumption for that interval.
- EXAMPLE: 3,128 counts times 0.1 Wh per count = 312.8 Wh for the interval. The virtual pulse constant is in primary units.
- For instantaneous quantities, (e.g. Volts Phase A), the average of the selected quantity divided by a value per count. Multiplying the channel count by the value per count gives the average value of the quantity over the interval.
  EXAMPLE: 11984 counts times 1.2 Volts per count = 14,380.8 Volts. The value per count is in primary units.)
- For the External Pulse Input, the channel count is the number of transitions (make-to-break and break-to-make) on the external energy pulse input. Scaling is determined by the device driving the input.
- For Totalization quantities, the result is the same as for Consumption quantities.

Any Load Profile channel can record up to 16,383 counts per interval. Select pulse constants to avoid exceeding this maximum.

A channel count is stored as a bit field like this (stored as an unsigned 16-bit word (U16)):

```
struct LP_CHANNEL
{
U16 event flag: 1;          //1 = record is a Special Event record with attached time stamp(s)
U16 overflow flag: 1;       //1 = channel count has overflowed at least once during the interval.
U16 count: 14;              //counts for the selected quantity for the interval
} lp_channel;
```

Any Load Profile record contains 1 to 12 of these bit fields. Only the first word in a record uses the event flag bit. All other words in the record has that bit set to 0.

There are two types of record stored in Load Profile: a Normal Interval Record and an Event Record.

A Normal Interval Record contains only channel counts for the quantities selected. The next record begins with the word immediately after the last word for the present record. All words in the Normal Interval Record have their *event flag* bit cleared. The Normal Interval Record has this format:

```
struct LP_CHANNEL channelCount[N];//where N is the configured number of channels.
```

An Event Record indicates that an interval was ended prematurely due to some special condition. The first part of an Event Record is the regular complement of channel counts that is found in the Normal Interval Record, except the first channel count has its *event flag* bit set.

An Event Record contains additional data to give details on the type of event and the time at which it occurred. The events that causes an Event Record to be stored are:

- Midnight
- Register Freeze (this can be configured to be omitted)
- Billing Period Reset
- Register Preset
- Power Outage
- Time Set
- Daylight Saving Time change
- Load Profile Reconfiguration

Each Event Record includes a bit field to indicate the type of event:

```
struct LP_EVENT
{
        U16 midnight:1;
        U16 freeze: 1;
        U16 billing reset: 1;
        U16 register preset: 1;
        U16 power outage: 1;
        U16 time set: 1;
        U16 daylight saving time: 1;
        U16 test mode: 1;
        U16 load profile reconfigured: 1;
```

```
        U16 spare: 7;
} lpEvent;
```

Each Event Record includes two time stamps, stored as an unsigned 32 bit number of seconds since midnight 1/1/70. The first time stamp in any Event Record is the date and time at which the event occurred. The Midnight, Freeze, Billing Period Reset, and Register Preset events are *instantaneous* conditions with no duration. Therefore, they insert the same time in the second time stamp. For other events, the second time stamp contains the time at which the condition ended (for a Power Outage) or the time after the event occurred (for a Time Set of Daylight Saving Time change).

The complete Event Record has this format:

```
struct EVENT_RECORD
{
        struct LP_CHANNEL channelCount[N]; //N is the number of
        channels per interval.
         //The first word has its event flag bit set to 1.
        struct LP_EVENT lpEvent; //bits to indicate the type of event
        time_t startTime; //time of event, or beginning of event
        time_t endTime; //time of end of event, if applicable
} eventRecord;
```

All records are stored and retrieved end-to-end with no padding in between. Therefore, it is very important to know the number of channels stored in each record. Otherwise it is impossible to determine the beginning of the next record. For that reason every *Ci20* Load Profile retrieval begins with one 16-bit word that is the number of channels per interval. This can range in value from 1 through 12, inclusive. Virtual pulse constants and value-per-count figures are not transmitted with Load Profile data and must either be entered by you, retrieved with a Verify Load Profile Configuration command, or obtained from the software that was used to configure the meter.

The length in bytes of any given Load Profile record is:

- If the *event flag* of the first channel count is:
  - Clear, the record length is 2 * N bytes.
  - Set, the record length is 2 * N + 10 bytes.

Any time the meter's Load Profile is reconfigured or the meter is given a Cold Start, a Load Profile Reconfiguration event is stored in the newly erased profile memory. This provides a valid time stamp for all subsequent intervals. Also, on a meter Cold Start a Register Freeze and Billing Period Reset events are stored after the Load Profile Reconfiguration event.

Appendix C. Commonly Used Data Types

Date / Time

To represent real-world time, *Ci20* uses an unsigned 32-bit number that is the number of seconds since midnight, January 1, 1970. This is identical to the *time_t* data type available in most C language development environments with one exception. The standard *time_t* type is defined as a signed 32-bit integer, which overflows into a negative number on Monday, January 18, 2038 at 22:14:08. The *Ci20*, using an unsigned integer, continues counting time correctly for another 60-odd years.

This means that until 2038, users can use the standard C time conversion functions like ctime() to convert a *Ci20* time stamp to human-readable form. Starting in 2038, the *Ci20* continues to work, but you need a different conversion function.

The exception to the *Ci20*'s use of the *time_t* type is in the Query Status command. that command is intended to have the same format across all meter types, and therefore uses the older BCD date-time string that was used by the JEM2.

Display Registers

All numeric registers (Consumption, Demand, Power Factor, Instantaneous, Thermal Emulation, Predicted Demand, but not Date / Time or Time of Peak Demand) are retrieved as IEEE 754 standard 32-bit (single precision) floating point values. They are capable of representing six significant digits, and are scaled to allow display of the selected primary units. For example, Watts, kiloWatts, megaWatts, or gigaWatts as selected at configuration, to three decimal places.

The data returned in response to the Read Normal Registers, Read Alternate Registers, and Read Test Registers commands is sufficient to convert and present the register readings in the same form as that of the meter display. For example, the same number of digits and decimal places. The data returned in response to the Read Registers - By Function or Read All Registers command does not include formatting information.

System Status Word

Meter status is recorded and reported in a bit field structure as described here. This fits into a U16 data type, and is sometimes referred to as the System Status Word.

```
struct SYSTEM_STATUS
{
  U16 battery warning: 1; //1 = accumulated time on battery approaching 2 years
  U16 config default: 1;    //1 = config error, default config used
  U16 Site Monitor alarm event: 1;   //1 = a Site Monitor alarm event has occurred
  U16 External Status: 1;  //reflects state of External Status Input 1 = mark
  U16 Threshold Alarm 1: 1; //1 = a Reg. Threshold 1 Alarm event has occurred
  U16 Threshold Alarm 2: 1; //1 = a Reg. Threshold 2 Alarm event has occurred
  U16 Threshold Alarm 3: 1; //1 = a Reg. Threshold 3 Alarm event has occurred
  U16 Threshold Alarm 4: 1; //1 = a Reg. Threshold 4 Alarm event has occurred
  U16 spare: 5;   //unused
  U16 Phase C Potential: 1; //1 = potential active
  U16 Phase B Potential: 1; //1 = potential active
  U16 Phase A Potential: 1; //1 = potential active
} systemStatus;
```

Site Status Word

Meter Site Monitoring status is recorded and reported in the Site Status Word. It fits into a U32 data type. This is its format:

```
struct SITE_STATUS{
  U32 Phase A over voltage:1;
  U32 Phase A voltage swell:1;
  U32 Phase A under voltage:1;
  U32 Phase A voltage sag:1;
  U32 Phase A PF low: 1;
  U32 Phase A PF high: 1;
  U32 Phase A power reversed:1;
  U32 Phase A over current: 1;
  U32 Phase A under current: 1;
  U32 Phase B over voltage:1;
  U32 Phase B voltage swell:1;
  U32 Phase B under voltage:1;
```

```
    U32 Phase B voltage sag:1;
    U32 Phase B PF low: 1;
    U32 Phase B PF high: 1;
    U32 Phase B power reversed:1;
    U32 Phase B over current: 1;
    U32 Phase B under current: 1;
    U32 Phase C over voltage:1;
    U32 Phase C voltage swell:1;
    U32 Phase C under voltage:1;
    U32 Phase C voltage sag:1;
    U32 Phase C PF low: 1;
    U32 Phase C PF high: 1;
    U32 Phase C power reversed:1;
    U32 Phase C over current: 1;
    U32 Phase C under current: 1;
    U32 Neutral current swell: 1;
    U32 Neutral over current: 1;
    U32 Voltages out of sequence: 1;
    U32 Voltage Imbalance: 1;
    U32 Current Imbalance: 1;
} siteStatus;   //1 = condition detected
```