COOPER Power Systems

McGraw-Edison® Voltage Regulator
CL-5 Series Microprocessor-Based Control
Digital Communications

Reference Data
R225-90-7

DATA 2458

Ordinal Point Assignments for CL-5 Series (5A, 5C, 5D and 5E) Regulator Controls

For Use With Data 2179 Protocol

When additional information is desired to satisfy a question not covered sufficiently for the users purpose, please contact your Cooper Power Systems representative.

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General Overview:

This document is intended to provide the ordinal points for the data base of the CL-5 control and Data 2179 protocol. The changes from the CL-5A to the CL-5C are the addition of a source side voltage calculation algorithm and a reactive power flow, bi-directional operation mode. The changes from the CL-5C to the CL-5D are extended line drop compensation limits, and additional configuration points for the regulator ANSI configuration and tap changer speed. The changes from the CL-5D to the CL-5E include a new set of operation counters as well as resettable operation counters, the addition of soft Add-Amp limits, the addition of source voltage demand, reconfiguration of voltage reduction mode which allows a tap to neutral feature, and enhancements to the profiler. The changes are displayed in **bold** in the ordinal mapping.

CL-5C additions:
Page 7, Added SBO-03
Page 8, Added Cross Ref. 2-56 to Seq# 31
Page 11, Added Seq# 03
Page 14, Added setting 6 (reactive power flow, bi-directional)
Page 16, Added OFF SET 005A, for configuration of the regulator type, 1 or 2

CL-5D additions:
Page 14, Extended the range of system line voltage down to 1200 (from 2400) volts, and the overall potential transformer ratio to 10.0 (from 20.0).
Page 14-15, Extended the limits for line drop compensation for forward and reverse settings from +/- 24 volts to +/- 96 volts.
Page 16, Added setting for regulator type and tap changer speed

CL-5E additions:
Page 9, Added Seq# 44, 45, 46, 47, 48, 49, for additional operations counters
Page 10, Added Seq# AC and AD, for source voltage demand
Page 11, Added Code/Parameters 27, 28, 29, and 30, for addition of source voltage demand
Page 14, Added Offsets 0008 and 000A, for operational counter updates
Page 15, Changed valid values of High and Low limits for Offset 0032
Page 16, Added Offsets 005E, 0060, and 0062, for addition of Soft Add-Amp feature
Page 16, Changed valid values of High and Low limits for Offsets 004A, 004C, 004E, and 0050. Also, added Offsets 0064 and 0066 for Profiler enhancements
Page 17, Added Offsets 0040, 0042, 0044, and 0046, for source voltage demand

Definitions:

"Scale Factor" is the factor by which a signed integer value read from the CL-5 is divided to get the value of the variable in the indicated units.

"Function Code" is the code used to access the parameter through the CL-5 front panel controls, and can be used in conjunction with document S225-10-10 for further description.

"Cross Reference" is with reference to the control's internal data base, and is listed for designers' information only. It is not useful to user.

Real-time Communications:

1.0 Real-time communication is offered in the CL-5 by implementing Cooper 2179.

2.0 Documents Referenced
- 2.1 R280-90-12, DATA 2179 "Cooper Power Systems Communication Protocol"
- 2.2 S225-10-10, Installation, Operation and Maintenance Instructions and Parts Replacement Manual for a VR-32 Regulator with a CL-5 series Control

3.0 Control Setup

3.1 Function Code 64 - Control Communications Address

In a multi-slave system, a method of node identification is required. This parameter allows a number of uniquely addressed nodes as specified by each protocol) to be connected on the system.

3.2 Function Code 65 - Communications Port Baud Rate

The real-time port is capable of 300, 1200, 2400, 4800, and 9600 baud rates. Transmit speed always equals receive speed. The baud rate code (1-5) of the control, must correspond to the baud rate of the system.

Code	Baud Rate
1	300
2	1200
3	2400
4	4800
5	9600

3.3 Function Code 66 - Communications Port Handshake Mode

The transmit/receive handshaking method is selectable so that different types of communication system interfaces can be accommodated. Handshake mode specifies the way in which the output at pin 4 and the input at pins 7 & 8 of P20 are applied in the communication scheme.

Mode 0 is No Handshaking. Pins 7/8, which are usually Request to Send, are ignored, and Pin 4, usually Clear to Send is always low. This mode is only useful on a single slave system.

Mode 1 is RTS/CTS Active, where the signal on pin 4 (CTS) goes high in response to Pins 7/8 (RTS) going high for at lease 20 milliseconds, provided the Data Reader port is not in use. Cts remains high until the reply transmission is completed, plus an additional 50 msec for hysteresis. CTS will also drop low if RTS is made low before the reply is started. This mode is only useful on a single slave system.

Mode 2 is Modem Control Mode for controlling a modem or fiber optic board where a transmit enable or "push-to-talk" signal is required. RTS is ignored. Pin 4, in this case Transmit Enable, goes high for a period programmed by Function Code 68 before transmission of the reply begins. This allows for stabilization of transmitter hardware before the message is actually sent. This signal remains high for 50 milliseconds after the reply is completed.

Mode	Pins 7 & 8, P20	Pin 4, P20
0	Ignored	Always Low
1	Active	High when 7/8 is High
2	Ignored	High when Transmitting

3.4 Function Code 67 - Communications Port Sync Characters

Defines the period of time the receive must be idle to assume the start of a message. A concept known as dead-line sync, is used to determine the start of the request message. When used on a ring configured communication system, the control "hears" request messages for devices at other nodes on the received data line. Since the first part of a message is the address, the control can determine if

the message is intended for it, and ignore the remaining bytes if not. A period of time, during which the received data line is idle defines the end of the previous message. This idle time is the dead-line sync period. The control is now synchronized so that the next byte received is considered the beginning of a new message.

The value programmed is the equivalent number of character periods that the receive line must remain inactive to be considered the end of a message. The control will determine the actual time delay internally, taking into account baud rate and the number of bits in the character. The range is zero to 10 characters.

3.5 Function Code 68 - Communications Port Transmit Enable Delay

As described in the section on handshaking modes, this parameter defines the delay before and after the transmit Enable signal on Pin 4 of P20 goes high before transmission of the reply begins. This allows for stabilization of transmitter hardware before the message is actually sent. The value entered specifies the number of milliseconds that elapse before transmission begins, in a range of zero to 100. When the modem interface is used, a delay of 50 milliseconds is suggested. See S225-10-10.

4.0 Implementation Details of Cooper 2179

4.1 Functions Supported

4.1.1 Basic Scan
- Simple Status data
- 16-bit signed Analog data
- 16-bit Pulse Accumulator data

4.1.2 Scan-by-table

4.1.3 Supervisory Control
- Select Open
- Select Close
- Operate
- Reset Select

4.1.4 RTU Internal Control & Configuration
- Pulse Accumulator reset
- Write to RTU Memory
  - Error File
  - Scan Tables
  - Parameter Table
  - Pseudo register (Min/Max Values) Reset

4.1.5 Return RTU Configuration
- Read RTU Memory
  - Error File
  - Scan Tables
  - "RAM" Parameters
  - Parameter Table
  - Pseudo Register (Min/Max Values)

Message format for requests and responses are described in the protocol document, R280-90-12.

4.2 Exception and Error Handling

4.2.1 If a remote receives a valid "broadcast" message, it executes the commanded function but does not respond with a return message. Instead,

the next time a message is to be sent in response to a specific (non-broadcast) command, the BAK bit (broadcast acknowledge) in the message is sent.

4.2.2 If a remote receives a message that contains its REMOTE address (multi-master addressing is not supported), but has framing errors, is of incorrect length, or if CRC fails to check, then no response is given. In the next message that the remote sends to the master, the appropriate error code in the port status byte will be set to indicate that an erroneous reception has previously occurred.

4.2.3 If a remote receives a message that is addressed to it and is otherwise correct, but contains an unrecognized function, command, sequence number, ordinal type, or event type, then the remote responds with a nine-byte message which echoes the function code, except with the NOP set. Unused bits of bit-oriented commands such as "Basic Scan" are not ignored and will cause an error if set/reset when not expected. If a select/operate or write/execute sequence had been in process when the unrecognized message was received, then the message will be considered an out-of-sequence message, and the sequence will be reset and the RST will also be set in the response. The remote takes no other action. Data will be placed in its error file which indicates what error has occurred. In the next message(s) that the remote sends to the master, the RRR bit in the RTU status byte will be set to warn the master to read the error file.

4.2.4 If a remote receives an out-of-sequence message, it responds with a nine-byte message which echoes the function code except with the RST bit set. An out-of-sequence message is any message requiring a prior "select" which has not been received, or any message (other than the expected one) received while a previously-started multiple-message sequence has not been completed. Data will be placed in its error file which indicates what error has occurred. In the next message(s) that the remote sends to the master, the ERR bit in the RTU status byte will be set to warn the master to read the error file.

4.2.5 In any case where the error file contains data, the error bit will be set and remain set until the file is read. In the event that multiple errors occur, the most recent information will overwrite previous data. After the master reads the error information, the ERR bit in the RTU status byte will be reset, but the error file data remains until cleared by a write sequence. The error file should be read and cleared promptly to prevent the possibility of data corruption from overwriting.

4.2.6 If the control experiences a power on reset, the "RTU needs configuration" bit will be set in the RTU status byte on subsequent messages. The bit is cleared automatically by writing the scan table file (Ordinal 3).

4.3 Expected Timing Parameters

Timing Parameter	Minimum	Typical	Maximum	Units
Turn-around time, each message (End of request to start of reply				
Basic Scan	100	375	600	mSec
Seq/Ordinal Read (each parameter)	10	50		mSec

Seq/Ordinal Write/Reset (each parameter)	20	100	500	mSec
Tap Change SBO Operations				
Direct-Drive Mechanism	1	3	5	Sec
Spring-Drive Mechanism	3	5	10	Sec
Message session length timeout (Start of request to end of reply)			20	Sec
Transmit Enable Hold Time after Message Complete		50		mSec
RTS active to CTS active delay	1	5		mSec

4.4 SBO/Control Internal Parameter Modification

4.4.1 When changing values via communication, the 2179 protocol permits writing up to 64 contiguous 2 byte ordinal parameters with a single message. Here's the typical scenario:

4.4.1.1 The entire message is received from the master and checked for communication errors.

4.4.1.2 Each parameter, in order, is checked for errors (such as too high or low), and if valid, is entered into the parameter table. If the parameter is not valid, further message processing is halted, and an error (including which parameter) is recorded in the error file (Ordinal 0).

4.4.1.3 Repeat Step b until all components of message are done or an error is detected.

4.4.1.4 Reply message is built and sent to master.

There will be a period that the control is operating with "mismatched" information. This is no different, however, than entering a new control configuration at the front panel one entry at a time. In either case, if many changes need to be made while on line, caution regarding intermediate states is warranted.

4.4.2 Special Cases

4.4.2.1 Parameters Changing in General

To maintain maximum communication channel bandwidth, messages which take a "long" time to execute will require special provisions for error handling. For these messages, when the remote receives a properly formatted message with no CRC or other errors, it will respond promptly with the normal response message which indicates to the master that the message was properly received and that execution has been started. The remote will go ahead with execution at its own pace, and assuming the execution is properly completed, no other response will be made. If the command is found to be not executable, then the remote will abort execution and put data on its error file which indicates what

error has occurred. In the next message(s) that the remote sends to the master, the ERR bit in the RTU status byte will be set to warn the master to read the error file.

Remote communication is not available during parameter changing.

Examples:

1. Write Execute messages. This is a case where the command may be PARTIALLY executed; that is the command executes until an error is detected and then stops ALL further execution at that point. An error code indicating "out-of-range" and the offset value which failed is placed in the error table.

2. Control operations which may inherently take a while to perform. A possible error is a control or regulator failure that prevents operation. An error code for "mechanism failure" is placed in the error table.

4.4.2.2 Tap Changing Operations

On some types of regulators the tap changing process can take up to 10 seconds to complete. During this period any attempt to communicate with the control will be ignored. When the tap changing process is complete normal communication will be resumed.

4.4.3 Application Hints on the 2458 Sequence/Ordinal Number Document

Ord/Offset	Description	Comment
Seq 42 & 43	Operation Counter	Concatenate these values to form the entire Operation Counter number
Seq 80 thru AD	Analogs	Values are corrected so that one count equals one unit (volt, amp, etc.) or one increment. Scaling by the appropriate scale factor is required by the Master. Reference is actually not needed, but maintained for compatibility
SBO-00	Raise One Tap	Normally a non-latching parameter that automatically returns to OFF. Select "Close" activates the function while select "Open" returns a NOP
SBO-01	Lower One Tap	Normally a non-latching parameter that automatically returns to OFF. Select "Close" activates the function, while select "Open" returns a NOP
SBO-02	Regulation Enable	Select "Close" sets the function/accessory ON, while Select "Open" sets it OFF>
SBO-03	Source Side Voltage Calculation	Select "Close" sets the function/accessory ON, while Select "Open" sets it OFF>
5-00	SW Version	Lower two digits define device type CL-4, CL-5
6-46 thru 6-4E	Comm Parameters	See section describing control setup

INPUT SUBSYSTEM: Sequence numbers used in BASIC SCAN and SCAN-BY-TABLE operations

Simple Status data type...

Seq# (Hex)	Cross Ref	Function Code	Description	Additional Comments/notes
30	5-1		State of Display Annunciators	(0 = OFF, 1 = ON)
				Bit 0 - "LOW" Bandwidth
				Bit 1 - "HIGH" Bandwidth
				Bit 2 - "LOW" Voltage Limiting
				Bit 3 - "HIGH" Voltage Limiting
				Bit 4 - "V. RED." Voltage Reduction
				Bit 5 - Spare Bit 6 - Spare Bit 7 - Spare
	2-42	69	State of Regulation Task (Blocked/Unblocked)	Bit 8 - 0 = Normal Automatic Operation 1 = Automatic Operation Inhibited
	1-13		Power Direction Indication (Control Sensing)	Bit 9 - 0 = Current flow is Determinate 1 = Current flow Indeterminate and Bit 10 is undefined
				Bit 10 - 0 = Forward current flow 1 = Reverse current flow
	1-27		Control Power Direction Status	Bit 11 - 0 = Forward current flow 1 = Reverse current flow
			State of Demand Values	Bit 12 - New Min/Max Time-tagged Available
				Bit 13 - Spare Bit 14 - Spare Bit 15 - Spare
31	4-1		State of Auto/Off/Manual Switch	Bit 0 - 0 = OFF/MANUAL 1 = AUTO
	4-0		State of Voltage Reduction Inputs	Bit 1 - Reduction #1 Bit 2 - Reduction #2
	4-7		State of Supervisory Switch	Bit 3 - Supervisory On
	2-56	39	Source-side Voltage Calculation Status	Bit 4 - 0 = Calculation off 1 = Calculation enabled
				Bit 5 - Spare Bit 6 - Spare Bit 7 - Spare Bit 8 - Spare Bit 9 - Spare Bit 10 - Spare Bit 11 - Spare Bit 12 - Spare Bit 13 - Spare Bit 14 - Spare Bit 15 - Spare

Pulse Accumulator input (counter) data type.....resettable. All data is 16-bit positive integer format.

Seq# (Hex)	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments/Notes
40	1	Repairs	0-1	93	Number of EPROM Corrections	
41	1	Resets	0-2	94	Number of Resets (Insanity)	
42 43	1 1	Taps	4-5 4-6	00	Operations Counter (100's) Operations Counter (10's & 1's)	**These two operation counter points must be concatenated to form the total count. Reset/Change is NOT allowed through remote communications.**
44	**1**	**Taps**	**4-11**	**00-1**	**Operations during past 24 hours**	
45	**1**	**Taps**	**4-12**	**00-2**	**Operations during past 30 days**	
46	**1**	**Taps**	**4-13**	**00-3**	**Operations since beginning of month**	
47	**1**	**Taps**	**4-14**	**00-4**	**Operations during last calendar month**	
48	**1**	**Taps**	**4-15**	**00-5**	**Operations since beginning of year**	
49	**1**	**Taps**	**4-16**	**00-6**	**Operations during last calendar year**	

Analog Input data type...

All data is signed 16-bit integer format.

Seq # (Hex)	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments/Notes
80	1			CALIBRATION REFERENCE		Fixed at 90% of full scale. (29491/7333H)
81	1			CALIBRATION REFERENCE		Fixed at zero.
82	1		0-3	95	Hardware Status	
83	See Comments	Amps	1-1	9	Load Current (primary)	If (CT Ratio <= 50) then 10, else 1
84	10	Volts	1-2	6	Load Volts (secondary)	
85	100	kV	1-3	10	Load Volts (primary)	
86	10	Volts	1-4	7	Source Volts (secondary)	
87	100	kV	1-5	11	Source Volts (primary)	
88	1	kVA	1-8	14	kVA Load	
89	1	kvar	1-9	16	kvar Load	
8A	1	kW	1-10	15	kW Load	
8B	100		1-11	13	Power Factor	
8C	10	%	1-12	12	Percent Regulation	
8D	10	Volts	1-14	8	Compensated Volts (secondary)	
8E	10	%	1-15	18-3	3rd Voltage Harmonic	
8F	10	%	1-16	18-5	5th Voltage Harmonic	
90	10	%	1-17	18-7	7th Voltage Harmonic	
91	10	%	1-18	18-9	9th Voltage Harmonic	
92	10	%	1-19	18-11	11th Voltage Harmonic	
93	10	%	1-20	19-3	3rd Current Harmonic	
94	10	%	1-21	19-5	5th Current Harmonic	
95	10	%	1-22	19-7	7th Current Harmonic	
96	10	%	1-23	19-9	9th Current Harmonic	
97	10	%	1-24	19-11	11th Current Harmonic	
98	10	hertz	1-26	17	Line Frequency	
99	See Comments	Amps	3-0	22-P	Current Demand (forward present)	If (CT ratio <= 50) then 10, else 1
9A	1	kVA	3-1	24-P	kVA Demand (forward present)	
9B	1	kvar	3-2	26-P	kvar Demand (forward present)	
9C	1	kW	3-3	25-P	kW Demand (forward present)	
9D	10	Volts	3-4	20-P	Load Volts Demand (forward present)	
9E	10	Volts	3-5	21-P	Compensated Volts Demand (forward present)	
9F	See Comments	Amps	3-6	32-P	Current Demand (reverse present)	If (CT ratio <= 50) then 10, else 1
A0	1	kVA	3-7	34-P	kVA Demand (reverse present)	
A1	1	kvar	3-8	36-P	kvar Demand (reverse present)	
A2	1	kW	3-9	35-P	kW Demand (reverse present)	
A3	10	Volts	3-10	30-P	Load Volts Demand (reverse present)	
A4	10	Volts	3-11	31-P	Compensated Volts Demand (reverse present)	
A5	10	Volts	4-4		Tap changer Calculated Motor Voltage	
A6	10		5-0	71	Voltage Reduction Active Remote	
A7	1		4-08	12-P	Present Tap Position	
A8	10	%	1-31	18-13	13th Voltage Harmonic	
A9	10	%	1-32	19-13	13th Current Harmonic	
AA	10	%	1-33	18-THD	Total Voltage Harmonic Distortion	
AB	10	%	1-34	19-THD	Total Current Harmonic Distortion	
AC	**10**	**Volts**	**3-96**	**29-P**	**Source Volts Demand (forward present)**	
AD	**10**	**Volts**	**3-103**	**37-P**	**Source Volts Demand (reverse present)**	

TIME-TAGGED INFORMATION SUBSYSTEM:

Types and formats used in retrieving time-tagged information

TYPE 0, Time-tagged information record.....Minimum/maximum Demand Values

Code/Parameter	Scale Factor	Units
01...Max Forward Load Voltage	10	Volts
02...Min Forward Load Voltage	10	Volts
03...Max Forward Compensated Voltage	10	Volts
04...Min Forward Compensated Voltage	10	Volts
05...Max Forward Load Current	*	Amps
06...Min Forward Load Current	*	Amps
07...Max Forward kVA	1	kVA
08...Min Forward kVA	1	kVA
09...Max Forward kW	1	kW
10...Min Forward kW	1	kW
11...Max Forward kVAR	1	kvar
12...Min Forward kVAR	1	kvar
13...Max Tap Position	1	
14...Min Tap Position	1	
15...Max Reverse Load Voltage	10	Volts
16...Min Reverse Load Voltage	10	Volts
17...Max Reverse Compensated Voltage	10	Volts
18...Min Reverse Compensated Voltage	10	Volts
19...Max Reverse Load Current	*	Amps
20...Min Reverse Load Current	*	Amps
21...Max Reverse kVA	1	kVA
22...Min Reverse kVA	1	kVA
23...Max Reverse kW	1	kW
24...Min Reverse kW	1	kW
25...Max Reverse kVAR	1	kvar
26...Min Reverse kVAR	1	kvar
27…Max Forward	**10**	**Volts**
28…Min Forward	**10**	**Volts**
29…Max Reverse	**10**	**Volts**
30…Min Reverse	**10**	**Volts**

* IF(CT RATIO <= 50) THEN 10, ELSE 1

TYPE 1, Time-tagged information record.....Regulator Load-profile Record

Event Type codes used: 00...this is a time event

Data values returned: As defined by user with Function Code 85 or Ordinal 6, offset 4A - 51

CONTROL OUTPUT SUBSYSTEM: Sequence numbers used in SELECT/OPERATE operations

Seq # (Hex)	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments/Notes
00			4-3		Raise Tap changer one tap	“Close” is only valid command
01			4-3		Lower Tap changer one tap	“Close” is only valid command
02			2-42	69	Control Regulation Enable	“Close” = Blocked “Open” = Unblocked
03			2-56	39	Source Side Voltage Calculation Feature	“Close” = On “Open” = Off

CL5 MEMORY, ORDINAL BLOCK 0: CL5 error information file (R/W)

Table format per specification PGE RTU Protocol REV 11, Appendix 2

Error codes defined for CL5 control:

Error Code (Hex)	Error Response Bits	Description	Specific Data							
			08	09	0A	0B	0C	0D	0E	0F
00		No Error	00	00	00	00	00	00	00	00
01	NOP&ERR	Illegal Command Code	CC	00	00	00	00	00	00	00
02	NOP&ERR	Illegal Sequence Number	SN	00	00	00	00	00	00	00
03	NOP&ERR	Illegal Scan-Table Number	TN	00	00	00	00	00	00	00
04	Not Used									
05	Not Used									
06	Not Used									
07	Not Used									
08	Not Used									
09	RST&ERR	SBO Operate without Arm	SN	00	00	00	00	00	00	00
0A	RST&ERR	SBO Arm with another Arm Pending	SN	00	00	00	00	00	00	00
0B	Not Used									
0C	RST&ERR	Another request with SBO Armed	00	00	00	00	00	00	00	00
0D	RST&ERR	Another request with Write Pending	00	00	00	00	00	00	00	00
0E	Not Used									
0F	Not Used									
10	Note 2	Previous SBO Operation not performed satisfactorily	SN	SE	00	00	00	00	00	00
11	NOP&ERR	Illegal Function Code	00	00	00	00	00	00	00	00
12	NOP&ERR	Illegal Ordinal Number	ON	00	00	00	00	00	00	00
13	NOP&ERR	Illegal ordinal bias or bias out of range	ON	OL	OH	CT	CT	00	00	00
14	Note 1	Unsuccessful Data Read or Write	LE	ON	OL	OH	00	00	00	00
15	NOP&ERR	Illegal time-tagged table Number	TN	00	00	00	00	00	00	00
20	ERR ONLY	Default clock data, clock not set	00	00	00	00	00	00	00	00
21	Not Used									
22	NOP&ERR	Illegal Real Time Clock	JH	JL	HR	MN	SC	00	00	00
23	Not Used									
24	Not Used									
25	Not Used									
26	Not Used									
27	Not Used									
28	Not Used									
29	Not Used									
2A	Not Used									
2B	Not Used									
2C	Not Used									
2D	ERR ONLY	Calculated number of events out of range	EN	00	00	00	00	00	00	00
2E	Not Used									
2F	Not Used									

Note 1: Responds with ERR only for “Reads”, and NOP & ERR for “Writes”
Note 2: Error is saved in error file only, not displayed on the front panel.

LEGEND

- CC Command Code
- CT Count
- EN Event Number
- JH Julian Day High Byte
- JL Julian Day Low Byte
- HR Hour
- LE Local Control Error as follows ...
  - 01 Control is in “Local Mode”
  - 02 Requested Data is Invalid
  - 03 Requested Data is Invalid and Default
  - 04 Reserved
  - 05 Value is too Large
  - 06 Value is too Small
  - 07 Invalid Internal Point Offset
  - 08 Invalid Operation for this Internal Point
  - 09 Invalid Internal Point Number
  - 0A Invalid Number of Internal Points
  - 0B Not Used
  - 0C Not Used
  - 0D Not Used
  - 0E Not Used
  - 0F Not Used
- MN Minute
- OH Ordinal Offset, High Byte
- OL Ordinal Offset, Low Byte
- ON Ordinal Number
- SC Seconds
- SE SBO operation error as follows ...
  - 01 Control not in automatic mode
  - 02 Another SBO in progress
  - 03 Mechanism failure
  - 04 Insufficient SBO operation power
- SN Sequence Number
- TO Time-Out Indication (FF if true, other data is irrelevant)
- TN Table Number

CL5 MEMORY, ORDINAL BLOCK 3: SCAN-BY-TABLE scan tables (R/W)

NOTE: Scan table data is stored in non-volatile memory in the CL5 Control. It is not required to re-initialize the data from the master after a reset.

Table format per specification...maximum length is 256 bytes

For more detailed information about this table’s format, refer to pages 14-18 of R280-90-12.

CL5 MEMORY, ORDINAL BLOCK 5: CL5 RAM

All data is 2 bytes long, low byte first.

Offset	Scale Factor	Units	Cross Ref	Function Code	Description
0000	100		0-0	89	Software Version/Device Number
0002			0-6	61	Control Communication Type/revision
0004			1-28	47	Voltage Calibration
0006			1-30	48	Current Calibration
0008			**4-9**	**00-date**	**Date total operations count was set**
000A			**4-10**	**00-time**	**Time total operations count was set**

CL5 MEMORY, ORDINAL BLOCK 6: CL5 Parameter Table (Read/write)

Note: Parameter Table data is stored in non-volatile memory in the CL5 Control. It is not required to re-initialize the data from the master after a reset.

All data is 2 bytes long, low byte first.

Off-set	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments	Limits High	Limits Low
0000	10	minutes	2-1	46	Demand Time Interval		60.0	3.0
0002	1	Amps	2-2	45	C.T. Primary Rating		2000	25
0004	10		2-3	44	P.T. Ratio		300.0	10.0
0006	1	Volts	2-4	43	System Line Voltage		36000	1200
0008	10	Volts	2-8	52	Bandwidth (reverse)		6.0	1.0
000A	10	Volts	2-9	55	Line Drop Compensation Reactive (reverse)		96.0	-96.0
000C	10	Volts	2-10	54	Line Drop Compensation Resistive (reverse)		96.0	-96.0
000E			2-11	56	Reverse Sensing Method 0 = Locked Forward 1 = Locked Reverse 2 = Reverse Idle 3 = Bi-directional 4 = Neutral Idle 5 = Co-Generation 6 = Reactive power flow bi-directional		**6**	0
0010	10	Volts	2-12	51	Set Voltage (reverse)		135.0	100.0
0012	1	seconds	2-13	53	Time Delay (reverse)		180	5
0014	1	%		2-14	57	Reverse Threshold Value %	5	1
0016	1		2-15	40	Regulator Identification		32766	1
0018	1		2-16	96	Level 1 Security Code		9999	1

CL5 MEMORY, ORDINAL BLOCK 6: CL5 Parameter Table (R/W), (continued)

Off-set	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments	Limits High	Limits Low
001A	1		2-17	97	Level 2 Security Code		19999	10000
001C	1		2-18	98	Level 3 Security Code		32766	20000
001E	1		2-19	41	Regulator Configuration	0 = Wye 1 = Delta Lag 2 = Delta Lead	2	0
0020	10	Volts	2-20	2	Bandwidth		6.0	1.0
0022	10	Volts	2-21	5	Line Drop Compensation Reactive		96.0	-96.0
0024	10	Volts	2-22	4	Line Drop Compensation Resistive		96.0	-96.0
0026			2-23	42	Control Operational Mode	0 = Sequential 1 = Time Integrating 2 = Averaging	2	0
0028	10	Volts	2-24	1	Set Voltage		135.0	100.0
002A	1	seconds	2-25	3	Time Delay		180	5
002C	1		2-26	80	Voltage Limiting Mode	0 = Off 1 = High Limit Only 2 = High and Low Limit	2	0
002E	10	Volts	2-27	81	High Voltage Limit		135.0	115.0
0030	10	Volts	2-28	82	Low Voltage Limit		115.0	105.0
0032	1		2-29	70	Voltage Reduction Mode		**Valid Values: 0, 1, 2, 3, 10, 11, 12, 13**	
0034	10	%	2-30	72	Local Voltage Reduction		10.0	0.0
0036	10	%	2-31	73	Remote Setting #1		10.0	0.0
0038	10	%	2-32	74	Remote Setting #2		10.0	0.0
003A	10	%	2-33	75	Remote Setting #3		10.0	0.0
003C	1	baud	2-40	60	Communication Channel #1 (Data Port) Baud Rate Code	1 = 300 2 = 1200 3 = 2400 4 = 4800	4	1
003E	1	baud	2-44	65	Communication Channel #2 (remote) Baud Rate Code	1 = 300 2 = 1200 3 = 2400 4 = 4800 5 = 9600	5	1
0040	1		2-43	64	Communication SCADA Address		32766	0
0042	1		2-45	66	Communication Channel #2 HandshakeMode Code	0 = No Handshaking 1 = RTS/CTS Active 2 = Modem Control Handshaking	2	0
0044	1	charact.	2-46	67	Communication Channel #2 Number of dead-line character times for re-synchronization		10	0

CL5 MEMORY, ORDINAL BLOCK 6: CL5 Parameter Table (R/W), (continued)

Off-set	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments	Limits High	Limits Low
0046	1	millisec.	2-47	68-1	Communication Channel #2 Transmit Enable Delay for Modem Control Handshake Mode		425	0
0048	1	millisec.	2-48	68-2	Communication Channel #2 Transmit Disable Delay for Modem Control Handshake Mode		100	0
004A			2-50	85-1	Function Code of Parameter Stored at Load Profile Entry #1		**Valid Values: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 29, 30, 31, 32, 34, 35, 36, 37**	
004C			2-51	85-2	Function Code of Parameter Stored at Load Profile Entry #2			
004E			2-52	85-3	Function Code of Parameter Stored at Load Profile Entry #3			
0050			2-53	85-4	Function Code of Parameter Stored at Load Profile Entry #4			
0052			2-54	76	Pulsed Mode: Number of Steps		10	1
0054			2-55	77	Pulsed Mode: Step Size		10.0	0.1
0056			6-05	50-1	Time Calendar/Clock - Year		2089	1990
0058			2-80	92	Security System Bypass		3	1
005A			2-57	39-1	Voltage Regulator Type	1 = Type A 2 = Type B	2	1
005C			2-58	49	Tap changer Type	0 = Quik Drive 1 = Spring/Direct Drive	1	0
005E	**1**		**2-59**	**79**	**Add-Amp Feature State**	**1 == "On" 0 == "Off"**	**1**	**0**
0060	**1**		**2-60**	**79-1**	**Add-Amp Upper Setting**		**Valid Values: 8, 10, 12, 14, 16**	
0062	**1**		**2-61**	**79-2**	**Add-Amp Lower Setting**		**Valid Values: -8, -10, -12, -14, -16**	
0064	**1**	**minutes**	**2-62**	**85**	**Profile Period**		**Valid Values: 5, 10, 15, 30, 60, 90, 120**	
0066	**1**		**2-63**	**85-5**	**Profile Report State**	**0 == "All" 1 == "Changed"**	**1**	**0**

CL5 MEMORY, ORDINAL BLOCK 0B: CL5 Psuedo-registers (R/W)

NOTE: These data are MAX/MIN registers for operating variables. When they are written by the WRITE RTU MEMORY function, the write "data" is ignored and the registers are instead set to the current value of the operating variable. All data is signed 16-bit integer format.

Off-set	Scale Factor	Units	Cross Ref	Function Code	Description	Additional Comments
0002	100		3-13	23-L	Power Factor at Minimum Demand kVA (forward)	
0004	100		3-14	33-H	Power Factor at Maximum Demand kVA (reverse)	
0006	100		3-15	33-L	Power Factor at Minimum Demand kVA (reverse)	
0008	See Comments	Amps	3-16	22-L	Current demand, forward minimum	If CT ratio <=50 then 10, else1
000A	See Comments	Amps	3-17	22-H	Current demand, forward maximum	If CT ratio <= 50 then 10, else1
000C	1	kVA	3-18	24-L	kVA Demand (forward minimum)	
000E	1	kVA	3-19	24-H	kVA Demand (forward maximum)	
0010	1	kar	3-20	26-L	kvar Demand (forward minimum)	
0012	1	kvar	3-21	26-H	kvar Demand (forward maximum)	
0014	1	kW	3-22	25-L	kW Demand (forward minimum)	
0016	1	kW	3-23	25-H	kW Demand (forward maximum)	
0018	10	Volts	3-24	20-L	Load Volts Demand (forward minimum)	
001A	10	Volts	3-25	20-H	Load Volts Demand (forward maximum)	
001C	10	Volts	3-26	21-L	Compensated Volts Demand (forward minimum)	
001E	10	Volts	3-27	21-H	Compensated Volts Demand (forward maximum)	
0020	See Comments	Amps	3-28	32-L	Current demand, reverse minimum	If CT ratio ≤ 50 then 10, else 1
0022	See Comments	Amps	3-29	32-H	Current demand, reverse maximum	If CT ratio ≤ 50 then 10, else 1
0024	1	kVA	3-30	34-L	kVA Demand (reverse minimum)	
0026	1	kVA	3-31	34-H	kVA Demand (reverse maximum)	
0028	1	kvar	3-32	36-L	kvar Demand (reverse minimum)	
002A	1	kvar	3-33	36-H	kvar Demand (reverse maximum)	
002C	1	kW	3-34	35-L	kW Demand (reverse minimum)	
002E	1	kW	3-35	35-H	kW Demand (reverse maximum)	
0030	10	Volts	3-36	30-L	Load Volts Demand(reverse minimum)	
0032	10	Volts	3-37	30-H	Load Volts Demand(reverse maximum)	
0034	10	Volts	3-38	31-L	Compensated Volts Demand (reverse minimum)	
0036	10	Volts	3-39	31-H	Compensated Volts Demand (reverse maximum)	
0038			3-40	27	Maximum % Boost/ Minimum % Buck	
003A			3-41	28	Minimum % Boost/ Maximum % Buck	
003C			3-66	27-H	Maximum Tap Position	
003E			3-69	28-L	Minimum Tap Position	
0040	**10**	**Volts**	**3-97**	**29-L**	**Source Volts Demand (forward min.)**	
0042	**10**	**Volts**	**3-100**	**29-H**	**Source Volts Demand (forward max.)**	
0044	**10**	**Volts**	**3-104**	**37-L**	**Source Volts Demand (reverse min.)**	
0046	**10**	**Volts**	**3-107**	**37-H**	**Source Volts Demand (reverse max.)**	

Data points accessible through front panel controls of the CL-5C, but not accessible through remote communications.

This data is not part of the communications interface. They are listed for reference only.

All data is 2 bytes long, low byte first.

Offset	Scale Factor	Cross Ref	Function Code	Description
	1	0-4	62	Channel #1 (front panel) Status
	1	0-5	63	Channel #2 (remote) Status

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