Serial Communications Protocol

Data 2179 – Revision 4

For Use With

Cooper Power Systems Apparatus Controls:

- Form 6 Recloser Control

- Form 5 Recloser Control

- Form 4C Recloser Control

- CL-6A Regulator Control

- CL-5C Regulator Control

- CL-5A Regulator Control

- CL-4C Regulator Control

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The protocol specified in this document is a subset of the "Remote Terminal Unit Protocol" developed by Pacific Gas and Electric Company, San Francisco, California. This protocol subset has been developed jointly by Cooper Power Systems and Pacific Gas and Electric Company. The protocol is incorporated in Cooper Power Systems' products for general use by Cooper Power Systems customers with the consent of Pacific Gas and Electric Company.

In the context of this specification, "RTU" means the Cooper Power Systems equipment incorporating this protocol, and "Master" means the device interfaced to and controlling the Cooper Power Systems equipment via this protocol.

1.0 INTRODUCTION

1.1 BASIC MASTER MESSAGE FORMAT

The following is a description of the physical format for the transmission of data between the MASTER and the REMOTE TERMINAL UNIT (RTU).

2 Characters	1 Character	1 Character	2 Characters		2 Characters
Master / RTU Address	Function Code	Command	Number of Characters	Data Field	CRC16

1.1.1   Character Format – ASYNC / 8 DATA Bits / 1 Stop Bit / No Parity

NOTE: Two byte words are sent low byte first, including ADDRESS and NUMBER OF CHARs, DATA and CRC16

1.1.2   RTU Address – Two characters that specify the address of the polling MASTER and the desired RTU. There are 5 bits for the MASTER address (0-1F HEX [0 to 31 decimal]) and 11 bits for the RTU address (000-7FE HEX [0-2046 DECIMAL]). An address of 7FF HEX is used for a broadcast message.

FORMAT FOR ADDRESS CHARACTERS (from master)

Character 2								Character 1							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
M04	M03	M02	M01	M00	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00
Master Address					**Remote Address**										

1.1.3   Function Code – A one character code that defines the function to be performed.

7	6	5	4	3	2	1	0
0	0	**Functional Operation**					

BITS 0-5 - Function that is to be performed
BITS 6-7 - Reserved for other system functions

TABLE 1-1 List of Function Codes

FUNCTION CODE	OPERATION
00	BASIC SCAN OPERATION – All data of type(s) specified in the COMMAND character will be returned in response.
03	Scan for FLOATING POINT quantities.
04	Retrieve TIME-TAGGED INFORMATION
0A	SCAN BY TABLE- Return data specified in the table named in the MASTER request.
10	SUPERVISORY CONTROL – Perform control operation defined in the COMMAND character and parameters
20	RTU INTERNAL CONTROL AND CONFIGURATION – Configure or control as specified in the COMMAND character and parameters
25	RETURN RTU CONFIGURATION – The RTU will respond with internal information as specified by the master.
40-F0	** CANNOT BE USED**

1.1.4 Master Message Command Character – A one-character message containing the specific operation within the function that the RTU should perform. The meaning of these command bits will change for specific functions and will be detailed when the function is discussed in later paragraphs.

7	6	5	4	3	2	1	0
Command Character							

1.1.5 Number of Characters – 2 characters that specify the number of characters in the DATA Field. If it is 00, there are no data characters. The maximum number of characters in the data field is 128 for a normal SCADA application.

1.1.6 Data Field – A variable length field containing operation information in addition to the function and command bytes (i.e., sequence numbers, parameters, configuration, etc.)

1.1.7 CRC16 – A 2 character CRC (Cyclical Redundancy Check) of all of the characters in the entire message.

$X_{16}+X_{15}+X_2+1$ is the polynomial
(initialized as 0000 for table look-up)

1.2 BASIC REMOTE MESSAGE FORMAT

2 Chars	1 Char	1 Char	1 Char	2 Chars	Data Field	2 Chars
Master / RTU Address	Function Code	Status	Port Status	No of Characters		CRC16

1.2.1 Character Format – ASYNC / 8 DATA Bits / 1 Stop Bit / No Parity

NOTE: Two byte words are sent low byte first, including ADDRESS NUMBER OF CHARACTERS, DATA and CRC16

1.2.2 RTU Address – Two characters that specify the addresses of the polling MASTER and the responding RTU.

FORMAT FOR ADDRESS CHARACTERS (from remote)

Character 2								Character 1							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
M04	M03	M02	M01	M00	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00
Master Address					**Remote Address**										

1.2.3 Function Code – A one function code that defines the purpose of the message (see table 1-1, Function Codes). The RTU generally echoes the function code sent by the MASTER, except when the RTU cannot perform the requested function due to an error, time-out, bad parameters, or some other condition that is not logical to the RTU.

7	6	5	4	3	2	1	0
RST	**NOP**	**Functional Operation**					

DESCRIPTION

Bit 00-05   FUNCTION normally an echo of the master function Character.

Bit 06   RESULT NOP – NO OPERATION. The RTU returns a NOP when it has reached time-out on a selected function; an invalid function or parameter; or other format error.

** IF PARITY, FRAMING OR CRC ERROS ARE DETECTED THE RTU WILL IGNORE THE MESSAGE AND NOT RESPOND **

Bit 07   RESULT RST RESET – The RTU returns a RST when it receives an out of sequence command while there is a select function active or an Operate or Execute command when no Select is active.

1.2.4   <u>Remote to Master Status Byte</u> – This character contains flags that inform the MASTER of current RTU STATUS

7	6	5	4	3	2	1	0

Bit 7:   1= Remote needs to be configured by MASTER. This flag is set with power on or RTU manual reset.

Bit 6:   0 = Always 0   - RESERVED -

Bit 5:   0 = Always 0   - RESERVED -

Bit 4:   0 = Always 0   - RESERVED -

Bit 3:   1 = Error - Read RTU error file to determine problem

Bit 2:   1 = Acknowledge broadcast message – set to inform the MASTER that the RTU has received an address of '7FF' HEX.

Bit 1:   0 = Always 0   - RESERVED-

Bit 0:   0 = Always 0   -RESERVED-

1.2.5   Remote Communications Port Status Byte – This character informs the MASTER of the status of all 4 RTU communications channels.

There are two Bit's for each port. If a port is not equipped, its status will be a Binary 01.

7	6	5	4	3	2	1	0

Bit 0-1:   COM Port 1 status

Bit 2-3:   COM Port 2 status (if equipped)

Bit 4-5:   COM Port 3 status (if equipped)

Bit 6-7:   COM Port 4 status (if equipped)

MEANING OF 2-BIT PORT STATUS:

00 = COMM PORT OK

01 = No data received for 1 minute or more

10 = PARITY or CRC error

11 = Loss of carrier

1.2.6   Number of Characters - 2 characters that specify the number of characters in the DATA FIELD. If it is 00, there are no data characters. The maximum number of characters in the DATA FIELD is 511 for normal SCADA functions.

1.2.7   Data Field - A variable length field containing information requested by the MASTER (i.e., STATUS and ANALOG quantities).

1.2.8   CRC16 - A 2 character CRC (CYCLICAL REDUNDANCY CHECK) of all of the characters in the entire message.

$X_{16}+X_{15}+X_2+1$ is the polynomial.
(INITIALIZE AS 0000 FOR TABLE LOOK-UP)

1.3   ASYNCHRONOUS DATA TRANSMISSION FORMAT

Each character is sent in an asynchronous manner using one (1) start bit, eight (8) data bits, one (1) stop bit and no parity. The character is transmitted/received low order bit (0) first. In this document bit 0 is on the right end of any byte and the formats are drawn so the order of transmission of characters is from left to right.

1.4   SYNCHRONOUS DATA FORMAT- TO BE DETERMINED WHEN REQUIRED

2.0   RTU CONFIGURATION

The following paragraphs contain information on RTU configuration.

2.1   SEQUENCE NUMBERS

This protocol provides transparency to the RTU hardware through the use of sets of SEQUENCE NUMBERS and allows the MASTER STATION to communicate with RTUs without regard to hardware characteristics.

Details on sequence number assignments for each device implementing this protocol are contained in separate specifications for each particular device.

As shown in TABLE 2-1, there is one set of sequence numbers for each subsystem in the RTU.

TABLE 2-1
SEQUENCE NUMBERS FOR RTU SUBSYSTEMS

- INPUT SUBSYSTEM: status, analog and pulse accumulator.
    Sequence #00 through FF (see 3.3.2 for description).

  - 00-1F ARE SEQ #s FOR 2-BIT STATUS CHANGES
  - 30-3F ARE SEQ #s FOR SIMPLE STATUS
  - 40-5F ARE SEQ #s FOR PULSE ACCUMULATORS
  - 80-FF ARE SEQ #s FOR ANALOG INPUTS

- CONTROL OUTPUT SUBSYSTEM
    Sequence #00 through FF (see 4.8 for description).

- SPECIAL CALCULATIONS SUBSYSTEM
    Sequence #00 through 7F (see 5.0 for description).

2.3 FORMAT FOR DATA TYPES - RTU SCAN RESPONSE

2.3.1 ABBREVIATIONS

The following table contains definitions of the abbreviations used in message formats.

TABLE 2-2
FORMAT ABBREVIATIONS

RA   REMOTE ADDRESS - two characters.
FN   FUNCTION CODE - defines required function.
C   COMMAND BYTE - defines specific functional
S   STATUS BYTE – current RTU status.
PS   PORT STATUS BYTE – contains 2 bits for each of 4 possible communications ports.
NC   NUMBER OF CHARACTERS – included in all MASTER and RTU messages to indicate the number of characters in the data field.
CRC CYCLICAL REDUNDANCY CHECK – Two characters that hold the result of character by character CRC calculation of all characters in the message.

2.3.2 <u>Bit Numbering Convention</u>

MSB   LSB
BIT 15 ◄--- BIT 00
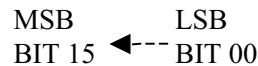
2.3.3 <u>Format for 2-bit status change</u> - 2 bits per status point, consisting of instantaneous and a change bit to indicate multiple changes of state between scans - sent in 16 bit groups.

2.3.4 <u>Format for Simple Status Points</u> - instantaneous state of status inputs when scanned (sent in 16 bit groups).

Low Order 8 Bits								High Order 8 Bits							
S07	S06	S05	S04	S03	S02	S01	S00	S15	S14	S13	S12	S11	S10	S09	S08
Character 1								Character 2							

2.3.5 <u>Format for sending 16 bit Analog Values</u> - returned in scan response if BIT 03 is set in the MASTER command character on a basic 1 scan request. The format in two's complement binary numbers.

Low Order 8 Bits								High Order 8 Bits							
A07	A06	A05	A04	A03	A02	A01	A00	+/- Sign	A14	A13	A12	A11	A10	A09	A08
Character 1								Character 2							

2.3.6 <u>Format for 16 Bit Pulse Accumulator</u>

Low Order 8 Bits								High Order 8 Bits							
PA07	PA06	PA05	PA04	PA03	PA02	PA01	PA00	PA15	PA14	PA13	PA12	PA11	PA10	PA09	PA08
Character 1								Character 2							

3.0 SCAN FUNCTIONS

3.1 FUNCTION 00 - BASIC SCAN FUNCTION

SCAN FUNCTION 00 returns data to the MASTER STATION for a particular COMMAND BYTE when it is desired to get all of a particular type of data returned from a scan request without the necessity of specifying SEQUENCE NUMBERS. For each of the command byte bits that are set, the RTU will return all of the specified type of data with its response. (See 3.3.2 for description)

3.1.1 <u>Description</u>

7	6	5	4	3	2	1	0	7	6	5	0	3	2	1	0
0	0	0	0	0	0	0	0	0	PA	0		SBA	2BS	0	SS
Function Code								Command							

Function Code	Command Bit		Function
			RETURN ALL:
00	Bit 00	(SS)	Simple Status Data
00	Bit 01	0	ALWAYS - 0 - RESERVED
00	Bit 02	(2BS)	2 Bit Data Status
00	Bit 03	(SBA)	16 Bit Analog Format
00	Bit 04	0	ALWAYS - 0 – RESERVED
00	Bit 05	0	ALWAYS - 0 – RESERVED
00	Bit 06	(PA)	16 Bit Pulse Accumulator Data
00	Bit 07	0	ALWAYS - 0 - RESERVED

3.2 BASIC SCAN OPERATION – TYPICAL MASTER / REMOTE EXCHANGES

The following paragraphs illustrate the rules of the basic
scan operation, along with some examples of its use. Data is always returned
by order of Sequence number (lowest Seq # first).

3.2.1 Example 1 - FUNCTION 00/COMMAND 09. In response to this function,
the RTU will return all simple status and all analog data in a 16 bit format.

Master to Remote Message

Address	Function Code	Command	Number of Characters	CRC
RA	00	09	00 00	

Remote to Master Response
(Assumes 16 Status and 4 Analogs)

Address	FN	S	PS	Number of Chars 0E 00		Simple Status		Analog 1		Analog 2		Analog 3		Analog 4		Check Chars
RA	00	S	PS	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	CRC

3.2.2 Example 3 – FUNCTION 00 / COMMAND 41. In response to this
function, the RTU will return all simple status and pulse accumulators only.

Master to Remote Message

Address	Function Code	Command	Number of Characters	CRC
RA	00	41	00 00	

Remote to Master Response
(assumes 16 status bits and 2 pulse accumulators)

Address	FN	S	PS	No of Chars 06 00		Simple Status		Pulse Accum #1		Pulse Accum #2		CRC	
RA	00	S	PC	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi

3.3 (deleted)

3.3.1 (deleted)

3.3.2 Remote Sequence Number Assignments

The following sequence number assignments are hardcoded in the RTU
firmware. The RTU documentation relates the individual numbers to specific
hardware points. This section covers only the sequence numbers for status,
analog and pulse accumulator data quantities. Sequence numbers for output
quantities will be covered in later sections.

3.3.2.1 2-Bit Status Change – a sequence number is assigned to each group
of 16 2-bit status change bits (2 bits for each of 8 contiguous status
inputs). There can be 32 groups of 2-bit status change bits,
representing 256 status inputs maximum (SEQ. #'s 00-of HEX).

1st set of 2-BIT STATUS CHANGE BITS is assigned Seq #00 Hex

.
.
/ /
.
.

2nd set of 2-BIT STATUS CHANGE BITS is assigned seq #1F Hex

3.3.2.2 SIMPLE STATUS – a sequence number is assigned to each group of 16 contiguous status inputs. There can be a maximum of 16 groups, which is 256 status bits maximum (SEQ. #'s 30-3F . HEX).

The 1st set of 16 STATUS BITS is assigned -----SEQ. #30 HEX

.

.

/ /

.

.

The 16th set of 16 STATUS BITS is assigned -----SEQ. #3F HEX

3.3.2.3 ANALOG INPUTS - a sequence number is assigned to each individual analog input point. There is a total of 128 sequence numbers available (SEQ. #s 80-0FF HEX).

THE 90% of FULL SCALE ANALOG REFERENCE POINT IS SEQ. #80 HEX

THE 0 VOLT ANALOG REFERENCE POINT IS SEQ. #81 HEX

THE FIRST FIELD-WIRED ANALOG POINT IS SEQ. #82 HEX

.

//

.

.

THE 126th FIELD-WIRED ANALOG POINT IS SEQ. # FF HEX

3.3.2.4 PULSE ACCUMULATOR - There is one sequence number assigned to each pulse accumulator. A maximum of 32 numbers is available (SEQ. #s 40-5F HEX).

The first pulse accumulator is assigned SEQ #40 HEX

The last pulse accumulator is assigned SEQ. #5F HEX

3.4   SCAN-BY-TABLE (16 bit analogs):
       Function 0A/Commands 41 through 4F

This function requires that tables exist in the RTU specifying the sequence number of the data quantities to be returned to the MASTER. Up to 15 tables can be configured and it is possible to retrieve 15 totally different sets of data from the RTU, using these scan-by-table modes with different commands.

3.4.1   Description

TN = Table Number

7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	0	1	0	0				
									SBA			TN3	TN2	TN1	TN0
Function Code								Command							

COMMAND
0A   BIT 01 (TN1) * Scan table address

FUNCTION CODE	BIT	FUNCTION
0A	BIT 00	(TN0) *
0A	BIT 01	(TN1) * Scan table address
0A	BIT 02	(TN2) * 1 thru F HEX
0A	BIT 03	(TN3) *
0A	BIT 04	ALWAYS 0 -RESERVED-
0A	BIT 05	ALWAYS 0 -RESERVED-
0A	BIT 06	(SBA) Return analog data in 16 bit format
0A	BIT 07	ALWAYS 0 -RESERVED-

3.4.2 SCAN TABLES

Each of the 15 commands (x1-xF) associated with this type of scan has an associated table in the RTU that specifies what data the RTU will transmit to the MASTER. Up to three of these tables can be concatenated to provide even more flexibility for data retrieval. The following is a description of these 15 tables.

COMMAND X1	All 15 tables appear sequentially in ram memory of the RTU
COMMAND X2	
COMMAND X3	These individual tables can be of varying lengths, as configuration requires
COMMAND X4	
COMMAND X5	The maximum of all 15 tables combined is 256 bytes (100 Hex)
COMMAND X6	
COMMAND X7	
COMMAND X8	There may be fewer than 15 tables end of tables is established by two consecutive bytes of 00
COMMAND XE	
COMMAND XF	The remainder of the unused 256 byte area should contain all zeros.

3.4.3   SCAN TABLE STRUCTURE

SCAN tables are groups of sequential bytes, and the individual tables can be varying lengths. The total of all 15 tables, however, cannot be greater than 256 decimal (100 Hex) bytes in length. These tables must be initialized by downloading the configuration from the MASTER STATION to the RTU.

7	6	5	4	3	2	1	0
Byte 1		ST1		ST2			
Byte 2		Number of bytes in this table					
Byte 3		First sequence number sent					
Byte 4		Second sequence number sent					
Byte 5		Third sequence number sent					
Byte n		Last sequence number sent					
Byte 1		ST1			ST2		
Byte 2		Number of bytes in this table					
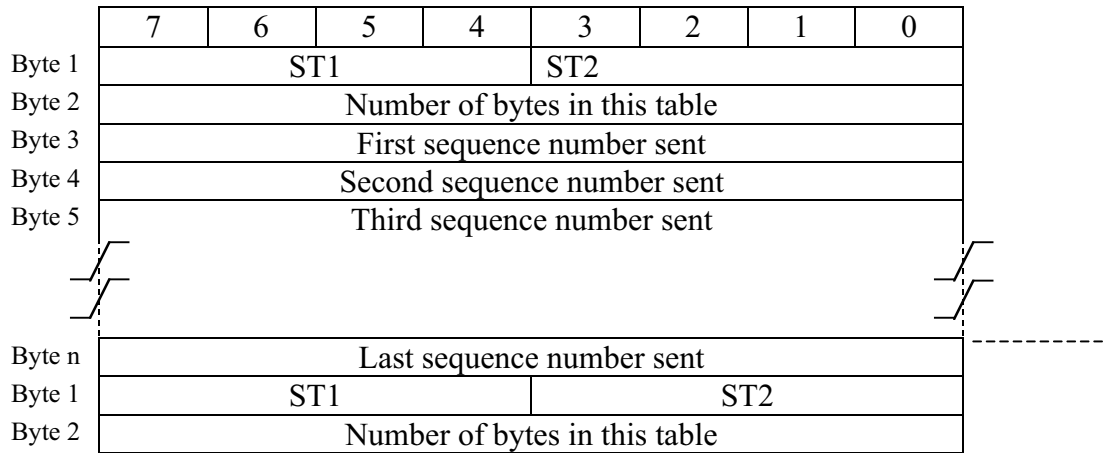
Byte 1: The first byte of each table specifies the numbers of the two other scan3x tables to concatenate to the response to this message. The data corresponding to the seq. #s in the table specified in ST1 will be sent first, followed by that specified in ST2 and finally by the data specified in this table. A 'O' in ST1 or ST2 indicates no table for that 'nibble' to concatenate

Byte 2: Specifies the quantity of sequence numbers in this table.

Byte 3: Sequence number of first data quantity to be sent. This could be for simple status, status counters, 2-bit status change, analog or pulse accumulator sequence numbers, and can be in any order.

Byte 4: Sequence number of the second data quantity.

Byte 5: Sequence number of the third data quantity.

Byte n: The last byte of this table.

Byte 1: First byte of the next table.

3.4.4 SCAN TABLE OPERATION

The following example describes the scan table operation when the MASTER command Byte is set to 1F HEX.

COMMAND   **MASTER TO REMOTE**

x1	0	0
	03	
	Seq #86	
	Seq #8A	
	Seq #80	

	RA	0A	1F	00 00	CRC

x2	1 F
	03
	Seq #31
	Seq #33
	Seq #32

REMOTE TO MASTER RESPONSE

x3	6 7
	02
	Seq #41
	Seq #46

RA	FN	S	PS	NC	#31	#33	#32	#86	#8A	#80	#40	#41	CRC

xF	2 1	Concatenation Numbers (Tables x2 first and x1 second)
	02	
	Seq #40	
	Seq #41	
	0 0	
	0 0	
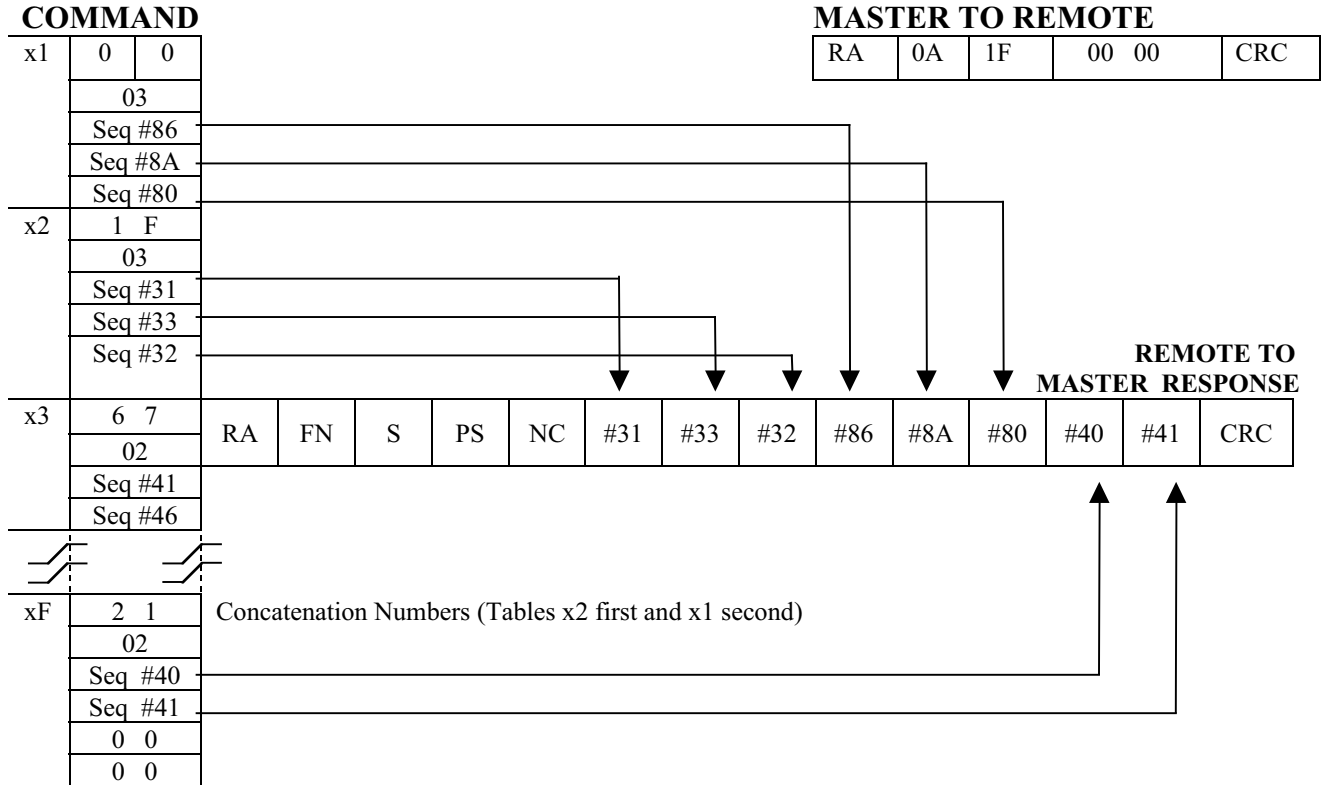
This command will cause the RTU to go to its SCAN table and find the section associated with xF hex (Table 15). It first checks the first location for concatenation files since the left nibble (SC 1) has A 2, the RTU will go to SCAN3x table x2 and use the seq. #'s in that table to send data. The right nibble (sc 2) has A 1, so the data corresponding to the seq #'s in table x1 will be sent next. Finally, the data corresponding to the seq #'s in the table xF will be sent.

Bit 4 in the command character tells the RTU to send any analog data in unpacked format.

The RTU returns the data corresponding to the following seq #'s.
1.   Seq #'s 31, 33, & 32 from table x2
2.   Seq #'s 86, 8A & 80 from table x1
3.   Seq #'s 40 & 41 from table xF
The last two bytes at the end of all tables must equal zero.

3.5 FUNCTION 04; RETRIEVE TIME-TAGGED INFORMATION

These functions are used when communicating with devices that are seldom scanned and are capable of retaining Time-tagged event and load profile history information. This function contains commands providing the flexibility of retrieving data, one record at a time or dumping all of a specific type of data.

There can be up to 32 different types of Time-tagged history files. The exact makeup of these files is application dependent, but the format for an individual record is a time tag followed by one or more data quantities. These data quantities can be either scanned values (Section 2.3) or Special Function values. (Section 6.0).

There is a positive acknowledgement from the master station for each transmission received. The RTU must be capable of re-transmitting the last message whenever it receives a poll from the master without an acknowledgement.

3.5.1 Description

7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	ACK	DMP	RT4	RT3	RT2	RT1	RT0
Function Code								Command							

FUNCTION CODE	COMMAND	FUNCTION
04	4x	Return single record from story type specified in RTO-RT4. Last exchange acknowledged.
04	0x	Re-transmit last single record message.
04	6x	Dump all event records for the history type specified in RT0-RT4. Last exchange acknowledged.
04	2x	Re-transmit last dump message.

*ACK – Bit 6 of the Command byte is the "Acknowledge" bit.
If= 1-   the last message was received error-free
If= 0-   re-transmit the last message.

DMP- Bit 5 of the Command byte is the "Dump" bit.

If= 1-   Send all records of specified history type. Total message length must be under 511 bytes. If a full dump will exceed that amount, send fewer bytes and set Bit 7 of the "Number of sets" character to a "1" to notify the master that there are more records to be sent.

If= 0-	Send a single record from the specified history type. If there are additional records in the file set Bit 7 of the "#of Sets" character to a "1" to notify the Masters there are more records to be sent.

RTO-RT4	This is a 5 bit field that specify a particular time-tagged history file. This allows for up to 32 different files.

3.5.2	Example of Function 04/Comman 4x.
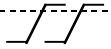	SEND SINGLE TIME-TAGGED RECORD
	In response the remote will return a single Time-tagged record.

Master to Remote Message

Address	Function Code	Command	Number of Characters	CRC
RA	04	4x	0000	

Remote to Master Response

Address	Function Code	S	PS	NC	Record		CRC
RA	04			XX			

TIME TAGGED RECORD FORMAT

Character 1								Character 2								Character 3							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
B		No of Sets								Event type								Julian Date					
x	0	0	0	0	0	0	1									0	0	0	0		Hundreds		

Character 4								Character 5								Character 6							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Julian date								Hour								Minutes							
Tens				Units				Tens				Units				Tens				Units			

Character 7								Character 8								Character 9							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Seconds								Value 1 Low								Value 1 High							
Tens				Units																			

Character 10										Character n-1								Character n								
7	6	5	4	3	2	1	0			7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Value 2 Low										Value n Low								Value n High							

WHERE:

B -   Bit 7 of # of sets is a flag indicating that there are additional records in the specified history file.
               1= Additional records in history file
               0= History file is empty

# of sets   Would always be set to indicate 1 set for this function

Event Type   Used to specify a unique triggering event. For history types triggered by time rather than events this value sill be 00.

20

3.5.3 Example of Function 04/Command 6X.
DUMP ALL TIME-TAGGED RECORDS
In response the Remote will return 11 records in the specified file. (NOTE: the maximum 511 character byte count per message must be observed.)

Master to Remote Message

Address	Function Code	Command	Number of Characters	CRC
RA	04	6x	00 00	

Remote to Master Response

Address	Function Code	S	PS	NC	RECORD	~	CRC
RA	04			XX			

Time Tagged Record Format

Character 1								**Character 2**								**Character 3**							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
B	No of Sets							Event type								Julian Date							
x	0	0	0	0	0	0	1									0	0	0	0	Hundreds			

Character 4								**Character 5**								**Character 6**							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Julian date								Hour								Minute							
Tens				Units				Tens				Units				Tens				Units			

Character 7								**Character 8**								**Character 9**							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Seconds								Value 1 Low								Value 1 High							
Tens				Units																			

Character 10								**Character n-1**								**Character n**							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Value 2 Low								Value n Low								Value n High							

WHERE:

B -   (Bit 7 of # of sets) is a flag indicating that there are additional records in the specified history file.

        1= Additional records in history file
        0= History file is empty

# of sets   Would contain a number equal to the number of records in this message

Event Type   Used to specify a unique triggering event. For history types triggered by time rather than event, this value sill be 00.

Characters 2-n repeated for each event, per number count in character 1.

4.0   SUPERVISORY CONTROL

The following paragraphs outline the functions used to provide direct digital or analog control of devices at the RTU station.

    4.1   DESCRIPTION

Function Code							
7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0

Command							
7	6	5	4	3	2	1	0
0	X	X	X	X	X	X	X

Function Code	Command Code	Function
10	00	Not Used – Reserved-
10	10	Control Select Open
10	11	Control Select Close
10	20	Operate Selected Point
10	22	Not Used – Reserved-
10	21	Reset Select
10	30	Not Used – Reserved-
10	31	Not Used – Reserved-
10	33	Not Used – Reserved-
10	34	Not Used – Reserved-
10	35	Not Used – Reserved-

    4.2 CONTROL SELECT OPEN – FUNCTION 10/COMMAND 10

Control Select Open is a select-before-operate function for a contact-open operation. The MASTER passed the sequence number of the desired output point with this function. There are 256 (00-FF HEX) sequence numbers for the output operation, corresponding to 256 hardware output points.

A typical sequence is as follows: the MASTER station will send the SELECT function with the desired sequence number to the RTU, which echos the MASTER request for verification. The MASTER will then send an OPERATE function to the RTU, which will open the selected point.

4.2.1   Master / Remote Exchange for a Control Select Open Operation

Master to Remote

Address	Function Code	Command	Number of Characters	Seq.#	CRC
RA	10	10	01 00		

Remote to Master Response (select verify)

Address	Function Code	S *	PS	NC	Seq #	CRC
RA	10			01 00		

When the RTU receives the OPEN command, it verifies that the sequence number is valid and ensures that no other select operation is active. If the sequence number is invalid or there is another select active, the RTU returns a RST (BIT 7 of FN) to the MASTER. If the select is accepted, an echo of the MASTER message is sent, and the RTU sets 5 second time-out period for the MASTER to send an OPERATE function. The RTU will cancel the select function after the time-out period, and will respond to a subsequent "OPERATE" command with a "NOP" (Bit 6 of FN)

4.3 CONTROL SELECT CLOSE – FUNCTION 10 / COMMAND 11
Control Select Close is a select-before-operate function for a contact close operation. The MASTER station passes the sequence number of the desired output point with this function. There are 256 (00-FF HEX) sequence numbers for the output operation, corresponding to 256 hardware output points.

A typical sequence is as follows: the MASTER station will send the SELECT function with the desired sequence number to the RTU. The RTU will echo the MASTER request for verification. The MASTER will then send an OPERATE function to the RTU and the RTU will close the selected point.

4.3.1   Master / Remote Exchange for a Control Select Close Operation

Master to Remote

Address	Function Code	Command	Number of Characters	Seq.#	CRC
RA	10	11	01 00		

Remote to Master Response (Select Verify)

Address	Function	S	PS	NC	Seq #	CRC

	Code	*				
RA	10			01 00		

When the RTU receives the CLOSE command, it verifies that the sequence number is valid and ensures that no other select operation is active. If the sequence number is invalid, the RTU returns an "NOP" (BIT 6 of FN) in its response. If there is already a select active, the RTU returns a RST) BIT 7 of FN) to the MASTER. If the select is accepted, an echo of the MASTER message is sent, and the RTU sets a 5 second time-out period for the MASTER to send an OPERATE function. The RTU will cancel the select function after the time-out period, and will respond to a subsequent "OPERATE" command with a "NOP" (Bit 6 of FN).

4.4 CONTROL SELECT OPEN/CLOSE OPERATE – FUNCTION 10 / COMMAND 20

After the MASTER receives an open or close verify message from the RTU, it must immediately send an OPERATE message to the RTU, which will cause the RTU to perform the selected function. The OPERATE message must be received within 5 seconds after the RTU sends the verify message, or it will time-out and abort. If the MASTER subsequently sends an operate message, the RTU will respond with a NOP (BIT 6 of FN) and take no action. If the MASTER sends any other type of message to the RTU while there is a select active, the RTU will reset the select function and will respond with a RESET (BIT 7 of FN) in its response. Its response will be a simple echo, with no other action taken.

4.4.1 Master / Remote Exchange for the Operate Function

Master to Remote Poll

Address	Function Code	Command	Number of Characters	CRC
RA	10	20	00 00	

Remote to Master Response

Address	Function Code	S	PS	NC	CRC
RA	10			00 00	

Or reset operation, the RTU

Address	Function Code	S	PS	NC	CRC
RA	50				

If the RTU has reached time-out, it will respond with a NOP status, telling the MASTER the operation was not performed because of time-out.

OR

Address	Function Code	S	PS	NC	CRC
RA	90			00 00	

If the RTU has had a select and has received a message other than OPERATE from the MASTER initiating the select, it will reset the select and return a RESET (FN, bit 07) in its response. The action requested by the out-of-sequence command will be ignored and only an echo will be returned, notifying the master that there is a select reset condition in the RTU.

4.5 RESET SELECT OPEN OR CLOSE OPERATION – FUNCTION 10/COMMAND 21

If, for any reason, the Master should want to abort the selected operation, it can issue a reset function and the RTU will immediately cancel the select. This might be done upon receipt of an invalid verify message from the RTU.

4.5.1   Master / Remote Exchange for the Reset Function

Master to Remote Message

Address	Function Code	Command	NC	CRC
RA	10	21	00 00	

Remote to Master Response

"RST" Bit 7 of FN is set

Address	Function Code	S	PS	NC	CRC
RA	90			00 00	

5.0   SPECIAL CALCULATIONS

The variables for calculations are defined by the 'PARAMETERS' buffer and are downloaded by the MASTER STATION and/or hard coded in the RTU for configuring during initialization.

5.1   SPECIAL CALCULATION RETRIEVAL – FUNCTION 03

This function is used to retrieve RTU calculated quantities in IEEE[1] Floating Point Format. Each calculated point is assigned a sequence number from 00 to 7FH, which means that there can be up to 128 special calculation values. Values are divided into 16 groups of 8, which are associated calculations using the same set of variables. Retrieval can be by individual, group or all sequence numbers. This function can be used for any requirement and is designed to be expanded.
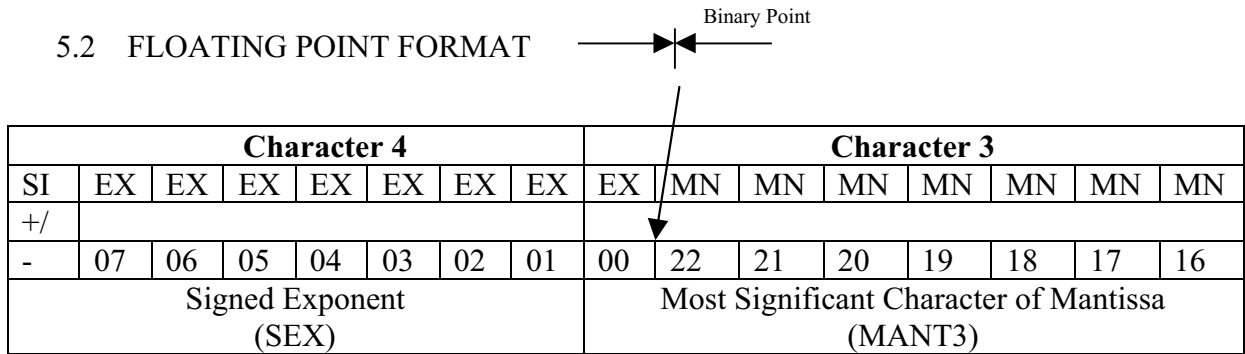
DESCRIPTION

7 SOE ENA	6 ACK	5 0	4 0	3 0	2 0	1 1	0 1	7 ALL	6 GRP	5 #	4 #	3 GN3	2 GN2	1 GN1	0 GN0
Function Code								Command							

Function Code	Command Code	Function
03	Bx	ALL=1: Send all special calculations (when bit 7 is set all other bits are ignored).
03	Ox	All=0: Send only special calculations specified by accompanying sequence numbers

_____
[1] IEEE Single Precision Floating Point Format

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5.2   FLOATING POINT FORMAT

Binary Point

Character 4								**Character 3**							
SI	EX	EX	EX	EX	EX	EX	EX	EX	MN	MN	MN	MN	MN	MN	MN
+/-	07	06	05	04	03	02	01	00	22	21	20	19	18	17	16
Signed Exponent (SEX)								Most Significant Character of Mantissa (MANT3)							

Character 2								**Character 1**							
MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN	MN
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Second Most Significant Character of Mantissa (MANT2)								Least Significant Character of Mantissa (MANT1)							

The standard IEEE single precision floating point format is used for returning calculated values when floating point is specified. 'MANT1' is sent first.

It should be noted that the LSB of the exponent is placed in MSB position in 'MANT3' BIT 23 of the MANTISSA). The MSB (BIT 23) of the MANTISSA is assumed to be A '1'. The binary point appears between this BIT and BIT 22.

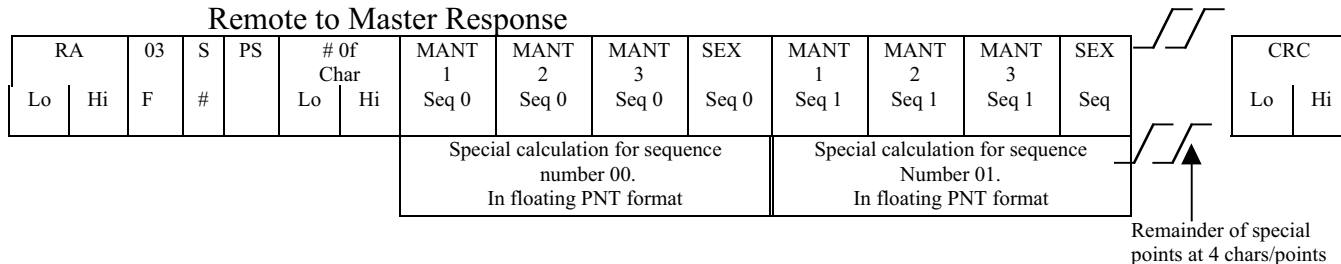## 5.3   SEND ALL SPECIAL CALCULATIONS MESSAGE IN FLOATING POINT FORMAT – FUNCTION 03/COMMAND 80

The RTU receives the MASTER 'ALL SPECIAL CALCULATIONS IN FLOATING POINT FORMAT' command and responds with only the calculations for sequence numbers that had been configured. It is very important that both the MASTER and RTU know which sequence numbers are configures in the system. The data field will always start with the lowest sequence number configured and work toward the highest, skipping over nonconfigured points.

5.3.1 MASTER / REMOTE EXCHANGE FOR ALL SPECIAL CALCULATIONS IN FLOATING POINT FORMAT

Master to Remote Message

Address	Function Code	Command	Number of Characters	CRC
RA	03	80	00 00	

Remote to Master Response

RA		03	S	PS	# 0f Char		MANT 1	MANT 2	MANT 3	SEX	MANT 1	MANT 2	MANT 3	SEX		CRC	
Lo	Hi	F	#		Lo	Hi	Seq 0	Seq 0	Seq 0	Seq 0	Seq 1	Seq 1	Seq 1	Seq		Lo	Hi

Special calculation for sequence number 00. In floating PNT format

Special calculation for sequence Number 01. In floating PNT format

Remainder of special points at 4 chars/points

5.4 SEND SPECIFIED SPECIAL CALCULATIONS MESSAGE IN FLOATING POINT FORMAT - FUNCTION 03/COMMAND 00

The sequence numbers of the desired points are included in the MASTER message.
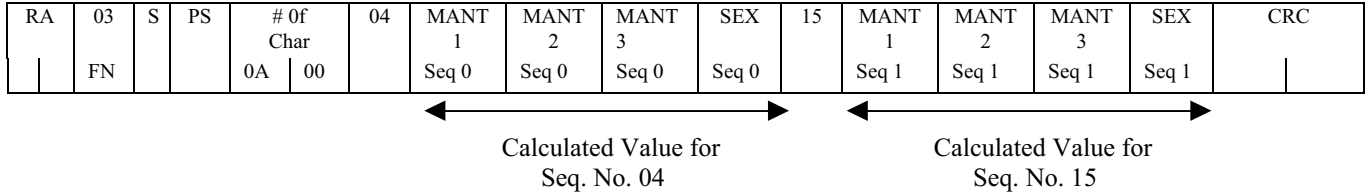
5.4.1 MASTER / REMOTE EXCHANGE FOR SPECIFIED SPEICAL CALCULATIONS IN FLOATING POINT FORMAT.

The MASTER commands the RTU to send two specified special calculations in floating point format.

The RTU receives the MASTER command 'SPECIFIED SPECIAL CALCULATIONS IN FLOATING POINT FORMAT' and responds with the appropriate message.

The request in the following example is for the calculations for SEQUENCE NUMBERS 04 and 15 to be returned.

Address	Function Code	Command	Number of Characters	1st Desired Seq No.	2nd Desired Seq. No.	CRC
RA	03	80	02 00	04	15	

RA	03	S	PS	# 0f Char	04	MANT 1	MANT 2	MANT 3	SEX	15	MANT 1	MANT 2	MANT 3	SEX	CRC
	FN			0A 00		Seq 0	Seq 0	Seq 0	Seq 0		Seq 1	Seq 1	Seq 1	Seq 1	

Calculated Value for Seq. No. 04   Calculated Value for Seq. No. 15

5.5 REMOTE RESPONSE WHEN THE MASTER REQUESTS A NONCONFIGURED SEQUENCEF NUMBER

When the MASTER requests a special calculation sequence number that is not configured, the RTU will assume that the entire message is incorrect, It will respond with the 'NOP' bit set in the function character and the offending sequence number(s) in the data field.

If other sequence numbers were requested, the MASTER must poll the RTU again to get their values.

Address	N	S	PS	No of Characters		Nonconfigured Seq. No.	CRC
RA	43			01	00	07	
				LO	HI		

Special Calculating Function Code with 'MOP' (BIT 6) Set

6.0 RTU INTERNAL CONTROL, FUNTION 20
6.1 DESCRIPTION
Configuration and control FUNTIONS and COMMANDS

7	6	5	4	3	2	1	0		7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0

	Type of Control Operation
Function Code	Command

FUNTION CODE	COMMAND CODE	FUNCTION
20	00	Initialize RTU Config., Standard Mode
20	11	Accumulator reset
20	30	Write to RTU memory
20	31	Execute write memory
20	38	Set RTU time

6.2 INITIALIZE RTU – FUNCTION 20 / COMMAND 00
When the RTU receives the INIT message, it will echo the master message and then go through all of its power-up routines.

6.2.1 MASTER / REMOTE EXCHNAGE FOR AN INTIALIZING FUNCTION, STANDARD MODE

MASTER TO REMOTE MESSAGE

Address	Function Code	Command	Number of Characters	CRC
RA	20	00	00 00	

REMOTE TO MASTER RESPONSE

Address	Function Code	S	PS	Number of Characters	CRC
RA	20			00 00	

6.3   RESET PULSE ACCUMULATOR – FUNCTION 20/COMMAND 11
The RESET PULSE ACCUMULATOR is used to clear a specified pulse accumulator in the RTU. The MASTER must pass the sequence number of the desired point along with the function (sequence numbers 40-5F HEX are valid). The RTU will echo the MASTER STATION message.

6.3.1 MASTER / RTU EXCHANGE FOR RESET PULSE ACCUMULATOR

MASTER TO REMOTE MESSAGE

Address	Function Code	Command	Number of Characters	Seq No.	CRC
RA	20	11	01 00		

REMOTE TO MASTER RESPONSE

Address	Function Code	S	PS	Number of Characters	Seq No.	CRC
RA	20			01 00		

6.4   WRITE TO RTU MEMORY – FUNCTION 20/COMMAND 30
The WRITE function supports the configuring of the RTU by the MASTER station. IF WRITE is used, the RTU must use RAM in the area that is assigned to downloadable tables. This feature allows dynamic reconfiguring of the RTU as operating requirements change. A point can be easily taken in or out of the RTU scan tables, report-by-exception deadbands can be changed, the order in which data is retrieved, and other basic functions can be controlled.

In order to ensure security, only specified areas of the RTU can be written into, while any memory location can be read. This is accomplished by using an ordinal number system that defines the function rather than the specified RTU memory address. In addition to the ordinal number, an offset from the beginning of the ordinal block can be defined, enabling the MASTER to change any parameter or group of parameters without rewriting the entire ordinal block. These blocks can be configured using the WRITE function or reviewed using the READ function.

6.4.1 FORMAT FOR WRITE TO RTU MEMORY – FUNCTION 20/COMMAND 30
The WRITE operation requires two messages. The WRITE command is used to inform the RTU that downloaded data is coming and where the RTU should place the data when it is received. The RTU does not respond to the WRITE command, and the MASTER immediately follows the WRITE command with an EXECUTE message containing the data to be stored in the locations specified. If any other message is sent the RTU resets the WRITE function.

MASTER WRITE MESSAGE

RA		Function Code	C	Number of Characters		BIAS		ORDIN	CRC	
LO	HI	20	30	03 LO	00 HI	LO	HI		LO	HI

MASTER EXECUTIVE MESSAGE

The MASTER passes two parameters to the RTU:

• BIAS and OFFSET specifies the number of locations from the start of the memory block of the specific ordinal.

• The ORDINAL NUMBER tells the RTU which block of memory is to be modified. O-F are valid ordinal numbers.

MASTER EXECUTE MESSAGE

RA		Function Code	C	Number of Characters				CRC	
LO	HI	20	31	LO	HI			LO	HI

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Data to be put
into RTU memory

When the download is complete, if there was no error in the MASTER message, the RTU replies with an echo of the CONTROL function. It there was an error, the RTU will return a NOP (FUNTIION CODE, BIT 06), telling the MASTER to retry.

REMOTE TO MASTER RESPONSE

Address RA		Function Code	S *	PS	Number of Characters		CRC	
LO	HI	20			00 LO	00 HI	LO	HI

* Communications, format, parameter and similar errors will cause the RTU to return a NOP (FUNCTION CODE, BIT 06), in the response. If any other message was received between WRITE and EXECUTE messages, the RTU will set "RST" (FUNCTION CODE, BIT 07). In either case, the RTU will not accept the EXECUTE data.
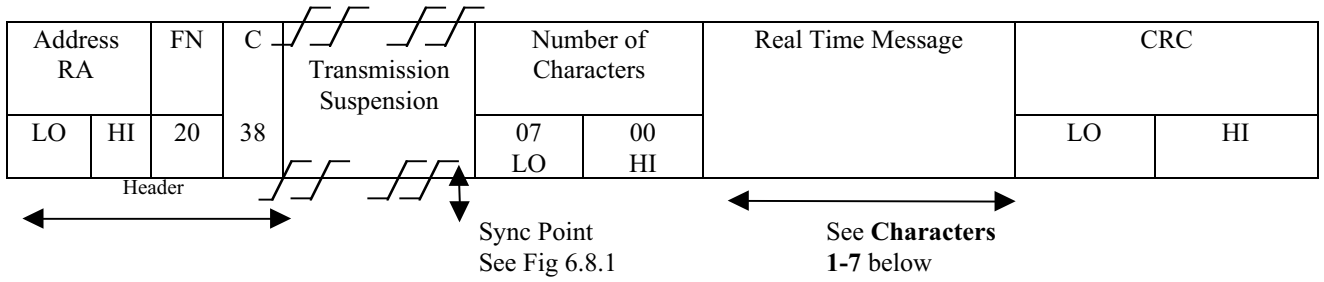
6.5 SET RTU TIME – FUNCTION 20 / COMMAND 38

This function is used by the MASTER to set the Real Time clock in the RTU.

6.5.1 SET RTU TIME

This function sends the system time (days through millisecs) to the RTU. It is accomplished by sending a SET TIME message to the RTU with the system time in the message. The time sent to the RTU is the exact time at the occurrence of the TIME SYNC point. The sync point is the 0 to 1 transition of the start bit for the LO byte of the # OF CHARS character (because the message has 7 characters, the bit 0 is guaranteed to be a 1). In order to prepare for the sync point, transmission of characters is suspended between the Command character and the LO byte of the # of CHARS for a minimum of 25 milliseconds. This Transmission Suspension is simply an idling of the line in the MARK condition. The Carrier remains turned on throughout the message.

MASTER TIME SET MESSAGE

Address RA		FN	C	Transmission Suspension		Number of Characters		Real Time Message	CRC	
LO	HI	20	38			07 LO	00 HI		LO	HI

Header

Sync Point
See Fig 6.8.1

See **Characters 1-7** below

CHARACTERS 1-7

0	0	0	0	Days 100 BCD				DAYS TENS BCD				DAYS UNIT BCD				HOURS TENS BCD				HOURS UNITS BCD			
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Character 1								**Character 2**								**Character 3**							

MINS TENS BCD				MINS ONES BCD				SEC TENS BCD				SEC UNITS BCD				0	0	0	0	MISC (MSB) BINARY			
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Character 4								**Character 5**								**Character 6**							

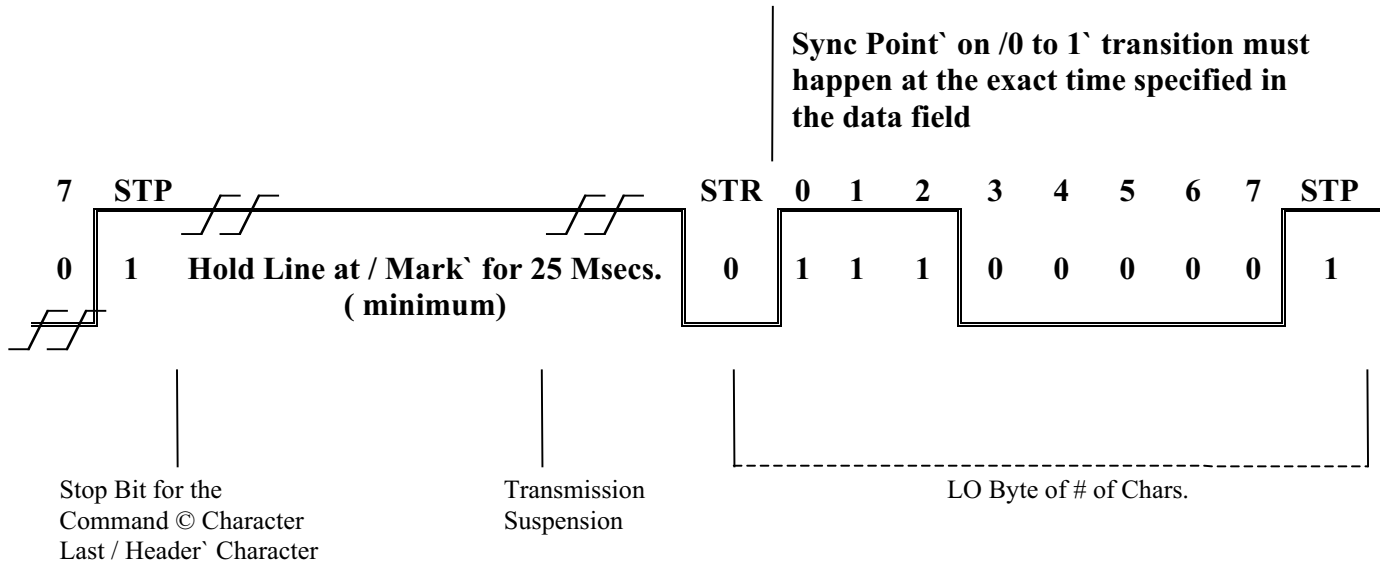| Millisecs (LSB) Binary |
|---|
| 7 6 5 4 3 \| 2 \| 1 \| 0 |
| **Character 7** |

NOTE: All characters except for Milliseconds are in BCD format. Milliseconds are a 12-Bit Binary number.

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Figure 6.8-1

Sync Point Description

The following figure is drawn as it would appear on an oscilloscope connected to the "TX DATA" line at the RS-232 level. It is used to depict the actual transmission of asynchronous characters and show the exact transition where the sync point occurs.

Bits are transmitted from Left to Right

Sync Point` on /0 to 1` transition must happen at the exact time specified in the data field

7	STP			STR	0	1	2	3	4	5	6	7	STP
0	1	**Hold Line at / Mark` for 25 Msecs. (minimum)**		0	1	1	1	0	0	0	0	0	1

Stop Bit for the
Command © Character
Last / Header` Character

Transmission
Suspension

LO Byte of # of Chars.

When the RTU receives the Header portion of the SET TIME message it must prepare to receive a new system time. The Transmission Suspension is generated so the RTU will be able to recognize this unique sequence and set up to trap the Sync Point as accurately as possible. The important aspect is whatever method is used, that it is accurate and repeatable within +/-1 millisec. The method must also allow for not changing the existing time with the time sent until the entire message has been received and verified.

6.5.2   REMOTE RESPONSE TO THE `SET TIME` COMMAND
After the RTU receives and successfully verifies the SET TIME Command it will respond with an echo of the Function with no characters in the data field. Should the RTU fail to verify the time set message, for any reason, it will set the NOP (bit 6 in it's Function byte) and echoes back to the MASTER.

The RTU will also set the NOP bit in its echo to a SET TIME if the RTU has a locally connected Time Standard and does not require Time Synchronization.

RA		Function Code	S	PS	Number of Characters		CRC	
LO	HI	20	*		00 LO	00 HI	LO	HI

7.0   RETURN RTU CONFIGURATION
FUNCTION 28

The following functions are used to read status, configuration, time, and other parameters from RTU memory.

								Type of Control Operation							
7 0	6 0	5 1	4 0	3 1	2 0	1 0	0 0	7	6	5	4	3	2	1	0
Function Code								Command							

Function Code	Command Code	Function
28	30	Read RTU Memory Contents
28	31	Read RTU Time

7.1   READ RTU MEMORY - FUNCTION 28 / COMMAND 30

The MEMORY READ operation is used by the MASTER station to get information About the RTU configuration, status and other parameters. As with the WRITE command, READ will pass an ordinal number, along with a bias offset and a number of quantities desired and the RTU will return the requested data.

7.1.1 MASTER / REMOTE EXCHANGE FOR A READ FUNCTION

MASTER READ MESSAGE

RA		Function Code	C	LO	HI	Bias		Ordin	CNT	CRC	
LO	HI	28	30	04	00	LO	HI			LO	HI

The MASTER passes three parameters to the RTU:

- BIAS or OFFSET specifies the number of locations from the start of the memory block or the specific ordinal.

- The ordinal number tells the RTU which block or memory is to be read. 0-F are valid numbers.

- The data count tells the RTU how many bytes of memory to return. A maximum count in one message is 511 characters; if more is required, multiple messages must be used.

REMOTE TO MASTER RESPONSE

RA		Function Code	S *	PS	No of Chars.		DATA from RTU Memory	CRC	
LO	HI	28			LO	HI		LO	HI

* If there is some error in the MASTER REQUEST MESSAGE, the RTU will set "NOP" (FUNCTION CODE< BIT 06) in its response. This response will be an echo for the master message.

7.2 READ RTU TIME - FINCTION 28 / COMMAND 31

This function is used by the MASTER station to retrieve the RTU REAL TIME clock data. It is generally used as part of a three step time synchronization sequence, but can be used anytime to verify RTU time (see Paragraph 6.8, SET RTU TIME – FUNCTION 20 / COMMAND 38 for full explanation).
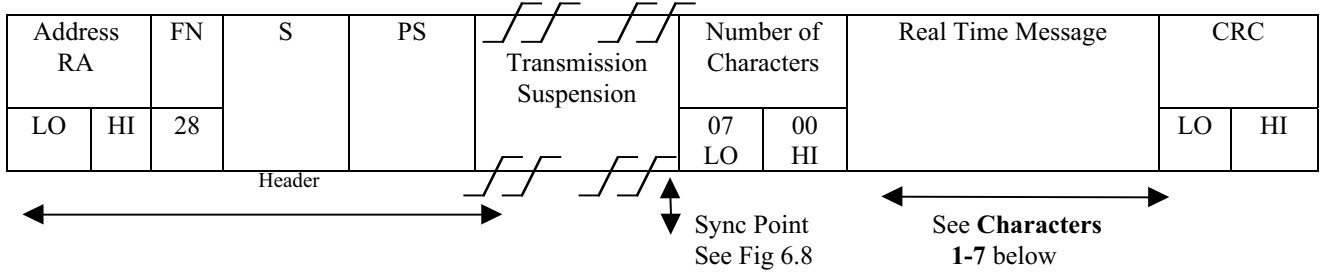
7.2.1 MASTER / REMOTE EXCHANGE FOR A READ TIME FUNCTION

MASTER TO REMOTE / READ RTU TIME` MESSAGE

Address RA		Function Code	Command	Number of Characters		CRC
LO	HI	28	31	00 LO	00 HI	

The RTU will respond by sending the contents of its REAL TIME clock.

MASTER TIME SET MESSAGE

Address RA		FN	S	PS	Transmission Suspension	Number of Characters	Real Time Message	CRC	
LO	HI	28				07 LO	00 HI		LO	HI

Header ⟵———————————————————⟶

Sync Point
See Fig 6.8

See **Characters 1-7** below ⟵———⟶

CHARACTERS 1-7

0	0	0	0	Days 100's BCD				DAYS TENS BCD				DAYS UNIT BCD				HOURS TENS BCD				HOURS UNITS BCD			
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Character 1								**Character 2**								**Character 3**							

MINS TENS BCD				MINS UNITS BCD				SEC TENS BCD				SEC UNITS BCD				0	0	0	0	MSEC (MSB) BINARY			
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Character 4								**Character 5**								**Character 6**							

Millisecs (LSB) Binary			
7	6	5	43210
Character 7			

When the MASTER receives the HEADER portion of this message, it will recognize that the RTU is going to send its time. During the Transmission Suspend period (minimum of 25 mseconds) the MASTER prepares to identify the Sync Point. The next character that will be sent by the RTU will be the LO byte for the # of Chars. Since the character count is equal to 7, there is guaranteed to be a 0 to 1 transition at the Sync Point. The exact Sync Point time will be in the DATA FIELD of the RTU's response. When the MASTER receives the Sync Point it will capture its own time and saves it along with the time received from the RTU. Since both times were captured in relation to the Sync Point, there should be no difference between the two times. except for communications delays, The assumption is made that any communications delay is equal in both directions. (It should be noted that the RTU time should be less than the MASTER time, due to communications delays) The MASTER will take the difference between the MASTER time and the RTU time, divide by 2 and use that value to send a time correction the RTU, using the SET TIME CORRECTION function. (Sec 6.9)

8.0 ORDINAL NUMBER DEFINITION

8.1 ORDINAL BLOCKS
The ORDINAL BLOCK system is used to enable the MASTER STATION to successfully configure the RTU without actually knowing the physical memory location of the desired parameters in the RTU memory.

The following table shows the various ordinal blocks, their numbers and the lengths.

Table Type	Ordinal Number	Table Length (Hex Bytes)	Allow Read/Write	Purpose
ERROR CODE FILE	00	10	R/W	Contain RTU error information
Not Used	01			Reserved
ROM	02	2000*		Retrieve Contents of RTU read-only memory
SCAN TABLES	03	100	R/W	Set up the 15 scan tables
Not Used	04			Reserved
RAM	05	800*	R	Retrieve contents of the RTU random access memory
PARAM BUFFER	06	As required	R/W	Set up parameters for special calculations done in the RTU
Not Used	07 through 0A			Reserved
PSEUDO REGISTER BUFFER	0B	256	R/W	16 Bit signed quantities that represent special values
Not Used	0C through 0FF			Reserved

* These values are minimums and may vary, depending on RTU type.

8.2 ERROR CODE FILE
This filed contains a recoverable error record for the specific type of RTU.

8.3 ROM
The ordinal allows the retrieving of the firmware in the RTU. A length of 2000 is specified, but this would be larger if the RTU has a greater amount of ROM.

8.4 SCAN TABLES
These tables are configured by the MASTER STATION to enable a more flexible scan capability. See Section 3.5 for more details.

8.5 RAM
This ordinal gives the MASTER the ability to read the contents of the RTU random access memory as required.

8.6 PARAMETERS BUFFER
This is an area through which the MASTER and RTU can pass parameters, calculations, data or any other information required for calculations for doing Special Applications. The types and structure of the parameters data is applications dependent and must be specifically defined for each application.

8.7 PSEUDO REGISTER BUFFER
These registers can contain any quantity that can be represented by a 16 bit binary number. They can be reset or preset by the MASTER Station, using the WRITE Function described in Section 6.4. Typical applications for these registers might be MIN/MAX VALUES, SLIDE-HANDS, META-METERS, COUNTERS or CALUCULATED quantities. These registers are treated as 16 bit, 2's compliment, binary numbers. For this reason any unsigned values, such as counters must be limited to a modulus of 32,768 decimal. (0-7FFF Hex). It is essential that the Master Station know the exact type and location of each value in this buffer, to insure proper interpretation of the information.

FORMAT FOR PSEUDO REGISTERS

Low Order 8 Bits								High Order 8 Bits							
P07	P06	P05	P04	P03	P02	P01	P00	+/- sign	P14	P13	P12	P11	P10	P09	P08
Character 1								Character 2							

APPENDIX A

EXAMPLE TRANSACTIONS

1. The following are actual (MASTER _ REMOTE) messages with differing addresses / commands for your use in checking your CRC algorithm. Remember that this protocol is "SMALL-ENDian" (INTEL byte order format). The generator polynomial is $X_{16} + X_{15} + X_{2} + 1$, initialized to zero.

   D2-0C-00-41-00-00-52-67 (CRC Low Byte is 52, CRC High Byte is 67)

   D2-04-00-49-00-00-32-64

   01-00-00-49-00-00-D0-07

2. The following is a sample exchange of a request to a F4C recloser control for a basic scan of its status and counter sequence numbers. The control is at address 1234 the master address is 1.

   Master _ Remote

   D2-0C-00-41-00-00-52-67

   Remote _ Master

   D2-0C-00-80-54-18-00   (Fixed header)

   8E-41-3D-C0-00-00-00-00-02-00-01-00-
   00-00-00-00-00-00-00-00-05-00-00-00   (Data bytes)

   3B-44   (CRC.)

   The response contains a seven byte fixed header followed by twenty-four data bytes followed by a two byte CRC. Also included is an indication that the control requires table initialization and that the COM port is okay.

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