E4000 RS232 Communications Protocol EA.02 xx.x

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Introduction

This document contains the specifications of the software protocol for the RS232 serial link of E4000.
This simple protocol is assumed to not require data checking which would be present for modem usage.

Protocol Summary

The protocol may be summarized as a Full Duplex, Master-Slave Protocol. The e4000 contains transmitter control hardware to support multi-drop connections on RS232.

Commands have the following format:
<ESC> The ESC control character may be sent to purge the command input buffer

<CR>Dnncxx,yy<CR> Read cell addressed by xx,yy
<CR>Dnncxx,yypppp<CR> Write the value pppp to cell addressed by xx,yy
<CR>Dnncxx,yyaaaa<CR> Write text string aaaa to string cell addressed by xx,yy

Field Descriptions

<CR>	carriage return character, hex value 0x0D
D	thefirst character must be upper or lower case “d”
nn	device id, ASCII 00-99[1]
c	command type
xx,yy	variable serial address 00,00 thru 99,99. Comma is optional.
pppp	ASCII numeric entry to be written
aaaa	ASCII text string to be written
<CR>	execution character, carriage return character, hex value 0x0D, to be sent to inform the unit to execute the command after it has been properly echoed and verified by the master device[2]

Syntax Summary

Nn	00-99
c	“V” or “v” value, or “M” or “m” message command
xx	00-99 command group
yy	00-99 specific command within group
pppp	ASCII numeric string may also contain a negative sign and decimal point
aaaa	ASCII text string, if a null string is desired send two double quotes, “”.

Command Line Editing Capabilities

E4000 does not accept the backspace character before the trailing <CR> for line editing. Command lines in progress are cancelled by sending an escape, <ESC> (0x1B), followed by a <CR> (0x0D).

Description and operation

The E4000 is programmed by writing numeric values or ASCII strings into a series of cells that have been defined for the E4000. Each cell conceptually has a value field, header field and units field. Message cells have text fields only. The fields may have attributes of “read only”, “read/write”, “write only” or not accessible. Refer to the protocol definitions for your particular product.

[1] Initial version EA.01.09.E
[2] <ESC> escape character may be sent if a command does not echo properly, this instructs the unit to purge the serial input buffer and **not execute** the command since it was not properly understood by the ES751

Parsing and Interpretation by the instrument

The command is parsed by the E4000 following reception of a trailing <CR>. Any appended <LF> characters will be ignored.

NOTE: The instrument will echo the command in lower case letters

The Master must wait for the Slave to respond with data or an error code, followed by a <CR><LF>, before sending the next command. The reset communications sequence of <ESC><CR> may be sent at any time, however.

Responses to a properly echoed command could be:
a) ASCII numeric value of cell
b) ASCII text units of a cell
c) error/verification code response

Communications Considerations for Driver Implementation

Architecture and Configuration

The communications architecture is a simple Master to Slave, polled response type whereby a single Master polls one or more Slave devices over an RS232 multidrop link.

The HHC or PC is considered the Master and the E4000 is considered the Slave.

The serial port parameters must match between the E4000 and the master i.e. baud rate, parity etc.

Timing issues must be addressed.

Timing Issues

This Protocol was designed to be simple ASCII character based. Please consider the following important points when writing a Master Device Driver for this Protocol:

1) When the Master sends a command to the slave, the trailing execution character, <CR>, should be withheld until the command has been repeated back by the E4000 and the Master device has verified that the command is correct. This will take several character times plus 20ms. When the "<CR>dnn" portion of the command is received by the E4000 it turns on its transmitter, if the transmitter is inactive. The addressed E4000 then initiates a repeat of all characters received, including the initial "<CR>dnn". The final <CR> character is sent if the command is repeated correctly. Waiting for the command repeat gives some security to the protocol. (If the returned command is not correct, the Master should issue an <ESC><CR> to clear the command buffer and then resend the command.)

2) When the trailing execution character, <CR>, of the command is sent by the Master it may take between 50ms and 400ms to receive a response. This is because the E4000 response follows parsing and execution of the command which takes a low priority in relation to the internal workings of the unit. Therefore, the Master should not send any other commands until a response terminated with a <CR><LF> is received. If the maximum response time has been exceeded then the Master should clear the line by sending an<ESC><CR> and waiting 200ms.

Error Codes
The error codes in the protocol are ASCII text messages. The responses are:

Response	
1) OK	- Command was valid and executed
2) COMMAND NOT FOUND	- The specified cell address is not defined or user tried to enter a value protected by the W&M switch
3) INVALID COMMAND	- The command code was invalid for this cell address
4) READ ONLY ITEM	- Write command failed because it is read only
5) BAD VALUE	- The value specified is out of range or not defined
6) INACTIVE ITEM	- Item chosen not valid in current setup

It is up to the Master device's application layer as to what action should be taken after encountering the above responses.

Serial Command Table

Key

R = Read Only
W = Write Only
R/W = Read and Write
R/W* = Read and Write (Variable protected by W&M switch)

Variables

Title	Init Version	Command	Type	Selections	Value
Temperature	EA.01.02.	00,04	R	n/a	n/a
Average Temperature[3]	EA.02.08	00,05	R	n/a	n/a
Gross Quantity Total	EA.01.02.	01,06	R	n/a	n/a
Net Quantity Total	EA.01.02.	01,07	R	n/a	n/a
Accumulative Quantity[4]	EA.01.02.	01,08	R	n/a	n/a

Batch Parameters

Title	Init Version	Command	Type	Selections	Value	
Batch[5]	EA.01.02.	03,00	R/W	None	0	
				Preset	1	
				Non-Preset	3	
Batch Status[6]	EA.01.02.	03,05	R	Filling	0	
				Stopped	1	
				Idle	2	
Remote START (ENTER)/ STOP (CANCEL)	EA.01.04.	03,06	W	0	CANCEL/STOP	
				1	START/ENTER[7]	
Batch Overrun Compensation	EA.01.02.	03,07	R/W	NO	0	
				YES	1	
Zero Flow Time out	EA.02.11.x	03,17	R/W	N/A	0-15[8]	
Batch Preset Type	EA.01.02.	03,27	R/W	Price	0	
				Quantity	1	
Preset Delivery?[9]	EA.01.08.	03,30	R/W	NO	0	
				YES	1	
Maximum Batch Size	EA.01.02.	03,16	R/W	n/a	Quantity	Price
					0-99999.999	0.01-999,999
Quantity To Deliver (Preset)	EA.01.02.	03,28	R/W	n/a	Quantity	Price
					0-9999.999	0.001-999,999
Pre-warn Quantity	EA.01.02	13,15	R/W	n/a	Must be less than Quantity To Deliver (03,28)	
Pre-set Relay Status	EA.01.02.	13,12	R/W	de-Energized	0	
				Energized	1	
Pre-warn Relay Status	EA.01.02.	13,18	R/W	de-Energized	0	
				Energized	1	

Date/Time

Title	Init Version	Command	Type	Selections	Value
Date	EA.01.02.	00,11	R/W	n/a	n/a
Date Format	EA.01.02.	03,25	R/W	MM/DD/YY	0
				DD/MM/YY	1
Time	EA.01.02.	00,12	R/W	n/a	n/a
Clock Type	EA.01.02.	00,22	R/W	24Hr	0
				12Hr	1
12Hr Clock AM/PM	EA.01.02.	00,23	R/W	AM	0
				PM	1

[3] Returns the average temperature during the delivery weighted by qty.
[4] Rollover is at 9,999,999
[5] Found on the Supervisor/Batch menu.
[6] Responds with INACTIVE ITEM if BATCH (03,00) is not set to PRESET (1)
[7] If START/ENTER is sent and the selected product has a K-factor of 999,999 or the Price Adjustment Option is 'ON' the register returns "BAD VALUE".
[8] A value of zero turns off the feature.
[9] Found on the Route/Delivery menu (displayed only when preset is selected from the Supervisor/Batch Screen)

Units

Title	Init Version	Command	Type	Selections		Value	
Temperature Units	EA.01.02.	02,05	R/W*	Deg. C		0	
				Deg. F		1	
Quantity Total Units	EA.01.02, EA.02.03.[10]	02,14	R/W*	gallons		1	
				liters		2	
				kilograms		3	
				pounds		4	
Quantity Resolution (Dec. Point)	EA.01.02.	02,19	R/W*	Units = gallons		Units = liters, pounds, kilograms	
				Selections	Value	Selections	Value
				0.1	1	1	0
				0.01	2	0.1	1
				0.001	3	0.01	2

Printer Port

Title	Init Version	Command	Type	Selections	Value	
Baud	EA.01.02.	14,04	R/W	300	3	
				600	6	
				1200	2	
				2400	1	
				4800	5	
				9600	0	
				19200	4	
Parity	EA.01.02.	14,05	R/W	None	0	
				Odd	1	
				Even	2	
Handshake	EA.01.02.	14,06	R/W	None	0	
				Software	1	
				Hardware	2	
Printer Select	EA.01.02. EA.01.06. EA02.07.	14.13	R/W	Epson	0	
				Blaster	1	
				InterMec PB42	2	
Printer Status[11]	EA.01.04.	14,12	R	**Status**	**Bit[12]**	**Rank[13]**
				No Printer Communication	0	1
				Slip printing not Possible	1	6
				Unused	2	
				Printer Off Line	3	3
				Unused	4	
				Unrecoverable Error	5	5
				Paper Feed Button in Use	6	4
				Out of Paper	7	2

HHC Port

Title	Init Version	Command	Type	Selections	Value
Network Device ID	EA.01.09.E/EA.02.03.E	15,.3	R/W	N/a	0-255
Baudrate	EA.01.02.	15,04	R/W	300	3
				600	6
				1200	2
				2400	1
				4800	5
				9600	0
				19200	4
Parity	EA.01.02.	15,05	R/W	None	0
				Odd	1
				Even	2

[10] Added mass units
[11] When the register receives this command it sends an Enable/Disable Automatic Status Back (GS a *n* – *n* = 26) command to the printer.
[12] The Printer Status command will return a hex number with the bits having the indicated meaning.
[13] The rank of the error message is used for the display of the error message on the unit. The unit will only show 1 error message but put the error message up by the lowest rank first.

Software Version

Title	Init. Version	Command	Type	Selections	Value
Software Version	EA.01.02.	19,01	R	n/a	n/a

Product Data

Title	Init Version	Command	Type	Selections	Value
Therm. Expansion Coef.	EA.01.02.	10,03	R/W•	n/a	n/a[14]
Reference Temperature	EA.01.02.	10,11	R/W•	n/a	n/a[1]
Base Density	EA.01.02.	10,13	R/W•	n/a	n/a[15]
Product Number To Edit (0-9)	EA.01.02.	10,17	R/W	n/a	n/a
Product Name (up to 12 char)	EA.01.02.	10,19	R/W•	n/a	n/a
Product Class	EA.01.02.	10,22	R/W•	none	0
				505LPG	1
				510LPG	2
				Fuel Oil	3
				Lube Oil	4
				Gasoline	5
				Kerosene	6
				JP4	7
				Expansion Factor	8
Gross price/unit	EA.01.02.	10,23	R/W	n/a	See foot note.[16]
discount $	EA.01.02.	10,24	R/W	n/a	See foot note.[8]
Tax 1	EA.02.XX	10,25	R/W	n/a	See foot note.[8]
Tax 2	EA.02.XX	10,26	R/W	n/a	See foot note.[8]
Tax 3	EA.02.XX	10,50	R/W	n/a	See foot note.[8]
Tax 4	EA.02.XX	10,51	R/W	n/a	0-100[1]
Tax 5	EA.02.XX	10,52	R/W	n/a	0-100[1]
Tax 6	EA.02.XX	10,53	R/W	n/a	0-100[1]
K-Factor	EA.01.02.	10,27	R/W•	n/a	pos. non-zero[17]
Misc Fee	EA.01.09.	10,60	R/W	n/a	≥ $0.00
Price Adjustment[18]	EA.01.03.	10,28	R/W	OFF	0
				ON	1
Multiple Deliveries Enable[19]	EA.01.02.	03,26	R/W	No	0
				Yes	1

Tax Names

Title	Init Version	Command	Type	Selections	Value
Tax 1 Name	EA.02.XX	10,54	R/W	n/a	n/a
Tax 2 Name	EA.02.XX	10,55	R/W	n/a	n/a
Tax 3 Name	EA.02.XX	10,56	R/W	n/a	n/a
Tax 4 Name	EA.02.XX	10,57	R/W	n/a	n/a
Tax 5 Name	EA.02.XX	10,58	R/W	n/a	n/a
Tax 6 Name	EA.02.XX	10,59	R/W	n/a	n/a

Temperature Factors

Title	Init. Version	Command	Type	Selections	Value
Offset Temperature	EA.02.11.X	08.21	R/W*	N/A	XX.xxxx
RTD Scalar	EA.02.11.X	08,27	R/W*	N/A	XX.xxxx

[14] Reported as inactive when the product class for the fluid number to edit is not 8.
[15] Reported as inactive when the product class for the fluid number to edit is not 3-7.
[16] The maximum net price must be less than or equal to $9.999/unit Quantity. Where:
Net Price ($) = Gross Price ($) – Discount ($) + Tax 1 ($) + Tax 2 ($) + Tax 3 ($) + Tax 4 ($) + Tax 5 ($) + Tax 6 ($)
where:
Gross Price ($), Discount ($), Tax 1 ($), Tax 2 ($), Tax 3 ($) are entered by the user in $/unit Quantity ($X.XXX).
Tax 4 ($), Tax 5 ($), Tax 6 are entered by the user as a percent (XX.X%)
Tax 4 ($) = (Gross Price ($) – Discount ($) + Tax 1 ($) + Tax 2 ($) + Tax 3 ($)) * Tax 4 (%)
Tax 5 ($) = (Gross Price ($) – Discount ($) + Tax 1 ($) + Tax 2 ($) + Tax 3 ($)) * Tax 5 (%)
Tax 6 ($) = (Gross Price ($) – Discount ($) + Tax 1 ($) + Tax 2 ($) + Tax 3 ($) + Tax 4 ($)) * Tax 6 (%)
[17] A product with a K-factor of 999,999 can not be selected for a delivery.
[18] Enables permanent adjustment of a product's price prior to delivery.
[19] Before revision EA.01.08.X this parameter operated globally. In revisions EA.01.08. and later it will operate on a product by product basis.

I/O Status

Title	Init Version	Command	Type	Selections	Value
Pre-set Relay Status	EA.01.02.	13,12	R/W	de-Energized	0
				Energized	1
Pre-warn Relay Status	EA.01.02.	13,18	R/W	de-Energized	0
				Energized	1
Control Input 1 Status	EA.01.02.	09,06	R	Inactive	0
				Active	1
Control Input 2 Status	EA.01.02.	09,07	R	Inactive	0
				Active	1
Control Input 3 Status	EA.01.02.	09,08	R	Inactive	0
				Active	1

Misc.

Title	Init. Version	Command	Type	Selections	Value
Meter SN	EA.01.02.	19,05	R/W*	n/a	6 char
Truck Number	EA.01.02.	19,06	R/W	n/a	7 char
Register Serial #	EA.01.02.	19,07	R/W*	n/a	6 char
Next Ticket Number	EA.01.02.	16,18	R/W	n/a	0-49999
Password	EA.01.02.	03,02	R/W	n/a	4 numbers
Pulse Input Type	EA.01.02.	05,27	R/W•	Single	0
				Dual	1
				Quad	2
Pulse Output[20]	EA.02.08	11,07	R/W	OFF	0
				ON	1
Printer Status Check[21]	EA.02.08	14,14	R/W*	NO	0
				YES	1
Delivery Authorization Required[22]	EA.02.08	03,32	R/W	NO	0
				YES	1
Delivery Authorized[23]	EA.02.08	03,31	W	NO	0
				YES	1
Print Zero Quantity Tickets	EA.01.08	16,19	R/W	NO	0
				YES	1
Temperature calibration factor	EA.01.02.	08,21	R/W•	n/a	n/a
RTD Active? [24]	EA.02.08	08,26	R/W*	NO	0
				YES	1
Device ID	EA.02.03.E	15,03	R/W	n/m	1-255
Print Average Temperature	EA.02.08	16,20	R/W	NO	0
				YES	1
Print non-Resettable Totalizer?	EA.02.08	16,21	R/W	NO	0
				YES	1

Compartments

Title	Init. Version	Command	Type	Selections	Value
# of Compartments	EA.02.11.X	03,37	R/W	N/A	1-8
Dispense from Compartment #	EA.02.11.X	03,36	R/W	N/A	1-8
Compartment 1 Volume Remaining	EA.02.11.X	01,22	R	N/A	N/A
Compartment 2 Volume Remaining	EA.02.11.X	01,23	R	N/A	N/A
Compartment 3 Volume Remaining	EA.02.11.X	01,24	R	N/A	N/A
Compartment 4 Volume Remaining	EA.02.11.X	01,25	R	N/A	N/A
Compartment 5 Volume Remaining	EA.02.11.X	01,26	R	N/A	N/A
Compartment 6 Volume Remaining	EA.02.11.X	01,27	R	N/A	N/A
Compartment 7 Volume Remaining	EA.02.11.X	01,28	R	N/A	N/A
Compartment 8 Volume Remaining	EA.02.11.X	01,29	R	N/A	N/A

[20] If YES, pulse output is enabled. Default is NO.
[21] If NO, the results of the printer status check is ignored by the e4k. Default is YES
[22] If YES, the e4k will require authorization in the form of a pulse at terminal 10 of the main PCB or via the Delivery Authorized (03,31) serial command. Default is NO>
[23] Serial command for delivery authorization via serial port.
[24] If YES, enables temperature measurement when the Product Class (10,22) is NONE. Temperature is available via 00,04 serial command. Default is NO.

Data Logger

Title	Init. Version	Command	Type	Selections	Value
Dump Data Log	EA.01.02.	18,00	W	stop dump	0
				start dump	1
Data Logger Size (max records)	EA.01.02.	18,01	R	# events possible	n/a
Data Log Current # of records	EA.01.02.	18,02	R	n/a	n/a
Dump Log from n records back[25]	EA.01.02.	18,03	W	n/a	< # of records
Log Pointer (back from current)	EA.01.02.	18,06	R	n/a	< # of records
Dump Record at Pointer	EA.01.02.	18,07	R	n/a	n/a
Clear Data Logger	EA.01.02.	18,08	R	n/a	n/a
Dump by Date	EA.02.11.X	18,11	W	N/A	Date Format[26]

Delivery Stage

Title	Init Version	Command	Type	Stage	Value (byte)
Delivery Stage	EA.01.04.	19,08	R	Register is entering the Delivery mode. The Delivery mode does not know the flow control mode at this time. If cancel is pressed unit will return to Configuration mode.	0_D (0_H)
				In flow control mode None and is waiting for 0 flow to be detected.	1_D (1_H)
				In flow control mode None and has detected flow stop. Waiting for operator to print ticket or timer to expire. If cancel is pressed this will end delivery. If Start is pressed unit will end delivery.	2_D (2_H)
				All batch mode end up here after printing a ticket. If cancel is pressed unit will return to menu mode. If Enter button is pressed Unit will print duplicate ticket.	3_D (3_H)
				Unit is in Non-preset mode. Unit is waiting here for relay timeout on delay to expire. If cancel is pressed and enough flow has come in unit will go to delivery stage 6 else return to the menu mode.	4_D (4_H)
				Unit is in Non Preset mode. Unit is waiting for batch time out delay to expire. If cancel is pressed unit will go to delivery stage 6.	5_D (5_H)
				Unit is in Non Preset Mode. If Cancel is pressed unit will end delivery. If Enter is pressed unit will return to delivery stage 5	6_D (6_H)
				Unit is in Preset delivery. And is waiting for relay turn on to expire. If cancel is pressed and enough flow has come in unit will go to delivery stag 12 else it will return to menu mode.	10_D (a_H)
				Unit is in Preset delivery. And is waiting for relay timeout to expire. If cancel is pressed Unit will issue the batch stop command and move to delivery Stage 12	11_D (b_H)
				Unit is in Preset delivery. If cancel command is issue unit will end delivery. If Enter is pressed unit will issue start batch command.	12_D (c_H)
				If cancel command is given unit will end delivery.	13_D (d_H)
				If cancel is pressed unit will end delivery.	14_D (e_H)
				Unit is monitoring flow waiting for Flow to stop. If cancel command unit will return to menu Mode. If Enter is pressed unit will engage relay and move to delivery stage 52.	50_D (32_H)
				If Cancel command is given unit will return to menu mode. If Start is issued unit will turn off display total and display rate. If Enter is pressed unit will return to Menu Mode.	51_D (33_H)
				Unit is monitoring flow and waiting for flow to stop. If Start is issued unit will turn off total and display rate.	52_D (34_H)
				In Preset mode display Batch error message.	98_D (62_H)
				In Preset mode display Batch error message.	99_D (63_H)
				If cancel command is given unit will return to menu mode. If Start is pressed unit will return to the Menu mode.	100_D (64_H)
				Out of delivery mode	200_D ($C8_H$)

[25] n is the number of records that you want to go back from the last record. If the last delivery was 100, it will be stored in record 0. So, if you wanted to reach delivery 50 you would set n to 49. If you were trying to reach delivery 75, n would be 74.
The pointer remains on the last record dumped. And the newest record (delivery) is always record 0. So, if record 3 is dumped and three more deliveries are made but not dumped the pointer will be at on record 3 not record 0.

[26] see Date/Time above

Special Messages

Title	Init Version	Command	Type	Selections	Value
Sign on message	EA.01.02.	d01m1000	R	n/a	n/a
Header 1 message	EA.01.02.	d01m1010	R/W	n/a	n/a
Header 2 message	EA.01.02.	d01m1011	R/W	n/a	n/a
Header 3 message	EA.01.02.	d01m1012	R/W	n/a	n/a
Header 4 message	EA.01.02.	d01m1013	R/W	n/a	n/a
Header 5 message	EA.01.02.	d01m1014	R/W	n/a	n/a
Trailer message 1	EA.01.02.	d01m1015	R/W	n/a	n/a
Trailer message 2	EA.01.02.	d01m1016	R/W	n/a	n/a
Trailer message 3	EA.01.02.	d01m1017	R/W	n/a	n/a
Trailer message 4	EA.01.02.	d01m1018	R/W	n/a	n/a
Pass through printing	EA.01.04.	d01m1019	W	n/a	n/a

Message Usage

When reading from the port, the operator can simply type in the address followed by the message number in the unit. The unit will reply back with the information that is presently stored in that location. To write a new message to the message location, simply start typing immediately after the message number. Any spaces added in after message number will be spaces in the message. Message 1000 is read only and will reply back, “Command Not Found” when trying to write to it.

Example of message syntax:
d01m1010ltron Neptune X

The above example will cause the following to be printed on line one on the next delivery ticket:

RSM Neptune X

Pass through printing
Message command 1019 works via HHC port only. The messages are truncated by the firmware to 40 characters. Any additional characters will be ignored. 1019 messages are not stored by the register but are passed directly to the printer for immediate printing.
Example of message syntax:

d01m1019RSM Neptune X

The above example will cause the following to be printed immediately:

RSM Neptune X

Printer Formatting

It is sometimes desirable to send formatting commands to the printer via the E4000. As explained in the protocol summary above the E4000 uses the ESC, CR, and LF characters as cancel and delimiter serial commands. The E4000 will make the following substitutions when it receives the indicated HEX value:

The E4000 receives via HHC	sends via the printer port
$F0_H$	$1B_H$ (ESC)
$F1_H$	$0D_H$ (CR)
$F2_H$	$0A_H$ (LF)

When the E4000 receives one of these HEX values at the HHC port, it will substitute the indicated character in the string that is sent out the printer port.