Modbus RTU communication protocol for ELR-4C series

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Modbus RTU protocol

Modbus is a master-slave communication protocol able to support up to 247 slaves organized as a bus or as a star network. The physical link layer is RS485.
The communication is half-duplex. The network messages can be Query-Response or Broadcast type. The Query-Response command is transmitted from the Master to an established Slave and generally it is followed by an answering message.
The Broadcast command is transmitted from the Master to all Slaves and is never followed by an answer.

Generic RTU message structure:

START OF FRAME = Starting message marker.
(silence on line for time >= 4 characters)
ADDRESS FIELD [1 CHAR] = Includes device address in which you need to communicate in Query-Response mode. In case the message is a Broadcast type it includes 00.
FUNCTION CODE [1 CHAR] = The operation code that you need to perform.
DATA FIELD [N CHAR] = Includes the data field.
ERROR CHECK [2 CHARS] = Field for the error correction code.
END OF FRAME = End message marker.
(silence on line for time >= 4 characters)

Wait time for response:
Request of 16 register (64 bytes) → typical 15ms / worst 30 ms
Request of 64 register (128 bytes) → typical 15ms / worst 50 ms
Scan rate max recommended: 250 ms

Reading multiple registers [function code 03h]

Reads the binary contents of holding registers (2X references) in the slave.
Broadcast is not supported. The Query message specified the starting register and quantity of register to be read.

QUERY:

	0° Byte	1° Byte	2-3° Byte	4-5° Byte	6-7° Byte	
Start of Frame	**Address Field**	**Function Code**	**Start Address**	**Number of Registers**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x03)* *(1 byte).*
START ADDRESS = *First register address to be read* *(2 byte).*
No. OF REGISTERS = *Number of registers (max 252 bytes) to read* *(4 bytes [1 long] for 1 measure value).*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

WARNING:
It is possible to read more than one variable at the same time only if their addresses are consecutive and the variables on the same line cannot be divided.
The register data in the response message are packet as two bytes per register, with the binary contents right justified within each byte.
For each register, the first byte contains the high order bits and the second contains the low order bits.

RESPONSE:

	0° Byte	1° Byte	2° Byte	n° Byte	n+1 - n+2° Byte	
Start of Frame	**Address Field**	**Function Code**	**Number of Bytes**	**Data**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1byte).*
FUNCTION CODE = *Operation code (0x03)* *(1 Byte).*
No. OF SEND BYTES = *Number of data bytes (0x00...??)* *(1 byte). 1 register requires 2 data bytes.*
D0, D1, ..., Dn = *data bytes (0x00...??)* *(Nr. of register x 2 = n. byte).*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

Write multiple registers [function code 10h]

Write values into a sequence of holding registers (2X references).

WARNING: It is possible to write more than one variable at the same time only if their addresses are consecutive and the variables on the same line cannot be divided. (max 64 bytes).

QUERY:

	0° Byte	1° Byte	2-3° Byte	4-5° Byte	6° Byte	n° Byte	n+1 - n+2° Byte	
Start of Frame	**Address Field**	**Function Code**	**Start Address**	**Number of Registers**	**Number of Bytes**	**Data**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x10)* *(1 byte).*
START ADDRESS = *First register address to be written* *(2 byte).*
No. OF REGISTER = *Number of registers to be written (1 to 4, ...)* *(2 byte).*
No. OF BYTES = *Number of data bytes (HEX)* *(1 byte): 1register requires 2 data bytes.*
D0,D1,..,Dn = *Data bytes (0x00...?)* *(1 byte) (Nr. of register x 2 = n. byte).*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

The normal response returns the slave address, function code, starting address and quantity of register preset.

RESPONSE:

	0° Byte	1° Byte	2-3° Byte	4-5° Byte	6-7° Byte	
Start of Frame	**Address Field**	**Function Code**	**Start Address**	**Number of Registers**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x10)* *(1 byte).*
START ADDRESS = *First register address to be written* *(2 byte).*
No. OF REGISTER = *Number of registers to be written* *(2 byte).*
ERROR CHECK = *Check sum.*
END OF FRAME = *End message marker.*

BROADCAST COMMAND:

It is possible to send a broadcast command (Address Field equal 0x00) for all write command.

QUERY:

	0° Byte	1° Byte	2-3° Byte	4-5° Byte	6° Byte	n° Byte	n+1 - n+2° Byte	
Start of Frame	**0x00**	**Function Code**	**Start Address**	**Number of Registers**	**Number of Bytes**	**Data**	**Check Sum**	**End of Frame**

RESPONSE: *No Response.*

Diagnostic [function code 08h]

This function provides a test for checking the communication system. Broadcast is not supported.
The instrument's protocol has only the sub-function 0 of the diagnostics sub-functions set of the standard modbus protocol.
The Query and the Response messages are the following:

QUERY:

	0° Byte	1° Byte	2-3° Byte	n° Byte	n+1 - n+2° Byte	
Start of Frame	**Address Field**	**Function Code**	**Sub Function**	**Data**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01...0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x08 HEX)* *(1 byte).*
SUB FUNCTION = *Sub-function 0 (0x00 0x00)* *(2 byte).*
DATA = *Max 10 data bytes.*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

RESPONSE:

The response must be the loopback of the same data.

	0° Byte	1° Byte	2-3° Byte	n° Byte	n+1 - n+2° Byte	
Start of Frame	**Address Field**	**Function Code**	**Sub Function**	**Data**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x08 HEX)* *(1 byte).*
SUB FUNCTION = *Sub-function 0 (0x00 0x00)* *(2 byte).*
DATA = *Data bytes.*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

DIAGNOSTIC EXAMPLE:

QUERY

Field Name	Example (Hex)
Slave Address	0x01
Function Code	0x08
Sub-function Hi	0x00
Sub-function Lo	0x00
Data Hi	0xF1
Data Lo	0xA7
Error Check (CRC)	0x??
	0x??

RESPONSE

Field Name	Example (Hex)
Slave Address	0x01
Function Code	0x08
Sub-function Hi	0x00
Sub-function Lo	0x00
Data Hi	0xF1
Data Lo	0xA7
Error Check (CRC)	0x??
	0x??

Report slave ID [function code 11h]

This function returns the type of the instrument and the current status of the slave run indicator. Broadcast is not supported.
The Query and the Response messages are the following:

QUERY:

	0° Byte	1° Byte	2 - 3° Byte	
Start of Frame	**Address Field**	**Function Code**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x11)* *(1 byte).*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

RESPONSE:

	0° Byte	1° Byte	2° Byte	3° Byte	4° Byte	5° - 6° Byte	
Start of Frame	**Address Field**	**Function Code**	**Byte Count**	**Slave ID**	**Run Indicator Status**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code (0x11)* *(1 byte).*
BYTE COUNT = *Number of data bytes (0x02)* *(1 byte).*
SLAVE ID = *Slave ID identifier (**0x73**)* *(1 byte).*
RUN INDICATOR STATUS = *Run indicator status (**0xFF**)* *(1 byte).*
DATA = *Data bytes*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

The normal response has the slave ID identifier (**0x73**) and the run indicator Status (**0xFF**).

REPORT SLAVE ID EXAMPLE:

QUERY

Field Name	Example (Hex)
Slave Address	0xXX
Function Code	0x11
Error Check (CRC)	0x??
	0x??

RESPONSE

Field Name	Example (Hex)
Slave Address	0x01
Function Code	0x11
Byte count	0x02
Slave ID	0x73
Run indicator status	0xFF
Error Check (CRC)	0x??
	0x??

Error message from slave to master

When a slave device receives a not valid query, it does transmit an error message.

RESPONSE:

0° Byte	1° Byte	2° Byte	3 - 4° Byte	
Start of Frame	**Address Field**	**Function Code**	**Error Code**	**Check Sum**	**End of Frame**

START OF FRAME = *Starting message marker.*
ADDRESS FIELD = *Device address (0x01... 0xF7)* *(1 byte).*
FUNCTION CODE = *Operation code with bit 7 high* *(1 byte).*
ERROR CODE = *Message containing communication failure* *(1 byte).*
CHECK SUM = *Check sum.*
END OF FRAME = *End message marker.*

ERROR EXAMPLE:

QUERY

Field Name	Example (Hex)
Slave Address	0x01
Function Code	0x03
Starting Address Hi	0x00
Starting Address Lo	0x00
Number Of Word Hi	0x00
Number Of Word Lo	0x05
Error Check (CRC)	0x??
	0x??

RESPONSE

Field Name	Example (Hex)
Slave Address	0x 01
Function Code	0x83 (1)
Error Code	0x02 (2)
Error Check (CRC)	0x??
	0x??

(1): Function Code transmitted by master with bit 7 high.
(2): Error type:
0x01 = Illegal Function
0x02 = Illegal data address
0x03 = Illegal data value
0x0F = Communication Protection Enabled
(password enabled)
Write PASSWORD parameter before retry.

Registers

The following tables shown all the device registers.

Measures – Long format

Register HEX	Register DEC	Word	Description	R/W	M.U.	Type
100	256	2	CURRENT 1	R	mA	Unsigned
102	258	2	CURRENT 2	R	mA	Unsigned
104	260	2	CURRENT 3	R	mA	Unsigned
106	262	2	CURRENT 4	R	mA	Unsigned
108	264	2	CURRENT FILTERED 1	R	mA	Unsigned
10A	266	2	CURRENT FILTERED 2	R	mA	Unsigned
10C	268	2	CURRENT FILTERED 3	R	mA	Unsigned
10E	270	2	CURRENT FILTERED 4	R	mA	Unsigned
110	272	2	MAX CURRENT 1	R	mA	Unsigned
112	274	2	MAX CURRENT 2	R	mA	Unsigned
114	276	2	MAX CURRENT 3	R	mA	Unsigned
116	278	2	MAX CURRENT 4	R	mA	Unsigned
118	280	2	MAX CURRENT FILTERED 1	R	mA	Unsigned
11A	282	2	MAX CURRENT FILTERED 2	R	mA	Unsigned
11C	284	2	MAX CURRENT FILTERED 3	R	mA	Unsigned
11E	286	2	MAX CURRENT FILTERED 4	R	mA	Unsigned
120	288	2	THD 1	R	% * 100	Unsigned
122	290	2	THD 2	R	% * 100	Unsigned
124	292	2	THD 3	R	% * 100	Unsigned
126	294	2	THD 4	R	% * 100	Unsigned
128	296	2	CREST FACTOR 1	R	[thousandths]	Unsigned
12A	298	2	CREST FACTOR 2	R	[thousandths]	Unsigned
12C	300	2	CREST FACTOR 3	R	[thousandths]	Unsigned
12E	302	2	CREST FACTOR 4	R	[thousandths]	Unsigned
130	304	2	STATUS 1	R	bit 0 set: ALARM bit 1 set: TRIP bit 2 set: OPEN bit 3 set: DISABLE bit 4 set: OVER	-
132	306	2	STATUS 2	R	See STATUS 1	-
134	308	2	STATUS 3	R	See STATUS 1	-
136	310	2	STATUS 4	R	See STATUS 1	-

Measures – Float format

Register HEX	Register DEC	Word	Description	R/W	M.U.	Type
200	512	2	CURRENT 1	R	mA	Float
202	514	2	CURRENT 2	R	mA	Float
204	516	2	CURRENT 3	R	mA	Float
206	518	2	CURRENT 4	R	mA	Float
208	520	2	CURRENT FILTERED 1	R	mA	Float
20A	522	2	CURRENT FILTERED 2	R	mA	Float
20C	524	2	CURRENT FILTERED 3	R	mA	Float
20E	526	2	CURRENT FILTERED 4	R	mA	Float
210	528	2	MAX CURRENT 1	R	mA	Unsigned
212	530	2	MAX CURRENT 2	R	mA	Unsigned
214	532	2	MAX CURRENT 3	R	mA	Unsigned
216	534	2	MAX CURRENT 4	R	mA	Unsigned
218	536	2	MAX CURRENT FILTERED 1	R	mA	Unsigned
21A	538	2	MAX CURRENT FILTERED 2	R	mA	Unsigned
21C	540	2	MAX CURRENT FILTERED 3	R	mA	Unsigned
21E	542	2	MAX CURRENT FILTERED 4	R	mA	Unsigned
2220	544	2	THD 1	R	% * 100	Float
222	546	2	THD 2	R	% * 100	Float
224	548	2	THD 3	R	% * 100	Float
226	550	2	THD 4	R	% * 100	Float
228	552	2	CREST FACTOR 1	R	-	Float
22A	554	2	CREST FACTOR 2	R	-	Float
22C	556	2	CREST FACTOR 3	R	-	Float
22E	558	2	CREST FACTOR 4	R	-	Float

Harmonics Input 1

Register HEX	Register DEC	Word	Description	R/W	Measure Unit	Type
1000	4096	2	1ST HARMONIC *(Fundamental)*	R	% * 100	Unsigned
1002	4098	2	2ND HARMONIC	R	% * 100	Unsigned
1004	4100	2	3RD HARMONIC	R	% * 100	Unsigned
1006	4102	2	4TH HARMONIC	R	% * 100	Unsigned
1008	4104	2	5TH HARMONIC	R	% * 100	Unsigned
---	---	---	---	---	---	---
107C	4220	2	63TH HARMONIC	R	% * 100	Unsigned

Harmonics Input 2

Register HEX	Register DEC	Word	Description	R/W	Measure Unit	Type
1100	4352	2	1ST HARMONIC *(Fundamental)*	R	% * 100	Unsigned
1102	4354	2	2ND HARMONIC	R	% * 100	Unsigned
1104	4356	2	3RD HARMONIC	R	% * 100	Unsigned
1106	4358	2	4TH HARMONIC	R	% * 100	Unsigned
1108	4360	2	5TH HARMONIC	R	% * 100	Unsigned
---	---	---	---	---	---	---
117C	4476	2	63TH HARMONIC	R	% * 100	Unsigned

Harmonics Input 3

Register HEX	Register DEC	Word	Description	R/W	Measure Unit	Type
1200	4608	2	1ST HARMONIC *(Fundamental)*	R	% * 100	Unsigned
1202	4610	2	2ND HARMONIC	R	% * 100	Unsigned
1204	4612	2	3RD HARMONIC	R	% * 100	Unsigned
1206	4614	2	4TH HARMONIC	R	% * 100	Unsigned
1208	4616	2	5TH HARMONIC	R	% * 100	Unsigned
---	---	---	---	---	---	---
127C	4732	2	63TH HARMONIC	R	% * 100	Unsigned

Harmonics Input 4

Register HEX	Register DEC	Word	Description	R/W	Measure Unit	Type
1300	4864	2	1ST HARMONIC *(Fundamental)*	R	% * 100	Unsigned
1302	4866	2	2ND HARMONIC	R	% * 100	Unsigned
1304	4868	2	3RD HARMONIC	R	% * 100	Unsigned
1306	4870	2	4TH HARMONIC	R	% * 100	Unsigned
1308	4872	2	5TH HARMONIC	R	% * 100	Unsigned
---	---	---	---	---	---	---
137C	4988	2	63TH HARMONIC	R	% * 100	Unsigned

Trip Setup Input 1

Warning: Must be send the entire parameter length (2 words or 1 word – see the long of each parameter) for a correct command setting.

Register HEX	Register DEC	Word	Description	R/W	Parameters	Default
2100	8448	2	FILTER	R/W	0: disable 1: 3° harmonic 2: 21° harmonic 3: 60479 4: 62423	**
2102	8450	2	RESET MODE	R/W	0: manual 1: automatic 2: reclosing	0
2104	8452	2	THREASHOLD [mA]	R/W	20 ÷ 30'000	**
2106	8454	2	DELAY [ms]	R/W	20 ÷ 10'000 *Note: the value must be a multiple of 20 ms at 50Hz*	**
2108	8456	2	HYSTERESIS	R/W	95 ÷ 50% over the limit set	90
210A	8458	2	FAIL SAFE TRIP	R/W	0: disable 1: enable	0
210C	8460	2	SELF RECLOSING NUMBER	R/W	1 ÷ 10	3
210E	8462	2	SELF RECLOSING DELAY	R/W	5 ÷ 600	10
2110	8464	2	SELF RECLOSING RESET TRY	R/W	10 ÷ 600	60
2112	8466	2	REMOTE TEST	R/W	0: no action 1: test	0
2114	8468	2	INPUT ENABLE	R/W	0: OFF 1: ON 2: INHIBIT RELAY	1

**: according with version/model.

Trip Setup Input 2: 2200^{HEX} to 2215^{HEX} / 8704^{DEC} to 8725^{DEC}
Trip Setup Input 3: 2300^{HEX} to 2315^{HEX} / 8960^{DEC} to 8981^{DEC}
Trip Setup Input 4: 2400^{HEX} to 2415^{HEX} / 9216^{DEC} to 9237^{DEC}

Alarm Setup Input 1

Warning: Must be send the entire parameter length (2 words or 1 word – see the long of each parameter) for a correct command setting.

Register HEX	Register DEC	Word	Description	R/W	Parameters	Default
2180	8576	2	RESET MODE	R/W	0: off 1: manual 2: automatic	2
2182	8578	2	THREASHOLD [mA]	R/W	20 ÷ 30'000	20
2184	8580	2	DELAY [ms]	R/W	20 ÷ 10'000 *Note: the value must be a multiple of 20 ms at 50Hz*	20
2186	8582	2	HYSTERESIS	R/W	95 ÷ 50% over the limit set	90
2188	8584	2	FAIL SAFE	R/W	0: disable 1: enable	0

Alarm Setup Input 2: 2280^{HEX} to 2289^{HEX} / 8832^{DEC} to 8841^{DEC}
Alarm Setup Input 3: 2380^{HEX} to 2389^{HEX} / 9088^{DEC} to 9037^{DEC}
Alarm Setup Input 4: 2480^{HEX} to 2489^{HEX} / 9344^{DEC} to 9353^{DEC}

Remote reset [trip/warning state]

Warning: Must be send the entire parameter length (2 words or 1 word – see the long of each parameter) for a correct command setting.

Register HEX	Register DEC	Word	Description	R/W	Parameters
2A00	10752	2	MANUAL RESET INPUT 1	W	Write $0x0A0A^{hex}$ (2570^{dec}) to reset
2A02	10754	2	MANUAL RESET INPUT 2	W	Write $0x0A0A^{hex}$ (2570^{dec}) to reset
2A04	10756	2	MANUAL RESET INPUT 3	W	Write $0x0A0A^{hex}$ (2570^{dec}) to reset
2A06	10758	2	MANUAL RESET INPUT 4	W	Write $0x0A0A^{hex}$ (2570^{dec}) to reset

Remote test

Warning: Must be send the entire parameter length (2 words or 1 word – see the long of each parameter) for a correct command setting.

Register HEX	Register DEC	Word	Description	R/W	Parameters
2A20	10784	2	MANUAL TEST INPUT 1	W	Write $0x5050^{hex}$ (20560^{dec}) to test
2A22	10786	2	MANUAL TEST INPUT 2	W	Write $0x5050^{hex}$ (20560^{dec}) to test
2A24	10788	2	MANUAL TEST INPUT 3	W	Write $0x5050^{hex}$ (20560^{dec}) to test
2A26	10790	2	MANUAL TEST INPUT 4	W	Write $0x5050^{hex}$ (20560^{dec}) to test

Log Input 1

Register HEX	Register DEC	Word	Description	R/W	M.U.
6800	26624	1	TYPE – LOG 1	R	1: TRIP 2: ALARM 3: TEST 4: OPEN 5: POWER ON
6801	26625	1	VALUE – LOG 1	R	Value [mA] (only for trip/alarm)
6802	26626	2	TIME – LOG 1	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
6804	26628	2	DATE – LOG 1	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
6806	26630	2	NOT USED – LOG 1	R	Not used
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----	----	----	----	-	----
6838	26680	1	TYPE – LOG 8	R	1: TRIP 2: ALARM 3: TEST 4: OPEN
6839	26681	1	VALUE – LOG 1	R	Value [mA] (only for trip/alarm)
684A	26682	2	TIME – LOG 8	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
684C	26684	2	DATE – LOG 8	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
684E	26686	2	NOT USED – LOG 8	R	Not used

Log Input 2

Register HEX	Register DEC	Word	Description	R/W	M.U.
6A00	27136	1	TYPE – LOG 1	R	1: TRIP 2: ALARM 3: TEST 4: OPEN 5: POWER ON
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6A4E	27214	2	NOT USED – LOG 8	R	Not used

Log Input 3

Register HEX	Register DEC	Word	Description	R/W	M.U.
6C00	27648	1	TYPE – LOG 1	R	1: TRIP 2: ALARM 3: TEST 4: OPEN 5: POWER ON
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----	----	----	----	-	----
6C4E	27726	2	NOT USED – LOG 8	R	Not used

Log Input 4

Register HEX	Register DEC	Word	Description	R/W	M.U.
6E00	28160	1	TYPE – LOG 1	R	1: TRIP 2: ALARM 3: TEST 4: OPEN 5: POWER ON
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6E4E	28238	2	NOT USED – LOG 8	R	Not used

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