



ELR-3BN

Modbus RTU communication protocol

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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 (**max 252 bytes**) 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): 1 register 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:

Start of Frame		0° Byte	1° Byte	2 - 3° Byte	End of Frame
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:

Start of Frame		0° Byte	1° Byte	2° Byte	3° Byte	4° Byte	5° - 6° Byte	End of Frame
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 (0x94)			(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 (0x94) 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	0x94
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:

Start of Frame		0° Byte	1° Byte	2° Byte	3 - 4° Byte	End of Frame
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 (4 bytes)

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.	Type
100	256	2	CURRENT TOTAL	R	mA	Unsigned
102	258	2	CURRENT DC	R	mA	Unsigned
104	260	2	CURRENT AC	R	mA	Unsigned
106	262	2	CURRENT AC-FILTER	R	mA	Unsigned
108	264	2	MAX CURRENT TOTAL	R	mA	Unsigned
10A	266	2	MAX CURRENT DC	R	mA	Unsigned
10C	268	2	MAX CURRENT AC	R	mA	Unsigned
10E	270	2	MAX CURRENT AC-FILTER	R	mA	Unsigned
110	272	2	THD	R	% * 100	Unsigned
112	274	2	TDD	R	% * 100	Unsigned
114	276	2	CREST FACTOR	R	[thousandths]	Unsigned
116	278	2	CURRENT DC-SIGN	R	mA	Signed
118	280	2	STATUS	R	bit 0 set: ALARM bit 1 set: TRIP bit 2 set: OPEN bit 3 set: DISABLE bit 4 set: AC OVER bit 5 set: MEMORY bit 6 set: DC OVER bit 7 set: ERR TOROID	-

Measures – Float format (4 bytes)

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.	Type
200	512	2	CURRENT TOTAL	R	mA	Float
202	514	2	CURRENT DC	R	mA	Float
204	516	2	CURRENT AC	R	mA	Float
206	518	2	CURRENT AC-FILTER	R	mA	Float
208	520	2	MAX CURRENT TOTAL	R	mA	Float
20A	522	2	MAX CURRENT DC	R	mA	Float
20C	524	2	MAX CURRENT AC	R	mA	Float
20E	526	2	MAX CURRENT AC-FILTER	R	mA	Float
210	528	2	THD	R	% * 100	Float
212	530	2	TDD	R	% * 100	Float
214	532	2	CREST FACTOR	R	[thousandths]	Float

Harmonics Input

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	Measure Unit	Type
1000	4096	2	1 ST HARMONIC (<i>Fundamental</i>)	R	% * 100	Unsigned
1002	4098	2	2 ND HARMONIC	R	% * 100	Unsigned
1004	4100	2	3 RD HARMONIC	R	% * 100	Unsigned
---	---	---	---	---	---	---
107C	4220	2	63 TH HARMONIC	R	% * 100	Unsigned

AC-Waveform ***

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	Range	Type
6000	24576	2	1 ST SAMPLE	R	0 ÷ 4095	Short
6001	24577	2	2 ND SAMPLE	R	0 ÷ 4095	Short
6002	24578	2	3 RD SAMPLE	R	0 ÷ 4095	Short
---	---	---	---	---	---	---
60FE	24830	2	256 TH SAMPLE	R	0 ÷ 4095	Short

***: to allow a correct and synchronous reading, the acquisition of a new waveform is performed after each reading of register 256 dec or 512 dec

DC-Waveform ***

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	Range	Type
6200	25088	2	1 ST SAMPLE	R	0 ÷ 4095	Short
6201	25090	2	2 ND SAMPLE	R	0 ÷ 4095	Short
6202	25092	2	3 RD SAMPLE	R	0 ÷ 4095	Short
---	---	---	---	---	---	---
62FE	25342	2	256 TH SAMPLE	R	0 ÷ 4095	Short

***: to allow a correct and synchronous reading, the acquisition of a new waveform is performed after each reading of register 256 dec or 512 dec

AC-Waveform Last Trip

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	Range	Type
7000	28672	2	1 ST SAMPLE	R	0 ÷ 4095	Short
7001	28673	2	2 ND SAMPLE	R	0 ÷ 4095	Short
7002	28674	2	3 RD SAMPLE	R	0 ÷ 4095	Short
---	---	---	---	---	---	---
70FE	28926	2	256 TH SAMPLE	R	0 ÷ 4095	Short

DC-Waveform Last Trip

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	Range	Type
7200	29184	2	1 ST SAMPLE	R	0 ÷ 4095	Short
7201	29186	2	2 ND SAMPLE	R	0 ÷ 4095	Short
7202	29188	2	3 RD SAMPLE	R	0 ÷ 4095	Short
---	---	---	---	---	---	---
72FE	29438	2	256 TH SAMPLE	R	0 ÷ 4095	Short

Event 1st [last]

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.
6800	26624	2	TYPE	R	1: TRIP 2: ALARM 3: TEST 4: AC OPEN 5: DC OPEN 5: POWER ON
6802	26626	2	TIME	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
6804	26628	2	DATE	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
6806	26630	2	CURRENT TOTAL	R	mA
6808	26632	2	CURRENT DC	R	mA
680A	26634	2	CURRENT AC	R	mA

Event 2nd

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.
6820	26656	2	TYPE	R	1: TRIP 2: ALARM 3: TEST 4: AC OPEN 5: DC OPEN 5: POWER ON
6822	26658	2	TIME	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
6824	26660	2	DATE	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
6826	26662	2	CURRENT TOTAL	R	mA
6828	26664	2	CURRENT DC	R	mA
682A	26666	2	CURRENT AC	R	mA

Event 3rd

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.
6840	26688	2	TYPE	R	1: TRIP 2: ALARM 3: TEST 4: AC OPEN 5: DC OPEN 5: POWER ON
6842	26690	2	TIME	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
6844	26692	2	DATE	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
6846	26694	2	CURRENT TOTAL	R	mA
6848	26696	2	CURRENT DC	R	mA
684A	26698	2	CURRENT AC	R	mA

Event 4th

Register ^{HEX}	Register ^{DEC}	Word	Description	R/W	M.U.
6860	26720	2	TYPE	R	1: TRIP 2: ALARM 3: TEST 4: AC OPEN 5: DC OPEN 5: POWER ON
6862	26722	2	TIME	R	byte order/meaning: EMPTY, HOUR, MINUTE, SECOND
6864	26724	2	DATE	R	byte order/meaning: DAY, MONYH, YEAR, YEAR
6866	26726	2	CURRENT TOTAL	R	mA
6868	26728	2	CURRENT DC	R	mA
686A	26730	2	CURRENT AC	R	mA

Trip Setup

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	RESET MODE	R/W	0: manual 1: automatic 2: reclosing	0
2102	8450	2	THRESHOLD [mA]	R/W	20 ÷ 30'000	**
2104	8452	2	DELAY [ms]	R/W	20 ÷ 10'000 <i>Note: the value must be a multiple of 20 ms at 50Hz</i>	**
2106	8454	2	HYSTERESIS	R/W	95 ÷ 50% over the limit set	90
2108	8456	2	FAIL SAFE	R/W	0: disable 1: enable	0
210A	8458	2	AC-FILTER	R/W	0: disable 1: 3° harmonic [RCM] 2: 21° harmonic [RCM] 3: 60479 [RCM] 4: 62423 [RCM]	**
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

** : according with version/model.

Alarm Setup

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	THRESHOLD [mA]	R/W	20 ÷ 30'000	20
2184	8580	2	DELAY [ms]	R/W	20 ÷ 10'000 <i>Note: the value must be a multiple of 20 ms at 50Hz</i>	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

Remote reset [trip/warning]

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	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	W	Write 0x5050 ^{hex} (20560 ^{dec}) to test

RTC - real time clock

Reg. HEX	Reg. DEC	Word	Description	R/W	Parameters
2A80	10880	2	HOUR	R/W	0 ÷ 23
2A82	10882	2	MINUTE	R/W	0 ÷ 59
2A84	10884	2	SECOND	R/W	0 ÷ 59
2A86	10886	2	DAY	R/W	1 ÷ 31
2A88	10888	2	MONTH	R/W	1 ÷ 12
2A8A	10890	2	YEAR	R/W	2023 ÷ 2099

Password Setup

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	PASSWORD	R/W	0: disabled	0
2182	8578	2	MAINTENANCE	R/W	2313 dec: disable relays ***	0

***: Write 0 to enable; at startup the value is always set to 0 (disable)

