Modbus RTU communication protocol for RI-SM and RI-R44 series

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 can be RS232 for a point to point connection or RS485 for a network.
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 Message Structure:

Start of frame	Address field	Function code	Data field	Error check	End of frame

START OF FRAME = Starting message marker
ADDRESS FIELD = Includes device address in which you need to communicate in Query-Response mode.
In case the message is a Broadcast type it includes 0x00.
FUNCTION CODE = Includes the operation code that you need to perform.
DATA FIELD = Includes the data field.
ERROR CHECK = Field for the error correction code.
END OF FRAME = End message marker.

Mode RTU communication frame structure:
START OF FRAME = silence on line for time >=4 characters
ADDRES FIELD = 1 character
FUNCTION CODE = 1 character
DATA FIELD = N characters
ERROR CHECK = 16 bit CRC
END OF FRAME = silence on line for time >=4 characters

Wait time for response:

Request length	8 Register (16 bytes)
Typical	15 mSec
Worst case	30 mSec
Scan rate max recommended ≥ 200 mSec	

Reading of the 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.

	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 = RI-SM, RI-R 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 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 128 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.

	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 = RI-SM, RI-R device address (0x01... 0xF7) (1 byte).
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.

See the TABLE OF RI-SM REGISTERS and the EXAMPLE.

Setup of the RI-SM parameters [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 of 4 consecutive register on the same message).

	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 = RI-SM, RI-R 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.

	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 = RI-SM, RI-R 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.

See the TABLE OF RI-SM REGISTERS and the EXAMPLE.

BROADCAST COMMAND:

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

	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.*

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:

	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 = RI-SM, RI-R device address (0x01... 0xF7) (1 byte).
FUNCTION CODE = Operation code (0x11) (1 byte).
CHECK SUM = Check sum.
END OF FRAME = End message marker.

	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 = RI-SM, RI-R 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 (**RI-SM-485 0x60, RI-R44-485 0x64**) (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 (***RI-SM-485 0x60, RI-R44-485 0x64***) 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	0x6X
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.

	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 = RI-SM, RI-R 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

RI-SM and RI-R44 registers

The following tables shown all the RI-SM and RI-R44 registers.

Measures RI-SM and RI-R44

Register HEX	Register DEC	Word	Description	R/W	Measure Unit RI-SM	Measure Unit RI-R44	Note
1200	4608	2	RESISTANCE	R	kΩ	Ω x100	Actual value of insulation if insulation exceeds max value (RI-SM: 30000kΩ - RI-R44: 1000kΩ), the instrument returns 0xFFFFFFFF
1202	4610	2	MINIMUM RESISTANCE	R	kΩ	Ω x100	Minimum value of insulation read
1204	4612	2	TRIP SET	R	kΩ	Ω x100	Value of trip set
1206	4614	2	ALARM SET	R	kΩ	Ω x100	Value of alarm set
1208	4616	2	STATE	R	----	----	Bit 0 set to 1: trip Bit 1 set to 1: alarm Bit 2 set to 1: link fail

Measures RI-R44H-V & RI-R44-V

Register HEX	Register DEC	Word	Description	R/W	Measure Unit	Note
1250	4688	2	RESISTANCE	R	kΩ	Actual value of insulation if insulation exceeds max value (RI-R44H: 2400kΩ), the instrument returns 0xFFFFFFFF
1252	4690	2	MINIMUM RESISTANCE	R	kΩ	Minimum value of insulation read
1254	4692	2	TRIP SET	R	kΩ	Value of trip set
1256	4694	2	ALARM SET	R	kΩ	Value of alarm set
1258	4696	2	STATE	R	----	Bit 0 set to 1: trip Bit 1 set to 1: alarm Bit 2 set to 1: link fail

Remote Test/Reset

Register HEX	Register DEC	Word	Description	R/W	Parameters
1300	4864	2	TEST	R/W	Write: - 0x5555 (21845 dec) to test trip led only. - 0xAAAA (43690 dec) to test trip relay and led. In auto recovery mode the test duration is 5 seconds, instead in the manual mode is necessary manual reset.
1302	4866	2	RESET	R/W	Write: - 0x5A5A (23130 dec) to reset trip/alarm (if resistance is over threshold trip/alarm) - 0xE0E0 (57568 dec) to reset minimum RESISTANCE INSULATION saved

Setup RI-SM & RI-R44

Register HEX	Register DEC	Word	Description	R/W	Parameters
1350	4944	2	PERCENT TRIP RECOVERY	R/W	1 ÷ 100: for example if set 10 is equal to +10% of trip threshold *Default: 10 (10%)*
1352	4946	2	PERCENT ALARM THRESHOLD	R/W	0 ÷ 100: for example if set 20 is equal to +20% of trip threshold *RI-SM-485 default: 20 (20%)* *RI-R44-485 default: 100 (100%)*
1354	4948	2	SIGNALS ALARM/TRIP	R/W	0: Alarm/Trip enabled *[Default]* 1: Alarm/Trip disabled
1356	4950	2	OVER LIMIT	R/W	0: Over limit control disabled. *[Default]* 1: over limit control enabled.
1358	4952	2	OVER LIMIT THRESHOLD	R/W	RI-SM-485: 0 ÷ 30000 *[Default 30000]* RI-R44-485: 0 ÷ 10000 *[Default 10000]* if RESISTENCE value is equal or greater than value set and OVER LIMIT is enabled the ALARM led blinking and the flag in the status is set.

Setup RI-R44-V & RI-R44H-V

Register HEX	Register DEC	Word	Description	R/W	Parameters
1350	4944	2	TRIP TRESHOLD	R/W	1 ÷ 999 kΩ *[Default: 100kΩ]*
1352	4946	2	TRIP RECOVERY THRESHOLD	R/W	1 ÷ 999 kΩ - *[Default: 110kΩ]*
1354	4948	2	ALARM TRESHOLD	R/W	1 ÷ 999 kΩ - *[Default: 200kΩ]*
1356	4950	2	ALARM RECOVERY THRESHOLD	R/W	1 ÷ 999 kΩ - *[Default: 220kΩ]*
1358	4952	2	DEBOUNCE	R/W	0 ÷ 10000 seconds - *[Default: 0]*
135A	4954	2	RECOVERY	R/W	0: manual *[Default]* 1: automatic
135C	4956	2	FAIL SAVE RELAY	R/W	0: disable *[Default]* 1: enable
135E	4958	2	LINK FAIL DISPLAYED	R/W	0: disable *[Default]* 1: enable

COM setup

Register HEX	Register DEC	Word	Description	R/W	Parameters
1400	5120	2	NODE ID*	R/W	0001h ÷ 00F7h (001 ÷ 247 dec) *[Default: 1]* **Note**: valid only in Slave Mode.
1402	5122	2	BAUD RATE*	R/W	0000h: 4800 Baud 0001h: 9600 Baud 0002h: 19200 Baud 0003h: 38400 Baud *[Default]* 0004h: 57600 Baud 0005h: 115200 Baud
1404	5124	2	STOP BITS*	R/W	0000h: 1 Stop Bit *[Default]* 0001h: 2 Stop Bits
1406	5126	2	PARITY*	R/W	0000h: None *[Default]* 0001h: Parity Odd 0002h: Parity Even
1408	5128	2	MINIMUM RESPONSE DELAY*	R/W	5 ÷ 100 ms *[Default: 10]* **Note**: valid only in Slave Mode.

* The Serial setting will be changed after the command response.

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