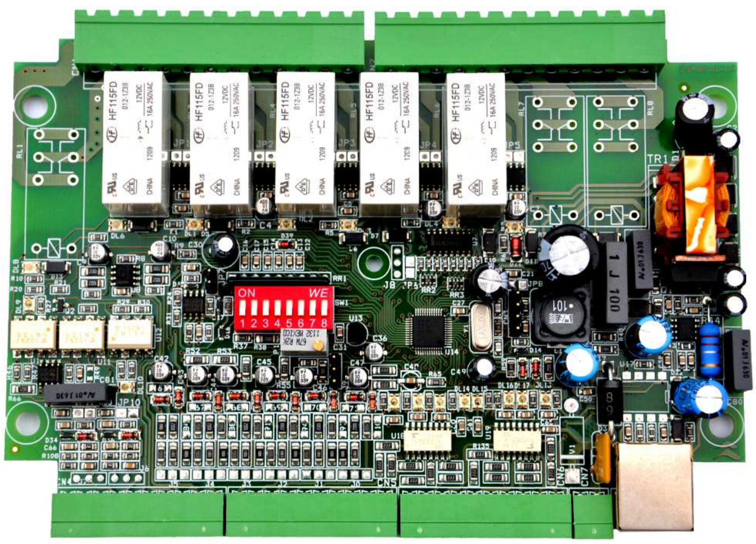
I/O BOARD

RB01C1



USER MANUAL

RB01C1 is a general purpose I/O board for applications in several fields like naval field, industrial field, building automation, factory automation.
An important feature that differentiates RB01C1 from other similar products is the measurements of the current in the common contact of the relays allowing control of the loads cennected to the output.
RB01C1 has two galvanically insulated communication lines, a standard RS485 and a CAN BUS.

1. Features

- **8 digital inputs with optical insulation**
- **5 analogue inputs**
- **2 inputs for frequency measurement**
- **5 output relays with Common, NO and NC contacts (SPDT)**
- **Measurement of the current in the Common contact of the relays**
- **2 low power analogue outputs**
- **Galvanically insulated RS485 serial communication line**
- **Galvanically insulated CAN BUS serial communication line**
- **Power supply: 12/24 VDC (from 10 to 35V) and from 8 a 24 VAC 50/60 Hz**
- **DIN rail version (DIN EN 50022) or grey ABS box**

RB01C1 inputs and outputs are managed by the serial communication lines using the MODBUS RTU protocol over RS485 and by a proprietary open protocol (similar to MODBUS RTU) over CAN BUS.

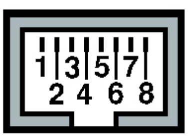
It is possible to use only one of the two serial lines or both. The serial lines are galvanically insulated by power supply and galvanically insulated one by the other.

the following actions can be performed:

- **read the logical level of the digital inputs (ON/OFF)**
- **read the value of the analogue inputs**
- **read the supply voltage (Vmax if power supply is AC)**
- **read the frequency / period in the dedicated inputs**
- **read the value of the current that flows through the relays contacts**
- **read the state of the relay outputs (ON/OFF)**
- **activate / deactivate the relays (ON/OFF)**
- **set the voltage on the low power analogue outputs**

For more informations on the serial lines see chap. 6,7,8, MODBUS RTU protocol (chap. 12) and the CAN BUS proprietary protocol (chap. 21).

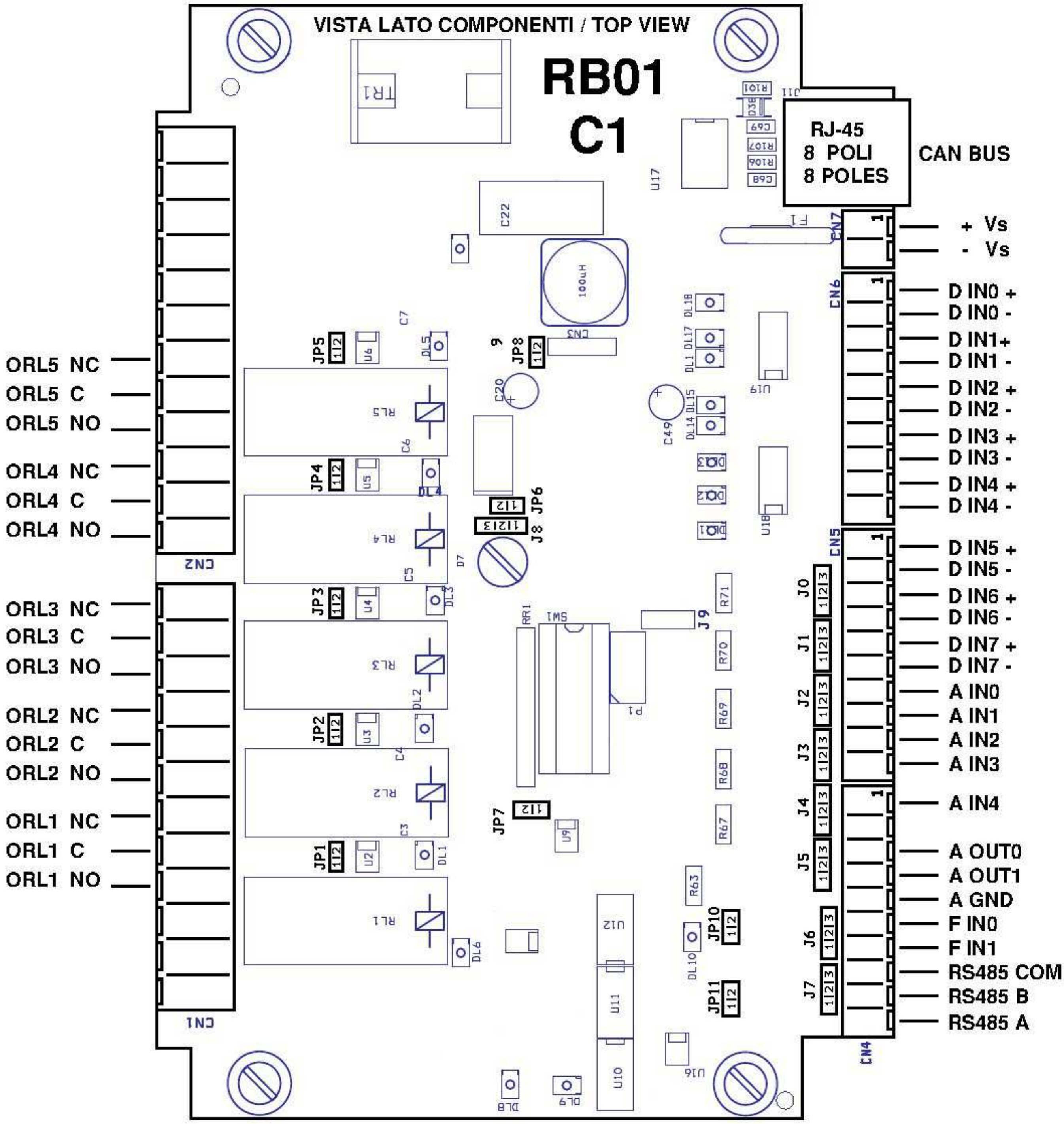
2. Connectors, Connections and jumper setting



RJ45 8 POLES
FRONT VIEW

1 Can L
2 Can L
3 GND
4 + Vsc
5 + Vsc
6 GND
7 Can H
8 Can H

CONNECTORS AND CONNECTIONS



LEGEND:

ORL5 NC relay 5 normally closed contact
ORL5 C relay 5 common contact
ORL5 NC relay 5 normally open contact

ORL4 NC relay 4 normally closed contact
ORL4 C relay 4 common contact
ORL4 NC relay 4 normally open contact

ORL3 NC relay 3 normally closed contact
ORL3 C relay 3 common contact
ORL3 NC relay 3 normally open contact

ORL2 NC relay 2 normally closed contact
ORL2 C relay 2 common contact
ORL2 NC relay 2 normally open contact

ORL1 NC relay 1 normally closed contact
ORL1 C relay 1 common contact
ORL1 NC relay 1 normally open contact

CAN BUS – 8 poles RJ45 connector for CAN BUS communication line

+Vs power supply connection (positive pole for DC supply)

-Vs power supply connection (common/negative pole DC supply)

D IN0+ digital input 0 positive pole contact
D IN0- digital input 0 negative pole contact

D IN1+ digital input 1 positive pole contact
D IN1- digital input 1 negative pole contact

D IN2+ digital input 2 positive pole contact
D IN2- digital input 2 negative pole contact

D IN3+ digital input 3 positive pole contact
D IN3- digital input 3 negative pole contact

D IN4+ digital input 4 positive pole contact
D IN4- digital input 4 negative pole contact

D IN5+ digital input 5 positive pole contact
D IN5- digital input 5 negative pole contact

D IN6+ digital input 6 positive pole contact
D IN6- digital input 6 negative pole contact

D IN7+ digital input 7 positive pole contact
D IN7- digital input 7 negative pole contact

A IN0 analog input 0
A IN1 analog input 1
A IN2 analog input 2
A IN3 analog input 3
A IN4 analog input 4

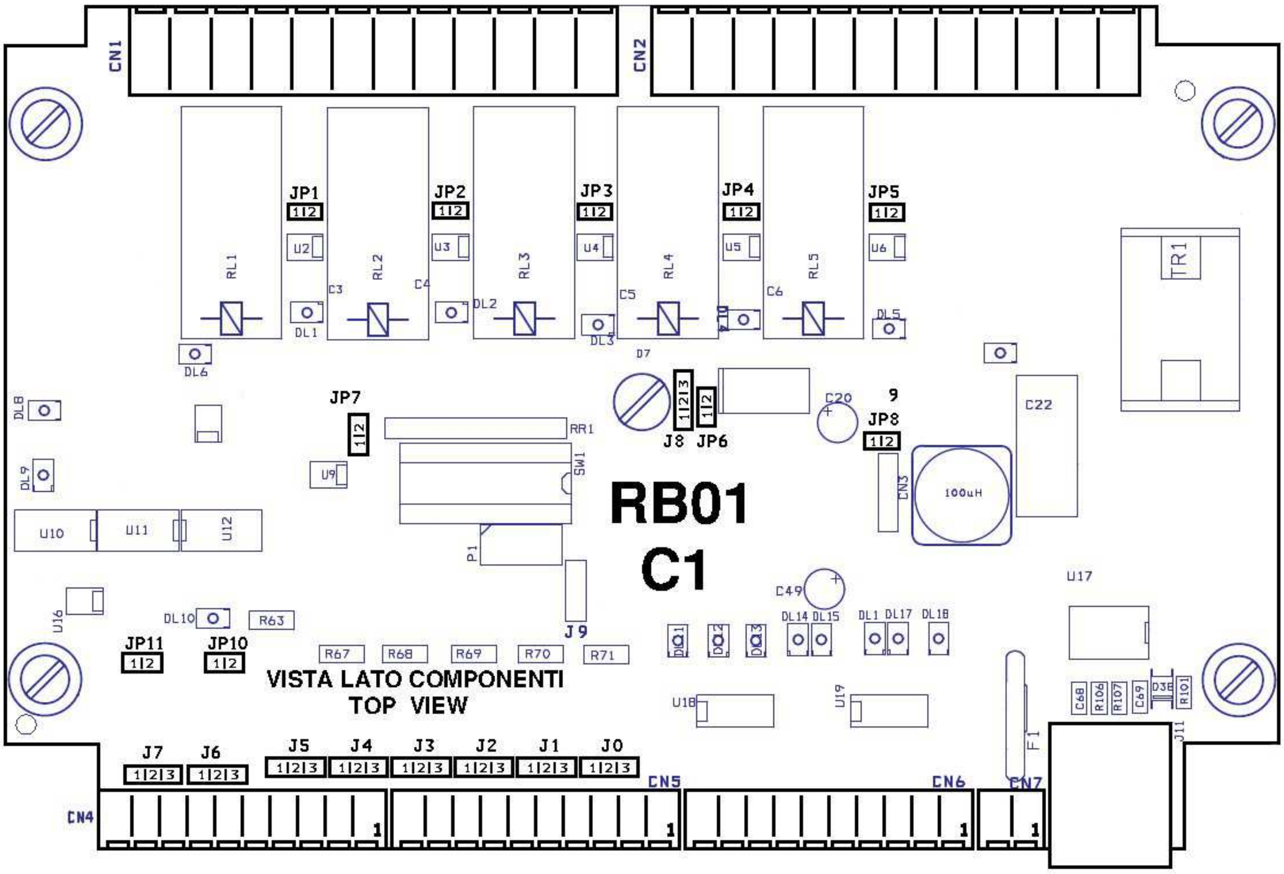
A OUT0 analog ouput 0
A OUT1 analog ouput 0

A GND **zero voltage reference for analogue inputs and outputs and for frequency inputs**

F IN0 input 0 for frequency measurement
F IN1 input 1 for frequency measurement

RS485 COM RS485 common reference
RS485 B connection to “B” of RS485
RS485 A connection to “A” of RS485

JUMPER SETTING



JUMPER SETTING AS SUPPLIED BY MANUFACTURER
Don't change the position of these jumpers for a correct functioning of the product.

JP0 1|2 JP1 1|2 JP2 1|2 JP3 1|2 JP4 1|2 JP5 1|2 ,
JP6 ▬ JP7 ▬ JP8 ▬ J8 1 ▬

See the configuration of the inputs for setting the other jumpers.

PINE S.r.l. is not responsible for malfunctioning or damaging to the board due to the wrong setting of the jumpers.

LEGENDA: 1|2 open jumper
▬ closed jumper (shortcircuited)

3. Configuration and reading of the analogue inputs

Every analogue input can be set, by jumpers, for reading a current, a resistance value or a voltage (this only on request).
The input has to be read at the proper address that depends on the input configuration:

INPUT CONFIGURATION	ADDRESSES
current (from 0 to 25 mA)	registers from 1280 to 1289 (0x0500 to 0x0509)
resistance (from 0 a 10 KΩ)	registers from 1408 to 1417 (0x0580 to 0x0589)
voltage (from 0 to 5V)	register from 1152 to 1161 (0x0480 to 0x0489)

The values (10 bit) read by A/D converter of the board are available on the registers 1664 - 1673. (0x0680 to 0x0689)
The values read by A/D converter are adjusted using the internal voltage reference and they are available on the registers 1536 – 1545 (0x0600 to 0x0609).
Keep attention to the units! *The units are available on the register's table. The units are not related to the precision and to the resolution of the reading. For the reading precision and resolution see the technical features chap. 6 and 8.*

TABLE FOR ANALOGUE INPUTS CONFIGURATION (see chap. 2)

	CURRENT	RESISTANCE	VOLTAGE	NOTES
AIN0	J0 3	J0 1	J0 1 2 3	
AIN1	J1 3	J1 1	J1 1 2 3	
AIN2	J2 3	J2 1	J2 1 2 3	
AIN3	J3 3	J3 1	J3 1 2 3	
AIN4	J4 3	J4 1	J4 1 2 3	
	J5 1 2 3	J5 1 2 3	J5 1 2 3	Input not used

4. Configuration and reading of the frequencies

It is possible to read the frequency (in the registers 1920-1923) and the period (in the registers 2048-2051) of the signal on the inputs F IN0 / F IN1.
The registers table shows the measure units.
ATTENTION
Keep attention to the units! *The units are available on the register's table. The units are not related to the precision and to the resolution of the reading. For the reading precision and resolution see the technical features chap. 6 and 8.*

TABLE FOR FREQUENCY INPUTS CONFIGURATION (see chap. 2)

	Input from "W" signal of alternator	Input from magnetic pick-up	Input from PNP sender	Input from pick-up and check of line continuity	NOTE:
FIN0	J6 1 2 3 JP10	J6 1 2 3 JP10 1 2	J6 1 JP10 1 2	J6 3 JP10 1 2	Line continuity is not available for RB01C1.
FIN1	J7 1 2 3 JP11	J7 1 2 3 JP11 1 2	J7 1 JP11 1 2	J7 3 JP11 1 2	Line continuity is not available for RB01C1.

5. Reading of supply voltage (Vs), digital inputs, analogue outputs, relay outputs

No setting is required.
See addresses table of the registers and the technical features.

6. Technical features of inputs and outputs

8 DIGITAL INPUTS

- optically coupled, insulation voltage 100 VAC
- ON state voltage from 6,0 to 30,0 VDC or from 6 a 24 VAC
- OFF state voltage from 0 to 1 VDC or from 0 a 0,7 VAC, or open circuit

5 ANALOGUE INPUTS

- not insulated, voltage is referred to negative pole of power supply (by the dedicated contact A GND)
- read by 10 bit A/D converter
- Inputs type selected by jumpers:
  - o current 0-25 mA (200 Ohm resistance to negative pole) this mean 0 V at 0 mA and 5 V at 25 mA
    current 4- 20 mA, 800 mV at 4 mA and 4,000V at 20 mA), accuracy: +/- 3 LSB or +/- 15mV
  - o voltage 0 – 5V, accuracy: +/- 3 LSB or +/- 15mV
  - o resistance (with pull-up of 200 Ohm +/-1%):
    - o from 0 Ohm to 1 KOhm, accuracy: +/- 5 LSB or +/- 30mV or +/- 15 Ohm (at 1 KOhm)
    - o from 1 KOhm a 10 KOhm, accuracy: +/- 5 LSB or +/- 30mV or +/- 450 Ohm (at 10 KOhm)

2 FREQUENCY INPUTS

- not insulated, voltage is referred to negative pole of power supply (by dedicated A GND)
- low pass filter for band reducing and eliminating high frequency noise (for filtering short circuit JP10 for FIN0 input, JP11 for FIN1 input
- max measurable frequency without filtering: 10,5KHz
- minimum time for low level and high level of signal - without filtering - 50 uS
- max measurable frequency with filtering: 2KHz
- minimum time for low level and high level of signal - with filtering - 250 uS
- max measurable period: 1,6 seconds
- minimum measurable voltage: 5 Vpp (peak to peak)
- max input voltage: 90 Vpp (peak to peak)
- accuracy: better than 0.1 %

5 OUTPUT RELAYS WITH N.OPEN AND N.CLOSED CONTACTS AVAILABLE (SPDT)

- contacts rating with resistive load:
  - o contact NO 12 A at 250 VAC and at 24 VDC
  - o contact NC 10 A at 250 VAC and at 24 VDC
  - o max switching power: 3000 VA on NO contact and 2500 VA on NC contact
  - o max switching voltage: 440 VAC, 300Vdc
- **Use fuses or equivalent devices for protecting relay's contacts** and use proper devices for avoiding dangerous overvoltages in case of inductive loads (RB01C1 has not protection devices).

- **Reading of the current that flows through the COMMON contact of the relays:**

  DC CURRENT
  - o DC current or the average value of the current in a cycle (if AC), accuracy: 1% and +/- 100 mA available for values greater than +/- 200 mA
  - o Direction of the DC current; sign is positive if the current enters in the COMMON terminal of the relay

SINUSOIDAL CURRENT

- Frequency: from 35 to 80 Hz, minimum peak to peak current amplitude 400 mApp.
  Accuracy: +/- 1 Hz for current values between 400 mA and 1 A peak-peak (between 140 mARMS and 350 mARMS if pure sine wave)
  Accuracy: +/- 0.2 Hz for current greater than 1App (about 350 mARMS if pure sine wave)
- Total True RMS value of the current (AC+DC), accuracy: 1% and +/- 150 mA
  available only if frequency is in the measurable range
- True RMS value of the only AC current, accuracy: 1% and +/- 150 mA
  available only if frequency is in the measurable range
- Peak to peak value of the current, accuracy: 1% and +/- 200 mA
  available only if frequency is in the measurable range
- Direction of the DC current or of the average current in a cycle; sign is positive if the current enters in the COMMON terminal of the relay

The value, the frequency and the direction of the current are not detectable for current lower than minimum measurable. In these cases their values are set to zero and the current direction (sign of the current) is not available.

NOT SINUSOIDAL CURRENT

- Frequency: from 35 to 80 Hz
- Minimum pulse width 1.5 mS
- Minimum peak to peak current amplitude 450 mApp.
  Accuracy depend on current waweform: better than +/- 5 Hz for current values between 450 mA and 1 A peak-peak
  better than +/- 0.2 Hz for current greater than 1App
- Total True RMS value of the current (AC+DC), accuracy: 1% and +/- 200 mA
  available only if frequency is in the measurable range
- True RMS value of the only AC current, accuracy: 1% and +/- 200 mA
  available only if frequency is in the measurable range
- Peak to peak value of the current, accuracy: 1% and +/- 250 mA
  available only if frequency is in the measurable range
- Direction of the DC current or of the average current in a cycle; sign is positive if the current enters in the COMMON terminal of the relay

In the higher byte of the registers used for current measurement there are 5 bits used for supplying informations on the current/frequency reading as showed below

16 bit format:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
x	x	x	x	x	x	x	x	VALUE							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
VALUE															

32 bit format (the same of two at 16 bit):

SIGN		N/A	UR	OR	RESERVED																										
-	+																														
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	x	x	x	x	x	x	x	VALUE																							

Bit 31, Bit 30 sign of the DC current or of the average current in a period:

01 = positive
10 = negative
00 = not available
11 = reserved

Bit 29 measure: 0 = available, 1=not available
Bit 28 measure: 0 = in range 1 = Under range
Bit 27 measure: 0 = in range 1 = Over range

Example: if the current is 550 mA DC (0x0226) and enters in the common terminal of the relay RL2 the registers 2820 - 2821 (0x0B04 – 0x0B05) content is:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	0	0	NOT USED								0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0

The registers 2564 – 2565, 2692 – 2693, ... content is:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	1	1	0	0	NOT USED								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Suggestions: if in your application you need less than 5 relays you can use the contacts NC and C of the unused relays as Amperometer (you'll read the current value as show in the table of addresses).

2 ANALOGUE OUTPUTS

- not insulated
- voltage range: 0-10V, max output settling time: 2 seconds over all the voltage range.
- accuracy: +/- 0,5% of the set value on the registers + offset amplitude of +/- 25 mV.
- load (to voltage reference A GND) >2 KOhm.

SUPPLY VOLTAGE

- 10 to 35 VDC, polarity inversion protection
- 8 to 24 VAC
- supply current at 12 VDC all the relays released: 50 mA
- supply current at 24 VDC all the relays released: 30 mA
- max supply current at 12 VDC all the relays excited: 450 mA
- max supply current at 24 VDC all the relays excited: 250 mA

7. Serial communication lines

RS 485 PROTOCOL: MODBUS RTU (see pag 12), GALVANICALLY INSULATED LINE
bit rate selected by dip switch (4 bit rate are available, as in BIT RATE SELECTION).

CAN BUS OPEN PROPRIETARY PROTOCOL similar to MODBUS RTU (see pag. 25), fixed bit rate at 250 Kbit/s, GALVANICALLY INSULATED LINE.

<u>BOARD ADDRESS</u>
An address between 0x11 and 0xF7 (with exception of address that have four zero in the lower bits of the address - this mean with exception of addresses 0x20, 0x30,…) may be assigned to the board.
The max number of possible addresses is 216, the max number of RB01C1 nodes is 62 (+ 1 node with a normal load) . The RB01C1 net load is half of a standard load.

<u>ADDRESS ASSIGNMENT</u>
Using the dip switch SW1 a new address can be assigned to the board (see ASSIGNEMENT VIA DIP SWITCH). Since only 4 switches are available for the 8 bit of address, the address assignment is done in two steps, 4 bit each time: the lower 4 bit and then the upper 4 bit or viceversa.

<u>BIT RATE SELECTION (only for RS 485)</u>
Available bit rate:

- 9600 bit/sec (switch 5,6,7,8 = 1000) in compliance with MODBUS spedification
- 19200 bit/sec (switch 5,6,7,8 = 1001) in compliance with MODBUS spedification
- 38400 bit/sec (switch 5,6,7,8 = 1010) **not** in compliance with MODBUS spedification
- 57600 bit/sec (switch 5,6,7,8 = 1011) **not** in compliance with MODBUS spedification

RB01C1 responds to a request in a time between 5 and 60 mS regardless of bit rate.

Attention: for bit rate higher than 19200 bit/sec RB01C1 may lose some message and not reply.
In these cases resend the message one or two time before declaring that the board is faulty.

SETTING VIA DIP SWITCH

The dip switch SW1 is used for setting the BIT RATE and for assigning the board ADDRESS.
Preset the new ADDRESS with the switches 5,6,7,8 and then confirm and store by switch 1 (see example in the next page).
Preset the new BIT RATE with the switches 5,6,7,8 and then confirm and store by switch 2 (see example in the next page).
Configuration sequence.
Assignment of a new address: set in the switches 5,6,7,8 the lower 4 bit of the address then set the switch 1 ON and then OFF respecting the fig. 1 timing for the lower 4 bit; then set in the switches 5,6,7,8 the higher 4 bit of the address then set the switch 1 ON and then OFF respecting the fig. 1 timing for the higher 4 bit of the address.
The same for the BIT RATE (only 4 bit are used): set in the switches 5,6,7,8 the new BIT RATE then set the switch 2 ON and then OFF respecting the fig. 1 timing.

EXAMPLE OF ADDRESS AND BIT RATE SETTING

Suppose you want to set the address 0xE3 = $(E3)_{16}$ and BIT RATE 19200 bit/sec.

ADDRESS

0xE3 is binary 1110 0011. “0” if the switch is in OFF position, ”1” if the switch is in ON position.
With reference to 1 fig.

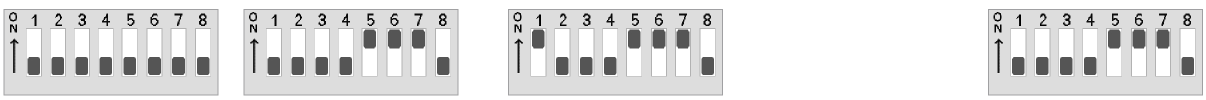
- set the switches 5,6,7,8 in ON,ON,ON,OFF position and then confirm and store by switch 1 with the timing for storing the higher 4 bit of the ADDRESS
- the switches 5,6,7,8 in OFF,OFF,ON,ON position and then confirm and store by switch 1 with the timing for storing the lower 4 bit of the ADDRESS

.

SET OF THE HIGHER 4 BIT OF THE BOARD ADDRESS

Set the higher 4 BIT (switch 1 is OFF) set switch 1 ON, wait for a time between 5 and 10 seconds then switch 1 OFF

|-------------------------|-------------------------|-------------------------|



SET OF THE LOWER 4 BIT OF THE BOARD ADDRESS

Set the lower 4 BIT (switch 1 is OFF) set switch 1 ON, wait for a time between 0,5 and 2,5 seconds then switch 1 OFF

|-------------------------|-------------------------|-------------------------|

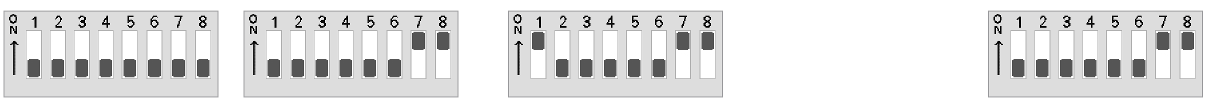


Fig. 1

BIT RATE 19200 bit/sec
With reference to fig 2:
- set the switches 5,6,7,8 in ON,OFF,OFF,ON position and then confirm and store by the switch 2 with the timing for storing the BIT RATE as in the following fig. 2

SET THE BIT RATE AT 19200 BIT/SEC

Set the bit rate at 19200 **set switch 2 ON, wait for a time between 0,5 and 2,5 seconds then switch 2 OFF**

|--|--|--------------------------|

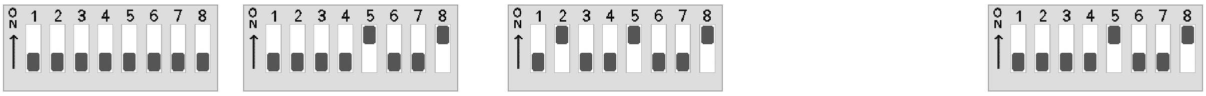


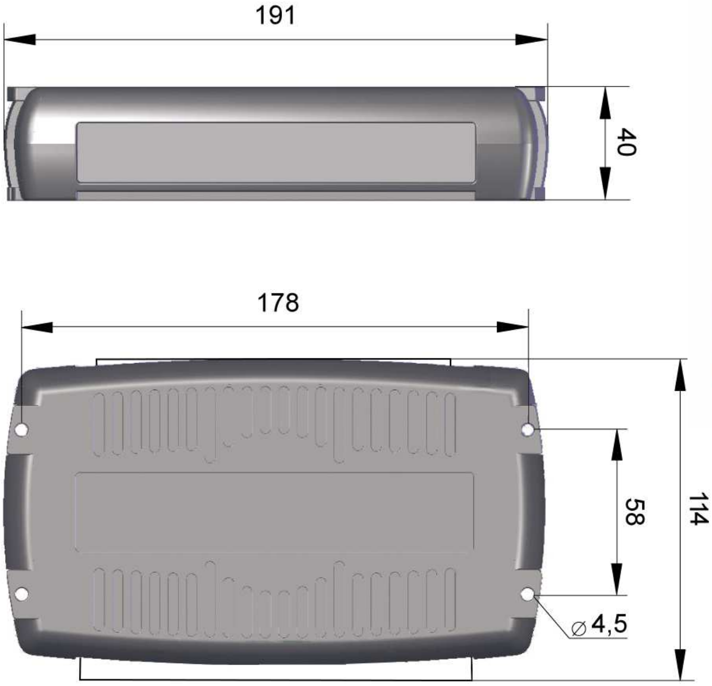
Fig. 2

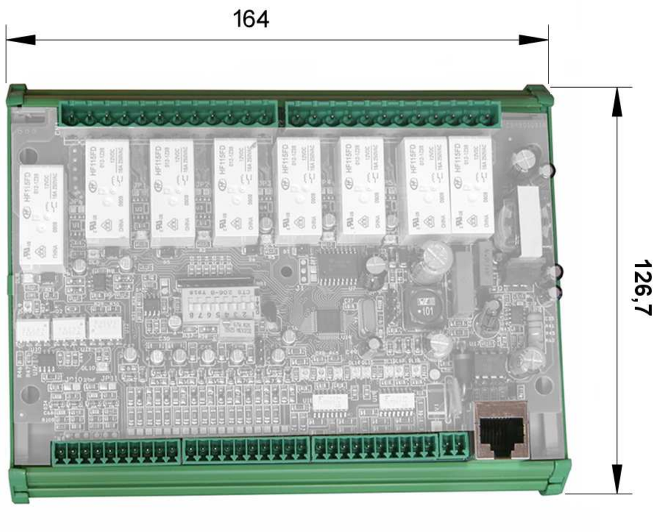
8. Technical data

SCHEDA DI I/O RBO1 C1 - MODELLO BASE (STANDARD) ELECTRONIC BOARD FOR I/O - BASIC MODEL RB01C1					
			conditions	min	MAX
Voltage Supply	Vs (contacts +Vs - Vs)		D.C Voltage	10 Vdc	35 Vdc
			A.C Voltage	8 Vac	24 Vac
Current Supply			All relays OFF Vs=12V		50 mA
			All relays ON Vs=12V		350 mA
			All relays OFF Vs=24V		30 mA
			All relays ON Vs=24V		200 mA
Internal fuse	3A self-resetting fuse on power supply				
Protections on Vs	Polarity inversion				
			conditions	min	MAX
Inputs	**5 Analog inputs** AIN0…AIN4	Current (4-20 mA compatible)		0 mA	25 mA
		Voltage (d.c. only)		0 V	5 V
		Resistance		0 Ω	10 KΩ
		Voltage Range on all analog inputs		-0,5 V	+5,5 V
	2 Counter inputs FIN0, FIN1	Input Frequency (without filtering)	Duty cycle 50%	0,6 Hz	10 KHz
		Input Frequency (with filtering)	Duty cycle 50%	0,6 Hz	2 KHz
		Input Voltage Range (Peak to peak)		5 Vpp	90 Vpp
	5 Digital inputs DIN0…DIN7 GALVANICALLY ISOLATED 400 Vrms	Input OFF	D.C Voltage	0 Vdc	1,0 Vdc
		Input OFF	A.C Voltage	0 Vac	0,7 Vac
		Input ON	D.C Voltage	6,0 Vdc	30,0 Vdc
		Input ON	A.C Voltage	6,0 Vac	24,0 Vac
Outputs	**2 Analog Outputs** AOUT0, AOUT1	Output range	Load > 2 KΩ	0	10V
		Settling time		1 second	2 seconds
	5 Relays RL1…RL5 VDE0435/0631/0700 **Contacts are not protected, they need external protection**	NO contact current	24 Vdc, 250 Vac		12 A
		NC contact current	24 Vdc, 250 Vac		10 A
		Switching Power			2500 VA
		Contact Voltage	Vac		440 Vac
			Vdc		300 Vdc
		Current sensors range	Absolute value	- 20 A	+ 20 A
		Measurable Current	DC	+/- 0.25 A	+/- 20 A
		Measurable Current	AC RMS value	0.15 A	14 A
CAN BUS	Standard 2.0 B (extended ID – 29 bit)		Specifications as iso 11898	Baudrate: 250 Kbit/sec	
	Protocol: see chap. 21		GALVANICALLY ISOLATED 100 Vrms		
RS 485	Standard EIA/TIA-485			Baudrate: see chap. 7	
	Protocol: MODBUS – see chap. 12		GALVANICALLY ISOLATED 100 Vrms		
Connectors	2 female connectors - 12 male poles p.		2 male connectors - 12 poles	Supplied with RB01C1	
	3 female connectors - 10 male poles p.		3 male connectors - 10 poles		
	1 female connector - 2 male poles p.		1 male connectors - 2 poles		
	1 female RJ45 connector - 8 poles		cable on request 1, 2, 5, 10 meters		
Case	Grey ABS (black on request)		UL94 5VA		
	DIN rail support (DIN EN 50022)		UL94 V-0		
Dimentions	ABS case version	Only box dimension	191 x 114 mm	h = 40 mm	
		Box + external connectors	191 x 133 mm	h = 40 mm	
	DIN rail version	Only DIN Profile support	164 x 126,7 mm	h = 58 mm	
		Profile support + external connectors	164 x 126,7 mm	h = 58 mm	
Working temperature	-10 °C / +60 °C				
Storage temperature		-30 °C / +80 °C			
For measurement precision/errors and for more informations see chap. 6 or contact PINE S.r.l.					

9. Dimensions

ABS enclosure





DIN EN 50022 profile support

10. Product codification

SCHEDA DI I/O RBO1C1
ELECTRONIC BOARD FOR I/O RB01C1

RB01 C1 X 01 B

RB01	series (product family)
C1	Output Current Measure Ver. 01
X	P ABS case / D DIN rail
01	revision SW 01
B	revision HW B

11. CE Conformity

CE	**Il costruttore dichiara che le schede elettroniche della serie RB01 sono conformi ai requisiti di compatibilità elettromagnetica e di sicurezza secondo le direttive 73/23/EEC, 89/336/EEC, 92/31/EEC, 93/68/EEC, 93/97/EEC ed EN 60945.** **The manufacturer declare that the electronic units of series RB01 are in conformity at requisition of electromagnetic compatibility and of security with directives 73/23/EEC, 89/336/EEC, 92/31/EEC and 93/68/EEC and 93/97/EEC and EN 60945 directives.**

RB01C1
MODBUS RTU PROTOCOL
Revision 1.0

RB01C1 is in compliance with MODBUS RTU protocol. In the following chapters there is the technical documentation for the serial communication RS485, as the “function code” list, the list of the “registers” and the measure resolutions and units. Many examples will help user for a quick start on using the board.
User has to be familiar with MODBUS RTU protocol and terminology. The official documentation can be found on the web site http://www.modbus.org.

Not all the timings are in accordance with standard timings of the MODBUS RTU so the user must use the timing of this manual.

12. MODBUS specifications valid on RB01C1

MODBUS protocol specifications:

Protocol	MODBUS V 1.1b
	MODBUS RTU OVER SERIAL LINE V1.02
Physic level	EIA/TIA - 485 RS-485 a 2 wires + common
Bitrate	9600, 19200, 38400, 57600 bps (see note 1)
Parity	Even
Stop bit	1
Frame timing (silent time)	> 10 ms
Delay (silent time) between bytes	< 5 ms
Available addresses	215 (see chap. 7)

1) The Error at 38400 bps (1.4%) and at 57600 bps (1.4%) is higher than 1% so these bit rates are not in accordance with the standard.

13. Function Codes supported by RB01C1

RB01C1 supports the following Function Codes:

Function Code	**Name**	**Description**
0x01	Read Coils	Read the digital outputs (coil state)
0x02	Read Discrete Inputs	Read the digital inputs
0x04	Read Input Registers	Read Input Registers
0x05	Write Single Coil	Write Single Coil
0x10	Write Multiple Registers	Write Multiple Registers

In **black** the recomended Function Codes.
In case of reception of a not supported Function Code, RB01C1 generates an Exception.

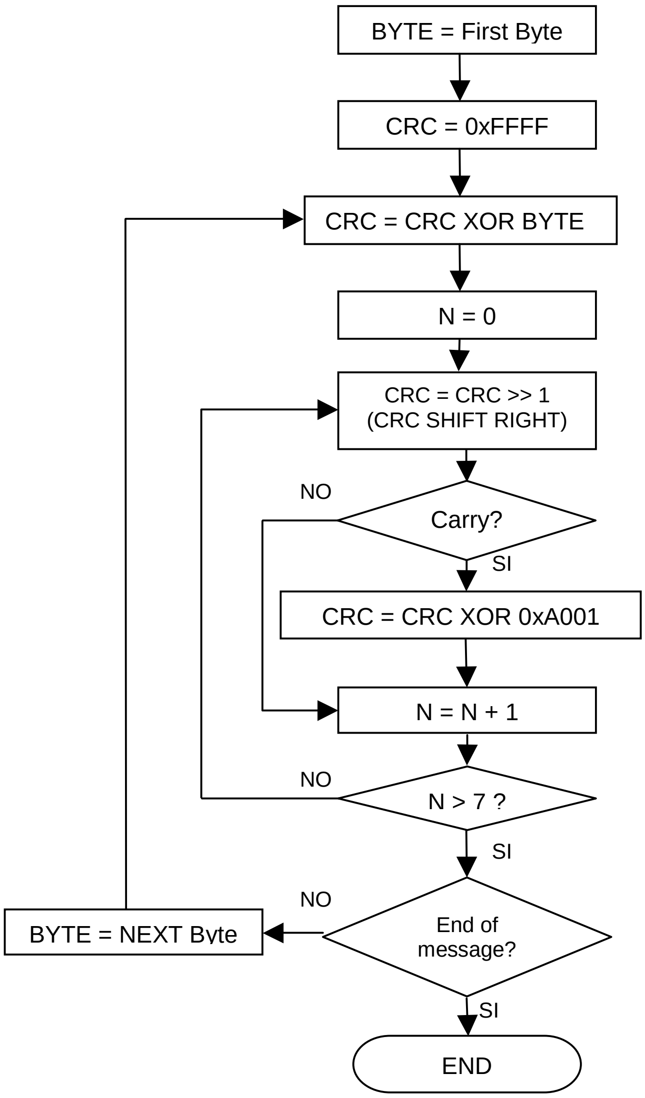
Notes and suggestions
All the RB01C1 boards are “slaves”, the unit that operates with RB01C1 is said “master”.
After a request (Function Code) master have to wait for the reply before sending another request.
If after a while the slave does not reply (a timeout is recomended) the "master" can resubmit the request (Function Code) or signal the error to the user (generating an alarm) in order to solve the problem.

The RB01C1 boards also process the broadcast messages (address 0x00), as required by the protocol. It's not suggest to use it because it has few applications and no reply is expected.

The examples will allow the use of RB01C1 in a short time.

Flow chart and example in "C" language for CRC calculation.

Flow Chart



Example in “C” language for CRC calculation

```
unsigned int modbus_calc_crc(unsigned char *data, unsigned int size)
{
  unsigned int crc;
  unsigned int i;
  unsigned char carry;
  unsigned char n;

  crc = 0xFFFF;

  i = 0;
  while(size) {
    crc = crc ^ data[i];

    n = 0;
    do {
      carry = crc & 0x01;
      crc >>= 1;

      if(carry)
          crc = crc ^ 0xA001;

      n++;
    } while(n <= 7);

    i++;
    size--;
  }

  return ( (crc&0xFF00)>>8 | (crc&0x00FF)<<8 );
}
```

14. RB01C1 Registers

For representing each I/O (digital inputs, analogues output, …) RB01C1 uses a 32 bit unsigned variable.
The size of a MODBUS register is 16 bit so each I/O variable of RB01C1 occupies two consecutive registers.
The 16 MSbit of the variable are stored in the register with the lower address and the 16LSbit in the register with the higher address. The read/write operation have to be done by using the couple/s of registers containing the I/O variable/s. It is not possible the read/write operation on a single 16 bit register.
We suggest to use the Function code (0x04) – Read Input Registers and the Function Code (0x10) – Write Multiple Registers for an easy access to the RB01C1 registers.

Example 1
Suppose you want to read the supply voltage of the RB01C1 and that its value is 12.000V that is 12000 mV.
With reference to the table of addresses (registers) in the chap. 15 this value is read from registers 1024 and 1025 as shown in the following table.

Registers	Value
…	…
1024	0x0000
1025	0x2EE0
…	…

0x indicates that the number is in hexadecimal base.
$(00002EE0)_{16} = (12000)_{10}$

The registers 1024 and 1025 have to be read using one command.
Any attempt for reading only the 1024 register or only the 1025 register will fail and RB01C1 will return an Exception.

15. RB01C1: table of the I/O Registers addresses

REGISTERS decimal	REGISTERS hexadecimal	I/O	UNITS	SIGN		N/A	UR	OR	OPERATION	DESCRIPTION
				-	+					
1024 - 1025	0x0400 – 0x0401	Vs	mV						Read	Supply Voltage
1152 - 1153	0x0480 – 0x0481	AIN0	mV						Read	Read these registers if the analogue input is set for reading a Voltage (see chap 3)
1154 - 1155	0x0482 – 0x0483	AIN1								
1156 - 1157	0x0484 – 0x0485	AIN2								
1158 - 1159	0x0486 – 0x0487	AIN3								
1160 - 1161	0x0488 – 0x0489	AIN4								
1280 - 1281	0x0500 – 0x0501	AIN0	uA						Read	Read these registers if the analogue input is set for reading a Current from 0 to 25 mA (see chap 3)
1282 - 1283	0x0502 – 0x0503	AIN1								
1284 - 1285	0x0504 – 0x0505	AIN2								
1286 - 1287	0x0506 – 0x0507	AIN3								
1288 - 1289	0x0508 – 0x0509	AIN4								
1408 - 1409	0x0580 – 0x0581	AIN0	0.1 Ohm			✓		✓	Read	Read these registers if the analogue input is set for reading a Resistance (see chap 3)
1410 - 1411	0x0582 – 0x0583	AIN1								
1412 - 1413	0x0584 – 0x0585	AIN2								
1414 - 1415	0x0586 – 0x0587	AIN3								
1416 - 1417	0x0588 – 0x0589	AIN4								
						0		0	Value in the range (from 0 to 10 KOhm)	
						0		1	Over range (from 10 KOhm to 50 KOhm)	
						1		0	Not Valid	
						1		1	Not available for over range (> 50 KOhm) *	
1536 - 1537	0x0600 – 0x0601	AIN0	0.1 bit						Read	Bits of the A/D converter (compensated)
1538 - 1539	0x0602 – 0x0603	AIN1								
1540 - 1541	0x0604 – 0x0605	AIN2								
1542 - 1543	0x0606 – 0x0607	AIN3								
1544 - 1545	0x0608 – 0x0609	AIN4								
1664 - 1665	0x0680 – 0x0681	AIN0	0.1 bit						Read	Bits of the A/D converter (not compensated)
1666 - 1667	0x0682 – 0x0683	AIN1								
1668 - 1669	0x0684 – 0x0685	AIN2								
1670 - 1671	0x0686 – 0x0687	AIN3								
1672 - 1673	0x0688 – 0x0689	AIN4								
1792 - 1793	0x0700 – 0x0701	DIN0	OFF / ON						Read	State of the Digital Inputs If read as registers: 0x00000000 = OFF 0x00000001 = ON
1794 - 1795	0x0702 – 0x0703	DIN1								
1796 - 1797	0x0704 – 0x0705	DIN2								
1798 - 1799	0x0706 – 0x0707	DIN3								
1800 - 1801	0x0708 – 0x0709	DIN4								
1802 - 1803	0x070A – 0x070B	DIN5								
1804 - 1805	0x070C – 0x070D	DIN6								
1806 - 1807	0x070E – 0x070F	DIN7								
1920 - 1921	0x0780 – 0x0781	FIN0	0.01 Hz			✓	✓	✓	Read	Frequency
1922 - 1923	0x0782 – 0x0783	FIN1								
						0	0	0	Value in the range (from 0,6 to 10,3 KHz)	
						1	0	1	Not Available for Over range (> 10,3 KHz) *	
						1	1	0	Not Available for Under range (< 0,6 Hz)*	
						x	x	x	Not Valid	
2048 - 2049	0x0800 – 0x0801	FIN0	0.1 uS			✓	✓	✓	Read	Period
2050 - 2051	0x0802 – 0x0803	FIN1								
						0	0	0	Value in the range (from 97us to 1,6666 S)	
						1	0	1	Not Available for Over range (> 1,6666 S)*	
						1	1	0	Not Available for Underrange (< 97 uS)*	
						x	x	x	Not Valid	
2304 - 2305	0x0900 – 0x0901	AOUT0	mV						Read / Write	Analogue Output Voltage
2306 - 2307	0x0902 – 0x0903	AOUT1								

2434 - 2435	0x0982 – 0x0983	ORL1	OFF / ON						Read / Write	State of Digital Outputs
2436 - 2437	0x0984 – 0x0985	ORL2								
2438 - 2439	0x0986 – 0x0987	ORL3								If read as registers:
2440 - 2441	0x0988 – 0x0989	ORL4								0x00000000 = OFF
2442 - 2443	0x098A – 0x098B	ORL5								0x00000001 = ON

REGISTERS decimal	REGISTERS hexadecimal	I/O	UNITS	SIGN -	SIGN +	N/A	UR	OR	OPERATION	DESCRIPTION
2562 - 2563	0x0A02 – 0x0A03	ORL1 C	mA			✓		✓	Read	Total True RMS value of the current (AC + DC) on the common contact of the relay
2564 - 2565	0x0A04 – 0x0A05	ORL2 C								
2566 - 2567	0x0A06 – 0x0A07	ORL3 C								
2568 - 2569	0x0A08 – 0x0A09	ORL4 C								
2570 - 2571	0x0A0A – 0x0A0B	ORL5 C								
						0		0	Value in the range (see chap. XXX)	
						0		1	See **	
						1		0	Not Available ***	
						1		1	Not Valid	
2690 – 2691	0x0A82 – 0x0A83	ORL1 C	mA			✓		✓	Read	True RMS value of the only AC current on the common contact of the relay
2692 - 2693	0x0A84 – 0x0A85	ORL2 C								
2694 – 2695	0x0A86 – 0x0A87	ORL3 C								
2696 – 2697	0x0A88 – 0x0A89	ORL4 C								
2698 – 2699	0x0A8A – 0x0A8B	ORL5 C								
						0		0	Value in the range (see chap. XXX)	
						0		1	See **	
						1		0	Not Available ***	
						1		1	Not Valid	
2818 – 2819	0x0B02 – 0x0B03	ORL1 C	mA	✓	✓			✓	Read	DC current value on the common contact of the relay + if enter in the C contact (average value of the current in case of AC+DC current)
2820 - 2821	0x0B04 – 0x0B05	ORL2 C								
2822 – 2823	0x0B06 – 0x0B07	ORL3 C								
2824 - 2825	0x0B08 – 0x0B09	ORL4 C								
2826 - 2827	0x0B0A – 0x0B0B	ORL5 C								
								0	Value in the range (from 0 mA to 19 A)	
								1	Over range (over 19 A)	
2946 – 2947	0x0B82 – 0x0B83	ORL1 C	mA			✓		✓	Read	Peak to peak value of the current on the common contact of the relay
2948 – 2949	0x0B84 – 0x0B85	ORL2 C								
2950 – 2951	0x0B86 – 0x0B87	ORL3 C								
2952 – 2953	0x0B88 – 0x0B89	ORL4 C								
2954 - 2955	0x0B8A – 0x0B8B	ORL5 C								
						0		0	Value in the range	
						0		1	See **	
						1		0	Not Available ***	
						1		1	Not Valid	
3074 - 3075	0x0C02 – 0x0C03	ORL1 C	0,01 Hz			✓			Read	Frequency of the AC current on the common contact of the relay The centesimal part is not significant
3076 – 3077	0x0C04 – 0x0C05	ORL2 C								
3078 - 3079	0x0C06 – 0x0C07	ORL3 C								
3080 – 3081	0x0C08 – 0x0C09	ORL4 C								
3082 - 3083	0xoC0A – 0x0C0B	ORL5 C								
						0			Value in the range (from 35 Hz to 80 Hz)	
						1			Not Available ***	

* If measure is not available for under range the value read will be 0x000000.
If measure is not available for over range the value read will be 0xFFFFFF.

** If positive or negative peak exceedes 19 Amps RB01C1 current sensor works over range so measure will be affected by a unknown error.

*** If AC frequency is lower than 35 Hz or higher than 80 Hz or pulse width il lower than 1,5 ms, the measures will be not available.

16. Function code (0x04 – Read Input Registers)

This function is used for registers reading.

Message format:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Slave Address	Function Code	Starting Address		Quantity of Input Registers		CRC	

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x04).

Byte 2, Byte 3 – Starting Address
Register Address –1 (as in MODBUS RTU).

Byte 4, Byte 5 – Quantity of Input Registers
Quantity of input registers to be read (two registers or a multiple of two, that is 4 byte or a multiple of 4 byte).

Byte 6, Byte 7 – CRC
CRC of the message.

Format of the reply.

Byte 0	Byte 1	Byte 2	Byte 3	…	Byte n	Byte n+1	Byte n+2
Slave Address	Function Code	Byte Count	Input Registers			CRC	

Byte 0 – Slave Address
Slave address that sent the message.

Byte 1 – Function Code
Function Code (0x04).

Byte 2 – Byte Count
Amount of bytes sent containing the required Input Registers. The same amount of “Quantity of Input Registers” x 2 (because the unit is the byte).

Byte 3 … Byte n – Input Registers
Content of the Input Registers required, from the lowest register to the highest.

Byte n+1, Byte n+2
CRC of the message.

Example 2
Suppose you want to read the digital input DIN0 of the RB01C1 (the address of RB01C1 is 0xA1).
With reference to the table of addresses (registers) in the chap. 15 this value is read in the registers 1792 and 1793 in decimal base that is 0x0700 and 0x0701 in exadecimal base. The byte 2 and 3 of the request will be 0x06 (byte 2) and 0xFF (byte 3) because 0x0700 – 1 = 0x06FF. If the DIN0 is “active” the content of the registers is:

Register	Value
1792 (0x0700)	0x0000
1793 (0x0701)	0x0001

Summarizing, the Starting Address is:
$(1792 – 1)_{10}$ = $(0700\text{-}1)_{16}$ = $(06FF)_{16}$ = 0x06FF

and the reading:
0x0000 in the register 1792 (0x0700)
0x0001 in the register 1793 (0x0701)

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xA1	0x04	0x06	0xFF	0x00	0x02	0x59	0xD3

Slave Address	Function Code	Starting Address (register address - 1)		Quantity of Input Registers		CRC	

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
0xA1	0x04	0x04	0x00	0x00	0x00	0x01	0x9A	0x4E

Slave Address	Function Code	Byte count	Content of register 1792 (0x0700)		Content of register 1793 (0x0701)		CRC	

If the input DIN0 is not "active", the reading returns 0x0000 in the register 1792 and 0x0000 in the register 1793.

Example 3
Suppose you want to read the voltage on the analogue input AIN0 and that this value is 1.250V.
The address of RB01C1 is 0x81.
With reference to the table of addresses (registers) in the chap. 15 this value is read in the registers 1152 and 1153 in decimal base that is 0x0480 and 0x0481 in exadecimal base.
The content of the registers is:

Register	**Value**
1152 (0x0480)	0x0000
1153 (0x0481)	0x04E2

Summarizing, the Starting Address is:
$(1152 – 1)_{10}$ = $(0480\text{-}1)_{16}$ = $(047F)_{16}$ = 0x047F

and the reading:
0x0000 in the register 1152 (0x0480)
0x0E42 in the register 1153 (0x0481)
that mean 0x 0000 04E2 = $(1250)_{10}$ mV = 1.250V

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x81	0x04	0x04	0x7F	0x00	0x02	0x5E	0xE3

Slave Address	Function Code	Starting Address (register address - 1)		Quantity of Input Registers		CRC	

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
0x81	0x04	0x04	0x00	0x00	0x04	0xE2	0xF8	0xC5

Slave Address	Function Code	Byte count	Content of register 1152 (0x0480)	Content of register 1153 (0x0481)	CRC

Example 4
Suppose you want to read the total true RMS value (DC+AC) of the current on the common contact of the relay 2 (ORL2 C) and that this value is 7.500 A.
The address of RB01C1 is 0x81.
With reference to the table of addresses (registers) in the chap. 15 this value is read in the registers 2564 and 2565 in decimal base that is 0x0A04 and 0x0A05 in exadecimal base.
The content of the registers is:

Register	Value
2564 (0x0A04)	0x0000
2565 (0x0A05)	0x1D4C

Summarizing, the Starting Address is:
$(2564 - 1)_{10} = (0A04\text{-}1)_{16} = (0A03)_{16}$ = 0x0A03

and the reading:
0x0000 in the register 2564 (0x0A04)
0x1D4C in the register 1153 (0x0A05)
that mean 0x 0000 1D4C = $(7500)_{10}$ mA = 7.500A N/A bit = 0 and OR bit = 0 (value in the range)

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x81	0x04	0x0A	0x03	0x00	0x02	0x9D	0xD3

Slave Address	Function Code	Starting Address (register address - 1)	Quantity of Input Registers	CRC

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
0x81	0x04	0x04	0x00	0x00	0x1D	0x4C	0x72	0xE9

Slave Address	Function Code	Byte count	Content of register 2564 (0x0A04)	Content of register 2565 (0x0A05)	CRC

17.Function Code (0x10) – Write Multiple Registers

The “Write Multiple Register” function is used for setting the value of one or more pairs of contiguous registers on RB01C1.

Message format:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	…	Byte n	Byte n+1	Byte n+2
Slave Address	Function Code	Starting Address		Quantity of Registers		Byte Count	Registers Value			CRC	

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x10).

Byte 2, Byte 3 Starting Address
Register Address – 1.

Byte 4, Byte 5 - Quantity of Registers
Quantity of the Registers to write.

Byte 6 – Byte Count
Quantities of bytes in the “Registers Value”.
This is “Quantity of Registers” x 2 (because a registers need 2 bytes).

Byte 7… Byte n – Registers Value
Value to be written in the registers, from the lowest register to the highest.

Byte n+1, Byte n+2 – CRC
CRC of the message.

Format of the reply:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Slave Address	Function Code	Starting Address		Quantity of Registers		CRC	

Byte 0 – Slave Address
Slave address that sent the message.

Byte 1 – Function Code
Function Code (0x10).

Byte 2, Byte 3 – Starting Address
Address from which you started writing – 1.

Byte 4, Byte 5 – Quantity of Registers
Amount of written registers.

Byte 6, Byte 7 – CRC
CRC of the message.

Example 5
Suppose you want to set in the analogue output A OUT0 a voltage of 6.730V (6730 mV that is 0x0000 1A4A).
The address of RB01C1 is 0x81.
With reference to the table of addresses (registers) in the chap. 15 the number 0x0000 1A4A has to be written in the registers 2304 and 2305 in decimal base, 0x0900 and 0x0901 in exadecimal base.

Summarizing, the Starting Address is:
$(2304 – 1)_{10}$ = $(0900\text{-}1)_{16}$ = $(08FF)_{16}$ = 0x08FF

and the value to write in the registers is:
0x0000 in the register 2304 (0x900)
0x1A4A in the register 2305 (0x901)

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11	Byte 12
0x81	0x10	0x08	0xFF	0x00	0x02	0x04	0x00	0x00	0x1A	0x4A	0xF8	0x3E

Slave Address	Function Code	Starting Address	Quantity of Registers	Byte Count	Registers Value	CRC

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x81	0x10	0x08	0xFF	0x00	0x02	0x6C	0x58

Slave Address	Function Code	Starting Address	Quantity of Registers	CRC

Example 6

Suppose you have to use the contacts ORL2_NC and ORL2_C, ORL5_NO and ORL5_C for activating / deactivating the loads. First you want activate the relays ORL2, ORL5 of the board RB01C1 with address 0x83.

It is possible to use the Function Code 0x10 two times, one time for RL2 relay and one time for RL5 relay.

ORL2:

With reference to the table of addresses (registers) in the chap. 15 you have to write 0x0000 in the register 2436 (0x0984) and 0x0001 in the register 2437 (0x0985).

Starting address is:

$(2436 - 1)_{10} = (0984\text{-}1)_{16} = (0983)_{16} =$ 0x0983

and the value to write in the registers is:

0x0000 in the register 2436 (0x0984)

0x0001 in the register 2437 (0x0985)

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11	Byte 12
0x83	0x10	0x09	0x83	0x00	0x02	0x04	0x00	0x00	0x00	0x01	0xB2	0x30

Slave Address	Function Code	Starting Address	Quantity of Registers	Byte Count	Registers Value	CRC

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x83	0x10	0x09	0x83	0x00	0x02	0xAD	0x9E

Slave Address	Function Code	Starting Address	Quantity of Registers	CRC

ORL5: as ORL2 but changing the register address (Starting Address).

Starting address is:

$(2442 - 1)_{10} = (098A\text{-}1)_{16} = (0989)_{16} =$ 0x0989

and the value to write in the registers is:

0x0000 in the register 2442 (0x098A)

0x0001 in the register 2443 (0x098B)

Example 7
Suppose you want to deactivate the relay RL2 of the board RB01C1 with address 0x83. As in the Example 6, you have to write 0x0000 in the register 2436 (0x0984) and 0x0000 in the register 2437 (0x0985).

Summarizing, the Starting Address is:
7$(2436 – 1)_{10}$ = $(0984\text{-}1)_{16}$ = $(0983)_{16}$ = 0x0983

and the value to write in the registers is:
0x0000 in the register 2436 (0x0983)
0x0000 in the register 2437 (0x0984)

18. Function Code (0x01) – Read Coils

This function is used for reading the state of one or more contiguous outputs, as the state of the relay coils.

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Slave Address	Function Code	Starting Address		Quantity of coils		CRC	

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x01).

Byte 2, Byte 3 – Starting Address
Register Address from which you start reading – 1.

Byte 4, Byte 5 – Quantity of coils
Quantity of the coils to be read.

Byte 6, Byte 7 – CRC
CRC of the message.

Format of the reply:

Byte 0	Byte 1	Byte 2	Byte 3	…	Byte n	Byte n+1	Byte n+2
Slave Address	Function Code	Byte Count	Coils Status			CRC	

Byte 0 – Slave Address
Address of the slave that sent the message.

Byte 1 – Function Code
Function Code (0x01).

Byte 2 – Byte Count
Amount of the bytes needed for representing the status of the outputs (of the coils).
Byte count = “Quantity of coils” / 8 (rounded up)
RB01C1 has a maximum of 8 coils so ***Byte count = 1***

Byte 3 … Byte n – Coil Status
Sequence of bits that represent the status of the outputs (colis).
‘1’ mean that output is active.
‘0’ mean that output is not active.
The unused bit are set to ‘0’.
The status of the first output is put in the least significant bit of the byte 3.
RB01C1 uses only the Byte 3.

Byte n+1, Byte n+2 – CRC
CRC of the message.

Example 8
Suppose you want to read the 5 coils of the RB01C1 (remember that read a coil is not the reading of the real value of the relay output contacts) and only ORL1 relay is energized.
The address of RB01C1 is 0x83.
With reference to the table of addresses (registers) in the chap. 15 this value is read starting from the registers 2434 (0x0982) up to the register 2443 (0x098B).

Summarizing, the Starting Address is:
$(2434 – 1)_{10}$ = $(0982\text{-}1)_{16}$ = $(0981)_{16}$ = 0x0981

The status of the 5 outputs is contained in a single byte, the byte 3 of the reply.

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x83	0x01	0x09	0x81	0x00	0x05	0xB1	0x9F
Slave Address	Function Code	Starting Address		Quantity of coils (5)		CRC	

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x83	0x01	0x01	0x01 see the details (*)	0xB8	0x30
Slave Address	Function Code	Byte Count	Coils Status	CRC	

(*) Details of byte 3

Byte 3							
b7	b6	b5	b4	b3	b2	b1	b0
UNUSED	UNUSED	UNUSED	ORL5 STATUS	ORL4 STATUS	ORL3 STATUS	ORL2 STATUS	ORL1 STATUS
0	0	0	0	0	0	0	1

If status of ORLX = 0 the output (the coil) is deactivated, If state of ORLX = 1 the output (the coil) is activated.
NOTE: “UNUSED” bits value is undefined so it may be any value.

19. Function Code (0x02) – Read Discrete Inputs

This function is used for reading the status of one or more contiguous discrete inputs.

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Slave Address	Function Code	Starting Address		Quantity of inputs		CRC	

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x02).

Byte 2, Byte 3 – Starting Address
Register Address from which you start reading – 1.

Byte 4, Byte 5 – Quantity of inputs
Quantity of the inputs to be read.

Byte 6, Byte 7 – CRC
CRC of the message.

Format of the reply:

Byte 0	Byte 1	Byte 2	Byte 3	…	Byte n	Byte n+1	Byte n+2
Slave Address	Function Code	Byte Count	Inputs Status			CRC	

Byte 0 – Slave Address
Address of the slave that sent the message.

Byte 1 – Function Code
Function Code (0x02).

Byte 2 – Byte Count
Amount of the bytes needed for representing the status of the inputs.
Byte count = “Quantity of inputs” / 8 (rounded up).
RB01C1 has a maximum of 8 inputs so **Byte count = 1**

Byte 3 … Byte n – Inputs Status
Sequence of bits that represent the state of the inputs.
‘1’ mean that input is active.
‘0’ mean that input is not active.
The unused bits are read as ‘0’.
The state of the first input is put in the least significant bit of the Byte 3.
RB01C1 uses only the Byte 3.

Byte n+1, Byte n+2 – CRC
CRC of the message.

Example 9
Suppose you want to read the 8 inputs DIN0…DIN7 of the RB01C1.
The address of RB01C1 is 0x95.
With reference to the table of addresses registers in the chap. 15 this value is read starting from the registers 1792 (0x0700) up to the register 1807 (0x070F).

Summarizing, the Starting Address is:
$(1792 – 1)_{10} = (0700\text{-}1)_{16} = (06FF)_{16}$ = 0x06FF

The state of the 8 inputs is contained in a single byte, the byte 3 of the reply.

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x95	0x02	0x06	0xFF	0x00	0x08	0x55	0xA0
Slave Address	Function Code	Starting Address		Quantity of inputs		CRC	

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x95	0x02	0x01	0x5E See the details (*)	0x0C	0x40
Slave Address	Function Code	Byte Count	Inputs Status	CRC	

(*) Details of byte 3

Byte 3							
b7	b6	b5	b4	b3	b2	b1	b0
DIN7 STATUS 0	DIN6 STATUS 1	DIN5 STATUS 0	DIN4 STATUS 1	DIN3 STATUS 1	DIN2 STATUS 1	DIN1 STATUS 1	DIN0 STATUS 0

The inputs DIN6, DIN4, DIN3, DIN2, DIN1 are activated.

20. Function Code (0x05) – Write Single Coil

This function allows to set the status of a relay output (a coil).

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Slave Address	Function Code	Output Address		Output Value		CRC	

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x05).

Byte 2, Byte 3 – Starting Address
Register Address – 1.

Byte 4, Byte 5 – Output Value
0x0000 – Output deactivated
0xFF00 – Output activated
All other value are not valid.

Byte 6, Byte 7 – CRC
CRC of the message.

The reply is the echo of the request (the same message).

Example 10
Suppose you want close the contacts ORL1_NO and ORL1_C by activating the relay ORL1 of the RB01C1.
The address of RB01C1 is 0xA2.

The Output Address is:
$(2434 - 1)_{10} = (0982\text{-}1)_{16} = (0981)_{16} =$ 0x0981

and the value to write in the registers is:
0xFF in the byte 4
0x00 in the byte 5

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xA2	0x05	0x09	0x81	0xFF	0x00	0xC7	0x1D

Slave Address	Function Code	Output Address	Output Value	CRC

Reply (echo)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xA2	0x05	0x09	0x81	0xFF	0x00	0xC7	0x1D

Slave Address	Function Code	Output Address	Output Value	CRC

21. Exceptions on MODBUS protocol

An EXCEPTION message will be generated in the following cases:

- Illegal Function Code: **0x01**;
- Quantity of Register = 0 or odd – illegal data address: **0x02**;
- odd Start Addresses – illegal data address: **0x02**;
- (Start Address + Quantity of Registers) > 65536 – illegal data address: **0x02**;
- attempt to read/write registers or coils or inputs not included in the Table of Addresses (registers) – illegal data address: **0x02**;
- attempt to write a read only registers – slave device failure: **0x04**;
- attempt to read with Function Code 0x02 Read Discrete Inputs something that is not a discrete input/digital input– illegal data address: **0x02**;
- attempt to read with Function Code 0x01 or write with Function Code 0x05 something that is not a coil, i.e. use them with an analogue input or output– illegal data address: **0x02**;
- attempt to write with the Function Code 0x05 Write Single Coil a value that is not accepted by this function – illegal data value: **0x03**.

In **bold** the Exception codes.

Example 11
As in the Example 2 suppose to read the digital input DIN0 of the RB01C1 with address 0xA1.
On registers reading we make a mistake: instead of reading the registers 1792 and 1793, are read the registers 1692 and 1693 which are not included on the register address table.

Summarizing, the wrong Starting Address is:
$(1692 – 1)_{10}$ = $(069C\text{-}1)_{16}$ = $(069B)_{16}$ = 0x069B

Message format (request)

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xA1	0x04	0x06	**0x9B**	0x00	0x02	0x18	0x0C

Slave Address	Function Code	Starting Address (register address - 1)	Quantity of Input Registers	CRC

Reply

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0xA1	**0x84**	**0x02**	0xC2	0xE3

Slave Address	Function Code	Exception Code	CRC

Byte 0 – Slave Address
Address of the slave board.

Byte 1 – Function Code
Function Code (0x04) or bit to bit (0x80).

0000 0100 or	0x04 or
1000 0000	0x80
1000 0100	0x84

Byte 2 – Exception Code
Exception Code 0x02.

Byte 3, Byte 4 – CRC
CRC of the message.

22. CANBUS proprietary protocol

RB01C1 uses a proprietary protocol over CAN-BUS 2.0.
The protocol is similar to the MODBUS but uses only a subset of MODBUS functions.
The bitrate is fixed to **250Kbit / s**, the ID is Extended-ID (29 bit).

The protocol includes the following messages:

Read Register 0x04	I/O registers reading
Write Register 0x10	I/O registers writing
Exception	Sent from RB01C1 when an error occurs during messages processing:

The messages have the following format:

ID (29 bit)	DLC	DATA[from 0 to 6 bytes]

Where:

ID is the massage identifier; it includes the sender, the destination and the FUNCTION CODE of the massage.

DLC is the amount of bytes of the message (from 0 to 6 bytes)

DATA[ ] data of the message (from 0 to 6 byte) its meaning depends on the FUNCTION CODE of the ID.

Bits of the identifier:

ID (29 bits)																												
bit																												
28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5 bit					8 bit								8 bit								8 bit							
RESERVED					FUNCTION CODE								DESTINATION ADDRESS								SOURCE ADDRESS							

The **RESERVED** 5 bits have to be set to 0x1D (in bit: 11101) in transmission and read 0x1D (in bit: 11101) in reception. **The messages with different value are discarded and no Exception will be generated**.

The **FUNCTION CODE** is the same of MODBUS and specifies the operation with the registers (Read Register / Write Register / Exception).

The **DESTINATION ADDRESS** is the recipient's address and is the same of the "SLAVE ADDRESS " of the MODBUS.
The RB01C1 boards also process the broadcast messages (destination address 0x00), as required by the protocol. It's not suggest to use it because it has few applications and no reply is expected.

The **SOURCE ADDRESS** is the address of the sender and **must to be different from 0x00.**

23. Read register

The Read Register function is used for reading the state of two contiguous registers (2 registers at 16 bits), starting from the STARTING ADDRESS.

Message format (request) :

ID				DLC	D0	D1
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS	
0x1D	0x04	0xWW	0xQQ	0x02	0xPPPP	

RESERVED
Fixed to 0x1D (in bits: 11101).

FUNCTION CODE
Function Code 0x04.

DESTINATION ADDRESS
Recipient's Address (as the "SLAVE ADDRESS in the MODBUS" , 1 byte).

SOURCE ADDRESS
Sender Address (1 byte).

DATA LENGTH CODE

Quantity of bytes of the data, fixed to 0x02.

STARTING ADDRESS (D0 e D1)
Register Address from which you start reading.
In D0 the highest part of the Register Address and in D1 the lowest.

Reply format:

<table>
<tr><td colspan="4">ID</td><td>DLC</td><td>D0</td><td>D1</td><td>D2</td><td>D3</td><td>D4</td><td>D5</td></tr>
<tr><td>RESERVED</td><td>FUNCTION CODE</td><td>DESTINATION ADDRESS</td><td>SOURCE ADDRESS</td><td>DATA LENGTH CODE</td><td colspan="2">STARTING ADDRESS</td><td colspan="4">REGISTER VALUE</td></tr>
<tr><td>0x1D</td><td>0x04</td><td>0xQQ</td><td>0xWW</td><td>0x06</td><td colspan="2">0xPPPP</td><td colspan="2">0x????</td><td colspan="2">0x????</td></tr>
</table>

RESERVED
Fixed to 0x1D (in bits: 11101).

FUNCTION CODE
Function Code 0x04.

DESTINATION ADDRESS
Address of the board that required the “Read Register” (1 byte).

SOURCE ADDRESS
Address of the board that reply (1 byte).

DATA LENGTH CODE
Amount of data bytes, fixed to 0x06.

STARTING ADDRESS (D0, D1)
The same STARTING ADDRESS of the request.

REGISTERS VALUE (D2, D3, D4, D5)
Content of the Input Registers required, ordered as in the following table:

D2	The 8 MSB of the register at address STARTING ADDRESS
D3	The 8 LSB of the register at address STARTING ADDRESS
D4	The 8 MSB of the register at address STARTING ADDRESS +1
D5	The 8 LSB of the register at address STARTING ADDRESS +1

Example 12
Suppose that you want to read the digital input DIN0 of the RB01C1.
RB01C1 address 0x81, requester address of the is 0x99.
With reference to the table of addresses (registers) in the chap. 15 this value is read in the registers 1792 and 1793 in decimal base that is 0x0700 and 0x0701 in exadecimal base. If the DIN0 is “active” the content of the registers is:

Register	Value
1792 (0x0700)	0x0000
1793 (0x0701)	0x0001

Summarizing, the Starting Address is:
$(1792)_{10} = (0700)_{16}$ = 0x0700

and the reading:
0x0000 in the register 1792 (0x0700)
0x0001 in the register 1793 (0x0701)

Message format (request)

ID				DLC	D0	D1
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS	
0x1D	0x04	0x81	0x99	0x02	0x0700	

Reply

ID				DLC	D0	D1	D2	D3	D4	D5
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS		REGISTER VALUE			
0x1D	0x04	0x99	0x81	0x06	0x0700		0x0000		0x0001	

Example 13
Suppose you want to read the true RMS value of the AC the current on the common contact of the relay 4 (ORL4 C) and that this value is 2.250 A (2250 mA).
RB01C1 address 0x81, requester address 0x99.
With reference to the table of addresses (registers) in the chap. 15 this value is read in the registers 2696 and 2697 in decimal base that is 0x0A88 and 0x0A89 in exadecimal base.

The content of the registers is:

Register	**Value**
2696 (0x0A88)	0x0000
2697 (0x0A89)	0x08CA

Summarizing, the Starting Address is:
$(2696)_{10} = (0A88)_{16}$ = 0x0A88

and the reading:
0x0000 in the register 2696 (0x0A88)
0x08CA in the register 2697 (0x0A89)
that mean 0x 0000 08CA = $(2250)_{10}$ mA = 2.250 A N/A bit = 0 and OR bit = 0 (value in the range)

Message format (request)

ID				DLC	D0	D1
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS	
0x1D	0x04	0x81	0x99	0x02	0x0A88	

Reply

ID				DLC	D0	D1	D2	D3	D4	D5
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS		REGISTER VALUE			
0x1D	0x04	0x99	0x81	0x06	0x0A88		0x0000		0x08CA	

24.Write register

The “Write Multiple Register” function is used for setting the value of two contiguous registers.

Message format (request):

<table>
<tr><td colspan="4">ID</td><td>DLC</td><td>D0</td><td>D1</td><td>D2</td><td>D3</td><td>D4</td><td>D5</td></tr>
<tr><td>RESERVED</td><td>FUNCTION CODE</td><td>DESTINATION ADDRESS</td><td>SOURCE ADDRESS</td><td>DATA LENGTH CODE</td><td colspan="2">STARTING ADDRESS</td><td colspan="4">REGISTER VALUE</td></tr>
<tr><td>0x1D</td><td>0x10</td><td>0xTT</td><td>0xYY</td><td>0x06</td><td colspan="2">0xZZZZ</td><td colspan="2">0x????</td><td colspan="2">0x????</td></tr>
</table>

RESERVED
Fixed to 0x1D.

FUNCTION CODE
Function Code 0x10.

DESTINATION ADDRESS
Recipient’s Address (as the “SLAVE ADDRESS in the MODBUS” , 1 byte).

SOURCE ADDRESS
Sender Address (1 byte).

DATA LENGTH CODE
Quantity of bytes of the data, fixed to 0x06.

STARTING ADDRESS (D0, D1)
Register Address from which you start writing.
In D0 the highest part of the Register Address and in D1 the lowest.

REGISTERS VALUE (D2, D3, D4, D5)
Value to be written in the registers, ordered as in the following table:

D2	8 MSB of the value to write to the register at the address STARTING ADDRESS
D3	8 LSB of the value to write to the register at the address STARTING ADDRESS
D4	8 MSB of the value to write to the register at the address STARTING ADDRESS +1
D5	8 LSB of the value to write to the register at the address STARTING ADDRESS +1

Reply format:

<table>
<tr><td colspan="4">ID</td><td>DLC</td><td>D0</td><td>D1</td><td>D2</td><td>D3</td><td>D4</td><td>D5</td></tr>
<tr><td>RESERVED</td><td>FUNCTION CODE</td><td>DESTINATION ADDRESS</td><td>SOURCE ADDRESS</td><td>DATA LENGTH CODE</td><td colspan="2">STARTING ADDRESS</td><td colspan="4">REGISTER VALUE</td></tr>
<tr><td>0x1D</td><td>0x10</td><td>0xYY</td><td>0xTT</td><td>0x06</td><td colspan="2">0xZZZZ</td><td colspan="2">0x????</td><td colspan="2">0x????</td></tr>
</table>

RESERVED
Fixed to 0x1D.

FUNCTION CODE
Function Code 0x10.

DESTINATION ADDRESS
Address of the board that required the “Write Registers” (1 byte).

SOURCE ADDRESS
Address of the board that reply (1 byte).

DATA LENGTH CODE
Amount of bytes of the data, fixed to 0x06.

STARTING ADDRESS (D0 e D1)
Register Address from which you start writing.
In D0 the highest part of the Register Address and in D1 the lowest.

REGISTER VALUE (D2, D3, D4, D5)
Value written in the registers, ordered as in the following table:

D2	8 MSB of the value writen to the register at the address STARTING ADDRESS
D3	8 LSB of the value writen to the register at the address STARTING ADDRESS
D4	8 MSB of the value writen to the register at the address STARTING ADDRESS +1
D5	8 LSB of the value writen to the register at the address STARTING ADDRESS +1

Example 14
Suppose you want to set a voltage of 6.730 V (6730 mV that is 0x0000 1A4A).in the analogue output AOUT0 RB01C1 address is 0x95, requester address 0xAB.
With reference to the table of addresses (registers) in the chap. 15 the number 0x0000 1A4A has to be written in the registers 2304 and 2305 in decimal base, 0x0900 and 0x0901 in exadecimal base.

Summarizing, the Starting Address is:
$(2304)_{10} = (0900)_{16}$ = 0x0900

and the value to write in the registers is:
0x0000 to the register 2304 (0x900)
0x1A4A to the register 2305 (0x901)

Message format (request) :

ID				DLC	D0	D1	D2	D3	D4	D5
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS		REGISTER VALUE			
0x1D	0x10	0x95	0xAB	0x06	0x0900		0x0000		0x1A4A	

Reply:

ID				DLC	D0	D1	D2	D3	D4	D5
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS		REGISTER VALUE			
0x1D	0x10	0xAB	0x95	0x06	0x0900		0x0000		0x1A4A	

25. Exception messages on CANBUS protocol

An EXCEPTION message will be generated in the following cases:

- Function Code not supported: – illegal Function Code: **0x01**;
- odd Start Addresses: – illegal data address: **0x02**;
- (Start Address + Quantity of Registers) > 65536: – illegal data address: **0x02**;
- attempt to write a read only registers: – slave device failure: **0x04**;
- Data lenght not in compliance with the Function Code: – illegal data value: **0x03**.

In **bold** the Exception codes.

Format of the Exception message:

ID				DLC	D0
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	EXCEPTION CODE
0x1D	0x??	0x??	0x??	0x01	0x??

RESERVED
Fixed to 0x1D.

FUNCTION CODE
Function Code is in compliance with Exception Function Code of MODBUS RTU.

DESTINATION ADDRESS
Address of the requester of the function not successfully processed (1 byte).

SOURCE ADDRESS
Address of the board that reply (1 byte).

DATA LENGTH CODE
Amount of bytes of the data, fixed to 0x01.

EXCEPTION CODE (D0)
Exception Code is in compliance with Exception Code of MODBUS RTU (exception code = (function code) or bit to bit (0x80).

Example 15
Suppose you want to set in the analogue output AOUT0 a voltage of 6.730V (6730 mV that is 0x0000 1A4A).
The address of RB01C1 is 0x95 and the address of the requester is 0xAB.
With reference to the table of addresses (registers) in the chap. 15 the number 0x0000 1A4A has to be written (**Function Code 0x10**) the registers 2304 and 2305 in decimal base, 0x0900 and 0x0901 in exadecimal base.

Summarizing, the Starting Address is:
$(2304)_{10} = (0900)_{16}$ = 0x0900

and the value to write in the registers is:
0x0000 to the register 2304 (0x0900)
0x1A4A to the register 2305 (0x0901)

Message format (request) with an error on Function Code:

ID				DLC	D0	D1	D2	D3	D4	D5
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	STARTING ADDRESS		REGISTER VALUE			
0x1D	**0x14**	0x95	0xAB	0x06	0x0900		0x0000		0x1A4A	

Reply:

ID				DLC	D0
RESERVED	FUNCTION CODE	DESTINATION ADDRESS	SOURCE ADDRESS	DATA LENGTH CODE	**EXCEPTION CODE**
0x1D	0x94	0xAB	0x95	0x01	**0x01**

FUNCTION CODE
Function Code (0x14) or bit to bit (0x80).

0001 0100 or	0x14 or
1000 0000	0x80
1001 0100	0x94

RB01C1 è prodotto in Italia da:

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