Environmental monitoring solutions

Alpha-Log

Communication protocols

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Revisions list

Issue	***Data***	***Description of changes***
Origin	27/11/2017	
a	12/04/2021	Removed Pluvi-ONE; added Alpha-Log and new command of Modbus RTU and Modbus TCP parts
b	15/11/2021	Added MQTT protocol; formatting of some tables
c	04/07/2022	Added examples of use with modpoll program

Notes about this manual

Table of contents

1 Introduction

Alpha-Log supports some different communication protocols. In addition to the native *SAP* protocol, it supports Modbus RTU and TCP, SDI-12, MQTT, TCP/IP and others.
This manual describes the *Modbus RTU* and *Modbus TCP* protocol in slave mode and MQTT protocol.

2 Modbus RTU protocol

Modbus RTU is a serial communication protocol widely used in industry to enable communication between a *master* (usually a PCor a SCADA system) and one or more *slaves* (measuring instruments, control or PLC), connected to the same communication bus. Modbus defines how the *master* and *slaves* devices establish and interrupt the communication, how messages are exchanged and how errors are detected. Only the master can initiate the communication.

Each device connected to the bus is assigned a unique address. A Modbus command contains the address of the destination device which the message is direct to. Only the addressed device will respond to the command, although other instruments are receiving the same message. All transmitted Modbus messages contain control information, that allow the receiver to evaluate their correct reception.

2.1 Messages format

Master/slave devices use following messages format:

Field name	***Size***	***Description***
Address	1 byte	The address of the slave device with which the master must communicate (instrument network address); broadcast message (ID = 0) is not supported
Function code	1 byte	Data field (payload) of variable length
Data	n bytes	Data payload
CRC16	2 bytes	Message control code calculated according to the CRC16 algorithm

After receiving the message, the slave device analyzes the correspondence between its own network address and the one contained in the message; it also evaluates the control code against the one calculated independently. If both conditions are verified, the slave device responds to the received message, otherwise it discards the message without transmitting any reply (§2.3.4).

2.1.1 Network address

The address is used to identify the message’s receiver: it includes the numeric address of selected slave device. It can have values from 1 to 247. Use 3DOM application to change the *network address*.

Broadcast messages (address = 0) are not supported.

2.1.2 Function code

Function code detects the command to excute or the manages command by the slave.
Instrument supports following function codes:

Function code	***Function name***	***Description***
01	Read Coils	It reads the status of the actuators and the operation state of the instrument
03	Read Holding Registers	It reads last acquired values by the instrument (digital and analogue measures)
04	Read Input Registers	Same as *Read Holding Registers*
05	Write Single Coil	It sets up an instrument's actuator state
0F	Write Multiple Coils	It resets the instrument's operation errors
10	Write Multiple Registers	It sets the system date time and some measurement configuration parameters
2B	Read Device Identification	It reads the instrument information

The instrument does not consider any function codes not included into the table, and in case of unmanaged command, it does not replay any errors (exception).

2.1.3 CRC16

CRC16 includes the cyclic redundancy code (*Cyclic Redundancy Check*) that has been calculated with CRC16 algorithm (polynomial X^16 + X^15 + X^2 + 1). For calculation of these two characters, the message is considered like one continuous binary number and its must important bit (MSB) is broadcast first.

2.2 Communication lines

Alpha-Log supports Modbus RTU on the RS485 (called *Com3*) and RS232 (called *Com2*) communication lines. Refer to the instrument manual to find the electrical connection diagram.

2.3 Supported functions

2.3.1 Read Coils

Use *Read Coils* to read instrument's actuators state and possible operation errors.

Note: the command does not provide the status of the actuators available on the ALIEM units possibly connected to Alpha-Log.

Following table sums up the meaning.

Coils	***Value***	***Meaning***
Status of actuators	0	Actuation output switched off
	1	Actuation output switched on
Operating status	0	Not in error
	1	Error

Address (Hex)	***Coil***	***Meaning***
Status of actuators		
0x00	01	Status of actuator no. 1
	02	Status of actuator no. 2
	03	Status of actuator no. 3
	04	Status of actuator no. 4
	05	*Not used*
	06	*Not used*
	07	*Not used*
	08	*Not used*
Operating status (errors)		
0x01	09	Error Read After Write
	10	Saved configuration not-valid
	11	Search error of storage page
	12	Max loop number exceeded during stored data search
	13	Overrun acceptance queue acquisition request
	14	Overrun storage queue acquisition results
	15	*Not used*
	16	Failed page writing in store
0x02	17	One or more pages of processing data lost
	18	Failed deleting store sector
	19	Timeout about waiting operation stop in store
	20	Store device not supported
	21	Wrong received message (check code not valid)
	22	Message repeated up to 3 times max.
	23	Message has been deleted owing to max repeat
	24	Error deleted during writing/reading of EEProm slave inside
0x03	25	Slave cannot operate because configuration hasn't been programmed
	26	Overflow reception of single message
	27	Messages queue full in slave
	28	All CISS errors about syntax
	29	CISS Error not specified (Unspecified)
	30	CISS Error (BadCommandCode)
	31	CISS Error (BadParameter)
	32	CISS Error (ParameterOutOfRange)
0x04	33	CISS Error (UnrecognizedCDV)
	34	CISS Error (BeyondMaxClassLevel)
	35	CISS Error (ParameterIndexOutOfRange)
	36	CISS Error (ClassIndexOutOfRange)
	37	CISS Error (RequestNotPermitted)
	38	*Not used*
	39	*Not used*
	40	*Not used*

Request

Function code	1 byte	0x01
Start address	2 bytes	from 0x00 to 0x27
Coils number	2 bytes	from 1 to 40

Answer

Function code	1 byte	0x01
Byte number	1 byte	1
Actuator/error status	1 byte	1=On, 0=Off

Error

Function code	1 byte	0x81
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see §2.4.

Example: reading request about instrument’s actuators state with ID equal to 01:

Request	
Field name	***(Hex)***
Device address	01
Function code	01
Start address (Hi)	00
Start address (Lo)	00
Actuators number (Hi)	00
Actuators number (Lo)	08
CRC16 (Hi)	3D
CRC16 (Lo)	CC

Answer to request with following values: 0, 0, 1, 0, 0, 0, 0, 0:

Answer	
Field name	***(Hex)***
Device address	01
Function code	01
Byte number	01
Value	04
CRC16 (Hi)	50
CRC16 (Lo)	4B

2.3.2 Read Holding Registers

Read Holding Registers and *Read Input Registers* are similar. In the Request use 0x03 function code for the first case and 0x04 for the second.

For more information, see *Read Input Registers* explanation command.

2.3.3 Read Input Registers

Use the function *Read Input Registers* to read last values acquired by the instrument, both analogue and digital measures, and the system date time. Acquired values can be read in numeric floating-point format by requesting them from the address 0 (0x0000) and in integer format from the address 1000 (0x03E8) while the date time from the address 2000 (0x07D0).

The address to set for each request is as follows:

Address (Hex)	***Number of registers***	***Meaning***
IEEE754 float values		
0x0000	2	Measure value 1
0x0002	2	Measure value 2
…	…	…
0x00C4	2	Measure value 99
Integer values (WORD)		
0x03E8	1	Measure value 1
0x03E9	1	Measure value 2
…	…	…
0x044B	1	Measure value 99
System date time (yy MM dd hh mm ss)		
0x07D0	1	yy MM
0x07D1	1	dd hh
0x07D2	1	mm ss

2.3.3.1 Values expressed in floating point format

Each measure value transmitted in floating point format required 4 byte, so it uses 2 Modbus registers. Floating point values are expressed as indicated in the IEEE754 standard.

Through program 3DOM it's possible select the data format between *Big Endian* and *Little Endian*. Data transmission, with option set to *false*, starts from the most significant byte (MSB - Most Signi-ficant Byte) while with option set to *true* it starts from the least significant byte (LSB). i.e. the value 11,0 is stored from the address 0x20 like follow:

			Memory address (Hex)	**(Hex) value in Big Endian format**	**(Hex) value in Little Endian format**
			…		
Value 11,0	Register 1	Byte 1	0x20 (Hi)	00	30
		Byte 2	0x20 (Lo)	00	41
	Register 2	Byte 1	0x21 (Hi)	41	00
		Byte 2	0x21 (Lo)	30	00
			…		

As the frame consists of 255 characters, it is possible to transmit max 60 measures for each request message. It is necessary arrange two requests to obtain all 99 measures.

The value -999999 (0xF02374C9), unless otherwise specified in the instrument configuration (parameter set via 3DOM), corresponds to *measure in error*.

Request

Function code	1 byte	0x04
Start address	2 bytes	from 0x0000 to 0x00C4
Number of registers	2 bytes	from 2 to 198 (max 120)

Answer

Function code	1 byte	0x04
Number of bytes	1 byte	2 x N*
Value	2 bytes x N*	

*N = number of measures.

Error

Function code	1 byte	0x84
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see chapter 2.4.

Data area

#Measure	1	2	3	4	5	6	…	99
Address (hex)	0x00	0x02	0x04	0x06	0x08	0x0A	…	0x0C4

Example: request for reading, in the float format, of measures 3 and 4 of instrument with ID equal to 01:

First measure that has to be read is number 3, so set up the start address 0x04, like specified in *Data area*. The output number (registers) is 0x04 because each measure consists of 2 bytes as specified in the request.

Request	
Field name	***(Hex)***
Device address	01
Function code	04
Start address (Hi)	00
Start address (Lo)	04
Output number (Hi)	00
Output number (Lo)	04
CRC16 (Hi)	B0
CRC16 (Lo)	08

Answer to request with values 99.0 for measure 3 (output value 1) and 101.0 for measure 4 (output value 2):

Answer	
Field name	***(Hex)***
Device address	01
Function code	04
Byte number	08
Output value 1 (byte 1)	00
Output value 1 (byte 2)	00
Output value 1 (byte 3)	42
Output value 1 (byte 4)	C6
Output value 2 (byte 1)	00
Output value 2 (byte 2)	00
Output value 2 (byte 3)	42
Output value 2 (byte 4)	C4
CRC16 (Hi)	13
CRC16 (Lo)	C9

2.3.3.2 Values expressed in integer binary format

In the integer binary format each measure consists of 2 bytes that is one Modbus register. Data format is *Little Endian.* Data storage starts from less significant byte (LSB). So the value 1149 (0x0545) is stored from the address 0x03E8 like follow:

			Memory address (Hex)	**Value (Hex) in Little Endian format**
			…	
Value 1149	Register 1	Byte 1	0x03E8 (Hi)	05
		Byte 2	0x03E8 (Lo)	45

The instrument uses the setting of the precision of each specific measurement (number of digits after decimal) to calculate the integer value transmitted by Modbus. For example, the value 23.45 of a measure set with two decimal values becomes 2345, while the value 68.4 of a measure set with a decimal value becomes 684.

Unlike to the floating point format, for the integer type it is possible to obtain all the 99 measures, which the data logger is capable, in a single request.
A value of -1 (0xFFFF), unless otherwise specified in the instrument configuration (parameter set via 3DOM), corresponds to *measure in error*.

Request

Function code	1 byte	0x04
Start address	2 bytes	da 0x03E8 a 0x044B
Number of registers	2 bytes	da 1 a 99

Answer

Function code	1 byte	0x04
Number of bytes	1 byte	2 x N*
Value	2 byte x N*	

*N = number of measures.

Error

Function code	1 byte	0x84
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see chapter 2.4.

Data area

# Measure	1	2	3	4	…	99
Address (hex)	0x03E8	0x03E9	0x03EA	0x03EB	…	0x044B

Example: request for reading, in the integer format, of measure 3 of instrument with ID equal to 01:

The measure that has to be read is number 3, so set up the start address 0x03EA, like specified in Data area. The output number (register) is 0x01 because the measure consists of 1 byte like specified in the request.

Request	
Field name	***(Hex)***
Device address	01
Function code	04
Start address (Hi)	03
Start address (Lo)	EA
Output number (Hi)	00
Output number (Lo)	01
CRC16 (Hi)	A5
CRC16 (Lo)	BA

Answer to request with value 1343:

Answer	
Field name	***(Hex)***
Device address	01
Function code	04
Byte number	02
Output value 1 (byte 1)	05
Output value 1 (byte 2)	3F
CRC16 (Hi)	FB
CRC16 (Lo)	04

The measure that has to be read is number 3, so set up the start address 0x03EA, like specified in *Data area*. The output number (register) is 0x01 because the measure consists of 1 byte like specified in the request.

2.3.3.3 System date time

Request

Function code	1 byte	0x04
Start address	2 bytes	from 0x07D0 to 0x07D2
Number of registers	2 bytes	from 1 to 3

Answer

Function code	1 byte	0x04
Number of bytes	1 byte	2 x N*
Value	2 bytes x N*	

*N = number of registers.
The sequence of date/time fields starting from address 0x07D0 is: yy MM dd hh mm ss

Error

Function code	1 byte	0x84
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see chapter 2.4.

Example: request for reading the date time of instrument with ID equal to 01:

Answer to request with date time 01/02/21 10:36:42:

Request	
Field name	***(Hex)***
Device address	01
Function code	04
Start address (Hi)	07
Start address (Lo)	D0
Output number (Hi)	00
Output number (Lo)	03
CRC16 (Hi)	B0
CRC16 (Lo)	86

Answer	
Field name	***(Hex)***
Device address	01
Function code	04
Byte number	06
Output value 1 (byte 1)	15
Output value 1 (byte 2)	02
Output value 2 (byte 1)	01
Output value 2 (byte 2)	0A
Output value 3 (byte 1)	24
Output value 3 (byte 2)	2A
CRC16 (Hi)	A4
CRC16 (Lo)	D7

2.3.4 Write Single Coil

Use *Write Single Coil* function to set up the state of instrument's actuators (digital outputs).

The value equal to *0x0000* sets up the actuator's output to *0*; *0xFF00* sets up the actuator's output to *1*. State *0* usually indicates actuator switched-off, and state *1* indicates actuator switched-on.

Request

Function code	1 byte	0x05
Start address	2 bytes	from 0x0000 to 0x0003
Value	2 bytes	0x0000 or 0xFF00

Answer

Function code	1 byte	0x01
Start address	2 bytes	from 0x0000 to 0x0007
Value	2 bytes	0x0000 or 0xFF00

Error

Function code	1 byte	0x85
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see §2.4.

Example: request to set up to 0 the state of actuator number 3 of the instrument with ID equal to 01:

Request	
Field name	***(Hex)***
Device address	01
Function code	05
Start address (Hi)	00
Start address (Lo)	02
Value (Hi)	00
Value (Lo)	00
CRC16 (Hi)	6C
CRC16 (Lo)	0A

Answer	
Field name	***(Hex)***
Device address	01
Function code	05
Start address (Hi)	00
Start address (Lo)	02
Value (Hi)	00
Value (Lo)	00
CRC16 (Hi)	6C
CRC16 (Lo)	0A

2.3.5 Write Multiple Coils

Use *Write Multiple Coils* function to reset possible operation errors detected through *Read Coils* function. This command executes on all bit together; it is not possible to reset only one or a group of errors. Following command reset all detected errors.

Request

Function code	1 byte	0x0F
Start Code	2 bytes	0x0000
Coil Number	2 bytes	32
Byte number	1 byte	4
Value	4 bytes	0x0000

Answer

Function code	1 byte	0x0F
Start Code	2 bytes	0x0000
Coil Number	2 bytes	32

Error

Function code	1 byte	0x8F
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see §2.4.

Example: request to set to 0 the operation errors of instrument with ID equal to 01:

Request	
Field name	***(Hex)***
Indirizzo dispositivo	01
Codice funzione	0F
Indirizzo inizio (Hi)	00
Indirizzo inizio (Lo)	00
Numero di coil (Hi)	00
Numero di coil (Lo)	20
Numero di byte	04
Valore 1 (Hi)	00
Valore 1 (Lo)	00
Valore 2 (Hi)	00
Valore 2 (Lo)	00
CRC16 (Hi)	C4
CRC16 (Lo)	88

Answer	
Field name	***(Hex)***
Device address	01
Function code	0F
Start address (Hi)	00
Start address (Lo)	00
Coils number (Hi)	00
Coils number (Lo)	20
CRC16 (Hi)	21
CRC16 (Lo)	79

2.3.6 Write Multiple Registers

Use *Write Multiple Registers* function to set the system date time and some measures configuration parameters.

The address to set for each request is as follows:

Address (Hex)	***Number of registers***	***Meaning***
System date time (yy mm dd hh mm ss)		
0x07D0	3	yy mm dd hh mm ss
Measure configuration		
0x07DA	5	Value used for measurement error in the decimal binary and floating point type, measure enable (up to max 32)

The configuration parameters of the measure that can be changed are:

- Value to assign to the measure when it is in error in the WORD format (2 bytes = 1 register);
- Value to assign to the measure when it is in error in the float format (4 bytes = 2 registers); use *Little Endian* format;
- Measure enabled status (one bit for each activation status of the measure for a maximum of 32 measures (4 bytes = 2 registers); the measure not enabled will be considered in error.

These parameters are stored permanently until they are reset or until the next reconfiguration of the instrument by 3DOM. In this case they are set with default values: -1 for binary decimal values, -999999 for floating point values, all measures enabled.

Example 1: request to set the system date time to 09/06/21 16:03:05 (yy/mm/dd hh:mm:ss format):

Request	
Field name	***(Hex)***
Device address	01
Function code	10
Start address (Hi)	07
Start address (Lo)	D0
Registers number (Hi)	00
Registers number (Lo)	03
Byte number	06
Value 1 (Hi)	15
Value 1 (Lo)	06
Value 2 (Hi)	09
Value 2 (Lo)	10
Value 3 (Hi)	03
Value 3 (Lo)	05
CRC16 (Hi)	B0
CRC16 (Lo)	32

Answer	
Field name	***(Hex)***
Device address	01
Function code	10
Start address (Hi)	07
Start address (Lo)	D0
Coils number (Hi)	00
Coils number (Lo)	03
CRC16 (Hi)	80
CRC16 (Lo)	85

Example 2: request to set the measures parameters with the following values: -12345 (0xCFC7) for measure in error for binary decimal type, -12345678 (0x4E613CCB) for measure in error for float type and all measures disabled except the first 3:

Request	
Field name	***(Hex)***
Device address	01
Function code	10
Start address (Hi)	07
Start address (Lo)	DA
Registers number (Hi)	00
Registers number (Lo)	05
Byte number	0A
Value 1 (Hi)	C7
Value 1 (Lo)	CF
Value 2 (Hi)	4E
Value 2 (Lo)	61
Value 3 (Hi)	3C
Value 3 (Lo)	CB
Value 4 (Hi)	07
Value 4 (Lo)	00
Value 5 (Hi)	00
Value 5 (Lo)	00
CRC16 (Hi)	6C
CRC16 (Lo)	11

Answer	
Field name	***(Hex)***
Device address	01
Function code	10
Start address (Hi)	07
Start address (Lo)	DA
Coils number (Hi)	00
Coisl number (Lo)	05
CRC16 (Hi)	20
CRC16 (Lo)	85

2.3.7 Read Device Identification

Use *Read Device Identification* to get information about instrument, i.e.: producing company name, type, code, serial number and instrument model.

Request

Function code	1 byte	0x2B
MEI type	1 byte	0x0E
Id code device reading	1 byte	01
Id object	1 byte	0x00

Answer

Function code	1 byte	0x2B
MEI*type	1 byte	0x0E
Id code device reading	1 byte	01
Compliance level	1 byte	0x01
Follow	1 byte	0
Next object Id	1 byte	Object Id number
Objects number	1 byte	3
Object 1 Id	1 byte	0
Object 1 Length	1 byte	26
Object 1 Value	object 1 length	"LSI-Lastem - Milan (Italy)"
Object 2 Id	1 byte	1
Object 2 Length	1 byte	23
Object 2 Value	object 2 length	Type, Code, Serial number and user name
Object 3 Id	1 byte	2
Object 3 Length	1 byte	7
Object 3 Value	object 3 length	Instrument version

Error

Function code	1 byte	Function code + 0x80
Exception code	1 byte	01 or 02 or 03 or 04

For detailed information on *Exception code* see §2.4.

Example: here below the example with Alpha-Log type ALP-001, serial number 18020267, firmware version 2.01.00 with ID set to 01:

Request	
Field name	***(Hex)***
Device address	01
Function code	2B
MEI type	0E
Id Code device reading	01
Id object	00
CRC16 (Hi)	70
CRC16 (Lo)	77

Answer	
Field name	***(Hex)***
Device address	01
Function code	2B
MEI* type	0E
Id Code device reading	01
Compliance level	01
follow	00
Id next object	00
Objects number	03
Object 1 Id	00
Object 1 length	1A
Object 1 value *	“LSI-Lastem - Milan (Italy)”
Object 2 Id	01
Object 2 length	17
Object 2 value *	“ALP-001; Serial18020267”
Object 3 Id	02
Object 3 length	07
Object 3 value *	“2.01.00”
CRC16 (Hi)	27
CRC16 (Lo)	3B

*Hexadecimal value for:

- Object 1 value:	[4C][53][49][2D][4C][61][73][74][65][6D][20][2D][20][4D][69][6C][61][6E][20] [28][49][74][61][6C][79][29]
- Object 2 value:	[41][4C][50][2D][30][30][31][3B][20][53][65][72][69][61][6C][31][38][30][32] [30][32][36][37]
- Object 3 value:	[32][2E][30][31][2E][30][30]

2.4 Exception codes

The exception codes are transmitted when the command sent to slave cannot be executed, even if it’s correct. The returned exception codes are the following:

Code	***Name***	***Meaning***
01	ILLEGAL FUNCTION (not supported at the moment)	The function code doesn’t correspond with one function supported by the slave device
02	ILLEGAL DATA ADDRESS	The register address specified is not valid
03	ILLEGAL DATA VALUE	The value to assign isn’t valid for specified address
04	SLAVE DEVICE FAILURE	Error detected during the command execution

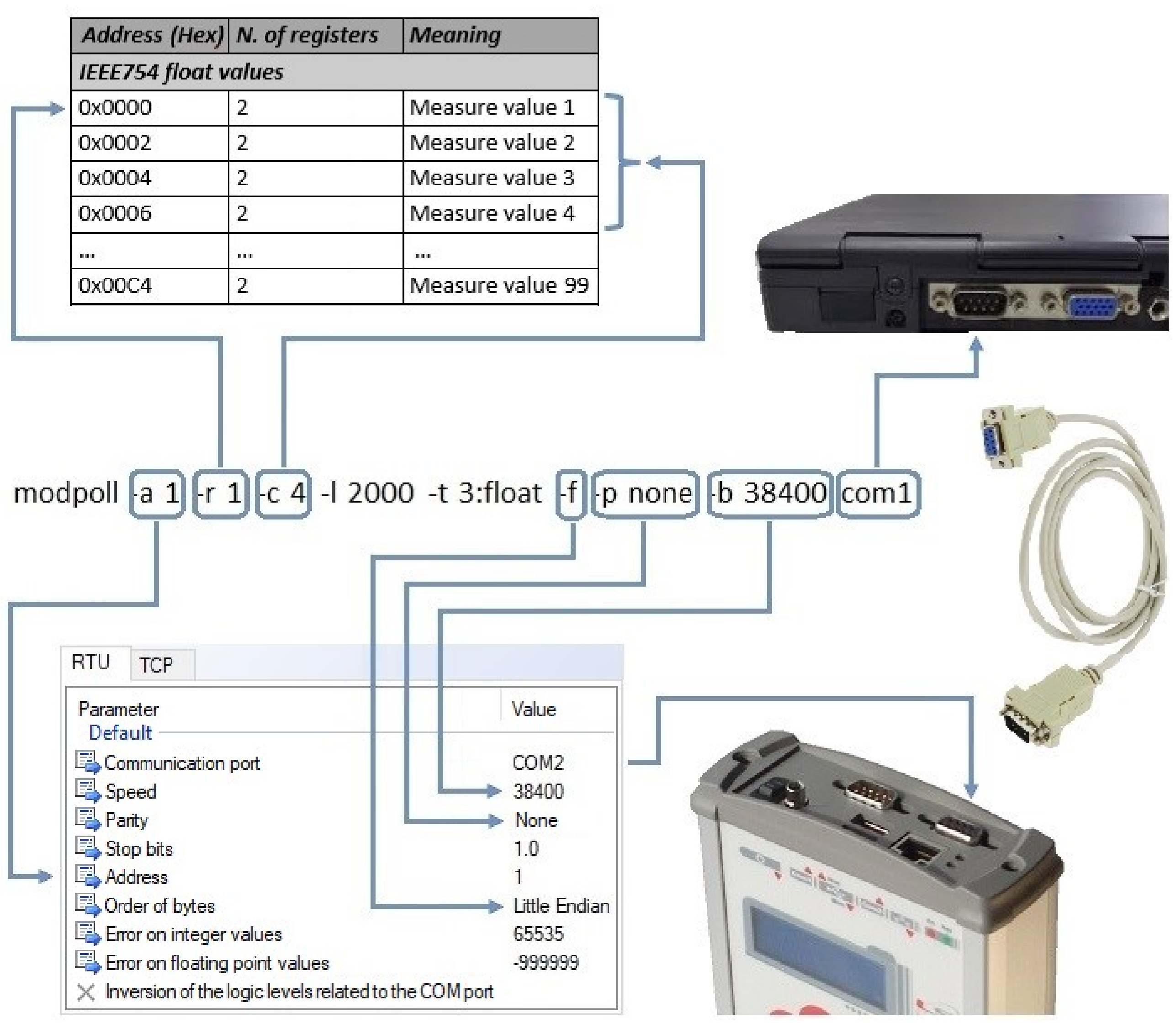
2.5 Check with modpoll program

The function codes 0x03 (Read Holding Registers) and 0x04 (Read Input Registers) can be checked with modpoll.

Modpoll is a command line based Modbus master simulation program. It can be downloaded for free from the website https://www.modbusdriver.com/modpoll.html.

With the modpoll -h command you get the list of parameters that can be used.

As an example, the "construction" of the *Read Input Register* command to request the values of the first 4 measurements of the Alpha-Log configured in Modbus Slave mode on the Com2 serial port is shown.



Address (Hex)	*N. of registers*	*Meaning*
IEEE754 float values		
0x0000	2	Measure value 1
0x0002	2	Measure value 2
0x0004	2	Measure value 3
0x0006	2	Measure value 4
...	...	...
0x00C4	2	Measure value 99

```
modpoll -a 1 -r 1 -c 4 -l 2000 -t 3:float -f -p none -b 38400 com1
```

Parameter	Value
Default	
Communication port	COM2
Speed	38400
Parity	None
Stop bits	1.0
Address	1
Order of bytes	Little Endian
Error on integer values	65535
Error on floating point values	-999999
Inversion of the logic levels related to the COM port	

Following the result:

```
modpoll 3.1 - FieldTalk(tm) Modbus(R) Master Simulator
Copyright (c) 2002-2011 proconX Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: Modbus RTU
Slave configuration...: address = 1, start reference = 1, count = 4
Communication.........: com1, 38400, 8, 1, none, t/o 1.00 s, poll rate 2000 ms
Data type.............: 32-bit float, input register table
Word swapping.........: Slave configured as big-endian float machine

-- Polling slave... (Ctrl-C to stop)
[1]: 22.604630
[3]: 12.187080
[5]: 1002.520020
[7]: 1002.234985
-- Polling slave... (Ctrl-C to stop)
[1]: 22.608200
[3]: 12.187080
[5]: 1003.099976
[7]: 1002.523254
-- Polling slave... (Ctrl-C to stop)
[1]: 22.608200
[3]: 12.187080
[5]: 1003.099976
[7]: 1002.523254
-- Polling slave... (Ctrl-C to stop)
[1]: 22.608200
[3]: 12.187080
[5]: 1003.099976
[7]: 1002.523254
…
```

3 Modbus TCP protocol

Modbus TCP is an extension of the Modbus RTU protocol. It uses the TCP interface in an Ethernet network. Error checking is not performed via CRC but at the IP frame level. The addressing of the devices is managed via IP.

3.1 Communication port

Alpha-Log can be reached via Modbus TCP if connected to the network via the Ethernet port or via a USB Wi-Fi stick. For more information, refer to the user manual of the instrument.

3.2 Addressing

The addressing of the devices is based on IP. Master and slave, or better, Client and Server, to communicate with each other must have the same range of IP addresses.
Use the 3DOM program to set the IP address.

Broadcast messages (address = 0) are not supported.

3.3 Supported functions

Modbus TCP supports the *Read Holding Registers* and *Read Input Registers* functions.

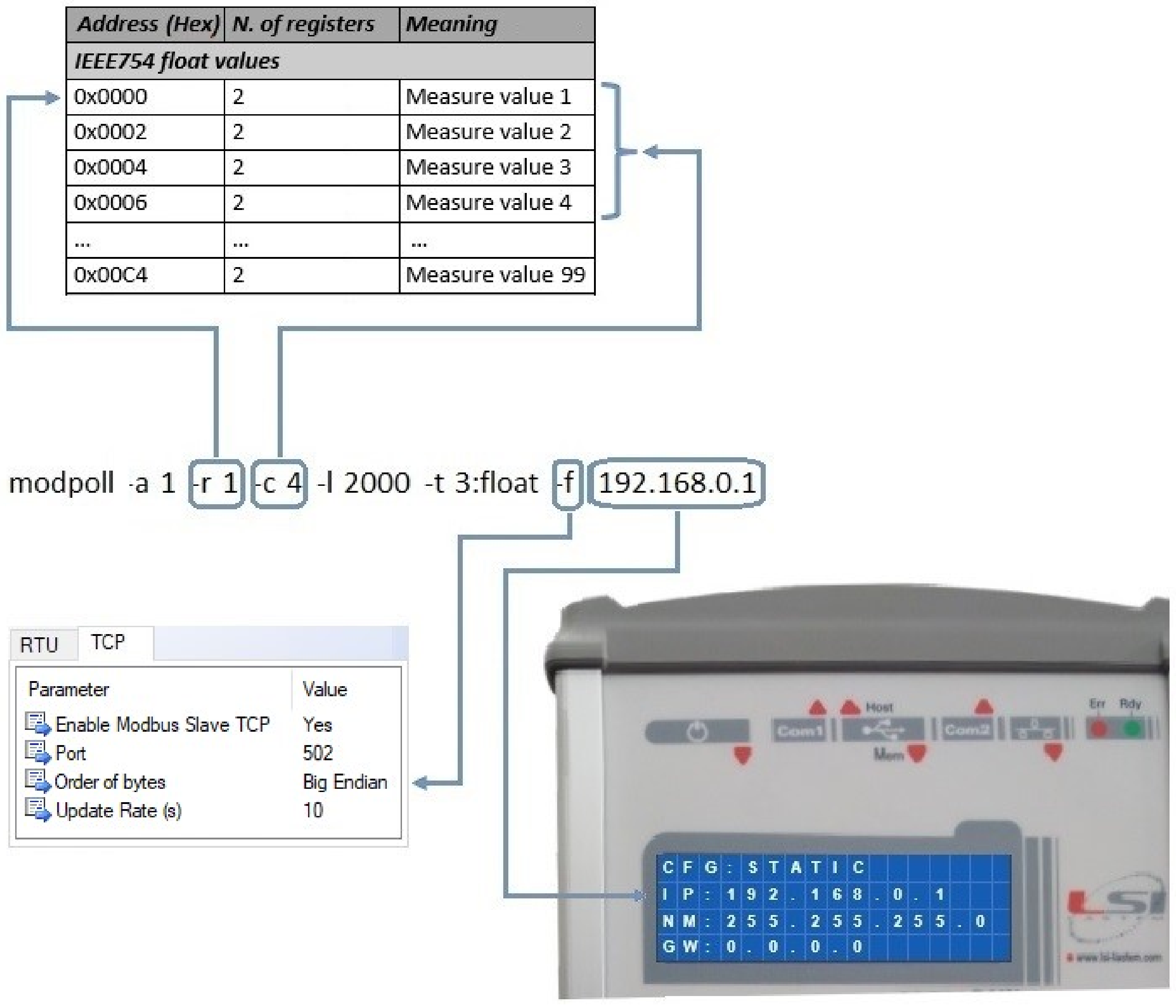
Function code	***Function name***	***Description***
03	Read Holding Registers	It reads last acquired values by the instrument (digital and analogue measures)
04	Read Input Registers	Same as *Read Holding Registers*

The functions are implemented exactly as in Modbus RTU. For more information refer to §2.3.2 and §2.3.3.

3.4 Check with modpoll program

As for Modbus RTU, also the function codes 0x03 (Read Holding Registers) and 0x04 (Read Input Regi-sters) of Modbus TCP can be verified with the modpoll simulation program. The parameters to be used are not those of the serial port but those of the TCP connection.

As an example, the “construction” of the Read Input Register command to request the values of the first 4 measurements of the Alpha-Log configured in Modbus Slave TCP is shown.



Address (Hex)	*N. of registers*	*Meaning*
IEEE754 float values		
0x0000	2	Measure value 1
0x0002	2	Measure value 2
0x0004	2	Measure value 3
0x0006	2	Measure value 4
…	…	…
0x00C4	2	Measure value 99

```
modpoll -a 1 -r 1 -c 4 -l 2000 -t 3:float -f 192.168.0.1
```

RTU TCP

Parameter	Value
Enable Modbus Slave TCP	Yes
Port	502
Order of bytes	Big Endian
Update Rate (s)	10

```
CFG:STATIC
IP:192.168.0.1
NM:255.255.255.0
GW:0.0.0.0
```

Below is the result:

```
modpoll 3.1 - FieldTalk(tm) Modbus(R) Master Simulator
Copyright (c) 2002-2011 proconX Pty Ltd
Visit http://www.modbusdriver.com for Modbus libraries and tools.

Protocol configuration: MODBUS/TCP
Slave configuration...: address = 1, start reference = 1, count = 4
Communication.........: 192.168.0.1, port 502, t/o 1.00 s, poll rate 2000 ms
Data type.............: 32-bit float, input register table
Word swapping.........: Slave configured as big-endian float machine

-- Polling slave... (Ctrl-C to stop)
[1]: 22.599998
[3]: 12.200000
[5]: 1002.700012
[7]: 1002.400024
-- Polling slave... (Ctrl-C to stop)
[1]: 22.599998
[3]: 12.200000
[5]: 1002.700012
[7]: 1002.400024
-- Polling slave... (Ctrl-C to stop)
[1]: 22.599998
[3]: 12.200000…
```

4 Protocollo MQTT

Alpha-Log supports the use of the MQTT protocol to send information such as data, diagnostics and configurations.

MQTT is a TCP/IP-based protocol based on the *publish-subscribe pattern* where one or more clients connect to a central server said *broker* and can send and receive data related to specific *topics*. The exchange of data takes place through two main actions:

- *publish*: the client tells the broker to publish the data related to a related topic;
- *subscribe*: the client asks the broker to send him all the information related to a topic of interest.

Each client can send information and subscribe to as many topics as they want without any limitation and the broker will simply act as a "card feeder" forwarding the messages identified by a certain topic to all clients currently connected and subscribed to that topic.

Each message sent, in addition to topic and payload, is also associated with a level of *QoS* and a flag called *retain*.

The QoS tells the broker with what certainty you want to deliver the message:

- 0 = At most once
- 1 = At least once
- 2 = Exactly once

The retain flag indicates whether the message, for the assigned topic, should be kept in memory by the broker. In this case the message will be distributed to the clients subscribed to the topic of the message not only in real time but also to a new subscription of the client, after its publication. The last message with retain sent on each topic will overwrite the message previously saved with retain on the same topic, thus always keeping the last message arrived (with retain) for each topic.

The payload of an MQTT message can have any format; Alpha-Log uses the JSON text format.

4.1 MQTT on Alpha-Log

AlphaLog is able to send data via MQTT protocol to a configurable broker.

The configuration of this service allows the choice of different parameters:

- the broker's hostname/ip address[mandatory]
- port, default=1883
- username, default=<empty>
- password, default=<empty>
- flags for sending different types of data:
  - instant
  - processed
  - diagnostic
  - alarms
- If you choose to send instant data, you can choose a sending rate (in seconds)

The topic of the messages is composed of a fixed and unmodifiable base, followed by a specific part for the type of message:

device/<model>/<serial>/<action>

where:

- *<model>*: is the technical code of the product (ALP001, ALP002, ALP*xxx* depending on the generation).
- *<serial>*: is the device's factory serial or user serial, if specified in the configuration.
- *<action>*: is the specific topic part for each type of data (for example, instantaneous data, metrics/inst).

An example topic for a second generation AlphaLog device that sends instant data and with serial 21030052 could be:

device/ALP002/21030052/metrics/inst.

All messages are transmitted with QoS=1 that cannot be modified by the user.

4.2 Data organization

The data produced by the tool are organized into:

- instantaneous data: the readings of the single sampling of the single variable (e.g. the current value of the ambient temperature);

- processed data: the statistical processing of an instantaneous data in a time interval (e.g. maximum value of the ambient temperature in the 5 minutes from 16:00:00 to 16:04:59)

The instant data is not saved in the instrument and can only be sent in real time, without the possibility of re-reading. The processed data are instead kept in the memory of the instrument and can be downloaded several times even after their creation.

The processed data produced are grouped by processing instalment: each processing instalment defines a processing basis. The processing bases are identified by a zero-based index decided automatically during configuration. For example, for three processing rates (60", 300", 600") you will have 3 processing bases (in order: 0, 1, 2).

4.2.1 Instantaneous data

The instant data message is a message containing the values of the last data taken from the device, without any statistical processing but with the necessary corrections (linearization, polynomial, etc.) The message is sent at a configurable range and cannot be retransmitted.

TOPIC	*device/<model>/<serial>/metrics/inst*

PAYLOAD

```
{
  "inst": [
    1022.4,
    14.1,
    0.0,
    287.48
  ],
  "time": "2021-10-28T10:04:21"
}
```

where:

- *Inst:* is an array of floating point numbers containing the instantaneous values of the measurements at that time, in case of measurement in error the transmitted value is *null*.
- *time*: is the timestamp in UTC of the time of reading data from the device.

4.2.2 Processed data

The processed data are derived from a statistical processing over time (average, minimum, maximum, standard deviation, etc.). This type of message is sent at a specified interval during configuration, and does not necessarily coincide with the processing rate.
For each processing base a message is sent containing all the variables processed at the processing rate associated with the base.

TOPIC	*device/<model>/<serial>/metrics/elabs*

PAYLOAD

```
{
  "elab_config_time": "2021-10-27T15:16:33",
  "last_elab_time": "2021-10-28T01:20:00",
  "first_elab_time": "2021-10-28T01:11:00",
  "base": 0,
  "original_filename":"M18050080-C20211027151633-B00-E20211028011100-
L20211028012000.txt",
  "serial": "18050080",
  "elab": [
   {
    "items": [
      45.376802,
      9.398528,
      200.0,
      7200.0,
      1014.59,
      1014.62,
      1014.67,
      35.54,
      35.55,
      35.55
    ],
    "time": "2021-10-28T01:11:00"
   }
  ]
}
```

where:

- *elab_config_time:* is the data configuration timestamp.
- *[first|last]_elab_time:* represent the timestamps of the first and last data of the current message.
- *base:* is the processing base to which the data belong.
- *original_filename:* is the name of the message source file, as well as searchable on the device file system in the data folder (*/var/local/ssb/data/history*).
- *serial:* is the factory device serial.
- *elab:* is an array of json objects composed of an items field (the double values resulting from statistical processing).
- *Time:* the reference timestamp for processing.

4.2.3 Configuration of processed data

The instantaneous/processed data, to be recognized, need a descriptive message that allows it to be mapped between double and variable arrays. This type of message, sent with a processing rate specified in the configuration phase, contains information about the measures transmitted.

TOPIC	*device/<model>/<serial>/config/metrics*

PAYLOAD	(see JSON below)

```
{
 "MsgUpdateRate": 10,
 "Measures": [
  {
   "MeasKey": "ATM",
   "Name": "ATM",
   "Unit": "",
   "UpdateRate": 5,
   "Prec": 2,
   "ElabSingleGuid": 65535,
   "Elabs": [
    {
     "Rate": 60,
     "Type": "ScalarStat",
     "Elements": "Min, Ave, Max",
     "CoupledGuid": 65535
    }
   ],
   "ProbeSerial": "",
   "ProbeCert": "",
   "WMOCode": "",
   "WMOLevel": ""
  },
  {
   "MeasKey": "TEMP",
   "Name": "TEMP",
   "Unit": "",
   "UpdateRate": 10,
   "Prec": 2,
   "ElabSingleGuid": 65535,
   "Elabs": [
    {
     "Rate": 60,
     "Type": "ScalarStat",
     "Elements": "Min, Ave, Max",
     "CoupledGuid": 65535
    },
    {
     "Rate": 300,
     "Type": "ScalarStat",
     "Elements": "Min, Ave, Max",
     "CoupledGuid": 65535
    }
   ],
   "ProbeSerial": "",
   "ProbeCert": "",
   "WMOCode": "",
   "WMOLevel": ""
  }
 ]
}
```

where:

- *MsgUpdateRate*: is the rate of sending instant data.
- *Measures*: is an array containing the data of the configured measurements (name, type, id, unit of measure, rate of sampling) and the elaborations configured for each of them. Among these parameters the most important are:
  - *Name*: measure name (free textual parameter)
  - *Unit*: measurement unit (free textual parameter)

- *UpdateRate*: sampling rate (whole, in seconds, if =0 the measurement does not carry out periodic sampling but communicates the new measurement value spontaneously)
- *Elabs*: measurement processing arrays, grouped by type (vector/scale) and by processing rate. Each element of the array contains several parameters, the most important of which are:
  - *Rate*: processing rate, in seconds
  - *Type*: type of processing (scalar or vector)
  - *Elements*: elaborations calculated on this measure in the time interval expressed by *Rate* (Inst, Min, Ave, Max, StdDev, Tot, Duration, TimeMin, TimeMax, PrevDir, RisDir, RisVel, StdDevDir, CalmPerc)

In the *Measures* array the measurements are in the same order as the instantaneous data, while to map the processed data you need to verify the sequence of information related to the processing of each measurement.

4.2.3.1 Configuration example

In the example *config/metrics* message above you can find two ATM and TEMP measurements that will reflect only the two values present in the array of instantaneous measurements. Each measurement is sampled every 5 and 10 seconds respectively.

For the ATM measurement, the minimum, average and maximum minute processing of the measured values in that time interval has been configured.

Two processing bases have been configured for the TEMP measurement:

- processing base 0: 60 seconds, with minimum, average and maximum
- processing base 1: 300 seconds, with minimum, average and maximum

The following values will then be produced:

- every 60 seconds: ATM[min], ATM[avg], ATM[max], TEMP[min], TEMP[avg], TEMP[max]
- every 300 seconds: TEMP[min], TEMP[avg], TEMP[max]

Assuming that the rate of data transmission is every 10 minutes (600"), the following *config/metrics* messages will be sent when data is sent:

- a message related to processing base 0, where in the *elab* array there will be 10 elements, each with 6 values within the *items* array.
- a message related to processing base 1, where in the *elab* array there will be 2 elements, each with 3 values within the *items* array.

In case of failure to send, the data will be put in a queue and then re-sent together with any new data created.

4.2.4 Diagnostic data

Diagnostic data is the data obtained by extracting information from different components of the system (Linux OS, data logging and sampling, communications, clocks, etc.)

TOPIC	*device/<model>/<serial>/status/diagnostic*

PAYLOAD

```
{
  "network": {
    "interfaces": {
      "eth0": {
        "tx_bytes": "241758",
        "ip": "192.168.1.69",
        "mac": "00:d0:69:4d:6f:de",
        "rx_bytes": "505146",
        "internet": {
          "status": true,
          "ip": "80.180.46.234"
        }
      }
    }
  },
  "device_space": {
    "used": 2461060.0,
    "perc_used": 81.2,
    "free": 569740.0,
    "is_full": false,
    "perc_free": 18.8,
    "total": 3030800.0
  },
  "com_stats": {
    "up_time": 84150.0,
    "COM": [
      {
        "tx_frames": 0,
        "name": "COM1",
        "rx_bytes": 0,
        "rx_frames": 0,
        "rx_failed": 0,
        "tx_bytes": 0
      },
      {
        "tx_frames": 0,
        "name": "COM2",
        "rx_bytes": 0,
        "rx_frames": 0,
        "rx_failed": 0,
        "tx_bytes": 0
      },
      {
        "tx_frames": 0,
        "name": "COM3",
        "rx_bytes": 0,
        "rx_frames": 0,
        "rx_failed": 0,
        "tx_bytes": 0
      },
      {
        "tx_frames": 0,
        "name": "COM4",
        "rx_bytes": 0,
        "rx_frames": 0,
        "rx_failed": 0,
        "tx_bytes": 0
      },
```

(continues)

PAYLOAD

```
      {
        "tx_frames": 0,
        "name": "COM5",
        "rx_bytes": 0,
        "rx_frames": 0,
        "rx_failed": 0,
        "tx_bytes": 0
      },
      {
        "tx_frames": 11425,
        "name": "COM6",
        "rx_bytes": 133377,
        "rx_frames": 11426,
        "rx_failed": 0,
        "tx_bytes": 230795
      }
    ]
  },
  "time": {
    "sbc": "2021-10-28T12:40:11",
    "sbc_uptime": "14:40:11 up 43 min, 1 user, load average: 0.25, 0.25, 0.32",
    "ssb": "2021-10-28T14:40:12"
  }
}
```

where:

- *network.interfaces*: is a dictionary of network interfaces, where the key is the system name of the interface and the value are its properties, with the following fields:
    - *tx_bytes, rx_bytes:* bytes transmitted and received.
    - *ip:* local IP address.
    - *mac:* MAC address.
    - *internet.status* e *internet.ip:* [optional] indicate if the device is accessible from the Internet and, if so, with which IP.
- *device_space*: contains information on available space in the device, where:
    - *is_full*: allows you to understand not only if the disk is full for too much data but also if there are too many files in the queue sending
    - *used, free*: total number of bytes, in use and free
    - *perc_used, perc_free*: percentage of space in use and free
- *com_stats*: contains information taken from the low-level sampling system: *uptime* is the number of seconds since the system is switched on while *COM* is the array containing the communication statistics of the various COM ports available. Each object related to the COM port consists of the following properties:
    - *name*: name of the COM port (COM1, COM2, etc.)
    - *tx_frames, rx_frames, rx_failed*: number of frames sent, received, error
    - *tx_bytes, rx_bytes*: number of total bytes transmitted and received
- *time*: contains information on system clocks:
    - *sbc*: is the UTC timestamp of the SBC card
    - *ssb*: is the timestamp with SSB card timezone
    - sbc_uptime: contains system boot information