E4000 air quality probe Modbus protocol

Ver	Date	Update
V1	Initial	Version Initial/Initial version
V2	10 June 2012	Temperature control with PID
V3	11 oct. 2012	ASCII & RTU
V4	22 mar 2013	New registers (heating and cooling setting points)

Summary

English

Modbus Protocol

The Modbus protocol allows a master unit to access up to 255 slaves units connected on a single bus. Each slave is assigned an address that distinguishes it from other slaves connected to the bus.

Transactions can be only initiated by the master and are of two types:
- Question / answer One slave is addressed
- Broadcast / no answer All slaves are addressed, but they shall not reply

Characteristics used for communication with Modbus protocol:

Characteristics	ASCII (7-bit)	RTU (8 bits)
coding System	hexadecimal (utilisation of ASCII printable characters (0-9, A-F)	Binary
Number of bits par character :		10
Start bits	1	1
data bits (least significant first)	7	8
parity (optional)	1 (odd parity)	No parity
Stop bits	1	1
Error Checking	LRC (Longitudinal Redundancy Check)	CRC16
Baud rate	1200	9600

In the rest of document, regarding the transmitted data, you will find the following information:
x = x-CHAR-BIT
This information indicates the size of the data transmitted in ASCII and RTU mode (x = y BIT ASCII RTU). For example, 2-CHAR = 8bits means that the ASCII frame, the information is coded on 2 bytes in RTU mode, the information is encoded in 8 BIT.

Error Checking LRC (Longitudinal Redundancy Check)
The error control used in ASCII mode is the RSC. The error control consists of a binary number transmitted as two ASCII characters representing a hexadecimal encoding. The characters ' :', CR, LF, and any other non-ASCII character are ignored in computing the RSC.

Address	02		0000 0010
Function	01		0000 0001
Start Add H.O.	00		0000 0000
Start Add L.O.	00		0000 0000
Quantity of Pts	00		0000 0000
	08		0000 1000
		Sum	0000 1011
		Complement at 1	1111 0100
		+1	0000 0001
Error Check	F5	Complement at 2	1111 0101

ASCII Raster

ASCII transmission mode is initiated by issuing a ':' character which indicates the beginning of the plot and characters carriage return and end of line (CR LF) to indicate the end. The end of line character (LF) is also used as a synchronization character that indicates that the transmitting station is ready to receive a new frame.

MASTER

BEGIN FRAME	ADDRESS	FUNCTION	DATA	ERROR CHECK	EOF	READY TO RECEIVE
:	2-CHAR =	2-CHAR =	N X 4-CHAR	2-CHAR = 8-	CR	LF

	8-BITS	8BITS	N X 16-BITS	BITS		

SLAVE

BEGIN FRAME	ADDRESS	FUNCTION	NUMBER OF DATA OCTETS = 2*N	DATA	ERROR CHECK	EOF	READY TO RECEIVE
:	2-CHAR = 8-BITS	2-CHAR = 8BITS	2-CHAR = 8BITS	N X 4-CHAR N X 16-BITS	2-CHAR = 8-BITS	CR	LF

RTU Raster

RTU mode transmission is in binary. Termination of the frame is determined by a time of silence of about 3.5 bytes (in our case about 30ms)

MASTER

ADDRESS	FUNCTION	DATA	ERROR CHECK CRC 16
8-BITS	8BITS	N X 16-BITS	BITS

SLAVE

ADDRESS	FUNCTION	NUMBER OF DATA BYTES	DATA	ERROR CHECK CRC 16
8-BITS	8BITS	8BITS	N X 16-BITS	16 BITS

Address field

The address field follows the first frame and consists of two ASCII characters.

Each slave must have a unique address and will only answer to queries that contained his address. When a slave reply, the address field of the latter shall inform the master about the origin of this response. In broadcast mode, the address used and 0. In this case, all slaves interpret the request, but don't respond.

Addresses are divided into 31 groups of 255 slaves as follows:

GROUP ADDRESS	LOCAL ADDRESS
2-CHAR = 16-BIT	2-CHAR = 16-BIT

The group addresses will only be used by repeaters. The slave receiver will only read the local address.

Function Field "Function"

The function code tells the recipient slave which function to address.

CODE	MEANING	ACTION
01	READ COIL STATUS	Obtains current status, (ON/OFF), of a group of logic coils.
02	READ INPUT STATUS	Obtains current status, (ON/OFF), of a group of discrete inputs.
03	READ HOLDING REGISTER	Obtains current binary value in one or more holding registers.
04	READ INPUT REGISTER	Obtains current binary value in one or more input registers.
05	FORCE SINGLE COIL	Force logic coil to a state of ON or OFF.
06	PRESET SINGLE REGISTER	Place a specific binary value into a holding register.
15	WRITE MULTIPLE COILS	Force a group of logic coils to a defined state.
16	PRESET MULTIPLE REGISTERS	Place specific binary values into a group of holding registers.

Number of data Field

This field contains a number indicating the number of bytes in the Data fields.

Data Field: "Data Field"

Data field contains informations necessary for the slave to process the command sent by the master, or contains information that is sent in response by the slave to the master.

Request from the master:

INPUT MODE : Function = 4

FIRST REGISTER	NUMBER OF REGISTERS TO READ
4-CHAR = 16-BIT	4-CHAR = 16-BIT

Request from master:

WRITE MULTIPLE REGISTERS : Function = 16

REGISTER'S ADDRESS	NUMBER OF REGISTERS TO WRITE	BYTE COUNT	VALUE(S) TO WRITE
4-CHAR = 16-BIT	4-CHAR = 16-BIT	2-CHAR = 8-BIT	4-CHAR = 16-BIT

The address of the first register is **0**

Read access : Function = 4 (0x04)

REGISTER #1 : SLAVE STATUS	REGISTER #2 : GAS	REGISTER # 3 : CONCENTRATION CO2	REGISTER # 4 : CONCENTRATION COV	REGISTER # 5 : TEMPERATURE
4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS

REGISTER # 6 : HUMIDITY	REGISTER #7 : 2 SPEEDS FAN ON OFF COMMAND	REGISTER # 8 : FAN THRESHOLDS	REGISTER # 9 : TYPES OF DRY CONTACTS SPEED 1 & 2	REGISTER # 10 : FAN COMMAND LINEAR
4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS

REGISTER # 11 : HEATER COMMAND IN %	REGISTER # 12 : FAN COOLING COMMAND IN %	REGISTER # 13 : HEATER SETPOINT	REGISTER # 14 : COOLER SETPOINT	REGISTER # 15 : FIRMWARE VERSION
4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS	4-CHAR = 16-BITS

Description of read records:

SLAVE STATUS: Register #1 (address 0)
08 Pre heating
09 B. I. T. OK
10 Temperature Failure
11 Failure Sensor
12 Power supply fault
13 EEPROM fault
14 Not calibrated
15 Calibration in progress

GAS: Register #2 (address 1) (not used, CO2 for E4000)
2-CHAR (16-BITS):
00 CO

01 O2
02 O3
03 H2
04 CH4
05 PARTICLES
06 RADON
07 H2S
0A NO2
0E EC
0F CO2 (code used to define E4000 board)

CO2 CONCENTRATION (in ppm): Register #3 (address 2)
2-CHAR (16-BITS):
Bit 0 to 14: Value
Bit 15 = 1: Saturation

VOC CONCENTRATION (in 0.01 ppm): Register #4 (address 3)
2-CHAR (16-BITS):
Bit 0 to 14: Value
Bit 15 = 1: Saturation

TEMPERATURE (in 0.1 °C): Register # 5 (address 4)
2-CHAR (16-BITS)
16 bits = temperature value (signed)

Examples
0°C = 0
12,9°C (value sent : 129) = 129 (decimal)
-5°C (value sent: -50) = -32718 (decimal) (complement at 2 on 16 bits: 1 bit for sign + 15 bits for value)

HUMIDITY in %: Register # 6 (address 5)
2-CHAR (16-BITS):
16 bits = humidity value (non signed)

2 SPEEDS FAN ON OFF COMMAND: Register # 7 (address 6)
2-CHAR (16-BITS):
Character 1: Fan Speed 1
Character 2: Fan Speed 2

00: alarm not trigged
FF: alarm trigged

Example:
- Fan 1 ON
- Fan 2 OFF

REGISTER #7 : ON OFF 2 FAN SPEEDS COMMAND			
Character 1		Character 2	
F	F	0	0
4-CHAR = 16-BITS			

FAN THRESHOLDS: Register # 8 (address 7)
2-CHAR (16-BITS)
Character 1: alarm level used for speed 1
Character 2: alarm level used for speed 2

‘00’: Level 1
‘FF’: Level 2

Example:

- Contact 1 threshold 1
- Contact 2 threshold 2

REGISTER # 8 : FAN THRESHOLDS			
Character 1		Character 2	
0	0	F	F
4-CHAR = 16-BITS			

TYPES OF DRY CONTACTS SPEED 1 & 2: Register # 9 (address 8)
2-CHAR (16-BITS)
Character 1: type of contact 1
Character 2: type of contact 2

'00': normally open (NO)
'FF': normally closed (NC)

Example:

- Contact 1 normally open
- Contact 2 normally closed

REGISTER # 9 : TYPES OF DRY CONTACTS SPEED 1 & 2			
Character 1		Character 2	
0	0	F	F
4-CHAR = 16-BITS			

FAN COMMAND LINEAR: REGISTER # 10 (ADDRESS 9)
2-CHAR (16-bit)
Value between 0 and 100%. This value can be used to control ventilation in continues. Similar to the 1-10V output. To be noted that to keep the building health a minimum of 10% is applied (1V).

HEATING COMMAND LINEAR: REGISTER # 11 (ADDRESS 10)
2-CHAR (16-bit)
Value between 0 and 100%. This value can be used to control heating in continues.

COOLING COMMAND LINEAR: REGISTER # 12 (ADDRESS 11)
2-CHAR (16-bit)
Value between 0 and 100%. This value can be used to control air conditioning in continues.

HEATER SETTING POINT (in 0.1 °C): Register # 13 (address 12)
2-CHAR (16-BITS)
16 bits = temperature value (unsigned)

Examples
20.9°C (value sent : 209) = 209 (decimal)

COOLER SETTING POINT (in 0.1 °C): Register # 14 (address 13)
2-CHAR (16-BITS)
16 bits = temperature value (unsigned)

Examples
28.9°C (value sent : 289) = 289 (decimal)

FIRMWARE VERSION: REGISTER #15 (ADDRESS 14)
2-CHAR (16-BITS)

Write access : Function = 16 (0x10)

Only the registers 13 and 14 are writable to allow adjustment of heating and cooling set points.

REGISTER # 13 : HEATER SETTING POINT	REGISTER # 14 : COOLER SETTING POINT
4-CHAR = 16-BITS	4-CHAR = 16-BITS

Description of writable registers

HEATER SETTING POINT (in 0.1 °C): Register # 13 (address 12)
2-CHAR (16-BITS)
16 bits = temperature value (unsigned)

Examples
20.9°C (value sent : 209) = 209 (decimal)

COOLER SETTING POINT (in 0.1 °C): Register # 14 (address 13)
2-CHAR (16-BITS)
16 bits = temperature value (unsigned)

Examples
28.9°C (value sent : 289) = 289 (decimal)

Response to master when using function 16 (0x10)

Write acknowledge :

FUNBCTION CODE (0x10)	REGISTER'S ADDRESS	NUMBER OF REGISTERS TO WRITE
2-CHAR = 8-BIT	4-CHAR = 16-BIT	4-CHAR = 16-BIT

When ending with an error :

ERROR CODE (0x90)	EXCEPTION CODE
2-CHAR = 8-BIT	2-CHAR = 8-BIT

The exception code used by the E4000 is the exception n° 3 (Illegal data value). This exception means that there are less than 5°C between heating and cooling set points.