Akros Series Modbus Communications

Instructions Manual

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1. INTRODUCTION

This manual is intended for users requiring digital communications with the MODBUS protocol for supervision, control and configuration of processes via the AK49, AK49H and AK96 controllers of the Akros series.

It is considered that the user has basic familiarity with communications protocols, and with operation of Akros series controllers.

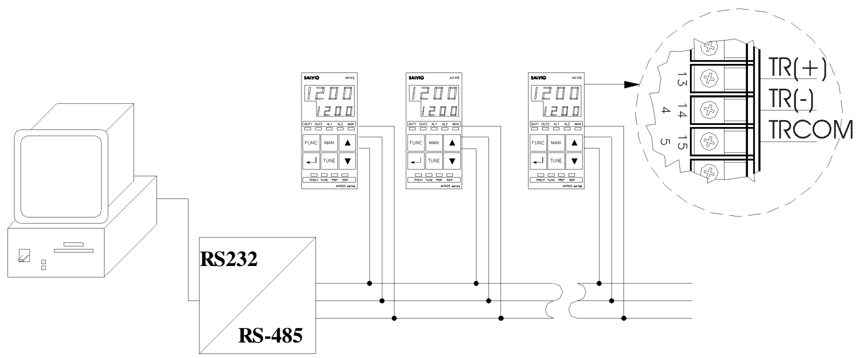
2. RS485 COMMUNICATIONS

2.1. RS485 Standard

The RS485 communications standard enables connection of one or more instruments via two conductors with a maximum length of 1200 m. In addition, it is advisable to connect a ground/shield wire as a common, in order to provide the line with additional noise protection.

2.2. Connections

The AK49, AK49H and AK96 models in the Akros series from SALVIO BUSQUETS admit connections to RS485 buses via two conductors plus one additional earth one. To use an RS485 connection from a PC, an RS-3232/RS485 converter needs to be inserted. If the converter provides RS485 communications to 4 conductors, the terminals marked as TX- should be connected to RX- and, in turn, the terminals marked TX+ to RX+. In this way, two lines will be obtained, which we shall identify as TR+ and TR-.



In addition, just after the last instrument in the line, a 220 Ohm termination resistance should be connected in the line between TR+ and TR-.

Run the communications cables along different paths from the power leads. The communications leads can be channelled next to signal leads if these are not exposed to interference source. We recommend using twisted pair cables, with a capacity between conductors of less than 60pF, rated characteristic impedance at 100 kHz of 100 Ohm, and a rated resistance of less than 100/Ohm/km (minimum 24 AWG conductors).

3. MODBUS PROTOCOL

3.1. Introduction

The MODBUS protocol defines a message structure which can be recognised by different units, regardless of the type of communications network used. The protocol describes the process for accessing information from a unit, how this should respond, and how error situations are notified.
The MODBUS protocol defines a digital communications network with a single master and one or more slave units.

3.2. Transmission mode

The transmission mode is the structure of the units of information contained in a message. The MODBUS protocol defines two transmission modes: ASCII (American Standard Code for Information Interchange) and RTU (Remote Terminal Unit). In a network of units connected by the MODBUS protocol, units **CANNOT** be shared by using different transmission modes.
The AK49, AK49H and AK96 in the Akros series communicate in RTU mode.

3.3. Message structure

A message consists of a sequence of characters which can be interpreted by the receiver. This sequence of characters defines the frame.
To synchronize the frame, the receiver units monitor the time interval elapsing between characters received. If an interval greater than three and a half times the time required to transmit a character is detected, the receiver unit ignores the frame and assumes that the following character it receives will be an address.

3.5T	**ADDRESS**	**FUNCTION**	**DATA**	**CRC**	**3.5T**
3.5 bytes	1 byte	1 byte	N bytes	2 bytes	3.5 Bytes

3.3.1 Address

The address field is the first of the frame after the synchronization time. It indicates the unit the message is addressed to. Each unit in the network must have a unique address assigned, other than zero.
Likewise, when a unit responds to a message, it must first send its address so that the master recognises the source of the message.
MODBUS enables messages to be sent to all the units at the same time, using the zero address to do this. However, to prevent conflicts with other units in the network, the AK49, AK49H and AK96 models in the Akros series do not accept this type of message.

3.3.1 Function

The function field tells the unit addressed what type of function it is to perform. The AK49, AK49H and AK96 models accept the following functions:

Code	Function
01 or 02	Read N bits (max. 255)
03 or 04	Read N registers (max 52)
05	Write 1 bit
06	Write 1 register
07	Read instrument status byte

see section 3.4 for a description of the functions

3.3.2 Data

The data field contains the information needed for the units to be able to perform the functions requested, or the information sent by the units to the master in response to a function.

3.3.3 CRC

The CRC field is the last in the frame and enables the master and the units to detect transmission errors. Occasionally, due to electric noise or interference of any other kind, certain modifications may occur to the message while it is being transmitted. The error control by CRC ensures that the receiver units or the master will not perform wrong actions due to accidental modification of a message.
The Akros series controllers do **NOT** send any response when they detect a CRC error in the frame received.
For CRC calculation, neither the stop nor parity bits are considered. Just the data.
The sequence for CRC calculation is described as follows:

1. Load a 16-bit register to 1's.
2. Perform an exclusive OR of the first 8 bits received with the high register byte, saving the result in the register.
3. Shift the register one bit to the right.
4. a) If the overflow bit is 1, perform an exclusive OR of the value 1010 0000 0000 0001 with the content of the register and save it in the register.
4. b) If the overflow bit is 0, go back to step 3.
5. Repeat steps 3 and 4 until 8 bit shifts have been made.
6. Perform an exclusive OR of the following byte of the frame with the 16-bit register.
7. Repeat steps 3 to 6 until all the bytes in the frame have been processed.
8. The content of the 16-bit register is the CRC, which is added to the message with the most significant bit first.

3.4. Description of the functions

3.4.1 Read N bits (Function Code 01 or 02)

This function enables the user to obtain the logical values (ON/OFF) of the bits of the unit addressed. The response data are packaged in bytes so that the first bit requested occupies the least significant bit of the first data byte. The next ones follow on so that, if they are not a multiple of 8, the remaining bits of the last byte are set to zero.

Master-unit frame:

Address of unit	Function Code (01 or 02)	Address of first bit		Number of bits to be read (max. 255)		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

unit-master frame:

Address of unit	Function Code	Number of bytes read	First data byte	....	Last data byte	CRC	
1 byte	1 byte	1 byte	1 byte	....	1 byte	MSB	LSB

For example: Read 2 bits from bit with address 3, of controller with address 2.

Master-unit:

Address of unit	Function Code	Address of first bit		Number of bits to be read		CRC	
02	01	00	03	00	02	4D	F8

Unit-master:

Address of unit	Function Code	Number of bytes read	First data byte	CRC	
02	01	01	03	11	CD

The response tells us that the bits of address 3 (AL1) and 4 (AL2) are set to 1. So, alarms AL1 and AL2 are activated. The response has assigned zeros to the addresses which have not been asked for from the master, which does not mean that their real value is zero.

3.4.1 Read N Registers (Function Code 03 or 04)

This function enables the user to obtain the registers value of the unit addressed. These registers store the numerical values of the controller's parameters and variables. The range of the data goes from 0 to 65536 (see section 4.2). The data corresponding to addresses of registers going over the last valid address of parameters are returned as zero (00 00).

Master-unit frame:

Address of unit	Function Code (03 or 04)	Address of first register		Number of registers to be read (max. 51)		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

unit-master frame:

Address of unit	Function Code	Number of bytes read	Value of first register		......	Value of last register		CRC	
1 byte	1 byte	1 byte	MSB	LSB	......	MSB	LSB	MSB	LSB

For example: Read 2 registers as from the register with address 3, of the controller with address 2.

Master-unit:

Address of unit	Function Code	Address of first register		Number of registers to be read		CRC	
02	03	00	03	00	02	34	38

Unit-master:

Address of unit	Function Code	Number of bytes read	Value of first register		Value of last register		CRC	
02	03	04	00	F0	00	3C	89	32

The response tells us that the registers of address 3 (Ti) and 4 (Td) have, respectively, the hexadecimal value of 00F0 and 003C. So, the corresponding decimal values are: TD=240 and Ti=60.

3.4.3 write a bit (Function Code 05)

This function enables the user to set the logical values (ON/OFF) of the bits of the unit addressed. To set a bit value of 0, 00h must be sent and to set a bir value of 1t, 01h or FFh. This value should be written in the **most significant byte**.

Master-unit frame:

Address of unit	Function Code (05)	Address of bit		Value of bit		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame:

Address of unit	Function Code (05)	Address of bit		Value of bit		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

For example: Set a value 1 to the bit of address 5, of the controller with address 2.

Master-unit:

Address of unit	Function Code	Address of bit		Value of bit		CRC	
02	05	00	05	01	00	DC	68

Unit-master:

Address of unit	Function Code	Address of bit		Value of bit		CRC	
02	05	00	05	01	00	DC	68

The response tells us that bit 5 (manual mode) has been set and the controller is therefore in manual control.

3.4.4 Write a register (Function code 06)

This function enables the user to modifiy the content of the parameters of the unit addressed. The values are sent scaled in accordance with the scale factor corresponding to each parameter, in a range between 0000h and FFFFh (see section 4.2).

Master-unit frame:

Address of unit	Function Code (06)	Address of register		Value of register		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame

Address of unit	Function Code (06)	Address of register		Value of register		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

For example: Assign the value 150 (0096h) to the register of address 01, of the controller with address 2.

Master-unit:

Address of unit	Function Code	Address of register		Value of register		CRC	
02	06	00	01	00	96	D8	11

Unit-master:

Address of unit	Function Code	Address of register		Value of register		CRC	
02	06	00	01	00	96	D8	11

The response tells us that register 1 (Heating setpoint) has received the value of 150.

3.4.5 Read instrument status byte (Function Code 07)

This function enables the user to obtain a fast reading of the status of the instrument addressed, by reading one single byte.

Master-unit frame:

Address of unit	Function Code (07)	CRC	
1 byte	1 byte	MSB	LSB

Unit-master frame:

Address of unit	Function Code	Status byte	CRC	
1 byte	1 byte	1 byte	MSB	LSB

For example: Request Status byte of the controller with address 2.

Master-unit:

Address of unit	Function Code	CRC	
02	07	41	12

Unit-master:

Address of unit	Function Code	Status byte	CRC	
02	07	0C	D2	30

The response tells us that bits 2 (AL1) and 3 (AL2) of the status byte are at 1. So, alarms AL1 and AL2 are activated.

Status byte:

bit	Parameter
0	1= overrange
1	1=underrange
2	1=AL1 enabled
3	1=AL2 enabled
4	1= Manual mode
5	1= Autotuning working
6	1= Pre-heating stage
7	1= User operating with keyboard

3.5. Error codes

Generally, errors appearing during operations to access and program units relate to invalid data in the frame. When a unit detects an error of this type, the response to the master consists of the unit's address, the function code, the error code and the CRC. To indicate that the response is an error notification, the most significant bit of the function code is set to 1.

The AK49, AK49H and AK96 models of the Akros series from SALVIO BUSQUETS use the following error codes:

Error code	Description
01	Invalid function
02	invalid data address field
03	invalid data field
06	Busy: Accessing the EEPROM.

With reference to Akros series controllers, the following cases should be considered:

If a unit receives a request for reading of N bits and goes over the last accessible address, the controller sends the value 00 in response for non-existent addresses.
If a unit receives a request for reading of N registers and goes over the last accessible address, the controller sends the value 00 00 in response for non-existent addresses.
If a unit receives a request for writing a register defined as "read only", the controller sends error code 2 in response.
If a unit receives a request for writing a register and a user is modifying a parameter from the keyboard at this moment, the controller sends error code 6 in response.
If a unit receives a request for writing a register or bit, but another parameter makes it incompatible (enabling autotuning in ON/OFF control, switching to manual mode whilst the autotuning function is enabled, modifying the power output in automatic control, etc...), the controller sends error code 03 in response.
If a unit receives a request for writing of a register or bit corresponding to an option not installed in the instrument, the controller sends error code 03 in response.
When the controller is in ON/OFF control mode with operation in manual mode, if it receives an order to modify the output power to a value between 1 and 100%, the regulator will switch to 100% regardless of the value, without returning any error code.

4. OPERATION OF THE AKROS SERIES

Models AK49, AK49H and AK96 of the Akros series equipped with an RS485 interface for modbus connection must be pre-configured.
The communications are made with a format of 1 start bit, 8 data bits and 1 stop bit. In addition, four parameters can be configured.
To do this, (see Akros series manual of instructions) you should access keyboard level 3 - by pressing and holding the **FUNC** key until the parameter **inp** appears - and advancing - by pressing the **FUNC** key repeatedly - until you come to the following parameters:

Address of the controller in the modbus network

Minimum value	0 (Modbus disabled)
Maximum value	255

Transmission speed

Value	Speed
0	2400 bauds
1	4800 bauds
2	9600 bauds
3	19200 bauds

Parity

Value	Parity
0	none
1	even
2	odd

Delay time

Minimum value	0
Maximum value	10

The dLAY value is the controller's waiting time before answering a frame sent by the master. The time is the result of multiplying the dLAY value by 10 ms. This parameter is required when delays occur in the switching of the receive/send modes in the RS232/RS485 conversion units. In this way, a wait time is created, enabling the communications to be synchronized and conflicts prevented.

4.1. Modbus table of addresses

There follows a list of all the parameters available via communications in the Akros series. All the keyboard-accessible parameters are available via the communications. However, due to the fact that the Akros series can be configured for a great variety of applications, if read or write of a parameter relating to an option not configured in the instrument is accessed, the controller responds with a code 03 error message (see section 3.5).

4.1.1 Modbus bit addresses

MODBUS bit address	Parameter
1	1= overrange *
2	1=underrange *
3	1=AL1 enabled *
4	1=AL2 enabled *
5	1= Manual mode
6	1= Autotuning operating
7	1= Pre-heating stage *
8	1= Operator working with keyboard *
9	1=°C 0=°F
10	1=Primary action: heating 0=Primary action: cooling
11	0=Control with discontinuous output * 1=Control with linear output
12	1= Control for servovalve *
13	1= controller for injection systems *
14	1=Cooling installed *
15	1=Linear transmission installed *
16	1=Direct linear retransmission 0=Inverse linear retransmission

* Read only addresses

4.1.2 Modbus register addresses

Address	Parameter	Description	Min.	Max.	Scaling	Notes
1	SP	Heating setpoint	SP.LL	SP.HL	Signed integer †	Primary setpoint. For actual setpoint, see ASP (51)
2	Pb	Proportional band	0.1	100.0	integer / 10	
3	Ti	Integral time	1	4000	integer	
4	Td	Derivative time	1	4000	integer	
5	Cy	Heating cycle	1	120	integer	
6	Hy	Heating hysteresis ON/OFF	1	9999	integer †	
7	dB	Servovalve deadband	1	20	integer	
8	REF.C	Cooling setpoint	-999	9999	integer †	
9	P.C	Cooling configuration	0	100	integer	
10	Cy.C	Cooling action cycle	1	120	integer	
11	Hy.C	Cooling action hysteresis	1	9999	integer †	

12	C.A1	Configuration alarm 1 0 – disabled 1 - absolute HI DIR 2 - absolute HI REV 3 – absolute LW DIR 4 – absolute LW REV 5 - relative HI DIR 6 - relative HI REV 7 - relative LW DIR 8 - relative LW REV 9 – WINDOW DIR 10 – WINDOW REV	0	10	integer	
13	SP.A1	absolute setpoint alarm 1	**	**	Signed integer †	Min/Max depend on the input scale
14	r.A1	relative setpoint alarm 1	-999	9999	Signed integer †	
15	Hy.A1	Hysteresis of alarm 1	1	9999	integer †	
16	C.A2	Configuration alarm 2 0 – disabled 1 - absolute HI DIR 2 - absolute HI REV 3 – absolute LW DIR 4 – absolute LW REV 5 - relative HI DIR 6 - relative HI REV 7 - relative LW DIR 8 - relative LW REV 9 – WINDOW DIR 10 – WINDOW REV	1	10	integer	

17	SP.A2	absolute setpoint alarm 2	**	**	Signed integer †	Min/Max depend on input probe
18	r.A2	relative setpoint alarm 2	-999	9999	Signed integer †	
19	Hy.A2	Hysteresis of alarm 2	1	9999	integer †	
20	S.SP	Secondary setpoint	SP.LL	SP.HL	Signed integer	
21	BIAS	Bias of input variable	-999	9999	Signed integer †	
22	unit	Units 0- °F 1- °C	0	1	integer	
23	out.L	Output limit	0	100	integer	
24	SP.LL	Setpoint low limit	(probe)	SP.HL	Signed integer †	
25	SP.HL	Setpoint high limit	SP.LL	(probe)	Signed integer †	
26	in.At	Initial autotuning 1- Enabled 0- Disabled	0	1	integer	
27	At.ty	Autotuning type 1- Step response 0- Relay feedback	0	1	integer	
28	Ct.ty	Control type 0 – On/Off 1- PID 2- PI+D	0	2	integer	
29	HEAT	Primary action 0 – Cooling 1- Heating	0	1	integer	

30	inP	Input probe 0- J (0..600°C) 1- L (0..600°C) 2- K (0..1200°C) 3- N (0..1200°C) 4- T (0..400°C) 5- R (0..1600°C) 6- S (0..1600°C) 7- RTD (0..600) 8- RTD (-99.9..200.0) 9- 0..5V 10- 0..10V 11- 0..20mA 12- 4..20 mA	0	12	integer	
31	dP	Decimal points	0	2	integer	only for linear input probes
32	inL	Start of linear input scale	-999	inH-1	Signed integer †	
33	inH	End of linear input scale	inL+1	9999	Signed integer †	
34	rSP	Remote setpoint 0- disabled 1- enabled	0	1	integer	
35	rSP.L	Start of remote setpoint scale	(probe)	rSP.H -1	Signed integer †	
36	rSP.H	End of remote setpoint scale	rSP.L +1	(probe)	Signed integer †	
37	Lrt	Linear retransmission 0- Inverse 1- Direct	0	1	integer	

38	Lrt.L	Start of linear retransmission scale	(probe)	Lrt.H-1	Signed integer †	
39	Lrt.H	End of linear retransmission scale	Lrt.L+1	(probe)	Signed integer †	
40	d.in	Digital input 0- Secondary setpoint 1- Keyboard protection	0	1	integer	
41	Code	Keyboard protection password	0	9999	integer	
42	Level	Keyboard protection level 0- Consulting but no modification 1- Consulting and modifying setpoint 2- No consulting or modification	0	2	integer	
43	Addr	Modbus controller address	0	255	integer	
44	bAud	Modbus transmission speed 0 –2400 1 –4800 2 –9600 3 –19200	0	3	integer	
45	Prty	Parity in Modbus comm. r/w 0 – none 1 – even 2 – odd	0	2	integer	

46	dLAy	Delay time in Modbus	0	10	integer	(x10 ms)
47	Out	Control output	0	100	integer	%
48	Status	Status byte * bit 0 1-overrange bit 1 1-underrange bit 2 1-AL1 enabled bit 3 1-AL2 enabled bit 4 1- Manual mode bit 5 1- Autotuning operating bit 6 1- Pre-heating stage bit 7 1- Operation with keyboard			integer	

49	Conf	Factory configuration * bit1 0-Control with discontinuous output 1-Control with linear output bit2 1-Control of servovalve bit3 1-Control of injection systems bit4 1-Cooling relay installed bit5 1-Linear retransmission installed bit6 0 bit7 0 bit8 0			integer	
50	PV	Value of the process variable *	**	**	0... start of scale 65535...End of scale	
51	ASP	Actual setpoint *	SP.LL	SP.HL	Signed integer †	Operative setpoint
52	DISP	Value of the process varialbe in display resolution *	**	**	Signed integer †	

* Read only registers

† If the input probe (inP) is number 8 (RTD /-99.9...200.0), it should be divided by 10. If the input probe is linear (inP = 9,10,11 or 12), in line with the value of dP (0, 1 or 2), it should be divided by 1, 10 or 100 respectively.

** The maximum and minimum values depend on the scale of the probe selected (inp).

4.2. Numerical format of the parameters

The parameters of the above table are scaled in three different ways:
Integers: Hexadecimal numerical values between 0000h and FFFFh (0 and 65535) inclusively.
Signed Integers: Hexadecimal numerical values with sign. Thus, for positive values the margin is reduced to values from 0000h to 7FFFh (0 to 32767) and for negative values, from 8001h to FFFFh (-32767 to –1) .
Scaled: The parameter 50 (PV) should be scaled to the scale values of the probe selected. Regardless of whether the scale of the probe has negative values, this parameter is always coded as an unsigned integer. Scaling subsequent to the probe scaling will generate the corresponding sign.