K31D

Communication protocol

User's guide

INDEX

1 Preface

This document is intended to describe the K31D series controllers using the MODBUS protocol in their communication capability and is mainly directed to technicians, system integrators and software developers.

The subject is subdivided in four levels of interest:

1. Describes the physical connection to the line;
2. Presents the data link protocol, that is a subset of the MODBUS RTU (JBUS) protocol;
3. Describes in detail each data that can be exchanged;
4. States performance characteristics of the system.

2 Physical connection

2.1 Interface

K31D series controllers are provided with a RS485 serial communication interface, insulated so that any problem arising from ground potential is removed.

While at rest, the instruments are in a receive condition and are revert to transmission after a correct message has been decoded that matches the configured address.

2.2 Line

The instruments are equipped with 2 terminals named A and B.
The connection between K31Ds has to be carried on in parallel, i.e. all A terminals have to be connected between them so as B terminals.

A termination resistor of 120Ω is required to maintain the quiescent condition on the line;

Adopted baud rate ranges from 1200 to 38400 baud, that is very satisfactory for application performance, yet very slow for RS485 interface. This fact allows the wiring of the line with a medium quality twisted pair cable: total capacity of the line should not exceed 200 nF.

The line can be up to 1000 meters in length.

3 Communication protocol

The protocol adopted by K31D series is a subset of the widely used MODBUS RTU (JBUS)[1] protocol, so that connections are easy for many commercial PLCs and supervisory programs.

For users needing to develop their own communication software, all information is available as well as implementation hints.

The MODBUS RTU (JBUS) communication functions implemented in K31D series are:

- function 3 - n word read;
- function 6 - one word write.

These functions allow the supervisory program to read and modify any data of the controller.

The communication is based on messages sent by the master station (host) to the slave stations (K31D) and vice-versa.

The slave station that recognizes its proper address in the message, analyses the content and, if it is formally and semantically correct, generates a reply message directed back to the master.

The communication process involves five types of messages:

from master to slave	from slave to master
function 3: n word read request	function 3: n word read reply
function 6: one word write request	function 6: one word write reply
	exception reply (as reply to both functions in abnormal conditions)

Each message contains four fields:

- **Slave address** (from 1 to 255): MODBUS RTU (JBUS) reserves address 0 for broadcasting messages, but, due to the implicit unreliability of this type of communication, it is not adopted for the K31D series;
- **Function code**: contains 3 or 6 for specified functions;
- **Information field**: contains data like word addresses and word values as required by function in use;
- **Control word**: a cyclic redundancy check (CRC) performed with particular rules for CRC16.

The characteristics of the asynchronous transmission are: 8 bits, no parity, one stop bit.

1 AEG Schneider Automation, Inc. registered trade mark

3.1 Function 3 - read n words

The number of words to be read must be less or equal four.

The request has the following frame:

slave number	3	first word address MSB	LSB	number of words MSB	LSB	CRC LSB	MSB
byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7

The normal reply (as opposed to exception reply) has the following frame:

slave number	3	NB no. of read bytes	Value of first Word MSB	LSB	Following Words	CRC LSB	MSB
byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte NB + 2	byte NB + 3

3.2 Function 6 - one word write

The request has the following frame:

slave number	6	Word address MSB	LSB	Value to be written MSB	LSB	CRC LSB	MSB
byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7

The normal reply (as opposed to exception reply) is merely an echo of the request message:

slave number	6	Word address MSB	LSB	Value to be written MSB	LSB	CRC LSB	MSB
byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7

3.3 The exception replay

K31D series instruments reply with an exception when the request is formally correct, but cannot be satisfied standing particular situations; the reply contains a code indicating the cause of the missing regular reply, the frame is:

slave number	Function code with most sign. bit set to 1	Exception code	CRC LSB	CRC MSB
byte 0	byte 1	byte 2	byte 3	byte 4

K31D series adopts a subset of MODBUS RTU (JBUS) exception code:

1 Unknown function code;

2 Invalid memory address;

3 Invalid data field;

6 Controller (or data) not ready.

Cyclic redundancy check (CRC)

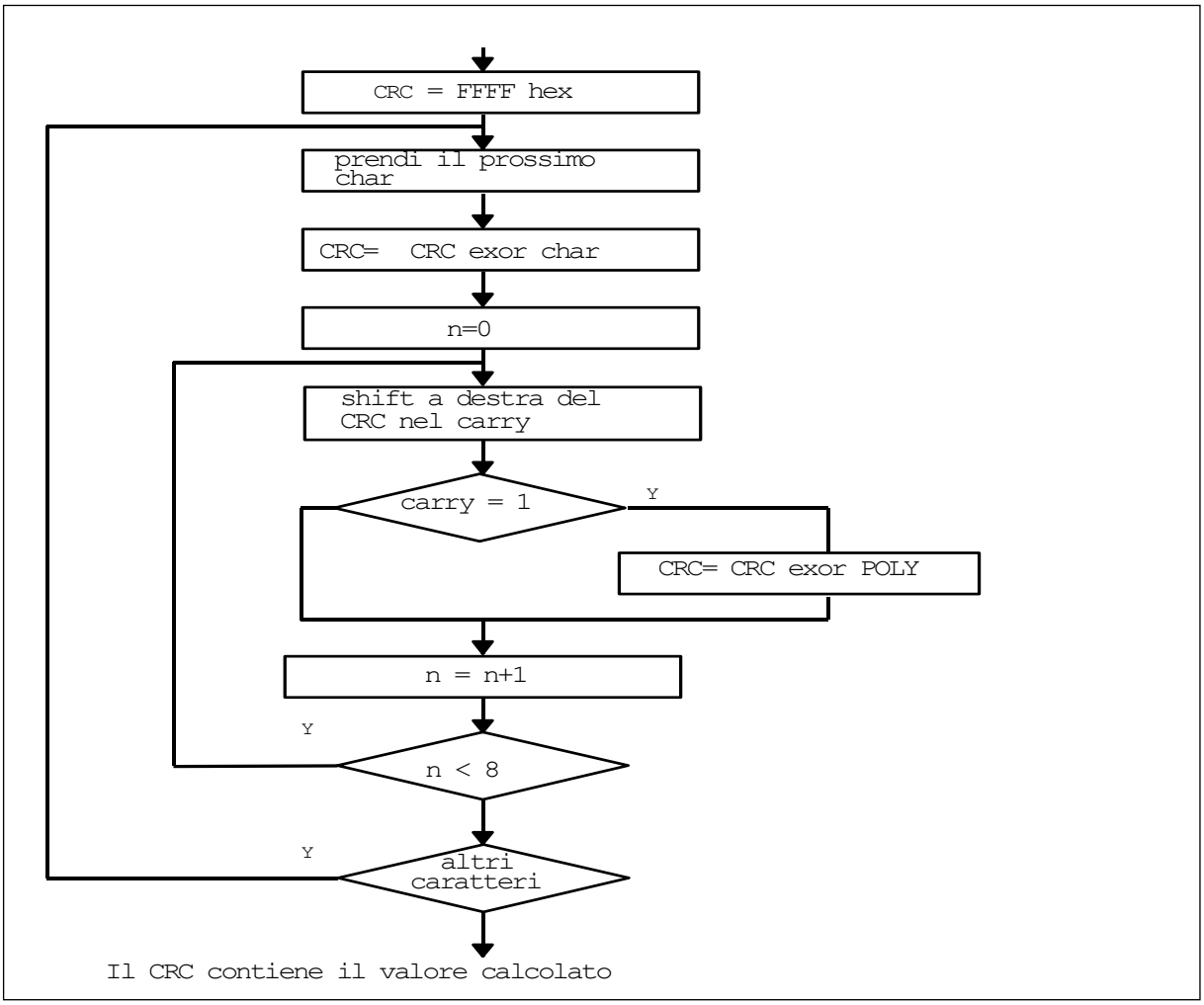
CRC is a check word that allows to verify the integrity of a message.

All messages, sent or received, have in the two last characters the CRC check word.

After receiving a request, the controller checks the validity of the received message comparing the received CRC with the calculated one.

When a reply is ready the controller calculates the CRC word and adds two characters at the end of the prepared message. The CRC calculation is performed on all the message characters, excluding the last two.

Being MODBUS RTU (JBUS) compatible, K31D series controllers adopt the same for CRC calculation algorithm. Schematically the algorithm is described by following diagram:



The polynomial adopted by MODBUS RTU (JBUS) is: 1010 0000 0000 0001.

Note: the first transmitted character of the CRC word is the least significant between calculated bytes.

4 Data exchange

This section contains information about data exchanged with K31D series controllers concerning numerical and not numerical data, with their formats and limits.

4.1 Some definitions

All exchanged data are in the form of 16 bit words.

There are two types of data: numerical and symbolic (or non-numerical).

Numeric data represents the value of a quantity (e.g. the measured variable, the set point, etc.).

Symbolic data represents a particular value in a set of values (e.g. the thermocouple type in the set of available ones: J, K, S ...).

Both the data type are coded as integer numbers: signed numbers for numerical and unsigned numbers for symbolic.

A numerical data, coded as an integer, is coupled with appropriate number of decimal digits to represent a quantity with the same engineering unit adopted by the instrument.

Numerical data are in fixed point representation; however we make a distinction between two kinds of data:

- the first type has a very precise and un-modifiable decimal point position;
- the second one has a programmable decimal point position (dP parameter).

4.2 Memory areas

All readable and writable data appear to be allocated as 16 bit words in the memory of the instrument.

The memory map has three areas:

- Variables,
- Parameters,
- Instrument identification code.

The following paragraphs examine the characteristics of each area.

4.2.1 Variables area

In this area there is a collection of the main K31D controller variables, it is a group of frequently computed or updated data residing in volatile memory.

These are the available data:

n.	address (HEX)	Description	Data type	Range of values/ symbols	Decimal figures	r/w	note
1	0200	PV : measured variable (signed integer)	N		dP	r	
2	0201	no. of decimals to be associated to PV	N		0	r	as DP parameter
3	0202	Power calculated by the controller	N		2	r	-100.0… 100.0%
4	0203	Power available on the heating output	N		2	r	-100.0… 100.0%
5	0204	Power available on the cooling output	N		2	r	-100.0… 100.0%
6	0205	Alarm 1 status	S	0: OFF 1: ON	0	r	
7	0206	Alarm 2 status	S	0: OFF 1: ON	0	r	
8	0207	Alarm 3 status	S	0: OFF 1: ON	0	r	
9	0208	Active Set Point	N		dP	r	
10	020A	LBA Alarm status	S	0: OFF 1: ON	0	r	
11	020F	Controller status	S	0: OFF 1: Auto. contr. 2: tuning 3: man. Contr.	0	r	
12	212	PV2: Variable measured by probe 2	N		dp	r	
13	213/214	PV2: Variable measured by probe 2	N			r	Floating Point
14	215	PV1 – PV2	N		DP	r	
15	216/17	PV1 – PV2	N			r	Floating point
17	0240	Digital Input 1 Status	S	0 = OFF 1 = ON	0	R	
18	0241	Digital Input 2 Status	S	0 = OFF 1 = ON	0	R	

Abnormal conditions of the process variable are reported as special word values which are beyond the normal result of a measure:

Abnormal condition	Returned value	Message displayed
Underrange (measure)	-10000	⊔⊔⊔⊔
Overrange (measure)	10000	▫▫▫▫
Overflow (A/D convertion)	10001	- - - -
Variable not available	10003	Not available

4.2.2 Parameters programming

The operating and configuration parameters can be read and written through serial communications.

If one tries to read or write a parameter not available for a certain instrument configuration, an error message is displayed: data not available. (6).

After writing in the parameters area, it is necessary to start the **CHECKSUM** calculation, writing any value at address HEX **039B**.

SP group (Set Point parameters)

Para meter	Address (HEX)	Description	Data type	No. of decimals	Possible values
nSP	2800	Select the number of the programmable Set Point	N	0	1… 4
SPAt	2801	Active Set Point selection	N	0	1… nSP
SP1	2802	Set Point 1	N	Dp	SPLL… SPHL
SP2	2803	Set Point 2	N	Dp	SPLL… SPHL
SP2HL	2804	Control High limit	N	Dp	-1999… 9999
SP2LL	2805	Control Low limit	N	Dp	-1999… 9999
SPLL	2806	Set Point Lower limit	N	Dp	-1999… SPHL
SPHL	2807	Set Point Higher limit	N	Dp	SPLL… 9999

InP group (parameters relative to the measurement inputs)

Para meter	Address (HEX)	Description	Data type	No. of decimals	Possible values
SEnS	2809	Probe type PTC, NTC input	S		0 = PTC; 1 = NTC
Pr2	280A	Probe 2 presence	S		0 = No, 1 = Yes
dp	280C	Number of decimal figures	N	0	0..3
Unit	280D	Engineering unit of the measurement	S		0 = °C, 1 = °F
FiL	280E	Input digital filter	N	1	0FF…20.0 s
OFS1	2810	Measuring Offset Probe 1	N	dP	-1999…9999
OFS2	2811	Measuring Offset Probe 2	N	dP	-1999…9999
rot	2812	Rotation of the measurement straight line	N	3	0.000 … 2.000
InE	2813	“OPE” functioning in case of measuring error	S		0=OR, 1=Ur, 2=OUr
OPE	2814	Output 1 power in case of measuring error	N	0	-100... 100
dIF	2815	Digital input function	S	0	0 = noF, 1 = AaC, 2 = Asi, 3 = Hold, 4 = OFF, 5 = CHSP, 6 = SP1.2, 7 = SP1.4, 8 = HE.Co

O1 group (parameters relative to outputs)

Para meter	Address (HEX)	Description	Data type	No. of decimals	Possible values
O1F	2816	Functioning of output 1	S		0 = OFF, 1 = 1.rEg, 2 = 2.rEg, 3 = Alno, 4 = Alnc 5 = Alni
O2F	2817	Functioning of output 2	S		0 = OFF, 1 = 1.rEg, 2 = 2.rEg, 3 = Alno, 4 = Alnc 5 = Alni

Para meter	Address (HEX)	Description	Data type	No. of decimals	Possible values
O3F	2818	Functioning of output 3	S		0 = OFF, 1 = 1.rEg, 2 = 2.rEg, 3 = Alno, 4 = Alnc 5 = Alni
O4F	2819	Functioning of output 4	S		0 = OFF, 1 = 1.rEg, 2 = 2.rEg, 3 = Alno, 4 = Alnc 5 = Alni

Al1 Group (parameters relative to alarm 1)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
OAL1	281A	Output where alarm AL1 is addressed	S		0 = OFF, 1 = Out1, 2 = Out2, 3 = Out3, 4 = Out4
Pr1A	281B	Process Value for AL1 Alarm	S		0 = Pr1, 1 = Pr2, 2 = P1 - P2, 3 = P1 - L
AL1t	281C	Alarm AL1 type	S		0 = LoAb, 1 = HiAb, 2 = LHAb, 3 = LodE, 4 = HidE 5 = LHdE
Ab1	281D	Alarm AL1 functioning	N	0	+0 = no function +1 = alarm hidden at the start up +2= alarm delayed +4 = alarm stored +8 = alarm acknowledged +16 = relative alarm hidden at the set point change
AL1	281E	Alarm AL1 threshold	N	Dp	AL1L... AL1H
AL1L	281F	Low threshold band alarm AL1 for high/low alarm	N	Dp	-1999… AL1H
AL1H	2820	High threshold band alarm AL1 for high/low alarm	N	Dp	AL1L… 9999
HAL1	2821	Alarm AL1 hysteresis	N	Dp	0 = 0FF 1… 9999
AL1d	2822	Activation delay of alarm AL1	N	Dp	0 = 0FF 1… 9999 s
AL1i	2823	Alarm AL1 activation in case of measuring error	S		0=no, 1=YES

Al2 group (parameters relative to alarm 2)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
OAL2	2824	Output where alarm AL2 is addressed	S		0 = OFF, 1 = Out1, 2 = Out2, 3 = Out3, 4 = Out4
Pr2A	2825	Process Value for AL2 Alarm	S		0 = Pr1, 1 = Pr2, 2 = P1 - P2, 3 = P1 - L
AL2t	2826	Alarm AL2 type	S		0 = LoAb, 1 = HiAb, 2 = LHAb, 3 = LodE, 4 = HidE 5 = LHdE
Ab2	2827	Alarm AL2 functioning	N	0	+0 = no function +1 = alarm hidden at the start up +2= alarm delayed +4 = alarm stored +8 = alarm acknowledged +16 = relative alarm hidden at the set point change
AL2	2828	Alarm AL2 threshold	N	Dp	AL2L... AL2H
AL2L	2829	Low threshold band alarm AL2 for high/low alarm	N	Dp	-1999… AL2H
AL2H	282A	High threshold band alarm AL2 for high/low alarm	N	Dp	AL2L… 9999
HAL2	282B	Alarm AL2 hysteresis	N	Dp	0 = 0FF 1… 9999
AL2d	282C	Activation delay of alarm AL2	N	Dp	0 = 0FF 1… 9999 s
AL2i	282D	Alarm AL2 activation in case of measuring error	S		0=no, 1=YES

Al3 group (parameters relative to alarm 3)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
OAL3	282E	Output where alarm AL3 is addressed	S		0 = OFF, 1 = Out1, 2 = Out2, 3 = Out3, 4 = Out4

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
Pr3A	282F	Process Value for AL3Alarm	S		0 = Pr1, 1 = Pr2, 2 = P1 - P2, 3 = P1 - L
AL3t	2830	Alarm AL3 type	S		0 = LoAb, 1 = HiAb, 2 = LHAb, 3 = LodE, 4 = HidE 5 = LHdE
Ab3	2831	Alarm AL3 functioning	N	0	+0 = no function +1 = alarm hidden at the start up +2= alarm delayed +4 = alarm stored +8 = alarm acknowledged +16 = relative alarm hidden at the set point change
AL3	2832	Alarm AL3 threshold	N	Dp	AL3L... AL3H
AL3L	2833	Low threshold band alarm AL3 for high/low alarm	N	Dp	-1999… AL3H
AL3H	2834	High threshold band alarm AL3 for high/low alarm	N	Dp	AL3L… 9999
HAL3	2835	Alarm AL3 hysteresis	N	Dp	0 = 0FF 1… 9999
AL3d	2836	Activation delay of alarm AL3	N	Dp	0 = 0FF 1… 9999 s
AL3i	2837	Alarm AL3 activation in case of measuring error	S		0=no, 1=YES

Group "LbA" (parameters relative to Loop Break Alarm)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
OLbA	2838	Output where alarm LbA is addressed	S		0 = OFF, 1 = Out1, 2 = Out2, 3 = Out3, 4 = Out4
Lbat	2839	Time necessary to activate alarm LbA	N	0	0 = OFF 1… 9999 s

Group "rEG" (parameters relative to control)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
Cont	283A	Control type	S		0 = Pid, 1 = On.Fa, 2 = On.FS, 3 = nr
Func	283B	Functioning mode output 1rEg	S		0 = Heat, 1 = Cool
PrrG	283C	Control Process Variable	S		0 = Pr1, 1 = Pr2, 2 = P1-2, 3 = P1-L, 4 = Pr1
Auto	283D	Autotuning Fast enable	N	0	0=OFF,1,2,3,4
SELF	283E	Selftuning enable	S		0=No, 1=YES
HSEt	283F	Hysteresis of ON/OFF control	N	Dp	9999…-1999
Pb	2840	Proportional band	N	Dp	0..9999
Int	2841	Integral time	N	0	0=0FF..9999 s
dEr	2842	Derivative time	N	0	0=0FF..9999 s
FuOc	2843	Fuzzy overshoot control	N	2	0.00..2.00
tcr1	2844	Cycle time of relay output 1	N	1	0.1..130. s
Prat	2845	Power ratio Cooling/Heating	N	2	0.01..99.99
tcr2	2846	Cycle time of relay output 2	N	1	0.1..130.0 s
rS	2847	Manual reset	N	1	-100.0..100.0%
CPdt	2848	Delay time for out 2.reG activation (compressor protection)	N	0	0=0FF..9999 s
SLor	2849	Gradient of rise ramp	N	2	0.00..99.99 >=100.00=InF Unit/min
dur.t	284A	Duration time	N	2	99.59 h.min >=100.00=InF
SLoF	284B	Gradient of fall ramp	N	2	0.00..99.99 Unit/min >=100.00=InF
St.P	284C	Soft-Start power	N	0	-100, -101=OFF, 100
SSt	284D	Soft-start time	N	2	0=0FF.. 7.59 h.min >=8.00=InF

Group "PAn" (parameters relative to the user interface)

Parameter	Address (HEX)	Description	Data type	No. of decimals	Possible values
USrb	284E	Functioning of key "U"	S		0=noF, 1=tune, 2=OPLO, 3=Aac, 4=Asi, 5=CHSP, 6=OFF
diSP	284F	Variable shown on the SV display	S		0=DEF (OFF), 1=Pou, 2=SPF, 3=Spo, 4=AL1, 5=AL2, 6=AL3, 7=HbA, 8=HbL
AdE	2850	Shift index	N	Dp	0=0FF..9999
Edit	2851	Fast programming of active Set Point and alarms	S		0=SE, 1=AE, 2=SAE, 3=SAnE
PASS	2852	Password to access the parameters	N		0… 9999
Add	2853	Device Serial Address	N		0… 255
baud	2854	Baud rate	S		0 = 1200, 1 = 2400, 2 = 9600, 3 = 19200, 4 = 38400

4.2.3 Identification code area

This area provides only information for identifying model, order code and software release of the K31D series instrument.

Starting from the address 0800H it is possible to read the instrument name (K31D31) and from the address 0x80A (up to 0x818) it is possible to read the instrument part number.

5 Performance

After receiving a valid request the instrument prepares the reply, then sends it back to the master station according following specifications:

- A minimum time is granted greater or equal 3 characters time (depending on adopted baud rate, allowing line direction reversal);
- The reply is ready to be transmitted in less than 20 ms except in case 3;

A 20 ms silence on the line is necessary to recover from abnormal conditions or erroneous messages; this means that a time less than 20 ms is allowed between any two characters in the same message.

It is not possible to write more than one word at the same time.

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