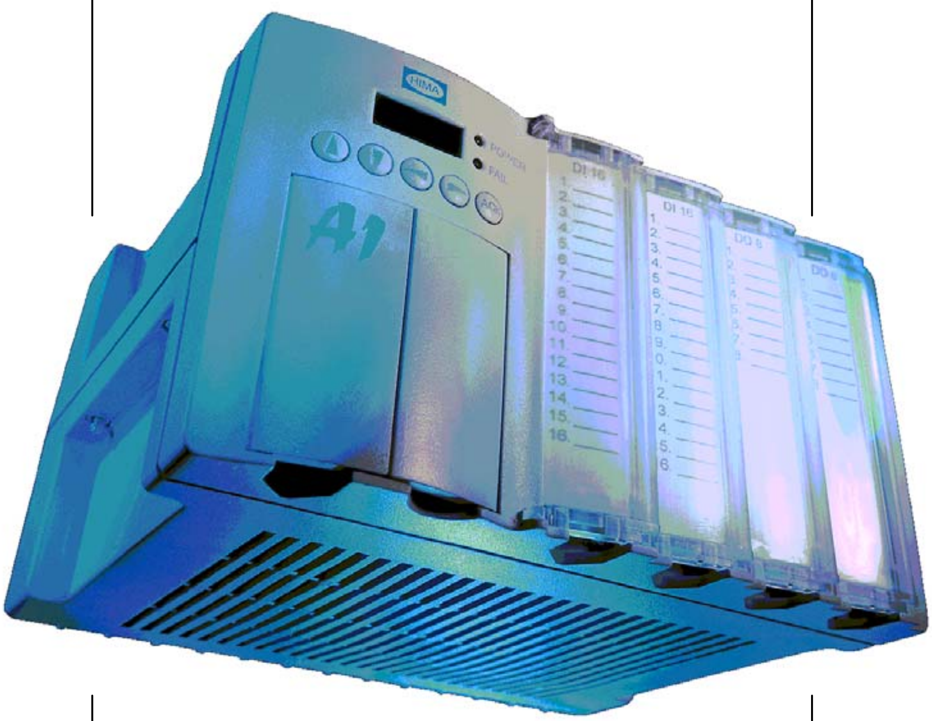
Safety-related Compact Control

A1/A1dig

Manual



HIMA

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1. The Compact Controller Family A1/A1dig

The safety-related compact controllers of the A-series contain the proven HIMA automation systems technology in an ergonomic, space-saving housing. This is made possible by the use of modern SMD production technology.

The following controllers are available:

A1 16 safe binary inputs, four safe analog inputs,
eight secure binary outputs

A1dig 32 safe inputs,
16 safe binary outputs

This handbook describes both compact controllers A1 and A1dig. Chapters which apply only to one type of controller are marked respectively.

1.1. Features of the A1 and A1dig Compact Controllers for ELOP

The compact controllers A1 and A1dig are approved for applications up to RC 4 in accordance with DIN V 19250, and satisfy the requirements of SIL2 as well as those of VDE 0116. This makes them ideal for smaller applications such as burner control.

<u>The significant characteristics of the A1 and A1dig compact controllers are:</u>

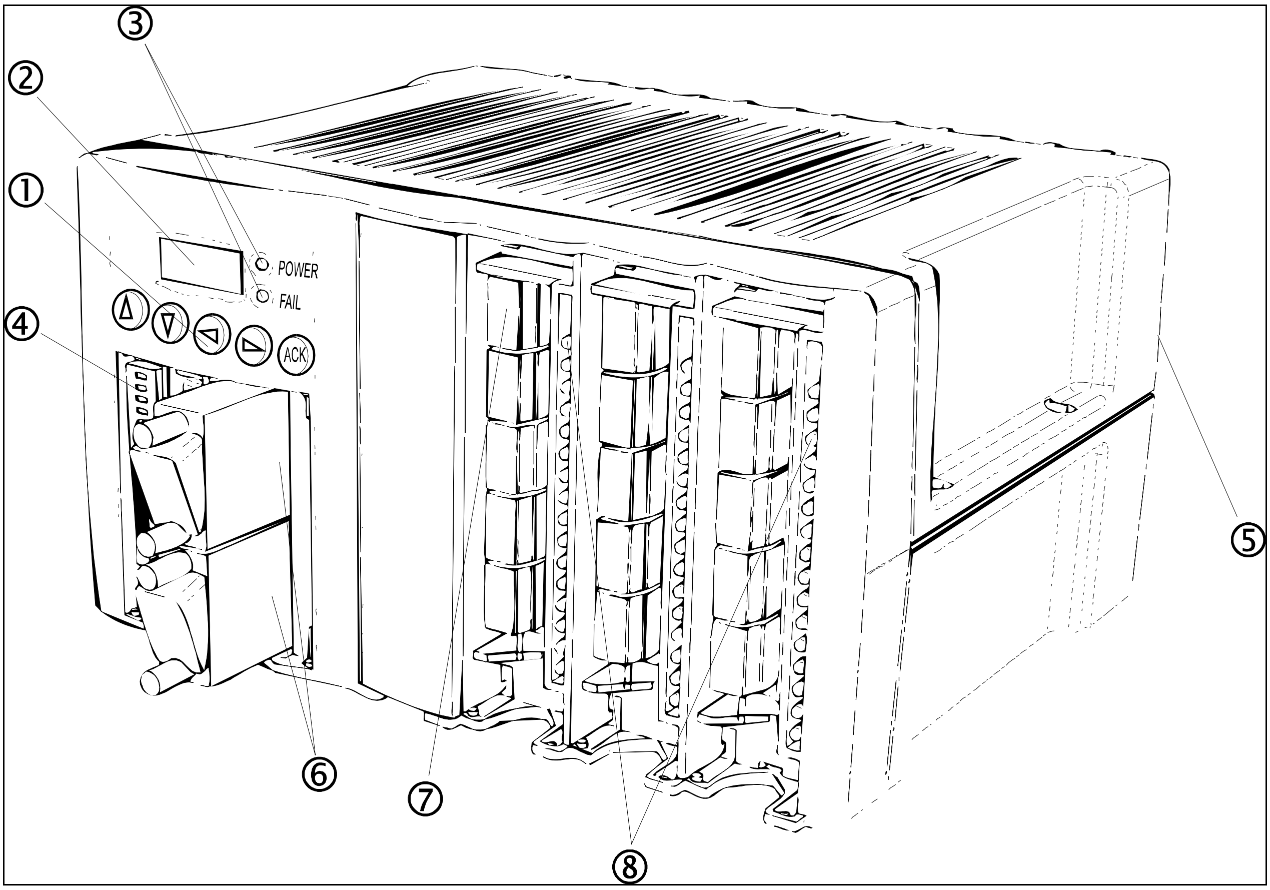
- Can be clipped to top-hat rails.
- Max. 640 kilobytes static storage, of which 128 kilobytes are CMOS RAM and 512 kilobytes are Flash EPROM. The RAM is maintained by a battery which is accessible from the front.
- Memory for application program: 41 kilobytes.
- Automatic tests for all inputs and outputs as well as of the central unit.
  CRC test of the static memory: RAM and EPROM are each duplicated (non-inverted and inverted) and are continuously compared by a hardware comparator during memory accesses.
- Internal hardware watchdog, safe against component failure, to ensure safe shut down in the event of a fault.
- Four character alphanumerical diagnostic display.
- Two LEDs for display of POWER and FAIL.
- Five push-buttons to call up information of the system and for acknowledgements.
- Two electrically isolated RS-485 interfaces with a maximum data rate of 57600 bit/s.
- Setting of the bus subscriber number and the standard baud rate (9600 or 57600 bit/s) by a DIP switch accessible from the front side.
- Input and output connections with Combicon terminals in blocks with four connections.

- LEDs for all binary inputs and outputs.
- Programmable with ELOP.
- W = 220 mm, H = 120 mm, D = 180 mm
- Weight: 2850 g
- Operating voltage: 24V= +20%/-15%, wss $\leq$ 15%
- Power consumption: 24 W (Idle), 50 W (max.)
- Max. input current: 16A
- Environmental conditions: 0...+60 °C, KUE in accordance with DIN 40040 / IEC 68
- Storage temperature: -40 °C...+85 °C without battery,
  -40 °C...+75 °C with battery

NOTE: User programs for the compact controls A1 and A1dig con be created with the programming tools ELOP and ELOP II. If ELOP II is used

- the memory for the user program in the A1/A1dig must be expanded to 100 Kbytes and
- the user program is not executed sequentially as with ELOP, but according to IEC 1131-3.

2. Design of the Compact Controls A1 and A1dig



(1) Five push-buttons to call up information and for acknowledgements

(2) Four character alphanumerical display

(3) LEDs for display of POWER and FAIL

(4) DIP switch for setting baud rate and bus subscriber number

(5) Fastening to top-hat rail

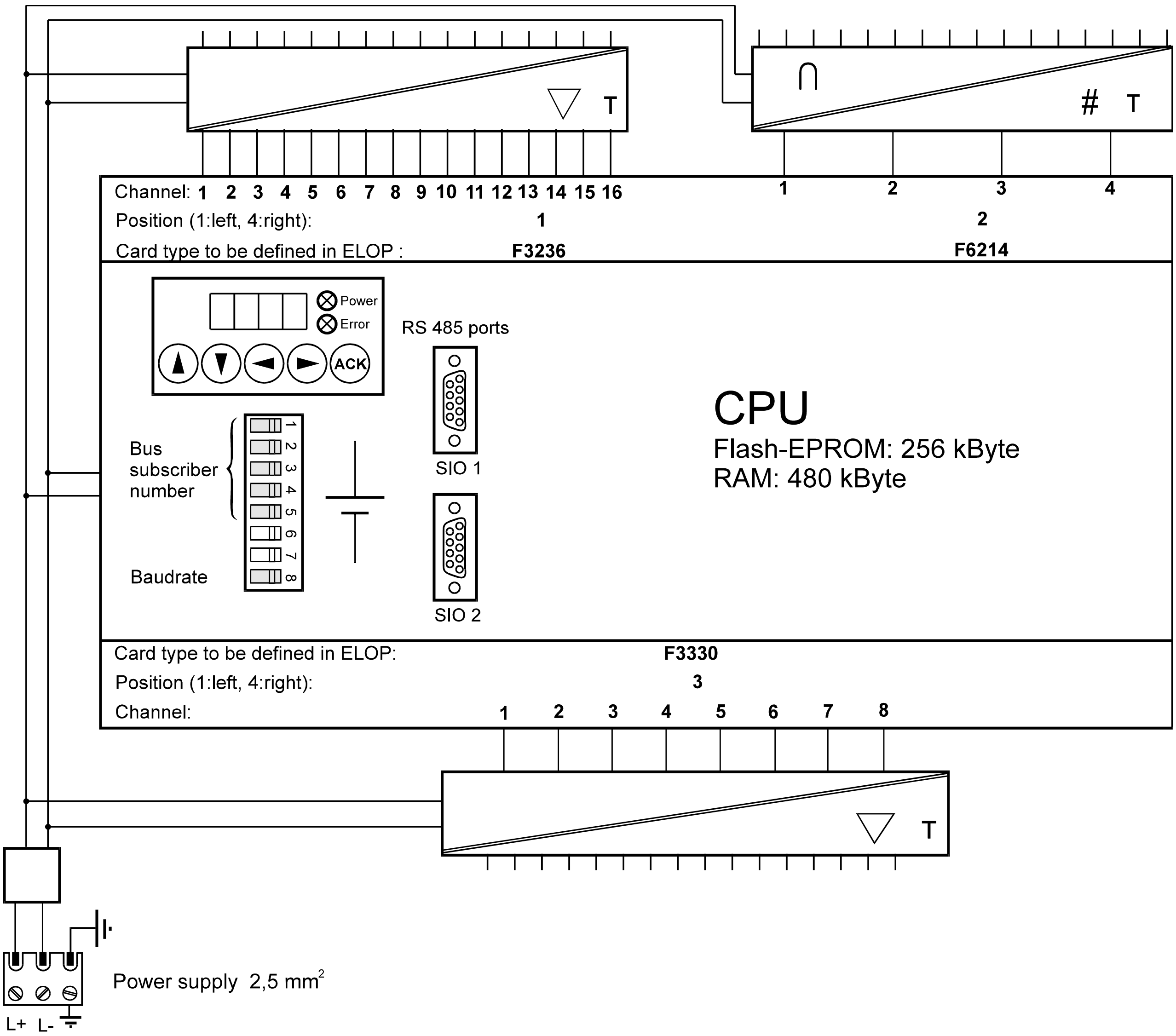
(6) Two RS-485 interfaces

(7) Combicon terminals in blocks of 4 connections

(8) LED display for binary inputs and outputs

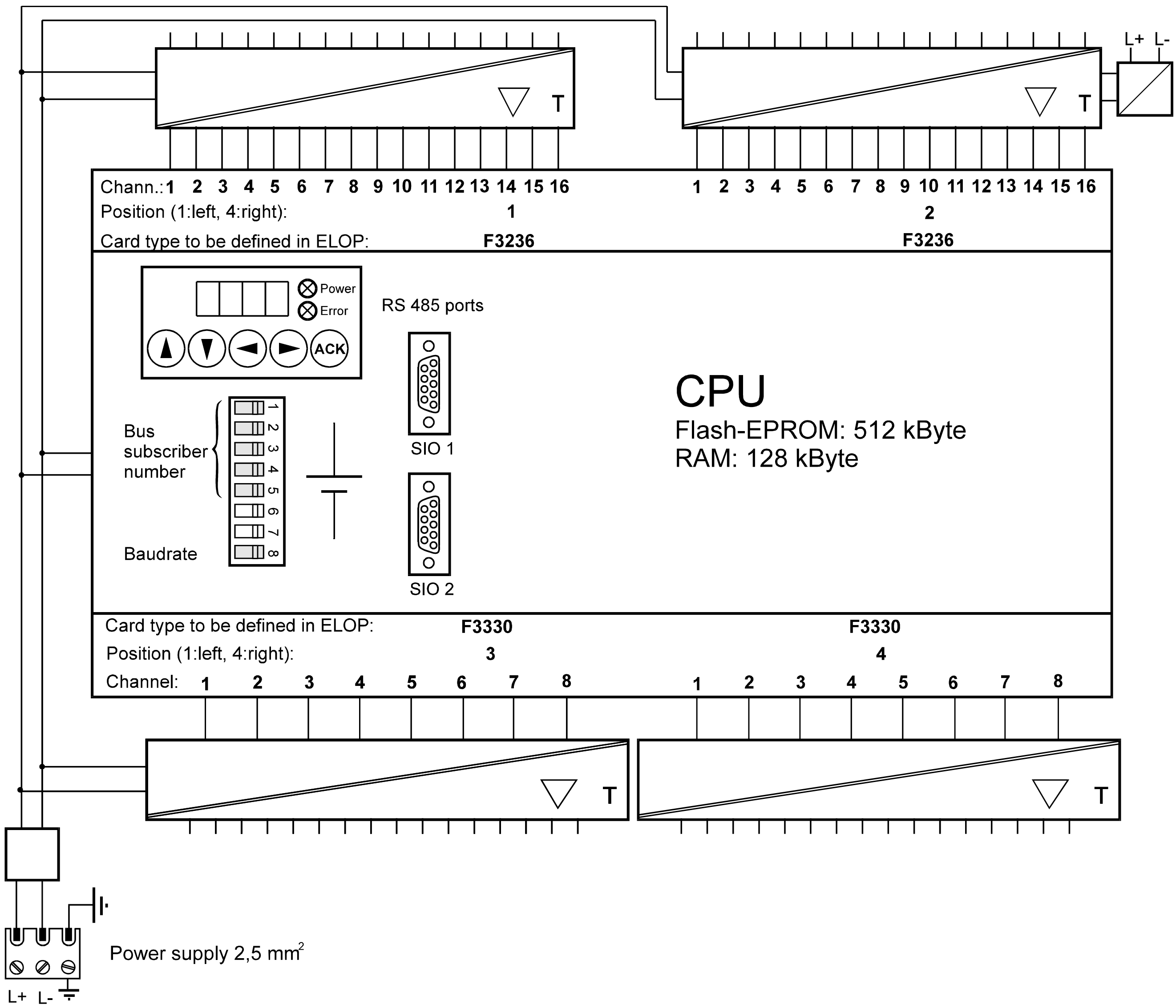
2.1. Block Diagrams

2.1.1. Block Diagram A1



Power supply 2,5 mm²

2.1.2. Block Diagram A1dig



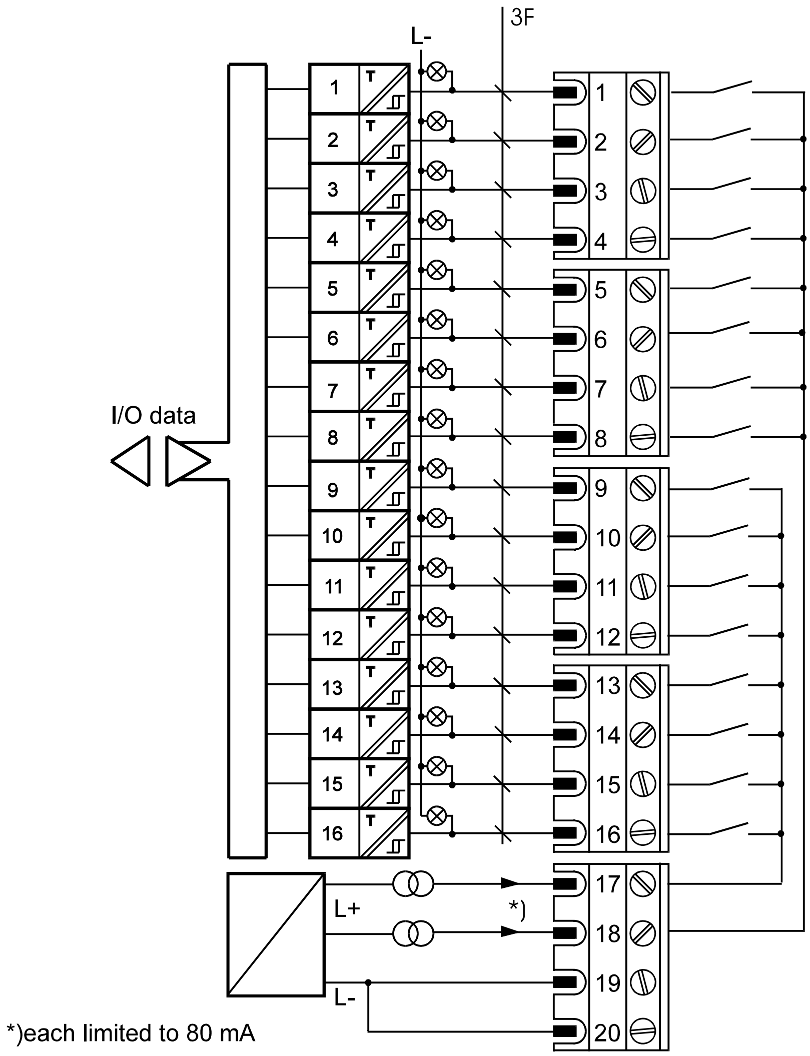
2.2. I/O Level

2.2.1. Safe Binary Input Channels DI

For binary signals with safe isolation.

Inputs: H-signal, 6 mA (3F) or mechanical contact 24 V

Switching time: typ. 8 ms



The following functions of the unit are continuously and fully tested during operation:

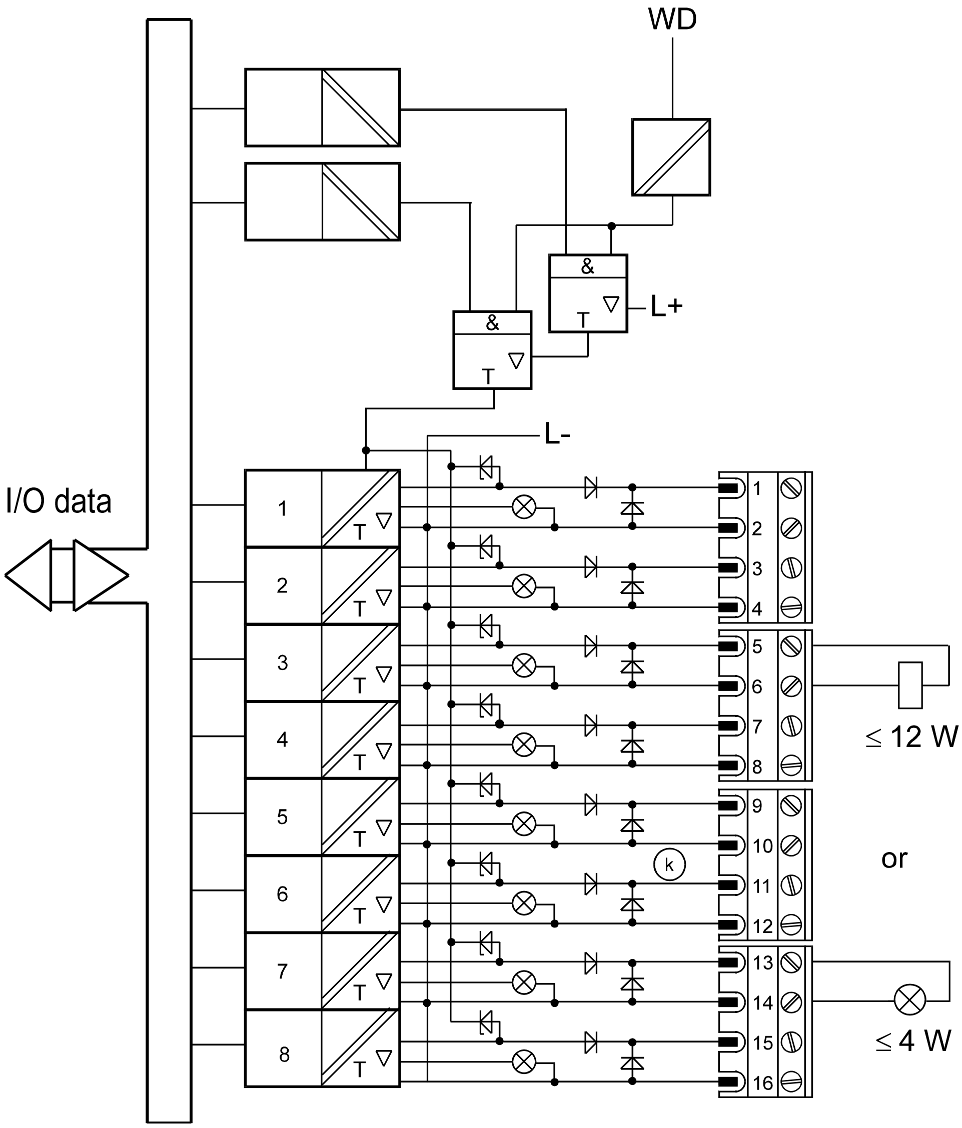
- Input cross-talk using a walking bit test
- Filter capacitors
- Readiness of unit

NOTE: A copy master for front panel labels for the binary input channels can be found in the appendix.

2.2.2. Safe Binary Output Channels DO

For resistive or inductive load up to 500 mA (12 W),
indicator lamp connection up to 4 W,
with integrated safety switch-off,
no output signal after L- line break

Outputs	500 mA, (k) short-circuit protected
Internal voltage drop	max. 2 V with 500 mA load
Permissible conductor resistance	max. 11 Ω (over the total path)
Under-voltage switch-off	≤ 16 V
Switching threshold for short-circuit current	0,75 ... 1,5 A
Output leakage current	max. 350 µA
Output voltage in gradual shut-off	max. 1,5 V
Duration of test signal	max. 200 µs



The channels are automatically tested during operation. The primary test functions are:

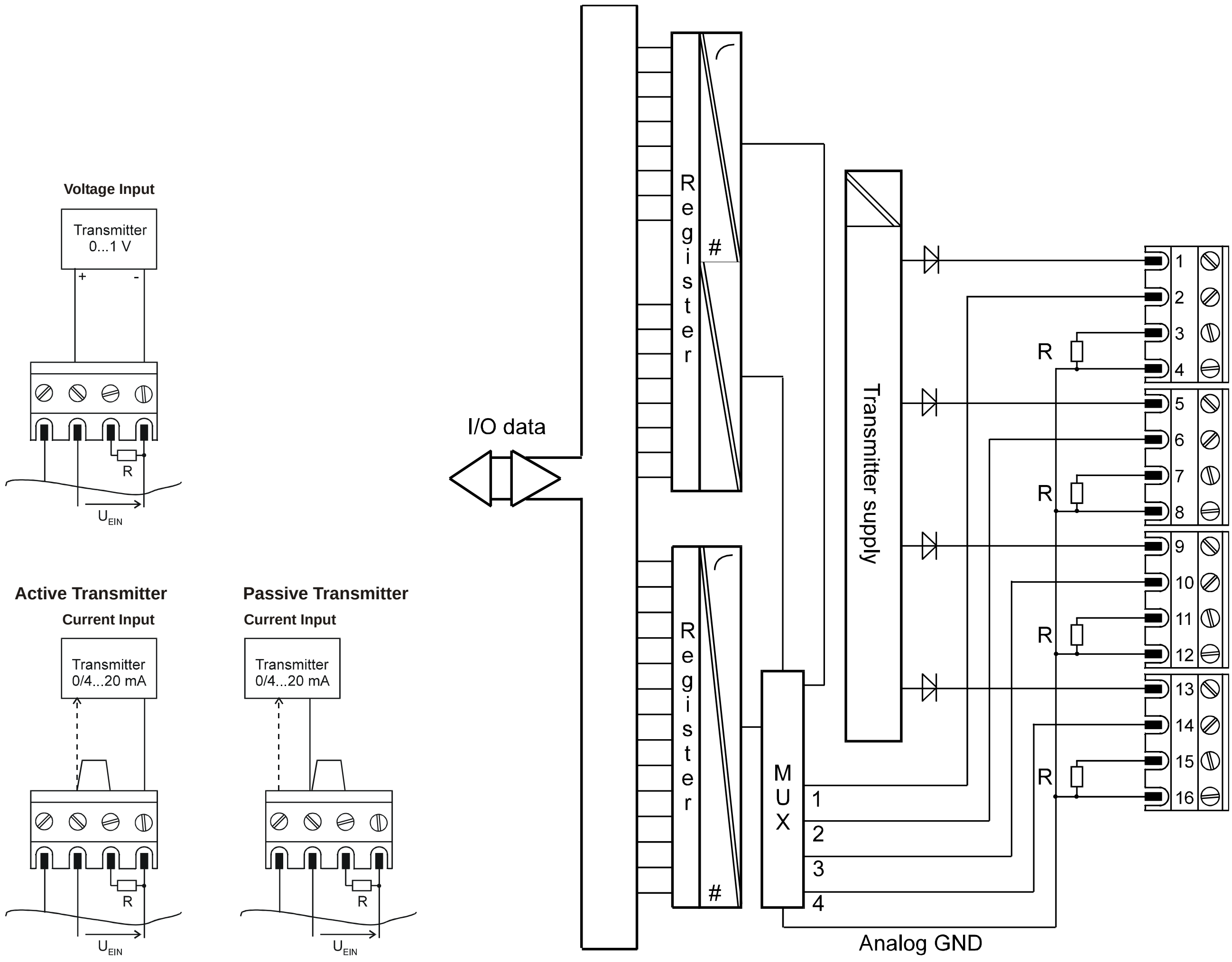
- Output signals are read back.
  The switching threshold for the reading back of a 0-signal is ≤ 6.5 V. If there is a fault, the 0-signal can rise to this level without the fault being recognized.
- Switchability, test signal and cross-talk (walking bit test).

NOTE: A copy master for front panel labels for the binary output channels can be found in the appendix.

2.2.3. Safe Analog Input Channels AI (only A1)

For transmitters in two-wire technique 4...20 mA,
Voltage inputs 0...1 V,
Current inputs 0...20 mA,
12 bit resolution

Input voltage	0...1,06 V (approx. 6 % overshoot)
Digital values	0 mV = 0, 1 V = 3840
Wait time after test	100 ms
R: Shunt for current measurement	50 Ω, 0,05 %, 0,125 W, T < 10 ppm/K
Input resistance	1 MΩ
Input filter time constant	approx. 10 ms
Transmitter power supply	25 V ... 20 V, 0...22 mA
Short circuit current	25 mA
Load resistance	max. 900 Ω
Read time	max. 100 ms for 4 channels
Intrinsic fault limit	0,4 % at 25 °C
Usable fault limit	0,7 % at 0...60 °C



Input terminal pin-out	Chan. 1	Chan. 2	Chan. 3	Chan. 4
Voltage output for transmitter power supply	1	5	9	13
Voltage input (+)	2	6	10	14
When using current transmitters (0/4...20 mA), must be bridged to (+)	3	7	11	15
Voltage input (-)	4	8	12	16

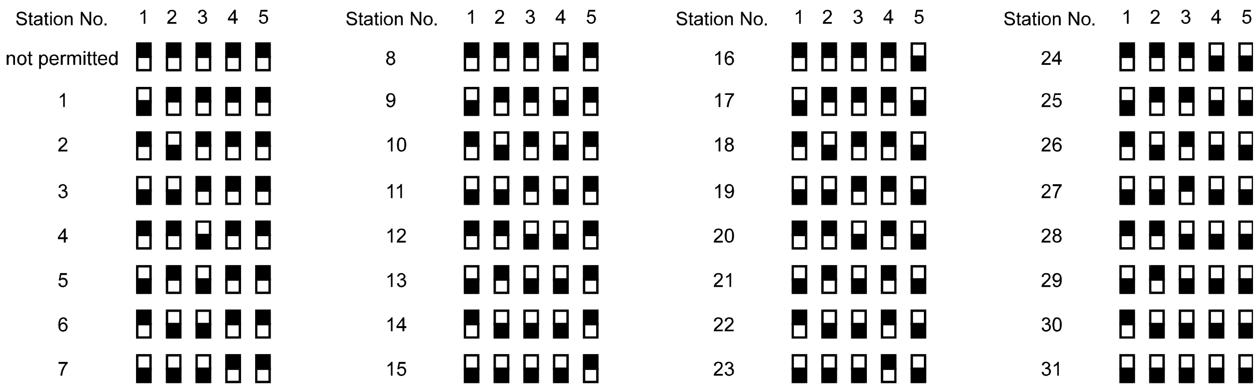
IMPORTANT: All unused channels must be terminated with 3.3 kOhm (pin 1-2, 5-6 etc.). Additionally the jumpers between pin 2-3, 6-7 etc. must be installed. Accompanying software module: HA-RTE-3.

ATTENTION: After wiring the AI module, the terminal plugs must be checked for proper contact to the input channels. Open input channels result in undefined (floating) values!

NOTE: A copy master for front panel labels for the analog input channels can be found in the appendix.

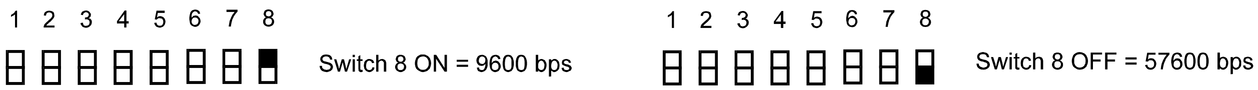
2.2.4. Setting the Bus Subscriber Number and Baud Rate

NOTE: Setting the bus subscriber number is carried out with DIP switches on the front panel.



Setting the baud rate

Setting of the standard baud rate with DIP switch 8 (valid for both ports):



2.2.5. Pinout of the RS-485 Interface

Pin	RS-485	Signal	Function
1		-	not used
2		RP	5 V, decoupled with diodes
3	A/A’	RxD/TxD-A	Receive/transmit data A
4	-	CNTR-A	Control signal A
5	C/C’	DGND	Data reference potential
6	-	VP	5 V, positive supply voltage
7	-		not used
8	B/B’	RxD/TxD-B	Receive/ transmit data B
9	-	CNTR-B	Control signal B

3. Notes on Start-Up and Maintenance

The power supply of the A1/A1dig is done via a Combicon terminal which is located behind the left cover. For not confusing the poles, a sticker on the inside of the cover shows the exact pinout of this terminal.

CAUTION: The A1/A1dig is not equipped with a reverse polarity protection! If the poles are changed by mistake, the internal fuse blows and the A1/A1dig has to be sent back to HIMA.

NOTE: Repair and maintenance of power and signal lines must only be carried out by qualified personnel. ESD protection is required!

3.1. Display

The current operating condition (and any possible fault) is automatically displayed on the four character diagnostic display of the A1/A1dig. Additionally, the four direction buttons can be used to request information from the system, or information about the program which is loaded (see the table of messages in chapter 4.6).

After selecting a menu point such as ‘SIO1’ or ‘SIO2’ the number of write transmissions from a master system connected to the serial interfaces can be displayed: If the interface is active, then the number will continually rise.

If there are problems with the connection of transmitters to the analog inputs of the A1, the display shows whether there is a broken connection (the card position and the channel are displayed) or whether there is a short circuit (only the card position is shown).

3.2. Battery

The battery can be accessed on the left hand side under the display, after the left cover has been opened. The battery is supplied separately and must be inserted before commissioning.

IMPORTANT: The polarity of the battery must be observed carefully.
The plus pole must be oriented to the top.

It is recommended that the backup battery is changed at intervals of 4 years. A lithium battery, e.g. a CR-1/2 AA 3V 900 mA, is available from HIMA, under part number 44 0000019.

3.3. DIL Switches

When the two covers beneath the display have been opened, there is access to both the interface connections (on the right) and the DIL switch for setting the bus subscriber number and the transmission rate (on the left).

If these are wrongly set, it can cause problems in establishing communication with the A1/A1dig. If the message ‘PLC OPERATION CAN NOT BE STARTED’ appears when ELOP attempts to establish communication with the A1/A1dig, it can have a number of causes:

1. The bus subscriber number has been set incorrectly.
2. The standard baud rate has been set incorrectly.
3. The wrong data connection cables are used.
4. The H7505 bus terminal (if used) is set incorrectly.

3.3.1. Bus Subscriber Number

It is essential for the communication that the bus subscriber number set on the A1/A1dig agrees with the number selected in the ELOP program under ‘PLC OPERATION’.

It may not be possible to check the hardware setting, because of the distance between the programming device and the control. In that case the F1 key can be used in PLC OPERATION to show all the bus participants.

3.3.2. Standard Baud Rate

The standard baud rate, with which an empty A1/A1dig can be loaded for the first time, is specified by the setting of DIL switch 8.
In the OFF position it is 57600 baud, and in the ON position it is 9600 baud. This baud rate must agree with the baud rate selected in ELOP under PLC OPERATION.

If the HK-ZKB-1 building block has not been used in the application program of ELOP or the resource settings under ELOP II have not been changed, this baud rate will continue to be used for communication.

But if this building block has been used to redefine the interface speed or the resource settings have been changed, after the end of the loading procedure (i.e. before the program has started) a ‘LINE BREAK’ can occur. In such cases it is then only possible to communicate with the control using the baud rate set with the building block. The software communications settings take priority.

3.4. Communication

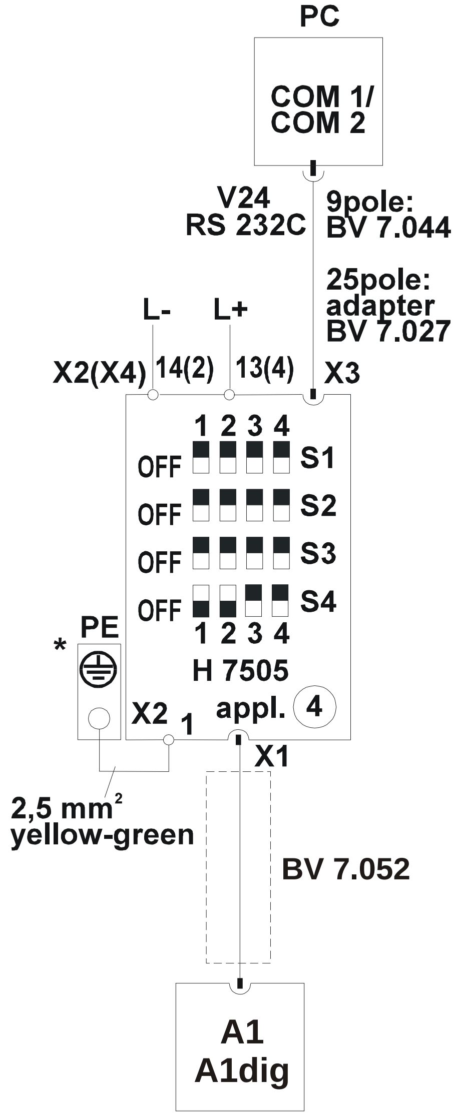
There are several ways to connect an A1/A1dig to other devices, which are explained in the following chapters.

3.4.1. Communication with Engineer- or PLESY-P-PC

Connecting the A1/A1dig to a PC is done through its RS 232 interface. Since the A1/A1dig has RS 485 interfaces, a conversion must take place.

A BV7043 data connection cable is all that is needed for a temporary connection of the two devices (e.g. for loading the application program by the engineering station). The necessary converter is contained in the cable, and is powered from the A1/A1dig interface.

If a permanent connection is needed (e.g. for the continuous supervision of logic or display of events), the H7505 interface converter must be used. In addition to the H7505, a BV 7044 is needed for the connection from the PC to the H7505, and a BV 7042 is also needed for the connection of the H7505 to the bus. The settings of the H7505 and the connections for the data connection cable can be seen in the drawing shown on this page.



3.4.2. Communication with other HIMA Automation Devices over HIBUS

Because communication is only taking place between automation devices with RS-485 interfaces, no conversion is necessary

To connect the A1/A1dig with the bus, only the BV 7040 data cable is necessary. It is plugged into one of the A1/A1dig interfaces with the 9-pole plug, and the 25-pole plug is inserted into the H7506 HIBUS terminal.

NOTE: If the A1/A1dig is connected to the end of the HIBUS with a H7506, the termination resistors must be switched in.

3.4.3. Communication with MODBUS Master Systems

Since master systems often have only RS-232 interfaces, a conversion of the interface signals is also necessary. The same configuration is applied here as for the connection of the A1/A1dig to a programming device (Exeption: H7505 in Appl. 10).

4. Communication under ELOP

If the A1/A1dig is used as an individual device, in other words if there is no exchange of data with other HIMA automation systems over a bus system, the programming device is connected directly with a BV 7043 data cable to one of the A1/A1dig serial interfaces.

The A1/A1dig can however be connected with the aid of a BV 7040 cable and a HIBUS terminal H7506 to any normal or safety-related HIBUS, for the exchange of data with other HIMA PLCs.

4.1. Coupling to other HIMA Automation Equipment via HIBUS

The A1/A1dig operating system is, amongst other things, developed to facilitate data transfer between HIMA automation devices via the HIBUS system. At least one H51 automation device with a coprocessor module is needed for this. It will be applied as PLC master and will control the data flow. Either of the A1/A1dig interfaces can be employed for this type of communication.

See the documentation for the HIBUS-F/FS firmware module and the H7505 interface converter for methods of implementation and configuration of the bus.

The data sent from an automation device are defined as network outputs, and the data to be received from another automation device are defined as network inputs. This procedure is not absolutely necessary, but assists the comprehensibility of the data exchange.

Monitoring the network area for the regular reception of data from the master system can be performed by the HK-ZBV-1 module. The network inputs of the area are then set to low (i.e. to 0) if the master does not write any data to the network area concerned within the defined time.

Depending on the technical safety requirements for the communication, two different HIBUS protocols may be used: non-safety related data transmission and safety-related data transmission.

4.1.1. Non safety-related Data Transmission

This is configured with the HIBUS-F firmware program. In this kind of transmission the PLC master works as a data collector: In other words, it first reads all the data to be transmitted from the connected automation devices, assembles the transmissions, and then writes these into the automation devices concerned.

4.1.2. Safety-related Data Transmission

This is configured with the HIBUS-S firmware program. The PLC master functions as an organizer on the bus. It does not itself read any data, but simply organizes the direct data exchange between the connected automation devices.

For this purpose, values are only transferred from network outputs to network inputs which carry, in the name coordination of the application program, the area identifier ”S”. The details of such a transmission then always consist of the transmission of data direct to the recipient, and of an acknowledgement sent to the master if the transmission has been correctly received. The master can then initiate the next data exchange.

Security techniques (CRC) are employed within the transmissions to ensure correct transmission independently of the medium. For this reason it is unimportant whether the bus-segment consists of copper, fiber glass or is a satellite link.

4.2. Coupling to HIMA Master Systems

HIMA master systems are personal computers on which HIMA firmware programs such as ELOP or PLESY II run. These systems can either be connected to the A1/A1dig directly by way of the serial interface, or can communicate with it via the HIBUS. The protocol used here is MODBUS, or a variant of it, which has been specially adapted for HIMA communication.

With the exception of the engineering station (ELOP), the HIMA master systems can only communicate with the A1/A1dig when it is in RUN mode.

4.2.1. Engineering Station (ELOP)

The engineering station is for programming, documenting, loading and monitoring the A1/A1dig. If the A1/A1dig is configured for non-safety related applications, then the ELOP HIMA firmware program is used for loading and for the monitoring of naming and logic.

For safety-related applications the HIMA ELOP-BS firmware program must be used.

4.2.2. Visualization System WizCon

The WizCon visualization system can be used to generate process diagrams which can be made dynamic through the evaluation of the A1/A1dig variables.

The visualization system can only write to the A1/A1dig network *inputs*.

Events can moreover be recorded and printed by the visualization system. The events to be registered (binary signal changes with time stamp) are defined in the ELOP application program in network area 2 (type B). The events which occur during operation are stored in a buffer. This is organized as a ring buffer containing 62 events, and the visualization system reads them from here. After they have been filtered or weighted these events can then be displayed on the screen or sent to a connected printer. The events can also be stored on the hard disc for later evaluation by the visualization system.

The visualization system can also display the progress of values as a trend curve on the screen, and store them on the PC hard disc. Historical trends can also be displayed if the variables are stored on the hard disc.

4.2.3. PLESY-P Recording, Annunciation and Archiving System

The alarms which occur during a process can be displayed on a monitor and/or printed out on a color printer, together with the time of their occurrence, the protocol text and possibly with text strings. At the same time all the incoming alarms can be archived on the hard disc. Further information is to be found in the PLESY-P handbook.

4.3. Coupling to External Systems

The A1/A1dig can communicate with external systems either by way of the MODBUS protocol, where it can be master or slave, or using the Siemens 3964R protocol, in which it is a slave. If the A1/A1dig is used as a slave system, no further settings are required in the application program.

If the interface parameters needed for communication with external systems differ from the standard HIMA parameters (9600/57600 baud, 1 stop-bit, even parity), they can be reconfigured with the aid of the HK-ZBK-1 building block.

4.4. Connection to DCS using the MODBUS Protocol

The MODBUS protocol is designed for transmission over a bus (such as HIBUS) in a master-slave system, and is generally used for coupling HIMA automation devices to process control systems. The A1/A1dig can be used as a slave system without further configuration.

The MODBUS protocol was defined by the firm of Gould Modicon. For this reason it is recommended that reference be made to the original documentation from AEG-Modicon for details which are beyond the scope of this device handbook.

As an aid to understanding, and to assist the correct configuration of the communication, the important properties are explained below.

The A1/A1dig only supports the RTU (Remote Terminal Unit) transmission mode. It is an asynchronous transmission with 8 data bits and CRC test:

Begin	Slave	Code	Data	Check data	End of transmission
T1 T2 T3	1 Byte	1 Byte	*	2 Bytes	T1 T2 T3

Begin/ End Identified by a pause of 3 1/2 characters (bytes) (T1 T2 T3)

Slave Address of the slave system
In the A1/A1dig: bus subscriber number, setting with the DIP switches at the front.

Code Function code:
Writing or reading of variables or events.

Data These include start address (area code and base address), number of addresses and data, according to function, see the instructions in the MODBUS protocol.

Check D. Security code
CRC code (Cyclic Redundancy Check), which is automatically generated by the transmitting system.

<u>Four functions can be realized with the MODBUS protocol:</u>

- Reading of variables such as inputs, outputs, flags etc.
- Writing of variables: network inputs
- Reading of events
- Time synchronization

The master system can read the following variables from and write to the A1/A1dig:

Type of variable	Read	Write
Physical inputs	X	-
Physical outputs	X	-
Flags, non volatile flags	X	-
Network inputs	X	X
Network outputs	X	-
Events	X	-
Time of automation device	If the H8-UHR-2 building block is used	X

Any number of binary signal changes at inputs, outputs etc. can be defined as an event in the ELOP application program.
The status of the binary signals in the current cycle is compared with the status in the previous cycle. When a change occurs, the relative address of the event, the current condition and the time of the automation device at the beginning of the cycle is placed in a buffer. Events that are recorded during the same cycle have therefore the same time-stamp.

NOTE: The reading of events (read out of the buffer store) can be done with special function codes that are not specified in the original MODBUS protocol, or by using standard codes.

4.4.1. Function Codes 1, 2, 3, 4 (Read Codes)

The start address is composed of two bytes, which contain the area code (bits 15...12) and the base address (bits 11...0). This arrangement means that 4096 names can be directly addressed in each area. Since a total of 3600 names can be defined within the ELOP firmware program, every name specified within the ELOP application program can be addressed in every area, with the exception of network area 1 (binary and digital outputs).

FUNCTION CODE 1 Read Status Binary Outputs (Read Coil Status)		
Area Code Bit 15 . . . 12	**Area**	**Base Address (decimal)**
0 0 0 0	Binary Outputs Network Area 1	0
0 0 0 0	Event Status Network Area 2	2048
0 0 0 1	Binary Outputs Network Area 2	4096
0 0 1 0	Binary Flags	8192
0 0 1 1	Binary Non-Volatile Flags	12288
0 1 0 1	Binary Testable Outputs	20480
0 1 1 0	Binary Outputs Network Area 3	24576
0 1 1 1	Binary Outputs Network Area 4	28672
1 0 0 0	Binary Outputs Network Area 5	32768
1 0 0 1	Binary Outputs Network Area 6	36864
1 0 1 0	Binary Outputs Network Area 7	40960
1 0 1 1	Binary Outputs Network Area 8	45056
Otherwise	Fault Code 2	

FUNCTION CODE 2 Read Status Binary Inputs (Read Input Status)		
Area Code Bit 15 . . . 12	**Area**	**Base Address (decimal)**
0 0 0 1	Binary Testable Inputs	4096
0 0 1 0	Binary Inputs Network Area 1	8192
0 0 1 1	Binary Inputs Network Area 2	12288
0 1 0 0	Binary Inputs Network Area 3	16384
0 1 0 1	Binary Inputs Network Area 4	20480
0 1 1 0	Binary Inputs Network Area 5	24576
0 1 1 1	Binary Inputs Network Area 6	28672
1 0 0 0	Binary Inputs Network Area 7	32768
1 0 0 1	Binary Inputs Network Area 8	36864
Otherwise	Fault Code 2	

FUNCTION CODE 3 Read Status Digital Outputs (Read Holding Register)		
Area Code Bit 15 . . . 12	**Area**	**Base Address (decimal)**
0 0 0 0	Digital Outputs Network Area 1	0
0 0 0 0	Events, Network Area 2	2048
0 0 0 0	Read Buffer Events Master 1	3072
0 0 0 0	Read Buffer Events Master 2	3584
0 0 0 1	Digital Outputs Network Area 2	4096
0 0 1 0	Digital Flags	8192
0 0 1 1	Digital Non-Volatile Flags	12288
1 0 0 0	Digital Outputs Network Area 3	32768
1 0 0 1	Digital Outputs Network Area 4	36864
1 0 1 0	Digital Outputs Network Area 5	40960
1 0 1 1	Digital Outputs Network Area 6	45056
1 1 0 0	Digital Outputs Network Area 7	49152
1 1 0 1	Digital Outputs Network Area 8	53248
Otherwise	Fault Code 2	

FUNCTION CODE 4 Read Status Digital Inputs (Read Input Register)		
Area Code Bit 15 . . . 12	**Area**	**Base Address (decimal)**
0 1 0 0	Digital Inputs Network Area 1	16384
0 1 0 1	Digital Inputs Network Area 2	20480
0 1 1 0	Digital Inputs Network Area 3	24576
0 1 1 1	Digital Inputs Network Area 4	28672
1 0 0 0	Digital Inputs Network Area 5	32768
1 0 0 1	Digital Inputs Network Area 6	36864
1 0 1 0	Digital Inputs Network Area 7	40960
1 0 1 1	Digital Inputs Network Area 8	45056
1 1 0 0	ANALOG Inputs	49152
Otherwise	Fault Code 2	

Error Codes when reading data	
Code	**Explanation**
2	Fault in the upper 4 bits Relative address too large (area exceeded, illegal address) Data >256 bytes (2048 bits, 128 words)
3	‘EFFECT’ not equal to FF00H or 0000H (binary values) All words are implemented internally as 16 bit values, i. e. there are no limitations concerning the value. The value limits are checked only by the output routines (illegal data value)

Example: Reading binary outputs

Slave number: 17
Function code: 1 (read status binary outputs)
Binary outputs: 20...56 = 37 names (21st to 57th name)

This yields a start address of 16384 (base address) + 20 = 16404, so that the request from the master system has the following form:

Type	Slave	Code	Start Address		Number	Check
DEC	17	1	16404		37	CRC
HEX	11	01	40	14	00 25	2 Bytes

The slave answers as follows:

Type	Slave	Code	Bytes	Data 27-20	Data 35-28	Data 43-36	Data 51-44	Data 56-52	Check
DEC	17	1	5	205	107	178	14	27	CRC
HEX	11	01	05	CD*	6B*	B2*	0E*	1B*	2 Bytes

*= possible values

CDH = 11001101D means, that in this case outputs 27, 26, 23, 22 and 20 have “1” signals and outputs 25, 24 and 21 have “0” signals.

4.4.2. Function Codes 5, 15, 6, 16 (Write Codes)

The start address is composed of two bytes, containing the area code (bits 15...12) and the base address (bits 11...0). This arrangement means that 4096 names can be directly addressed in each area. A total of 3600 names can be defined within the ELOP firmware program. Thus, every name specified within the ELOP application program can be addressed in every area, with the exception of network area 1 (digital inputs, function codes 6, 16).

FUNCTION CODE 5 **Write Single Binary Network Areas (Force Single Coil)**	**FUNCTION CODE 15** **Write Multiple Binary Network Areas (Force Multiple Coils)**	
Area Code Bit 15 . . . 12	**Area**	**Base address (decimal)**
0 0 0 0	Binary Inputs Network Area 1	0
0 0 0 1	Binary Inputs Network Area 2	4096
0 0 1 0	Binary Inputs Network Area 3	8192
0 0 1 1	Binary Inputs Network Area 4	12288
0 1 0 0	Binary Inputs Network Area 5	16384
0 1 0 1	Binary Inputs Network Area 6	20480
0 1 1 0	Binary Inputs Network Area 7	24576
0 1 1 1	Binary Inputs Network Area 8	28672
Otherwise	Fault Code 2	

FUNCTION CODE 6 **Write Single Digital Network Inputs (Preset Single Register)**	**FUNCTION CODE 16** **Write Multiple Digital Network Inputs (Preset Multiple Registers)**	
Area Code Bit 15 . . . 12	**Area**	**Base address (decimal)**
0 0 0 0	Digital Inputs Network Area 1	0
0 0 0 0	Time Synchronization	2048
0 0 0 1	Digital Inputs Network Area 2	4096
0 0 1 0	Digital Inputs Network Area 3	8192
0 0 1 1	Digital Inputs Network Area 4	12288
0 1 0 0	Digital Inputs Network Area 5	16384
0 1 0 1	Digital Inputs Network Area 6	20480
0 1 1 0	Digital Inputs Network Area 7	24576
0 1 1 1	Digital Inputs Network Area 8	28672
Otherwise	Fault Code 2	

Error Codes when writing data	
Code	**Explanation**
2	Fault in the upper 4 bits Relative address too large (area exceeded) Data >256 bytes 256 bytes (2048 bits, 128 words)
3	‘EFFECT’ not equal to FF00H or 0000H (binary values) All words are implemented internally as 16 bit values, i. e. there are no limitations concerning the value.

Example: Write to a binary network input in network area 2

Slave number: 17
Function code: 5 (force single coils)
Binary outputs: 173 (174th name)

This yields in an absolute address of 4096 (base address) + 173 = 4269.
Value of the network input: “1” signal

The request from the master system has the following form:

Type	Slave	Code	Start Address		Data	Check
DEC	17	5	4269		65280	
HEX	11	05	10	AD	FF 00	2 Bytes

The slave answers as follows:

Type	Slave	Code	Start Address		Data	Check
DEC	17	5	4269		65280	
HEX	11	05	10	AD	FF 00	2 Bytes

4.4.3. Function Code 8 (Loop Back Diagnostic Test)

The diagnostic code 0 of function code 8 is used to request the slave to repeat the master’s request transmission.

Code	Explanation
0	Return query data

Valid for all HIMA slaves.
The HIMA master knows all the diagnostic codes.

4.4.4. Function Codes 65, 66, 67 (Events)

Binary signal changes at any inputs, outputs or flags can be defined as an event in the ELOP application program.

The status of the binary signals in the current cycle is compared with the status in the previous cycle. When a change occurs, the relative address of the event, the current condition and the time in the automation device at the beginning of the cycle are placed in a buffer. Events that are recorded during the same cycle therefore have the same time stamp.

Events are specified in network area 2. A maximum of 1024 events can be configured.

Codes 65, 66, 67, which are free in the original MODBUS protocol, are used for the transfer of events from a slave system to a master system:

Function Codes 65, 66, 67		
Code	**Function**	**Explanation**
65	Read event value (status of the events)	Supplies the status of all event names (without time)
66	Read new event (address, status)	Returns the events from the event buffer with time stamp
67	Most recently sent event	Request to repeat the last transmission

Transmission formats (event read)

SLAVE	**CODE**	**BC**	**HO**	**LO**	**HO**	**LO**	**ERROR CHECK**
	65	Byte count	Starting point		Qty. of points		✓
	66	not used	not used		not used		✓
	67	not used	not used		not used		✓

Function code 65: Read event values (status of events)

Address counting always starts (STARTING-POINT) at 0.

The number of events (QUANTITY OF POINTS) is always the total number of events in network area 2. The values are transmitted in compressed form.

Function code 66: Read new event

Relative address counting starts with 0.
The events are stored in the buffer as eight bytes with the following meanings:

Relative Address		Value	Time				
LO Low value byte	HO High value byte	a “0” or “1” signal (1 byte)	ms 0...99 milliseconds	ds 0... 9 deciseconds	s	m 0...59 minutes	h 0...23 hours

The buffer contains 62 events. A maximum of eight events (= 64 bytes) are transmitted at any one time. Buffer overflow is indicated with FFFF (hex). Under certain circumstances these overflow flags are also transmitted. This increases the maximum length to 66 bytes.

The buffer remains blocked for new events until the overflow flag has been read out. Then the buffer can be freshly written.

BYTE COUNT	Explanation
0	No new events have occurred
< 64	All current events are contained in the response
≥ 64	Further events may be contained in the buffer

Function code 67: Most recently transmitted event

Code 67 is only possible after code 66, when the master system has not correctly received the response to code 66. It causes the slave system to repeat its last response.

A code 65 should be sent after a new start or after a slave system buffer overflow. In normal operation, code 66 (or code 67, if necessary) should repeatedly be sent by the master system.

Error messages during the interrogation of events:

Code	Explanation
1	Code 67 was not preceded by code 66.
2	In code 65 ‘STARTING POINT’ ≠ 0 or number of events has not been defined correctly.

4.4.5. Event Interrogation with Standard Codes 1, 3

The interrogations implemented with the special codes 65, 66 and 67 can also be performed with standard codes 1 and 3. This is particularly important if the master system does not support the special codes.

The following functions are possible:

- Interrogation of the status of events using code 1 or code 3.
- Reading events (address, status, time) using code 3.

Reading the events can also be done with two master systems, if these use different base addresses for the read out. For instance, the first master system uses the base address 3072 and the second uses the base address 3584. The reading is done from the same event buffer.

The event names are defined within the application program in ELOP, in network area 2. A maximum of 1024 event names can be specified.

Status Interrogation with Code 1

From base address 2048 onward, the status of a name defined as an event in network area 2 can be accessed with code 1.

Enquiry from the master:

Slave	Code	Start Address		Number of Events		Checksum
		HO	LO	HO	LO	
xx	1	≥2048		max. 1024		

The slave answer is as laid down for code 1.

Status Interrogation with CODE 3

As from base address 2048, the status of names defined as events in network area 2 can be accessed with code 3. Each digital value contains 16 events.

Enquiry from the master:

Slave	Code	Start Address		Number of Words		Checksum
		HO	LO	HO	LO	
xx	1	≥ 2048		max. 64		

Slave reply:

Slave	Code	Byte Count	1. Digital Value		. . . .	Checksum
xx	3	xx	xx	xx		xx

In the last digital value the unused bits are set to “0”.

Event Interrogation with Code 3

Any binary signal changes at inputs, outputs or flags can be defined as an event in the ELOP application program.

The status of the binary signals in the current cycle is compared with the status in the previous cycle. When a change occurs, the relative address of the event, the current condition and the time in the automation device at the beginning of the cycle are placed in a buffer. Events that are recorded during the same cycle have therefore the same time stamp.

The buffer contains a maximum of 62 events. If more events occur, there is a buffer overflow. This is marked by FFH in all eight bytes. New events will only again be transferred to the buffer when the overflow flag has been read out.

Each event is saved in the buffer using eight bytes, which have the following meaning:

Relative Address		Value	Time				
HO	LO		ms 0...99 milliseconds	ds 0...9 decisecond	s 0...59 seconds	m 0...59 minutes	h 0...23 hours

Relative Address counting begins with 0.

Indicating the overflow of the event buffer:
All eight bytes have the value FFH.

All the events which have occurred are contained in the slave’s response, or the buffer is empty:
The remaining eight bytes of a transmission have the value EEH.

When the events are interrogated using code 3, the number of events that are read from the buffer is just the number that the master has requested. Since an event consists of eight bytes, 4 words must always be read for this. This means that a maximum of 31 events x 4 words = 248 bytes per request must be read.

In order to be able to distinguish a repeated request from a new request, two different relative addresses in alternation must normally be used for the requests.

If a request is received with the same relative address as the previous request, it is assumed that the last response was not correctly received by the master, and that the master therefore is requesting the same events again.

At the beginning of communication and after the overflow of the event buffer, it is recommended that the status of all events is read, either with code 1 or with code 3.

Base addresses:	1. Master:	3072
	2. Master:	3584

Examples:

The master system requests the maximum number of events:	The master system requests one event at a time:
1. Request/transmission: Start address: 3072 Number of digital values: 124	1. Request/transmission: Start address: 3072 Number of digital values: 4
2. Request/transmission: Start address: 3073 Number of digital values: 124	2. Request/transmission: Start address: 3076 Number of digital values: 4
3. Request/transmission: Start address: 3072 Number of digital values: 124	3. Request/transmission: Start address: 3072 Number of digital values: 4

Error Messages in the Interrogation of Events

Code	Explanation
2	Relative address or number of values is not as specified

4.4.6. Time Synchronization, Code 70

The clock time and the date of automation devices can be synchronized by a master over the MODBUS using code 70. The master uses slave address 0 to address all automation devices. There are no slave responses.

Slave	Code	Byte Counter	Data								CRC
0	70	8	ms	ds	s	min	h	d	m	a	xx

Clock time:	ms	0...99 milliseconds	Date:	d	1...31 days
	ds	0...9 deciseconds		m	1...12 months
	s	0...59 seconds		a	0...99 years
	min	0...59 minutes			
	h	0...23 hours			

If only the clock time is to be transmitted, then d should be set to 0; if only the date is to be transmitted, then ms should be set to 255.

The clock time which is sent is the moment when the first character of the transmission is transmitted. The clock time is corrected in the slave, bearing in mind the time needed for the transmission.

4.4.7. Time Synchronization, Code 6

The clock time in the automation device can also be set using code 6. The telegram with code 6 must contain the number of milliseconds since the last complete minute, so that values lie in the range from 0...59999. The master uses slave address 0 to address all automation devices. There is no answer from the slaves.

The time which is transmitted is the moment when the first character is sent. The clock time is corrected in the slave, bearing in mind the duration of the transmission.

4.4.8. Configuration in the Application Program (ELOP)

No further specifications are needed in the application program. The HK-ZBK-1 must only be provided in the application program if the type of transmission differs from the standard setting. The standard setting is 9600 or 57600 baud, depending on the setting of the DIL switch on the front of the A1/A1dig.

NOTE: If the HK-ZBK-1 module is used, the baud rate prescribed here is definitive, independently of the setting of the DIL switch.

The master system can read all the variables of the automation device, and can write to network binary and digital inputs.

Both of the A1/A1dig interfaces can be used for the data transmission using the MODBUS protocol. When a name has been assigned, and type ”B” has been entered in the network area concerned, then the names of the binary and digital network inputs and outputs can be defined.

The master system can write to the network inputs in the network areas which are not defined as type ”S” (safety-related transmissions). Network inputs in network areas with type ”S” are only provided for the communication of safety-related HIMA automation devices among themselves (HIBUS-FS firmware).

4.4.9. Counting of the Relative Addresses in the Application Program (ELOP)

The numbering of relative addresses in each area of the name co-ordination always begins in the MODBUS protocol at 0. In other words, the first name of an area has relative address 0. It is oriented towards the sequence of the input (assembly 1, 2,.., block 1, 2,..) and not to the sequence of the assemblies in the sub-rack!

The best way to determine the relative addresses is to make use of the module-related documentation print-out of the name coordination.

An address is reserved for every channel (occupied or unoccupied) in all the binary input and output modules.

An address is allocated to each name in the name allocation of all the blocks, so that the channels which have not been given names are not to be counted!

The introduction of new names into blocks implies shifting all the subsequent addresses in their range. It is therefore recommended to specify reserve names, or to write new names at the end of an area. This is the only way to make it possible for later program changes to be loaded on-line.

4.4.10. Operation of the A1/A1dig in Connection with Process Control Systems

Advice is given below on certain special features of the connection to process control systems. Familiarization with the details of the MODBUS implementation in the process control system is recommended.

The communication takes place only when the A1/A1dig is in the RUN state, and exclusively in RTU mode (Remote Terminal Unit, specified in the MODBUS handbook).

The values sent by the master system are processed in the application program at the start of the following cycle, and in this way are treated like physical inputs. Only after the data on the network inputs have been accepted, an acknowledgement is sent to the master system.

The data requested by the master system is sent immediately, even in the middle of a cycle.

The default values in the operating system are as follows:

Transmission type:	RTU
Parity bit:	1 (even)
Baud rate:	9600 / 57600 Baud (DIL switch on front of the A1/A1dig)
No. of stop bits:	1

The baud rate, parity and number of stop bits can be changed if necessary in the application program using the HK-ZBK-1 building block.

The slave number is specified by the user by setting the bus subscriber number (the digital switch on the front of the A1/A1dig). The counting of the relative addresses begins at 1 in some process control systems, but with 0 in the HIMA automation system (in accordance with the specification in the MODBUS handbook).

In some process control systems the writing and the reading back of binary and digital names is done through the same address in each case. For this reason the same names must be defined in the same sequence in the HIMA automation device, both as network inputs and as network outputs.

The procedure is as follows:

- Specification as network inputs of all the names that are to be written by the process control system.
- Implicit allocation (same name) of the network input to network outputs, i.e. acceptance of the network inputs as network outputs in the same sequence.
- Network outputs (results of logic functions), which will only be read by the process control system, are then defined as the network outputs following the ones specified above.
- If the process control system can only read digital values, it may be necessary to change binary into digital values by means of appropriate software building blocks.

4.5. Connection with the 3964R Protocol (SIEMENS Devices)

In contrast to the MODBUS protocol, the Siemens 3964R protocol is not conceived as a bus system, but as a point-to-point connection.

It is recommended to obtain the documentation for the 3964R protocol from Siemens, and to become acquainted with the special features of the master.

The HIMA A1 and A1dig automation device can only be used as a slave system. Either of the A1/A1dig interfaces can be used for this kind of transmission and communication.

The network areas 1 and/or 2 (identical with the interface) used are to be defined as type ”6" in the name coordination. Only the 3964R’s data type B (data element) is supported.

HIMA requires the block check character (BCC) as an element in the telegram.

4.5.1. 3964R Protocol Function Summary

Basically two functions are to be distinguished in the 3964R Siemens protocol:

- Writing variables
  Only network inputs are possible
  SEND command, command code AD
- Reading variables
  E.g. inputs, binary or digital flags etc.
  FETCH command, command code ED

A maximum of 128 bytes can be read or written at any one time.

The master system can write to those network inputs of network areas which are not defined as type ”S” (safety-related transmissions).

Network inputs in network areas with type ”S” are only provided for the communication of safety-related HIMA automation devices between themselves.

4.5.2. Implemented Write Codes

The data are written following a SEND command. The individual areas are addressed using data elements (DE) and the address (names) using data words (DW).

Area of the name coordination		Address of the 1st name in the area			
				DE	DW
Network area 1	Binary inputs Digital inputs	03H 04H	00H 00H		
Network area 2	Binary inputs Digital inputs	0CH 0DH	00H 00H		
Network area 3	Binary inputs Digital inputs	15H 16H	00H 00H		
Network area 4	Binary inputs Digital inputs	1EH 1FH	00H 00H		
Network area 5	Binary inputs Digital inputs	27H 28H	00H 00H		
Network area 6	Binary inputs Digital inputs	30H 31H	00H 00H		
Network area 7	Binary inputs Digital inputs	39H 3AH	00H 00H		
Network area 8	Binary inputs Digital inputs	42H 43H	00H 00H		

Allocation of the binary ELOP names to the data elements and data words:

16 binary ELOP names are addressed with one data word. In other words, each block of 16 network binary inputs is defined with one data word.

To ensure a simple allocation of the ELOP blocks to the data words, the names in the blocks should be given without gaps, and the blocks always completely occupied.

Example:

The 12th binary network input in the third block of network area 2 is defined in data element 0CH and data word 02H.

In every network area theoretically 4096 binary names can be addressed; the ELOP program module can handle a maximum of 3600 names.

Allocation of the digital ELOP names to the data words:

A digital ELOP name is addressed with every data word. In other words each block with 16 network digital inputs is defined with 16 data words.

To ensure a simple allocation of the ELOP blocks to the data words, the names in the blocks should be entered without gaps and the blocks always fully occupied.

Example:

The twelfth digital network input in the third block of network area 2 is defined in data element 0DH and data word 2BH.

A maximum of 2048 digital names can be addressed in each network area.

4.5.3. Implemented Read Codes

The data are read with a simple FETCH command. The individual areas are addressed using data elements (DE) and address (names) using data words (DW).

Name allocation area		**Address of the 1st name in the area**			
				DE	DW
Network area 1	Binary inputs Digital word inputs	03H 04H	00H 00H		
Network area 2	Binary inputs Digital word inputs	0CH 0DH	00H 00H		
Network area 3	Binary inputs Digital word inputs	15H 16H	00H 00H		
Network area 4	Binary inputs Digital word inputs	1EH 1FH	00H 00H		
Network area 5	Binary inputs Digital word inputs	27H 28H	00H 00H		
Network area 6	Binary inputs Digital word inputs	30H 31H	00H 00H		
Network area 7	Binary inputs Digital word inputs	39H 3AH	00H 00H		
Network area 8	Binary inputs Digital word inputs	42H 43H	00H 00H		
Network area 1	Binary outputs Digital outputs	4BH 4CH	00H 00H		
Network area 2	Binary outputs Digital outputs	54H 55H	00H 00H		
Network area 3	Binary outputs Digital outputs	5DH 5EH	00H 00H		

Name allocation area		**Address of the 1st name in the area**			
				DE	DW
Network area 4	Binary outputs Digital outputs	66H 67H	00H 00H		
Network area 5	Binary outputs Digital outputs	6FH 70H	00H 00H		
Network area 6	Binary outputs Digital outputs	78H 79H	00H 00H		
Network area 7	Binary outputs Digital outputs	81H 82H	00H 00H		
Network area 8	Binary outputs Digital outputs	8AH 8BH	00H 00H		
Binary flags		93H	00H		
Binary non-volatile flags		94H	00H		
Binary testable inputs		96H	00H		
Digital flags		97H	00H		
Digital non-volatile flags		9FH	00H		
Analog inputs		C7H	00H		

For the allocation of the binary and digital ELOP names to the data elements and data words, see chapter 4.5.2. In every digital area a maximum of 2048 ELOP names can be addressed.

4.5.4. Error Messages to the Master

Code	Explanation
0	No fault
1	Format fault: transmission structure faulty, for example - wrong checksum - wrong coordination flag - wrong identification - wrong command type (not A or E) - wrong data type (not D) - request with data (ED) - write command without data (AD) - no doubled DLEs - telegram header > 10 bytes
2	Address error: address supplied is wrong or invalid (area not defined by HIMA)
3	Count error: number = 0, or bigger than range, or number >128 bytes

4.6. Diagnostic Display on the Central Unit

The diagnostic display consists of a 4-character alphanumeric display and two light-emitting diodes. The green diode indicates operation, and the red diode indicates faults in the I/O or CPU area.

The ACK (acknowledge) button serves to reset the fault display (in a fault-stop the ACK key has the effect of a system reset).

With the four keys ⇐, ⇒, ⇑, ⇓ information can be called up from the automation device, as explained in the following table:

Diagnostic display		Explanation	Retrieval of information
Text	Example		
BATI	——	RAM support battery voltage in central unit too low	
BN	2	Bus subscriber number, setting of the DIL switches 1-7	1x⇓, 3x⇒
BS41/51 V5.0-5 (9706)	——	Identification, version and issue of the operating system	4x⇓

Diagnostic display		Explanation	Retrieval of information
Text	Example		
CB1 CB2 CB3		for internal diagnostic purposes	5x⇓ 6x⇓ 7x⇓
C.TIME	0064	Cycle period in milliseconds	1x⇓, 4x⇒
DATE	0212	Date in DDMM format	1x⇓, 8x⇒
EPROM-CRC	83B3	CRC of the operating system EPROMS: Is compared with the value given in the operating system security certificate	4x⇓, 1x⇒
F	47	Display of the most recently occurred fault (see ‘List of Fault Codes’) Display during current fault: ZB/CU: CPU ZB/CU: MEMORY ZB/CU: REALTIME CLOCK ZB/CU: CLOCK LOGIC OFF FATAL ERROR W-DOG COUPLING UNIT/OTHER	1x⇒ 1x⇓
iiii		no project loaded	
K-IS	0120	Diagnostic code for further manufacturer tests	2x⇒
K-SO	0034	Diagnostic code for further manufacturer tests	3x⇒
KEY	0022	Diagnostic code for further manufacturer tests	4x⇒
MAX170-ERR	0013	Diagnostic code for further manufacturer tests	5x⇒
NW 1	0012	Network 1, network area 1 No change in value: No data for NW 1	2x⇓, 2x⇒ 2x⇓, 2x⇒, 1x⇓
NW 2	1A22	Network 2, network area 2 No change in value: No data for NW 2	2x⇓, 3x⇒ 2x⇓, 3x⇒, 1x⇓
NW 3	D031	Network 3, network area 3 No change in value: No data for NW 3	2x⇓, 4x⇒ 2x⇓, 4x⇒, 1x⇓
NW 4	040F	Network 4, network area 4 No change in value: No data for NW 4	2x⇓, 5x⇒ 2x⇓, 5x⇒, 1x⇓
NW 5	4015	Network 5, network area 5 No change in value: No data for NW 5	2x⇓, 6x⇒ 2x⇓, 6x⇒, 1x⇓
NW 6	0FF2	Network 6, network area 6 No change in value: No data for NW 6	2x⇓, 7x⇒ 2x⇓, 7x⇒, 1x⇓

Diagnostic display		**Explanation**	**Retrieval of information**
Text	Example		
NW 7	03DE	Network 7, network area 7 No change in value: No data for NW 7	2x⇓, 8x⇒ 2x⇓, 8x⇒, 1x⇓
NW 8	B019	Network 8, network area 8 No change in value: No data for NW 8	2x⇓, 9x⇒ 2x⇓, 9x⇒, 1x⇓
ONLINE	——	Mono online alteration being performed	
PROJEKT	——	Project name, depending on the project loaded	1x⇓
RUN	——	Automation device in normal operation	
RUN-VERSION	23AD	Version number, generated in operation from all values	1x⇓, 2x⇒
SIO1	0012	Interface 1 of the automation device No change in value: No data over interface 1	2x⇓ 3x⇓
SIO2	1A7F	Interface 2 of the automation device No change in value: No data over interface 2	2x⇓, 1x⇒ 2x⇓, 1x⇒, 1x⇓
STOP		Stop from programming device, stop from operating system	
TIME	1431 3132 32.3	Time in hours/minutes Time in minutes/seconds Time in seconds/deciseconds	1x⇓, 5x⇒ 1x⇓, 6x⇒ 1x⇓, 7x⇒
VERSION	AC34	Project version number	1x⇓, 5x⇒

5. Communication under ELOP II

5.1. Coupling to other HIMA Automation Devices

The operating systems are designed for data transfer between HIMA automation devices via HIBUS. This requires at least one automation device H51 with a coprocessor module which is used as the PLC master. Both interfaces of the A1/A1dig can be used for this.

The data to be sent by an automation device are defined as variables with the attribute *HI-BUS Export*. The data received from another automation device are defined as variables with the attribute *HIBUS Import*.

The monitoring of the safety-related communication for correct receipt of data by the master system is defined in the notebook of the resource type. The imported data are then set to low (i.e. 0) if no data are described by the Master system within the defined time.

5.1.1. Non Safety-related Data Transmission

For configuration, the FBS editor must be started with the program type from the resource type. The declaration takes place in the A1/A1dig *Variable Allocation* under point *HIPRO-N*.

During operation, the PLC master reads all data to be transferred to the attached controls, assembles the transmissions for the attached controls and then sends the data to the automation devices.

5.1.2. Safety-related Data Transmission

For configuration, the FBS editor must be started with the program type from the resource type. The declaration takes place in the der A1/A1dig *Variable Allocation* under point *HIPRO-S*.

In operation, the PLC master organizes the direct data transfer between the individual automation devices. It does not store the data itself. Although the data is transferred via the HI-BUS, this can be regarded as point-to-point connection.

5.2. Coupling to HIMA Master Systems

HIMA Master Systems are personal computers with operating system Windows® running HIMA firmware programs such as ELOP II or WizCon. These can be connected directly to the serial interface of the A1/A1dig or communicate via MODBUS. Communication takes place only if the A1/A1dig is in RUN mode. The only exception to this is communication with the engineering station (ELOP II).

5.2.1. Engineering Station (ELOP II)

The engineering station is used for programming, loading, monitoring and documenting the function of the A1/A1dig with the software and planning system ELOP II.

5.2.2. Visualization System WizCon

The visualization system WizCon is used for configuration of any process images, interpretation and writing of variables of the A1/A1dig.

The visualization system can only write variables of the automation device with the attribute *MODBUS read and write*.

Also using the visualization system, events can be listed and printed out. The individual variables are given the property event controlled in the A1/A1dig *Variable Allocation.*

The events are stored in the HIMA automation device and there retrieved by the visualization system, where they are then output to screen or the connected printer. For subsequent analysis on the visualization system, the events can also be stored on the hard disk. The event text is configured and defined in the visualization system WizCon.

Using the visualization system, variables can also be shown on screen as trend curves and stored on the hard disk of the PC. If the variables are stored on the hard disk, historic trends can also be shown.

5.2.3. Logic Plan controlled Reporting

The purpose of logic plan controlled reporting is to record events (signal change with time) in the central part of the A1/A1dig and print out events with interpretation on a connected printer.

NOTE: For logic plan controlled reporting, only interface 2 of the A1/A1dig can be used.

The property *reporting* is allocated to the individual variables in the A1/A1dig *variable allocation*. The events and texts are a component part of the user program. Additional functions can be achieved using software building block HK-LGP-3 (see description of software building block).

5.3. Coupling to External Systems

The operating system is designed to communicate via the MODBUS Protocol as slave and master system and via the Siemens Protocol 3964R as slave system. If the A1/A1dig is used as slave system, no further HIMA standard building blocks are required in the user program.

If the A1/A1dig is used as MODBUS Master, the HIMA standard building block HK-MMT-3 must be used. The functions of the module are given in the module description.
The interface parameters can be preset in the notebook (*Settings*) of the resource if they deviate from the standard settings (9600 baud or 57600 baud, 1 stop bit, parity bit even).

Communication with the external systems takes place only if the A1/A1dig is in RUN mode.

The external system can read all variables of the automation devices with the attribute *Read*. The data obtained from an external system must have the attribute *Write*.

5.4. Coupling to Process Control Systems via MODBUS Protocol

The MODBUS Protocol is designed for transfer to a bus (e.g. HIBUS) as master-slave system and is normally used for coupling HIMA automation devices to a process control system. The A1/A1dig can be used as a slave system without further modules and as a master system with module HK-MMT-3.

The MODBUS Protocol was defined by the company Gould Modicon. We recommend obtaining the documents on MODBUS directly from AEG-Modicon and finding out about any special features of the master system.

For information, the main properties are explained below.

In the A1/A1dig, only the transfer mode RTU (Remote Terminal Unit) is used as normal between computer systems. The transfer is asynchronous with 8 bits and CRC security code.

The data transfer mode RTU generally has the following format:

Beginn	Slave	Code	Data	Check data	End of transmiss.
T1 T2 T3	1 Byte	1 Byte	Number of bytes depends on function, number of addresses and data	2 Bytes	T1 T2 T3

Start/End of transmission identified by 3 1/2 characters (bytes) pause

Slave Address of slave system (for HIMA: bus subscriber number, setting to central module)

Code Function code
Write or read variables, events

Data Start address
Number of addresses and data depending on function, see definitions in MODBUS protocol.

Check data Security code:
CRC Code (Cyclic Redundancy Check), which is formed automatically by the sending system.

Using the MODBUS Protocol, four functions can be achieved:

- Read variable
- Write variable
- Read events
- Time synchronization

The Master system can read and write variables of the HIMA automation device which are defined using the attribute *Modbus Read and Write*. Any boolean signal change of variable can be defined as an event in ELOP II.

The status of the boolean signal in the current cycle is compared with the status in the previous cycle. On a change, the number of the event, the current status and the time of the automation device at the start of the cycle are stored in a buffer memory. Events detected in the same cycle have the same time stamp.

Events can be read (read-out of buffer memory) with special function codes not agreed in the original MODBUS Protocol or with standard codes (see detection of events).

5.4.1. Read Codes 1, 3

For Boolean variables, the function code 1 “READ COIL STATUS” is used and for integer variables, function code 3 “READ HOLDING REGISTER”. The associated MODBUS addresses can be taken from the resource documentation *RES Docu (generated)*.

Error Codes (when reading data)

Code	Explanation
2	Address too big, variable not available. Data > 256 bytes (2048 boolean values, 128 integer values)

Example: Read Boolean Variables

Slave Number: 17
Function code: 1
Boolean Variable: 20...56 = 37 variables

The start address can be taken directly from the *RES Docu (generated)*.

Start address: 20

Request from Master System:

Type	Slave	Code	Start Address		Data	Check
DEC	17	5	37		65280	
HEX	11	05	00	25	FF 00	2 Bytes

Reply from Slave:

Type	Slave	Code	Bytes	Data 27-20	Data 35-28	Data 43-36	Data 51-44	Data 56-52	Check
DEC	17	1	5	205	107	178	14	27	CRC
HEX	11	01	05	CD*	6B*	B2*	0E*	1B*	2 Bytes

* = possible values

CDH = 11001101D, i.e. the variables 27, 26, 23, 22 and 20 have “1” signal and the variables 25, 24 and 21 have “0” signal.

The automation device sends the data to the master system immediately on request.

For an example of reading the buffer memory of events, see chapter 5.4.5

5.4.2. Write Codes 5, 15, 6, 16

For boolean variables, function codes

- 5 FORCE SINGLE COIL and
- 15 FORCE MULTIPLE COILS

are used.

For integer variables, function codes

- 6 PRESET SINGLE REGISTER and
- 16 PRESET MULTIPLE REGISTERS

are used.

The associated MODBUS addresses can be taken from the resource documentation *RES Docu (generated)*.

Error Codes when writing data:

CODE	Explanation
2	Address too big
3	”EFFECT” not equal to FF00H or 0000H (Boolean values)

Example: Writing a boolean variable

Slave Number: 17
Function code: 5 (Write single variable)
Boolean Variable: 37

The address can be taken direct from *RES Docu (generated)*.

Address: 37

Transmission from Master:

Type	Slave	Code	Start Address		Data	Check
DEC	17	5	37		65280	
HEX	11	05	00	25	FF 00	2 Bytes

Reply from Slave:

Type	Slave	Code	Start Address		Number	Check
DEC	17	5	20		37	CRC
HEX	11	05	00	14	00 25	2 Bytes

The A1/A1dig takes over the data transmitted as the variable at the start of the next cycle. Thus the longest reaction time is approximately the cycle time of the automation device.

5.4.3. Loop Back Diagnostic Test, Code 8

The diagnosis code 0 of function code 8 is used to request the slave system to repeat the request transmission from the master.

Code	Explanation
0	Return query data

Valid for all HIMA Slaves.
The HIMA Master knows all 21 diagnosis codes.

5.4.4. Function Codes for Events 65, 66, 67

Any boolean signal change of variable can be defined in ELOP II as an event.

The status of the Boolean signals in the current cycle is compared with the status in the previous cycle. On a change, the number of the event, the current status and the time of the automation device at the start of the cycle are stored in a buffer memory. Events which are detected in the same cycle have the same time stamp..

To transfer events from the slave system to a master system, the free codes in the original MODBUS protocol 65, 66, 67 are used:

Code	Function	Explanation
65	Read event value (Status of event)	Gives the status of all event names without time
66	Read new events (address, status, time)	Returns the events from the event buffer with time
67	Last events sent	Request to repeat last transmission

Send formats (Read events):

SLAVE	CODE	BC	HO	LO	HO	LO	ERROR CHECK
	65	Byte count	Starting point		Qty. of points		✓
	66	not used	not used		not used		✓
	67	not used	not used		not used		✓

Function code 65: Read event value (Status of events)

‘STARTING-POINT’ is always 0.

‘QUANTITY OF POINTS’ is always the total number of events (highest number + 1). The values are transferred compressed.

Function code 66: Read new events

The events are stored in the buffer with 8 bytes with the following occupation:

Event number: to *RES Docu (generated)*

Event number		Value	Time				
LO Lower value byte	HO Higher value byte	a 0 or 1 signal (1 Byte)	ms 0...99 Milliseconds	ds 0... 9 Deciseconds	s 0...59 Seconds	m 0...59 Minutes	h 0...23 Hours

The buffer contains 62 events. Max. 8 events (= 64 bytes) are transferred at one time

The buffer overflow is marked with FFFFH (Hex). This overflow mark is also transferred; then the maximum length is increased to 66 bytes. The buffer remains blocked for new events until the overflow mark is read. Then the buffer can be rewritten.

Byte count	Explanation
0	No new events occurred
< 64	All current events contained in the reply
≥ 64	Further events can be contained in the buffer

Function code 67: Last events sent

Code 67 is only possible after Code 66, if the master system has not received Code 66 correctly. It causes the slave system to repeat its last reply.

After a new start or buffer overflow of the slave systems, Code 65 should be sent. In normal operation, Code 66 and Code 67 are sent in cycles by the master system.

Error messages when querying events:

Code	Explanation
1	Code 67 was not preceded by Code 66
2	In Code 65 'STARTING POINT' is ≠ 0 or number of events has not been given correctly

5.4.5. Event Query with Standard Codes 1, 3

Queries carried out with special codes 65, 66 and 67 can also be carried out with standard codes 1 and 3. The following functions are possible:

- Query status of events via code 1
- Read out of events (number, status, time) via code 3

Events can be read using two Master systems which use different start addresses on read-out. The first Master system uses the start address 3072 and the second uses start address 3584. The read-out takes place via the same event buffer.

The event variables are defined within ELOP II (attribute *event-controlled*). Max. 1024 events can be agreed.

Status query with Code 1

From start address 2048, the status of the variable defined as an event can be accessed using *Read Status Boolean Variable*..

Request from Master:

Slave	Code	Start-Address		Number of events		Check
		HO	LO	HO	LO	
xx	1	≥ 2048		max. 1024		

Reply from Slave as defined in Code 1.

Event query with Code 3

Any boolean signal change of variables can be defined in ELOP II as an event.

The status of the boolean signals in the current cycle is compared with the status in the previous cycle. On a change, the number of the event, the current status and the time of the automation device at the start of the cycle are stored in a buffer memory. Events which are detected in the same cycle have the same time stamp.

The buffer memory contains max. 62 events. If more events occur, a buffer overflow is recorded which is marked by the 8 byte FFH. New events are only included in the buffer memory again when the overflow mark has been read.

Each event is stored in the buffer memory with 8 bytes which have the following meaning:

Event number		**Value**	**Time**				
HO	LO		ms 0...99 Milliseconds	ds 0...9 Deciseconds	s 0...59 Seconds	m 0...59 Minutes	h 0...23 Hours

The event number can be taken from the *RES Docu (generated)*.

- Identification of event buffer overflow: All 8 bytes have the value FFH.
- All events occurring are contained in the reply from the slave or the buffer memory is empty:
- All 8 bytes of the remaining data in the transmission have the value EEH.

On an event query with code 3, the number of events read from the buffer memory (max. 31 events x 4 integer values = max. 31 x 8 bytes) is that specified in the query from the Master system. As an event consists of 8 bytes, 4 integer variables must always be read together.

To distinguish a repeated query from a new query, in normal operation at least two alternating start addresses must be queried.

If a query is received with the same start address as the previous query, it is assumed that the last reply was not correctly received by the master and the master therefore requests the same events again.

At the start of communication and after overflow of the event buffer, it is recommended that the status of all events is read with Code 1.

Start addresses:

1. Master: 3072
2. Master: 3584

Example: The Master system requests the maximum number of events:

1st request/transmission: start address: 3072	number of integer variables: 124
2nd request/transmission: start address: 3073	number of integer variables: 124
3rd request/transmission: start address: 3072	number of integer variables: 124

Example: The Master system requests one event in each case:

1st request/transmission: start address: 3072	number of integer variables: 4
2nd request/transmission: start address: 3076	number of integer variables: 4
3rd request/transmission: start address: 3072	number of integer variables: 4

Error Messages on Event Query:

Code	Explanation
2	Start address or number of values does not match agreed data.

5.4.6. Time Synchronization, Code 70

Time and date of automation devices can be synchronized by a master via MODBUS. Code 70 is used for this. The master contacts all automation devices with slave Address 0. There is no reply.

Time:	ms	0...99 Milliseconds	Date:	d	1...31 Days
	ds	0...9 Deciseconds		m	1...12 Months
	s	0...59 Seconds		a	0...99 Years
	min	0...59 Minutes			
	h	0...23 Hours			

If only the time has to be sent, set d = 0. If only the date has to be sent, set ms = 255.

The time set is the time of sending the first character of this transmission. The time in the Slave is corrected with the delay caused by the transmission duration.

5.4.7. Time Synchronization, Code 6

The time in the automation device can also be set with code 6. For this the telegram with code 6 must contain the number of milliseconds since the last full minute, i.e. values lie in range 0...59999. The master addresses all automation device with slave address 0. There is no reply.

The time sent is the time of transmission of the first character of this transmission. The time in the slave is corrected by the delay from the transmission duration.

5.4.8. Operating the A1/A1dig in Connection with Process Control Systems

Some features of the connection to process control systems are discussed below. We recommend finding out about details of the MODBUS coupling to the process control system.

Communication takes place only with the A1/A1dig in RUN mode and only in RTU mode (Remote Terminal Unit, defined in the MODBUS manual).

The values sent by the master system are processed in the user program at the start of the next cycle and are treated as physical values. Only when the data are taken as the variables is an acknowledgment sent to the master system.

The data requested by the master system are sent immediately from the cycle to the master system.

The following standard values are defined in the operating system:

Transfer mode:	RTU
Parity bit:	1 (even)
Baud rate:	9600 Baud or 57600 Baud (DIL switch on front of A1/A1dig)
Number of stop bits:	1

The baud rate, parity and stop bits can be modified in the resource settings if required.

The slave number is defined by the user setting the bus subscriber number (coding switch on front of A1/A1dig).

In some process control systems, the counting method of the addresses begins at 1, in the HIMA automation system at 0 (as agreed in the MODBUS manual).

5.5. Coupling with Protocol 3964R (SIEMENS Devices)

In contrast to the MODBUS Protocol, the SIEMENS Protocol 3964R is designed not as a bus system but as a point-to-point connection.

We recommend obtaining documents on the Protocol 3964R from SIEMENS and finding out about special features of the master.

The HIMA automation devices A1and A1dig can only be used as a slave system. Both interfaces of the A1/A1dig can be used for this type of data transfer. Only data type D (data modules) of protocol 3964R is supported. HIMA requires the Block Check Character (BCC) as part of the telegram.

The variable to be read or written is defined in the resource (ZK edit) with the attribute *Siemens Protocol*.

5.5.1. Overview of Functions of Protocols 3964R

The Siemens protocol 3964R distinguishes between two functions:

- Write variables,
  SEND Order, Command AD
- Read variables,
  FETCH Order, Command ED

A maximum of 128 bytes can be read or written at a time.

5.5.2. Write Codes

The data are written after a SEND order. The individual variables are addressed via data modules (DB) and data words (DW).

Allocation of Boolean Variables to the Data Modules and Data Words:

16 Boolean variables can be addressed with a data word. The address can be taken from the resource documentation *RES Docu (generated)*.

Allocation of Integer Variables to Data Words:

Each data word addresses an integer variable. The address can be taken from the resource documentation *RES Docu (generated)*.

5.5.3. Read Codes

The data are read with a FETCH order. The individual variables are addressed via data modules (DB) and data words (DW).

5.5.4. Error Codes at the Master

Error code	Explanation
0	No error
1	Format error: Structure of transmission error, for example Incorrect checksum Incorrect coordination marker Incorrect ID Incorrect command type (not A or E) Incorrect data type (not D) Query with data (ED) Write command without data (AD) No duplicate DLEs Telegram header > 10 Bytes
2	Address error: Address is incorrect or invalid (variable not defined by HIMA)
3	Number error: Number = 0 or larger than the number of variables defined or number > 128 bytes

5.6. Diagnostic Display

The diagnostic display consists of a four-digit alphanumeric display and two LEDs marked ‘POWER’ and ‘FAIL’ on the front of the A1/A1dig.

Information can also be retrieved from the automation device via two buttons explained below. One button is used to select the next lower or next higher level, the other to select further information in the same level.

Diagnostic Display		**Explanation**	**Retrieval of information**
Text	Example		
BATI	——	Voltage of RAM buffer battery in central unit too low	
BN	2	Bus subscriber number, setting of DIL switch 1-7	1x⇓, 3x⇒
BS41/51 V6.0-6 (9636)	——	Identification, version and issue of operating systems	4x⇓
CB1 CB2 CB3		for internal diagnosis purposes	5x⇓ 6x⇓ 7x⇓
C.TIME	0064	Cycle time in Milliseconds	1x⇓, 4x⇒
DATE	0212	Date in format DDMM	1x⇓, 8x⇒
EPROM-CRC	6F59	CRC of operating system EPROM: compare with data in safety certificate of operating systems	4x⇓, 1x⇒
F	47	Display of last error occurring Display on current error: ZB/CU: CPU ZB/CU: MEMORY ZB/CU: REALTIME CLOCK ZB/CU: CLOCK LOGIC OFF FATAL ERROR W-DOG COUPLING UNIT/OTHER	1x⇒ 1x⇓
iiii		no project loaded	
K-IS	0120	Diagnosis code for further manufacturer tests	2x⇒
K-SO	0034	Diagnosis code for further manufacturer tests	3x⇒
KEY	0022	Diagnosis code for further manufacturer tests	4x⇒

Diagnostic Display		**Explanation**	**Retrieval of information**
Text	Example		
KONFIGURATION	HIMA	Configuration name	1x⇓
MAX170-ERR	0013	Diagnosis code for further manufacturer tests	5x⇒
NW 1	0012	Network 1, network area 1 No value change: No data for NW 1	2x⇓, 2x⇒ 2x⇓, 2x⇒, 1x⇓
NW 2	1A22	Network 2, network area 2 No value change: No data for NW 2	2x⇓, 3x⇒ 2x⇓, 3x⇒, 1x⇓
NW 3	D031	Network 3, network area 3 No value change: No data for NW 3	2x⇓, 4x⇒ 2x⇓, 4x⇒, 1x⇓
NW 4	040F	Network 4, Interconnection segment 4 No value change: No data for NW 4	2x⇓, 5x⇒ 2x⇓, 5x⇒, 1x⇓
NW 5	4015	Network 5, Interconnection segment 5 No value change: No data for NW 5	2x⇓, 6x⇒ 2x⇓, 6x⇒, 1x⇓
NW 6	0FF2	Network 6, Interconnection segment 6 No value change: No data for NW 6	2x⇓, 7x⇒ 2x⇓, 7x⇒, 1x⇓
NW 7	03DE	Network 7, Interconnection segment 7 No value change: No data for NW 7	2x⇓, 8x⇒ 2x⇓, 8x⇒, 1x⇓
NW 8	B019	Network 8, Interconnection segment 8 No value change: No data for NW 8	2x⇓, 9x⇒ 2x⇓, 9x⇒, 1x⇓
ONLINE	——	Mono reload carried out	
PROGRAMM	PRO1	Program name	1x⇓, 1x⇐
RESSOURCE	H51RT	Resource name	1x⇓
RUN	——	Automation device in normal mode	
RUN-VERSION	3402	RUN version No., formation in operation, dep. on all values	1x⇓, 2x⇒
SIO1	0012	Interface 1 of automation device No value change: No Data via interface 1	2x⇓ 3x⇓
SIO2	1A7F	Interface 2 of automation device No value change: No Data via interface 2	2x⇓, 1x⇒ 2x⇓, 1x⇒, 1x⇓
STOP		Stop from programming device, stop from operating system	
TIME	1431 3132 32.3	Time in hours/minutes Time in minutes/seconds Time in seconds/deciseconds	1x⇓, 5x⇒ 1x⇓, 6x⇒ 1x⇓, 7x⇒
CODE VERSION	AC34	Code version number	1x⇓, 1x⇒

6. A1/A1dig principle Functions

6.1. General

The safety-related A1/A1dig cyclically processes the program which has been entered. The cycle consists, in a simplified form, of three parts:

- Reading the input signals
- Processing the logic functions
- Writing the output signals

In the safety-related A1/A1dig the following important functions are added to this:

- Extensive self-tests
- Tests of the I/O modules during operation

The memory areas are divided as follows:

- Operating system
- Application program (logic functions)
- Area for parameters and constants
- Area for variables, divided into an RWN area (read/write area, non-volatile) and an RWV area (read/write area, volatile).

The operating system is stored in a non-volatile memory (flash EPROM). The variable area, the application program and the parameters are stored in a RAM. The RAM is battery buffered.

In safety-related automation devices, a secondary shut-down method is needed to ensure safety. The primary shut-down method is given by a logic signal.

The secondary shut-down method is implemented in the output modules by a series circuit of three semiconductors (integrated safety shut-down is). Thus if there is a fault, a defect output module is automatically brought into the safe, low-energy condition. If there is a fault in the central unit, the output modules are switched off by means of a fail-safe watchdog signal.

6.2. Cycle Procedure

A cycle is processed in five phases:

Phase 1:	Perform the cyclical self-tests Cyclical consistency checking
Phase 2:	Read and test inputs
Phase 3:	Process user logic
Phase 4:	Write output values
Phase 5:	Read back and compare outputs

If a difference is established in the secure output modules between the external output signals which are read back and the internally stored output signals, the output module concerned is shut down in that very cycle.

The procedure under ELOP II is the same with the difference that phase 3 is not performed in a sequence but according to the regulations of the IEC 1131-3 section 4.1.3.

6.3. Test Routines

Individual faults which could lead to a dangerous operational condition are recognized within the fault tolerance time (minimum 1 s) by the self-testing equipment. This time is specified in the HZ-PA1-1 parameter module as safety time.

Failures which can only have a safety-critical effect if they are combined with additional faults are recognized by the background tests within the secondary fault onset time. The secondary fault onset time is specified by the parameterization of the safety time (fault tolerance time). The operating system defines it as 3600 times greater.

A distinction is made in the tests between:

- **Tests within the safety time**
  They are performed within the safety time (foreground tests).
  Reaction time: Immediately, at the latest within the safety time.
- **Tests within the secondary fault onset time**
  They are performed within the second/multiple fault onset time and are distributed over many cycles (background tests).
  Reaction time: Immediately when recognized, at the latest within the secondary fault onset time.

  Reaction time: At the most, twice the cycle time. If, for example, a safety time of one second is required for the process, the cycle time may not be longer than 500 ms.

6.3.1. Central Unit

The A1/A1dig most important tests are explained below:

- **CPU Test**
  The CPU Test is a foreground test with the following individual tests:
  - command and addressing modes,
  - writability of the flags and of the commands controlled by flags,
  - writability and the alterability of registers,
  - test of the ALU (arithmetic logic unit)
- **Test of Memory Regions**
  The operating system, the application program, the constants and parameters as well as the variable data are stored both directly and in inverted form in the central unit. They are continuously checked for complementary equivalence by a hardware comparator.
- **Test of Flash EPROM**
  The content of this memory area is checked by a CRC test.
- **RAM Test**
  The RAM areas are checked, especially for cross-talk, by a write/read test.
- **Watchdog Test**
  The watchdog signal is switched off if it is not triggered with various bit-patterns by the CPU within a prescribed period of time.
  In a further test, the ability of the watchdog signal to be switched off is checked.
- **Test of the Connection to the I/O Area**

6.3.2. Safe Input Modules

For the safe input modules the system checks whether the channels (low or high signals) can be switched through. This test of functional capability is performed after every read of the input signals.

When there is a fault in the input module, a low signal is internally generated for the logical processing. Simultaneously the defect module position is shown. This automatic mechanism is in effect the implementation of broken conductor safety in hard-wired controllers, where a broken conductor or a fault in an input amplifier produces a low signal, normally leading to shut-down.

In the testable analog input channels, a test value is switched through using a D/A converter, re-converted through an A/D converter, and compared.

For safety-related applications, safety-related sensors should be used when possible. Their mode of failure is defined and demonstrated. Non-secure sensors in safety circuits must be used redundantly. When any sensor activates, shut-down must follow straight away.

Sensors are often used redundantly for reasons of availability. Here, the activation of a sensor should not lead to shutting down the process. In practice this is achieved either through a 2oo2 arrangement of secure sensors, or with a 2oo3 arrangement of non-secure sensors.

In all redundant arrangements of sensors the monitoring of equivalent function with a specified tolerance time is important. Additionally, non-secure sensors must be regularly checked for functionality by operating staff, e.g. every three months. Monitoring the correct function and notification of a fault is ensured in the safety-related A1/A1dig by the tests which run automatically during operation.

6.3.3. Testable Output Modules

In the testable binary output channels, the output signals are read back and are compared with the output states of the application logic. Additionally, within the secondary fault onset time, a walking bit test is performed, in which, in each round, a different bit is inverted for a maximum of 0.2 ms. In this way, without influencing the function of the connected process, the switchability of the output is checked, even when the logic signal has the same state for a long time. ‘Sleeping’ faults are therefore also rapidly recognized.

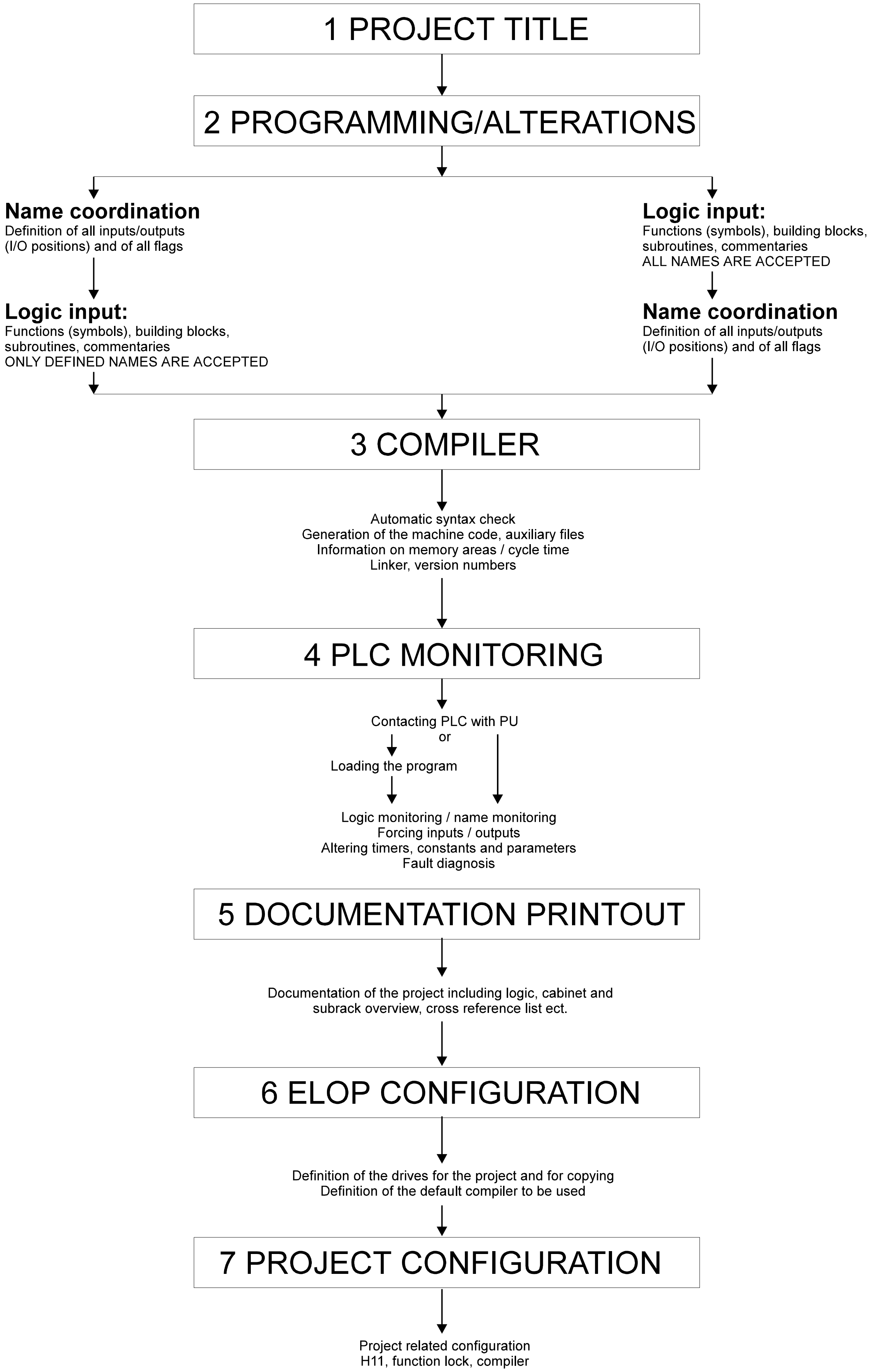
6.4. Programming the A1/A1dig under ELOP

HIMA’s ELOP program package (extended logic plan programming) can be used to program the A1/A1dig. This software can run on any normal PC without additional hardware.

6.4.1. Parameterization

To parameterize the A1/A1dig, the HZ-PA1-1 building block must be called once in one of the logic parts. Its configuration, and the basic requirements for programming the A1/A1dig, can be seen in the following table:

Application logic	**ELOP from V. 5.0**		
Configuration of the building block HZ-PA1-1	Input 1	F86/94..(20,30,40,41,42):	40
	Input 2	Number of Central Units (1,2):	1
	Input 4	Number of Power Supplies (1-3):	1
	Input 12	Behavior with Output Error (D,N,E):	D
Compiler	C41/51 ≥ V 5.0-5 (9205)		
Operating system	BS41/51 V 5.0-5 (9706)		


1 PROJECT TITLE
2 PROGRAMMING/ALTERATIONS
Name coordination
Definition of all inputs/outputs
(I/O positions) and of all flags
Logic input:
Functions (symbols), building blocks,
subroutines, commentaries
ONLY DEFINED NAMES ARE ACCEPTED
Logic input:
Functions (symbols), building blocks,
subroutines, commentaries
ALL NAMES ARE ACCEPTED
Name coordination
Definition of all inputs/outputs
(I/O positions) and of all flags
3 COMPILER
Automatic syntax check
Generation of the machine code, auxiliary files
Information on memory areas / cycle time
Linker, version numbers
4 PLC MONITORING
Contacting PLC with PU
or
Loading the program
Logic monitoring / name monitoring
Forcing inputs / outputs
Altering timers, constants and parameters
Fault diagnosis
5 DOCUMENTATION PRINTOUT
Documentation of the project including logic, cabinet and
subrack overview, cross reference list ect.
6 ELOP CONFIGURATION
Definition of the drives for the project and for copying
Definition of the default compiler to be used
7 PROJECT CONFIGURATION
Project related configuration
H11, function lock, compiler

6.4.2. Name Coordination

In the name coordination the menu points 1 “BINARY VALUES” and 2 “DIGITAL/ANALOG VALUES” are used for the assignment of the symbolic names used in the logic for the physical inputs and outputs. The specification of the necessary flags is also done here. The modules within the A1/A1dig are thus to be entered in the name allocation as follows:

Place (l. to r.)	**No. of Channels/Type**	**Entries in the ELOP-Name coordination**				
		Area in the name co-ordination	**Cabinet**	**Rack**	**Pos.**	**Type**
A1						
1	16 binary inputs	binary testable inputs	1	1	1	F 3236
2	4 analog inputs	analog testable inputs	1	1	2	F 6214
3	8 binary outputs	binary testable outputs	1	1	3	F 3330
4	not used	---	---	---	---	---
A1dig						
1	16 binary inputs	binary testable inputs	1	1	1	F 3236
2	16 binary inputs	binary testable inputs	1	1	2	F 3236
3	8 binary outputs	binary testable outputs	1	1	3	F 3330
4	8 binary outputs	binary testable outputs	1	1	4	F 3330

Under point 3 ‘NETWORK’ of the name coordination, the configuration of the network in which the A1/A1dig is operating is specified. In this way data can be exchanged with other automation devices, operating or recording stations, using so called network inputs and outputs.

6.4.3. Logic

The following functions are available in the ‘Logic’ menu:

- Generating the logic
- Calling up modules
- Introducing commentary
- Generating sub-programs
- Copying of existing logic

6.4.4. Compiling and Loading the Program

After the ‘Compiler’ point has been selected in the main ELOP menu, a syntax check proceeds automatically, followed by the generation of the machine code and the linking.

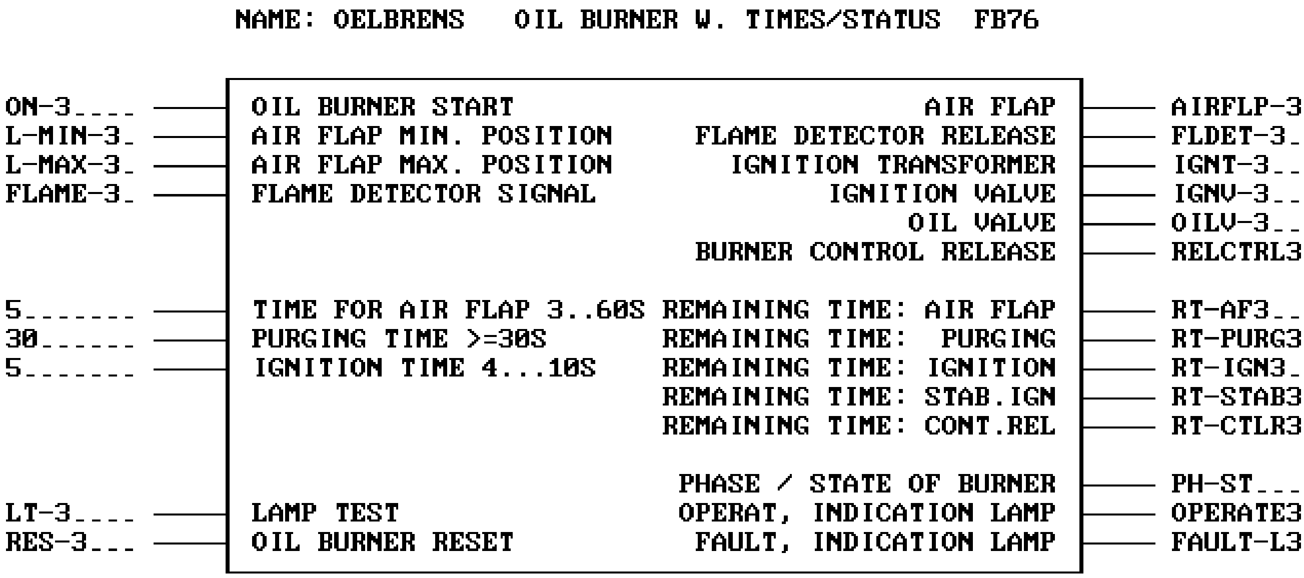
The machine code generated in this way can then be transferred to the A1/A1dig battery backed RAM.

6.4.5. Applications with the A1/A1dig

Complex standard functions which are repeatedly needed can be assembled into their own building blocks using the ELOP-M (ELOP macro generation) program module. After the logic has been generated with ELOP, the ELOP-M program module is used to define the module prototype.

The *BSEBIBL1* library can be obtained from HIMA, which, amongst others, contains the module for oil burner control described briefly below.

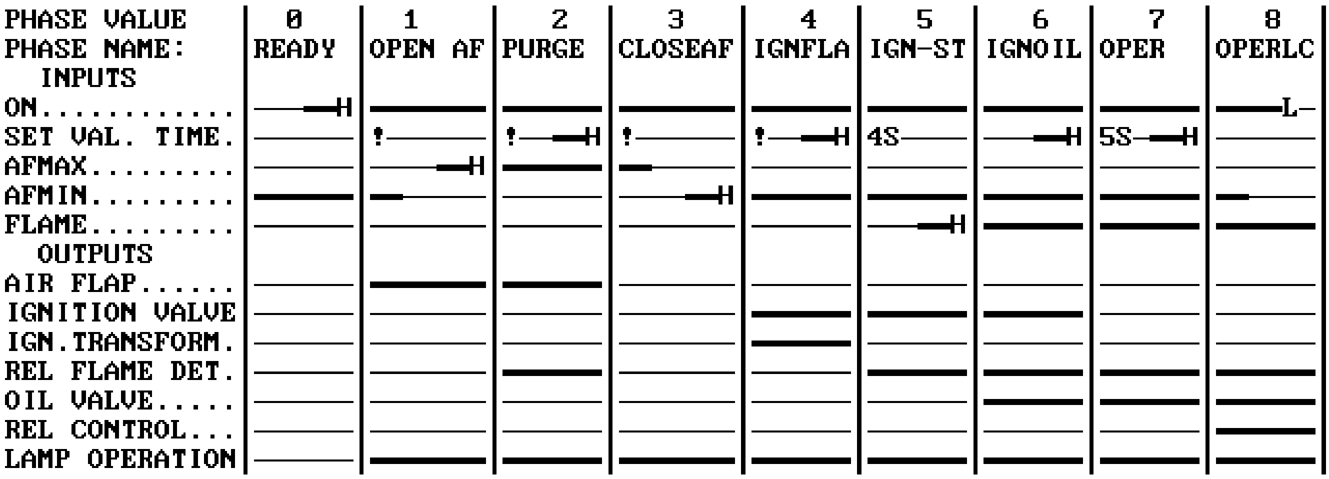
Mask of the OELBRENS building block (oil burner with pre-aeration and status display):



The OELBRENS building block has the following properties:

- Times which can be defined within a reasonable range.
- Display of time remaining during the burner start-up.
- Display of the stage or status of the burner during a technical process fault. This can be used for interpretation on a text display or process control system.

The burner control process can be seen in the following diagram:



! = TAKING OVER OF THE TIMER SET VALUE AS CURRENT TIME WHEN PHASE IS CHANGING

MALFUNCTIONS RESULT IN PHASES >10

PHASES WITH MALFUNCTION		11 /AFMAX& T>SET	12 /AFMAX 13 FLAME	14 /AFMIN& T>SET		15 /FLAME & T>SET	16 /FLAME	17 /FLAME	17 /FLAME

RELEASE DURING MALFUNCTIONS RESULTS IN PHASE 0, ALSO SWITCHING OFF (ON = LOW)

NORMAL OPERATION PHASES OF THE BURNER:

0 BURNER READY TO START
1 OPENING AIR FLAP
2 PURGING PHASE
3 CLOSING AIR FLAP
4 IGNITION OF IGNITION FLAME
5 IGNITION STABILIZATION FLAME
6 IGNITION OF OIL
7 BURNER IN OPER.(CONTR.NOT RELEASED)
8 BURNER IN OPER.(CONTROL RELEASED)

MALFUNCTION PHASES OF THE BURNER:

11 NO MAX. POS. OF AIR FLAP AFTER OPEN.
12 NO MAX. POS. OF AIR FLAP DURING PURGE
13 FLAME DETECTOR DET. FLAME DUR. PURGE
14 NO MIN. POS. AIR FLAP AFTER CLOSING
15 NO FLAME AFTER IGN. STABILIZATION
16 FLAME BREAK DOWN AFTER IGN. OF OIL
17 FLAME BREAK DOWN DURING OPERATION
18 POSITION MIN AND MAX OF AIR FLAP AT SAME TIME IN THE PHASES 1 TO 7

The module generated with ELOP-M can also be used in safety-related installations like the A1/A1dig, after it has been accepted by a certified test establishment (TÜV). The module described above for burner controllers has been TÜV certified, and can be used in safety-related controllers.

6.5. Programming the A1/A1dig under ELOP II

After an operating system change, the A1/A1dig can also be programmed with ELOP II. As programming in this way is much more complex than programming with ELOP, not every detail can be described in this manual. We therefore recommend consulting the ELOP II User Manual for details.

Programming the A1/A1dig using the HIMA software ELOP II imposes the following hardware requirements on the PCs used:

Component	minimum	recommended
Microprocessor	Pentium 133 MHz	Pentium II 400 MHz
RAM	64 MB	128 MB
Graphics card	2 Mbytes XGA	8 Mbytes XGA

Windows® NT 4.0 with Service Pack 3 or newer is required.

NOTE: ELOP II can only be run with a dongle, which is best connected to the second parallel port of the PC.

6.5.1. Parameter Setting

The A1/A1dig parameters are no longer set via a module as under ELOP, but in the properties of the resource type. There the following settings can be made:

Security: Here the various security parameters of the A1/A1dig are set. It is also possible to block certain functions of the A1/A1dig.

Security parameter:
- Security time
- Security requirement
- Watchdog

I/O Parameters: These define the I/O and variable processing in the event of an error and sets the behavior of the A1/A1dig in the event of an error (display, emergency off or normal operation).

7. Concepts in Safety Engineering

The complexity of technical systems and the concentration of ever greater amounts of energy in small spaces in the pursuit of process economy are rising more and more. This brings ever greater significance to the concepts of safety, reliability and availability.

7.1. Safety

There are numerous definitions for the concept of safety, which have been developed by a wide variety of advisory bodies. What all definitions have in common, is that safety implies an adequate freedom from danger to persons and to property. In part 2 of the DIN 31000 standard, safety is defined as a situation in which the risk is not greater than the limiting risk. At the same time however, the fact that absolute safety is not possible in a technological setting is also expressed.

The danger presented by large power generating or chemical plant, or by transport technology in railways and airplanes, is governed by the system as a whole. This kind of plant or system must be monitored, and must be able to be brought into defined safe conditions by automatic equipment. This means that in fact the critical faulty behavior is a failure in the function of the control and monitoring equipment.

Safe control is, for instance, needed for the automation of railways, elevators, escalators, burners, presses etc. These must be designed in such a way that neither a fault in one of their components nor any external influence can lead to a dangerous condition.

The safe condition is that condition into which a system can be taken from the current operating condition, and which has a lower risk potential than the normal operating conditions specific to that system. In general, the absolutely safe condition is the condition of lowest energy. It is however often the case that transition to that condition cannot safely be effected by a simple step such as switching off. For instance, an airplane in flight has - considered as a system - no safe condition. In such cases the risk can only be reduced by the use of redundant systems, such as a pair of engines, or by duplicated navigation systems.

7.2. Reliability

Reliability is the property of technical equipment of being able to fulfil its function during the period of its operation. This is generally no longer possible if a component has failed. The MTBF (mean time between failure) is therefore often used as a measure of reliability. This figure may either be determined statistically from the systems in operation, or by calculation from the failure-rate of the components used.

Reliability is not the same as the safety of a system! Unreliable systems can be safe if, for instance, individual failures always lead to the safe operating condition.

7.3. Availability

Availability is the probability that a system is in functioning order. It is expressed as a percentage, and is calculated from the mean operating time between two failures, i.e. the MTBF (mean time between failure), and the mean duration of failures MDT (mean down time).

The MDT is composed of the fault recognition time and - in modular systems - the time needed for the exchange of faulty modules. The availability of a system is significantly improved by a short fault recognition time. Fast fault recognition is achieved in modern electronic systems by automatic test routines and is assisted by a detailed diagnostic display. The availability can be increased through redundancy, such as parallel central devices or I/O-modules, or by multiple transducers at the same measurement point. The redundant components are arranged in such a way that the functionality of the system is not affected. A detailed diagnostic display is an important element in availability here too.

Measures to raise availability do not affect safety. Nevertheless, the safety of redundant systems, or of redundant arrangements, is only guaranteed if automatic test routines run in the course of operation, or if checks are made at regular intervals (in the case of transducer circuits in 2-from-3 arrangements). If one component fails, it must be possible for the faulty section to be safely switched off.

8. Safety Standards and Guidelines

The safety standards and guidelines published in the past were, as a rule, oriented toward specific technical equipment applications. A classical example of this that could be mentioned here is DIN VDE 0116 for 'the electrical fittings on furnaces'. For a long time it was the only standard which contained concrete statements regarding the safety of hard-wired controllers and - after some rework - also of programmable logic controllers and automation equipment. Its requirements were often adopted in other application areas for which no standards yet existed.

The new basic safety standards look at the entire complex of safety, independently of specific applications. Requirement categories, and the most general measures for the satisfaction of a requirement category, are defined, depending on the risk involved. It is only in the group standards that possible measures are explicitly described in terms of their effectiveness, the time which they might consume and the additional costs in terms of hardware and software. Product standards are included here. This division of standards and guidelines corresponds to the CEN classification, which has been valid in Europe since 1992.

8.1. Safety Considerations for Process Control Protection Equipment according to DIN V 19250

A systematic route to the drawing up of technical safety requirements is indicated in the fundamental safety considerations for process control protection equipment in accordance with DIN V 19250. Advice is given on which combinations of steps are suitable for the fulfillment of concrete safety tasks.

The technical safety requirements, and the steps which are necessary for their satisfaction, become higher as the risk which has to be covered increases. The risk is to be reduced at least down to the limiting risk, using process control and other measures.

The process control component of risk is qualitatively described with risk parameters, and the requirements are grouped into requirement categories. The technical and non-technical measures can be many and varied, so that no fixed allocation is generally possible.

8.1.1. Risk Parameters

The risk is determined by the extent of damage and the frequency with which that damage occurs. The frequency is primarily determined by the parameters of duration of occupancy, possibility of averting danger, and the probability of the undesired events.

R = f (D, O, A, P)

D = extent of damage
O = duration of occupancy
A = possibility of averting danger
P = probability of events

With additional graduations in the individual parameters, the risk R is defined as follows:

<table>
<tr><th colspan="3">Extent of damage D</th></tr>
<tr><td>D1</td><td>slight injury</td><td rowspan="4">D1 and D4 do not leave any room for interpretation, whereas this is possible for D2 and D3. The D2 parameter is applied when, for instance, the risk at a machine or installation at which it is clear that only one person will be working (a lathe, the inspection or repair of part of an installation) is to be judged, or when there is no possibility of immediate damage to a large area. D3 must always be applied when, in the worst case, a number of people could be affected. This would certainly be true, for example, in the case of an explosion.</td></tr>
<tr><td>D2</td><td>serious, lasting injury to one or more persons, the death of one person</td></tr>
<tr><td>D3</td><td>death of more than one person</td></tr>
<tr><td>D4</td><td>catastrophic effects, many deaths</td></tr>
<tr><th colspan="3">Duration of occupancy of the danger area O</th></tr>
<tr><td>O1</td><td>rare to occasional stay</td><td rowspan="2">The parameters O1 and O2 refer to the period of time for which persons remain in the danger area. In the process engineering field the parameter O1 ‘rare to occasional’ applies most often.
We are here particularly considering inspection or repair activity. In areas where manual work is still to an extent necessary, and where persons spend time primarily in the danger area (e.g. neighboring shipping bays) the O2 parameter applies.</td></tr>
<tr><td>O2</td><td>frequent to constant stay</td></tr>
<tr><th colspan="3">Aversion of danger A</th></tr>
<tr><td>A1</td><td>possible under certain circumstances</td><td rowspan="2">Installations may have objective properties, such as supervised or unsupervised operation, or good escape routes. There is, in addition, a not inconsiderable contribution from subjective properties. Here it is particularly important to raise the question of the recognition of the danger. The question to be asked is whether the person who would be affected by the fault is in any position to recognize a danger that might arise. This depends on their degree of training, on auxiliary methods used (warning lamps, measuring instruments) and also on the person’s individual experience.</td></tr>
<tr><td>A2</td><td>not possible</td></tr>
</table>

<table>
<tr><th colspan="3">Probability of undesirable events (without process control protection equipment) P</th></tr>
<tr><td>P1</td><td>extremely low probability</td><td rowspan="3">This controversial parameter has a considerable influence on the safety measures to be selected. The question is the probability of occurrence of an undesired event in the absence of any kind of process control safety equipment. It can often be seen that other existing process control safety equipment is relied upon when determining this parameter. This is not permissible. Every set of process control safety equipment must be independently considered.

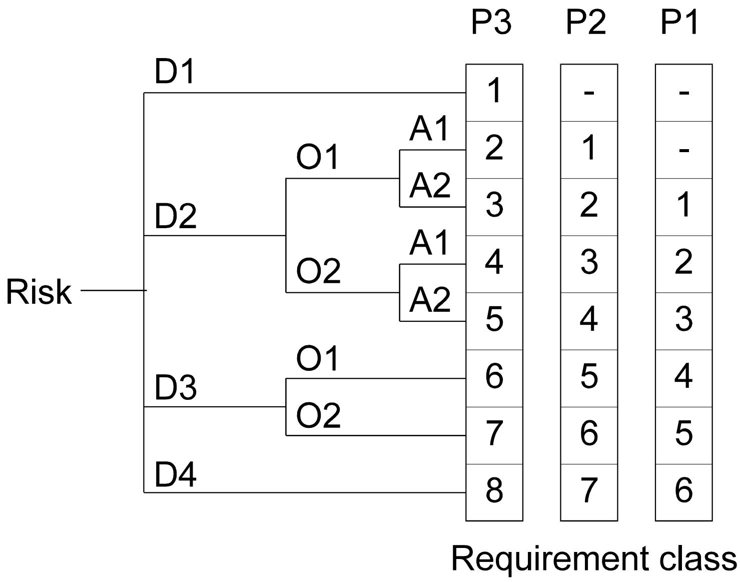
A ‘very low probability (P1)’ can be assumed if many identical or similar examples of an installation exist and are operated without there having been any cases of serious faults werden.

The other extreme is a ‘relatively high probability (P3)’, which should always be applied if processes are relatively new and there are no historical values regarding their behavior. P3 is also assumed when chemical or engineering processes are being operated close to their limits, and the process control operating equipment is continuously regulating and adjusting the process. In the majority of cases the probability of occurrence lies in the ‘low’ range (P2).</td></tr>
<tr><td>P2</td><td>low probability</td></tr>
<tr><td>P3</td><td>relatively high probability</td></tr>
</table>

8.1.2. Risk Graph and Requirement Categories

Every combination of risk parameters leads to a risk evaluation set. Theoretically the classifications mean that 48 combinations are possible.

The predominance of certain risk parameters means that fewer than 48 combinations are meaningful in practice. For the P parameter, only eight combinations are practically reasonable, and these are defined as requirement categories.



8.1.3. Steps to be taken for the Requirements Classes

Automation equipment is constructed in a manner similar to that of computers. This means that it is no longer intelligent to consider every individual physical fault cause. The principal reasons are:

- In contrast to traditional engineering, the effect of a fault (the degree of damage) can not be deduced from the cause of a fault.
- The emphasis in the consideration of faults shifts from the random physical fault to the systematic software fault.

Because of these factors, faults in automation equipment are not treated in detail, but rather according to their type, their basic cause and the time of their occurrence:

- Faults which have arisen during the period before commissioning must be approached with measures for fault avoidance, e.g. faults in the specification, in the programming, the production etc.
- Faults which arise after the commissioning must be approached with measures for fault control, e.g. faults in the hardware, faults caused by handling, external influences etc.

A number of appropriately adapted measures are needed to avoid the faults mentioned above, or to bring them under control. The effectiveness of the measures is again divided into the levels of simple, medium and great.

Measures for the control and avoidance of faults in the case of:

- Systematic hardware and software faults
- Handling faults, operating errors, manipulation
- Faults triggered by operating and environmental influences

The failure of technical apparatus can be caused by:

- Random hardware faults, such as those classified as simple
- Multiple faults due to fault clustering (statistical).
  These can only be tackled with measures for fault avoidance

The possible measures which can be taken for automation equipment (computers), their effectiveness, costs etc. are described in DIN V VDE 0801. The manufacturer of automation equipment selects the appropriate combination of measures in order to adapt the automation device to the specific requirements of the application, such as available functions, safe condition, fault tolerance time, measures for the increase of availability etc.

The implementation and the effectiveness of the measures in the various requirement categories are examined by independent testers (e.g. TÜV), and are confirmed with a safety certificate and a test report.

Appendix

Copy master for labeling strips:

binary inputs	analog inputs	binary outputs
1	1	1
2	2	2
3	3	3
4	4	4
5		5
6		6
7		7
8		8
9		
10		
11		
12		
13		
14		
15		
16		
DI 16	AI 4	DO 8

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