Energoautomatyka

TECHNICAL REFERENCE MANUAL
EXECUTING CONTROLLER
Type ES-10

ES-SYSTEM

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1. INTENDED USE

The “ES -10” executing controller is a component of ES –SYSTEM. It is designed to provide „intelligent” control of actuating components, and especially to connect electronic data processing systems with hydraulic actuators. It is a microprocessor-based unit whose algorithm is determined by programming the control and regulation structure (application program) in the controller memory.

The controller is fitted with the following set of inputs and outputs: 4 analog inputs, 6 binary inputs, two binary outputs, power output power in the form of H- bridge and two RS channels.
Saving the application program, modification of programs and settings as well as current review of the controller operation is performed via serial ports of the standard personal computer. The Controller is provided with Flash-type memory which stores tuning data and which stores the application program.

The Controller provides analogue and digital variables in two communication networks RS-485 or RS-422. The data are made available using the MODBUS-RTU standard.
The controller can be programmed at the factory by the algorithm agreed with the user or by the user himself.

2. COMPLETE DELIVERY DATA

The Controller comes with:
- Guarantee Card
- Quality Control Certificate

Each batch of controllers is delivered with:
- Technical Reference Manual, ES-10
- Service cable, RS-232 – only, if specified in the order.

3. TECHNICAL DESCRIPTION

3.1. TECHNICAL DATA

3.1.1. Power supply $21 \div 27V_{DC}$ /0.2 A max.

3.1.2. Analog inputs (XA)

- number of inputs	4
- nominal range of input signals	4 ÷ 20 mA
- resolution of A/C conversion	12 bits
- accuracy of input conversion	0.1 %
- Additional conversion errors (including ambient temperature)	+ / - 0.1 %
- max. voltage drop across input circuit	3 V
- galvanic separation between inputs and from central circuitry of the controller	
-- electric strength	500V/50Hz/1 min.
-- insulation resistance	$\geq$ 20M Ω

3.1.3. Binary inputs (XB)

- number of inputs	2
- supply voltage of initiators (external)	19 ÷ 30 V
- current through a closed initiator circuit	4 ÷ 7 mA
- galvanic separation of the group of 6 inputs from the central circuitry of the controller	
- - electric strength	500 V / 50 Hz / 1 min
- - insulation resistance	$\geq$ 20M Ω

3.1.4 Binary outputs (YB)

- number of outputs	2
- type of output	Universal AC / DC
- levels of output signals	
- - resistance at switching on	≤ 24 in
- - maximum output voltage at switching off	300 V
- - Output current loading capacity	≤ 100 mA
- galvanic isolation between outputs and from the central circuitry of the controller:	
- - electric strength	500 V / 50 Hz / 1 min
- - insulation resistance	≥ 20M Ω

3.1.5 . Power output unit - pulse outputs WIL and WIR

CMOS keys arranged to H-type bridge

- type of outputs: turning the bridge on and independent control of bridge branches	
- max. control voltage for H bridge **- U3**	30 V
- max. momentary current (1 ms)	10 A
- max. average current in both bridge branches	3 A
- type of control	programmable
- protection against overloading	
- - immediate	2.5A+/-20%
- - thermal (in semiconductor structure)	150 °C
- galvanic separation from other circuits of the controller:	
- - electric strength	500 V / 50 Hz / 1 min
- - insulation resistance	≥ 20M Ω

3.1.6 . Serial links COM1, COM2:

- number of serial links	2

- Link type RS-422, RS -485 or RS -232 without the possibility of simultaneous transmission and reception,

- Maximum transmission rate	115200 bits / second (BPS)
- character length	8 bit
- parity control	even parity
- galvanic separation between the links and from the other circuits o f the controller	
- - electric strength	500 V / 50 Hz / 1 min
- - insulation resistance	≥ 20M Ω

- communication protocols

COM1 - MODBUS- RTU - SLAVE and special protocol with tool software
COM2 - MODBUS- RTU - Master or MODBUS- RTU - SLAVE and special protocol with tool software

3.1.7 Software parameters

- application software	graphic structure
- procedure directory acc. to	„D100.LIB – Procedure directory”
- program run time variable,	depending on application program size
- run time for 100 test procedures	ca. 5 ms
- max. size of application program (ca. 1000 procedures)	8 KB

3.1.8. Operating conditions

- ambient temperature	0÷50°C
- relative humidity	≤ 75%
- sinusoidal vibrations	10÷55 Hz/0,15 mm
- noise emission	level N

3.1.9. Dimensions [H x W x D] 106 * 90 * 58

3.1.10. Weight ca. 0.25 kg

3.2. PRINCIPLE OF OPERATION

The ES-10 is based on the ultra-low-power MSP430 series micro-controller from Texas Instruments. The micro-controller collects external information and processes them according to the algorithm contained in the application program and supports serial transmission channels. It is a 16-bit processor of RISC architecture containing internal RAM and Flash memory, and extended set of peripherals like 12-bit A/D converter, two 16-bit counters provided with high-speed input control unit (HSI), high-speed output control unit (HSO), 2 USART serial channels and 48 programmable input/output ports (HSO). In addition, the micro-controller provides "watch dog" program control, restart from supply voltage activation, and special JTAG link for programming the micro-controller flash memory. The interfaces (circuits enabling to contact with external units) are galvanic separated from the microprocessor. The hub interfaces are:

- analog inputs - 4 inputs
- binary inputs - 6 inputs
- binary outputs - 2 outputs
- output power unit - „H" bridge
- 2 serial links - RS type.

Analog inputs are separated with the line optoisolators, and the primary circuits are fed from an input signal that provides easy separation between the channels. Gains of input channels are determined at the factory tuning, and the results are recorded in a non-volatile memory.
Binary outputs are in the form of electronic relays that may operate DC and AC circuits.
The serial link of RS-422 standard (Fig. 1) may be connected to the RS-485 standard, or – with using a special cable delivered with the controller – it may be connected to the channel of the RS-232 standard.

3.3 DESIGN

The ES-10 controller is placed in a closed housing mountable on standard „T-35" terminal strips where it occupies about 106 mm. External circuits shall be connected via 3 connection blocks with 23 spring-type terminals each. The connection blocks can be disconnected from the controller without the need to disconnect the wires. A 9-pin drawer-type connector (socket) is located on the front side of the controller to allow for serial transmission (COM1 and COM2) and two alarm LEDs: red – „CPU Stop" and green – „CPU Start", whose alarm codes are specified in table 1.

4. APPLICATION SOFTWARE

The controller processes the analog and binary information. They may be constants or variables, wherein the variables in turn are divided into internal and external variables, namely the inputs and outputs of the controller. The concept of the variable includes its name. The names are made up exclusively from the characters from the range of the code of hexadecimal numbers **(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F)**.
The **external variables** have the following names assigned:

- binary inputs	**XB1 ÷ XB6**	name	**BB00 ÷ BB05**
- binary outputs	**YB1 and YB2**	name	**BC00 and BC01**
- analog inputs	**XA1 ÷ XA4**	name	**AE00 ÷ AE03**
- power pulse outputs	**WIR and WIL**	name	**BD01 and BD02**
- WIR and WIL power outputs switching/interlocking output		name	**BD00**

To use the controller in the control circuits of hydraulic systems the relevant special procedures are provided:
- alternate pulse control - **PWM_P**
- differential pulse control - **PWM_R**
- independent pulse control - **PWM_N**

For **internal variables** the following names are assigned:

analog variables	**A000 ÷ A1FF**	**- 512 variables**
binary variables	**B000 ÷ B7FF**	**- 2048 variables**

Binary variables **B7B0 - B7FF** are used by the operating system to create information usable in the application program (cannot be used as the outputs of procedures) .
Currently the following are used:

Binary variables B7B0 ÷ B7CF are designed for "MODBUS- Master" communication; they control proper connection with network numbers 1 to 32 – the proper statuses are set if there is communication; zeroing if there is an interruption in communication.

Binary variable B7FC – start-up cycles of the program (5 cycles after restart) ("1" – if there are starting cycles)

The source "application program" is created as a graphical scheme composed of interconnected functional graphical blocks. Structural elements are blocks of declarations and procedures, connections among procedures, external connections and connection names. Graphic blocks corresponding to the procedures and declarations of the programming language are included in the library file named **D100.LIB**.
Inputs and outputs of the procedures are connected according to the algorithm.
The "application program" is executed in the sequence in accordance with the assigned numbers of declarations and procedures. The procedure or declaration number is a combination of letters and numbers. The order of execution is determined by the order of the letters in the alphabet and then the number. The program must include the "**Beginning**" declaration with the lowest number and the **"End"** declaration with the highest number. All ends of procedures should be connected, i.e., they must be assigned a variable or constant of a right type – namely, the analog ends with analog names, binary ends with binary names.
Thus saved "application program" is compiled by **ESTool** utility. As a result of compilation a batch program is created with the name as the graphical structure with the extension "bin". The batch program should be downloaded to the controller (RAM memory) using the utility and then the command "rewrite to flash memory" shall be given . During rewriting, the program is interpreted into the "executable" form and stored in non-volatile flash memory .

5. INSTALLATION AND START-UP

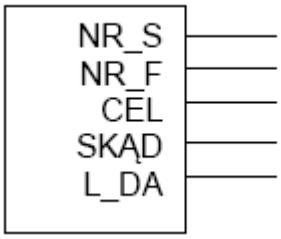
The ES-10 Controller is intended for installation on T-35 terminal strips. It is provided with connection blocks with 12 spring-type terminals each. The connection blocks enable easy installation/removal of the controller without disconnecting the system wires. The connection blocks are provided with „coding keys", which allows the insertion of the connection block to a proper base. The connection blocks are adjusted to receive wires of max. cross section area 0.08 to 1.5 mm^2. Terminals are "opened" by means of special tool delivered by the manufacturer of terminals (WAGO) or with using the screwdriver 2.5 mm in width. Connecting to the standard PC with the cable delivered with the controller is via the RS-232C port, fitted with the standard **ESTool** utility for direct monitoring of current signals in the program structure and simple activation of the controller.

6. COM1 & COM2 CONTROLLER SERIAL INTERFACES

The ES -10 controller has two serial channels of the RS type. The channels are made to the RS-422 electrical standard. They can be connected in the RS -485 standard, or using a special cable supplied by the manufacturer, they can be connected to the interface of the RS- 232 standard - Figure 1
Both RS channels are programmed in the special standard for communication with tool programs in the **ESTool** package and in the **MODBUS-RTU-SLAVE** standard (i.e. they can be connected into the MODBUS network in which they respond to the communication initiatives of the "MASTER" component governing the network).

Both channels automatically detect whether there is communication with the **ESTool** tool program or the communications in the **MODBUS_SLAVE** network. Both RS channels of the controller respond to frames in the MODBUS standard if the controller is assigned a network number. The network number is assigned via the ESTool utility where one shall go from the menu " TOOLS " to the command "NETWORK NUMBER ". Network numbers must be within the range of 1-32 .
The **COM 2 Channel** is also programmed with **MODBUS-RTU-MASTER** protocol, i.e. it can be designed to collect information from other components connected to the MODBUS network.
Initiating action in this mode (MODBUS MASTER) requires the inclusion of "**MOD-TASK**" ("communication task") procedures in the application program off the controller. The procedure (graphical symbol below) describes the task by providing at the ends of the procedure:

NR_S - network number of the SLAVE component (decimal number of CD01- CD32)
NR_F - function number(type of task) list of functions implemented in the controller and recording method below.
CEL- place of destination for transmitted data (the first data number)
SKAD - place of data downloading (the first data number)
L_DA - the amount of data transferred (decimal number of CD01- CD99) .



Graphic symbol of "MOD_TASK" procedure

The data exchange components in the MODBUS standard are the binary variables and 16-bit registers. In the **ES- 1x** series controllers the data exchange components are internal binary are analog variables. Access to the binary and analog variables is direct, i.e. write/read consists in direct pointing out the variables which are relevant to specific transfer by specifying the names of variables at the ends of the "communication task" procedure.
The internal analog variables during the data exchange are converted to/from a four-byte floating-point form to/from a fixed point form in the "U2" code transmitted in the MODBUS standard. **The range of analog variables is limited to the range of + / -1**.
The application program of ES controllers may contain up to 120 "MOD- TASK" procedures.
The MODBUS standard provides about 20 types of functions (numbered), of which the following are available in the ES-1x series controllers (the names declared at the ends of the procedure are specified in brackets):

No. 1 (CD01) **read a block of output binary variables (from the “SLAVE” component)**
No. 2 (CD02) **read a block of input binary variables (from the “SLAVE” component)**
No. 3 (CD03) **read a block of output registers (from the “SLAVE” component)**
No. 4 (CD04) **read a block of input registers (from the “SLAVE” component)**
No. 5 (CD05) **set output binary variable (in the “SLAVE” component)**
No. 6 (CD06) **write a register (in the "SLAVE" component)**
No. 15 (CD15) **write a block of binary variables (in the "SLAVE" component)**
No 16 (CD16) **write a block of registers (in the element " SLAVE ")**
No 22 (CD22) **send an analogue variable, if it was overwritten**
No 23 (CD23) **send an binary variable, if it was overwritten**

Notes to the list of functions:
1. The communication protocol of the ES- 1x series controllers does not distinguish between the input and output variables, all types of the above frames are treated as concerning the internal variables. For example, any binary variable can be read with the frame "1" or "2".
2. The frame for the function 5 is sent (i.e. the change of binary variable in the “SLAVE” component takes place) if the change in the source binary variable (in the MASTER) took place.
3. The functions "22" and "23" were implemented using the MODBUS standard reserve numbers.
The variables that have been "overwritten" (changed) by an external device, i.e. the MODBUS network are marked each time in the ES controllers after overwriting. The "22" and "23" functions allow sending the variables one time after overwriting, respectively analog and binary one, to the SLAVE component.

7 MANUFACTURER

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Table 1 ES-10 controller alarm codes

No	CPU Stop Red	CPU Run Green	
1	○	⊗	Program execution from Flash memory
2	⊗	○	Error in application program
3	⊗	⊗	No program in Flash memory
4	⊗	⊗	Rewriting program to Flash memory
5	⊗	○	Exceeded possibility of writing application program to Flash memory
6	⊗	⊗	Exceeded possibility of writing constant part of application program to Flash memory
7	⊗	⊗	Exceeded possibility for procedures to use RAM

Diode statuses given in table above:

○ LED is off

⊗ LED is continuously on

⊗ slow blinking, 1 Hz

⊗ quick blinking, 5 Hz

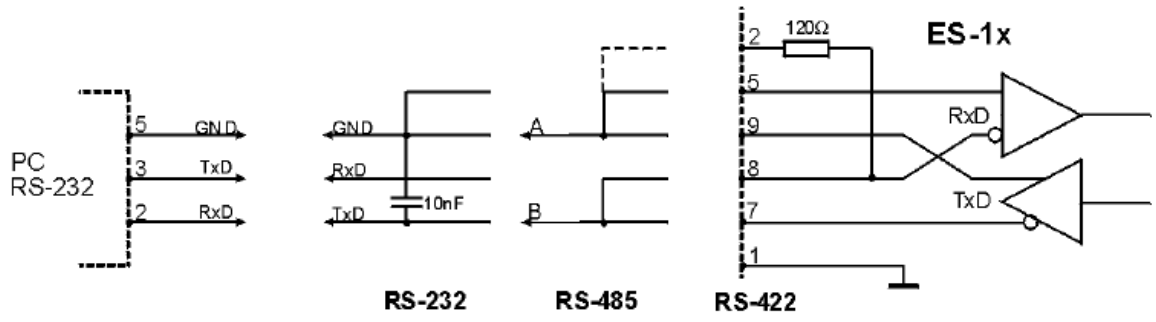


Fig. 1 COM1 and COM 2 (RES422/RS485/RS4232) serial channels of the controller

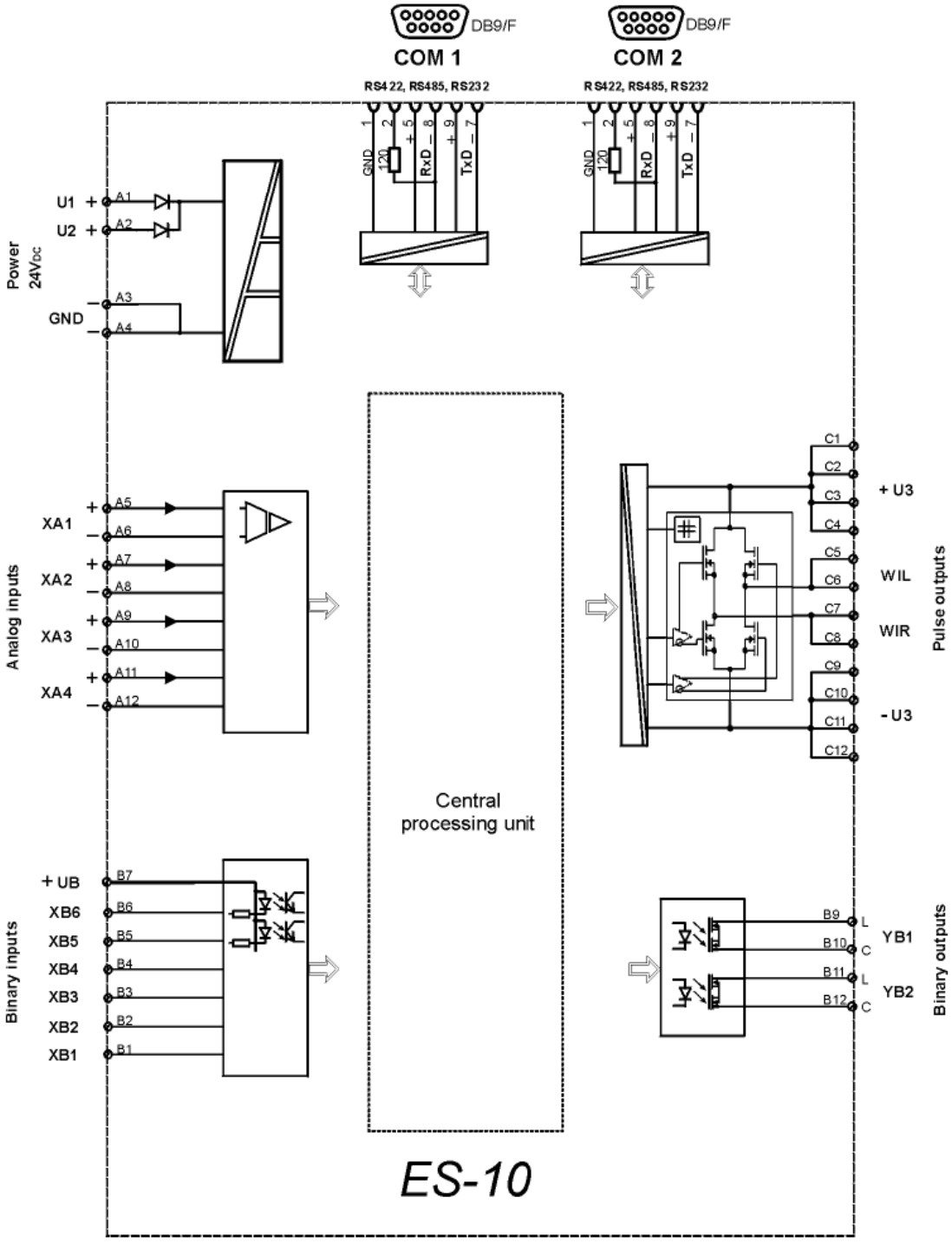
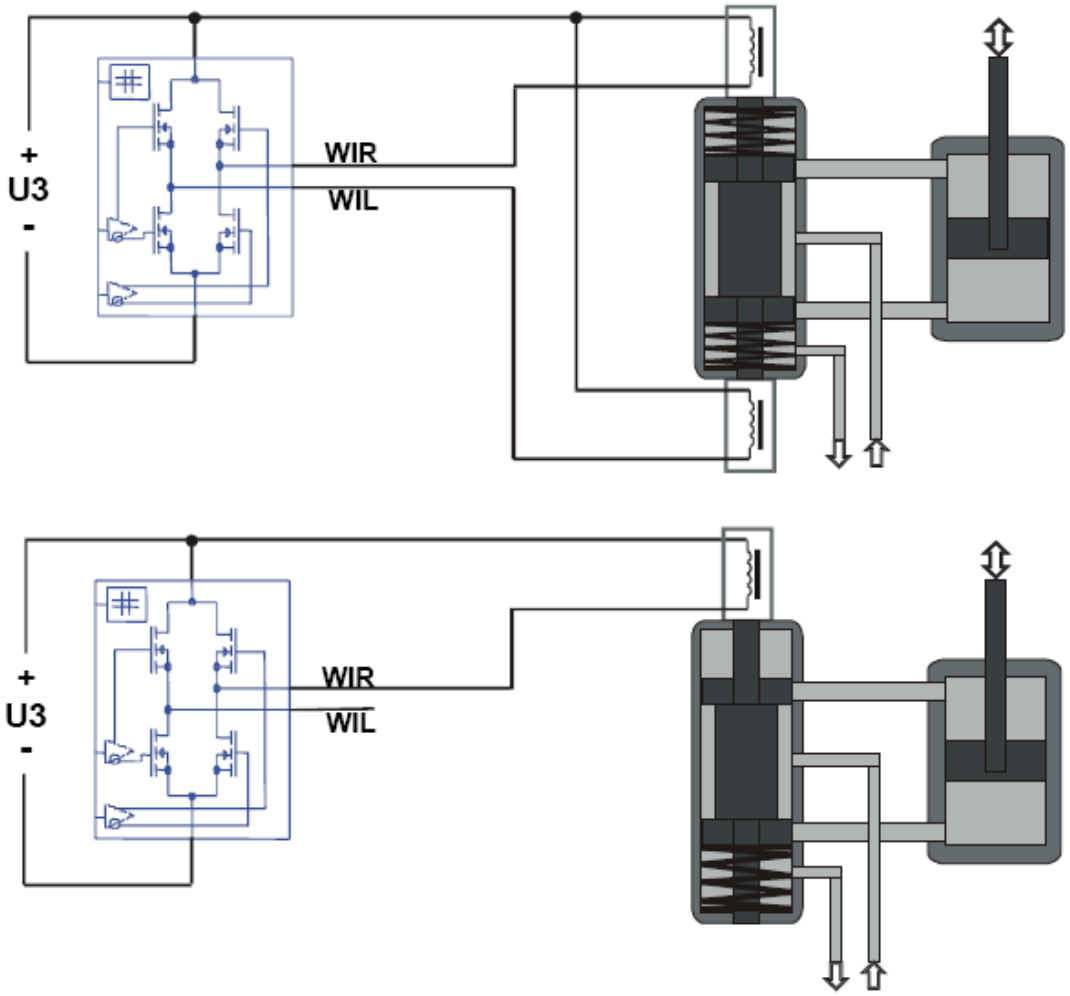
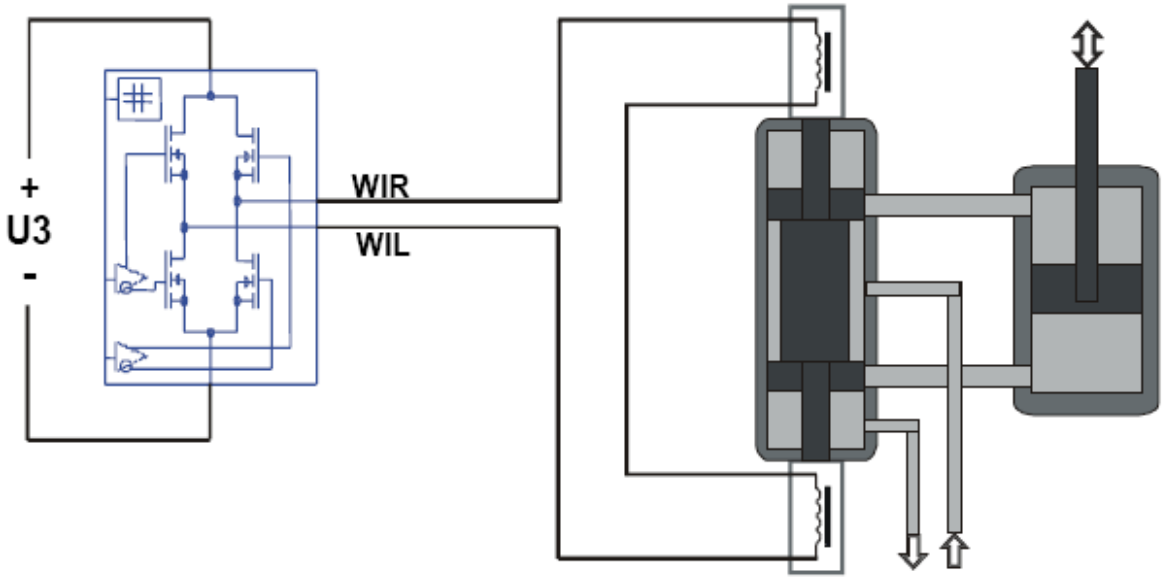


Fig.2. Block diagram of the controller



a) - Actuating circuits with independent coils



b) - Actuating circuits with push-pull coil arrangement

Fig.3. Exemplary hydraulic connections of actuating circuits