institute MIHAILO PUPIN

AUTOMATION & CONTROL SYSTEMS

Basic components of turbine control system ARS TSControl and ARS THControl for steam and hydro turbines

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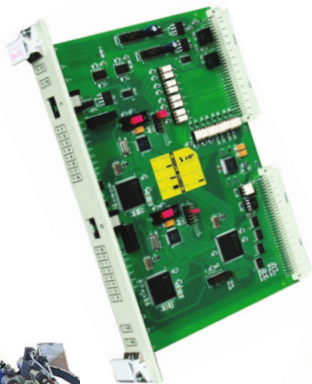
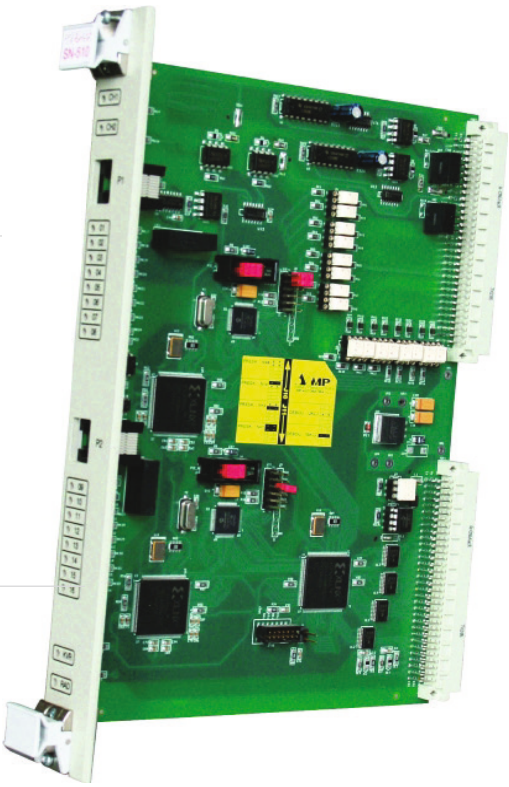
CONTENT:



BOP02

Digital input/output module



Overview

- Atlas overspeed protection
- Two independent channels
- Compatible with 3-wire inductive proximity switches, PNP type
- 8 digital outputs per channel with settable (programmable) action and polarity ranges (NC/NO)
- Maximum capacitry: 12 modules per 19” rack
- LED indications: active input and output signals
- LED indications: active and faulty signals (RAD/KVR)

Application

Basic application of BOP02 module is measurement of rotation speed of turbine in thermo and hydroelectric plants. Pulse signal frequency is proportional to the turbine rotation speed. Based on turbine speed in real time, the module generates digital outputs (8 per channel). One of the outputs is typically an overspeed protection signal. All outputs are programmable in terms of action and polarity (NC/NO). The module consists of a built-in prescaler that enables reactions based on 1, 2, 4, or 8 digital input signals. The input signal is buerable and can be sent up to 100 m away.

Design

Double Eurocard: 233.4x162.5mm. Front mask dimensions are 262x30mm so as to t into 19” racks.

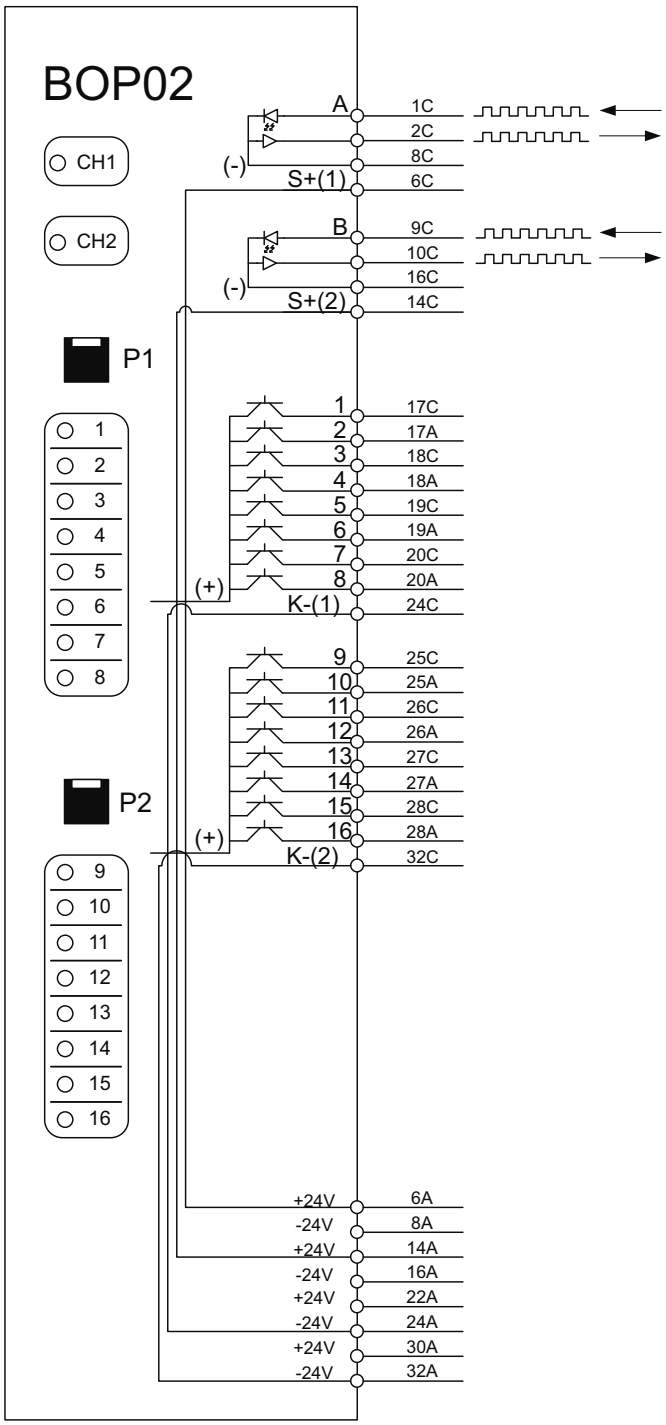
Interface

Number of inputs	2
Number of outputs	16
Interface type	optocoupler
Galvanic isolation	2kV between the input and electronic part

Technical specications

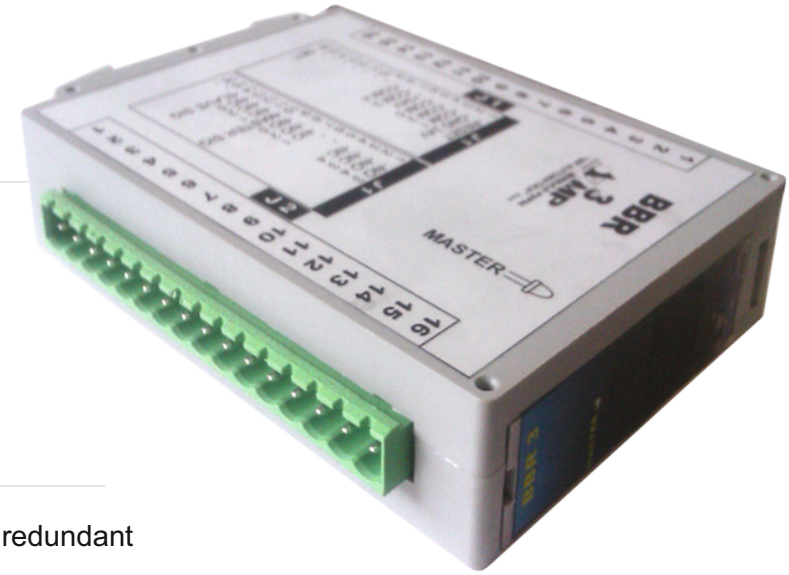
Input signal voltage level	Vs = 24/VDC
Input current	7 mA (14 mA when forwarding input signal)
Voltage supply	5VDC from communication bus
Measuring range	0 to 5000 rpm
Precision	0.01%
Scan period	1 ms
Power consumption	130 mA @ 5V
Working temperature	0 to50˚C
Relative humidity	5 to 95%

BOP02 – CONNECTOR P2			
	C	B	A
1	INPUT_A		
2	INPUT_A_BUF		
3			
4			
5			
6	+24V	+24V	+24V
7			
8	GND_24V	GND_24V	GND_24V
9	INPUT_B		
10	INPUT_B_BUF		
11			
12			
13			
14	+24V	+24V	+24V
15			
16	GND_24V	GND_24V	GND_24V
17	COMMAND1_A		COMMAND2_A
18	COMMAND3_A		COMMAND4_A
19	COMMAND5_A		COMMAND 6_A
20	COMMAND7_A		COMMAND 8_A
21			
22	+24V	+24V	+24V
23			
24	GND	GND	GND
25	COMMAND1_B		COMMAND 2_B
26	COMMAND3_B		COMMAND4_B
27	COMMAND5_B		COMMAND6_B
28	COMMAND7_B		COMMAND8_B
29			
30	+24V	+24V	+24V
31			
32	GND_24V	GND_24V	GND_24V



BBR3

Fast bistable relay



Overview

- Fast bistable impulse relay
- 5 contacts (NC+NO)
- Signalization of the relay status (set or reset)
- LED indication of relay status

Function description and application

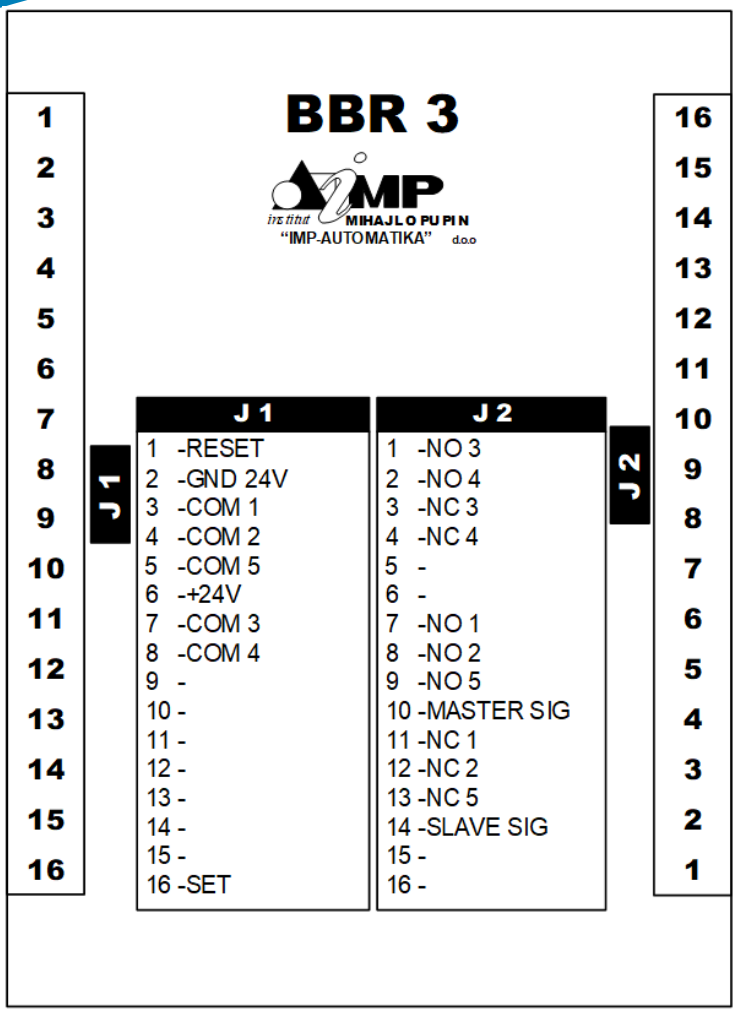
Setting position of proportional valves (4-20mA) in redundant conguration (active PLC / standby PLC)

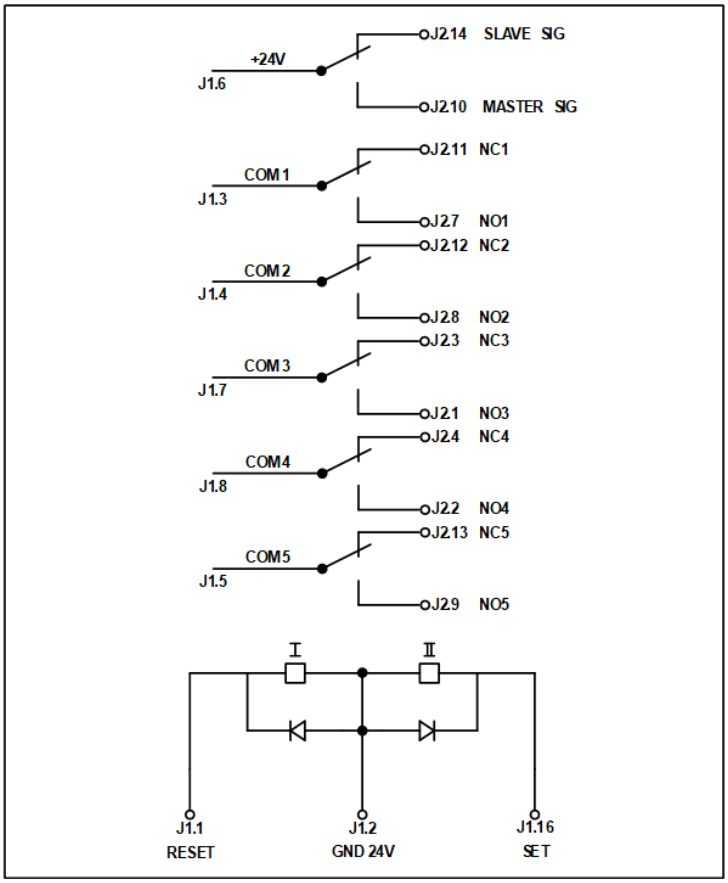
Design

Module BBR3 is placed in the box 120x22x80mm. Dimensions of modules with attached connectors are 120x22x110mm. The module is intended for mounting on a standard DIN rail.

Technical specications

Maximum switching current	5A
Maximum switching voltage	220VDC/250VAC
Electrical endurance	Typical 5 x 10^6 operations
Mechanical endurance	Typical 10^8 operations
Power consumption	140mW
Power supply	24VDC
Maximum switchover time	4ms


BBR 3
MP
MIHAJLO PUPIN
"IMP-AUTOMATIKA" d.o.o
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
J 1
J 2
1 -RESET
2 -GND 24V
3 -COM 1
4 -COM 2
5 -COM 5
6 -+24V
7 -COM 3
8 -COM 4
9 -
10 -
11 -
12 -
13 -
14 -
15 -
16 -SET
1 -NO 3
2 -NO 4
3 -NC 3
4 -NC 4
5 -
6 -
7 -NO 1
8 -NO 2
9 -NO 5
10 -MASTER SIG
11 -NC 1
12 -NC 2
13 -NC 5
14 -SLAVE SIG
15 -
16 -
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1


+24V
J1.6
J2.14 SLAVE SIG
J2.10 MASTER SIG
COM 1
J1.3
J2.11 NC1
J2.7 NO1
COM 2
J1.4
J2.12 NC2
J2.8 NO2
COM 3
J1.7
J2.3 NC3
J2.1 NO3
COM 4
J1.8
J2.4 NC4
J2.2 NO4
COM 5
J1.5
J2.13 NC5
J2.9 NO5
I
II
J1.1
RESET
J1.2
GND 24V
J1.16
SET

Atlas dAPV-p

Digital automatic valve positioner

Application

The Atlas dAPV-p is a digital automatic valve positioner designed to control hydraulic servo drives through proportional or pulse directional control valves. Proportional directional control valves are controlled by pulse-width modulated signal (PWM outputs), while pulse directional control valves are controlled by digital signals of certain duration. The cascade control structure, which closes the feedback at the position of the pilot valve and the hydraulic servo drive, enables the control of complex hydraulic systems in thermal and hydro power plants, as well as other energy or industrial plants. One device controls two independent hydraulic servo drives. It is intended for mounting on a DIN rail inside the electric cabinet.

Technical characteristics

- Procesor AM3358 1GHz ARM Cortex-A8
- 10/100Mbit LAN
- RS-232/485 port (galvanically isolated)
- 4GB 8-bit eMMC
- 6 analog current inputs with software range selection: [0,20]mA, [4,20]mA, [0,40]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA
- 2 analog voltage inputs with software range selection: [-1,1]V,[-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0, 0.1]V i [0, 50]mV
- 3 digital galvanically isolated inputs - 24V
- 6 digital galvanically isolated inputs - 24V
- Program cycles 5ms and signal acquisition 1kHz (1ms)
- PWM outputs:
  - range: [0, 1.5]kHz = [0, 100]%
  - PWM output voltage is equal to the power supply voltage
  - maximum PWM output current is 4A (8A total for all PWM outputs)
  - do not connect minus poles of PWM outputs to each other
- Maximum cross-section of the conductor:
  - for analog inputs, digital inputs and outputs and PWM outputs: 1mm
  - for power supply: 2.5mm
- Power supply voltage range: [10, 32]VDC
- Permitted voltage drops that do not aect the device operation 5s
- Consumption: 5W
- Temperature range: [0, 65] OC
- Supported communication protocols:
  - IEC 60870-5-101 Master/Slave
  - IEC 60870-5-102 Master
  - IEC 60870-5-103 Master
  - IEC 60870-5-104 Client/Server
  - MODBUS RTU i TCP Master/Slave
  - MODBUS TCP Client/Server
  - SPA Master
  - IEC 61850 Client/Server
  - DNP3 Master/Slave
  - Hart Master
  - Probus Master
  - BACNET Master
  - GOOSE
  - Neo Master
  - FINS Master
  - DLMS

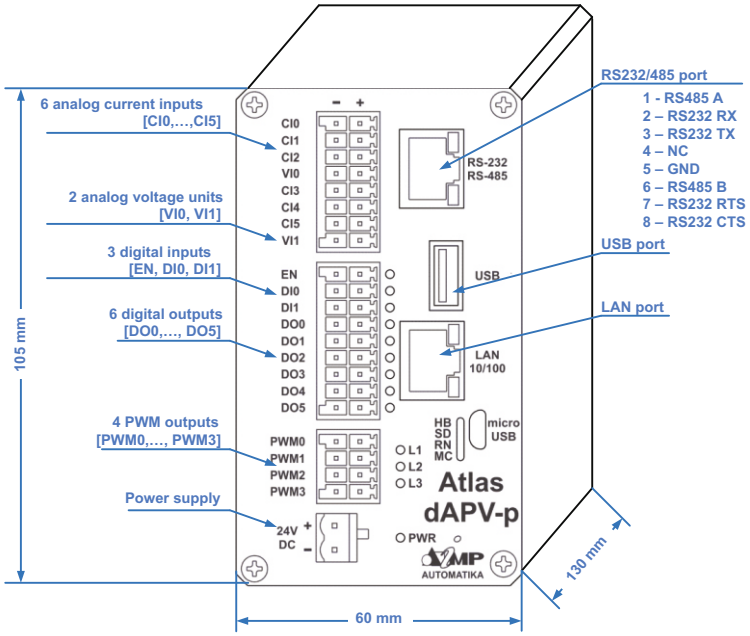


Figure 1 – Front view of devices with input/output signals, dimensions and pinouts for RS-232 / RS-485 ports

Inputs and outputs schemes

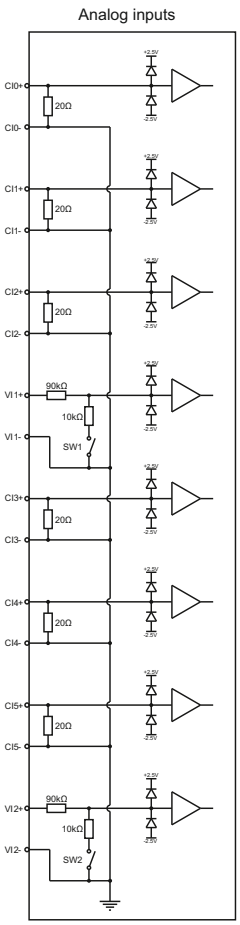


Figure 2 - Analog inputs CI0...CI5
(Software controlled switches SW1 and SW2 are in the **open** position for the following analog inputs voltage ranges [0, 50] mV, [0, 100] mV, [-50, 50] mV and [-100, 100] mV.
Software controlled switches SW1 and SW2 are in the **closed** position for the following analog inputs voltage ranges [0, 500] mV, [0, 1] V, [-500, 500] mV and [-1, 1] V)

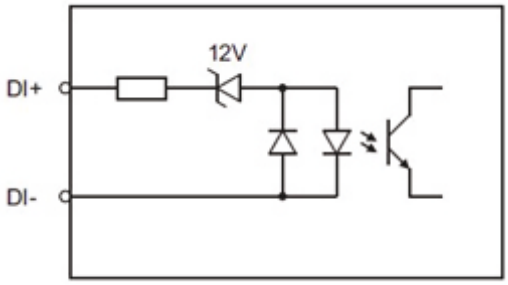


Figure 3 - Galvanically isolated digital inputs EN, DI0 and DI1

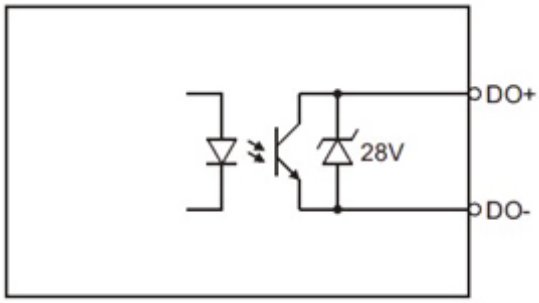


Figure 4 - Galvanically isolated digital outputs DO0... DI5

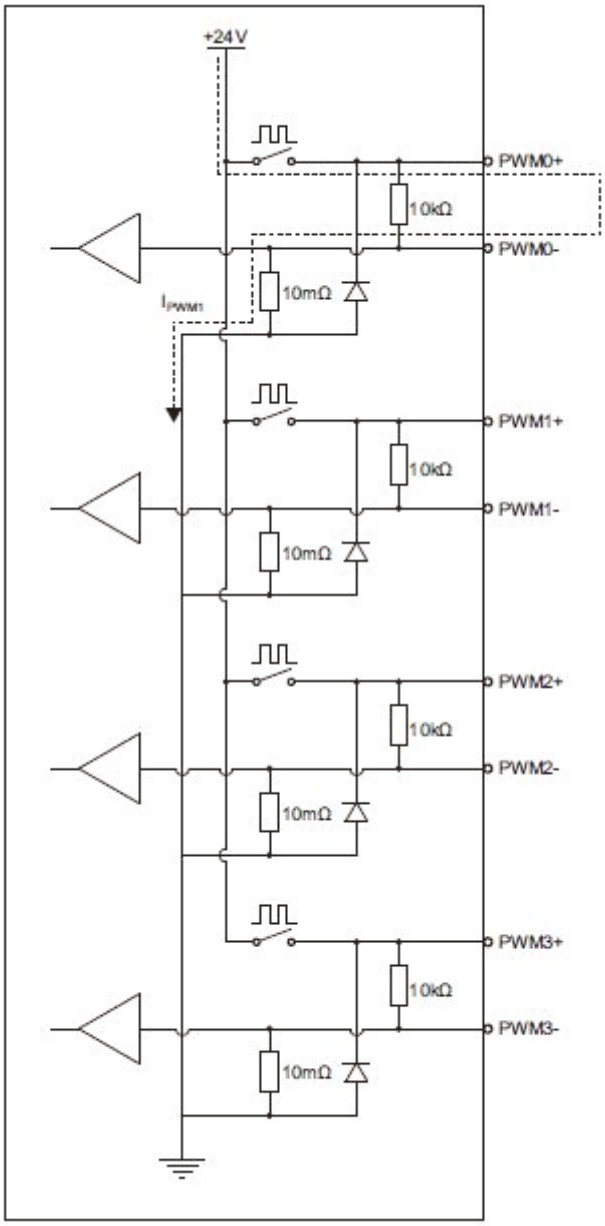


Figure 5 - PWM outputs PWM0... PWM3
(Do not connect minus poles of PWM outputs to each other)

Examples of applications for hydraulic servo drives control

Atlas dAPV-p can be used to control various types of hydraulic directional control valves in hydraulic installations adapted to the specications of the project. It is possible to provide control of a wide range of hydraulic directional control valves (proportional or pulse) for hydraulic installations with dierent nominal pressures. Also, due to the possibility of a cascade control structure, it can be applied in hydraulic installations where a directional pilot valve comes before the hydraulic directional control valve Examples of hydraulic installations where Atlas dAPV-p can be applied are shown in Figures 6 and 7.

The Atlas dAPV-p module can be connected to the superior level of PCS / RTU / PLC control with standard industrial protocols.

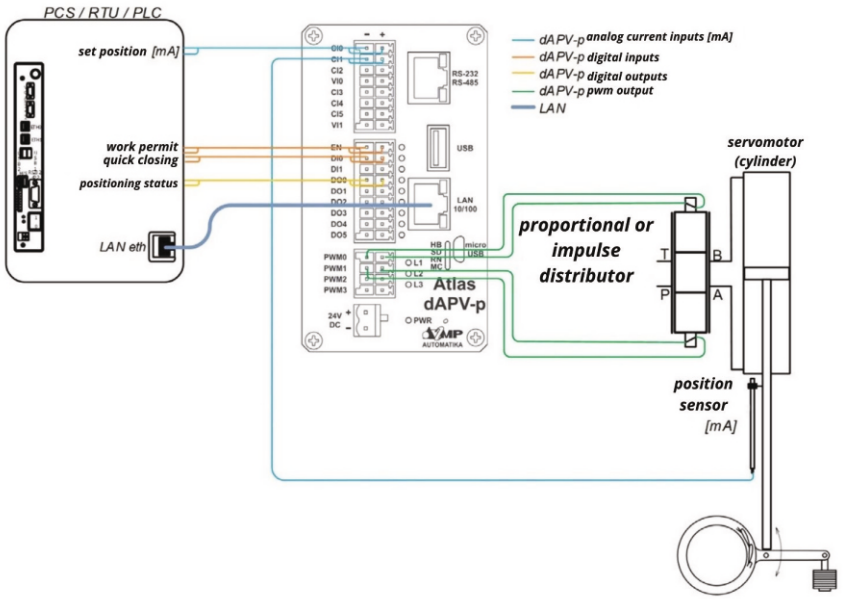


Figure 6 – Control of the hydraulic servo driver position through a proportional or pulse directional control valve, using the Atlas dAPV-p module

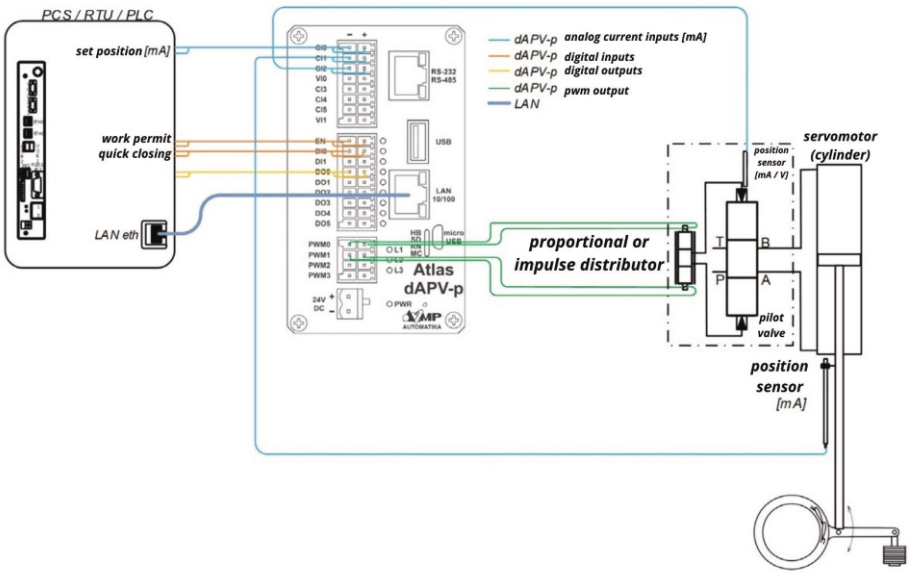


Figure 7 – Control of the hydraulic servo driver position through a proportional or pulse directional control valve with a pilot valve, using the Atlas dAPV-p module

Control algorithm

The control algorithm is based on cascade control with PID controllers. It is possible to deactivate the cascade control and realize the structure with a single PID regulator, with the appropriate selection of parameters. Table 1 describes wire input and output signals, Table 2 shows communication signals, and Table 3 shows parameters of the position controller adjustment for the algorithm from the Figure 8.

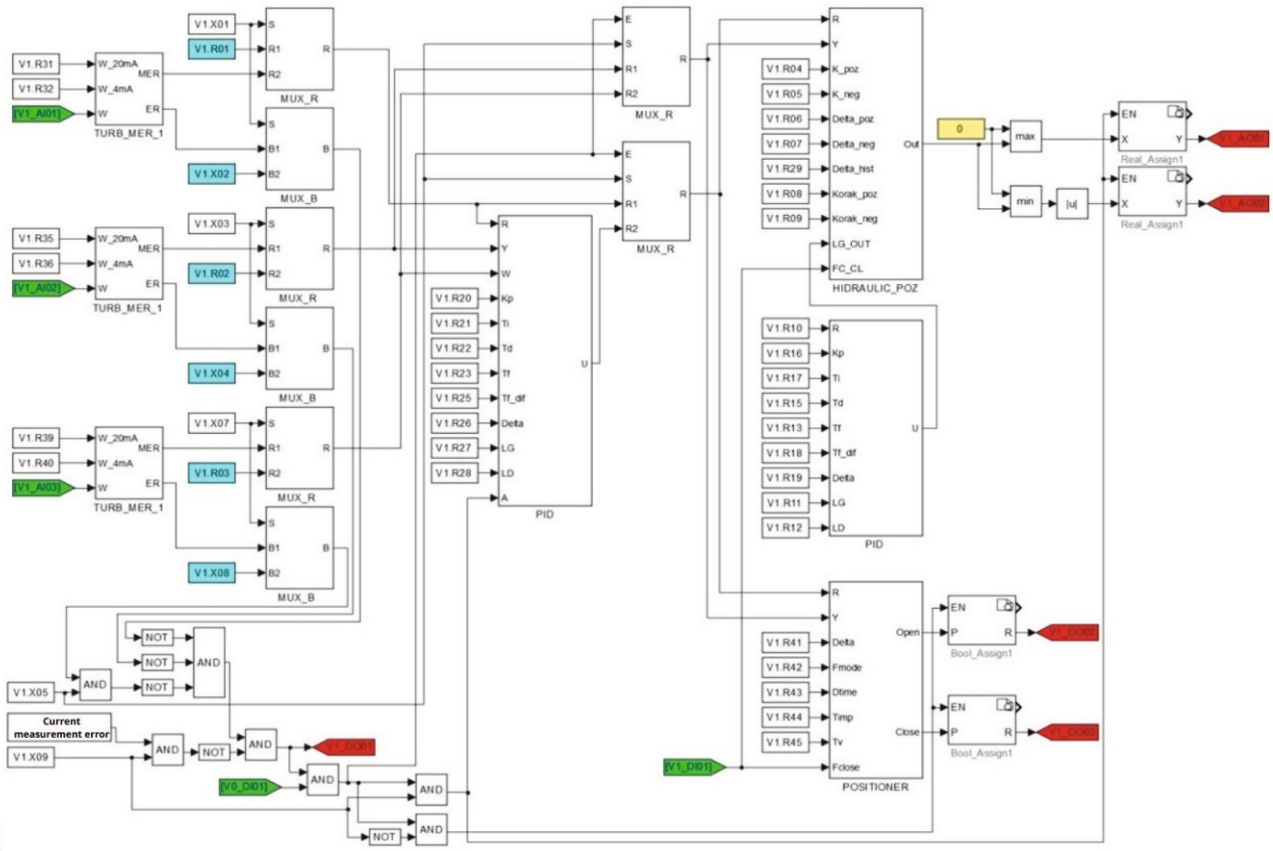


Figure 8 – Algorithm for positioning hydraulic drives on the Atlas dAPV-p module for one directional control valve (V1). It is analogous for the second directional control valve V2

Table 1 – Wire input and output signals of the algorithm from the Figure 8 for one directional control valve (V1). It is analogues for the second directional control valve V2.

Technical designation	Description	Type	Connecting to daPV	Range	Physical unit range
Wire input signals					
V1_AI01	Servo drive 1 default position	REAL	CI0	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V1_AI02	Servo drive 1 measured position	REAL	CI1	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V1_AI03	Servo drive 1 pilot valve measured position	REAL	CI2	0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
			VI0	[-1, 1]V, [-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0, 0.1]V i [0, 50]mV	
V2_AI01	Servo drive 2 default position	REAL	CI3	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V2_AI02	Servo drive 2 measured position	REAL	CI4	[0,20]mA, [-20,20]mA, [- 10,10]mA i [-5,5]mA	[0,100]%
V2_AI03	Servo drive 2 pilot valve measured position	REAL	CI5	0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
			VI1	[-1, 1]V, [-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0, 0.1]V i [0, 50]mV	
V0_DI01	Permission for dAPV module operation (0-operation not permitted, 1-operation permitted)	BOOL	EN	{0,1}	{0,1}
V1_DI01	Request for fast closing of servo drive 1 (0-request not active, 1-request active)	BOOL	DI0	{0,1}	{0,1}
V2_DI01	Request for fast closing of servo drive 2 (0-request not active, 1-request active))	BOOL	DI1	{0,1}	{0,1}
Wire output signals					
1_AO0V	The width of the PWM signal on the opening of the servo drive 1 PWMnom is the nominal frequency of the PWM signal. When the value of this signal is 0%, the ratio of the pulse width and break is 50% and when it is 100%, the pulse is 100%,and the break is 0%.	EAL R	WM0 P	0,100]% [	PWMnom,0]Hz [
V1_AO02	The width of the PWM signal on the closing of the servo drive 1 PWMnom is the nominal frequency of the PWM signal. When the value of this signal is 0%, then the ratio of the pulse width and break is 50% and when it is 100%, the pulse is 100%, and the break is 0%.	REAL	PWM1	[0,100] %	[PWMnom,0]Hz
2_AO0V	The width of the PWM signal on the opening of the servo drive 2 PWMnom is the nominal frequency of the PWM signal. When the value of this signal is 0%, then the ratio of the pulse width and break is 50% and when it is 100%, the pulse is 100%, and the break is 0%.	EAL R	WM2 P	0,100]% [	PWMnom,0]Hz [
V2_AO02	The width of the PWM signal on the closing of the servo drive 2 PWMnom is the nominal frequency of the PWM signal.When the value of this signal is 0%, then the ratio of the pulse width and break is 50% and when it is 100%, the pulse is 100%, and the break is 0%.	REAL	PWM3	[0,100] %	[PWMnom,0]Hz
V1_DO01	Servo drive 1 positioning status (0 -not correct, 1-correct)	BOOL	DO0	{0,1}	-
V1_DO02	Pulse on opening for servo drive 1 pulse directional control valve control	BOOL	DO1	{0,1}	-
V1_DO03	Pulse on closing for servo drive 1 pulse directional control valve control	BOOL	DO2	{0,1}	-
V2_DO01	Servo drive 2 positioning status (0 -not correct, 1-correct)	BOOL	DO3	{0,1}	-
V2_DO02	Pulse on opening for servo drive 2 pulse directional control valve control	BOOL	DO4	{0,1}	-
V2_DO03	Pulse on closing for servo drive 2 pulse directional control valve control	BO L	DO5	{0,1}	-

Table 2 – Communication input and output signals of the algorithm from the Figure 8 for a single directional control valve (V1). It is analogues for the second directional control valve V2.

Techn. designation	Description		Range	Physical unit range
Communication input signals				
V1.R01	Default position	REAL	[0,100]	[0,100]%
V1.X02	Correctness of the default position (0-incorrect, 1 - correct)	BOOL	{0,1}	-
V1.R02	Measured position	REAL	[0,100]	[0,100]%
V1.X04	Correctness of the measured position (0-incorrect, 1 - correct)	BOOL	{0,1}	-
V1.R03	Pilot valve measured position	REAL	[0,100]	[0,100]%
V1.X08	Correctness of the pilot valve measured position (0-incorrect, 1 - correct)	BOOL	{0,1}	-

Table 3 – Algorithm parameters from the Figure 8 for one directional control valve (V1). It is analogues for the second directional control valve V2.

Techn. designation	Description	Type	Range	Predefined value
Parameters for setting control structure				
V1.X01	SD1 POSITION SETTING-WIRE/COMMUNICATION Selection of position se翮 ng (0-wire, 1-communication)	BOOL	{0,1}	0
V1.X03	SD1 POSITION MEASURING- WIRE/COMMUNICATION Selection of position measuring (0-wire, 1-communication)	BOOL	{0,1}	0
V1.X07	PV1 POSITION MEASURING- WIRE/COMMUNICATION Selection of position measuring (0-wire, 1-communication)	BOOL	{0,1}	0
V1.X05	PV1 ACTIVE Selection of cascade position control (0-inactive, 1-active)	BOOL	{0,1}	0
V1.X09	SD1 PULSE CONTROL/PWM Selection of the directional control valve control method (0-pulse , 1-PWM)	BOOL	{0,1}	1
Parameters for position controller of the proportional directional control valve controlled by PWM signals				
V1.R04	SD1 HYDRAULIC_POS K_POS proportional gain of the position controller when the difference between the default and the measured position is positive	REAL	[0,100]	1
V1.R05	SD1 HYDRAULIC_POS K_NEG proportional gain of the position controller when the difference between the default and the measured position is negative	REAL	[0,100]	1
V1.R06	SD1 HYDRAULIC_POS DELTA_POS dead zone of the position controller when the difference between the default and the measured position is positive	REAL	[0,100]%	0.05
V1.R07	SD1 HYDRAULIC_POS DELTA_NEG dead zone of the position controller when the difference between the default and the measured position is negative	REAL	[0,100]%	0.05
V1.R29	SD1 HYDRAULIC_POS DELTA_HIST Position controller dead zone hysteresis	REAL	[0,100]%	0
V1.R08	SD1 HYDRAULIC_POS STEP_POS Control hop when the positive difference between the default and measured position, which was positive, comes out of the dead zone	REAL	[0,100]% ([PWMnom,0]Hz)	0
V1.R09	SD1 HYDRAULIC_POS STEP_NEG Control hop when the positive difference between the default and measured position, which was negative, comes out of the dead zone	REAL	[0,100]% ([PWMnom,0]Hz)	0

	Parameters for the maximum current limiters through the coils of the proportional directional control valve controlled by PWM signals			
V1.R10	SD1 CURRENT PID R Maximum permitted current	REAL	[0,3]A	2
V1.R16	SD1 CURRENT PID KP Proportional PID limiter gain	REAL	[0,100]	1
V1.R17	SD1 CURRENT PID TI time constant of the integral gain of the PID limiter	REAL	[0,100]s	1.5
V1.R15	SD1 CURRENT PID TD time constant of the differential gain of the PID limiter	REAL	[0,100]s	0
V1.R13	SD1 CURRENT PID TF time constant of the NP filter of the current measurement	REAL	[0,100]s	0
V1.R18	SD1 CURRENT PID TF_DIF time constant of the NP filter of the differential gain of the PID limiter	REAL	[0,100]s	0
V1.R19	SD1 CURRENT PID DELTA PID limiter dead zone	REAL	[0,100]%	0
V1.R11	SD1 CURRENT PID LG PWM PID limiter maximum PWM frequency	REAL	[0,100]% ([PWMnom,1500]Hz)	100
V1.R12	SD1 CURRENT PID LD PWM PID limiter minimum PWM frequency	REAL	[0,100]% ([PWMnom,1500]Hz)	0
	Parameters for the corrective position PID controller in the cascade position control			
V1.R20	SD1 VALVE PID KP PID controller proportional gain	REAL	[0,100]	1
V1.R21	SD1 VALVE PID TI time constant of the integral gain of the PID controller	REAL	[0,100]s	2
V1.R22	SD1 VALVE PID TD time constant of the differential gain of the PID controller	REAL	[0,100]s	0
V1.R23	SD1 VALVE PID TF Time constant of the NP filter measurement	REAL	[0,100]s	0
V1.R25	SD1 VALVE PID TF_DIF Time constant of the differential gain NP filter	REAL	[0,100]s	0
V1.R26	SD1 VALVE PID DELTA PID controller dead zone	REAL	[0,100]%	0
V1.R27	SD1 VALVE PID LG Pilot valve maximum position	REAL	[0,100]%	100
V1.R28	SD1 VALVE PID LD Pilot valve minimum position	REAL	[0,100]%	0
	Parameters for scaling the wired default position			
V1.R31	SD1 DEFAULT POSITION TURB_MEA_1 W_20mA Current value corresponding to the maximum default position 100%	REAL	[0,20]mA	20
V1.R32	SD1 DEFAULT POSITION TURB_MEA_1 W_4mA Current value corresponding to the minimum default position 0%	REAL	[0,20]mA	4
	Parameters for scaling the wired measured position			
V1.R35	SD1 MEASURED POSITION TURB_MEA_1 W_20mA Current value corresponding to the maximum measured position 100%	REAL	[0,20]mA	20
V1.R36	SD1 MEASURED POSITION TURB_MEA_1 W_4mA Current value corresponding to the minimum measured position 0%	REAL	[0,20]mA	4
	Parameters for scaling the wired measured position of the pilot valve			
V1.R39	PV1 MEASURED POSITION TURB_MEA_1 W_20mA Voltage value corresponding to the maximum measured position 100%	REAL	[-1,1]V	0.5
V1.R40	PV1 MEASURED POSITION TURB_MEA_1 W_4mA Voltage value corresponding to the minimum measured position 0%	REAL	[-1,1]V	-0.5
	Parameters for the position controller of the pulse directional control valve controlled by the pulse commands			
V1.R41	SD1 POSITIONER DELTA Position controller dead zone	REAL	[0,100]%	0.05
V1.R42	SD1 POSITIONER FMODE- value of the absolute difference between the default and the measured position, above which the permanent command is issued on opening or closing	REAL	[0,100]%	5
V1.R43	SD1 POSITIONER DTIME maximum waiting time between the two pulses when the absolute difference of the default and measured position is beyond the controller dead zone	REAL	[0,100]s	0.1
V1.R44	SD1 POSITIONER TIMP pulse duration when there is no active permanent command on the opening or closing	REAL	[0,100]s	0.1
V1.R45	SD1 POSITIONER TV Offset in relation to the maximum and minimum default position for issuing pulse commands. If the default position is more than 100%-Tv (/ less than 0% + Tv), then the pulses on the opening (/closing) are given.	REAL	[0,100]%	0

Software

Atlas dAPV-p is delivered with one of the following two software packages:

- dAPV-p-jed is a web based interface, which serves to parameterize all parameters of the modules given in the Figure 8, as well as to monitor process values in real time. All input and output analog and digital signals can be monitored in the form of timing diagrams. This ensures simple and reliable release of the hydraulic system into operation and generation of appropriate reports about the performed settings.

  Requirements:
  - Windows or Linux operating system
  - Web Browser (Mozilla Firefox, MS Explorer, Google Chrome,..),
  - MySQL server.

- dAPV-p-nap (Figures 9-14) is a software package based on the EDICOPT software package, which, in addition to the parameterization, allows the user to create algorithms according to the specics of a given project. dAPV-p-nap also enables the setting and testing of all communication protocols that are supported in the Atlas dAPV-p module.

  Requirements:
  - Windows or Linux operating system,
  - EDICOPT software package, produced by the Institute Mihailo Pupin,
  - MySQL server.

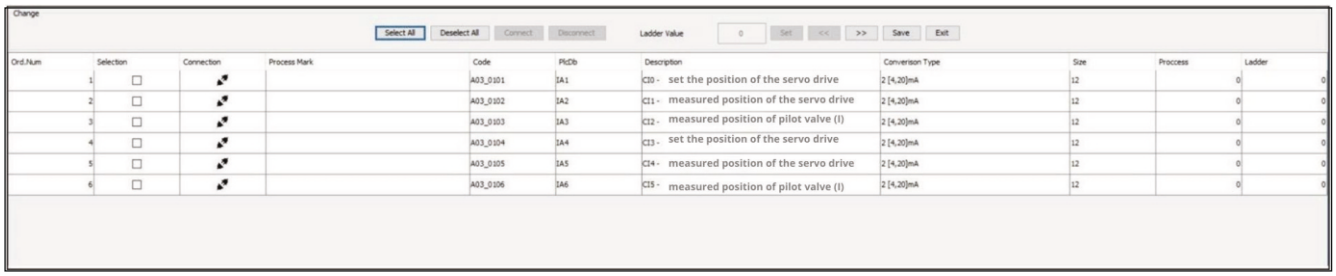


Figure 9 – EDICOPT - Table of the analog inputs

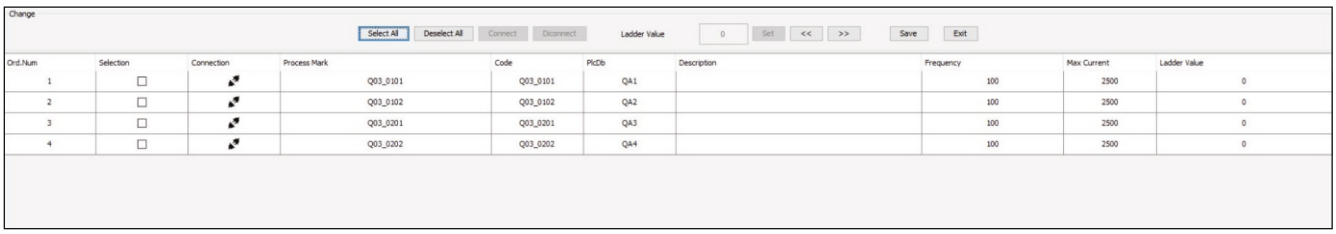


Figure 10 – EDICOPT - Table of the analog outputs

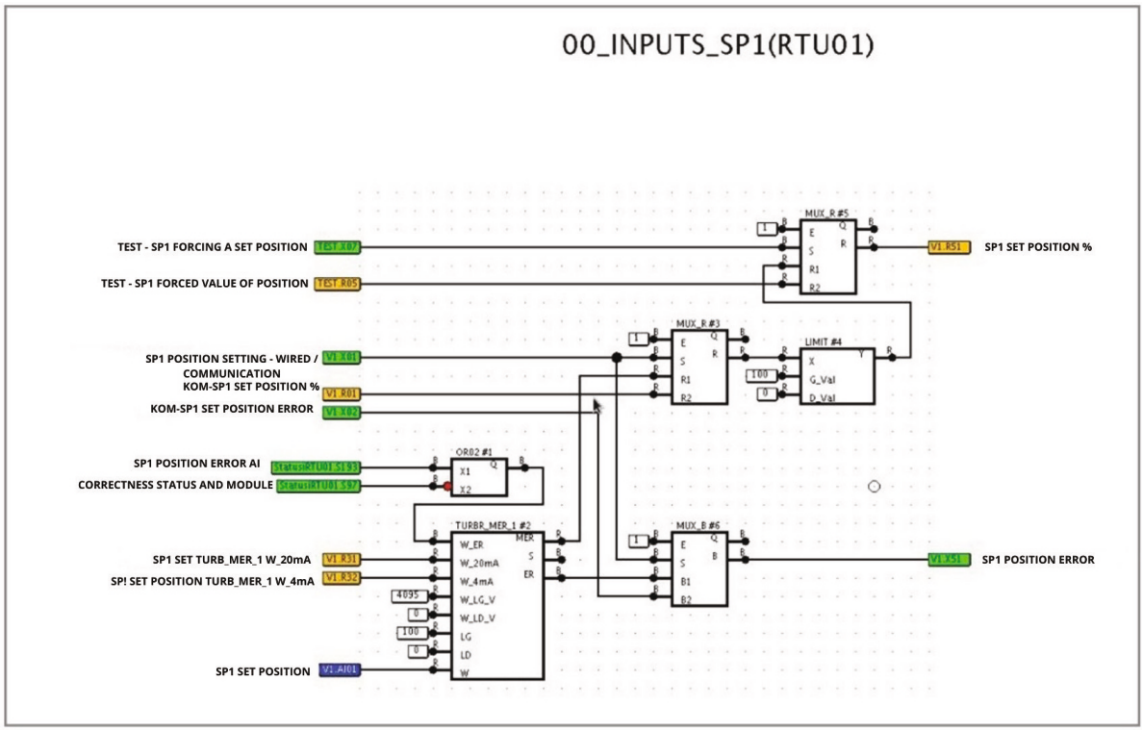


Figure11 – EDICOPT - Oine FBD dijagram

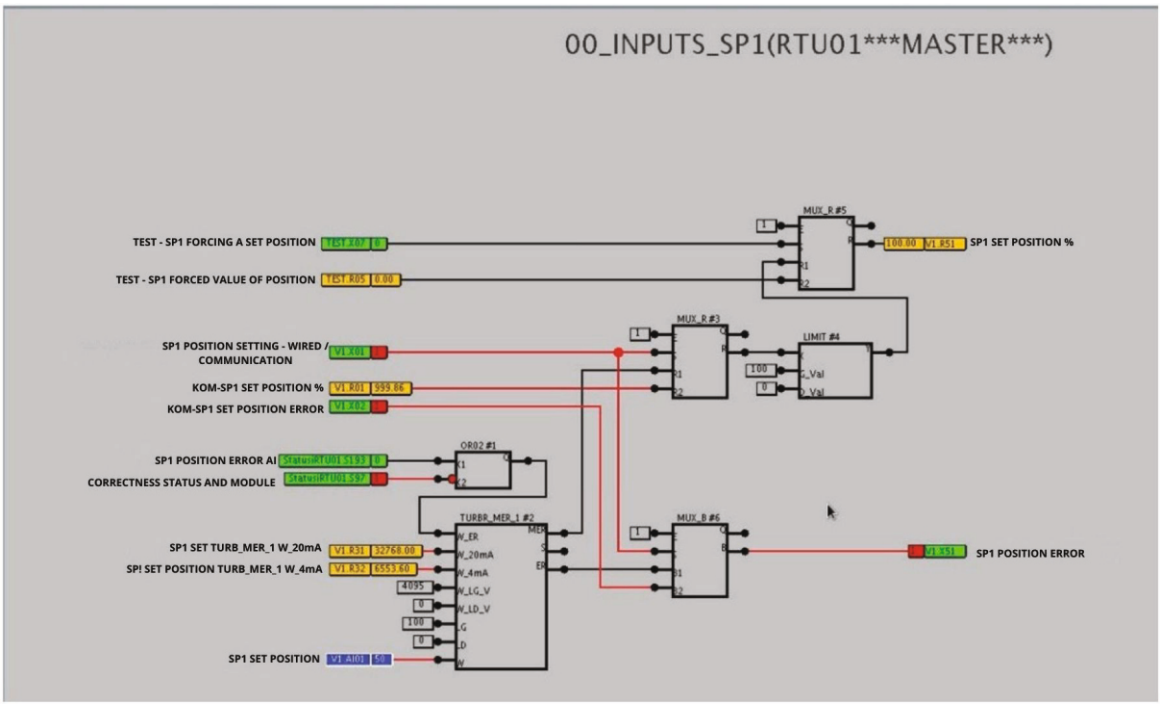


Figure 12 – EDICOPT - Online FBD dijagram

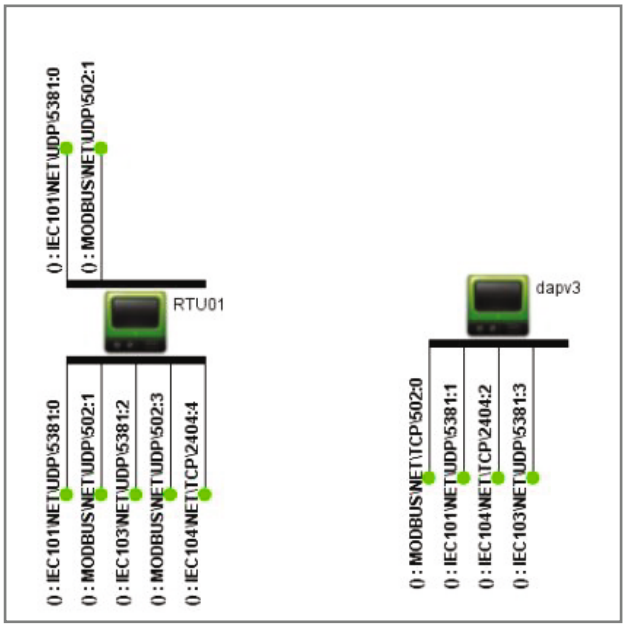


Figure 13 – EDICOPT - Layout of the module in the topology

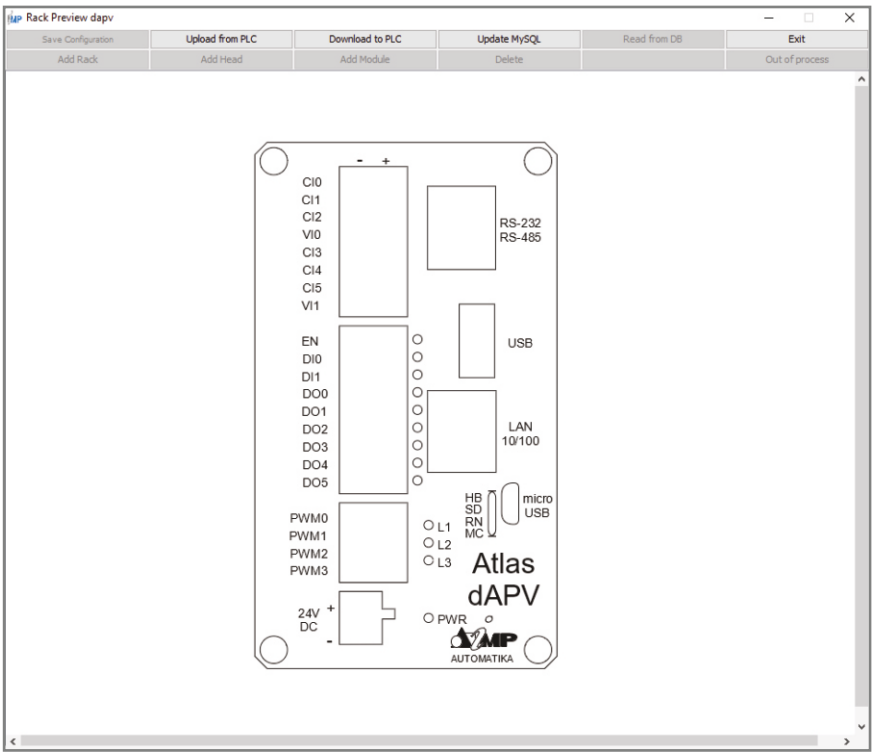


Figure 14 - EDICOPT - Layout of the "Rack Prop" menu

Atlas dAPV-s

Digital automatic valve positioner with the functions of the control and protection systems of the hydro and steam turbines

Application

The Atlas dAPV-s is a digital automatic valve positioner designed to control hydraulic servo drives via proportional or pulse directional control valves. Proportional directional control valves are controlled by a current signal (mA outputs), while pulse directional control valves are controlled by digital signals of certain duration. The cascade control structure, which closes the feedback at the position of the pilot valve and hydraulic servo drive, enables control of complex hydraulic systems in thermal and hydro power plants, as well as other energy or industrial plants. One device controls two independent hydraulic servo drives. It is intended to be mounted on a DIN rail inside the electrical cabinet.

In addition, the Atlas dAPV-s has the functions of a turbine controller of hydro or steam turbines, because it has the ability to close the feedback by measuring the speed:

- acquisition of high frequency counter pulse signals and generation of an analog speed signal, which can be transmitted by communication or wire to another control system,
- overspeed monitoring - creation of digital outputs as speed thresholds, if the speed measurement exceeds a value, a digital protection or alarm signal is generated,
- control of hydraulic drives with current or digital outputs and thus achieve turbine speed automatic control.

Technical characteristics

- Procesor AM3358 1GHz ARM Cortex-A8
- 10/100Mbit LAN
- RS-232/485 port (galvanically isolated)
- 4GB 8-bit eMMC
- 6 analog current inputs with software range selection: [0,20]mA, [4,20]mA,[0,40]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA
- 2 analog voltage inputs with software range selection: [-1,1]V,[-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0,0.1]V i [0, 50]mV
- 3 digital inputs (galvanically isolated) - 24V
- 6 digital inputs (galvanically isolated) - 24V
- Program cycle: 5ms, signal acquisition1kHz (1ms)
- 2 current outputs in the range [0,20]mA, 16bit
  - o maximum voltage of the current outputs is equal to the supply voltage
  - o maximum load resistance: 500Ω at 24V power supply
  - o control measurement of the current output current
- 2 counter digital inputs (galvanically isolated): 24V
  - o maximum frequency: 10kHz
- Maximum conductor cross-section:
  - o for analog and digital inputs and outputs: 1mm2
  - o for power supply: 2.5mm2
- Power supply voltage range [10, 32]VDC
- Permitted supply voltage drops that do not aect the operation: 5s
- onsumption: 5W
- Temperature range: [0, 65] OC
- Mounting on the DIN rail
- Supported communication protocols:
  - o IEC 60870-5-101 Master/Slave
  - o IEC 60870-5-102 Master
  - o IEC 60870-5-103 Master
  - o IEC 60870-5-104 Client/Server
  - o MODBUS RTU
  - o TCP Master/Slave
  - o MODBUS TCP Client/Server
  - o SPA Master
  - o IEC 61850 Client/Server
  - o DNP3 Master/Slave
  - o Hart Master
  - o Probus Master
  - o BACNET Master
  - o GOOSE
  - o Neo Master
  - o FINS Master
  - o DLMS

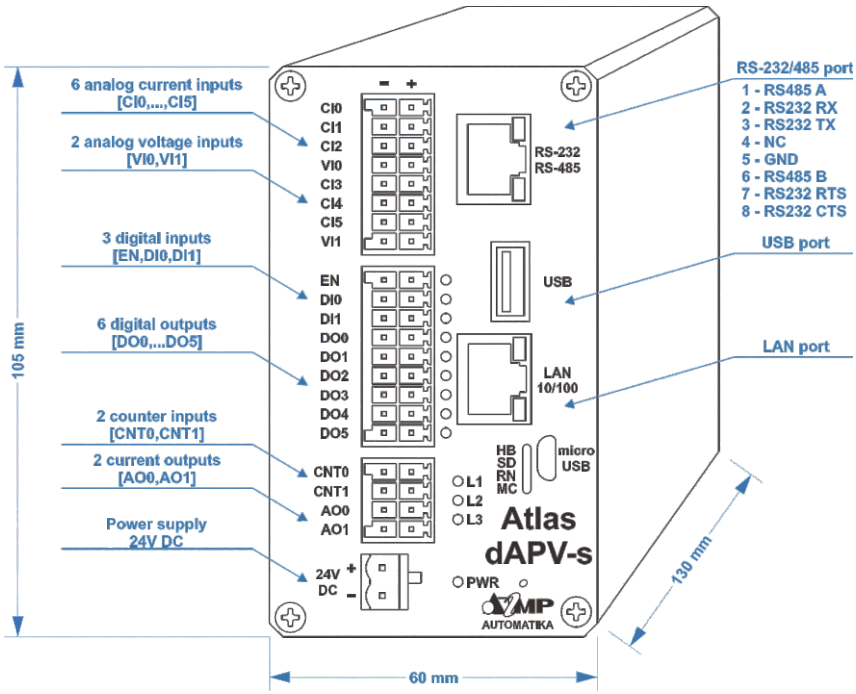


Figure 1 – Front view of the device with input-output signals markings, dimensions and pinout ports RS-232 / RS-485

Input and output schemes

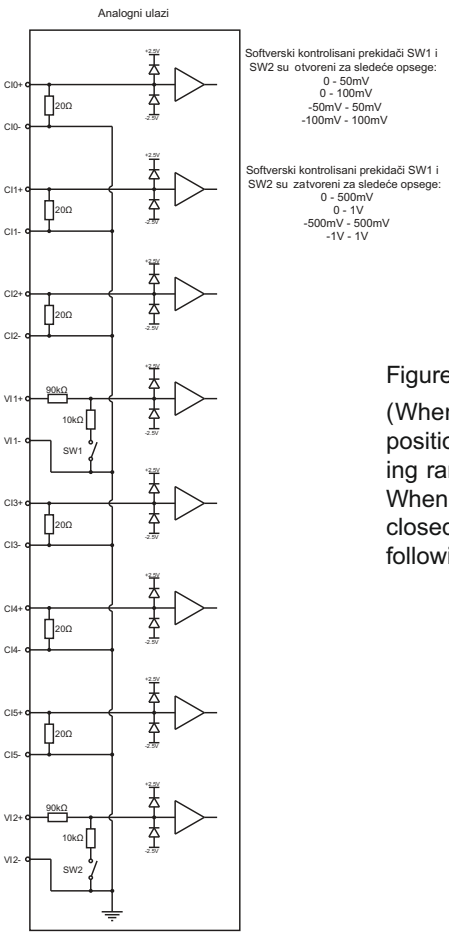


Figure 2 - Analog inputs CI0,...CI5

(When software-controlled switches SW1 and SW2 are in the open position, the voltage of the analog inputs is measured in the following range: [0, 50] mV, [0, 100] mV, [-50, 50] mV and [-100, 100] mV . When the software-controlled switches SW1 and SW2 are in the closed position, the voltage of the analog inputs is measured in the following range: [0, 500] mV, [0, 1] V, [-500, 500] mV and [-1, 1] V).

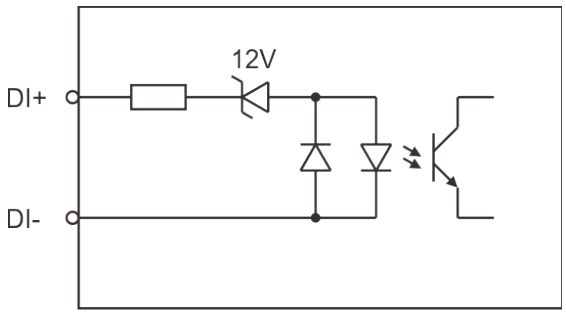


Figure 3 - Galvanically isolated digital inputs and counter digital inputs EN, DI0, DI1, CNT0 and CNT1

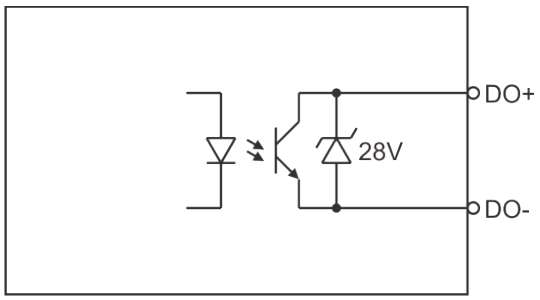


Figure 4 - Galvanically isolated digital outputs DO0,... DI5

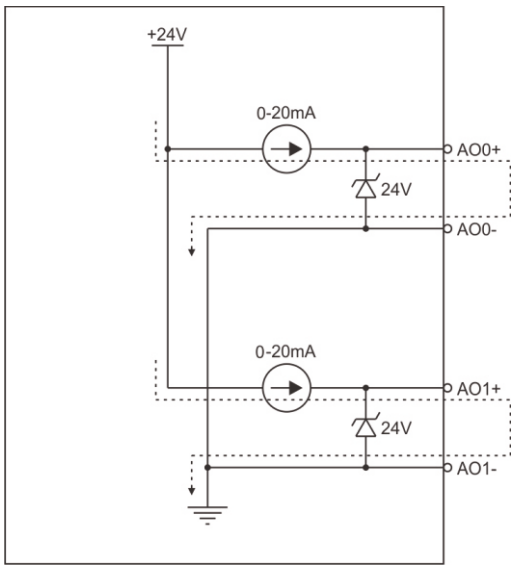


Figure 5 - Current outputs AO0 and AO1

Application examples for hydraulic servo drives control

Atlas dAPV-s can be used to control dierent types of hydraulic directional control valves in hydraulic installations adapted to the specics of a given project. It is possible to cover the control of a wide range of hydraulic directional control valves (proportional or pulse) for hydraulic installations with dierent nominal pressures. Proportional directional control valves are positioned by a current signal, e.g. if there is a three-position proportional directional control valves controlled by a current output in the range [4.20] mA, then for:

- 4mA on the proportional directional control valve, the direction of the oil from the cylinder to the tank is fully opened and then the drive goes into closing position at maximum speed,
- 12mA proportional directional control valve is in the central position, the oil does not go in any direction and the drive is idle in the current position (does not go into closing or opening position),
- 20mA on the proportional directional control valve, the direction of the oil

In this case, the opening speed is regulated by changing the current signal in the range [12.20] mA, and the closing speed in the range [4.12] mA.

Also, due to the possibility of the existence of a cascade control structure, it can be applied in hydraulic installations where there is a directional pilot control valve before the hydraulic directional control valve. Examples of hydraulic installations where Atlas dAPV-s can be applied are shown in Figures 6 and 7.

The Atlas dAPV-s module can be connected to the PCS / RTU / PLC master control level by standard industry protocols.

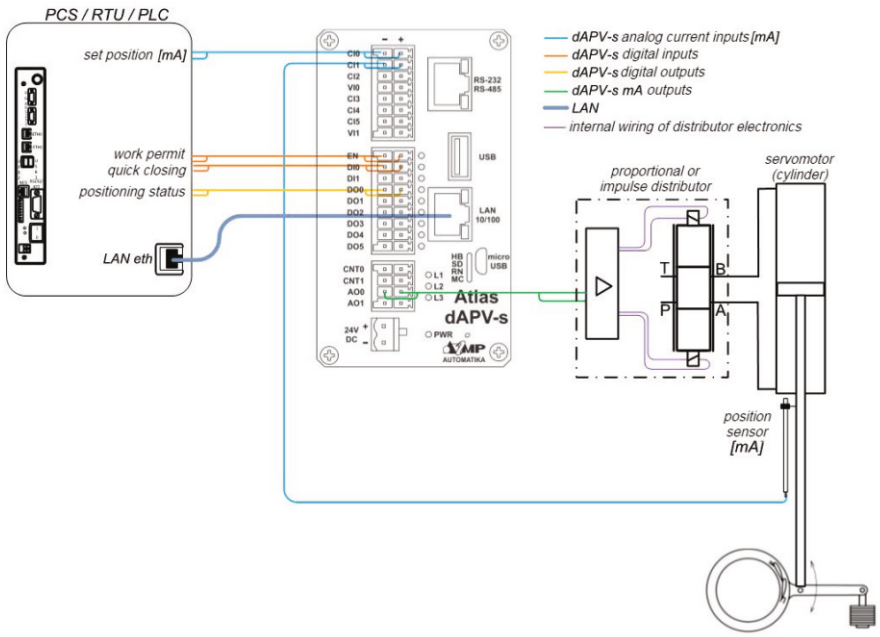


Figure 6 – Control of the position of the hydraulic servo motor via the internal electronics of the proportional or pulse directional control valve using the Atlas dAPV-s module

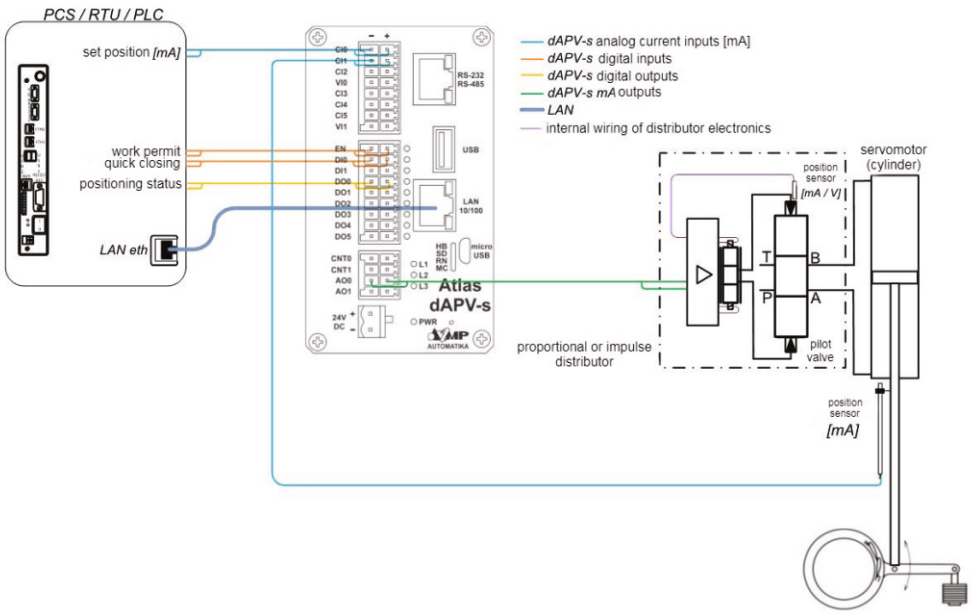


Figure 7 – Control of the position of the hydraulic servo motor via the internal electronics of the proportional or pulse directional control valve with pilot valve using the Atlas dAPV-s module

Application examples for turbine controllers

Figure 8 shows an example of hydro-turbine control using the Atlas dAPV-s module. Through the two digital counter inputs CNT0 and CNT1, the turbine speed is acquired via two inductive probes, mounted next to the toothed wheel on the turbine shaft. The Atlas dAPV-s module is then controlled by the position of one or two hydraulic servomotors. Turbine speed setting can be performed from the master PCS / RTU / PLC control levels, and it is also possible to set up automatic turbine speed setting and turbine performance up to 0o / min to nominal speed and perform unit synchronization. Also, due to the digital outputs on the Atlas dAPV-s module, it is possible to generate digital signals of high-speed protection operation and introduce them into the turbine switch-o circuit.

The main advantages of using the Atlas dAPV-s module as a turbine controller are reected in the following:

- acquisition of turbine speed via two independent digital counter inputs, whereat the basic redundancy on the main measurement of the turbine controller is achieved,
- the possibility of controlling two hydraulic servo drives simultaneously, which covers a wide range of hydropower plants (all types of Kaplan and Francis turbines, as well as Pelton with one needle),
- thanks to programming according to the standard in the EDICOPT software package, it is possible to create complex speed reference assignment structures in dierent operating states. The complexity of the algorithm is not a limiting factor in terms of hardware performance,
- formation of high-speed protection signal, in case the turbine speed exceeds the dened limits and protective stop of the turbine,
- due to the wide range of communication protocols, the Atlas dAPV-s module as a turbine control system can be easily integrated into the master power plant management system.

This device is a cheap, ecient and optimal all-in-one solution for modernization, of smaller or larger extent, of existing hydro or steam turbines.

For more details about the application of the dAPV-s module in turbine control systems, a detailed turbine control algorithm, as well as customization to your requirements, please contact e-mail automatika@pupin.rs with the title "dAPV-s turbine controller".

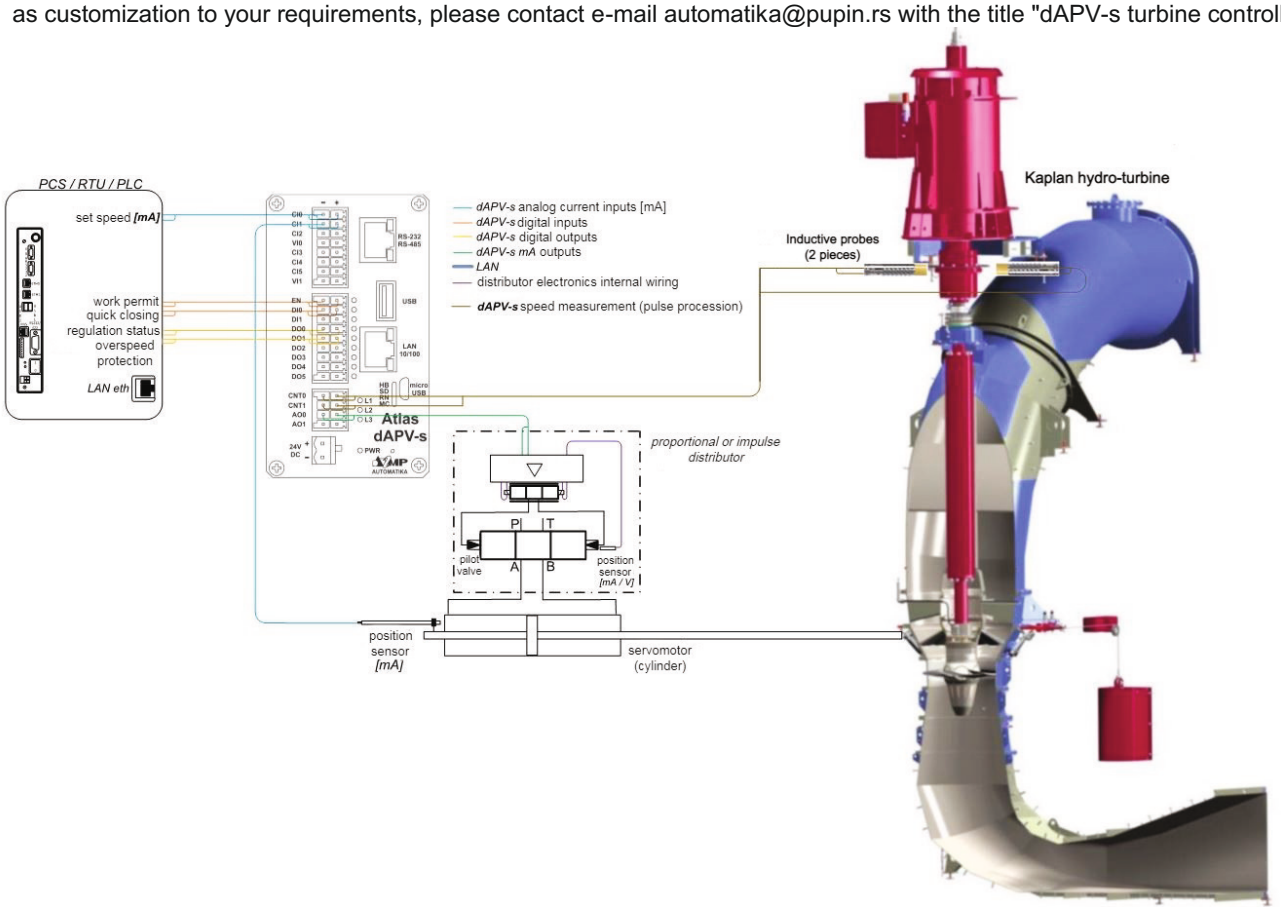


Figure 8 – Application of Atlas dAPV-s module for turbine control system for Kaplan hydro-turbine

Hydraulic servo drive control algorithm

The control algorithm is based on cascade control with PID controllers. It is possible to deactivate the cascade control and realize the structure with one PID controller, with the appropriate choice of parameters. Table 1 describes the wired input and output signals, Table 2 describes the communication signals, and Table 3 shows the position controller setting parameters for the algorithm of Figure 9.

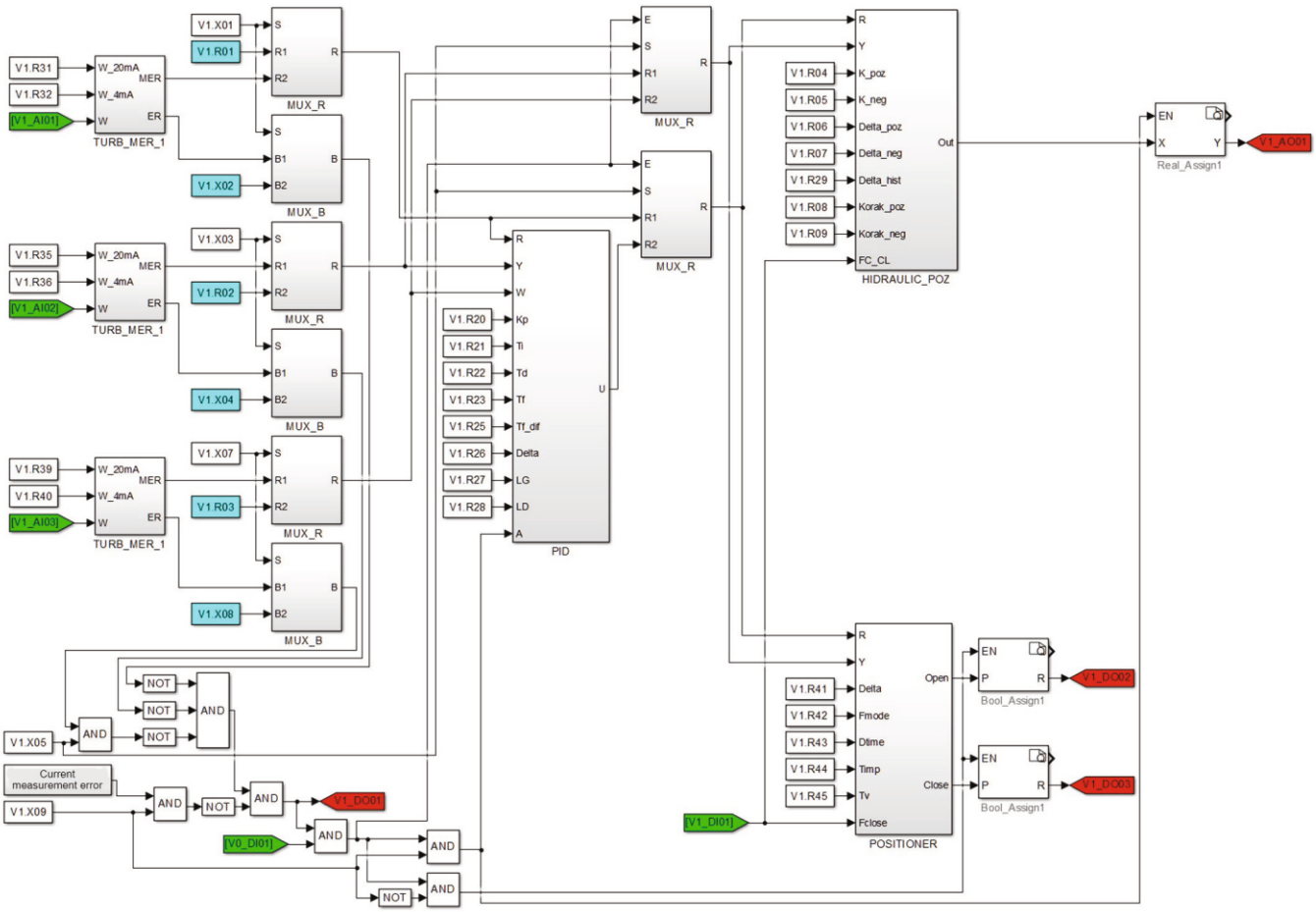


Figure 9 – The algorithm for the hydraulic drives positioning on the Atlas dAPV-s module with one directional control valve (V1), for the other directional control valve (V2) is analogous

Table 1 – Wired input and output signals of the Atlas dAPV-p module and connection to the control algorithm from Figure 9

Technical designation	Description	Type	Connecting to dAPV	Range	Physical unit range
Wire input signals					
V1_AI01	Servo drive 1 set position	REAL	CI0	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V1_AI02	Servo drive 1 measured position	REAL	CI1	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V1_AI03	Servo drive 1 pilot valve measured position	REAL	CI2	0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
			VI0	[-1, 1]V, [-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0, 0.1]V i [0, 50]mV	
V2_AI01	Servo drive 2 set position	REAL	CI3	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V2_AI02	Servo drive 2 measured position	REAL	CI4	[0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
V2_AI03	Servo drive 2 pilot valve measured position	REAL	CI5	0,20]mA, [-20,20]mA, [-10,10]mA i [-5,5]mA	[0,100]%
			VI1	[-1, 1]V, [-0.5, 0.5]V, [-0.1, 0.1]V, [-50, 50]mV, [0, 1]V, [0, 0.5]V, [0, 0.1]V i [0, 50]mV	
V0_DI01	Permission for dAPV module operation (0- operation not permitted, 1-operation permitted)	BOOL	EN	{0,1}	{0,1}
V1_DI01	Request for fast closing of servo drive 1 (0-request not active, 1-request active)	BOOL	DI0	{0,1}	{0,1}
V2_DI01	Request for fast closing of servo drive 2 (0-request not active, 1-request active))	BOOL	DI1	{0,1}	{0,1}
/	Rotation speed - pulse counter inputs	REAL	CNT0	f=[0,10]kHz	f*60/Nz [10*o/min]
/	Rotation speed - pulse counter inputs	REAL	CNT1	f=[0,10]kHz	f*60/Nz [10*o/min]
Wire output signals					
V1_AO01	Current signal of the hydraulic directional control valve 1 set position	REAL	AO0	[-100,0,100]%	[4,12,20]mA
V2_AO01	Current signal of the hydraulic directional control valve 2 set position	REAL	AO1	[-100,0,100]%	[4,12,20]mA
V1_DO01	Servo drive positioning status 1 (0-not correct, 1-correct)	BOOL	DO0	{0,1}	-
V1_DO02	Opening pulse for servo drive 1 pulse directional control valve control	BOOL	DO1	{0,1}	-
V1_DO03	Closing pulse for servo drive 1 pulse directional control valve control	BOOL	DO2	{0,1}	-
V2_DO01	Servo drive positioning status 2 (0-not correct, 1-correct)	BOOL	DO3	{0,1}	-
V2_DO02	Opening pulse for servo drive 2 pulse directional control valve control	BOOL	DO4	{0,1}	-
V2_DO03	Closing pulse for servo drive 2 pulse directional control valve control	BOOL	DO5	{0,1}	-

Table 2 – Communication signals of the algorithm from Figure 8 for one (V1), for the other directional control valve (V2) is analogous

Technical designation	Description	Type	Range	Physical unit range
	Communication input signals			
V1.R01	Set position	REAL	[0,100]	[0,100]%
V1.X02	Correctness of the set position (0-not correct, 1- correct)	BOOL	{0,1}	-
V1.R02	Measured position	REAL	[0,100]	[0,100]%
V1.X04	Correctness of the measured position (0-not correct, 1- correct)	BOOL	{0,1}	-
V1.R03	Pilot valve measured position	REAL	[0,100]	[0,100]%
V1.X08	Correctness of the pilot valve measured position (0-not correct, 1- correct)	BOOL	{0,1}	-

Table 3 – Parameters of the algorithm from Figure 8 for one (V1), for the other directional control valve (V2) is analogous

Technical designation	Description	Type	Range	Predefined value
	Parameters for se翮 ng control structure			
V1.X01	SP1 POSITION SETTING – WIRE /COMMUNICATION choice of position se翮 ng(0-wire, 1-communication)	BOOL	{0,1}	0
V1.X03	SP1 POSITION MEASURING - WIRE /COMMUNICATION choice of position measuring (0-wire, 1-communication)	BOOL	{0,1}	0
V1.X07	PV1 POSITION MEASURING - WIRE /COMMUNICATION choice of position measuring (0-wire, 1-communication)	BOOL	{0,1}	0
V1.X05	PV1 ACTIVE choice of casacade position control (0-not active, 1-active)	BOOL	{0,1}	0
V1.X09	SP1 PULSE/PWM CONTROL choice of the directional control valve control mode (0-pulse, 1-PWM)	BOOL	{0,1}	1
	Parameters of the position controller of the proportional control valve controlled by PWM signals			
V1.R04	SP1 HIDRAULIC_POZ K_POZ proportional gain of the position controller when the difference between the set and measured position is positive	REAL	[0,100]	1
V1.R05	SP1 HIDRAULIC_POZ K_NEG proportional gain of the position controller when the difference between the set and measured position is negative	REAL	[0,100]	1
V1.R06	SP1 HIDRAULIC_POZ DELTA _POZ dead zone of the position controller when the difference between the set and measured position is positive	REAL	[0,100]%	0.05
V1.R07	SP1 HIDRAULIC_POZ DELTA _NEG dead zone of the position controller when the difference between the set and measured position is negative	REAL	[-100,0]%	-0.05
V1.R29	SP1 HIDRAULIC_POZ DELTA_HIST dead zone hysteresis of the position controller	REAL	[0,100]%	0
V1.R08	SP1 HIDRAULIC_POZ KORAK_POZ control jump when the positive difference between the set and measured position, which was positive, comes out of the dead zone	REAL	[0,100]%	0
V1.R09	SP1 HIDRAULIC_POZ KORAK_NEG control jump when the positive difference between the given and measured position, which was negative, comes out of the dead zone	REAL	[0,100]%	0

Parameters for correction PID position controller in cascade position control				
V1.R20	SP1 VENTIL PID KP PID controller proportional gain	REAL	[0,100]	1
V1.R21	SP1 VENTIL PID TI time constant of integral gain of PID controller	REAL	[0,100]s	2
V1.R22	SP1 VENTIL PID TD time constant of differential gain of PID controller	REAL	[0,100]s	0
V1.R23	SP1 VENTIL PID TF time constant of the measurement NP filter	REAL	[0,100]s	0
V1.R25	SP1 VENTIL PID TF_DIF time constant of the differential gain NP filter	REAL	[0,100]s	0
V1.R26	SP1 VENTIL PID DELTA PID controller dead zone	REAL	[0,100]%	0
V1.R27	SP1 VENTIL PID LG pilot valve maximum position	REAL	[0,100]%	100
V1.R28	SP1 VENTIL PID LD Pilot valve minimum position	REAL	[0,100]%	0
Parameters for scaling the wired set position				
V1.R31	SP1 DEFAULT POSITION TURB_MER_1 W_20mA current value corresponding to the 100% maximum set position	REAL	[0,20]mA	20
V1.R32	SP1 DEFAULT POSITION TURB_MER_1 W_4mA current value corresponding to the 0% minimum set position	REAL	[0,20]mA	4
Parameters for scaling the wired measured position				
V1.R35	SP1 MEASURED POSITION TURB_MER_1 W_20Ma current value corresponding to the 100% maximum measured position	REAL	[0,20]mA	20
V1.R36	SP1 MEASURED POSITION TURB_MER_1 W_4mA current value corresponding to the 0% minimum measured position	REAL	[0,20]mA	4
Parameters for scaling the pilot valve wired measured position				
V1.R39	PV1 MEASURED POSITION TURB_MER_1 W_20mA voltage value corresponding to the 100% maximum measured position	REAL	[-1,1]V	0.5
V1.R40	PV1 MEASURED POSITION TURB_MER_1 W_4mA voltage value corresponding to the 0% minimum measured position	REAL	[-1,1]V	-0.5
Parameters for the position controller of the pulse directional control valve controlled by the pulse commands				
V1.R41	SP1 POZICIONER DELTA position controller dead zone	REAL	[0,100]%	0.05
V1.R42	SP1 POZICIONER FMODE value of the absolute difference between the set and measured position, above which a permanent opening or closing command is issued.	REAL	[0,100]%	5
V1.R43	SP1 POZICIONER DTIME maximum waiting time between the two pulses when the absolute difference of the set and measured position is beyond the controller dead zone	REAL	[0,100]s	0.1
V1.R44	SP1 POZICIONER TIMP pulse duration when there is no active permanent command on the opening or closing	REAL	[0,100]s	0.1
V1.R45	SP1 POZICIONER TV Offset in relation to the maximum and minimum set position for issuing pulse commands. If the set position is (more than 100% -Tv / less than 0% + Tv), then the pulses for (opening / closing) are given.	REAL	[0,100]%	0

Software

Atlas dAPV-p is delivered with one of the following two software packages:

- dAPV-s-jed is a web based interface, which serves to parameterize all parameters of the modules given in the Figure 8, as well as to monitor process values in real time. All input and output analog and digital signals can be monitored in the form of timing diagrams. This ensures simple and reliable commencement of the hydraulic system and generation of appropriate reports about the performed settings.

  Requirements:
  - Windows or Linux operating system,
  - Web Browser (Mozilla Firefox, MS Explorer, Google Chrome,..),
  - MySQL server.

- dAPV-s-nap (slike 10-14) je softverski paket baziran na EDICOPT softverskom paketu, koji pored parametrizacije, omogućava • dAPV-s-nap (Figures 10-14) is a software package based on the EDICOPT software package, which, in addition to the parameterization, allows the user to create algorithms according to the specics of a given project. dAPV-s-nap also enables the setting and testing of all communication protocols that are supported in the Atlas dAPV-s module.

  Requirements:
  - Windows or Linux operating system,
  - EDICOPT software package, produced by the Institute Mihailo Pupin,
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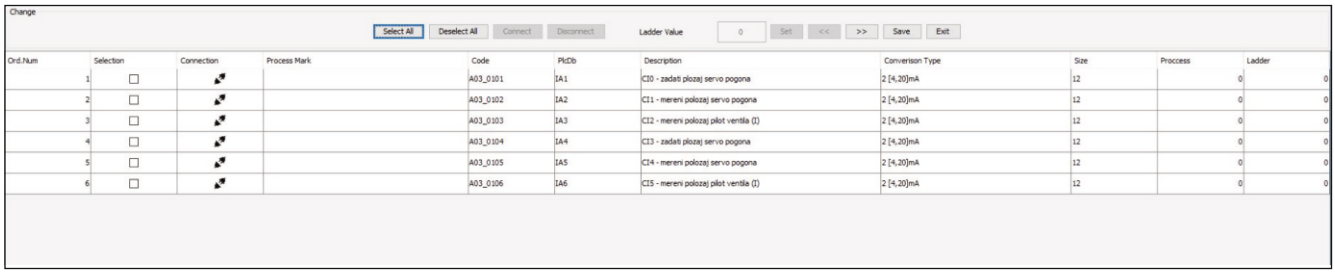


Figure 10 – Edicopt – Table of analog inputs

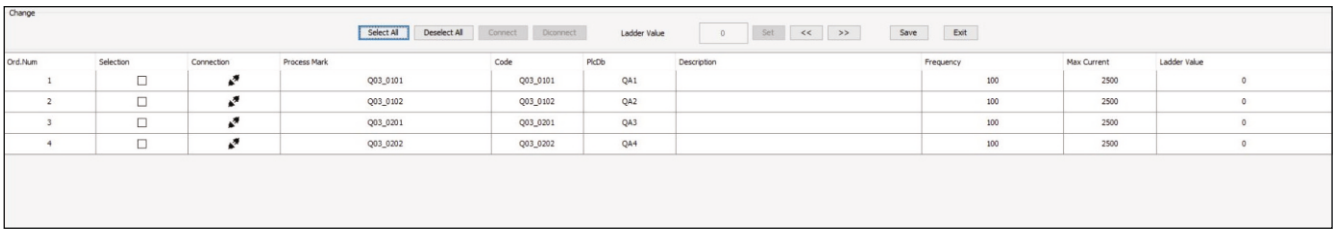


Figure 11 – Table of analog outputs

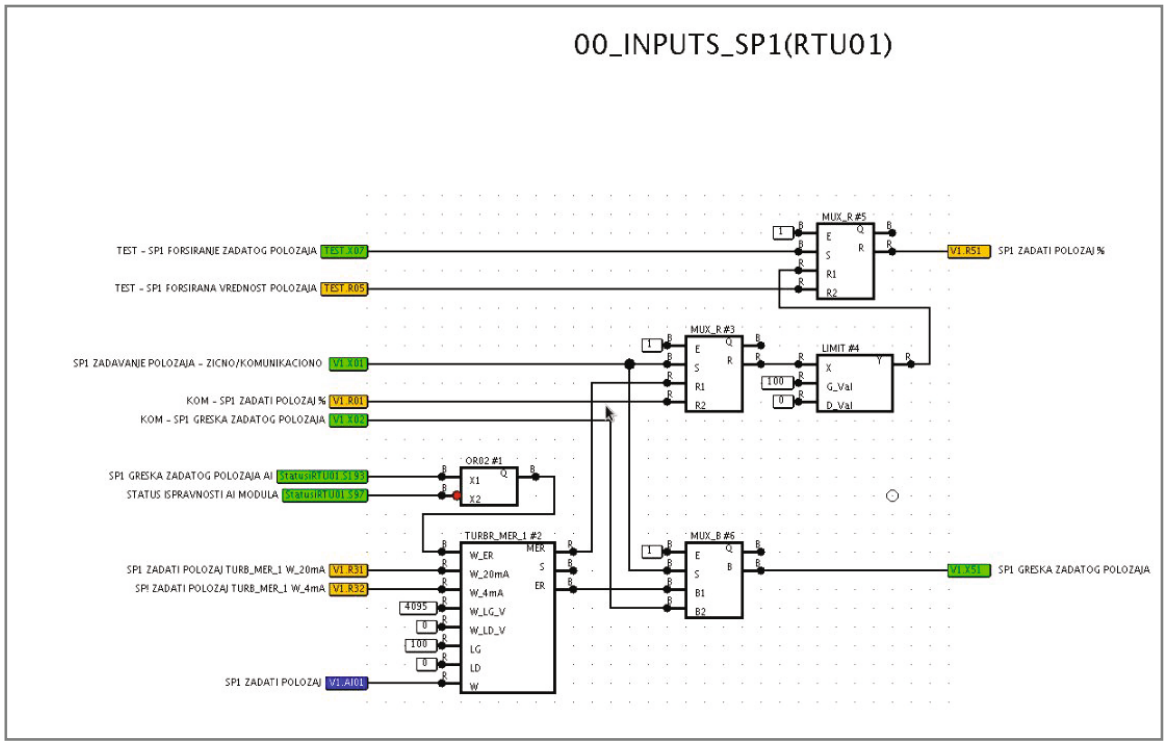


Figure 12 – Edicopt - Oine FBD diagram

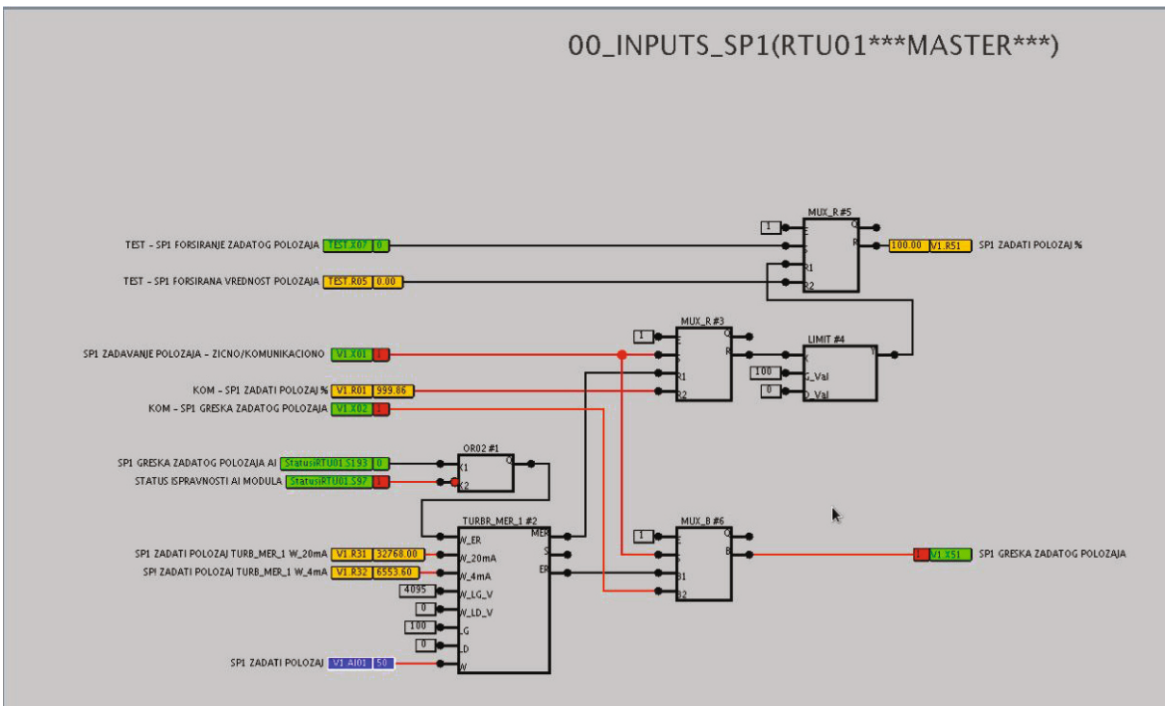


Figure 13 – Edicopt - Online FBD diagram

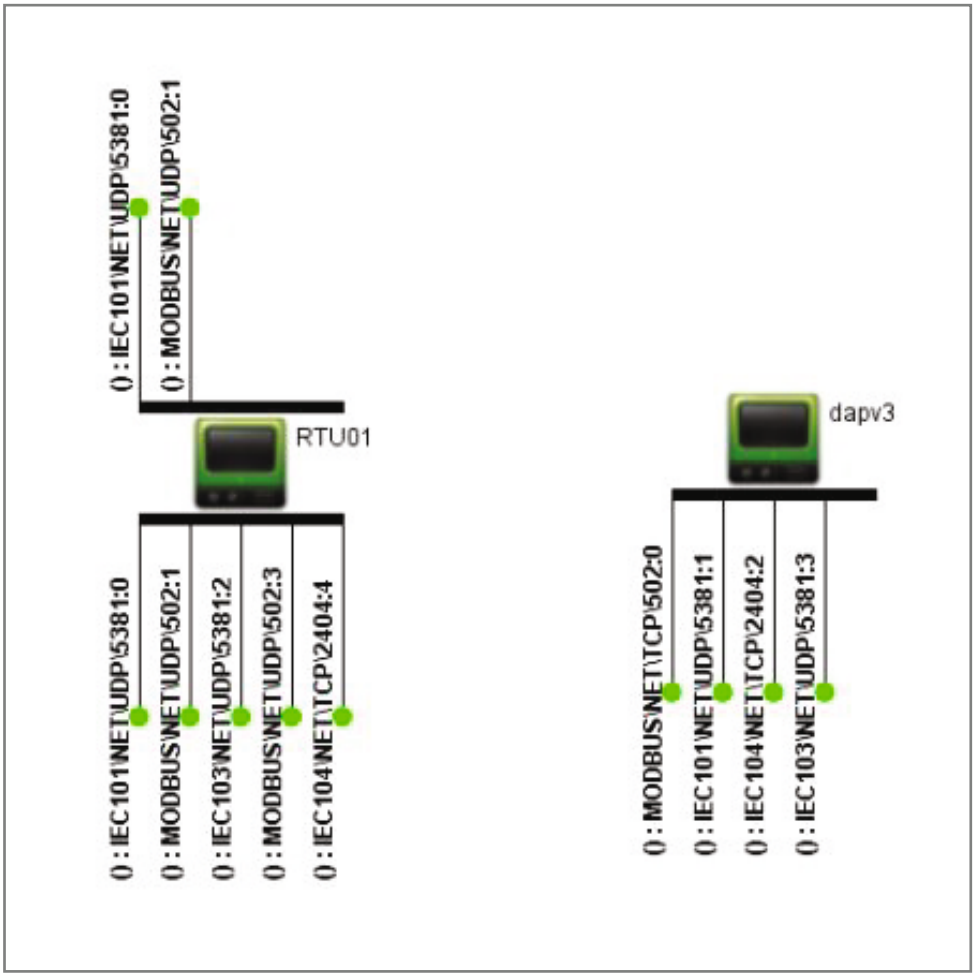


Figure 14 – Edicopt –Module layout in topology

iDisp6

Display module

Functions

- Measuring size display module for MMS devices
- Six-digit display with a xed number of decimal places
- Serial communication LED indication
- Possibility of connecting an analog current input
- Software setting of module operation mode
- Connection to other modules via RS485 bus
- Galvanic isolation of analog input in relation to power supply
- Digit height 14mm

Application

The iDispl6 digital output module enables the display of the measured size in engineering units, which arrives via the RS485 bus. Depending on the choice of operating mode type, the size arriving from the SCADA directly or via the Atlas RTL module is displayed, and the locally measured size on the module itself can also be displayed.

Design

Plastic box (dimensions WxDxH 96x48x110mm)

Connections

At the rear, 2 pin power switches, 3 RS485 pin switches and 2 pin analog power input switches.

Technical specication

Operating temperature:	0-50°C
Operating humidity:	5 to 95% RH
Input type:	Programmable analog input current range 4 to 20mA,
	0 to 20mA, -20 to 20mA, 1 to 10mA, 0 to 10mA,
	-10 to 10mA, 0 to 5mA, -5 to 5mA
Power supply:	9-32VDC
Consumption:	max 200mA

PIN LAYOUT:

IN		
PIN	**SIGNAL**	**DESCRIPTION**
I+	**I+**	**CURRENT INPUT**
I-	**I-**	**CURRENT OUTPUT**

RS485		
PIN	**SIGNAL**	**DESCRIPTION**
	RS485	
A	**A**	**RECEPTION/DELIVERY**
B	**B**	**RECEPTION/DELIVERY**
C	**C**	**COMMON POINT**

24V	
PIN	**DESCRIPTION**
V+	**+12V (24V)**
V-	**Gnd12V (Gnd24V)**

IMP-PHA

Movable hydraulic generator

Project description

The mobile hydraulic generator (IMP-PHA) is an IMP-Automation & Control System product intended for testing hydraulic equipment, as well as for testing hydraulic equipment in the eld. It consists of a metal trolley (110 x 80 [cm]) on which there is a sump tank - a metal tray for collecting any leaked oil during the hydraulic consumers' connection to the generator.
The sump tank has an oil tank, dimensions 70 x 60 x 50 [cm], electric motor 4 [kV], variable ow pump 0 ÷ 40 [L / min], and an electrical cabinet attached to the carrier on the trolley, Picture 1. The reservoir is internally protected with a special zinc powder that is resistant to oil, high temperatures, and mechanical shocks, Picture 2.

Picture 1. IMP-PHA – front view

Picture 2. A reservoir from the inside

The reservoir cover contains ller neck with cap, level gauge, thermometer, hydraulic block with preparation group (safety and relief valve), as well as control manifolds (NO6, NO10, …).

On the side of the reservoir, there are level glass, electric heater 370 [W], return lter, plug, and ball valve for oil discharge.

The variable ow pump allows meeting the needs of any hydraulic consumer (or more of them), in the range 0 ÷ 40 [L / min]. There is a possibility of increasing the ow by installing an electric motor twice the speed (2800 [min-1]).

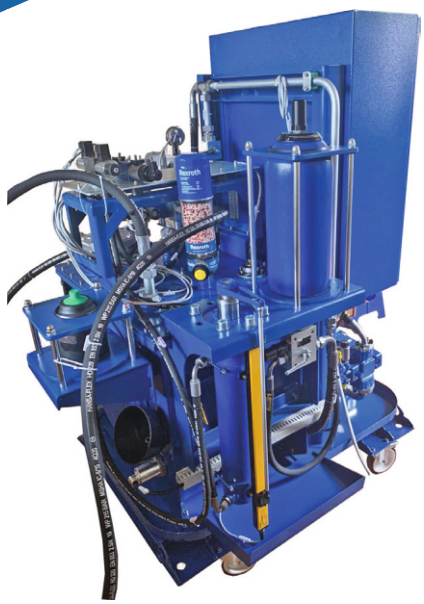
It is possible to maintain any pressure in the system, in the range of 20 ÷ 280 [bar]. An operator can manually set the value on the touch screen. This hydraulic generator can be easily pulled manually to any hydraulic consumer and provided with appropriate working sizes (p, Q, P).

In addition, it is possible to test individual devices correctness on the spot until the plant operation necessary conditions have been provided (e.g in the hydropower plant the supply line DN700 is not lled with water, L = 1600 [m]), and pressure transmitters can be tested using appropriate oil pressure generated by IMP-PHA, etc.).

If there are certain problems during the generator work - IMP-PHA is taken to the generator and connected at a certain place in the installation (directly to the actuator - servo motor, hydraulic motor, or distributor) and in a short time is found and removed plant failure.

The IMP-PHA is equipped with a mechanical safety valve that primarily protects the installation from overload. The installation is made with an ERMETO-sealing system, which withstands working pressure PN250 [bar]. On the IMP-PHA, there is also a hydraulic accumulator with a nominal volume of V0 = 6 [L], which provides a stable pressure in the system with minimal oscillations due to a sudden change in oil consumption in consumers.

Finally, it should be said that IMP-PHA is easy to use, adapted for work in the laboratory and the eld in all conditions, can monitor the system, as well as the ability to connect to another arbitrary volume reservoir.



Picture 3. IMP-PHA – side view

Information:

Poer supply:	3 x 380 [V] AC
Power:	Pn = 4 [kW]
Pressure:	Pn = 20 ÷ 280 [bar]
Flow:	QN = 0 ÷ 40 [L/min]
Volume:	VN = 145 [L]
Oil:	HV - 46
Filter:	3 [µm]
Weight:	400 [kg]
Dimensions:	L x W x H = 1.2 x 0.85 x 1.5 [m]

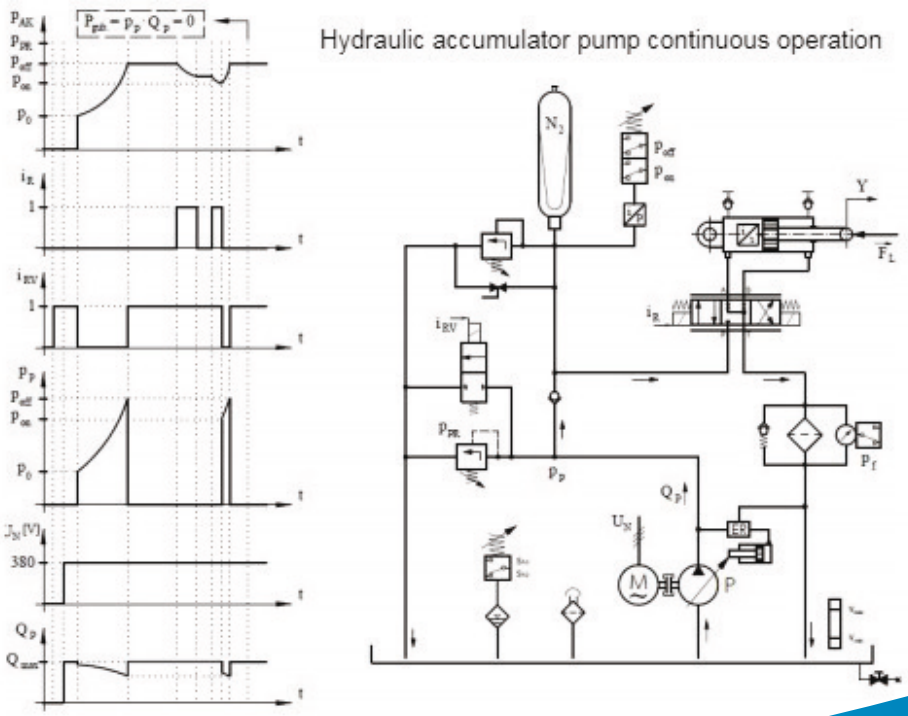
Electric drive

The IMP-PHA control cabinet contains compact components for power supply and power distribution, electricity, operation management, and supervision as well as mutual communication. A device for protection against inappropriate phase sequence is installed to prevent the pump from starting in the wrong direction.

The pump motor drive is protected by a motor protection switch of adjustable rated overload current 10 ÷ 16 [A], and a feedback signal from the contactor.

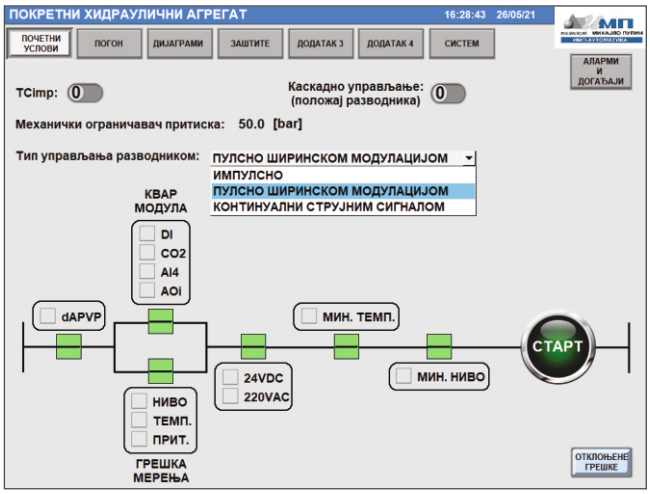
On the cabinet, in addition to the touch screen, for drive control and monitoring, there are 2 sockets for power supply to external consumers with 220 [V] AC and 2 LAN ports for communication with internal electronic components manufactured by the Institute "Mihajlo Pupin".

Picture 4. IMP-PHA - connection to TCimp block

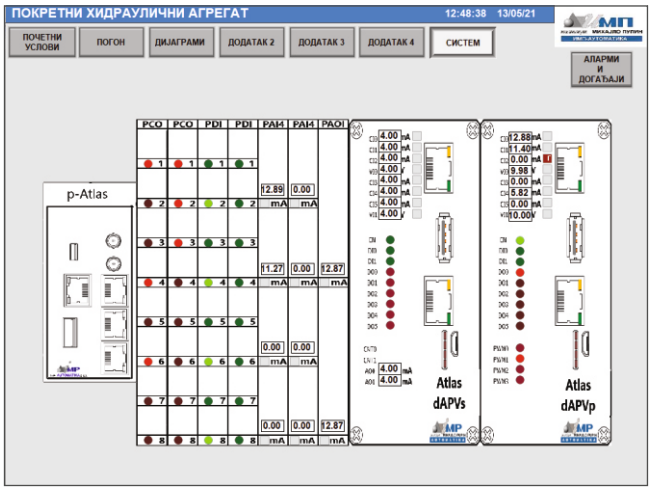


Picture 5. Hydraulic scheme with diagrams

Control and regulation system



Picture 6. Starting IMP-PHA initial conditions



Picture 7. PicoAtlas®-RTL, Atlas dAPV-s, and Atlas dAPV-p

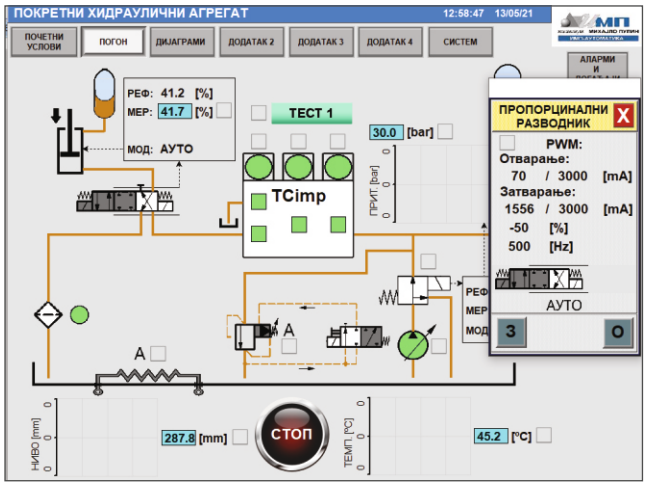
The system is based on picoAtlas®-RTL which consists of:

- CPU module,
- DI - digital input module,
- CO2 - digital output module,
- AI4 - analog input module, and
- AOi - analog output module.

The modules provide the signals:

- 16 digital input signals,
- 8 digital output signals,
- 8 analog input signals 0 ÷ 20 [mA], and
- 2 analog output signals 0 ÷ 20 [mA].

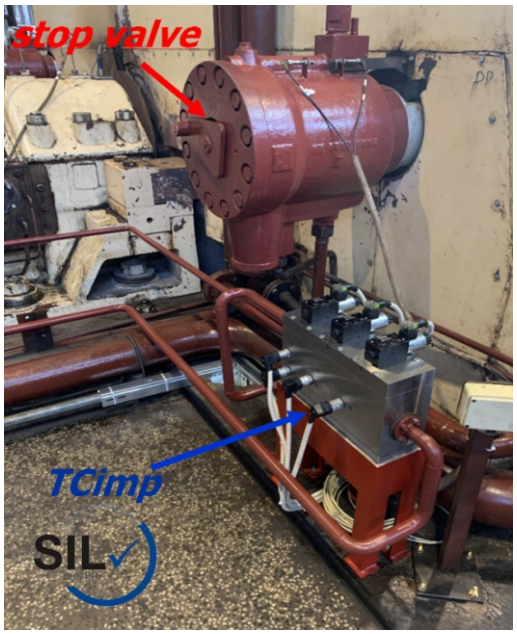
Also, the system includes digital automatic valve positioners Atlas dAPV-p and Atlas dAPV-s, whose main purpose is to control hydraulic servo drives via proportional or pulse distributors. Proportional distributors are controlled by a pulse width modulated signal (PWM outputs to dAPV-p in the frequency range 0 ÷ 1500 [Hz], with a maximum output current of 4 [A]) or a current signal (mA outputs to dAPV-s), while pulse distributors manage digital signals of a certain duration. The cascading management structure that closes the feedback at the position of the pilot valve and the hydraulic servo drive, enables the complex hydraulic systems control that is possible to see in hydro and thermal power plants. With this conguration, it is possible to manage 3 independent hydraulic servo drives at the same time.



Picture 8. Hydraulic scheme active display

In addition, the Atlas dAPV can perform part of the turbine regulator function on hydraulic and steam turbines; enables faster and more precise control of the executive hydraulic system. This device has 2 digital counting inputs with a maximum signal frequency of 10 [kHz], which are used to transmit the turbine speed signal. The Atlas dAPV device maintains (regulates) the oil pressure in the hydraulic system.

Device description



TCimp is an electro-hydraulic block that is applied in the steam, hydro and gas turbines protection systems, as well as in the process industry.

The protection function is based on the interruption of the oil flow and hydraulic drives closing in case two of the three protection channels are active - the "2 out of 3" principle. The oil cut-off channels are controlled via three solenoid two-position valves, which are wired to an electronic protection system. At the same time, when the oil supply is interrupted, the oil is drained from the hydraulic drives towards the oil tank.

In case of the protection activation on only one of the three channels or due to a measurement error or due to failure of a part of the protection block, the alarm is activated, but the oil flow to the hydraulic drives is not interrupted (the turbine or the process remains in operation). Channel condition monitoring is performed via four pressure switches that are mounted on the protective block and wired to the regulation and/or monitoring system.

According to the API-670 standard, periodic testing of all components in the protective circuit of rotary machines (except the final drive) is required, without affecting its operation. The TCimp electro-hydraulic block is designed on the principle of "2 out of 3" so that it is possible to check the disconnection of only one channel, without affecting the other two, which does not interfere with the machine operating. In the electronic part of the protection system, the automatic channel test function is implemented, which is periodically activated every 24 hours in normal operation, without any disturbances in the operating of the turbo unit.

Tcimp electro-hydraulic block is certified according to the requirements of the IEC 61508 standard and can be applied in systems where SIL3 level of functional safety is required (DEKRA Certificate No. ZP/C002/22, 3. 3. 2022).

By virtue of the "2 out of 3" principle, it has been achieved a high level of reliability, together with the compliance with industry standards API-670, API-612 and API-611.

The application of the TCimp block diagram in the steam turbine protection circuit is shown in the Figure 1.

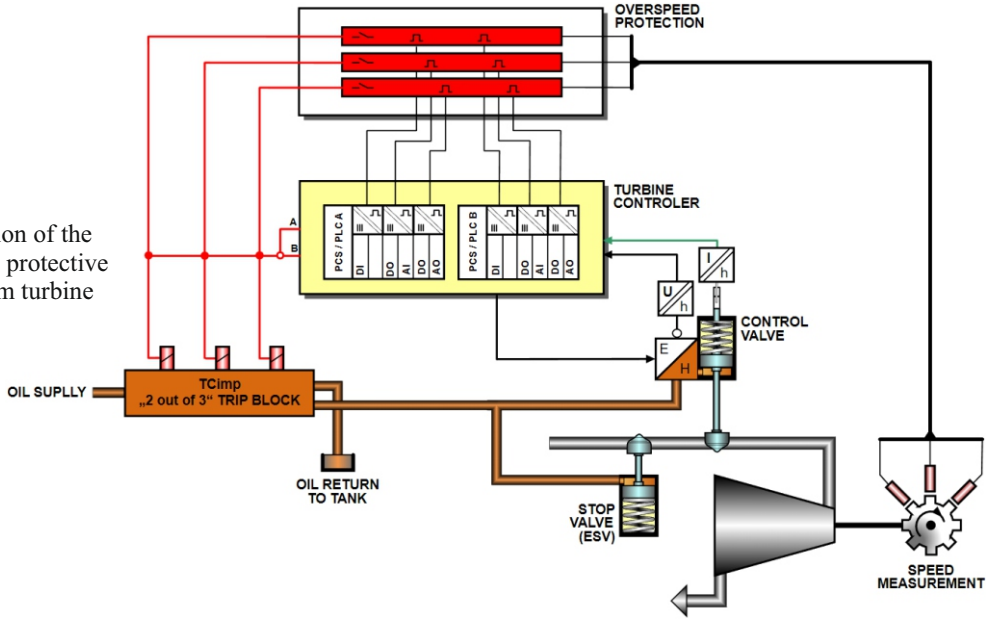


Figure 1 - Application of the TCimp block in the protective and regulatory steam turbine system

Technical characteristics

Performance
· "2 out of 3" protection function
· Three solenoid valves cut off the feed oil supply and drain the system in the case of a power failure on "2 out of 3" channels
· The solenoid distributor response time from 0.05s to 0.1s
· The protective function action detection on 3 protective channels is carried out via 4 pressure switches
· The safety function is realized by an internal spring on each individual solenoid distributor
· Functional safety level SIL3
· Average failure probability PFD_{AVG} 1,54 x 10^{-4}

Hydraulic characteristics
· Working pressure [1.50] bar
· Maximum flow 720 l/min at 10 bar differential pressure (Figure 2)
· Oil temperature [30, 60] °C
· Oil type: hydraulic oils ISO 6743/4 (L-HV), DIN 51524/3-HVLP
· Recommended oil purity 20/18/15 according to ISO 4406
· Viscosity ISO VG32, ..., ISO Vg46 according to DIN 51519
· Diameter of the inlet and drainage (into the tank) of oil connection Dn25
· Diameter of oil connection according to hydraulic drives DN20

Electrical characteristics
· Supply voltage 24 VDC
· Consumption of one solenoid distributor 1.29A (31W) out of a total (3) distributors
· Maximum allowed current through the pressure switch contacts 4A (96W)
· The electrical connection diagram is shown on the Figure 3

Ambient characteristics
· Ambient temperature [-25, 60] °C
· Ingress protection IP65
· ATEX II 2G Ex IIC T4 Gb on request

Physical characteristics
· External dimensions (length x width x height) 380 mm x 223 mm x 309 mm
· Package dimensions (length x width x height) 470 mm x 250 mm x 340 mm
· Mass net 92 kg, gross 96 kg

Technical data for ordering:
• working oil pressure _____ [bar]
• maximum flow _____ [l/min]

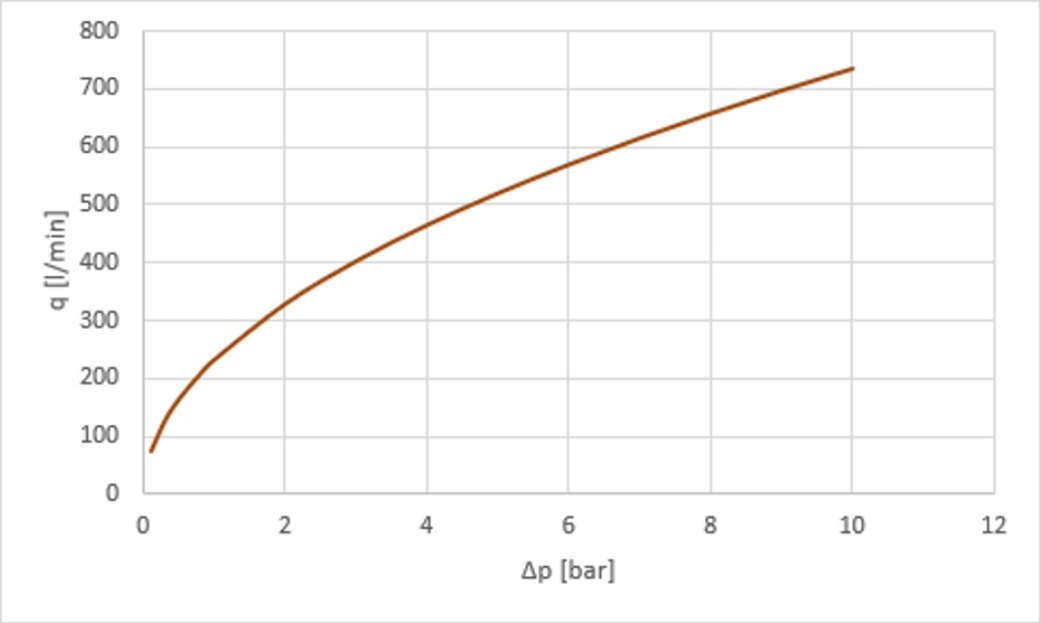


Figure 2 - PQ characteristic of the TCimp protection block

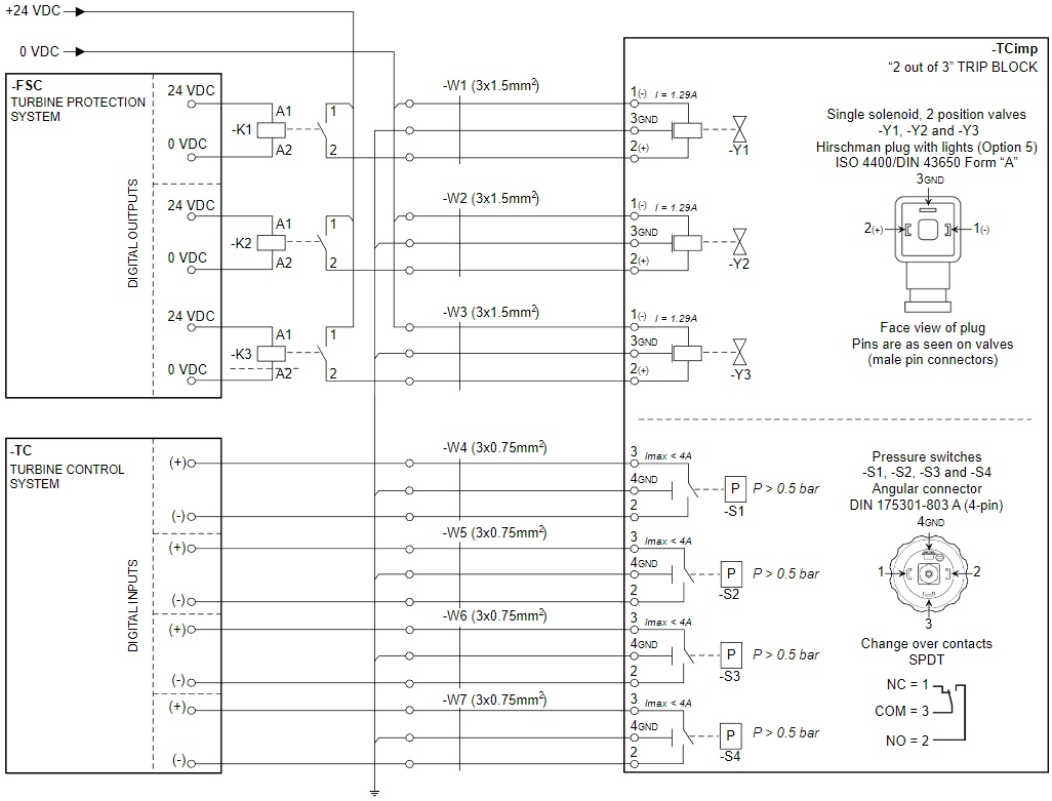
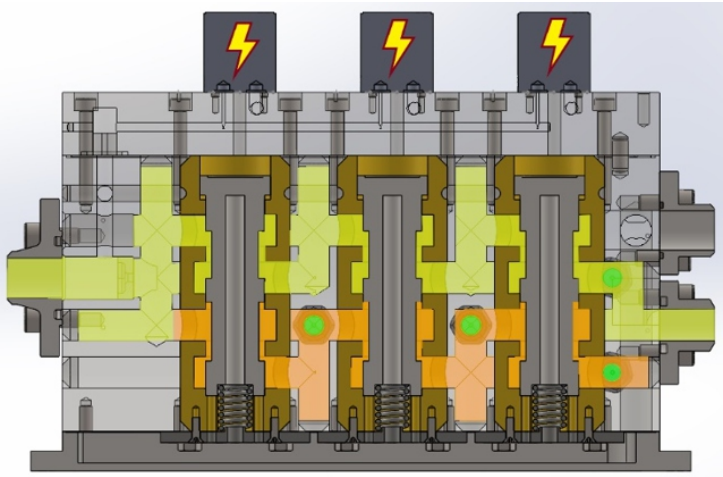
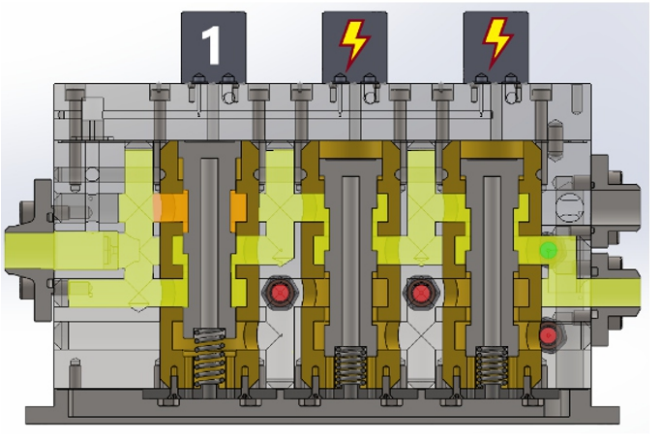


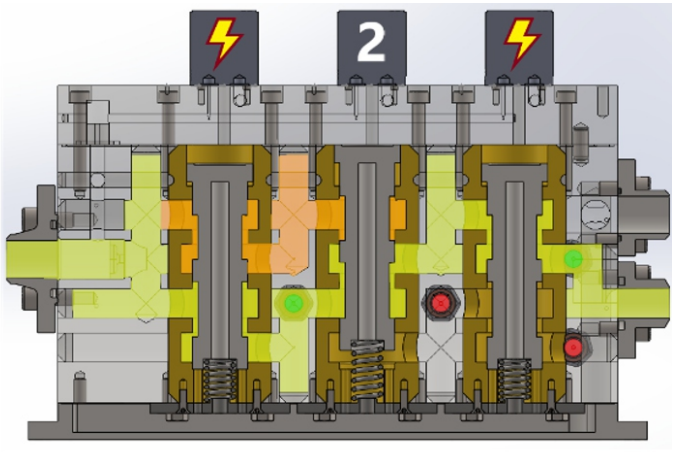
Figure 3 - Electrical wiring diagram of the TCimp protection block

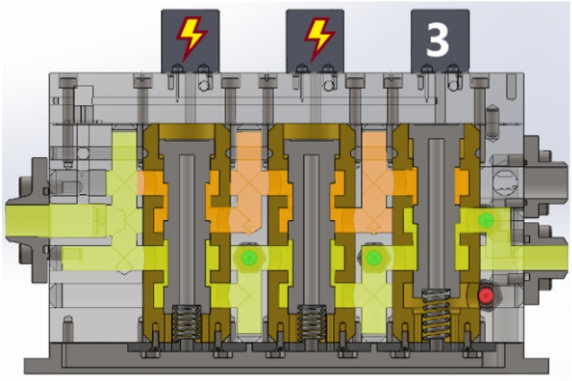
Working principle

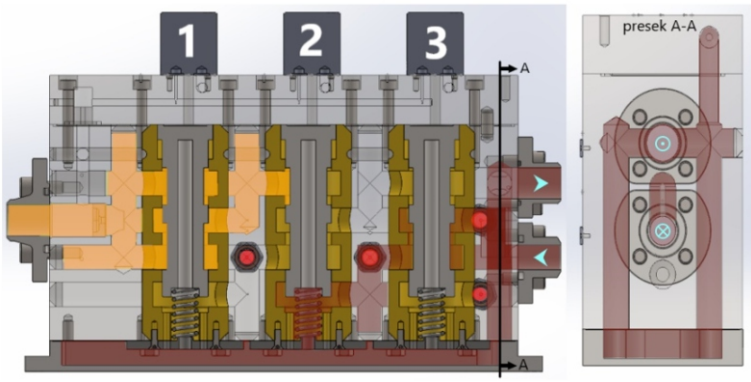


Display of oil flow when there are aroused (label ⚡) certain solenoid hydraulic distributors: 3 aroused, 2 awake and all awake.









Testing

IMP conducts a variety of tests throughout the development process, during and after the production. Tests provide calculation data (eg. number of test cycles in the endurance test), showing machine characteristics (eg. reaction time), ensure production quality (eg. input inspection, dimensional testing, non-destructive testing, leak test and functional test). Figure 4 shows the test settings for the TCimp block.

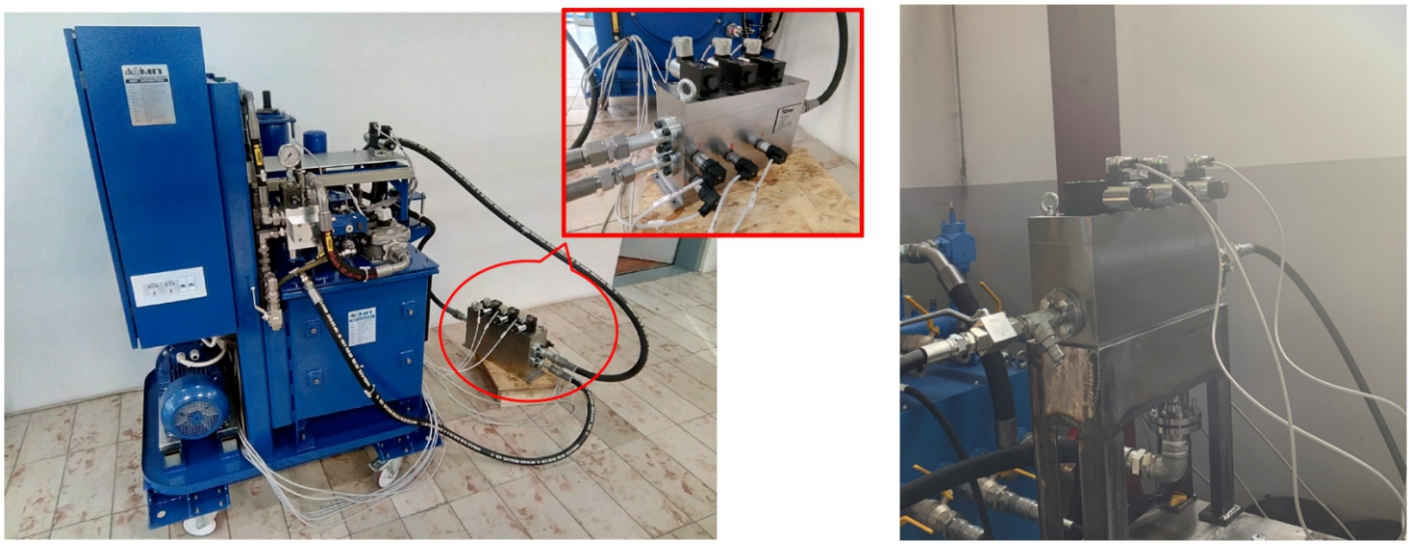
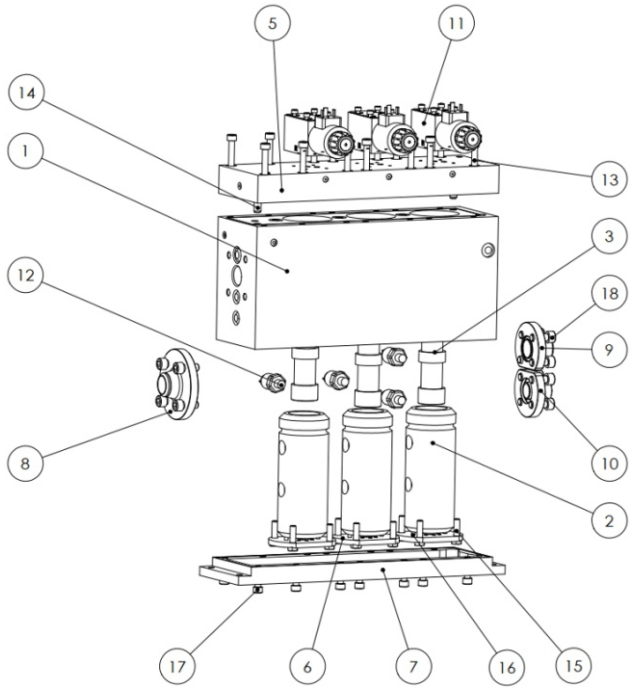


Figure 4 - Test settings for the TCimp block

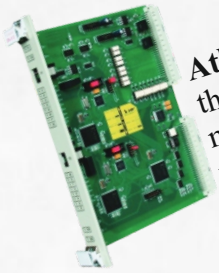
Assembly drawing

Tcimp parts list:

Housing (with chokes)	- pos. 1 - 1 piece
Piston sleeve	- pos. 2 - 3 pieces
Clip	- pos. 3 - 3 pieces
Spring	- pos. 4 - 3 pieces
Housing cover (with chokes)	- pos. 5 - 1 piece
The bottom of the piston sleeve	- pos. 6 - 3 pieces
The bottom of the housing	- pos. 7 - 1 piece
Inlet flange	- pos. 8 - 1 piece
Drainage flange	- pos. 9 - 1 piece
Outlet flange	- pos. 10 - 1 piece
Parker solenoid valve	- pos. 11 - 3 pieces
Wika pressure switch	- pos. 12 - 4 pieces
Screw M8 DIN 912	- pos. 13 - 14 pieces
Centering pin DIN EN ISO 8735	- pos. 14 - 2 pieces
Screw M8 DIN EN 24015	- pos. 15 - 12 pieces
Screw M5 DIN EN ISO 7046-1	- pos. 16 - 6 pieces
Screw M8 DIN 912	- pos. 17 - 14 pieces
Screw M10 DIN 912	- pos. 18 - 12 pieces



Turbine control system components and ARS TSControl-Atlas protection

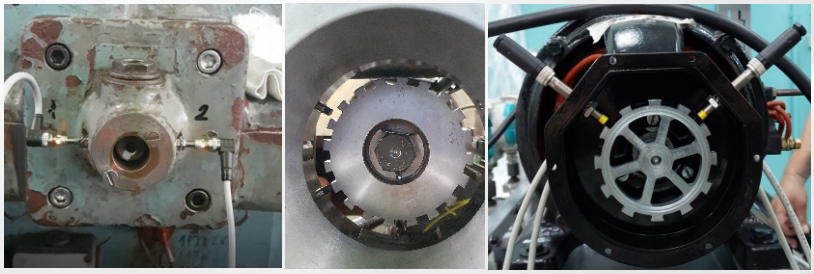


Atlas BPC/BOP
the turbine speed measurement/overspeed protection module

Atlas dAPV-p
digital automatic hydraulic positioner servo-motor

IMP-PHA
movable hydraulic generator

Atlas BVM8
module for vibromonitoring and rotary machine protection



Turbine speed measurement systems

ARS TSControl-Atlas
Steam turbine regulation and protection system of the Institute Mihajlo Pupin - Automation & Control System