TURBINE REGULATOR

I. TURBINE CONTROL SYSTEM

Turbine Control System consist of:

1.1 Protection System(provides emergency tripping functions and protection to the turbine)

- Speed measurements fail and speed sensors failed protection(two out of three speed input selection)
- MW measurement protection before synchronization
- 103% over speed protection (105% while synchronization)
- 109% over speed protection
- Pumps failed protection
- Governers not ready (HPCV&MPCV contingency) protection
- Low control oil pressure(oil pressure to safety valves) protection
- Operator pushbutton protection
- Protective action on External protections

1.2 Operator Auto and Manual System (includes all the features and functions of Local Control Mode)

- Remote latching of the turbine
- Speed feedback loop
- Operator adjustable speed demand
- Operator adjustable speed rate
- Over speed test capability (electrical, mechanical)
- Automatic synchronizer interface
- Minimum load pickup on breaker closure(Initial MW pickup)
- Valve open loop – direct valve position control
- Operator adjustable valve position demand
- Operator adjustable valve position rate
- Throttle pressure loop
- Operator adjustable throttle pressure demand
- Operator adjustable throttle pressure rate
- MW loop
- Operator adjustable MW demand
- Operator adjustable MW rate

- Primary control (Frequency MW correction)
- Bump less transfer from auto to manual
- Operator manual control

LDC controling Turbine Control System)

- Remote MW load control(MW demand from LDC)
- Remote Throttle Pressure control(TP set point from LDC)
- **Remote Auto System(includes all the features and functions of Remote Control Mode)**

3 Remote Auto System(includes all the features and functions of Remote Control Mode) i.e.

LDC controling Turbine Control System)

- Remote MW load control(MW demand from LDC)
- Remote Throttle Pressure control(TP set point from LDC)

II. TURBINE CONTROL SYSTEM DESCRIPTION

CONTENTS

A TURBINE CONTROL FUNCTIONAL DESCRIPTION

TABLE OF CONTENTS

ENERGOINVEST KIBERNETIKA BEOGRAD
Turbine Controller at TPP UGLJEVIK 300 MW
Basic design

1. GENERAL

The Turbine Control System executes improved turbine speed and load control by setting position of the turbine control valves. The Turbine Control System also controls live steam pressure in the boiler. Besides, the Turbine Control System provides emergency tripping functions and protection to the turbine.

The Turbine Controller maintains low reheat pressure set point by closing the BP dump valves to desired position before synchronization. The low reheat pressure set point is

selected automatically and is used until the turbine is synchronized. The Controller maintains relationship between position of the MP control valves and BP dump valves during load change.
The Turbine Controller operates basically in automatic mode. The manuel mode is for maintenance only. In the automatic mode while on load control the operator allows the LDC (Load Demand Computer) to control the load or the throttle pressure set point. All modes are switched bumbles because of tracking actual value by the system.

2. TURBINE CONTROLLER

The Turbine Controller operates in Remote Control Mode(ref. to point 2.3) or Local Control Mode.In Local Control Mode there are the Operator Automatic Control Mode and Manual Control Mode(ref. to point 2.4).

In Operator Automatic Control Mode the operator can enter a speed, load, or throttle pressure target along with a rate, this allows the controller to institute a desired ramp. The controller includes logic to verify that the target and its rate entered by operator are valid values. In addition, the system automatically verifies that the speed targets are not within any known blade resonance ranges. If the operator entered target or rate is false, the controller will reject these targets and hold speed or load until valid settings are provided.

There are three feedback loops in the automatic mode available for control: speed, megawatts and throttle pressure, and several protective features built into the Turbine Control auto operation system.

2.1. Protective Functions

The controller monitors TG unit speed by using two-of-three logic based on inputs from magnetic speed pickup sensors.
Failure of two from three speed channels before synchronization will cause the Speed Loop failure (the Speed Loop off) and a turbine trip. Failure of three speed channels after synchronization will cause a turbine trip.

The selected speed is used not only for speed control and primary control (frequency MW correction) but also for 103% over speed protection (105% while synchronization.).
If the TG unit is on Speed Control and the speed ever goes above 103% the over speed protection logic will clear the outputs of the HP and MP valve control cards; the valves will close instantly . The over speed protection logic is operational regardless of operating mode (Auto or Manual).

This logic can be defeated by means of ,, RUN TEST,, puschbutton on the Manuel ponel graphics and the operator can disable the 103% over speed protection to test the electrical and hidro-mechanical over speed trip function (this is done to allow increasing speed of the TG unit to test both the electrical and/or mechanical over speed trip function) or to test over speed protection action directly(the system will request the HP and MP control valves to close regardless of turbine speed).
The test function is only operational before synchronization.When is disabled the 103% over speed protection (,,RUN TEST,, puschbutton is selected), the electrical over speed trip function test is switch on automatically, HPSV, MPSV, HPCV and MPCV will close instantly. The operator can selected from the graphics (,,MECHANICAL,, puschbutton) the mechanical over speed test.The electrical over speed set point is changed from the normal 109% to 112%.
The operator can re-enable the electrical over speed trip set point (,, STOP,, puschbutton is selected). The electrical set point will also return to the normal set point anytime the TG unit trips or automatically five minutes after it was disabled.The time-based function is to prevent the operator from leaving the electrical over speed feature locked out.
Also, the operator can switch off the mechanical over speed trip function test and switch on the electrical over speed trip function test (,,ELECTRICAL,, puschbutton iz selected)
Also, the selected speed is used for 109% over speed protection (the electrical over speed set point is 109%)
Into the Turbine Control outo operation system are built also, several protective functions(emergency tripping functions):

- Pumps failed protection
- Governers not ready (HPCV& MPCV contingency) protection
- Low control oil pressure (oil pressure to safety valves) protection
- Operator pushbutton protection and
- Protective action on External protections

2.2 Automatic Mode Feedback Loops

In the normal operator automatic mode the controller will raise and lower the control valves in response to a change of the set point by the operator. The set point value is calculated as expected percent of flow that is needed to achieve the target entered by operator. The controller will open or close the valves at the selected rate to the value, where it believes, this set point should be reached. Due to changes of turbine throttle pressure or pressure in the condenser, the actual load may not match the requested set point. This is defined as Open-Loop Automatic Control.

The operator has an option of placing in or out of service three types of feedback loops. That will help in fine-tuning the TG unit output to match the desired operator entered target.

Speed Feedback Loop must be in service whenever the TG unit is on speed control in the automatic mode.(the turbine latched & auto). If the Speed Loop is to be placed in service, the operator has to select

it from the control graphic. The speed inputs have to be valid and the Throttle Pressure Loop and the Open Loop off (out of service).

Megawatt Feedback Loop uses the measured unit load and compares it to the requested set point. It will modulate the control valve position as needed to maintain this set point regardless of the turbine throttle pressure and pressure in the condenser.
This is very slowly responding loop since the megawatt time constants are normally very large. The Megawatt Loop can be placed in service any time the TG unit is on Load Control in operator automatic mode.
The loop will be rejected, if the operator takes it out of service or the megawatt inputs fail.
It is possible to operate turbine both with the Megawatt Loop and the Primary Control at the same time to pravide the frequency deviation compensation by reasing and lowering the control valve set point.
Throttle Pressure Feedback Loop uses the measured throttle pressure and compares it to the set point entered by the operator. The operator can then ramp the throttle pressure from its current value to the desired set point at an entered rate. The selection of Throttle Pressure Feedback Loop can be done when all other feedback loops are taken out of service.

2.3 Remote Control (LDC controling Turbine Control System)

There are two modes of Remote Control:

- Remote MW Load Control and
- Remote Throttle Pressure Control

2.3.1 Remote MW Load Control Mode

When LDC (Load Demand Computer) is in auto mode, the turbine is synchronized, engaged LDC loop (engaged MW loop of Turbine Controller), LDC demand has good quality and LDC tracks MW(MW demand from LDS is equal with MW reference demand from MW loop of Turbine Controller) LDC controling TCS automatically(Remote MW Load Control).
The remote MW demand will adjust the MW set point up and down to change the actual MW while the MW target from MW loop tracks the MW target and MW set point. So that transfer is bumbles. Once in Remote MW Load Control, the operator puschbuttons ,,GO,, and , ,,HOLD,, will not be operable.
The operator can switch on or switch off the Remote MW Load Control from the control graphic.

2.3.2 Remote Throttle Pressure Control Mode

When LDC is in auto mode and the turbine is synchronized or the operator is switch on the Remote Control Mode, the Throtte Pressure loop is in operation (LDC mode is TF) and TP set point from LDC has good quality, TCS is in Remote Throttle Pressure Control Mode.
The TCS target will remain fixed at the value entered by the operator and TP set point will be adjusted by the remote bias signal of up to 70 kPa. The operator will be able to observe the amount of remote bias by looking at the difference bet ween the set point and the target. The actual throttle pressure wil transfer into the target and set point upon exsiting Remote TP Pressure Control Mode.
So that transfer is bumbles. Once in Remote TP Pressure Control, the operator puschbuttons ,,GO,, and ,,HOLD,, will not be operable .
The operator can switch on or switch off the Remote TP Pressure Control from the control graphich.

2.4 Manual Control

In this mode the operator directly controls the valve demand signal and the rate by the increase and decrease pulses on the graphic. In result the system controls the TG unit speed, MW load, or throttle pressure ramp rate. The controller will accept the operator valve demand set point and maintain the position relationship between the HP and MP control valves.

The operator can select Manual Control at any time by poking the " Manual" field on the manual panel graphics.

3. CONTROLLER SYSTEM DESCRIPTION

3.1 Controller

System is based on the Allen-Bradley 1756-L61 ControlLogix controller. It is a scalable controller solution that is capable of addressing a large amount of I/O points. Controller is placed in the backplane chassis powered by 1756-PA75 power supply. The backplane is able to serve up to eight independent modules.

Due to critical process structure and to ensure uninterrupted control operation as well as high reliability are used two base chassis with 1756-RM redundancy modules connected to separate backplanes. Redundancy modules are connected by high speed optical cable to ensure fast switching between "Active" and "Standby" controller in case of any failure.

The I/O modules are placed on three separate backplane chassis powered by the same power supply as controller chassis. Basically there are used five different types of I/O modules.

There are used ControlNet 1756-CN2 modules for communication among controllers and I/O modules.

The controller structure is shown on the Figure 1.

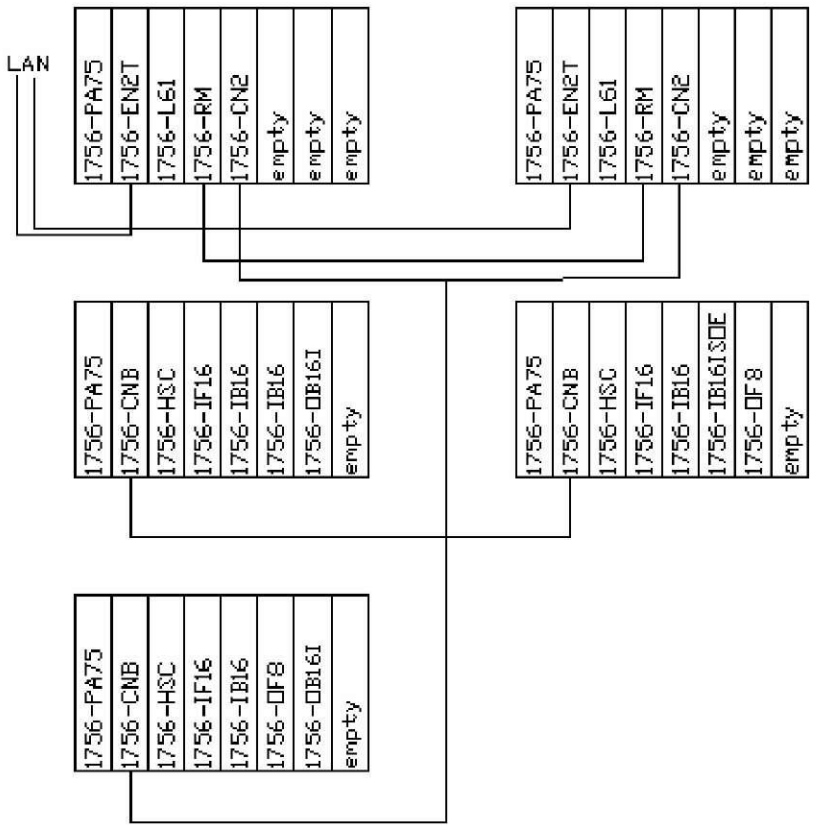

Figure 1. Controller structure Diagram

3.2 Valve positioner system

The valve positioner system is based on MOOG M3000 automation system. The system is consists of
programmable controller (Moog Servo Controller - MSC), software (Mood Axis Control Software -
MACS) and components (servomotors, servo-drives, servo-valves, etc.)

Moog Servo Controller MSC

MSC is freely programmable multi-axis controller with IEC 61131 development environment. It is
designed to realization of fast and precise controls, suitable for electrical and hydraulic drives. Controller
structures are definable with cycle times from 400 ^s.

Figure 2. The Moog Servo Controller PLC

Module data	**MSC controller**
Assembly	Plug-in terminal strips for screwing or clamping
Temperature range	+5 °C to 55 °C
Processor	PowerPC Processor
Memory	32 bit, RISC architecture with floating point unit 2MB burst RAM 4,5MB burst Flash EEPROM
Interfaces	
Ethernet(10BaseT)	10 Mbit/s; 8-pled RJ45 connection

2 independent CAN interfaces	10 kBit/s to 1 Mbit/s (adjustable)
>>WCAN<<	WideCan: 2 Sub-D >>WCAN<< connectors
LocalCAN	LocalCAN: in the side E-bus socket
>>MACS<< on front cover	Communication with the MACS software on the PC
>>SIO<< on front cover	For free use in the application program
Extension bus (E-bus)	Connectors on right and left of module for connecting up to 7 additional M3000 modules.
Digital inputs/outputs	
Voltage supply of the digital I/O	24 V DC (18-32 V DC) SELV pursuant to IEC 61131-2
Current consumption of the digital I/O	0,3 A in idling; all outputs active: 4 A
8 digital inputs and outputs	Individually configurable in MACS as input or output. Inputs: type 1 (current-consuming) pursuant to IEC 61131-2 Outputs: max. 0.5 A Sustained short-circuit protected
Watchdog output	Signalizes readiness for operation of the analog and digital outputs.
Analog Inputs/Outputs	
Voltage supply to analog I/O	Internal via a DC/DC converter
8 analog inputs	16 Bit; individually configurable in the MACS software as ±10 V, ±10 mA or 4-20 mA; overvoltage protection up to ±40 V
2 analog outputs	16 Bit; each ±10 V, additionally individually configurable in the MACS software as ±10 mA, ±50 mA or 4-20 mA Overvoltage protection up to ±40 V; sustained short-circuit protected

MOOG D633 servo control valves

The D633 is Direct Drive Valve (DDV) with electric closed spool position control. Valve is throttle valve for 3-, 4-, and 2x2-way applications. It is suitable for electrohydraulic position, velocity, pressure or force control systems including those with high dynamic response requirements.

The spool drive device is a permanent magnet linear force motor which can actively stroke the spool from its spring centered position in both directions. This is an advantage compared with proportional solenoids with one force direction only. The closed loop spool position electronics and pulse width modulated (PWM) drive electronics are integrated into the valve.

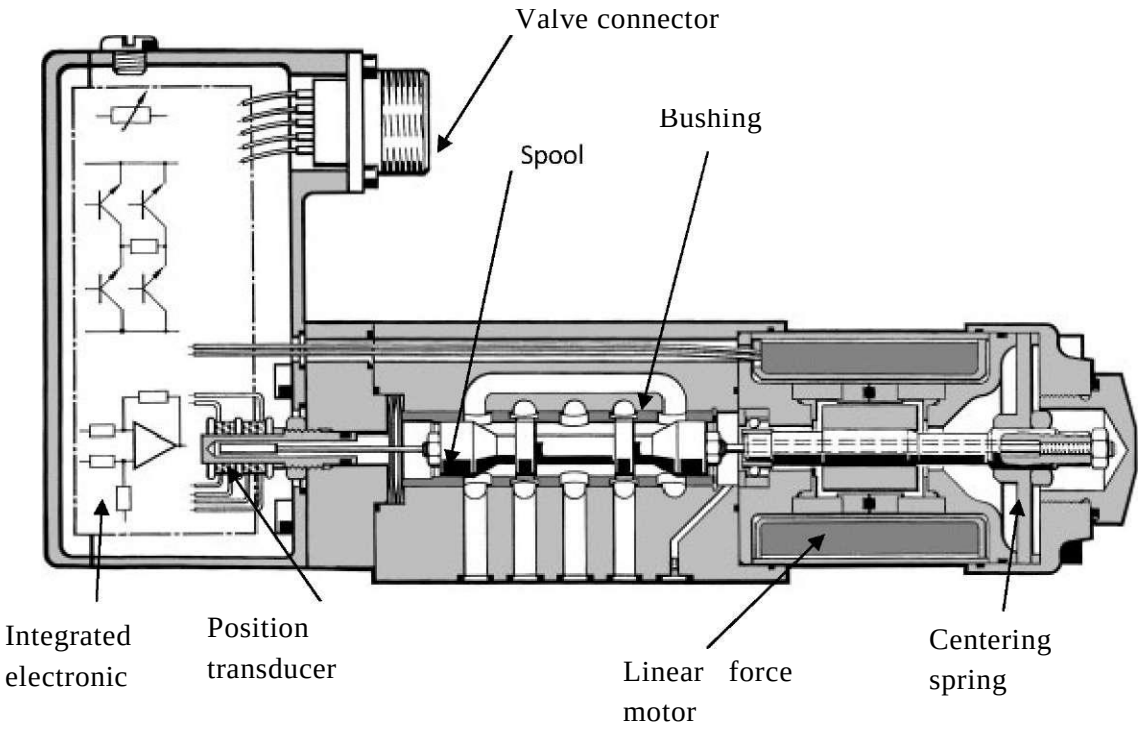

Figure 3. Servo Control Valve Schematics

Micropulse transducers

A whole valve positioner system is shown on the Figure 5.

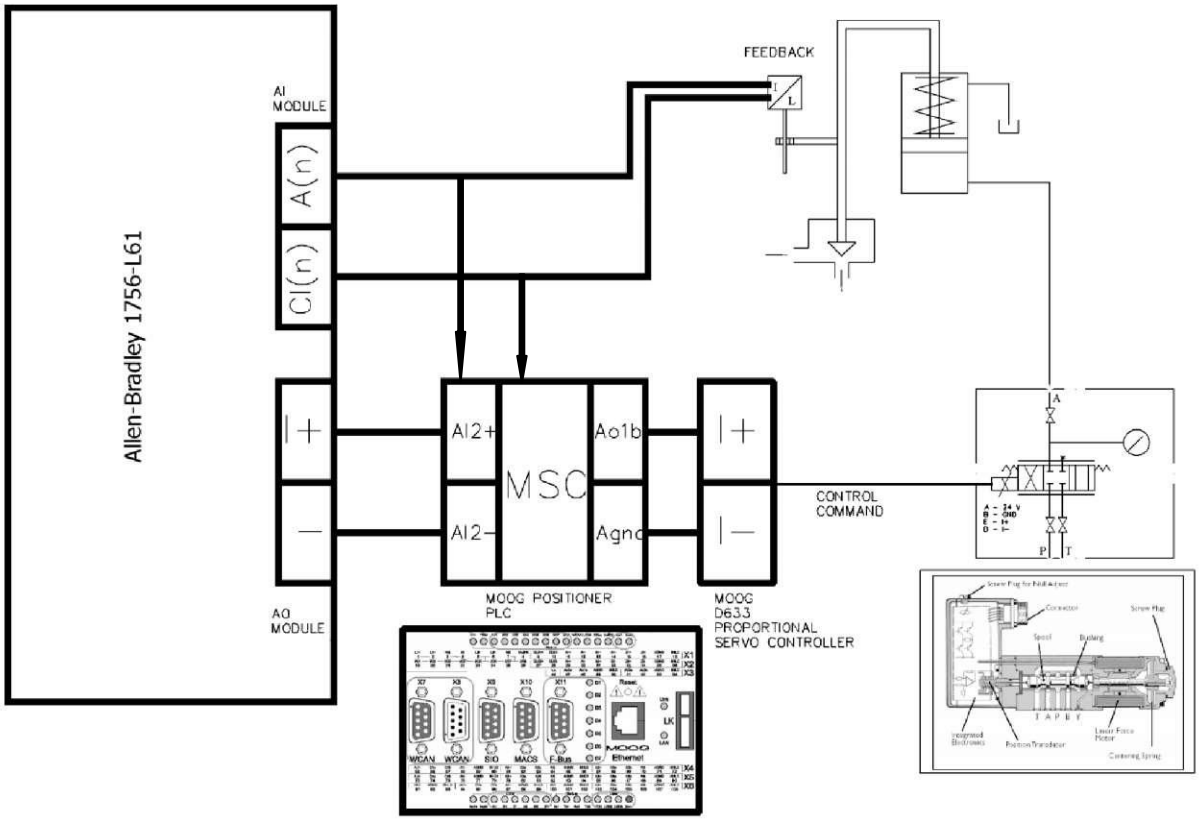

Figure 5. Positioning System Diagram

3.3 Turbine rotation speed sensors

The RPM Transducer PR 9376 is ideally suited for contactless measurement of rotational frequency of
ferromagnetic machinery components. Universal design, simple mounting and excellent characteristics
enable it to be used in a wide range of applications.

Due to high resolution, fast internal electronic and the sharp edged output pulses the PR 9376 is suitable for measurement of extremely high as well as very low rotational speeds with high resolution.

The head of PR 9376 is a differential sensor consisting of two magneto sensitive semiconductor resistors which are connected in series and mounted above a small permanent magnet. Two resistors of the
transducer- electronic part complete this configuration into a Wheatstone Bridge which controls a following DC-switching amplifier with fast push-pull short circuit proof output.

Specification:

- Principle measurement - Differential magnetic field sensor
- Triggering - Contactless by mechanical trigger marks
- Trigger frequency range - 0 . 20 kHz
- Output - Short circuit proof push-pull output stage
- Output pulse voltage - HIGH 10 V, LOW 1 V
- Pulse rise and fall time - < 1 ^s

Figure 6. Rotation Speed Sensors

3.4. Control Logic

It consists of 18 separate control

sheets. *S05_ TC_mjerenja:*

Related inputs - MW measurement, Pressure setpoint from LDC, throttle pressure (and signal quality), LDC output MW, control oil pressure (and signal quality)
Related outputs - active power > 30 MW, active power < 10 MW, active power, pressure setpoint value from LDC, throttle pressure, throttle pressure measurement failed, load setpoint value from LDC

S06_SPEED_MED_SEL_OVERSPEED_SETPOINTS:
Related inputs - turbine rotor rotation speed, speed measurement failed, valve position frequency limiter, mechanical over speed test
Related outputs - speed sensor manual request, turbine rotation speed, close cv protection setpoint, turbine over speeded, turbine speed in limits, over speed protection setpoint, mechanical turbine over speed, speed measurement failed

S08_ MUT_ control_logic:
Related inputs - turbine latched/not latched, IP stop valve opened/closed, HP stop valve opened/closed, open safety valves, external TG protection, close safety valves, MUT ready/opened/closed Related outputs - HP SV not opening/closing, IP SV not opening/closing, all safety valves are opened, MUT open/close command

S09_ TC_DUMP_ CV_LOGIC:
Related inputs - active power > 30 MW, generator synchronized, turbine latched/not latched, turbine over speeded, block speed protection over speed test, external TG protection, speed measurement failed
Related outputs - overload protection, over speed protection, HP valve PLW, IP valve PLW, bypass valve PRA, valve position frequency limiter

S10_ TC_ PROTECTIONS:
Related inputs - turbine valves contingency, external turbine protection, boiler protection, off turbine safety valves, mechanical turbine over speed, speed measurement failed, speed sensor manual request, generator synchronized, acknowledge turbine protection, TG trip reason
Related outputs - external TG protection, TG trip is active, open turbine solenoid command, TG trip reason

S11_ Turbine_latched_logic:
Related inputs - generator breaker on, control oil pressure to safety valves is OK
Related outputs - generator synchronized/not synchronized, turbine latched/not latched *S12_ OVER_SPEED_ TEST_LOGIC:*
Related inputs - on/off over speed test, generator synchronized, external TG protection Related outputs - block speed protection over speed test

S19_AUTO_SYNCHRONIZA TION_LOGIC:
Related inputs - on/off auto synchronization, turbine in manual control, generator synchronized, turbine speed > 2950 rpm, synchronization request more rpm, increase/decrease pushbutton for synchronization
Related outputs - auto synchronization on, auto synchronization is valid, synchronizer increase/decrease

S20_ TURBINE_MANUALAUTO_LOGIC
Related inputs - TP loop on/off, speed loop on, turbine in auto, turbine latched, HP/IP governor in manual, speed loop selected, turbine to manual, HP valves contingency, IP or LPBP valves contingency, mechanical turbine over speed, generator synchronized, turbine latched, manual reject HP/IP governor Related outputs - turbine in auto/manual, manual reject HP/IP governor, HP/IP valves in auto, initial MW pickup, turbine valves contingency, engage SP loop, engage LDC loop, engage MW loop, engage TP loop

S21_ OVE RSPE ED_SELE CTI ON_ L OGIC:
Related inputs - engage SP loop, generator synchronized, speed loop on, speed measurement failed, speed loop off, open loop on, block speed protection over speed test, mechanical turbine speed test, turbine not latched
Related outputs - speed loop selected, selected loop interlock, mechanical over speed test, mechanical and el. Over speed test is not active, electrical test turbine speed is not active, electrical test turbine speed

S22_SPEED_LOOP_SELECTION_LOGIC:
Related inputs - select SP setpoint, new speed demand is not valid, auto synchronization on, speed setpoint in resonance range, new speed rate out of limits, select SP rate, generator synchronized, speed controller is tracking valve position, generator synchronized, external TG protection, turbine not latched, speed delta > 50 rpm, turbine in manual control
Related outputs - new speed setpoint is not valid, new speed setpoint enabled, wrong speed rate selection, new speed rate enabled, speed SP is tracking

S23_SPEED_LOOP_SELECTION:
Related inputs - turbine speed > 3000 rpm, turbine in manual control, turbine speed in limits, hold over speed test, mechanical and electrical over speed test is not active, speed SP is tracking, speed demand is changing, select SP setpoint, speed loop selected, hold changes pushbutton, auto synchronization on, go to change, speed in resonance range, block speed protection over speed test, engage over speed test, over speed protection, turbine not latched, generator not synchronized Related outputs - speed controller is tracking valve position, hold changes, close valves

S24_MW_LOOP_LOGIC:
Related inputs - generator not synchronized, MW loop selected, MW controller is tracking valve position, MW delta in limits, hold changes pushbutton, select MW setpoint, go to change, boiler runback, turbine remote control

Related outputs - MW controller is tracking PV, hold MW

changes *S25_MW_LOOP_LOGIC:*

Related inputs - turbine in manual control, MW delta high limit active, generator not synchronized, MW loop selected, select MW setpoint, MW rate out of limits, select MW rate,
Related outputs - MW controller is tracking valve position, enter MW setpoint from keyboard, enter MW rate enabled

S26_REMOTE_LOOP_SELECTION:
Related inputs - LDC in auto mode, generator synchronized, remote control on/off, MW loop selected, engage LDC loop, open loop on, LDC MW output demand quality, LDC does not track LDC in BF, boiler follow mode, coordinate control - boiler follow mode, turbine remote control, MW loop on, TP loop selected, MW loop off, turbine follow mode, TP demand is not valid
Related outputs - turbine remote control, select MW loop interlock, MW loop on

S27_TP_RATE_SELECTION_LOGIC:
Related inputs - select TP rate, operator entered setpoint/TP rate in limits, select TP setpoint, TP loop selected, hold changes pushbutton, TP demand is changing, go to change, take nominal parameters, turbine remote control

Related outputs - new setpoint/TP rate enabled, TP controller is tracking PV, hold TP

changes *S28_LOOPS_SELECTION_LOGIC:*

Related inputs - TP loop off, turbine remote control, coordinate control boiler follow mode, engage MW loop, open loop on, engage LDC loop, LDC base mode, TP loop on, turbine follow mode, boiler runback, active power < 10 MW, boiler follow mode, throttle pressure measurement failed, MW loop on Related outputs - MW loop selected, TP loop selected, on TP loop entry rate selected, selected TP loop interlock

S29_ OPEN_LOOP_LOGIC:
Related inputs - on open loop, turbine speed rotation speed, generator synchronized, turbine in auto, speed loop selected, TP loop selected, turbine valves contingency, turbine over speeded, turbine not latched, MW loop on, turbine in manual control, turbine remote control, open loop on, go to change, select open loop interlock, hold changes pushbutton, open loop demand is

3.4 Load Loop

It is consists of 3 separate control sheets. The logic of this loop is used for turbine control when running in load loop.

S45_ M W_Loop_Setpoint_ Rate_ Mem ory:
Related inputs - initial MW setpoint, initial MW pickup, MW loop selected, MW loop on, turbine remote control, select MW rate, turbine remote control, runback limit, active power, MW controller is tracking PV, enter MW rate enabled, runback rate, TG runback load limit enabled, generator synchronized, hold MW changes
Related outputs - LDC does not track LDC in BF, MW demand in memory, MW rate out of limits, MW rate in memory, MW rate

S46_MW_Loop_Output:
Related inputs - MW rate, MW controller is tracking PV, MW demand in memory, initial pickup, frequency corrector, active power
Related outputs - MW reference demand, MW delta high limit active, MW delta in limits, MW loop delta

S47_MW_Loop_Demand:
Related inputs - throttle pressure, valve position setpoint, MW reference demand, active power, MW loop on, generator synchronized, MW loop selected, open loop on, MW controller is tracking valve position
Related outputs - initial MW setpoint, MW loop valve position demand

3.5 Pressure Loop

It is consists of 2 separate control sheets. The logic is used when turbine operates in

pressure loop. *S55_ TP_Setpoint_Rate_Memory:*
Related inputs - select TP setpoint/rate, take nominal parameters, new TP setpoint/rate enabled, pressure sepoint value from LDC, turbine remote control, boiler follow mode, TP controller is tracking PV, on TP loop entry rate selected, turbine remote control, hold TP changes
Related outputs - select TP setpoint, operator entered setpoint/rate is in limits, TP demand in memory, TP rate in memory, TP rate value

S56_ TP_Setpoint_ Calculation:
Related inputs - TP rate value, TP controller is tracking PV, engage TP loop, active power, throttle pressure, TP demand in memory, valves position setpoint, TP loop selected,
Related outputs - TP demand is changing, TP loop delta, TP loop valve position demand, TP reference

3,6 Speed Loop

It is consists of 5 separate control sheets. The loop is providing logic when turbine is operating in speed loop mode.

S30_RESONA N CE_ RANGES_CALCULA TING:
Related inputs - turbine speed rotation speed, speed reference, generator synchronized, speed, in resonance range

Related outputs - resonance range calculator output, speed in resonance range, resonance range

1 - 4 *S32_ FREQ UENCY_ CORECTION:*

Related inputs - turbine rotation speed, MW loop on, primary control ON/OFF pushbutton
Related outputs - frequency corrector, frequency corrector to LDC, turbine speed > 2970

S35_Speed_Setpoint_Rate_Memory:
Related inputs - synchronizer increase/decrease, mechanical over speed test is not active, electrical turbine speed is not active, new speed setpoint enabled, generator synchronized, speed SP is tracking, resonance range calculator output, select SP setpoint, select SP rate, new speed rate enabled, auto synchronization on, mechanical and electrical over speed test is not active, hold changes, Related outputs - speed rate in memory, speed loop rate, new speed rate out of limits, speed demand in memory, new speed demand is not valid, speed setpoint in resonance range, setpoint in resonance range 3

S36_Speed_Setpoint_calculation:
Related inputs - speed loop rate, speed in resonance range, speed SP is tracking, speed demand in memory, turbine rotation speed

Related outputs - speed demand is changing, speed delta > 50 rpm, SP loop delta, speed

reference *S37_Speed_Loop_Demand:*

Related inputs - throttle pressure, IP/HP governor in manual, speed controller is tracking valve position, turbine rotation speed, speed reference, valves position setpoint, close valves Related outputs - speed loop valve position demand

3.7 Valve Control

It is consists of 6 separate control sheets. The loop is providing logic for valve control.

S32_ LPBP_ Valves_ Control:
Related inputs - IP valves position setpoint
Related outputs - LPBP valves position setpoint

S60_Loop_Selection:

Related inputs - turbine valves contingency, turbine over speeded, valves position setpoint, open loop reference, speed loop valve position demand, speed loop selected, MW loop valve position demand, TP loop valve position demand, MW loop selected, TP loop selected, open loop on, turbine in auto, open loop rate in memory, go to change valve position, open loop on, valve position loop delta, valves position setpoints, open loop demand in memory, open loop reference

Related outputs - open loop demand in memory, open loop delta, open loop demand is changing, open loop reference, valve position loop delta, valve position demand

S61_ HP_IP_Valves_Output:

Related inputs - turbine latched/not latched, open loop on, turbine in manual control, TG trip is active, valve position demand, turbine rotation speed, block speed protection over speed test, valve position frequency limiter, valves position set point, IP valves to auto, manual reject IP governor, IP governor to auto/manual, HP valves to auto, manual reject HP governor, HP governor to auto/manual Related outputs - IP valves position setpoint, IP governor in manual, HP valves position setpoint, HP governor in manual, valves position setpoint, IP/HP mastation track

S62_ HP_Valves_Output:

Related inputs - HP valve #1 - 7 measurement # 1 - 2, HP valves position setpoint, Moog valve HP #1 - 7 ready, TP #1 - 2 HP valve #1 - 7 ready, MCS #1 - 2 ready

Related outputs - HP valve #1 - 7 selected position measurement, contingency HP valve #1 - 7, HP valve #1 - 7 setpoint and electrical error HP valve #1 - 7

S64_LPBP_ Valves_Output:

Related inputs - IP valve #1 - 2 position measurement #1 - 2, IP valves position setpoint, Moog valve IP #1 - 2 ready, TP #1 - 2 IP valve #1 - 2 ready, MSC #5 - 6 ready, LPBP valve #1 - 2 position measurement #1 -2, LPBP valves position setpoint, Moog valve BV #1 - 2 ready, TP #1 - 2 BV #1 - 2 ready Related outputs - IP valve #1 - 2 position measurement, contingency IP valve #1 - 2, IP valve #1 - 2 position, electrical error IP valve #1 - 2, LPBP valve #1 - 2 selected position measurement, contingency LPBP valve #1 - 2, LPBP valve #1 - 2 position setpoint, electrical error LPBP valve #1 - 2

S65_ Valves_ Contingency:

Related inputs - electrical error HP valve #1 - 7, electrical error IP valve #1 - 2, electrical error LPBP valve #1 - 2

Related outputs - HP valves contingency, IP or LPBP valves contingency

3.8 Operator interface

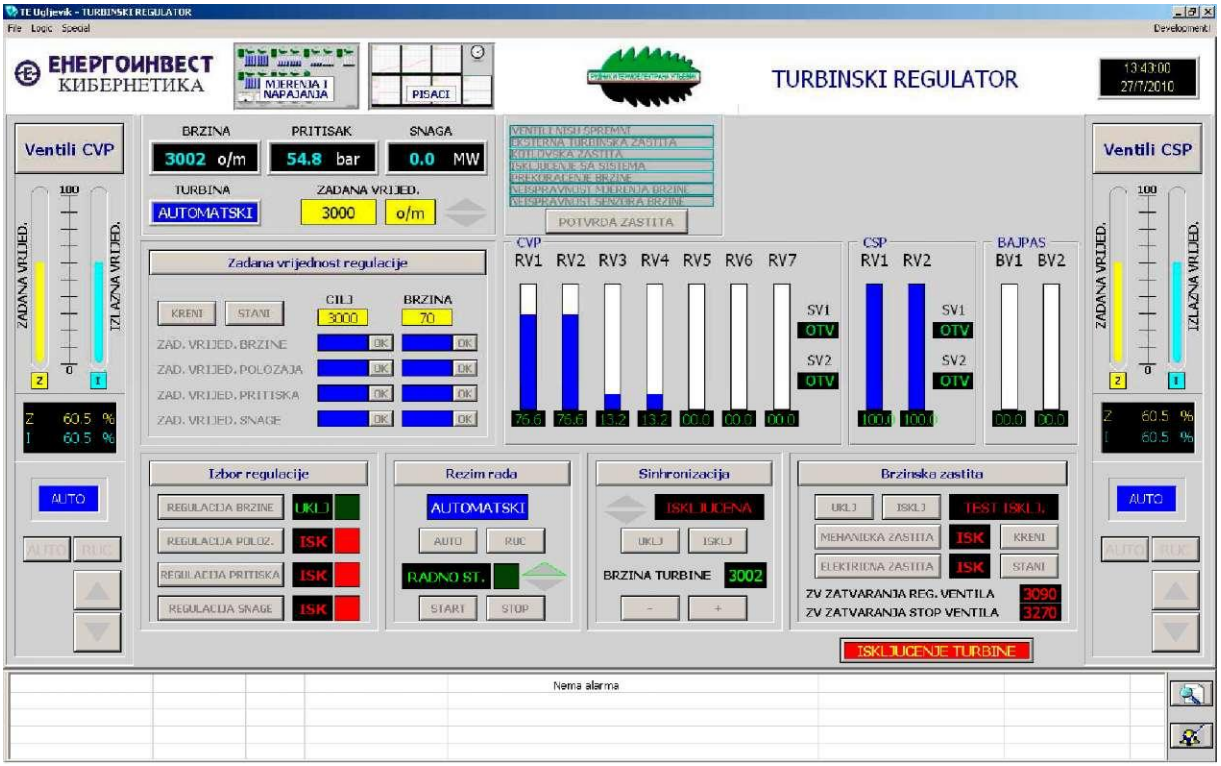

Figure 7. Main Graphic Window

The main operator graphic window is shown on the Figure 7. All important process information is visible on the main graphic.

The window is divided into 11 parts according to scope of control. Only one part can be managed at the same time.

3.8.1 Header

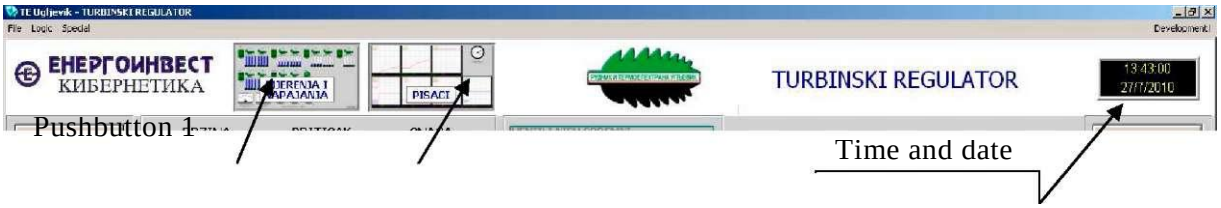

Figure 8. Header of Main Window

On the header part you can find two pushbuttons and one information area. The pushbutton 1 is opening new window „measuring and power supply" (Figure 99). The pushbutton 2 is opening new window „trends" (10). The information area contains time stamp information.

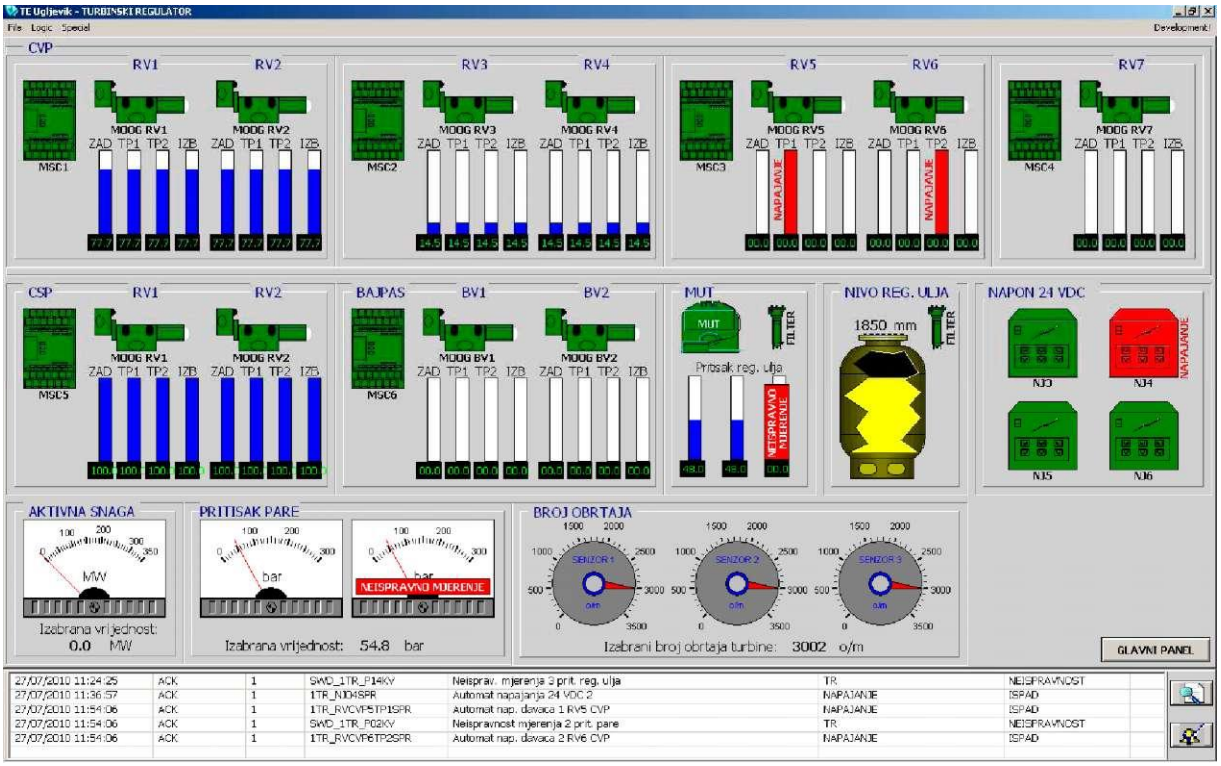

Figure 9. Measuring and Power Supply Window

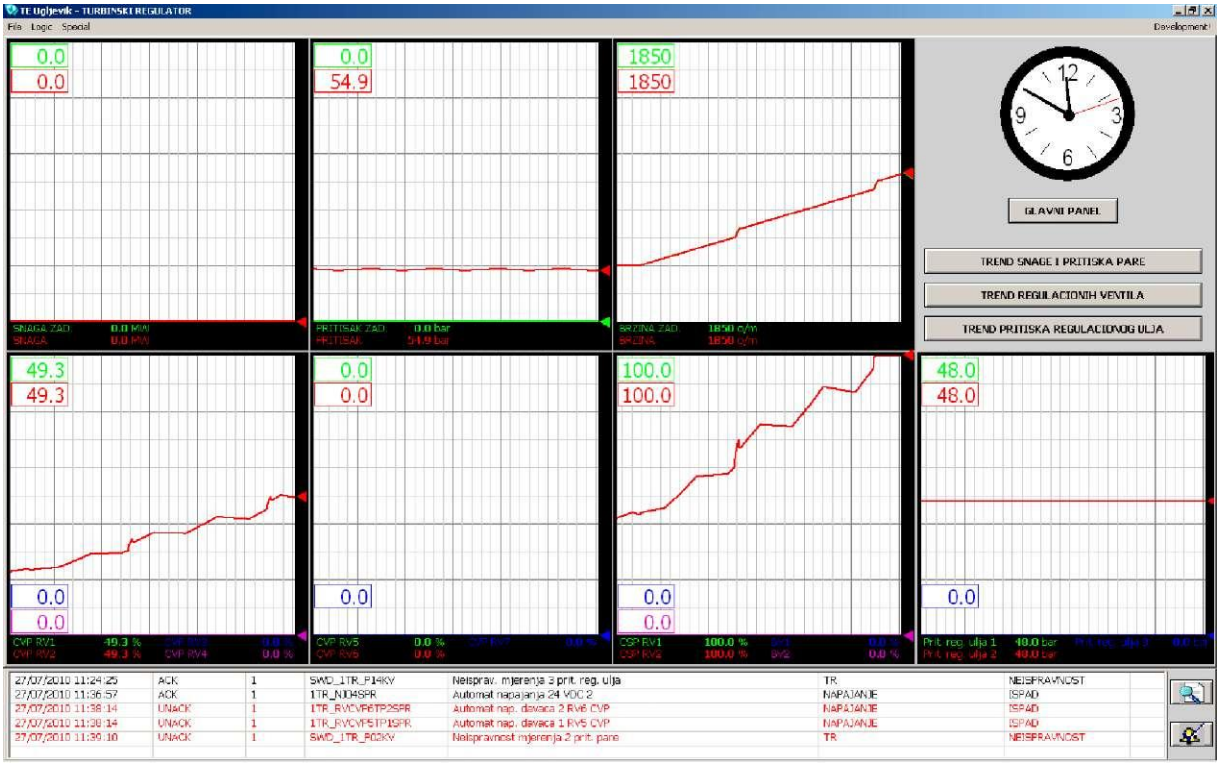

Figure 10. Trends Window

3.8.2 Measuring and power supply window

The graphic window is designed to provide online monitoring of:

- actual position of valves (HP, IP, BP, MUT) [%]
- valves setpoint [%]
- Moog valves position [%] (and power supply - red color means out of order)
- Oil pressure on MUT valve [bar]
- Oil filter state (red color means replace)
- Level of oil in tank [mm]
- power supply state (red color means out of order)
- Active power [MW]
- Steam pressure [bar]

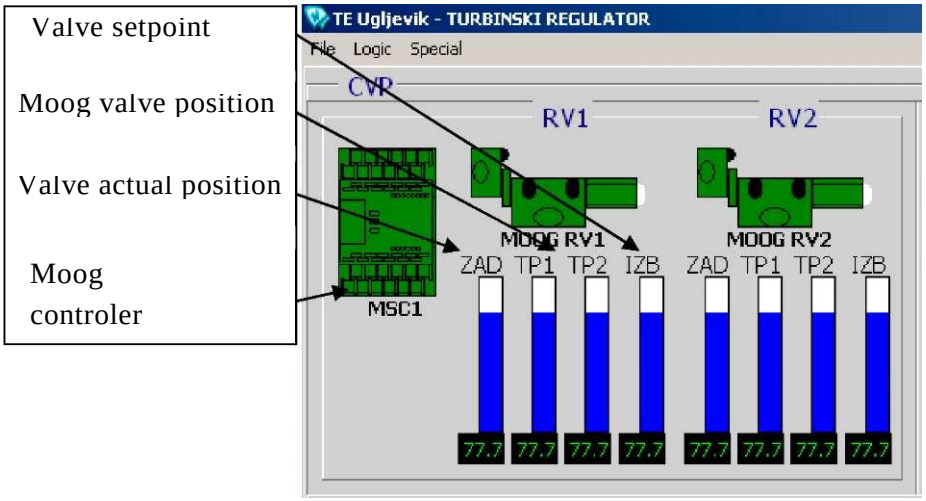

Figure 11. Valve Information

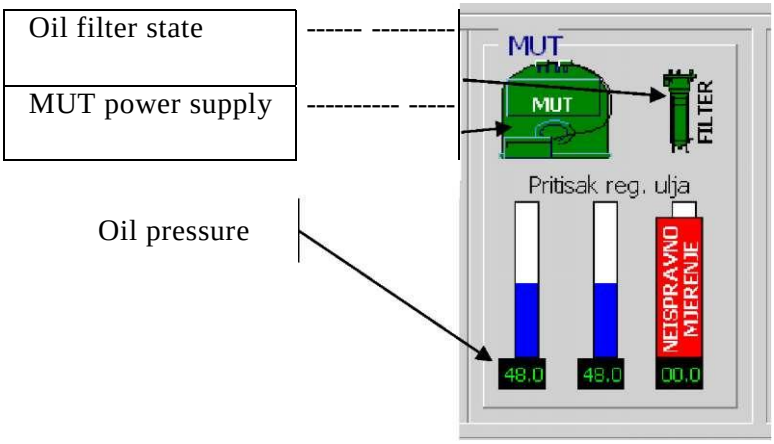

Figure 12. MUT Valve

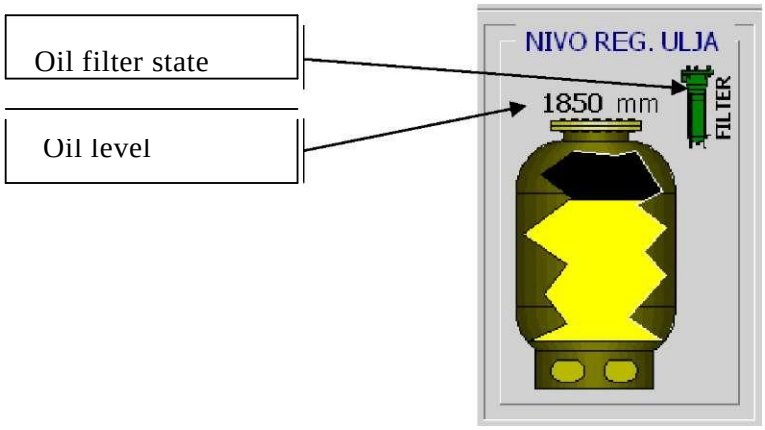

Figure 13. Oil Level

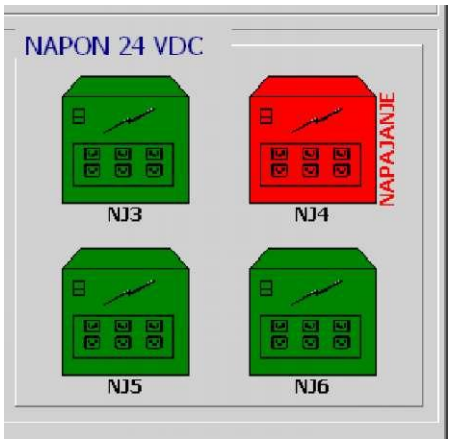

Figure 14. Power Supply State

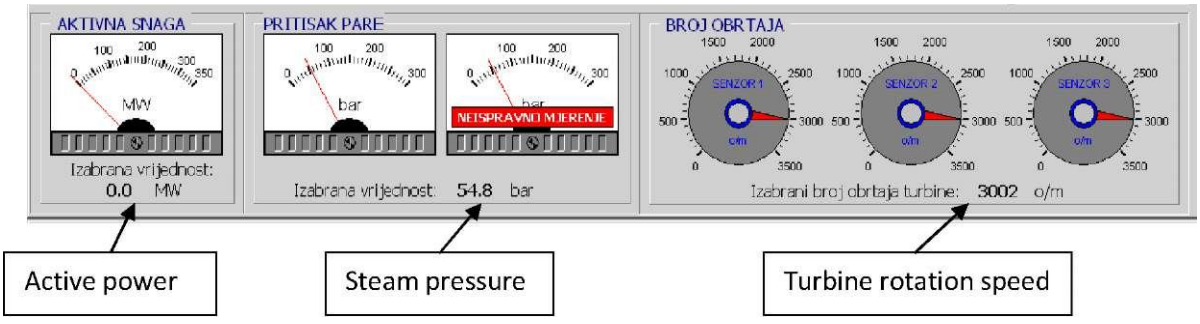

Figure 15. Active Power, Steam Pressure, Turbine Rotation Speed

There is a pushbutton "GLAVNI PANEL" to return back to the main window.

3.8.3 Trends window

The window is providing time behavior selected variables and theirs setpoints:

- Active power
- Steam pressure
- Turbine rotation speed
- Valve position

3.8.4 High/Intermediate pressure valves control

To activate the control field, there is necessary to press the „Ventili CVP"/"Ventili CSP" button first. Even
if the area is not activated there are visible actual information about the setpoint and real value. This

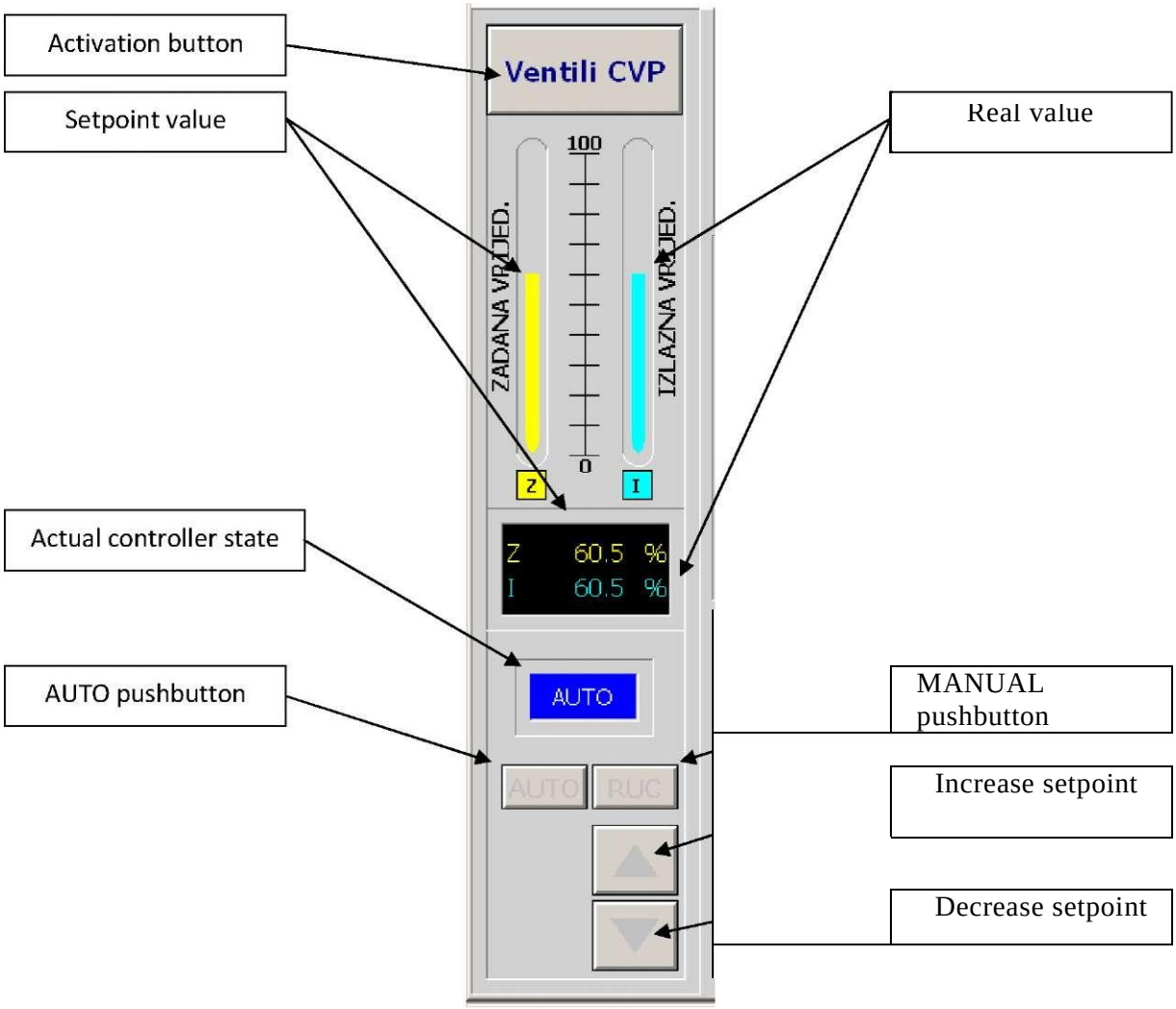

Figure 16. HP Valve Control

To change controller state from/to "AUTO"/"MANUAL" use appropriate pushbutton. When the "MANUAL" mode is active a two pushbuttons are active as well. These pushbuttons are used to increase/decrease setpoint value.

3.8.5 Regulation options

After activation this area you are able to choose the regulation scheme:

- Speed loop
- Open loop
- Pressure loop
- Load loop

The availability of desired regulation is depends on the current turbine state. When the field on the left side of the area is green colored the scheme is available. When the color is red the conditions for regulation are not met.

Figure 17. Regulation Options

3.8.6 Regulation setpoint

The area is closely associated with the previous „Regulation options" area. When active you are able to

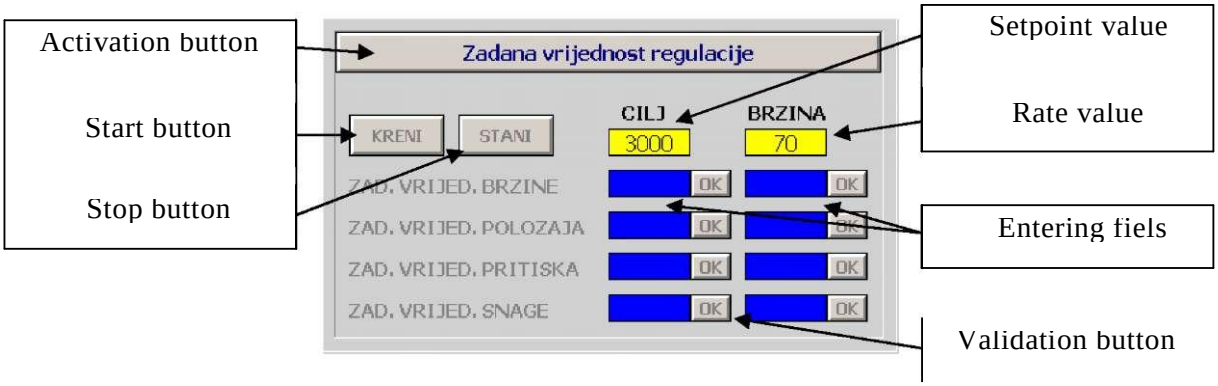

Figure 18. Regulation Setpoint

After mouse click into enabled entering field new window is populated (Figure 19). By mouse click on specified number the new value is created. To correct the entered value you can use the "Backspace" button. By click on the "OK" button the new value is entered to the specified regulation setpoint/rate area. To validate the new value press the button next to the new value.

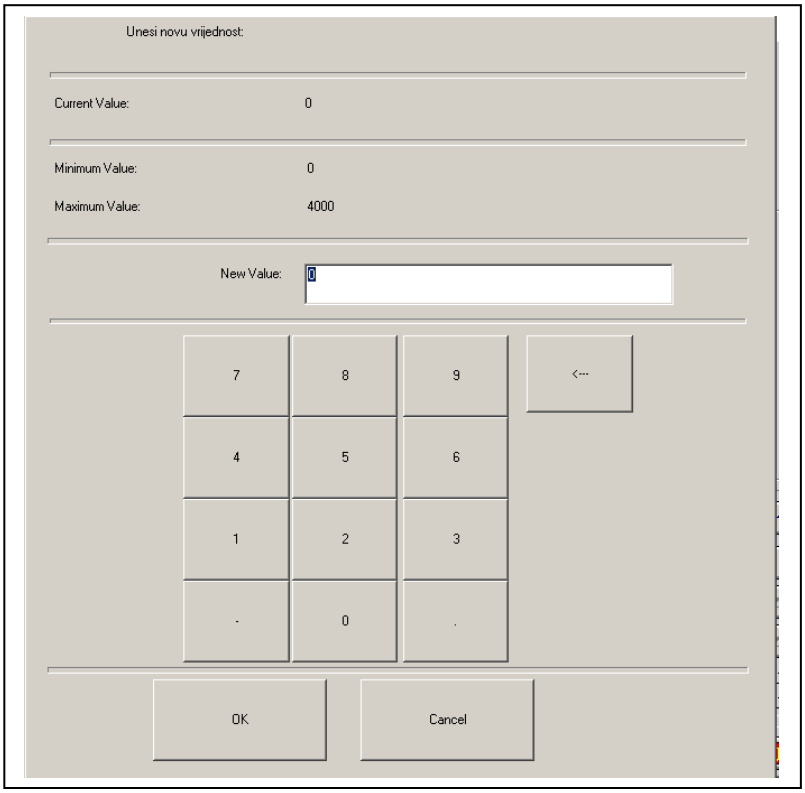

Figure 19. Setpoint Value Window

When the entering of the new values is finished the "Start" button need to be pressed (note: when rate value is changed only, no need to press the "Start" button).

3.8.7 Notification area

The area contains both the information fields and control fields as well. The basic information about turbine rotation speed, steam pressure, active power and actual regulation state are available. There is ability to slightly change actual value of variable according to selected regulation.

Figure 20. Notification Area

3.8.8 Turbine trip notification area

When turbine is going to trip for some reason, you can find it in this part of main graphic window. As shown on the Figure 2121 there are seven options for turbine trip. No other operation is possible until the acknowledge button is pressed.

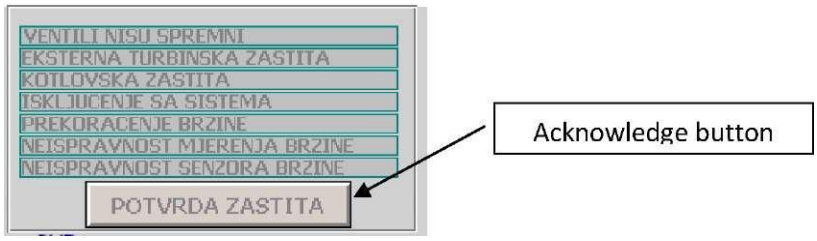

Figure 21. Turbine Trip Information

If there is more than one turbine trip condition met only the first one is signalized by red color. Rests of them are signalized by green color.

3.8.9 Valve area

The part is designed to monitor actual state of the high pressure valves, the intermediate pressure valves and the bypass valves as well. A value represents the percentage of the valve opening range.

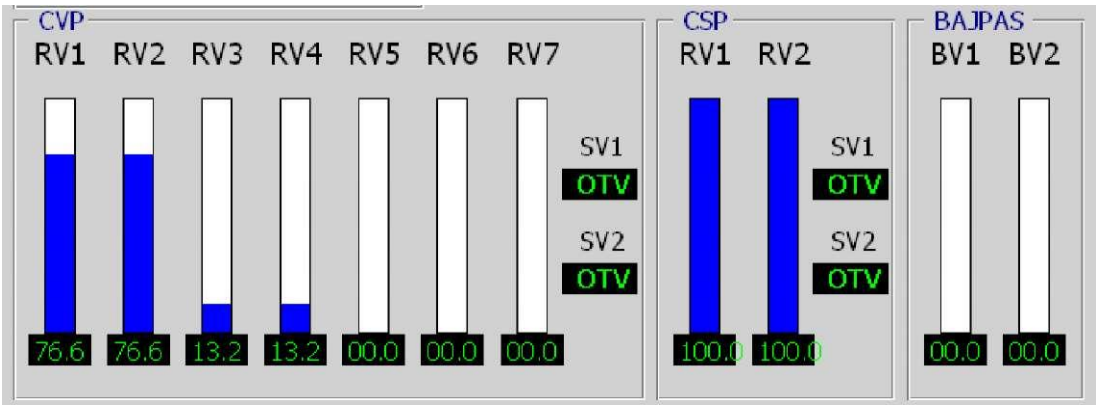

Figure 22. HP/IP/BP Valves Area

On the area you are able to monitor a valve contingency as well. The contingency is signalized by red color mark under the valve name.

There are not any control buttons or active pokes in the area.

3.8.10 Auto/Manual option

This area is used to select between turbine regulation mode - "automatic" and "manual". Actual regulation mode is signalized by the text field below the activation button.

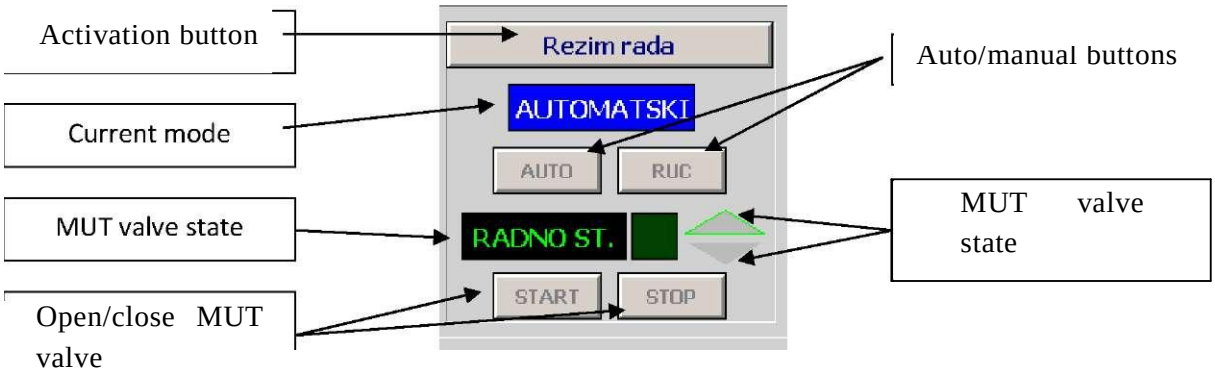

Figure 23. Auto/Manual Area

At the bottom part of the area there are MUT control push buttons. You can open or close MUT valve automatically by pressing the "Start" button or "STOP" button respectively. The notification arrow shows which direction of moving is activated. Greed colored arrow means opening; red colored is used for closing.

3.8.11 Synchronization

This part is designed to control automatic synchronization logic. You can turn on the automatic mode by pressing the "UKLJ" button or turn off it by pressing "ISKLJ" button when the area is activated. The actual state of the synchronization is shown on the text field.

When operate in the automatic synchronization mode you can see actual rotation speed tuning on the notification arrows next to text field.

When operate in the manual mode, you can use two push buttons ("-" and "+") to slightly change the turbine rotation speed

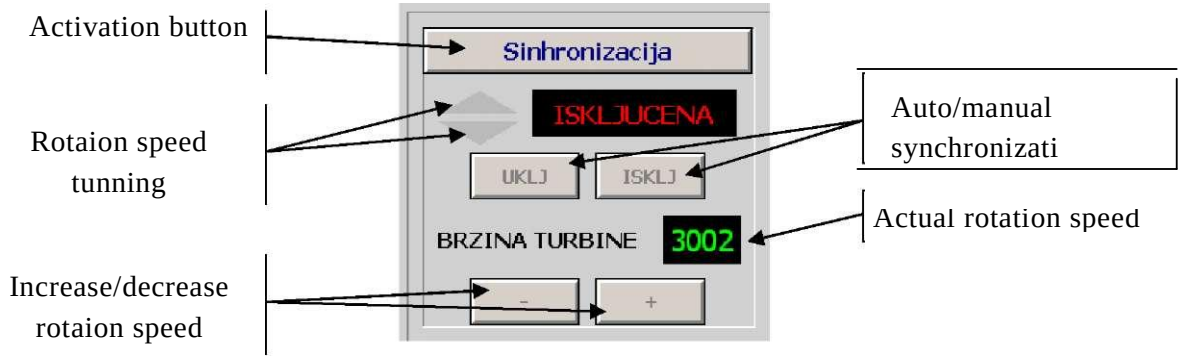

Figure 24. Synchronization Area

3.8.12 Turbine testing

After activation of this part of the main graphic windows you can perform two turbine tests. To start a testing there is necessary to choose what test you want to start and then press the "Kreni" button. To cancel the active test the "Stani" button need to be pressed.

Figure 25. Test Area

The turbine rotation speed limits for the regulation valves and the stop valves are show on the area at the bottom part.

In the bottom part of the area there is button to manual unlatch the turbine (force trip).

3.8.13 Error log

The log area contains all communication information between the controller and the graphic. When some error or alarm occurs you can find it in the log window.

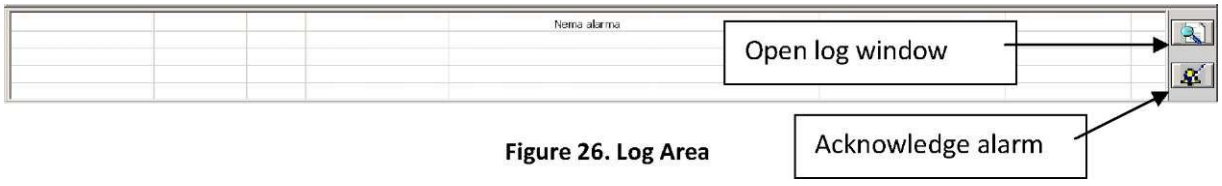

Figure 26. Log Area

Error/alarm messages are red colored in contrast to the normal communication which is blue colored (log 0) or black colored (log 1).

To open a detailed survey of the communication the open log button need to pressed.

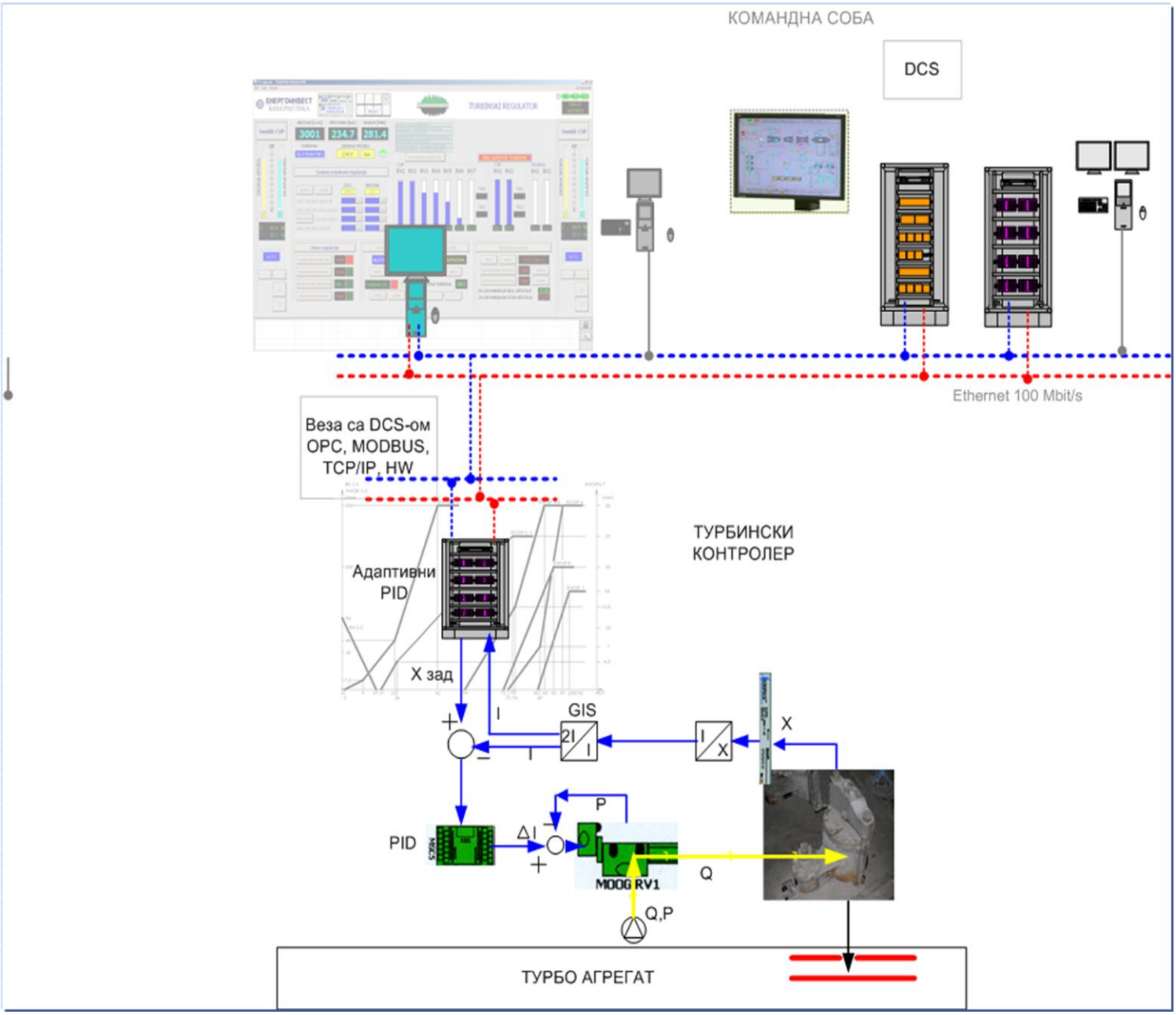

Figure 27.General shema of turbine regulator

Datum Vrijeme		Stanje	Prior,	Oznaka	Opis	Grupa	Vrijechost	
27/07/2010	10 41:26		700	1TR 1DZ4Z	Stop vent, 2 CSP 2atvoren	TR	Da	A
27/CI7/2010	10 41:26	ACK RTN	1	1TR PRVCVP2SPR	Automat nap. MOOG RV2 CVP	NAPA JANJE	UKLJUCEN	
27/07/2010	10 41:26	ACK RTN	1	1TR BV2TP1SPR	Automat nap, davaca 1BV2	NAPA	UKLJUCE	
27/07/2010	11 19:17		900	OPD MUT OTV	Oper. Turbinu u radni polozaj	TR	Da	
27/07/2010	11 19:17		900	OPD_MUT_OTV	Oper. Turbinu u radni polozaj	TR	Ne	
27/07/2010	11 19:18		700	1TR MUTKO	Komanda otvaranja MUT-a	TR	Da	
27/07/2010	11 19:18		700	1TR_MUTSZ	Zatvoren MUT	TR	Ne	
27/07/2010	11 19:27		700	1TR MUTKO	Komanda otvaranja MUT-a	TR	Ne	
27/07/2010	11 19:27:		700	1TRJVIUTSO	Otvoren MUT			
27/07/2010	19:27:28		700	TfR_lDZlZ		TR	Da	
27/07/2010	11 19:28		700	TfR_lDZlZ		TR	Da	
27/07/2010	11 19:28		700	1TR 1DZ2Z	Stop vent, 2 CVP zatvoren	TR	Ne	
27/07/2010	11 19:28		700	1TR_1DZ3Z	Stop vent. 1CSP zatvoren	TR	Ne	
27/07/2010	11 19:28		700	1TR_1DZ4Z	Stop vent, 1CVP otvoren	TR	Da	
27/07/2010	11 19:34		700	1TR 1DZ1O	Stop vent, 1CVP otvoren	TR	Da	
27/07/2010	11 19:34		700	1TR 1DZ20	Stop vent. 2 CVP otvoren	TR	Ds	
27/07/2010	11 19:34		700	1TR 1DZ30	Stop vent, 1CSP otvoren	TR	Da	
27/07/2010	11 19:34		700	1TR_1DZ40	Stop vent. 2 CSP otvoren	TR	Da	
27/07/2010	11 19:39		600	SWD_TURB_AUTO	Turbina u automatskom rezimu	TR	AUTO	
27/07/2010	11 19:39		600	SWD_TURB_RAD	Turbina u radnom polozaju	TR	Da	
27/07/2010	11 21:03	UNACK	1	SWD_1TR_P 14KV	Neisprav. mjerenja 3 prit. reg. ulja	TR	NEISPRAVNOST	
27/07/2010	11 21:14	ACK_RTN	1	SWD_1TR_P 14KV	Neisprav, mjerenja 3 prit, reg. ulja	TR	uredu	
27/07/2010	11 21:28	UNACK	1	5WD_1TR_P14KV	Neisprav. mjerenja 3 prit. reg. ulja	TR	NEISPRAVNOST	
2//U//2U1U	11 24:28	ACK	1	SWD_11 R_H14KV	Neisprav, mjerenja 3 prit, reg. ulja	1K	NblbHKAVNUb 1	
27/07/2010	11 24:58		900	rOPD_OBR_ZV	Oper. Nova ciljana ZV brzine	TR	Da	
27/07/2010	11 24:58		800	OPA_OBR_ZV	Oper. Ciljana ZV brzine	TR	3000	
"27/07/2010	11 24:59		500	SWA_OBR_ZV	Ciljana zadana vrijed. brzine	TR	3000	
27/07/2010	11 24:59		900	OPD_OBR_ZV	Oper. Nova ciljana ZV brzine	TR	Ne	
27/07/2010	11 25:01		900	lQPD_OBR_GRD	Oper. Nova brzina prom. ZV brzine	TR	Da	
"27/07/2010	11 25:01		800	rOPA_OBR_GRD	Oper. Brzina prom, ZV brzine	TR	70	
27/07/2010	11 25:02		900	OPD_OBR_GRD	Oper. Nova brzina prom, ZV brzine	TR	Ne	
27/07/2010	11 25:02		500	PSWA_QBR_GRD	Brzina prom. ZV brzine	TR	70	
27/07/2010	11 25:05		900	rOPD_ZV_KRENI	Oper. Rromena zad, vrijed. Kreni	TR	Da	
27/07/2010	11 25:05		900	OPD_ZV_KRENI	Oper. Promena zad. vrijed. Kreni	TR	Ne	
27/07/2010	11 28:56		900	OPD_OBR_ZV	Oper. Nova ciljana ZV brzine	TR	Da	
27/07/2010	11 28:56		800	OPA_OBR_ZV	Oper. Ciljana ZV brzine	TR	700	
27/07/2010	11 28:57		500	swa_obr1žv	Ciljana zadana vrijed. brzine	TR	700	

"27/07/2010	11 28:57		900	OPD_OBR_ZV	Oper. Nova ciljana ZV brzine	TR	Ne	
27/07/2010	11 28:58		900	OPD_ZV_KRENI	Oper. Rromena zad, vrijed. Kreni	TR	Da	
27/07/2010	11 28:58		900	OPD_ZV_KRENI	Oper. Promena zad. vrijed. Kreni	TR	Ne	

Figure 28 Example of testing of turbine regulator