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One Solution for Simulation of Steam Turbine Power 350MW

ARS-TSSimPXI

Idea About Simulator

The global industry trend is to reduce all costs regardless of their origin. In electrical industry, one part of solutions for reducing the number of plant dropouts is system optimization and good personnel training.

- Simulators and training systems represent a modern method of training staff that operates in various sectors of a power plant (production, maintenance etc.) An inadequate training often leads to non-professional reactions in critical situations.

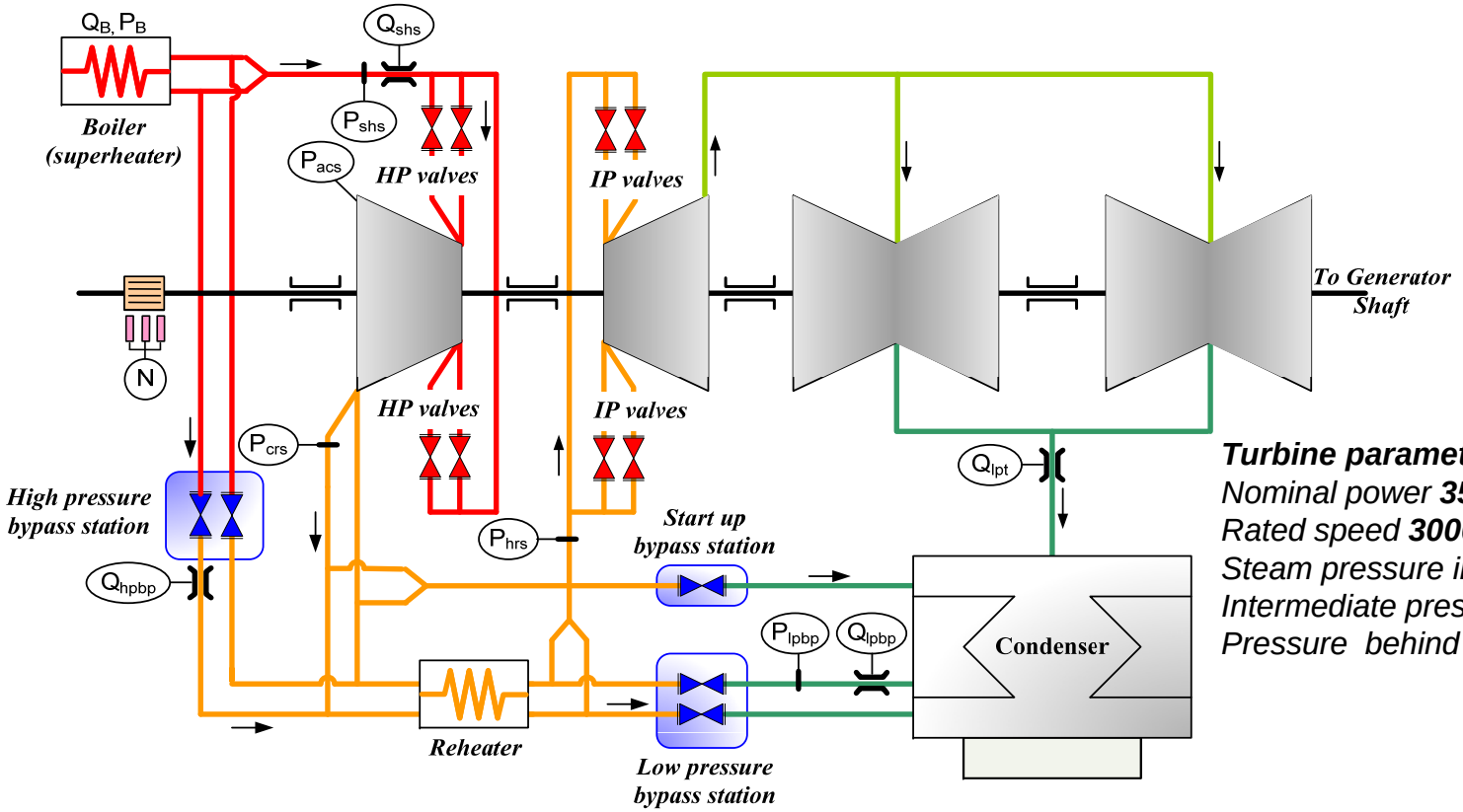
- Some of the advantages of such training systems are the possibility of a thorough analysis of a recorded event, the possibility to set the simulator to a state preceding a turbine trip or another critical situation and the analysis of various influences on the plants stability.
- The price of the insurance policy significantly diminishes if the personnel have been trained on a certified training system.

Simulator Usage

The turbine simulator consists of several hardware and software components and it is used for testing of turbine governor and turbine protection:

- in the phase of installation
- during design and optimization of the algorithm
- for factory acceptance test
- during testing and putting into operation a complete integrated system on facility
- training of staff with the new system of regulation before the first turbine startup

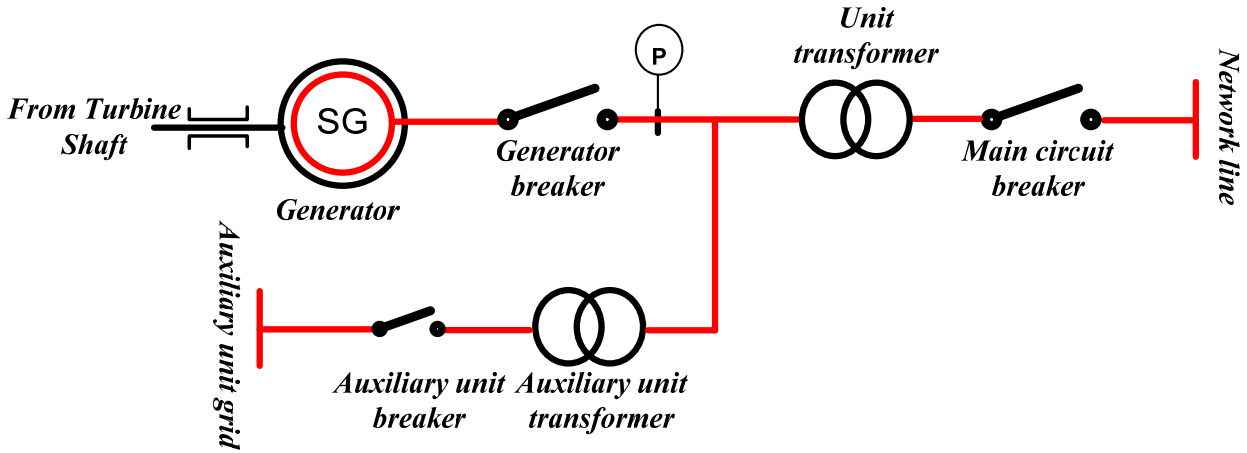
Steam Turbine



Turbine parameters:
*Nominal power **350MW***
*Rated speed **3000rpm***
*Steam pressure in front of turbine **180bar***
*Intermediate pressure **42.4bar***
*Pressure behind LP chamber **6bar***

Condensate steam turbine of 350MW, type 18-K-348, manufacturer ZAMECH (Elblag, Poland) is considered for the modeling approach. This turbine installed at Unit B2 of TPP "Kostolac B", Drmno, Serbia.

Generator



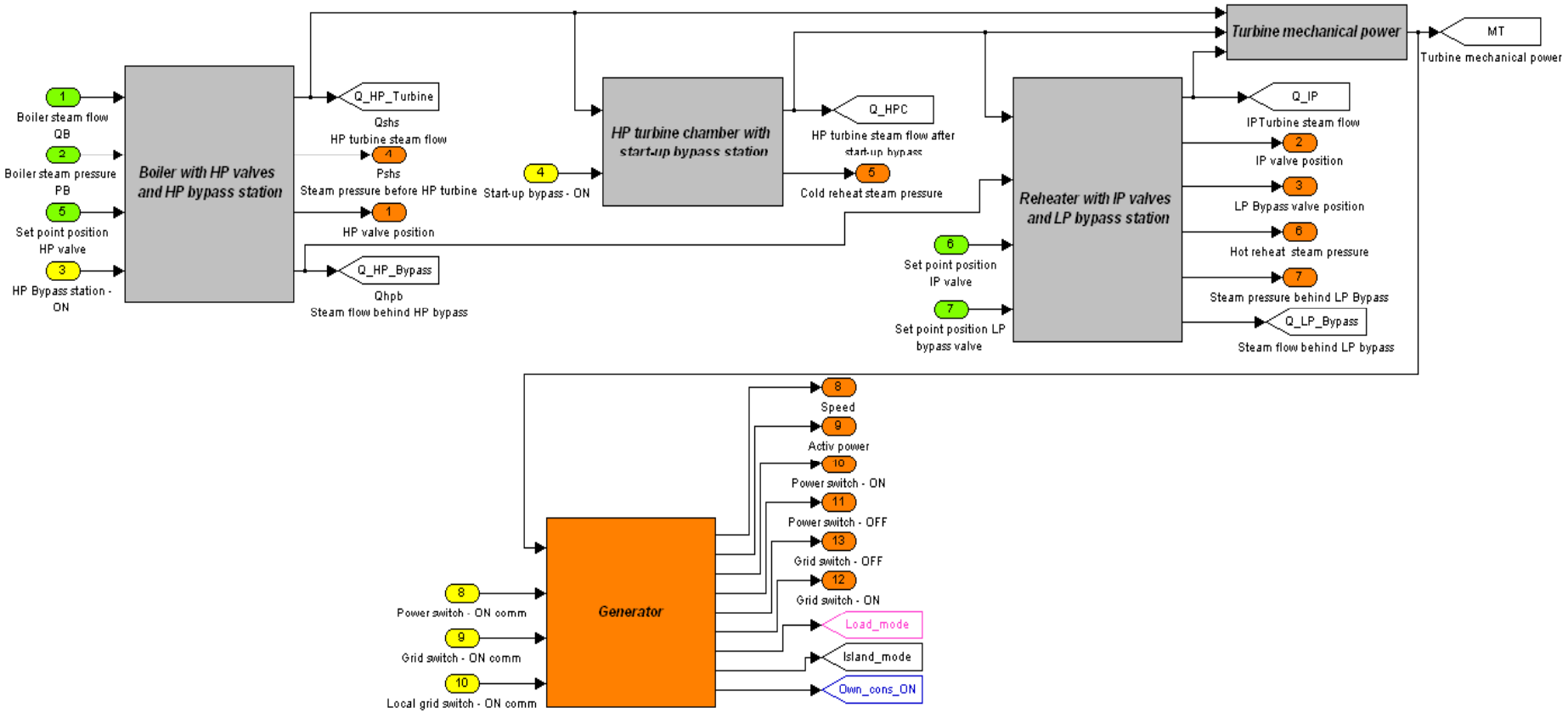
Generator (nominal voltage 410kV, nominal power *P* = 410MW, cosφ=0.85) over generator breaker, unit transformer (nominal power 410MW, incoming voltage 410kV, outgoing voltage 22kV) and main circuit breaker is connected with network. Auxiliary unit transformer is connected at generator voltage.

Turbine Model

Turbine model is designed so that it can fully complete simulation of important real process parameters. Overall model contains:

- Boiler model,
- HP, LP and start-up bypass station model,
- Electro-hydraulic servo drive,
- Model of control valves,
- Reheter model,
- Turbine mechanical power model,
- Generator model

Turbine Model



Structure of turbine-generator model

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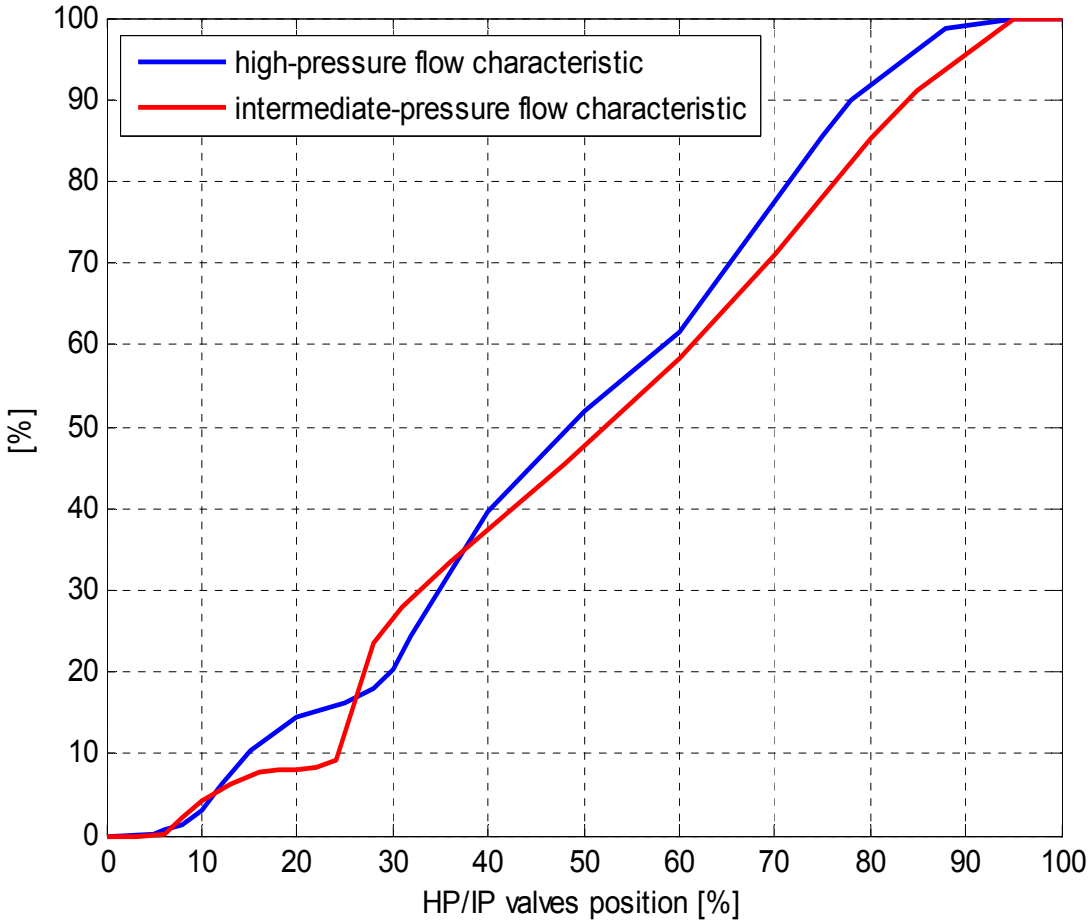
Turbine Model – *steam flow characteristic*



Nonlinear functions define

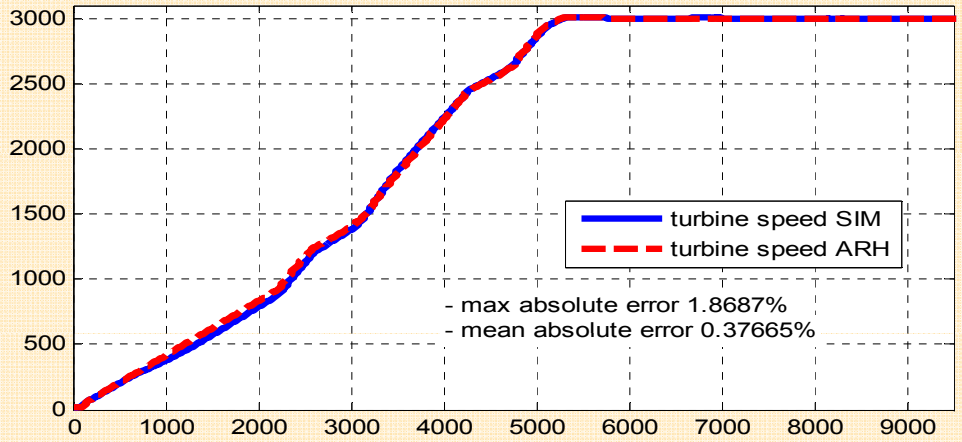
the flow of steam through HP valves depending on the HP valve position.

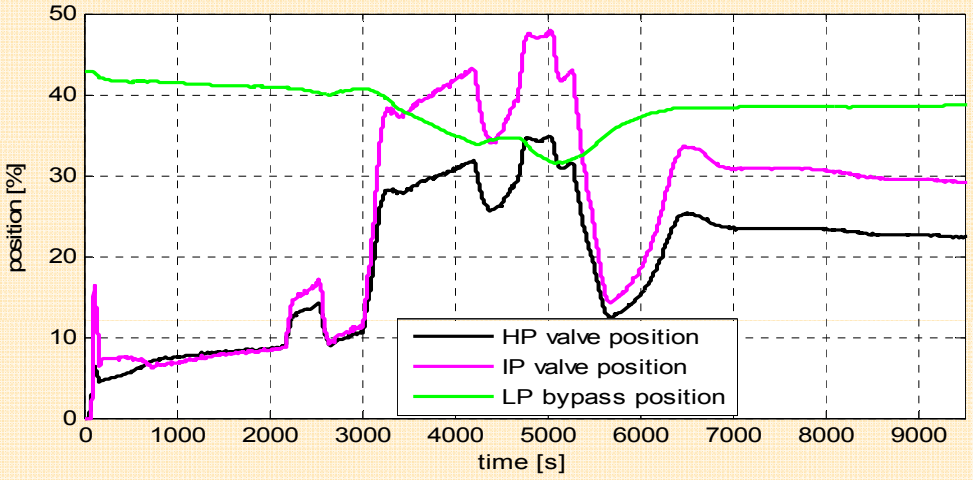
Similarly, flow of steam through IP valves is showed also These nonlinear function are the most important part of model, since it defines steam flow linearization through turbine. Values of these functions are obtained from measurements of steam flow and valve position, taken during different turbine operating conditions.

Results – *model VS real plant (verification)*

The comparison of the obtained parameters by the simulation showed satisfactory matching with real data.

Increasing turbine speed from a cold state with position of HP valves, IP valves and LP bypass station





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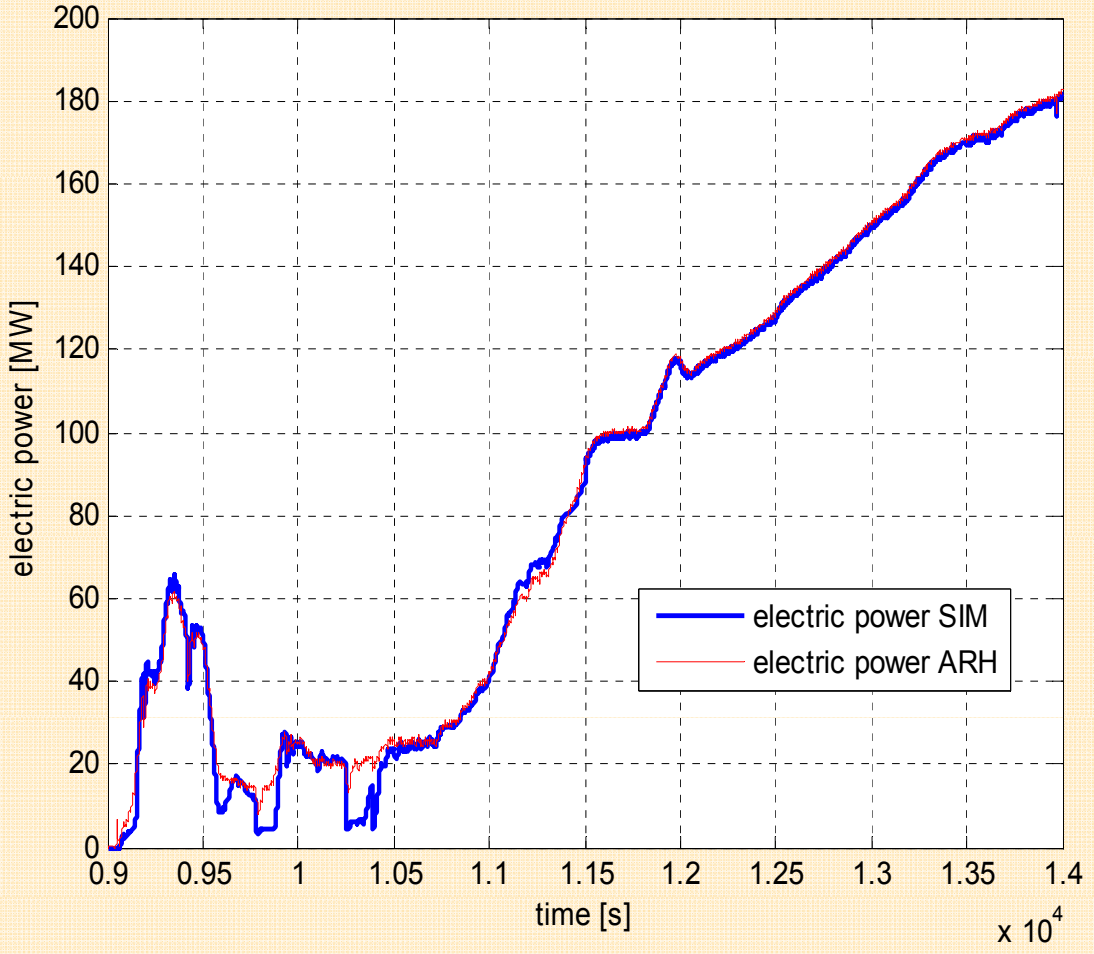
Results – *model VS real plant (verification)*

Increasing turbine power after sinhronization to power grid



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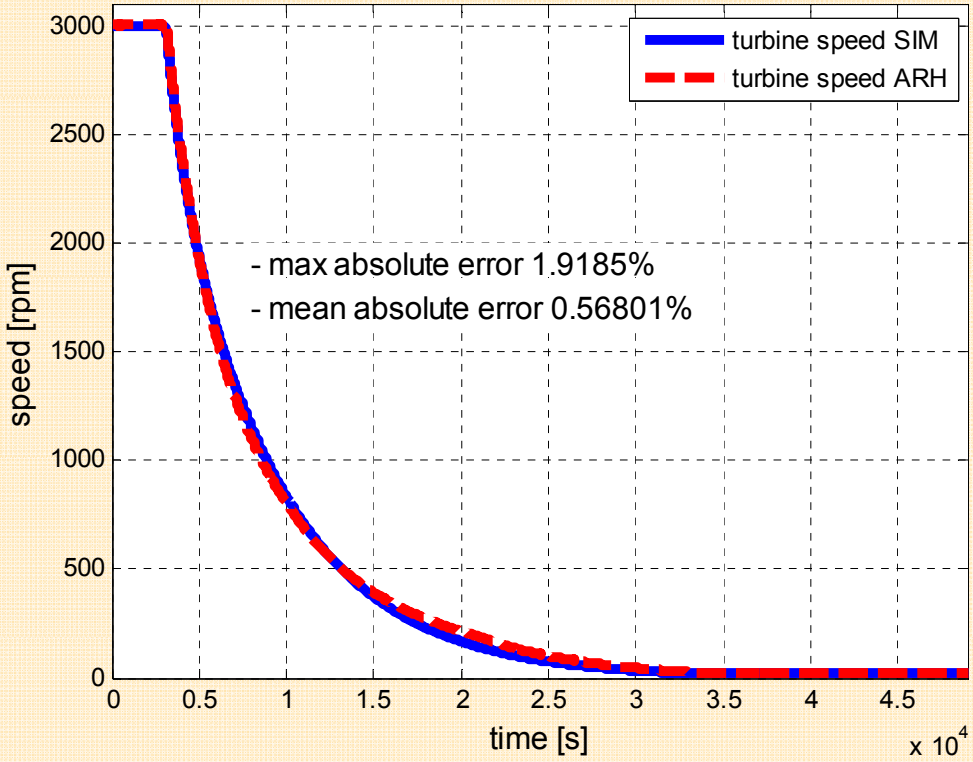
Results – *model VS real plant (verification)*

Comparative analysis of simulated and real turbine speed during turbine droopout and speed reducing



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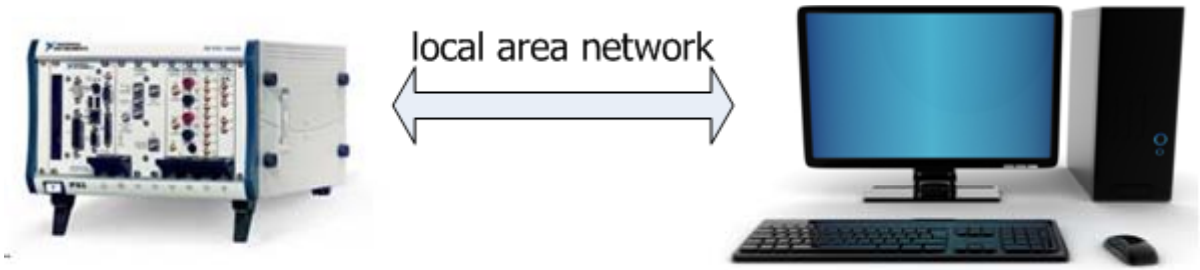
Hardware – *for real-time simulations*

To operate the model in real time it is used *National Instruments PXI-1044 platform* which consists of:

- ***Embedded controller PXI-8105***, that satisfies demands for real-time work. The used operating system is ***LabView® 2009 Real Time v.9.0***.
- ***Multi-function acquisition card M-Series, type PXI-6289*** has four 16-bit analog outputs, 16 differential analog inputs, 48 digital bidirectional channels and two pulse outputs with maximum output frequency of 80MHz.
- ***Multi-function acquisition card M-Series, type PXI-6723*** has 32 analogue outputs, 8 digital bidirectional channels and two pulse outputs with maximum output frequency of 20MHz.

Simulator user interface is situated on the computer, PC with MS Windows® operating system, which is separated from the real-time controller and it communicates with the real-time controller through a local area network.



Turbine governor & Simulator

Turbine governor

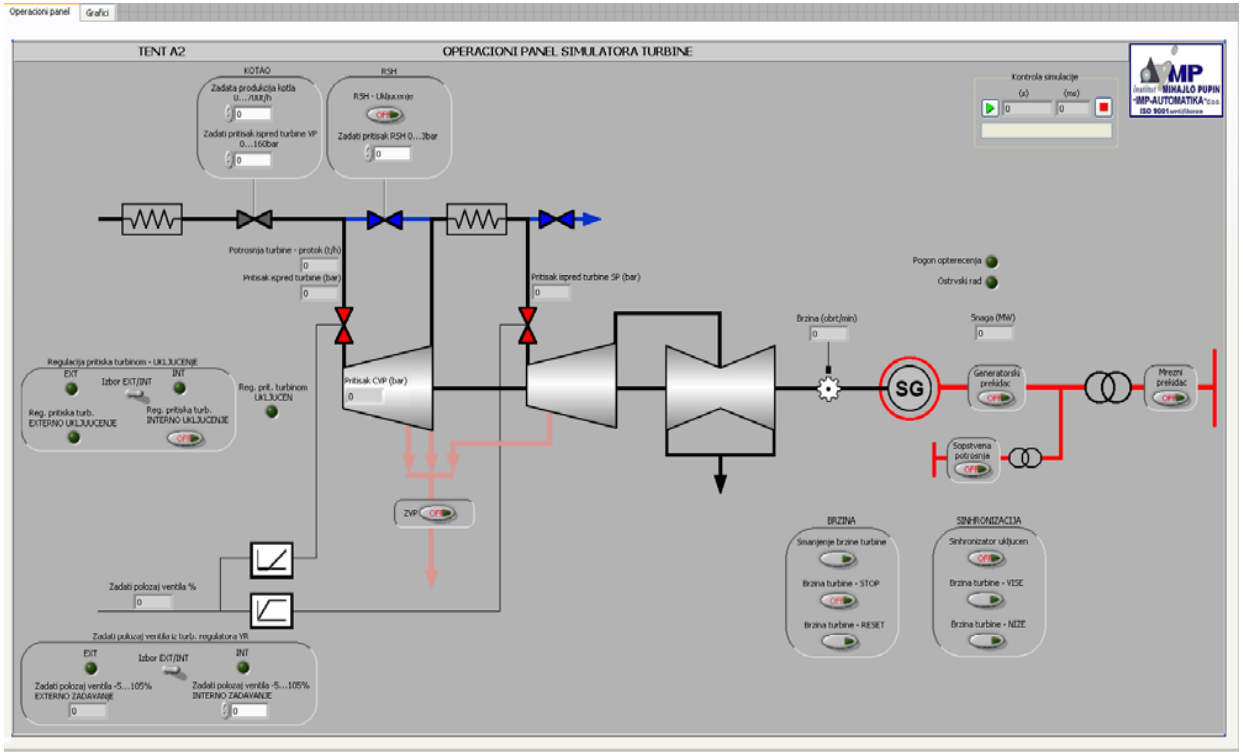
Simulator

Connection

Operation Panel for Simulation

The operation panel is used to:

- start or stop the real-time simulation
- set some digital or analog input variables
- turn on certain system parts (bypass stations, generator breaker,...)
- monitoring simulator output signals such as electric power, rotation speed of the turbine or steam turbine pressure



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Conclusion

- Complete training system realistically reflects the behavior of the real system in all operating modes,
- Simulator enables training and testing of the plant personnel without any risk to the actual turbine equipment and it is possible to simulate certain incidental states that rarely occur,
- More convenient to train staff how to behave in critical situations in the simulator than on real plant,
- This model can be integrated into other simulator tools,
- Further development of the described simulator will be reflected in the modeling of mechanical measurements on the turbine (vibrations and shifts) and the temperature of the material in some parts of turbine.

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