PRIMARY CONTROL OF VOLTAGE AND POWER IN SLOVAK POWER SYSTEM

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Introduction

Modeling and simulation of power systems is useful process for their development nowadays. Engineers should be able to project more complex control systems with these tools. Mainly control parts of the power systems are primary voltage control and primary power control. The obtained model must be documented and compared with the real measurement for optimisation of these control mechanisms. We've chosen the product of The MathWorks; Matlab/SimPowerSystems for modeling and simulation of this system. The model of power system of Slovak Republic is shown on fig. 1.

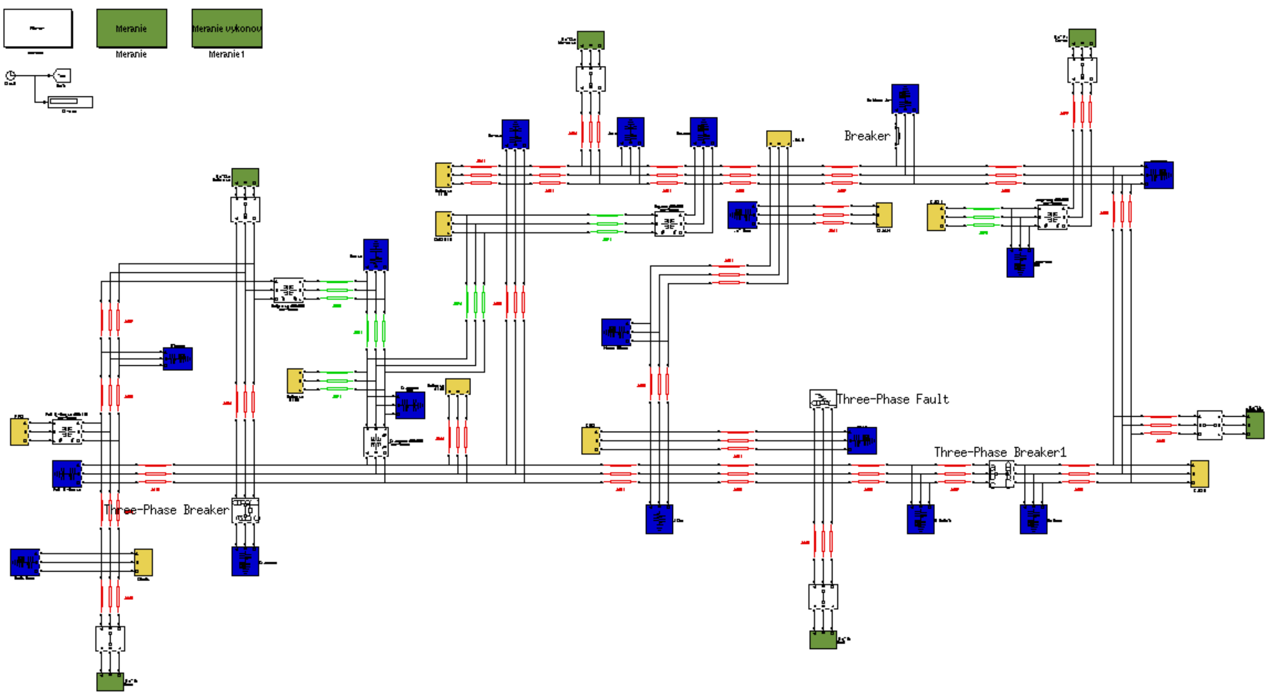

Fig. 1 Schematic of power system of Slovak Republic designed in Matlab/SimPowerSystem

400 kV and 220 kV model of power system

Schematic of power system of Slovak Republic was designed with help of the map of power system of Slovak Republic desigend by SEPS. At first we made a network topology; position of the loads and buses and their connection by power lines. The modeled synchronous machines in the model were: Mochovce, Bohunice V1 a V2, Gabčíkovo, Vojany 1 a 2, Nováky B 2 blocks, PPC BA, Liptovskej Mare and Čierny Váh two blocks. The modeled buses were: Stupava, Pod. Biskupice, Gabčíkovo, Križovany, Bošáca, Varín, Sučany, Spišská Nová Ves, Lemešany, Moldava, R. Sobota, Levice, Horná Ždaňa and Senica. Then we've connected the foreign power stations to the transmission system. Detailed part of the model is shown on fig. 2.

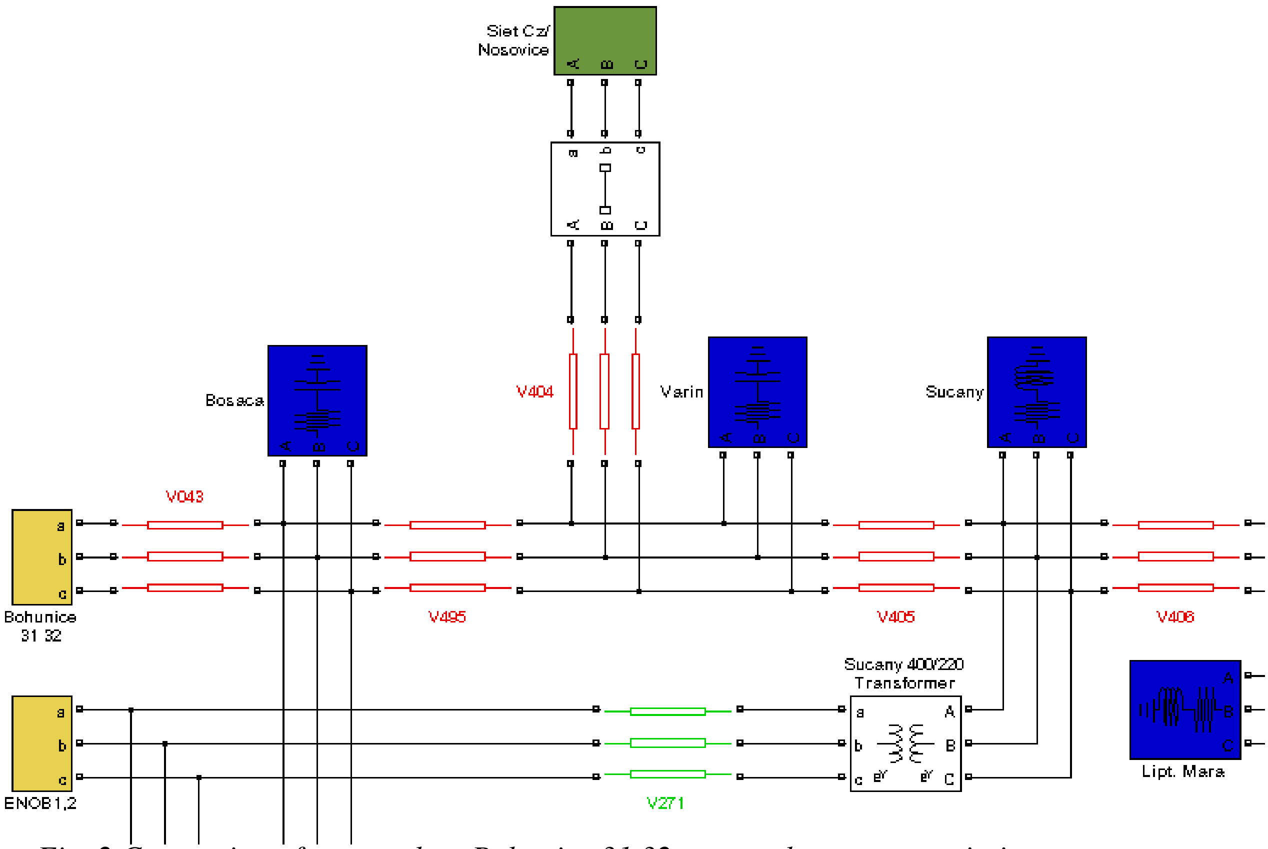

Fig. 2 Connection of power plant Bohunice 31,32 power plant to transmission system

Modeling of the power plant describes fig. 3. We should see 4 blocks of power plant Mochovce, power connection lines V046, V047 and the block of active and reactive power measurement on the figure.

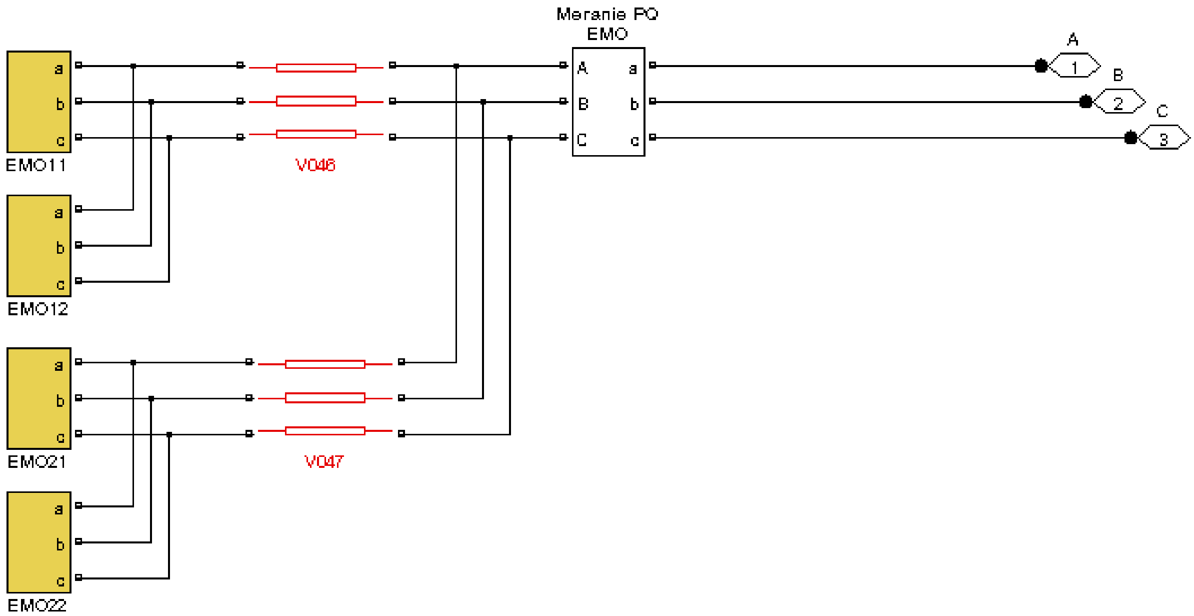

Fig. 3 Connection of the blocks of nuclear power plant Mochovce

Each of the blocks consists of synchronous machine model, model of exciter, primary voltage control, steam or hydro turbine, primary power control, speed control while the power plant is in island operation, power system stabilizer and block transformer. Connection of these parts is shown on fig. 4. The different types of turbines and exciting systems were used while modeling miscellaneous power plant blocks.

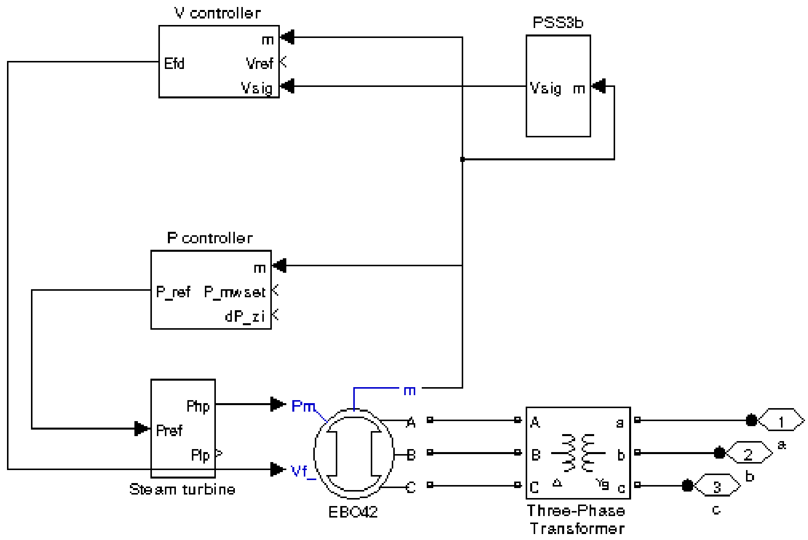

Fig. 4 The inner connection of block EBO42

Primary voltage control

Primary voltage control must maintain synchronous machine voltage V_{nG} in (+ 5% až - 10%) V_{nG} limits, while respecting the value of own load. Primary voltage control is usually supplied by the other systems, e.g. power system stabilizer PSS.
Exciting system is used for control of voltage of synchronous machine. The model of exciting system, commonly used in Slovak power plants, is shown on fig. 5. The system consists of PI voltage controller and simplified model of exciter, which is modeled by gain k.

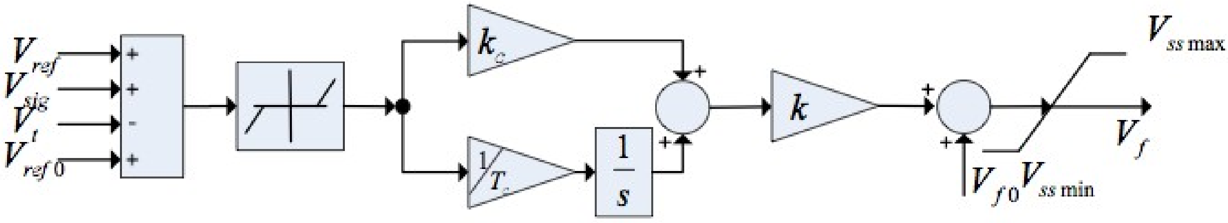

Fig. 5 Model of exciting system

Parameters of exciting system:

V_{ref}	- reference voltage value
V_t	- synchronous machine voltage
V_{sig}	- correction signal (PSS, derivation feedback)
V_{ref0}	- initial reference value of voltage, usually V_{ref0} =1
V_{f0}	- initial value of exciters voltage
k_c	- proportional gain of PI- controller
T_c	- integration gain of PI- controller
k	- gain of exciting system
V_{min} ,V_{max}	- limits of exciting voltage

The exciter was modeled like gain k, because of computing and modeling difficulties. Fig. 6 shows reaction of primary power controller of EMO11 after the step change of reference voltage value. We should see a reaction of dead zone on controller error on this figure.

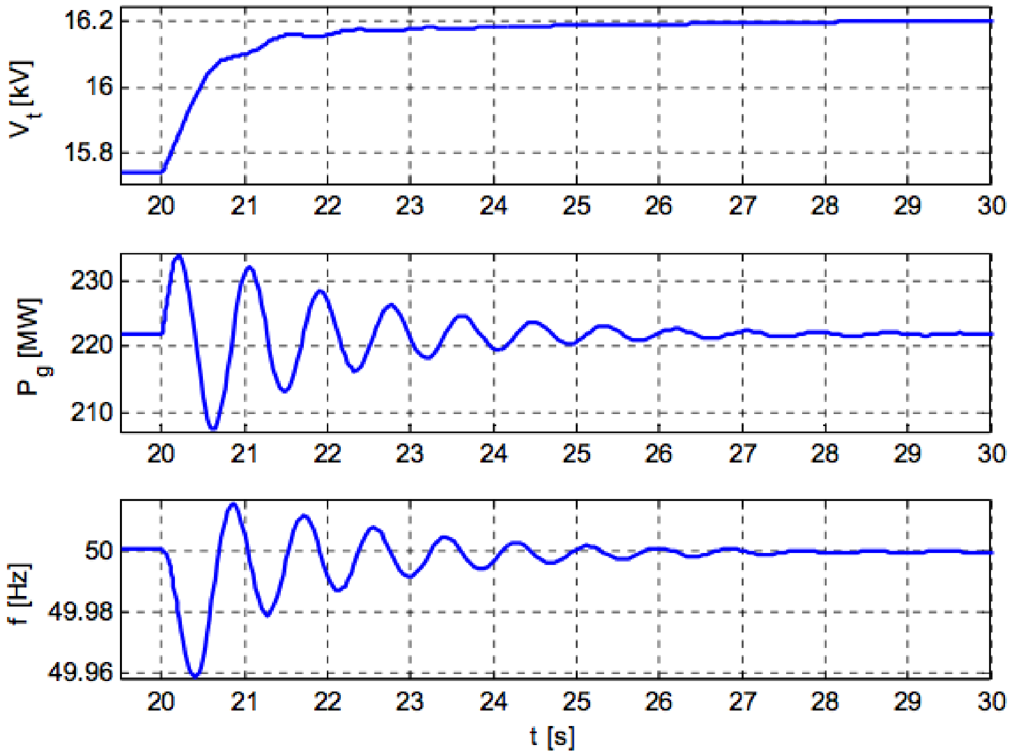

Fig. 6 Step change of reference voltage value on EMO11 by 5% at t-20 s, with PSS off

Primary power control

Primary power controller, shown on fig. 7, consists of PI controller and frequency corrector. The speed of reference value change Pref is limited by ramp. Signal from frequency corrector is connected to the sum component of controller error. This signal provides primary frequency control. Controller output is then limited.

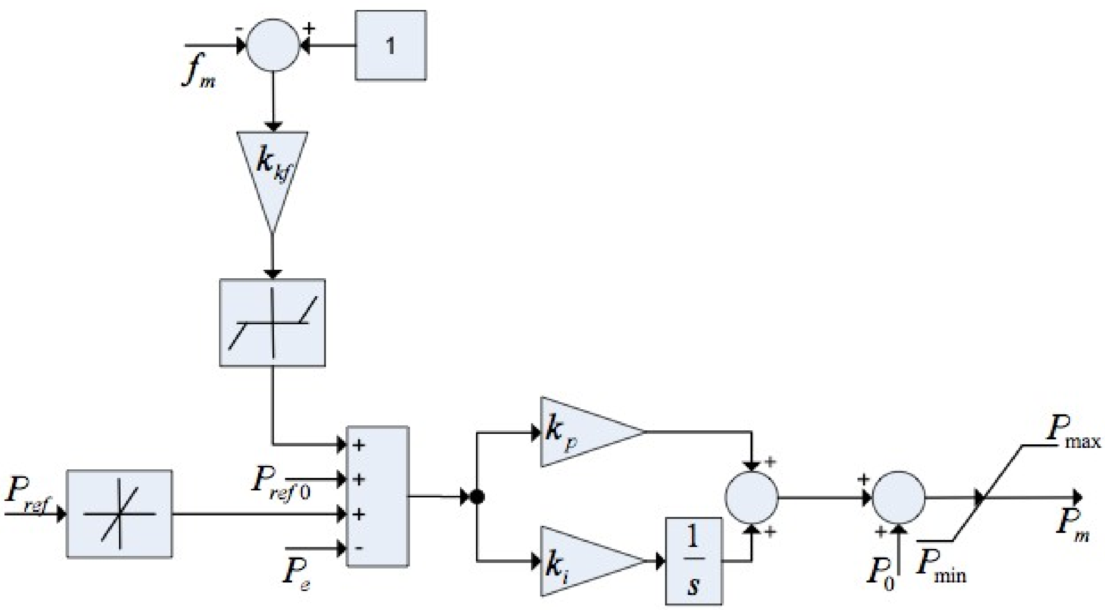

Fig. 7 Model of active power and frequency control

Parameters of active power controller:

P_e	- electric power
k_{kf}	- gain of frequency corrector
P_{ref}	- reference value of power
P_{ref0}	- initial reference value of power
k_p	- proportional gain of PI - controller
k_i	- integration gain of PI - controller
P_0	- initial value of power
P_{max},P_{min}	- limits of power
P_m	- reference power for turbine servo
f	- frequency of synchronous machine voltage

Following experiment was made to show the reaction of primary power control: disconnection of nuclear power plant EBO31 and EBO32 (400 MW of generation) from the grid. The experiment is shown on fig. 8 and was measured on EBO41.

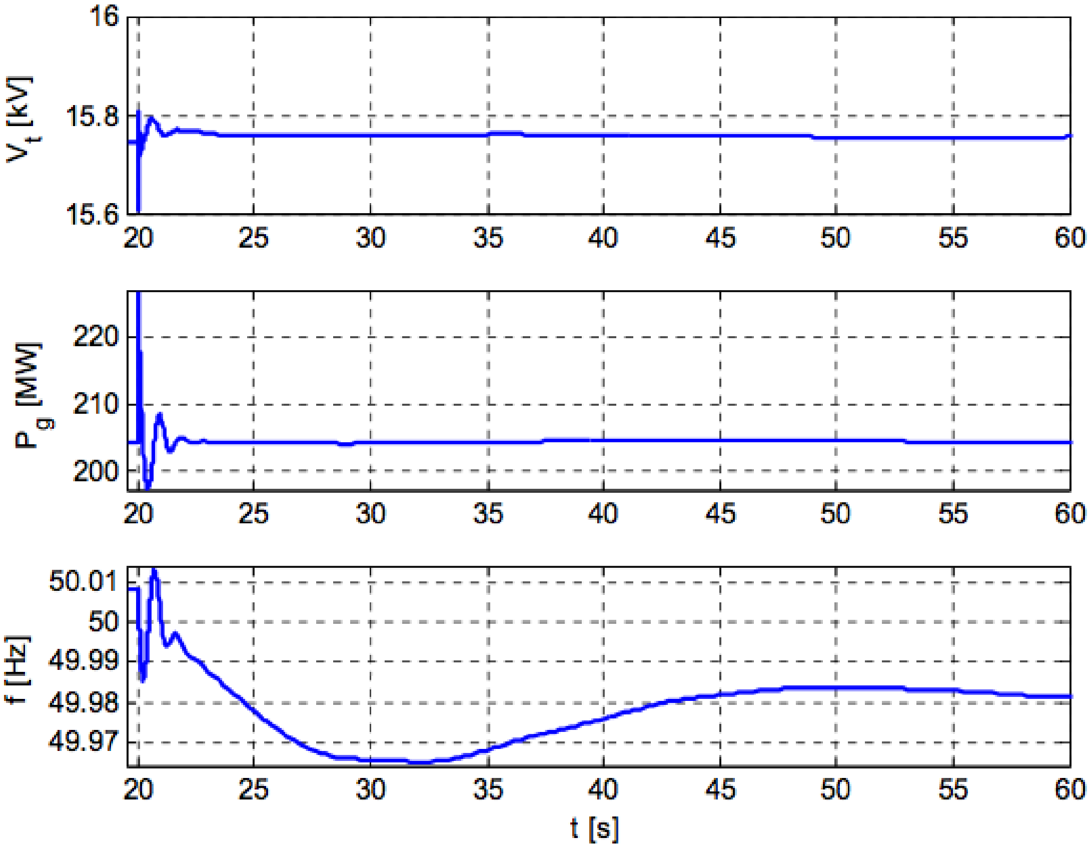

Fig.8 Disconnection of nuclear power plant EBO31 and EBO32 from the grid, measured on EBO41

Conclusion

Model of power system of Slovak republic was made for studying of primary voltage and power control. Primary voltage control keeps the voltages of synchronous machines and buses of transmission system on constant level. Experiments were made on the modeled primary voltage control and then verified by real measurements. Primary power controller was modeled by recommendations of UCTE, e.g. the falling of frequency must be stopped to 15 s. Short time reliable simulations then should be made on this model.

Acknowledgement
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