SIMPOWERSYSTEM IN EDUCATION

M. Foltin, M. Ernek, J. Hnát

Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and
Information Technology, Ilkovičova 3, 812 19 Bratislava, Slovak Republic

Introduction

Nowadays the number of of students in scientific specialization Power Engineering has slightly decreased . This fact is probably caused by relatively high difficulty of this study. It requires a deep knowledge from the area of physics and mathematics and their applications. This subject often handles abstract and hard to imagine electromagnetic processes. These processes are often described by complex differential equation schemes.

With the evolution of powerful calculating unit, simulation and computing environments gain ground, that can calculate steady state in power system by means of input parameters. After exact definition of changes, fails if appropriate, in the net it is possible to examine dynamic behavior of electric system as well as individual net components (generators, conducts…). Energetic simulation environments are often characterized by complicated control and require certain knowledge, until necessary model is made. On these accounts we decided to construct virtual laboratory oriented for power engineering education.

1. Virtual laboratory

The aim of the virtual laboratory is to access simple network model assigned for series of experiments for student community. By that they should gain deeper knowledge in area of dynamic processes in the system. Virtual laboratory is accessible via internet and user doesn't need any special software except standard browser. All necessary calculations and experiments are made on the server side and after simulation of appropriate experiment these calculations are available to end user. Necessary web server, calculating environment MATLAB and simulation environment SIMULIK are installed on the server (in our case Apache). To solve complex power engineering problems, it is necessary to use SimPowerSystems. It is a MathWorks company special product, which contains blocks library

for simulation of power systems. For the interconnection of whole MATLAB calculating system with Apache web server we used MatlabWebServer [4, 7]. You can visit our free virtual laboratory on the adress www.vr-lab.info/energo.

2. Structure of electrical model in virtual laboratory

A simulation model, which can be used for experiments, is modeled according to the real part of power system in Slovakia, island Mochovce. You can see the structure of the model on the figure 2.1.
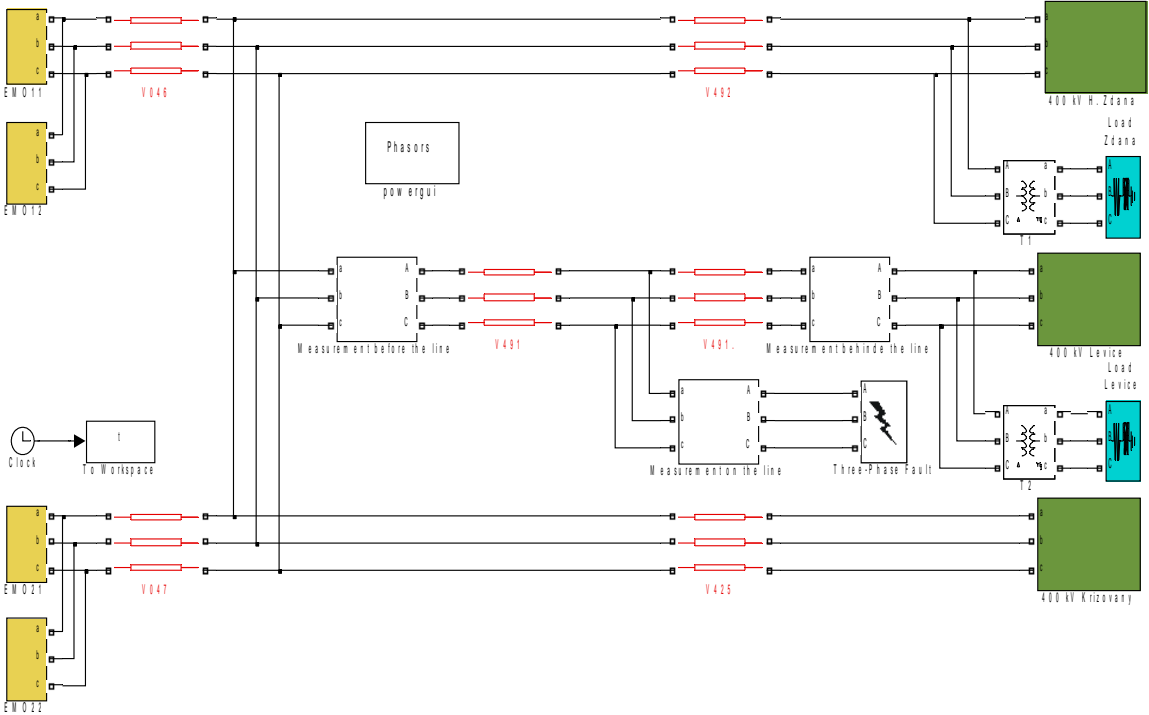

Fig. 2.1 Structure of island Mochovce

The model consists of four controlled synchronous machines, which are connected through a transformer to the lines V046 and V047. These lines are then connected through lines V492, V491 and V425 to the control rooms, which are connected to the high power supplies . The line V491 can be used to simulate experiments (three phase fault, ground fault) and then analyze effects of the fault.

The internal structure of the blocks EMO consists of a synchronous machine block and an excitation control, which is realized by PI controller, power system stabilizer and block transformer. The power system stabilizer is realized like PSS3b system. You can find the structure of these parts on the figures 2.2, 2.3 and 2.4.
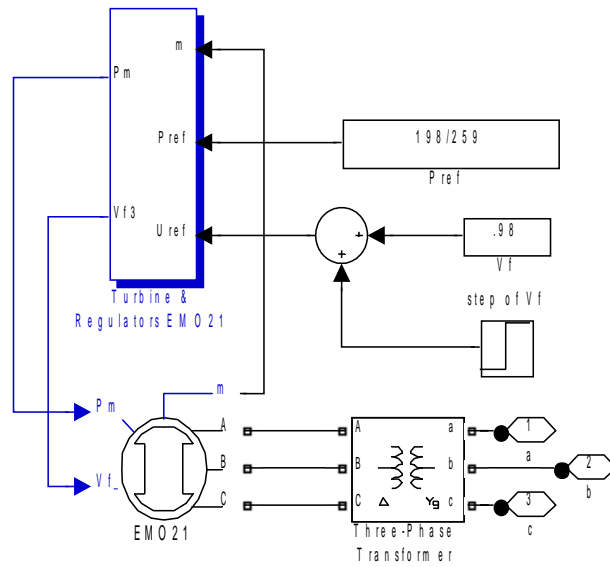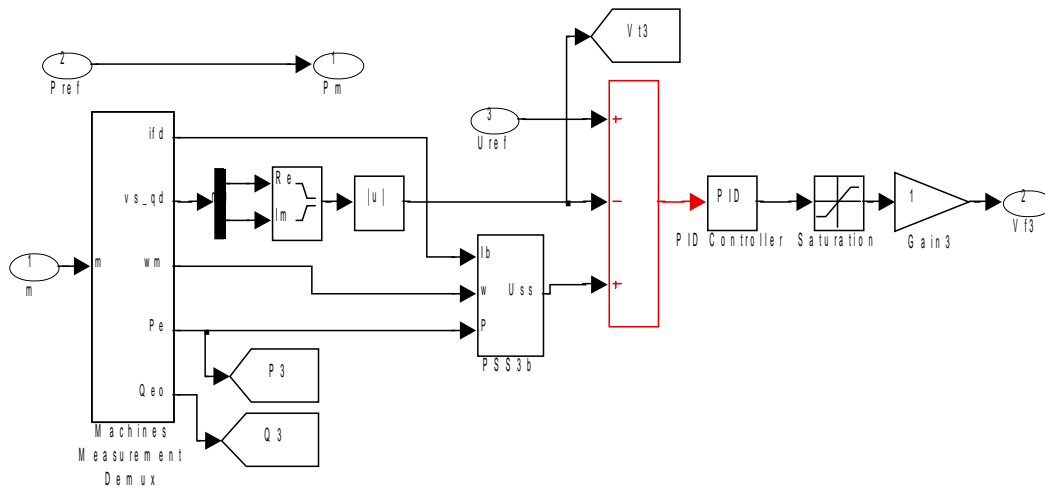
Fig. 2.2 Model of the block EMO21-detail

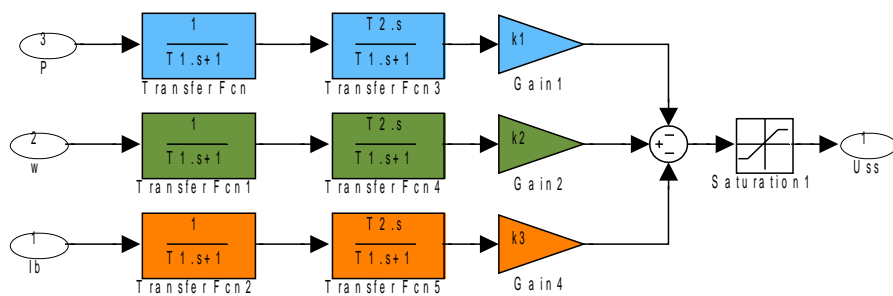*Fig. 2.3 Structure of the excitation control EMO21*

Fig. 2.4 Structure of the block PSS3b

Visitor of the virtual laboratory can change parameters of PI controller and power system stabilizer and observe changes of quality of control and stability of the power system in case of the fault on line V491.

3. Experiments in virtual laboratory

In the previous chapter we described the structure of the simulation model of island Mochovce. Now we can introduce our web interface where you can have a look at the structure of the modeled power system and enter the parameters to the table shown on figure 3.1 .

Parameters:	
Simulation time (start and end time) [s]:	0 30
Parameters of three phase fault:	
Select phases to fault:	
Phase 1	☐
Phase 2	☐
Phase 3	☐
Ground	☐
Time of the fault (start and end time) [s]:	20 20.2
Distance of the fault on V491 (from the V.Dur) [km]:	5
Parameters of excitation control and PSS:	
Excitation control:	
proportional gain k_p:	20
integral gain k_i:	4
PSS:	
on/off	☐
from output active power P_e:	
gain k_1:	0.3
time constant T_1:	0.02
time constant T_2:	0.3
from frequency ω_e:	
gain k_2:	20
time constant T_3:	0.02
time constant T_4:	0.22
from field current I_f:	
gain k_3:	0.15
time constant T_5:	0.02
time constant T_6:	0.35
Step change of setpoint	
Step change of setpoint V_{set}:	0.02
Time of step change t_{set}:	5
	Start simulation

Fig. 3.1. Interface for setting the parameters

It is possible to set the parameters of the excitation control and power system stabilizer in the block of EMO21. Another possibility is to set the type of the fault. This may be a step change of the voltage setpoint on EMO21 or fault on line V491. The parameters are described by figures 2.2, 2.3 a 2.4. The first and the oldest experiment was a simulation of three phase fault on line V491. In this simulation you can set whether there will be a phase to phase fault,

a ground fault or a three phase fault; the distance in kilometers where the fault appears on the line; and the time when the fault begins and ends. Another possible experiment is the change of the voltage setpoint on the block EMO21, with defined parameters of the excitation control and power system stabilizer of this block. After you have entered the parameters and set the model you can start the simulation pushing the button "Start simulation".

When the simulation ends the calculation script returns back to the web interface for plotting the graphs. Here you can generate the graph from the simulated datas. The observed values are: voltage, current and active and reactive power before and behind the line V491 and in fault location, which we advice to use when you simulate faults. You can decide what kind of preview of the simulated values, divided by the location of the measurement, is going to be shown, or choose which simulated values have to be plot into one graph.

Preview after simulation of the fault			
Behind the line ▾		Generate graph	
Select variables for graph			
Before the line			
	Phase 1	Phase 2	Phase 3
V	□	□	□
I	□	□	□
P	□	Q	□
In fault location			
	Phase 1	Phase 2	Phase 3
V	□	□	□
I	□	□	□
P	□	Q	□
Behind the line			
	Phase 1	Phase 2	Phase 3
V	□	□	□
I	□	□	□
P	□	Q	□
		Generate graph	

Fig. 3.2. Input interface of the graph generation

Another possibility is to observe the values of the synchronous machine EMO21 such as voltages, currents electrical power and torque. We advice to plot these variables when you have experimented with the excitation control from the block EMO21. Setting the graphical output is like in the generating graph after simulation of the fault.

After you pushed the button *Generate graph* matlab the webserver launches the output

scripts, which generate the graph from the written data on server that have been written with the unique identifier *mlid*. We used this method because the data could not be rewritten and it permits a work of several users on server in the same time. You can set eight different graphs on one figure, where each of the graphs has its own colour. A description of each colour is written in the graph legend. After the graph has been generated the name of the file contains the identifier mlid, like file with simulated datas. Finally this graph is shown on the output web page in jpeg format.
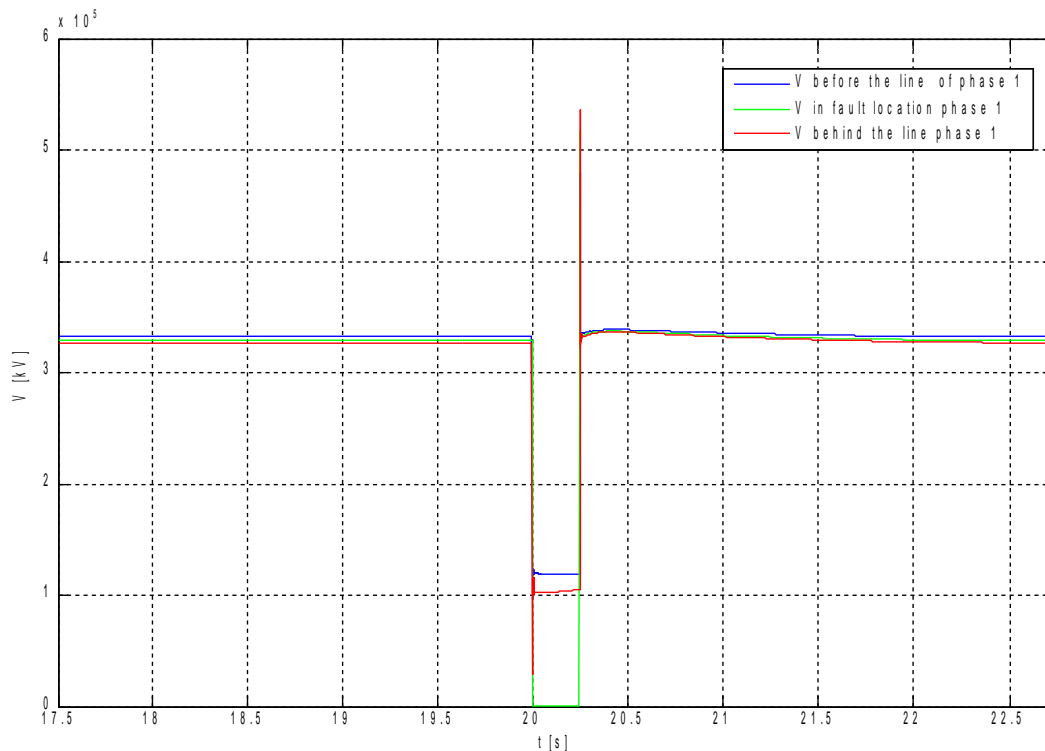

Fig. 3.3. Generated graph after experiment of phase to ground fault in time 20 s with duration of 250 ms

Standard parameters of the excitation control and the PSS are shown in the tables: tab. 3.1 a 3.2.

Parameter	Value
k_p	20
k_I	4

Tab. 3.1 Parametres of PI regulator na EMO21

	Parameter	Value
Feedback of active power - P	k_1	0.3

	Parameter	Value
	T_1	0.02
	T_2	0.3
Feedback of frequency napätia - ω	k_2	20
	T_3	0.02
	T_4	0.22
Feedback of the field current prúdu I_b	k_3	0.15
	T_5	0.02
	T_6	0.35

Tab. 3.2 Parameters of PSS3b on EMO21

Parametres of simulation	Value
Time - t [s]	30
Fault time [start stop] - t_s [s]	[20 20.25]
Distance of fault [km]	5

Tab. 3.3 Simulation parameters

Phase	Status
Phase 1	Off
Phase 2	Off
Phase 3	Off
Ground	Off

Tab. 3.4 Faulting of phases on line V491

4. Conclusion

In this paper we intended to make the education of Power Engineering more attractive. Visitor could easy learn how to tune excitation control (PI controller and PSS) and realize experiments, which could not be realized in the real world (three phase fault) and observe the effect of this fault in power system. One part of the above mentioned laboratory dedicated to the Power Engineering education is going to be used in the education process on FEI STU. Other parts of the laboratory are under construction and this expansion is supported by the grant KEGA 3/3075/05.

5. Reference

[1]   Mathworks: Getting started with Matlab, version 7.1, 2005

[2]   Mathworks: Getting started with Simulink, version 6, 2005

[3]   Mathworks: Using Simulink, version 6, 2005

[4]   Mathworks: Matlab Web Server, version 1, 2005

[5]   Mathworks: SimPowerSystems User's Guide, version 4, 2005

[6]   Broža, P.: Programování www stránek pro úplné začátečníky, Praha, computer
press,   2000, 172

[7]   Foltin, M., Bartoš, S., Kollárčík, M., Sekaj, I.: Budobvanie virtuálneho laboratória
a   návrh regulátorov cez sieť. 11. ročník konference MATLAB 2003. Praha,
Česká   republika: 25.11.2003, s. 126-130.

Contacts

www.vr-lab.info/energo

martin.foltin@stuba.sk