Title: Modelling and Simulation of 4 Machine 10 bus system using OpenModelica and OpenIPSL

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Abstract: The power system model shall be used to study the voltage stability at different buses. The power system model consists of 4 generators, 10 buses, 2 constant PQ loads, 11 lines, 4 transformers, and 2 Shunt admittances. The system is on a 100 MVA base. The submitted model implemented in OpenModelica language using OpenIPSL package shown in Figure 1. The model represents presents scenario of fault at load bus 10 for the duration of 0.4 seconds (4 seconds to 4.4 seconds) and cases of line trip at one of the lines between bus 5 to bus 6 and one of the lines from bus 9 to 10 at different intervals of time. For all analysis of this system, the lower voltage magnitude limits at all buses are 0.95 p.u. and upper limits are 1.05 p.u. Simulation obtained shows voltage profiles at various buses for different buses in different cases..

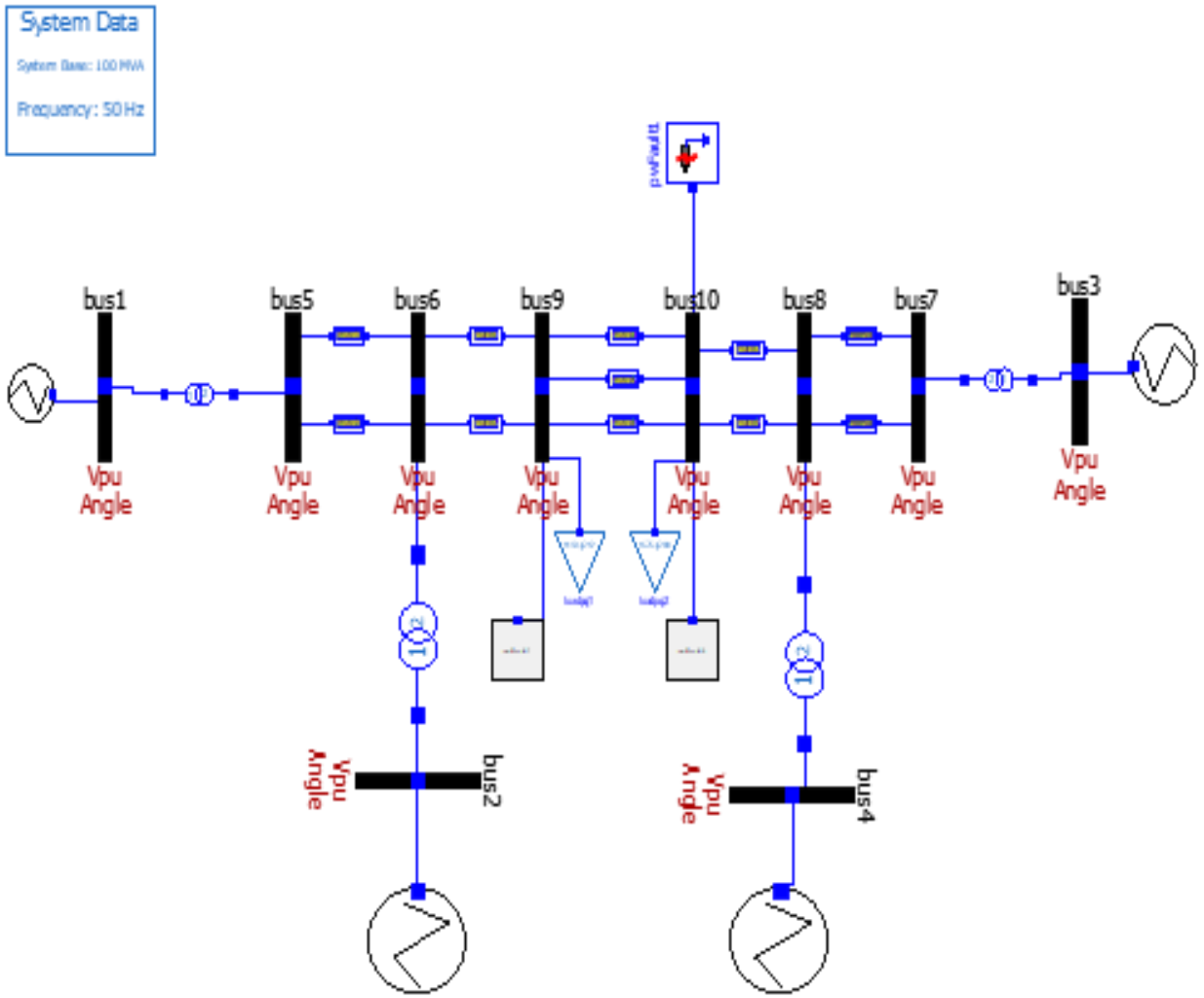

Figure 1: Implementation of 4 Machine 10 bus system using OpenModelica and OpenIPSL.

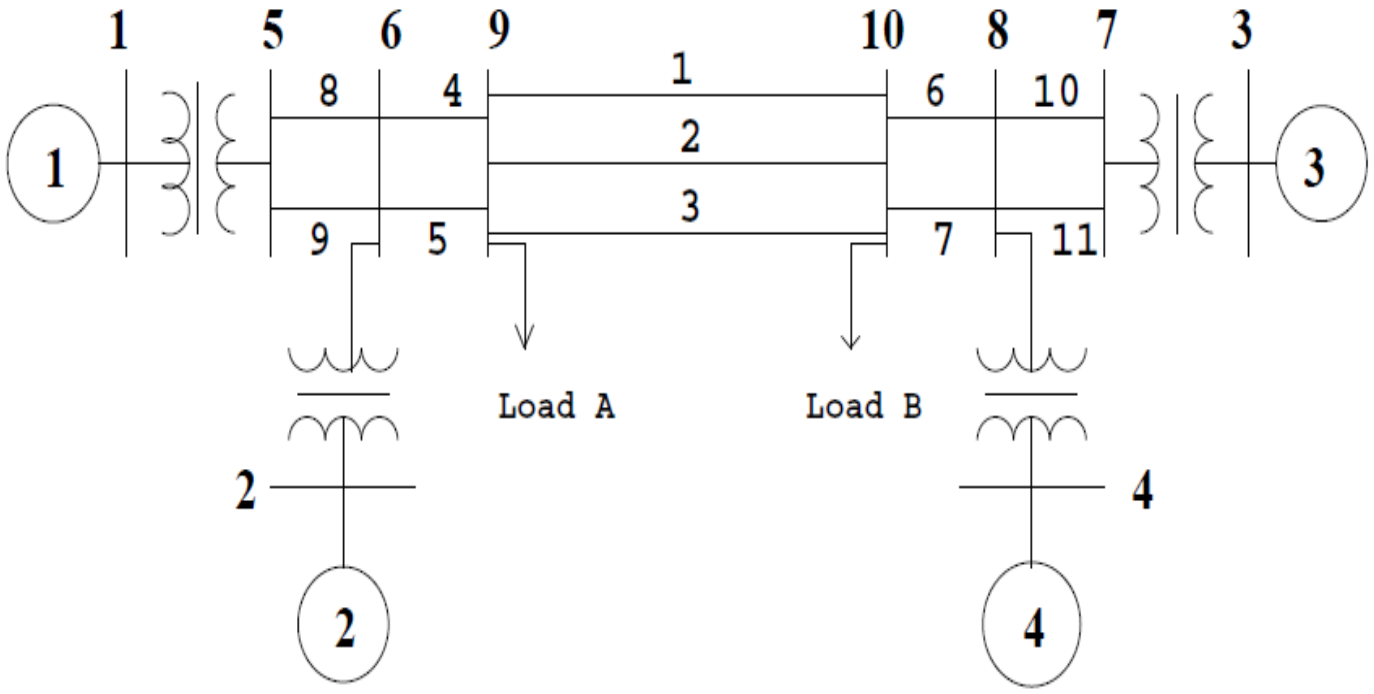

Figure 2: Single line diagram (SLD) of 4 Machine 10 bus system.

Explanation:

This model uses the following components:

Component Name	Class Path	Number
Two Winding Transformer	OpenIPSL.Electrical.Branches.PSAT.TwoWindingTransformer	4
Three phase fault	OpenIPSL.Electrical.Events.PwFault	1
Constant PQ Load	OpenIPSL.Electrical.Loads.PSAT.LOADPQ	2
Generators	OpenIPSL.Electrical.Machines.PSSE.GENROU	4
Steam Turbine-Governor	OpenIPSL.Electrical.Controls.PSSE.TG.TGOV1	4
Excitation System	OpenIPSL.Electrical.Controls.PSSE.ES.ESDC1A	4
Buses	OpenIPSL.Electrical.Buses.Bus	10
PwLine	OpenIPSL.Electrical.Branches.PwLine	11
Shunt Admittance	OpenIPSL.Electrical.Banks.PwShuntB	2
Sysdata block	OpenIPSL.Electrical.SystemBase	1

Table 1: Components used in system

The 4 Machine 10 bus system model implemented in OpenModelica language using OpenIPSL package, is used to study the voltage stability at different buses. The system is on a 100 MVA base. For all analysis of this system, the lower voltage magnitude limits at all buses are 0.95 P.u. and upper limits are 1.05 P.u. The type of generator used is a “round rotor generator model (quadratic saturation)”. The generator models in the implemented network use turbine governor and excitation system.

Case I: A fault applied at load bus

A fault is simulated for the duration of 4 to 4.4 seconds at the 10th bus. During the fault, we can observe from the bus voltage profiles, that the voltage dip is more for the 10th bus as it is the fault bus and the severity of the fault decreased as we move away from the fault bus. The simulation shows profiles at various buses and waveforms obtained are observed.

The simulation result of all 10 Bus voltages shown below.

Bus no.	Bus Voltage magnitude (p.u.)
1	1.04711
2	1.03005
3	1.04841
4	1.03174
5	1.04566
6	1.02832
7	1.04701
8	1.02996
9	1.0213
10	1.02202

Table 2: Bus voltage magnitude (p.u.) of all buses obtained

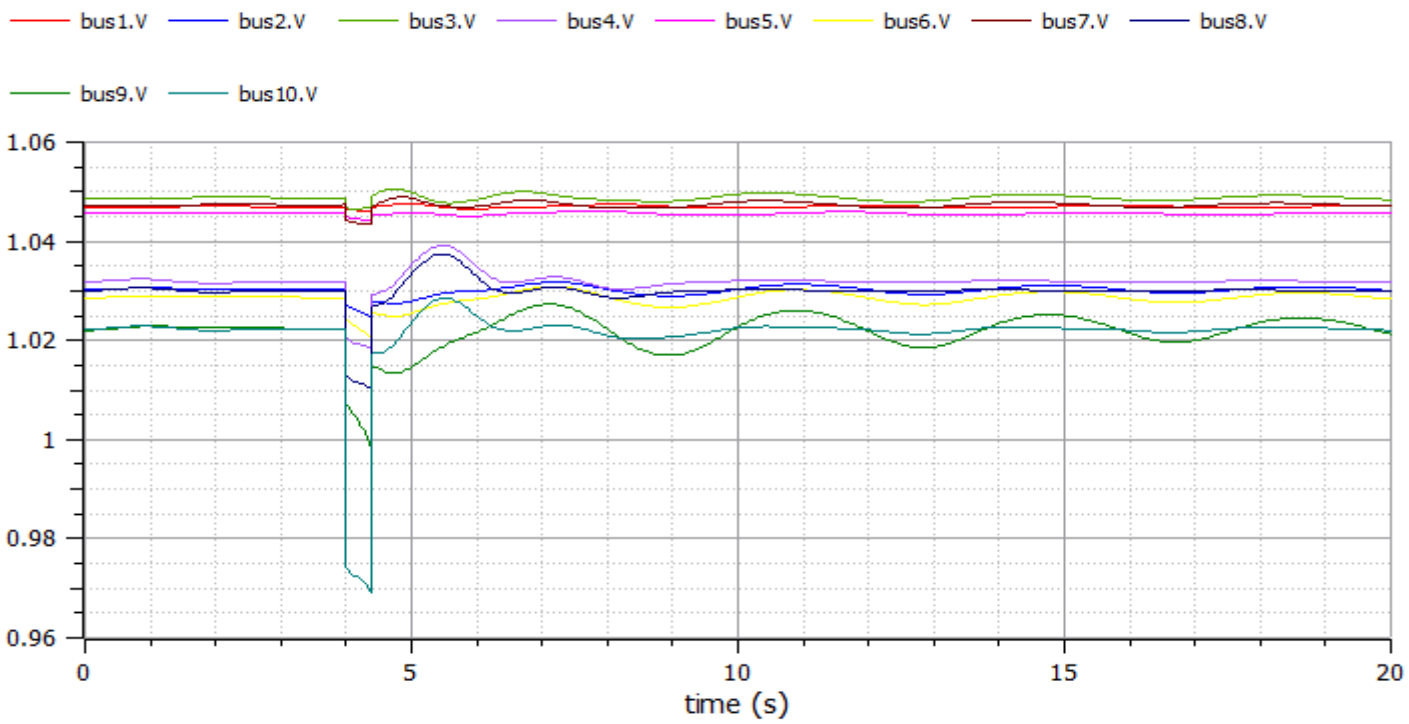

Figure 3: The voltage profiles of simulated 4 Machine 10 bus system

Case II: Transmission line trip

In this case, a transmission line is tripped at one of the lines between bus 5 to bus 6 from 3 to 3.4 seconds and one of the lines between bus 9 and 10 at 7.6 to 8 seconds. During the line trip at line 8 between 5 and 6, we can observe from the bus voltage profiles given in figure 4, that the voltage dip is not only for those respective buses but voltage dip is observed in a maximum number of buses as they were getting power supply from generator 1. During the line trip at line 1 between 9 and 10, we can observe from the bus voltage profiles given in figure 5, that the voltage dip decreased as we move away from the affected buses. Simulation obtained shows profiles at various buses and waveforms obtained are observed.

The simulation result of all 10 Bus voltages shown below.

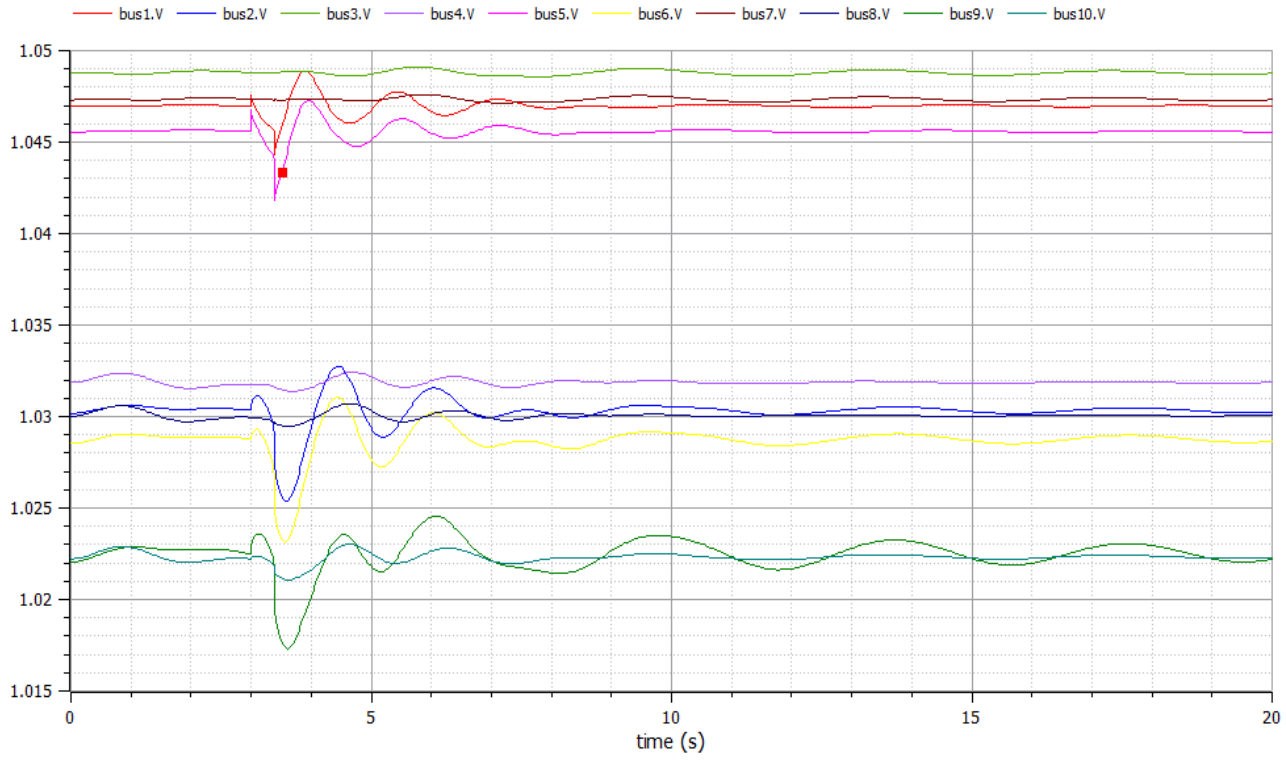

Figure 4: The voltage profiles of simulated 4 Machine 10 bus system

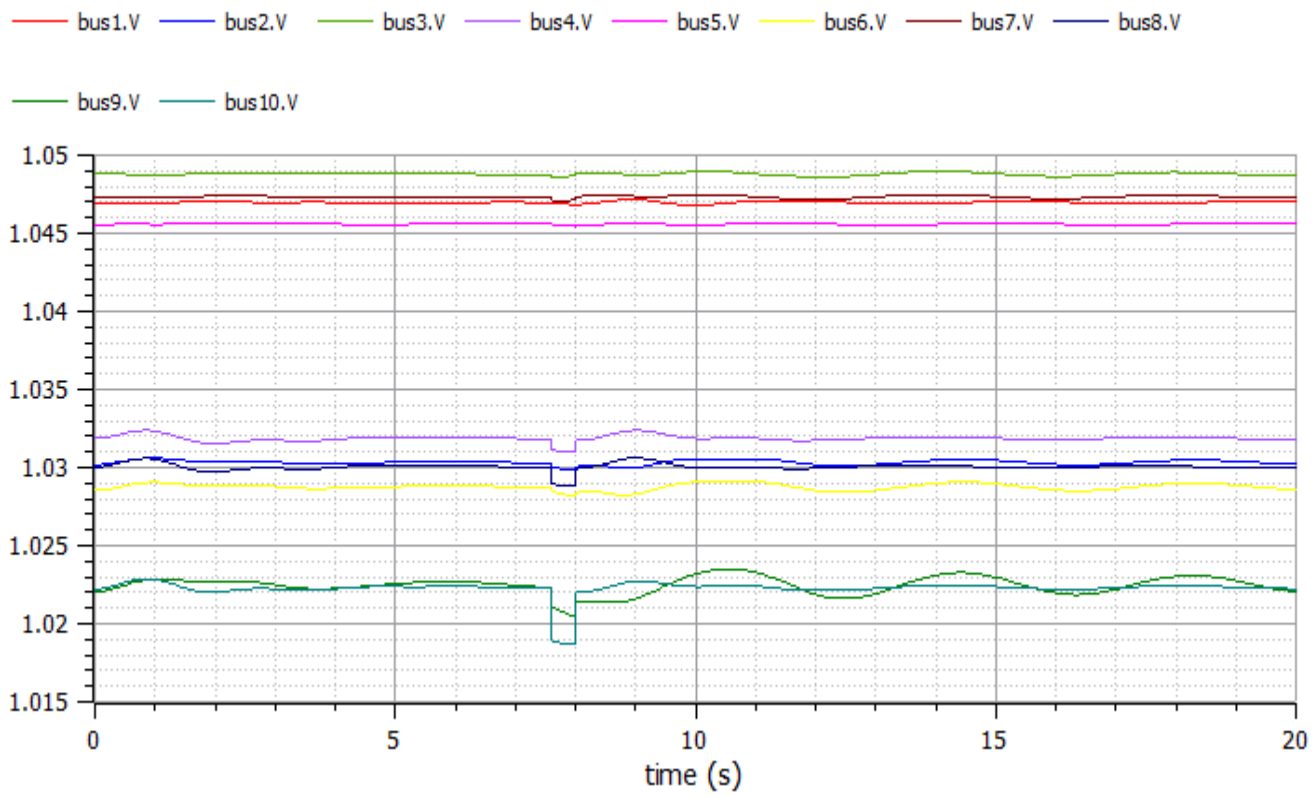

Figure 5: The voltage profiles of simulated 4 Machine 10 bus system

Conclusion:

The implemented 4 machine 10 bus system in Modelica represents the cases of system behaviour. In case 1 depicts voltage before and after the fault occurs at the 10^{th} bus. In case 2 represents voltage behavior during transmission line at different places at different intervals of time. During all study cases Bus voltage magnitudes (p.u.) of all 10 buses obtained are found to be between 0.95 p.u and 1.05 p.u. The relation between line impedance and fault severity observed.