

Title: Modelling and simulation of 51 bus system using OpenModelica and OpenIPSL

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Abstract:

The 51 bus system is used to study the voltage stability at different busses by designing and simulating the power system in OpenModelica language using OpenIPSL Library .The designed power system model consist of 12 generators connected to Automatic Voltage Regulator (AVR), 15 transformers, and 30 loads. The system is on a base of 100 MVA. The submitted model is shown in Figure 1.

The designed system is subjected to the following conditions , and the voltage stability of the power system at these conditions are being observed.

1. The field voltage to the generator at bus 1 is disturbed by changing the reference voltage in AVR at a particular time.
2. A balanced three-phase to ground fault is simulated at Bus 28 between 4 to 4.4 seconds.

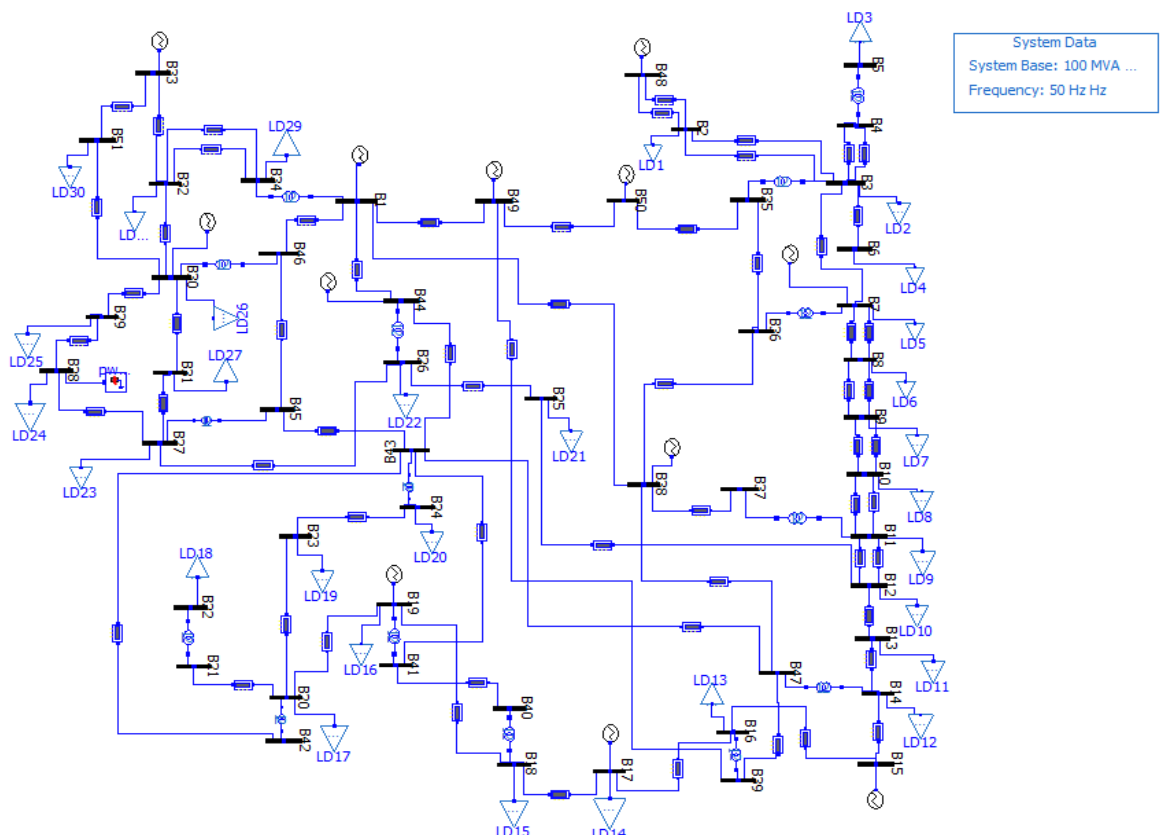


Figure1 Modelling of 51 bus power system in OpenModelica using open IPSL

Explanation:

The model uses the following components:

Component Name	Class Path	Number
Automatic Voltage Regulator (AVR)	OpenIPSL.Electrical.Controls.PSAT.AVR.AVRTypeII	12
Two Winding Transformer	OpenIPSL.Electrical.Branches.PSAT.TwoWindingTransfoer	15
PQ Load	OpenIPSL.Electrical.Loads.PSAT.LOADPQ	30
Generator (orderVI)	OpenIPSL.Electrical.Machines.PSAT.Order6	12
Bus	OpenIPSL.Electrical.Buses.Bus	51
PwLine	OpenIPSL.Electrical.Branches.PwLine	62
Switch	Modelica.Blocks.Logical.Switch	1
Pulse	Modelica.Blocks.Sources.Pulse	1
Boolean constant Block	Modelica.Blocks.Sources.BooleanConstant	1
System Data Block	OpenIPSL.Electrical.SystemBase	1

Table 1 Components used in the modeling

The 51 bus power system is being implemented in the modelica language to study the voltage stability of the buses in the system at different conditions. The system has a base of 100 MVA and a voltage base of 11KV

Case1: Introducing a *Balanced three phase to ground fault in the power system.*

In this model a balanced three phase to ground fault is being simulated at the bus 28 for a time period of 0.4 seconds (4 seconds to 4.4 seconds) in the total simulation time of 20 seconds. The type of generator used is synchronous generator of order 6 and which is connected to AVR of type II. From the simulated result it is observed that during the time of fault a voltage drop occurs at all the buses, but the voltage drop at the generator buses are minimum or negligible since the generators are connected to AVR. The voltage profile of the power system during fault is shown in Figure2. It shows that the voltages of all the buses are between 1.08 p.u to 0.9 p.u. The maximum fault voltage occurs at the faulted bus28. Since the generators in the system are connected to Automatic Voltage Regulator (AVR) the oscillation of voltage after fault is reduced.

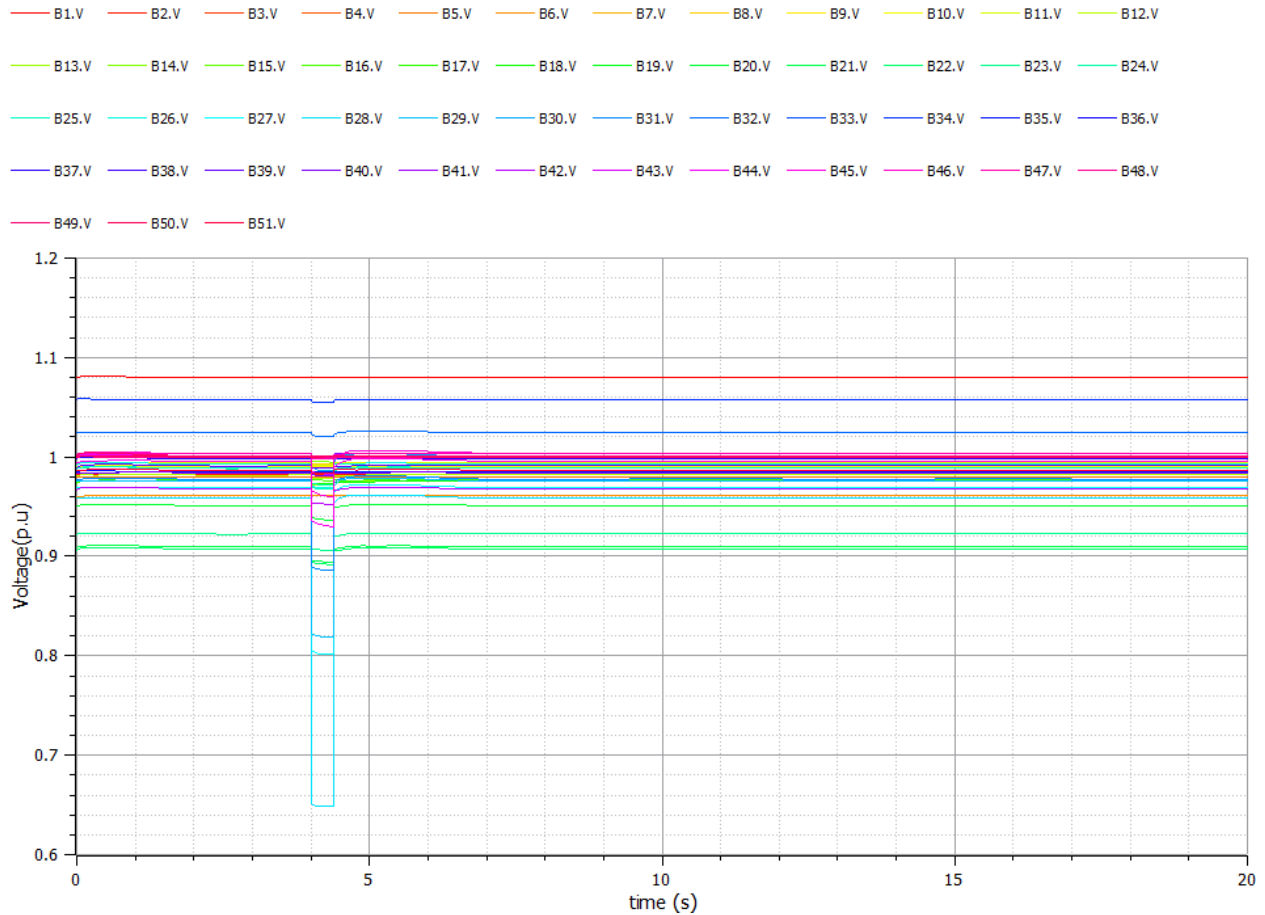


Figure2 Voltage profile of all buses during fault

Case2: Introducing disturbance signal to reference voltage of AVR

In this model a unit pulse signal is being given to reference voltage of AVR connected to the generator at bus1. This pulse wave signal is given from a pulse generator as shown in Figure3. The voltage profiles of all the buses during the AVR disturbance is shown in figure4. Due to the effect of the unit pulse signal which starts at 7th second the voltage at the buses increase rapidly to a end of high amplitude of the pulse and then it start decreasing. It is not becoming stable immediately after the pulse, since the disturbance is given to the AVR. This oscillation can be stopped by adding additional power system stabilizer to the generator. The voltage of the generator buses other than bus1 remains almost constant, since it is already connected to the AVR.

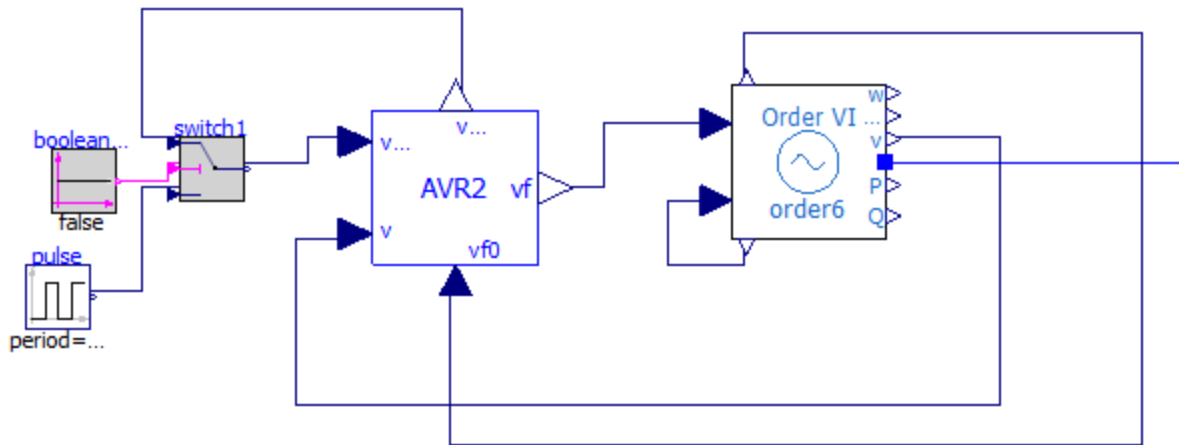


Figure3 AVR and Generator Connection along with AVR disturbance

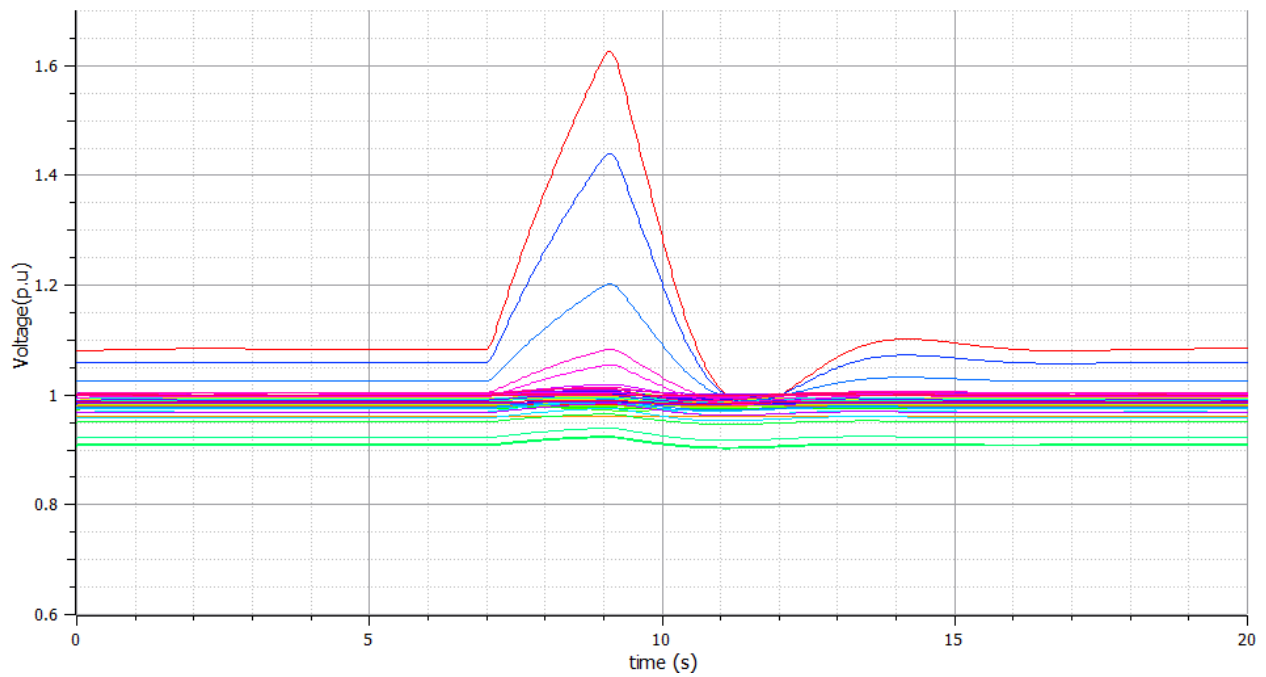
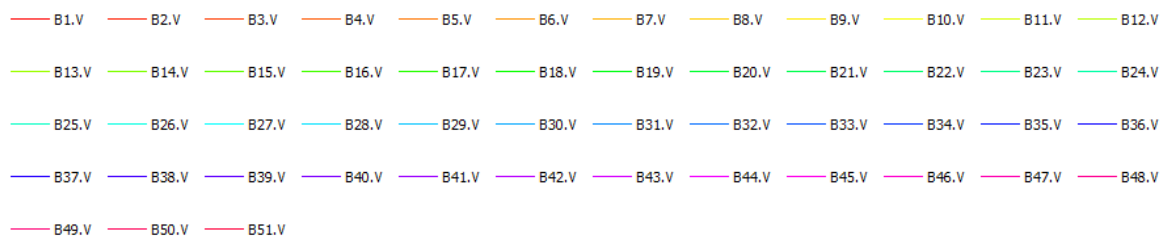


Figure4 Voltage profile of all buses during AVR disturbance

	Voltage magnitude of all buses (Case:1)			Voltage magnitude of all buses (Case:2)		
Bus	Pre-fault voltage (p.u.)	Voltage during fault (p.u.)	Post-fault voltage (p.u.)	Voltage before AVR disturbance (p.u.)	Voltage during AVR disturbance (p.u.)	Voltage after AVR disturbance (p.u.)
1.	1.08018	1.0796	1.08018	1.08424	1.62537	1.08424
2.	0.982657	0.982611	0.982657	0.982649	0.982755	0.982649
3.	0.980352	0.980317	0.980352	0.980341	0.980533	0.980341
4.	0.980187	0.98015	0.980187	0.980176	0.980363	0.980176
5.	0.980184	0.980146	0.980184	0.980173	0.980365	0.980173
6.	0.960838	0.960801	0.960838	0.960826	0.951024	0.960826
7.	0.999932	0.999895	0.999932	0.99991	1.000012	0.99991
8.	0.994202	0.993863	0.994202	0.993916	0.994597	0.993916
9.	0.991429	0.990508	0.991429	0.990639	0.992225	0.990639
10.	0.991916	0.990456	0.991916	0.990645	0.993068	0.990645
11.	0.995881	0.993782	0.995881	0.994073	0.997423	0.994073
12.	0.985337	0.981642	0.985337	0.986521	0.98187	0.986521
13.	0.984667	0.981012	0.984667	0.975449	0.980924	0.975449
14.	1.00125	0.997879	1.00125	0.999026	1.00668	0.999026
15.	0.999916	0.999863	0.999916	0.999902	1.00017	0.999902
16.	0.980196	0.97862	0.980196	0.977364	0.978468	0.977364
17.	1.00001	0.999983	1.00001	1.00001	1.00008	1.00001
18.	0.976026	0.973261	0.976026	0.975791	0.978032	0.975791
19.	1.00006	0.999845	1.00006	1.00006	1.00026	1.00006
20.	0.951559	0.936711	0.951559	0.951427	0.965074	0.951427
21.	0.910115	0.89418	0.910115	0.909974	0.924669	0.909974
22.	0.9079	0.892082	0.9079	0.907759	0.922623	0.907759
23.	0.922882	0.90577	0.922882	0.922742	0.939687	0.922742
24.	0.989166	0.971497	0.989166	0.989029	1.00727	0.989029
25.	0.989494	0.969137	0.989494	0.988681	0.995205	0.988681
26.	0.993363	0.970164	0.993363	0.993031	0.999887	0.993031
27.	0.969308	0.801635	0.969308	0.969398	0.992383	0.969398
28.	0.958761	0.648625	0.958761	0.958821	0.975722	0.958821
29.	0.97581	0.819299	0.97581	0.958821	0.985932	0.958821
30.	1.00003	0.986104	1.00003	1.00003	1.00423	1.00003
31.	0.97783	0.886648	0.97783	0.977875	0.991246	0.977875
32.	1.0247	1.0204	1.0247	1.02603	1.20235	1.02603
33.	1.00023	1.00005	1.00023	1.00023	1.0027	1.00023
34.	1.05715	1.05525	1.05715	1.06003	1.44032	1.06003
35.	0.985324	0.98527	0.985324	0.985203	0.98826	0.985203
36.	0.999919	0.999822	0.999919	0.999826	1.00267	0.999826

37.	0.99853	0.998027	0.99853	0.998236	1.00455	0.998236
38.	1.00059	1.00035	1.00059	1.00057	1.00711	1.00057
39.	0.992213	0.99017	0.992213	0.990927	0.999778	0.990927
40.	0.984526	0.981411	0.984526	0.984341	0.9872	0.984341
41.	1.00332	0.998636	1.00332	1.00325	1.00951	1.00325
42.	0.968444	0.952622	0.968444	0.968322	0.984674	0.968322
43.	1.00072	0.983027	1.00072	1.00059	1.01964	1.00059
44.	1.00059	0.998997	1.00059	1.00059	1.0055	1.00059
45.	0.996113	0.930306	0.996113	0.996446	1.05459	0.996446
46.	1.00405	0.960328	1.00405	1.00458	1.08345	1.00458
47.	1.00406	0.998866	1.00406	1.00311	1.01395	1.00311
48.	1.00003	1.00002	1.00003	1.00003	1.00014	1.00003
49.	1.00103	1.00044	1.00103	1.00029	1.01169	1.00029
50.	1.0002	1.000001	1.0002	1.00029	1.00074	1.00029
51.	0.986869	0.982548	0.986869	0.986871	0.990117	0.986871

Table 2 Voltage magnitude of all the buses in p.u

Conclusion:

The implemented 51 bus model in OpenModelica represents the system behavior before and after the fault occurs at the 28th bus. It also represents the behavior of the system when the field voltage to the generator of bus1 is changed by changing the reference voltage of the AVR. Bus voltages of the all the 51 buses is found to be between 1.1 p.u to 0.9 p.u.