Title: Modelling of 10 bus system using Modelica and OpenIPSL

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Abstract:

The 10-bus power system(Glover's text book Case) has seven generating units,ten buses, nine transmission lines (PwLine) lines, and four transformers. The system base is 100 MVA and bus 1 is considered as a swing bus. A three-phase balanced fault is simulated in one of the buses for the duration. The purpose of this power system simulation is to study the voltage stability at multiple buses.
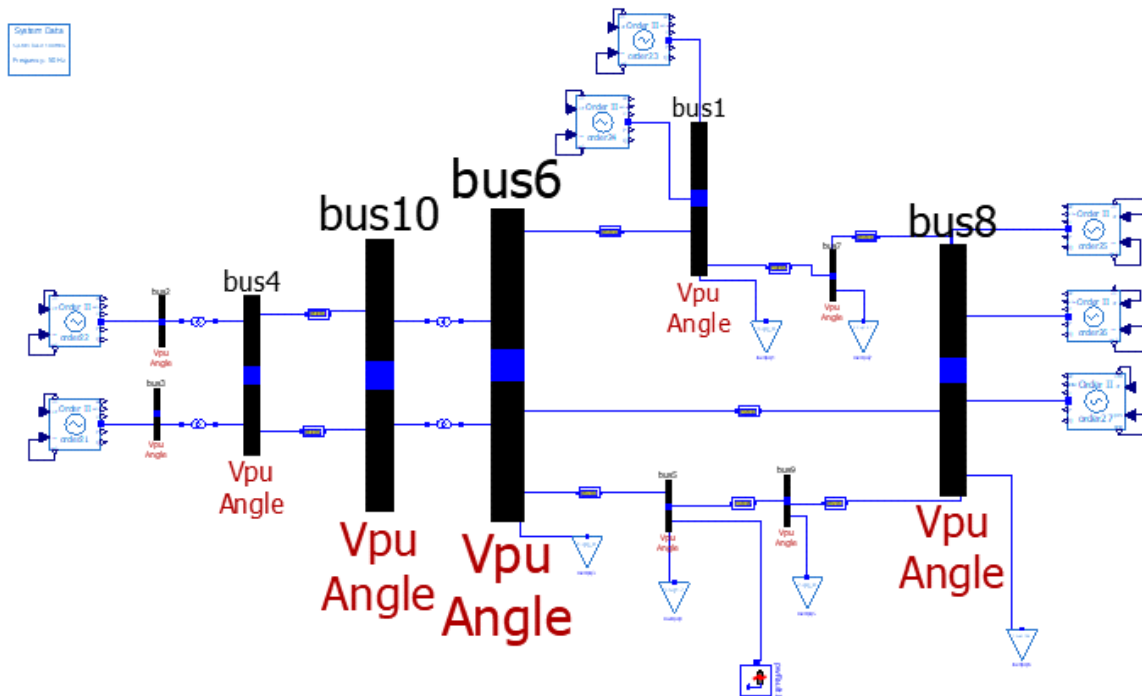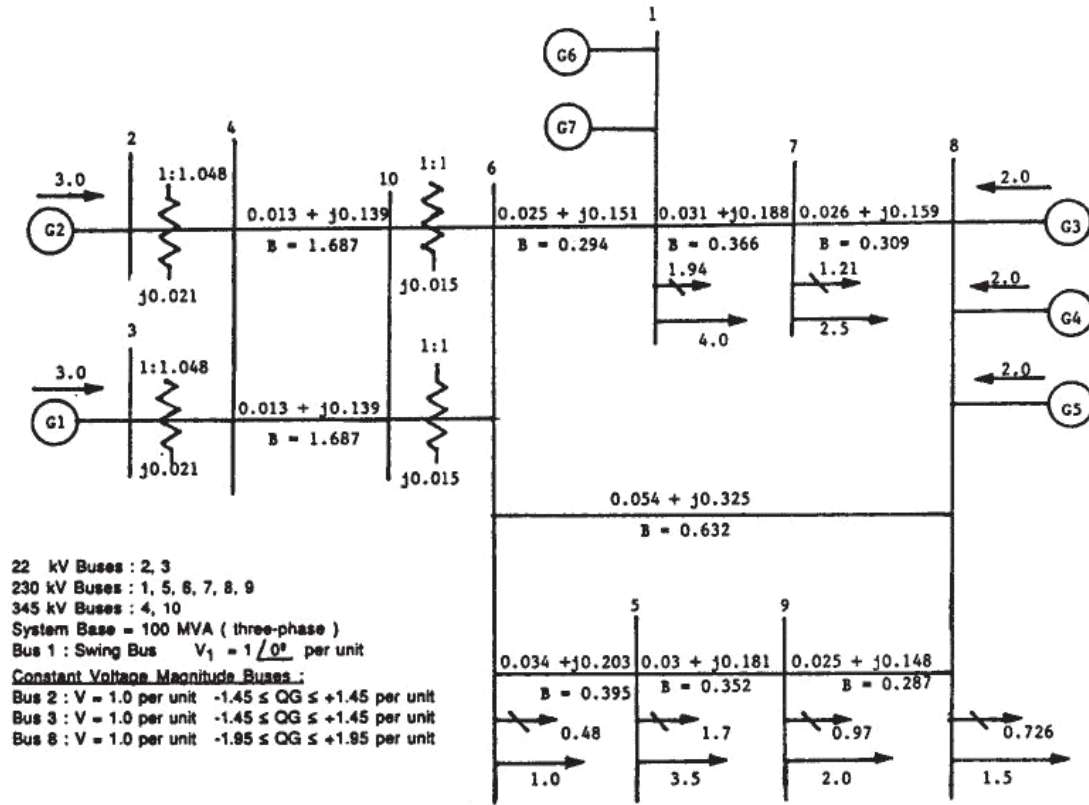

Figure 1: Implementation of 10 bus system using Modelica and OpenIPSL.

Figure content:

1

G6

G7

2
3.0
G2
1:1.048
j0.021

4
10
0.013 + j0.139
B = 1.687

1:1
j0.015

6
0.025 + j0.151
B = 0.294

0.031 + j0.188
B = 0.366
1.94

0.026 + j0.159
B = 0.309
1.21

7

8

2.0
G3

2.0
G4

4.0

2.5

3
3.0
G1
1:1.048
j0.021

0.013 + j0.139
B = 1.687

1:1
j0.015

0.054 + j0.325
B = 0.632

2.0
G5

5
9

0.034 + j0.203
B = 0.395
0.48
1.0

0.03 + j0.181
B = 0.352
1.7
3.5

0.025 + j0.148
B = 0.287
0.97
2.0

0.726
1.5

22 kV Buses : 2, 3
230 kV Buses : 1, 5, 6, 7, 8, 9
345 kV Buses : 4, 10
System Base = 100 MVA (three-phase)
Bus 1 : Swing Bus $V_1 = 1 \angle 0°$ per unit
Constant Voltage Magnitude Buses :
Bus 2 : V = 1.0 per unit   -1.45 ≤ QG ≤ +1.45 per unit
Bus 3 : V = 1.0 per unit   -1.45 ≤ QG ≤ +1.45 per unit
Bus 8 : V = 1.0 per unit   -1.95 ≤ QG ≤ +1.95 per unit

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

Explanation:
This model uses the following components:

Table 1: Components used in system.

Component Name	Class Path	Number
Two Winding Transformer	OpenIPSL.Electrical.Branches.PSAT.TwoWindingTransformer	4
Three phase fault	OpenIPSL.Electrical.Events.PwFault	1
Voltage Dependent Load	OpenIPSL.Electrical.Loads.PSAT.VoltDependant	6
Generator	OpenIPSL.Electrical.Machines.PSAT.Order2	7
Bus	OpenIPSL.Electrical.Buses.Bus	10
PwLine	OpenIPSL.Electrical.Branches.PwLine	9
Sysdata block	OpenIPSL.Electrical.SystemBase	1

 The 10 bus model implemented in Modelica language using OpenIPSL package, is used to study the voltage stability at different buses. The system is on 100 MVA base. For all analysis of this system, the lower voltage magnitude limits at all buses are 0.9 p.u. and upper limits are 1.1 p.u. The type of generator used is second order

synchronous machine. A fault is simulated for the duration of 3.5 to 4 seconds at the 5th bus. During the fault, we can observe from the bus voltage profiles, that the voltage drop is more for the 5th bus as it is the fault bus and the severity of the fault is decreased as we move away from the fault bus.At the pw line 1 perturbation parameters for t1 and t2 provided as 7 and 7.5 seconds for opening which can be seen in below waveforms. Simulation obtained shows profiles at various buses and waveforms obtained are observed.

The simulation result of the all 10 Bus voltages shown below.
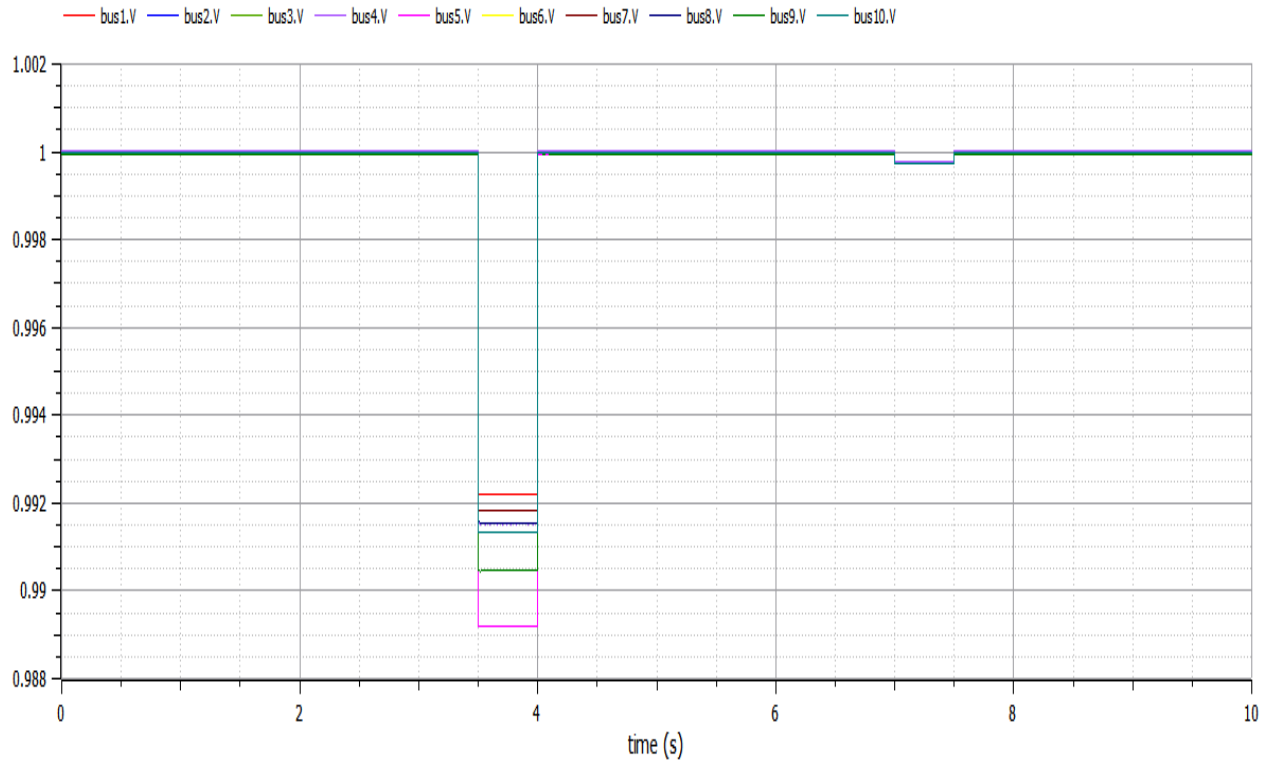
Figure 3: The voltage profiles of simulated 10 bus.

Bus no.	Bus Voltage magnitude (p.u.)
1	0.99997
2	1.00002
3	1.00002
4	1.00002
5	0.99995
6	0.99999
7	0.99996
8	0.99997
9	0.99996
10	0.99999

Table 2: Bus voltage magnitude (p.u.) of all 10 buses.

Conclusion:

The implemented 10 bus model in Modelica represents the system behaviour before and after the fault occurs at the bus 5. Bus voltage magnitude (p.u.) of all 10 buses obtained are found to be between 0.9 p.u and 1.1 p.u. The voltage stability and fault severity is also observed.