Title: Modelling of a 3-bus system under fault using the OpenIPSL

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Abstract:

The simulation represents power system modelling of a 3-bus system consisting 1 generator of order III at bus 1 and an infinite bus at bus 2. Here, Bus 1 is generator bus, Bus 2 is slack bus and Bus 3 is considered as load bus. Voltage dependent loads are connected at all the buses. PwLine 3 is subjected to a three-phase balanced fault from 20 sec for a duration of 2 sec. The circuit breakers are connected to nullify the effect of fault on the voltage profiles of each bus. The power system model is shown in Figure 1.

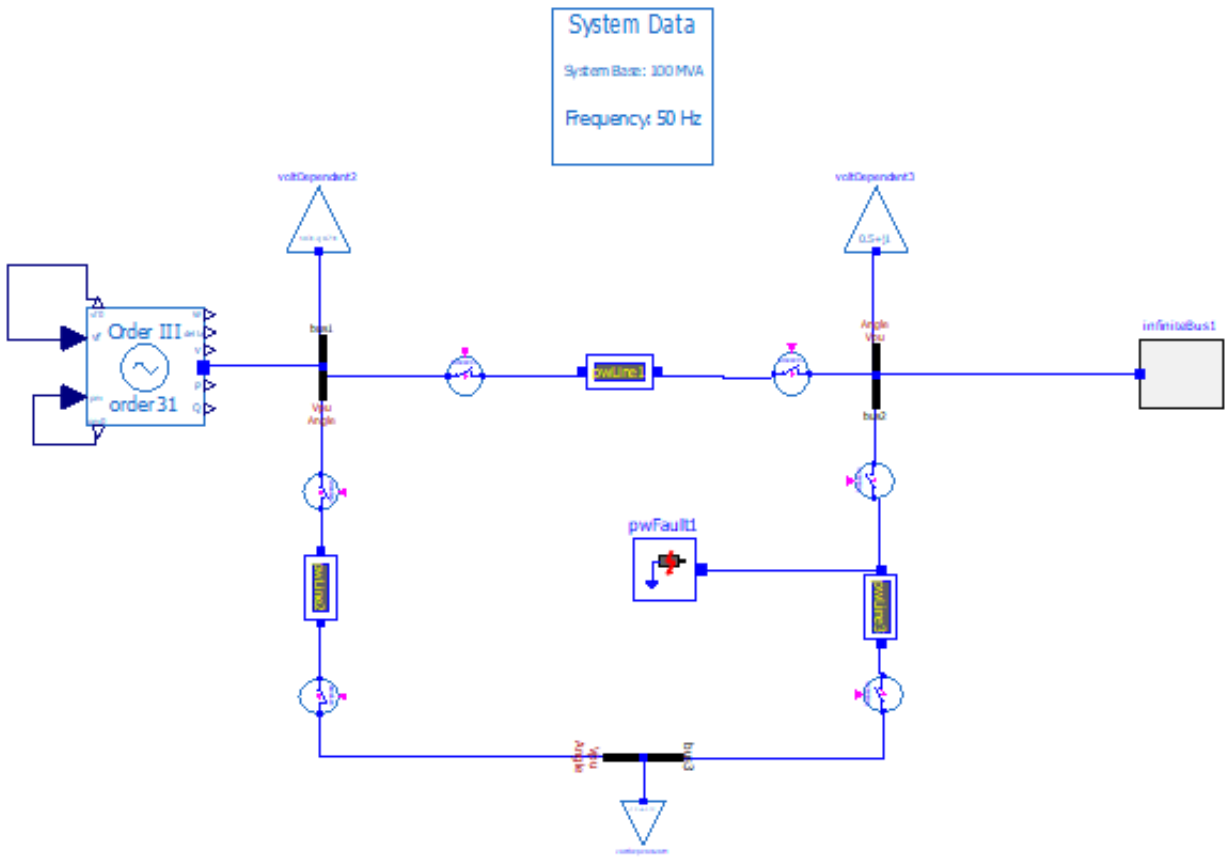

Fig 1. Modelling of a 3-bus power system for a three-phase fault

Explanation:

The above model consists of the following components

Component name	Path	Quantity
Generator (order 3)	OpenIPSL.Electrical.Machines.PSAT.Order3	1
Bus	OpenIPSL.Electrical.Buses.Bus	3
Transmission Line	OpenIPSL.Electrical.Branches.PwLine	3
Load	OpenIPSL.Electrical.Loads.PSAT.VoltDependant	3
System block	OpenIPSL.Electrical.SystemBase	1
Infinite bus	OpenIPSL.Electrical.Buses.InfiniteBus	1
Three phase fault	OpenIPSL.Electrical.Events.PwFault	1
Circuit breaker	OpenIPSL.Electrical.Events.Breaker	6

The system is subjected to following conditions

1. Introducing a three-phase balanced fault at the power line 3 starting from 20 sec for duration of 2 sec.
2. Opening and reclosing of circuit breaker between bus 2 and power line 3.

The outputs under above conditions are observed and explained.

Case 1: Simulating the three-phase fault at power line 3

In this model, the balanced three-phase fault is simulated at power line 3 for a duration of 2 sec starting from 20 sec. The voltage profiles of all the buses under the fault are plotted (refer to figure 2).

During the fault, we can observe from the bus voltage profiles that the severity of fault is maximum at bus3 i.e. load bus, minimum at bus1 i.e. generator bus and has no effect at slack bus. It is observed that the voltage is stabilized after the fault is cleared. We can also observe that even after the fault is cleared the system consists of persistent oscillations in its voltage profile. These oscillations can be damped by using additional controllers like, Turbine governor (TG), Power system stabilizers (PSS) and Automatic Voltage Regulator (AVR) on the generator's side.

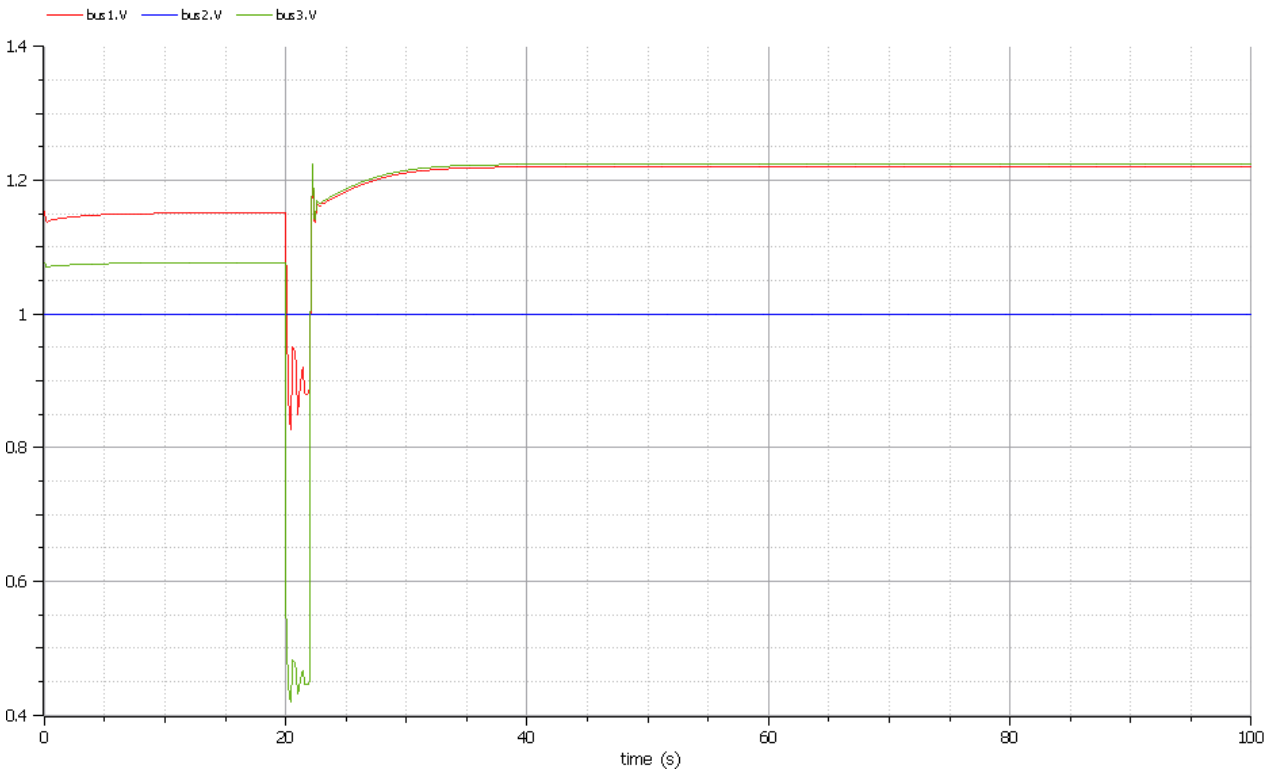

Fig 2. Voltage profile of the buses during three phase fault

Case 2: Simulation of the circuit breaker between bus 2 and power line 3

In this model, circuit breakers are used to reduce the effect of the three-phase fault on the voltage profile of the system. Among them the circuit breaker between bus 2 and power line 3 is simulated to observe the effect of it on the voltage profile of the buses in the presence of balanced three-phase fault at power line 3 for a duration of 2 sec starting from 20 sec. The voltage profiles of all the buses under the fault in the presence of the enabled circuit breaker are plotted (refer to figure 3).

In the previous case it is observed from the bus voltage profiles that during the fault the voltages of the load bus and the generator bus are dipped. Though dipping was more for load bus, minimum for generator bus and fault has no effect at the slack bus. But in the presence of enabled circuit breaker it is observed that the voltage is stabilized even during the fault and the system is stable. If the circuit breaker is made disabled during the fault then the effect of fault can be clearly visible and the voltage profile of the system becomes same as fig. 2. There exist some initial oscillations in the bus voltages due to the initialization errors.

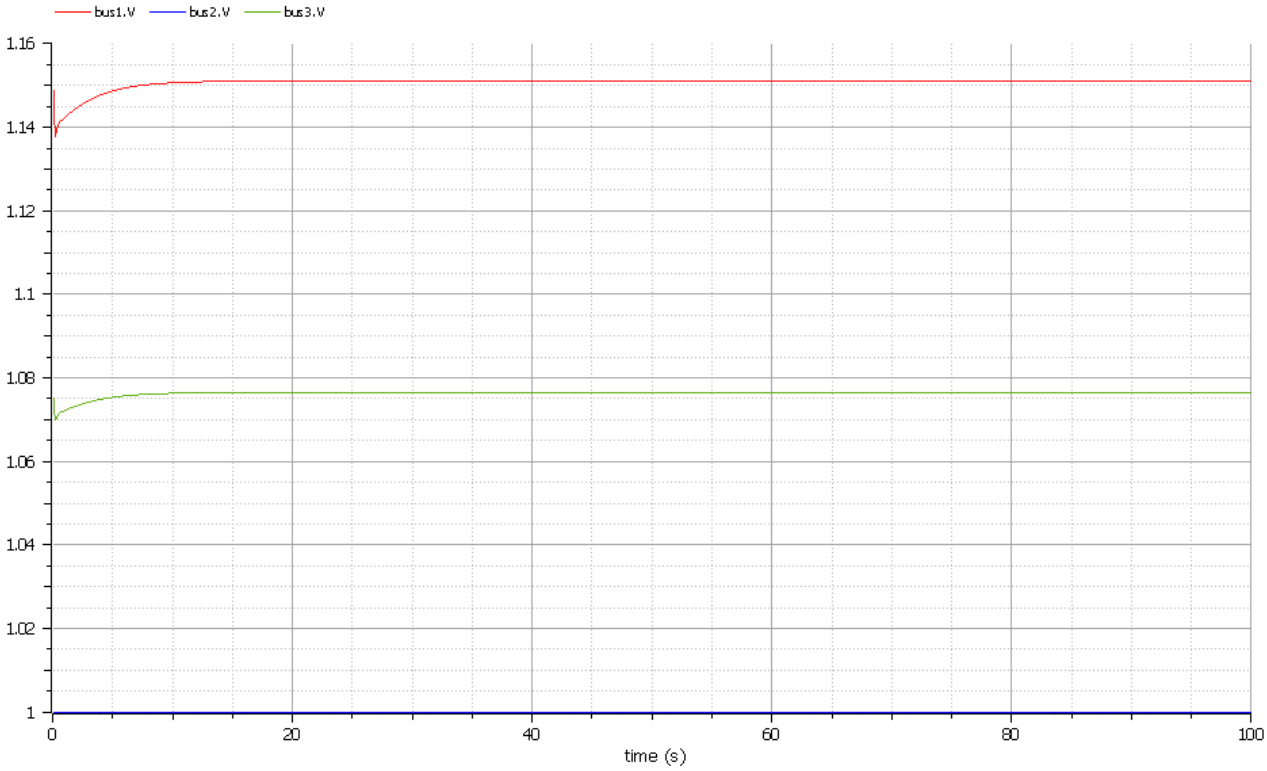

Fig 3. Voltage profile of the buses during three phase fault in the presence of enabled circuit breaker

Conclusion:

The model represents the behavior of the system under a three-phase balanced fault condition and opening and reclosing of the circuit breaker. The relation between enabling of circuit breaker and fault severity is also observed. In the case of a three-phase balanced fault, voltages of all the buses except the slack bus are affected and voltages remain stable at all the buses after the fault is cleared. But during the fault in the presence of enabled circuit breaker there is no effect of fault on the bus voltages, so no dipping occurs in the voltage profile of buses. The generator is an uncontrolled one and hence the system becomes oscillating even after the fault is being cleared. The system can be brought back to the stable condition in less duration by adding more controls such as Power System Stabilizers (PSS), Turbine governor (TG) and Automatic Voltage Regulator (AVR).