Title: Modelling of Benin, Onitsha and Alaoji system (330Kv) using Modelica and the OpenIPSL

Name of the Contributors: Samboju Sai Kiran
Institution/Organization: IIT Bombay(India)
Email:sambojusaikiran@gmail.com

Abstract:

Modelica implementation of a part of the 330Kv Nigerian network, Benin, Onista and Alaoji lines(330Kv) using the OpenIPSL library is shown in Figure 1. The robustness of the power system is largely determined by its response to the disturbances. The transmission lines in the Nigerian network are mostly radial and are overloaded. I considered one of the overloaded lines for my case and subjected it to different conditions and observed the response. The line between Benin and Onitsha is the only line which connects southeastern network with the rest of the network. This can be seen in the single line diagram of the Nigeria 330-kV transmission grid shown in Figure 2. Here there are two transmission lines connected in parallel between Benin and Onitsha out of which the pwline1 is connected to a breaker (which is normally open). Below are the two cases which have been simulated.

1. Closure of pwline1 before the fault.
2. Closure of pwline1 during the fault.

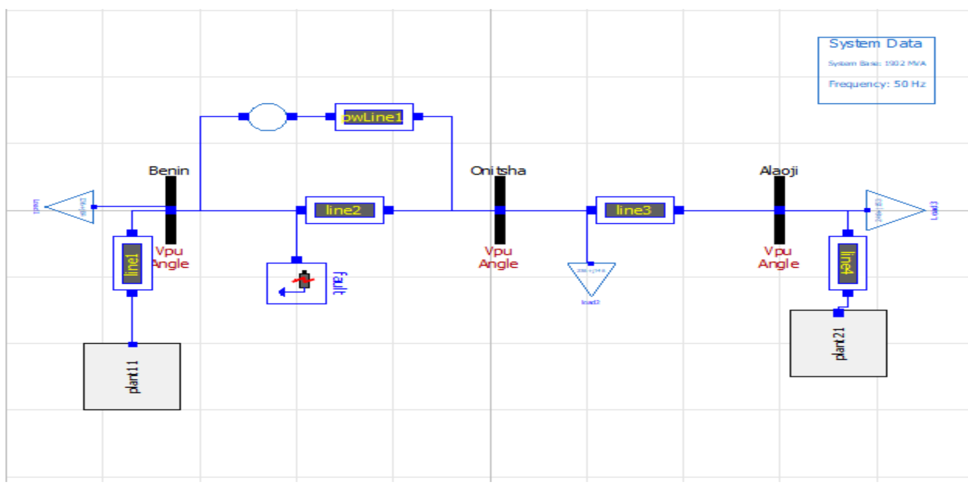


Figure 1: Modelling of Benin, Onitsha and Alaoji lines (330Kv) using Modelica and the OpenIPSL

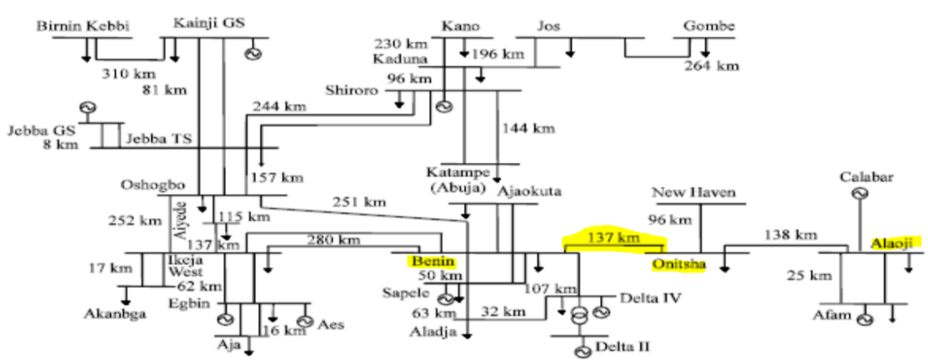


Figure 2: Single line diagram of the Nigeria 330-kV transmission grid

Note: Kindly include all the 3 models (Benin_onisitsha_alaoji_330kv, Benin_onisitsha_alaoji_330kv_V1 and Benin_onisitsha_alaoji_330kv_V2) present in the zip file provided

Explanation:

This model uses the following components

Component Name	Path	Number
Breaker_type_open	Benin_onisitsha_alaoji_330kv_V1.Breaker_type_open	1
Two Winding Transformer	OpenIPSL.Electrical.Branches.PSAT.TwoWindingTransformer	2
Three phase fault	OpenIPSL.Electrical.Events.PwFault	1
PQ Load	OpenIPSL.Electrical.Loads.PSAT.LOADPQ	3
Generator (Order IV)	OpenIPSL.Electrical.Machines.PSAT.Order6	2
Bus	OpenIPSL.Electrical.Buses.Bus	3
PwLine	OpenIPSL.Electrical.Branches.PwLine	5
Sysdata block	OpenIPSL.Electrical.SystemBase	1

In this model, a part of the Nigerian network is considered and the system is subjected to different conditions and the output is observed. The transmission lines in the Nigerian network are mostly radial and there is less number of loops in the network. The line between Benin and Onitsha is one of the line which is overloaded and the only line which connects the southeastern Nigerian network with the rest of the network. This line is subjected to different conditions. A parallel line is introduced with the help of breaker (normally open) and connected in the circuit at two different instances as mentioned below.

Case 1: *Closure of breaker before three-phase balanced ground fault. (refer to Benin_onisitsha_alaoji_330kv_V2)*

The line impedance of pwline1(connected to the breaker) and line2 is equal and connecting them in parallel makes the effective impedance is exactly half of its individual value. The pwline1 is connected in parallel to line2 with the help of a breaker(normally open) which is connected in series with pwline1. The pwline1 is introduced into the circuit between 3 to 4 secs. At 3 secs the breaker is closed and the effective impedance between Benin and Onitsha decreases which results in the rise of the voltage profile of Alaoji and Onitsha buses. The Benin voltage profile also decreases as shown in figure 3. When the breaker is opened at 4 secs the voltage profile is brought back to the previous state. The fault is created at 5 secs and lasts for 2 secs and cleared at 7 secs. During the fault, we can observe from the bus voltage profiles that the voltage dip is more for Benin bus as it is the fault bus and the severity of the fault is decreased as we move away from the fault bus. We can also observe that the switching of lines causes less disturbance compared to three-phase balance ground fault.

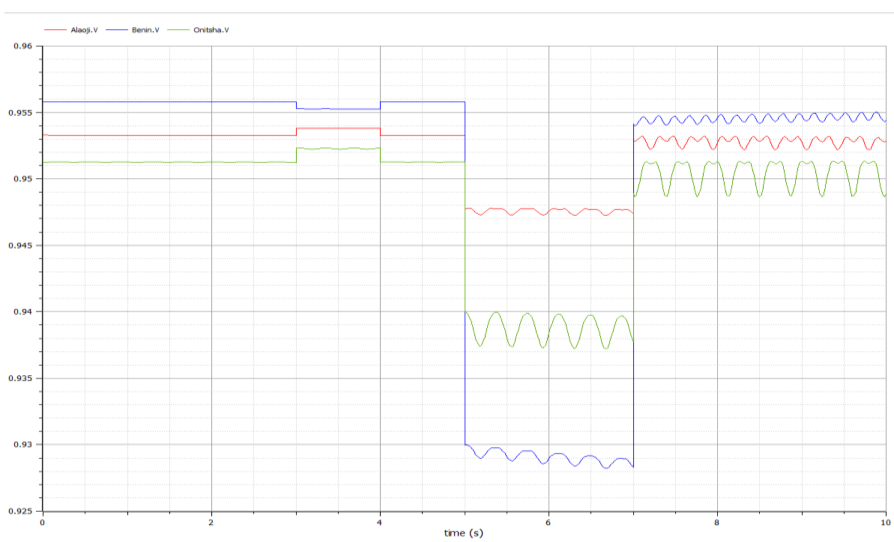
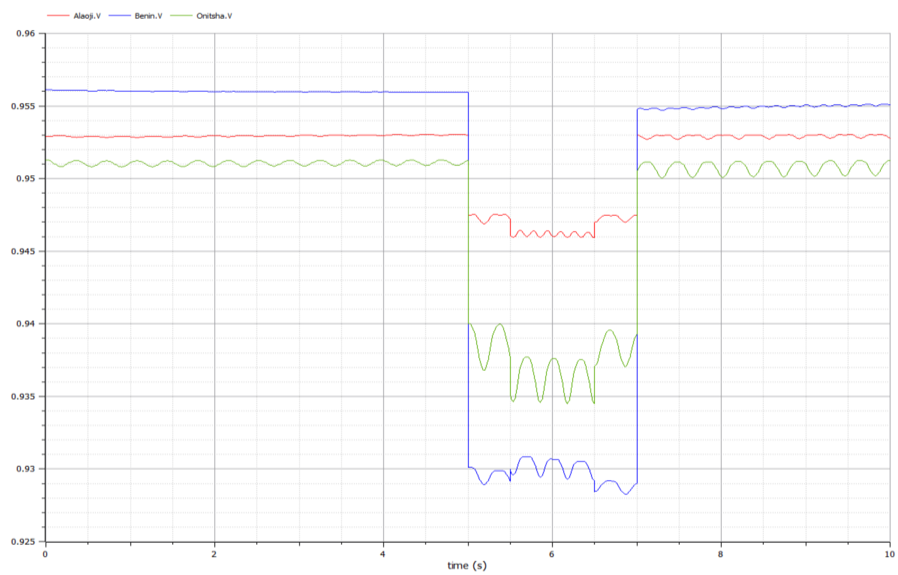


Figure 3: Voltage profiles of Buses

Case 2: *Closure of breaker during a three-phase balanced ground fault. (refer to Benin_onisitsha_alaoji_330kv_V2)*

The pwline1 is introduced into the circuit between 5.5 to 6.5 secs. The three-phase balanced ground fault is created at 5 secs and lasts for 2 secs and cleared at 7 secs. At 5.5 secs the breaker is closed and the effective impedance between Benin and Onitsha decreases which results in the severity of the fault at Alaoji and Onitsha buses as shown in figure 4. This is because the impedance between the fault point and buses(Alaoji and Onitsha) decreases the severity of the fault increases i.e. the voltage dip increases. While Benin voltage profile remains almost unaffected as there is no impedance change involved between the fault point and the bus. When the breaker is opened at 6.5 secs the voltage profile is brought back to the previous state. 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 (Turbine governor (TG) and Power system stabilisers(PSS)) on the generator's side.



Conclusion:

This model is a part of the Nigerian 330Kv network and the line between Benin and Onitsha is subjected to different conditions. The model represents the behaviour of the system under both the conditions i.e. the sudden switching of the line into the system and three-phase ground fault condition. The relation between line impedance and fault severity is also observed. The generator (order IV) is an uncontrolled one and hence the system becomes oscillating even after the fault is being cleared. This can be clearly seen from the voltage profile at the fault bus. The system can be brought back to stable condition by adding more controls such as Power System Stabilizers (PSS) and Turbine governor (TG).