Working Note on Generator Interfacing into a Transient Simulation

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# Generator Model

All the standard synchronous generator dynamic models interface to the network via an equivalent circuit as

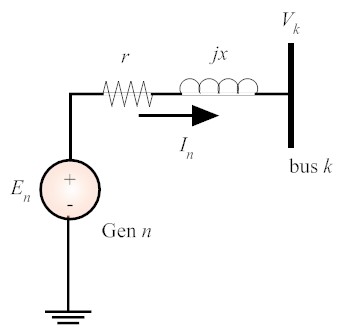


Figure 1: Generator equivalent circuit

where

*En* = generator’s internal voltage

*In*= generator’s injection current

*r + jx* = generator’s impedance

*Vk* = bus k voltage.

The internal voltage *En* is algebraically calculated from the state variables of generator *n*. Examples include the following.

## Sub-transient Model

For a typical sub-transient model, *En* is the sub-transient voltage transformed via Park’s. Similarly, the impedance is the sub-transient d-axis impedance. That is,

(1)

armature resistance (2a)

= sub-transient d-axis reactance (2b)

NOTE: ALL INFO I’VE SEEN HAS X”d=X”q. IF THIS IS NOT TRUE, I’M NOT SURE WHAT TO DO WITH (2b).

The network input to the sub-transient model is the injection current transformed via Park’s to the d/q axes. That is

(3)

Typically, the dq internal voltage is derived from the sub-transient fluxes as

(4a)

(4b)

where is the generator’s pu speed. A variety of models are used to derive the sub-transient fluxes.

# Network Interfacing Calculations

Let’s assume we have a traditional network with loads modelled as impedances. The following are the equations to calculate the generator injection currents. Assume we have *N* buses and *M* generators.

Network admittance matrix with generators and loads NOT connected. Order *N*x*N*.

(5a)

Vector of generator admittances via Figure 1. If bus *k* has a generator connected to it, then for that bus/generator. If bus *k* has no generator, then = 0. Order *N*x1.

(5b)

Vector of load admittances. If bus *k* has a load connected to it, then for that bus, where *Vk*0 is the initial voltage at bus *k* from the power flow solver. *P* and *Q* are the loads. If bus *k* has no generator, then = 0. Order *N*x1.

(5c)

Generator to Bus interconnecting admittance matrix. for generator *n* connected to bus *k*. If generator *n* is not connected to bus *k*, . Order *N*x*M*.

(5d)

Generator admittance matrix. Order *M*x*M*. (5e)

Using the above admittance matrices, connecting the generators via Figure 1, and connecting the loads as impedances to the network, the overall circuit equations are

(6)

where

vector of bus voltages. Order *N*x1.

vector of generator injection currents via Figure 1. Order *M*x1.

vector of generator internal voltages via Figure 1. Order *M*x1.

(7)

Equations (6) is used to connect generators to the network. In this case, *E* and *V* are known, and *I* is calculated as

(8a)

(8b)

is termed the “reduced” admittance matrix. Alternatively, (6) can be used to solve for *V* when *E* is known.

(9a)

(9b)

is termed the “bus recovery” admittance matrix.

# Initialization

All generator state variables must be initialized from the power flow before the simulation iteration can be initiated. The generator current injection vector derived from the power flow solution is used to conduct this initialization. The initial injection current at the *n*th generator is

(10)

where

initial generated power at generator *n*

initial bus voltage at generator *n* (bus *k*).

# Solution algorithm

# Example

As an example, consider the following system from EELE 555. See the file d2m\_sub\_excFastTGR\_tg1\_PSS\_YbusExample.m for the calculation of *YRed* and *YRecov*.

