ECEN 667
Power System Stability

Lecture 12: Transient Stability, Part 2

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Announcements

- Homework Assignment #3 is online – do not need to turn in but please complete before the first exam.
- Exam 1 in class Thursday, October 9^{th}
- Review the slides and PowerWorld examples

Recall, Partitioned-Explicit Approach with RK2

1. Explicitly use f to find the derivatives for $k_{1f} = \Delta t\ f\big(x(t), y(t)\big)$
2. Need to solve g implicitly to find the term $y(t) + k_{1g}$

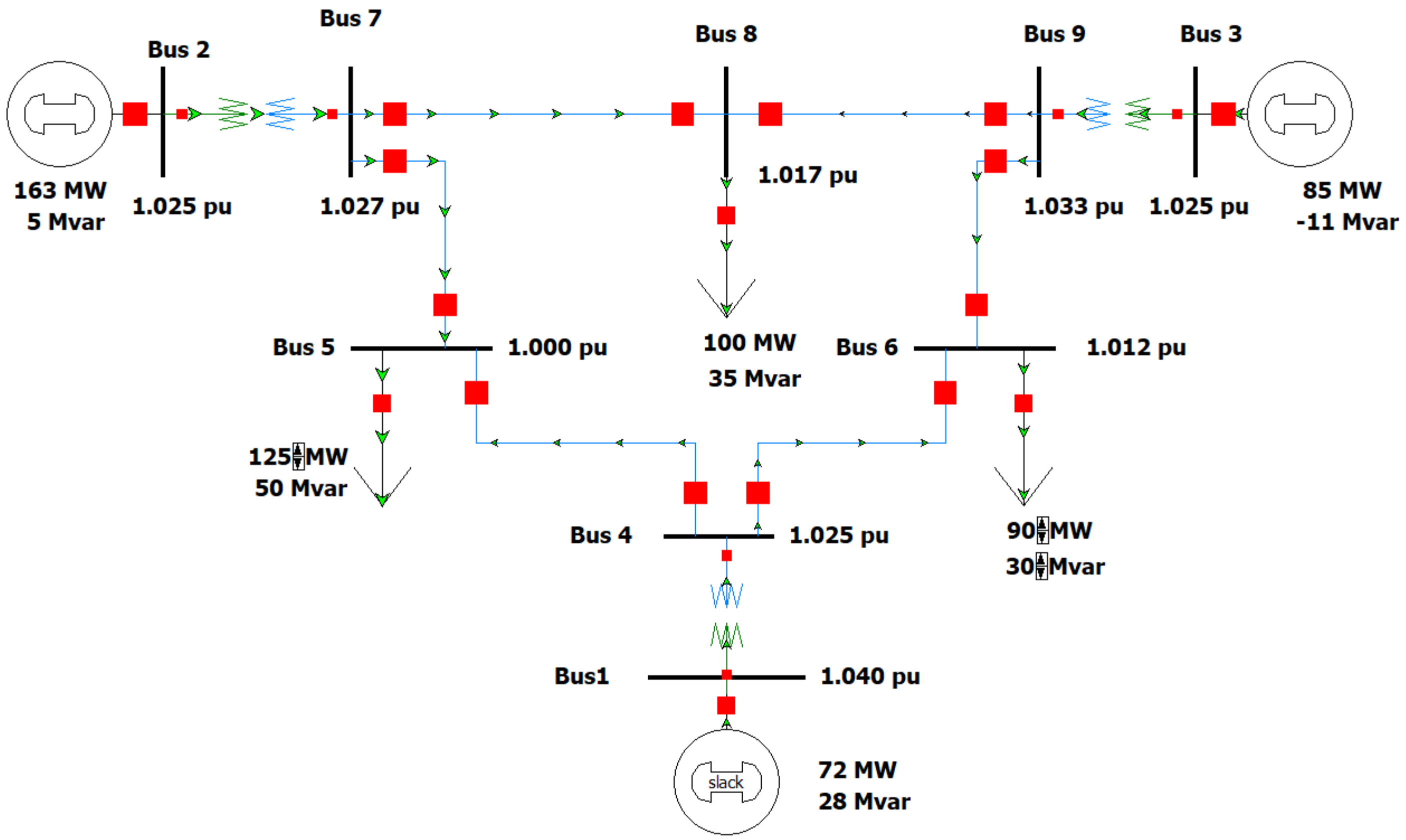
   in $0 = g\big(x(t) + k_{1f}, y(t) + k_{1g}\big)$
3. Now use f again to find the derivatives for $k_{2f} = \Delta t\ f\big(x(t) + k_{1f}, y(t) + k_{1g}\big)$
4. New value of $x(t + \Delta t) = x(t) + \frac{1}{2}\big(k_{1f} + k_{2f}\big)$
5. Now implicitly solve g to find $y(t + \Delta t)$

   $0 = g\big(x(t + \Delta t), y(t + \Delta t)\big)$

More steps, but especially if g is linear you do not need a Jacobian or iterative approach.

WSCC 9-Bus Case

- Each generator modeled with GENROU + IEEET1 Exciter + TGOV1 generator
- Notice
  - Initial state variables
  - Y-bus matrix
  - Impedance load models
  - For this example, the network equation portion g will still be linear



ZIP Loads

- Previously we have only used impedance loads, which is a static model
- Later on we will discuss load modeling in more detail, including dynamic load modeling
- For now, we will introduce ZIP loads, which is another static model. ZIP stands for
  - Z – constant impedance
  - I – constant current
  - P – constant power
- Let's go back and look at our 9-bus example with ZIP load models set such that loads are represented by a model with 30% constant power, 30% constant current and 40% constant impedance

Nonlinear Network Equations

- With constant impedance loads the network equations can usually be written with **I** independent of **V**, then they can be solved directly (as we've been doing)

$$\mathbf{V} = \mathbf{Y}^{-1}\mathbf{I}(\mathbf{x})$$

- In general this is not the case, with constant power loads one common example. Hence in general a nonlinear solution with Newton's method is used
- We'll generalize the dependence on the algebraic variables, replacing **V** by **y** since they may include other values beyond just the bus voltages

Nonlinear Network Equations, Cont.

- Just like in the power flow, the complex equations are rewritten, here as a real current and a reactive current
  YV – I(**x**,**y**) = **0**
- The ZIP load is an example of this, because the current injection is a non-linear function of the algebraic variable V.
- For each bus we add two new variables and two new equations
- The “Newton Solution” is similar to power flow
  - Make a Jacobian for the equations
  - Iterate until the residual g is below some tolerance ϵ
  - Each iteration, use $y^{(n+1)} = y^{(n)} - J\left(y^{(n)}\right)^{-1} g\left(y^{(n)}\right)$