Is There a Paper on the OpenDSS Solution Method?

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Question

I can see the solution process described in the User Manual, but I would like to understand the solution algorithm better. Do you have a technical paper on it? How does it compare with a Newton-Raphson or Gauss-Seidel power flow?

Answer

Unfortunately, we have yet to write such a paper.

Update August 2011:

There is now a paper. Tom McDermott and Roger Dugan presented a paper at the IEEE PES General Meeting in Detroit on July 28, 2011 that contains a description of the solution method. It was presented in a panel on Open Source Software. You can find the paper on IEEE Xplore if you have an account. It is copyrighted so we can't include it here, unfortunately.

What you see in the User's Manual and the training slides on the solution process is basically all there is. Don't make more of it than it is.

It is a very basic and simple iterative (possibly) nodal admittance solver not unlike what is in programs like Spice, EMTP, and EMTDC except that it is strictly in the phasor domain (frequency domain). And it works quite well with distribution systems (and small transmission systems) that have a dominant power source. It works for other situations as well, but may take more tweaking.

You have access to the source code so you can see how it works. Look for the SolveSnap procedure in Solution.pas and follow the code. Also, look at the computation of the "injection currents" in the Load object and other power conversion elements.

Please note that "Newton-Raphson" and "Gauss-Seidel" are simply numerical methods for solving systems of nonlinear equations. While these names have become synonymous with particular power flow formulations, there are other formulations of the power flow problem to which these numerical methods could be applied. OpenDSS has another formulation.

You may have noted one of the options for the solution algorithm is called "Newton" (see Help on Algorithm option). However, that should not be confused with the traditional Newton-Raphson power flow formulation as taught for transmission system analysis. Technically, it is a Newton-Raphson method because it uses the Y matrix as the Jacobian for Newton's method to solve a set of nonlinear equations. The "Normal", or default, solution method is more akin to a Fixed Point iteration. It is more sensitive to ill-conditioned problems than the Newton method, but works for >95% of distribution circuits and does so with about half the number of numerical operations. So we use it to take advantage of the speed of the algorithm. In fact, I think the last time we had to resort to a Newton method to solve an ill-conditioned circuit was more than 7 years ago and we have solved 100's of distribution circuits since then.

Also, in the training slides (http://electricdss.svn.sourceforge.net/viewvc/electricdss/Training/August2010Training.ppt?view=log) is an explanation of the load model that illustrates how OpenDSS minimizes the exposure to convergence failure by switching to linear (constant Z) models when the load voltage gets outside the defined normal range.

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