OpenDSS Circuit Solution Technique

The normal circuit solution technique in the EPRI OpenDSS program may be concisely written as a simple *fixed-point* iterative method:

$$V_{n+1} = [Y_{system}]^{-1} I_{PC}(V_n) \quad n = 0, 1, 2, \dots \text{ until converged}$$

In words, after building Y_{system}, the process starts with a guess at the system voltage vector, V_0, and computes the *compensation* currents from each power conversion (PC) element to populate the I_{PC} vector. Using a sparse matrix solver, the new estimate of V_{n+1} is computed as shown. This process is repeated until a convergence criterion is met. For distribution systems, convergence is typically achieved in 4-10 iterations for the initial power flow solution and 2-3 iterations for subsequent solutions in a time series. The Y_{system} matrix is not refactored until there is a major change in the system configuration. Thus, this method is very fast for a quasi-static time-series (QSTS) simulation.

Lines, transformers, etc., are called power delivery (PD) elements and are completely modeled by their primitive nodal admittance matrix. Loads are considered to be PC elements that are modeled by a Norton equivalent in which the constant, linear Norton admittance is included in Y_{system}. The nonlinear characteristics of the load, if any, are represented by the compensation current sources in the Norton equivalent. This formulation can accommodate a wide variety of load models in which I_{PC} can be expressed as a consistent function of V_n. This formulation was adapted from the program's heritage as a harmonics solver in which all the loads were constant impedance.

As with most fixed-point iterations, the initial guess has to be fairly close to the final answer. This is easy to achieve by simply performing a direct solution of the nodal admittance matrix with $I_{PC} = 0$ for loads and generators. This allows for initialization of even the most unusual circuit and transformer configurations.

The circuit solution formulation is essentially the same whether the program is performing a power flow, short circuit, harmonics, stray voltage, or dynamics solution. This technique works for any number of phases and is not very sensitive to circuit configuration.