Computation of the Stability Region by the Straddle Orbit Method and the Visualization for the Power System Transient Stability Analysis

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The 2-dimensional classical model is often used for understanding the transient stability of single-machine infinite-bus system, but the influence of dynamics of the generator excitation circuit over system stability is not necessarily negligible. This paper presents a way to compute the precise transient stability region of 3-dimensional single-machine infinite-bus system model numerically by adaptation of the straddle orbit method.

The computation of the transient stability region is the computation of the basin of the stable equilibrium point that corresponds to the operating point in the steady state. The basin boundary is formed by the inset (= stable manifold) of the saddle point that is often indicated by uep (unstable equilibrium point).

Fig. 1 shows the schematic figure of the straddle orbit method which was proposed in Battelino, Grebogi, Ott, Yorke and Yorke, *Physica D*,**32**,pp.296–305, 1988. First, select two points (p_a and p_b) that straddle the inset of the uep, that is, p_a is in the basin of sep_a and p_b is in the basin of sep_b. Using the bisection method, these points are made to get closer. Then solve the differential equation of the model using each of the two points as the initial condition for some time. Because the points gradually diverge from each other, pause the computation and use the bisection method to get them closer again. Repeating these procedure, the solution orbit that is almost identical to the inset of uep, i.e., the transient stability region boundary is obtained.

The computed stability region boundaries are visualized in the state space as 3D graphical drawings for the purpose of understanding the phenomenon. The visualization has been done with a free raytracer POV-Ray (`http://www.povray.org/`). Fig. 2 and Fig. 3 indicate the results for T'_{do}= 7.61 s and 0.5 s. The red and blue spheres are the sep and the uep, respectively. The green points indicate the orbit during the fault sequence. The white points are the transient stability region boundary.

The Web page (linked from `http://www.t-kita.net/`) where you can plot the computed data from various points of view on demand is also available.

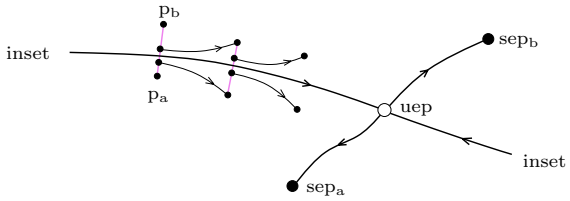

Fig. 1. Straddle orbit method

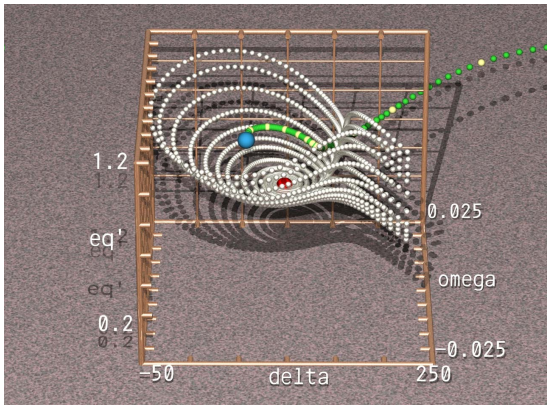

Fig. 2. Computed transient stability region boundary (T'_{do} = 7.61s)

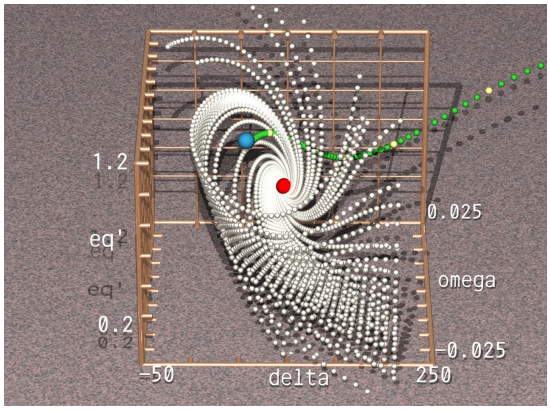

Fig. 3. Computed transient stability region boundary (T'_{do} = 0.5s)