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Fast emergency control strategy calculation based on dynamic equivalence and integral sensitivity

Key words: Emergency control; Transient stability; Numerical integration; Dynamic equivalence; Integral sensitivity

Corresponding author: Jian-quan WANG
E-mail: Wangjq@zju.edu.cn
http://orcid.org/0000-0003-0019-6878

Motivation

To simplify the transient stability analysis of a large-scale power system and realize real-time emergency control, a fast transient stability simulation algorithm based on real-time dynamic equivalence is proposed.

Main idea

Generator models are grouped and aggregated according to a fast numerical integration. A fast calculation method of the admittance matrix is proposed to calculate the parameters of an equivalent system, and numerical integration is performed using the obtained equivalent system. Then, based on integral sensitivity, a new fast emergency control strategy is proposed for the equivalent system. The final emergency control strategy is obtained by mapping the control strategy for the equivalent system back to the original system.

Method

1. Fast transient stability simulation algorithm based on real-time dynamic equivalence

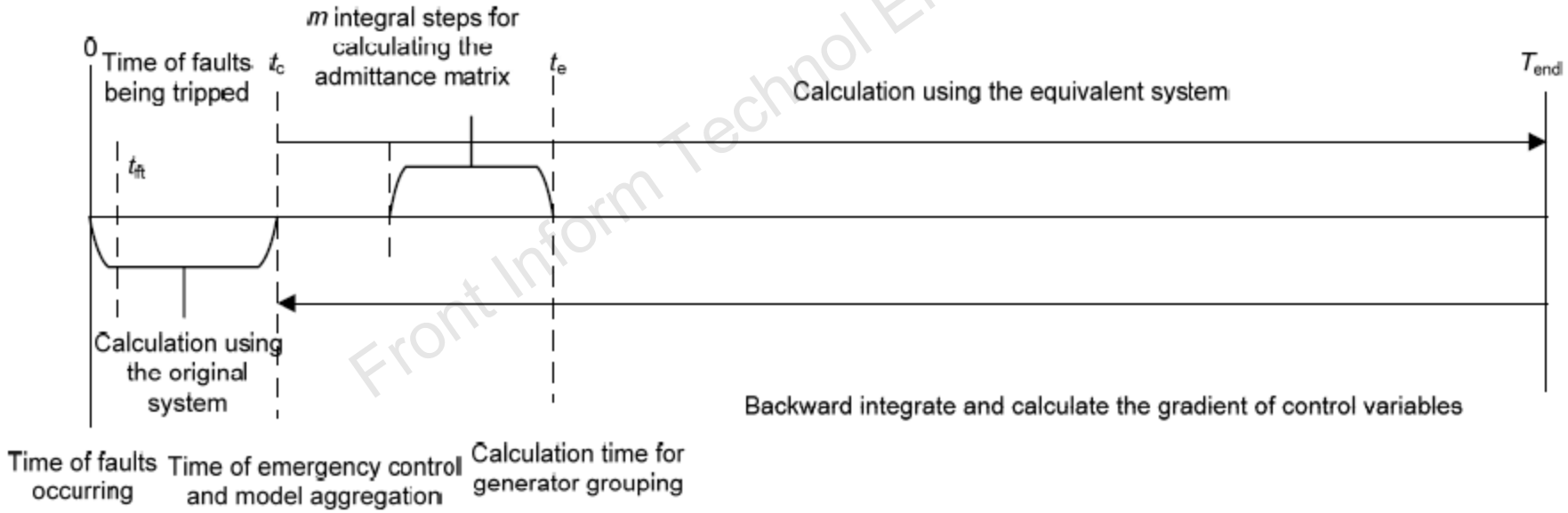

Fig. 2 Timing points and calculation processes

Method

2. Fast emergency control strategy algorithm based on integral sensitivity

All kinds of emergency control algorithms can be described as an optimal control problem that aims at minimizing certain control costs while regarding security and stability as constraints. Using the method of integral sensitivity, the control sensitivity of the transient stability constraint function is calculated and the emergency control strategy is obtained for the equivalent system.

Method

3. Reverse mapping of the emergency control strategy

The link between the control variable of the equivalent system and the original system is the relevant capacity of the generators and loads. Reverse mapping can be performed only when the specific power supply situation from each generator to each load is obtained.

Major results

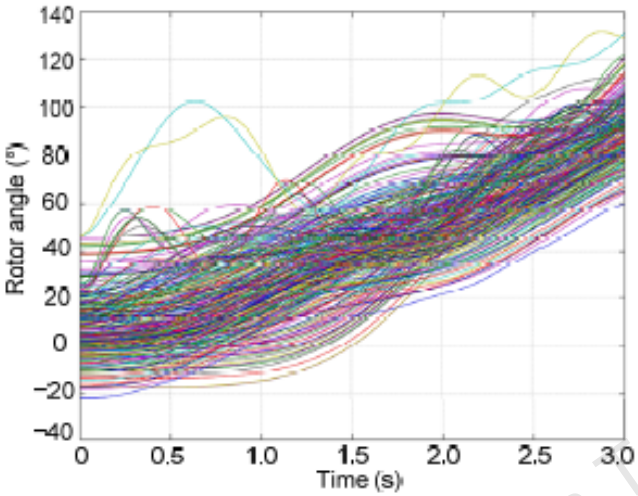

Fig. 4 Rotor angles computed by the conventional numerical integration algorithm (References to color refer to the online version of this figure)

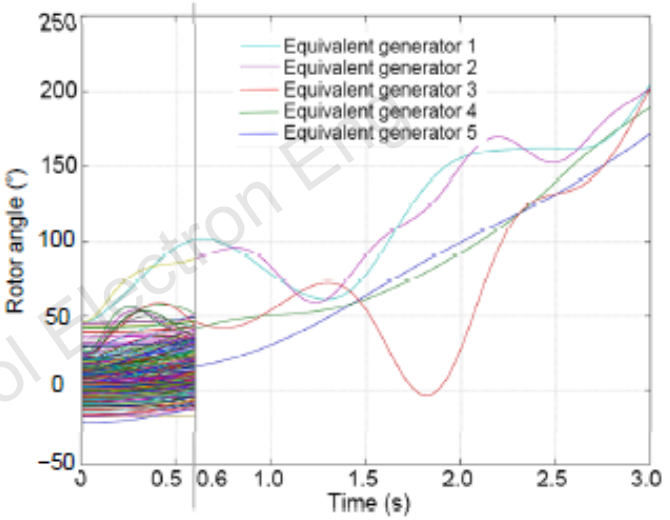

Fig. 5 Rotor angles computed by the proposed algorithm in case 1 (References to color refer to the online version of this figure)

There were 100 faults tested on the East China Power System. In all these tests, it was found that the number of generator groups seldom exceeded 10, which led to a great reduction in calculation time. The proposed algorithm can obtain the accurate maximum rotor angle difference, with an error that did not exceed 10%. This algorithm saved more than 60% of the calculation time on the East China Power System, demonstrating its potential for real-time applications.

Conclusions

The algorithm not only has high precision, good convergence, and good adaptability, but also greatly simplifies the calculation. The results are expected to realize online fast transient stability analysis and fast emergency control.