CHAPTER 6:

CONCLUSIONS

For the contingencies that lead the system to a loss of synchronism, the use of programs for solving a set of differential and algebraic equations is necessary. The numerous computer runs that must be operated by engineers to determine the stability limits for all stability scenarios make traditional time-domain simulation programs inappropriate for large power system analysis. On the other hand, direct methods and more specifically the energy approach may alleviate the computing burden. But, most of the direct methods have to face strong limitations because of an over simplification of the system model. An interesting alternative solution may be a method belonging to the class of direct methods while alleviating the impact of the power system model. This thesis developed and investigated a direct method for transient stability analysis using the energy approach [1] and the Phasor Measurement Units (PMUs). The originality of this new method resulted from a combination of a prediction of the post-fault trajectory based on PMUs and the Transient Energy Function of a multimachine system. Thanks to the PMUs, the weakness of the direct methods was overcome. The post-fault trajectory was approximated by means of a 2nd-order auto-regressive model. A least squares estimator was used to estimate the parameters of the model. The post-fault trajectory was predicted until the exit point located on the p.e.b.s. was reached. This exit point was then set as starting point for the detection of the c.u.e.p. using an improved version of the Shadowing method which made use of the Ball-Drop method [22]. The transient potential energy at the c.u.e.p. was then compared to the transient energy at the clearing time. The energy margin between these two values was used as index of stability. If the energy margin was negative, the system was considered unstable; otherwise it was stable. This new method was tested on a 3-machine system and the 10-machine New-England power system. Its efficiency to assess the transient stability of a power system for the first and the second swing was demonstrated. To conclude, an essential asset of this real-time approach is its adaptability to any kind of operating and fault conditions. Being free from any off-line regulation, it is intrinsically robust with respect to modeling errors, and is able to cope with unforeseen events. Concerning the practical feasibility, we have supposed that real-time generator data can be provided with sufficient accuracy and sampling rates by phasor measurement devices placed in each one of the main power plants of the considered power system. We have also assumed that existing communication systems are able to comply with required data rates, which has been found to be one sample every 30 milliseconds.

This thesis has mainly focused on the assessment of the transient stability margin. To complete the approach, a control device should be added. The algorithm developed in this thesis should act on control devices so that the system is steered away from while preserving a smooth transition to normal operating conditions. In the Curve-Fitting method, the index of stability is expressed in terms of an energy. Thus, an approach would be to realize the control device as a function of a varying energy. As explained earlier, the system is assessed to be transiently unstable if the stability margin is negative. In that case, a straight forward suggestion for stabilizing the system is to increase the decelerating power (Pe-Pm) so as to get a positive energy margin. In practice, there are mainly two types of control actions, which are the reduction of the mechanical power or the increase of the electrical power. One example to increase the electric power is to connect braking resistors as shown in Figure 6.1. A dynamic braking is one of the effective methods reported to enhance transient stability [19]. It has been observed [19] that a coordinated resistor-capacitor braking strategy with the excitation control provides the best response for transient instability and subsequent oscillations following a large disturbance. Recent studies have shown that the combination of resistors and capacitors eliminates the electromechanical as well as electrical transients in the system better than with just resistor or resistor-reactor strategies. Another advantage to use the dynamic braking as control device is the fact that the energy they absorb can be rapidly modulated in real time. The location of the braking device is shown on figure 6.1.

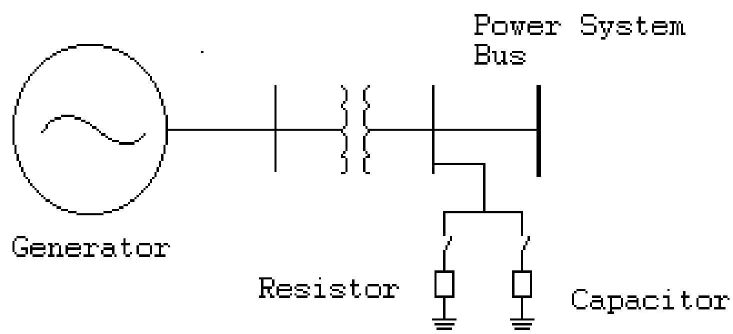

Figure 6.1: Braking resistor-capacitor location for a generator

When the generator accelerates, the resistor is switch on to absorb the increase in energy. On the contrary, when the machine is in deceleration, the switch is on the capacitor that reduces the terminal voltage of the generator, reducing the output power and thus, reducing the deceleration of the machine. There are a variety of possible strategies for using the brake. One approach would be to consider the idea of local dynamic braking where the energy taken up by the brake is under feedback control. This approach is quite different from the conventional use of dynamic brakes in power systems. That is, the conventional brakes are simply turned on and usually absorb whatever power it is designed for. Furthermore, the control device is said to be local, in the sense that the control of each machine depends only on information available at the machine. The action of local dynamic braking is evaluated in term of energy whereas for conventional braking, it is in term of power. This makes on-line implementation of the control strategies easy and more suitable for the energy approach. However, the introduction of resistor-capacitor local dynamic braking in the approach has to be considered only as a proposal for further study. Further research is necessary in order to introduce them within the developed scheme.