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INFLUENCE OF POWER SYSTEM STABILIZER ON THE TRANSIENT STABILITY

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Abstract: *Major disturbances occurring in the high-voltage grid undermine the transient stability of the electrical power system. If the high-voltage grid to which a power plant is connected, is not sufficiently strong a close disturbance may result in long lasting and poorly dumped oscillations despite the fact that the synchronicity of generators is maintained. Within the necessary restoring time the system is particularly vulnerable to additional disturbances which may occur. One of the measures of rapid and efficient oscillation dumping consists of building-in the power system stabilizer (PSS) in the exciting systems of vulnerable generators.*

Key words: *transient stability, high voltage network, excitation system, power system stabilizer*

1. INTRODUCTION

The stability of electrical power system can most simply be defined as its ability to continue stable operation after disturbance occurrences. Pending on their seriousness, one can distinguish minor and major disturbances related stability. The synchronous operation of generator is endangered by close and remote short-circuits in the network, by line and load interruptions, errors in accessory generators and turbine systems, etc.

What can be observed in transient stability are rapid changes as a consequence of mainly short-circuits in the grid provoked by extensive rotor swings. In that case the system stability maintenance depends on drive operation conditions prior to disturbance (load, generation, network configuration) as well as on nature of the disturbance (category of defect, location of occurrence, clearing time, etc.).

In case that a power plant is connected to an insufficiently strong high-voltage grid a major close disturbance in the network and disconnection of defective line can provoke long lasting and poorly dumped oscillations of generator's rotor, and can result in its instability after the transient period as well. This paper proposes possible solution to this problem by installing the power system stabilizers in the exciting systems of generators connected to an insufficiently strong grid. So far, the analysis of the impact of PSS has been primarily limited to their performance in situations of minor disturbances, which are able to undermine the small-signal stability of the system. Further researches in determining the PSS applicability in solving the problems of transient stability should be aimed at finding optimal PSS characteristics and locations in order to achieve better results in improving system stability when major and minor disturbances take place.

2. POWER SYSTEM STABILIZER

The applied exciting systems of the generator have significant impact on electrical power system's transient stability in situation of major disturbances in the grid. In order to enable generators to maintain the synchronous operations on the grid in situation of major disturbances it is necessary to keep the magnetic flux constancy in the rotor by forcing the exciting condition. It is also possible to provide the generator's exiting system with some extra functions as to make them as efficient as possible in situations of major disturbances in the grid. One of those is the installation of power system stabilizers (PSS) in the generator's exiting system. The basic purpose of PSS is to introduce an additional stabilizing signal into the exciting circle of the generator, which contributes to better rotor swing dumping (Figure 1).

The swing dumping in the system helps improve its dynamic characteristics, which is especially important in terms of small-signal stability, when the PSS application on some generators can efficiently contribute to a more quality system performance.

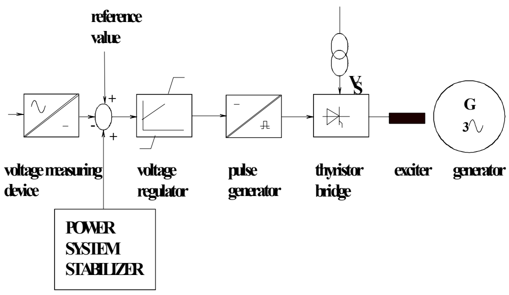

Fig. 1. Function diagram of excitation system

The PSS utilization in some generators in the electrical power system, in terms of transient stability, has a point if the high-voltage grid to which the generator is connected, is not strong enough (large network impedance in connecting grid-node), as the major disturbances and line disruptions give rise to long lasting and poorly dumped oscillations of generators. A long transient period of bringing system back in to a new well-balanced status following a major disturbance in the grid, undermines its safe operation and makes it vulnerable to possible additional disturbances which may appear during the transient period. The usual signals used as input PSS signals are the shaft rotation speed, power and frequency in a generator's grid-node connection to the electrical power system.

3. EXAMPLE

As an illustration, an example of a positive impact of PSS on dumping of oscillations caused by major disturbances in the grid is given. It observes a system consisting of approximately 100 grid-nodes, about thirty generators, about three hundred lines and fifty transformers. Transmission network is composed of 400 kV, 220 kV and 110 kV voltage levels. As a major disturbance which brings the system out of balance situation, we took a three-pole short-circuit on 400 kV line in a close vicinity of a hydro power plant consisting of two 2x180 MVA aggregates. The hydro power plant is connected to the system by two 400 kV lines, and the network impedance in the connecting grid-node is Z_d=19.5 Ω.

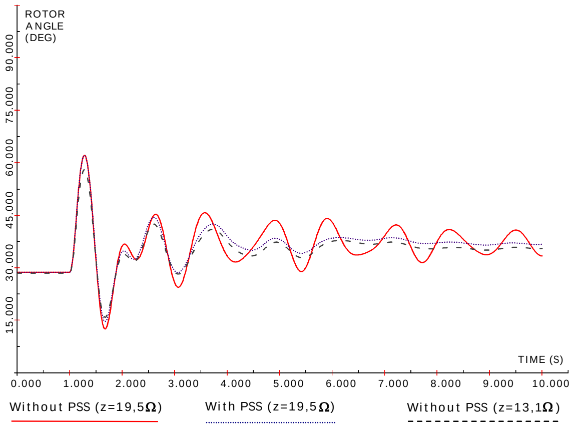

Fig. 2. Curve of rotor swing of generator of hydro power plant in situation of close three-pole short-circuit on 400 kV line depending on PSS utilization in exciting system of generator and network impedance in connection grid-node

In another analyzed case the same hydro power plant is connected to a stronger node in the grid connected to the remaining electrical power system via four 400 kV lines, and network impedance in that connecting grid-node is Z_d=13.1 Ω. The disturbance is cleared within 100 ms by permanent disconnection of the defective line. The generators of the hydro power plant in vicinity of three-pole short-circuit situation, are excited by a modern static exciting system. The simulation of system operation in a timing scope is used to check on forms of transient occurrences in situation of the considered disturbance pending on PSS utilization and design used in exciting systems of generators of the close hydro power plant, and pending on network impedance in the power plant's connecting grid-node (Figure 2).

In case that PSS is not built-in in the exciting system of the generator of the observed plant, connected to the grid-node with a bigger network impedance, the poorly dumped and long lasting oscillations appear in the system. With the application of PSS in both generators the oscillations are much better dumped and the system regains its new balance. In case of plant's connection to a more powerful node in the network, i.e., to a node with lower network impedance, the oscillations are dumped quickly enough even without the use of PSS in the generator's exciting systems.

4. CONCLUSION

The problem of transient stability becomes increasingly important with construction of bigger and bigger generation units, which are at the same time more and more distant from consumption centers. In case that the generation units are connected to an insufficiently powerful high-voltage grid, a major disturbance can provoke enduring and ill-dumped oscillations of generator's rotor swing. One of the measures to functionally solve this problem is the installation of power system stabilizers in the exciting systems of the exposed generators in the system. For the PSS installation proposed are the generators which are connected to grid-nodes where the network impedance is relatively high. It is necessary to carefully choose the sort of PSS performance and its parameters, which should be done through analysis of system operation in the timing scope, through calculations of eigenvalues and frequency responses. This paper shows on a realistic example the analysis procedure concerning the impact of PSS installation in the exciting system of generators of a hydro power plant connected to a not enough powerful high-voltage grid. The analysis uses the method of simulation of system's operation in the timing scope.

5. REFERENCES

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