TRANSPORT ANALYSIS OF A WIND-DRIVEN INDUCTION GENERATOR

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ABSTRACT
The transient behavior of wind-driven induction generator is analyzed. The generator is assumed to be running at steady-state with a certain real and reactive power flow conditions when a sudden disturbance occurs. An example of the disturbance may be a sudden disconnection from the utility grid. The generator is modeled using the universal machine model and the grid is represented by a constant voltage source. It is found that dangerous over-voltages occur few seconds after disconnection from the grid due to self-excitations at the new higher speed.

1. INTRODUCTION

The self-excited induction generator (SEIG) is basically an induction machine which is driven by a prime-mover such as a wind turbine while a capacitor is connected across its stator terminals. The capacitor in this case provides the lagging reactive power necessary to establish the air-gap flux. The machine in this case is said to be self-excited and a voltage is generated across its stator terminals. The generator can supply real and reactive power to a local load as a stand-alone generator but the magnitude and frequency of the generated voltage will vary with speed variations. In addition to supplying the local load, the machine can also be connected to a utility grid to supply any surplus power. The advantage of this mode of operation is that the capacitor is not necessary since reactive power can be provided by the utility. Moreover the terminal voltage and frequency are stabilized by the utility. Steady-state performance of the generator as a stand-alone or grid connected has been thoroughly investigated in the literature [1]-[4]. Transient performance such as the response to a sudden disconnection from the grid or sudden capacitor failure or load rejection has not been investigated by some authors [5]-[8]. In this paper, transient performance of the induction generator is investigated. In the grid-connected, the generator is assumed to supply a local load while connected to a utility grid through a Δ/Y step-up transformer and a transmission line as shown in Fig. 1, whereas in the standalone mode the generator is supplying a local load through a short transmission line.

The EMTP Alternative Transient Program (ATP) [9] is used to simulate the system. The induction generator is modeled using the universal machine (UM) model while the transmission line is simulated using a lumped series R-L elements since it is relatively short, and the transformer is modeled as three single-phase transformers.

2. GRID-CONNECTED OPERATION

In this mode of operation, the generator is assumed to be running at steady-state under certain real and reactive power-flow condition when it is suddenly disconnected.
from the grid. The transient response of the terminal voltage (rms) is shown in Figures 2, 3, and 4.

It is noted that, the higher the resistance and the lower the capacitance the higher the voltage following disconnection. It is also noted that voltage reaches to a much higher peak value before settling down to a new steady-state value. The corresponding line currents are shown in Figures 5, 6, and 7.
Speed variations as a result of disconnection from grid are shown in Figures 8, 9, and 10.

3. STAND-ALONE OPERATION

In this mode of operation the induction generator is supplying a local load when a single-line short-circuit show the terminal voltage in all phases including the faulted phase.

Fig. 8: Speed for $C=181 \mu F$, different values of $R$

Fig. 9: Speed for $C=126 \mu F$, different values of $R$

Fig. 10: Speed for $C=90 \mu F$, different values of $R$

Fig. 11 Voltage of the faulted phase (Phase A)

Fig. 12 Voltage of the healthy phase (Phase B)
Figures 15, 16, and 17 show the resulting line currents (instantaneous values).

4. CONCLUSION

In this paper, the transient performance of the induction generator driven by a constant-torque prime mover is investigated. Two modes of operation were considered, namely, the grid-connected mode and the stand-alone mode. In the grid-connected mode, the generator is assumed to supply certain real power to the grid while receiving or supplying certain amount of reactive power to the grid. The amount of real power delivered and the amount of reactive power delivered or received are important factors affecting the transient response of the generator when it is suddenly disconnected from the grid.
The computer simulation results are found to be in full agreement with some of the previously published works [5, 6, 8]. It is found that the generator voltage reaches to a dangerously high transient values before reaching to a new steady-state value which is higher than the grid voltage. These high voltage levels may cause capacitor or load failure. The smaller the excitation capacitance disconnected with the generator, the higher the transient and new steady-state voltage. The higher the resistance disconnected with the generator the higher the transient and steady-state voltage. Transient response of the stand-alone generator following a short-circuit at its terminal is also investigated. It is found that short-circuit on one phase cause the generator to lose self-excitation. Short-circuit current increases for a while as expected but goes to zero within few cycles, confirming the fact that the induction generator has self-protection against short-circuits due to loss of excitation.

5. REFERENCES


