

Inrush Current Limitation in Wind Generators by SCR Based Soft-starter during grid connection

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Abstract: -High Inrush current & harmonics is a generic problem wind generators during grid connection. The designed SCR based soft-starter successfully limits the high inrush current during the connection of the wind-turbine system to the grid. The proposed SCR based soft starter using will be simulating in PSCAD on a three-phase induction generator. Expected results will show a significant reduction in high inrush current and smooth connection of the three phase induction generator to the grid with small impact on the power quality. A small-scale wind turbine coupled three phase induction generator is an attractive choice for an isolated grid hybrid power system in remote areas because of its low cost, compactness, ruggedness, high reliability, low inertia and ease in control. In this work, a SCR based soft starter for limiting the high inrush current during the connection of the small-scale wind turbine coupled three phase induction generator to an isolated weak grid has been proposed. Soft-starter is designed to reduce inrush current or surge in current while achieving a proper synchronism between the generator and the grid.

Keywords: - Control system, Grid, PSCAD, SCR, Soft starter, Wind Turbine.

I. INTRODUCTION

The vast majority of the wind turbines in the world are equipped with grid-connected induction generators. Single phase or three-phase squirrel cage rotor type induction generators are preferred rather than synchronous generators because of their cost-effectiveness, robustness, compactness, ruggedness, low inertia and the need of little maintenance [1]. For large scale distributed power supply three-phase induction generators are extensively used. Directly connected induction generator based wind turbines of more than 800 KW are normally equipped with soft-starter to limit massive inrush current to the supply and to connect the system smoothly to the grid without massive mechanical shocks or vibrations that could damage the gear box, bearings and the couplings [2]. In paper [1-5, 7] a few techniques for the soft starter of induction generator has proposed and implemented. Soft-starters based on semiconductor devices such as thyristors, triacs, IGBTs and power resistors have been described in paper [2-5]. All of the soft-connection strategies are done for either three phase large induction machines or for single phase motors. Past research indicates that soft-starters are widely used during the start up of induction motors/AC motors in industrial drives applications [8], [9], [10], [11], [12] to reduce mechanical stresses on the drive system and electrical stresses on the electrical supply. In wind power applications, directly connected squirrel cage induction generator needs to be equipped with soft-starter to minimize the effect on wind turbine generation system during the process of connecting of the wind turbine system to the grid [13], [14], [15], [16]. As the self-excited induction generator of a fixed-speed wind turbine is directly connected to the grid, a soft-starter is used to reduce the inrush current during connection. There are few techniques have been found in the literature which are extensively used as a soft-starter in wind power generation system. A 20 kW Gazelle wind turbine [21] has been commercialized by Gazelle Wind Turbines Ltd which uses SCR based soft-starter to reduce the inrush current during synchronism. The above recommended soft-connection strategies have been used for 15kW or more rated wind energy conversion system. However further research and development is needed to be extended on soft-connection strategy for 3kW or less rated wind turbine system to provide the quality power to the grid and also to reduce the electrical and mechanical stresses on the entire

system. Direct connection of the induction generator to the grid results in high inrush currents, which are undesirable particularly in the case of weak grids and can also cause severe torque pulsations and probably damage to the gearbox, High inrush current during grid connection with induction generator, Massive mechanical shocks or vibrations during interfacing of induction generator Development of transient & Harmonics. Connection and disconnection of electrical equipment in general and induction generators/motors especially, gives rise to so called transients, that is short duration very high inrush currents causing both disturbances to the grid and high torque spikes in the drive train of a WT with a directly connected induction generator. Its disturbances to the grid during switching operations and exerted Load on the gearbox. The voltage changes due to the inrush current of a switching and the flicker effect of the switching.

II. SOFT STARTING TECHNIQUE

Design of Soft Starter

A soft-starter is a device used with AC electric motors/generators to temporarily reduce the load and torque in the power train of the machine during start up. It decreases the mechanical stress on the motor and the shaft, as well as the electro dynamic stresses on the attached power cables and electrical distribution network. Thus it helps in extending the life span of the system. In figure, a typical connection circuit of a small scale variable speed wind turbine with three phase induction generator to an isolated grid is presented. The main purpose of the soft-starter is to create electrical isolation between the wind turbine system and the grid for a very short time to limit the starting high inrush current of the induction generator during the transient period. After that transient period, the wind turbine system is directly connected to the grid through the bypass switch.

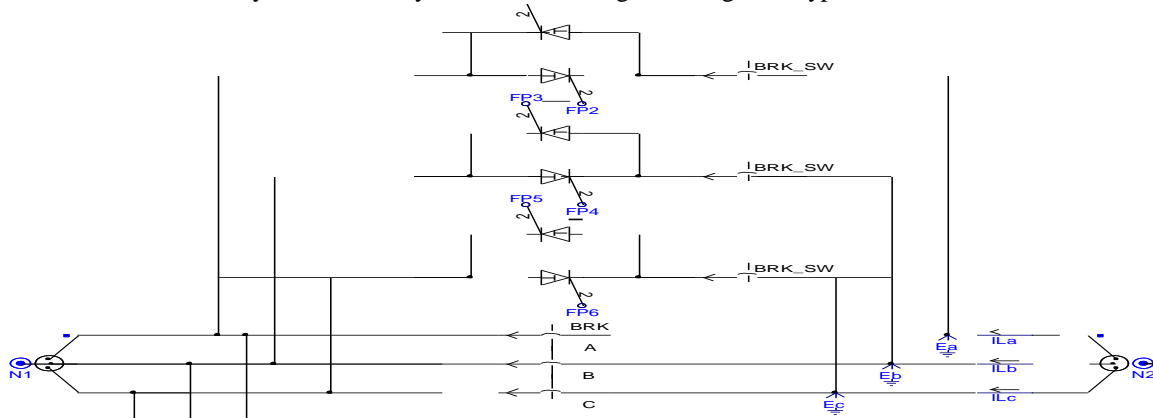


Fig.1 SCR Based soft starter-Model in PSCAD.

The soft starter has a limited thermal capacity and is short circuited by a contactor able to carry the full load current when connection to the grid has been completed. In addition to reducing the impact on the grid, the soft starter also effectively dampens the torque peaks in the air gap of the generator associated with the peak currents and hence reduces the loads on the gearbox.

Developing the model in PSCAD simulating tool

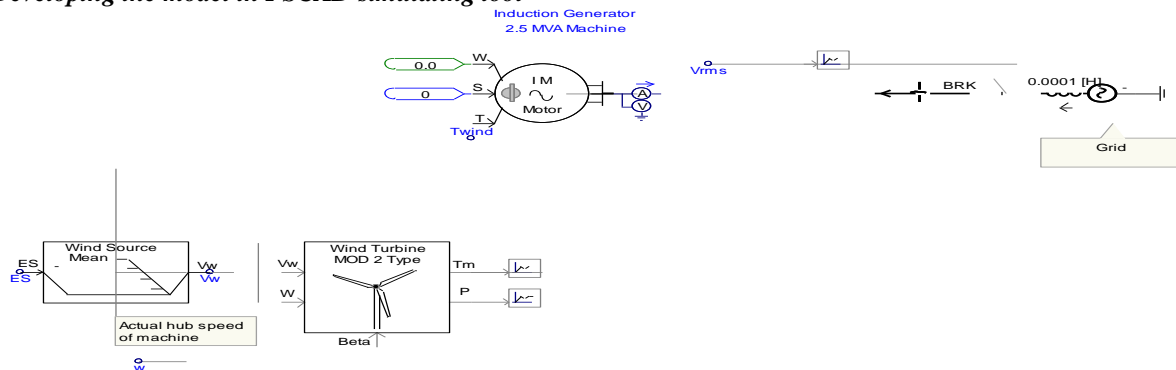


Fig.2 Wind mill with grid-Model in PSCAD.

Wind Turbine & soft starter model in PSCAD simulating tool

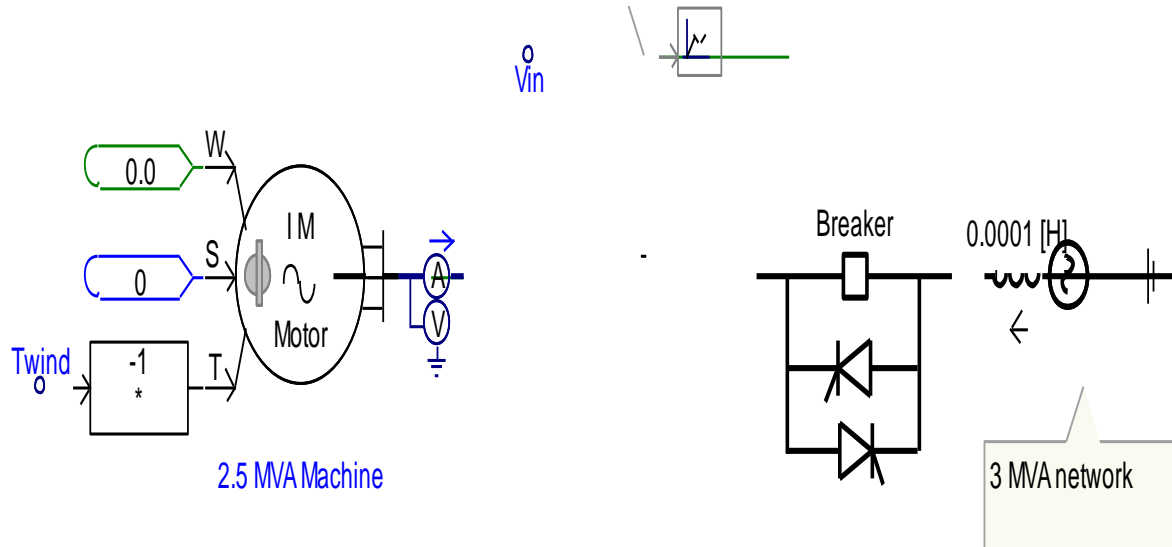


Fig.3 Wind mill & soft Starter with grid-Model in PSCAD.

Inrush current without soft starter

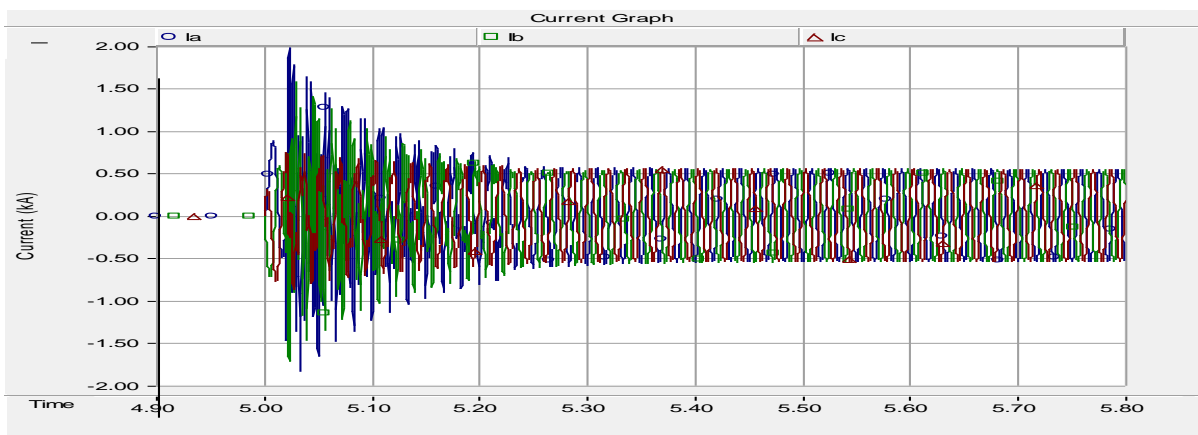
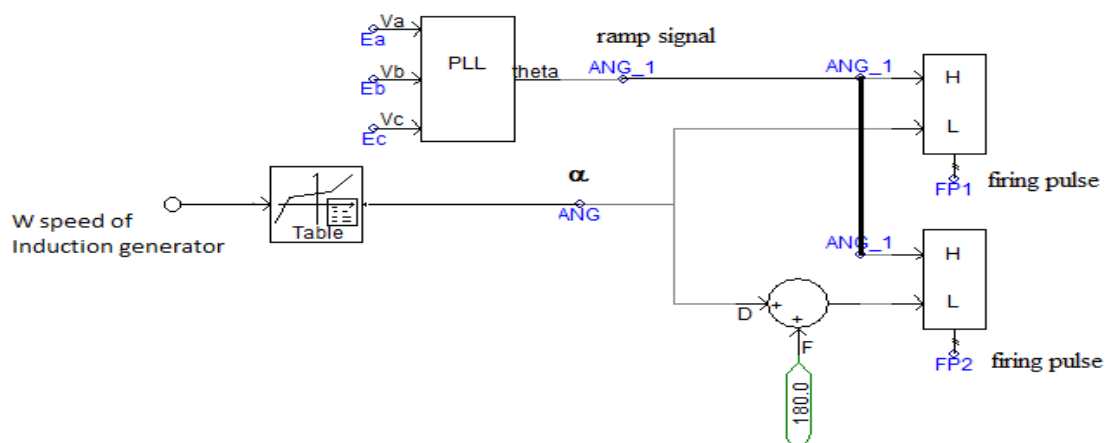


Fig.4 Inrush Current without soft starter

Control of firing angle of SCR in soft starter



Gate Pulses of SCRs in soft starter

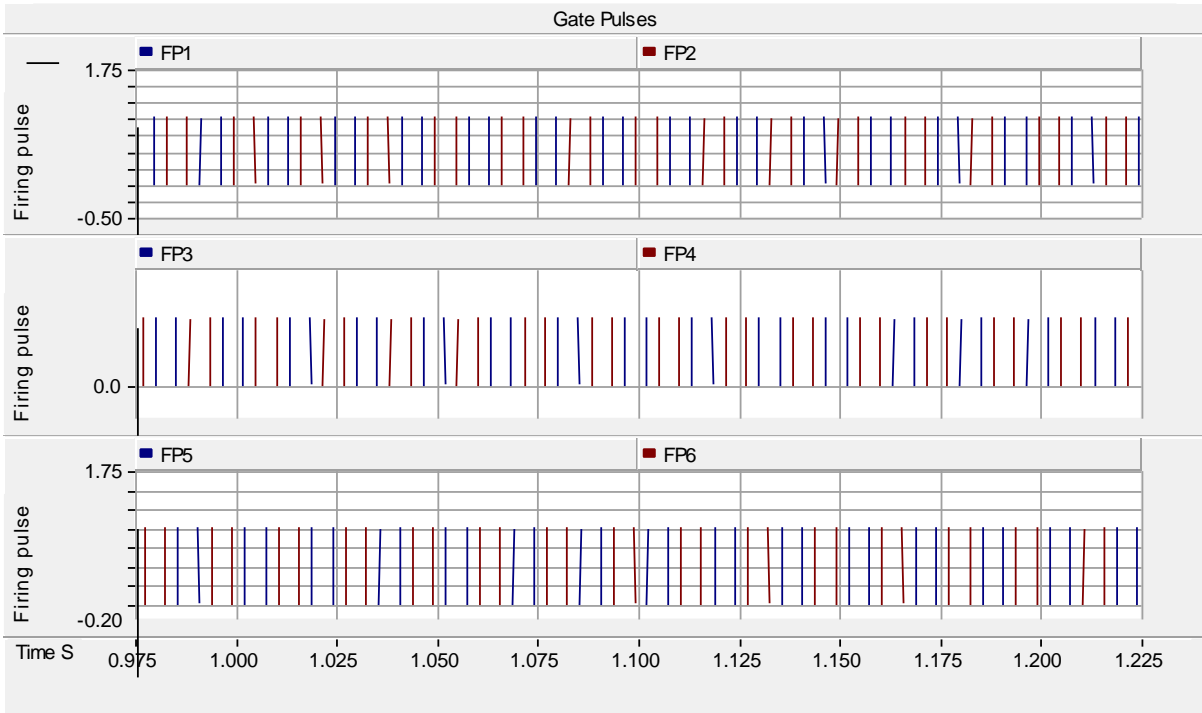


Fig.5 Gate Pulses of SCRs in soft starter

Voltage Graph with soft starter

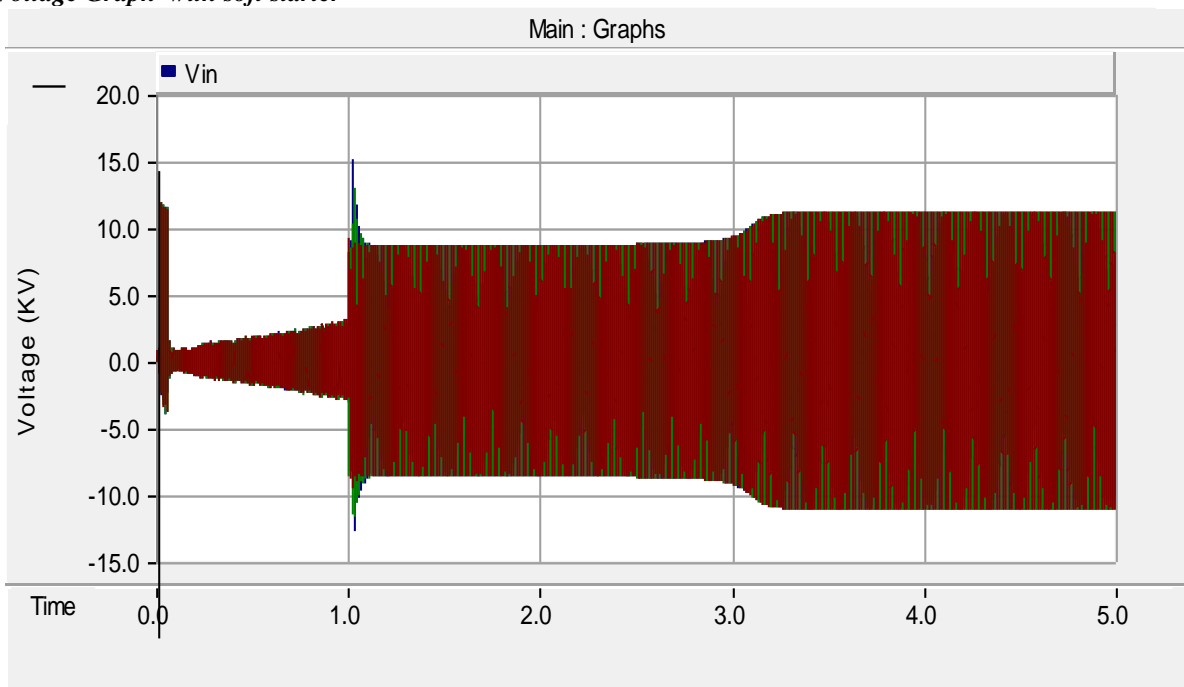


Fig. 6 Voltage Graph with soft starter

Inrush Current with soft starter

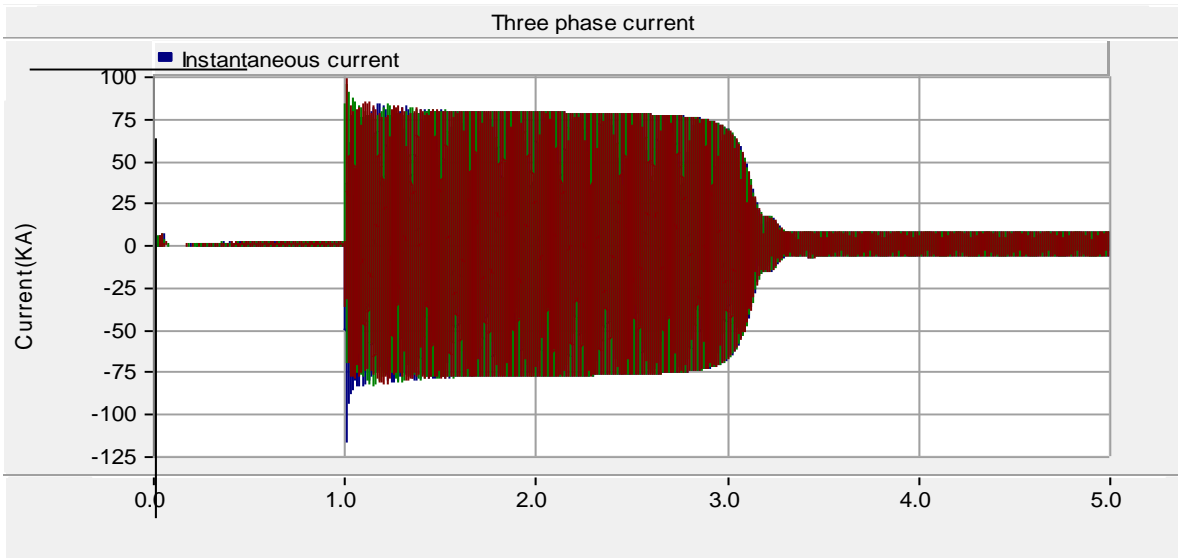


Fig.7 Inrush Current limited with SCR soft starter

Real Power, Reactive Power & Speed – Torque Characteristics of Wind Poly phase Generator

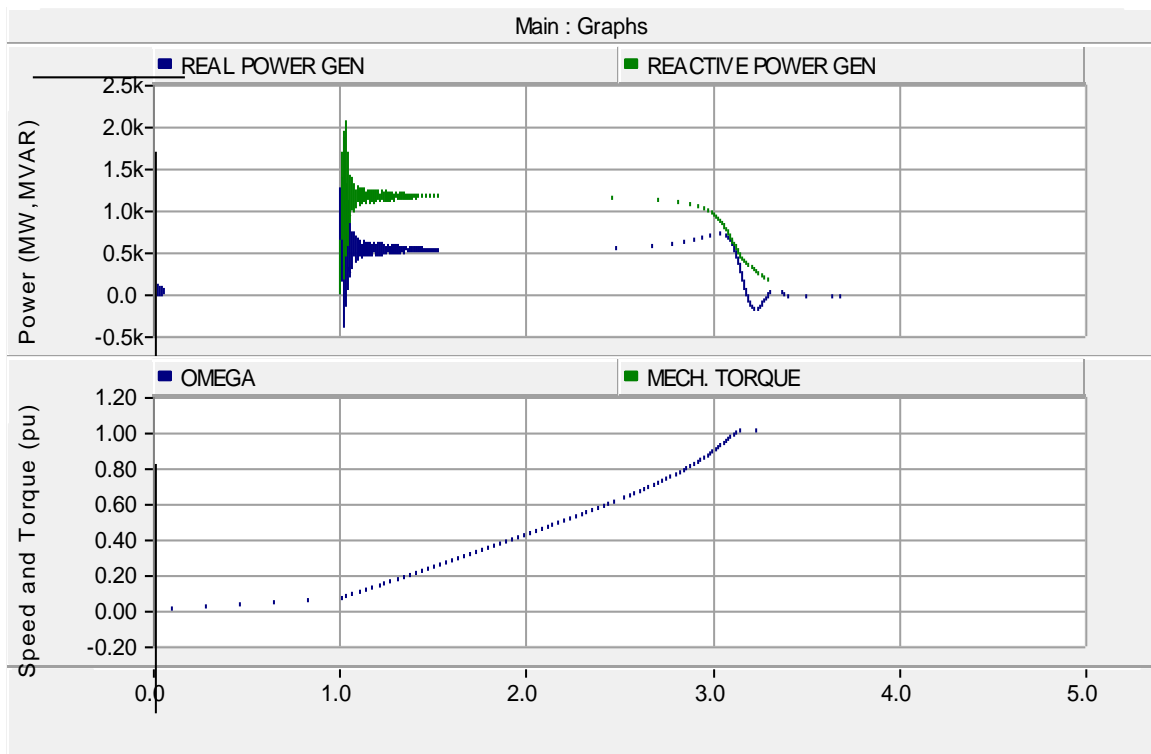


Fig. 8 Real Power, Reactive Power, Speed & Torque Graphs in PSCAD.

III. CONCLUSIONS

This paper describes the design, selection strategy, operation and some test results of a SCR based soft starter for a polyphase induction-generator based grid connected wind turbine with graphical representation of Voltage, Current Power & Speed & Torque of Poly phase induction generator, The Modelling has been done in PSCAD simulation tool. The data has been collected from wind farms & Tech. Specifications of Suzlons. The soft-starter setup is much cheaper which is a good technical benefit for small induction generator based wind turbines.

IV. ACKNOWLEDGEMENT

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