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Modeling of Grid Connected Fixed Speed Wind Farm

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ABSTRACT: This paper presents modelling and simulation of a wind turbine driving a grid connected induction generator. A DC motor is used to emulate the performance of the wind turbine. Different parts of the system have been modelled using MatLab – Simulink. A model of a DC motor derived by a converter is employed to emulate the performance of the wind system. A speed control loop is used to force the dc motor shaft to follow the induction generator shaft which is coupled to the wind turbine.

Now-a-days global warming is the most burning issue found in many of the climate summits. Many researchers and scientists are working in their own relevant areas to reduce global warming by using different techniques. Over the past few decades wind energy has shown the fastest rate of growth of any form of electricity generation with its development simulated by concerns of national policy makers over climate change, energy diversity and security of supply.

I. INTRODUCTION

Conservation of non-renewable resources motivate to explore the new avenues of resources for electricity generation which could be clean, safe and more valuable to serve the society for a long period. The renewable energy sources can be a better replacement of the polluted non-renewable sources in order to meet the growing demand for power due to rapidly growing economy and expanding population.

As per World Energy Outlook (WEO)-2011 the prospects for renewable energy based electricity generation hinge critically on government policies to encourage their development. Worldwide, the share of renewable energy in electricity supply increases from 19% in 2008 to 22% in 2025 in the new policies scenario. The rising fossil-fuel prices and declining costs in wind energy make it more competitive with conventional hydropower that has been the dominant renewable source of electricity for decades. The recent strong growth in new technologies for wind power has created expectations among policy makers and the industry alike, that these technologies will make a major contribution to meet growing electricity needs in the near future. It has also been forecasted that the increase in electricity generation from renewable sources between 2008 and 2025 will be primarily derived from wind and hydro power, which will contribute 26% and 21% of the additional demand respectively.

II. MODEL STRUCTURE

The general structure of a model of a constant-speed wind electric generation system consists of models of the rotor, the drive train and the generator including wind speed model and grid. Each one of the blocks is shown in Figure, will be discussed in the subsequent sections. The grid model is a conventional load-flow model of a network. The individual models are connected to the grid model to realize a simulation model of WECS. The important functional blocks of wind turbine are: Wind model, Aerodynamic model, Transmission model and Blade angle model. The dynamic interaction between wind farm and power system are studied both under normal operation and grid fault events.

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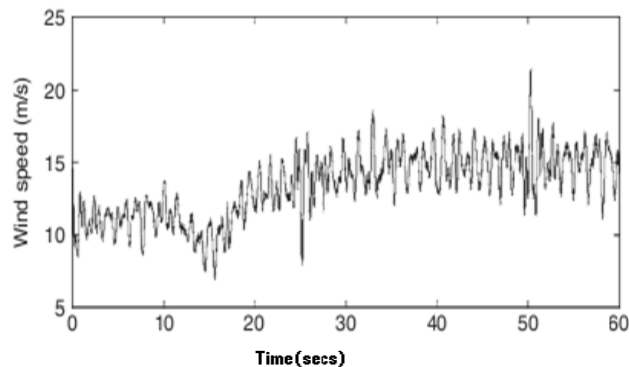
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III. WIND FARM

The output of the first block in Figure 2.1 is a wind speed sequence. One approach is to model the wind as a sequence of wind speed or time series. The advantage is that the real wind speed measured in the wind mast is used. In the analytical approach, the wind speed is assumed to be a sum of the four components as given in equation

$$V_w(t) = V_{wa} + V_{wr}(t) + V_{wg}(t) + V_{wt}(t)$$



IV. PITCH ANGLE CONTROLLER MODEL

During the high wind velocity, the blades of wind turbine have to be pitched away from the wind to produce constant power output. This can be achieved by using a slewing drive which precisely angles the blade to withstand high wind velocity. In this design, servomotors are incorporated on each blade, which is controlled by a precision PID controller. The Optimal beta control block sets the appropriate value of pitch angle for the given wind velocity. The DIGSILENT model of the pitch controller is shown in the Figure. The input signal is V_w and output signal is B . The internal variables are y_i , $bref$, x_e and y . The parameter variables are array Beta, K , T , K_p and T_i . With the help of common model block, the values of the parameter variable are entered as shown in Figure

V. FRAME

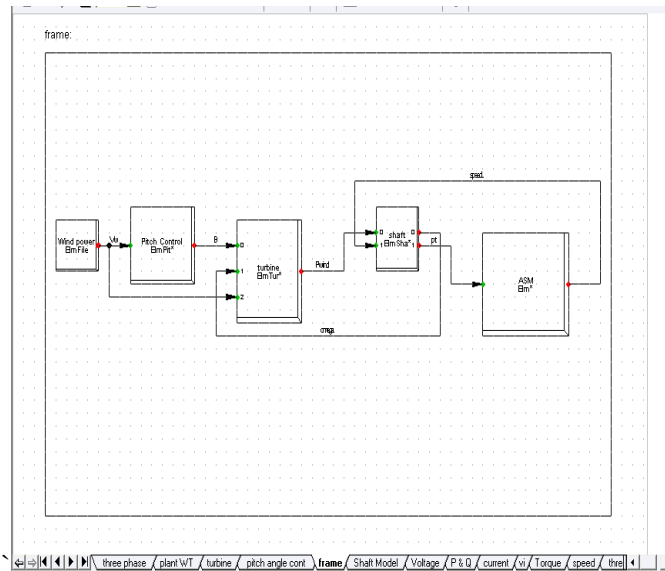
A Frame is a type of block definition which includes a number of slots for integrating the various blocks defined. All the individual blocks such as Turbine blk, Shaft model blk, Pitch angle controller blk, built in model of Induction Machine (ASM blk) are connected together through the slot with help of Frame definition as shown in Figure 2.16. When a slot in the frame definition is selected the project block gets opened where in number of functional block already defined are displayed. Then, the appropriate blocks are selected to realize a constant speed wind turbine driven squirrel cage induction generator for connecting to the grid.

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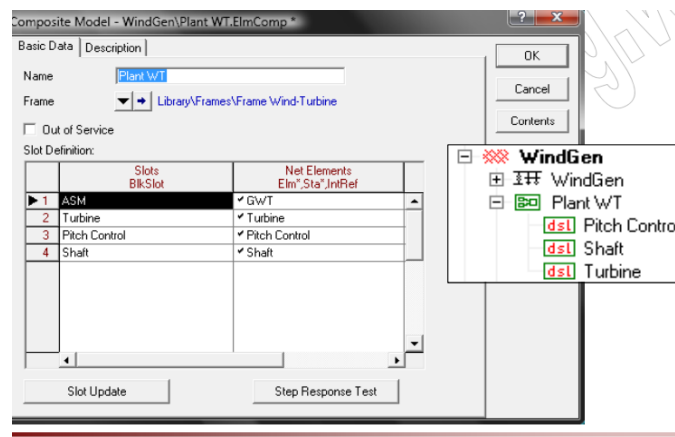
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VI. COMPOSITE MODEL

In the frame definition, the wind electric generator system is modeled to integrate all the blocks that have been discussed in the previous section. In order to connect the wind electric system to the grid, the composite model is used. In the composite model a frame is selected for linking the individual slots to the variables of the common model. The various slots and their linking to the common block variables are shown in Figure.



VII. INDUCTION MACHINE MODEL

The induction generator namely ASM Elm available in library has been selected for wind electric generator. It has several advantages, such as robustness, mechanically simple, maintenance free and low cost. The major disadvantage is that the stator needs a lagging reactive power (VAR) from the source. The reactive power may be supplied by the grid or by a capacitance bank. The generator's magnetic field is established only if it is connected to the grid.

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VIII. CONCLUSION

With a view to getting a better understanding of a wind electric system, a generic model is introduced, where the various independent elements of a wind turbine and their interaction are explained. The individual blocks such as turbine BlkDef (block), shaft BlkDef, pitch angle control BlkDef were designed with mathematical model using DSL. All the individual blocks were connected together with help of frame definition block including built-in model of ASM BlkDef. The values of the parameter variable in each block are entered using common model. The composite model (ElmComp) connects the frame slot and common model. Finally, the grid connected fixed wind turbine was built with help of power system component such as bus bar, transformer, cable, feeder etc from the software. The power electronics based soft starter present in the library was used to interface the wind generator with the grid. It is used to reduce the starting transient current when the generator is synchronized with the grid. The induction generator absorbs the reactive power from the grid and this may affect the grid voltage profile. The amount of reactive power absorbed will be reduced by connecting a capacitor bank near to the generator bus bar.

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