



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 9, September 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

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Simulation of Fixed Speed Wind Farm

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ABSTRACT: The rapidly growing wind industry is highly expressing the need for education and training world wide, particularly on the system level. Modelling and simulating wind generator system using Digsilent provides expert help in understanding wind systems engineering and system design. Working under Digsilent we present the integration of the developed WECS model with public electrical grid. A test of the calculated power and Cp related to the experimental equivalent data, using statistical analysis is performed. The statistical indicators of accuracy show better results of the presented method with RMSE: 21%, 22%, MBE: 0.77%, 0.12% and MAE:3%, 4%. On the other hand we study its behaviour when integrated in whole power system. Three level of wind speeds have been chosen: low with 5m/s as the mean value, medium with 8m/s as the mean value and high speed with 12m/s as the mean value. These allowed predicting and supervising the active power produced by the system, characterized respectively by the middle powers of -150 kW, -250 kW and -480 kW which will be injected directly into the public electrical grid and the reactive power, characterized respectively by the middle powers of 60 kW, 180 kW and 320 kW and will be consumed by the wind generator.

KEYWORDS: Simulation, Fixed speed wind farm, Wind energy conversion system, Digsilent.

I. INTRODUCTION

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 Fig 1.1 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.

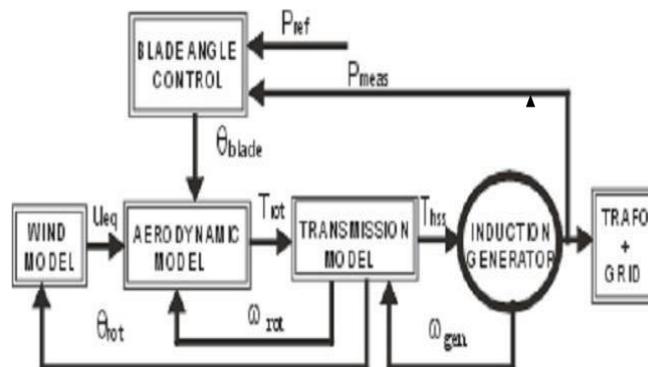


Figure 1.1 General structure of fixed speed wind electric

II. WIND POWER PLANTMODEL

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 InductionMachine (ASMBlk) are connected together through the slot with help of Frame definition as shown in Figure 3.1. 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. 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.

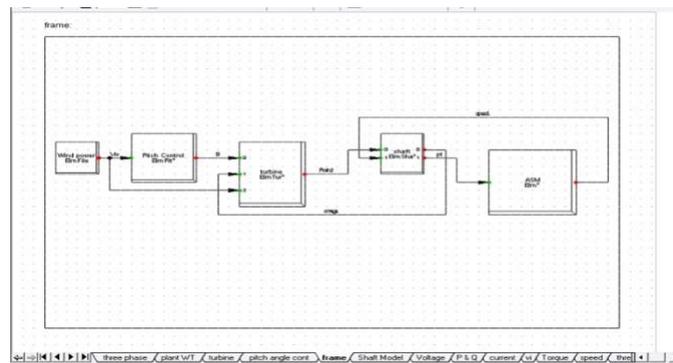


Figure 2.1 Frame definition to form slot to integrate all the blocks

III. GRID CONNECTION

DigSILENT consists of inbuilt power system components like transformer, Cable (power cable, underground, overhead cable), Feeder, Busbar, Terminal, Current transformer, Voltage transformer, Capacitor bank, Industrial load, Consumer load and Soft starter. The grid connected wind electric system is modeled with the help of these components. The induction generator unit is directly connected to the soft starter through the step up transformer for reducing the starting transient current. The Reactive power flow absorbed from the grid is controlled by suitable capacitor bank connected at generator bus bar.

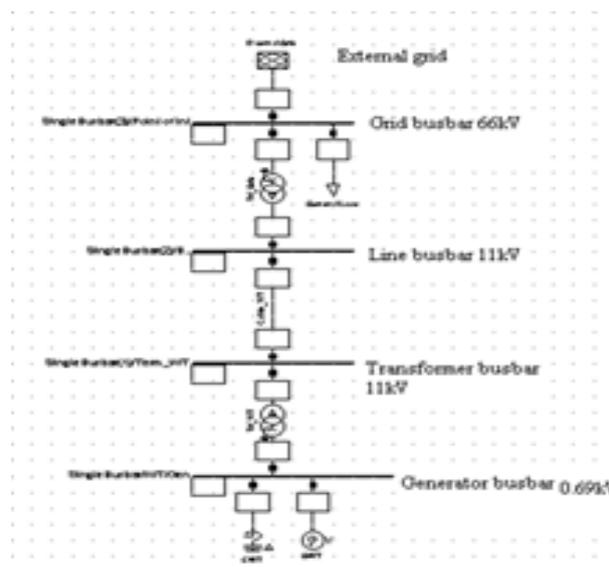


Figure 3.1 Layout of wind electric system in DIgSILENT

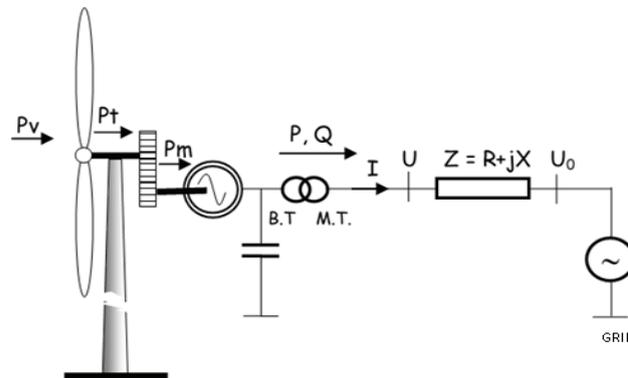


Figure 3.2 Schematic Diagram of Fixed Speed Wind Electric System

A. SoftStarter

The soft-starter is a simple and cheap power electrical component used in fixed-speed wind electric system for interfacing it to the grid without causing starting transient current. Without a soft-starter, the transient current can raise up to 7–8 times the rated current, which can cause severe voltage disturbances on the grid. The soft-starter contain stwothyristors

connected back- back in each phase to control the starting current. After the transient period, the thyristors are by passed by a mechanical switch for reducing the losses.there by a mechanical switch for reducing thelosses of the overall system.

B. CapacitorBank

The capacitor bank is used in the fixed-speed turbines to supply reactive power to the induction generator so that the power factor is improved in the grid. The generators of wind turbines can have a full load dynamic compensation, where a certain number of capacitors are connected or disconnected continuously, depending on the average reactive power demand of the generator over a predefined period of time. The capacitor banks are usually mounted at the bottom of the tower or to the nacelle. The rating of the capacitor bank is usually about 30% of the kVA rating of themachine.

IV. SIMULATION OF THE SUBSTATION

The steady and dynamic state stabilities were analyzed for a wind generator connected to the grid in the previous chapter. Wind farm consists of six wind generator each with capacity 600k Wat 690 V are taken for the analysis. The total capacity of this wind farm is 3.6MW. The power quality analyzers were connected at this substation to record the various power quality issues.

Each wind turbine is connected to an 11 kV bus bar. The induction generators, soft-starters and the capacitor banks for reactive power compensation and step up transformer are placed at the foot of wind turbine. The control of active and reactive power is based on the measured reactive power at the point of common coupling. The wind turbine controller must be able to adjust the production of wind turbine, according to the demands imposed by the system operator. In case of normal operating conditions, the wind turbine has to produce maximum power. In power limited operation mode, the wind turbine has to limit its production to the rated power for wind speed greater than rated values.

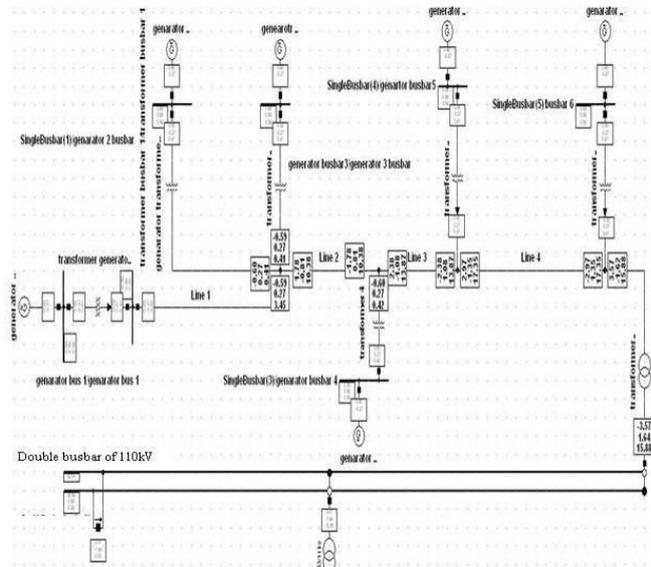


Figure 5.3 Simulation Model of the substation in DIGSILENT

A. Frequency Variations

Frequency variation in the power system depends upon the power demand. When the generated power and the load demand are equal, the value of frequency is 50Hz. Under the light load condition, the excess generated power is absorbed by the external grid. The frequency of the each bus bar is remain constant. When the load is increased above the generated power, infinite grid busbar supply the power to compensate therefore the busbar frequency is remain constant.

B. Simulation of wind electric system for various wind speeds

If the wind velocity decreases below its rated value (12m/s), the generated power also decreases. The fixed speed wind generator is also known as constant voltage source, generates constant voltage from rated wind velocity 12m/s to cut in speed 3.5m/s. As the wind velocity is reduced gradually, the generated power and current reduce accordingly. The speed and real power variations depend upon the speed of the wind. When the wind velocity comes nearer to the cut in speed of 3.5m/s, the induction generator behaves like an induction motor and starts absorbing the reactive and real power from the grid.

C. Dynamic Analysis

In dynamic analysis as discussed in chapter 3, the wind speed is assumed to vary from cut in speed to cut out speed (3.5m/s to 20m/s) as shown Figure 5.6. As the wind turbines are a few Km apart, the wind speed at individual wind turbines are assumed to have different values in the simulation.

The wind generator 1 which is a few km away from grid bus bar and the generator 6 which is nearer to the grid bus bar are taken for the analysis. Various scenarios such as Transient stability analysis, three phase fault, and sudden increase of load, load flow harmonics and flickering are simulated. The electromechanical transient (RMS) simulation is executed for 600 seconds and the various data such as real power, reactive power, current, electrical and mechanical torques are recorded.

The pitch controlled wind turbine used in this model. When the speed of the wind is varying, the power generated is equal to or less than that of the rated value as shown in Figure 5.7. When the speed is below the rated value, the pitch control mechanism is deactivated. The induction generator absorbs the reactive power from the grid or from the capacitor banks.



V. 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.

ACKNOWLEDGMENT

We would like to extend our sincere thanks to all those who played a role in the completion of this project. Firstly, we are highly indebted to RMK Engineering College for their constant supervision and support. We would also like to thank Dr T. Magesh for his guidance, and encouragement throughout the project work. Lastly, we are immensely grateful to all those involved in this project as without their inspiration and valuable suggestion it would not have been possible to develop the project within the prescribed time period

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