Control Strategy of Induction Generator Connected to Grid.

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Abstract:- There has been an increasing use of induction generator particularly in wind power applications. In generator operation, a prime mover (turbine, engine) drives the rotor above the synchronous speed. Stator flux still induces currents in the rotor, but since the opposing rotor flux is now cutting the stator coils, active current is produced in stator coils, and motor now operates as a generator, and sends power back to the electrical grid. In this project, squirrel cage induction generator is used due to its simple and robustness and generator side field oriented control strategy is applied. And grid side unit vector template control strategy will apply in future.

Keywords:- Turbine, Squirrel Cage Induction Generator, Field Oriented Control Strategy

I. INTRODUCTION

Initial interest in renewable energy such as wind energy, solar energy, fuel cell, tidal power and geothermal power is due to the oil crises of the 1970s and fear of resource depletion and political insecurity resulted in frenetic research and development activity, impressive technological and bold energy policy experiments. Among these, wind power generation is relatively economic and hence developed commercially. Fixed speed wind electric generators (WEGs) are popular in the market because of their capability to extract more energy than fixed speed machines, reduced mechanical stress and aerodynamic noise. Induction generators operated by vector control techniques have fast dynamic response and accurate torque control which are advantageous in variable speed operation The robust, relatively maintenance-free and cheap induction machines have long been used as a good choice as the electrical generator in WEG systems, albeit those are fixed speed systems. The vector or field-orientated control of induction generator yields high dynamic performance ideal for variable-speed WEG systems too.

There are Many Advantages of Squirrel Cage Induction Generator Over Conventional Generators.

- Simple and robust construction.
- Inexpensive as compared to the conventional synchronous generator.
- Minimal maintenance.
- Standalone application, no fixed frequency.
- Less material costs because of the use of electromagnets rather than permanent magnets.
- Inherent Over Load Protection

As a result, Squirrel Cage Induction Generator are being used in a wide range of Standalone Or Grid Connected Wind Farms.

1.1 Modeling Of Wind Energy System

The mechanical power that can be extracted from a wind turbine is given by

$$P_w = 0.5\ C_P A V^3$$

Where *ϱ* is the air density, *A* is the area swept by the turbine blades, *Cp* is the performance coefficient of the turbine and *v* is the wind velocity. A typical performance coefficient curve is shown in Figure where *β* is the blade pitch angle.

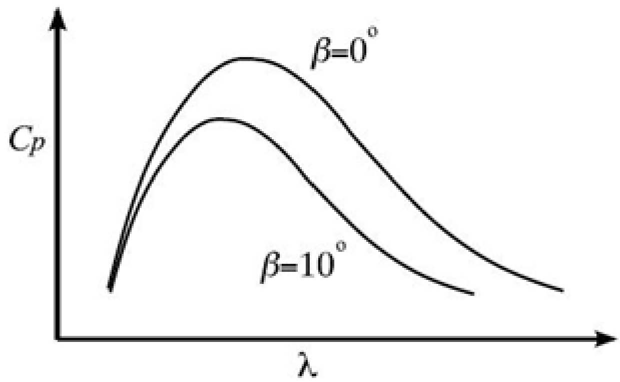


Figure 1 Typical performance coefficient vs. tip speed ratio curve showing the effect of varying the blade pitch angle.[1,2]

The performance coefficient is dependent on the tip speed ratio λ is given by

$\lambda =$

Where t is the rotational speed of the turbine and R is the turbine radius. It can be seen that λ should be held constant to harness maximum power from the wind. The turbine rotational speed must therefore increase as the wind speed increases. When the wind turbine reaches its maximum rotational speed however, blade pitch angle control can be employed to shed the excess wind power. Increasing the blade pitch angle decreases the optimum Cp and λ value as shown in Figure 1.

1.2 The Induction Generator System

The system is shown in Figure 2. The following are the system components: (i) horizontal axis wind turbine, (ii) gear, (iii) three phase SCIG, (iv) generator side converter, (v) DC link capacitor, and, (vi) grid side converter synchronized to a three phase grid.[2]

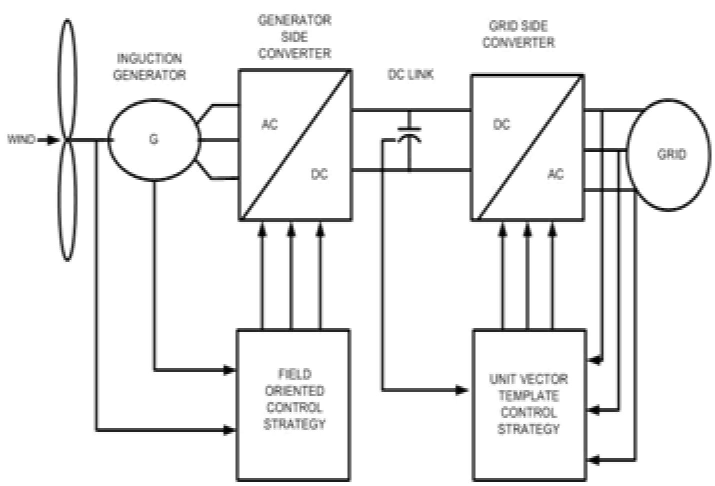


Figure 2: Schematic Diagram of SCIG [2,3]

Here the active power is flowing from the wind turbine to the grid and reactive power from the grid to the generator. A pair of back to back PWM converters is connected between the SCIG and the grid for asynchronous operation. That facilitates the Fixed speed operation of the wind power generation system. The power from the generator is rectified by the generator side converter. This converter also supplies the magnetization current of the machine. The supply side converter supplies the generated power to the utility grid.

II. SIMULATION ON WIND TURBINE

General simulation of wind turbine using PSIM can be done by using math function block. In this simulation the quantities related to turbine is used in that math function block. Before simulation of Squirrel Cage Induction Generator system, simulation of wind turbine is necessary. Although wind turbine generators can be interfaced directly with the power system, the use of a power electronic interface is preferred since it permits variable speed operation and thus offers increased power extraction from the wind. Figure for turbine simulation is shown in figure 3 given below:[4,5]

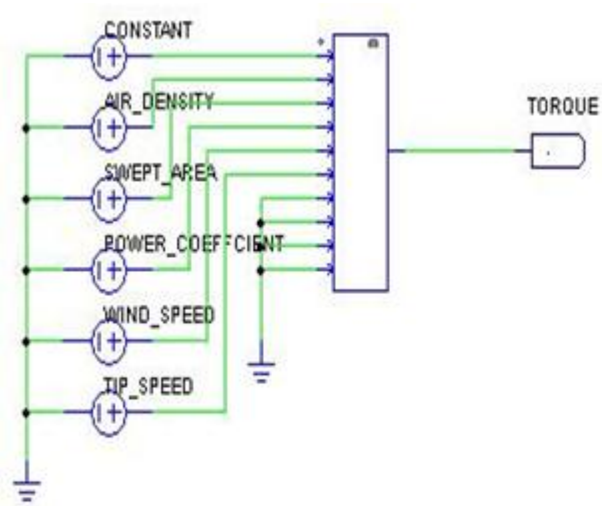


Figure 3 wind turbine simulation [3]

Torque output from wind turbine is constant and it is shown in figure 3 given below:

Figure 4 output torque of wind turbine

III. GENERATOR SIDE CONVERTOR CONTROL

Figure 5 shows the generator side converter control scheme for SCIG. The three phase stator currents are converted to direct axis and quadrature axis components with the help of abc to dq transformation. These are then compared with the corresponding reference values. Idref sets the machine flux level which is maintained constant. For power flow control, Idref is derived from generator side converter output current. Iqref is derived from generator speed. The two control loops provide vd and vq respectively. Using these voltages three phase modulating signals are generated and sent to the PWM generator that provides gate signals to drive the generator side converter.

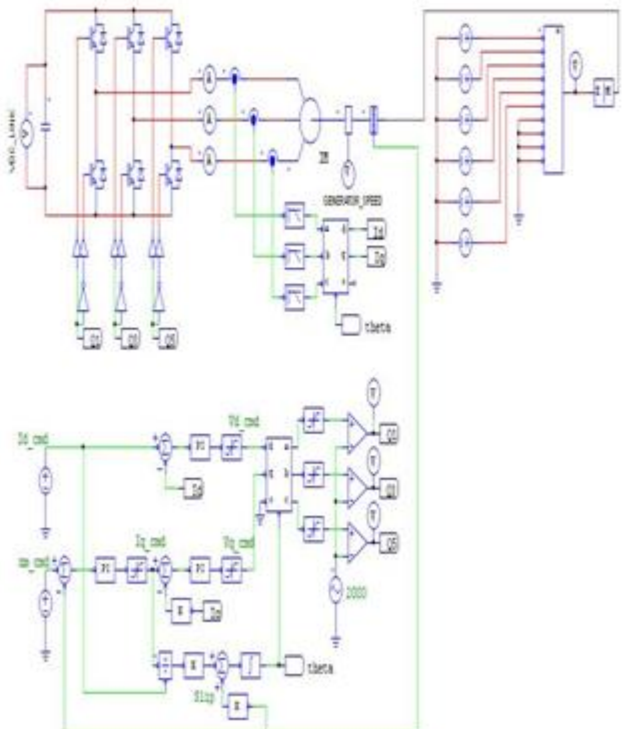


Figure 5 Field oriented control strategy on generator side.[4,5]

IV. GRID SIDE CONVERTOR CONTROL

The control scheme approach is based on injecting the currents into the grid using “bang-bang controller.”

The controller uses a hysteresis current controlled technique. Using such technique, the controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for switching operation. The control system scheme for generating the switching signals is shown in Figure The control algorithm needs the measurements of several variables such as three-phase source current, V_{DC} voltage inverter current with the help of sensor. The current control block, receives an input of reference current and actual current are subtracted so as to activate the operation of in current control mode.[12,13]

4.1 Grid Synchronization

In three-phase balance system, the RMS voltage source amplitude is calculated at the sampling frequency from the source phase voltage) and is expressed, as Sample template, sampled peak voltage, as in

The in-phase unit vectors are obtained from AC source—phase voltage and the RMS value of unit vector as shown in
= , = , =

The in-phase generated reference currents are derived using in-phase unit voltage template as, in where is proportional to magnitude of filtered source voltage for respective phases. This ensures that the source current is controlled to be sinusoidal. The unit vectors implement the important function in the grid connection for the synchronization This method is simple, robust and favourable as compared with other methods.

4.2 Bang-Bang Current Controller

Bang-Bang current controller is implemented in the current control scheme. The reference current is generated as in and actual current are detected by current sensors and are subtracted for obtaining a current error for a hysteresis based bang-bang controller. Thus the ON/OFF switching signals for IGBT of Grid side converter are derived from hysteresis controller [13]

The switching function for phase ‘a’ is expressed as

Where HB Is A Hysteresis Current-Band, Similarly The Switching Function , Can Be Derived For Phases “B” And “C”.

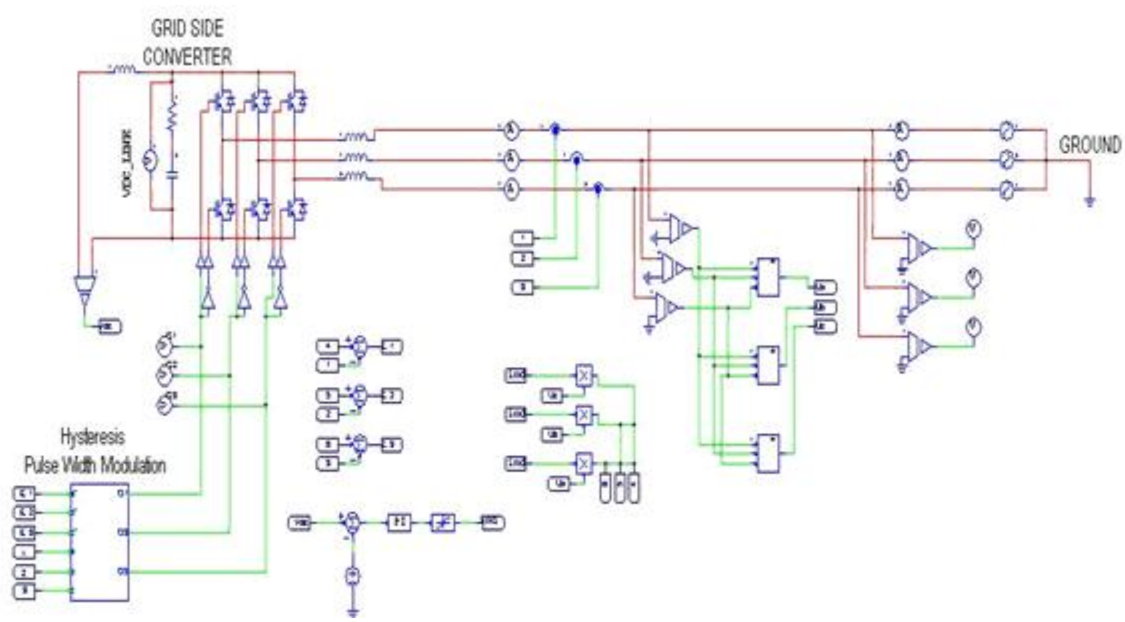
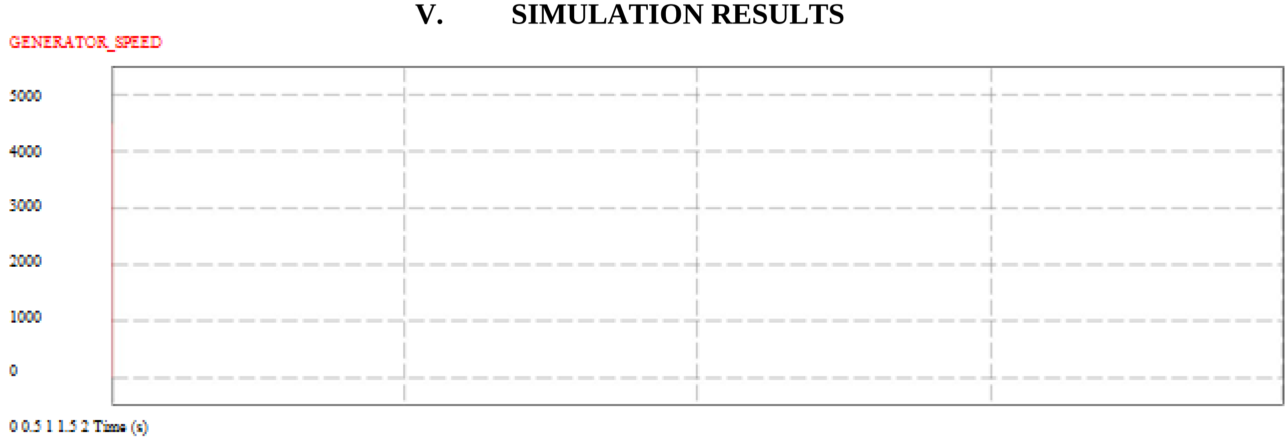
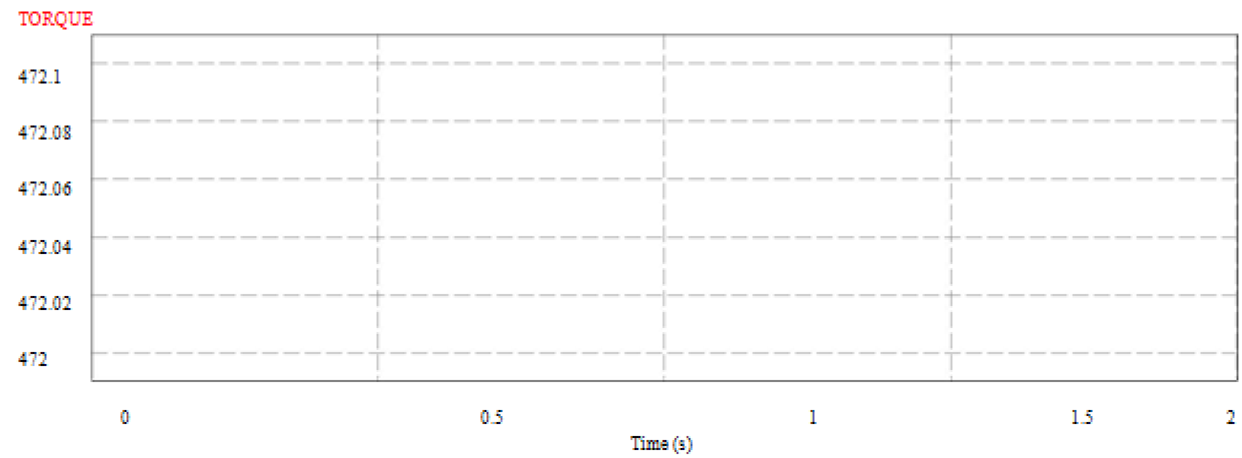


Figure 5 Unit Vector Template control strategy on grid side [13]

V. SIMULATION RESULTS

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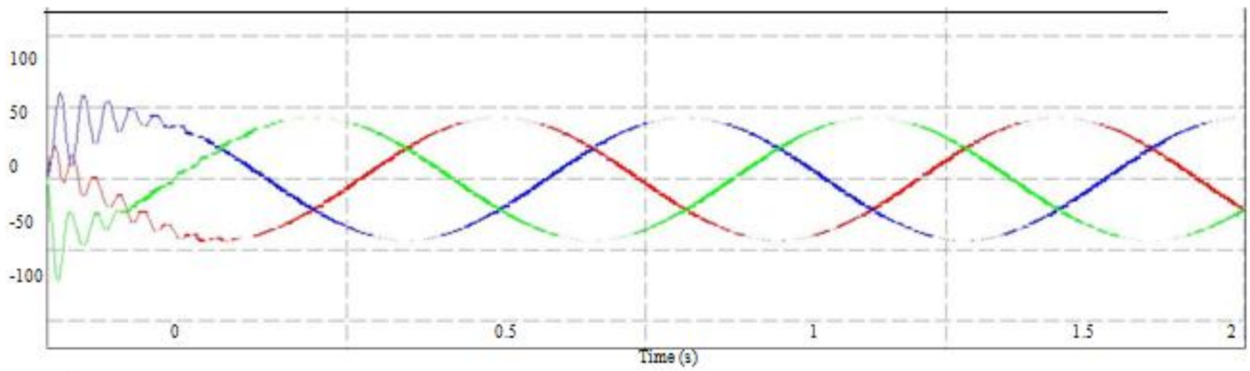
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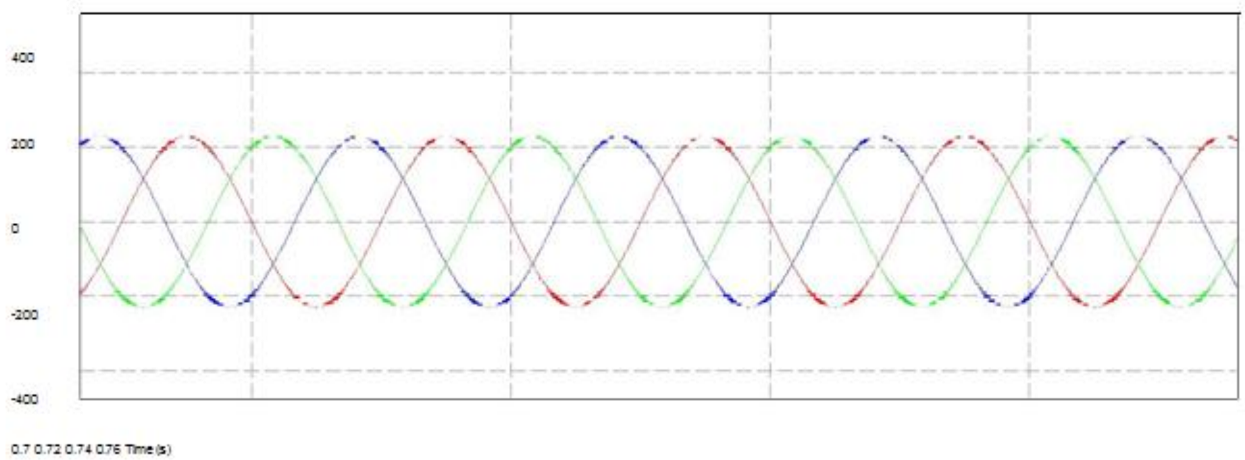
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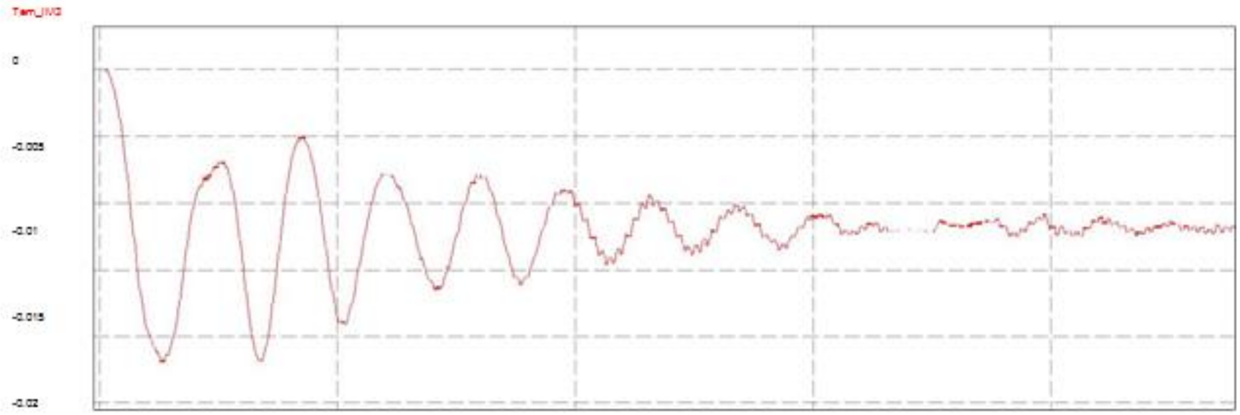
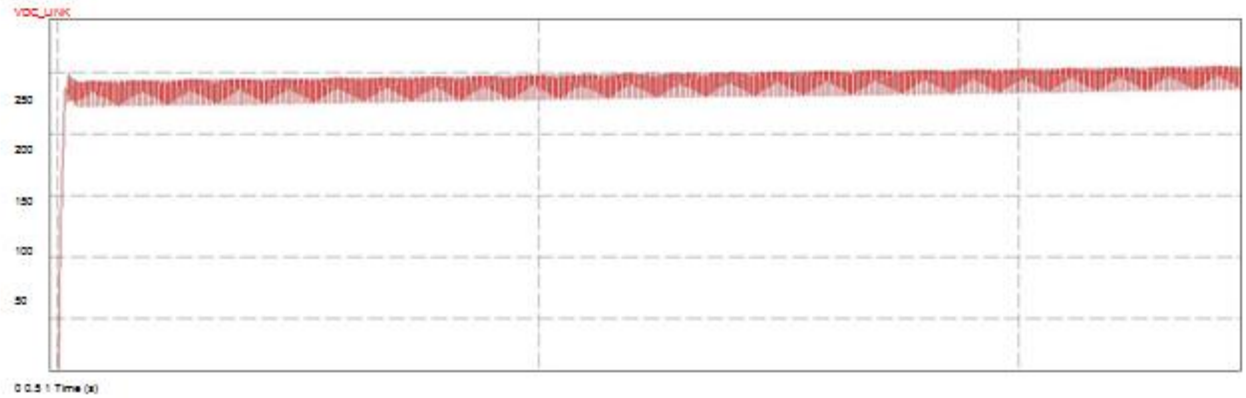
0.7 0.72 0.74 0.76 Time (s)





VI. CONCLUSION

In this Paper Generator Side Control Strategy is applied and unit vector template Control Strategy is applied on grid side after that the whole System is connected to grid and active and reactive power is controlled by respective control technique and also total harmonic distortion is very less and within it's acceptable limit as per IEC without connecting any filter or facts device.

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