PI Controller for 3Phase Matrix Converter in Wind Energy Conversion System

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Abstract : The non conventional energy resources are very important in our daily concerns. The wind power has become an attractive solution for the generation of electricity. In wind energy conversion system Squirrel Cage Induction Generator (SCIG) are used to generate electrical energy from the mechanical energy produced by wind turbine. SCIG is connected to the Matrix Converter. MC is in 3x3 matrix forms, it has four quadrants, fully controlled bidirectional switch. MC is used to convert variable voltage and frequency into desired voltage and frequency. Space Vector Pulse Width Modulation (SVPWM) techniques are used to trigger the pulses of MC switches. The generator speed and reactive power are controlled using PI Controller and wind energy conversion system parameters are presented.

IndexTerms - Wind turbine with squirrel cage induction generator, Matrix Converter, Space vector modulation, PI Controller, MATLAB/Simulink

I. INTRODUCTION

The non- conventional resources are vital in our daily concerns. Due to the economical prices of oil and fossil fuels with resulted in global warming has given an alternate for the use of renewable energy resources for the generation of electricity. Wind power has become an attractive solution for this purpose. It has seen a linear increase in the utilization where in the wind power plants are developed with the wide range of capacity. As the electricity can be generated in different form of energy such as wind energy as it is renewable form. There is no additional cost are required once it is installed. There is no requirement of any fuels for the generation of power. By using this form of energy helps to conserve natural sources.

SCIG is maximum normally used generator. Because it has additional benefits of excessive reliability, low maintenance requirement, cost and is very light. It mainly consists of rotor and stator winding. One is connected to mesh and other is determined by wind turbine.

Major benefit of SCIG is reduction with conductor compared to slip ring motor due to this there will be low copper losses and absence of slip rings leads to get higher efficiency in case of SCIG and also there is no any problem of sparkling.

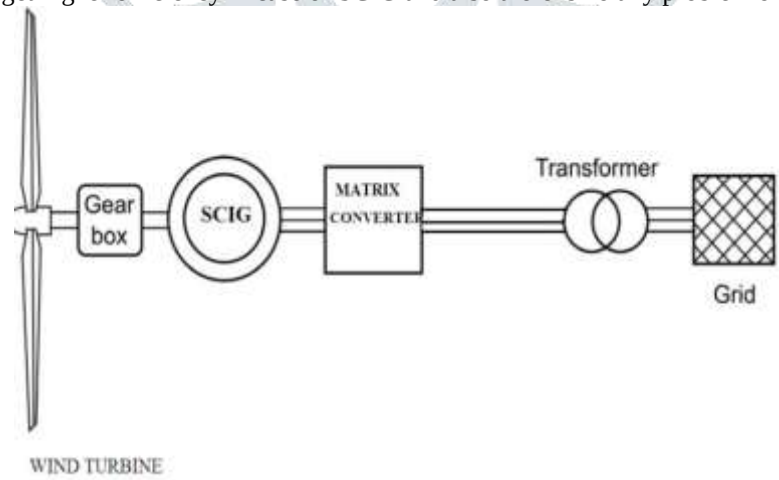

Fig 1 Block diagram of wind turbine with SCIG connected to the grid

In the above fig, the wind turbine is connected to a gear box then equipped with the induction generator. SCIG has a advantage with wind system where the nominal value is reached faster over DFIG. The SCIG connected to the grid through matrix converter. Matrix converter is converter with three input and three output phases of nine bidirectional switches in a 3x3 matrix form.

The control strategy that are provided for the switches that generate the pulses for switches and also control both input and output voltage to be constant. This strategy is referred as space vector pulse width modulation. By this strategy can expect better efficiency and high gain at the output hence this is accepted widely than other PWM method.

II. METHODOLOGY

As wind passes through the turbine blade leads to the production of lift inducing torque. Torque that are developed then passed to the power train sequentially connected to the gearbox. The angular speed generated by the gearbox of the generator is low then stepped up to high rotational speed. Turbine helps to convert the kinetic energy into mechanical energy. Then it is converted into electrical energy using induction generator. Power develops in induction generator where the stator winding carries the reactive power and produces the alternating current. The rotating magnetic field that are produced in stator and produces current in rotor magnetic field helps to develop its own magnetic field. The interaction between stator and rotor magnetic field produces torque in the rotor. When the speed is above synchronous speed generates the power in induction generator. The induction generator is connected to grid through matrix converter where the controlled output is obtained using bi-directional switch.

III. SIMULATION DIAGRAM

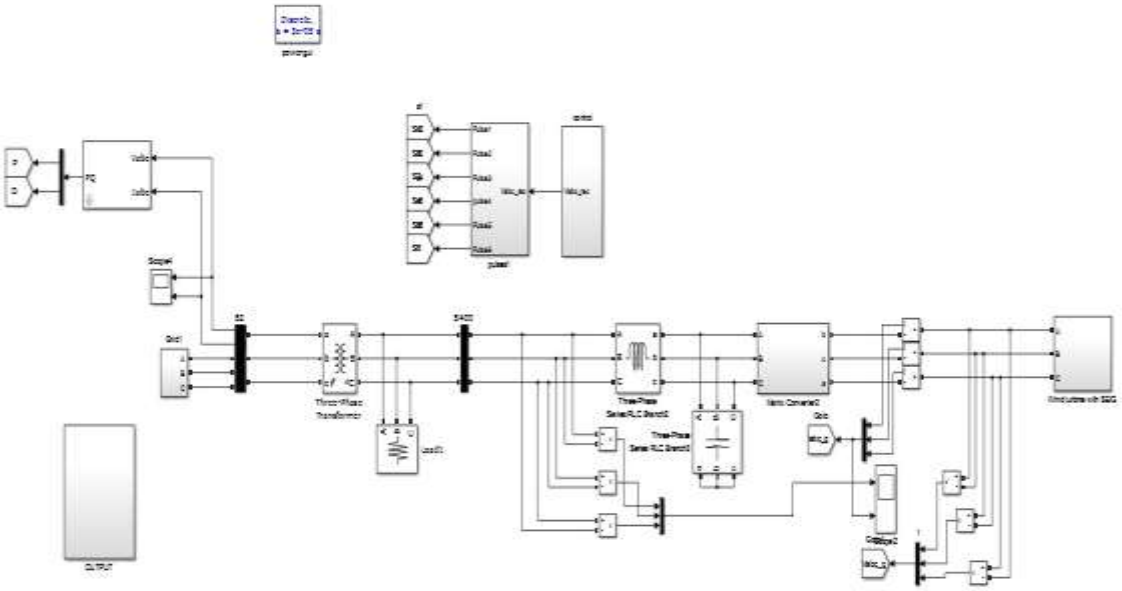

Fig 2 Simulation diagram of Wind turbine with SCIG connected to grid through Matrix Converter

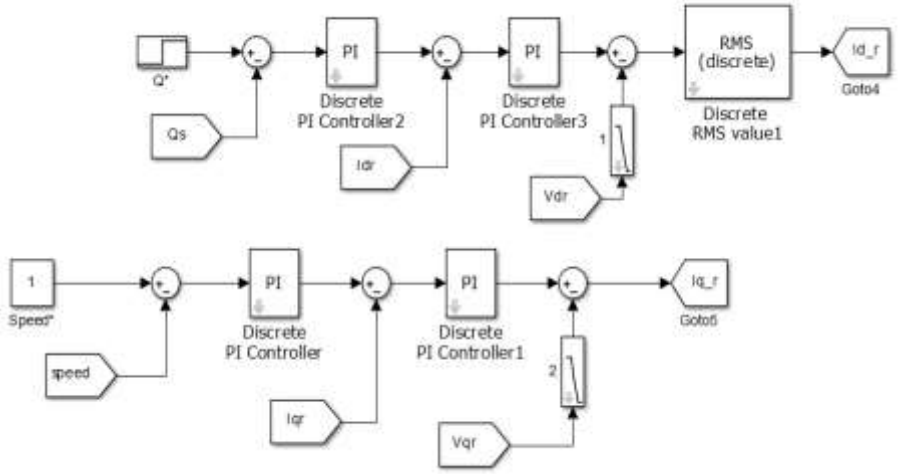

Fig 3 Simulation diagram of PI Controller in SCIG

IV. SIMULATION RESULTS

The simulation study of matrix converter based wind energy system is simulated by simulink software package. The WECS comprises of 3 major parts, those are Wind turbine, Matrix Converter, Induction Generator and Controller. The simulation results of various parameters related to performance of Matrix Converter fed WECS are presented.

Fig 4.1(a),4.1(b),4.1(c) shows the wind turbine parameters such as wind speed, rotor speed and torque for the wind speed profile of step change, impulse and ramp.

In step change input, wind speed changes from14m/s to 16m/s, the corresponding rotor speed and torque developed by the turbine are changes with the wind speed. But in impulse and ramp change, wind speed changes from 10m/s to 14m/s.

A. WIND TURBINE

Fig 4.1(a) Step change in wind speed

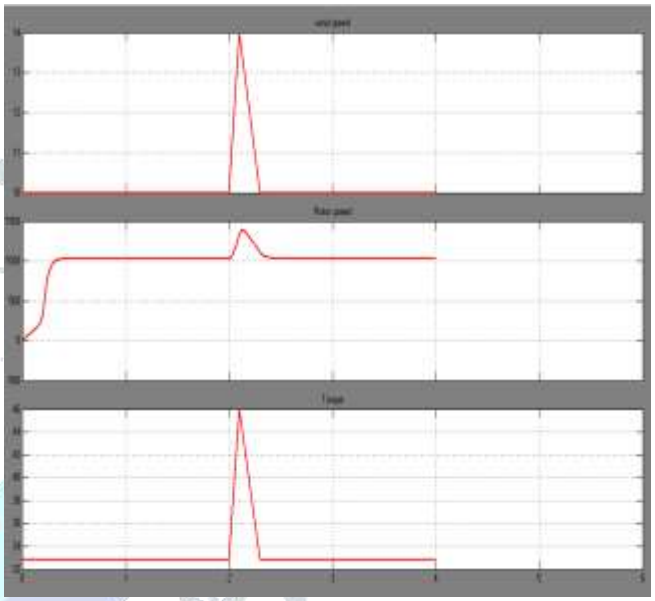

Fig 4.1(b) Impulse change in wind speed

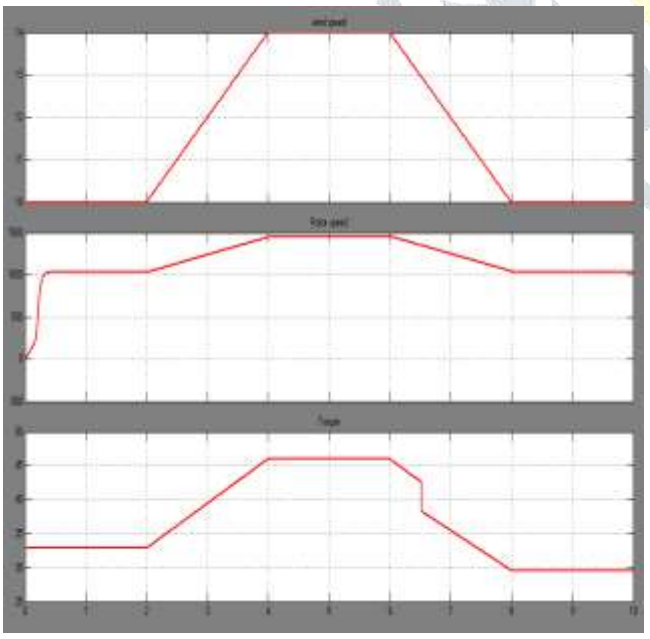

Fig 4.1(c) Ramp change in wind speed

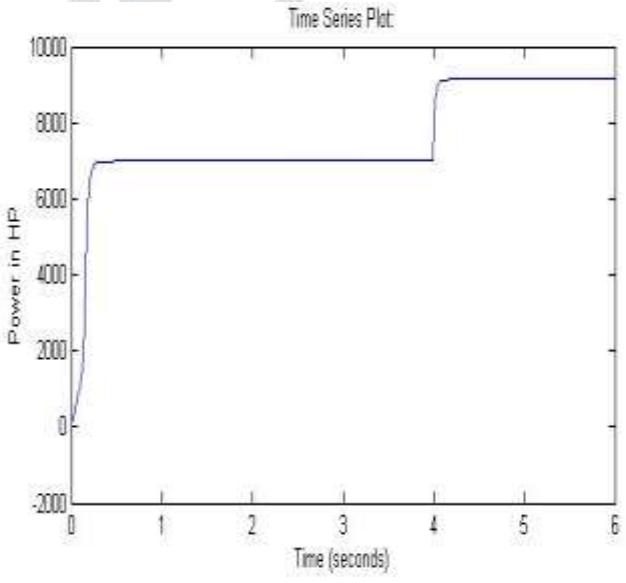

Fig 4.2(a) Mechanical power from wind turbine

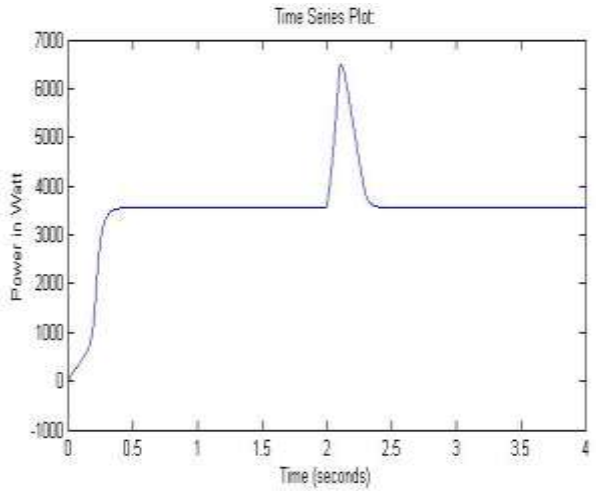

Fig 4.2(b) Mechanical power from wind turbine

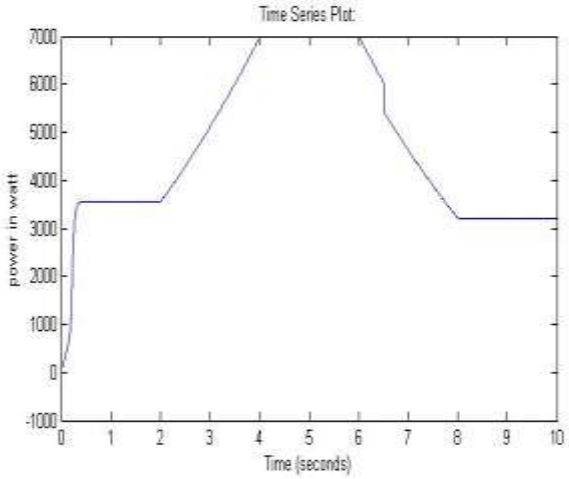

Fig 4.2(c) Mechanical power from wind turbine

Fig 4.2(a),4.2(b),4.2(c) shows the mechanical power generated by wind turbine in step change ,impulse change and ramp change wind speed

B. **SCIG**

Fig 4.3(a),4.3(b),4.3(c) shows the active and reactive power of SCIG for step change, impulse change and ramp change in wind speed using PI Controller. The reactive power reference changes from inductive nature to capacitive nature and hence the reactive power measured from the machine changes from negative to positive. As the wind speed increased the real power generated from the machine also increases.

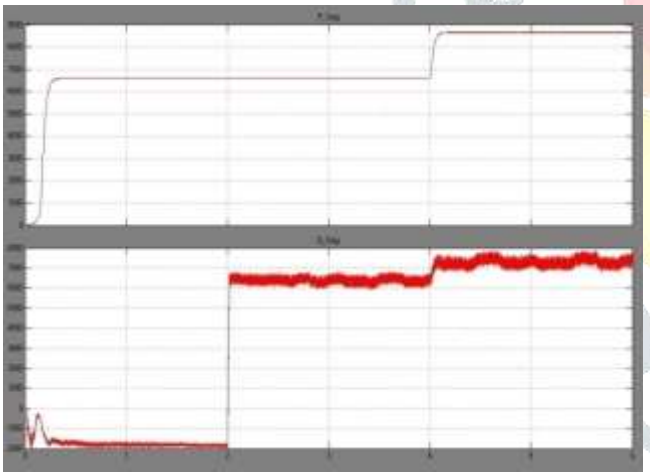

Fig 4.3(a) Active and reactive power of SCIG in step change wind speed using PI Controller

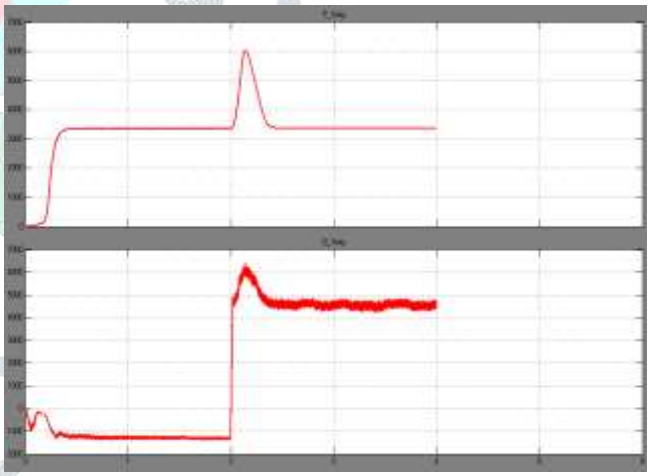

Fig 4.3(b) Active and reactive power of SCIG in impulse change

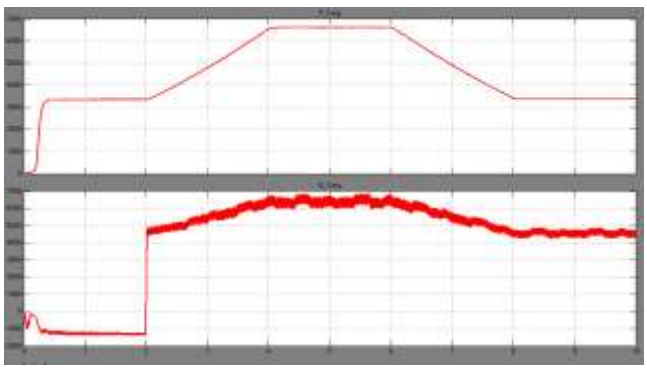

Fig 4.3(c) Active and reactive power of SCIG in ramp change wind speed using PI Controller

C.MATRIX CONVERTER

Fig 4.4 shows the output voltage and output current waveform of Matrix Converter in step change, impulse change and ramp change wind speed

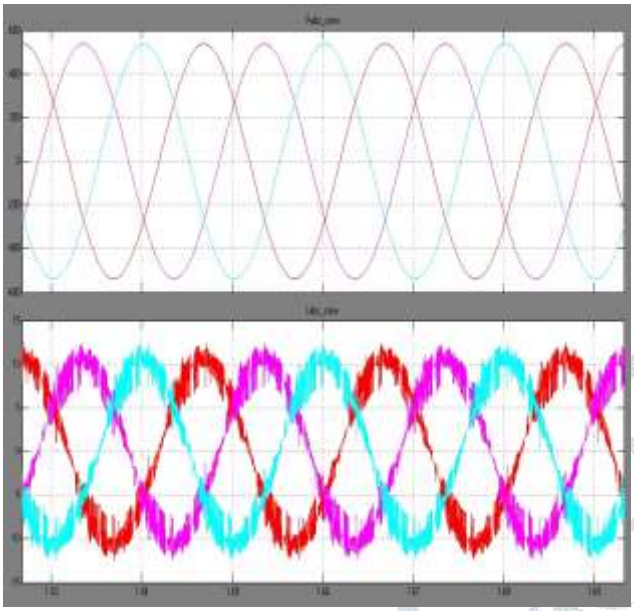

Fig 4.4 Output voltage and Output current waveform of MC

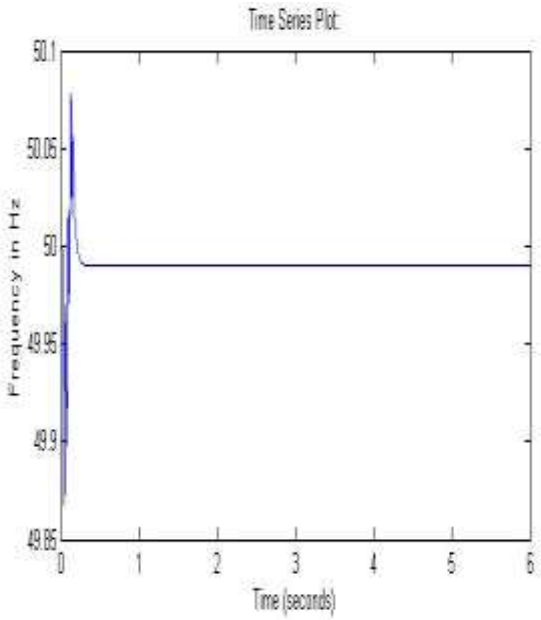

Fig 4.5 Output frequency of Matrix Converter

Fig 4.5 shows output frequency of Matrix Converter in step change , impulse change and ramp change wind speed. The function of Matrix Converter should be maintained desired frequency

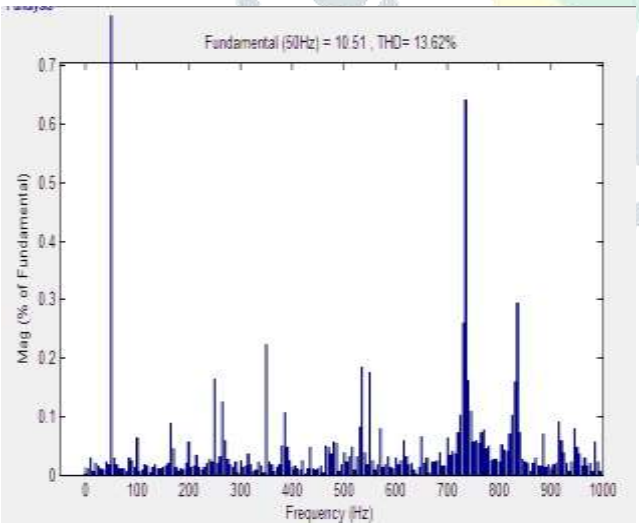

Fig 4.6 Total Harmonic Distortion using PI Controller

Fig 4.6 shows the Total Harmonic Distortion (THD) is 13.62% in step change wind speed using PI Controller

V. CONCLUSION

The PI Controller for Matrix Converter based wind energy system is simulated by simulink software package. The WECS comprises of 3 major parts, those are Wind turbine, Matrix Converter, Induction Generator and Controller. The Matrix Converter is fed by SCIG which is driven by wind turbine. SVPWM technique is used to generate the pulses for switches and also control both input and output voltage to be constant. The Matrix Converter is controlled using PI control scheme. Simulation result shows that some parameters like wind speed, torque developed by the wind turbine, rotor speed, active and reactive power SCIG.

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