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Simulink Modelling of Current Control of Induction Generator by Using Hybrid Active Filter in Wind Energy System

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ABSTRACT: This paper is presents the SIMULINK modeling of current control of self excited induction generator using hybrid active filter in wind system. The current control of self-excited induction generator(SEIG) is an isolated power source whose terminal voltage and frequency are controlling by the excitation capacitance or the load impedance this is calculating the minimum excitation capacitance using the equivalent circuit for analyze the steady state operation of self-excited induction generator. A new method based on hybrid active filter for controlling the current of the self excited induction generator in wind system.

In wind system, wind turbine blades are depend upon the air flow, these air flow are rotate the turbine and generate kinetic energy into electrical energy then generated the electricity. these project are represented the working of the wind turbine when air is flow low and high these are generated the electricity and control the current of induction generator.

The Hybrid active power filter was implemented using a shunt active power filter and connected to the wind generator and loads in order to compensate the current harmonics and reactive power. A hybrid filters which is a combination of series active filter and shunt passive filter. Among the various available combinations, active-passive combination is effective as it has the advantages of both active and passive filters. The characteristics of the passive filter are improved avoiding the problems of series and parallel resonances. The series APF with a shunt connected passive filter is widely used due to the above advantages. Thus, the control of series APF with shunt connected passive filter is studied and analyzed the current control. This project a new control strategy based on hybrid active power filter for controlling the current of self-excited induction generator when generator is connected to a load. This is also represents the analysis and modeling of dynamic model of SEIG. Basically a strategy based on an active power filter (APF) for controlling the current and power of the self-excited induction generator (SEIG).

KEYWORDS: Self excited induction generator (SEIG), Hybrid active power filter, Wind system, wind turbine, wind generator, shunt active power filter, SIMULINK.

I. INTRODUCTION

Today, the main source of electricity generated is fossil fuels like coal, oil, and natural gas and these are a non-renewable energy source. These fossil fuels have limited reserves and will run out in the future. Apart from that another drawbacks of this non-renewable energy source are it produces pollutant gases when fuels are burned and increases cost of generation. However more attention is being given to renewable energy such as wind, micro-hydro, solar, tidal wave, bio-fuel etc. Out of these renewable energy source wind energy seems to be important and promising source because it is clean and abundant resource that can produce electricity with no emission of pollutant gas and economically viable.

Induction generators are commonly used for wind powered electric generation, especially in remote and isolated areas, because of their relative advantages over conventional synchronous generator such as brush-less rugged construction , low cost, less maintenance, simple operation, self-protection against faults, good dynamic response and capability to generate power at varying speed. A three-phase induction machine can be made to work as a self-excited induction generator where a three-phase capacitor bank is connected across the stator terminals to supply the reactive power

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requirement of a load and generator. In a grid connected induction generator driven by a wind turbine the magnetic field is produced by excitation current drawn from the grid.
The fundamental problem with using the SEIG was its inability to control the terminal voltage and frequency under varying load conditions. Active Power Filters (APF) are often used in applications where low current harmonics are desirable and/or improvement of quality of energy taken from the power grid are needed. With the use of APF, it is possible to draw near perfect sinusoidal currents and voltages from the grid or renewable distributed power sources. Moreover, it will be possible to balance load currents in different phases which itself is important in stand-alone power generation like wind turbines as for the case of unsymmetrical load currents, it could lead to torque pulsation in generator's shaft and a decrease of reliability. With the use of APF it is also possible to control reactive power and keep unity power factor that is why they are mainly used in industry where DC current is needed e.g. aluminum plants, train power substations, arc welders etc.

II. SYSTEM CONFIGURATIONS

The basic system diagrams are shown in fig.1. It consists of a three-phase induction machine can be made to work as a self-excited induction generator where a three-phase capacitor bank is connected across the stator terminals to supply the reactive power requirement of a load and generator. In a grid connected induction generator driven by a wind turbine the magnetic field is produced by excitation current drawn from the grid. The wind turbine and the induction generator (WTIG) are shown in fig.1.

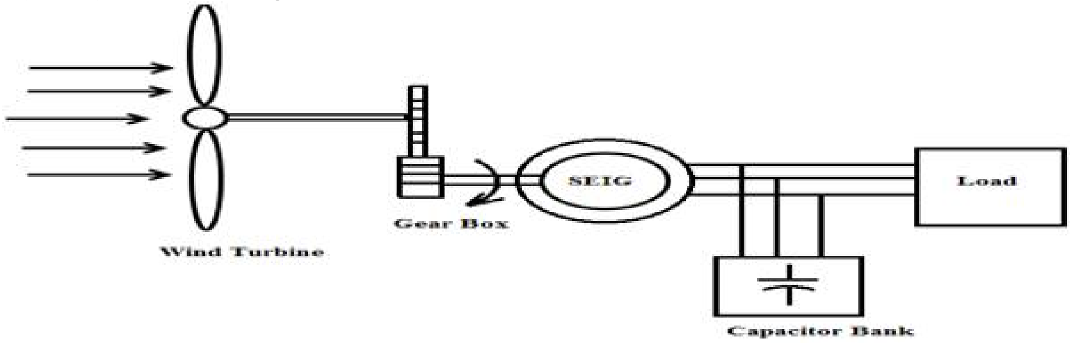

Fig.1. Schematic diagram of wind driven induction generator

The stator winding is connected directly to the grid and the rotor is driven by the wind turbine. The power captured by the wind turbine is converted into electrical power by the induction generator and is transmitted to the grid by the stator winding. The pitch angle is controlled in order to limit the generator output power to its nominal value for high wind speeds. In order to generate power the induction generator speed must be slightly above the synchronous speed. But the speed variation is typically so small that the Wind turbine induction generator is considered to be a fixed-speed wind generator. The reactive power absorbed by the induction generator is provided by the grid or by some devices like capacitor banks, SVC, STATCOM or synchronous condenser.

The block diagrams of current control of self excited induction generator in wind system are shown in fig.2. The Simplified Synchronous Machine block models both the electrical and mechanical characteristics of a simple synchronous machine. The electrical system for each phase consists of a voltage source in series with an RL impedance, which implements the internal impedance of the machine. The value of R(Resistance) can be zero but the value of L(inductance) must be positive. The generator is operated as an SEIG by connecting a fixed terminal capacitor of such a values as to result in rated terminal voltage at full load.

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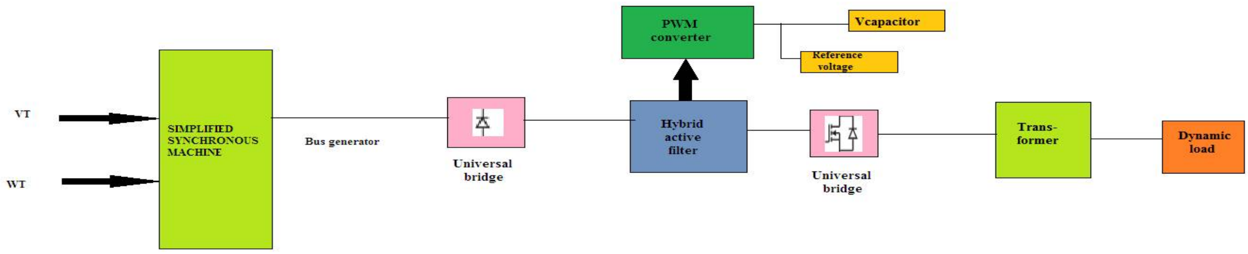

Fig.2. block diagram of proposed system

When SEIG supplies a non-linear load, the load draws a fundamental component of current and harmonic current from the generation systems, which are to be properly controlled. The universal bridge are working the AC to DC converter. The Hybrid APF can compensate the harmonic current by continuously tracking the changes in harmonic content. APF's consists of a voltage fed converter with a PWM current controller and an active filter controller that realizes an almost instantaneous control As the input power is nearly constant, the output power of the SEIG must be held constant at all consumer loads. Any decrease in load may accelerate the machine and raise the voltage and frequency levels to prohibitively high values, resulting in large stresses on other connected loads.

III. ANALYSIS AND MODELLING

The excitation system deals with the differential form of d-q components of stator voltage as follows

$$\frac{dv_{sq}}{dt} = \frac{i_{cq}}{C_{eq}} \quad (1)$$

$$\frac{dv_{sd}}{dt} = \frac{i_{cd}}{C_{ed}} \quad (2)$$

Where C_{eq} = Capacitor value along q axes

C_{ed} = Capacitor value along d axes.

The Instantaneous Power Theory was developed by with the objective of applying it to the control of active power filters. This is achieved by transforming main voltage and load current into two axis $\alpha - \beta$ co-ordinates by:-

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} i_{L\alpha} \\ i_{L\beta} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix} \quad (4)$$

The instantaneous active and reactive p_L and q_L can be expressed as:-

$$\begin{bmatrix} p_L \\ q_L \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} i_{L\alpha} \\ i_{L\beta} \end{bmatrix} \quad (5)$$

These instantaneous active and reactive powers can be decomposed into oscillatory and average terms as:-

So the powers to be compensated are

$$P_c = -p + p_{loss} \quad (6)$$

$$q_c = -q_L \quad (7)$$

Where *ploss* = the active power needed to cover the filter loss and to maintained the desired voltage in the dc link.

The reference compensation currents are obtained by inverting the matrix

$$\begin{bmatrix} i_{c\alpha} \\ i_{c\beta} \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} -p + p_{loss} \\ -q_L \end{bmatrix} \quad (8)$$

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$$\begin{bmatrix} i_{ca}^{*} \\ i_{cb}^{*} \\ i_{cc}^{*} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & o \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_{c\alpha} \\ i_{c\beta} \end{bmatrix} \quad (9)$$

In order to separate the direct term of the instantaneous power from the alternating one. DC-link voltage regulator is designed to give both good compensation and an excellent transient response. The actual DC-link capacitor voltage is compared by a reference value.

SIMULINK MODELLING

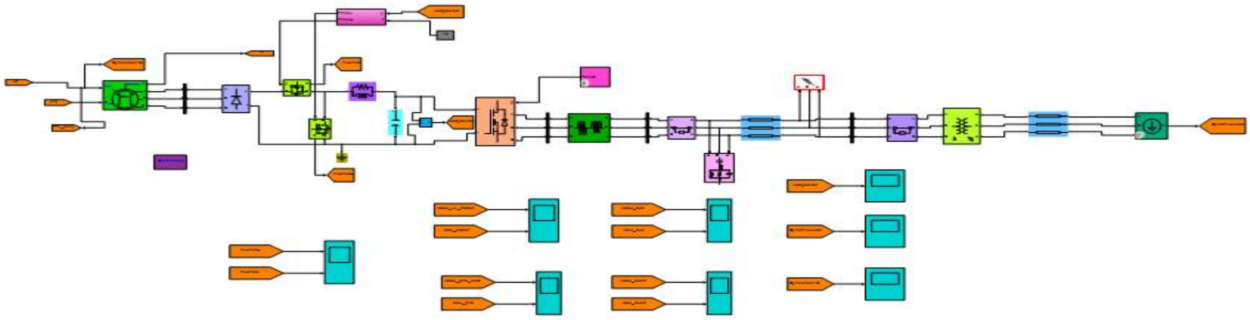

Fig.3. simulink modeling of current control of wind system

IV. SIMULINK RESULTS

A simulation is developed to model the control strategy based on controlling the current of a Self-Excited Induction Generator. The complete system mainly consists a SEIG and a Hybrid active power filter to compensate the harmonic current and a dynamic load.

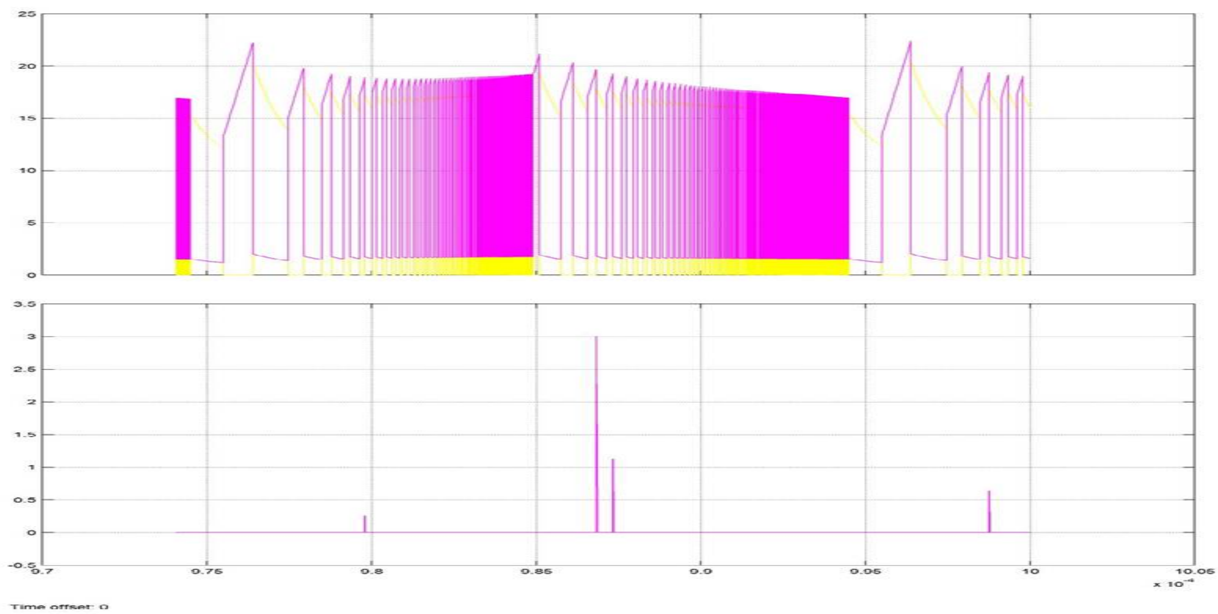

Fig.4. Variations of voltage(volts) vs time(seconds) of MOSFET L(lower) and MOSFET H(higher) connected to PWM converter and universal bridge converter

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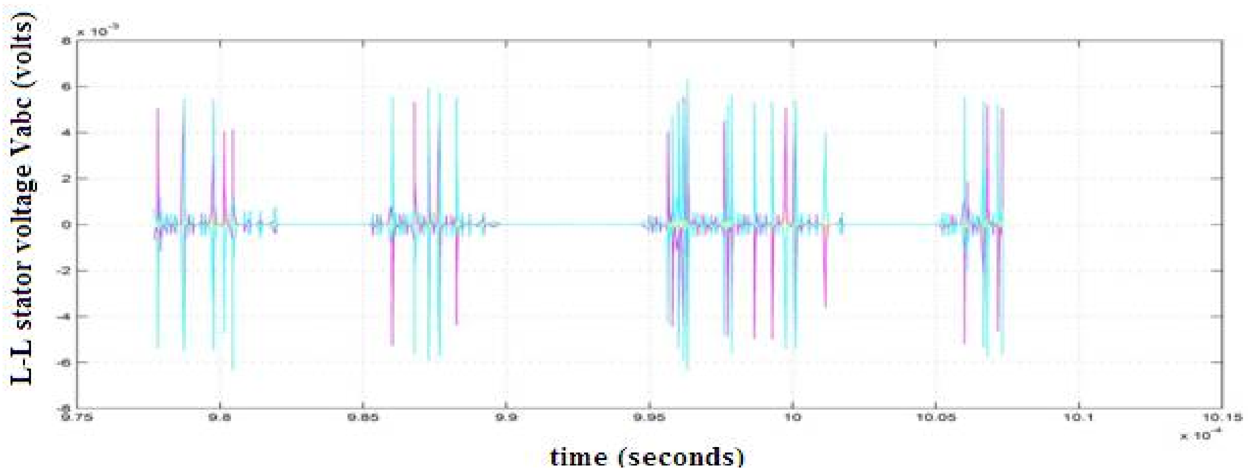

Fig.6. Variations of line to line terminal stator voltage with time of bus generator

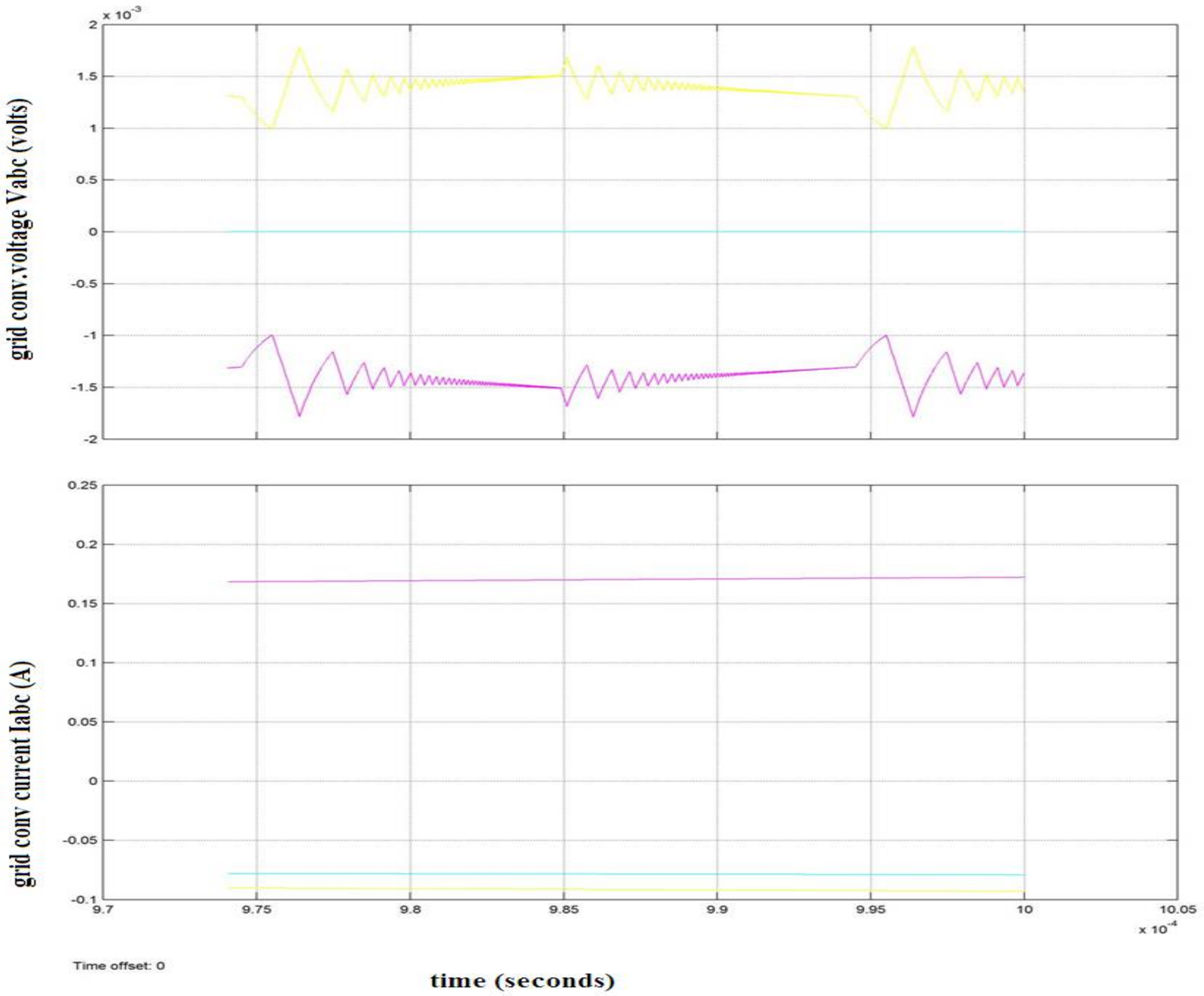

Fig.5. variations of voltage Vabc (volts) VS time (sec.) and current Iabc (A) VS time of grid converteter

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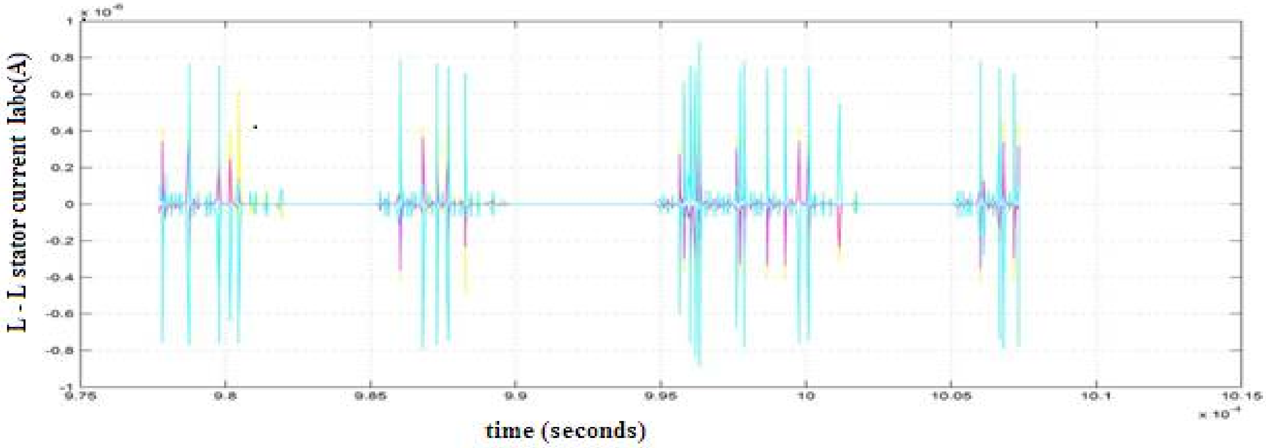

Fig.7. Variations of line to line terminal stator current with time of bus generator

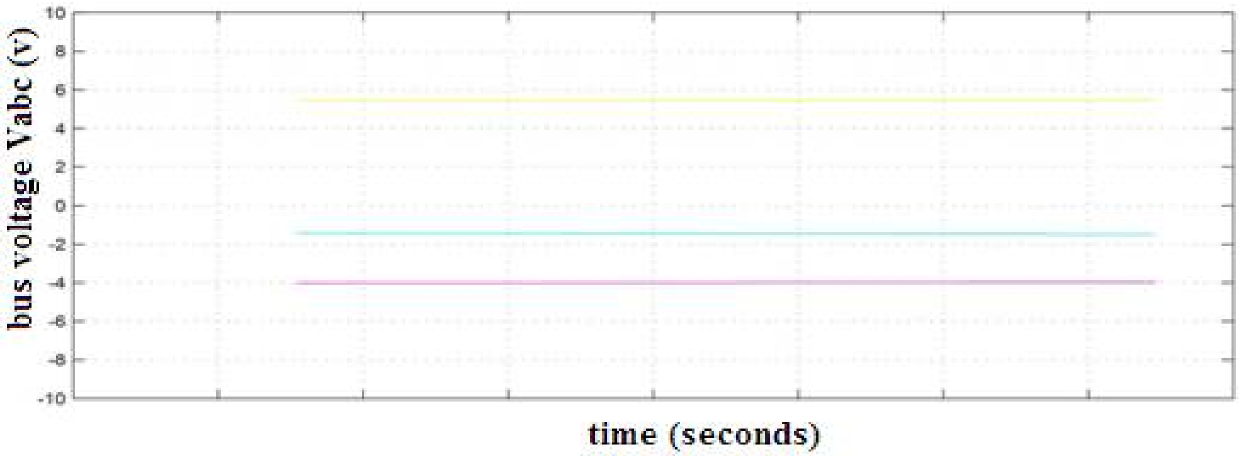

Fig.8. Variations of bus voltage Vabc (volts) with time of bus generator

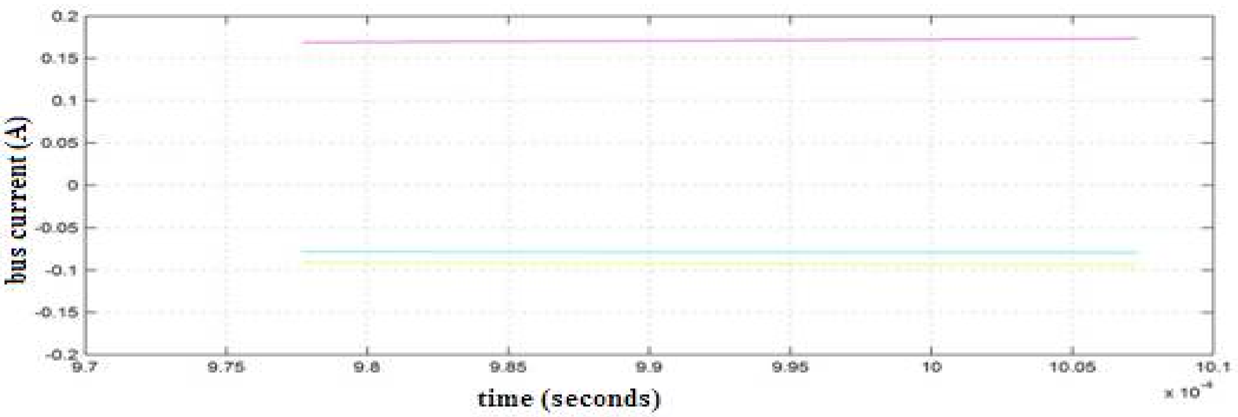

Fig.9. Variations of bus current Iabc (A) with time of bus generator

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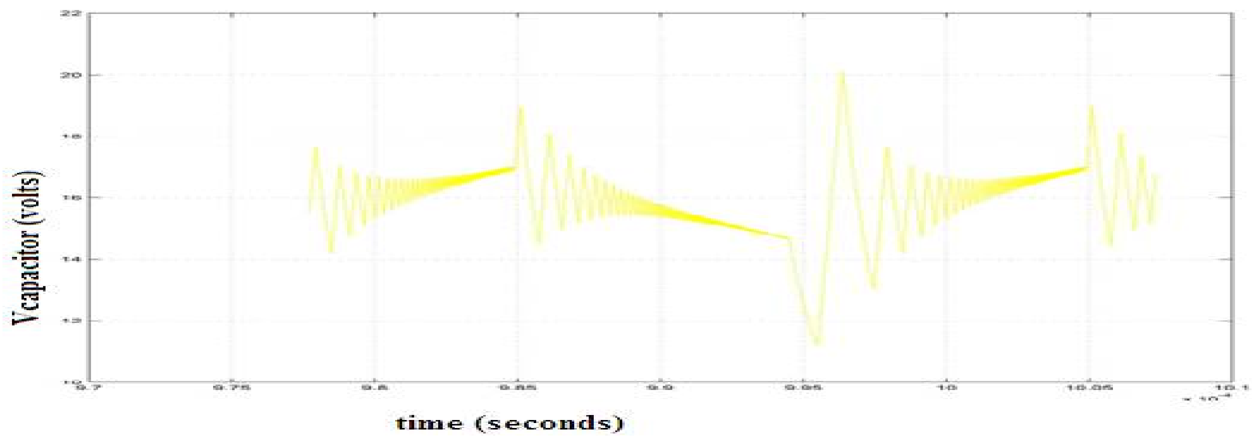

Fig.10. Variations Vcapacitor with time of PWM feedback converter

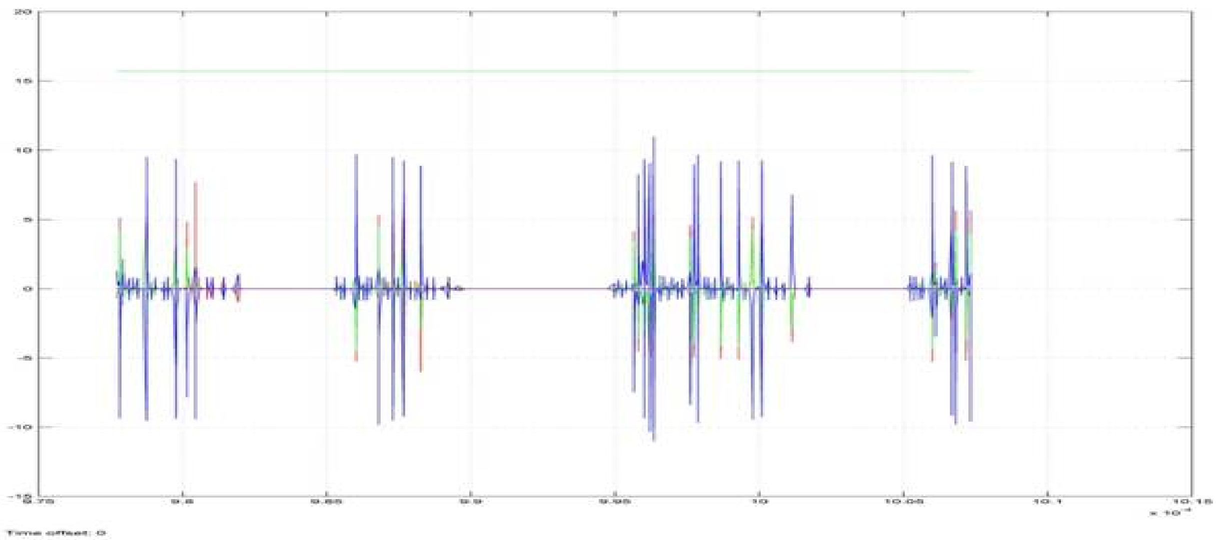

Fig.11. Variations of voltage, current with time of synchronous machine

This result contains two parts. **First part** represents dynamic behavior of SEIG at various conditions. **Second part** represents the dynamic performance of proposed algorithm under dynamic condition various waveform is shown to verify the effectiveness of this approach.

V. CONCLUSIONS

My first objective is to investigate the dynamic performance of SEIG at different transient condition. From the above discussion we can conclude that Voltage developed depends upon Value of capacitor, Speed of the rotor. Value of Excitation Capacitance, Load connected. The proposed control strategy is simulated in MATLAB SIMULINK environment to check the performance of the control strategy in improving the system behavior. A simulation is developed to model the control strategy based on p-q theory for controlling the current of a Self-Excited Induction Generator. The complete system mainly consists a SEIG and a hybrid active power filter to compensate the harmonic current.

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