

Implementation of STATCOM-based Three Phase VSI Inverter for Voltage Regulation of Three Phase SEIG

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ABSTRACT: Implementation of STATCOM-based Three Phase VSI Inverter for Voltage Regulation of Three Phase SEIG presents a voltage regulation scheme for three phase Self Excited Induction Generator(SEIG) feeding a three phase load in standalone configuration with Phase Angle Control scheme (PAC). The proposed scheme uses a switching of VSI inverter at appropriate instants and signals are generated by comparing the actual load voltage with reference voltage. SCHEME for its VSI inverter. The required simulation study for this scheme is studied in Proteus Software the model aims at the controlled output voltage of SEIG through STATCOM with PHASE ANGLE CONTROL

KEYWORDS: self-excited induction generator (SEIG), Triggering, VSI inverter, PAC, STATCOM.

I.INTRODUCTION

The standalone power systems harnessing renewable energy sources like wind, hydro, bio, solar, and so on offer various advantages such as low capital cost and reduced development time. A squirrel-cage induction machine operating as a self-excited induction generator (SEIG) is apparently a suitable choice for sustainable power generating system because of its low cost, high torque/weight ratio, brushless construction, robustness, less maintenance and inherent short circuit protection. SEIG operates on a constant speed but the terminal voltage of SEIG needs to be regulated within the limits during load changes. The voltage control can be achieved by connecting an adjustable reactive power source that continuously injects varying reactive power as per the system needs which is a STATCOM. The model aims at the controlled output voltage of SEIG through STATCOM with PHASE ANGLE CONTROL SCHEME for its VSI inverter. Where STATCOM offers instantaneous voltage control of SEIG through reactive power compensation with load balancing (during unbalanced load). A zero crossing detector is used to detect zero crossing magnitude of load which is then compare with reference value and required magnitude is generated by using VSI inverter. The problem of unbalanced voltage and current are very common in most of the grid. That is why it is very important to limit these voltage imbalanced and current imbalanced. Here VSI inverter of back to back pair is turned on for a variable portion of the cycle that it conduct. Power is regulated by advancing or delaying the point at which the inverter switch is turned on within each cycle, which will help to control fast changing load. **The prototype presents a voltage regulation scheme for three phase SEIG feeding a three phase load in standalone configuration with phase angle control scheme. It proposed switching of three phases of VSI inverter at appropriate instants using zero crossing detector (ZCD and required signals are generated by comparing actual value with a reference value through micro controller programming.**

II.LITERATURE REVIEW

The standalone power systems harnessing renewable energy sources like wind, hydro, bio, solar, and so on offer various advantages such as low capital cost and reduced development time. A squirrel-cage induction machine operating as a self-excited induction generator (SEIG) with a capacitor bank connected across its terminals is

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

apparently a suitable choice for sustainable power generating system. When SEIGs are driven by bio-gas/diesel engines, they operate at constant speed irrespective of load fluctuations. Hence, the generation frequency is less affected by load perturbations, but the terminal voltage varies with varying loads. Therefore the terminal voltage of SEIG needs to be regulated within the limits during load changes. [1] Voltage imbalance may arise because of asymmetric faults, line impedances or loads. It would be most appropriate to specify limits for voltage imbalance, because it. These problems are particularly serious for self-excited induction generator (SEIG) -based wind turbine without voltage source converter (VSC) grid interface. The ability of the wind turbine generator to remain connected to the grid is affected by these pulsations. For SEIG, its stator current can be highly unbalanced even with a small voltage imbalance. The sampled voltage measurement is sent to voltage control, which is compared with the reference voltage assigned for the terminal bus. The voltage error drives the voltage regulators. The voltage control determines the reference reactive current and sends it directly to the inner current control of the STATCOM for fast voltage response. [2] A wide variety of control strategies using power electronic technology have been developed for the three-phase SEIG. Some of these proposals, which are based on a shunt-connected PWM voltage source inverter supplying reactive current to the induction generator, represents an application of the AC voltage controller to maintain a constant generated output voltage from the single-phase SEIG under varying load requirements. As load requirements change, the triggering delay angle of the TCR is adjusted to maintain a constant generated output voltage from the single-phase SEIG. The information about the phase angle is very important to control the flow of active and reactive power and to turn on and off power electronics device. Phase locked loops (PLL) are used as an important techniques for grid synchronization and to track the phase angle. For single phase synchronization linear PLL is used, whereas for three phase grid synchronization synchronous reference frame (SRF). [3,4]Several voltage regulating schemes have been reported for SEIG-based autonomous power generation systems. The methods reported in have employed passive elements for voltage regulation. *Bimet al.* have proposed a voltage compensation method for a three-phase SEIG using the long-shunt method. *Shirdharet al.* have used the short-shunt compensation method for a three-phase SEIG. The SVC-based voltage regulating methods would generate low-order harmonic currents caused by the switching of line currents and they also involve large size and heavy weight of passive elements. With the development of fast acting self-commutating switches, pulse width modulated (PWM) voltage source inverter (VSI)-based static reactive power compensators (STATCOMs) have been evolved. These STATCOM based voltage regulators exhibit better dynamic performance and their voltage regulation capability would not be affected by nature of the load. [5, 6]

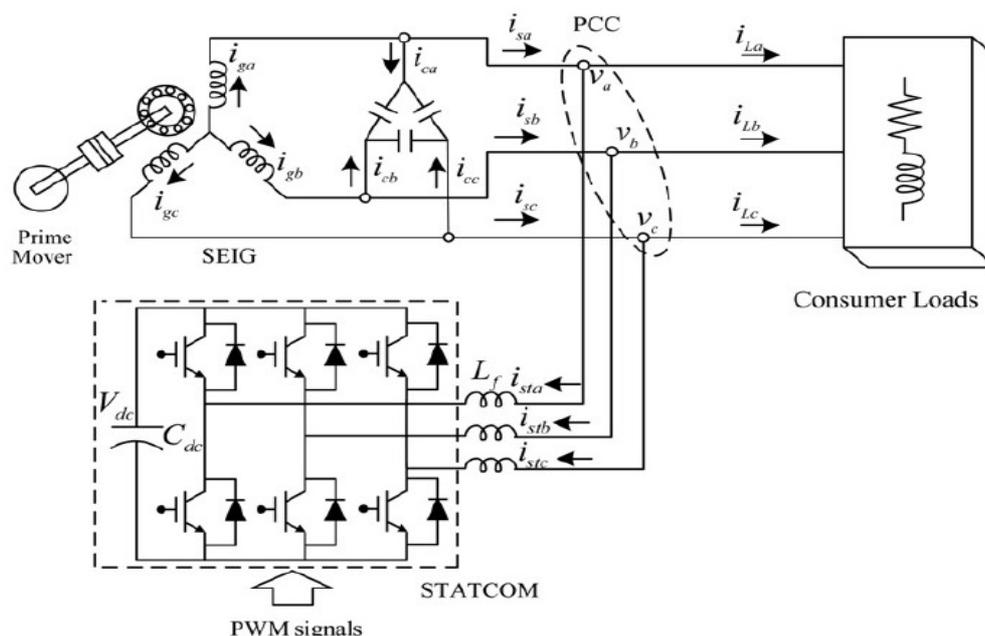


Fig 1:- schematic of SEIG-STATCOM system

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Recently the Voltage Source Inverter (VSI) based Static VAR compensators have been used for reactive power control. These compensators are known as Advanced Static VAR Compensator (ASVC) or Static Synchronous Compensator (STATCOM) The Static Synchronous Compensator (STATCOM) is a shunt connected reactive compensation equipment which is capable of generating and/or absorbing reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system. The STATCOM provides operating characteristics similar to a rotating synchronous compensator without the mechanical inertia, due to the STATCOM employ solid state power switching devices it provides rapid controllability of the three phase voltages, both in magnitude and phase angle. The STATCOM basically consists of a step-down transformer with a leakage reactance, a three-phase GTO or IGBT voltage source inverter (VSI), and a DC capacitor. [7] Wind turbines are often installed at high wind speed sites, which are remote, and have only weak electrical networks. In these cases, the effects of active and reactive power flows on the voltage quality are increased. Due to developments in power semiconductor switching devices and control techniques, the power ratings of converter type VAR compensators have increased. Also, switching device costs are decreasing to a level where this type of equipment may provide a cost-effective method of improving the power quality of wind farms. For the stand-alone applications of the three-phase self-excited induction generator (SEIG) driven by the variable-speed prime mover (VSPM), the appropriate method of regulating its terminal voltage is the adjustment of the capacitor value continuously. The adjustable excitation capacitor value for the three-phase induction generator can be achieved by various control strategies using microprocessor and DSP based power electronic and digital technologies. Some of these proposals use inverters and field-orientation algorithms to excite and control the three-phase induction generator. [8] Thyristors based, phase angle controlled, speed regulators are widely used for energy efficient control of single phase induction motors. This leads to power saving but adversely affects the life of insulation in the motors due to non-sinusoidal voltage and current waveforms. The voltage waveform is one of the parameters characterizing power quality. In general the effect of non-sinusoidal voltage and current waveform is associated with insulation degradation due to thermal ageing, but it has been clearly shown that the effect of voltage peak, rate of rise of voltage and wave shape also play significant role in insulation degradation [9] In remote and hilly areas where there is no centralized grid available, a single phase distributed generation scheme can be effective to fulfil household requirements and also the needs of small scale industries. Many of the remote locations do not have access to grid electricity because of the distribution network not being able to reach such locations due to prohibitively high installation cost. This problem can be alleviated by generating electricity using non-conventional resources of energy locally which is termed as decentralized generation. Many such electrical sources can be connected together to form a local small-scale grid known as micro-grid. Energy sources such as small-scale hydropower, and biogas are all being employed successfully in rural electrification projects in the developing world. In a micro-grid, the self-excited induction generator (SEIG) can be effectively used for harnessing power from a micro-hydro project in a decentralized manner because of its rugged nature and maintenance-free operating capability [10].

III. RELATED WORK

The final design so far is a result of software simulation and hardware implementation. The results were first performed and checked in software by simulation method with programming and then applied for the hardware implementation. The software used is PROTEUS SOFTWARE and programming is done in CODE VISION AVR (automatic program generator) the main components used in hardware are detailed with their ratings in the following table.

| SR.NO. | COMPONENT | RATING |
|--------|------------------------------|---|
| 1. | Supply transformer | 12 V |
| 2. | Current transformer | 12 V |
| 3. | Potential transformer | 9 V |
| 4. | Mosfet (IRF 540) | V _{dss} -100v, I _d -33A |
| 5. | Micro controller- At MEGA 16 | - |
| 6. | Optocoupler-TLP 260 | - |

Table 1:- list of component

International Journal of Innovative Research in Science, Engineering and Technology

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The project presents a STATCOM model employing a phase angle control scheme implemented for an unbalanced voltage regulation. The designed STATCOM consist of VSI inverter with six switches connected back to back to get required output, with a zero crossing detector. Some parts of hardware are design separately and then connected on board. They are as follows.

IV.HARDWAREDESIGN

i. Inverter Switch: -The design of STATCOM basically starts from inverter switch. The VSI inverters form by connecting six inverter switches in a required manner (connected back to back). One of the switch form is shown in fig 2. Where MOSFET is use as an operating switch, which is driven by optocoupler IC TLP 250, connectors are shown for supply from individual transformers for each switch and LED to show ON/OFF position of switch. Other connected components are resistor, capacitor and zener diode.

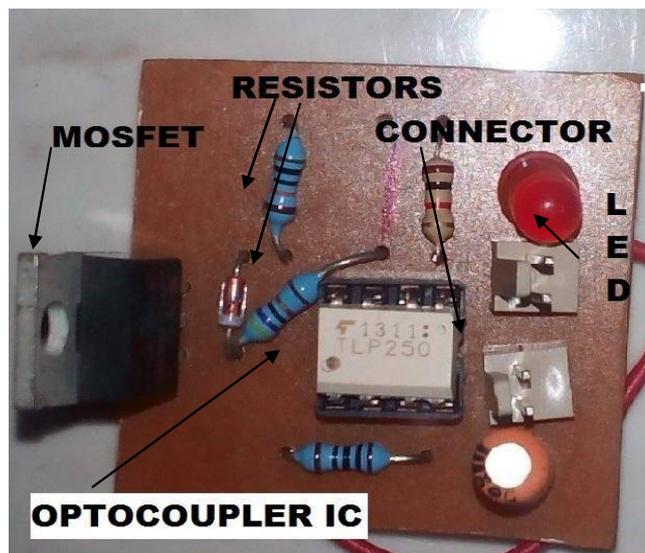


Fig 2:- VSI inverter switch

ii. PCB Design: -The main control circuit is placed on PCB which is design by drawing circuit in PROTEUS designing software. The main programmable controller At MEGA 16 is placed on, components are connected as shown in fig 3. Program to read individual phase currents and phase voltages is dumberd in micro controller. It is also programmed for triggering control of inverter switches and to read zero crossing magnitude, which corresponds to individual phase correction. The used AVR micro controller At MEGA 16 is having a features like it is 40 pin IC, inbuilt ADC, four output port, PWM channel etc. The AC supply provided to circuit is converted into DC with rectifier circuit, and pre-set is connected as variable resistor to adjust the output.

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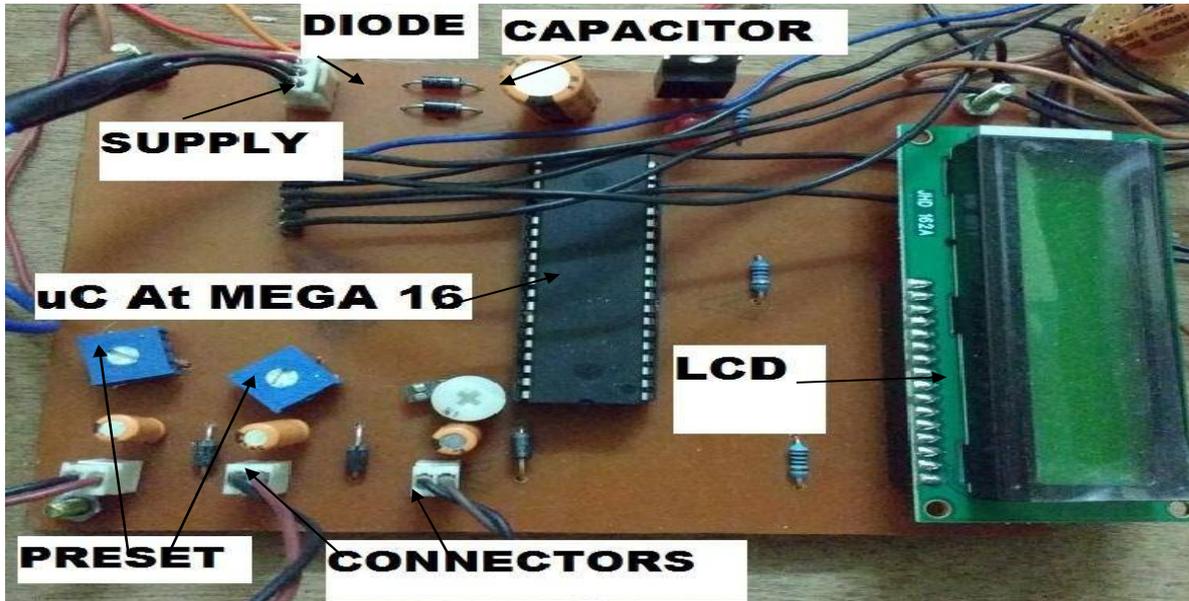


Fig 3: PCB design for control circuit

iii. Overall hardware: - As shown in fig.4. The current transformers and potential transformers will read the individual current and voltage of each phase respectively. Inverter switches and output connected to ADC can be observe.

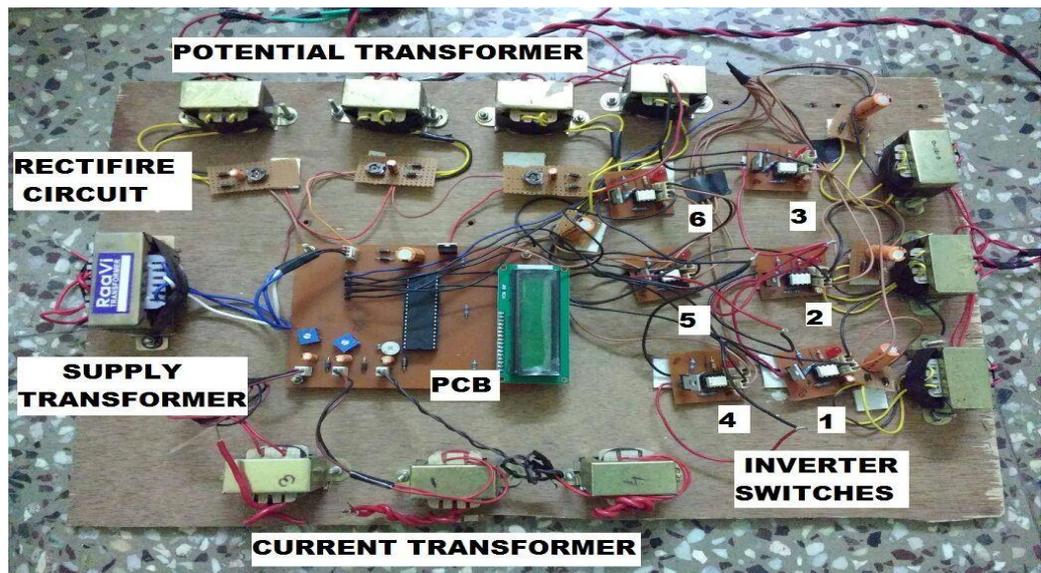


Fig 4:- overall hardware of PAC scheme

International Journal of Innovative Research in Science, Engineering and Technology

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V. EXPERIMENTAL SETUP

Model tested on standard load (according to the availability of load and source), for the operation, on giving 50v DC to inverter, output of 29v is obtained (Vrms) on connecting RL load. Different screen shots showing the connections, wiring, equipment arrangements and obtained waveform on Digital oscilloscope are shown in pictures below.

1. Complete experimental set up showing all connected hardware with supply and load can be observe from fig.
- 5.



Fig 5:- Complete Experimental Setup

2. Inverter connection with supply with the help of connecting wires on experimental panel is shown in fig. 6

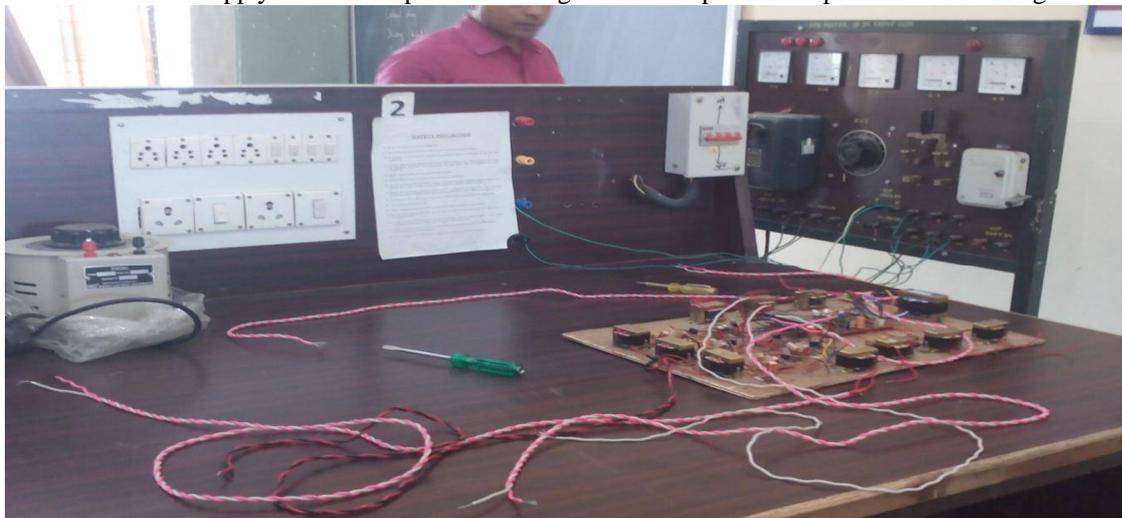


Fig 6:- Inverter Connection with DC Supply

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VI. EXPERIMENTAL RESULTS

Model is tested for different voltages. On application of 50 v DC, inverter output of 29 v(vrms) is obtained. Which is measured on Multimeter, as shown in fig.7.



Fig 7:-inverter output

Waveform corresponding to the output generated is obtained and is shown in fig.8.

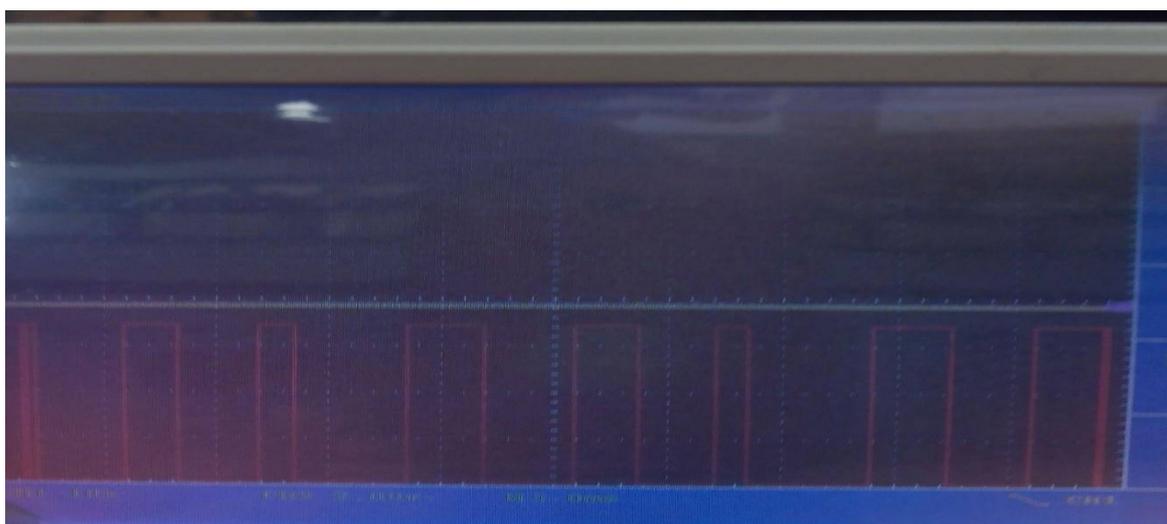


Fig 8:-square wave output waveform

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VI.CONCLUSION

- Model giving nearly required compensation and voltage regulation of SEIG by phase angle controlling.
- Exact positive and negative half of cycles are monitored ,compared and required value is generate
- Square wave output is generated from designed three phase inverter

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