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# A Novel Topology for Three-Phase SEIG Feeding Single-Phase Loads by using STATCOM Based Controller

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**ABSTRACT:** A novel topology for three-phase SEIG feeding single-phase loads by using static synchronous compensator (STATCOM)s deals with single-phase power generation by a three-phase self-excited induction generator (SEIG) working in concurrence with a STATCOM with the combination of dc capacitor. The STATCOM is used to decrease the unbalanced currents caused by single-phase loads that is connected across the two terminals of the three-phase SEIG. Therefore, the SEIG is able to feeding single-phase loads up to its maximum power. Moreover, the diode clamped multilevel inverter with self sustaining of capacitor (STATCOM) changes the SEIG terminal voltage through reactive power compensation and also decreases the harmonics injected by consumer loads. To generate gating pulses of the three-phase STATCOM by using Single-phase synchronous D-Q frame theory-based control algorithm is used to it. The performance of the SEIG–STATCOM system is evaluated for both linear and nonlinear single-phase loads. Moreover, the performance of the SEIG and the terminal voltage consequently to the maximum output power .

**KEYWORDS:** Self-excited induction generator (SEIG), single phase synchronous D-Q frame theory,diode clamped multilevel inverter with self sustaining with capacitor (STATCOM).

### I.INTRODUCTION

A proper existence of capacitance of squirrel-cage induction machine with its stator terminals connected is popularly known as a self-excited induction generator (SEIG)[1][2]. Due to the special advantages of the squirrel-cage induction machine over the conventional synchronous machine such as less cost, brush-less construction, severity, economical, and short-circuit protection, SEIGs are being employed in far-off and inaccessible power generating systems as mechanical energy conversion equipments[3]-[4]. When an SEIG is driven by prime movers such as biomass, biogas, and biodiesel engines, the frequency of the generated voltage is almost constant from no load to full load. But, poor voltage regulation has been the major drawback of an SEIG in its applications. Hence, the terminal voltage of an SEIG needs to be regulated during load. Perturbations For SEIG-based autonomous power generation systems several voltage regulating schemes have been reported. A voltage compensation method for a three-phase SEIG using the long-shunt method Bim et al[5] have proposed. the short-shunt compensation method for a three-phase SEIG Shirdhar et al[6] have used. The methods employing only passive elements are not accomplished of regulating the terminal voltage when the character of the load changes. Therefore, some attempts have been made to maintain a constant terminal voltage using active switches which use the combination of a fixed capacitor and thyristor-controlled inductor known as static Var compensator (SVC).

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. By the improvement 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 enhanced dynamic performance and their voltage regulation capability would not be affected by nature of the load.

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Since various isolated power generating systems feed single-phase loads, single-phase induction generators can also be used. A single-phase induction machine with a proper excitation capacitance can be used as a generator. In general, single-phase machines are limited to relatively less power outputs. For bigger power ratings above 5 kW, three-phase machines are more efficient, cheaper, and readily available. Hence, a three phase SEIG can be used in single-phase applications. Numbers of attempts have been made to operate a three-phase SEIG in a single-phase mode [7]-[10]. In all these methods, the SEIG cannot be loaded up to its maximum power rating, requires de-rating of the machine. in addition to, the SEIG currents are not balanced and unequal voltages across the generator windings are the major drawbacks of the abovementioned single-phasing methods of a three-phase SEIG. In this task, another method of feeding single-phase loads using a three-phase SEIG without de-rating the machine is planned. In this method, a three-phase SEIG works in conjunction with a three-phase STATCOM and the single-phase loads are connected across two of the three terminals of the SEIG. The benefit of integrating a STATCOM in an SEIG based individual power generation feeding single-phase loads is three types—first, generator currents balancing; second, voltage regulation; and third, decreases the harmonics injected by nonlinear loads. .

The STATCOM involves compensating currents to make the SEIG currents balanced and regulates the system voltage as much. Moreover then, this method offers balanced voltages across the generator windings and ensures the sinusoidal winding currents while feeding nonlinear loads. Although several publications have been reported on the STATCOM-based controller for SEIG systems, all the functions of a STATCOM such as current balancing, voltage regulation, and harmonic currents decreases are not experimentally demonstrated. Singh et al[11] proposed simulation of the PI (Proportional plus Integral) controller-based control method for enhancement of voltage profile improvement using the STATCOM. The major disadvantage of the PI controller-based control method is its unsteadiness under transients as it does not consider load currents while estimating the amplitudes of active and reactive components of reference source currents. The outputs of the STATCOM's dc-bus voltage PI controller and the system AC voltage PI controller are directly accounted as the amplitudes of active and reactive components of reference source currents, correspondingly. Therefore, the control algorithm requires adjustment of PI controller gains under transients; And also it causes severe peak overshoot and undershoot of the dc-bus voltage of the STATCOM. Dastagir and Lopes[12] have proposed the experimental explanation of SEIG voltage control employing a battery-assist STATCOM using usual three-phase D-Q frame theory-based control. The transient response of this method is found to be listless as the system is steadily reaching steady state after disturbance.

## II.CONVENTIONAL METHOD

In this conventional method, a method is used feeding single-phase loads using a three-phase SEIG without de-rating the equipment is used. In this scheme, a three-phase SEIG works in combination with a three-phase STATCOM and the single-phase loads are associated with two of the three terminals of the SEIG. The advantage of integrating a STATCOM in an SEIG based individual power generation feeding single-phase loads is threefold—first, generator currents balancing; second, voltage regulation; and third, mitigate the harmonics injected by nonlinear loads. The STATCOM injects compensating currents to make the SEIG currents balanced and regulates the system voltage as well. Moreover, this method offer balanced voltages across the generator windings and ensures the sinusoidal winding currents when feeding nonlinear loads. Fig.1 show the representation diagram of the STATCOM compensated three-phase SEIG feeding single-phase loads. The conventional model consists of an SEIG driven by renewable energy-based prime mover. The STATCOM regulates the system voltage by maintains equilibrium among the reactive power circulations within the model. Moreover, the STATCOM reduces harmonics injected by nonlinear loads and provide load balancing when feeding single-phase loads. The unbalanced load currents in a three-phase system are can be divided into two sets of balanced currents known as negative sequence components and positive sequence components . In order to get balanced source currents, the source must be free from the negative sequence components of load currents. Therefore, when the STATCOM is connected across PCC, it supplies the negative sequence currents needed by the unbalanced load or it draws another set of negative sequence currents which are exactly  $180^{\circ}$  out of phase to these are drawn by unbalanced load so as to nullify the effect of negative sequence currents of unbalanced loads.

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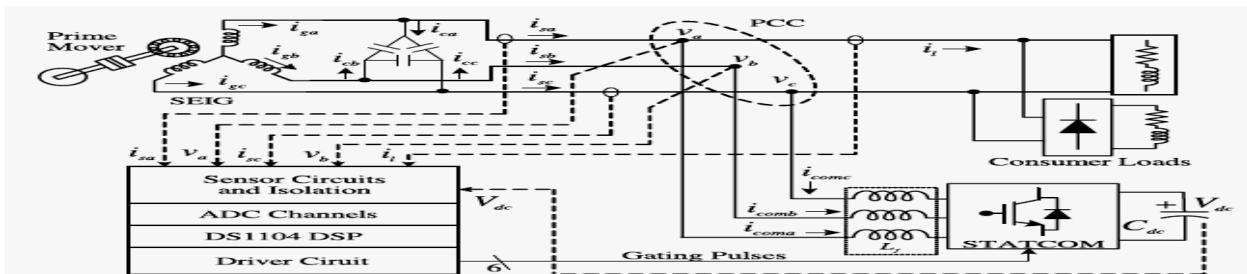


Fig.1 Shows schematic diagram of SEIG-STATCOM conventional method

The conventional control takes the load current into explanation, the average active and reactive power components of load current are subtracted / added to the output of the dc-bus voltage PI controller and also ac voltage PI controller, respectively. Therefore, in the proposed control algorithm, adjustment of PI controller gains is not necessary under transients. Because the system under investigation is an isolated power generating system feeding local loads, the generated voltages are presumed to be balanced. The conventional method of feeding single-phase loads from a three-phase SEIG is tested by using simulation and the advantages of incorporating a STATCOM to balance SEIG currents and system voltage regulation are demonstrated with simulation results. More over the terminal voltage corresponding to the maximum power output is identified.

Fig. 2 shows the block diagram of the proposed single-phase synchronous D-Q frame theory-based control algorithm for the three-phase STATCOM. The reference source currents ( $i_{sa}^*, i_{sb}^*, i_{sc}^*$ ) for regulating the terminal voltage and current balancing are computed using a single-phase synchronous D-Q frame theory applied to the three-phase SEIG system.

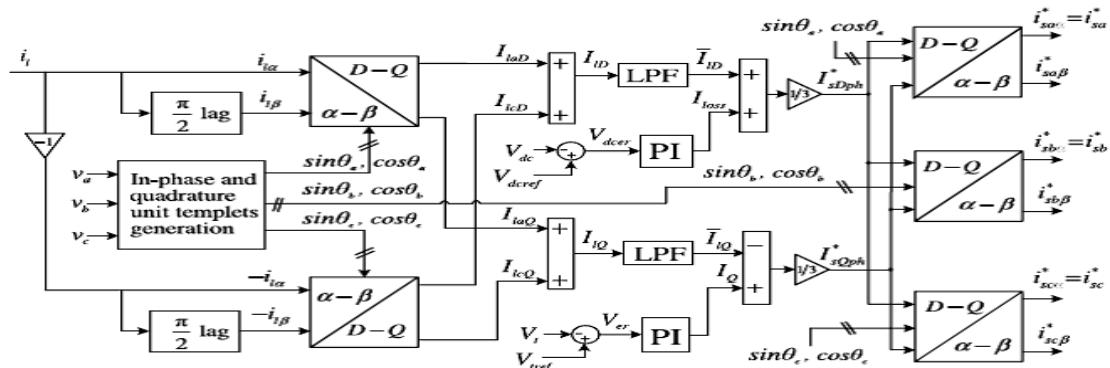


Fig. 2. Shows block diagram of the single-phase synchronous D-Q theory control algorithm for the STATCOM.

### III.PROPOSED METHOD

A five-level, three-leg MOSFET-based VSI with a self sustaining dc-bus capacitor is used as a STATCOM. The STATCOM is connected at point of common coupling (PCC) through filter inductors as shown in Fig. 1. The STATCOM regulates the system voltage by maintaining equilibrium among the reactive power circulations within the system. Moreover, the STATCOM decreases harmonics injects by nonlinear loads and provides load balancing while feeding single-phase loads. The unbalanced load currents in a three-phase system can be divide into two sets of balanced currents known as positive sequence components and negative sequence components. In order to achieve balanced source currents, the source should free from the negative sequence components of load currents. Therefore, when the STATCOM is coupled across PCC, it gives the negative sequence currents required by the unbalanced load or it taken another set of negative sequence currents which are exactly  $180^\circ$  out of phase to those gets by unbalanced load so as to abolish the effect of negative sequence currents of unbalanced loads.

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Proper existence of capacitance of squirrel-cage induction machine with its stator terminals connected to a reactive power source (capacitance) is popularly known as a self-excited induction generator (SEIG) [1] [2]. Due to the specific advantages of the squirrel-cage induction machine over the conventional synchronous machine such as low cost, brush-less construction, ruggedness, cheap, and inherent short-circuit protection, SEIGs are being employed in remote.

## CONTROL ALGORITHM OF THE STATCOM

Fig. 3 shows the block diagram of the controlling model of proposed single-phase synchronous D-Q frame theory-based control algorithm to the three-phase STATCOM. The reference source currents are ( $i_{sa}^*, i_{sb}^*, i_{sc}^*$ ) for balancing the terminal voltage and current balancing are compute by using a single-phase synchronous D-Q frame theory applied to the three-phase SEIG system.

In order to make things easier the circuit analysis of the proposed model of the single phase D-Q frame theory based control algorithm to the three phase diode clamped multilevel inverter, some models are ready as follows. Fig. 3 shows the block diagram of the proposed model of the single-phase synchronous D-Q frame theory-based control algorithm of the three-phase (STATCOM)diode clamped multi level inverter. The reference source currents are, ( $i_{sa}^*, i_{sb}^*, i_{sc}^*$ ) used for regulating the terminal voltage and current balancing are computes by using a single-phase synchronous D-Q frame theory apply to the three-phase SEIG system.

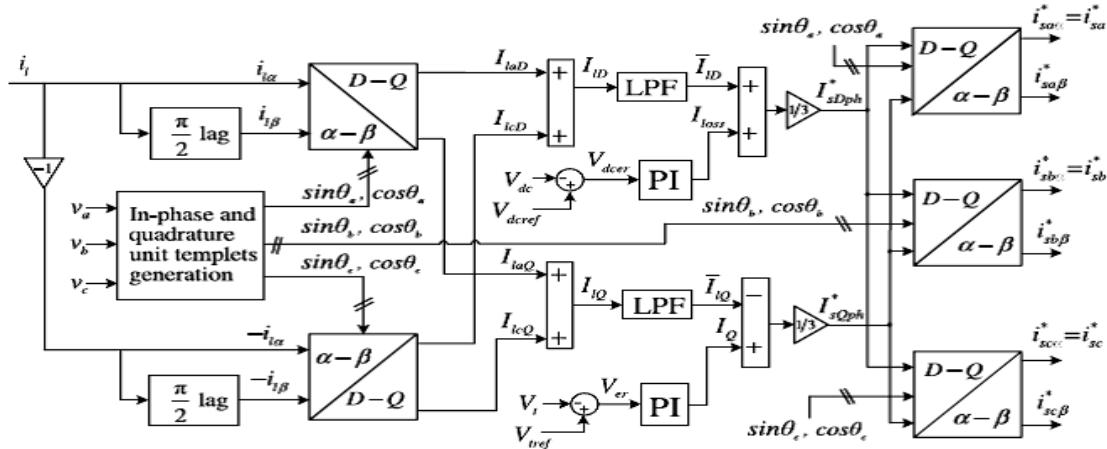


Fig.3. Block diagram of the single-phase synchronous D-Q theory control algorithm to the proposed model

## D-Q FRAME THEORY FOR SINGLE-PHASE SYNCHRONOUS ROTATION:

It is simple to design a controller to the three-phase system in synchronously rotating D-Q frame because of the all the time-varying signals of the model become dc quantities and also time-invariant. In case of the three-phase system in the beginning, the three-phase voltages or currents (in abc frame) are transformed to a stationary frame ( $\alpha - \beta$ ) and then to synchronously rotating D-Q frame. Therefore, an arbitrary periodic signal  $x(t)$  with a time period of "T" can be represented in a stationary  $\alpha - \beta$  frame as the

$$x_\alpha(t) = x(t); x_\beta(t) = x\left(t - \frac{T}{4}\right). \quad (1)$$

For a single-phase system, the concept of the stationary  $\alpha - \beta$  frame and synchronously rotating D-Q frames relative to the arbitrary periodic signal  $x(t)$  is illustrated in Fig.3. The signal  $x(t)$  is represented as vector. The angle  $\theta$  is the rotating angle of the D-Q frame and it is defined as

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$$\theta = \int_0^t \omega dt \quad (2)$$

Where  $\omega$  is the angular frequency of arbitrary variable  $\vec{x}$ . The components of the arbitrary single-phase variable  $x(t)$  in the stationary reference frame are changed into the synchronously rotating D-Q frame using the transformation matrix “C” as

$$\begin{bmatrix} x_D \\ x_Q \end{bmatrix} = C \begin{bmatrix} x_\alpha \\ x_\beta \end{bmatrix} \quad (3),$$

$$C = \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}. \quad (4)$$

### Reference Source Currents Estimation Using Single-Phase Synchronous Rotating D-Q Frame Theory:

Considering PCC voltages as balanced and sinusoidal, the amplitude of the PCC voltage (or system voltage) is estimated as in

$$V_t = \sqrt{\frac{2}{3}(v_a^2 + v_b^2 + v_c^2)}. \quad (5)$$

Consider one of the three phases at a time and then transform the currents and voltages of that particular phase into a stationary  $\alpha - \beta$  frame, then the PCC voltages and load current in stationary  $\alpha - \beta$  frame are represented as

$$v_{a\alpha}(t) = v_a(t); \quad v_{b\alpha}(t) = v_b(t); \quad v_{c\alpha}(t) = v_c(t) \quad (6)$$

$$v_{a\beta}(t) = v_a \left( t - \frac{T}{4} \right) \quad (7a)$$

$$v_{b\beta}(t) = v_b \left( t - \frac{T}{4} \right) \quad (7b)$$

$$v_{c\beta}(t) = v_c \left( t - \frac{T}{4} \right) \quad (7c)$$

$$i_{l\alpha}(t) = i_l(t); \quad i_{l\beta}(t) = i_l \left( t - \frac{T}{4} \right). \quad (8)$$

Therefore, the Q-axis and D-axis components of the load current in phase “a” are estimated as

$$\begin{bmatrix} I_{laD} \\ I_{laQ} \end{bmatrix} = \begin{bmatrix} \cos \theta_a & \sin \theta_a \\ -\sin \theta_a & \cos \theta_a \end{bmatrix} \begin{bmatrix} i_{l\alpha} \\ i_{l\beta} \end{bmatrix} \quad (9)$$

Where the  $\cos \theta_a$  and  $\sin \theta_a$  are estimated using  $v_{a\alpha}$  and  $v_{a\beta}$  as follows:

$$\begin{bmatrix} \cos \theta_a \\ \sin \theta_a \end{bmatrix} = \frac{1}{\sqrt{v_{a\alpha}^2 + v_{a\beta}^2}} \begin{bmatrix} v_{a\alpha} \\ v_{a\beta} \end{bmatrix}. \quad (10)$$

$I_{laD}$  Represents the active power component of the load current, whereas  $I_{laQ}$  represents to the reactive power component of the load current in phase “c” are estimated as

$$\begin{bmatrix} I_{lcD} \\ I_{lcQ} \end{bmatrix} = \begin{bmatrix} \cos \theta_c & \sin \theta_c \\ -\sin \theta_c & \cos \theta_c \end{bmatrix} \begin{bmatrix} -i_{l\alpha} \\ -i_{l\beta} \end{bmatrix}. \quad (11)$$

The D-axis components of the load current in phases “a” and “c” are added together to obtain the equivalent D-axis current component of total load on the SEIG as

$$I_{lD} = I_{laD} + I_{lcD}. \quad (12)$$

$$I_{lQ} = I_{laQ} + I_{lcQ}. \quad (13)$$

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The equivalent D-axis and Q-axis current components of total load are decomposed into the two parts namely fundamental and oscillatory parts as

$$I_{ID} = \overline{I}_{ID} + \widetilde{I}_{ID} \quad (14)$$

$$I_{IQ} = \overline{I}_{IQ} + \widetilde{I}_{IQ}. \quad (15)$$

The dc-bus voltage error of the diode clamped multilevel inverter  $V_{deer}$  at  $k^{\text{th}}$  sampling instant is expressed as

$$V_{deer}(k) = V_{deref}(k) - V_{de}(k) \quad (16)$$

where  $V_{deref}(k)$  and  $V_{de}(k)$  are the reference and sensed dc-bus voltages of the diode clamped multilevel inverter at  $k^{\text{th}}$  sampling instant, respectively. In the present investigation, the dc-bus voltage reference is set as 400 V.

The output of the PI controller for maintaining a constant dc bus voltage of the diode clamped multi level inverter at  $k^{\text{th}}$  sampling instant is expressed as

$$\begin{aligned} I_{loss}(k) &= I_{loss}(k-1) + K_{pd} \{V_{deer}(k) + V_{deer}(k-1)\} \\ &\quad + K_{id} V_{deer}(k) \end{aligned} \quad (17)$$

Therefore,  $\overline{I}_{ID}$  is added to  $I_{loss}$  and distributed among all the phases equally to obtain the D-axis component of the reference source current in the each phase which can be expressed as

$$I_{sDph}^* = \frac{\overline{I}_{ID} + I_{loss}}{3}. \quad (18)$$

$I_{sDph}^*$  also indicates the active power component of the current that should be supplied by the source after compensation. The PCC voltage error  $Ver(k)$  at  $K^{\text{th}}$  sampling instant is given as

$$Ver(k) = Vt(\text{ref}) (k) - Vt(k) \quad (19)$$

Where  $Vt(\text{ref})$  is the amplitude of the reference PCC voltage and  $Vt(k)$  is the amplitude of sensed three-phase ac voltages at the PCC terminals, at  $k^{\text{th}}$  instant.

The output of the PI controller for maintaining the PCC voltage at the reference value in  $k^{\text{th}}$  sampling instant is expressed by

$$\begin{aligned} I_Q(k) &= I_Q(k-1) + K_{pa} \{Ver(k) + Ver(k-1)\} \\ &\quad + K_{ia} V_{er}(k) \end{aligned} \quad (20)$$

Where  $K_{pa}$  and  $K_{ia}$  are the proportional and the integral gain constants of the PI controller,  $Ver(k)$  and  $Ver(k-1)$  are the voltage errors at  $k^{\text{th}}$  and  $(k-1)^{\text{th}}$  instants, respectively.

The per phase Q-axis component of the reference source current required to regulate the system voltage is defined as the

$$I_{sQph}^* = \frac{I_Q - \overline{I}_{IQ}}{3}. \quad (21)$$

$I_{sQph}^*$  indicates the magnitude of the reactive power component of the current .

Using the D-axis and Q-axis components of currents derived in (18) and (21), the phase "a,"  $\alpha$ - axis and  $\beta$ -axis components of the reference source current can be estimated as the

$$\begin{bmatrix} i_{sa\alpha}^* \\ i_{sa\beta}^* \end{bmatrix} = \begin{bmatrix} \cos \theta_a & \sin \theta_a \\ -\sin \theta_a & \cos \theta_a \end{bmatrix}^{-1} \begin{bmatrix} I_{sDph}^* \\ I_{sQph}^* \end{bmatrix}. \quad (22)$$

In the above matrix, the  $\alpha$ -axis current represents the reference source current of actual phase "a," and the  $\beta$ -axis current represents the current that is at  $\pi/2$  phase lag which belongs to the fictitious phase. Therefore, one can have

$$i_{sa}^* = I_{sDph}^* \cos \theta_a - I_{sQph}^* \sin \theta_a. \quad (23)$$

Similarly, reference source currents for phases "b" and "c" are estimated as the

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$$i_{sb}^* = I_{sDph}^* \cos \theta_b - I_{sQph}^* \sin \theta_b \quad (24)$$

$$i_{sc}^* = I_{sDph}^* \cos \theta_c - I_{sQph}^* \sin \theta_c. \quad (25)$$

Three-phase reference source currents ( $i_{sa}^*$ ,  $i_{sb}^*$  and  $i_{sc}^*$ ) are compared by the sensed source currents ( $i_{sa}$ ,  $i_{sb}$ ,  $i_{sc}$ ) and the current errors are computed as

$$i_{aerr} = i_{sa}^* - i_{sa} \quad (26a)$$

$$i_{berr} = i_{sb}^* - i_{sb} \quad (26b)$$

$$i_{cerr} = i_{sc}^* - i_{sc}. \quad (26c)$$

These current error signals are fed to the current-controlled PWM pulse generator for switching the IGBTs of the STATCOM. Thus, the generated PWM pulses are applied to the STATCOM to achieve sinusoidal and balanced source currents along with the desired voltage regulation.

### STEADY-STATE PERFORMANCE OF THE SEIG-STATCOM SYSTEM FEEDING WITH LINEAR LOADS

Fig.4 shows the steady-state performance of the SEIG-diode clamped multilevel inverter system feeding a single-phase resistive load . Fig. 4(a) shows the SEIG current ( $i_{ga}$ ) along with the PCC line voltage  $v_{ab}$  . Fig. 4(b) shows the harmonic spectra of the SEIG current in phase “a.” The total harmonic distortion (THD) of generator currents is found less than 9% meeting requirements on current harmonics. Fig. 4(c) shows the RMS (root mean square) value of the PCC line voltage ( $v_{ab}$ ) and its harmonic spectrum. Fig. 4(d) shows the single-phase load current under rated loading. Fig. 4(e) and (f) shows the generated power ( $P_{gen}$ ) and the power consumed by single phase loads ( $P_{load}$ ) which are connected across the phases “a” and “c.” It has been observed that the generator is feeding a single-phase load, which is almost the rated capacity of a generator without any unbalance in voltages and currents. Fig. 4 Steady-state performance of the SEIG-STATCOM system feeding single-phase linear loads. (a)  $v_{ab}$  and  $i_{ga}$  . (b) THD of  $i_{ga}$  . (c) THD of  $v_{ab}$  . (d)  $v_{ab}$  and  $i_l$  . (e)  $P_{gen}$  . (f)  $P_{load}$  .

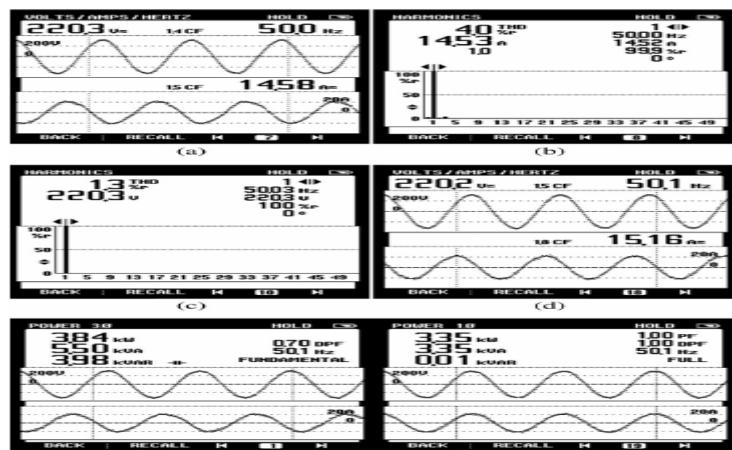


Fig.4 shows Steady-state performance of the SEIG-STATCOM system feeding single-phase linear loads. (a)  $v_{ab}$  and  $i_{ga}$  . (b) THD of  $i_{ga}$  . (c) THD of  $v_{ab}$  . (d)  $v_{ab}$  and  $i_l$  . (e)  $P_{gen}$  . (f)  $P_{load}$

### Steady-State Performance of the SEIG-STATCOM System Feeding Single-Phase Nonlinear Loads

The steady-state performance of the SEIG-diode clamped multilevel inverter system feeding nonlinear loads is shown in Fig. 5 The generator currents ( $i_{ga}$ ,  $i_{gb}$ , and  $i_{gc}$ ) and the PCC line voltage  $v_{ab}$  are shown in Fig. 5(a). Fig. 5(b) shows the balanced three-phase source currents  $i_{sa}$ ,  $i_{sb}$ , and  $i_{sc}$  . The steady-state waveforms of the PCC voltage  $v_{ab}$  , the load current  $i_l$  , the dc-bus voltage  $V_{dc}$ , and the RMS value of the PCC line voltage  $V_{tRMS}$  are given in Fig. 5(c). The dc-bus voltage and the RMS PCC line voltage are seen to be quite stable in steady state. The compensation currents injected by the diode clamped multilevel inverter to balance the source currents are shown in Fig. 5(d). From

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Fig. 5(a), it is observed that the SEIG currents are balanced and sinusoidal which demonstrates the harmonics suppression and load balancing capabilities of the diode clamped multilevel inverter.

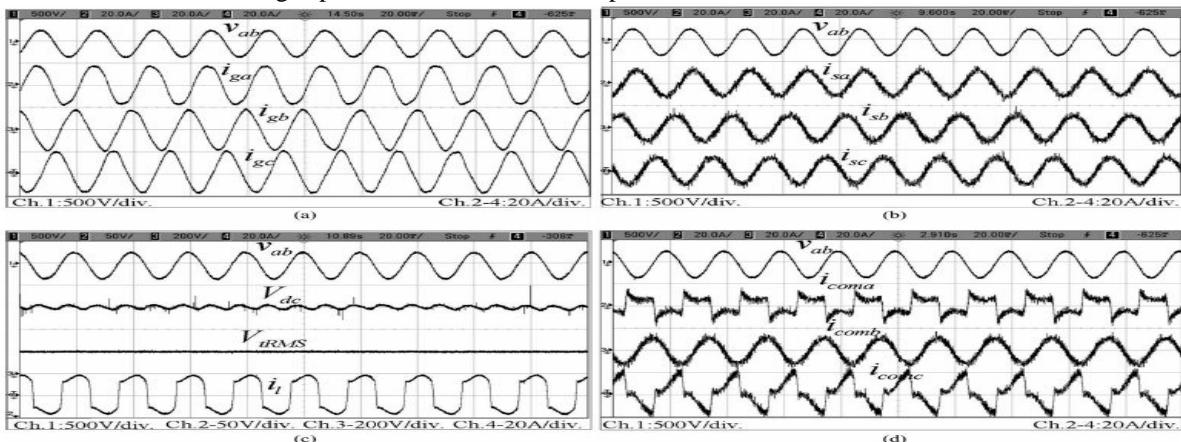


Fig. 5 Shows Steady-state performance of the SEIG-STACOM system feeding single-phase nonlinear loads. (a)  $v_{ab}$ ,  $i_{ga}$ ,  $i_{gb}$ , and  $i_{gc}$ . (b)  $v_{ab}$ ,  $i_{sa}$ ,  $i_{sb}$ , and  $i_{sc}$ . (c)  $v_{ab}$ ,  $V_{dc}$  and  $V_{tRMS}$  and  $i_l$ . (d)  $v_{ab}$ ,  $i_{comA}$ ,  $i_{comB}$  and  $i_{comC}$ .

### V.SIMULATION MODEL AND RESULTS

A simulation design of the STATCOM controller in decreasing harmonics, balancing the unbalancing currents and improving the voltage is implemented by using the MATLAB SIMULINK with the help of five level diode clamped multi level inverter, linear and non linear loads, controllers, and sub systems as shown in figure 6.

#### FOR LINEAR LOADS

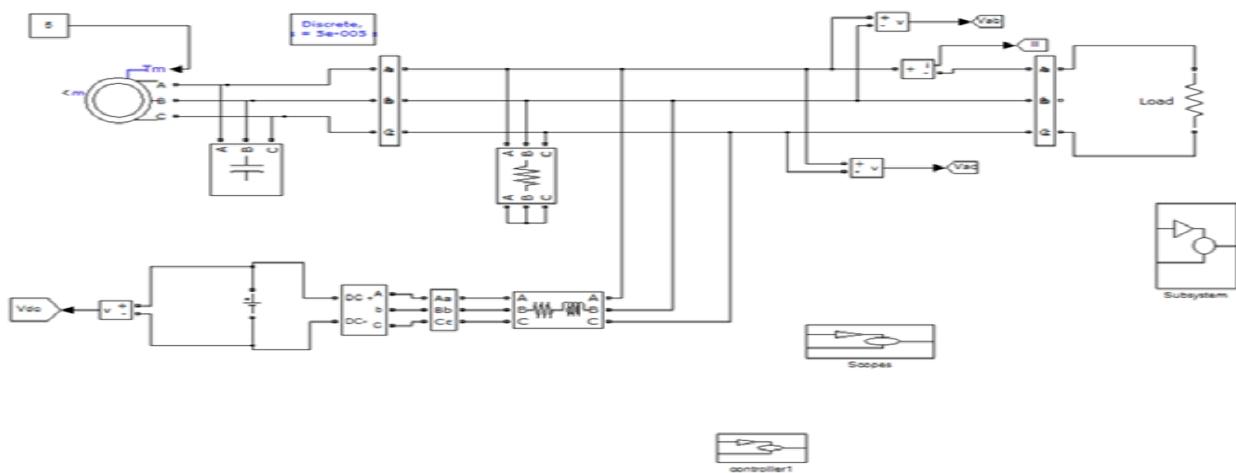


Fig. 6 Shows simulation model for SEIG-STACOM fed with linear loads

A prototype of the proposed SEIG-STATCOM system has been developed and tested by using the simulation model. The simulation results presented in Figs. demonstrate the performance of the developed system under steady state conditions. Fig. 7 shows an steady-state performance of the SEIG-STATCOM system feeding a single-phase

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resistive load. Fig. Shows 7.1. shows phase voltage and generated gate current, Fig : 7.2. shows Phase voltage and load current, Fig:7.3 show power load, Fig:7.4 Shows Vab and load current (Il) magnitude, Fig:7.5 Voltage of input signals, Fig :7.6 shows three phase generator currents, Fig:7.7 Shows three phase generated voltage and three phase generator currents

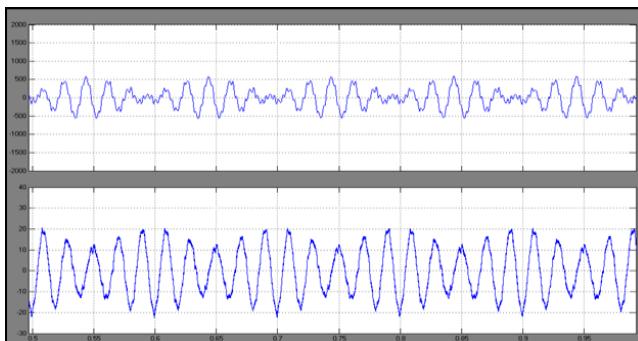


Fig: showss6.1 shows  $v_{ab}$  and  $i_{ga}$  .

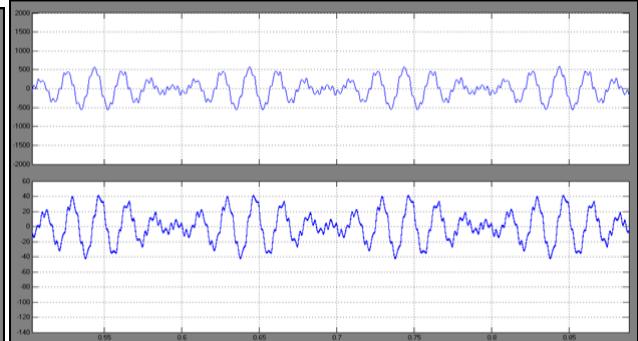


Fig : Shows7.2 shows  $V_{ab}$  and  $i_l$

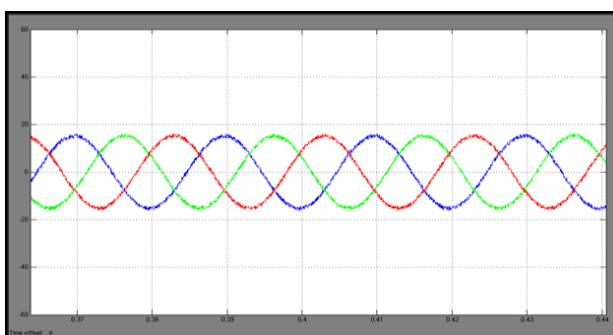


Fig: 6.3 Shows P load

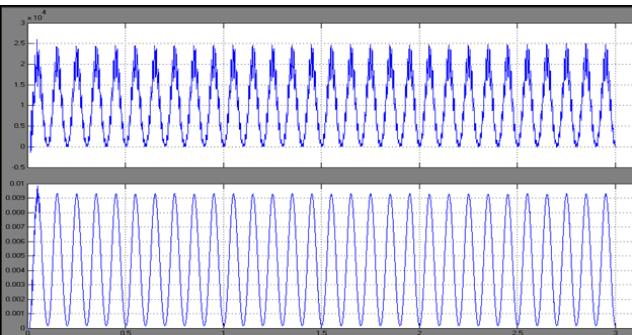


Fig: 6.4 Shows  $V_{ab}$  and  $I_l$  magnitude

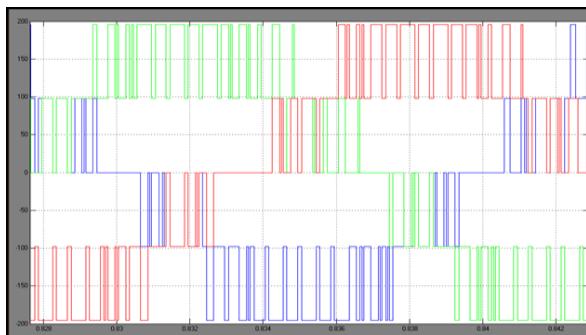


Fig: 6.5 Shows Voltage of input signals

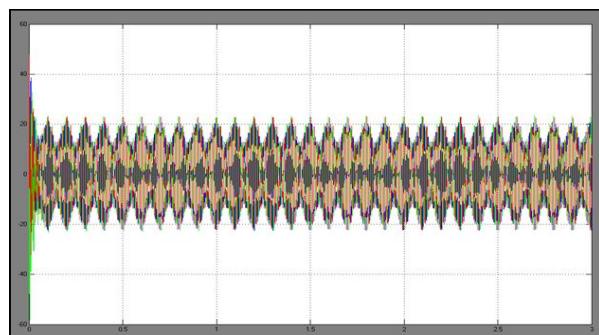


Fig : 6.6 Shows  $I_{abcg}$

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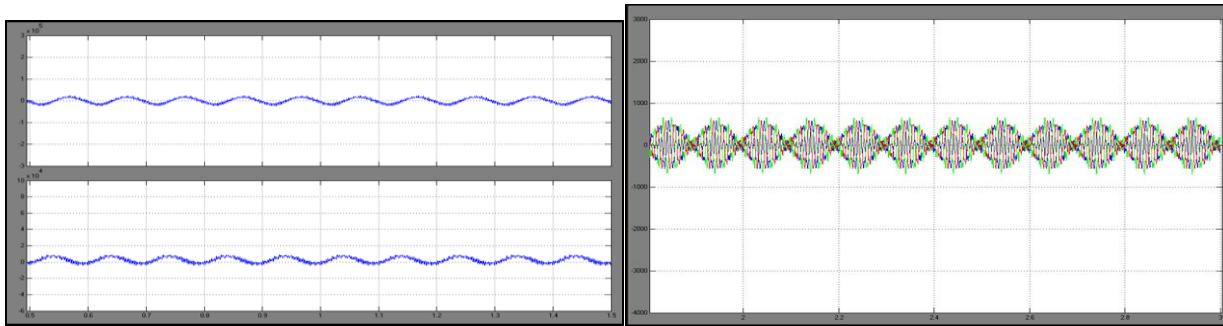


Fig: 6.7 Shows Vabcg and Iabcg

fig: 6.8 Shows Vabcg

### FOR NONLINEAR LOADS

The steady-state performance of the SEIG-STATCOM model feeding nonlinear loads is shown in Fig. 7 .The generator currents ( $i_{ga}$ ,  $i_{gb}$ , and  $i_{gc}$ ) and the PCC line voltage  $v_{ab}$  are shown in the Fig.7.3. Fig. 7.4 Shows the balanced three-phase source currents  $i_{sa}$ ,  $i_{sb}$ , and  $i_{sc}$ . The steady-state waveforms of the PCC voltage  $v_{ab}$  , the load current  $i_l$  , the dc-bus voltage  $V_{dc}$ , and the RMS value of the PCC line voltage  $V_{tRMS}$  are given in Fig. 7.2. The dc-bus voltage and the RMS PCC line voltage are seen to be relatively stable in steady state. The compensation currents injects by the STATCOM to stabilize the source currents are shown in Fig. 7.1 From Fig. 7.5, it is observe that the SEIG currents are balanced and sinusoidal which demonstrates the harmonics reduces and load balancing capabilities of the STATCOM.

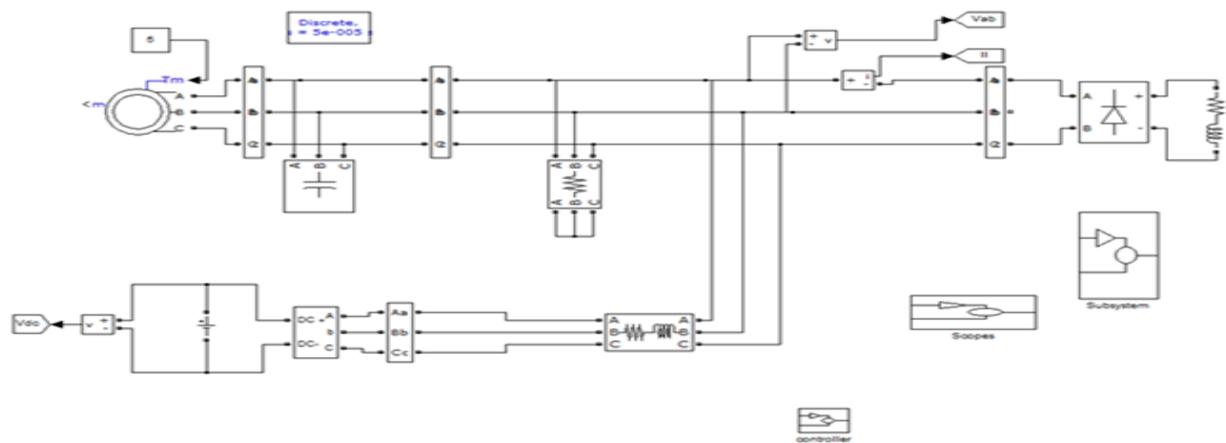


Fig. 7 Shows Simulation model for SEIG-STACOM fed with linear loads

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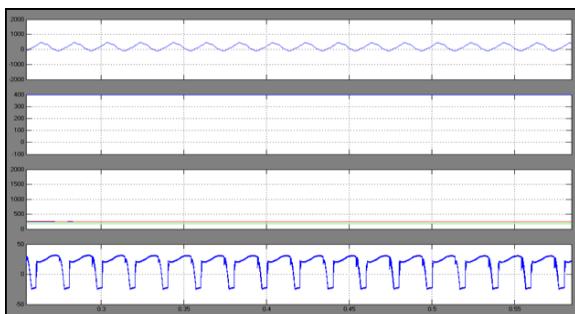


Fig:17.1 Shows Vab,Vdc,Il,Iab

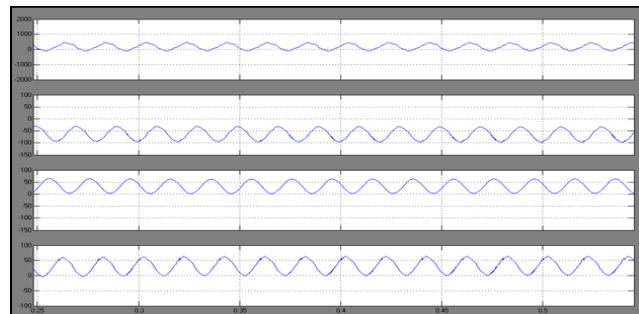


Fig:7.2 Shows Vab Vdc, Il, Iab

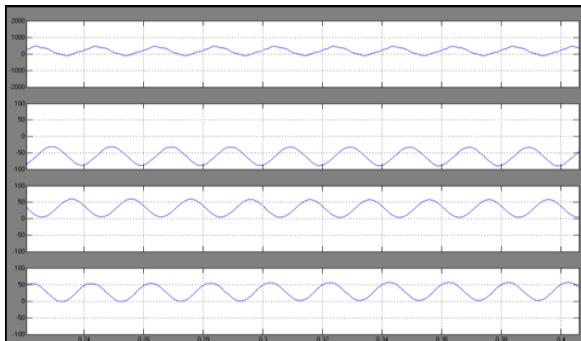


Fig:7.3 shows Vab ,Iabcg

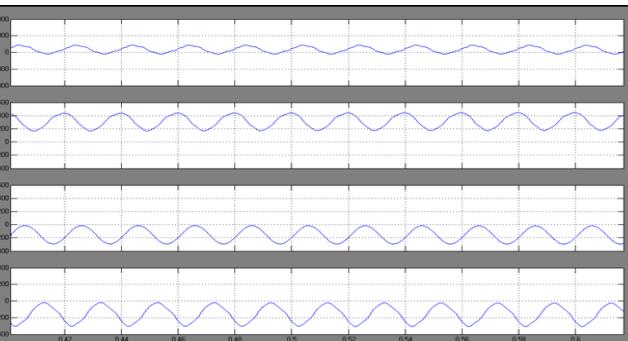


Fig:7.4 Shows Vab, Iabc

## VI.CONCLUSION

A novel topology for three-phase seig feeding single-phase loads by using STATCOM is explained by using the MATLAB software. and it has been proved that, the SEIG is able to feed single phase loads up to its maximum power. A single-phase synchronous D-Q frame theory-based on control of a three-phase STATCOM has been proposed, and discussed, and analysis corresponding with there corresponding wave forms of model. The proposed model of single-phase synchronous D-Q frame-based on control using the STATCOM, in addition to current balancing, the STATCOM is able to manage the terminal voltage of the generator and decreases the harmonic currents injected by nonlinear loads The adequate performance demonstrated by the developed the STATCOM-SEIG combination promises a potential application for isolated power generation using renewable energy sources like solar panels in remote areas with improved power quality.

## REFERENCES

- [1] E. D. Bassett and F. M. Potter, "Capacitive excitation for induction generators," *Trans. Amer. Inst. Elect. Eng.*, vol. 54, no. 5, pp. 540–545, May 1935.
- [2] J. E. Barkle and R. W. Ferguson, "Induction generator theory and application," *Trans. Amer. Inst. Elect. Eng.*, vol. 73, no. 1, pp. 12–19, Jan. 1954.
- [3] (2013). [Online]. Available: <http://www.picohydro.org.uk>
- [4] N. Smith, *Motors as Generators for Micro-Hydro Power*. London, U.K.:ITDG Publishing, 1994.
- [5] E. Bim, J. Szajner, and Y. Burian, "Voltage compensation of an induction generator with long-shunt connection," *IEEE Trans. Energy Convers.*, vol. 4, no. 3, pp. 526–530, Sep. 1989.
- [6] L. Shridhar, B. Singh, C. Jha, B. Singh, and S. Murthy, "Selection of capacitors for the self regulated short shunt self excited induction generator," *IEEE Trans. Energy Convers.*, vol. 10, no. 1, pp. 10–17, Mar. 1995.
- [7] T. Chan and L. L. Lai, "A novel single-phase self-regulated self-excited induction generator using a three-phase machine," *IEEE Trans. Energy Convers.*, vol. 16, no. 2, pp. 204–208, Jun. 2001.
- [8] T. Chan, "Performance analysis of a three-phase induction generator selfexcited with a single capacitance," *IEEE Trans. Energy Convers.*, vol. 14, no. 4, pp. 894–900, Dec. 1999.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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[9] T. Chan and L. L. Lai, "Capacitance requirements of a three-phase induction generator self-excited with a single capacitance and supplying a single-phase load," *IEEE Trans. Energy Convers.*, vol. 17, no. 1, pp. 90– 94, Mar. 2002.

[10] S. S. Murthy, B. Singh, S. Gupta, and B. M. Gulati, "General steady-state analysis of three-phase self-excited induction generator feeding three phase unbalanced load/single-phase load for stand-alone applications," *IEE Proc.* —

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