A Comprehensive Guide to Feeding Single-phase Loads with Seig

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Abstract— The thesis describes the use of a three-phase self-excited induction generator (SEIG) in conjunction with a three-phase static synchronous compensator (STATCOM) to generate single-phase power.The DC source is a photovoltaic (PV) panel, and the control method is based on D-Q frame theory. The quality of power is impacted when wind energy is added to an electric grid.The power quality measures in the grid system are affected by SEIG in the following ways: active power, reactive power, voltage variation, flicker, harmonics, and electrical behavior of switching operation.In order to correct for the imbalanced currents created by single-phase loads connected across the two terminals of the three-phase SEIG, a STATCOM control method is used.STATCOM is connected at the point of common coupling in the proposed design. A control technique based on single-phase synchronous D-Q frame theory is employed to produce gating pulses for three-phase STATCOM.Using a 3.7-kW, 230-V, Y-connected induction machine, the suggested technique of generating single-phase electricity from the three-phase SEIG is experimentally explored.The SEIG–STATCOM system's performance is assessed for single-phase loads that are linear and nonlinear.Additionally, the SEIG's performance at various terminal voltages is examined, and the terminal voltage that corresponds to the maximum power production is found.

I. INTRODUCTION

The term "self excited induction generator" refers to an externally driven squirrel-cage induction machine whose stator terminals are linked to a reactive power source (capacitance). With regard to mechanical energy conversion, squirrel-cage induction machines (SEIGs) are used in remote and isolated power generating systems because of their unique advantages over conventional synchronous machines. These advantages include low cost, brush-less construction, ruggedness, affordability, and built-in short-circuit protection.

When prime movers like biomass, biogas, and biodiesel engines power an SEIG, the frequency of the voltage generated remains nearly constant throughout the load range. The main disadvantage of an SEIG in its uses, however, has been inadequate voltage regulation. Therefore, during load disturbances, the terminal voltage of an SEIG must be adjusted. There have been several documented voltage regulation strategies for SEIG-based autonomous power production systems. When the nature of the load varies, the approaches that solely use passive elements are unable to regulate the terminal voltage. Consequently, several attempts have been made to use active switches that employ the static variable compensator (SVC), a combination of a fixed capacitor and thyristor-controlled inductor, to maintain a constant terminal voltage.

Due to the switching of line currents, the SVC-based voltage regulating techniques produce low-order harmonic currents. Additionally, they require large and heavy passive components. The voltage regulation capabilities of STATCOM-based voltage regulators is unaffected by the kind of load and they work better dynamically.

II. LITERATURE REVIEW

Among isolated microhydro power facilities, induction machines (IMs) are highly common. This machine is an AC single-excited one. A three-phase IM's stator winding is connected to a three-phase ac source, and the rotor winding gets its energy from the stator through electro-magnetic induction. An IM operates in generator and motor mode as determined by the slip value..

i. The rotor rotates in the direction of the rotating field created by the stator currents while the motoring mode is engaged ($0 < slip < 1$). At a standstill, the slip is1, while at synchronous speed, it is 0.

ii. When the rotor is driven above synchronous speed by a prime mover and the stator terminals are coupled to a constant frequency voltage source, the system is in the generating mode ($-1 < slip < 0$). SEIG uses a cage rotor design that is excited by shunt capacitors attached to its terminals·.

There are two types of shunt capacitors: variable and constant. The architecture of the IG is extremely similar to that of the induction motor, with some potential efficiency gains. An induction generator is also referred to as an asynchronous generator since its speed is not synchronous while it operates.

Fig. 1. Self Excited Induction Generator

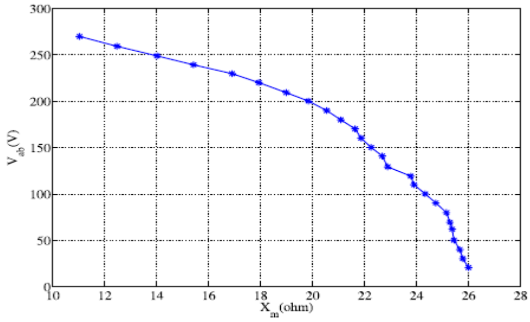

Fig. 2.Magnetizing characteristics of a three-phase SEIG

III. STATCOM BASED CONTROLLER

A STATCOM, one of the numerous devices in the FACTS family, is a regulating device that controls the system's reactive power flow regardless of other system characteristics. STATCOM is unable to exchange actual power with the ac system and lacks long-term dc energy support. In order to improve transient characteristics, increase transient stability margins, and reduce system oscillations brought on by dynamic disturbances, STATCOMs in transmission systems primarily handle only fundamental reactive power exchange and provide voltage support to buses by modulating bus voltages.

A link reactor connects the inverter output to the a.c supply side. A three phase inverter, usually a PWM inverter, using SCRs, MOSFETs, or IGBTs, a D.C. capacitor that supplies the inverter's D.C. voltage, and filter components to remove high frequency components caused by the PWM inverter make up a STATCOM. The inverter generates a three phase voltage from the capacitor on the d.c. side. The a.c supply and this are in harmony. This voltage is connected to the a.c. supply side via the connection inductor. This is how STATCOM operates on a fundamental level.

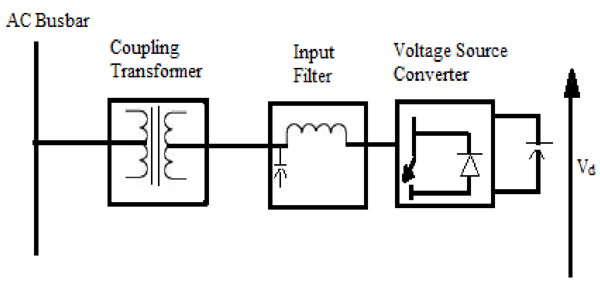

Fig.3.Connection of a STATCOM to a bus bar

The reactive power moves from the source with a higher voltage magnitude to the source with a lower voltage magnitude, and the active power moves from the leading source to the trailing source when two AC sources with the same frequency are coupled via a series inductance.

The active power flow is determined by the phase angle difference between the sources, and the reactive power flow is determined by the voltage magnitude difference between the sources.Thus, a STATCOM can be used to regulate the reactive power flow by changing the magnitude of the VSC voltage with respect to source bus voltage.

IV. PROPOSED METHADOLOGY

The system comprises of a prime mover based on renewable energy and an SEIG. The "a" and "c" phases of the SEIG are used to link the single-phase consumer loads. STATCOM is a two-level, three-leg insulated gate bipolar transistor (IGBT)-based voltage sensing interface (VSI) with a self-sustaining dc-bus capacitor.

By keeping the system's reactive power circulations in balance, the STATCOM controls the voltage inside the system. In addition, the STATCOM balances load while feeding single-phase loads and reduces harmonics introduced by nonlinear loads. Positive sequence components and negative sequence components are the two sets of balanced currents that make up the unbalanced load currents in a three-phase system..

To generate balanced source currents, the source needs to be free of the load currents' negative sequence components. The STATCOM supplies the negative sequence currents required by the unbalanced load or, when connected across PCC, draws a different set of negative sequence currents that are precisely 180 degrees out of phase with those drawn by the unbalanced load in order to counteract the effects of negative sequence currents from unbalanced loads.When the text update is complete, the paper is ready for the template. Using the Save As command, make a copy of the template file, and then name your paper in accordance with the convention adopted by your conference. Select all the items in this newly created file, then import your.

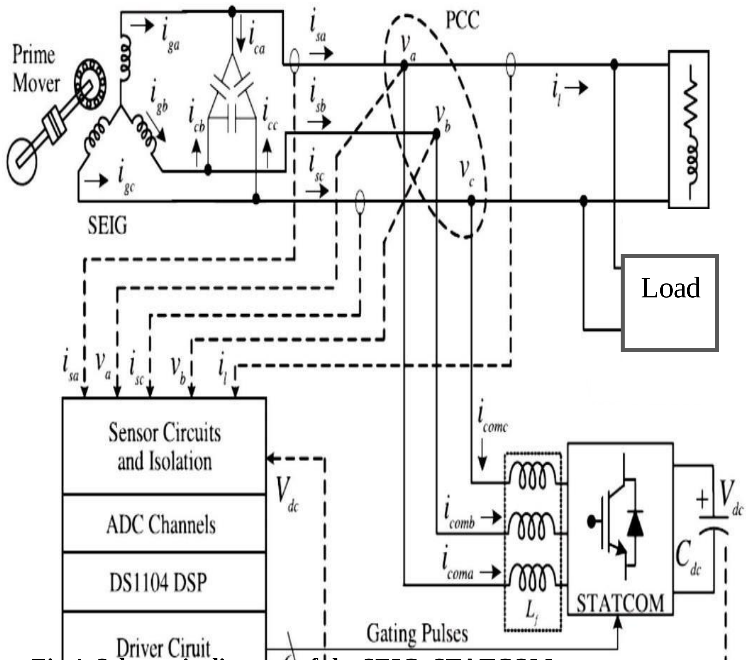

Fig.4. Schematic diagram of the SEIG–STATCOM system feeding single-phase loads.

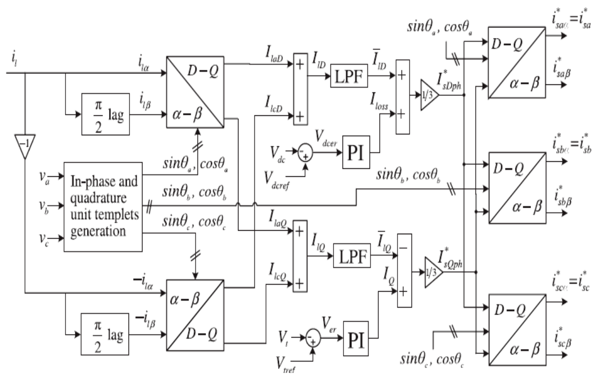

Fig.5. Block diagram of the single-phase synchronous D-Q theory control algorithm for

The suggested single-phase synchronous D-Q frame theory-based control method for the three-phase STATCOM is depicted in Fig. 6's block diagram. The three-phase SEIG system's reference source currents are determined by applying a single-phase synchronous D-Q frame theory to the terminal voltage regulation and current balancing calculations.

Under randomly fluctuating loads, the suggested control strategy for the STATCOM in frequency perturbed systems prevents synchronization loss. Additionally, its functionality is only shown for linear loads that are balanced in three phases. The three-phase STATCOM system's control algorithm, which can provide balanced source currents even in the presence of significant imbalance currents and voltages brought on by single-phase loads, serves as the foundation for the proposed single-phase synchronous D-Q frame.

SIMULATION MODEL OF SYSTEM

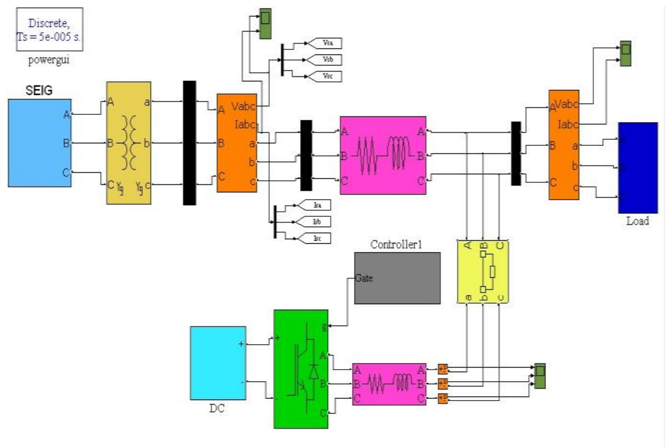

Fig. 6. Simulation model of proposed system

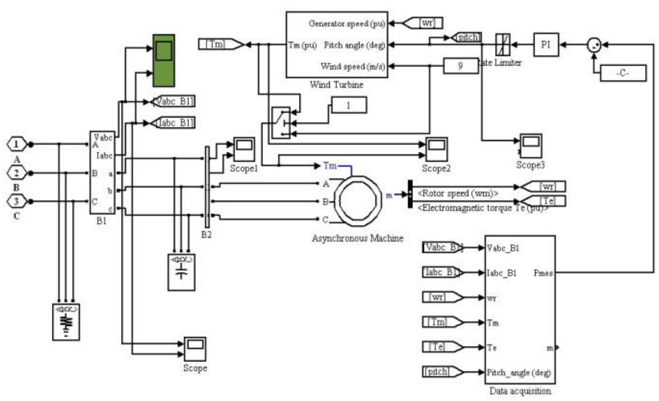

Fig.7. SIMULATION DIAGRAM OF LOAD

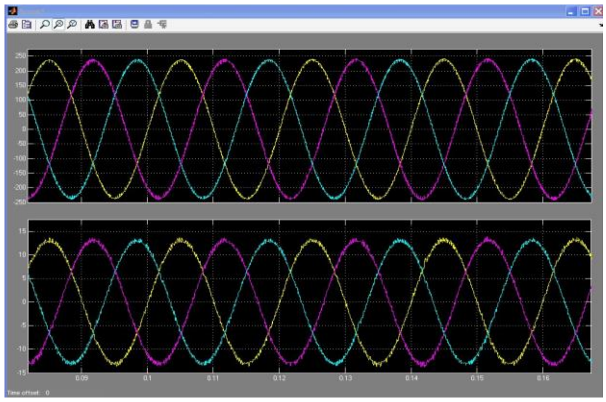

Fig.8.WAVEFORM OF SOURCE

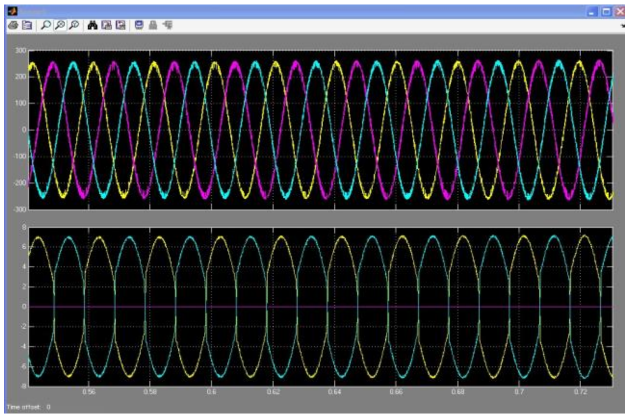

Fig.9.WAVE FORM OF LOAD

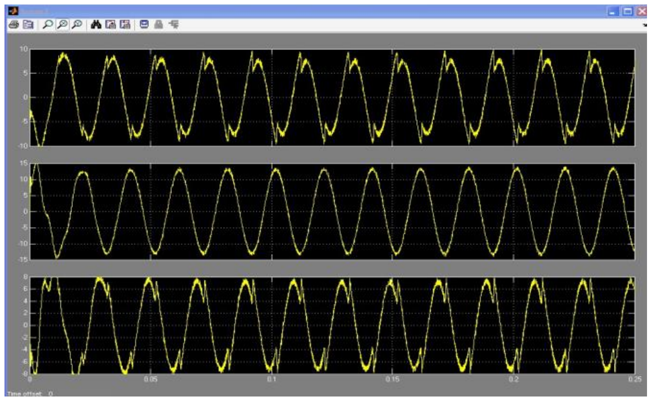

Fig.10.WAVE FORM OF STATCOM

VI. RESULTS AND DISCUSSION

A working prototype of the suggested SEIG-STATCOM system has been created and put under various stresses in experiments. The experimental findings shown in show how well the created system functions in both dynamic and steady state scenarios. Making Power Factor Adjustments By controlling the reactive power output, the STATCOM can increase the power factor of the system, reduce losses, and improve overall efficiency.

Increased Flexibility of Control The STATCOM's sophisticated control algorithms enable it to adjust to various operating environments and maximize the SEIG system's performance.Overall, voltage regulation, power quality, and system stability can all be enhanced by combining a three-phase SEIG system feeding single-phase loads with a STATCOM-based controller. It fulfills the unique needs of the single-phase loads while allowing for the effective use of the SEIG.

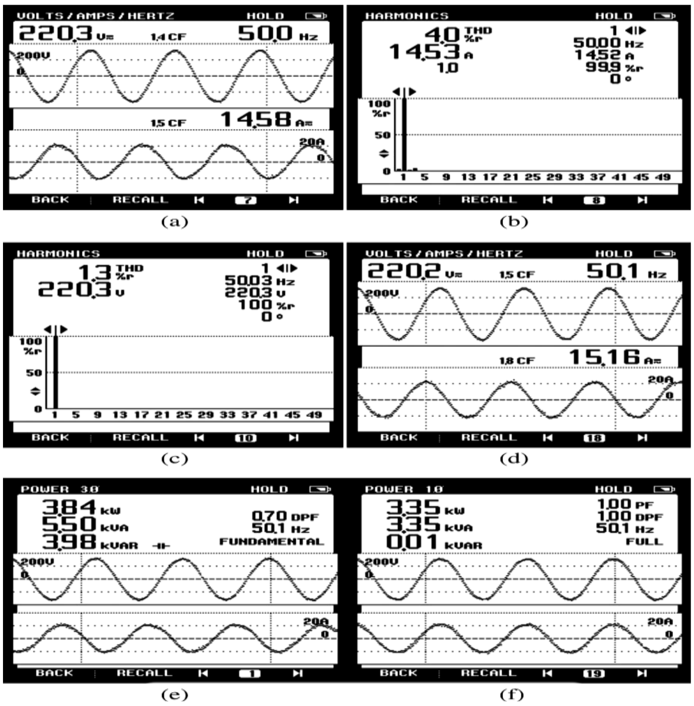

Fig.11. Steady-state performance of the SEIG–STATCOM system feeding single-phase linear loads. (a) v_{ab} and i_{ga} (b) THD of i_{ga} (c) THD of v_{ab} (d) v_{ab} and i_l (e) P_{gen} (f) P_{load}

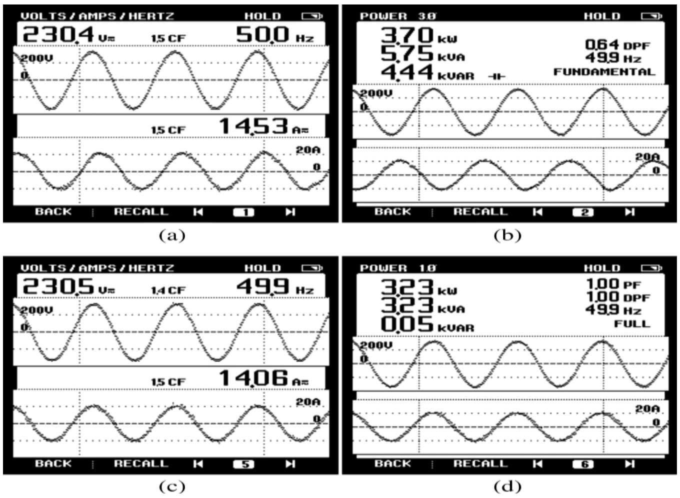

Fig. 12. SEIG output power and load powers at the rated voltage(a) v_{ab} and i_{ga} (b)P_{gen} (c) v_{ab} and i_l (d) P_{load}

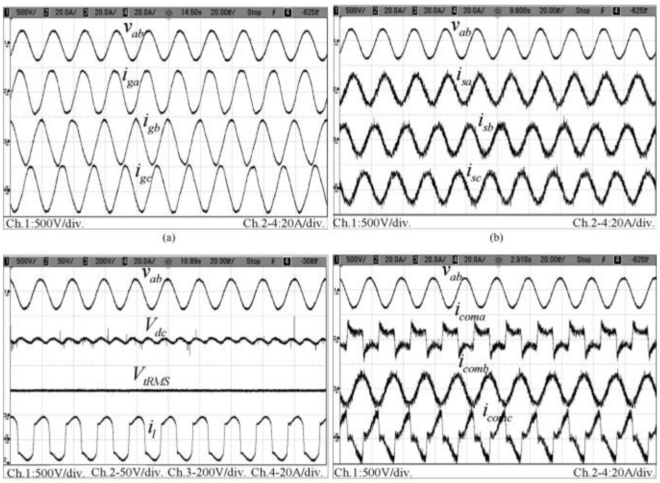

Fig. 13. Steady-state performance of the SEIG–STACOM system feeding single-phase nonlinear loads. (a) v_{ab} , i_{ga} , i_{gb}, and i_{gc} (b) v_{ab} , i_{sa} , i_{sb}, and i_{sc} (c) v_{ab} , V_{dc} and V_{tRMS} and il (d) v_{ab} , $i_{com\,a}$, i_{comb} and $i_{com\,c}$.

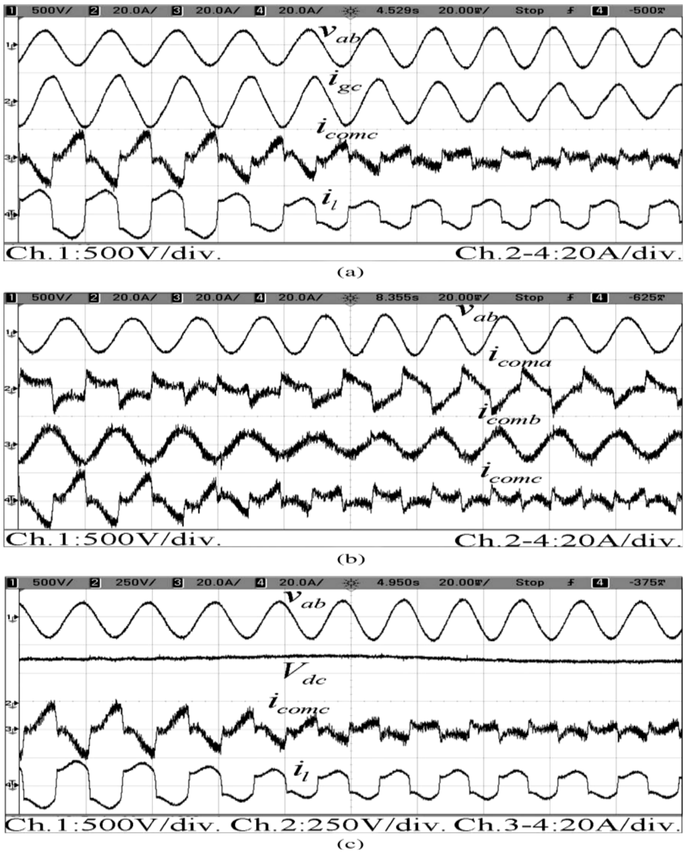

Fig.14. Dynamic performance of the SEIG–STATCOM during load removal.(a) vab , icom c , ig c and il. (b) vab , icom a , icom b and icom c. (c) vab , Vdc ,icom c and il .

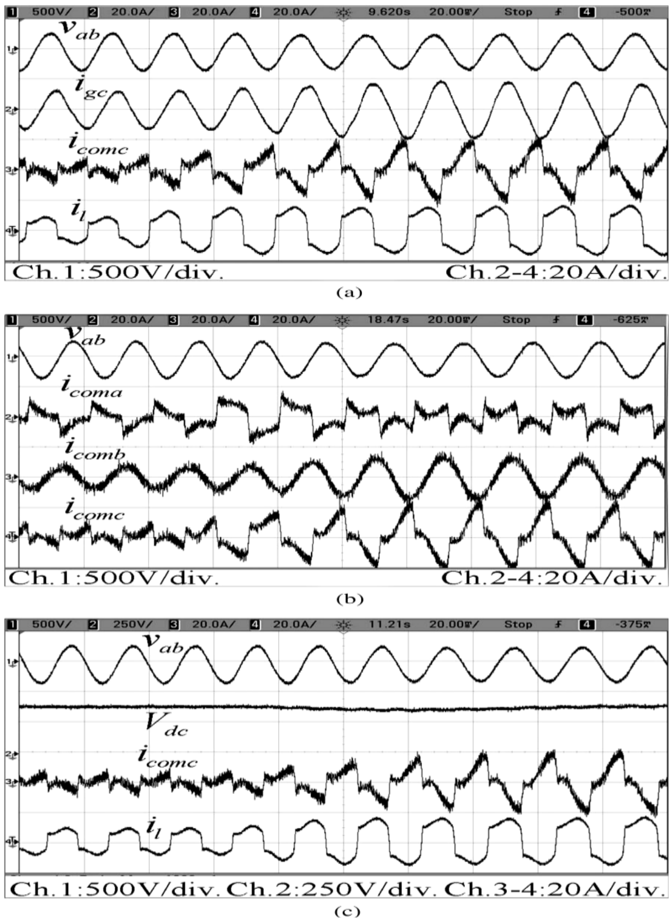

Fig.15. Dynamic performance of the SEIG–STATCOM during load application.(a) v_{ab} , $i_{com\,c}$, $i_{g\,c}$ and i_l (b) v_{ab} , $i_{com\,a}$, $i_{com\,b}$ and $i_{com\,c}$ (c) v_{ab} , V_{dc} , $i_{com\,c}$ and i_l

PERFORMANCE OF THE SEIG AT DIFFERENT TERMINAL VOLTAGES AND RATED WINDING CURRENT

v_{ab} (V)	i_{ga} (A)	P_{gen} (kW)	Q_{gen} (kVAr)	S_{gen} (kVA)	PF	i_l (A)	P_{load} (kW)
240	14.53	3.48	4.99	6.05	0.58	12.53	3.02
230	14.53	3.7	4.44	5.75	0.64	14.06	3.23
220	14.58	3.84	3.98	5.5	0.7	15.16	3.35
210	14.57	3.89	3.66	5.31	0.73	16.21	3.42
200	14.56	3.91	3.26	5.06	0.77	16.66	3.37
190	14.56	3.86	2.84	4.76	0.81	17.06	3.24
180	14.56	3.74	2.61	4.53	0.83	17.3	3.11
170	14.53	3.57	2.43	4.29	0.83	17.25	2.96

Table 1.

V. CONCLUSION

Testing the suggested technique of feeding single-phase loads from a three-phase combination of SEIG and STATCOM has demonstrated that the SEIG can feed single-phase loads up to its rated capacity. For the purpose of current balancing the SEIG system, a single-phase synchronous D-Q frame theory-based control of a three-phase STATCOM has been developed, described, and experimentally implemented.

Results from experiments have shown that the suggested single-phase synchronous D-Q frame-based control with the STATCOM is capable of efficiently balancing current. The STATCOM can suppress the harmonic currents introduced by nonlinear loads and control the generator's terminal voltage in addition to balancing current.

To determine the terminal voltage that corresponds to the maximum power output, the SEIG's performance at various voltages has been examined experimentally. It has been noted that the generator can provide 3.91 kW without going above the rated winding current when the SEIG is run at 200 V as opposed to the rated voltage. A possible use for isolated power generation employing renewable energy sources in remote places with enhanced power quality is promised by the developed STATCOM–SEIG combination's good performance.

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