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PERFORMANCE IMPROVEMENT OF SELF-EXCITED INDUCTION GENERATOR USING CAPACITOR BANK BASED ON PID CONTROLLER

This article discusses the operation of induction generators under fixed load and varying load conditions. One significant disadvantage of induction generators is their inherent need for reactive power. When connected to a load, it uses reactive power, and to regulate the output voltage, it requires a permanent external reactive source installed in the stator winding. Another weakness of induction generators is the instability of the voltage produced if there are fluctuations in the load being served. The ***goal*** *of this research is to improve the performance of a self-excitation induction generator (SEIG) using a capacitor bank based on a PID controller. The task carried out by the controller is to maintain the SEIG output voltage at a stable voltage value during load fluctuations in the system. The PID controller regulates the reactive power supplied to the SEIG system to ensure a stable output voltage despite load fluctuations. It achieves this by adjusting the proportional, integral, and derivative actions based on the error signals. One of the system stabilities is determined by the stability of the voltage generated. The* ***objective*** *of this research is to obtain a capacitor value that is appropriate to changes in the load being served so that the voltage generated has a small error percentage and the speed required to serve the load from the induction generator. The* ***method*** *applied in this research is to model the SEIG under load conditions connected to a capacitor bank. A capacitor bank is a source of reactive power that is added or subtracted from a system. The SEIG is modeled using MATLAB SIMULINK 2023a software and is driven by a DC motor. The output voltage of the SEIG system is input to the PID controller and the output is fed to the capacitor bank. The PID controller selects the value of the capacitor that will be injected to obtain a constant voltage value. The research* ***results*** *show that the SEIG system with a PID controller can control or maintain its output voltage at the initial voltage or a new steady voltage within the required error percentage range. The error percentage for the peak and rms (root rean square) voltage) is in the range of 0 % to 2 %. It can be* ***concluded*** *that the SEIG system with a PID controller has good performance and is in a stable condition when there are fluctuations in the load served by the generator. It is hoped that the system created can be applied to small-scale power generators in rural areas.*

Keywords: *Performance improvement; induction generator; capacitor bank; PID controller; error percentage.*

1. Introduction

This section presents the motivation of research that content about the usage of traditional energy sources as an electrical energy source highlights operational factors that impact efficiency and reliability. It gives a good motivation to do research for changing it to be a self-excited induction generator (SEIG) as a friendly machine. The previous researches related to this research related to its research gap are stated in the section of the state of art. The objective of this research is to optimize the performance of SEIGs by employing a PID-controlled capacitor bank to maintain voltage stability under varying load conditions. The approach includes modeling the SEIG system and analyzing its performance under different load scenarios.

The research optimized the performance of SEIGs by employing a PID-controlled capacitor bank to maintain voltage stability under varying load conditions.

1.1. Motivation for Research

Every nation in the globe makes a constant effort to lower the CO2 emissions caused by traditional energy sources, and its main objective is to tackle the problem of the energy crisis [1]. An effort has been conducted by the previous researchers related to the energy crisis [2], related to the comparison between the conventional and renewable energy to reduce the environmental pollution [3, 4].

A biogas generator that converts the biogas energy to electrical energy is friendly machine and it can reduce the operational characteristics. [5] compared the performance of the LPG generator and the biogas generator added by the LPG fuel, the result shows that the addition of a small amount of biogas into the combustion chamber of the genset machine can avoid significant exhaust gas pollution. Also, the biogas generator

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was studied by [6] using the main energy source from cow dung by mixing the three types of material (rice straw, corn cobs, and water hyacinth) separately. The mixture of cow dung and rice straw is the best mixture that can operate the generator for a longer time. The other mixture, biogas and hydrogen is conducted by [7, 8], the total biogas of 493.2 l is mixed by the hydrogen flow rate of 2.5 l/min and can operate 220 V, 3.1 A generator.

The other type of generator that can be classified in the friendly machine is SEIG. Because it uses a self-excitation system to operate, the SEIG is an alternate method for improving the operational efficiency of small-scale energy systems, making it relevant to rural and isolated energy applications. An excitation source consisting of capacitors mounted on its terminal is provided by the SEIG, an induction generator that operates independently of the utility grid [9, 10].

1.2. State of Art

Self-Excited Induction Generators (SEIG) have gained attention as an efficient solution for renewable energy applications, particularly in remote areas. Recent studies have highlighted that the combination of the reactive power supply and the active load significantly influences the voltage and frequency stability of SEIGs. Optimizing the excitation capacitance has become a key factor in ensuring stable operation during the grid disconnection and reconnection processes, as well as in the islanding mode [11, 12]. In addition, innovative configurations such as the *Fukami* setup and the use of partial power converters have proven to enhance the reliability of SEIG systems. These technologies can mitigate inrush current effects, improve reactive power regulation, and support sustainable operation even in the event of component failures [13, 14].

The performance of the SEIG has been studied by [15, 16] in terms of its output voltage and power. A mathematical model is developed by [15] for the output voltage and power based on the value of per unit frequency and per unit speed. The performance of the SEIG is also studied by [17] by applying a PI controller and direct torque control using *MATLAB SIMULINK*. The outcome demonstrates that the suggested control strategy for the generator's internal parameter variation.

In nonconventional energy applications like wind, micro, or mini hydro power plants, induction generators are commonly used. The use of induction generators in lieu of synchronous generators has many well-known benefits, including lower unit and size costs, improved performance, brushless operation, ease of maintenance, and reduced risk of short circuits [18, 19]. Voltage and frequency fluctuations are two common SEIG issues that arise from plant sources because they are sensitive to changes in load. Its efficiency and performance may be impacted by variations in the frequency and voltage [20, 21]. When the SEIG is operating under normal conditions, the voltage and frequency remain stable [22, 23].

The SEIG can operate steadily if an actual capacitor is applied. The application of the capacitor on the SEIG with the PI controller is applied by [24, 25] with wind as the prime over to move its rotor, its dynamic performance is tested by modelling the capacitor connected to the voltage source inverter with its switching components are controlled by a proposed control strategy and it shows that it has the effectiveness of the proposed control strategy. The installation of the capacitor on the SEIG is also applied by [26, 27] with the wind as the prime over for moving its rotor. A state variable equation is modeled in the system including the capacitor, its frequency, output voltage and power are observed and analyzed following the load fluctuation condition.

1.3. Objective and Approach

The objective of this research is to optimize the performance of SEIGs by employing a PID-controlled capacitor bank to maintain the voltage stability under varying load conditions. To stagger the voltage and rotor speed of the SEIG, this research uses a PID controller to organize the capacitor bank value as both an excitation source and a reactive power source. Because the SEIG is developed with a stable voltage in this study, its relative state is constant. A modeling of SEIG system driven by the DC motor was constructed using MATLAB SIMULINK. The PID controller circuit responds to the plan's output signal by the construction of simple derivatives (D), integrals (I), and proportions (P) [26]. The performance of the SEIG system for its normal operation condition and in the fluctuation load condition are observed to know its performance improvement by applying the PID controller.

1.4. Case Study

A case study of a SEIG that is moved by a DC motor has been conducted in this research. They were simulated using *MATLAB SIMULINK* based on their block sets and electrical and mechanical parameters. The SEIG is loaded by RLC load for a condition operation of fixed load and varying load. A suitable value of the capacitor is needed to achieve a suitable value of the output voltage of the SEIG. This is because the varying load affects its output voltage; thus, a PID controller is applied in this system to maintain its output voltage of 230 V. There are three case studies in this research to observe the performance of the SEIG. The first case study is that the SEIG is loaded for a fixed value of load and capacitor, its objective is to validate the model following the electrical and mechanical parameters given. The second and third case studies are that the SEIG is loaded by varying load with and without the PID controller, its objective is to compare the performance of the SEIG operation with and without the PID controller.

2. Materials and methods of research

This section presents the research methodology of the output voltage controller of the SEIG using a capacitor bank based on the PID controller.

2.1. Proposed Methods and Design of the SEIG System

A case study of a SEIG that is moved by a DC motor has been conducted in this research. They were simulated using *MATLAB SIMULINK* based on their A flow chart of the research methodology is shown in Fig. 1. The data parameters of the SEIG and the DC motor as a prime mover of the SEIG are shown in this section. The SEIG in a condition connected to the RLC loads and the DC motor are modelled using MATLAB SIMULINK. A capacitor bank is connected to the output terminal of the SEIG to enable it to reach its nominal output voltage.

A suitable value of the capacitor bank is decided to achieve a suitable output voltage of SEIG in the RLC load condition. In addition, a scenario of capacitor bank injection is conducted on the operating system of SEIG. A comparison of the SEIG's performance with and without the PID controller is observed and analyzed.

A block diagram of the SEIG is shown in Fig. 2 with its data parameters is shown in Table 1 [29, 30]. It is as a modification of SEIG by [31] by adding its prime mover using DC motor with its data parameters is shown in Table 2 [29, 30]. The SEIG is a three-phase induction generator. A fixed capacitor, *C*, is required to operate the SEIG for achieving its rated output voltage in the condition connected to the three-phase load.

In the steady-state operation condition of the SEIG, the SEIG sends its active power, P_L, and reactive power, Q_L, to the three-phase load. At the same time, the capacitor bank injects its reactive power, Q_E; thus, a reactive power, Q_G, is injected into the SEIG and affects its operation. The suitable values of the reactive powers, Q_E and Q_G, are required to maintain the output voltage of the SEIG.

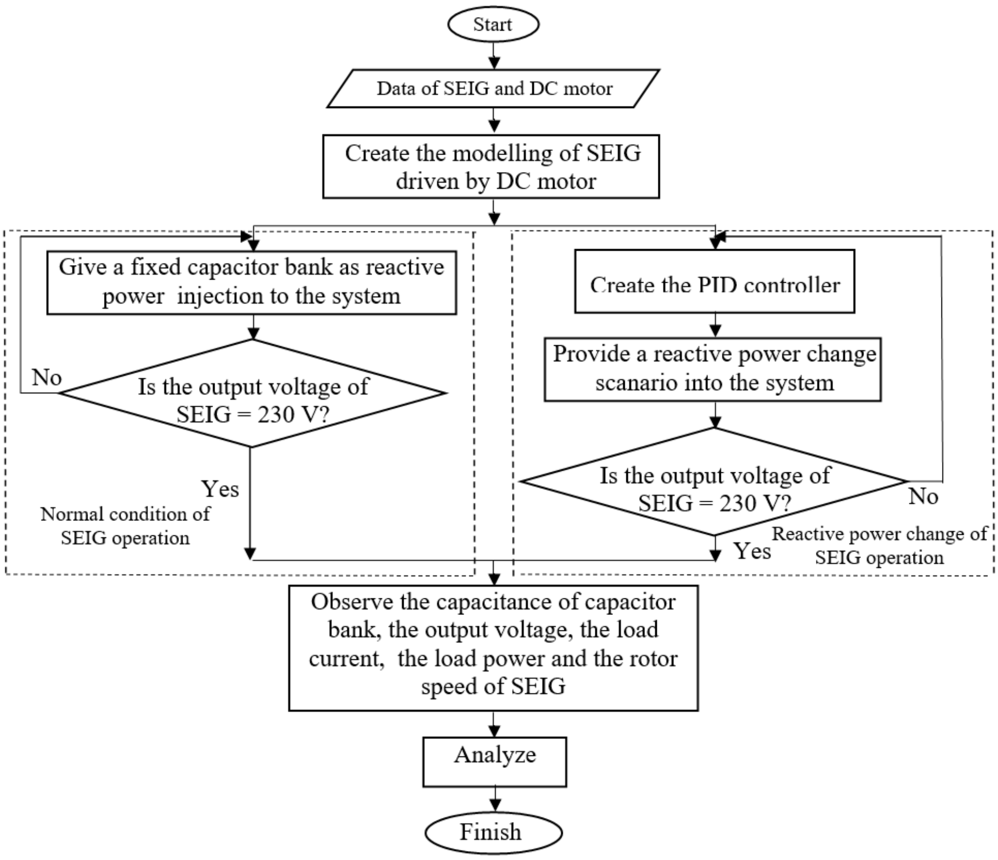

Fig. 1. Flow chart of research study Modelling of SEIG in RLC Load Condition

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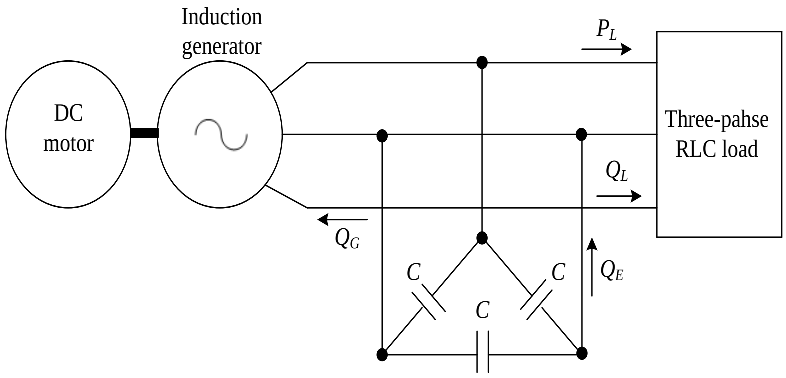

Fig. 2. A block diagram of the SEIG [28, 29]

Table 1

The data parameters of the SEIG

Parameter	Value
Rated power, P_e (W)	1500
Rated voltage, V_s (V)	230
Rated speed, ω (rad/s)	157
Pole pair, P	2
Rotor resistance, Rr (Ω)	2.24
Stator resistance, Rs (Ω)	5.51
Rotor inductance, Lr (H)	20.35×10^{-3}
Stator inductance, Ls (H	20.35×10^{-3}

Table 2

The data parameters of the DC motor

Parameter	Value
DC supply voltage, V_{DC} (V)	220
Rated armature current, I_a (A)	9
Rated speed, ω (rad/s)	157
Armature resistance, R_a (Ω)	1.4
Armature inductance, La (H)	$27\text{x}10^{-3}$

Fig. 3 shows the proposed output voltage controller of the SEIG using a capacitor bank based on the PID controller. In this case, the SEIG is loaded by a constant three-phase RLC load. A scenario is conducted to change the injection of the reactive power, Q_E to the system.

The injection of the reactive power, Q_E, causes a change in the total RLC load power in the system and affects the output voltage of SEIG, exactly for its root means square voltage for line to neutral, V_{rms}. However, the PID controller works fast to vary the capacitor bank to maintain the output voltage of the SEIG of 230 V.

Fig. 4 shows proposed modelling of the output voltage controller of the SEIG using a capacitor bank based on the PID controller using MATLAB SIMULINK. An induction generator is modelled as a three-phase system generator. Its input parameters are shown in Table 1, and it is driven by a DC motor with its parameters as shown in Table 2. They are in a block of the SEIG driven by the DC motor.

2.2. Design of SEIG System Using Matlab

The output terminal of the induction generator is connected to the three-phase RLC load and connected to a three-phase capacitor bank system. It is constructed using a three-phase variable resistor and capacitor. A value of the capacitance of the capacitor is required to be able to run the SEIG system in its nominal output voltage for serving the three-phase RLC load. In this case, a capacitor capacitance of 1 nF is required to be injected into the SEIG system and to maintain the nominal output voltage of the SEIG system in its normal operation condition.

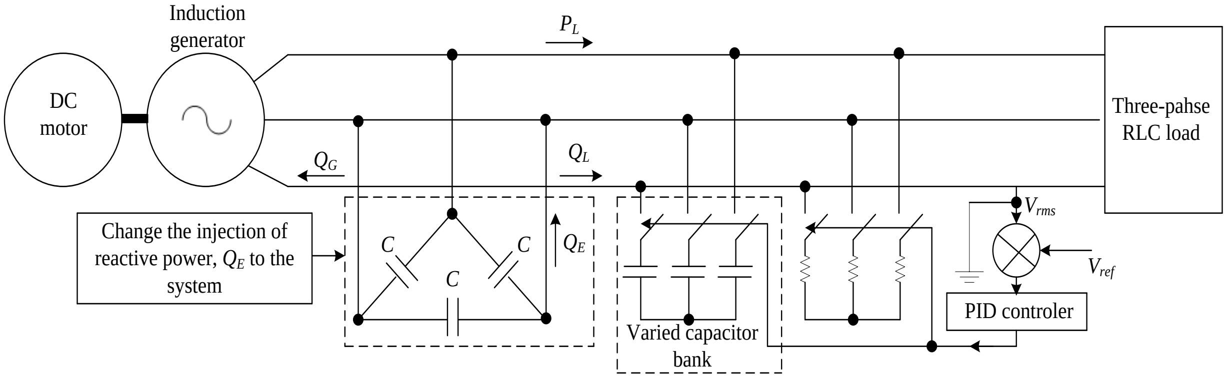

Fig. 3. A proposed output voltage controller of the SEIG using a capacitor bank based on a PID controller

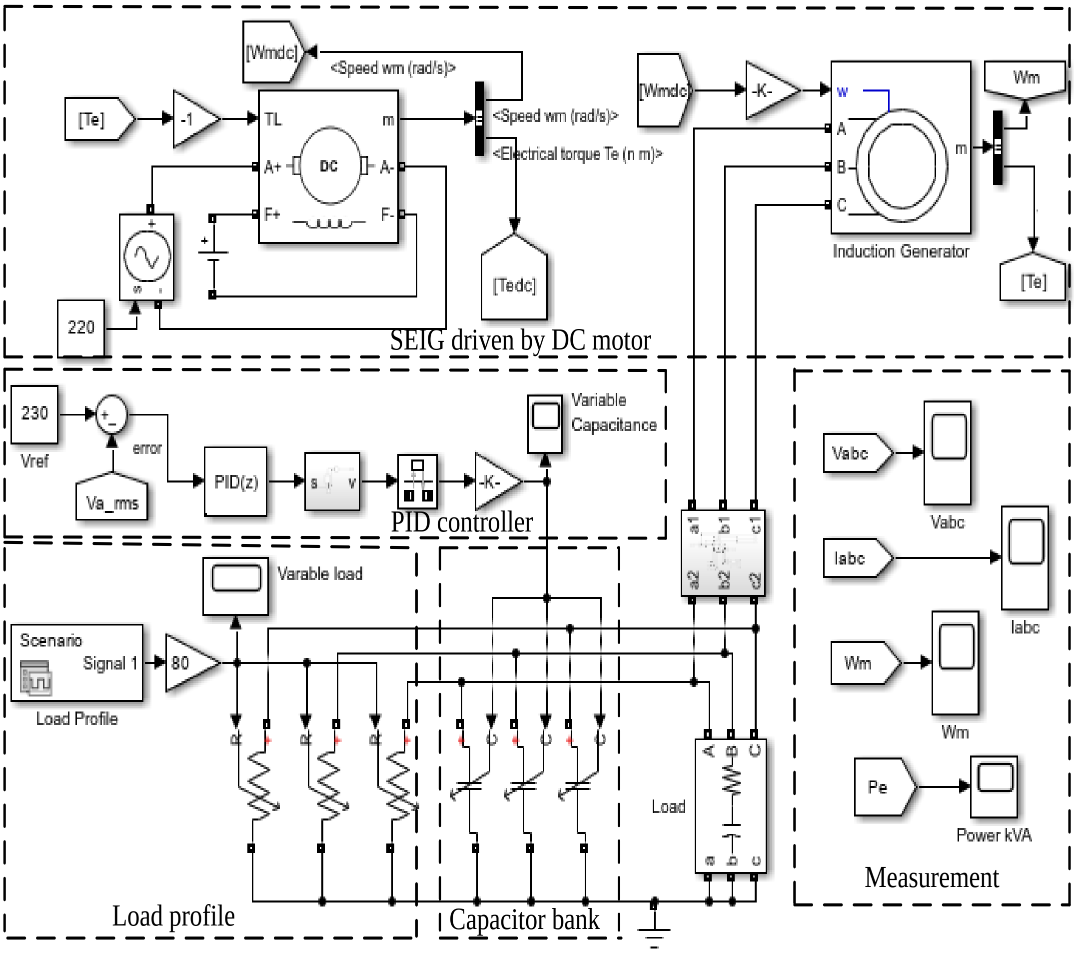

Fig. 4. A proposed modelling of SEIG using MATLAB SIMULINK

A scenario of the capacitor capacitance change is conducted as a change in the reactive power, Q_E injected into the system during 25 s. The reactive power and RLC load as a total power of the SEIG system affects its nominal output voltage. A transient value of the output voltage of the SEIG system can occur if it has no a voltage controller. In this paper, a PID controller is proposed to maintain the output voltage of the SEIG system in its steady-state value. An observation and analysis were conducted for the capacitance of the capacitor bank and the SEIG's output voltage, load current, load power and rotor speed.

2.3. PID Controller

The PID controller is applied to the SEIG to overcome the voltage fluctuations caused by the load changes that will cause the operation of the self-excited induction generator or SEIG to become unstable. The PID controller essentially regulates the appropriate capacitor value to be injected into the system. The 230 V voltage reference is used as an input reference to inject the reactive power through variable capacitor injection. The total capacitor value required is obtained based on the reactive power required by the SEIG to serve a certain load. Table 3 shows the PID parameter value used in the experiment.

Table 3

The data parameters PID Controller

Parameter	**Value**
P	0.1
I	0.05
D	0

3. Results and Discussion

This section presents the simulation results of the SEIG system based on the PID controller. The SEIG is simulated in three conditions. The first is in a normal operation condition with a specific value of the capacitor capacitance, the second and third are in the capacitor capacitance change with and without the PID controller, respectively. The analysis was conducted for the capacitance of the capacitor bank and the SEIG's output voltage, load current, load power and rotor speed for the SEIG's normal operation condition. Also, a comparison of its performances is conducted for the SEIG system with and without the PID controller.

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3.1. Performance of the SEIG in the Normal Operation Condition

The normal operation condition of the SEIG system means that the system serves the three-phase RLC load with a specific value of per-phase capacitor capacitance of 60 uF to maintain its rms output voltage of 230 V, as shown in Fig. 5 and Fig. 6, respectively, for an operation time of 25 s.

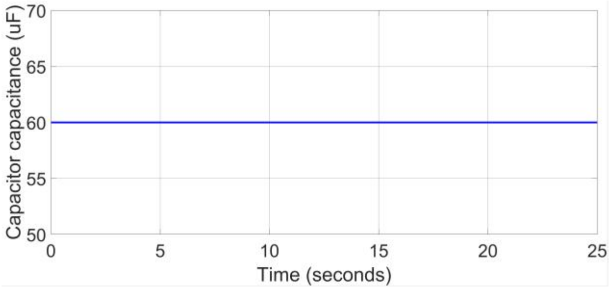


Fig. 5. Capacitor capacitance of 60 uF

Fig. 5 indicates the value of the reactive power, Q_E injected into the SEIG system, where its value is for the capacitor capacitance of 60 uF during the period time of 25 s. Fig. 6 shows the three-phase voltage waveform for a period time of 25 s.

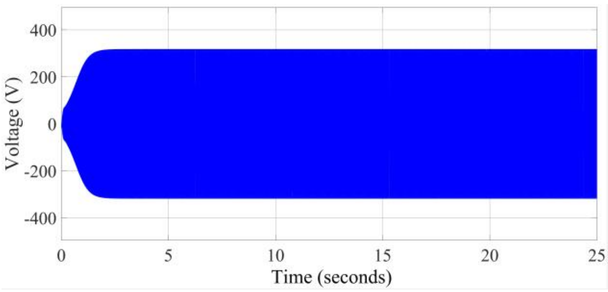


Fig. 6 Voltage of the SEIG system

This capacitor bank can maintain the rms voltage of 230 V, as shown in Fig. 7 or its peak voltage around 317.764 V, as shown in Fig. 8. However, it is clear for capturing the voltage waveform in the range time of 10.00 s to 10.06 s. There is no fluctuation in the voltage during the SEIG system operating in the normal operation condition.

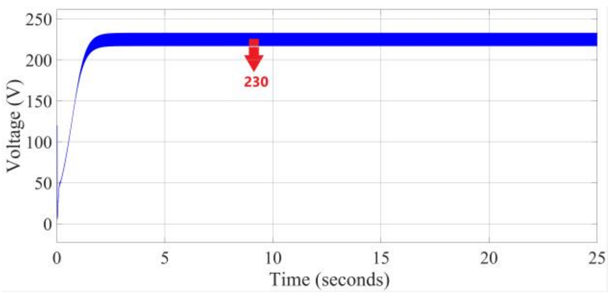


Fig. 7. RMS Voltage of the SEIG system

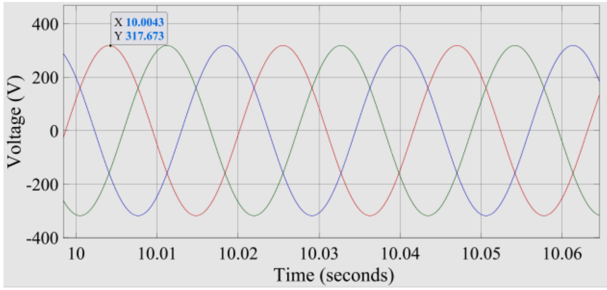


Fig. 8. Three-phase voltage waveform at a given time

Following Fig. 7 that two types of load load the SEIG system, three-phase load and three-phase resistive load that injected by a constant value of 80 (load profile), where it is as multiplication of the three-phase resistive load. These all loads and added by the value of the reactive power, Q_E are as the total load of the SEIG system. Thus, a current of 4.8 A flows through the system, as shown in Fig. 9 and the total active power is 1.5 kW, as shown in Fig. 10.

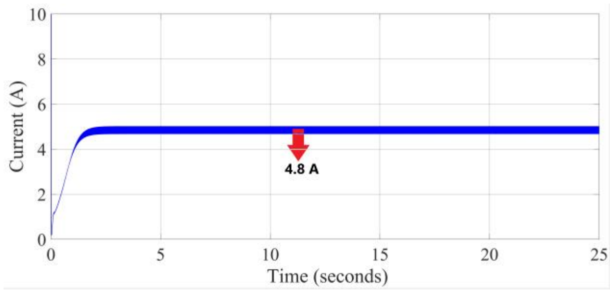


Fig. 9. Current of the Normal Operation Condition

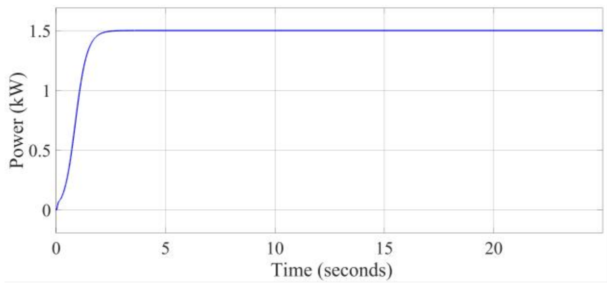


Fig. 10. Total active power

The normal operation condition of the SEIG system for its rms voltage of 230 V, current of 4.8 A and power of 1.5 kW needs its rotor speed of 157 rad/s. This SEIG's rotor speed of 157 rad/s is the same as the rotor speed of the DC motor. At the initial time, the graph of the rotor speed shows that the speed in a transient condition and then it can reach a steady state value of 157 rad/s as shown in Fig. 11. These all conditions can be stated that the SEIG system operated in a stable condition for the normal operation condition.

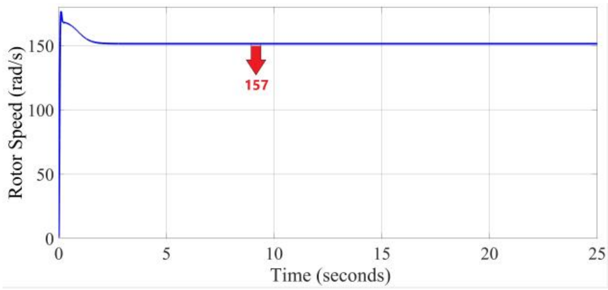
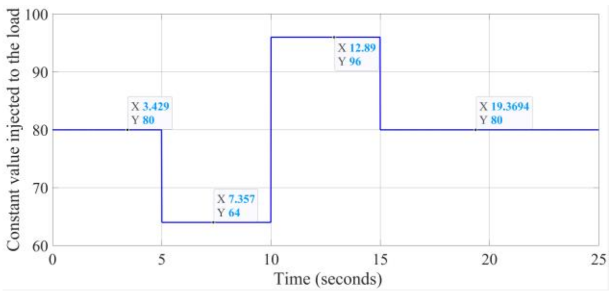


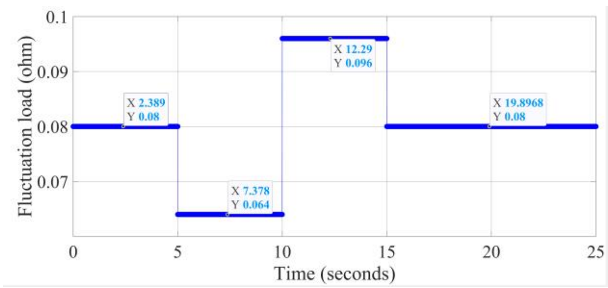
Fig. 11. Rotor speed

3.2 Performance Improvement of the SEIG Using PID Controller in The Operation of the Fluctuation Load Condition

The fluctuation load condition is conducted based on the three-phase resistive load that is injected by a constant value of 80 (load profile), where it is varied by 20% below and above the value of 80 during the period time of 25 s, as shown in Fig. 12(a). The per-phase resistive load on the load profile is 1mΩ, thus fluctuation load is in the unit of ohm, as shown in Fig. 12(b). The resistive load of 0.08 Ω is for the normal operation condition of the SEIG system, it is reached at the time below 5 s, at the time of 5 s above and below 10 s that the resistive load goes down to 0.064 Ω, at the time of 10 s above and below 15 s that the resistive load goes up to 0.096 Ω, after that goes back to 0.08 Ω (normal operation condition).



(a) Constant value injected into the load



(b) Fluctuation load in ohm

Fig. 12. Fluctuation load condition

The PID controller works to maintain the performance of the SEIG system or to bring the parameters of the SEIG into a new steady-state condition with their achievable error percentage (±5% [32]). The PID controller will add or subtract the value of the capacitance of the capacitor bank, as shown in Fig. 13, following the fluctuation load condition, as stated in Fig. 8. When there is no fluctuation load (0.08 Ω as a fluctuation load reference in the profile load) for the period time of below 5 s, the PID controller detects the value of the capacitance of the capacitor bank of 1.42 µF as shown in Fig. 13. When the fluctuation load goes down 0.064 Ω for period time of 5 s to below 10 s, the PID controller adds 14.28 µF into the system; thus, the value of the capacitance of the capacitor bank is 15.67 µF. When the fluctuation load goes up 0.096 Ω for period time of 10 s to below 15 s, the PID controller subtract 5.12 µF (refer its fluctuation load reference) from the system; thus, the value of the capacitance of the capacitor bank is -6.79 µF.

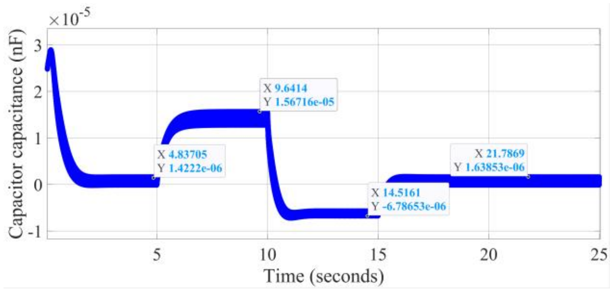


Fig. 13. Capacitor capacitance injected to the system

A comparison of the performance of the SEIG with and without the PID controller in the fluctuation load condition (following Fig. 12) is observed and analyzed to prove that by applying the PID controller can improve its performance. Each voltage waveform is observed for the decreasing and increasing the per-phase resistive load on the load profile. Fig. 14 shows the three-phase voltage waveform of the SEIG without the PID controller. It has a steady-state peak voltage of 318.26 V for the normal operation of the SEIG system.

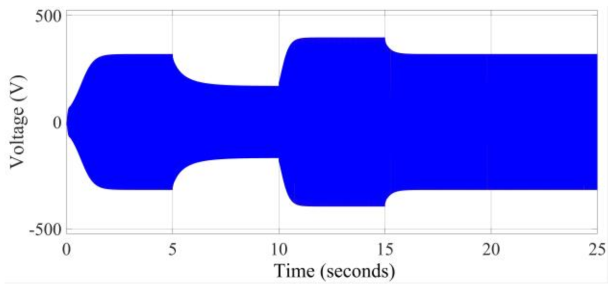


Fig. 14. Three-phase voltage waveform without the PID controller

When the resistive load is reduced in the load profile, the peak voltage drops to 179.03 V, so the error

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percentage is 43%, as shown in Fig. 15. This indicates that the decrease of the resistive load can decrease its peak voltage until to a value of the lowest voltage. It can also be said that the SEIG is not in stable condition. When the resistive load is increased in the load profile, its peak voltage reaches a peak voltage of 395.95 V, as shown in Fig. 16, thus it has an error percentage of 24 %. It also indicates that the SEIG is not in a stable condition.

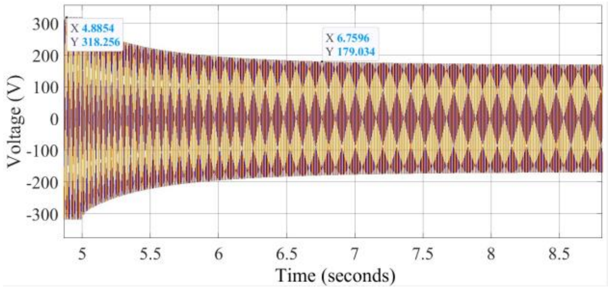

Fig. 15. Three-phase voltage waveform without the PID controller when the load decreases

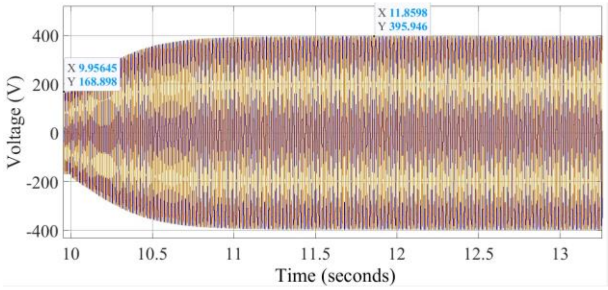

Fig. 16. Three-phase voltage waveform without the PID controller when the load increases

Fig. 17 shows the three-phase voltage waveform of the SEIG with the PID controller. It has a steady-state peak voltage of 327.44 V for the normal operation of the SEIG system. When the resistive load is decreased in the load profile, its peak voltage decreases to 280.97 V, but it can return to a new steady-state peak voltage of 327.16 V (following Fig. 18); thus, it has an error percentage of 0%. This indicates that the decrease in resistive load causes the PID controller to inject the capacitance of the capacitor bank into the system with its values of capacitance, as shown in Fig. 13. This also indicates that the SEIG is in a stable condition. When the resistive load is increased in the load profile, its peak voltage reaches a higher peak voltage of 417.01 V, but it can return to a new steady-state peak voltage of 324.79 V; thus, it has an error percentage of 1.12 % (following Fig. 19). It also indicates that the SEIG is in a stable condition

Fig. 20 shows the rms voltage of the SEIG without the PID controller. It has a steady-state rms voltage of 231.13 V for the normal operation of the SEIG system. When the resistive load is decreased in the load profile, its peak voltage decreases to 119.69 V; thus, it has an error percentage of 48%. This indicates that the decrease of the resistive load can decrease its peak voltage until to a value of the lowest voltage. It can also be said that the SEIG is not in stable condition. When the resistive load is increased in the load profile, its rms voltage reaches a rms voltage of 293.68 V; thus, it has an error percentage of 27%. It also indicates that the SEIG is not in a stable condition.

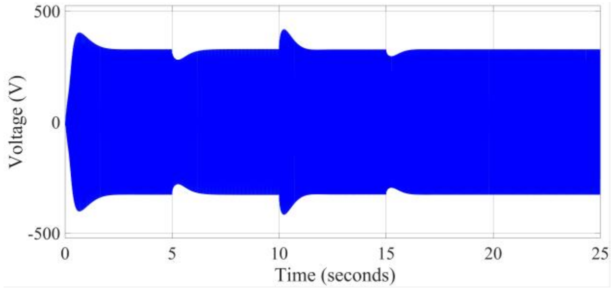

Fig. 17. Three-phase voltage waveform with the PID controller

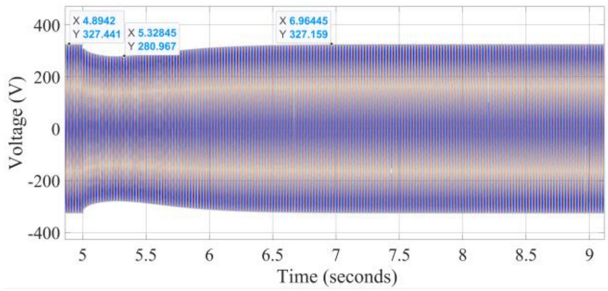

Fig. 18. Three-phase voltage waveform with the PID controller when load decreases

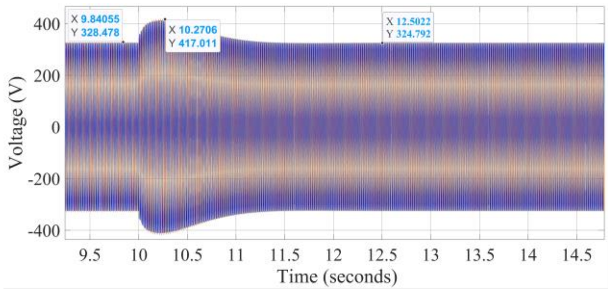

Fig. 19. Three-phase voltage waveform with the PID controller when the load increases

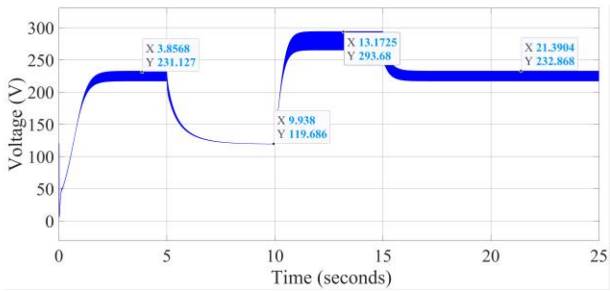

Fig. 20. RMS voltage without the PID controller

Fig. 21 shows the rms voltage waveform of the SEIG with the PID controller. It has a steady-state peak voltage of 238.88 V for the normal operation of the SEIG system. When the resistive load is decreased in the load profile, its peak voltage decreases to 189.66 V, but it can return to a new steady-state rms voltage of 244.04 V; thus, it has an error percentage of 2%. This indicates that the decrease in the resistive load causes the PID controller to inject the capacitance of the capacitor bank into the system with its values of capacitance, as shown in Fig. 13. This also indicates that the SEIG is in a stable condition. When the resistive load is increased in the load profile, its peak voltage reaches a higher rms voltage of 308.22 V, but it can return to a new steady-state rms voltage of 235.04 V; thus, it has an error percentage of 1.6%. It also indicates that the SEIG is in a stable condition.

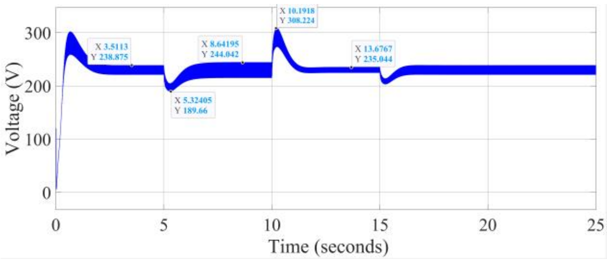

Fig. 21. RMS voltage with the PID controller

Table 4

Error percentage

Parameter	Error percentage (%)			
	Decreasing resistive load		Increasing resistive load	
	Without PID	With PID	Without PID	With PID
Peak voltage	43	0	24	1.3
rms voltage	48	2	27	1.6

The error percentage is referred to as a performance indicator of the SEIG system. It can be listed as stated in Table 4. In the decreasing or increasing of the resistive load in the load profile, the SEIG system without the PID controller shows that their error percentage is very big, they are out of the required range (abjectly ±5%). This indicates that the SEIG system without the PID controller does not have good performance and is not in a stable condition. The SEIG system with the PID controller shows that their error percentage is in the range of 0% to 2%, it is in the required range of error percentage. This indicates that the SEIG system with the PID controller has a good performance and is in a stable condition when the fluctuation load occurs in the system.

The simulation results demonstrate that implementing a PID controller in the SEIG system effectively maintains the output voltage stability under varying load conditions. Without the PID controller, the system exhibits significant voltage instability, with error percentages reaching up to 48%. In contrast, with the PID controller, the voltage error is successfully minimized to an acceptable range of 0...2 %. Additionally, the PID controller's adjustment of the capacitor bank capacitance provides a rapid response to load fluctuations, ensuring that the voltage remains at its nominal value. This validates the proposed approach, which significantly enhances the overall performance and reliability of the SEIG system, making it suitable for applications with variable loads.

4.Conclusions

This study presents a robust PID control mechanism for SEIG systems, emphasizing the voltage stability under fluctuating loads. The novel approach demonstrated performance improvements through reduced error percentages. Future research could incorporate adaptive control strategies and IoT integration.

A self-excited induction generator (SEIG) is modelled using MATLAB SIMULINK. It is driven by a DC motor and a capacitor bank is installed to overcome the operation of the SEIG system. The SEIG system in the normal operation condition and the fluctuation load condition is observed and analyzed for its performance. Thus, some statements can be concluded as stated below.

In the normal operation condition, the SEIG system obtains the per-phase capacitor bank of 1 nF. This capacitor capacitance is able to maintain its rms voltage of 230 V without fluctuation values. In addition, this condition gives its current, total power and rotor speed of 4.8 A, 1.5 kW and 157 rad/s.

The SEIG system with the PID controller can add or subtract the value of the capacitance of the capacitor bank to or from the system. It can control or maintain its output voltage in the initial voltage or in a new steady-state voltage, but it is still in the required error percentage. Its error percentages (peak and rms voltage) are in the range of 0% to 2%, which is in the required range of error percentage. This indicates that the SEIG system with the PID controller has a good performance and is in a stable condition when the fluctuation load occurs in the system.

Further development of the created system may include the use of adaptive control techniques and machine learning algorithms to improve the system's response to unpredictable load changes. In addition, integration with the smart grid and the Internet of Things (IoT) technology can enable remote monitoring, more efficient energy management, and better system maintenance predictions.

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Conflict of Interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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The manuscript has no associated data.

Use of Artificial Intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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ПОЛІПШЕННЯ ХАРАКТЕРИСТИК ІНДУКЦІЙНОГО ГЕНЕРАТОРА З САМОЗБУДЖЕННЯМ З ВИКОРИСТАННЯМ КОНДЕНСАТОРНОЇ БАТАРЕЇ НА ОСНОВІ ПІД-РЕГУЛЯТОРА

М. Сюкрі, А. Сюхада, А. Акхяр, Т. Тармізі

Предмет цієї статті обговорює роботу асинхронних генераторів при фіксованому та змінному навантаженні. Одним із істотних недоліків індукційних генераторів є їх властива потреба в реактивній потужності. При підключенні до навантаження він використовує реактивну потужність, а для регулювання вихідної напруги потрібне постійне зовнішнє реактивне джерело, яке встановлено в обмотці статора. Іншим недоліком індукційних генераторів є нестабільність виробленої напруги при коливаннях навантаження, що обслуговується. Метою даного дослідження є підвищення продуктивності індукційного генератора самозбудження

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(СЕІГ) з використанням конденсаторної батареї на основі ПІД-регулятора. Завдання, яке виконує контролер, полягає в підтримці вихідної напруги SEIG на стабільному значенні напруги під час коливань навантаження в системі. Одна зі стійкостей системи визначається стабільністю генерованої напруги. Мета цього дослідження полягає в тому, щоб отримати значення конденсатора, яке відповідає змінам навантаження, що обслуговується, щоб генерована напруга мала невеликий відсоток похибок, і швидкість, необхідну для обслуговування навантаження від індукційного генератора. Метод, застосований у цьому дослідженні, полягає в моделюванні SEIG в умовах навантаження, підключеного до батареї конденсаторів. Конденсаторна батарея – це джерело реактивної потужності, яка додається до системи або віднімається від неї. SEIG моделюється за допомогою програмного забезпечення MATLAB SIMULINK 2023a і приводиться в дію двигуном постійного струму. Вихідна напруга системи SEIG надходить на ПІД-контролер, а вихід подається на конденсаторну батарею. ПІД-контролер вибирає значення конденсатора, який буде введено для отримання постійного значення напруги. Результати дослідження показують, що система SEIG з ПІД-регулятором може контролювати або підтримувати свою вихідну напругу на рівні початкової напруги або нової сталої напруги в межах необхідного відсоткового діапазону помилки. Відсоток похибки для пікової та середньоквадратичної напруги (корінь квадратний) знаходиться в діапазоні від 0% до 2%. Можна зробити висновок, що система SEIG з ПІД-регулятором має гарну продуктивність і перебуває в стабільному стані, коли є коливання навантаження, яке обслуговує генератор. Є надія, що створену систему можна буде застосувати до малих електрогенераторів у сільській місцевості.

Ключові слова: підвищення продуктивності; індукційний генератор; батарея конденсаторів; ПІД-регулятор; відсоток помилки.

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