Static Var Compensator Modeling with PID Control to Improve Power Factor

Azmi Rizki Lubis[1], Marwan Affandi[1], Muchsin Harahap[1], Muhammad Akram Haidar Syah[1], Ilham Rizky Ananda[1], Hasan Yanmar Lubis[1], Nadira Alfiyantika[1], Anzila Nada Zahra[1], Michael Sinaga[1]

{azmirizkilubis@unimed.ac.id[1], marwanelektro@unimed.ac.id[1], faizaawan496@gmail.com[1], mhdakram.5231230021@mhs.unimed.ac.id[1], ilham.5233230004@mhs.unimed.ac.id[1], hasanyanmarlubis@gmail.com[1], nadirayntka99@gmail.com[1], anzilandzahra@gmail.com[1], michaelsinaga@gmail.com[1] }

Universitas Negeri Medan, Jalan Willem Iskandar Pasar V Medan Estate[1]

Abstract. The power factor represents the ratio between active power and apparent power, which decreases when reactive power demand increases. Static Var Compensator (SVC) is a device used to compensate reactive power, stabilize load variations, and improve power quality in industrial systems. However, its performance depends on an effective control strategy. This study aims to analyze the effect of SVC on power factor improvement and to implement Proportional-Integral-Derivative (PID) control for regulating the reactive power supplied by the Fixed Capacitor–Thyristor Controlled Reactor (FC-TCR) type SVC. Modeling and simulation were carried out using MATLAB/Simulink with load data from the Adolina PTPN IV Palm Oil Mill. The design of the capacitor and inductor resulted in values of 0.0163 F and 0.000623 H, enabling reactive power variation from 0 to 742,198 VAR. Simulation results show that the PID controller successfully regulates the firing angle of the thyristors in response to load changes, achieving a stable power factor of 0.99 under different operating conditions. The outcomes also demonstrate good agreement between analytical calculations and simulation results, validating the accuracy of the model. Overall, the application of PID control in SVC provides effective reactive power compensation, reduces the generator burden, and improves energy efficiency in industrial electrical systems.

Keywords: Power Factor, Static Var Compensator, FC-TCR, PID Control

1 Introduction

Industry is one of the sectors that heavily relies on inductive loads, particularly large-capacity electric motors used in conveyors, pumps, and other machinery [1]. These motors require reactive power for magnetization, which often reduces the power factor and increases current flow in the system [2]. A low power factor leads to higher apparent power, greater generator burden, and reduced efficiency of the power system. Therefore, reactive power compensation is essential to maintain system stability and efficiency [3].

ICIESC 2025, September 16, Medan, Indonesia

DOI 10.4108/eai.16-9-2025.2361024

Static Var Compensator (SVC) is widely applied to improve power factor and power quality by controlling reactive power through thyristor-based switching. The FC–TCR (Fixed Capacitor–Thyristor Controlled Reactor) type SVC can provide fast and dynamic reactive power compensation. However, its performance strongly depends on the control method used to adjust the firing angle of the thyristors [4].

Previous studies have examined various approaches, such as fixed firing angle adjustments, mathematical formulations without automatic control, and fuzzy logic-based methods [5]. While these methods improve the power factor, they often fail to consistently maintain it close to unity under varying load conditions. This indicates the need for a more robust control strategy that ensures stable and accurate compensation [6].

To address this gap, this study proposes the application of a Proportional-Integral-Derivative (PID) controller to regulate the firing angle of the FC–TCR SVC [7]. With automatic adjustment, the PID controller is expected to improve the power factor to 0.99 under different load variations, thereby reducing generator burden and enhancing overall energy efficiency [8].

2 Methods

In this research, the general method applied is modeling and simulation using MATLAB-Simulink software. This approach is used to analyze a Static Var Compensator (SVC) control system, specifically the Fixed Capacitor-Thyristor Controlled Reactor (FC-TCR) type, controlled by the Proportional Integral Derivative (PID) method to improve the power factor of a palm oil mill's load. Data analysis techniques in this research involve several detailed calculation and design methods to solve the identified problems.

2.1 Calculating Apparent Power Before and After Power Factor Correction

The purpose of calculating apparent power before and after power factor correction is to determine the changes that occur following the correction. Once the active power and reactive power are known, the apparent power can be calculated. The equation used to calculate apparent power can be expressed using Equation (1) below :

$$S = \sqrt{P^2 + Q^2} \tag{1}$$

Where :

S = Apparent Power (VA)
Q = Reactive Power (VAR)
P = Active Power (Watt)

2.2 Determining the FC-TCR Rating

The FC and TCR ratings are determined based on data obtained from observation results. Several calculations are needed to determine the FC-TCR rating. Determining the capacitor rating :

$$C = \frac{Q_{fc}}{V^2 \times 2\pi F} \tag{2}$$

Determining the TCR reactor value :

$$X_c = \frac{1}{2\pi \times F \times C} \quad (3)$$

The capacitive reactance is equal to the inductive reactance (XC = XL). Therefore, the inductance value in Henry can be determined using equation (4).

$$X_L = 2\pi \times F \times L \quad (4)$$

Where:

Xc = Capacitive reactance (ohm)
X_L = Inductive reactance (ohm)
V = System voltage (V)
f = Frequency (Hz)
L = Inductance (Henry)
C = Capacitance (Farad)

The PID controller parameters, namely proportional gain (Kp), integral gain (Ki), and derivative gain (Kd), are typically tuned to optimize the control system's response. In this study, the Ziegler-Nichols method is used for this purpose. The tuning process begins by setting Ki and Kd to zero and gradually increasing Kp until the system exhibits sustained oscillations, known as the critical gain (Kcr), with a specific oscillation period (Pcr). Once these critical values are identified, the PID parameters are calculated using the Ziegler-Nichols tuning rules: Kp =0.6×Kcr, Ki=2×Kp/Pcr, and Kd=Kp×Pcr/8. These parameters are then fine-tuned to better suit the system's dynamics. The relation to the firing angle (α) is direct; the PID output, after tuning, is translated into a firing angle that determines when the thyristors switch during each AC cycle. By adjusting α, reactive power can be controlled precisely to maintain the target power factor. Proper tuning ensures that the firing angle responds quickly to load changes, minimizes overshoot, and stabilizes around the desired reactive power setpoint, thereby optimizing system performance and energy efficiency.

2.3 Calculation of SVC Reactive Power at Alpha Angle

SVC generates reactive power from the capacitor, and that reactive power is absorbed by the inductor. The amount of reactive power absorbed by the inductor is influenced by the firing angle in alpha according to equation (5).

$$Q_{SVC} = Q_C - Q_L \quad (5)$$

Q_c is the reactive power generated by the capacitor. Since the capacitor used is a purely capacitive load, it can be calculated using equation (6).

$$Q_C = 3 \times V \times I \times Sin\,\varphi \quad (6)$$

Q_L is the reactive power generated by the inductor. Since the inductor used is a purely inductive load, it can be calculated using equation (7).

$$Q_L = 3 \times V \times I \times Sin\,\varphi \quad (7)$$

The current flowing through the TCR is influenced by the firing angle (Alpha), and thus can be calculated using equation (8).

$$I_{(\alpha)} = \frac{V}{X_L}\left(\frac{2\pi}{\pi} - \frac{2\alpha}{\pi} + \frac{sin\,sin\,(2\alpha)}{\pi}\right) \quad (8)$$

The current flowing through the capacitor can be calculated using equation (9).

$$I_C = \frac{V}{X_C} \tag{9}$$

2.4 Designing the Control System

Before designing the control system to be used, it is necessary to first design the SVC circuit. The SVC circuit to be used is an FC-TCR type SVC. This system consists of a fixed capacitor connected in parallel with a reactor. The reactor is connected in series with anti-parallel thyristors, and the entire assembly is connected in parallel with the system at the midpoint of the transmission line or near the fluctuating load [9]. The SVC circuit diagram can be seen in Fig 1. The next stage is designing the control system for the SVC. The input data of this system is the difference between the average reactive power from the source and the reference reactive power. The reference reactive power, also called the set point, represents the amount of reactive power expected to be supplied by the power source or generator. The output of the PID controller, in the form of a firing angle ranging from 90°–180°, will then be converted into pulses [10]. These pulses serve as the input to the Thyristor gate and control the amount of reactive power absorbed by the inductor. The block diagram of the control system circuit to be used can be seen in Fig 2.

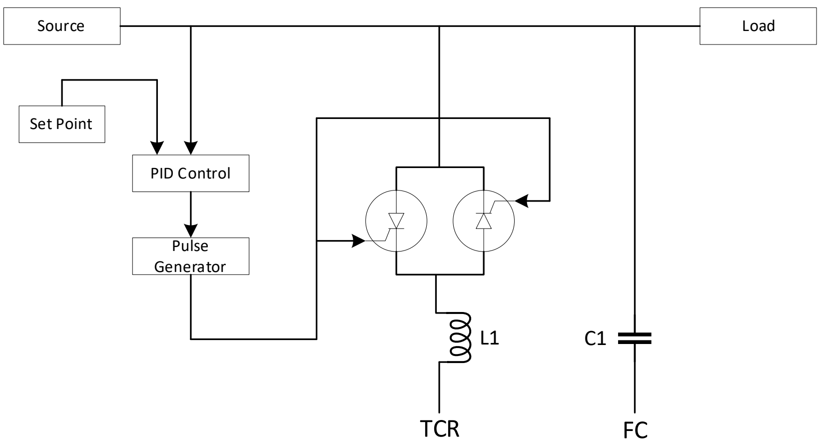

Fig. 1. Overall System Modeling

As shown in Fig 2, the control system used is a PID controller. The PID controller (Proportional, Integral, Derivative) is a common control method used in automation systems to regulate process variables and maintain the setpoint value. The variable to be controlled is the amount of reactive power to be absorbed by the TCR according to the firing angle of the Thyristor [11].

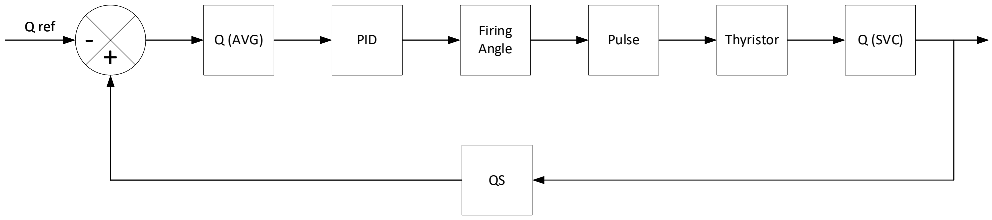

Fig. 2. SVC Control System Block Diagram

In the control block diagram of the Static Var Compensator (SVC), the error signal is calculated as the difference between the measured reactive power and the desired reactive power setpoint. This error signal is then fed into the PID controller, which consists of proportional (Kp), integral (Ki), and derivative (Kd) components. The proportional part responds directly to the present error magnitude, the integral part accumulates the past errors to eliminate steady-state offset, and the derivative part predicts future error trends to enhance system stability. The output of the PID controller is an control signal representing the firing angle (α), typically within the range of 90° to 180°. This firing angle signal is subsequently converted into control pulses that trigger the thyristors at precise moments, thereby controlling the conduction angle of the TCR. This process dynamically adjusts the firing angle based on the reactive power demand, ensuring that reactive power compensation is optimized. As a result, the reactive power supplied by the TCR is regulated to maintain the system's power factor at the setpoint, improving overall energy efficiency and system stability.

The PID parameters (Kp, Ki, Kd) can be adjusted if necessary to improve control performance and ensure the system operates optimally. The proportional constant (Kp), integral constant (Ki), and derivative constant (Kd) are obtained through tuning so that the system response meets the desired specifications. Tuning is the process of finding controller parameters according to the system requirements [12]. The method that will be used to obtain the PID parameters is the Ziegler–Nichols method [13]. The steps carried out in this method are: (1) Set the values of Ki and Kd to 0, (2) Increase the value of Kp and find the critical gain (Kcr) that produces sustained oscillations, (3) Determine the period (Pcr), (4) Perform calculations based on Table 1.

Table 1. Ziegler-Nichols PID Parameter

Control Type	K_p	T_i	T_d
P	0.5 K_{cr}	∞	0
PI	0.45 K_{cr}	$\frac{1}{1.2} P_{cr}$	0
PID	0.6 K_{cr}	0.5 P_{cr}	0.125 P_{cr}

$$K_I = 2 \times \frac{Kp}{Ti} \tag{10}$$

$$K_d = Kp \times Td \tag{11}$$

2.5 Understanding and Operating Principles of PID Controller

The Proportional-Integral-Derivative (PID) controller is one of the most widely used control methods in automation systems to regulate a process variable, aiming to reach and maintain a desired setpoint efficiently and stably. In the context of the SVC system with PID control, this controller manages the firing angle of the thyristor (α), adjusting the reactive power absorbed by the TCR to achieve an optimal power factor. Mathematically, the PID control output is expressed as:

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_d \frac{de(t)}{dt} \tag{12}$$

Where:

u(t) = The control signal, which is translated into the firing angle (α) of the thyristor.
e(t) = The error between the setpoint (SP) and the measured process variable (PV).
Kp = Proportional gain, which determines the immediate response to the current error.
Ki = Integral gain, which considers the accumulation of past errors to eliminate steady-state offset.
Kd = Derivative gain, which predicts future error trends based on the current rate of change, dampening overshoot and oscillations.

In practical applications, this control output u(t) is converted into a firing angle (α), typically within a range of 90° to 180°, and used to control the thyristor switching in the TCR.

2.6 Controller Operation

The operation of the controller begins with the measurement of variables, such as reactive power or the firing angle. The measured value is then compared with the desired setpoint, and the difference between the two is defined as the error, e(t). This error is then processed through the PID (Proportional–Integral–Derivative) formula. The three components work together to generate the control signal, u(t), which determines how much reactive power is absorbed or supplied by the Thyristor Controlled Reactor (TCR).

Next, the control signal u(t) is translated into the firing angle (α). This angle dictates the precise switching time of the thyristor during each AC cycle. Through this mechanism, the system automatically adjusts itself so that the reactive power provided by the TCR dynamically matches the load requirements. Importantly, the process operates in a continuous feedback loop. The system consistently monitors the controlled variable (reactive power or firing angle) and fine-tunes α in real time based on the error. With properly tuned parameters Kp, Ki, and Kd, the controller delivers a fast and stable response, with minimal overshoot and steady-state error, ensuring that the target power factor—for example, 0.99—is consistently maintained.

2.7 Tuning PID Parameters

The gains Kp, Ki, and Kd should be carefully tuned for optimal performance. The popular Ziegler-Nichols method is often used, which involves increasing Kp until the system oscillates (critical gain) and then calculating the corresponding Ki and Kd based on the oscillation period. Proper tuning ensures the SVC system responds swiftly, remains stable, and effectively maintains the desired power factor.

In summary, the PID controller enables the SVC system to automatically and dynamically adjust the firing angle of the thyristors, controlling reactive power flow efficiently according to load variations, and ultimately improving the power factor of the system.

3 Results and Discussion

This research commenced with the collection of load data at the Adolina PTPN IV Palm Oil Mill, encompassing active power, reactive power, and power factor at the main bus. This data varied during the observation period. Subsequently, from the obtained data, calculations were performed to analyze the effect of power factor improvement on apparent power. Then, under maximum load conditions, recalculations were conducted to determine the magnitude of reactive power that needed to be compensated.

Based on the reactive power value at maximum load, the capacitor and inductor values to be used in the Static Var Compensator (SVC) were calculated. Once these values were obtained, calculations were carried out to understand how the SVC operates based on variations in the firing angle (alpha) from 90° to 180°.

The application of the Proportional Integral Derivative (PID) control method to control the firing angle of the Thyristor Controlled Reactor (TCR) in the SVC was performed using simulation software. This simulation aimed to verify whether the PID control method could effectively control the TCR's firing angle according to the reactive power required by the SVC for compensation.

3.1 Power Factor Improvement Using SVC

The SVC used in this research is of the Fixed Capacitor – Thyristor Controlled Reactor (FC-TCR) type. This device consists of a capacitor with a fixed capacitance and an inductor controlled by Thyristors. In compensating reactive power using an FC-TCR type SVC, it is necessary to calculate the values of the capacitor and inductor to be used.

The SVC consists of a Fixed Capacitor (FC) and a Thyristor Controlled Reactor (TCR), requiring calculations for the capacitor and inductor values based on the maximum reactive power demand. The largest load identified required a reactive power of 738,111 VAR. The capacitor value (C) was calculated using equation

$$C = \frac{738{,}111}{(380^2 \times 2\pi \times 50)} = 0.016270639 \text{ F}$$

Capacitive reactance (Xc) was calculated using

$$X_c = \frac{1}{(2\pi \times 50 \times 0.01627)} = 0.195634532\ \Omega$$

Since Xc = XL in the SVC used, the inductor value (L) was calculated using

$$X_L = 2\pi \times F \times L$$

$$X_L = \frac{0.195}{2\pi \times 50} = 0.000622724 \text{ H}$$

Based on these calculations, the capacitor used in the simulation is 0.016270639 Farad and the inductor is 0.000622724 Henry.

3.2 Reactive Power Generated by SVC at Alpha Angle

The reactive power generated by the SVC can be varied by adjusting the firing angle (alpha). Based on the inductor value, the current flowing at the alpha angle was calculated using equation (8). The current flowing at Alpha angle 90° was calculated as follows:

$$I_{(\alpha)} = \frac{220}{0.195}\left(\frac{2\pi}{\pi} - \frac{2(90°)}{\pi} + \frac{sin\, sin\, (2(90°))}{\pi}\right) = 1124.5\ A$$

The current flowing through the capacitor (IC) was calculated using equation (9):

$$I_C = \frac{220}{0.195} = 1124.5 \text{ A}$$

Using equation (6), the reactive power generated by the capacitor (QC) is:

$$Q_C = 3 \times\ 220 \times 1124.5 \times Sin\ 90° = 742198 \text{ VAR}$$

The reactive power generated by the inductor (QL) was found using equation (7):

$$Q_L = 3 \times 220 \times 1124.5 \times Sin\ 90° = 742198 \text{ VAR}$$

Then, the total 3-phase reactive power generated by the SVC (QSVC) using equation (5) is:

$$Q_{SVC} = 742198 - 742198 = 0 \text{ VAR}$$

Based on the calculations, the reactive power generated by the SVC at a firing angle of 90° is 0. This is because the TCR is always on, causing maximum current to flow through the inductor. The current flowing through the capacitor and inductor are equal, thus canceling each other out, resulting in very little current through the SVC and no reactive power generated.

As the firing angle increases from 90° to 180°, the current through the inductor decreases. The maximum reactive power that can be generated is at an angle of 180°, reaching 742198.4 VAR, where no current flows through the inductor, meaning the reactive power generated by the capacitor is not absorbed by the inductor.

3.3 Performance of the Proportional Integral Derivative (PID) Control Method in Controlling Reactive Power Generated by Static Var Compensator

The PID control method was applied to regulate the firing angle (α) of the Thyristor Controlled Reactor (TCR). The controller generates a firing angle based on the difference between the required reactive power of the load and the reactive power provided by the SVC. This difference is defined as the error signal, and the deviation between the error and zero is referred to as the Delta Error, which represents how far the system is from the desired setpoint of reactive power compensation.

(a) Load 1

For the first test, the load had an active power of 1,200,000 W and a reactive power of 909,100 VAR. The PID controller adjusted the firing angle to 180°. However, the Delta Error did not reach zero because the maximum reactive power capacity of the SVC (736,256 VAR) was lower than the reactive power demand of the load. Despite this limitation, the system achieved a power factor of 0.99. The reactive power generated (736,256 VAR) was close to the calculated theoretical value of 742,198 VAR, indicating good model accuracy.

(b) Load 2

For the second load with 732,200 W active power and 588,400 VAR reactive power, the PID controller reached steady state in less than 0.2 seconds. The firing angle stabilized at 132°, producing 589,465 VAR of reactive power. The Delta Error converged to nearly zero, indicating that the reactive power setpoint was effectively met. The resulting power factor was 0.99, with minimal overshoot and fast response time.

(c) Load 3

For the third load with 500,000 W active power and 100,000 VAR reactive power, the PID controller reduced the firing angle from 135° to 95°. At this point, the SVC generated 100,930 VAR of reactive power. The Delta Error converged to zero, showing that the compensation matched the load requirement accurately. The power factor reached 0.99, and the apparent power was reduced to 508,579 VA.

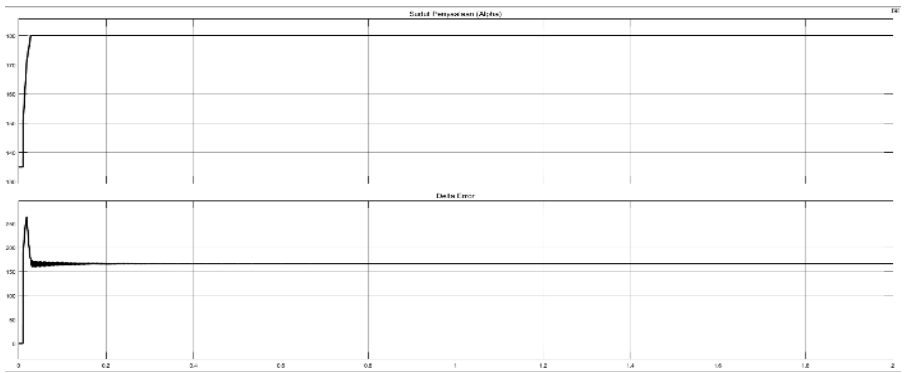

Fig. 3. Firing Angle and Delta Error Load 1

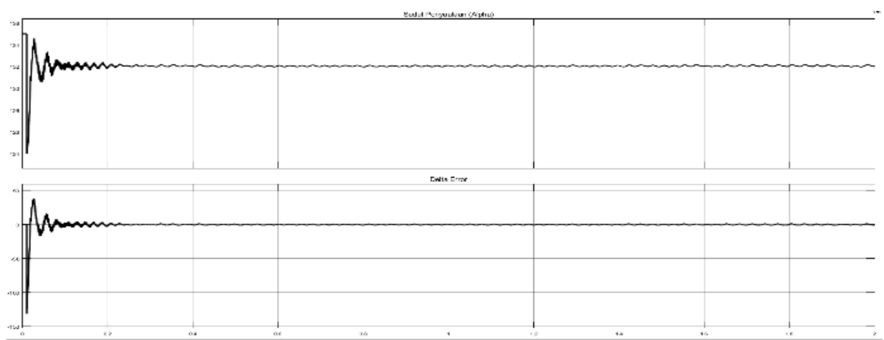

Fig. 4. Firing Angle and Delta Error Load 2

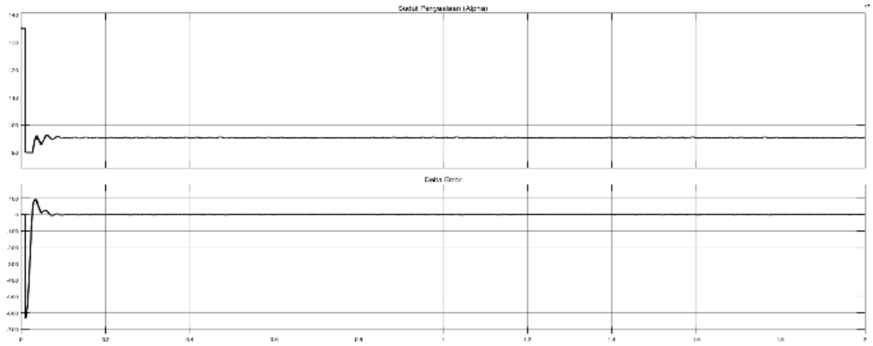

Fig. 5. Firing Angle and Delta Error Load 3

Overall, the tests confirm that the SVC with PID control can dynamically adjust the firing angle to match reactive power demands across different load conditions. The interpretation of Delta Error as the difference between the required and compensated reactive power clarifies the system's performance. Although Load 1 highlighted the limitation of maximum SVC capacity, the PID control method still maintained the power factor close to unity. The simulation results for each load can be seen in Table 2.

Table 2. Simulation results for each load

Parameter	Load 1	Load 2	Load 3
Active Power (W)	1,200,000	732,200	500,000
Apparent Power (VA)	1,201,846	734,739	508,579
Reactive Power (VAR)	736,256	588,400	100,000
Power Factor	0.99	0.99	0.99

4 Conclusion

This research has successfully demonstrated the effectiveness of Static Var Compensator (SVC) with PID control in improving power factor in industrial electrical systems. Based on the analysis and simulation results conducted, several important conclusions can be drawn.

First, power factor improvement through reactive power compensation has proven to significantly reduce apparent power. This occurs because active power remains constant while reactive power decreases due to capacitor compensation, making the apparent power, which is the resultant of both powers, smaller. This reduction in apparent power directly improves the power factor since the power factor is the ratio between active power and apparent power. When apparent power decreases while active power remains constant, the power factor will increase toward the ideal value of 1.

Second, the FC-TCR (Fixed Capacitor-Thyristor Controlled Reactor) type SVC successfully improves power factor by automatically controlling the thyristor firing angle. Using a 0.0163 Farad capacitor and a 0.000623 Henry inductor, the SVC can generate reactive power varying from 0 to 742,198.4 VAR. The larger the firing angle (90°-180°), the smaller the current flowing through the inductor, causing the current flowing through the SVC to become larger and the generated reactive power to increase accordingly.

Third, the implementation of PID (Proportional Integral Derivative) control method on the SVC has proven highly effective in controlling reactive power according to load requirements. With control parameters obtained through the Ziegler-Nichols method and fine-tuned (Kp = 0.06, Ki = 9, and Kd = 0.000234), the system can achieve a power factor of 0.99 under various varying load conditions. The PID control automatically adjusts the thyristor firing angle based on the difference between measured reactive power and the desired setpoint.

Fourth, testing on three different types of loads demonstrates good SVC adaptation capability. For the first load with 1,200,000 W active power and 909,100 VAR reactive power, the SVC generated a firing angle of 180° with 736,256 VAR reactive power. For the second load with 732,200 W active power and 588,400 VAR reactive power, the system reached steady state in less than 0.2 seconds with a firing angle of 132°. For the third load with 500,000 W active power and 100,000 VAR reactive power, the firing angle decreased to 95°.

Fifth, simulation results show good agreement with theoretical calculation results, although there are slight differences because the simulation accounts for losses due to cable resistance, system power factor, and harmonics generated by the TCR. This indicates that the simulation model created is appropriate and reliable for SVC system analysis.

Overall, this research proves that SVC with PID control can be relied upon for reactive power optimization across various types of loads, thereby reducing the burden on generators and improving electrical energy usage efficiency. The power factor improvement up to 0.99 across various load variations demonstrates that this system is highly effective for industrial applications with varying load characteristics.

Acknowledgments.

This research was funded by the Institute for Research and Community Service (LPPM) of Medan State University which has provided funding support through the Basic Research scheme for the 2025 Fiscal Year with Contract Number 0018/UN33.8/PPKM/PD/2025, so that this research can be carried out properly.

References

[1] V. Yarlagadda, V. R. Babu, P. Gude, and S. Bagari, "Coordination Control of PSS and SVC for Dynamic Stability Improvement of Steam Power System," in *2025 Fourth International Conference on Power, Control and Computing Technologies (ICPC2T)*, 2025, pp. 240–245. doi: 10.1109/ICPC2T63847.2025.10958758.

[2] A. Ulya, "ANALISIS DAN SIMULASI PENGARUH PEMASANGAN CAPASITOR BANK UNTUK PERBAIKAN FAKTOR DAYA MENGGUNAKAN SIMULINK PADA SISTEM TENAGA LISTRIK DI PT. BOGOWONTO PRIMALARAS," *MEDIA ELEKTRIKA*, vol. 12, p. 1, Dec. 2019, doi: 10.26714/me.12.1.2019.1-11.

[3] A. R. Lubis, M. Affandi, and D. A. Sutopo, "JTEV (Jurnal Teknik Elektro dan Vokasional) Peningkatan Kualitas Kelistrikan Workshop Teknik Elektro Unimed Menggunakan Double Tuned Filter," vol. 9, no. 1, 2023, doi: 10.24036/jtev.v9i1.121285.

[4] N. Chothani, M. Joshi, D. Patel, and M. Raichura, "Adaptive PID Controller based Static Var Compensation in EHV Transmission Line," in *2021 International*

Conference on Communication information and Computing Technology (ICCICT), 2021, pp. 1–6. doi: 10.1109/ICCICT50803.2021.9510157.

[5] J. Wu, L. Li, T. Zhou, L. Liu, Z. Liu, and Y. Gong, "Study on Simple Field Test Method for Thyristor Control Performance of SVC," in *2021 IEEE 5th Conference on Energy Internet and Energy System Integration (EI2)*, 2021, pp. 4111–4114. doi: 10.1109/EI252483.2021.9713191.

[6] M. Singh, D. K. Verma, S. Ralhan, and M. Patil, "Performance Analysis of SVC Supplementary Controller in Multi-machine Power System Network," in *2019 International Conference on Electrical, Electronics and Computer Engineering (UPCON)*, 2019, pp. 1–6. doi: 10.1109/UPCON47278.2019.8980089.

[7] R. P. Upadhyai and L. Garg, "An Integration of the SVC and STATCOM Technologies into Wind-Based Power Systems," in *2022 International Conference on Futuristic Technologies (INCOFT)*, 2022, pp. 1–6. doi: 10.1109/INCOFT55651.2022.10094533.

[8] Z. Liu, "SVC video transmission optimization algorithm in software defined network," *China Communications*, vol. 15, no. 10, pp. 143–149, 2018, doi: 10.1109/CC.2018.8485476.

[9] V. Waghamare and A. S. Salvi, "Industrial purposed advance controlling strategy for SVC compensator firing system using microprocessor," in *2017 2nd International Conference for Convergence in Technology (I2CT)*, 2017, pp. 686–689. doi: 10.1109/I2CT.2017.8226217.

[10] A. Gelen and T. Yalcinoz, "The behaviour of TSR-based SVC and TCR-based SVC installed in an infinite bus system," in *2008 IEEE 25th Convention of Electrical and Electronics Engineers in Israel*, 2008, pp. 120–124. doi: 10.1109/EEEI.2008.4736670.

[11] R. Ding, Z. Cao, and M. Fan, "The research of optimal control system of SVC for reactive compensation of single-phase load," in *Proceedings of the 29th Chinese Control Conference*, 2010, pp. 1843–1847.

[12] S. Banerjee, R. Roshan, K. Bhattacharya, and M. A. Alam, "Reduction of Power losses & Improvement of power transfer with SVC & TCSC using Sensitivity Index," in *2018 4th International Conference for Convergence in Technology (I2CT)*, 2018, pp. 1–5. doi: 10.1109/I2CT42659.2018.9058125.

[13] Alimuddin, G. Nurhalim, and R. Arafiyah, "Optimization Placement Static Var Compensator (SVC) Using Artificial Bee Colony (ABC) Method On PT PLN (Persero) Jawa-Bali, Indonesia," in *2018 1st International Conference on Computer Applications & Information Security (ICCAIS)*, 2018, pp. 1–4. doi: 10.1109/CAIS.2018.8442011.