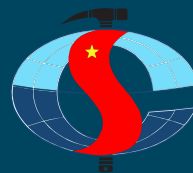




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Volume 2

Earth, Mine, and Environmental Sciences for
Green, Sustainable, and Prosperous Development
in the Era of a Nation's Rise



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AND ENVIRONMENTAL SCIENCES FOR SAFE
AND SUSTAINABLE DEVELOPMENT**

Volume 2:

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Foreword

The publication series “*Advances in the Earth, Mining and Environmental Sciences for Safe and Sustainable Development*” was conceived as a platform to promote scientific innovation, interdisciplinary collaboration, and knowledge exchange in support of safer, greener, and more sustainable development. *Volume 1: Advanced Technologies and Artificial Intelligence in the Earth and Environmental Sciences* established this foundation by highlighting the rapid emergence of digital technologies, artificial intelligence, and computational approaches that are reshaping the way we observe, analyze, and understand the Earth system.

Building upon this momentum, *Volume 2: Earth, Mine, and Environmental Sciences for Green, Sustainable, and Prosperous Development in the Era of a Nation’s Rise* extends the vision of the series into a broader scientific and societal context. While Volume 1 emphasized technological advancement, Volume 2 focuses on how these technologies - along with traditional and emerging scientific approaches - are being integrated to address real-world challenges related to environmental stewardship, sustainable resource management, climate resilience, and green growth.

This volume comprises 79 peer-reviewed articles contributed by authors from 10 countries and regions, reflecting an expanding network of international collaboration and the growing global commitment to advancing Earth, mining, and environmental sciences. The diversity of institutional backgrounds and research approaches represented here underscores the relevance of these topics to the shared pursuit of green, resilient, and inclusive development.

The volume is structured into three thematic parts, each representing a critical axis of sustainability-oriented research:

Part 1 – Earth, Mine and Environmental Sciences towards the Sustainability

This part brings together studies on geohazards, geotechnical engineering, mining science, hydrogeology, and environmental geology. The contributions highlight innovative approaches to landslide and geohazard assessment, advanced geotechnical modeling and underground construction behavior, sustainable mining practices, and environmental monitoring for land, water, and geological systems. These works reinforce the essential principles of ensuring safety, environmental protection, and sustainable resource utilization, forming the foundation for resilient national progress.

Part 2 – Digital Transformation for Prosperous Development

The second part illustrates how AI, machine learning, remote sensing, WebGIS, and geospatial intelligence are revolutionizing data acquisition, environmental monitoring, hazard prediction, and decision-making. The studies presented explore big data and deep learning techniques for landslide modeling, WebGIS-based early warning systems, UAV and hyperspectral imaging applications, groundwater forecasting, air quality assessment, and digital transformation-driven environmental governance. These contributions

demonstrate the transformative role of digital technologies in fostering prosperous, evidence-based, and future-ready development.

Part 3 – Green Development: Perspectives of the Earth, Mine and Environmental Sciences

The final part focuses on the scientific foundations and practical pathways toward green growth, environmental restoration, and sustainable livelihoods. The articles cover marine and coastal ecosystem management, microplastic pollution, wastewater treatment, green materials and circular economy solutions, biodiversity and climate-related studies, greenhouse gas monitoring, and sustainable tourism planning. Collectively, these contributions reflect a holistic, interdisciplinary approach to green development, integrating environmental science, socio-economic considerations, and policy-relevant insights.

As a whole, Volume 2 presents a comprehensive and timely collection of scientific advances that align with national and global priorities for sustainability. It showcases how Earth, mining, and environmental sciences are evolving to meet the challenges of a rapidly changing world, advancing the shared goal of a safer, greener, and more prosperous future.

We extend our sincere appreciation to all authors, reviewers, editors, and supporting institutions for their dedication and contributions. Their collective efforts have made this volume a meaningful addition to the scientific literature and a valuable reference for researchers, practitioners, policymakers, and students.

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Improving power quality in underground mines' grid by utilizing SVC system

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Abstract: The operational efficiency of underground mining systems is strongly dependent on the reliability and performance of electrical equipment, particularly electric motors used for ventilation, pumping, conveyor drives, and hoisting mechanisms. As mining operations expand in both scale and depth, the demand for electrical power has significantly increased, leading to a higher concentration of heavy-duty electrical loads. Consequently, the stability and quality of the supplied electrical power have become critical factors determining both the productivity and safety of the mining process. In many underground mines, the power supply is typically characterized by long cable runs, uneven load distribution, and the presence of nonlinear devices. These factors contribute to undesirable power quality issues such as voltage fluctuation, unbalanced load currents, and harmonic distortion. Among these, the most pervasive problem is the degradation of the power factor due to the inductive nature of electric motors and transformers. A poor power factor not only increases the apparent power demand from the grid but also causes excessive losses in cables, transformers, and switchgear, thereby reducing the overall efficiency of the electrical network. To address these challenges, this study investigates the use of a Static Var Compensator (SVC) as an advanced and flexible solution for improving power quality in mining power distribution systems. The SVC is a member of the Flexible AC Transmission Systems (FACTS) family and operates by dynamically controlling the reactive power in the system through thyristor-controlled reactors (TCR) and thyristor-switched capacitors (TSC). By continuously adjusting the

reactive power compensation according to real-time load variations, the SVC can maintain a near-unity power factor and stabilize the bus voltage within acceptable limits. A simulation is implemented in ETAP to prove the use of SVC in term of mitigating voltage dips and flicker, ensuring the smooth operation of sensitive control and protection devices.

Keywords: Power quality, mining, SVC, ETAP simulation.

INTRODUCTION

SVC overview in mining and industrial application

Mathematic basic equation of SVC

The Static Var Compensator (SVC) (a typical presented in figure 1) is a mature shunt-connected reactive-power device belonging to the FACTS family that provides fast, continuous reactive power support to an AC bus. Its principal objective is to control bus voltage and the system balance of reactive power by injecting or absorbing reactive current ($I_{q_}$), such that the voltage magnitude V at the point of connection remains within pre-set limits under dynamic load variations. The simplest steady-state representation of SVC action can be expressed as an equivalent variable susceptance B_{svc} (positive for capacitive action, negative for inductive action) connected to the compensated bus (as presented in equation (1)) [12], [16]:

$$Q_{svc} = V^2 B_{svc} \quad (1)$$

where Q_{svc} is the reactive power provided (positive = capacitive), and V is the bus RMS voltage.

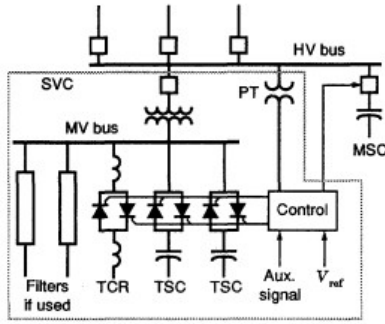


Figure 1: Typical SVC system

Operationally, a conventional SVC comprises combinations of thyristor-controlled reactors (TCR), thyristor-switched capacitors (TSC), and passive harmonic filters. A typical control loop measures bus voltage V and computes a reactive command ΔQ using, for example, a PI (or advanced) regulator; the converter/thyristor stage then modulates current so that the net reactive injection satisfies equation (2):

$$Q_{net}(t) = Q_{TSC}(t) + Q_{TCR}(t) + Q_{filters} \approx Q(t) \quad (2)$$

Fast thyristor phase-angle control of the TCR gives near-continuous inductive adjustment (firing-angle α controls effective reactance), while TSC steps supply capacitive blocks when required. The analytical relation between TCR firing angle α and fundamental reactive current I_1 is well documented in [15], [16]. From a dynamics viewpoint, SVC acts as a voltage-dependent reactive source: around an operating point, the small-signal relation can be linearized as (3).

$$\Delta Q_{svc} \approx K_v \Delta V + \dots \quad (3)$$

where K_v is the static droop or slope parameter implemented in voltage control (negative droop for over-excited behavior). That fast dynamic response (millisecond timescale) is central to advantages reported across field and simulation studies: mitigation of voltage sags, flicker suppression during large transient currents (e.g., arc furnaces, motor starting), improved damping of electromechanical oscillations, and support for weak bus voltage under increased distributed generation penetration [13], [15], [17].

Applications of SVC on Medium Voltage grid and Mining industry

SVCs have been deployed historically at transmission and large industrial points; recent research demonstrates successful MV and distribution-level use for localized power-quality issues (voltage regulation, flicker mitigation, power-factor correction) and for stabilizing grids that host renewables or heavy loads such as furnaces, large conveyors, and variable-speed drives [24], [21], [14]. In mining, site characteristics — long feeders, large asynchronous motor starting currents, and a mix of nonlinear loads — create a compelling use case for SVC: it can reduce voltage dips during hoist or conveyor starting, lower flicker generated by arc furnaces or welding, and improve transformer loading by raising the power factor [12]. Utilizing SVC in mining industry must consider the following sides affection as listed:

Disadvantages & technical risks

Although the Static Var Compensator (SVC) has proven to be an effective solution for dynamic reactive power support, several inherent system and control limitations restrict its performance in demanding industrial and mining environments. One of the most significant weaknesses is that the reactive current output of an SVC decreases proportionally with voltage magnitude, thus its capability to provide compensation diminishes under undervoltage conditions [17]. In addition, the use of thyristor-controlled reactors (TCR) and thyristor-switched capacitors (TSC) produces characteristic harmonics that require complex filter networks to prevent resonance and voltage distortion [13], [15]. The inclusion of large passive filters and reactor banks increases system bulk and installation area, while the response speed of SVCs—typically on the order of tens of milliseconds—is slower than converter-based STATCOMs, reducing their effectiveness in mitigating fast transients [15], [17]. Improper placement or sizing of SVC units can also lead to suboptimal performance

or, in extreme cases, instability due to poor coordination with network impedance and protection systems.

In addition to these inherent control constraints, the operational and environmental conditions of industrial and mining systems impose further challenges. Harsh underground environments characterized by dust, humidity, and vibration require robust protection, enhanced cooling, and corrosion-resistant components, leading to increased maintenance frequency and cost. The complexity of control coordination and the need for skilled technical personnel represent further barriers, as fine-tuning droop slopes, filter resonance, and communication with upstream protection devices are critical to ensure stability [16]. Moreover, in networks with extensive nonlinear loads—such as arc furnaces, large conveyor drives, and high-power motors—SVCs may inadvertently amplify specific harmonics or cause undesirable resonant conditions if network impedance and harmonic spectra are not accurately modeled [13]. These issues perform a careful pre-installation studies and continuous monitoring in mining applications, where load dynamics are highly variable and sensitive to voltage fluctuations. In summarizing 4 keys consideration is listed as:

1. Harmonic generation and filter-design risk. TCR switching introduces characteristic harmonic currents; undersizing or poor filter design can create harmonic amplification or resonances with mine networks — an area of active research and failure modes documented in [15], [23]. Proper network impedance assessment and tuned passive or active filters are mandatory.

2. Initial capital and maintenance: power-electronic valves, control electronics and cooling/protection increase capex and opex compared with conventional switched capacitors; life-cycle economics must factor in energy savings, avoided penalties and maintenance costs [13], [21].

3. Environmental and ruggedization challenges: underground mines impose high dust, humidity, shock/vibration — the SVC enclosures, cooling and filtering must be industrialized for such environments, or the devices must be located on surface substations with suitable HV/MV transformers [1], [7].

4. Control complexity & staff skills: advanced control (e.g., PMU-assisted schemes or fuzzy/PI hybrids) can improve performance but requires trained engineers for commissioning and maintenance [19], [21].

Economic considerations (industrial & mining)

Economic viability is case dependent. The main benefits are reduced energy losses, improved power factor (reducing utility penalties), fewer production interruptions from voltage instability, and deferred network reinforcement. Market reports indicate modest but steady SVC market growth (driven by industrial modernization and renewable integration) — adoption is attractive where high-power motors or furnaces cause frequent voltage events, [21]. A robust cost-benefit analysis should include: (i) capex amortization, (ii) maintenance and replacement of power-electronics, (iii) avoided downtime costs in mining processes, (iv) tariff savings from better power factor, and (v) potential needs for additional harmonic filters or monitoring equipment [22], [15].

SVC in mining industry

In modern underground coal mines, mechanized excavation and extraction systems are increasingly dominated by advanced equipment such as roadheaders, shearer-loaders, and fully mechanized mining complexes integrating multiple high-power electric drives [4]. These machines operate in conjunction with remote control systems, automated protection circuits, and various auxiliary devices designed to enhance safety and operational efficiency. However, the electrical supply feeding such systems is inherently subjected to a wide range of dynamic disturbances, including motor starting

currents, voltage sags caused by heavy-load acceleration, and overvoltage events arising from switching transients or unstable source conditions [4].

As a result, the power supply network within the mining environment experiences continuous fluctuations (as shown in figure 2) that can compromise the stability of voltage and current parameters. Such variations may violate established power quality standards, thereby leading to voltage dips, harmonic distortion, and flicker phenomena [1]. These disturbances exert detrimental impacts on the operational reliability of mining electrical equipment—particularly sensitive electronic controls, relay protection devices, and variable-speed drives—whose performance and lifespan are directly dependent on voltage stability [1]. Consequently, maintaining consistent power quality becomes a critical prerequisite for the reliable and safe operation of high-capacity electrical systems in modern underground coal mining enterprises.

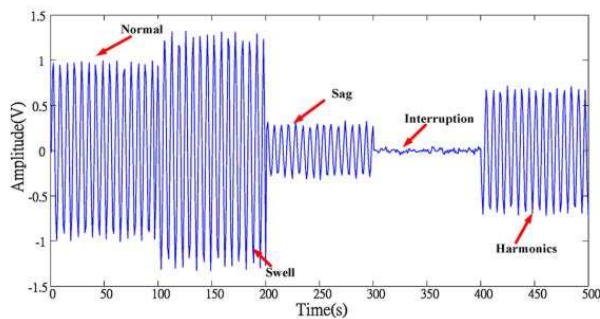


Figure 2. An interruption of power failure in mining grid

As mentioned previously and according to comparative studies and field cases, SVC remains a cost-effective and technically robust solution for many industrial power-quality needs if (and only if) careful pre-deployment studies (impedance/harmonics), filter design, environmental protection and lifecycle economics are addressed [12], [13], [15], [21]. In mining, where reactive transients and voltage dips from large motor starts are frequent, SVC can materially improve production reliability and equipment lifetime. However, the final choice between SVC, STATCOM, or hybrid approaches

must be informed by site-specific dynamic studies, total cost of ownership, and the availability of skilled operational staff [25], [2].

PROPOSE THE USE OF SVC

To enhance power quality in underground coal mining systems, the deployment of Static Var Compensators (SVCs) has proven to be one of the most effective solutions. SVCs are advanced reactive power compensation devices based on power electronic components such as thyristors or triacs equipped with gate control mechanisms, allowing dynamic adjustment of the firing angle in response to voltage variations [6]. The control system, often implemented using microcontrollers such as 8051, PIC16F877, or VAR controllers, provides real-time control of the reactive power exchange between the power source and the load, thereby stabilizing voltage profiles during transient conditions [7].

Structurally, an SVC typically comprises three major functional modules, namely the Thyristor-Controlled Reactor (TCR), Thyristor-Switched Reactor (TSR), and Thyristor-Switched Capacitor (TSC) units [6], [7] (exhibited in figure 3). The TCR allows smooth and continuous regulation of reactive power absorption by adjusting the conduction angle of the thyristor valves, which results in fine-tuned compensation suitable for variable load conditions. The TSR, by contrast, operates in a stepwise switching manner, offering rapid connection and disconnection of reactor banks to respond to sudden changes in reactive demand. Meanwhile, the TSC serves as a dynamic source of capacitive reactive power, delivering fast voltage support during periods of under-voltage, ensuring system voltage remains within acceptable limits [7].

According to [21], SVC systems offer rapid response times in the order of milliseconds, making them particularly beneficial for industrial grids with fluctuating loads such as conveyors, hoists, and ventilation fans in mining environments. Furthermore, [18] demonstrated that the use of coordinated TCR-TSC control significantly mitigates voltage dips

and flicker, which are common issues in mining power systems due to high inrush currents during motor starting. Studies such as [20] also emphasize that SVC-based compensation improves both power factor and harmonic performance, thus extending the operational lifespan of electric drives and reducing the likelihood of protection relay malfunctions.

However, the effectiveness of SVCs is contingent upon appropriate system design, including the tuning of control algorithms, placement within the power distribution network, and harmonic filtering strategies, as excessive reactive power switching may itself introduce distortions if not properly managed [6], [24]. Consequently, SVC implementation in mining applications must consider both electrical performance and operational safety, especially in confined underground environments where voltage stability is directly tied to the reliability of electrically driven excavation and transport systems [7], [25].

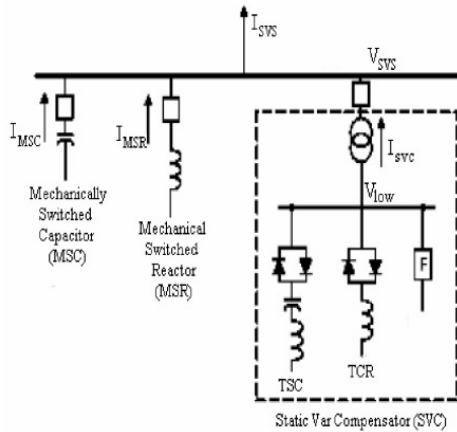


Figure 3. SVC employing TSC and TCR.

Although the SVC system is composed of discrete modules such as TCR, TSC, and TSR, its overall control action exhibits quasi-continuous regulation of reactive power, owing to the combined effect of smooth thyristor firing-angle modulation in the TCR and stepwise compensation through TSC and TSR banks [8], [9], [11]. The integration of these subsystems allows the SVC to maintain a nearly linear voltage–current (U – I) characteristic

within its operating range, as illustrated in Figure 4, thereby providing seamless voltage stabilization under rapidly changing load conditions. Each component of the SVC is connected to the power network through thyristor valve assemblies rather than traditional circuit breakers, ensuring fast, contactless switching and minimizing mechanical wear [8], [9].

This topology enables extremely high control responsiveness—with adjustment times typically below 40 milliseconds—which effectively eliminates transient delays that are often observed in conventional capacitor–reactor switching schemes [11]. According to [22], such rapid dynamic response is essential in industrial and mining networks, where the load fluctuates sharply during conveyor starting, hoist braking, or coal cutting operations. Moreover, [24] reported that the use of thyristor-controlled elements significantly enhances system reliability by reducing switching surges and suppressing voltage flicker during cyclic loading.

The primary operational function of an SVC is to regulate both voltage magnitude and reactive power flow at its point of connection to the grid, as represented in Figure 5. This dual control capability allows the SVC to either absorb or generate reactive power depending on system requirements, maintaining the desired voltage profile and improving the stability margin of the power network [9], [25]. Consequently, SVCs serve not only as voltage stabilizers but also as active dynamic compensators that ensure steady-state and transient voltage support in medium-voltage industrial and mining grids.

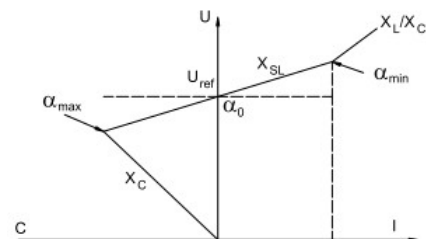


Figure 4. U – I Characteristic of SVC

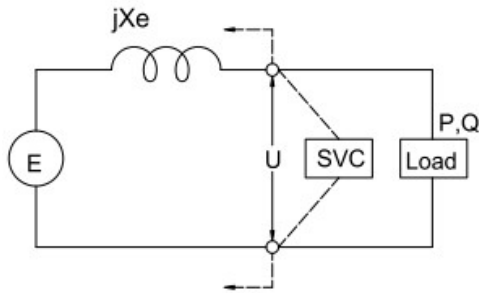


Figure 5. Modifying Voltage profile by SVC

The voltage at the load busbar of an electrical system tends to decrease progressively as the active and reactive components of the load power increase, particularly in the absence of any reactive power compensation devices. This relationship is represented by characteristic curve (a) in Figure 6, which depicts the natural voltage drop behavior of the network caused by the reactive power absorbed by inductive loads. In such conditions, the system operates with a lagging power factor, and voltage stability at the load terminals becomes highly sensitive to load variations [6], [7].

When a Static Var Compensator (SVC) is introduced into the network, the situation improves significantly. The SVC provides dynamic reactive power support within its rated operating range, as shown by characteristic curve (b) in Figure 6. By injecting capacitive reactive power during voltage sags and absorbing reactive power during overvoltage conditions, the SVC maintains a flatter voltage profile and prevents large deviations in bus voltage magnitude under varying load conditions [8], [9], [11]. This stabilizing action not only enhances voltage quality but also reduces power losses along distribution feeders and improves the voltage regulation index of the overall system, as demonstrated in [20] and [22].

However, if the SVC were designed without any upper limitation on its reactive power output, the voltage at the load bus could, in theory, be maintained perfectly constant regardless of load variations, as illustrated by characteristic curve (c) in Figure 6. In practice, such

unlimited control is neither technically feasible nor economically justified because excessive reactive power generation could lead to overcompensation and system resonance issues, especially in weak grids with high harmonic content [7], [24], [25]. Therefore, modern SVC installations incorporate protective constraints and control saturation mechanisms to ensure operational safety and harmonic compliance. These control limits guarantee that voltage regulation remains within acceptable tolerances while preventing device overstress and excessive network distortion.

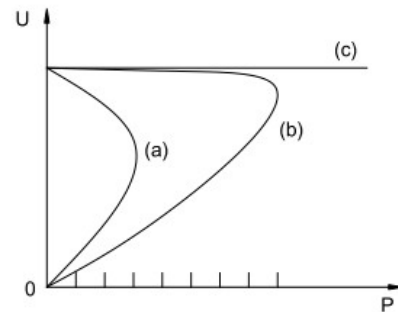


Figure 6. Voltage wave form with and without SVC

SIMULATION AND RESULTS

The ETAP software was employed to simulate the single-line diagram of the power supply system for an underground mining area [3]. The electrical network parameters—including load data, line lengths, and conductor sizes—were input into the model to accurately represent the operating conditions of the mine's distribution system. The electrical schematic was then analyzed using power flow equations to determine the voltage variations occurring along different sections of the network under varying load conditions. Subsequently, the optimal placement of the Static Var Compensator (SVC) was identified based on nodes exhibiting the greatest voltage deviation. Finally, capacitor compensation units were modeled at each bus where voltage drops were detected, enabling a comparative assessment of system performance before and after reactive power compensation.

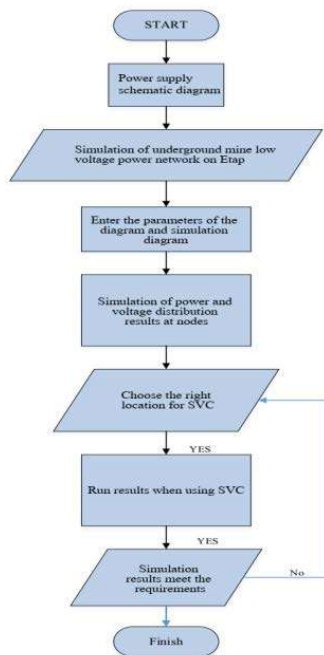


Figure 7. Proposed algorithm of utilizing ETAP for analysing the use of SVC in mining grid

Simulation diagram of the mining grid is performed in figure 8 and 9.

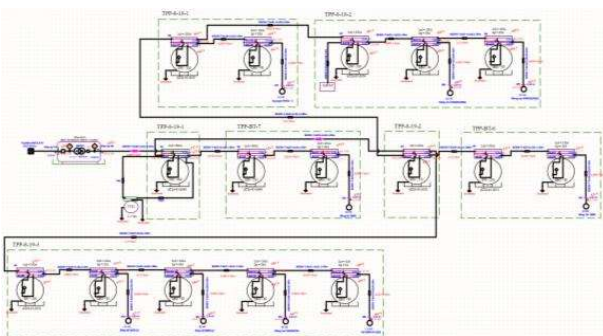


Figure 8. Simulation diagram of mining underground mine without SVC installation

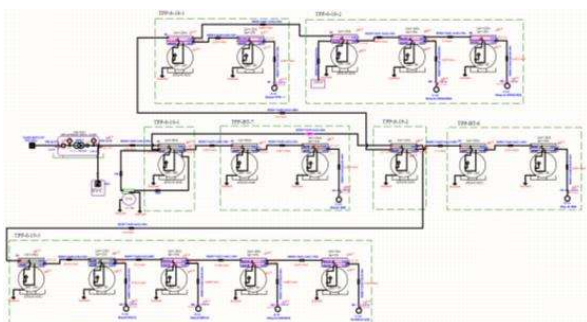


Figure 9. Simulation diagram of mining underground mine with SVC installation

The simulation results obtained from the ETAP software demonstrate a significant improvement in the voltage profile across the distribution network after implementing the Static Var Compensator (SVC). As shown in Figure 10, the voltage magnitude at the load buses increased by approximately 15% compared to the base case without reactive compensation. This enhancement verifies that the SVC effectively maintains a stable voltage level under varying load conditions by dynamically injecting reactive power to counteract voltage drops along the feeder. The smoother slope of the post-compensation curve also indicates a reduction in voltage deviation between buses, contributing to improved system stability and power quality [6], [8], [21].

In contrast, Figure 11 illustrates the variation in active power at different buses before and after SVC installation. While a slight decrease in active power flow is observed following compensation, this reduction is minor and does not adversely affect system efficiency. Instead, it reflects the redistribution of reactive power within the network, which alleviates voltage stress and minimizes reactive losses in transmission lines [7], [20], [22]. The results confirm that SVC integration not only enhances voltage support but also improves the overall power factor and operational reliability of the mining electrical network. Consequently, the use of SVCs in underground mine power systems is validated as a technically and economically feasible approach to maintaining power quality in dynamically varying industrial environments.

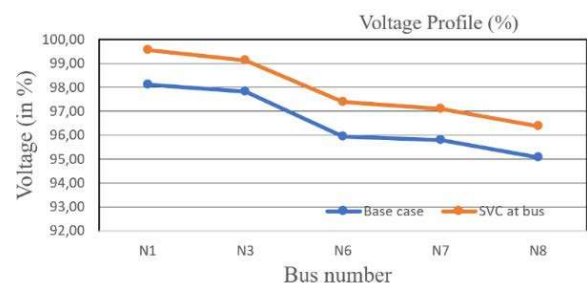


Figure 10. Voltage wave forms before and after SVC installation

Table 1: Power generation before SVC installation

SUMMARY OF TOTAL GENERATION, LOADING & DEMAND				
	MW	Mvar	MVA	% PF
Source (Swing Buses):	0.267	0.132	0.297	89.69 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	0.267	0.132	0.297	89.69 Lagging
Total Motor Load:	0.260	0.122	0.287	90.51 Lagging

Table 2: Power generation after SVC installation

SUMMARY OF TOTAL GENERATION, LOADING & DEMAND				
	MW	Mvar	MVA	% PF
Source (Swing Buses):	0.275	-0.125	0.302	91.03 Leading
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	0.275	-0.125	0.302	91.03 Leading
Total Motor Load:	0.260	0.122	0.287	90.51 Lagging

CONCLUSION

Voltage sag and instability are recognized as major factors affecting power quality, particularly in electrical systems supplying large industrial loads. Such disturbances are especially pronounced in underground mining networks, where multiple high-power electric motors operate simultaneously under variable mechanical stresses. To address this issue, the deployment of a Static Var Compensator (SVC) is proposed as an effective strategy for improving voltage quality and system stability in low-voltage mining grids. The simulation results clearly demonstrate that the integration of SVCs enhances voltage regulation performance, with the busbar voltage level increasing by approximately 15% compared to the uncompensated case, without any significant rise in transmitted power or network losses.

The findings confirm that SVC installation not only strengthens voltage stability margins but also contributes to smoother reactive power flow and improved reliability of the mine's electrical supply. For optimal operation, it is recommended that SVC units be installed at nodes with the greatest voltage sensitivity and configured with adaptive control algorithms capable of responding to rapid load fluctuations. Periodic harmonic monitoring and controller tuning should be conducted to ensure system compatibility and prevent

overcompensation. Moreover, integrating SVC control into a supervisory monitoring platform would allow real-time adjustment of reactive power, thereby maximizing the operational efficiency and safety of underground power distribution systems.

REFERENCES

1. Đỗ Như Ý (2019). Nghiên cứu đề xuất giải pháp giảm dao động điện áp trong mạng điện mỏ. Tạp chí Công nghiệp mỏ, số 5.
2. Hồ Việt Bun (2025). Nghiên cứu ứng dụng phần mềm ETAP trong thiết kế, kiểm tra, quản lý và vận hành mạng cấp điện trong các xí nghiệp mỏ. Tạp chí Công nghiệp mỏ, số 3.
3. Hồ Việt Bun (2025). Nghiên cứu giải pháp nâng cao chất lượng điện áp ở mạng điện hạ áp mỏ hầm lò. Hội thảo quốc tế Thúc đẩy đổi mới và phát triển kết nối các nguyên tắc để tạo ra tác động toàn cầu (Fostering Innovation and Development: Connecting Disciplines to Create Global Impact).
4. Thông tư số 39/2015/TT-BCT ngày 18 tháng 11 năm 2015 của Bộ Công Thương Quy định hệ thống điện phân phối.
5. В. И. Кочкин, Ю. Г. Шакарян, Применение гибких (управляемых) систем электропередачи переменного тока в энергосистемах, 311с-2011.
6. M.Biswas, and K.Das, Voltage Level Improving by Using Static VAR Compensator (SVC), Global Journal of Researches in Engineering, 11(5), 2011, 13–18.
7. Khandani, S. Soleymani, and B. Mozafari., "Optimal Placement of SVC To Improve Voltage Profile Using Hybrid Genetics Algorithm And Sequential Quadratic Programming", conference on electrical power distribution network (EPDC), 2011.
8. Siddique, A., Xu, Y., Aslami, W., Albatsh, F.M. : Application of series FACT devices SSSC and TCSC with POD controller in electrical power system network. In Proceedings of the 2018 13th IEEE Conference on Industrial Electronics and Applications (ICIEA), Wuhan, China, pp. 893–899 (31 May 2018–2 June 2018).
9. Mohammed Osman Hassan, "S. J. Cheng, Senior Member, IEEE, Zakaria Anwar Zakaria, Steady-State Modeling of SVC and TCSC for Power Flow Analysis Proceedings of the International Multi Conference of Engineers and Computer Scientists", 2009.

10. V. Ganesh, K. Vasu, K. Venkata Rami Reddy, M. Surendranath Reddy, "Improvement of Transient Stability through SVC", 2012.
11. Mohammed Osman Hassan, "S. J. Cheng, Senior Member, IEEE, Zakaria Anwar Zakaria, Steady-State Modeling of SVC and TCSC for Power Flow Analysis Proceedings of the International Multi Conference of Engineers and Computer Scientists", 2009.
12. J. L. Olabarrieta Rubio, "A Comparative Study of Static VAR Systems for Voltage Support and Power-Quality Improvement," Icrepq Conference Paper / PDF, 2023. [Online]. Available: <https://pdfs.semanticscholar.org/4b67/e12ae880be0ca056cccb0aa6293bacab911c.pdf>. Semantic Scholar
13. H. G. Júnior, "General-compensation-purpose Static Var Compensator (SVC)," Journal / Elsevier, 2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2468067218300518>. ScienceDirect
14. M. P. Suresh, "Optimizing smart microgrid performance: Integrating solar generation and static VAR compensator for EV charging impact," ScienceDirect / Renewable Energy Reports, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2352484724001252>. ScienceDirect
15. R. M. A. Velásquez, "Harmonic failure in the filter of Static Var Compensator," Electric Power Systems Research / Elsevier, 2020. [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S1350630719307381>. ScienceDirect
16. "Static VAr compensator models for power flow and dynamic analysis," IEEE / Technical report (SVC modeling), 2017. [Online]. Available (PDF): https://ptabdata.blob.core.windows.net/files/2017/1PR2017-01135/v8_Exhibit%201005%20-%20IEEE%20SVC.pdf. ptabdata.blob.core.windows.net
17. M. N. Absar, "Power quality improvement of a proposed grid-connected renewable hybrid system by incorporating SVC," Energy Reports / Elsevier, 2023. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S240584402305123X>. ScienceDirect
18. "Design of Static Var Compensator (SVC) for Improving Power Supply of Solar Energy Connected to the Grid," Conference/ResearchGate, 2024. [Online]. Available: https://www.researchgate.net/publication/354922798_Design_of_Static_Var_Compensator_SVC_for_Im proving_Power_Supply_of_Solar_Energy_Connected_to_the_Grid. ResearchGate
19. F. Alsalem, "Static VAr Compensator Control Using Phasor Measurement Units," Environmental Systems Engineering / Wiley, (article), 2024. [Online]. Available: <https://scijournals.onlinelibrary.wiley.com/doi/full/10.1002/ese3.70114>. scijournals.onlinelibrary.wiley.com
20. R. N. Krasnoperov et al., "Performance evaluation of a low-voltage SVC utilizing IoT monitoring and control," Applied Energy / Elsevier, 2025 (design/experimental). [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0378779624010733>. ScienceDirect
21. "Static VAR Compensator for power-factor correction on heavy industry (case studies: arc furnace, traction)," Applied Case Studies / AIP & Industry Papers, 2016. [Online]. Available: https://www.researchgate.net/publication/288484863_Application_of_Static_Var_Compensator_of_Ultra-High_Power_Electric_Arc_Furnace_for_Voltage_Drops_Compensation_in_Factory_Power_Supply_System_of_Metallurgical_Enterprise. ResearchGate
22. A. R. Berdugo-Sarmiento, "Improving the Operation of Transmission Systems Based on Centralized and Distributed SVC Strategies," MDPI Energies / 2025, 2025. [Online]. Available: <https://www.mdpi.com/2673-4826/6/3/40>. MDPI
23. "Application of static var compensator with harmonic filters in heavy industry," ResearchGate / Case study, (2019–2024 surveys). [Online]. Available: https://www.researchgate.net/publication/332825538_Application_of_static_var_compensator_with_harmonic_filters_in_the_heavy_industry. ResearchGate
24. "Applying SVCs on Distribution Systems — practitioner white paper / IEEE-related," Technical Paper / PDF, (open access discussion), 2010–2020. [Online]. Available: https://cdn.b12.io/client_media/zaTQ9XtD/7c243e6c-d8b3-11ea-b5bf-0242ac110002-IEEEpaper2.pdf. B12
25. "Comparative assessment: SVC vs STATCOM — power quality & dynamic performance," Conference/Journal comparative studies, 2023. (See Olabarrieta Rubio and follow-ons). [Online]. Available: <https://onlinelibrary.wiley.com/doi/10.1155/2023/2218048>. Wiley Online Library