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FACTS Devices Based Power Flow Control in Electrical Power System: A Review

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***Abstract*—In this Review paper discuss on the different FACTS devices analysis. From the last few decades, power demand has significantly increased. However, this growing power demand is not pursued by enhancing the power generation and transmission capacity. Consequently, power plants are running at their maximum capacity to accommodate the growing electric load requirement. In this review types of FACTS devices for their different operational and control has been included as well as comparison cost for different FACTS devices have also been presented. The operating principles and applications of the main FACTS controller for transient as well as steady state stability enhancement are also presented. For power system operation and control, this study will be very helpful to the researchers for a quick reference relevant to the main FACTS controllers.**

***Keywords*—FACTS; TCSC; SSSC; SVC; STATCOM; UPFC; power network stability.**

I. Introduction

The power transfer capacity of transmission lines. The power transmission system must be able to handle most of the energy supplied to end of consumer by the generating station [1]. The electrical system must provide reliable power to the consumer in general and in particular to the industries. Electricity demand is growing rapidly but the new expansion of generation stations and transmission lines has the financial and environmental problems. To improve reliability by transmitting the power to end users or points of use, several advanced techniques have been introduced in terms of a support system.The capability of a transmission system to transfer the power is compromised by different following stages like transient stability, thermal limits and dynamic stability. These confines express the electrical power that will be transferred without causing damage to the transmission line system and electrical equipment's. When a small interruption appears in the power network, it leads to low-frequency electromagneticallyoscillations.

FACTS significantly alter the technique in which transmission systems are designed, established and controlled together with enhancements in system flexibility, benefit utilization and the system performance [9], [10]. The FACTS are the static device used for the AC transmission of electrical power to improve controllability and enhance power transfer capability. The main role of FACTS is to manage the congestion, increasing power transfer capability, reliability, controlled the power flow, enhancing security, and other system performance. The FACTS devices are capable to control the different electrical parameters in the transmission system. Due to minimum installation cost, fast active power, better optimum location, controllability and security of power system, the FACTS are installed on ultra-high voltage.

The flexible AC transmission system is akin to high voltage DC and related thyristor developments, designed to overcome the limitations of the present mechanically controlled AC power transmission systems. By using reliable and high-speed power electronic controllers, the technology offers five opportunities for increased efficiency of utilities. · Greater control of power so that it flows on the prescribed transmission routes. · Secure loading of transmission lines to levels nearer their thermal limits. · Greater ability to transfer

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between controlled areas. · Prevention of cascading outages. · Damping of power system oscillation. Static Var compensator (SVC) improves the system performances by controlling the magnitude of voltage.

II. LITERATURE SURVEY

Naladi Ram Babu, et. al. (2023)- In this research study, A contemporary ideologies in the AGC fled is presented in this work. Recent advancements include development in realistic RES models, modern, advanced, and cascade controller design, the incorporation of virtual inertia and PLL in HVDC systems, modelling of accurate HVDC tie-line system, and the application of HPA–ISE, FACTS, and ESD integration for AGC issue has gained importance. The classification of different AGC/LFC strategies has been paid special attention, and its salient characteristics are emphasized[01].

Raju Wagle., et. al. (2023)- This research work, Future distribution networks (DN) are subject to rapid load changes and high penetration of variable distributed energy resources (DER). Due to this, the DN operators face several operational challenges, especially voltage violations. Optimal power flow (OPF)- based reactive power control (RPC) from the smart converter (SC) is one of the viable solutions to address such violations. However, sufficient communication and monitoring infrastructures are not available for OPF-based RPC. With the development of the latest information communication technology in SC, cyber-physical co-simulation (CPCS) has been extensively used for real-time monitoring and control. Moreover, deploying OPFbased RPC using CPCS considering the controller design of SC for a realistic DN is still a big challenge. Hence, this paper aims to mitigate voltage violations by using OPF-based RPC in a real-time CPCS framework with multiple SCs in a realistic DN. The OPF-based RPC is achieved by performing the CPCS framework developed in this study. The CIGRE medium-voltage DN is considered as a test system. Real-time optimization and signal processing are achieved by Python-based programs using a model-based tool chain of a real-time DN solver and simulator. Real-time simulation studies showed that the proposed method is capable of handling uncertain voltage violations in real time[02].

Mohd Herwan Sulaiman., et.al. (2022) – In this research work presented, seven metaheuristic algorithms namely BMO, MPA, MFO, PSO, GSA TLBO and HBO have been proposed to solve OPF with the FACTS allocation problems. To analyse and assess the performance of all algorithms in solving the problems, they have been applied on two OPF objective functions viz. transmission loss as well as generation cost on modified IEEE 14-bus system through four cases. Statistical and comparative analysis show that TLBO and HBO produce very competitive performance and outperformed the rest of algorithms for most of the cases. Therefore, they can be an effective alternative for solving OPF problem with the presence of FACTS devices[03].

Ahmed A. Shehata. et. al. (2019) - The presented Meta-heuristic algorithms have been extensively used to allocate different types of FACTS devices such as Static Var Compensator (SVC), Thyristor-Controlled Series Compensator (TCSC), and Unified power flow controller (UPFC). One of the most popular techniques is the GWO algorithm, characterized by an easy implementation, a few variables that have to be adapted, and fast conversion to the final solution. Despite these advantages, it suffers from a loss of diversity that results in trapping in local optima. This paper proposed a new hybrid algorithm, namely the AGPSO-GWO algorithm, to address the standard GWO algorithm's issues. The suggested technique used the enhanced strategy of the AGPSO technique to improve the accuracy and efficiency of the classic GWO algorithm. The AGPSO-GWO algorithm has been applied on the IEEE 30 and 118 bus power systems (as a medium and large scale) to determine the optimum location and size of the SVC, TCSC, and UPFC individually. The FACTS are allocated to minimize active power loss, voltage deviation, and power system operating cost. These objectives have been optimized in single and multi-objective forms. Simulation results proved the effectiveness of the new approach (AGPSO-GWO technique) in optimizing the single and multi-objective functions. Besides, the locations of FACTS devices and ratings have been determined simultaneously. The findings show that optimal FACTS devices allocation diminishing power loss and voltage deviation as well as the system operating cost. In addition, the non-optimized location leads to poor objective values for single and multi-objective optimization [04].

Sarthak Chopra, et. al. (2022) - In this research work, a novel EOPF-based hierarchical scheme for islanded AC micro grids. The proposed centralized offline energy management scheme uses the HCPQ bus formulation which takes into account the effect of primary and secondary control dynamics. The energy management algorithm is validated on a modified MV CIGRE benchmark network by performing two different case studies. The simulation results from the case studies indicate a good performance for the proposed energy management algorithm. The optimization objective of minimizing cost was achieved, along with maintaining bus voltages and system frequency within the desired range, securing power balance, and ensuring that the various components are within their operational limits. Additionally, shorter droop time frames and voltage soft limits allow for more flexibility in the system by ensuring reliable operation [05].

Divya Shende, et. al. (2021) - In this research work, The UPFC explains in this article can enhance electrical network power quality. UPFC also has the ability to maintain an exact voltage w. r. t. Can offer actual and receptive power stream control simultaneously. The goal of this research is to explore and to analyse UPFC's potential to enhance the grades of electricity in the System of Electricity. This article presents different novel topologies for FACTS controllers. It thereby improved the quality of total power[06].

BO LIU, et. al. (2021) - This research work, the variable impedance-based FACTS devices into the ACOPF model to minimize the weighted sum of operation costs, system losses, and load shedding costs. The FACTS devices are modelled as variable reactance of lines, which are introduced into the proposed ACOPF model as extra decision variables. This work derives the gradient and Hessian matrices of the proposed model with respect to the line impedance and load curtailment. Those matrices are used to build an open-source interior-point solver for the proposed ACOPF model based on MATPOWER[07].

Ibrahim M. Mehedi., Wang, et. al. (2021) -This research workas a result, Different FACTS devices have been evaluated as fault current limiters in this paper. The performance of the SSSC, STATCOM, and UPFC are being studied among several FACTS devices. SSSC does not contribute significantly to fault current and voltage regulation, whereas it focuses exclusively on reactive power flow. On the contrary, UPFC and STATCOM are able to reduce fault current besides correcting voltage and regulating current. STATCOM and UPFC absorb reactive power from the system in a manner that greatly reduces fault currents. Stability, transients, and voltage control are better achieved with UPFC than STATCOM. As a result, the system's critical clearing time will be lengthened due to the low fault current. The switchgear and protection system will not need to be changed, so it will be possible to transmit more power. By including FACTS in a transmission and distribution system, both economic benefits and reliability are provided [08].

III. POWER FLOW CONTROL

Power Flow Control refers to the management of the flow of electrical power on a power system network using power electronic devices such as FACTS (Flexible AC Transmission Systems) devices, HVDC (High-Voltage Direct Current) systems, and transformers.

In power systems, it is essential to maintain a balance between the supply of electrical power and the demand for power. Any imbalance can lead to voltage instability, power outages, and damage to electrical equipment. Power Flow Control allows the network operators to adjust the voltage, phase angle, and impedance of the network to maintain this balance.

Power Flow Control devices can be used to manage the flow of power in a variety of situations. For example, when there is a high demand for electricity in one area, the devices can be used to redirect power from other areas to meet the demand. Additionally, they can be used to control the flow of power between interconnected power systems, which can help to improve the stability and reliability of the networks.

Overall, Power Flow Control is an important technique for managing the flow of electrical power in power system networks, and can help to improve the stability, reliability, and efficiency of the networks.

USES

Power Flow Control is a technique used to manage the flow of electrical power on a power system network. It involves adjusting the settings of power electronic devices such as FACTS (Flexible AC Transmission Systems) devices, HVDC (High-Voltage Direct Current) systems, and transformers to control the voltage, phase angle, and impedance of the network.

Here are some steps on how to use Power Flow Control:

1. Identify the areas in the power system network that require power flow control. This can be done by analyzing the network topology, load demand, and power generation capacity.
2. Determine the type of Power Flow Control device that is appropriate for the identified areas. Different types of devices have different functions and capabilities, and the selection of the device should be based on the specific requirements of the network.
3. Design the Power Flow Control system based on the requirements of the network. This involves setting the parameters of the device, such as the phase angle, voltage, and impedance, and determining the optimal operating conditions.
4. Install the Power Flow Control device in the network. This may involve physical installation, software configuration, and testing to ensure that the device is operating correctly.
5. Monitor the Power Flow Control system to ensure that it is operating as intended. This involves analyzing the performance of the device, measuring the voltage and current levels in the network, and making adjustments to the device settings as necessary.
6. Evaluate the effectiveness of the Power Flow Control system. This involves analyzing the performance of the network before and after the installation of the device, and determining whether the system is meeting the requirements of the network.

Overall, the use of Power Flow Control can help to improve the stability, reliability, and efficiency of power system networks, and is an important tool for managing the flow of electrical power.

WORK

Power Flow Control works by using power electronic devices such as FACTS (Flexible AC Transmission Systems) devices, HVDC (High-Voltage Direct Current) systems, and transformers to adjust the voltage, phase angle, and impedance of the power system network.

Here are the basic steps involved in how Power Flow Control works:

1. Monitoring: Power Flow Control begins with monitoring the power system network to determine the current flow of electrical power, as well as the voltage, frequency, and other relevant parameters.

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2. Analysis: Based on the monitoring data, the power system operator can analyze the flow of power, identify areas of congestion or overloading, and predict the future demand for power.
3. Adjustment: Power Flow Control devices are then used to adjust the flow of electrical power in the network, either by diverting power from congested areas to less congested areas or by increasing or decreasing the voltage levels in different parts of the network.
4. Monitoring: The system is then monitored again to determine whether the adjustments made by the Power Flow Control devices have been effective in maintaining the balance between power supply and demand, and in improving the stability and reliability of the network.

Overall, Power Flow Control is an important tool for managing the flow of electrical power in power system networks, and can help to improve the stability, reliability, and efficiency of the networks.

IV. POWER FLOW CONTROL ARCHITECTURE

Power Flow Control in Architecture refers to the management and optimization of electrical power distribution within a building or structure. The goal is to ensure that the flow of electrical power is controlled and regulated to meet the demands of the building's electrical systems in the most efficient and effective way possible.

There are several techniques and technologies that can be used to control power flow in Architecture. One common approach is the use of building automation systems (BAS) that can monitor and control the electrical systems within the building. These systems can be programmed to adjust lighting, HVAC, and other electrical systems based on occupancy, weather conditions, and other factors to optimize energy usage and minimize waste.

Another approach to power flow control in Architecture is the use of renewable energy sources such as solar panels, wind turbines, or geothermal systems to generate electricity on-site. These systems can be integrated with the building's electrical systems and can provide a clean, reliable source of power that can be used to offset the building's energy consumption.

Additionally, power flow control can be achieved through the use of energy-efficient equipment, such as LED lighting, high-efficiency HVAC systems, and energy-efficient appliances. These technologies can help to reduce overall energy consumption and minimize waste.

Overall, power flow control in Architecture is an important consideration for building owners and operators who want to minimize energy costs, reduce their environmental impact, and ensure the reliability and efficiency of their electrical systems.

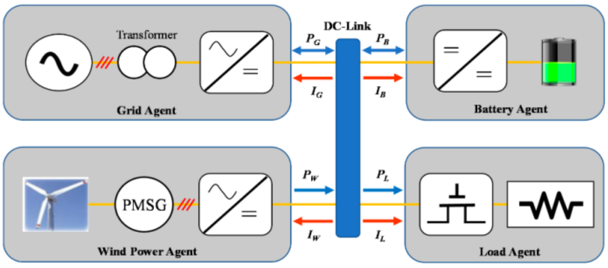

Fig 1 Power Flow Control Architecture

"Architecture Power Flow Control" can refer to the management and optimization of power flow within a building or structure. In this context, it typically involves the use of various technologies and techniques to control and manage the flow of electrical power in order to minimize waste and ensure efficient use of resources.

One common approach to power flow control in architecture is through the use of building automation systems (BAS) that can monitor and control the various electrical systems within a building, including lighting, HVAC, and other systems. BAS can help to optimize energy usage by adjusting systems based on occupancy, weather conditions, and other factors.

Another approach to power flow control in architecture is the use of renewable energy sources, such as solar panels or wind turbines, to generate power onsite. These systems can be integrated with the building's electrical systems and can provide clean, reliable power that can be used to offset the building's energy consumption.

Overall, power flow control in architecture is an important consideration for building owners and operators who want to minimize energy costs, reduce their environmental footprint, and ensure the reliability and efficiency of their electrical systems.

V. CONCLUSION

In this survey paper discuss power flow control Also discuss the literature survey of FACTS Devices Based Power Flow Control in Electrical Power System. Discuss the Different FACTS devices have been evaluated as fault current limiters in this paper. The performance of the SSSC, STATCOM, and UPFC are being studied among several FACTS devices. SSSC does not contribute significantly to fault current and voltage regulation, whereas it focuses exclusively on reactive power flow. On the contrary, UPFC and STATCOM are able to reduce fault current besides correcting voltage and regulating current. STATCOM and UPFC absorb reactive power from the system in a manner that greatly reduces fault currents. Stability, transients, and voltage control are better achieved with UPFC than STATCOM. As a result, the system's critical clearing time will be lengthened due to the low fault current. The switchgear and protection system will not need to be changed, so it will be possible to transmit more power. By including FACTS in a transmission and distribution system, both economic benefits and reliability are provided.

References

[1] Naladi Ram Babu1,Sanjeev Kumar Bhagat,Lalit Cha ndra Saikia ,Tirumalasetty Chiranjeevi3 · Ramesh D evarapalli4,Fausto Pedro García Márquez"ACompre hensive Review of Recent Strategies on Automatic Generation Control/Load Frequency Control in Power Systems"Accepted: 13 August 2023.

[2] Raju Wagle1 Pawan Sharma1 Charu Sharma1 Mohammad Amin2 Jose Luis Rueda3 Francisco Gonzalez-Longatt "Optimal power flow-based reactive power control in smart distribution network using real-time cyber-physical co-simulation framework"1 February 2023.

[3] Mohd Herwan Sulaiman , Zuriani Mustaffa"Optimal placement and sizing of FACTS devices for optimal power flow using metaheuristic optimizers"Volume 8, September 2022, 100145.

[4] AhmedA. Shehata , Mohamed A. Tolba , Ali M. El-Rifaie , Nikolay V. Korovkin "Power system operation enhancement using a new hybrid methodology for optimal allocation of FACTS devices"Volume 8, November 2022, Pages 217-238

[5] Sarthak Chopra, Gowtham Meda Vanaprasad, Gibran David,Agundis Tinajero, Najmeh Bazmohammadi, J uan C. Vasquez, Josep M. Guerrero "Power-flow-based energy management of hierarchically controlled islanded AC microgrids"Volume 141, October 2022, 108140.

[6] Divya Shende, Prashant Jagtap and Rutuja Hiware "Review of enhanced power quality using unified power flow control system in electrical network"2021.

[7] Bo Liu , (Member, Ieee), Qihui Yang , Hang Zhang, (Member, Ieee), And Hongyu Wu "An Interior-Point Solver for AC Optimal Power Flow Considering Variable Impedance-Based Facts Devices"October 22,Volume 9, 2021 2021.

[8] Ibrahim M. Mehedi,Jahin Al Hasan Joy,Md. Rafiqul Islam,NayeemaHasan,Ubaid M. Al-Saggaf,AhmadH.Milyani,Ahmed,I.Iskanderani,Abdu llahAbusorrah,MuhyaddinRawaand Hussain Bass "Reducing Fault Current by Using FACTS Devices to Improve Electrical Power Flow"Volume 2021 | Article ID 8116816.

[9] H. Schmitt, "Fault current limiters report on the activities of CIGRE WG A3.16," *Proceedings of the IEEE PES General Meeting*, vol. 5, 2006.

[10] L. Kovalsky, X. Yuan, K. Tekletsadik, A. Keri, J. Bock, and F. Breuer, "Applications of superconducting fault current limiters in electric power transmission systems," *IEEE Transactions on Appiled Superconductivity*, vol. 15, no. 2, pp. 2130–2133, 2005.

[11] Y. Xin, W. Gong, X. Niu et al., "Development of Superconducting Fault Current Limiters," in *Proceedings of the 6th International Conference on Power System Technology*, pp. 1–5, Chongqing, China, July 2006.

[12] R. F. Giese, *Fault Current Limiters—A Second Look*, Argonne National Laboratory, Paris, France, 1995.

[13] T. Yazawa, E. Yoneda, J. Matsuzaki et al., "Design and test results of 6.6 kV high-Tc superconducting fault current limiter," *IEEE Transactions on Appiled Superconductivity*, vol. 11, no. 1, pp. 2511–2514, 200.

[14] R. K. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, Anshan Publishers, Anshan, China, 1st edition, 2007.

[15] González, Rosa Morales, et al. "Applied Internet of Things architecture to unlock the value of smart microgrids." IEEE Internet of Things Journal 5.6 (2018): 5326-5336.

[16] Nasir, Mashood, et al. "Solar PV-based scalable DC microgrid for rural electrification in developing regions." IEEE Transactions on sustainable energy 9.1 (2017): 390-399.

[17] Azaza, Maher, and Fredrik Wallin. "Multi objective particle swarm optimization of hybrid micro-grid system: A case study in Sweden." Energy 123 (2017): 108-118.

[18] Robert, Fabien Chidanand, Gyanendra Singh Sisodia, and Sundararaman Gopalan. "The critical role of anchor customers in rural microgrids: Impact of load factor on energy cost." 2017 International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC). IEEE, 2017.

[19] Sahoo, Subham, and Sukumar Mishra. "A distributed finite-time secondary average voltage regulation and current sharing controller for DC microgrids." IEEE Transactions on Smart Grid 10.1 (2017): 282-292.

[20] Astapov, Victor, and Sergei Trashchenkov. "Design and reliability evaluation of standalone microgrid." 2017 18th International Scientific Conference on Electric Power Engineering (EPE). IEEE, 2017.

[21] Merabet, Adel, et al. "Energy management and control system for laboratory scale microgrid based wind-PV-battery." IEEE transactions on sustainable energy 8.1 (2016): 145-154.

[22] Kumar, Vivek, and Rajesh Gupta. "Voltage control and power balance in a standalone microgrid supported from solar PV system." 2016 IEEE Region 10 Conference (TENCON). IEEE, 2016.

[23] Ali, Ikbal, and SM Suhail Hussain. "Communication design for energy management automation in microgrid." IEEE Transactions on Smart Grid 9.3 (2016): 2055-2064.

[24] Akter, Most Nahida, Md Apel Mahmud, and Amanullah MT Oo. "A hierarchical transactive energy management system for microgrids." 2016 IEEE Power and Energy Society General Meeting (PESGM). IEEE, 2016.

[25] Atia, Raji, and Noboru Yamada. "Sizing and analysis of renewable energy and battery systems in residential microgrids." IEEE Transactions on Smart Grid 7.3 (2016): 1204-1213.

[26] Leskarac, Domagoj, et al. "Testing facility for research and development of Smart-MicroGrid technologies." 2015 IEEE PES Asia-Pacific Power

and Energy Engineering Conference (APPEEC). IEEE, 2015.

[27] Fregosi, Daniel, et al. "A comparative study of DC and AC microgrids in commercial buildings across different climates and operating profiles." 2015 IEEE First International Conference on DC Microgrids (ICDCM). IEEE, 2015.

[28] Lázár, Eniko, et al. "SCADA development for an islanded microgrid." 2015 IEEE 21st International Symposium for Design and Technology in Electronic Packaging (SIITME). IEEE, 2015.

[29] Diaz, Enrique Rodriguez, et al. "Intelligent dc microgrid living laboratories-a chinese-danish cooperation project." 2015 IEEE First International Conference on DC Microgrids (ICDCM). IEEE, 2015.

[30] Murenzi, Jean Pierre, and Taha Selim Ustun. "The case for microgrids in electrifying Sub-Saharan Africa." IREC2015 The Sixth International Renewable Energy Congress. IEEE, 2015.

[31] Thale, Sushil S., Rupesh G. Wandhare, and Vivek Agarwal. "A novel reconfigurable microgrid architecture with renewable energy sources and storage." IEEE Transactions on Industry Applications 51.2 (2014): 1805-1816.

[32] Shadmand, Mohammad B., and Robert S. Balog. "Multi-objective optimization and design of photovoltaic-wind hybrid system for community smart DC microgrid." IEEE Transactions on Smart Grid 5.5 (2014): 2635-2643.

[33] Laaksonen, Hannu, Dmitry Ishchenko, and Alexandre Oudalov. "Adaptive protection and microgrid control design for Hailuoto Island." IEEE Transactions on Smart Grid 5.3 (2014): 1486-1493.

[34] Shi, Wenbo, et al. "Evaluating microgrid management and control with an implementable energy management system." 2014 IEEE International Conference on Smart Grid Communications (SmartGridComm). IEEE, 2014

