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Enhancing Power Transfer through the Implementation of Flexible AC Transmission Systems

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Abstract –

In recent years, the electrical power industry has faced numerous challenges due to technological advancements, leading to the expansion of manufacturing and product-based firms. This growth has resulted in an escalating power demand that surpasses the available supply. The efficiency of the power system is significantly affected by two crucial factors: damping and frequency oscillation, as every unit of load increase linearly impacts efficiency. To address these challenges, Flexible AC Transmission System (FACTS) technology has emerged as a concept focusing on active and reactive power control monitoring to enhance the operation of electrical power system networks.

This study employs Flexible AC Transmission Systems (FACTS) to approximate the functioning of stable power system networks. Developed by the Electric Power Research Institute (EPRI), FACTS utilizes various power electronic devices to effectively regulate power flow. Key components of FACTS technology encompass high-power electronics, diverse thyristor devices, microelectronics, communications, and intricate control actions.

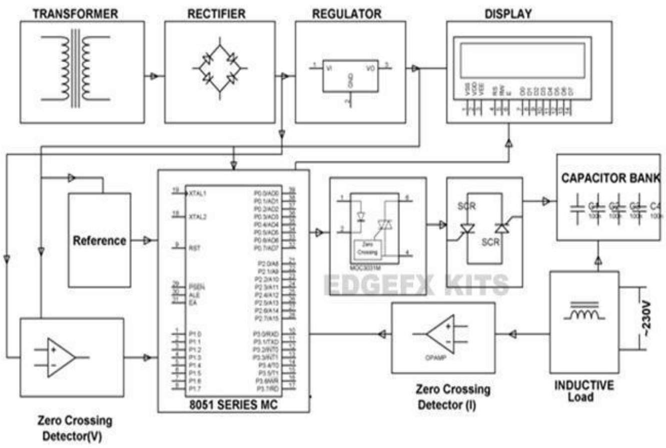
To validate the proposed system, soft computing techniques such as Fuzzy Logic, Genetic Algorithm, BAT algorithm, and Artificial Neural Network concepts are employed. These techniques are utilized to fine-tune the settings of a grid-connected multiline system generating renewable energy. A Simulink model is constructed and analyzed using soft computing approaches to assess the potential of a grid-connected power flow controller in a multi-line power system. The obtained results are then compared with established methods for enhancing performance characteristics.

Keywords : FACTS (Flexible AC Transmission System), Damping and Frequency Oscillation, Electric Power Research Institute (EPRI)

1. INTRODUCTION

The converter stands out as a critical component in electrical power systems due to its ability to translate electrical properties. This circuit accepts various electrical systems, be it AC or DC, as input and consistently outputs values irrespective of voltage or current fluctuations. Collaborating with inductors and capacitors, the converter facilitates effective conversion and control.[1] With diverse functions to modify input forms, converters are integral in managing voltage fluctuations, as noted by Cortés, P et al. Most electronic devices, including computers, personal gadgets, and solar chargers, incorporate converters, subject to investigation and assessment in various research methods. This research particularly emphasizes the power flow converter.

Needs Of FACTS



1.1 Electronic Power Converters

[2] The legs of the converter circuit consist of lines containing static switches. The input voltage or current into the circuit can vary. A three-level converter is an electrical device that transforms Direct Current (DC) from a battery to Alternating Current (AC) and vice versa.

2. Devices in FACTS

Hingorani (1991) introduced the FACTS concept, comprising two generations: traditional thyristor switched capacitors/quadrature tap changing transformers and GTO-based controllers. In these cases, the schemes of the generation are employed as Voltage Source Converters (VSC). Figure 2 categorizes conventional and FACTS devices, along with their generating types, based on the operation type. Thyristor-controlled setups regulate the process using powerful static switches in shunt or series RLC transformers. Various FACTS devices include Thyristor Valve Compensation with a Voltage Source Converter for Switched Shunts, FACTS Compensator for Static Synchronous Events (Conventional), Static VAR Compensator (STATCOM), Static Synchronous Series Capacitor with Thyristor Control (TCSC), and Interline Power Flow Controller (IPFC) These devices, such as the Interline Power Flow Controller (IPFC), are pivotal in regulating and controlling the flow of electricity between two points. The IPFC specifically focuses on compensating for interline power flow in a switched series circuit of a phase-shifting transformer. By manipulating the ON and OFF durations of the thyristor switches, variable reactance approximations of the settling capacitor and reactor banks can be achieved. The FACTS controller, utilizing Voltage Source Converters (VSC) and GTO thyristors, facilitates self-commutated DC to AC conversion. This capability enables the creation of internal capacitive and inductive reactive power for the transmission line.

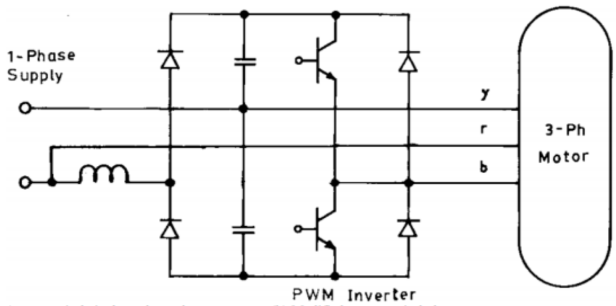


Fig 1. (a) Asymmetrical single-to-three-phase converter. (b) Modified asymmetrical phase converter.

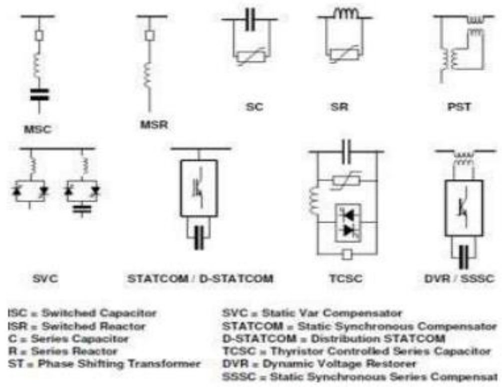


Fig. 2. Traditional Classification of FACTS

3. Power Flow Control Devices

The continuous advancement of power flow control equipment significantly contributes to the expansion of global power systems. The introduction of unexplained power flows puts significant stress on the transmission network, leading to concerns about grid congestion. Simultaneously, unexpected grid congestion issues can arise without warning. To address these challenges, one approach is to control electricity flows, providing a means to optimize the current transmission network without the need for extensive infrastructure development, considering the associated political, environmental, and social considerations. This paper emphasizes the growing preference for power utilities and transmission network modifications to adopt power flow control devices.[4]

In comparison to conventional stability compensation schemes, the introduction of additional devices for congestion management in the transmission system results in a significantly faster growth rate of external devices than in a typical system. The parallel functioning of this module is rooted in a phenomenon known as regulated electrical power flows. Adjustments to system characteristics, such as system voltage magnitude, line impedance, and transmission angle, play a crucial role in regulating the flow of electrical power.

4. High Power Electronic Device

The power electronic component selected for the bridge circuit in the recommended simulation is carefully chosen. In the Simulink converter model, thyristors serve as the default devices. A model analogous to the Voltage Source Converter (VSC) type is generated by selecting a switching function based on VSC, incorporating two voltage sources on the AC side and a current source on the DC side to

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replace the switches. Harmonics typically formed by the bridge are induced by employing the same firing pulses as the other power electronic components.

If the nominal Voltage Source Converter (VSC) is employed, the average-model type of VSC is used to represent the power-electronic switches. In contrast to previous power electronic devices, the suggested model utilizes reference signals (ref), representing average voltages generated at the ABC terminals of the bridge circuit.[5] Harmonics are not reflected in the proposed model, enabling the system's use with longer sample durations while maintaining average voltage dynamics. An example is a high-capacity AC-DC-AC converter, where this method employs a DC link system to simulate a diode-based rectifier and an IGBT inverter using the Universal Bridge block.

5. Harmonics Analysis of the Proposed System
The faults identified in the intended Interline Power Flow Controller (IPFC) components, along with the types of harmonics, include:
- Resonance in series and parallel
- Increase in RMS/Peak Value

The sources of harmonics are categorized as follows:
- Static vs. Dynamic
- Voltage source vs. Current source
- Utility companies, customers, and manufacturers
- IEC/IEEE standards on harmonics with harmonic limits

5.1 Optimal Location for the IPFC
To maximize the benefits of the proposed Interline Power Flow Controller (IPFC), it must be strategically installed in the intended grid-connected power system. As a multi-line FACTS controller, the proposed IPFC involves connecting two separate transmission lines to a single bus. The conventional method of selecting the ideal location proves ineffective when determining the controller's placement. The proposed simulated device regulates real and reactive power flow in transmission lines by modifying the compensation mechanism using the Voltage Source Converter (VSC).[6]

6. Output Waveforms
The output voltage of the proposed system varies from 0.9 to 1 for all buses linked to the transmission line. Any sudden change in load on a transmission line causes a load imbalance in the transmission system. While the real power consumption of the load increases, the flow of reactive power across the lines accelerates.

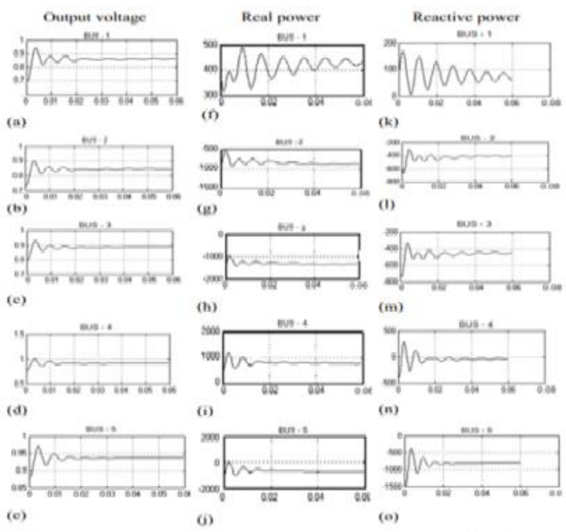
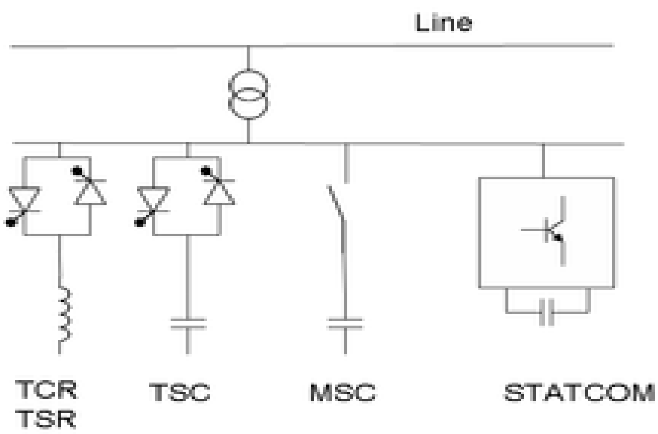


Fig. 3. Output Power real and reactive

By absorbing reactive power and injecting real power, our proposed controller ensures the stability of the grid-linked system[7]. Despite the initial instability and oscillations in the system, the waveform obtained from the suggested Simulink model indicates a gradual stabilization over time.

6.1 Output Waveforms of Sub-System
Figures 3, 4, and 5 depict the graphical representations of real and reactive power outputs from systems with and without IPFC, as generated by the proposed Simulink module.



7. Conclusion

Real-time power electronics equipment necessitates control and dynamic adjustment for various transmission modules. In such scenarios, the Unified Power Flow Controller (UPFC) is employed to address power transmission concerns and ensure efficient electricity delivery. However, its limitations in handling multiline power systems led to the proposal of the Interline Power Flow Controller (IPFC) in this paper, aiming for enhanced operational reliability and economic efficiency. The comprehensive literature review guided the precise design of the control unit, optimizing the utilization and regulation of the existing transmission system architecture, complemented by compensated FACTS controllers.

In response to this approach, the Interline Power Flow Controller module, along with windmill and solar-PV systems, was developed. These devices, serving as power sources, are connected to the electric grid. Throughout this investigation, the MATLAB Simulink model is utilized for testing and verification, specifically designed for a grid-connected system to ensure stability. IPFC is evaluated by examining real-time, reactive-time, and output voltage waveforms for various loads in the grid, facilitating the transmission of real and reactive power between transmission lines.

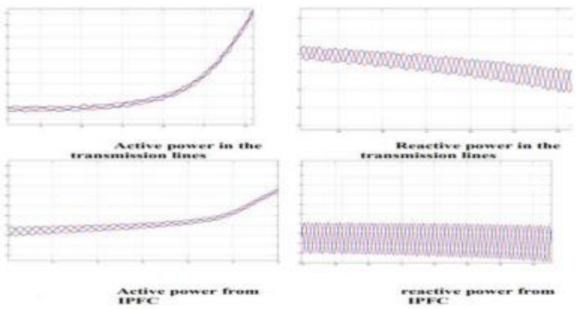


Fig. 4. Output Power

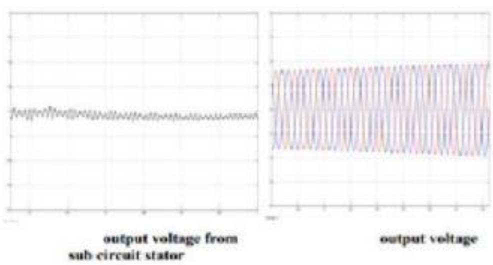


Fig. 5. Output Power

References:

[1] Kazemi, A., & Karimi, E. (2006). "The effect of interline power flow controller (IPFC) on damping interarea oscillations in the interconnected power systems." In Proceedings of the 41st International Universities Power Engineering Conference, vol. 2, pp. 769-773. IEEE.

[2] Abido, M. A. (2009). "Power system stability enhancement using FACTS controllers: A review." The Arabian Journal for science and engineering, 34(1B), 153-172.

[3] Akagi, Hirofumi, Shigenori Inoue, and Tsurugi Yoshii. (2007). "Control and performance of a transformerless cascade PWM STATCOM with star configuration." IEEE Transactions on Industry Applications, 43(4), 1041-1049.

[4] Mishra, Akanksha. "Congestion management of deregulated power systems by the optimal setting of Interline Power Flow Controller using Gravitational Search algorithm." *Journal of Electrical Systems and Information Technology* 4, no. 1 (2017): 198-212.

[5] Alam, M. J. E., K. M. Muttaqi, and Darmawan Sutanto. "Mitigation of rooftop solar PV impacts and evening peak support by managing the available capacity of distributed energy storage systems." *IEEE transactions on power systems* 28, no. 4 (2013): 3874-3884.

[6] Ali, Mohd Hasan, Bin Wu, and Roger A. Dougal. "An overview of SMES applications in power and energy systems." *IEEE transactions on sustainable energy* 1, no. 1 (2010): 38-47.

[7] Almoataz Y. Abdelaziz, Metwally A. El-Sharkawy and Mahmoud A. Attia (2015) Optimal Location of Thyristor Controlled Series Compensation and Static VAR Compensator to Enhance Steady-state Electric Power Components and Systems. vol.43, no.18