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POWER QUALITY ENHANCEMENT USING A UNIFIED POWER FLOW CONTROLLER (UPFC)

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ABSTRACT: The Unified Power Flow Controller (UPFC) is a sophisticated electrical device. It is a FACTS (Flexible AC Transmission System) device that is employed in power transmission networks to regulate voltage and power flow. The utilization of a transmission line with a Unified Power Flow Controller (UPFC) at the transmitting end to instantly regulate reactive power and voltage is recommended by computer modeling. Control technology has the potential to significantly improve the transient behavior of power systems following transient events as a result of its rapid dynamic reactivity. Transmission line active and reactive power cannot be regulated in the absence of UPFC. The UPFC is able to detect changes in reference values with the assistance of simulated control systems. The series voltage source converter angle command and AC and DC voltages are among the distinctions. In this control system, firing pulses are generated for both converters through universal pulse width modulation. MATLAB/PSCAD simulations will be implemented to assess the performance of the UPFC.

Keywords: -*UPFC, FACTS, Power Quality, Transient Control.*

I. INTRODUCTION

The architecture and functionality of power systems have been enhanced by global advancements in power infrastructure utility technologies. In order to accommodate technological advancements, power systems—generation, transmission, and distribution—must be more profitable and efficient. Users of electricity are becoming more apprehensive about the quality of their electricity. The significance of power quality has increased as sensitive electronics and nonlinear loads are implemented in residential and commercial settings [2]. Power quality can be influenced by a variety of factors, including arcing devices, load switching, embedded generation, enormous motor initiation, sensitive equipment, storm and environmental damage, and network architecture. The quality of power on the load side (PQ) must be enhanced due to the increasing complexity and responsibility of industrial processes. This encompasses the precise regulation of voltage within strict constraints, the absence of harmonic distortion, and an uninterrupted energy supply. In order to enhance resilience, the majority of power systems in developing nations with interconnected networks are consolidating generation reserves. The system became unstable, which resulted in widespread blackouts and made power flow control impossible. This raised security concerns. The malfunction sequences described above may be the result of a combination of variables. These encompass network congestion, poor maintenance, power system connectivity issues, and systematic design and execution defects. In order to prevent these repercussions, guarantee the passage of electricity, and maintain the

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stability and reliability of the system, it is necessary to construct new transmission lines. Nevertheless, the broad-linked power system is constrained in its ability to incorporate transmission lines. Budgetary and environmental constraints are applicable. It is the responsibility of power engineers to integrate new transmission lines into an existing power system. They are interested in identifying methods to enhance the flow of power over existing lines while simultaneously ensuring the safety and stability of the transmission system. In the late 1980s, the Electric Power Research Institute (EPRI) developed a technology that could enhance the reliability, stability, and flow of power by utilizing the extant power infrastructure. "FACTS technology" is implemented in powered electronic devices. Modern control technology improves the controllability and efficacy of power systems within the constraints of power flow and stability.

II. FACTS CONTROLLERS

The voltage, impedance, and phase angle of high-voltage alternating current transmission lines are dynamically regulated by FACTS controllers. Classification is simplified by dividing FACTS controllers into four categories.

1. Series controllers.
2. Shunt controllers.
3. Combined series-series controllers.
4. Combined series-shunt controllers.

2.1 SERIES CONTROLLERS

The line is subjected to electric potential by each subsequent controller. When the voltage and line current are in phase quadrature, the series controller is the sole device capable of supplying or absorbing reactive power. Power management is indispensable for all phases of interaction.

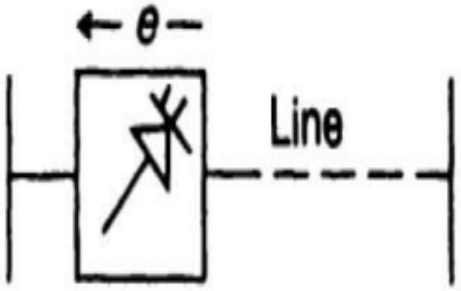


Figure 2.1 Static Synchronous Series Compensator (SSSC) is one such series controller.

2.2 SHUNT CONTROLLERS

At the connecting point, each shunt controller facilitates the entry of current into the system. The shunt controller generates or absorbs reactive power that fluctuates when the injected current is in phase quadrature with the line voltage. Power management is indispensable for all phases of interaction.

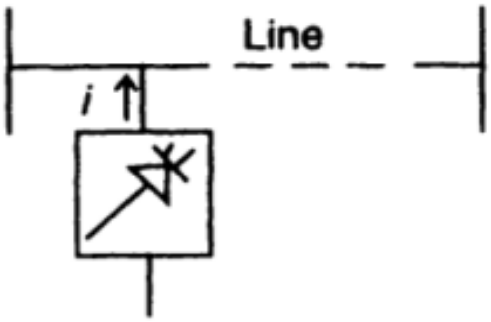


Figure 2.2 Static Synchronous Compensator (STATCOM) is one such controller

2.3 COMBINED SERIES-SERIES CONTROLLERS

In a multilane transmission system, this could be a synchronized succession of distinct series controllers. A unified controller can serve as an alternative to individual series controllers, which offer reactive compensation for each line. Power connections are employed by this controller to distribute power across lines.

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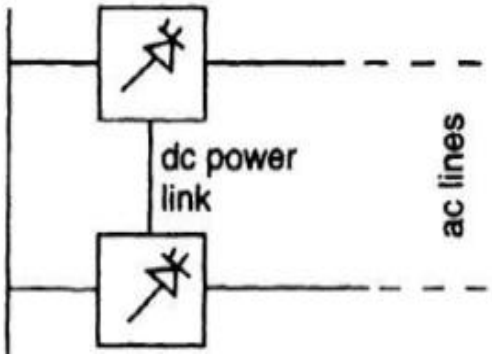


Figure 2.3 Interline Power Flow Controller comes in this category.

2.4 COMBINED SERIES-SHUNT CONTROLLERS

This could be a single power flow controller that includes both series and shunt components or a coordinated assembly of shunt and series controllers. Both alternatives are viable. System current is generated by a combination of series and shunt controllers. The voltages of the shunt and series controllers are connected in series. When connected, the series and shunt controllers are capable of legitimately transmitting electricity through an electrical connection.

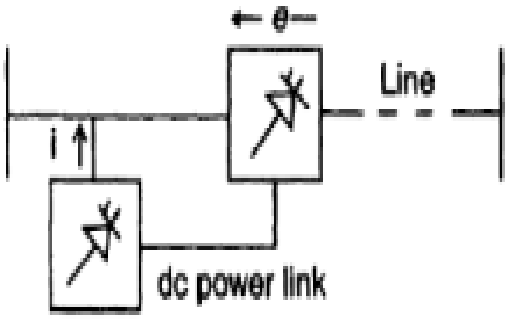


Figure 2.4 Interline Power Flow Controller comes in this category.

III. THE PROPOSED SYSTEM FOR POWER QUALITY USING UNIFIED POWER FLOW CONTROLLER (UPFC)

3.1 The Operating Principal of UPFC

Two Voltage Source Inverters (VSIs) are connected to the power supply by coupling transformers in the Unified Power Flow Controller (UPFC). The VSIs, which are the primary components of the UPFC, are connected by a shared DC storage capacitor. Series transformers connect the other in series, while shunt transformers connect one Voltage Source Inverter (VSI) in parallel with the transmission system. A series transformer is an additional transformer. The UPFC is depicted in its most basic configuration in Figure 3.1.

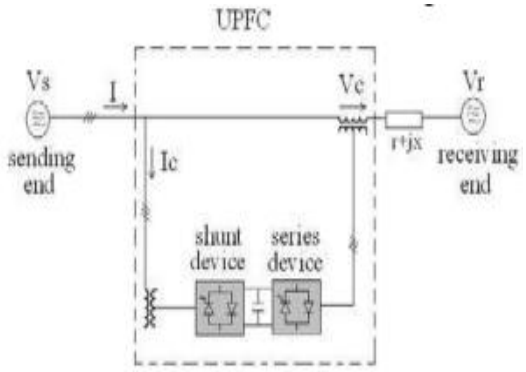


Fig3.1 Basic functional scheme of UPFC

A symmetrical three-phase voltage system (Vse) is injected into the transmission line by a series inverter to regulate active and reactive power. The magnitude and phase angle of this voltage system can be adjusted independently. This system facilitates the transfer of active and reactive electricity between the inverter and the line. Electronic components are supplied with reactive power by the series inverter, while the DC terminals are supplied with active power.

By extracting positive or negative direct current power from the line, the shunt inverter modifies the voltage across the

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storage capacitor. The inverter and transformer losses limit the UPFC's capacity to absorb net actual power from the line. By exchanging reactive power with the line, the residual capacity of the shunt inverter can be employed to modify the connection point voltage. Exchange reactive electricity.

The two Voltage Source Inverters (VSIs) operate independently by dividing the direct current (dc) side. In these instances, the shunt inverter functions as a Static Synchronous Compensator (STATCOM) by generating or absorbing reactive power to regulate the voltage at the connection point. As a Static Synchronous Series Compensator (SSSC), the series inverter regulates power and current along the transmission line.

UPFC serves in numerous capacities. In order to facilitate the operation of the shunt inverter, a regulated current is introduced into the transmission line.

3.1.1 VAR Control Mode

Reference inputs for VAR requests may be capacitive or inductive. The inverter gating is adjusted by the shunt inverter control to achieve the desired current. The var reference is transformed into a shunt current demand that is appropriate. A feedback signal that corresponds to the direct current bus voltage (Vdc) is required to implement this control method.

3.1.2 Automatic Voltage Control Mode

The shunt inverter regulates reactive current by independently adjusting the transmission line voltage at the connection point to a reference value. The shunt coupling transformer is powered by voltage feedback signals from the transmitting end bus, which are received by the control mode. The series inverter alters the magnitude and phase angle of the voltage by injecting voltage in series with the line, thereby influencing the transmission of line power. Voltage can be measured using a variety of methods.

Direct Voltage Injection Mode: The direct voltage injection mode directly pertains to the amplitude and phase angle of the series voltage.

Phase Angle Shifter Emulation mode: The reference input displays the phase difference between the sending and receiving voltages.

Line Impedance Emulation mode: The reference input is identified in Line Impedance Emulation mode by the phase difference between the voltages of the transmission and reception terminals.

Automatic Power Flow Control Mode: The transmission line must be connected to reference inputs P and Q in order to maintain Automatic Power Flow Control Mode. This is applicable regardless of system modifications.

3.2 UPFC Construction

An integrated voltage source converter (UPFC) is composed of a series converter and a shunt converter. These converters are connected by a shared direct current link. Static synchronous compensators (STATCOMs), also known as shunt converters, provide reactive power in addition to DC power for both inverters in AC systems. The phase angle and voltage magnitude of the transmission line are adjusted by series converters, also known as Static Synchronous Series Compensators (SSSC). In numerous sectors, transformers and power electronic converters are employed. Both voltage source converters utilized a single DC capacitor [5]. The energy storage capacity of this direct current (DC) capacitor is frequently restricted. As a result, the active voltage of the series converter must be

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equivalent to that of the shunt converter. Reactive power selection is facilitated by shunt or series converters, which enhances the control of power flow. The connection transformer prevents the device from connecting to the system. The three-phase UPFC-transmission line linkage concept is illustrated in Figure 3.2.1.

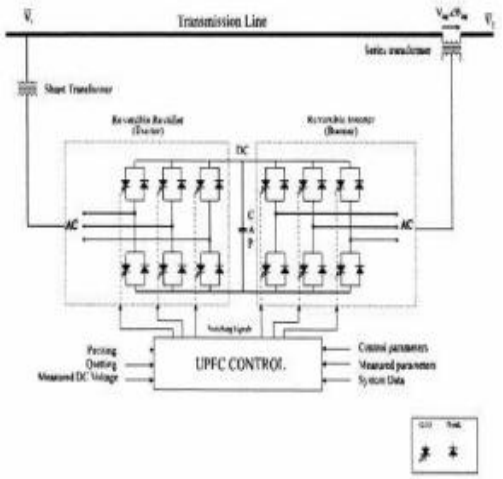


Figure 3.2.1: Schematic diagram of three phase UPFC connected to a transmission line [2] Control.

The voltage V1 must be supplemented with a series voltage (VS) with a specific amplitude and phase shift (φ) in order to regulate power transmission. This results in a secondary line voltage, V2, that exhibits discrete magnitude and phase shifts. The phase shift (δ) between V2 and V3 fluctuates as angle φ changes. A voltage-current phasor diagram with a single-line representation of the Unified Power Flow Controller is illustrated in Figure 2.

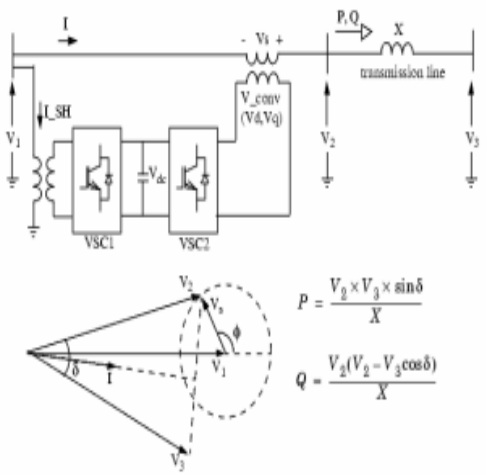


Figure 3.2.2: Single line diagram of UPFC and phasor diagram of voltage and current

IV. EXPERIMENTS CARRIED OF 22KV TRANSMI SSION LINE SYSTEM WITH UPFC DEVICE.

As power systems evolve, the significance of power flow management on transmission lines is increasing in order to satisfy power transfer requirements, particularly as electric energy markets expanded. As a result of advancements in power circuit technology, UPFC is now a viable option for meeting the demands of the future power system. This sophisticated power system component concurrently and adaptively regulates voltage, active power flow, and reactive power flow [10]. In the subsequent section [11-12], a transmission line is assessed in MATLAB/SIMULINK using a Unified Power Flow Controller (UPFC).

A. Simulink model of 22 kV Transmission Line.

The simulation model for the 22 kV single-line transmission system is depicted in Figure 4.1. The magnitude of the voltage is depicted in the outputs of the model simulation in Figures 4.2 and 4.3.

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The figures depict the actual and reactive power fluxes that pass through the line.

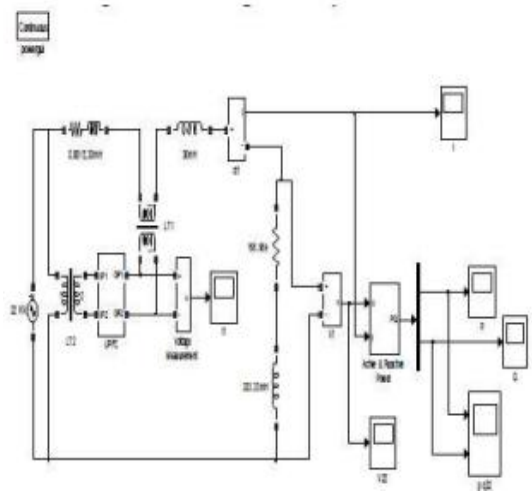


Fig.4.1. Simulink Model of 22 k V Transmission Line.

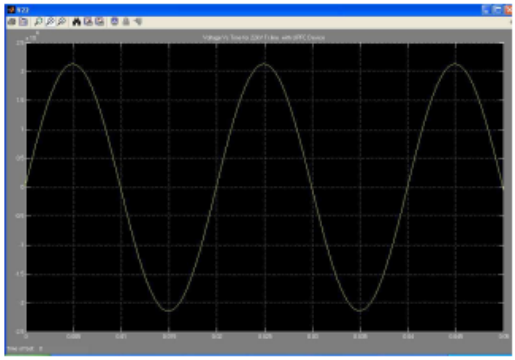


Fig.4.2. Voltage magnitude of 22 kV Transmission Line.

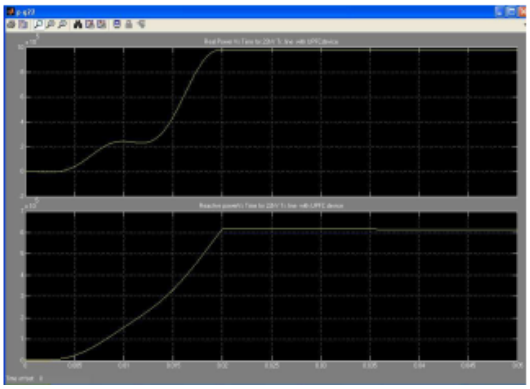


Fig.4.3. Real and Reactive power flows of 22 kV Line.

During the steady-state period of t = 0.02 seconds, the wave morphologies suggest a voltage magnitude of 21.23 kV, an actual power of 98.15 MW, and a reactive power of 61.64 MVAr. These values are determined by the magnitude of the voltage.

V. CONCLUSIONS

The study employs Matlab Simulink to simulate a three-phase system-connected Unified Power Flow Controller (UPFC). The results of research indicate that UPFC modeling and power system analysis can effectively resolve large-scale network issues and improve dependability. The Unified Power Flow Controller (UPFC) and its impact on power quality are evaluated by examining a variety of control parameters. The three-phase, three-wire transmission system was incorporated into the 22 kV analysis in MATLAB using the UPFC phasor model. The regulation and efficacy of the transmission line-specific Unified Power Flow Controller (UPFC) are the focus of this investigation. The UPFC is capable of efficiently managing both reactive and active power along the transmission line, as indicated by the simulation.

FUTURE SCOPE

Harmonics can be reduced while active and reactive power can be regulated with UPFC. The multilayer response of transformers results in a reduction in heat generation. This is the result of harmonic reduction, a critical step in the process of aligning simulation results with forecasts. Additionally, they are employed in the field of power quality.

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