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Power Quality Enhancement by Using UPFC

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Abstract- Energy crisis is a major problem for power system engineers; it is sparked by the enormous demand for energy in the distribution industry. The energy crisis issue might be lessened by upgrading the power system, but it is a time-consuming, difficult, and expensive procedure. Flexible AC Transmission Controllers are an option for this problem. A FACTS controller is made up of a number of controllers, such as SVC, SSSC, UPFC, IPFC, and others that can control the power system's real and reactive power, voltage, and phase angle. Unified Power Flow Controller is the most crucial FACTS controller (UPFC). The most adaptable FACTS device for actual and reactive power flow control and voltage regulation is the Unified Power Flow Controller (UPFC). It is possible to manage the power flow and so significantly lessen the energy issue by integrating UPFC into our contemporary power system. By modelling the power system in MATLAB- SIMULINK, UPFC may allow simultaneous control of real and reactive power flow, enhancing the power system's performance, power quality, and voltage profile.
Keywords: UPFC; SVC; SSSC; UPFC; IPFC

1. Introduction

It is necessary to improve by constructing additional transmission lines, substations, and associated hardware, the electrical system in order to meet the demand for electricity as a result of the impact of increased industrialization, but doing so is very challenging, time-consuming, and expensive. Thus, FACTS technologies offer the best alternate solutions. A detailed UPFC control system model that takes into account Both the actual Reactive and actual power regulation for the transmission line to which the series inverter is connected, as well as power transfer between shunt and series inverters. When flash insecurity is found, a nonlinear programming framework is offered for assessing corrective actions to improve the dynamic security of power systems [1, 2]. The study offers a method for expressing unified power inflow regulators (UPFCs) in steady-state analyses that is based on the novel notion that the findings of the Newton-Raphson(NR) cargo-inflow analysis' simplified voltage results at each replication should be interpreted as dynamic variables.

A Flexible Alternating Current Transmission

A range of resources used in electrical networks to get over static and dynamic transmission capacity limits are referred to as "Flexible AC Transmission Systems." According to the IEEE, data refers to interspersed current transmission systems that use grounded static regulators, power electronics, and other technologies to improve control and power transfer capabilities. These systems' primary goals are to enhance system performance and transmission quality while also swiftly supplying inductive or capacitive reactive power to the network.

A system (FACTS) [3] is a collection of stationary equipment used to transmit alternating current electrical energy. The network's controllability and power transmission capacity are to be improved. Power electronics are typically the basis of the system.

The FACTS controllers can be classified as

1. Regulators for shunt connections
2. A set of regulator connections
3. Combo series-series regulators,
4. Regulators in the combination shunt series

Data regulators can be divided into two categories.

A grounded voltage source motor and

B grounded voltage source impedance.

i) Static Variable Compensator (SVC) is one type of variable impedance regulator (deviate connected) Phase-shifting thyristor transformer

ii) Compensator or Thyristor Series Capacitor (TCSC)

iii) Shunt and series combined the grounded VSC

The following are data regulators: Static Synchronous Series Compensator (SSSC) and STATCOM (Static Synchronous Compensator) (series connected)

iv)The UPFC, or Unified Power Flow Controller (combined shunt- series)

The system's power quality and responsibility are increased by installing Data bias, especially the unified power inflow regulator (UPFC). In order to improve the performance, power quality, and responsibility of the power system, UPFC may provide contemporaneous management of factual and reactive power inflow.

2. Unified Power Flow Controller

In order to deal with a range of utility issues, UPFC has already been proposed for ultimate Control and dynamic correction of alternating current transmission systems [4-7]. It comprises of a series voltage source converter that provides phase shifting and/or series compensation, as well as a shunt voltage source converter that supplies reactive and active power over the DC connection.

A. *UPFC controller and its structure*

The control system of UPFC is made up of internal control and functional operational control. The internal controller transmits control signals to the converter valves, prompting them to react appropriately to the converter output voltage using internal reference variables i1ref, iqref, and vpqref. The demands of the series voltage supply are promptly and independently met by series power converters. Unrestricted-circle current control regulates both the active and reactive power components of a shunt motor. The use of the unified power inflow regulator, a crucial FACTS regulator device, enables the ability to control the power inflow in a transmission line. The following are some of the benefits of UPFC.

Both active and reactive power flow can be controlled and improved.

B. Voltage regulation can be done

Figure 1 displays the UPFC's single line diagram. A UPFC is made up of a shunt and a series converter. A shunt converter is connected to a transmission line in parallel, whereas a series converter is connected to a transmission line in series.

C. Operation of UPFC

Two voltage source inverters (VSIs), which share a common dc storage capacitance and are coupled to the power system via coupling factories, are what the UPFC relies on. One VSI is connected in series to the transmission system by a series motor, while the other is connected in shunt by a shunt motor. A series inverter is used to connect a symmetrical, three-phase voltage system (Vc) with programmable magnitude and phase angle in series with the transmission line in order to handle the active and reactive power flows. The line and this inverter will exchange active and reactive power as a result. Although active power is sent to the dc stations, reactive power is electronically inventoried by the series inverter.

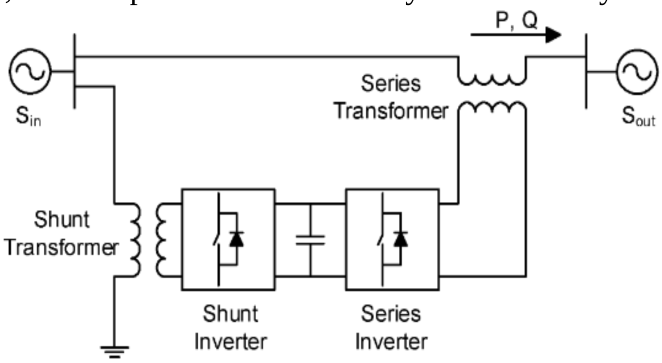

Fig. 1 Transmission system with a single power flow controller

The shunt inverter maintains a constant voltage across the Vdc storage capacitor while drawing dc terminal power from the line (positive or negative). Because of this, the UPFC's net real power consumption from the line is only comprised of inverter and motor losses. Reactive power can be transferred along the line using the shunt inverter's residual capacity, resulting in voltage regulation at the connection point. The two VSIs can function independently of one another by dividing the dc sides. Because of this, in comparable circumstances, the shunt inverter performs as a STATCOM to regulate the level of voltage at the connection point, which produces or absorbs reactive power. The series inverter acts as an SSSC instead (Static Synchronous Series Compensator). To control the flow of current and, consequently, the flow of power over the transmission line, it either produces or consumes reactive power.

3. Proposed System

With Simulink, a modern power system may be represented. Figure 2 depicts a 66KV transmission network single line diagram. Shivansamudra, in this real-time system, a generating station where power is generated transmits the electricity generated to Sathegala, a load zone.

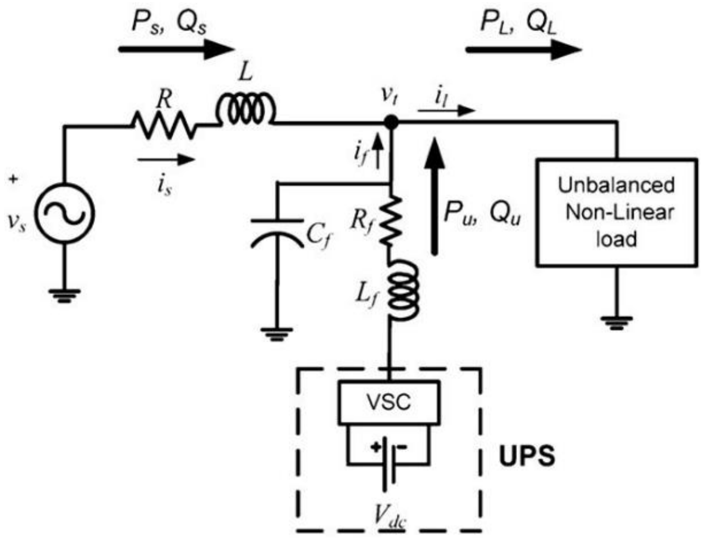

Fig. 2 displays a single line diagram of a 2.2KV/66KV transmission system.

A. Description of Single Line Diagram

Transmission networks using 2.2KV/66KV are controlled by UPFCs. Figure 2 illustrates a single-line diagram of a distribution system that incorporates the UPS. For simplicity, it is assumed that the UPS is powered by a battery with a dc voltage of V. The load is intended to be nonlinear and imbalanced. A feeder's far end has a load attached to it with an impedance of R + jwL, which is provided by a source (v). To get rid of switching harmonics, an LC filter is connected to the VS C output. The circuit losses are shown by the letters L and C, which stand in for the inductance and capacitance of the system, respectively. The letter v stands in for the PCC voltage. This problem can be remedied by including UPFC into the system. Between buses 3 and 4, there is a UPFC that will control the line's power flow. The UPFC power (shunt and series) converter is used in conjunction with generator 1's output power. The 15MW UPFC converters are configured for the given load. The series converter will boost voltage in 0.1 pu increments, increasing the voltage profile of the system and delivering the necessary real and reactive power to the power system.

4. Control System

The following equations for the magnitudes of the injected voltage in series and shunt are produced using the Pulse Width Modulation technique on the two VSCs.

$$v_{SH} = m_{SH} \frac{V_{DC}}{\sqrt{2} n_{SH} V_B}$$

$$V_{SE} = m_{SE} \frac{V_{DC}}{\sqrt{2} n_{SE} V_B} \qquad (1)$$

The phase angle of $V_{SH} and V_{SE} are$

$$\delta_{SH} = \angle(\delta_S - \phi_{SH})$$
$$\delta_{SE} = \angle(\delta_S - \phi_{SE}) \qquad (2)$$

The integrated power flow controller is made up of one shunt converter, as shown in FIG. 1, In addition to a link capacitor, two back-to-back voltage source transformers (ie) are utilized in series. From one current interpolation to the next, the complete circuit acts as a power motor. Voltage Source Motor (VSC) Motor 1 is connected to the line by a coupling motor. Another voltage source motor (VSC) motor 2, which is connected to the transmission line by an interface motor. On the side of the conversion that uses interspersing current, each motor has the ability to power the transmission line. Reactive power is generated or absorbed when switching between two converters. Series-connected converters' main purpose is to inject voltages with independently adjustable magnitudes and phase angles between 0 and 360 degrees. Shunt converter 1 is largely utilised to supply converter 2 with It requires the transmission line's true power. The voltage is transferred from the DC common to the AC line and then injected using a three-level voltage source converter. The voltage across the intermediate circuit capacitor discharges when a voltage is applied to the line. There are four different control strategies that can be used to regulate the voltage, active power, and reactive power of transmission lines.

(1) UPFC-based multilevel converter,
(2) DC capacitor voltage balancing in a rectifier/inverter combo.

5. Results & Discussion

The Matlab-Simulink was used to model the single line diagram of the transmission network in Figure 3. The incorporation of UPFC by choosing external control of the bypass breaker is one of the model's noteworthy characteristics. Every 5 seconds, the breaker is turned on, enabling the addition of the UPFC block to the transmission network.

Table-I
Simulation Parameter

Parameter	Value
Input Voltage	440V
Frequency	50Hz
Vdc	440V
Rectifier Load of Resistance	60 O

The purpose or function of UPFC starts at T=0.15sec, causing an injection of voltage and power. Figures 8 and 9 display the essential simulation result waveform with and without the UPFC. Figure 6 displays the system's simulation results using UPFC. With the UPFC block in the system, the following observations have been made.

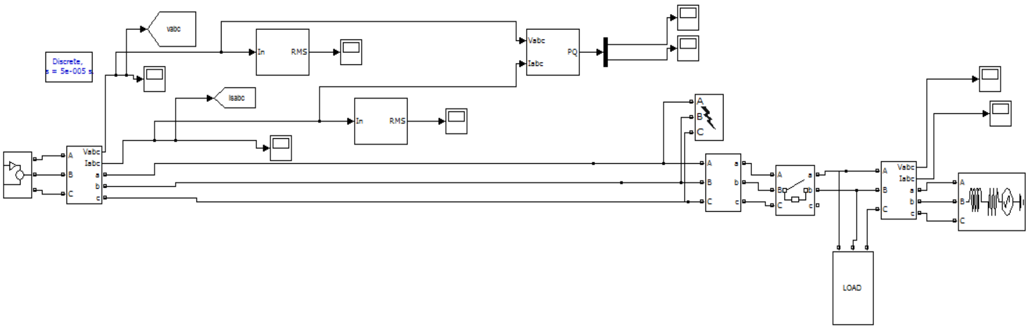

Fig. 3 Model for simulation without UPFC

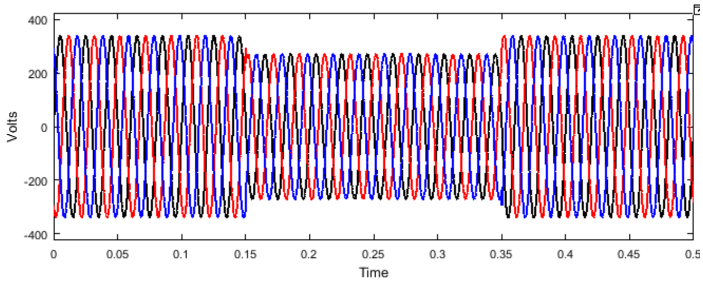

Fig. 4 Source voltage

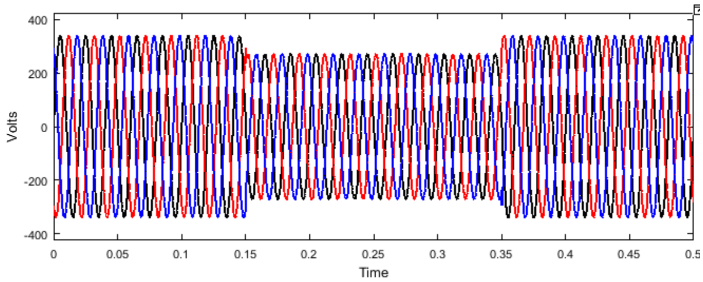

Fig. 5 Load voltage

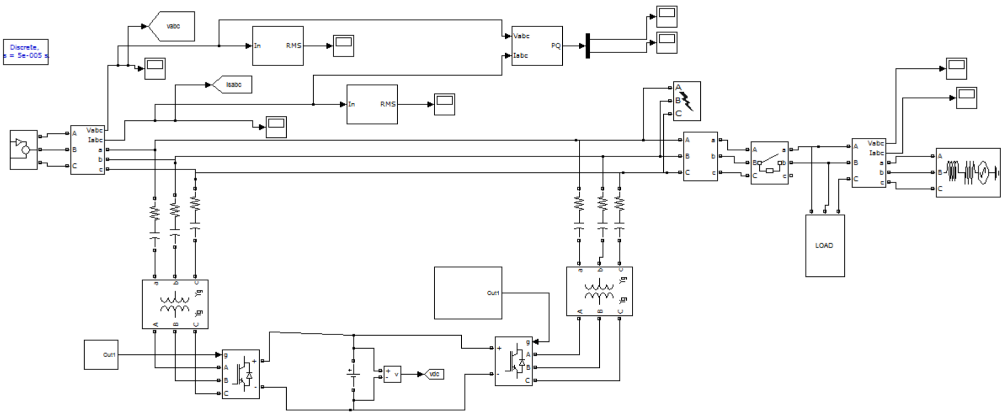

Fig. 6 model for simulation

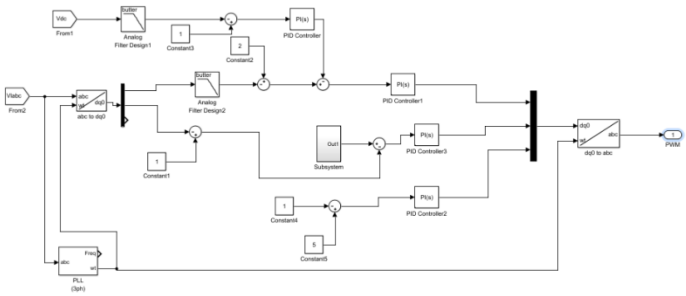

Fig. 7 Control Circuit

6. Results

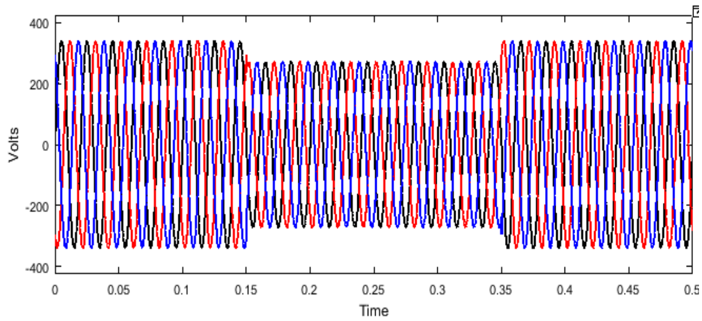

Fig. 8 sag with source voltage

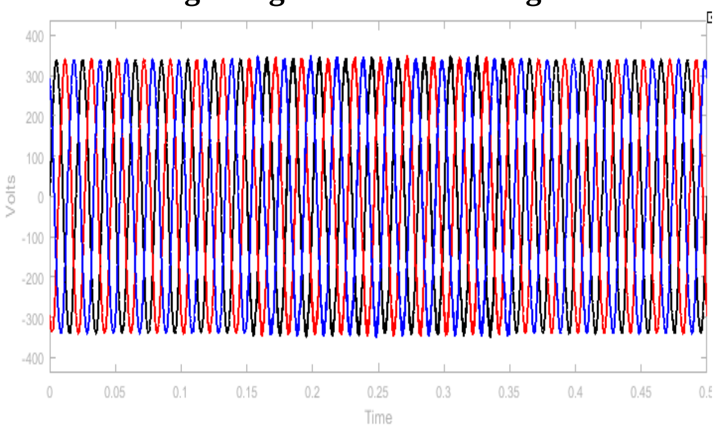

Fig. 9 Load voltage without sag

The simulation model without UPFC is shown in Fig. 3, and the load-related voltage sags are shown in Figs. 4 and 5. While the linear power is expressed in megawatts, the voltage across the buses is expressed in per unit (PU) (MW). Figure 5 shows the voltage harmonics throughout three phases. Only linear load is present since non-linear load is known to be present in the system. Figure 6 features UPFC. Consistent results are obtained because the voltages and line power on all three buses are set to the proper values. Voltage Similar to a normal situation, sags in load voltage are eliminated shown in fig.9. The results also contain a quick Fourier analysis of the model and the computing of harmonics across each of the three bus voltages.

7. Conclusion

The quality of the power is influenced by voltage, actual and reactive power, and other factors. It is now possible for UPFC to regulate the flow of electricity thanks to its incorporation into the current power system. The energy demand can be met with the aid of UPFC even if the generator or transformer unit trips. The required 0.1 pu of voltage is injected by the UPFC's series converter, which further improves the voltage profile. The real power and reactive power adjustment provided by the system's UPFC block has improved the quality of the power in the modern power system.

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