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INNOVATIVE POWER FLOW CONTROL USING INTERLINE POWER FLOW CONTROLLERS

Dr. V. LAKSHMI DEVI, *Professor,*
Department of EEE,
SRI VENKATESWARA COLLEGE OF ENGINEERING (Autonomous), Tirupathi.

ABSTRACT: A cutting-edge technology for managing power flow over transmission lines, the interline power flow controller (IPFC) is the focus of this study. We use MATLAB to build and test the IPFC model. For subnetwork or multiline systems, an interline power flow controller is a versatile instrument for managing power flow. The IPFC, or Interline Power Flow Controller, uses FACTS to offer series correction. A converter regulates the flow of electricity across many transmission lines that share a single corridor. An integral part of the system is a VSC that shares voltage sources and has a dc-link input. The active power transfer is handled by the single dc-link, while the reactive power exchange is handled by the VSCs' individual transmission systems.

Keyword- *Interline Power Flow Controller (IPFC), Voltage Source Converter (VSC), Transmission Line, Reactive Power.*

I. INDRODUCTION

The increasing deployment of high-performance computer components within enterprises has posed significant challenges to electricity distribution infrastructure. Nonlinear pressures serve as the primary source of these issues. These devices frequently encounter issues related to current imbalance and harmonic leakage, in addition to utilizing significant amounts of reactive power. In response to the increasing demand for energy, transmission capacity and output have been expanded, and power systems have recently been integrated. Consequently, dynamic stability is crucial for the sustainment of substantial power sources. A practical and economical approach to alleviating power system fluctuations is the deployment of power system stabilizers (PSS). The Power System Stabilizer (PSS) [I] is unable to effectively mitigate oscillations resulting from major disturbances, such as three-phase defects at the generator terminals. Static Variable Compensators (SVC), Unified Power Flow Controllers (UPFC), and Static Synchronous Compensators (STATCOM) are among the devices utilized in Flexible AC Transmission Systems (FACTS).

By minimizing modifications and informing the principal control loop, they improve the stability of the power system. A distinct category of FACTS device utilized for series regulation is the Interline Power Flow Controller (IPFC). This device enables the efficient regulation of power distribution across multiple lines. A common DC link interconnects multiple voltage source converters (VSCs) within the IPFC. The selected transmission line (slave or master) may be sequentially modified by each VSC. This facilitates the transfer of reactive electricity through the transmission mechanism of each VSC. Reactive energy demands in residential and commercial environments are the main contributors to issues in power quality. Non-resistive loads require reactive power in conjunction with increased RMS current. As a result, electrical distribution and transmission networks generate elevated levels of heat. It has long been proposed that local reactive power be generated through the use of synchronous machinery or capacitor banks.

The application of STATIC VAR compensators for stabilizing power systems has advanced significantly. This is attributable to the increasing production of products and electrical systems. Such measures seem ineffective and could potentially exacerbate issues within the power system when losses caused by current and voltage harmonics are significant. Our confidence in these systems is diminished owing to the intricacy involved in correcting reactive energy. These compensatory components are also likely to be influenced by the motions of the system. Over the past three decades, researchers have been motivated by the need for effective solutions to power quality issues, particularly harmonics, the expansion of the power electronics sector, and advancements in digital signal processing.

They were instructed to develop enhanced and more adaptable techniques for addressing issues related to electrical quality. These improved options are designated as IPFC compensators. These IPFCs are responsible for compensating specified levels of reactive power and controlling irregular currents and voltages. The attenuation device for low-frequency waves must be designed based on the nonlinear dynamic model of the power system. Nonetheless, owing to the complexity of this approach, the linear dynamic model of the system is frequently employed for analysis and controller development within a specific operational state. The accuracy of the controller and the necessary degree of variation damping are subsequently assessed using the nonlinear dynamic model.

Interline Power Flow Controller:

Recent developments in FACTS research have enabled the development of an innovative device referred to as the Interline Power Flow Controller (IPFC). This site contains a substantial number of series voltage source converters (VSCs). Although distributed over multiple lines, they remain interconnected at their DC terminals. Each Voltage Source Converter (VSC) is capable of incrementally regulating reactive power by delivering real power to the primary DC connection via its dedicated line. The IPFC facilitates the effective administration of multiple communication lines from a centralized location. The excess energy generated by these lines during periods of inactivity could be harnessed by other lines to maintain the stability of the electrical supply. This function corrects the reactive power and voltage reductions induced by resistors. Furthermore, it redistributes power demands from overburdened lines to under loaded lines, balances the flow of active and reactive power, and improves system performance by mitigating dynamic challenges. When utilized in this configuration, the IPFC provides a multi-line inverter with a highly efficient approach to power transmission. Figure 1 illustrates a fundamental schematic of the IPFC.

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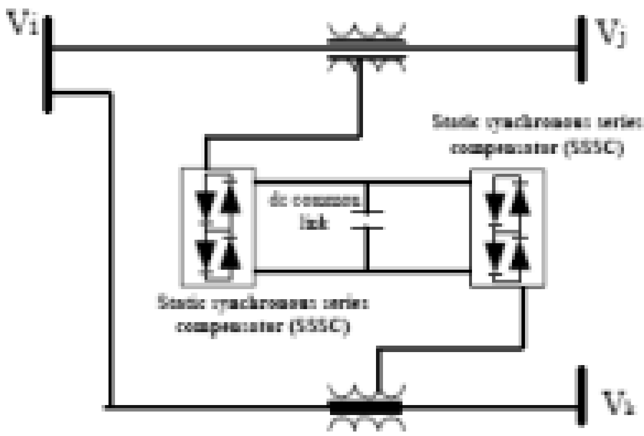

Fig 1 Schematic representation of IPFC

Controlling Scheme:

An ABC-DQ transformation block and a phase-locked loop (PLL) are utilized to derive phase information from the voltage vabc. The grid voltage signal Vabc is converted into Vd and Vq during this procedure.

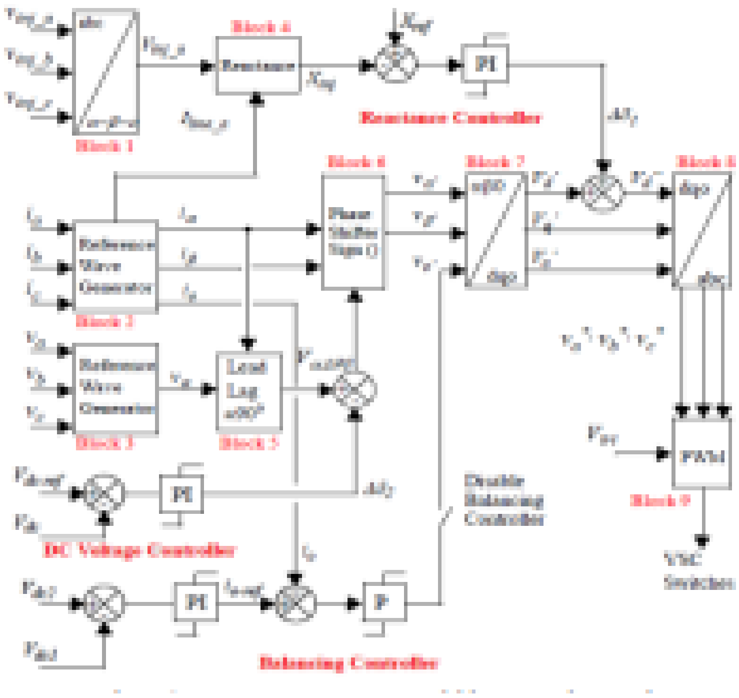

Fig 2 VSC controlling circuit

That is to say, active power and reactive power are distinct concepts. In this thorough comparison, the direct current voltage (Vdc) is compared to a reference value (VdcRef). The voltage produced by the error transfer between vdc and vdcref is controlled by an auxiliary proportional-integral (PI) controller. The three-phase power's d component is not the same as this. The PI controller modifies the command signal's q-component by comparing the three-phase voltage's q-component to a zero-reference value.

Following the inverse translation, the dq components of the voltage are obtained using the methodology that explains the relationship between current and voltage. A space vector PWM (SVPWM) controller will generate the switch control signals.

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Basic Structure & Principle of Operation of Ipfc

The IPFC extensively employs DC-to-DC converters within its fundamental architecture. Each individual pertains to an issue related to a transmission line. The converters are connected to the AC power lines and their DC terminals through various varieties of coupling transformers. The transmission line of any converter can be configured to deliver active power and series reactive compensation to a single direct current connection.

Within the M series, there exists a unique series converter with two degrees of control freedom. This is due to the necessity of balancing the received and transmitted active electricity. Nonetheless, the remaining m−1 series converters in an IPFC with m series converters exhibit two degrees of control flexibility. Because of its integrated real power with the support system, it functions similarly to a UPFC. By serving as a series converter within the secondary line and modifying its amplitude and phase angle, it also influences the voltage in the primary system (or line). To compensate for the removal of two lines, the IPFC consists of two processors.

A primary distinction between a shunt converter and a series converter is that the former functions as an auxiliary element within a Unified Power Flow Controller (UPFC). A slave converter is a device connected to the primary IPFC system, while a master converter is a device associated with the secondary system. The master converter controls the active and reactive voltages to ensure they stay within specified limits. Conversely, the slave converter controls the DC voltage across the capacitor and the reactive voltage.

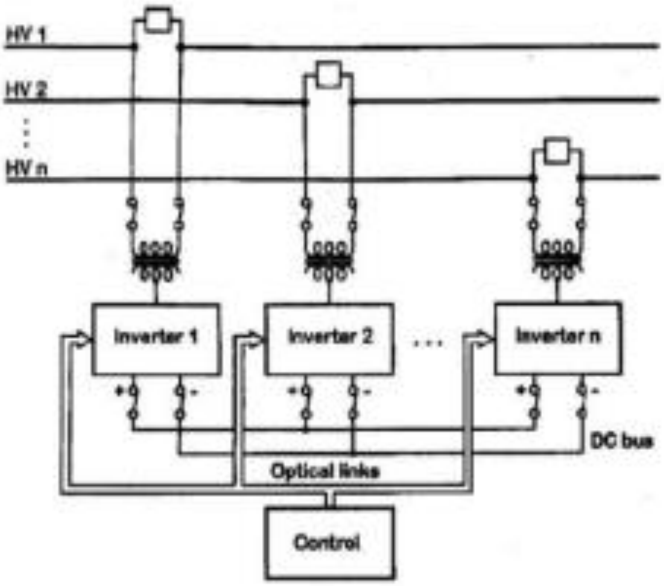

Fig.3. A Interline Power Flow Controller comprising n converters

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II. SIMULATION AND RESULTS

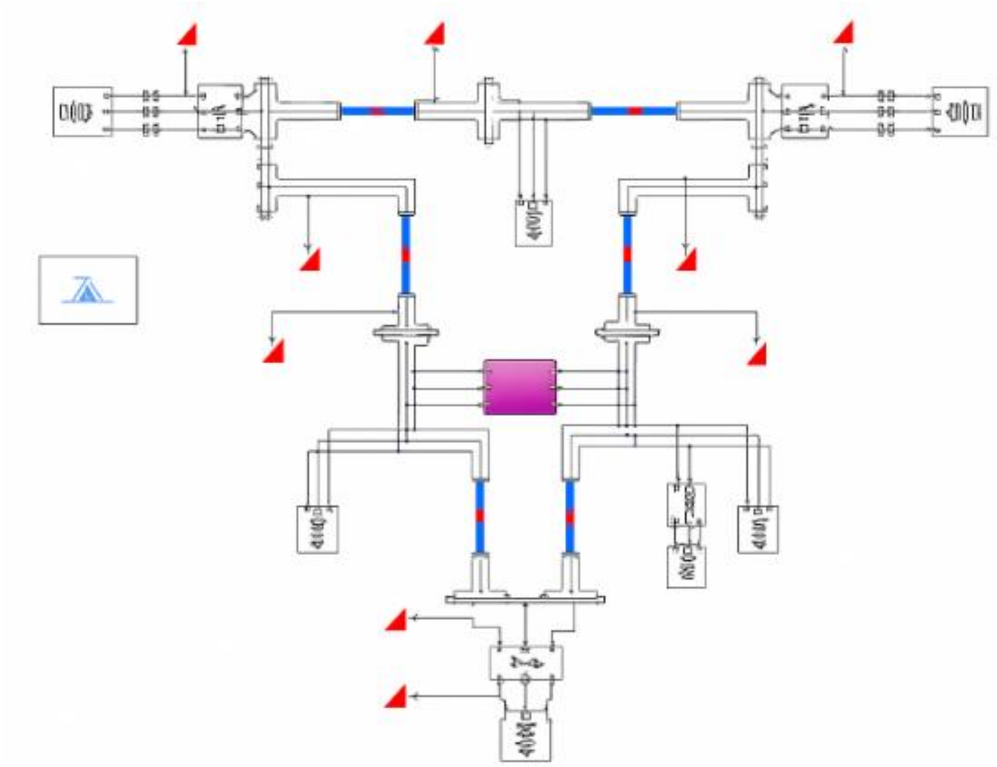

Fig 4 Simulink model of IPFC controller

Figure 4 Illustrates the fundamental power system, demonstrating how the IPFC can alter electricity transmission and the overall power system. Figure 4 depicts the power supply utilized for the IPFC test. Table 1 displays the voltage levels and profiles for each transmission line without the inclusion of IPFC. Furthermore, it displays the measurements of real and reactive power flow. This knowledge enables a more comprehensive comprehension of the manner in which IPFC impacts the power grid.

Table 1 load flow analysis of IEEE 9 Bus system(fault condition)

Bus no	Base voltage	Phase angle	P	Q
1	1.04	0.00	210.07	117.64
2	1.03	0.39	163	53,80
3	1.03	-2.47	85	18.52
4	0.98	-6.80	0.00	0.00
5	0.89	-14.87	177.33	110.93
6	0.98	-8.61	78.35	30.4
7	1.00	-5.33	0.00	0.00
8	0.99	-7.18	90.13	31.55
9	1.02	-5.17	0.00	0.00

Table 2 load flow analysis of IEEE 9 Bus system(with IPFC)

Bus no	Base voltage	Phase angle	P	Q
1	1.04	0.00	107.60	46.06
2	1.03	6.81	163	17.50
3	1.03	2.27	85	3.63
4	1.02	-3.35	0.00	0.00
5	0.99	-6.69	121,12	48,57
6	0.99	-.5.53	88.97	34,60
7	1,02	1.23	0.00	0.00
8	1.01	-1.56	101.39	35.48
9	1.02	-0.44	0.00	0.00

To evaluate the influence of IPFC, three case studies conducted subsequent to the initial data collection— which did not employ IPFC— are presented and analyzed.

III. CONCLUSION

This study examines multiple variables to determine the influence of IPFC on the power system. The voltage profile and the transmission lines' active and reactive power flows are two examples. An Interline Power Flow Controller (IPFC) has been demonstrated to transfer energy. This model considers the line charging susceptibility and the complex impedance of the series coupling transformer. The figure illustrates how the IPFC can alter the voltage profiles of adjacent buses, reducing reactive power and increasing active power transmission across the lines. The voltage level on the bus connected to the IPFC inverters may subsequently increase.

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