AN INNOVATIVE METHOD FOR MANAGING POWER FLOW IN TRANSMISSION SYSTEMS WITH INTERLINE POWER FLOW CONTROLLERS

#1K. Ramakrishna Prasad, Associate Professor,
#2J. Kanthaiah, Assistant Professor,
#3M. Prathima, Assistant Professor,
Department of Electrical and Electronical Engineering,
SAI SPURTHI INSTITUTE OF TECHNOLOGY, SATHUPALLY, KHAMMAM.

ABSTRACT-

The current work describes an innovative technology dubbed the interline power flow controller (IPFC), which is intended to regulate power flow in transmission systems. The IPFC model is constructed and simulated using MATLAB. An interline power flow controller is a versatile device that can be used to control the flow of electricity in sub networks or multiline systems. The Interline Power Flow Controller (IPFC) uses FACTS for series compensation. A converter efficiently regulates power transfer across several transmission lines within the same corridor. The system is made up of one or more typical dc-link voltage source converters (VSCs). Active power transfer is facilitated by the shared dc-link between the VSCs, whereas reactive power exchange occurs separately via their own transmission systems.

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

I. INDRODUCTION

The increased use of power electronic components in industry has caused major disruptions in electric power distribution networks, mostly owing to nonlinear loads. In addition to considerable reactive power consumption, harmonic emissions and current imbalance occur often. The dynamic stability of power systems is an important aspect of ensuring the stability of major power systems, especially with the recent interconnection of power systems and growth of transmission and generation to meet rising power demand. Power system stabilizers (PSS) are a cost-effective and realistic solution for improving power system oscillation stability. Severe disruptions, such as three-phase faults at generator terminals, can cause oscillations that the Power System Stabilizer (PSS) cannot suppress [I]. Flexible AC Transmission System (FACTS) controllers include static variable compensators (SVC), static synchronous compensators (STATCOM), and unified power flow controllers (UPFC). These controllers can increase the stability of power systems by minimizing oscillations and providing an additional signal to the main control loop. The Interline Power Flow Controller (IPFC) is a new FACTS controller designed for series compensation. It has the unique ability to efficiently manage power flow across many lines. The IPFC makes use of several voltage source converters (VSCs) linked together by a shared dc-link. Every VSC is capable of exchanging reactive power with its own transmission system and providing series compensation for the selected transmission line (slave or master line).Power quality issues are primarily focused with the use of reactive power in residential and industrial loads. Non-resistive loads not only increase RMS current values, but they also contribute to increased heat generation in power distribution and transmission networks by using reactive power. It has long been suggested that reactive power should be generated locally using synchronous machines or capacitor batteries. The growth of power electronics and semiconductor production has tremendously aided the use of STATIC VAR compensators for reactive power correction. However, these treatments appear to be ineffectual and may exacerbate difficulties in power systems when there are high levels of current and voltage harmonic emissions. These systems are considered unstable in modern technologies due to their unique function of correcting reactive power, which is fundamentally based. Furthermore, there is a high probability of interaction between these compensatory elements and system harmonics. Researchers have been spurred throughout the last three decades by the growth of the power electronics sector, advances in digital signal processing, and a growing desire for effective solutions to power quality issues, particularly harmonics. They were encouraged to propose novel, adaptable, and improved solutions to power quality issues. These advanced solutions are referred to as IPFC compensators. These IPFCs not only provide selective reactive power compensation, but they also attempt to manage harmonic currents and voltage. The damping controller for low frequency oscillations must be designed using the power system's nonlinear dynamic model. Nonetheless, due to the complexities of this method, the linear dynamic model of the system is frequently used at a specific operational state for analysis and controller design. The controller is then tested within the nonlinear dynamic model to ensure that it is precise and has the proper level of oscillation damping.

Interline Power Flow Controller:

The Interline Power Flow Controller (IPFC) is a novel device that emerged as a result of recent advances in FACTS research. This component is made up of numerous series voltage source converters (VSCs) that are coupled at their DC terminals and routed onto multiple lines. As a result, each Voltage Source Converter (VSC) is capable of providing real power to the shared DC connection via its own line while also adjusting for reactive power sequentially. The IPFC allows them to successfully manage many transmission lines at a single substation. In fact, unused lines generate excess power, which can be used by other lines to manage actual power. This capability enables the transfer of power demands from overloaded to underloaded lines, equalization of real and reactive power flows, compensation for resistive line voltage drops and corresponding reactive line power, and improved effectiveness of a compensating system for dynamic disturbances. As a result, the IPFC provides a very effective power transmission method to a multi-line substation. Figure 1 depicts a schematic illustration of the IPFC.

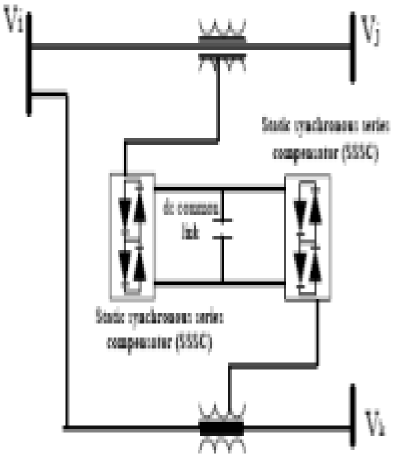


Fig 1 Schematic representation of IPFC

Controlling Scheme:

To obtain phase information, the voltage v_{abc} is processed through a phase locked loop (PLL) and an abc-dq transformation block. This conversion transforms the grid voltage signal V_{abc} into V_d and V_q.

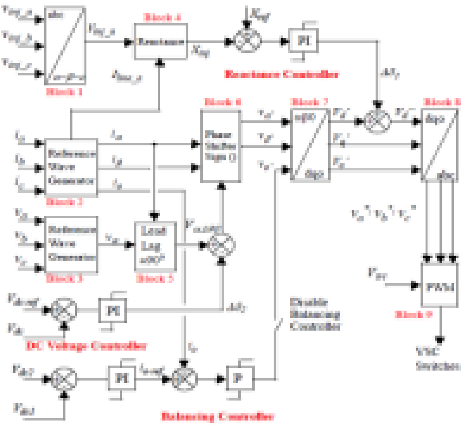


Fig 2 VSC controlling circuit

Thus, it is possible to separate active and reactive power. Following that, a detailed analysis is performed to compare the direct current voltage (vdc) to a preset reference value (vdcref). After passing the error between vdc and vdcref via a PI controller and comparing it to the d component of the three-phase voltage, the resultant voltage is handled by a second PI controller as the output. Meanwhile, the PI controller produces an output that regulates the q component of the command signal by comparing the q component of the three-phase voltage to a predetermined value of zero.

Following the inverse transformation, the dq components of the voltage are calculated using the formula that describes the relationship between current and voltage. The switch control signals will then be executed using a space vector PWM (SVPWM) control module.

Basic Structure & Principle of Operation of Ipfc

In its basic configuration, the IPFC employs a large number of dc to dc converters, each of which provides series compensation for a specific transmission line. The converters are coupled to the AC systems and connected at their DC terminals by a series of coupling transformers. This technology allows any converter to be configured to deliver active power from its own transmission line to a shared direct current connection while simultaneously providing series reactive compensation[5].Except for the one series converter, which has only one control degree of freedom due to the need for balanced active power exchange among the m series converters, an IPFC with m series converters gives two control degrees of freedom for the remaining m-1 series converters. An IPFC, like a UPFC, regulates the amplitude and phase angle of the injected voltage in the primary system (or line) by exchanging real power with the support system (which also functions as a series converter in the second line). The IPFC has two converters that compensate for two lines. The primary distinction between a UPFC and a series converter is that in the latter case, the shunt converter serves as a supporting system. The phrase "master converter" refers to the series converter connected to an IPFC's prime system, whereas "slave converter" refers to the series converter connected to the support system. The slave converter regulates the amplitude of the reactive voltage and the DC voltage across the capacitor, whereas the master converter keeps both the active and reactive voltage within defined limits.

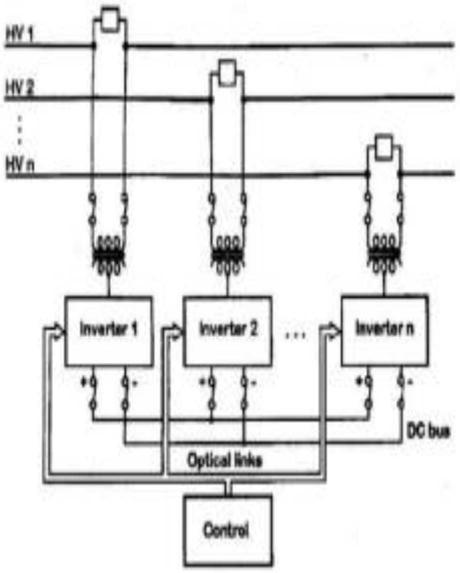


Fig.3. A Interline Power Flow Controller comprising n converters

II. SIMULATION AND RESULTS

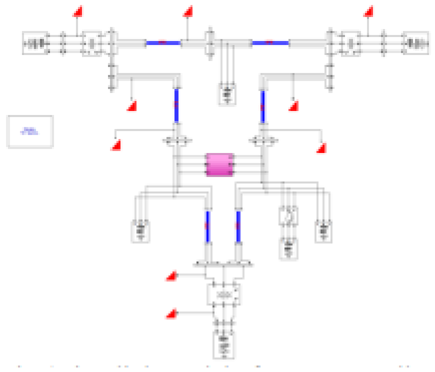
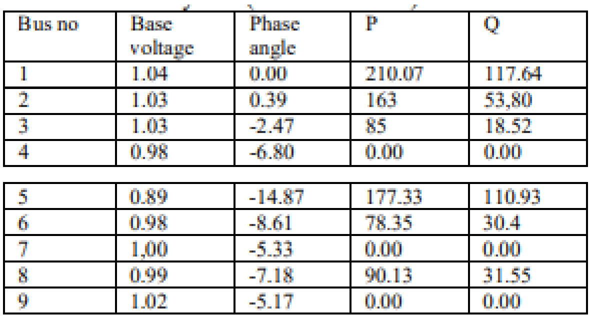


Fig 4 simulink model of IPFC controller

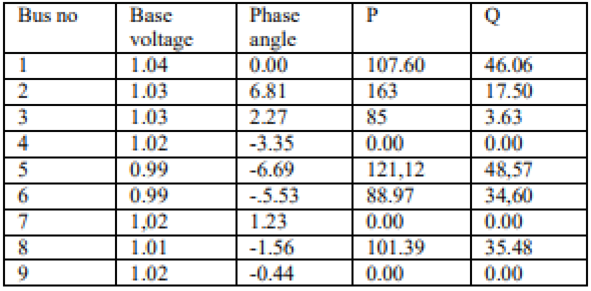
Figure 4 depicts the most basic power system, which is designed as a test power system to examine the impact of IPFC on the power system and power flow. Figure 4 shows the test power supply using IPFC. Table 1 shows the power flow statistics, including voltage magnitude and profile, as well as real and reactive power flow, in all transmission lines in the absence of IPFC. This information is useful in understanding the impact of IPFC on the power system.

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

The impact of IPFC is investigated through the presentation and analysis of three case studies that were undertaken after collecting preliminary results in the absence of IPFC.

III. CONCLUSIONS

This study looks at the impact of IPFC on the power system and analyzes numerous parameters, including voltage profile and actual and reactive power flow in the system's transmission lines. The Interline Power Flow Controllers' (IPFC) power injection model has been introduced. This model takes into account the series coupling transformer's complex impedance as well as the line charging susceptance. The example demonstrates the capacity of the incoming IPFC to raise the bus voltage connected to IPFC converters, significantly alter the voltage profile of surrounding buses, and increase active power flow while decreasing reactive power flow through the lines.

REFERENCES

1. Carsten, L., 2002. Security constrained optimal power flow for uneconomical operation of FACTS-devices in liberalized energy markets. IEEE Trans. Power Delivery, 17: 603-608.
2. Enrique, A., C.R. Fuerte-Esquivel, H. Ambriz-Perez and C. Angeles-Camacho, 2004. FACTS Modelling and Simulation in Power Networks. West Sussex, England: John Wiley & Sons Ltd., pp: 200-201,227-228, 267-307.
3. Jun, Z. and Y. Akihiko, 2006. Optimal power flow for congestion management by interline power flow controller (IPFC). International Conference on Power System Technology, Chongqing, China. Peng, Y., Y. Ying and S. Jiahua, 2004. A reliable UPFC control method for optimal power flow calculation. Proceeding 2004 IEEE Power Engineering

Society General Meeting, Denver, pp: 1178-1183.

4. Teerathana, S., A. Yokoyama, Y. Malachi and M. Yasumatsu, 2005. An optimal power flow control method of power system by interline power flow controller (IPFC). Proceeding 7th International Power Engineering Conference, Singapore, pp: 1-6.
5. Venkataraman, P., 2002. Applied Optimization with Matlab Programming. John Wiley & Sons, New York, pp: 353.
6. Xiao-Ping, Z., H. Edmund and Maojun, 2001. “Mike” Yao, Modeling of the Generalized Unified Power Flow Controller (GUPFC) in a nonlinear interior point OPF. IEEE Trans. Power Sys., 16: 367-373.
7. Ying, X., Y.H. Song and Y.Z. Sun, 2000. Power injection method and linear programming for FACTS control. Proceeding 2000 IEEE Power Engineering Society Winter Meeting, Singapore, pp: 877-884.
8. Zhang, X.P., 2003. Modelling of the interline power flow controller and the generalized unified power flow controller in Newton power flow. IEE Proceedings Generation, Transmission and distribution, 150:268-274.