

SIMULATION AND DESIGN OF REAL POWER CONTROLLED IPFC SYSTEM USING PSPICE

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Abstract

This paper describes closed loop controlled inter Line Power flow controller used in power system. An Inter line power flow controller is VSC-based FACTS controller for series compensation with the unique capability of power management among multilines of a sub-station. The FACTS technology is essential to alleviate these difficulties by enabling utilities to get most service from their transmission facilities. FACTS controllers can control series impedance, shunt impedance, current, voltage and phase angle. Different FACTS controller's circuits are simulated using PSPICE software package. IPFC is used to improve the power flow and to provide a power balance of a transmission system. The circuit model of IPFC was developed and the same is used for simulation.

Key Words FACTS, SSSC, IPFC, TCR, PSPICE.

I. INTRODUCTION

As a result of Flexible AC transmission system, considerable effort has been spent in recent years on the development of power electronics based power flow controllers [1]. They employ self-commutated inverters as synchronous voltage sources. The power electronics based voltage sources can internally generate and absorb reactive power without the use of capacitors and reactors. They can facilitate both real and reactive power compensation and thereby can provide independent control for real and reactive power flow [2, 3].

The Interline Power Flow Controller (IPFC) scheme proposed provides, together with independent controllable reactive series compensation of each individual line, a capacity to directly transfer real power between the compensated lines. This capability makes it possible to equalize both real and reactive power flow between the lines; transfer power demand from overland to under loaded lines; compensate against resistive line voltage drops and the corresponding reactive power demand; increase the effectiveness of the overall compensating system for dynamic disturbances[4,5]. The IPFC can potentially provide an effective scheme for power transmission management at a multi-line substation.

In the literature [1] to [9], the simulation of closed loop system with phase angle difference is not presented. In the present work, the circuit model for

closed controlled IPFC is developed and the same is used for simulation.

1.1. Interline Power Flow Controller

The basic principles of the Interline Power Flow Controller (IPFC) employs a number of DC to AC inverters each providing series compensation for different line as showing in Fig.1.1. The series compensation is provided by Static Synchronous Series Compensators [6].

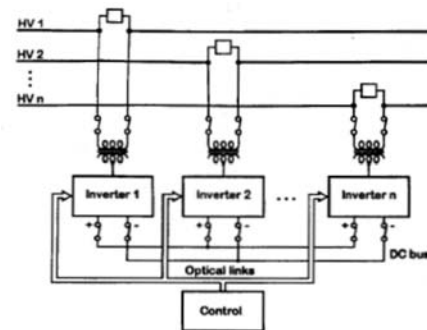


Fig.1. Block Diagram of an Inter line Power flow Controller

The Compensating inverters are linked together at the DC terminals. The compensators in addition to provide series reactive compensation can be controlled to supply real power exchange through the dc link from its own transmission line[7]. Thus surplus power available in underutilized lines is made available by other lines. This arrangement mandates the rigorous maintenance of the overall power balance at the

common dc terminal by appropriate control action, using the general principle that the under loaded lines are to provide help, in the form of appropriate real power transfer, for the overloaded lines [8-10].

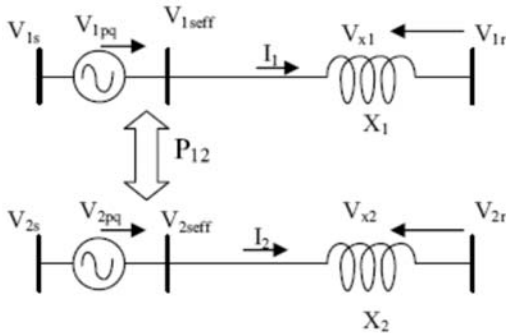


Fig. 2. Basic Interline Power flow controller

The elementary IPFC scheme consisting of two back-to-back dc to ac inverters each compensating a transmission line by series voltage injection is shown in Fig. 2. Two synchronous voltage sources, with phasors V_{1pq} and V_{2pq} in series with transmission lines 1 and 2, represent the two back-to-back dc to ac inverters. The common dc link is represented by a bi-directional link for real power exchange between the two voltage sources. Transmission Line 1, represented by reactance X_1 , has sending end bus with voltage phasor V_{1r} . The sending end voltage phasor of line 2, represented by reactance X_2 , is V_{2s} and the receiving end voltage phasor is V_{2r} .

All sending end and receiving end voltages are constant with fixed amplitudes, $V_{1s} = V_{1r} = V_{2s} = V_{2r} = 1 \text{ p.u.}$, and with fixed angles resulting in transmission angles, $\delta_1 = \delta_2$.

The line impedances and the rating of the two compensating voltage sources are identical, that is $V_{1pqmax} = V_{2pqmax}$ and $X_1 = X_2 = 0.5 \text{ p.u.}$

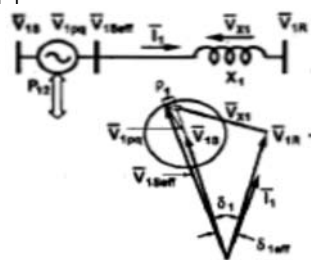


Fig. 3. For prime system and phasor diagram

Fig.3 is the phasor diagram defining the relationship between V_{1s} , V_{x1} and the inserted phasor voltage V_{1pq} . The inserted voltage phasor V_{1pq} is added to the fixed end voltage phasor V_{1s} to produce the effective sending end voltage. The difference between V_{1s} self and V_{1r} , gives the compensated voltage V_{x1} , across, X_1 . As $r1$ is varied over its full 360 range, the end of phasor V_{1pq} moves along a circle with its centre at the end of V_{1s} .

The rotation of phasor V_{1pq} with angle $r1$ modulates both the magnitude and angle phasor V_{x1} and therefore both real power P_{1R} and reactive power Q_{1R} vary with $r1$ in a sinusoidal manner as shown in Fig.4. The voltage source inverter (V_{1pq}) supplies or absorbs both real power (P_{1pq}) and reactive power (Q_{1pq}), which are also sinusoidal functions of angle r .

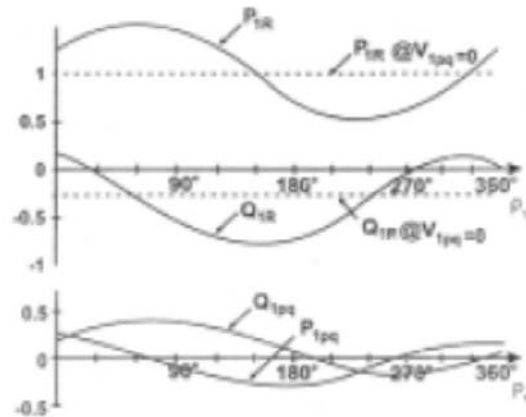


Fig. 4 Variation of the Real and Reactive Power with Respect to Phase Angle

II SIMULATION RESULTS

The circuit model of IPFC is shown in Fig 5a. In this model, the series transformers are represented as voltage dependent voltage sources. The real power waveform without IPFC is shown in Fig. 5b. The real power waveform with IPFC is shown in Fig 5c. From Fig 5c, it can be seen that the real power is increased.

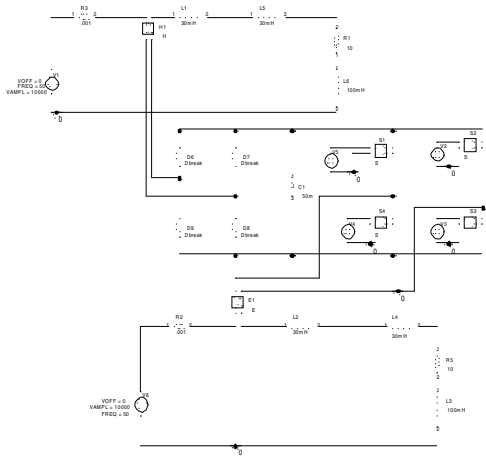


Fig 5a. Circuit model of IPFC with phase difference

The circuit model of IPFC with different values of voltages is shown in Fig .6a.Lines 1&2 operate at 11kv and 10kv respectively.

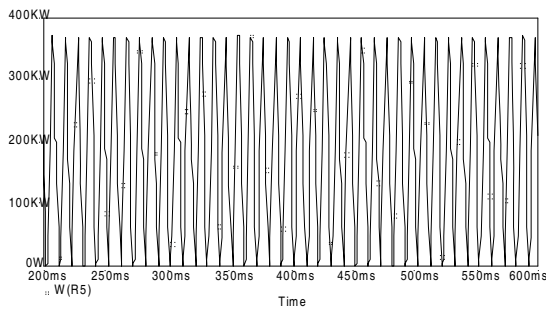


Fig. 5b. Real power without IPFC

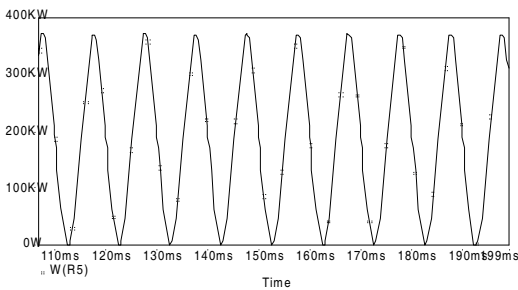


Fig. 5c. Real power with IPFC

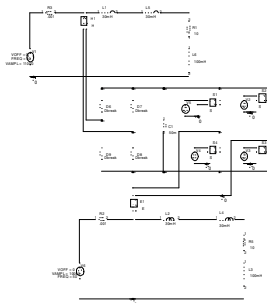


Fig. 6a. Circuit model of IPFC with different voltages.

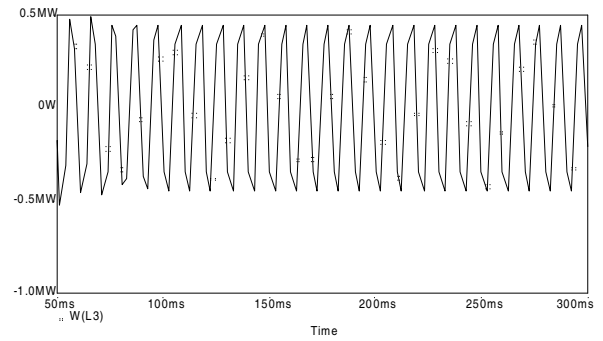


Fig. 6b.The Reactive power without IPFC

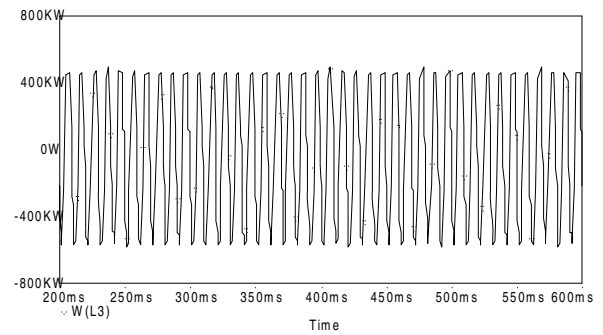


Fig. 6c.The Reactive power with IPFC

From Fig.6c, it can be observed that the Reactive power is increased.

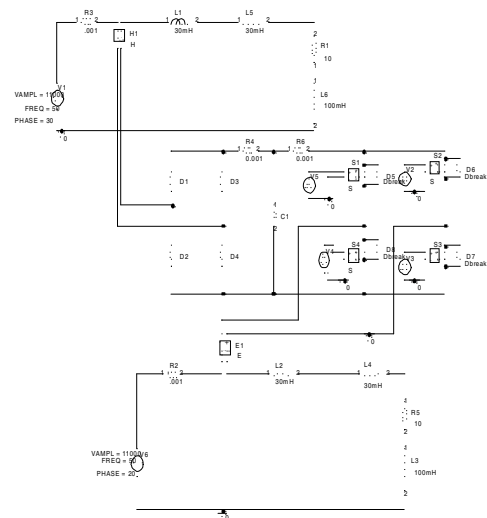


Fig. 7a.circuit model with different phase angles.

The circuit model with different phase angles is shown in Fig 7a.Sources at lines1 and 2 operate at 20° and 30° respectively. Real and reactive powers in line1 are shown in Figs 7b&7c respectively. Real and reactive powers in line 2 are shown in Figs 7d & 7e respectively.

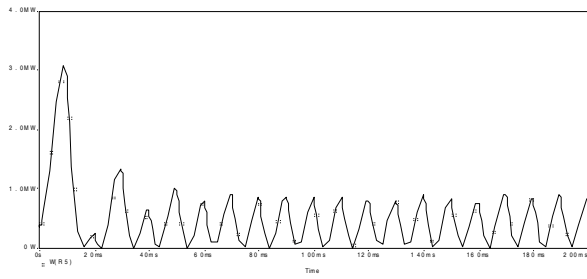


Fig. 7b. Real power in line1

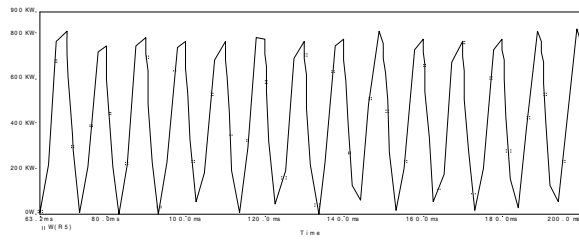


Fig. 7c. Reactive power in line1

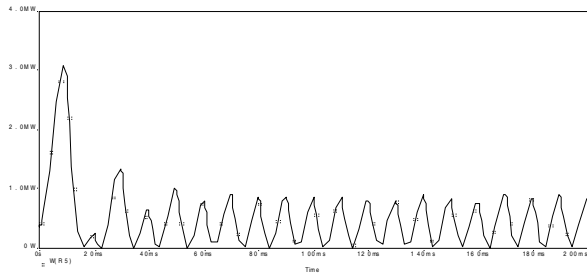


Fig. 7d. Real power in line2

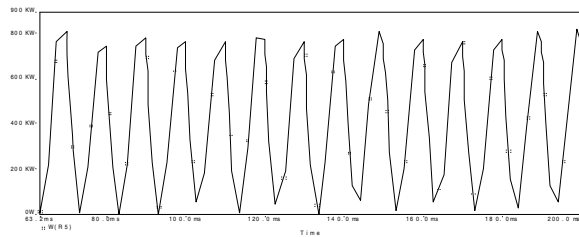


Fig. 7e. Reactive power in line2

III. CLOSED LOOP SYSTEM

Closed loop controlled IPFC system with phase angle difference between two lines is shown in Fig.8. Two transmission lines, one with phase angle 0° and other with the 20° is considered. Sending end

voltages are sensed and they are applied to the compensator. The output of the compensator is rectified using a rectifier. The different between compensator output and reference voltage are amplified by a differential amplifier. This output controls the switch in the IPFC.

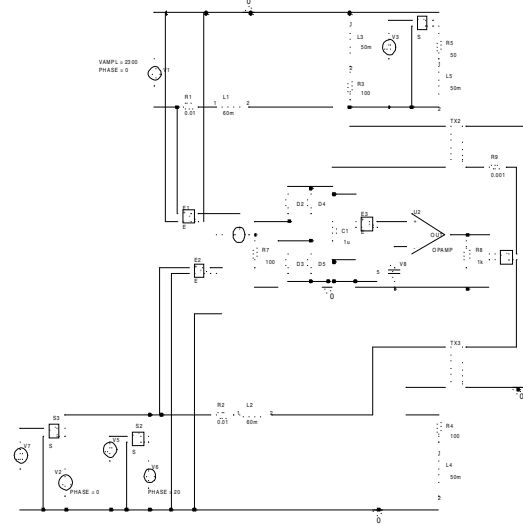


Fig. 8. Circuit Model of closed loop system with phase difference

Real power with and without compensation over loaded line is shown in the Figs 8a & 8b. From Figs 8a & 8b it can be seen that real power drawn from the source with compensation is less than the real power drawn from the source without compensation. Fig.8c. shown that input power in the normal load line with compensation.

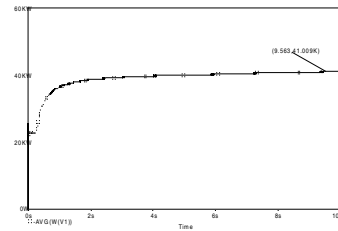


Fig. 8a. Power in the over loaded line with compensation

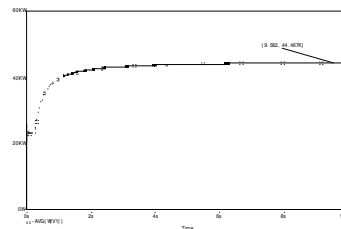


Fig. 8b. Power of over loaded line without compensation

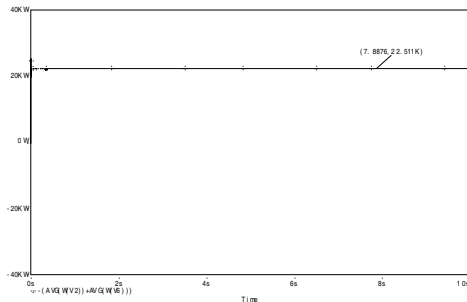


Fig. 8c. Power in the normal loaded line with compensation

IV. CONCLUSION

A new circuit model for IPFC with phase difference is developed and the same is simulated to study the real and reactive power flows. The circuit model for open loop and closed loop systems are presented. They are used to simulate the two line system to study real and reactive power flows. It is observed that the real and reactive powers are increased by the presence of IPFC. The IPFC is a viable solution to balance the power flow in a transmission system.

V. REFERENCES

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