Abstract - This paper describes the theory and the modeling technique of a Flexible Alternating Current Transmission Systems (FACTS) device, namely, Unified Power Flow Controller (UPFC) using an Electromagnetic Transients Program (EMTP) simulation package. The UPFC, in this paper, consists of two solid-state voltage source inverters which are connected through a common DC link capacitor. Each inverter is coupled with a transformer at its output. The first voltage source inverter, known as Static Synchronous Compensator (STATCOM), injects an almost sinusoidal current, of variable magnitude, at the point of connection. The second voltage source inverter, known as Static Synchronous Series Compensator (SSSC) injects an almost sinusoidal voltage, of variable magnitude, in series with the transmission line. This injected voltage can be at any angle with respect to the line current. The exchanged real power at the terminals of one inverter with the line flows to the terminals of the other inverter through the common DC link capacitor. In addition, each inverter can exchange reactive power at its terminals independently. The functionalities of the models have been verified.

Keywords - AC transmission, FACTS, power flow controller, power converter, inverter, thyristor, GTO, etc.

I. INTRODUCTION

Electric power flow through an alternating current transmission line is a function of the line impedance, the magnitudes of the sending-end and receiving-end voltages, and the phase angle between these voltages. Essentially, the power flow is dependent on the voltage across the line impedance. Fig. 1a shows a simple line diagram of a single transmission line with an inductive reactance, \( X_L \), and a series insertion voltage, \( V_{dq} \), connecting a sending-end voltage source \( V_s \) and a receiving-end voltage source \( V_r \), respectively. The voltage across the transmission line reactance, \( X_L \), is

\[
V_X = V_s - V_r - V_{dq} = I X_L
\]

where \( I \) is the current in the transmission line.

The voltage, \( V_X \), across the transmission line can be changed by changing the insertion voltage, \( V_{dq} \), in series with the transmission line and, consequently, the line current and the power flow in the line will change. Consider the case where \( V_{dq} = 0 \)

Flexible Alternating Current Transmission Systems (FACTS) devices, namely STATic Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC), are used to control the power flow through an electrical transmission line connecting various generators and loads at its sending and receiving ends. The UPFC, in this paper and existing references, consists of two solid-state voltage source inverters which are connected through a common DC link capacitor. Each inverter is coupled with a transformer at its output. The first inverter, known as STATic Synchronous Compensator (STATCOM), injects an almost sinusoidal current, of variable magnitude, at the point of connection. The second inverter, known as Static Synchronous Series Compensator (SSSC) injects an almost sinusoidal voltage, of variable magnitude, in series with the transmission line. When the STATCOM and the SSSC operate as stand-alone devices, they exchange almost exclusively reactive power at their terminals. While operating both the inverters together as a UPFC, the exchanged power at the terminals of each inverter can be reactive as well as real. The exchanged real power at the terminals of one inverter with the line flows to the terminals of the other inverter through the common DC link capacitor.