

Two-Level Inverter Based STATCOM for High Power Applications with PQ controller

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ABSTRACT:-

Flexible Alternating Current Transmission System (FACTS) technology opens up new opportunities for controlling power and enhancing the usable capacity of present, as well as new and upgraded lines. This second generation FACTS device which enables independent control of active and reactive power besides improving reliability and quality of the supply. This paper describes the real and reactive power flow control through a transmission line by placing the series and shunt converter at the sending end of an electrical power transmission system. Simulations are carried out in Matlab/Simulink environment to validate the performance.

Index Terms---- *dc-link voltage balance, multilevel inverter, static compensator (STATCOM), active and reactive power control.*

I.INTRODUCTION

In today's highly complex and interconnected power systems, there is a great need to improve electric power utilization while still maintaining reliability and security. While power flows in some of the transmission lines are well

Below their normal limits, other lines are overloaded, which has an overall effect on deteriorating voltage profiles and decreasing system stability and security.

Because of all that, it becomes more important to control the power flow along the transmission lines to meet the needs of power transfer. On the other hand, the fast development of solid-state technology has introduced a series of power electronic devices that

made FACTS a promising pattern of future power systems. Power flow between two buses of a lossless transmission line is given by : $P_{ij} = \frac{V_i V_j}{X_{ij}} \sin(\delta_i - \delta_j)$ where, V_i and δ_i are the bus voltage magnitude and angle, V_j and δ_j are the j^{th} bus voltage magnitude and angle, X_{ij} is the line reactance. Thus, from the equation (1), it is clear that the power flow is a function of transmission line impedance, the magnitude of the sending end and receiving end voltages and the phase angle between voltages. By controlling one or a combination of the power flow arrangements, it is possible to control the active, as well as, the reactive power flow in the transmission line. With FACTS technology, such as Static Var Compensator (SVC), Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC) etc., bus voltages, line impedances and phase angles in the power system can be regulated rapidly and flexibly. These FACTS controllers are based on voltage source converters. Thus, FACTS can facilitate the power flow control, enhance the power transfer capability, decrease the generation cost, and improve the security and stability of the power system [1]-[2]. A Static Synchronous Series Compensator (SSSC) is a member of FACTS family which is connected in series with a power system. It consists of a solid state voltage source converter which generates a controllable alternating current voltage at fundamental frequency. When the injected voltage is kept in quadrature with the line current, it can emulate as inductive or capacitive reactance so as to influence the power flow through the transmission line. While the primary purpose of a SSSC is to control power flow in steady state, it can also improve transient stability of a power

system. The UPFC is a member of the FACTS family with very attractive features. The UPFC is able to control, simultaneously or selectively, all the parameters affecting power flow in the transmission line (voltage, impedance, and phase angle). It is recognized as the most sophisticated power flow controller currently, and probably the most expensive one. The UPFC, which consists of a series and a shunt converter connected by a common dc link capacitor, can simultaneously perform the function of transmission line real/reactive power flow control in addition to UPFC bus voltage/shunt reactive power control. The shunt converter of the UPFC controls the UPFC bus voltage/shunt reactive power and the dc link capacitor voltage. The series converter of the UPFC controls the transmission line real/active power flows by injecting a series voltage of adjustable magnitude and phase angle, on the other hand, the series part known as SSSC can be controlled without restrictions. The phase angle of series voltage can be chosen independently from line current between 0 and 2π , and its magnitude is variable between zero and a defined maximum value. The parallel part known as STATCOM injects an almost sinusoidal current of variable magnitude at the point of connection. In this paper series and shunt converter simulated in Matlab/Simulink environment. The real and reactive power flow control performance of the series and shunt converter has been evaluated. The simulation results show the effectiveness of series and shunt converter on real and reactive power flow control through a transmission line.

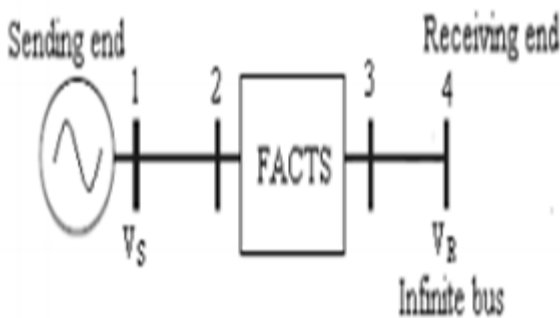


Fig. 1 FACTS device

II. CASCADED TWO-LEVEL INVERTER-BASED MULTILEVEL STATCOM

In this paper, a static var compensation scheme is proposed for a cascaded two-level inverter-based multilevel inverter. The topology uses standard two-level inverters to achieve multilevel operation. The dc-link voltages of the inverters are regulated at asymmetrical levels to obtain four-level operation. To verify the efficacy of the proposed control strategy, the simulation study is carried out for balanced and unbalanced supply-voltage conditions. Fig. 2 shows the power system model considered in this paper. Fig. 3 shows the circuit topology of the cascaded two-level inverter-based multilevel STATCOM using standard two-level inverters. The inverters are connected on the low-voltage (LV) side of the transformer and the high-voltage (HV) side is connected to the grid. The dc-link voltages of the inverters are

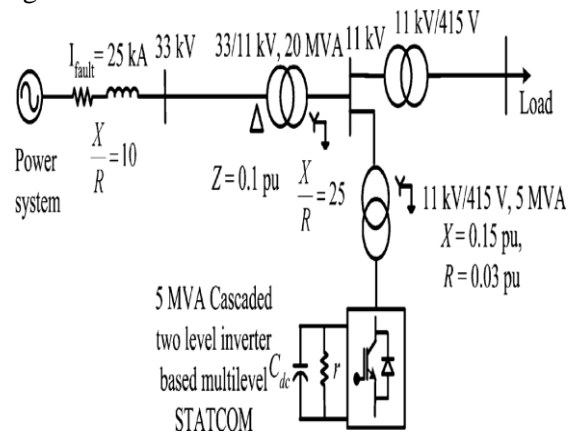


Fig. 2. Power system and the STATCOM model.

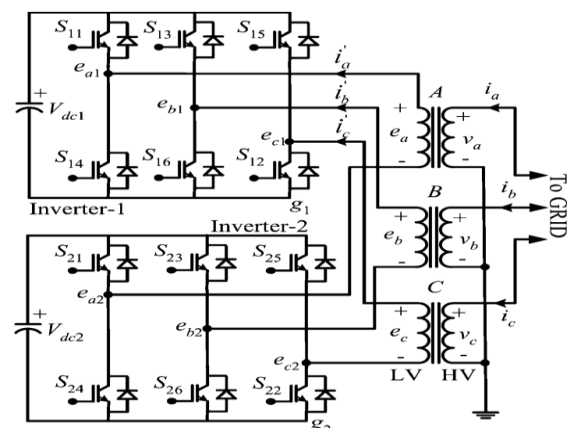


Fig. 3. Cascaded two-level inverter-based multilevel STATCOM.

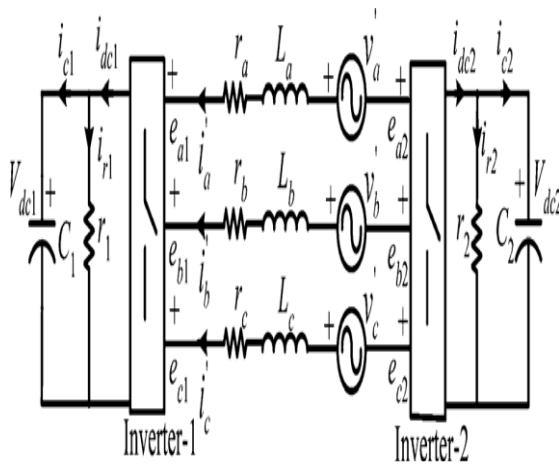


Fig. 4. Equivalent circuit of the cascaded two-level inverter-based multilevel STATCOM.

maintained constant and modulation indices are controlled to achieve the required objective. The proposed control scheme is derived from the ac side of the equivalent circuit which is shown in Fig. 4. In the figure, V_a , V_b and V_c are the source voltages referred to LV side of the transformer, r_a , r_b and r_c are the resistances which represent the losses in the transformer and two inverters, L_a , L_b and L_c are leakage inductances of transformer windings, and e_{a1} , e_{b1} , e_{c1} and e_{a2} , e_{b2} , e_{c2} are the output voltages of inverters 1 and 2, respectively. r_1 , r_2 are the leakage resistances of dc-link capacitors C_1 and C_2 , respectively. Assuming $r_a = r_b = r_c = r$, $L_a = L_b = L_c = L$.

III. P&Q CONTROL

Series and shunt converter is similar to the variable reactance because the injected voltage and current to the circuit by this device are changing depend upon to the system conditions and the loads entering/getting out. For responding to the dynamic and transient changes created in system, This utilizes the series converter. One side of the converter is connected to the AC system and the other side is connected to a capacitor and battery which in the system we assume DC source as battery. If a dynamic change in system will be occurred, the energy of battery will be converted to the ac form by converter and then injecting this voltage to the circuit the changes will be damped appropriately. To control the active and reactive powers of bus, the control circuit as shown in

Fig. 2 is utilized. For controlling the powers, first, sampling from the voltage and current is done and transformed to the dq0 values. Active and reactive powers of bus-2 are calculated using their voltage and current in dq0 references and compared with the determined reference and the produced error signal is given to the PI controllers. Adjusting parameters of the PI controllers, we are trying to achieve the zero signal error, such that powers can follow the reference powers precisely. Then, the output of the controllers are transformed to the abc reference and given to the PWM.

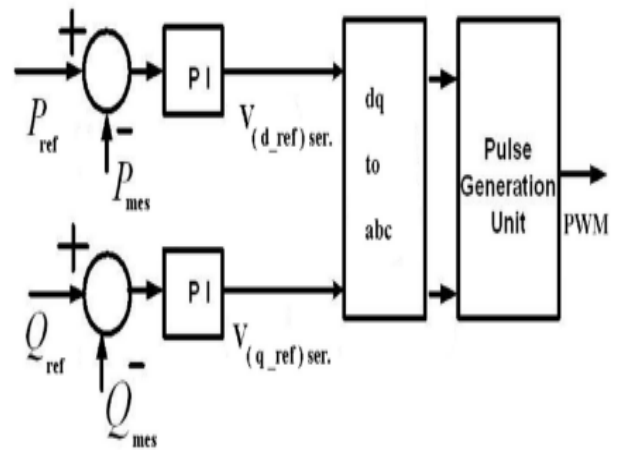


Fig .5 Control Scheme.

IV. SIMULATION RESULTS

Define system ratings as(change this to vary the system ratings)

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Command Window
>> P=5000

P =

      5000

>> Q=2000

Q =

      2000
  
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Simulation diagram:

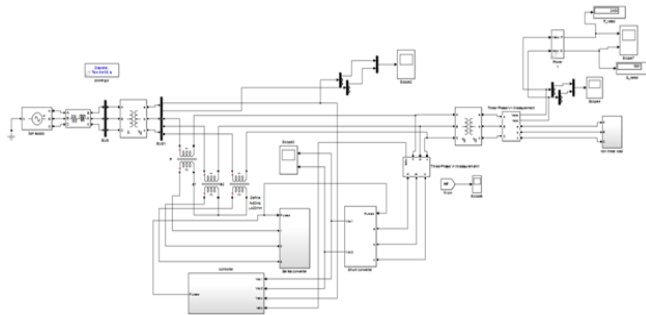


Fig.6 Matlab/Simulink diagram

Controller action:

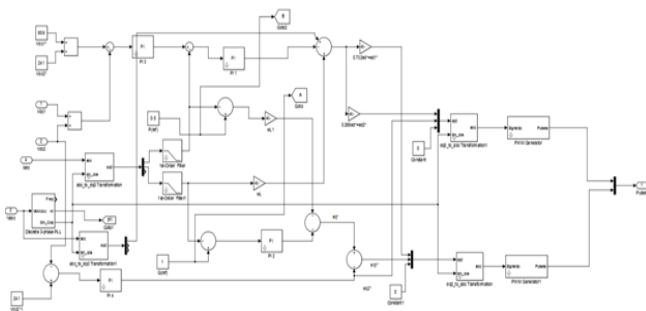


Fig.7 active and reactive power controller action

Voltages and currents:

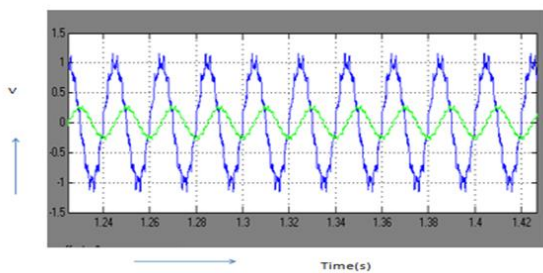


Fig.8 simulated output voltage and current wave forms

Controlled Active and reactive powers to load

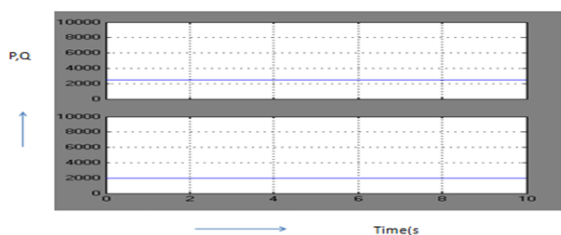
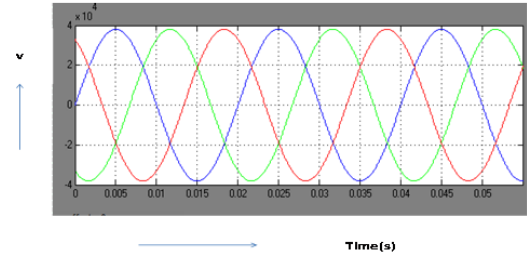


fig.9 output control of active and reactive power

Source voltage:

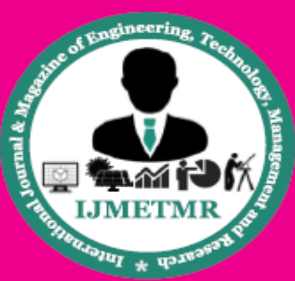


V. CONCLUSION

In this study, the Matlab/Simulink environment is used to simulate a simple single machine infinite bus power system with series and shunt converter connected to a three phase three wire transmission system. The control and performance of the system intended for installation on a transmission line is presented. Simulation results show the effectiveness of paper series and shunt converter on controlling the power angle oscillations and real and reactive power flow through the line. From the simulation results, it is inferred that there is an improvement in the real and reactive power flow through the transmission line with paper series and shunt converter.

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