International Journal of Research in Engineering, Science and Management
Volume-2, Issue-7, July-2019
www.ijresm.com | ISSN (Online): 2581-5792

Improving the Voltage Profile and the Line Power Flows in Various Controlling System by UPFC

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***Abstract*: The UPFC is that the most versatile of the FACTS devices. The thyristor switched capacitor (TSC) thyristor controlled reactor (TCR), and phase angle regulator however it may provides extra flexibility by combining a number of the functions of the higher than controllers. The most operate of the UPFC is to manage the flow of real and reactive power by injection of a voltage nonparallel with the conductor. Each the magnitude and therefore the phase angle of the voltage are often varied severally. Power flow in prescribed routes, loading of transmission lines nearer to their thermal limits and may be utilized for stability of the power system. In this paper UPFC used for improving the voltage profile and power flows in various controlling system.**

***Keywords*: FACTS, TSC, DPC, TCR, UPFC.**

1. Introduction

With rapid industrialization and increased standards of living, the demand for electricity has increased tremendously. The financial and environmental concerns have prompted to look for ways and means to maximize the utilization of the available resources and explore measures to enhance the performance of the existing systems. For better utilization of existing installation, thereby reducing the need for additional transmission lines. The author envelops an innovative approach based on voltage source converter is used for the designing of detailed model of GUPFC in MATLAB. A detailed comparison is done between a detailed GUPFC model and M-UPFC for power flow control (active power, reactive power and voltage) [1]. In this paper author gives a detailed information of voltage source, converter (VSC) based FACTS device like UPFC and its operation, as shunt, series and combined shunt-series device at the time of single-line to ground fault [2]. A multi objective improved particle swarm optimization (IPSO) for placing and sizing the series modular multilevel converter-based unified power flow controller (MMC-UPFC) FACTS devices to manage the transmission congestion and voltage profile in deregulated electricity markets [3]. This paper used Flexible AC Transmission System (FACTS) device specifically Unified Power Flow Controller (UPFC) because of its useful properties on series and shunt devices and used Genetic Algorithm (GA) to determine the optimal location and values of UPFC to achieve the voltage stability of electric power transmission system [4]. They propose a sensor-less control scheme to achieve independent real and reactive power flow control using the transformer-less UPFC. Typically, UPFCs are installed near the sending end which is far away from the receiving end [5]. The author have given the design and compares the performance of nonlinear, coupled and direct power controllers (DPC) which are used for three-phase, matrix converters working, as unified power flow controllers (UPFC). A complete model, of the converter-based UPFC fitted with a modified venturing, high-frequency, pulse width modulator is used to design the nonlinear controllers for the transmission line, active (p) and reactive (q), powers [6]. A direct power control (DPC) for, converters operating as unified power flow, controllers (UPFCS). In this type of Matrix converters, (MCS) which is always allow the, direct ac/dc power, conversion without dc, energy storage links; therefore, the MC-based UPFC (MC-UPFC), has reduced volume and cost, reduced capacitor power losses, together with, higher reliability [7]. In this paper, shows the MXC concept is extended to medium-voltage (MV) level to provide a high-power drive that has bidirectional power flow capability and very low harmonics in input current and output voltage. MV MXC is implemented by using power cell which are connecting power cells in series which consist of three-phase input and single-phase output MXC [8]. It presents the basic operating principle of a single phase matrix converter, two phases to single phase matrix converter, three phases to single phase matrix converter and three phases to three phase matrix converter [9]. The method is directly applicable to UPFCs operation with a high-level line optimization control. Through the selection of weighting coefficients used in the objective function which is formed from the weighted difference between the specified reference inputs and their optimal values, the method represents the priority assigned for any UPFC control function in constraint or limit resolution [10].

2. Theory of UPFC

The Unified Power Flow Controller (UPFC) was projected initially for real turn-off time control and dynamic compensation of ac transmission systems. The Unified Power Flow Controller is consists of two converters, that are considered, as voltage sourced inverters using gate thyristor valves, as illustrated, in Figure 1. These inverters, labeled "VSC1" and "VSC2" within the figure are operated with a standard dc link provided by a dc storage condenser. With this arrangement the ac power device during which the real power can freely flow in either direction between the ac terminals of the two inverters and every inverter will severally generate also as output terminal. Since the series converter of the UPFC will inject a voltage with variable magnitude and phase angle it will exchange real power with the transmission line with the help of series transformer. Once the power balance isn't maintained, at that scenario, the capacitor cannot stay at a constant voltage. Shunt branch can also severally exchange reactive power with the system.

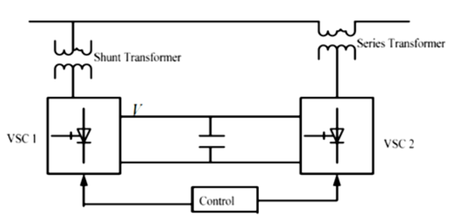

Fig. 1. The Conventional View of UPFC

Inverter 2 provides the main function of the UPFC by injecting a voltage V_{pq} with controllable magnitude $V_{pq}(0\leq V_{pq} \leq V_{pqmax})$ and phase angle ρ $(0\leq\rho \leq 360°)$, at the power frequency, injected with current, by a transformer. This injected, voltage taken as constant ac, voltage source. The transmission current which will be flows through this source resulting in power exchange between it and the ac system. Real power, exchanged at the ac terminal (i.e., at the terminal, of the transformer) and the inverter help to convert the ac power into dc power in the system, after that the DC appears, at the point of in the DC link as positive or negative, power demand. Power exchanged at the terminal is generated internally through the inverter.

3. Proposed methodology

A. Power system of proposed UPFC

Figure 2 shows the general configuration of 3-phase matrix converter as an ac regulator. The usual UPFC topology is replaced by a matrix converter that is placed in shunt combination with transmission line as shown in figure 2.

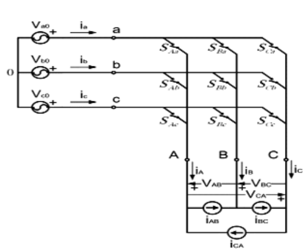

Fig. 2. Phase matrix converter

We choose single machine infinite bus (SMIB) system for verifying our proposed work performance as shown in figure3.

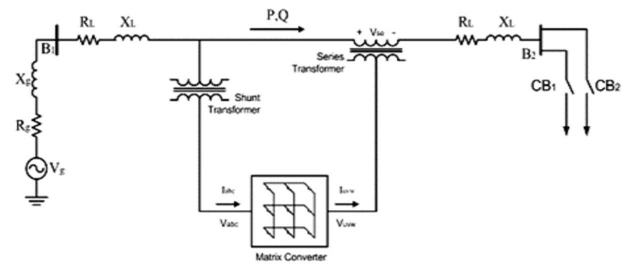

Fig. 3. Power system with proposed scheme of UPFC

The feeding network has been represented by its Thevenin's equivalent circuit on bus B1. The UPFC given along transmission line (Fig. 3). The STATCOM side of the UPFC is connected in shunt with the transmission line using a step-down transformer.

The SSSC side of the UPFC is connected in series with the transmission line. The basic operation of this side is to inject a voltage (v_{se}) of required magnitude, phase and frequency in series with transmission to control the active and reactive powers flow. This injected voltage is almost quadrant with the transmission line current. As a result, it plays the role of an inductance or capacitance in series. It is assumed that the input voltages of the matrix converter after the step-down shunt transformer are three-phase balanced sinusoidal voltages as follows

$$\left.\begin{aligned} V_a &= V_m \cos\theta_{av} = V_m \cos(\omega t) \\ V_b &= V_m \cos\theta_{bv} = V_m \cos(\omega t - 120^0) \\ V_c &= V_m \cos\theta_{cv} = V_m \cos(\omega t + 120^0) \end{aligned}\right\} \quad (1)$$

Hence the expected line side current is the shunt side is described as

$$\left.\begin{aligned} I_a &= I_m \cos\theta_{av} = I_m \cos(\omega t - \phi_{in}) \\ I_b &= I_m \cos\theta_{bv} = I_m \cos(\omega t - 120^0 - \phi_{in}) \\ I_c &= I_m \cos\theta_{cv} = I_m \cos(\omega t + 120^0 - \phi_{in}) \end{aligned}\right\} \quad (2)$$

Where $\phi_{in} = \theta_{av} - \theta_a$ is the line side power factor angle.

The fundamental component of the voltage injected into the transmission line in the series side is described as

$$\left.\begin{aligned} V_u &= V_o \cos\theta_{au} = V_o \cos(\theta_{out}) \\ V_v &= V_o \cos\theta_{bv} = V_o \cos(\theta_{out} - 120^0) \\ V_w &= V_o \cos\theta_{cw} = V_o \cos(\theta_{out} + 120^0) \end{aligned}\right\} \quad (3)$$

Where θ_{out} is the output angle.

4. Results and analysis

A. *Performance evaluation of the mc based UPFC*

In order to analyze the performance of the matrix converter based UPFC, suitable simulation is performed using MATLAB/SIMULINK. The results shown below demonstrate the multiple functionality of UFPC in improving the voltage profile and the line power flows. The parameters of the studied system are given in Table 1.

Table 1
Power System Parameters

Three phase ac source	
Rated Voltage	230KV x 1.03
Frequency	50Hz
Short Circuit Level	10,000MVA
Base Voltage	230KV
X_g/R_g	8
Transmission Line	
Resistance per unit length	0.01755Ω/KM
Inductance per unit length	0.8737 mH/KM
Capacitance per unit length	13.33 nF/KM
Shunt Transformer	
Nominal Power	150MVA
Frequency	50HZ
Nominal Voltage	230 KV/27 KV
Magnetizing reactance and resistance	500 pu
Series Transformer	
Rated voltage	42 KV/21/KV
Rated Power	100MVA
Magnetizing reactance and resistance	500 pu
IGBT switches	
Internal resistance	0.001Ω
Snubber resistance	0.1MΩ
Snubber Capacitance	Infinite

The load variations are given to study the performance of the UPFC. The load with ratings of 300 MW, 150 MVAr connected at load bus B2. When UPFC is not connected the transmission line current is lagging the transmission line voltage as shown in Figure 4. This results a poor power factor of 0.544 lag.

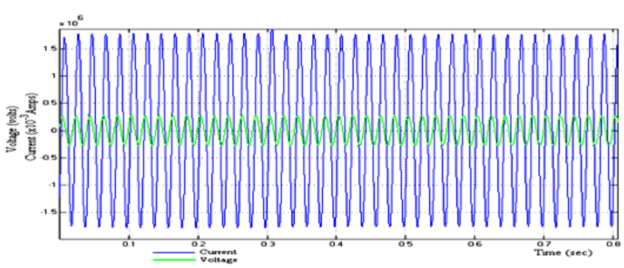

Fig. 4. Transmission line voltage and current without matrix converter

When the proposed scheme of UPFC with matrix converter is connected to the test system, the STATCOM part of the UPFC operates in the capacitive mode in order to reduce phase difference between transmission line voltage and current. STATCOM injects 0.24 pu of reactive power into the ac power system as shown in Figure 4 and the corresponding d-q components of the STATCOM current are described in Figure 5. The phase difference between the transmission line current and the voltage is reduced to 14.3° as described in Figure 5, thereby STATCOM improves the power factor of the line from 0.544 lag to 0.956 lag. Hence the STATCOM controller increases the modulation index from 0.778 to 0.83 which increases the total reactive power injection to 0.325 pu (from Figure 4) and the phase angle is corrected to 16°lag which leads to a power factor of 0.961 lag. Thus with the STATCOM controller the line current is almost in phase with the voltage as depicted in Figure 5.

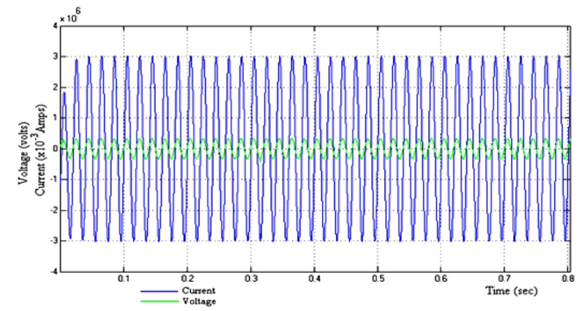

Fig. 5. Transmission line voltage and current with matrix converter

Before compensation for any load variations, there was a dip in the supply voltage and the supply currents were lagging. But when UPFC is connected to the power system a uniform voltage profile is maintained, three phase supply currents are almost in phase with the supply voltage and maintains power flow over the line to the desired set reference value irrespective of load variations.

5. Conclusion

The method is discussed part by part, starting with demonstrate the multiple functionality of UFPC in improving the voltage profile and the line power flows. Operation in reactive power control mode, reactive power injections by the STATCOM in capacitive mode, operation in automatic power flow control mode, SSSC injected voltage and transmission line current, real and reactive power flow.

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