Annals of the University of Petroşani, Electrical Engineering, 25 (2023)

BENEFITS OF STATCOM COMPENSATOR SUPPORTING THE AIMS AND OBJECTIVES OF EUROPEAN POWER SYSTEMS

MARIA DANIELA STOCHITOIU [1]

Abstract: Flexible AC transmission system (FACTS) plays an important role in raising the level of implementation of renewable energy resources, having ability in continuous controlling the active and reactive power in the network. The paper emphases that the increasing demands for a stable supply of electricity is rising which determine the need for sophisticated and more intelligent system control for power system. The STATCOM compensator provide the necessary features to avoid technical problems in the power systems that increase transmission capacity and system stability very efficiently and they assist in prevention of cascading disturbances.

Key words: transmission capacity, point of common coupling, system stability.

1. INTRODUCTION

When connecting new transmission lines and controlling power flow and voltage stability under a variety of operating conditions, the STATCOM device offers system operators an effective way to meet the financial and regulatory requirements for power systems (fig.1).

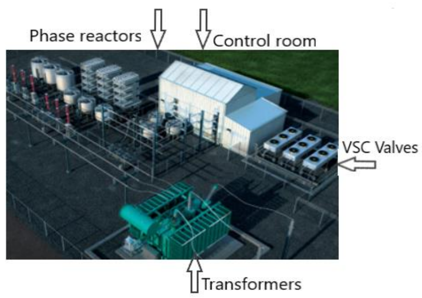

Fig.1. The STATCOM components are integrated within advantage facilities

The presence of perturbing users in the electrical distribution network is leading to a diminution of the energy quality level of the power supplied to other users

[1] *Ph.D., Associate Prof. Eng., University of Petrosani, danielastochitoiu@upet.ro*

connected to the same bars, so adopting of measurements for level in the limits accepted by international norms.

Fast-compensating reactive power sources like STATCOM, which can improve power factor and system voltage stability and offer real time voltage control, can help systems recover more quickly from unexpected events. A voltage-source converter (VSC) of a certain type, a dc capacitor, and a coupling transformer are used to link the VSC in shunt to the power network in a STATCOM.

An essential method for distributed supplier to perform dynamic reactive power compensation is by placing dynamic compensation devices at the point of common coupling (PCC).

Dynamic compensation device is static synchronous compensator (STATCOM). By using dynamic reactive power support from STATCOM, the transient voltage stability will be increased and the system voltage can be quickly restored after a grid fault.

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The preferred nominee for rapidly voltages changes, system voltage control or frequent voltage variations is the efficient equipment STATCOM. It has an important role in distributed generation when the voltage can sudden decrease and the low levels of voltage can lead to instability in the power net.

2. FLICKER PHENOMENON COMPENSATION

The definition of flicker is like a visual impression of fluctuation of light intensity. This is caused by the voltage amplitude variations in the frequency range (0,5 and 25Hz). The voltage variations are the result of consumed power adjustment. The main cause of flicker appearance is electric arc furnace used in metal melting. These consumed active power and reactive power into stochastic state. The electric arc furnace are producing voltages perturbances that are the base of flicker appearance. Installing a STATCOM equipment in parallel with electric arc furnace is an efficient solution for resolving the flicker problems (figure2). Also, it is establishing a stable voltage level in the point of common coupling PCC ensuring the more efficient operating of furnace.

The STATCOM equipment can absorb inductive reactive power and also supply capacitive reactive power when capacitors are tied in parallel. These are settled for different harmonics frequency and have to prevent the harmonics amplifier due to resonance phenomenon in energetical systems [4], [5].

The STATCOM, which is coupled to the PCC, is used to regulate the voltage there in the desired range. The reactive power supplied to the power grid can be controlled, by controlling the ac output voltage magnitude of the STATCOM.

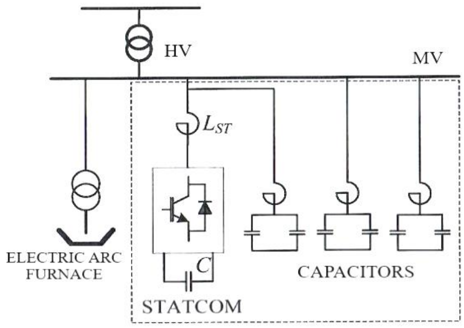

Fig. 2. Single wire STATCOM connection diagram

The regulator is in open loop and the voltage and current are measured. The reactive component is filtered through a pass down filter and the resulted current is a part of reference current. The second part of the filtered voltage and current is obtained from a closed loop regulator where are measured the values from electric grid. The reactive components are compared with a settled values and the difference are representing the inputs for PI controller [6].

3. INCREASING THE ELECTRIC GRID TRANSMISSION CAPACITY

STATCOM device can be described as a current source connected in parallel from point of view of electro - energetical system, because the area control current is not in dependence with the voltage $\underline{V}_{STATCOM}$, and the control parameter for STATCOM is I_Q.

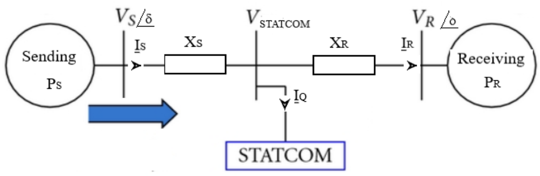

Fig. 3. Equivalent diagram of the electrical network with STATCOM for transmission system

$$\underline{V}_{STATCOM} = \underline{V}_S - j\underline{I}_S X_S \quad (1)$$

$$\underline{I}_R = \underline{I}_S - \underline{I}_Q \quad (2)$$

$$\underline{I}_R = \frac{\underline{V}_{STATCOM} - \underline{V}_R}{jX_R} \quad (3)$$

Taking into account the above relations it can obtain:

$$\underline{I}_S = \frac{\underline{V}_S - \underline{V}_R}{j(X_S + X_R)} + \underline{I}_Q \frac{X_R}{X_S + X_R} \quad (4)$$

In the above relation it can replace the first relation and obtain [4]:

$$\underline{V}_{STATCOM} = \underline{V}_S - \frac{\underline{V}_S - \underline{V}_R}{(X_S + X_R)} - j\underline{I}_Q \cdot \frac{X_S X_R}{X_S + X_R} = \underline{V}_{STATCOM0} - j\underline{I}_Q \cdot \frac{X_S X_R}{X_S + X_R} \quad (5)$$

$$\underline{V}_{STATCOM0} = \frac{\underline{V}_S X_R + \underline{V}_R X_S}{(X_S + X_R)} \quad (6)$$

$\underline{V}_{STATCOM0}$ – represents the voltage to STATCOM in case it isn`t connect to system, as $\underline{I}_Q = 0$.

Due to $\underline{I}_Q = jI_Q \cdot \frac{\underline{V}_{STATCOM0}}{V_{STATCOM0}}$, the equation (5) becomes:

$$\underline{V}_{STATCOM} = \underline{V}_{STATCOM0} + I_Q \cdot \frac{\underline{V}_{STATCOM0}}{V_{STATCOM0}} \cdot \frac{X_S X_R}{X_S + X_R} = \underline{V}_{STATCOM0}\left(1 + \frac{I_Q}{V_{STATCOM0}} \cdot \frac{X_S X_R}{X_S + X_R}\right) \quad (7)$$

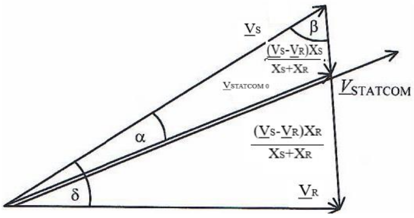

Fig. 3. Phasor diagram

The above relation shows that $\underline{I}_Q$ is phased with $\frac{\pi}{2}$. Aplying the sinus theorema for the figure 3, it can write:

$$\frac{\sin\beta}{\sin\delta} = \frac{V_R}{|\underline{V}_S - \underline{V}_R|} \quad (8)$$

$$\frac{\sin\beta}{\sin\alpha} = \frac{V_{STATCOM0}}{\frac{X_S|\underline{V}_S - \underline{V}_R|}{X_S + X_R}} \quad (9)$$

$$\sin\alpha = \frac{V_R \cdot X_S \cdot \sin\delta}{V_{STATCOM0}(X_s + X_R)} \quad (10)$$

The generated power and transmissed

$$P_S = P_R = \mathrm{P} = \frac{V_{statcom} \cdot V_S}{X_S} \sin\alpha = \frac{V_{STATCOM} \cdot V_R \cdot V_S \cdot \sin\delta}{V_{STATCOM0}(X_s + X_R)} \quad (11)$$

$$\mathrm{P} = \frac{V_R \cdot V_S \cdot \sin\delta}{(X_s + X_R)} \cdot \left(1 + \frac{I_Q}{V_{STATCOM0}} \cdot \frac{X_S X_R}{X_S + X_R}\right) \quad (12)$$

The improvement of transmission capacity is direct proportionally with I_Q[4].For determining the maximum transmission power, the above relation has to derive with the ratio of $\frac{X_S}{X_R}$, matched null. Considering $V_s = V_R$, the efficient position for STATCOM equipment is in the middle of the electrical line.

4. INCREASING THE RESERVE OF TRANSITORY AND STATIC STABILITY

The transitory stability can be defined as the ability of supply synchronous generator to remain in synchronism after a major perturbance in the electrical network like shortcut in the transport network; out of operation of supply unit or overload. The reaction of the electrical grid after the perturbation is characterized by large variations of intern angles of generators, transmitted power, the level of voltages in common points, etc. A generator or a group of generators are becoming instable when appear large difference between intern angles of generators. If this difference is into a range, the system is remaining stable. Specialty literature treats this subject using the equal areas criterium. For a generator connected to an infinite power line, the difference angle between transitory voltage of generator and reference phasor (line voltage) is δ and the dependence P(δ) is shown below.

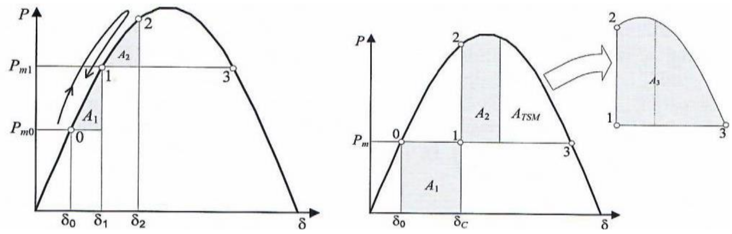

Fig. 4. Maximizing the area for optimal control

In case of growth of mechanical power, the operating points of systems are following the transitory characteristic between 0 and1. Due to excess of mechanical power to electric power, the rotating masses are accelerated. That determines the increasing of A_1 and kinetic energy, the angle δ is increasing to δ_2 where the excess of kinetic energy is no longer transformed in potential energy. The generator is decelerating when the electric power is more than mechanical power. In point 2 the rotor is changing the rotation direction trending to point 1. The rotor would oscillate around point1 between point0 and point 2 in a lack of attenuation. The recurrence is not possible in the point 3, over that, the electric power is smaller than mechanical power and the rotation masses are accelerated and the system becomes instable. The system is stable as well as area A_1 is smaller than A_3. The difference between A_3 and A_2 is the margins of transitory stability, and when this becomes negative the system also becomes instable. After elimination of defect the optimal behaviour is ensured through maximization of areaA_3 [2],[4],[9],[11].

The efficiency of STATCOM is in dependence with the defect period time. The STATCOM effective power is 25% less another equipment, for example Static Var Compensator.

5. HARMONICS ATTENUATION

Harmonic attenuation refers to the level of harmonic current emissions and how they affect harmonic voltages at the compensator's connection point. The currents add to the harmonic grid voltages already present at the connection site by creating harmonic voltages in grid impedances [6],[7]. Standards and transmission operators are setting limits for harmonic voltages at the connection point which are exceeded in some cases with the present current emissions. The explanation of obtaining better results with STATCOM can be explained by the fact these are better behaviour to low voltages being capable to supply more reactive power. As the problem of power oscillations appears especially in heavy loaded networks, where can appear in dynamic stage low levels voltages, the STATCOM utilisation is indicated [8],[10].

6. CONCLUSIONS

The advantages of STATCOM in comparation with fixed capacitors mounting in the derivation node involve high response speed and ability to maintain a constant reactive current and providing dynamic reactive power support, the system voltage can be established shortly after grid fault, and the transient voltage stability will be improved. The STATCOM responds like a voltage source, which may control the injected current almost independently of the network voltage. In addition, controllable-shunt compensators, like STATCOM may contribute to resolve the flicker phenomena and to the transient stability of the system and transmission capacity increasing for electrical grid.

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