THE ROLE OF STATCOM IN DYNAMIC COMPENSATION OF ELECTRICAL NETWORKS

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Abstract: The STATCOM device is based on the voltage source converter has been implemented in many power systems as way for the dynamic compensation of electrical networks for maintain the voltage level and to rise the transmission capacity in transitory operating steady as well as oscillations damping. The paper presents the theoretical aspects regarding the configurations of the STATCOM and the implementation role.

Keywords: power flow control, controller, transmission capacity, power system.

1. INTRODUCTION

The STATCOM device represents an efficient solution for the system operators for power systems in efficiency way to meet the economic and regulatory requirements under conditions of connection of new transmission lines and the need of stability voltage and power flow control under various operating conditions.

This device is equivalent with an ideal synchronous machine for producing three phase sinusoidal voltages at fundamental frequency. The STATCOM system shows the same operating characteristics as turning synchronic compensator without mechanical inertia. The device is allowing to control fast the module and angle phase of three phase voltages in the connection point. The based components are semiconductors GTO and IGBT used in voltage source converter (VSC), which has performances on reactive power control [1],[5].

The STATCOM device, usually has in composition a transformer, a converter/inverter voltage source and a capacitor operating at direct current voltage (figure 1). The control element of STATCOM is fully controlled valve. The thyristor GTO and a diode are connected antiparallel forming a turn-off asymmetrical device. Due to the current flows in both directions through voltage source converter, the valves have to be bidirectional. The valve resistance is null when GTO is on and the valve resistance is infinite when the GTO is off.

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The operating consists to maintain the capacitor loaded at continuous voltage V_{dc} and to provide with VSC an voltage $\underline{V_0}$ in phase with the network voltage $\underline{V}$ [2].
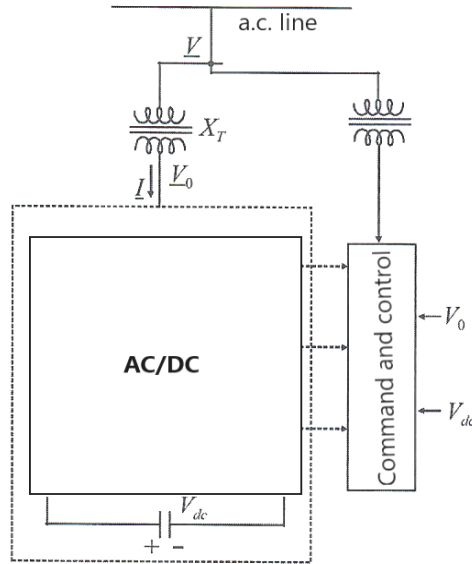

Fig.1. The STATCOM scheme

The difference between those two voltage amplitudes is applied to the inductive reactance X_T and determines the reactive current flow:

$$\underline{I} = \frac{\left(\underline{V} - \underline{V_0}\right)}{jX_T} \quad (1)$$

The effective value of this voltage difference determines the amplitude of reactive current and the sign (positive or negative) as the dephasing sense between network voltage and current. The reactive power Q is:

$$Q = \frac{1 - \frac{V_0}{V}}{X_T} \cdot V^2 \quad (2)$$

The electrical network perceives the STATCOM device as a variable impedance of reactive element. The reactive properties of STATCOM are depending of voltage amplitude V_0 from output inverter going from stored energy capacitor. The V_0 measurement is depending of capacitor potential V_{dc}.

The device works as an inductance when the current is phased with $\pi/2$ behind the voltage and absorbs reactive energy and the device works as a capacitor when the current is phased with $\pi/2$ beyond the voltage supplying reactive energy (figure 2). If $V_0 = V$ the current flows through the impedance is null and there is not energy exchange [3],[1].
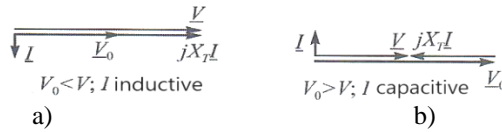
Fig.2. The phase voltages schemes

The possibility of exchange the energy even inductive or capacitive using only one inductance X_T is the advantage of this device. In comparation with Static Var Compensator based on current source converter, the STATCOM device has not capacitive element which can determines resonance phenomena with inductive elements form electrical network. STATCOM can produce an inductive current and supply the capacitive current which is not depending by the connected network voltage. The device can supply nominal capacitive current for any alternative voltage.

STATCOM device can be operated in electroenergetical power systems resolving some features.

2. STATCOM OPERATING FIELDS

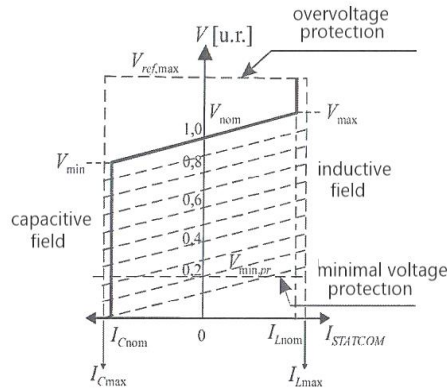The STATCOM behavior in static steady is described by V-I characteristic (figure 3). There are three operating fields:
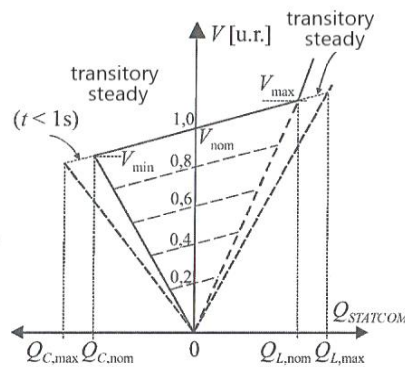

Fig.3. The V-I characteristics

Fig.4. The V-Q characteristics

- linear control field, delimitated by nominal currents (I_{Cnom}, I_{Lnom}) and maximum currents (I_{Cmax}, I_{Lmax}) for short term steady;
- capacitive field, where STATCOM delivers in the connection node a constant current equal with capacitive maximum current;
- inductive field, where STATCOM absorbs in the connection node a constant current equal with inductive maximum current.

Without the current restrictions there are some voltage operating restrictions as:
- maximum restriction of reference voltage ($V_{ref,max}$);
- protection restriction of minimum voltage ($V_{min, pr}$).

The maximum reactive power produced by a STATCOM device is equal with the current multiplied voltage and in the transitory stage the STATCOM can increase the

current values on the limited period of time in dependence with the temperature of semiconductors junction (figure 4) [5], [6], [7]. The characteristic behavior of STATCOM can be equivalent with a voltage source behind of reactance and fast control the amplitude and phase angle.
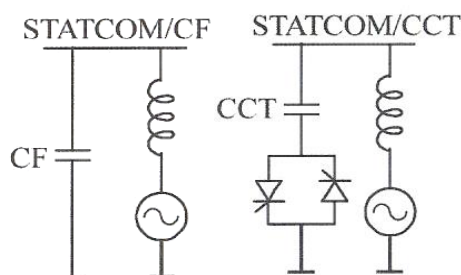

Fig.5. The mounting STATCOM schemes

Some possibilities of STATCOM mounting, in schemes with fixed capacitor or with thyristor switched capacitor are shown above.

3. 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.

REFERENCES

[1]. M. Eremia, s.a, *Dispozitive FACTS Concepte si aplicatii in electroenergetica*, Editura Agir, , Bucuresti, 2017.
[2]. M. Eremia, s.a, *Electric Power System. Electric Networks,* Editura Academiei Romana, Bucuresti, 2006.
[3]. A. Kumar, s.a, *Power system stability Enhancement using FACTS controllers*, International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM), 2012.
[4]. Jun Ql, S.a.., *Comparative study of SVC and STATCOM reactive power compensation for prosumer microgrids with DFIG based wind farm integration*, IEEE, 2020
[5]. M.D. Stochitoiu, s.a. *A brief review of approach the role of FACTS devices,* Annals of electrical engineering, 22, 2020.
[6]. M.D. Stochitoiu, s.a. *Modern opportunities of power flow circulation control a.c. transmission systems,* DOI: 10.5593/sgem2019, SGEM 2019, Bulgaria, 2019.
[7]. Yunkai Lei, s.a. *Comparison of UPFC, SVC and STATCOM in improving commutation failure immunity of LCC-HVDC Systems,* IEEE Access 2020.3011113, 2020.