Enhancement in Power System Performance through Compensation Technique

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ABSTRACT

Flickering Voltage has become one of the most severe power quality problems (especially in loads like electrical arc furnaces) and much attention has been paid to it lately. With the semiconductor industry developing and progressing at a very fast pace lots on new devices such as the compensators based on voltage source converters, FACTS devices have been developed which have been found quite successful in mitigating the voltage flickering and achieving good power quality. This paper covers dealing with the voltage flicker mitigation and compensation using he Static Synchronous Compensator (STATCOM). The obtained results show that STATCOM is very efficient and effective for the flicker compensation. All the simulations have been performed on the **MATLAB Software.**
Keywords: STATCOM, DVR, PMSG wind turbine, Harmonics.

I. INTRODUCTION

Power quality has taken a centre stage in the present scenario as there has been a marked increase in the use of electronic equipment used in communication and information technology, power electronics equipments such as adjustable speed drives (ASD), programmable logic controllers (PLC), energy-efficient lighting, which has led to a complete change of electric loads nature. These loads being nonlinear in nature are the cause of reduction in power quality. The industrial equipments along with the house hold equipments have become more and more sensitive due to the increase usage of digital components. The most critical areas are the continuous process industry and the information technology services.

Disturbance brings along with itself lots of financial losses and reduction in productivity. This implies that some measures must be taken in order to achieve higher levels of Power Quality.

Use of renewable energy has increased through time and integration of renewable energy such as wind, photovoltaic, fuel cell, and tidal to the grid solved many problems and replenished the exceeding and ascending need for electrical energy. Integration of the renewable energy with the grid has lead to a more complex electrical network or "Grid".

Electric arc furnace, the main generator of voltage flicker, behaves in the form of a constant reactance and a variable resistance. Connecting this type of load to the network produces voltage variation at the common point of supply to other consumers.

In addition to the aforesaid procedures for the compensators, the active filters are used for the voltage flickers mitigation as well . Furthermore, the mitigating devices based on Static VAR Compensator (SVC) such as Thyristor Switched Capacitor TSC [18], Thyristor Controlled Reactor (TCR) [19], and FCTCR [20], are the most frequently used devices for reduction in the voltage flicking. SVC devices achieved an acceptable level of mitigation, but because of their complicated control algorithms, they have problems such as injecting a large amount of current harmonics to the system and causing spikes in voltage waveforms. Advent of FACTS devices make them ideal for use in a power system and especially in the voltage flicker mitigation. In this

respect, the FACTS devices based on voltage-source converters have been able to improve the problems related to SVC. The technique is to use STATCOM for voltage flicker compensation to overcome the aforementioned problems related to other techniques.

The rest of this paper is organized as follows. Section II reviews the techniques of harvesting power from renewable energy sources, Section III discusses the power quality issues, Section IV talks about improvement techniques followed by result analysis in Section V and conclusion in Section VI.

II. METHODS AND MATERIAL

A. Controlling System

The concept of instantaneous reactive power is used for the controlling system. Following this, the 3-phase voltage upon the use of the park presented by Akagi [24] has been transformed to the synchronous reference frame (Park or dq0 transformation). This transformation leads to the appearances of three instantaneous space vectors: Vd on the d-axis (real or direct axis), Vq on the q-axis (imaginary or quadrature axis) and V0, from the 3-phase voltage of Va, Vb and Vc. The related equations of this transformation, expressed in the MATLAB software, are as follows:

$$V_d = \frac{2}{3}(V_a \sin(\omega t) + V_b \sin(\omega t - \frac{2\pi}{3}) + V_C \sin(\omega t + \frac{2\pi}{3})) \tag{1}$$

$$V_q = \frac{2}{3}(V_a \cos(\omega t) + \cos(\omega t - \frac{2\pi}{3}) + \cos(\omega t + \frac{2\pi}{3})) \tag{2}$$

$$V_0 = \frac{1}{3}(V_a + V_b + V_c) \tag{3}$$

A dynamic computation shows that the voltage oscillations in the connecting node of the flicker-generating load to the network are created by 3 vectors: real current (ip), imaginary current (iq) and the derivative of the real current with respect to time (di_p/dt). In general, for the complete voltage flicker compensation, the compensating current (ic) regarding the currents converted to the dq0 axis is given as :

$$i_c = j(i_q + i_p \frac{R}{X} f + \frac{1}{\omega} \frac{di_p}{d\omega} f + k) \tag{4}$$

where R and X are the synchronous resistance and reactance of the line and f is the correcting coefficient. The constant k is also used to eliminate the average reactive power of the network . If the compensation current of the above equation is injected to the network, the whole voltage flicker existing in the network will be eliminated. Regarding the equation, related to the dq-transformation of the 3-phase-voltages to the instantaneous vectors, it is obvious that under the conditions of accessing an average voltage flicker, Vd and V0, the obtained values are close to zero and Vq is a proper value adapting to the voltage oscillation of the network.

B. Basic Scheme

The compensator must stay in synchronous operation with the AC system at the compensated bus at all operating conditions including major disturbances. The compensator must be able to regulate the bus voltage for voltage support and improved transient stability, or control it for power oscillation damping and transient stability enhancement. The study also includes few methods of controllable VAR generation. The compensator within input MVA rating and operating frequency band acts as a perfect amplifier forcing the magnitude of the regulated terminal voltage to follow the effective voltage reference. The overall losses with reactive power compensation and without compensation will be studied and analyzed. For series compensation, it is seen that the AC power transmission having long distance is primarily limited by series reactive impedance of the line. Series capacitive compensation cancels a portion of reactive line impedance thereby increasing the transmittable power. The various series compensations are highly effective in both controlling power flow and in improving stability. This minimizes the receiving end voltage variation and prevents the possibility of voltage collapse. It is seen that the power capability of series line compensation to control the transmitted power can be utilized much more effectively to increase the stability limit and to provide power oscillation damping. The electric length of the line can be shortened to meet it power transmission parameter by fixed (percent) compensator of the line and it can be fixed or controllable series capacitor compensation that minimize end voltage variation of radial line and prevent

voltage collapse. It is suitable for post fault system and can be highly effective in power oscillation damping.

C. Proposed Model

The proposed system explores the effect of using STATCOM to improve the power quality.
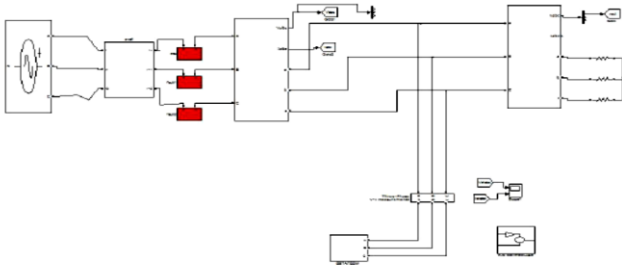

Figure 1. Proposed Simulink Model.

The Above block shows the proposed scheme with STATCOM. The figure above shows the grid with STATCOM connected in parallel to it. The STATCOM is used for Active filtering.

STATCOM Operation

When the load will be connected to the system, the voltage and current at the Grid will be distorted and will need to be filtered. Here the STATCOM (Active filter) will be activated and will inject the exact current into the system needed to cancel the effect of the harmonics. This reference injected current will be generated by the hysteresis control technique.

The STATCOM has been identified a device which can quickly respond to assist in improving the power quality and stability of the wind farms. Previous studies have been limited to reactive power control only. STATCOM supplemented with a Battery storage system can provide more benefits to the wind farm and the associated power systems. Battery energy storage scores over other technologies in terms of low losses. Other technologies, e.g. flywheels, are also suitable and when lifetime and maintenance costs are included, may be preferable. When power fluctuation occurs in the system, the battery energy storage system can be used to level the power fluctuation by charging and discharging operation. Also, during a sag or fault the system can be used to boost the stability margin by absorbing active power from the wind farm. Many STATCOMs have a (limited)

transient overload capability and this can be used during sags or faults.

III. RESULT AND DISCUSSION

We have connected a STATCOM for removal of harmonics. The fault is injected in the system at time t = 0.4 to t= 0.6 and the result of the simulation are given below.
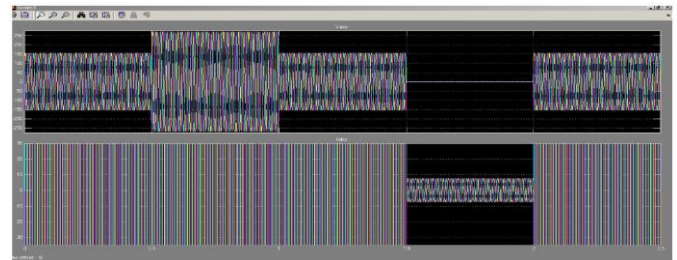

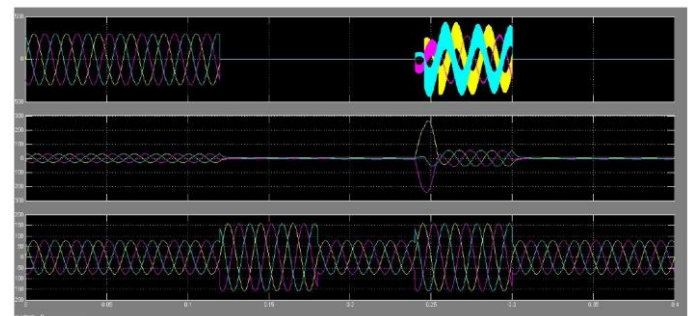**Figure 2.** System Load voltage and current

STATCOM

Figure 3. STATCOM removing harmonics

In figure 3 above we observe that when the STATCOM comes into play at time t = 0.25 to t=0.3 and the harmonics are reduced.

IV. CONCLUSION

The design and application of STATCOM technology based on voltage-source converters for voltage flicker mitigation is discussed in this paper. All the simulated results which have been performed in MATLAB show that the STATCOM can reduce the voltage flicker caused by nonlinear loads such as electric arc furnaces.We also observe that the STATCOM removes the harmonics from the system in presence of fault .

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