Solution of Power Quality Problems using DSTATCOM

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Abstract - A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a mis-operation of end use equipments. Utility distribution networks, sensitive industrial loads, and critical commercial operations all suffer from various types of outages and service interruptions which can cost significant financial 1oss per incident based on process down-time, lost production, idle work forces, and other factors. With the restructuring of Power Systems and with shifting trend towards Distributed and Dispersed Generation, the issue of Power Quality is going to take newer dimensions. The aim therefore, in this work, is to identify the prominent concerns in the area and thereby to recommend measures that can enhance the quality of the power, keeping in mind their economic viability and technical repercussions. In this paper electromagnetic transient studies are presented for the following distribution static compensator (D-STATCOM).

Index Terms—Power quality improvement, DSTATCOM.

I. INTRODUCTION

Power quality is certainly a major concern in the present era. The causes of power quality problems are generally complex and difficult to detect. Technically speaking, the ideal AC line supply by the utility system should be a pure sine wave of fundamental frequency (50/60Hz).Different power quality problems, their characterization methods and possible causes are discussed above and which are responsible for the lack of quality power which affects the customer in many ways. We can therefore conclude that the lack of quality power can cause loss of production, damage of equipment or appliances or can even be detrimental to human health. It is therefore imperative that a high standard of power quality is maintained.

The electronic devices are very sensitive to disturbances. The development in fast and reliable semiconductors devices (GTO and IGBT) allowed new power electronic configurations to be introduced to the tasks of power Transmission and load flow control. The FACTS devices offer a fast and reliable control over the transmission parameters, i.e. Voltage, line impedance, and phase angle between the sending end voltage and receiving end voltage. On the other hand the custom power is for low voltage distribution, and improving the poor quality and reliability of supply affecting sensitive loads. Custom power devices are very similar to the FACTS. Most widely known custom power devices are DSTATCOM, UPQC and DVR.

DSTATCOM is very well known and can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system. It is a custom power device which is gaining a fast publicity during these days due to its exceptional features like it provides fast response, suitable for dynamic load response or voltage regulation and automation needs. DSTATCOM can be applied on wide range of distribution and transmission voltage.

This paper describes that the power electronic based power conditioning using custom power devices like DSTATCOM can

be effectively utilized to improve the quality of power supplied to the customers.

II. POWER QUALITY AND RELIABILITY

Power quality and reliability cost the industry large amounts due to mainly sags and short-term interruptions with distorted and unwanted voltage wave forms. The main concern for the consumers of electricity is the reliability of supply. Here we define the reliability as the continuity of supply.

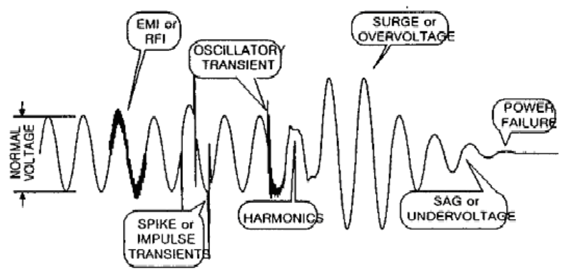

Fig.1 Power Quality and Reliability

As shown in Fig.1, the problem of distribution lines is divided into two major categories. First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage.

Both the reliability and quality of supply are equally important. For example, a consumer that is connected to the same bus that supplies a large motor load may have to face a severe dip in his supply voltage every time the motor load is switched on. In some extreme cases even we have to bear the black outs which is not acceptable to the consumers. There are also sensitive loads such as hospitals (life support, operation theatre, and patient database system), processing plants, air traffic control, financial institutions and numerous other data processing and service providers that require clean and uninterrupted power. In processing plants, a batch of product can be ruined by voltage dip of very short duration. Such customers are very wary of such dips since each dip can cost them a substantial amount of money. Even short dips are sufficient to cause contactors on motor drives to drop out. Stoppage in a portion of process can destroy the conditions for quality control of product and require restarting of production. Thus in this scenario in which consumers increasingly demand the quality power, the term power quality (PQ) attains increased significance.

Transmission lines are exposed to the forces of nature. Even though the power quality problem is distribution side problem, transmission lines are often having an impact on the quality of the power supplied. It is however to be noted that while most problems associated with the transmission systems arise due to the forces of nature or due to the interconnection of power systems, individual customers are responsible for more substantial fraction of the problems of power distribution systems.

III. DSTATCOM

The Distribution Static Compensator (DSTATCOM) is a voltage source inverter based static compensator (similar in many respects to the DVR) that is used for the correction of bus voltage sags. Connection (shunt) to the distribution network is via a standard power distribution transformer. The DSTATCOM is capable of generating continuously variable inductive or capacitive shunt compensation at a level up its maximum MVA rating. The DSTATCOM continuously checks the line waveform with respect to a reference ac signal, and therefore, it can provide the correct amount of leading or lagging reactive current compensation to reduce the amount of voltage fluctuations. The major components of a DSTATCOM are shown in Fig. 2. It consists of a dc capacitor, one or more inverter modules, an ac filter, a transformer to match the inverter output to the line voltage, and a PWM control strategy. In this DSTATCOM implementation, a voltage-source inverter converts a dc voltage into a three-phase ac voltage that is synchronized with, and connected to, the ac line through a small tie reactor and capacitor (ac filter).

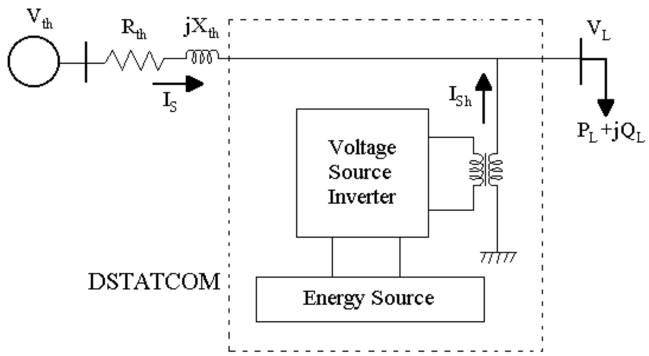

Fig.2 Basic configuration of DSTATCOM

In this work, the performance of VSC based power devices acting as a voltage controller is investigated. Moreover, it is assumed that the converter is directly controlled (i.e., both the angular position and the magnitude of the output voltage are controllable by appropriate on/off signals) for this it requires measurement of the rms voltage and current at the load point.

The DSTATCOM is commonly used for voltage sags mitigation and harmonic elimination at the point of connection. The DSTATCOM employs the same blocks as the DVR, but in this application the coupling transformer is connected in shunt with the ac system, as illustrated in Fig.2. The VSC generates a three-phase ac output current which is controllable in phase and magnitude. These currents are injected into the ac distribution system in order to maintain the load voltage at the desired voltage reference.

IV. MATLAB MODELS

(A) Model without DSTATCOM compensation

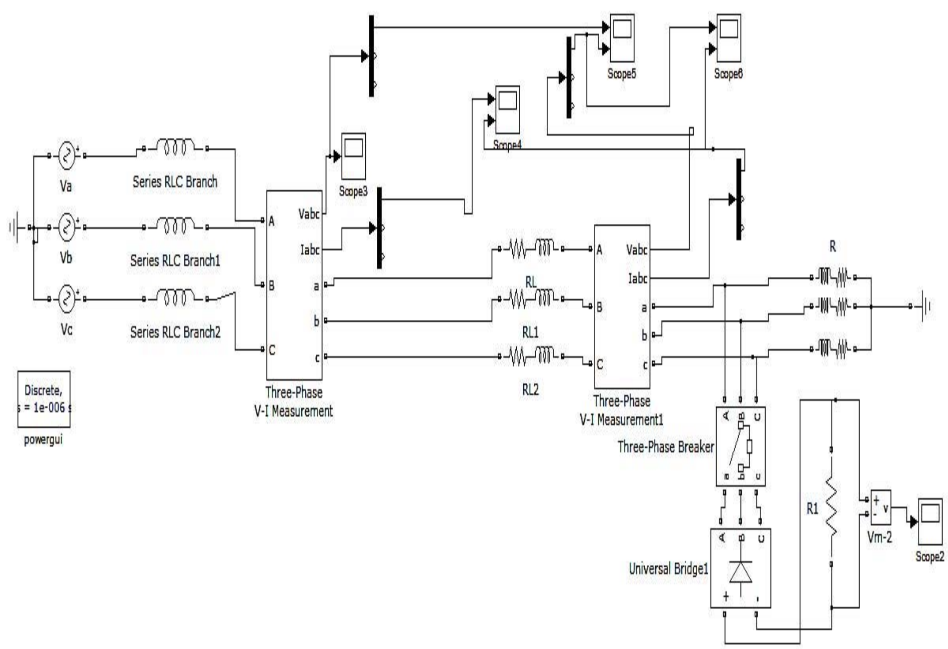

Fig. 3 Simulink Model of Uncompensated Lines with Non-Linear Load

(B) Model with DSTATCOM compensation

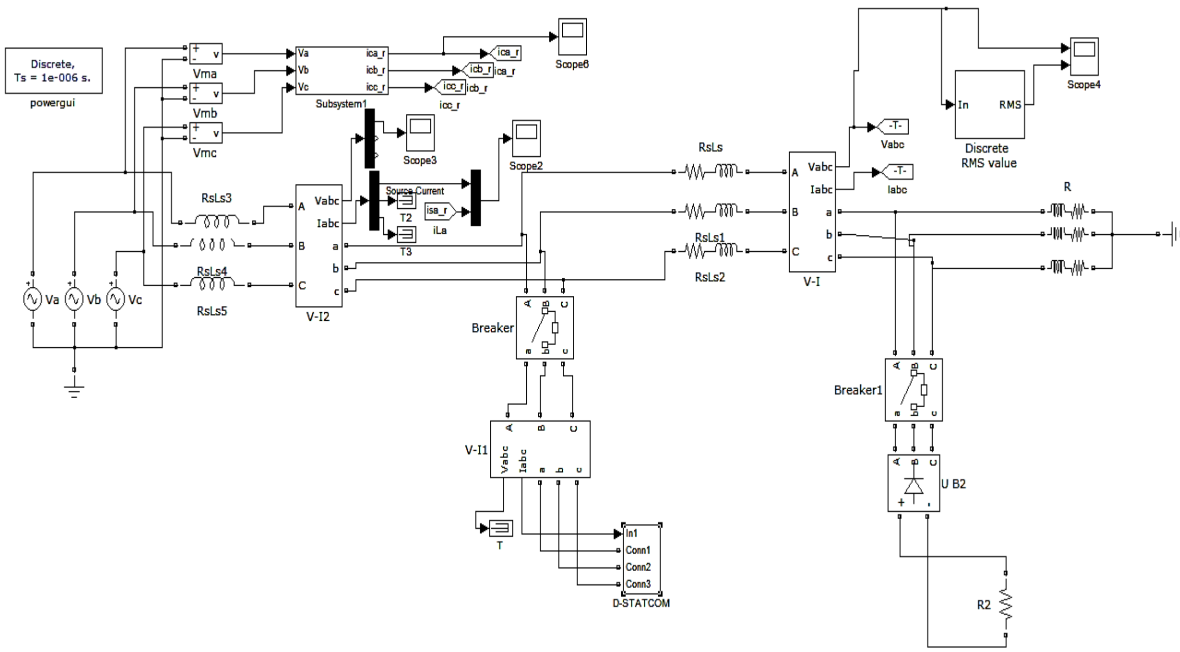

Fig. 4 Simulink Model of Compensated Lines with Non-Linear Load

V. EXPERIMENTAL RESULTS

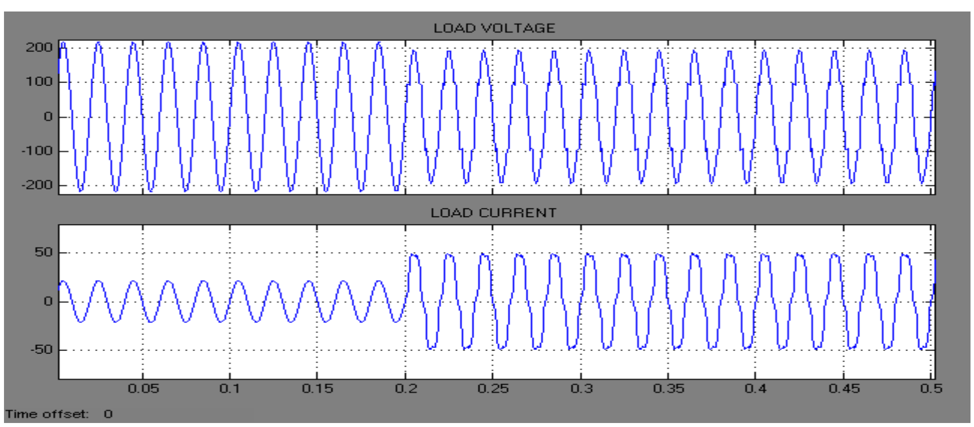

Fig.5 Load Voltage & Load Current respectively with Inductive Load in the Uncompensated Line

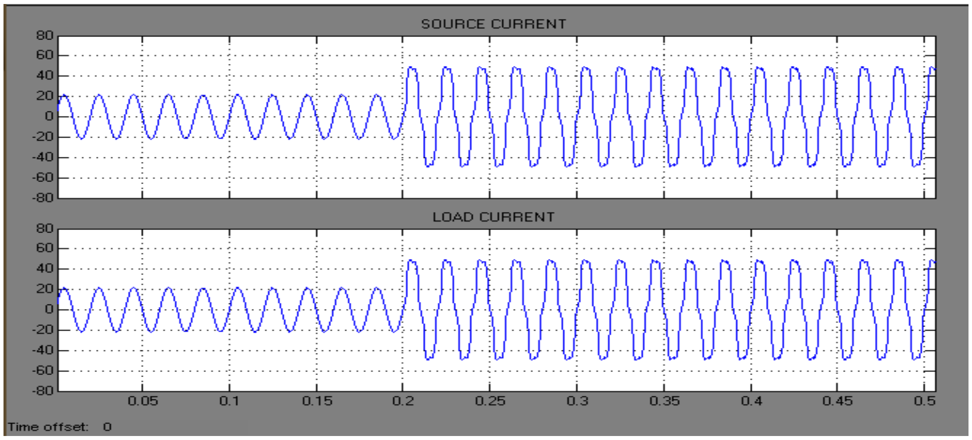

Fig.6 Source Current & Load Current respectively with Inductive Load
in the Uncompensated Line

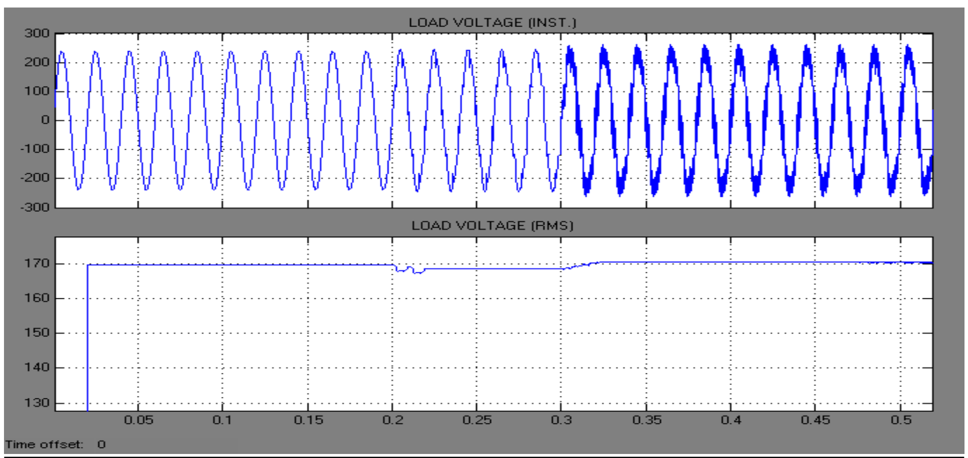

Fig. 7 Load voltage (Instantaneous & RMS) with Inductive Load
in the compensated Line

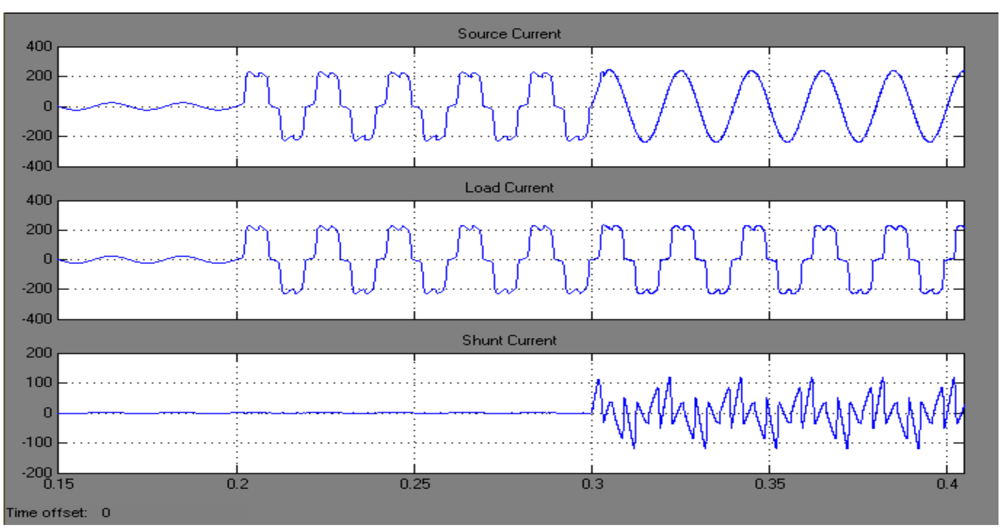

Fig. 8 Source Current, Load Current & Shunt Current respectively
with Inductive Load in the compensated Line

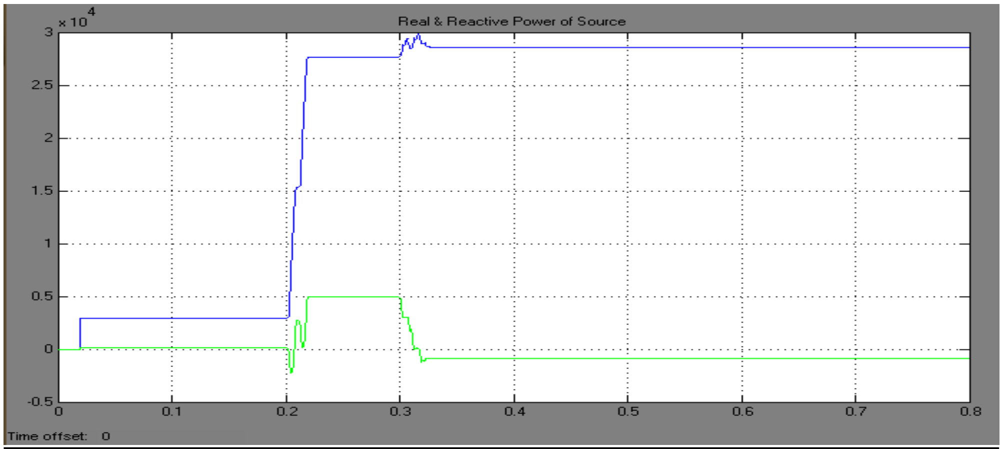

Fig. 9 Real & Reactive Power of Source with Inductive Load
in the compensated Line

Case 1: Simulation without DSTATCOM compensation (a non-linear load is applied after 0.2 seconds the start of the simulation).
Considering that there is a fixed inductive load is connected to the line. After 0.2 second when the circuit breaker is closed and a non-linear load is applied, the Load voltage gets reduced and Load current get increased (fig. 5). Due to nonlinear load both the Source current & Load current get distorted (fig.6).

Case 2: Simulation with DSTATCOM compensation (a non-linear load is applied after 0.2 seconds and the DSTATCOM after 0.3 seconds the start of the simulation).
Considering that there is a fixed inductive load is connected to the line. After 0.2 second when the circuit breaker is closed and a non-linear load is applied, the Load Voltage gets reduced and both the Source Current & Load Current get increased as well as distorted. Also the Reactive Power requirement gets increased.
After 0.3 second when the DSTATCOM is taken in the circuit the Source current becomes sinusoidal and free from harmonics because now the shunt current requirements of non-linear load are fulfilled by DSTATCOM. Now the Load Voltage & the Reactive Power again get reduced and become constant. (fig 7, fig 8, fig 9).
Above all simulation results obtained justify these facts that DSTATCOM compensation provides harmonics less better sinusoidal Source current, improved Load Voltage and reductions in Reactive Power.

VI. CONCLUSION

Custom Power (CP) devices can be used, at reasonable cost, to provide high power quality and improved power service. These Custom Power devices provide solutions to power quality at the medium voltage distribution network level. This project presents the detailed modeling of one of the custom power products, DSTATCOM is presented using instantaneous P-Q theory, used for the control of DSTATCOM are discussed. These control algorithms are described with the help of simulation results under linear loads. The control scheme maintains the power balance at the PCC to regulate the dc capacitor voltages. PWM control scheme only requires voltage measurements. This characteristic makes it ideally suitable for low-voltage custom power applications. The control scheme was tested under a wide range of operating conditions, and it was observed to be very robust in every case. Extensive simulations were conducted to gain insight into the impact of capacitor size on DSTATCOM harmonic generation, speed of response of the PWM control and transient overshooting. It was observed that an undersized capacitor degrades all three aspects. On the other hand, an oversized capacitor may also lead to a PWM control with a sluggish response but it will reduce D-STATCOM harmonic generation and transient overshooting. It is concluded that a DSTATCOM though is conceptually similar to a STATCOM at the transmission level; its control scheme should be such that in addition to complete reactive power compensation, power factor correction and voltage regulation the harmonics are also checked, and for achieving improved power quality levels at the distribution end.

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