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Reactive Power and Unbalance Load Controlled by New Adeline Based Algorithm by Using DSTATCOM

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ABSTRACT:

The majority of power consumption has been drawn in reactive loads such as fans, pumps etc. The excessive reactive power demand increases feeder losses and reduces the active power flow capability of distribution system where as unbalancing affects the operation of transformers and generators DSTATCOM can be used for the compensation of reactive power and unbalance loading in distribution system. The performance of the DSTATCOM depends on the control algorithm i.e. the extraction of the current components. In this paper DSTATCOM is controlled by IRP and SRF theory for compensation of reactive power and unbalance and these methods are compared with a new Adeline based algorithm. Adeline based control algorithm is simple and need less computational efforts, The mathematical derivation of the p-q and SRF theory has been employed to demonstrate the behavior of DSTATCOM.

An Adeline based control technique has resulted inconsiderable improved performance of DSTATCOM.The estimation of this reference current through Adeline utilizes LMS algorithm for calculation of weights. Here DSTATCOM system with lagging power factor loads connected to 3-phase, 3-wire distribution system.The lagging power-factor load is realized by star connected resistive inductive (R-L) load DSTATCOM provides reactive power as needed by the load and therefore the source current remains at unity power factor (UPF). The proposed algorithm is based on the extraction of current component in phase with the unit voltage template. The Adeline based technique utilizes LMS algorithm to calculate the weights, and all the calculations are performed online therefore the algorithm is able to extract reference current.

A MATLAB based simulation study of these three control techniques of DSTATCOM is presented. Simulation results demonstrate the effectiveness of these three control algorithms of DSTATCOM for compensation of reactive power burden and unbalanced loading.

INTRODUCTION:

In the early days of power transmission in the late 19th century problems like voltage deviation during load changes and power transfer limitation were observed due to reactive power unbalances. Today these Problems have even higher impact on reliable and secure power supply in the world of Globalization and Privatization of electrical systems and energy transfer. 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, DVR among them DSTATCOM is very well known and can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system .The performance of the DSTATCOM depends on the control algorithm i.e. the extraction of the current components.

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For this purpose there are many control schemes which are reported in the literature and some of these are instantaneous reactive power (IRP) theory, instantaneous compensation, instantaneous symmetrical components, synchronous reference frame (SRF) theory, computation based on per phase basis, and scheme based on neural network. Among these control schemes instantaneous reactive power theory and synchronous rotating reference frame are most widely used. This project focuses on the compensating the voltage sag, swells and momentary interruptions. The dynamic performance is analyzed and verified through simulation.

REACTIVE POWER AND ITS CONTROL:

Reactive power flow on the alternating current transmission system is needed to support the transfer of real power over the network. In alternating current circuits energy is stored temporarily in inductive and capacitive elements, which can result in the periodic reversal of the direction of energy flow. The portion of power flow remaining after being averaged over a complete AC waveform is the real power, which is energy that can be used to do work. Transmission connected generators are generally required to support reactive power flow. For example on the Great Britain transmission system generators are required by the Grid Code Requirements to supply their rated power between the limits of 0.85 power factor lagging and 0.95 power factor leading at the designated terminals.

DSTATCOM AND ITS OPERATION:

The flexible ac transmission technology allows a greater a control of power flow. Since these devices provide very fast power swing damping, the power transmission lines can besecurely loaded up to their thermal limits. In a similar way power electronic devices can be applied to the power distribution systems to increase the reliability and quality of power supplied to the customers.The DSTATCOM is a three-phase and shunt connected power electronics based device.

It is connected near the load at the distribution systems. It consists of a dc capacitor, three-phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy. The basic electronic block of the D-STATCOM is the voltage-sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency.

CONTROL ALGORITHMS FOR DSTATCOM:

For reactive power compensation, DSTATCOM provides reactive power as needed by the load and therefore the source current remains at unity power factor (UPF). Since only real power is being supplied by the source, load balancing is achieved by making the source reference current balanced. The reference source current used to decide the switching of the DSTATCOM has real fundamental frequency component of the load current which is being extracted by these techniques. The control algorithms for the DSTATCOM are Instantaneous reactive power theory, synchronous reference frame theory, adaline based control technique. The adaline based control algorithm improves in better performance and reduces the computational efforts of the system. These control algorithms using DSTATCOM can be discussed in this chapter.

CONTROL OF DSTATCOM BY P-Q THEORY:

Fig 6.2 shows the dynamic performance of DSTATCOM using the p-q theory based current extractor. The considered load is reactive at 0.8 lagging power factor. The Iref is the realpart of the load current. The load has been increased from 16kVA to 32kVA at 0.12sec and unbalanced is introduced at 0.18 sec. After 0.24 sec the dynamics are shown in reverse sequence. The operation of DSTATCOM controlled by the p-q theory is shown in Fig 6.2. The dynamics and unbalance conditions are simulated as per the previous case. The delay incompensation can be seen from source current waveforms. This delay is due to the low pass filter (LPF) used for filtering power signals. Moreover, p-q theory uses voltage signals to compute instantaneous active and reactive powers, any distortion and unbalance in voltage will lead to inaccurate calculation of reference source currents which should contain only real fundamental frequency component of load current. The matlab based model of DSTATCOM basedinstantaneous reactive power (p-q) theory is shown in fig 6.2.

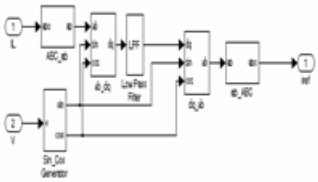

Fig 6.2: Instantaneous reactive power (p-q) theory

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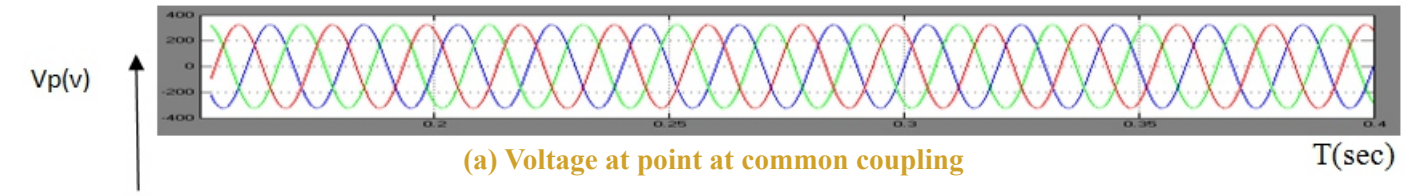
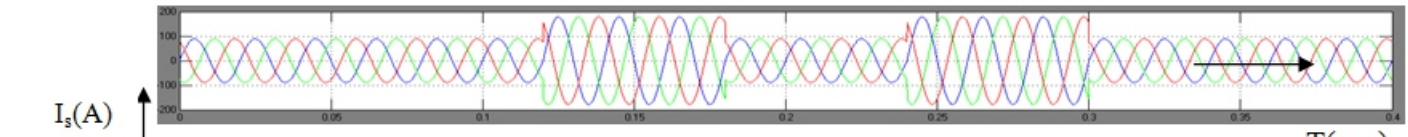
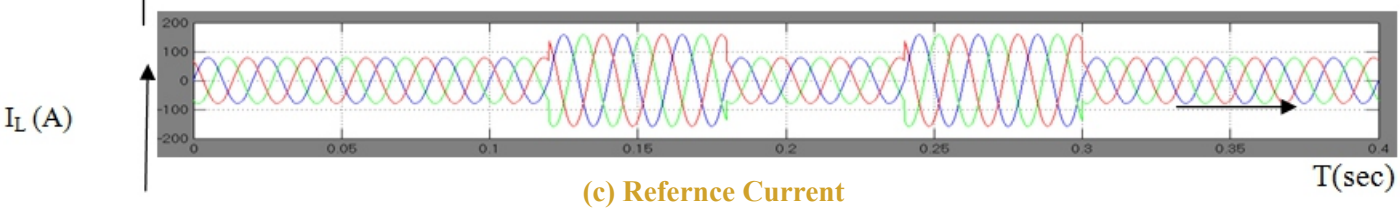


(a) Voltage at point at common coupling

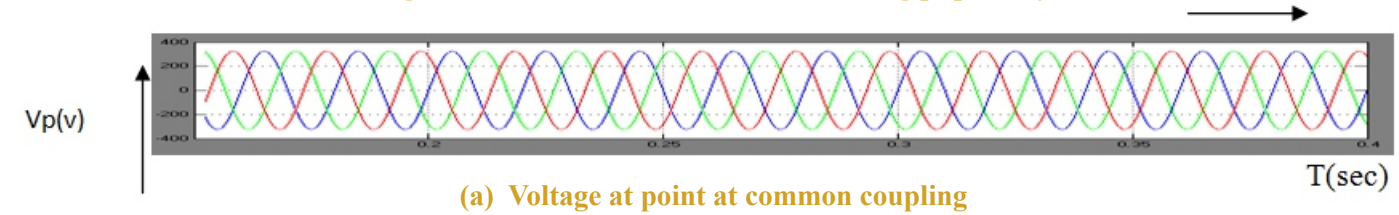


(b) Source Current

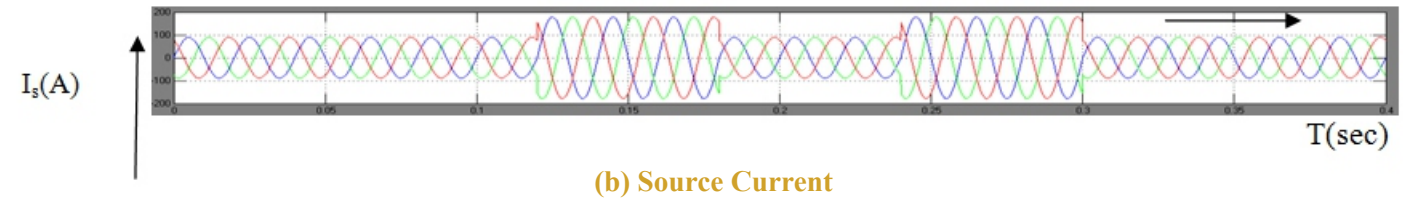


(c) Refernce Current

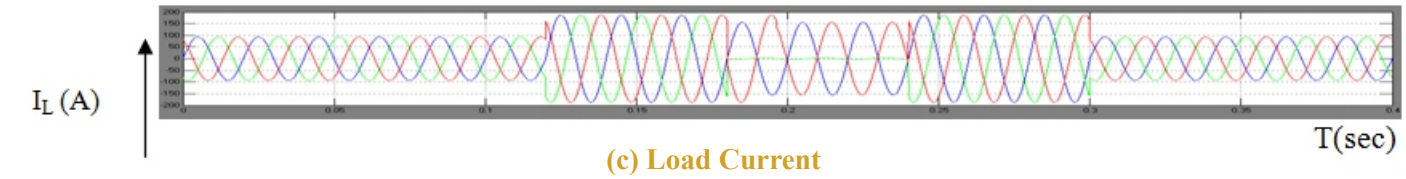
Fig 6.3: Reference current extraction using p-q theory



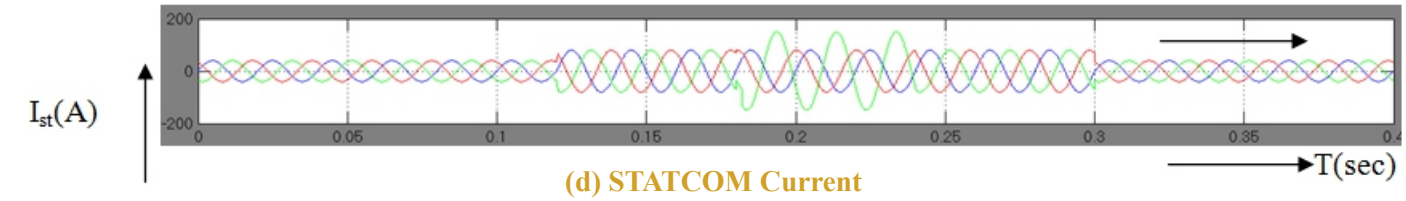
(a) Voltage at point at common coupling



(b) Source Current



(c) Load Current



(d) STATCOM Current

Fig 6.4: Dynamic performance of the DSTATCOM controlled by p-q theory

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CONTROL OF DSTATCOM BY SRF THEORY:

The matlab based model of DSTATCOM based synchronous reference frame theoryis shown in fig 6.5.Fig 6.6 shows the extraction of real fundamental current component of load current by SRF theory and the performance of the DSTATCOM is controlled by SRF theory is presented in Fig 6.7.The effect of delay due to LPF used for filtering signals in d-q frame can be seen in extracted reference currents waveform in Fig 6.5. The generation of voltage templates (sine and cosine) plays an important role in calculation of reference source currents.

These templates are generated using PLL and therefore the tuning of PLL is crucial. The operation of PLL slows and italso imposes some amount of delay in computation. The simulation is carried out for similar load changes and unbalanced conditions as of previous case.

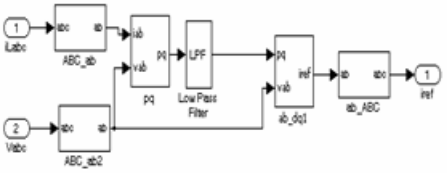
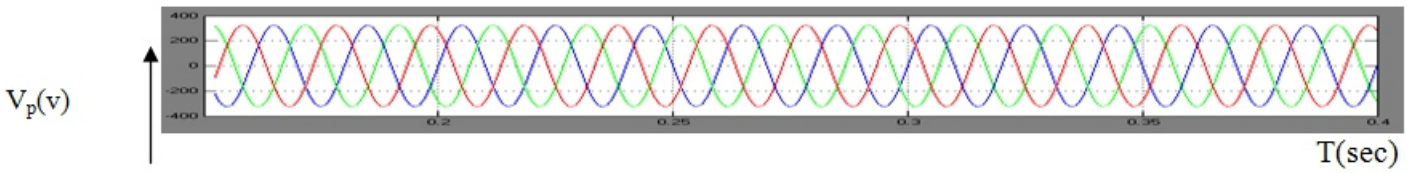
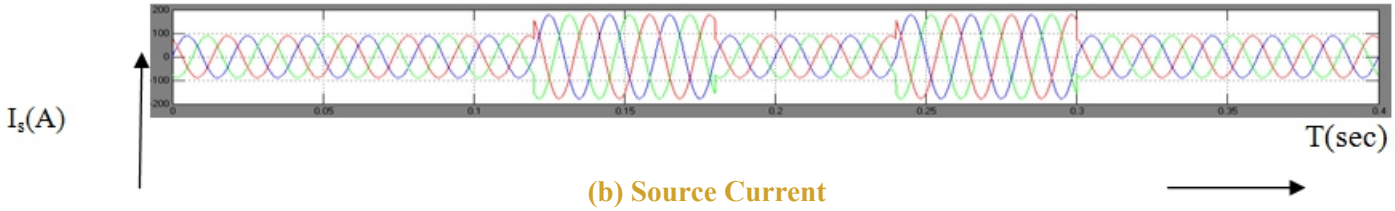


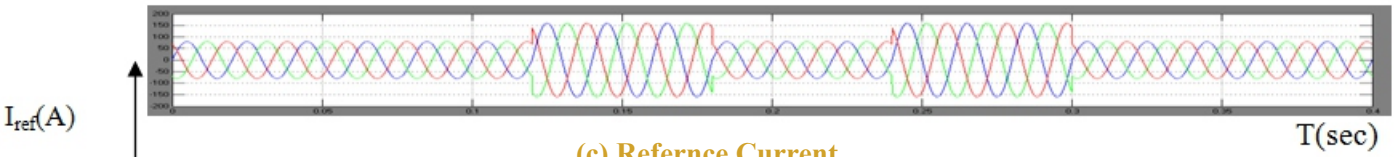
Fig 6.5:MATLAB based model of current extraction using SRF theory



(a) Voltage at point at common coupling

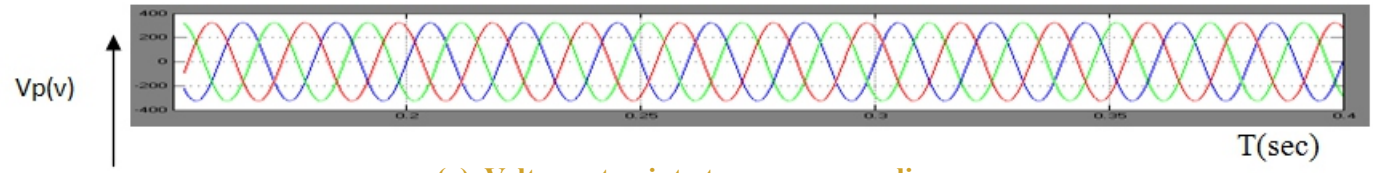


(b) Source Current

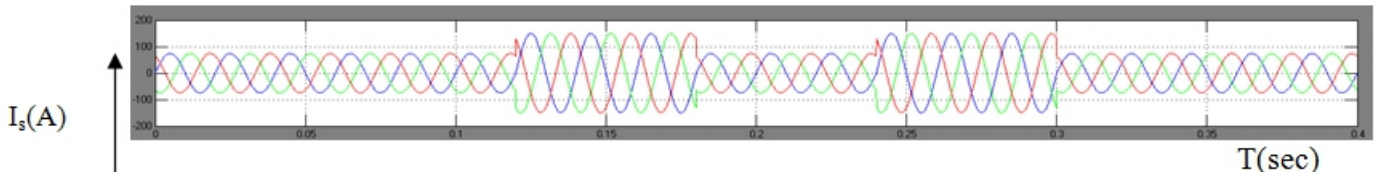


(c) Refernce Current

Fig 6.6: Reference current extraction using SRF theory



(a) Voltage at point at common coupling



(b) Source Current

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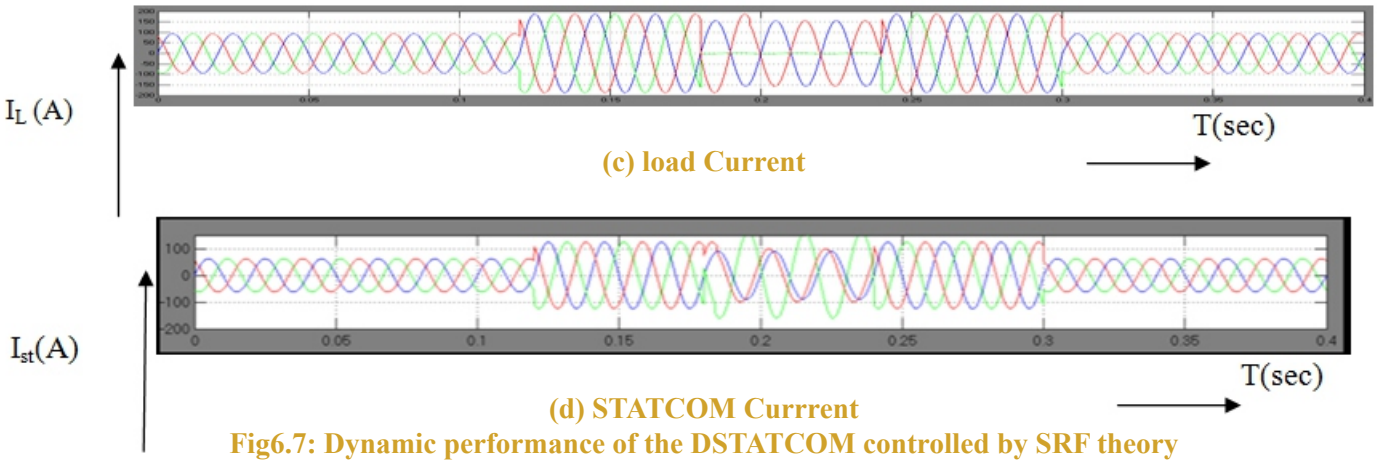


(c) load Current

(d) STATCOM Currrent

Fig6.7: Dynamic performance of the DSTATCOM controlled by SRF theory

CONTROL OF DSTATCOM BY ADALINE BASED ALGORITHM:

The matlab based model of DSTATCOM based adaline based algorithm is shown in fig 6.8.

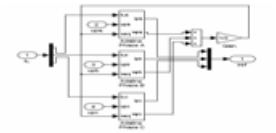
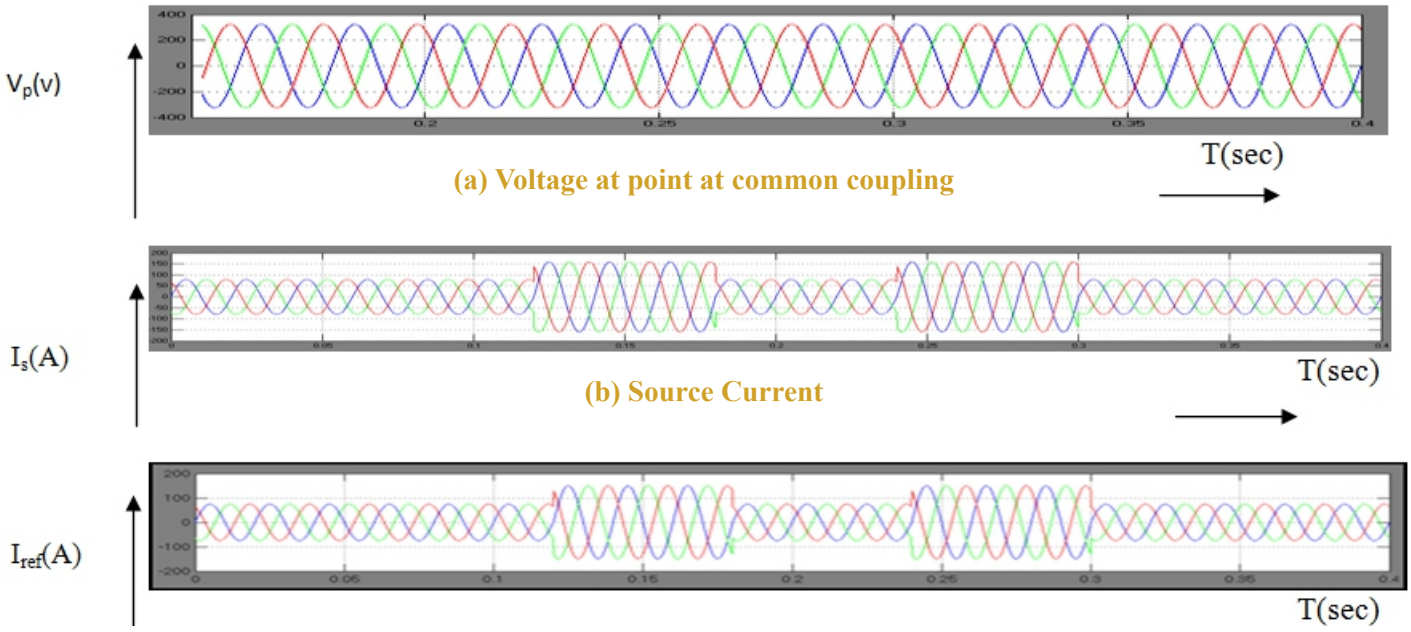


Fig6.8:Dynamic performance of the DSTATCOM controlled byADALINE BASED ALGORITHM.

Extraction of reference currents by Adaline based current extractor is shown in Fig 6.9. The performance of the DSTATCOM is shown in Fig 6.10. It can be observed that the DSTATCOM controlled by the Adaline is able to meet the load changes within one cycle of the sine wave. The advantage of the Adaline based extractor is that it requires less computation efforts and therefore the implementation of this technique is much simpler. Moreover, the inherent linearity of Adaline makes it as a fast technique. The speed of convergence can be varied by varying the value of η (convergence coefficient).



(a) Voltage at point at common coupling

(b) Source Current

(c) Refernce Current

Fig6.9: Reference current extraction using Adaline based current extractor

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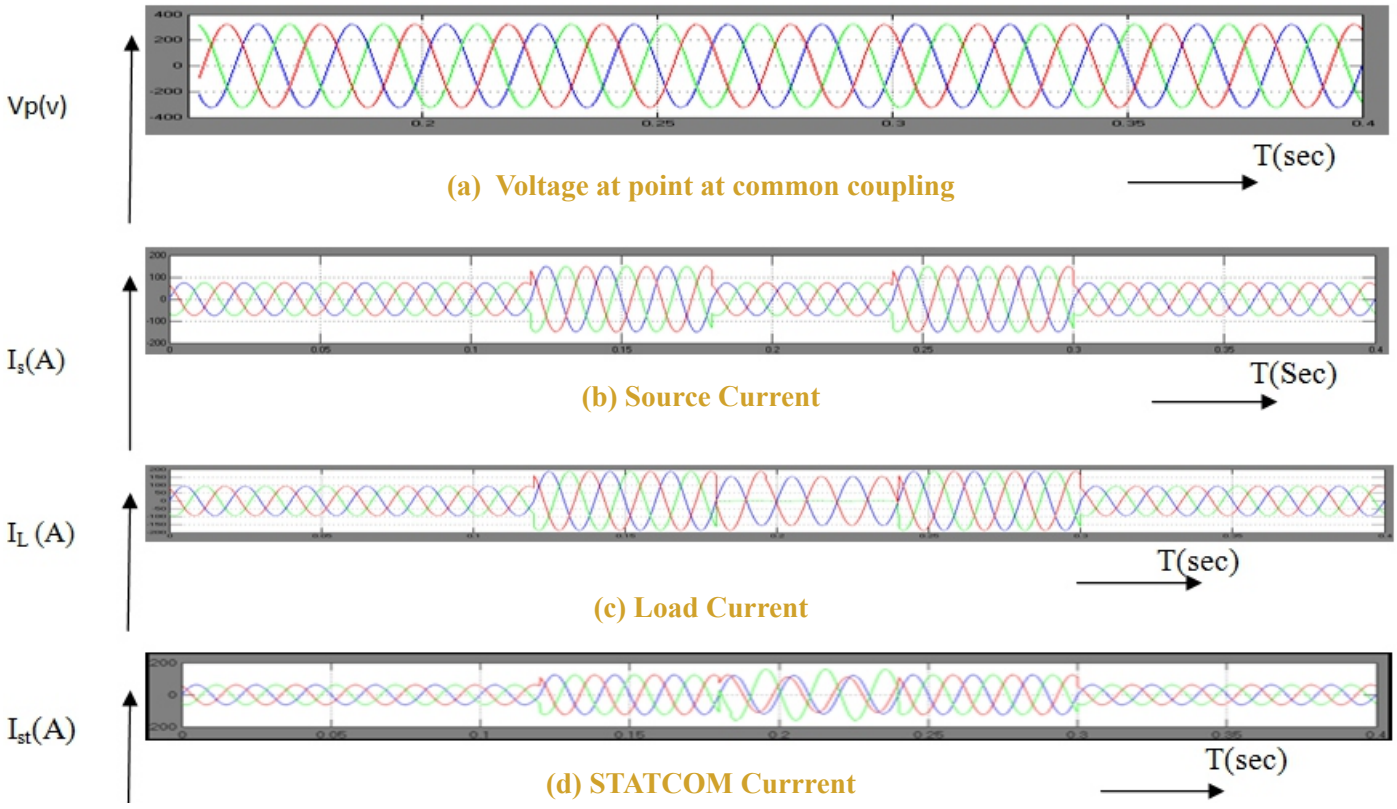
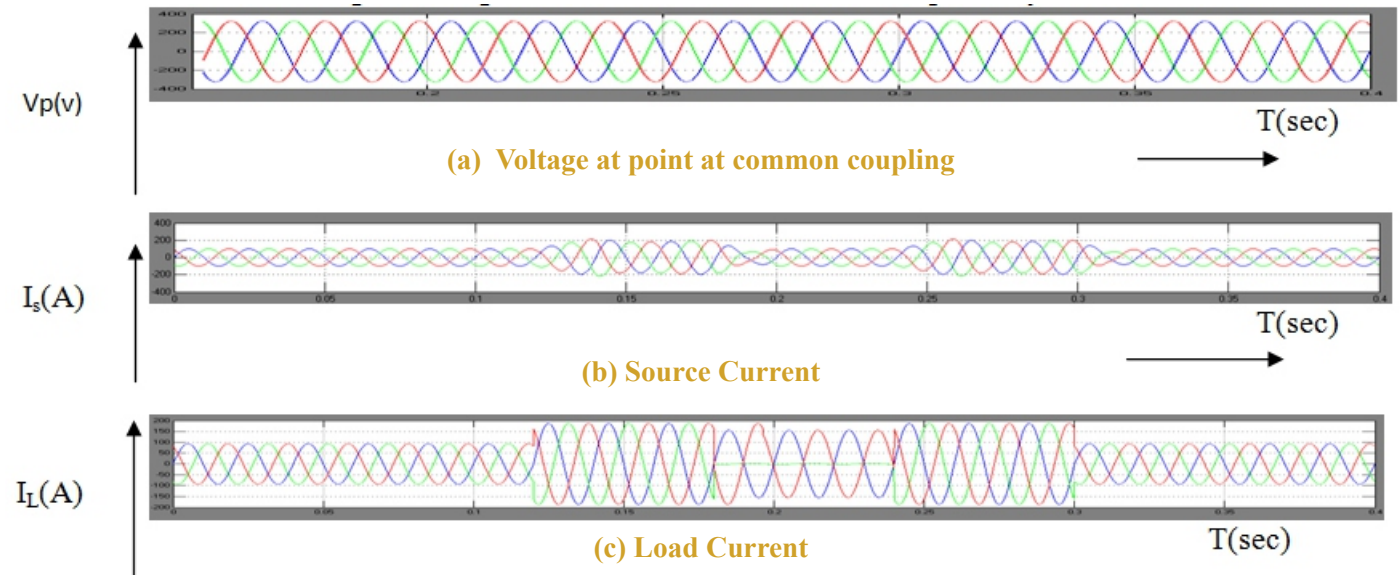


Fig 6.10: Dynamic performance of the DSTATCOM controlled by Adaline based current extractor

SELF SUPPORTING DC BUS OF DSTATCOM:

The operation of DSTATCOM with self supporting dc bus is shown in Fig 6.11. The dc bus voltage (vdc) is maintained at 800V. The effect of load change can be seen on dc bus voltage.

Further the second harmonic oscillations are observed in case of unbalancing of load. The action of PI controller is to maintain the dc bus voltage at reference value and it can be said that the dc bus voltage is brought to reference value within a couple of cycle of sinewave.



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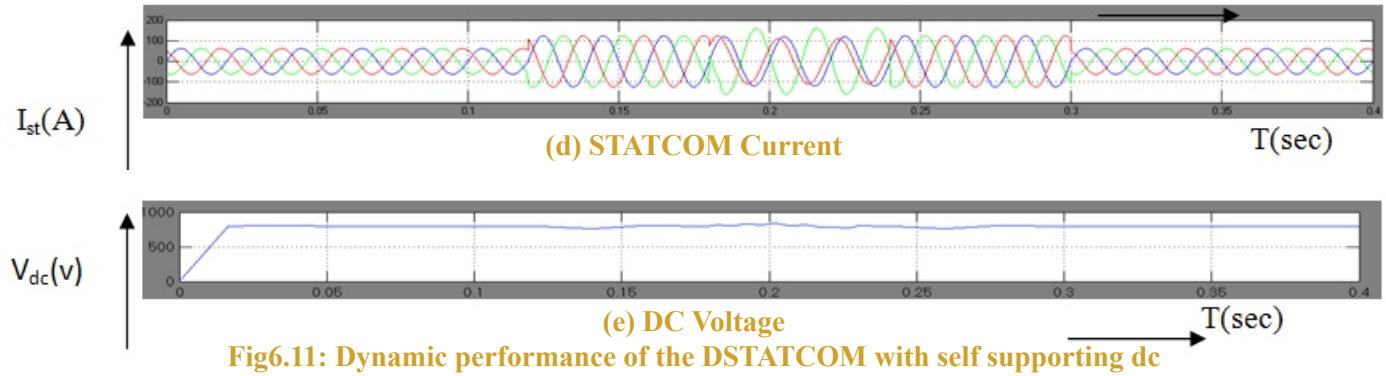

Fig6.11: Dynamic performance of the DSTATCOM with self supporting dc bus controlled by Adaline based current extractor

CONCLUSION:

In this chapter, we discussed about the simulation results obtained forcontrol algorithms i.e., instantaneous reactive power theory(PQ theory), synchronous reference frame theory(SRFtheory), adaline based theory, self supporting dcbus controlled by adaline based currentextractorfor the DSTATCOM for both the reference current extraction for every method anddynamic performance of the DSTATCOM. The obtained results are compared in this chapter and the benefits for the adaline theory compared to conventional methods are: an adaline based control technique has resulted in considerable improved performance of DSTATCOM and this technique utilizes LMS algorithm to calculate the weights, and all the calculations are performed online therefore the algorithm is able to extract reference current components in case of varying load condition which otherwiseis not possible with other neural network based current extraction techniques. MATLAB based results have verified the effectiveness of these control algorithms.

The mathematical derivation of the p-q and SRF theory has been employed to demonstrate the behavior of DSTATCOM. An Adaline based control technique has resulted in considerable improved performance of DSTATCOM. The Adaline based technique utilizes LMS algorithm to calculate the weights, and all the calculations are performed online therefore the algorithm is able to extract reference current components in case of varying load condition which otherwiseis not possible with other neural network based current extraction techniques. MATLAB based results have verified the effectiveness of these control algorithms.

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