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An Enhancement of Power Quality by the use of D-STATCOM and Soft Computing Techniques

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ABSTRACT

The present the rising reality of consignment plus consciousness of customers, superiority of power is flattering very significant matter. At whatever time consignment is also switch on or off, the impedance of line changes. This alters in impedance because disturb in sum authority full and total power command. As power is straight comparative to square of electrical energy, so the scale of electrical energy is exaggerated [1-3]. As consignment in authority scheme change at fast speed, the scale of electrical energy too change at the similar speed .This usual alter in scale of electrical power cause warp in normal waveform of electrical energy. For the improved authority excellence there are two effects to consider that electrical energy waveform be supposed to be factual and scale must be steady. So it can be said to excellence of authority get imprecise at constant base .The need of control excellence can cause loss of damage of tools, loss of production or even can lead system towards unsteadiness. So the plan of the control scheme is supposed to be such that constancy of the scheme is maintain by overcome all these variation [5].

This document present completion of a three stage sharing stationary compensator (DSTATCOM) by a back propagation (BP) control algorithm for its function such as harmonic elimination, consignment matching and immediate power recompense for power factor correction, and nil energy regulation below nonlinear loads. A BP-based control algorithm is used for the extraction of the fundamental weighted value of active and reactive power components of load currents which are required for the estimation of reference source currents. A prototype of D-STATCOM is residential using a digital indicator central processing unit, and its presentation is deliberate under various operating conditions. The presentation of D-STATCOM is found to be acceptable with the future control algorithm for various types of loads [2].

KEYWORDS: *Back propagation (BP) control algorithm, harmonics, load balancing, power quality, weights, voltage source converter (VSC).*

I. Introduction

The excellence of accessible supply power has a straight financial impact on industrial and domestic sectors which affect the enlargement of any state. This issue is more severe in electronic based system. The stage of harmonics and hasty authority order are accepted parameters that specify the amount of deformation and reactive power demand at an exacting bus of the usefulness. The vocal quality is one of the majorities ordinary evils report in low and medium-level allocation system. It is due to capacitors which are worn for power factor alteration (PFA) and starting place impedance. Power converter-based tradition power devices are helpful for the decrease of power quality troubles such as PFC, harmonic recompense, electrical energy sag/swell reward, quality due to deformation, and energy flicker decrease within particular global principles[2].

These CPDs comprise the sharing stationary compensator (DSTATCOM), forceful electrical energy restorer, and united power quality conditioner in dissimilar configurations. A quantity of of their new topologies is also report in the text such as the not direct matrix converter base vigorous compensator where the dc-link capacitor can be removed. Additional original configurations are base on stack multi cell converters wherever the main features are on the add to in the integer of production electrical energy level, devoid of transformer process in addition to usual personality complementary of rapid capacitor voltage, etc. The presentation of any convention control device depends very much upon the manage algorithm used for the position current judgment and gating pulsation making scheme. Some of the classical control algorithms are the Fryze power theory, Budeanu theory, p-q theory and SRF theory, Lyapunov-function-based control and nonlinear control method, etc [2-6]. lots of non representation and preparation base option control algorithms are report in the journalism with application of soft computing technique such as neural network, fuzzy logic and Adaptive neuro-fuzzy, etc. Adaptive knowledge, personality association, real time process, plus responsibility tolerance from side to side superfluous in order are main compensation of these algorithms. A neural network-based manage algorithm such as the Hopfield-type neural network is also used for the opinion of the amplitude and stage angle of the basic part together with extremely indistinct voltage by the supposition of known authority incidence[6].

In this document, a BP algorithm is implemented in a three phase push linked tradition control tool recognized as DSTATCOM for the removal of the biased worth of freight full of life power and reactive power present mechanism in nonlinear masses. The future manage algorithm is worn for choral repression plus freight complementary in PFC and zero electrical energy parameter (ZVR) mode by means of dc electrical energy rule of DSTATCOM. In this BP algorithm, the preparation of weights has three stages. It include nourish ahead of the contribution sign preparation, computation and BP of the mistake signals, and development of training weights. It might hold one or more than one layer. Permanence, differentiability, and no lessening repetitiveness are the main uniqueness of this algorithm. It is based on a arithmetical method and does not require particular features of purpose in the erudition procedure. It also has flat difference on mass alteration due to batch update features on weights. In the preparation procedure, it is sluggish due to additional number of knowledge steps, but after the preparation of weights, this algorithm produces very fast trained output response. In this request, the planned control algorithm on a DSTATCOM is implementing for the recompense of nonlinear loads [7].

II. SYSTEM CONFIGURATION AND CONTROL ALGORITHM

An electrical energy basis converter base DSTATCOM is linked to a three stage ac mains feed three phase linear/nonlinear loads with interior grid impedance which is exposed in Fig. 1. [1]

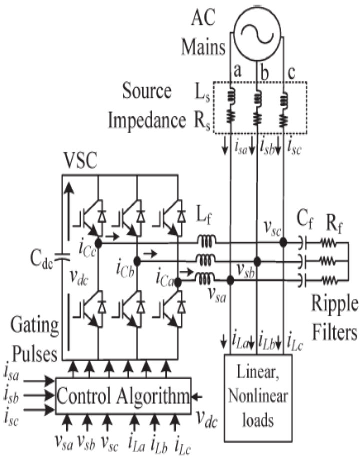


Fig.1: Essential VSC-based DSTATCOM

The presentation of DSTATCOM depends winning the correctness of vocal present detection. For dipping wave in compensate currents, the tuned values of interfacing inductors (L_f) are linked at the ac production of the VSC. A three stage sequence combination of capacitor (C_f) and a resistor (R_f) represents the shunt passive ripple filter which is connected at a point of common coupling (PCC) for reducing the high frequency switching noise of the VSC. The DSTATCOM currents (i_{Cabc}) are inject as necessary compensating currents to cancel the reactive power components and harmonics of the load currents so that loading due to reactive power component/ harmonics is reduced on the distribution system. For the considered three phase nonlinear load with approximately 24 Kw[1-6].

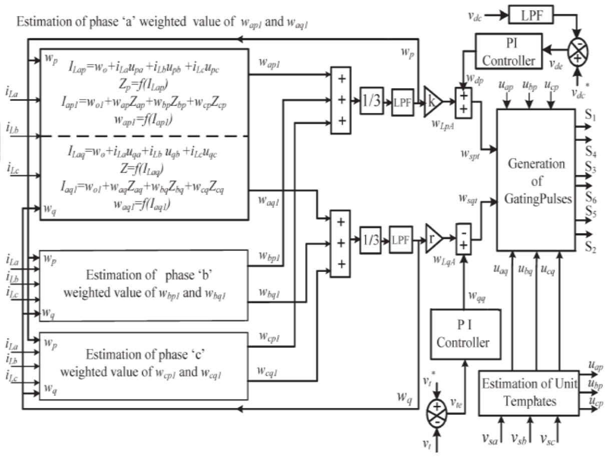


Fig. 2. Assessment of position currents using BP manage algorithm

Fig.2 shows the figure of the BP preparation algorithm for the assessment of position source currents from side to side the biased value of load lively power and reactive power existing components. In this algorithm, the phase PCC voltages(V_{sa}, V_{sb} and V_{sc}), basis currents (i_{sa}, i_{sb}, and i_{sc}) load currents (i_{La}, i_{Lb} and i_{Lc}) and dc bus voltage is necessary for the withdrawal of orientation basis currents(i^*_{sa}, i^*_{sb} and i^*_{sc}).

Present two main modes for the process of this algorithm: The first one is a feed forward, and the second is the BP of error or supervised learning. The aspect request of this algorithm for the opinion of a variety of control parameter is known as follow.

A. Assessment of biased rate of standard basic weight Active and Reactive Power Components

A BP preparation algorithm is used to approximation the three phase biased charge of weight useful power current components (W_{ap}, W_{bp}, and W_{cp}) and reactive power current (W_{aq}, W_{bq} and W_{cq}) from impure load currents using the feed forward and supervised principle. In this inference, the contribution sheet for three phases (a, b, and c) is uttered as,

$$I_{Lap} = W_o + i_{La}u_{ap} + i_{Lb}u_{bp} + i_{Lc}u_{cp} \quad (1)$$
$$I_{Lbp} = W_0 + i_{Lb}u_{bp} + i_{Lc}u_{cp} + i_{La}u_{ap} \quad (2)$$
$$I_{Lcp} = W_0 + i_{Lc}u_{cp} + i_{La}u_{ap} + i_{Lb}u_{bp} \quad (3)$$

Where $W_0$the chosen worth of the first is mass and u_{ap}, u_{bp}, and u_{cp} is the in-phase unit template.

In-phase unit template is predictable by sense PCC stage voltages(V_{sa}, V_{sb}, and V_{sc}). It is the family member of the phase voltage and the amplitude of the PCC voltage(V_t). The amplitude of sensed PCC voltages is estimated as,

$$v_t = \sqrt{\frac{2(v_{sa}^2 + v_{sb}^2 + v_{sc}^2)}{3}} \quad (4)$$

The in-phase unit template of PCC voltages(u_{ap}, u_{bp}, and u_{cp}) are predictable as [13]

$$u_{ap} = \frac{v_{sa}}{v_t}, \quad u_{bp} = \frac{v_{sb}}{v_t}, \quad u_{cp} = \frac{v_{sc}}{v_t} \quad (5)$$

The extract principles of I_{Lap}, I_{Lbp}, and I_{Lcp} are approved from side to side a sigmoid function as an activation function, and the production Signals (Z_{ap}, Z_{bp}, and Z_{cp}) of the feedforward section are expressed as, [7]

$$Z_{ap} = f(I_{Lap}) = \frac{1}{(1 + e^{-I_{Lap}})} \quad (6)$$
$$Z_{bp} = f(I_{Lbp}) = \frac{1}{1 + e^{-I_{Lbp}}} \quad (7)$$
$$Z_{cp} = f(I_{Lcp}) = \frac{1}{1 + e^{-I_{Lcp}}} \quad (8)$$

The predictable principles of Z_{ap}, Z_{bp}, and Z_{cp} are fed to a hidden layer as key signals. The three phase outputs of this layer (I_{ap1}, I_{bp1}, and I_{cp1}) earlier than the commencement meaning are uttered as,

$$I_{ap1} = w_{01} + w_{ap}Z_{ap} + w_{bp}Z_{bp} + w_{cp}Z_{cp} \quad (9)$$
$$I_{bp1} = w_{01} + w_{bp}Z_{bp} + w_{cp}Z_{cp} + w_{ap}Z_{ap} \quad (10)$$
$$I_{cp1} = w_{01} + w_{cp}Z_{cp} + w_{ap}Z_{ap} + w_{bp}Z_{bp} \quad (11)$$

Where w_{01}, w_{ap}, w_{bp}, and w_{cp} are the chosen rate of the first heaviness in the concealed layer and the efficient values of three phase weights using the standard biased value (w_p) of the active control current part as a feedback signal.

The efficient weight of phase "a" is an active power existing mechanism of consignment current "w_{ap}" at the n^{th} example immediate is spoken as,

$$w_{ap}(n) = w_p(n) + \mu\{w_p(n) - w_{ap1}(n)\} f^1(I_{ap1}) z_{ap}(n) \quad (12)$$

where $w_p(n)$ and $w_{ap}(n)$ are the average weighted value of the active power component of load currents and the updated weighted value of phase "a" at the n^{th} sampling instant, respectively, and $w_{ap1}(n)$ and $z_{ap}(n)$ are the phase "a" fundamental weighted amplitude of the active power component of the load current and the output of the feed forward section of the algorithm at the nth instant, respectively. $f^1(I_{ap1})$ And μ are represented as the derivative of I_{ap1} components and the learning rate [1-7].

Similarly, for phase "b" and phase "c," the updated weighted values of the active power current components of the load current are expressed as,

$$w_{bp}(n) = w_p(n) + \mu\{w_p(n) - w_{bp1}(n)\} f^1(I_{bp1}) z_{bp}(n) \quad (13)$$
$$w_{cp}(n) = w_p(n) + \mu\{w_p(n) - w_{cp1}(n)\} f^1(I_{cp1}) z_{cp}(n) \quad (14)$$

The extract ethics of $I_{ap1}, I_{bp1}, and\ I_{cp1}$ are approved from side to side a sigmoid purpose as an commencement function to the estimation of the basic active mechanism in terms of three phase weights $w_{ap1}, w_{bp1} and\ w_{cp1}$ as,

$$w_{ap1} = f(I_{ap1}) = \frac{1}{(1 + e^{-I_{ap1}})} \quad (15)$$

$$w_{bp1} = f(I_{bp1}) = \frac{1}{(1 + e^{-I_{bp1}})} \quad (16)$$

$$w_{cp1} = f(I_{cp1}) = \frac{1}{(1 + e^{-I_{cp1}})} \quad (17)$$

The normal influenced amplitude of the basic active power components (w_p) is predictable using the amplitude sum of three phase freight active power components $(w_{ap1}, w_{bp1}, and\ w_{cp1})$ divided by three. It is necessary to understand load complementary features of DSTATCOM. Mathematically, it is expressed as [6],

$$w_p = \frac{(w_{ap1} + w_{bp1} + w_{cp1})}{3} \quad (18)$$

First-order low-pass filters are worn to divide the low down incidence mechanism. "K" denotes the scale issue of the extract active power components of current in the algorithm which is shown in Fig. 2. Behind untying the low-frequency machinery and scale to the real value since the output of the creation function is between 0 and 1, it is represented as w_{LPA}.

Likewise, the biased amplitudes of the imprudent power components of the load currents $(w_{aq}, w_{bq}, and\ w_{cq})$ of the basic fill current are extracting as,

$$I_{Laq} = w_0 + i_{La}u_{aq} + i_{Lb}u_{bq} + i_{Lc}u_{cq} \quad (19)$$

$$I_{Lbq} = w_0 + i_{Lb}u_{bq} + i_{Lc}u_{cq} + i_{La}u_{aq} \quad (20)$$

$$I_{Lcq} = w_0 + i_{Lc}u_{cq} + i_{La}u_{aq} + i_{Lb}u_{bq} \quad (21)$$

Where w_0 is the chosen rate of the first mass and u_{aq}, u_{bq}, and u_{cq} are the quadrature components of the unit template.

The quadrature unit templates $(u_{aq}, u_{bq}, and u_{cq})$ of the phase PCC voltage are predictable by equation (5) as,

$$u_{aq} = \frac{(-u_{bp} + u_{cp})}{\sqrt{3}}, \quad u_{bq} = \frac{(3u_{ap} + u_{bp} - u_{cp})}{2\sqrt{3}} \quad and$$

$$u_{cq} = \frac{(-3u_{ap} + u_{bp} - u_{cp})}{2\sqrt{3}} \quad (22)$$

The extract morals of $I_{Laq}, I_{Lbq}, and\ I_{Lcq}$ are approved from side to side a sigmoid function as an start function to the opinion of $Z_{aq}, Z_{bq}, and\ Z_{cq}$

$$Z_{aq} = f(I_{Laq}) = \frac{1}{(1 + e^{-I_{Laq}})} \quad (23)$$

$$Z_{bq} = f(I_{Lbq}) = \frac{1}{1 + e^{-I_{Lbq}}} \quad (24)$$

$$Z_{cq} = f(I_{Lcq}) = \frac{1}{1 + e^{-I_{Lcq}}} \quad (25)$$

The predictable standards of $Z_{aq}, Z_{bq}, and\ Z_{cq}$ are fed to the concealed layer as input signals. The three phase output of this layer $(I_{aq1}, I_{bq1}, and\ I_{cq1})$ before the activation function can be represented as,

$$I_{aq1} = w_{01} + w_{aq}Z_{aq} + w_{bq}Z_{bq} + w_{cq}Z_{cq} \quad (26)$$

$$I_{bq1} = w_{01} + w_{bq}Z_{bq} + w_{cq}Z_{cq} + w_{aq}Z_{aq} \quad (27)$$

$$I_{cq1} = w_{01} + w_{cq}Z_{cq} + w_{aq}Z_{aq} + w_{bq}Z_{bq} \quad (28)$$

Where $w_{01}, w_{aq}, w_{bq}, and\ w_{cq}$ are the chosen value of the first mass in the concealed layer and the efficient three weights using the standard biased worth of the reactive power components of currents (w_q) as a feedback signal, respectively.

The efficient weight of the phase "a" is a reactive power components of load currents "w_{aq}" at the nth sampling instant is expressed as,

$$w_{aq}(n) = w_q(n) + \{w_q(n) - w_{aq}(n)\} f^1(I_{aq1})Z_{aq}(n) \quad (29)$$

$w_q(n)\ and\ w_{aq}(n)$ are the standard biased worth of the reactive power component of load currents and the updated weight in the n^{th} sampling instant, respectively, and $w_{aq1}(n)\ and\ Z_{aq}(n)$ are the phase "a" weighted amplitude of the reactive power current component of load currents and the output of the feed forward section of the algorithm at the nth instant, respectively. $f^1(I_{aq1})$, and μ are presented as the derivative of I_{aq1} components and the learning rate.

Similarly, for phase "b" and phase "c," the updated weighted values of the reactive power current components of the load current are expressed as

$$w_{bq}(n) = w_q(n) + \mu\{w_q(n) - w_{bq1}(n)\} f^1(I_{bq1}) z_{bq}(n) \quad (30)$$

$$w_{cq}(n) = w_q(n) + \mu\{w_q(n) - w_{cq1}(n)\} f^1(I_{cq1}) z_{cq}(n) \quad (31)$$

The extracted values of $I_{aq1}, I_{bq1}, and\ I_{cq1}$ are passed through an activation function to the estimation of the fundamental reactive component in terms of three phase weights $w_{aq1}, w_{bq1}, and\ w_{cq1}$ as,

$$w_{aq1} = f(I_{aq1}) = \frac{1}{(1+e^{-I_{aq1}})} \quad (32)$$

$$w_{bq1} = f(I_{bq1}) = \frac{1}{(1+e^{-I_{bq1}})} \quad (33)$$

$$w_{cq1} = f(I_{cq1}) = \frac{1}{(1+e^{-I_{cq1}})} \quad (34)$$

The standard mass of the amplitudes of the basic reactive power current components (w_q) is predictable by the amplitude sum of the three phase load reactive power components of the load current $(w_{aq1}, w_{bq1}, and\ w_{cq1})$ divided by three. Mathematically, it is expressed as,

$$w_q = \frac{(w_{aq1} + w_{bq1} + w_{cq1})}{3} \quad (35)$$

First-order low-pass filters are used to separate the low frequency component. "r" denotes the scaled factor of the extracted reactive power components in the algorithm which is shown in Fig. 2. After unraveling low-frequency components and scaling to the actual value because the output of the activation function is between 0 and 1, it is represented as $w_{LqA.}$[1-8]

B. Amplitude of Active Power Current Components of Reference Source Currents

An mistake in the dc bus energy is obtain following compare the position dc bus energy V_{dc}^* and the sense dc bus electrical energy V_{dc} of a VSC, and this error at the nth example immediate is spoken as,

$$v_{dc}(n) = v_{dc}^*(n) - v_{dc}(n) \quad (36)$$

This electrical energy fault is fed to a relative–integral (PI) manager whose production is essential for preserve the dc bus electrical energy of the DSTATCOM. At the nth example immediate, the output of the PI controller is as follows:

$$w_{dp}(n) = w_{dp}(n-1) + K_{pd}\{v_{de}(n) - v_{de}(n-1)\} + k_{id}v_{de}(n) \quad (37)$$

Where $K_{pd}\ and\ k_{id}$ are the family member and necessary add to constants of the dc bus PI manager and $v_{de}(n)\ and\ v_{de}(n-1)$ are the dc bus electrical energy error in the n^{th} and $(n-1)^{th}$ immediate, and $w_{dp}(n)\ and\ w_{dp}(n-1)$ are the amplitudes of the active power constituent of the basic reference current at the n^{th} and $(n-1)^{th}$ instant, in that order.[8]

The amplitude of the active power current mechanism of the orientation basis current (w_{spt}) is predictable by the totaling of the production of the dc bus PI controller (w_{dp}) and the standard scale of the load active currents (w_{LpA}) as,

$$w_{spt} = w_{dp} + w_{LpA} \quad (39)$$

C. Amplitude of Reactive Power Components of Reference Source Currents

A mistake in the ac bus electrical energy is achieve after compare the amplitudes of the reference ac bus voltage v_t^* and the sensed ac bus voltage

v_t Of a VSC. The extracted ac bus voltage error v_{te} At the n^{th} sampling instant is expressed as

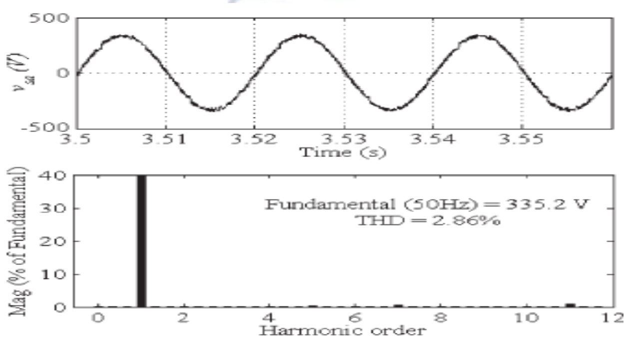
$$v_{te}(n) = v_t^*(n) - v_t(n) \quad (39)$$

III. SIMULATION RESULTS PLUS CONVERSATION

MATLAB with SIMULINK and Sim Power System toolboxes is worn for the growth of the imitation replica of a DSTATCOM and its managing algorithm. The appearance of the BP algorithm in the time area for the three phases DSTATCOM is replicated for PFC and ZVR mode of process underneath nonlinear loads. The presentation of the manage algorithm is experiential beneath nonlinear loads.

A. Performance of DSTATCOM in PFC Mode

The lively presentation of a VSC-based DSTATCOM is deliberate for PFC form at nonlinear loads. The presentation index is the phase voltages at PCC(v_s), impartial source currents(i_s), and load currents. [6]



(a)

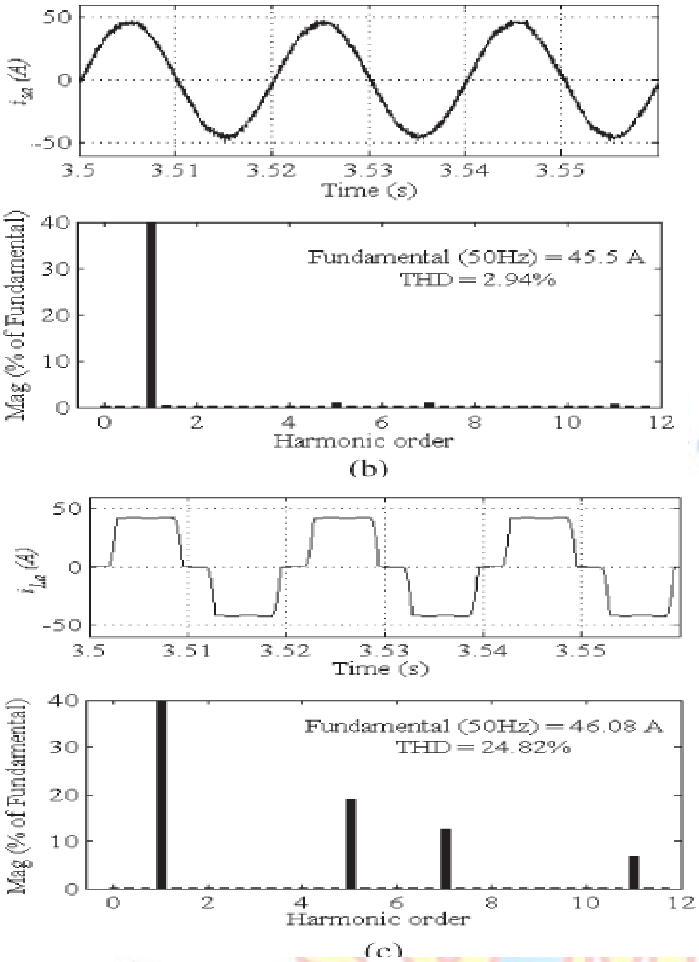
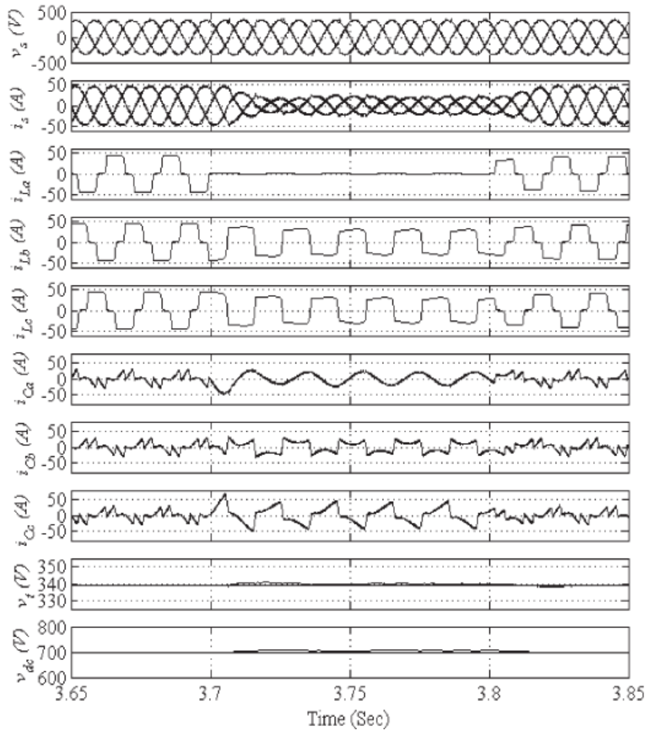


Fig. 4. Waveforms plus vocal spectrum of (a) PCC energy of phase "a," (b) source current of phase "a," plus (c) consignment current of phase "a" in PFC mode.

The waveforms of the phase "a" voltage at PCC (v_{sa}), source current (i_{sa}), and load current (i_{La}) are shown in Fig. 4(a)–(c), respectively. The total harmonic distortion (THD) of the phase "a" at PCC voltage, source current, and load current are found to be 2.86%, 2.94%, and 24.82%, respectively. It is experiential that the DSTATCOM is clever to do the function of weight complementary and vocal removal with far above the ground accuracy.

B. Performance of DSTATCOM in ZVR Mode

In ZVR mode, the amplitude of the PCC voltage is regulated to the reference amplitude by injecting extra leading reactive power components. The dynamic performance of DSTATCOM in terms of PCC phase voltages(v_s) balanced source currents (i_s) ,load currents ($i_{La}, i_{Lb}, and\ i_{Lc}$) ,compensator currents($i_{Ca}, i_{Cb}, and\ i_{Cc}$), amplitude of voltages at PCC (V_t), and dc bus voltage (V_{dc}) waveforms is shown in Fig. 5



IV. CONCLUSION

The proposed BPT control algorithm has been used for the extraction of reference source currents to generate the switching pulses for IGBTs of the VSC of DSTATCOM. Various functions of DSTATCOM such as harmonic elimination and load balancing have been demonstrated in PFC and ZVR modes with dc voltage regulation of DSTATCOM. From the simulation and implementation results, it is concluded that DSTATCOM and its control algorithm have been found suitable for the compensation of nonlinear loads. Its performance has been found satisfactory for this application because the extracted reference source currents exactly traced the sensed source currents during the steady state as well as dynamic conditions. The dc bus voltage of the DSTATCOM has also been regulated to the rated value without any overshoot or undershoots during load variation. Large training time in the application of the complex system and the selection of the number of hidden layers in the system are the disadvantages of this algorithm.

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