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Design and Simulation of PFC Based DC-DC Buck – Boost Converter Fed DC Motor System

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ABSTRACT:The devices generally used in industrial, commercial and residential applications need to undergo rectification for their proper functioning and operation. They are connected to the grid comprising of non-linear loads and thus have non-linear input characteristics, which results in production of non-sinusoidal line current. Also, current comprising of frequency components at multiples of line frequency is observed which lead to line harmonics. Due to the increasing demand of these devices, the line current harmonics pose a major problem by degrading the power factor of the system thus affecting the performance of the devices. Hence there is a need to reduce the line current harmonics so as to improve the power factor of the system. This has led to designing of Power Factor Correction circuits.Power Factor Correction (PFC) involves two techniques, Active PFC and Passive PFC. In our project work we have designed an active power factor circuit using Buck Converter for improving the power factor. Average Current Mode Control method has been implemented with buck converter to observe the effect of the active power factor corrector on the power factor. The advantage of using Buck Converter in power factor correction circuits is that better line regulation is obtained with appreciable power factor. The proposed concept can be implemented to DC motor drive Applications for two switch buck boost converter by using mat lab/Simulink software.

Index Terms-Two Switch Buck Boost, Power Factor Correction, Two Mode Control Scheme.

I INTRODUCTION

Now a day with increasing use of power converter devices and power electronic loads, more emphasis is given to power factor correction (PFC) and reduction in total harmonic distortion (THD) in the current drawn from the power utility. In order to improve the power quality, researchers have given more attention on development of new topologies on power converter. Improvements can be achieved by PFC techniques. Since now, various passive and active power factor correction circuits have been proposed, of which active power factor circuits found to be more advantageous. Thus active PFC techniques have rapidly become a vigorous research topic in the power electronics field and efforts have been made on the development of the PFC converters [1]. Various power factor correction (PFC) techniques for buck converter boost converter, buck boost converter topologies are employed to overcome the power quality problems. This paper proposes a Two Switch Buck Boost converter along with a power factor correction control to improve the power factor and hence reduce the THD. Two switch buck boost converter have the ability of both step up and step down with low voltage stress when compared with the basic converter. These converters have two switches, Ql and Q2 which are operated independently [2]. A two mode control scheme is discussed in this paper. In this scheme when input voltage is greater than the output voltage Q2 is always kept off and pulse signals to Q, is controlled to regulate the output voltage then TSBB converter is equivalent to a buck converter and when input voltage is less than the output voltage QJ is always kept on and Q2 is controlled to regulate the output voltage then TSBB converter is equivalent to a boost converter.

II CONTROL STRATEGIES FOR PFC IN AC/DC CONVERTERS

For one stage PFC converters, the main challenge is the availability of only one control variable to perform voltage regulation and power factor correction in a single step. As a result, in the design of the controller, a tradeoff needs to be considered between output voltage regulation and power factor correction. For single-stage PFC converters many control techniques have been designed [3]-[8] which are classified as follows.

1. Peak current control
2. Hysteresis current control
3. Average current-mode control

Each of these control techniques is explained briefly below

1. Peak Current Control

In Peak Current Control, the positive slope of the inductor current is controlled so that it is equal to a reference value in each switching cycle. The inductor current increases when the switch is on, till instantaneous current reaches the reference value and then the switch is turned off The product of the voltage compensator output and the sensed input voltage gives the sinusoidal current reference, and it is used to keep the input current in phase with the input voltage. Absence of current compensator for the controller and

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constant switching frequency is the peculiarity of this scheme. Such a control scheme is shown in fig. 1.

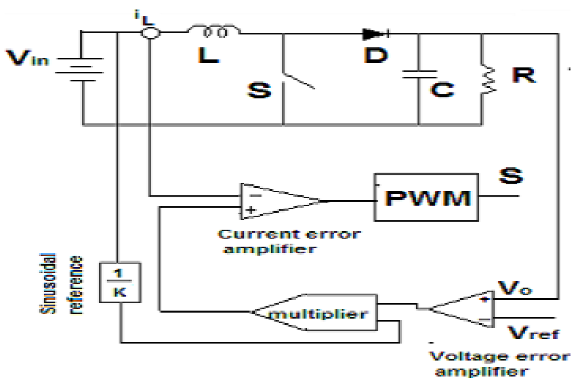


Fig1 :peak current control

2. Hysteresis current control:

Fig 2 shows the hysteresis control scheme. In this type of control with respect to maximum and minimum boundary limits two sinusoidal current references are generated. To achieve input current with small ripple narrow hysteresis band is desired. More narrower the band higher will be the switching frequency. Usually hysteresis control can be improved in a constant frequency operation but it results in increase of complexity of the controller. So, based on circuit components such as switching devices and magnetic components the hysteresis band should be optimized. Also change in switching frequency causes change in line voltage. In this control technique, the switch is turned on when the inductor current goes below the lower reference and is turned off when the inductor current shoots above the upper reference, which gives rise to a variable frequency control. Also with this control technique the converter works in CCM.

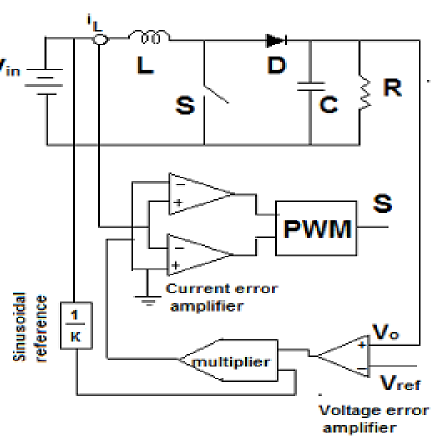


Fig2: Hysteresis current control

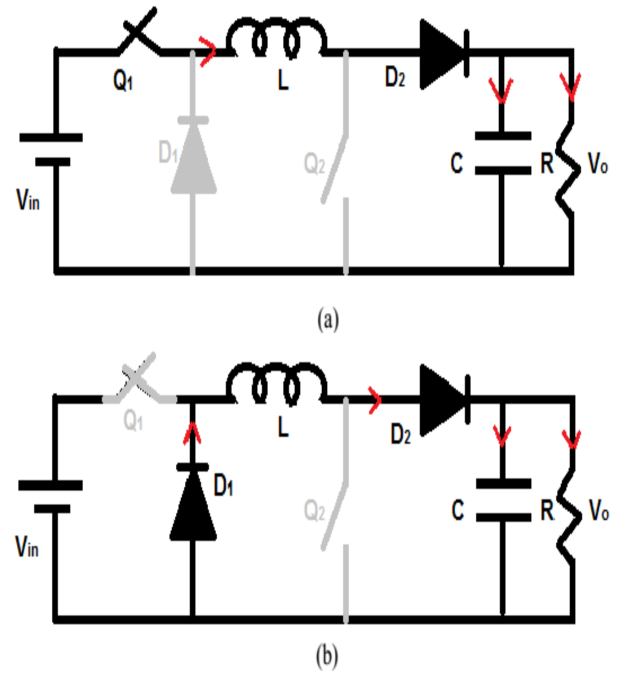


Fig 3 (a) Q. is 'on' and Q, is 'off' for buck mode (b) Q. and Q2 are 'off' for buck mode

3. Average current-mode control:

The technique of "average current-mode control" is shown in fig. 3. There are two control loops- one for improving the power factor and the other for voltage regulation. The inner current loop compensator minimizes the error between sensed input current and the current reference so as to obtain a unity power factor and reduce higher order harmonics in input current. In this technique converter operates in CCM mode. The main advantages of this technique is that more sinusoidal input current waveforms are obtained at fixed switching frequency and is less sensitive to noise, at the expense of additional compensator.

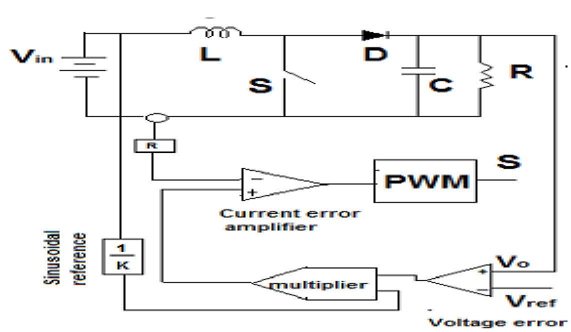


Fig 4: Average Current-mode control

III OPERATION PRINCIPLE OF TSBB:

The two-switch buck-boost (TSBB) converter, as shown in fig. 4, is a cascade connection of simple buck and boost converters [9]-[12]. There are two active switches in the TSBB converter, QI and Q2 which are switched ON and OFF depending on the input voltage.

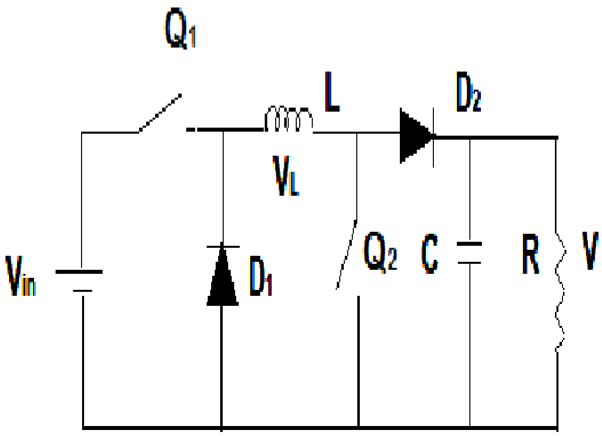
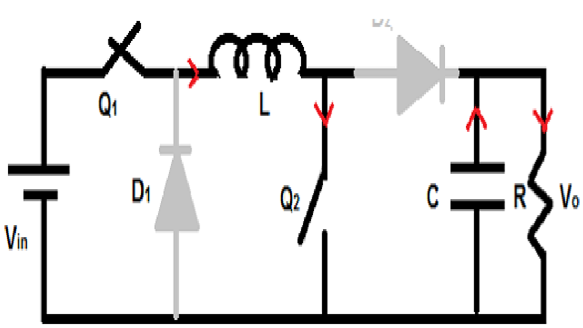
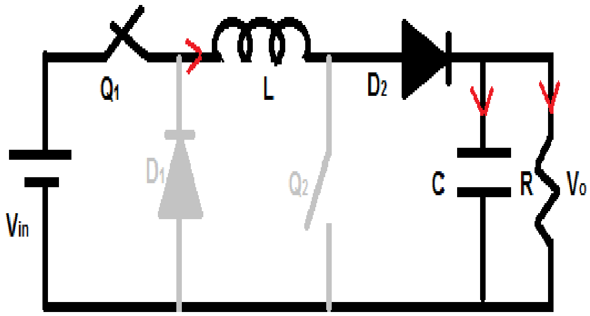


Fig.5. Schematic diagram of TSBB



(c)



(d)

Fig 6 (c) Q. and Q2 are 'on' for boost mode (d) Q. 'on' and Q, is 'off' for boost mode

The voltage conversion of the TSBB converter operated in continuous current mode (CCM) [3].

$$V0 = d1/1-d2Vin \quad (1)$$

where dl and d2 are the duty cycles of switches QI and Q2 respectively. When the input voltage goes higher, the TSBB converter operates in buck mode, where d2 = 0, then Q2 is always OFF, and dl is controlled so as to maintain the output voltage constant; when the input voltage goes lower, the TSBB converter operates in boost mode, where dl = 1, then QI is always ON, and d2 is controlled to regulate the output voltage. Thus, the voltage conversion of the TSBB converter with twomode control scheme can be written as [10]

Vo=(d1 vin,d2=0(vin>/vo)----

(2)

IV. MODES OF OPERATION OF TSSB

Fig. 5 (a), (b), (c) and (d) gives the different modes of operation TSBB when the switch QI and Q2 are operated.

Model:

When input is higher than the output TSBB operates as a simple buck converter, then Q2 is permanently 'off and QI will be switching.

(a) When QI is 'on' then the input supplies the load and charges the capacitor. Since the input also charges the inductor, the current flow to the load is restricted and there is only a gradual build up. Also diode DI is reverse biased and D2 is forward biased.

(b) When QI is kept 'off, DI is forward biased and the stored energy in the inductor discharges and once the stored energy in inductor falls down, the capacitor begins to supply the load.

Mode II:

When input is lower than the output TSBB operates as a simple boost converter, then QI is permanently 'on' and Q2 will be switching.

(c) When Q2 is 'on' the input charges the inductor. The capacitor which is charged in the previous cycle supplies the output. Both the diodes D, and D2 are reverse biased.

(d) When Q2 is kept 'off, D, is reverse biased and the stored energy in the inductor discharges. This charge along with the input will feed the load and charge the capacitor.

V DESIGN OF Two SWITCH BUCK BOOST CONVERTER:

The Two Switch Buck Boost converter is designed for CCM mode depending on the input voltages, output

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voltage and power. The input voltage variation is from (2IOV-250V) for an output of 220V, lkW. The design steps are given as follows:

$$D = \frac{V_o + V_D}{V_o + V_{in} + V_D} \tag{3}$$

Where VD represents diode voltage, YOU! and Yin represents the input and output voltage respectively.

The inductor and capacitor design is as,

$$L = \frac{V_0 \ x \ D}{f \ x \ \Delta I_L} \tag{4}$$

$$C = \frac{I_0 \ x \ D}{f \ x \ \Delta V_0} \tag{5}$$

VI TSBB ALONG WITH POWER FACTOR CORRECTION CIRCUIT

Fig. 6 shows a two switch buck boost converter along with the PFC control. There are two control loops. An outer control loop for voltage correction and an inner feed forward control loop for power factor correction. The output voltage is compared with the reference voltage, the error thus obtained is multiplied with a unit input voltage so that the error voltage follows the shape of the input voltage. The output is then compared with inductor current and the error compared with the required saw tooth waveform to give necessary pulses to each switch. If output voltage is higher than reference voltage it goes to buck mode, when output voltage is lower than reference voltage then they operate in boost mode [13]-[16].

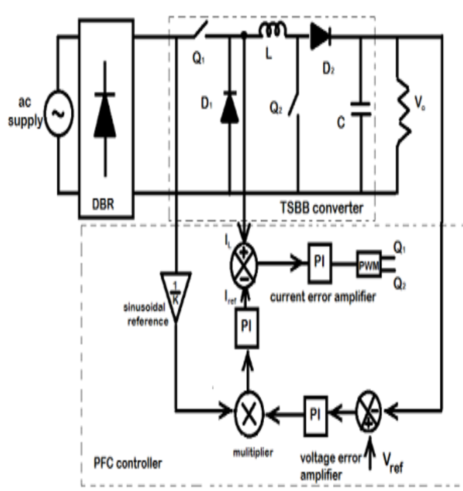

Fig.7. Schematic diagram of TSBB with PFC

VII. DC MOTOR

DC motors are preferred where widespeedrange control is required. Phase controlled converters provide an adjustable dc voltagefrom a fixed ac input voltage. DC choppers are also providing dc output voltage from a fixed dc inputvoltage. The use of phase controlled rectifiers and dc choppers for the speed control of dc motorsmodern industrial controlled applications. DC drives are classified into the following methods:

A.DC Motor Control System

Figure 4 shows theschematic arrangement of a two quadrant controller's dc drives system .The figure showing the 2 control loops. First one is outer speed control loop and the other one is inner current control loop. The feedback signal of speed is derived from a tacho generator. Although alternatively an approximation of the motor speed can be derived by feeding back a signal proportional to the motor voltage.The Position criticism can be incorporated for servo applications by utilizing a position encoder on the engine shaft. The pace input circle contrasts the taco yield voltage and a pace reference signal. The voltage signal blunder gives the present reference command.In that present summon sign is contrasted and the genuine engine current in the internal control circle. In this control circle incorporates the current cutoff setting which shields that engine and the device from over streams. On the off chance that the controller requests a substantial pace change then the present interest is kept up beneath the greatest level by this present farthest point setting.Motoring or recovering operation is distinguished in circuit straightforwardly from the extremity of the blunder voltage flag and used to figure out if it is the base or top MOSFET and which is controlling the current. The motoring recovering rationale circuit incorporates a few hysteresis to guarantee that control does not waver between the motoring and recovering modes at low engine currents. There are conceivable methods for controlling so as to control engine current the changing successions to the fundamental Power Metal oxide semiconductor (MOS) device. In resistance band control the engine current is contrasted and the reference sign and a permitted current swell resilience. Amid motoring operation the real current is more prominent than the permitted greatest estimation of the resistance band. At that point the yield comparator turns off the door drive to the force MOSFET in this manner the permitting engine current to fall. at the point when the comparator walks out on The present then free wheels until it achieves the lower furthest reaches of the resilience band, .by Using this present control procedure the powerful variable, depending up on the rate at which the armature current changes, however the top to crest current swell in the framework is steady. by utilizing Beat width regulation (PWM) system current control Alternately the device can be exchanged a steady recurrence . Here the present blunder contrasted and altered recurrence triangular wave and the comparator yield is then used to give the sign to the principle exchanging device. Whenever the blunder sign is not exactly the triangular transporter then the gadget is exchanged off. At the point when the blunder sign is more prominent than triangular wave then the power gadget is switched on.

VIII MATLAB/SIMULINK RESULTS

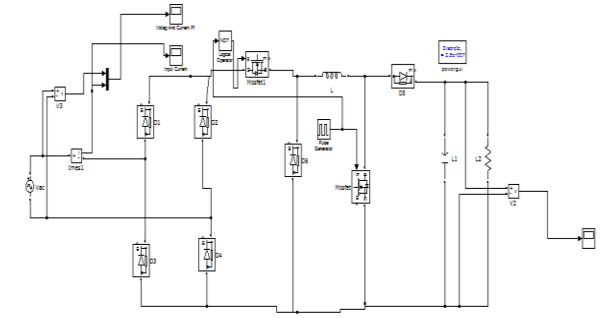

Fig 8Matlab/simulation conventional circuit of TSBB without PFC

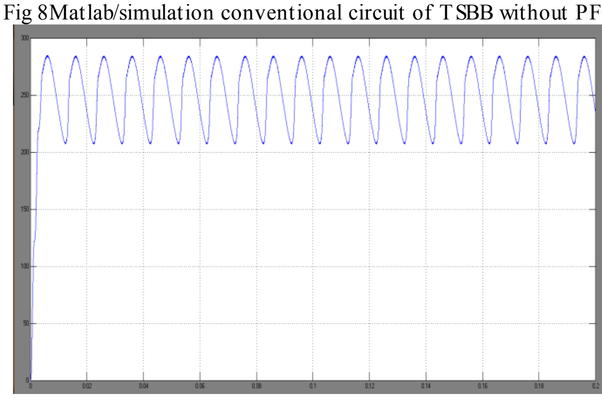

Fig 9 Matlab/simulation wave form of output voltage

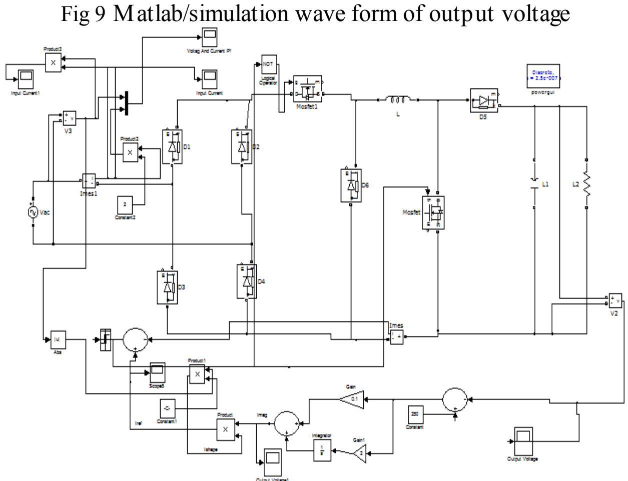

Fig 8 Matlab/simulation conventional circuit of TSBB with PFC

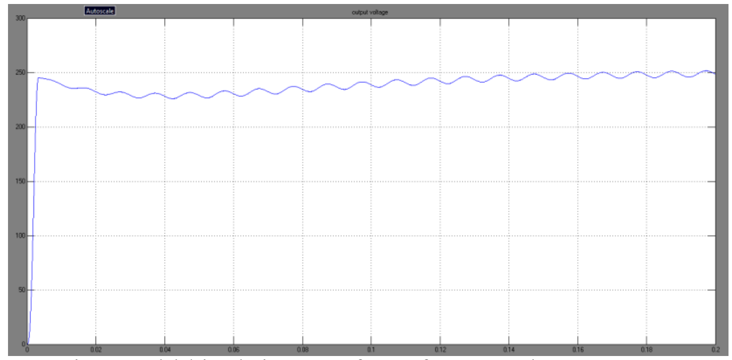

Fig 9 Matlab/simulation wave form of output voltage

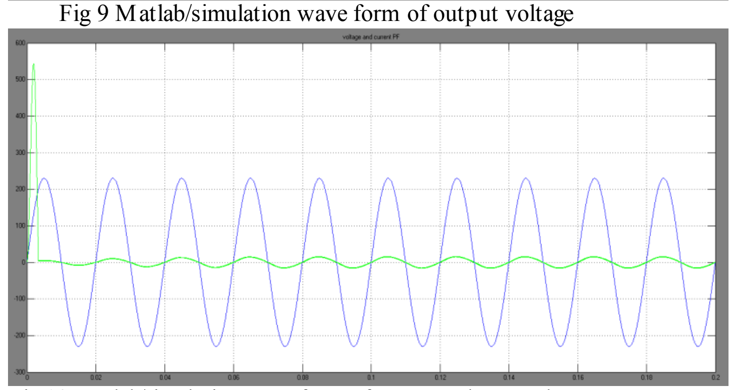

Fig 10 Matlab/simulation wave form of output voltage and current power factor

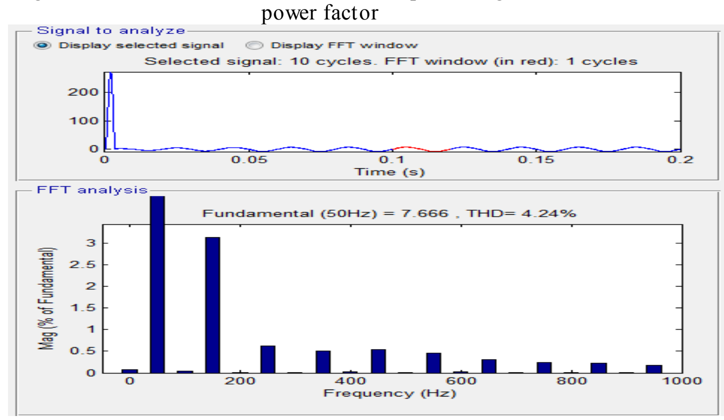

Fig 11 THD Analysis of current with PFC

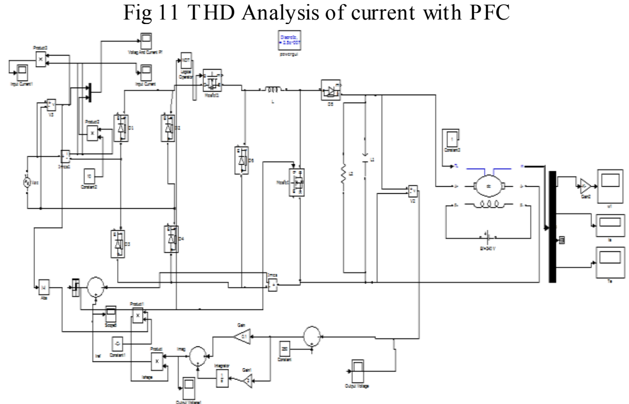

Fig 12 Matlab/simulation proposed circuit of TSBB with PFC and DC motor

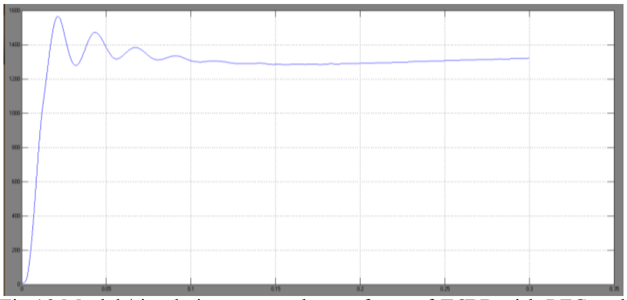

Fig 13 Matlab/simulation proposed wave form of TSBB with PFC and DC motor speed

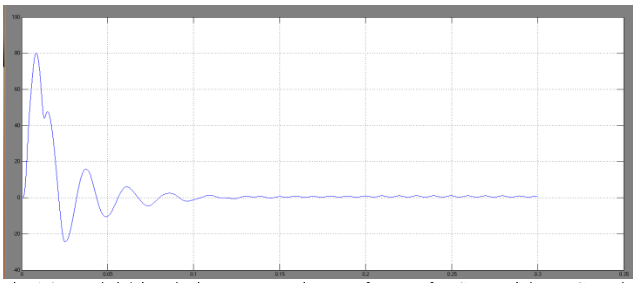

Fig 14 Matlab/simulation proposed wave form of TSBB with PFC and DC motor current

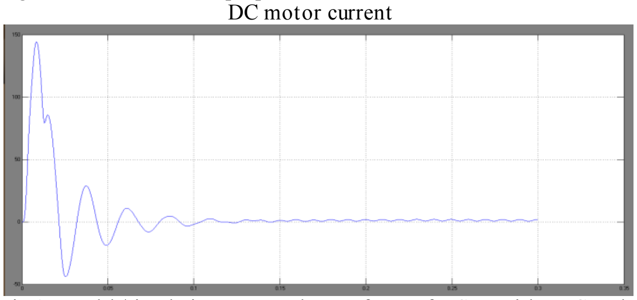

Fig 15Matlab/simulation proposed wave form of TSBB with PFC and DC motor torque

CONCLUSION

Widespread use of power electronics loads has given more attention to power factor correction (PFC) and reduction in harmonic distortion in the current drawn from the electric power utility. Various power factor correction (PFC) techniques such as buck converter boost converter, buck boost converter topologies are employed to overcome the power quality problems. This paper proposes a Two Switch Buck Boost converter along with a power factor correction control to improve the power factor and hence reduce the THD. The Two Switch Buck Boost Converter has the advantage of reduced switching losses. Study on DC motor drive has been done and an average current mode controller which was found to be more effective has been selected. Simulation of the converter with and without PFC controller has been performed in MATLAB/Simulink. Using this controller power factor correction and voltage regulation were achieved with single stage.

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