TEST Engineering & Management

March - April 2020
ISSN: 0193-4120 Page No. 1942 - 1949

Power Factor Correction using Two Switch Buck Boost Converter Fed DC Motor System Using MATLAB

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Article Info
Volume 83
Page Number: 1942 - 1949
Publication Issue:
March - April 2020

Article History
***Article Received**: 24 July 2019*
***Revised**: 12 September 2019*
***Accepted**: 15 February 2020*
***Publication**: 18 March 2020*

Abstract

Now-a-days the usage of power electronic systems has expanded to new and wide application range but the presence of harmonics could even be an enormous problem. The nonlinear operation of power semi converters and presence of bridge rectifiers in electronic devices for AC-DC conversion resulted during a high Total Harmonic Distortion (THD) and low Power Factor (PF). Thus, there arise the need for an influence factor correction circuit in conjunction with the power converters for limiting the allowable harmonics on the power lines, and hence to reinforce the power factor. Active PFC and Passive PFC are the two power factor correction techniques. This paper aims to develop a lively power factor correction (PFC) for single phase AC/DC converter, alongside a Two Switch Buck-Boost converter. The converter is designed and simulated in MATLAB Simulink Results obtained from simulation shows Power factor is improved at source side.

Keywords: *Power Factor Correction; Total Harmonic DIstortion.*

1. Introduction

Now a day with increasing use of power converter devices and power electronic loads, more emphasis is given to power actor correction (PFC) and reduction in total harmonic distortion (THD) in the current drawn from the power utility. In order to enhance the facility quality, researchers have given more attention on development of latest topologies on power converter. Improvements can be achieved by PFC techniques. Since now, various passive and active power factor correction circuits are proposed, of which active power factor circuits found to be more advantageous. Thus active PFC techniques have rapidly become an active research topic within the power electronics field and efforts are made on the event of the PFC converters [1]. Various power factor correction (PFC) techniques for buck converter boost converter, buck boost converter topologies are employed to beat the facility quality problems. A Two Switch Buck Boost converter with an influence factor correction control to enhance the facility factor which reduces the THD has been proposed in this paper. The main advantage of two switch buck boost converter is the capability of both step up and step down with low voltage stress when compared with the convential converter. Ql and Q2 are the two switches in the converters which are operated independently [2]. A bouble 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 like a lift 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

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perform voltage regulation and power factor correction in a single step. As a result, in the design of the controller, a trade-off 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.

- Peak current control
- Hysteresis current control
- Average current-mode control

1. Peak Current Control:

In Peak Current Control, the positive slope of the inductor current is controlled in order that it's adequate 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 constant switching frequency is that the peculiarity of this scheme. Such an impact scheme is shown in fig.1

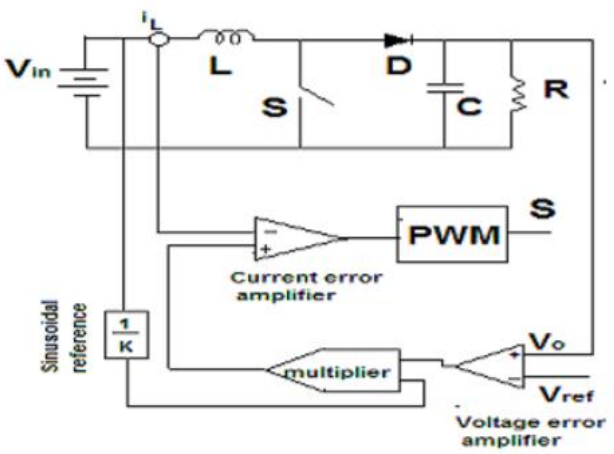

Fig. 1. Peak Current Control

2. Hysteresis current control:

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

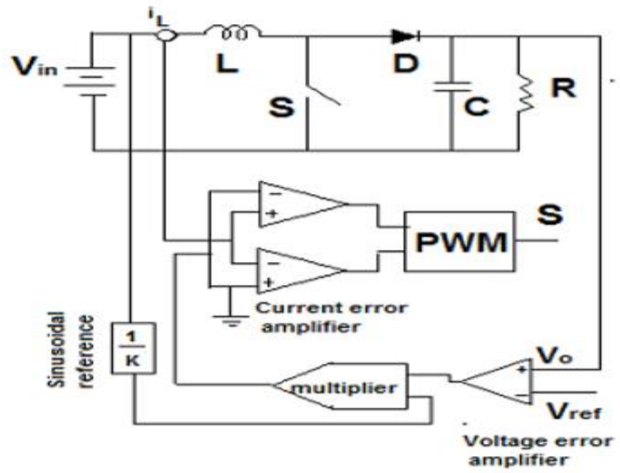

Fig. 2. Peak Current Control

3. Average current-mode control:

The following fig 3 shows the method of average current-mode control. There are two control loops- one for improving the facility factor and therefore 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

Published by: The Mattingley Publishing Co., Inc.

this technique converter operates in CCM mode. The main advantages of this method 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.

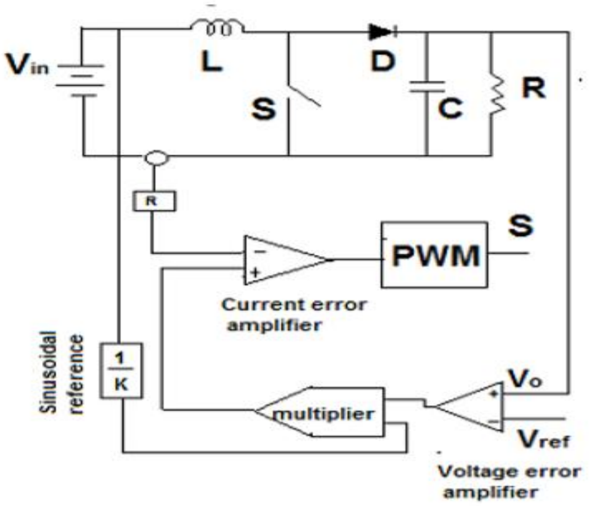

Fig 3: Average Current-mode control

III OPERATION PRINCIPLE OF TSBB:

The below figure i.e. fig.4 is two-switch buck-boost (TSBB) converter, is a cascade connection of simple buck and boost converters. Q1 and Q2 are two active switches in the TSBB converter which are switched ON and OFF depending on the input voltage.

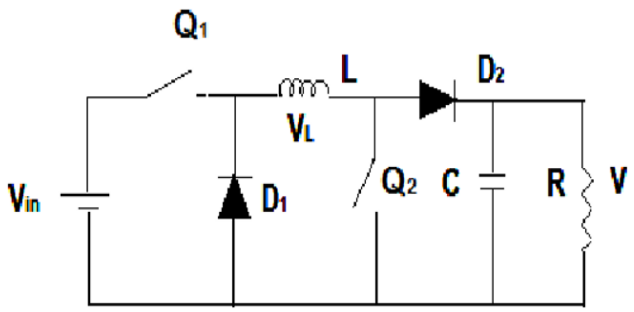

Fig.4. Schematic diagram of TSBB

The voltage equation which explains the conversion of the TSBB converter operated in continuous current mode (CCM)

V0 =d1/1-d2Vin

(1)

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

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

(2)

IV. MODES OF OPERATION OF TSSB

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

Mode I: t TSBB operates as a simple buck converter when input is higher than the output, 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. As the input charges the inductor, the current flow to the load is restricted and there is only a gradual build up. Also diode D2 is forward biased and DI is reverse 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.

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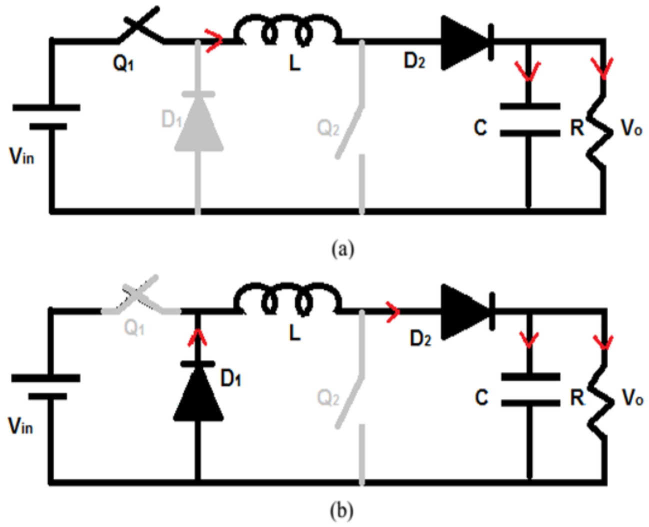

Fig 5 (a) Q1 is 'on' and Q2 is 'off' for buck mode (b) Q1 and Q2 are 'off' for buck mode

Mode II: When input is less than the output TSBB operates as an easy boost converter, then QI is permanently 'on' and Q2 are going to be switching.
(c) When Q2 is 'on' the input charges the inductor. The capacitor which is charged within the previous cycle supplies the output. The diodes D1, and D2 are reverse biased.
(d) When Q2 is kept 'off, D, is reverse biased and therefore the stored energy within the inductor discharges. Therefore charge along with the input will feed the load and charge the capacitor.

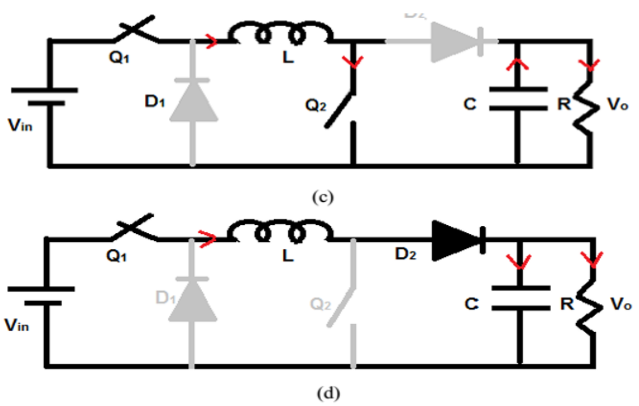

Fig 5 (c) Q1 and Q2 are 'on' for boost mode (d) Q1 'on' and Q2 is 'off' for boost mode

V DESIGN OF Two SWITCH BUCK BOOST CONVERTER: The Two Switch Buck Boost converter is meant for CCM mode counting on the input voltages, output voltage and power. The input voltage variation is from (2IOV-250V) for an output of 220V, 1KW. The design steps are given as follows:

$$D = \frac{V_O + V_D}{V_O + V_{in} + V_D}$$

Where represents diode voltage, and represents the input and output voltage respectively. The inductor and capacitor design as

$$L = \frac{V_O * D}{f * \Delta I_L}$$

$$C = \frac{I_O * D}{f * \Delta V_O}$$

VI TSBB ALONG WITH POWER FACTOR CORRECTION CIRCUIT

Fig. 6 shows a two switch buck boost converter alongside the PFC control. There are two control loops. For voltage correction an outer control loop and for power factor correction an inner feed forward control loop. The output voltage is compared with the reference voltage; the error thus obtained is multiplied with a unit input voltage in order that the error voltage follows the form of the input voltage. The output is then compared with inductor current and therefore the error compared with the specified saw tooth waveform to offer necessary pulses to every switch. If output voltage is above reference voltage it goes to buck mode, when output voltage is less than reference voltage then they operate in boost mode.

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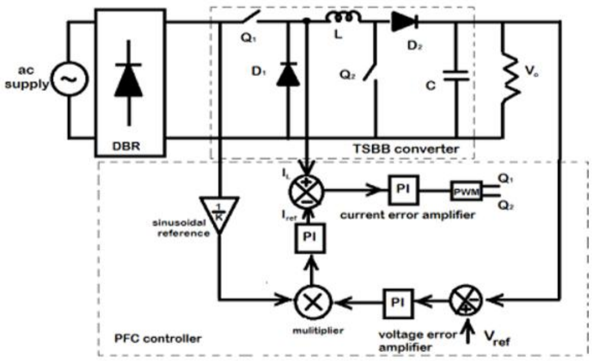

Figure6: Schematic diagram of TSBB with PFC

VII. DC MOTOR

When wide speed range control is required DC motors are preferred. Phase controlled converters provide an adjustable dc voltage from a hard and fast ac input voltage. DC choppers are also providing dc output voltage from a fixed dc input voltage. The use of phase-controlled rectifiers and dc choppers for the speed control of dc motors modern industrial controlled applications. DC drives are classified into the following methods:

A.**DC Motor Control System**

Figure 4 shows the schematic 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 therefore the other one is inner current control loop. The feedback signal of speed springs from a tacho generator. By feeding back a signal proportional to the motor voltage although alternatively an approximation of the motor speed can be derived. By utilizing a position encoder on the engine shaft the Position criticism can be incorporated for servo applications. The pace input circle contrasts the taco yield voltage and a pace reference signal. The voltage signal blunder gives this reference command. In that present summon sign is contrasted and therefore the genuine engine current within the control circle. In this control circle incorporates the present cut-off setting which shields that engine and therefore the device from over streams. By this present farthest point setting on the off chance that the controller requests a substantial pace change then the present interest is kept up beneath the greatest level. 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. The real current is more prominent than the permitted greatest estimation of the resistance band in amid motoring operation. At that point in order the permitting engine current to fall the yield comparator turns off the door drive to the force MOSFET . 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 is often exchanged a gentle 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 isn't precisely the -triangular transporter then the gadget is exchanged off. The power gadget is switched on at the point when the blunder sign is more prominent than triangular wave then the power gadget is switched on.

VIII MATLAB/SIMULINK RESULTS

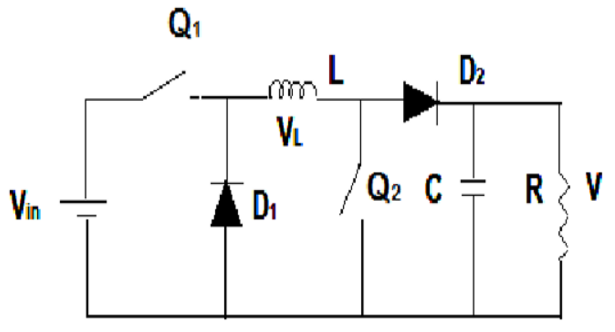

Figure7: Block Diagram of Conventional circuit of TSBB without PFC

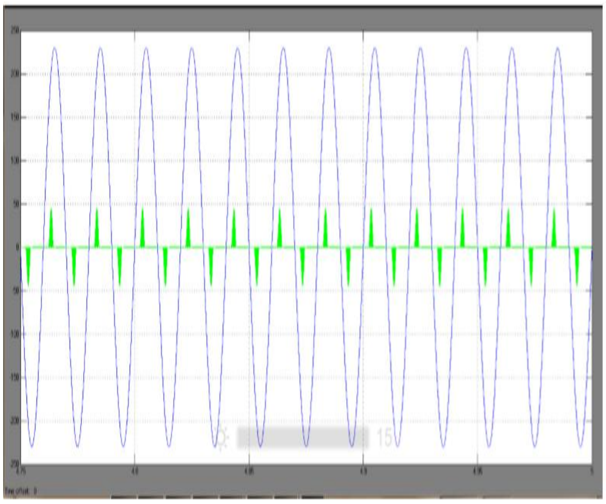

Figure8: Matlab/simulation wave form of output voltage

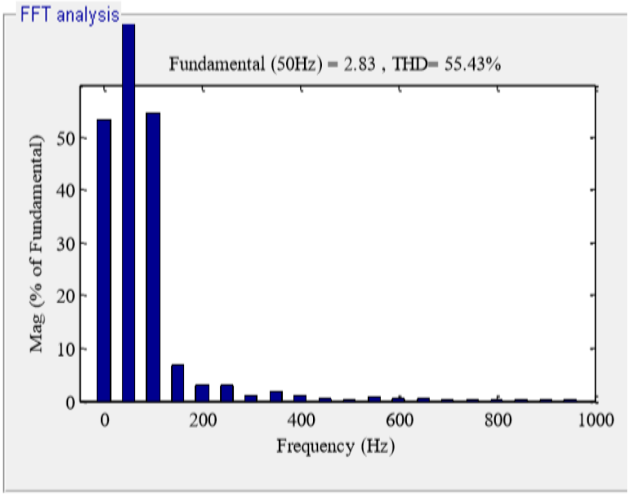

Figure9: THD Analysis of current without PFC

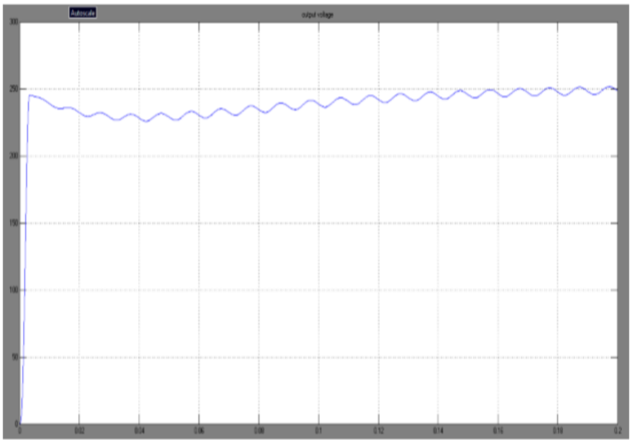

Figure10: Matlab/simulation wave form of output voltage

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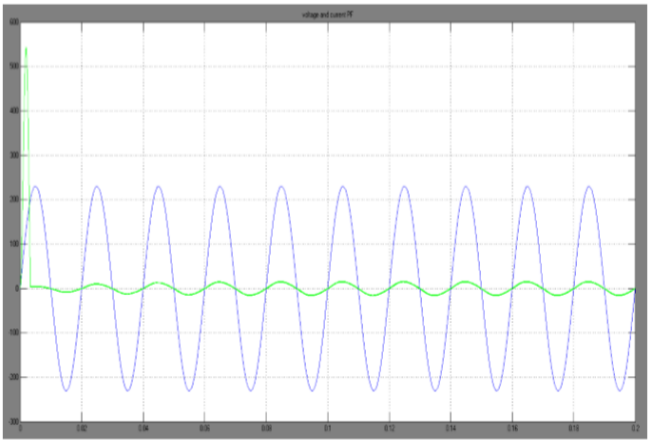

Figure11: Matlab/simulation wave form of output voltage and current power factor

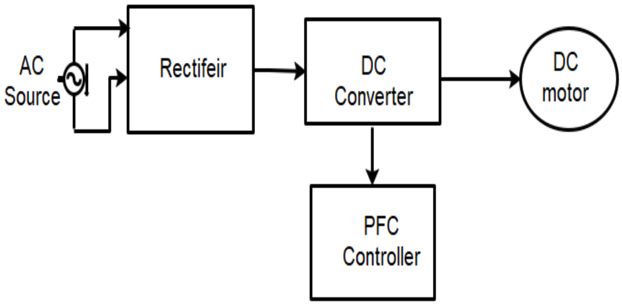

Figure12: Matlab/simulation proposed circuit of TSBB with PFC PI Controller and DC motor

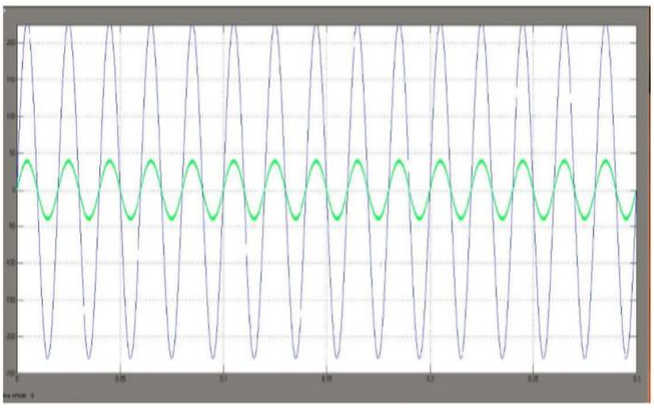

Figure13: Matlab/simulation wave form of output voltage and current power factor

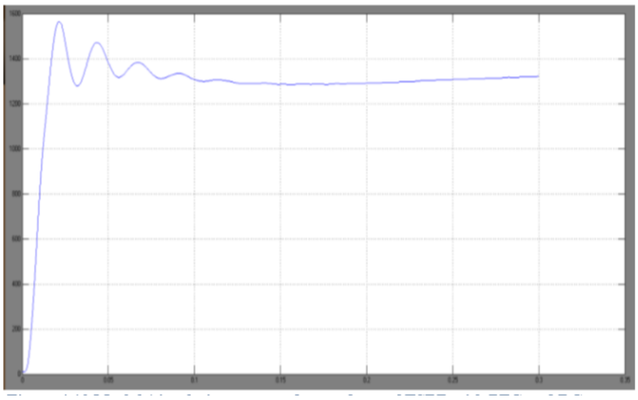

Figure14: Matlab/simulation proposed wave form of TSBB with PFC and DC motor speed

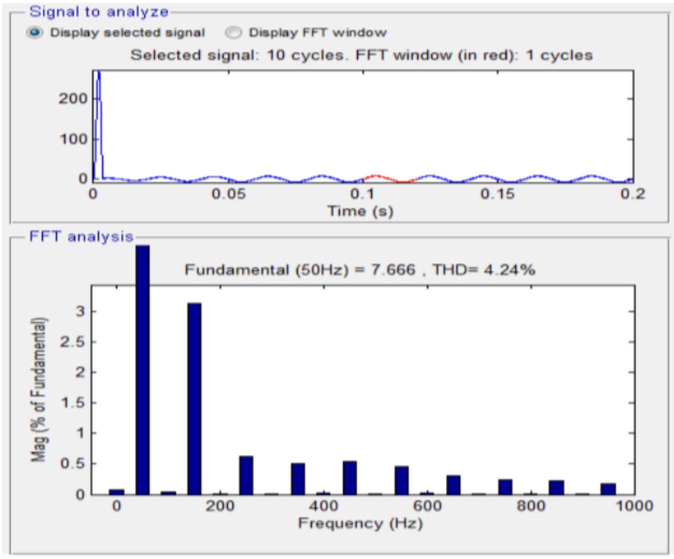

Figure15: THD Analysis of current with PFC

THD analysis has been done. After incorporating the Power factor Correction circuit i.e. Fuzzy controller, the total harmonic distortion has been reduced, THD to 4.24%.

S.NO	Cases	THD of Input Current
1	Without PFC Controller	55.43%
2.	With PFC Controller	4.24%

CONCLUSION

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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 alongside an influence factor correction control to enhance the facility factor and hence reduce the THD. The Two Switch Buck Boost Converter has the advantage of reducing switching losses. Study on DC motor drive has been done and a mean current mode controller which was found to be simpler has been selected. The performance of the converter with and without PFC controller has been evaluated in MATLAB/Simulink. Using this controller technique the voltage regulation and power factor correction were achieved with single stage.

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