

# **Design and Implementation of Three Phase Ac-Dc Converter for Dc Drives**

S.Arunvijay<sup>1</sup>, M.Praveen Santhoshkumar<sup>2</sup>, M.Muruganandam<sup>3</sup>, S.Saravanan<sup>3</sup>

P.G. Student, Department of Power Electronics and Drives, Muthayammal Engineering College, Rasipuram,  
Namakkal, Tamilnadu, India<sup>1</sup>

Assistant Professor, Dept of EEE, Muthayammal Engineering College, Rasipuram, Namakkal, Tamilnadu, India<sup>2</sup>

Professor, Dept of EEE, Muthayammal Engineering College, Rasipuram, Namakkal, Tamilnadu, India<sup>3</sup>

**ABSTRACT:** The project will examine how a reduced switched converter with capacitive input filter operates in the boost mode and how a reduced switch converter operates in buck and boost modes. Three-phase ac-dc buck-boost converters can step up input voltage and step down input voltage based on the ANN closed loop error correction method. As such, they can be used in applications that require a converter that can operate over a wide range of conditions. In this proposed mode introduce an auto adjustment of duty cycle based upon the ANN control algorithm from the output voltage feedback.

**KEYWORDS:** Buck boost operation, ANN algorithm, Filter circuits, closed loop control.

## **I. INTRODUCTION**

Power electronic converters operating from the utility mains can generate current harmonics that are injected into the mains. The dramatic growth in the use of electrical equipment in recent years has resulted in a greater need to limit these harmonics to meet regulatory standards. This can be done by some form of power factor correction (PFC) to shape the input phase currents so that they are sinusoidal and in phase with the phase voltages. Three-phase PFC is typically done by using a six-switch converter either to process the bulk of the power fed to the load or to be an active filter that processes only a portion of the power fed to the load. Using a six-switch converter, however, is costly and complicated given the number of active switches that must be used and the sophisticated control needed to ensure a good power factor. Cheaper and simpler methods of performing three-phase active input PFC have been developed using converters with less than six switches [1]–[8]. One such converter, first proposed in [7], is a single-switch boost converter that can be designed to operate so that its line currents operate in the discontinuous conduction mode and are bounded by a sinusoidal envelope. Many three-phase ac-dc converters that perform PFC with a reduced number of switches share variations of the converter proposed in [7] and their output voltage is always higher than their input voltage because they are boost-type converters. This is a drawback if there is a need for a converter that needs to operate for a wide range of input ac voltages and/or produce range of output dc voltages such as a front-end rectifier for a commercial product that must work with several ranges of ac voltages. Relatively few reduced switch three-phase ac-dc buck-boost rectifiers have been proposed in the power electronics literature[9]–[15] mainly due to topological constraints. One is the three-phase ac-dc single-switch buck-boost converter shown in Fig. 1 [8], which will henceforth be referred to as the conventional converter in this paper. The converter is operated with a constant duty cycle throughout the line cycle and is designed so that its input capacitors operate in the discontinuous voltage mode (DVM), which results in naturally sinusoidal input currents. Like a boost converter, inrush and short-circuit currents can be limited by the presence of an inductor,  $L_o$ , in Fig. 1.

This converter, however, has a drawback that has restricted its use: the switch has a very large peak voltage stress (>1 kV for buck mode, >1.5 kV for boost mode) regardless of whether its output voltage is made to be lower or higher than its input voltage. This is especially the case when the output voltage is higher than its input voltage. Such a high peak voltage stress has made the converter in Fig. 1 impractical so that it is rarely used in industry. In this paper, a new

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

three-phase reduced switch buck–boost converter is described. The paper will examine how a reduced switched converter with capacitive input filter operates in the boost mode and how a reduced switch converter operates in buck and boost modes. Such an examination has not been performed in the literature to the best of the authors’ knowledge. In this paper, the operation of the new ac–dc buck–boost converter, which is an advance on the work performed in [16], is explained in detail; its steady-state characteristics are determined by analysis and are then presented for both buck and boost operating modes. Based on the results of the analysis, a procedure that can be used in the design of the converter’s key components is developed and then demonstrated with an example. The feasibility of the proposed converter is confirmed with results obtained from an experimental prototype.

## II. MODELLING OF BUCK BOOST OPERATION

The three-phase ac–dc buck–boost converter examined is shown in Fig. 2. The converter is similar to the conventional converter shown in Fig. 1 as the input section is the same and input PFC is performed by the charging and discharging of the input capacitors. The main difference between the new converter and the conventional converter is that each of the switches in the converter under test sees a line-to-neutral voltage (the voltage across one of the three input capacitors) across it rather than a line-to-line voltage (the voltage across two input capacitors), which is the case for the switch in the conventional converter.

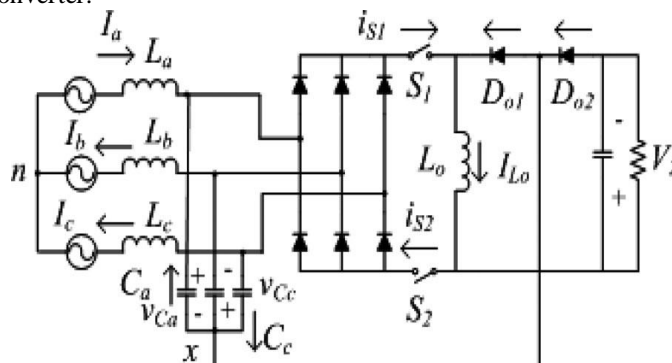


Fig.1 Ac–Dc Reduced Switch Buck–Boost Converter.

Since a switch in Fig. 1 sees a line-to-neutral voltage instead of a line-to-line voltage. As a result of reducing the peak voltage stress, lower rated devices can be used instead of what can be used in the conventional converter for the same operating conditions and the use of devices with the same rating will allow for a larger operational range. It should be noted that if output capacitor  $C_o$  is completely discharged, the inrush current can be limited by the presence of buck–boost inductor  $L_o$  just like it can be limited by the boost inductor in a boost converter. Moreover, short-circuiting current is also limited by the presence of inductor  $L_o$ . It is possible for both switches to be on at the same time during regular steady-state operation, as will be shown below, so that the inadvertent short-circuiting of switches does not result in converter destruction. Similar to a PWM dc–dc single-switch buck–boost converter, the proposed converter operates as a buck converter when its duty cycle,  $D < 0.5$  and as a boost converter when  $D > 0.5$ . In this section, the operation of the proposed converter when  $D < 0.5$  and  $D > 0.5$  is explained. The equivalent circuit diagrams for the proposed converter steady-state operation when  $D < 0.5$  and  $D > 0.5$  are given in Figs. 3 and 4 and the typical waveforms of the two operations are given in Figs. 5 and 6, respectively. It should be noted that the switch status is shown in the modal circuit diagrams. If a component is conducting current, it is shown in the figure; if not, then it is not. The following assumptions are made to simplify the modal equations for the steady-state operation of the converter.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

## III. PROPOSED CONTROL

### A. Block diagram

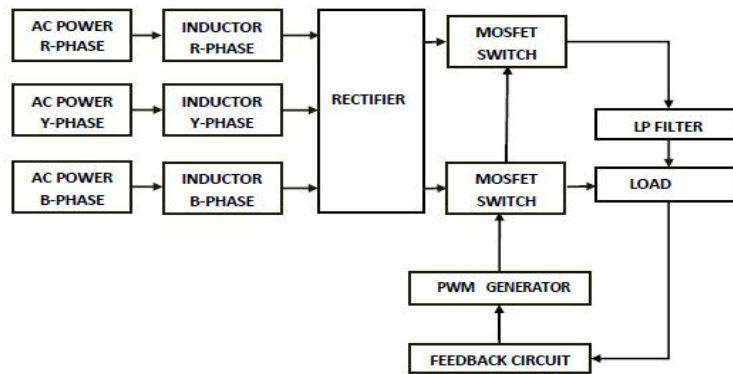


Fig .2 .Block diagram of proposed control

Three-phase electric power is a common method of alternating current electric power generation, transmission, and distribution. It is a type of polyphase system and is the most common method used by electrical grids worldwide to transfer power. It is also used to power large motors and other heavy loads. A three-phase system is usually more economical than an equivalent single-phase or two-phase system at the same line-to-ground voltage because it uses less conductor material to transmit electrical power. The filters are used to reduce the noise and other unwanted signals present in the rectified signals. Full wave rectifiers and bridge rectifiers are used for rectifying the AC supply voltage. Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals, the body (or substrate) of the MOSFET is often connected to the source terminal, making it a three-terminal device like other field-effect transistors. Because these two terminals are normally connected to each other (short-circuited) internally, only three terminals appear in electrical diagrams. The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common. The load is a DC motor, named as PMDC (permanent magnet direct current motor) as per our requirement we can choose the load. The pulses for the switches are given by using PWM generators. A DC motor is used as the load. A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy. It is of vital importance for the industry today, and it is equally important for engineers to look into the working principle of a DC motor in details that has been discussed in this article. In order to understand the operating principle of a DC motor we need to first look into its constructional feature.

### B. Perturb and Observe algorithm

The scope of this teaching package is to make a brief induction to Artificial Neural Networks (ANNs) for people who have no previous knowledge of them. We first make a brief introduction to models of networks, for then describing in general terms ANNs. As an application, we explain the back propagation algorithm, since it is widely used and many other algorithms are derived from it.

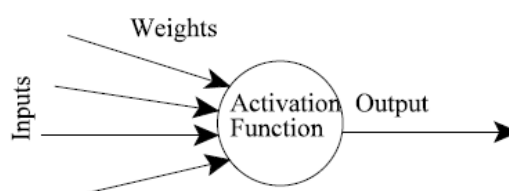


Fig.3 An artificial neuron

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

The activation function of the artificial neurons in ANNs implementing the i back propagation algorithm is a weighted sum (the sum of the inputs x multiplied by their j i respective

$$A_j(\bar{x}, \bar{w}) = \sum_{i=0}^n x_i w_{ji} \quad (1)$$

We can see that the activation depends only on the inputs and the weights. If the output function would be the identity (output=activation), then the neuron would be called linear. But these have severe limitations. The most common output function is the sigmoid function:

$$O_j(\bar{x}, \bar{w}) = \frac{1}{1 + e^{-A_j(\bar{x}, \bar{w})}} \quad (2)$$

The sig moidal function is very close to one for large positive numbers, 0.5 at zero ,and very close to zero for large negative numbers. This allows a smooth transition between the low and high output of the neuron (close to zero or close to one). We can see that the output depends only in the activation, which in turn depends on the values of the inputs and their respective weights. Now, the goal of the training process is to obtain a desired output when certain inputs are given. Since the error is the difference between the actual and the desired output, the error depends on the weights, and we need to adjust the weights in order to minimize the error. We can define the error function for the output of each neuron:

$$E_j(\bar{x}, \bar{w}, d) = (O_j(\bar{x}, \bar{w}) - d_j)^2 \quad (3)$$

## IV. EXPERIMENTAL RESULTS

A simple, proof-of-concept, experimental prototype of the proposed converter was built to confirm its feasibility. The converter was implemented with main circuit components  $L_a = L_b = L_c = 1.3$  mH,  $C_a = C_b = C_c = 220$  nF,  $L_o = 1.3$  mH, and  $C_o = 1500$   $\mu$ F. The experimental waveforms were obtained for the specification mentioned in Section IV. It should be noted that the peak output voltage ripple was negligible and was less than 1% for all loads .Fig 4 and 5 show typical output speed and output current waveforms for loads of 2 kW and 500 W for output voltages 150 and 500 V.

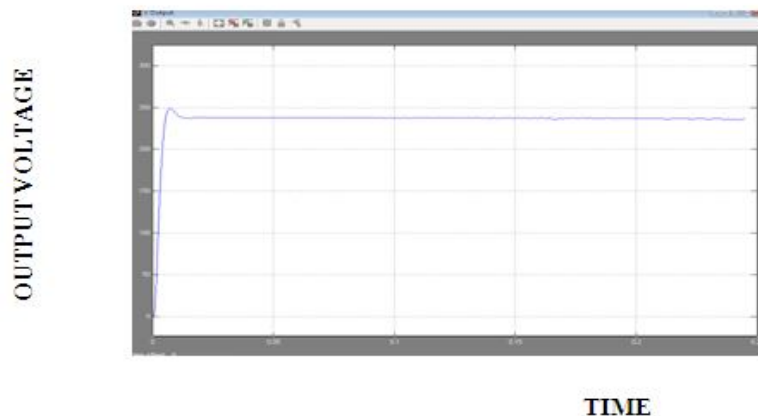


Fig.4 Simulated Output Voltage

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

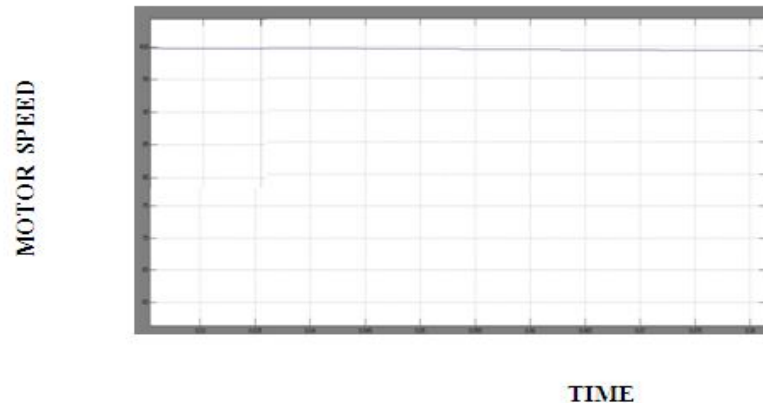


Fig.5 Simulated Motor Parameters

### E. CONCLUSION

Three-phase ac–dc buck–boost converters can step up input voltage and step down input voltage. As such, they can be used in applications that require a converter that can operate over a wide range of conditions. The size and cost of these converter scan be reduced if they are implemented with reduced switch opologies, but few such topologies have been proposed in the power electronics literature due to topological constraints. It has been shown in the literature that it is possible to implement a three-phase ac–dc buck–boost converter with a capacitive input filter using just a single switch, but although this converter is very attractive, it is also impractical because of its very high peak switch voltage stress. As a result, a new three-phase reduced switch buck–boost converter with significantly reduced peak switch voltage stresses that is based on the single-switch converter was discussed in this paper. This paper examined how a reduced switched converter with capacitive input filter operates in the boost mode (as opposed to the conventional approach of operating a reduced switch converter with inductive input filter in the boost mode), which has not been previously addressed. It also examined how a reduced switch converter can operate in both buck and boost modes, which also has not been previously addressed. In this paper, the operation of the new ac–dc buck–boost converter was explained in detail; its steady-state characteristics were determined by analysis and were then presented for both buck and boost operating modes. Based on the results of the analysis, a procedure that can be used in the design of the converter’s key components was developed and then demonstrated with an example. The feasibility of the proposed converter is confirmed with results obtained from an experimental prototype .It was found that operating a reduced switch converter with capacitive input filter in the boost mode means that there is less current available to fully discharge the input capacitors during switching cycles, which results in distorted input line currents,

thus the need for smaller input capacitors. The use of smaller input capacitors results in increased switch stress so that a compromise must be considered in the design of the converter that works satisfactorily in both modes. Other properties that were determined are as follows: the converter has a better efficiency when working in boost mode than in buck mode, nearly sinusoidal input currents with minimal input filtering can be obtained naturally if there is sufficient current flowing in the converter to discharge the input capacitors, the input and output currents of the converter are continuous, and the input capacitors voltages have a dc component due to the nature of the two-switch buck–boost topology that does not affect the input PFC. It should be noted that most of the properties and characteristics discussed in this paper have not been mentioned anywhere in the power electronics literature that is related to reduced switch buck–boost converters.

### REFERENCES

- [1] B. Tamyurek and D. A. Torrey, “A three-phase unity power factor singlestageAC-DC converter based on an interleaved Flyback topology,” *IEEETrans. Power Electron.*, vol. 26, no. 1, pp. 308–318, Jan. 2011.
- [2] G. Tibola and I. Barbi, “A single-stage three-phase high power factorrectifier with high-frequency isolation and regulated DC-bus based on theDCM SEPIC converter,” in *Proc. IEEE Int. Symp. Circuits Syst.*, May15–18, 2011, pp. 2773–2776.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

- [3] T. Soeiro, T. Friedli, and J. Kolar, "Design and implementation of a three phase buck-type third harmonic current injection PFC rectifier (SWISSRectifier)," IEEE Trans. Power Electron., vol. 28, no. 4, pp. 1608–1621, Apr. 2013. WIJERATNE AND MOSCHOPOULOS: NOVEL THREE-PHASE BUCK-BOOST AC-DC CONVERTER 1343
- [4] A. Mohammadpour, M. R. Zolghadri, and M. Ferdowsi, "Constant input power control of a three phase isolated buck+boost rectifier," in Proc. IEEE 32nd Int. Telecommun. Energy Conf., Jun. 6–10 2010, pp. 1–6.
- [5] A. A. Badin and I. Barbi, "Unity power factor isolated three-phase rectifier with two single-phase buck rectifiers based on the Scott transformer," IEEE Trans. Power Electron., vol. 26, no. 9, pp. 2688–2696, Sep. 2011.
- [6] K. Yao, X. Ruan, C. Zou, and Z. Ye, "Three-phase single-switch boost PFC converter with high input power factor," in Proc. IEEE Energy Convers. Congr. Expo., Sep. 12–16, 2010, pp. 2921–2928.
- [7] A. R. Prasad, P. D. Ziogas, and S. Manias, "An active power factor correction technique for three-phase diode rectifiers," IEEE Trans. Power Electron., vol. 6, no. 1, pp. 83–92, Jan. 1991.
- [8] E. Ismail and R. W. Erickson, "Single-switch 3 $\Phi$  PWM low harmonic rectifiers," IEEE Trans. Power Electron., vol. 11, no. 2, pp. 338–346, Mar. 1996.
- [9] S. Lakshmi Priya, R. K. Raghav, M. Muruganandam, "A Thirteen Level Inverter Design Based on Hybrid MLI Topology for Minimum THD", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 4, issue, 2, pp. 976-983, feb. 2015.
- [10] M. Saravanakumar, C. Harris Naveena, M. Muruganandam, "Bidirectional Modular Multilevel DC/DC Converter with Wide Range of Control", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 4, issue, 2, pp. 984-989, feb. 2015.
- [11] A. R. Borges and I. Barbi, "A single stage buck-boost three-phase rectifier with high power factor operating in continuous conduction mode (CCM)," in Proc. IEEE Int. Symp. Circuits Syst., May 15–18, 2011, pp. 2777–2780.
- [12] L.-S. Yang, T.-J. Liang, and J.-F. Chen, "Analysis and design of a novel three-phase AC-DC buck-boost converter," IEEE Trans. Power Electron., vol. 23, no. 2, pp. 707–714, Mar. 2008.
- [13] M. Baumann and J. W. Kolar, "Minimization of the DC current ripple of a three-phase buck-boost PWM unity power factor rectifier," in Proc. IET Power Convers. Conf. Osaka, 2002, vol. 2, pp. 472–477.
- [14] V. F. Pires and J. F. A. Silva, "Single-stage three-phase buck-boost type AC-DC converter with high power factor," IEEE Trans. Power Electron., vol. 16, no. 6, pp. 784–793, Nov. 2001.
- [15] J. W. Kolar, H. Ertl, and F. C. Zach, "A novel three-phase single-switch discontinuous-mode AC-DC buck-boost converter with high-quality input current waveforms and isolated output," IEEE Trans. Power Electron., vol. 9, no. 2, pp. 160–172, Mar. 1994.
- [16] S. K. Bassan, D. S. Wijeratne, and G. Moschopoulos, "A three-phase reduced-switch high-power-factor buck-type converter," IEEE Trans. Power Electron., vol. 25, no. 11, pp. 2772–2785, Nov. 2010.
- [17] M. Muruganandam, H. Naveena, C. S., S. Dhanapriya, "Evaluation of Diabetic Macular Edema From Color Retinal Images", International Journal of Advanced and Innovative Research, vol. 3, issue, 12, pp. no. 284-287, dec. 2014.
- [18] J. Vinoth, T. Muthukumar, M. Muruganandam, "Implementation of Distributed Maximum Power Point Tracking for Partially Shaded PV Systems", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 4, issue, 2, pp. 702-709, feb. 2015.