International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Improved Power Quality Switched Inductor CUK Convertor for Variable Speed DC Motor with PIC Microcontroller

S. Shanmugapriya, S. Geethanjali, Suryakanta Swain, Devesh Goel, Harshavardhan Goud

Abstract: In this paper, low current pressure and high productivity with diminished components have been used to get high step down gain. A single-staged switched inductor Cuk converter is used for correcting the power factor, Different parts of the proposed converter are analyzed in continuous current mode (CCM). Operational analysis and design equations are analyzed. The performance analyses of the proposed converter concerning power quality such as voltage total harmonic distortion (THD), current THD and complete power factor are done with different kinds of load, for example, resistive load and battery load at constant voltage (CV) and constant current (CC). It is utilized to drive a DC motor at variable speeds with the assistance of a PIC microcontroller.

Index Terms: Power Quality, Variable DC motor drive, Total Harmonic distortion, CUK convertor.

I. INTRODUCTION

These days power supplies with power correction systems are required for wide range of applications such as communication, car, PC and biomedical. For many types of electronic equipment power system with active power factor correction is required to meet some standards. The vast majority of power factor correction rectifiers utilize boost converter from their front end. This converter gives numerous favorable circumstances, for example, normal power factor correction capacity and simple control. However transformer and additional converter is required for low voltage applications such as telecommunications to step down voltage for their requirements.

Revised Manuscript Received on 30 July 2019.

* Correspondence Author

S. Shanmugapriya*, Assistant Professor, Department of Electrical & Electronics Engineering, SRM Institute of Science and Technology, India

. **Geethanjali,** Assistant Professor, Department of Electrical & Electronics Engineering, SRM Institute of Science and Technology, India

Suryakanta Swain, UG student. B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India.

Devesh Goel, UG student, B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India.

Harshavardhan Goud, UG student. B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India.

Also, boost converters experience the ill effects of high input current that builds an expense of safety required for the separation of devices between the line voltage and load. Cuk converter has many advantages such as low ripple factor and continuous output current and step up/step down output voltage. It has disadvantage of having lower efficiency [1].

II. PROPOSED SYSTEM

A high-efficiency Cuk topology has been proposed. This topology execution is assessed depending on the number of components and effectiveness, complexity and harmonic distortion. The proposed topology has low swell factor. Utilization of two phase PFC converters is broadly polished in which the correction of power factor is completed in the primary stage, and in the second stage voltage/current guideline is carried out. On necessity, reasonable converter topology can be utilized at the second stage. Further, the PFC converters (i.e., non-isolated/isolated) are intended for working in continuous or discontinuous conduction mode. Be that as it may, these two-arrange converters experience the ill effects of high component counts and poor efficiency. Despite the fact that many cost effective topologies are accounted for high efficiency of single-stage converters, these are uncommon to be seen for low-power applications. A switched inductor based single staged converter for all inclusive for the application input voltage has been proposed for electric bicycle battery. The converter enables the decrease in switching losses and conduction because of low switch current pressure/stress. The peaky current issues are eliminated as the inductor is set at input side. The duty cycle contrasts with conventional converters therefore bringing about an advantage of points of interest in the proposed topology [2].

III. OPERATION OF CUK CONVERTOR

CUK convertor is a DC-DC converter that can aid in stepping up or stepping down the voltage. This is done by varying the duty ratio.

$$\frac{V_0}{V} = \frac{D}{1-D}$$

Bidirectional energy flow is allowed by using switch and diode in CUK converter. There are two inductors, capacitors and a transistor in form of switch in CUK converter [3]. Figure 1 shows a DC-DC Cuk converter. The output voltage is negative with reference to input voltage because it is inverting converter.

Capacitor C is connected alternately to the input and the output of the converter and is used to transfer the energy as shown in figure 2.

L_1 and L_2 are used to convert the input and output voltage sources into a current source,. Constant current is maintained by the inductor for short time, so it can act as current source. Prevention of resistive current limiting and also associated energy can be prevented by using charging capacitor with current source. Continuous and discontinuous modes are two modes of operation for Cuk converter. But it can also be operated in voltage discontinuous mode too [4].

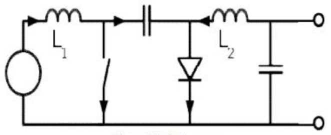


Figure 1 Cuk Converter

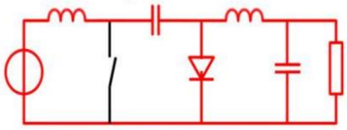


Figure 2 Cuk Converter Operation Circuit

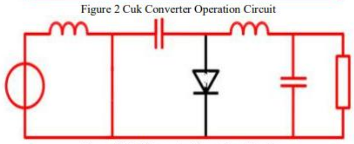


Figure 3 Cuk Converter Operation Circuit

A. Continuous mode

The energy stored in the inductor has to be the same from starting and during commutation cycle. Energy in the inductor during the steady state is given by:

$$E = \frac{1}{2} L I^2$$

This also means that the current through the inductor has to be same from beginning and end of commutation cycle. As current is related to the voltage, it is given by:

$$V_L = L\frac{dI}{dt}$$

In order to satisfy the steady state conditions, the average value of the inductor voltages should be zero during the commutation period. If capacitors C and C_0 are large enough for voltage ripple across them to be negligible, inductor voltage becomes [5]:

- L_1 is connected in series with C and VI in off state. Therefore $V_{L1} = V_i - V_0$.L_2 is connected to output capacitor and diode D is forward biased. Therefore $V_{L2} = V_0$
- In on state, L_1 is directly connected to input source. Hence $V_I = V_T$. L_2 is connected in series with C and output capacitor, hence $V_{L2} = V_0 + V_C$

The converter operates in off state from D·T to T and on state from t = 0 to t = D·T (D is duty Cycle). The average value of V_{L1} and V_{L2} are therefore:

$$V_{L1} = D * V_i I + (1 - D) * V_I - V_C$$

$$V_{L2} = D * (V_0 + V_c) + (1 - D) * V_0$$

Since the two average voltages have to be zero for steady state conditions, using last equation we can write:

$$V_C = -\frac{V_0}{D}$$

Average voltage across L_1 is:

$$V_{L1} = V_i + (1 - D) * \frac{V_0}{D}$$

This can be written as:

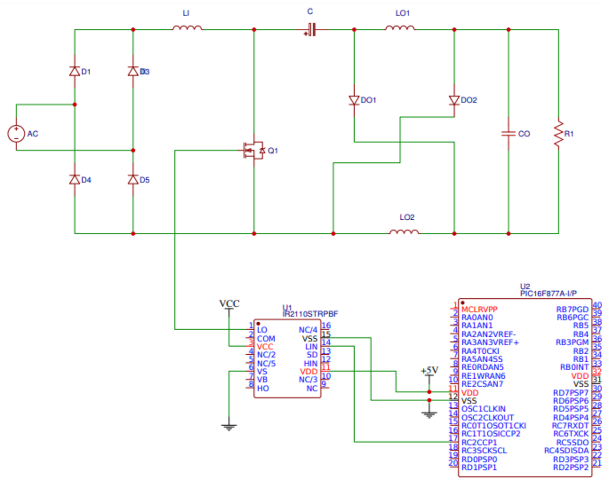
$$\frac{V_0}{V_i} = \frac{-D}{1 - D}$$

B. Discontinuous mode

Inductor is known to provide continuous current, whereas capacitor is known to provide continuous voltage. Both when used in rectifier filter or in DC-DC convertors. If the inductor value is much lesser, we would have a discontinuous current. Minimum inductance is calculated to be [6]:

$$L_{1min} = \frac{(1 - D)^2 R}{2D f_s}$$

Here f_s is switching frequency.



CIRCUIT DIAGRAM OF PROPOSED SYSTEM

IV. CIRCUIT

A. Power supply unit

A Regulated Power Supply is used to give the power to this circuit. A step down transformer is used to take 230 V A.C. from the mains and give 12 V A.C. as output. This is given as input to the rectifier. A pulsating DC output is obtained from the rectifier. For obtaining pure DC voltage, the rectifier's output voltage is given to the filter. This removes any AC component that is still present after rectification. For obtaining pure DC voltage, this is fed to a voltage regulator [7].

B. Transformer

For operating electronic equipment, DC voltages such as 5V,9V or 12V is required. These voltages can't be obtained directly. So the A.C. input of 230 V is needed to be stepped down to the voltage level as required. We use a step-down transformer to step down 230V AC to 0-12V AC [8].

C. Rectifier

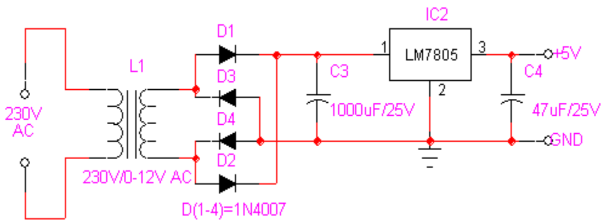
The rectifier takes the output of the transformer as input. The rectifier used may be half/full wave to convert A.C. to pulsating D.C. Due to good stability and full wave rectification we have used bridge rectifier.

D. Filter

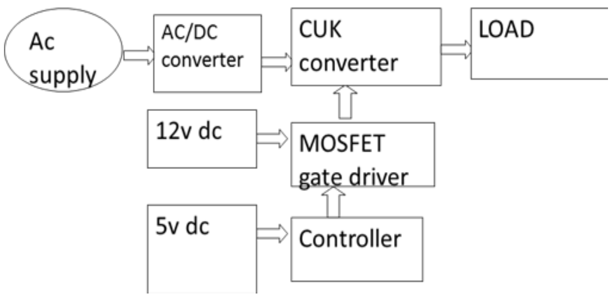
To remove the ripples from the output of the rectifier and also smoothen the D.C., we use capacitive filter. If the main input voltage and load is maintained constant, the output of the filter would also remain constant. A voltage regulator is applied to prevent variation of D.C. voltage due to load or input voltage fluctuations. This is done at the output stage.

E. Voltage regulator

This is used to regulate the voltage input given to it. It is an electrical regulator to maintain an constant voltage level. We need 5V and 12V in our circuit. So we use voltage regulator, 7805 and 7812.



CONVERTOR CIRCUIT

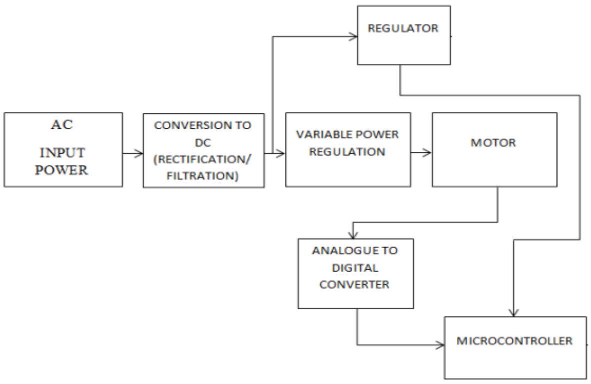


BASIC BLOCK DIAGRAM OF CIRCUIT

V. DC MOTOR CONTROL

A block diagram of the speed control of the DC motor is given below. For controlling the motor at speed (desired), we have used closed-loop control system. It is a 40 pin, 8 bit CMOS flash PIC Microcontroller chip (PIC16F877A) was programmed for this purpose. The overall circuit connection is shown in figure. There are two supply lines. One is given to the motor and other is given to the controller. To control the speed of the motor, input switches along with the microcontroller are used which control the voltage entering the motor due to the potentiometer.

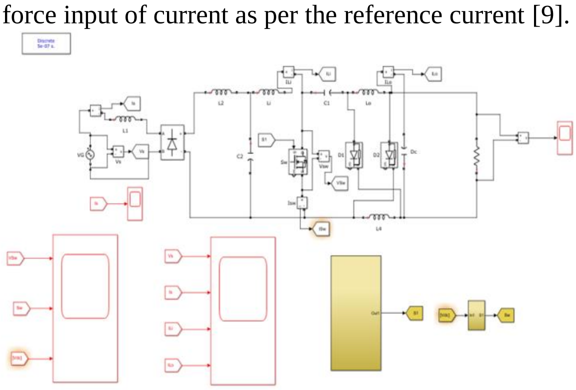
The input switches can be used to drive in 3 different speeds :low, medium and high. An isolator circuit is used between the convertor and the PIC microcontroller due to their varying operating voltages. The circuit also doubles up as the voltage regulating circuit for the signals between microcontroller and convertor.



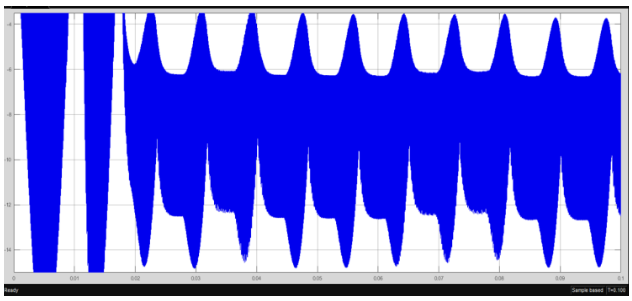
BLOCK DIAGRAM OF SPEED CONTROL OF DC MOTOR

VI. POWER FACTOR CORRECTION

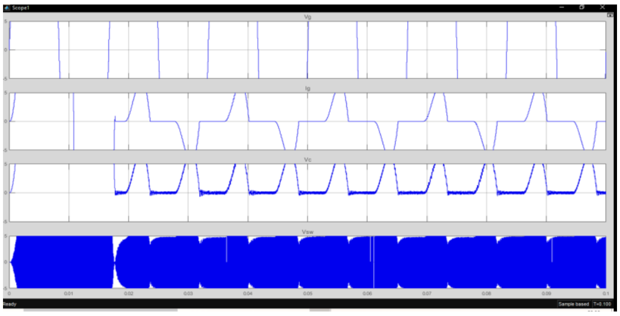
For several reasons, we see that quality of the absorbed power by electronic equipment from utility line is increasing. Power available in the grid is reduced due to low power factor. Cross inference is caused through the line current impedance in various systems in the same grid due to high harmonic distortion of line current. For an ideal power factor, it should be similar to similar to the resistor on supply while the output voltage is regulated. The converter must draw sinusoidal current to get sinusoidal line voltage .For that we must have an appropriate sinusoidal reference. Our objective is to control by force input of current as per the reference current [9].



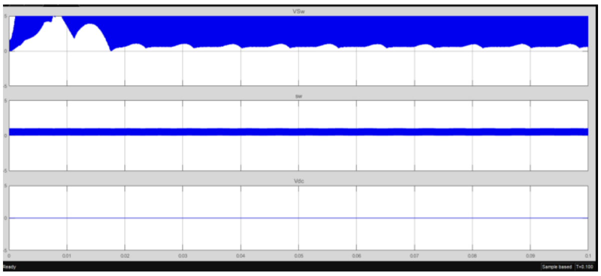
SIMULATION DIAGRAM



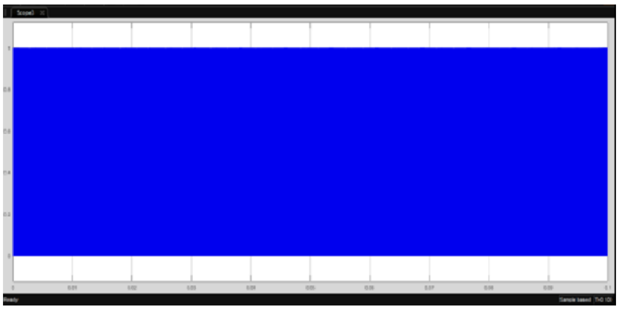
CURRENT WAVEFORM

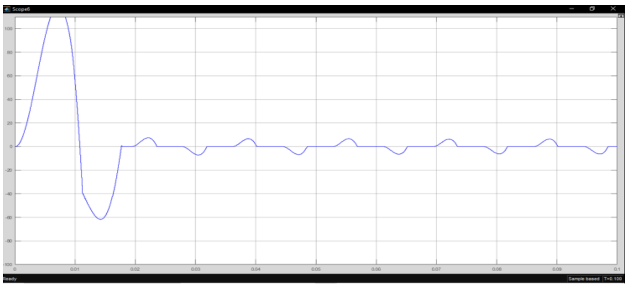


VOLTAGE WAVEFORM



VOLTAGE WAVEFORMS





CURRENT WAVEFORM

VII. CONCLUSION

We have studied various topologies of CUK converter. The proposed topology is found to have improved power factor, harmonic distortion, ripple factor and supply current. Also we have analyzed the technique for current control used to improve quality of power of CUK. Simulation and analysis was carried out using MATLAB Simulink for the average and peak current and hysteresis. The simulation shows that hysteresis control offered PF close to unity. The supply current THD is 3% compared to the other techniques.

The microcontroller is able of control the motor is a generic way at 3 different speeds with the help of the improved power factor due to switched inductor Cuk convertor.

REFERENCES

1. B. R. Ananthapadmanabha, R. Maurya; S. R. Arya, "Improved power quality switched inductor Cuk converter for battery charging applications," *IEEE Trans. Power Electr.*, vol. 33, Issue 11, Nov. 2018.
2. S. Pal, B. Singh, A. Shrivastava, A. Chandra, K.-Al-Haddad, "Improved power quality opto-couplerless Cuk converter for flickerless LED lighting," *IEEE Energy Conv. Congress Exposition*, 2015.
3. S. Fareed, "Design and implementation of bridgeless Cuk converter for controlled BLDC motor," *Int. J. Con. Theory Appl.*, vol. 9, Issue 2, 2016.
4. V. Krishnan, K. U. Vinayaka, S. Sanjay, "Speed control of induction motor drive using PFC CUK converter fed quasi Z-source inverter," *Int. Conf. Comput. Power Energy Info. Comm.*, 2016.
5. J. Viswanatha Rao, L. K. Uttarala, K. K. Vanukuru, S. R. Davu, "Sepic converter FED BLDC drive with closed loop speed control," Int. Conf. Signal Proc. Comm. Power Emb. Sys. (SCOPES), 2016.
6. B. Moon, H. Y. Jung, S. H. Kim, S.-H. Lee, "A modified topology of two-switch buck-boost converter," IEEE Access, vol. 5.
7. F. Caricchi, F. Crescimbini, F.G. Capponi, L. Solero, "Study of bi-directional buck-boost converter topologies for application in electrical vehicle motor drives," *APEC '98 Thirt. Ann. Appl. Power Electron. Conf. Exp.*
8. Landsman "A unifying derivation of switching DC-DC converter topologies," 1979 IEEE Power Electronics Specialists Conference.
9. A. Khaligh, "A multiple-input dc-dc positive buck-boost converter topology" 2008 Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition.

AUTHORS PROFILE

S. Shanmugapriya received BE and ME degrees in Electrical and Electronics Engineering and Power Systems Engineering from Annamalai University in 2003 and 2005, respectively, and is working towards her PhD degree. She is working as an Assistant Professor, Department of Electrical & Electronics Engineering, SRM Institute of Science and Technology, India since 2006. Her research interests are in the areas of state estimation, evolutionary algorithms and power system analysis.

S. Geethanjali received BE and ME degrees in Electrical and Electronics Engineering and Power Systems Engineering from Annamalai University in 2004 and 2006, respectively, and is working towards her PhD degree. She is working as an Assistant Professor, Department of Electrical & Electronics Engineering, SRM Institute of Science and Technology, India since 2007. Her research interests are in the areas of smart grid, evolutionary algorithms and power system protection.

Suryakanta Swain is final year UG student. He is currently studying B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India. His research includes Energy auditing, Power electronics, Wireless Transmission and Power System.

Devesh Goel is final year UG student. He is currently studying B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India. His research includes Energy auditing, Power Electronics, Wireless Hybrid electric vehicle.

Harshavardhan Goud is final year UG student. He is currently studying B Tech EEE in SRM Institute of Science and Technology, Kattankulathur, India. His research includes Energy auditing, Power Electronics, Internet of things.