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Power Factor Correction Using Sepic Dc-Dc Converter in Industrial Motor Drives

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Abstract

Brushless DC electric motors (BLDC electric motors), Power Factor Correction (PFC), and speed control with a Single-Ended Primary Inductor Converter (SEPIC) are all articulated. An innovative method for controlling motor speed and PFC using SEPIC and managing DC link voltages is proposed, as well as a viable solution for driving applications. SEPIC in discontinuous mode is used to achieve power factor correction for speed control over a wide range. The system is simulated in MATLAB, and the results show that it is valid and feasible. SEPIC converter can be used in power factor correction circuits. The conventional SEPIC converter was primarily designed to provide a non-pulsating input current, operating in continuous current mode with both inductors, and only DC-DC conversion was considered. The modified SEPIC converter is designed to operate as an AC-DC converter and can be viewed as a cascade of a modified boost converter and a buck-boost converter. The modified SEPIC converter is intended to operate as an AC-DC converter and is composed of a modified boost converter and a buck-boost converter in series. The boost converter uses discontinuous current, whereas the buck-boost converter uses continuous current. Since a high power factor is achieved naturally in this manner, a simple feedback control technique is required to regulate the output voltage.

Keywords: *BLDC Motor, SEPIC converter Speed control Power factor correction PI controller.*

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I. INTRODUCTION

In recent years, it has become increasingly important to improve power quality (PQ) at supply A.C mains, and to do so in accordance with International Power Quality paradigms. Typically, power factor corrected (PFC) converter fed D.C motor drive applications maintain a power factor greater than 0.9 and THD less than 5% for class- (D) applications. The diode bridge rectifier based PFC fed D.C motor drive flows non-sinusoidal current from the supply side; as the non-controlling switching devices are reverse polarized at that time, the supply voltage is lower than the DC link capacitor potential; however, it passes more current when the source voltage is greater than the capacitor voltage. As a result, more PQ issues occur at ac mains with a low power factor and higher THD. As many such drives are provided all together at various conditions, these PQ issues become more meticulous for the sake of usefulness. It has been reported that Zeta, SEPIC, and Cuk converters fed special electrical machines and DC motors. Several controllers for Luo Converter and BLDC motor drives are well documented. The recent SEPIC converters fed BLDC motor drive for PFC method, on the other hand, have not been reported in these literatures.

As a result, the purpose of this article is to build the PI controller using a SEPIC converter to regulate the output voltage/speed and improve PFC. The remainder of the paper covers BLDC motor operation and controller design, controller mechanism, simulation results, and finally conclusions.

II. PROPOSED SYSTEM

This proposed system aims to implement power factor correction (PFC) in Brushless motor drives using SEPIC converter topologies. In order to improve the power quality (PQ) corrected power factor converter is vital. VSI is used as a speed control. To condense conduction loss and amount of components diode bridge rectifier is removed. The maximum power can be extracted by means of perturb and observe the technique. The ripples can be minimized by the low pass filter. A new bidirectional bridgeless isolated SEPIC converter is used to achieve power factor close to unity. The outline of the proposed system is shown in Fig.2.1.

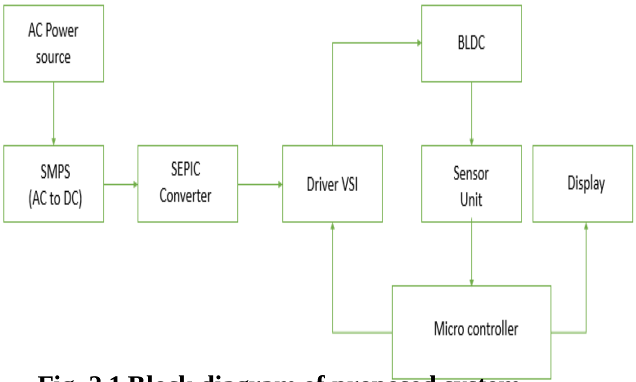


Fig. 2.1 Block diagram of proposed system

III. METHODOLOGY

3.1 Methodology of proposed system

The SEPIC converter will be used in discontinuous conduction mode to achieve the improved power factor. The speed control can be accomplished by controlling the VSI (Voltage source inverter) feeding the BLDC drive. The Atmel 328 microcontroller is used in Voltage source inverter in order to control the pulse.

3.2 Working

In bridgeless SEPIC converter, the extraordinary intend of DC side inductor is to support the dc current and high rate wrinkle current. It needs three additional passive elements. It adds the converter's quantity and mass. It doubles the output voltage and the output filter quantity is raised. While working in Continuous conduction mode Voltage and current loop is essential for standard PFC converters. When the converter operates in discontinuous conduction mode the power circuit is easy and current loop is not needed for the proposed converter.

BLDC motor consists of neither commutator nor brushes. The rotor is composed of the permanent magnet, where the stator is composed of the number of windings. Therefore, the direction of the conductor current on the stator is monitored electronically. Hall sensor is used to determine the position during commutation. The position of the rotor depends on the precise position of the stator. It has semiconductor switches to enable and disable the stator winding when needed. Switches current from winding to winding forcing the rotor to turn by varying pulse motor is rotated. Electronically switched motors are not the same as other motors such as brushless DC motors. In brush-type motor, switching is performed using a commutator and graphite brushes. In an electronically commutated brushless motor, it is carried out by switching electronics.

It obtains information on the position of the rotor through sensors using a microprocessor. Electronic commutation is obtained by using a three-phase voltage source inverter (VSI) [10]. The BLDC motor is connected after the diodes bridge rectifier (DBR) and the DC link capacitor. When DC link voltage is higher than the supply voltage it draws current only for a small time.

IV. HARDWARE DESCRIPTION

4.1 Brushless DC motor

Fig 4.1.1 Brushless DC motor

A brushless DC electric motor, also called an electronically commutated motor or, a synchronous motor using a direct current (DC) electric power supply. It uses a closed loop electronic controller to switch DC currents over the motor windings producing magnetic fields that efficiently rotate through space and that the magnet permanent rotor follows. The controller adjusts the amplitude and phase of the direct current pulses to control the speed and torque of the motor. This control system is a replacement for the mechanical switch (brushes) used in many conventional electric motors.

The construction of a brushless motor system is generally similar to a permanent magnet synchronous motor (PMSM), but may also be a switched reluctance motor, or an induction motor (asynchronous).They also use neodymium magnets and be outrunners (the stator is surrounded by the rotor), inrunners (the rotor is surrounded by the stator), or axial (the rotor and stator are flat and parallel).

4.2 SEPIC Converter:

Fig 4.2.1 SEPIC converter

The single-ended primary-inductor converter (**SEPIC**) is a type of DC/DC Converter that makes the electrical voltage at its output to be greater than, less than, or equal to that at the input side. The output of the SEPIC is controlled by the duty cycle of the control switch (S1).

A SEPIC is basically a boost converter followed by an inverted buck-boost converter, it is thus similar to a conventional buck-boost converter, but has the advantage of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (therefore can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch S1 is turned off enough, the output (V_0) drops to 0 V, following a fairly hefty transient dump of charge. SEPICs are useful in applications where the battery voltage may be higher or lower than that of the intended regulator output. For instance, a single lithium-ion battery typically discharges from 4.2 volts to 3 volts; if other components need 3.3 volts, then SEPIC converter would be effective.

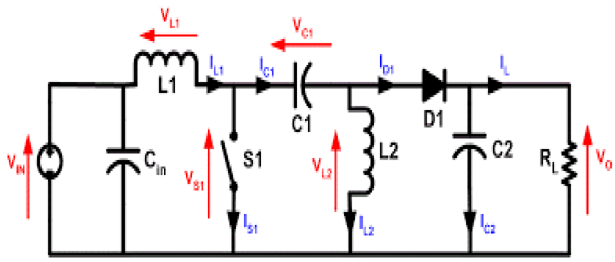


Fig 4.2.2 Circuit diagram for SEPIC converter

4.3 Voltage Source Inverter

In the VSI, switches are enabled and disabled at regular intervals to provide rectangular voltage pulses at each phase.

Fig 4.3.1 VSI Circuit

4.4 Switched Mode Power Supply (SMPS)

Fig 4.4.1 SMPS

SMPS is the Switched Mode Power Supply circuit which is designed to obtain the regulated DC output voltage from an unregulated DC or AC voltage. Switch Mode Power Supplies are becoming common place and have replaced in most cases the traditional linear ac-to-dc power supplies as a way to avoid power consumption, decrease heat dissipation, as well as size and weight. Switched mode power supplies can now be found in most PC's, power amplifiers, TV's, dc motor drives, etc., and just about anything that requires a highly efficient supply as switched mode power supplies are increasingly becoming a much more mature technology.

4.5 Relay

Fig 4.5.1 Relay

A relay shown in figure 4.5.1 is a switch that is electrically actuated. It consists of a set of input terminals for one or several control signals, and a set of contact terminals in operation. The switcher can have any number of contacts in several forms of contact, such as making contacts, breaking contacts, or combinations. Relays are used when a circuit needs to
be controlled by a low-power independent signal or when multiple circuits need to be controlled by a single signal.

4.6 Voltage Sensor

Fig 4.6.1 Voltage Sensor

A voltage sensor shown in the figure is a sensor for calculating and monitoring the amount of voltage in an object. The voltage sensors make it possible to determine either the AC voltage or the DC voltage level. The input for this sensor can be voltage while the output is switches, analog voltage signal, current signal, audible signal, etc.

4.7 Current Sensor

A current sensor shown in figure 4.7.1 is a device that senses the electric current in a wire and produces a signal proportional to that current. The signal produced may be an analog voltage or current or even a digital output. The generated signal then makes it possible to display the measured current in an ammeter, or may be stored for further analysis within a data acquisition system, or may be used for control purposes.

Fig 4.7.1. Current Sensor

4.8 LCD Display

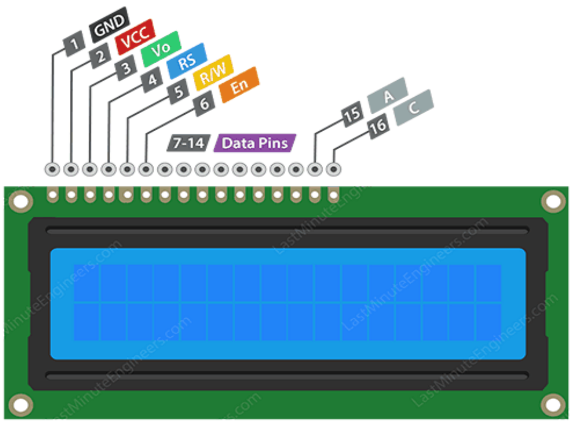


Fig 4.8.1 LCD display

It is far easier to connect an I2C LCD display than a standard LCD display. Simply connect 4 pins rather than 12. First connect the VIN spindle to the 5V output on the Arduino and connect GND to the ground. Now we keep to the pins that are used for I2C communication. On the Arduino boards with the R3 layout, the SDA (data line) and the SCL (clock line) are on the pin heads next to the AREF pin. In addition, they are called A5 (SCL) and A4 (SDA).

4.9 Arduino (ATmega328P)

Arduino is an open source microcontroller board based on the Microchip ATmega328P microcontroller developed by Arduino cc. The board is provided with digital and analogue input/output (I/O) pin assemblies that can be interfaced with various extender boards and other circuits.

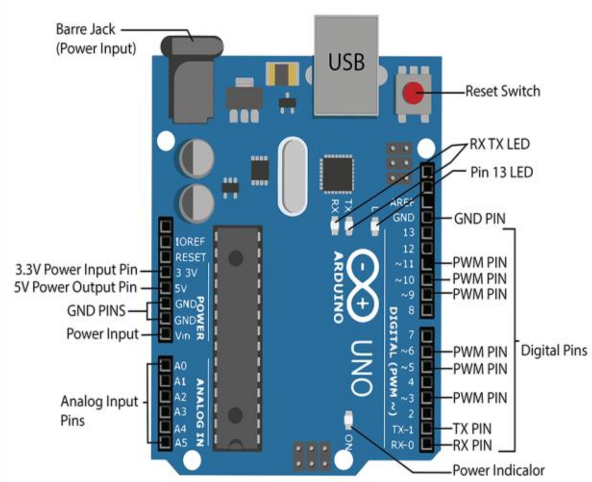


Fig 4.9.1 Arduino Microcontroller

Each of the 14 digital pins and 6 analog pins of the Uno can be used as an input or output, under software control (via pinMode(), digitalWrite(), and digitalRead() functions). They are powered by 5 volts. Each pin can supply or receive 20mA as the recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50K ohm. No more than 40mA should be exceeded on an I/O pin to prevent permanent damage to the microcontroller. The Uno has 6 analog inputs, labeled A0 to A5; each one provides 10-bit resolution (i.e. 1024 different values). By default, they measure 5 volt ground, although the upper end of the range can be changed using the AREF pin and the analogReference() function.

V. SOFTWARE DESCRIPTION

5.1 MATLAB

MATLAB is a high-end language and interactive environment for digital computing, visualisation and programming. The integrated language, tools and mathematical functions enables to explore multiple approaches and achieve a solution faster than a spreadsheet or programming language such as C, Java, etc.

5.2 Software Specifications

Software	Version
MATLAB	R2017a
Arduino IDE	1.8.13

Table 5.2.1 Software Specifications

5.3 Simulation Diagram

The following figure 5.3.1 represents the simulation model of SEPIC dc-dc converter and figure 5.3.2 represents the simulation model of boost converter.

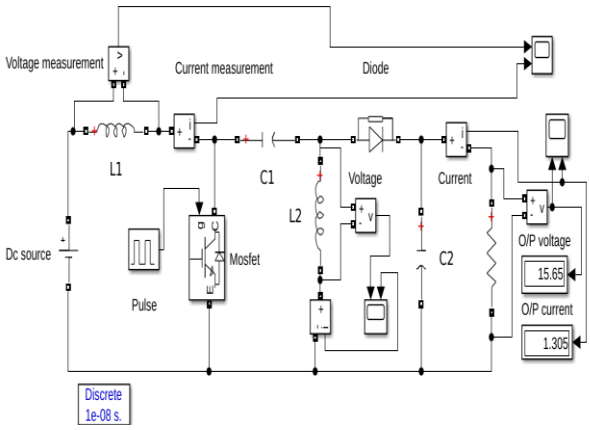


Fig 5.3.1 SEPIC DC-DC Converter circuit

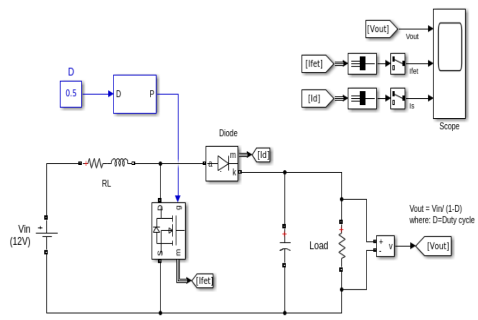
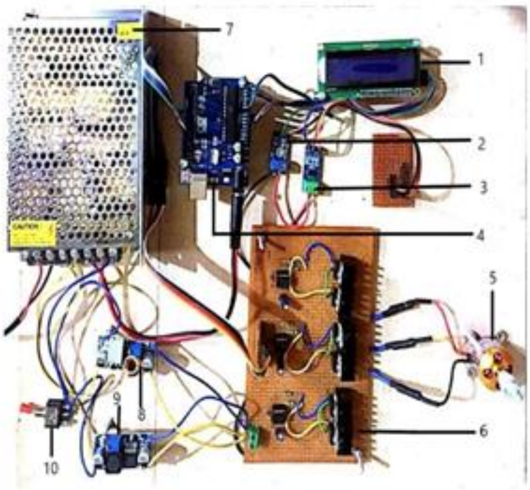


Fig 5.3.2 DC-DC Boost Converter

VI. RESULTS

6.1 Hardware Result



1. LCD Display
2. Voltage Sensor
3. Current Sensor
4. Arduino
5. BLDC Motor
6. Driver Circuit
7. SMPS
8. BOOST Converter
9. SEPIC Converter
10. Switch

Fig 6.1.1 Hardware Circuit Design

Fig 6.1.2 Power factor output with Boost Converter

Fig 6.1.3 Power factor output with SEPIC converter

6.2 Software Result

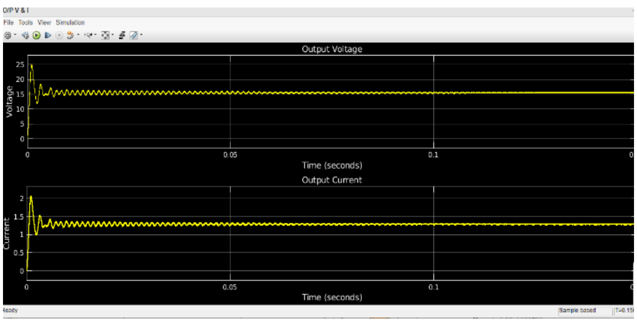


Fig 6.2.1 Simulation Result with SEPIC converter

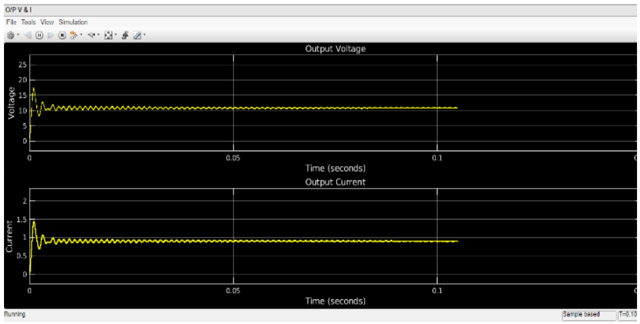


Fig 6.2.2 Simulation Result with Boost converter

VII. CONCLUSION AND FUTURE SCOPE

A Comparative analysis of the SEPIC converter and the Boost converter in BLDC motor drives was suggested. Based on the results obtained from the proposed system, we can conclude that SEPIC converter is most suitable as it gives the high efficiency output, improved power factor, reduced torque ripples and good speed response for the BLDC drives when compare to the conventional Boost converters.

The power factor correction techniques can be applied to the industries, power systems and also households to make them stable and due to that the system and the efficiency become stable. These resources will address grid parity in the future. This topology can also be applied to applications where low losses, high power density, low weight and volume are required.

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