

Improved Power Factor Correction for BLDC Drive Using Fuzzy Logic Controller

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ABSTRACT: This paper presents a DCM based PFC (Power Factor Correction) based BL (Bridgeless)-Single phase single ended primary inductance converter (SEPIC) converter fed BLDC (Brushless DC) motor drive. The proposed converter topologies are implemented to provide the near unity power factor in a successful manner. The *proposed speed control* scheme has the work of DC link voltage control proportional to the desired speed of the BLDC motor. The converter combines the PFC and DC link voltage control and uses a single controller. The bridgeless SEPIC converter topology is used to obtain the low conduction losses and low range of heat sinks for the switches. The proposed system is designed with Fuzzy controller and simulated to operate around a wide range of speed control with near unity power factor at input side. The proposed power factor correction converter limits the harmonic distortion (THD) below 5% of total current at AC mains.

KEYWORDS: BLDC, Bridgeless SEPIC converter, THD, Power factor correction, fuzzy logic controller

I. INTRODUCTION

In recent years BLDC motors are considerably used in a aerospace, Motion control and defence applications such as vehicle tracking, gyroscope, aircraft on swine instrumentation, fuel monitoring position and quick actuators because of their valuable efficiency, high starting torque, reliability, decline maintenance, less chat compared to brushed DC motor [1]. The stator of the BLDCM comprises of three-phase combined windings and rotor has dependable magnets. It is furthermore recognized as an electronically commutated motor (ECM) considering an electric commutation created on rotor position by a three-phase voltage source inverter (VSI) is used [16], [17]. Thus, the problems associated with brushes, one as sparking, and exasperate and roar of the commutator chamber of deputy are excluded. A conventional BLDC motor fed by a Diode bridge rectifier results in total harmonic distortion of supply current in the range of 60% which leads the reduced power factor. The IEC 61000-3-2 standard is recommended for the high power factor and improved power quality at a way with element and gone straight power action at the supply is chosen [18]. Hence an efficient drive system is necessary to give a wide range of speed act with power factor correction and righteous power action at the AC mains at an capable cost.

Due to growing concerns on the power quality, PFC has acquired an important issue. A boost converter is one of the well-known PFC topologies, due to its simple circuitry, simple control scheme and low number of passive elements. Even though a boost converter is accepted as a typical PFC converter, its produce voltage must be higher than its input voltage [5]. The dc output voltage is interminably higher than the peak input voltage, Size of EMI filter is high, input-output isolation cannot be implemented plainly, larger PFC inductance, the startup inrush current is valuable, and there is a lack of current limiting during overload conditions [6],[7]. To overcome the problems associated with help type PFC converters, specifically in universal applications where the output voltage is degrade than the input voltage the step up/down converters one as buck-boost, cuk, SEPIC can be used. Generally, these kinds of converters include a full-bridge diode rectifier on an input path, so that switching losses on the full-bridge diode occur and it will be worse especially at the low line. To improve the power supply efficiency and the switching losses, the distinctive topologies for non isolated and isolated power converter circuits have been exposed in [8], [9].

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To overcome these drawbacks, different bridgeless topologies are recommended for step-up/step-down applications have been introduced in [10]–[12]. In [10], three semiconductor switches in the current conduction path during each cycle. In [11], a bridgeless PFC circuit based on the SEPIC topology is presented.

The selection of mode of operation is a tradeoff between the allowed stresses on PFC switch and cost of the around system during the operating mode of front-end converter. The two different modes of operation are depending on design parameters; either continuous or discontinuous conduction mode approach may lead the converter. In this design, a BLDC motor drive fed by a PFC BL-SEPIC operates in four modes. At the time of starting or overloading inrush current is created. The inrush current occurring at start-up or overload was eliminated by operating the PFC in discontinuous conduction mode (DCM), it also gives natural protection for switches, low input ripple, and less electromagnetic interference (EMI) [15]. In this paper a fuzzy controlled BL-SEPIC is analysed in terms of harmonic reduction.

II. PROPOSED PFC BRIDGELESS SEPIC CONVERTER FED BLDC MOTOR DRIVE

The proposed converter consists of four switches and diodes are used in Figure 1. The frontend consists of a SEPIC converter comprised of inductors L_1 and L_2 , typical capacitor C_1 , diode D_1 and turn out capacitor C_2 . The changes from the rule SEPIC configuration are the diode D_1 is covering in the return path. This is to not allow the flow of current during the periods of negative emf. A, B, and C are the three windings and the currents on them are controlled by turn on and turn off of the switches S_A , S_B and S_C correspondingly. Single switch per phase is used, so the currents through them are unidirectional. The diodes D_A , D_B and D_C act as freewheeling diodes to allow the winding currents to dissipate when the switches are turned off during the process of phase commutation. The output of the converter is used to excite the three phases of the machine, and the voltage of capacitor C_1 is used to demagnetize the phases around turn-off and for current control.

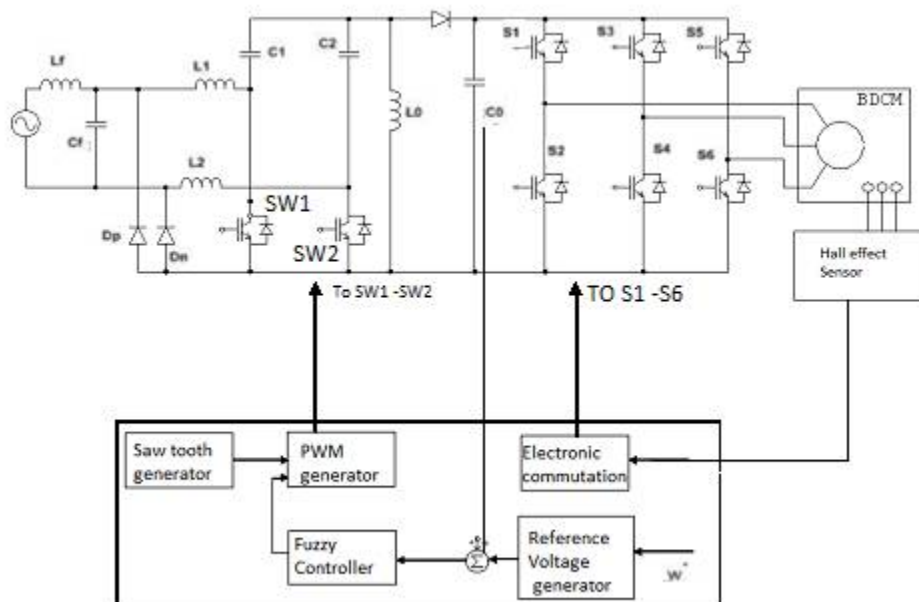


Figure 1 Block diagram of BL-SEPIC fed BLDC drive

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III. SIMULATION RESULTS

The operation of the projected topology has been verified by simulation for MATLAB/SIMULINK. The rotor position is sensed by means of three Hall Effect sensors, and the motor position information is used to determine the phase winding to be excited. The machine speed is derived from the position of inputs and is compared with the speed reference to generate the current references. Fuzzy logic control is used to standardize the phase currents to the reference current. The dc bus voltage is regulated by PWM control of the switch S1. Performances indices such as supply voltage (V_{in}), supply current (i_s), DC link voltage (V_{dc}), speed are analyzed for determining the performance of proposed BLDCM drive. Power quality indices such as PF (Power Factor), THD (Total Harmonic Distortion) of supply side are analyzed for demonstrating the improved power quality at AC mains.

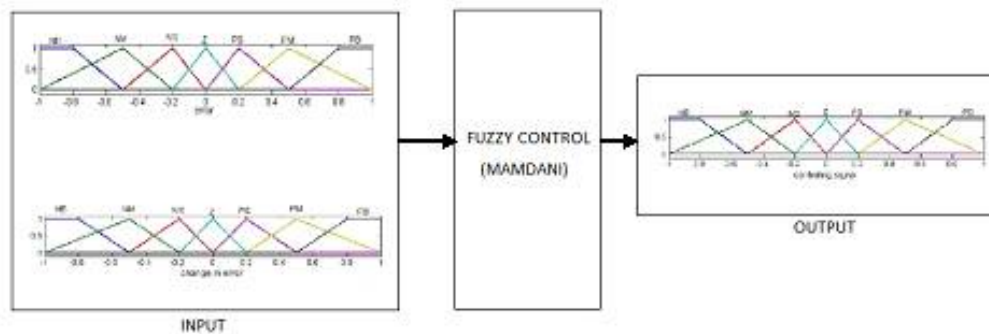


Figure 2 Fuzzy Logic Controller

The fuzzy logic controller ran with the input and output normalized universe $[-1,1]$. The Figure 2 shows the Fuzzy logic controller used MATLAB simulation. The design of a Fuzzy Logic Controller needs the choice of membership function, after a suitable membership functions are chosen, a rule based should be created, it consists of If-Then rules that completely determines the parameters of the system, these rules very much resembles with the human thought and thus provides intelligence to the system. The rules implemented for the control of BLDC Motor by using DC link voltage control topology. The simulation is carried out for Fuzzy control scheme in MATLAB/SIMULINK.

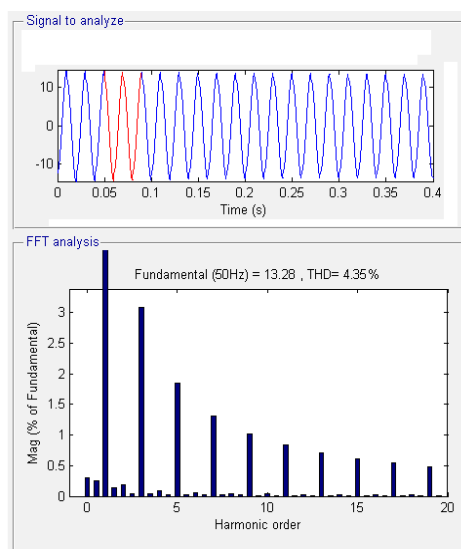


Figure 3. Input Voltage and THD of the proposed circuit

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The mamdani fuzzy inference system is implemented with triangular membership functions as input and output variables. The inputs to the Fuzzy controller are voltage error and change in voltage error. The output is the controlling signal given to BL-SEPIC for PFC. Figure 3 shows the source current with 4.37% THD which is according to standard limits. For different input voltages the speed of the BLDC is varied and the power factor is also maintained as shown in Figure 4.

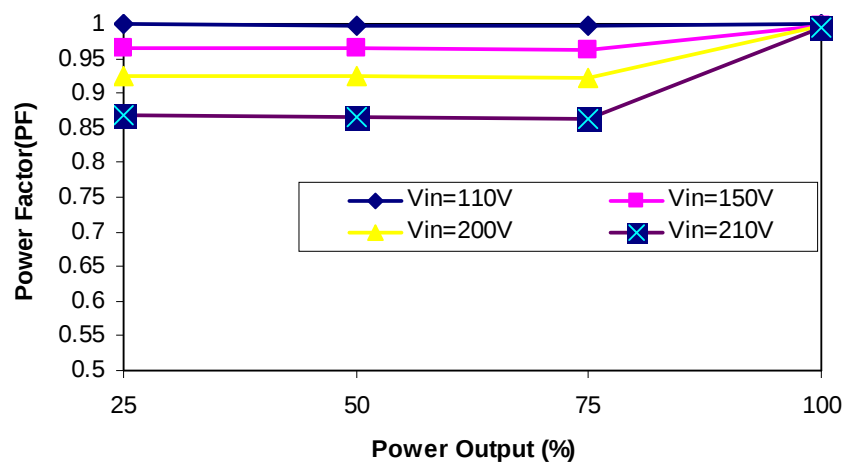


Figure 4 Power factor Vs output for different input

Table1 Performance of the proposed BL-SEPIC PFC drive with Diode Bridge PFC

Parameters	Obtained Values	
	Without Diode Bridge PFC	BL-SEPIC
Power Factor	0.872	0.998
THD	21%	4.35%

Table 1 gives comparative results with conventional Diode Bridge PFC and BL-SEPIC. The parameters compared are power factor and THD. The obtained values after simulation shows the better results for usage of BL-SEPIC PFC compared with conventional PFC circuits.

IV. CONCLUSION

The Simulink model for a BLDC Motor drive system with stator current control by using Simulink blocks has been developed and operated at rated speed. A mathematical expression of the system is simply incorporated in the MATLAB simulation and the usage of numerous appliance boxes and support guides simplifies the simulation of large control system. Simulink is effective of recommending real time results with reduced simulation time process and debugging. Usually in such drive system the inverter is driven by Fuzzy Logic controller. The Simulink simulation allows performance study of BLDC Motor drives with DCM. It is found that the power factor is near unity with the use of BL-SEPIC converter. The efficiency increases due to the increase in the power factor.

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