Soft Computing Technique of Bridgeless SEPIC Converter for PMBLDC Motor Drive

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ABSTRACT

A novel speed controller for the three-phase Brushless DC (BLDC) Motor Drive is proposed using a closed-loop AC-DC Bridgeless SEPIC Converter in continuous Conduction mode. This design proposes a single stage AC-DC converter with ON and OFF state equivalent circuits for 400W, 48V at 2450 rpm PMBLDC motor drive. The Fuzzy based voltage and current controlling method is proposed in this design. The voltage controlling method is used to control the speed for BLDC motor and the current controlling method is used to improve the power factor in AC supply. The speed of BLDC motor is observed with voltage disturbance and the constant motor speed is maintained. The proposed control method on SEPIC converter fed PMBLDC motor drive is modeled by Simulink/Matlab.

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1. INTRODUCTION

The permanent Magnet Brushless Direct Current Motor (PMBLDC) is gaining attention from various Industrial and household appliance like medical, fans and pumps due to of its high efficiency, compact, low noise and low maintenances[1]-[3]. The ratio of torque delivered to the size of the Motor is high making it useful. The technique to improve the efficiency of the Motor drive by power factor correction converter (PFC) play an important role in the energy saving during energy conversion [4]-[6].

A solid-state AC-DC conversion of electric power is widely used for electric drive system for adjustable-speed drives, switch mode power supply (SMPS) [7],[8], uninterrupted power supply (UPS) [9],[10] interface with non-conventional energy sources such as PV, battery, fuel for electric vehicles, telecommunication system, Mills. Many of existing active technique to correct power factor focus on line shaping technique such as continuous conduction mode (CCM) [11],[12], discontinuous conduction (DCM) [13] mode. DCM is well suitable for low power application because of its low cost implementation by increasing the switching frequency in PFC. The power factor of a single stage voltage control fed converter is not high as compared to current fed converters. Some converters has two stages to transfer the power input to load which is also leading to power losses, so single stage PFC is preferred [14],[15].

For PFC converter, SEPIC [16]-[18] topology can be used when an output voltage lower than the maximum input voltage is required. SEPIC topology is advantageous, it allows the use of ripple steering technique in order to reduce the switching frequency components of the input current without additional circuit [19]-[21]. The bridgeless PFC rectifier increases power density and reduce noise emissions. The Bridgeless SEPIC PFC converter with continuous conduction mode (CCM) has been used in broad range of applications and this model is proposed in this paper [22]-[24].

2. PROPOSED BRIDGELESS SEPIC CONVERTER FED BLDC DRIVE

2.1. Basic Bridgeless SEPIC Converter

The basic Bridgeless SEPIC converter circuit is shown in Figure 1. A 400 watts single switch SEPIC power factor correction operating in continuous conduction mode (CCM and it consists of 3 inductions, 3 capacitance and 1 diode. The Bridgeless SEPIC converter is a buck-boost converter and it converts fixed AC to variable DC Voltage in single power stage.

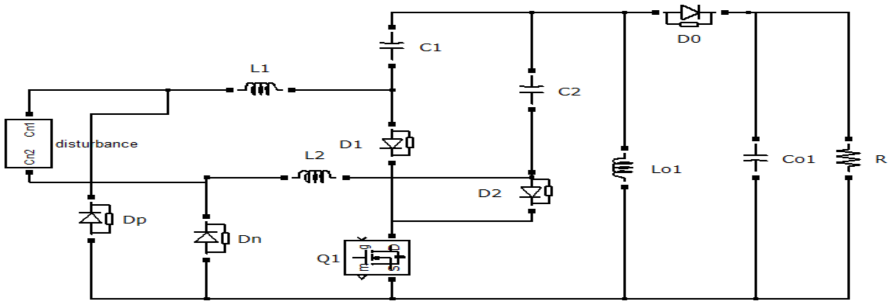

Figure 1. Proposed bridgeless SEPIC Converter circuit

The modes of operation of proposed circuit diagram shown in Figure 2. It shows the ON and OFF state equivalent circuit. During the ON state, inductance (L1) stores the energy, diode (D1) in OFF state. Capacitance (C1) transfers energy to inductor (Lo1), Capacitance deliver the power to load. Figure 2(a) shows the ON state of the switch Q1. And Figure 2(b) shows the OFF state of switch Q1. If the switch is closed Inductor (L1) and capacitance (Co) deliver the power to the load.

Table 1. The Bridgeless SEPIC with FLC converter circuit parameter

Circuit parameter	
Supply Voltage	200V
Load Resistance	10Ω
DC link Voltage	48V
Input Induction	2mH
Source frequency	50Hz
Output capacitance	1200µF
Switching frequency	25KHz

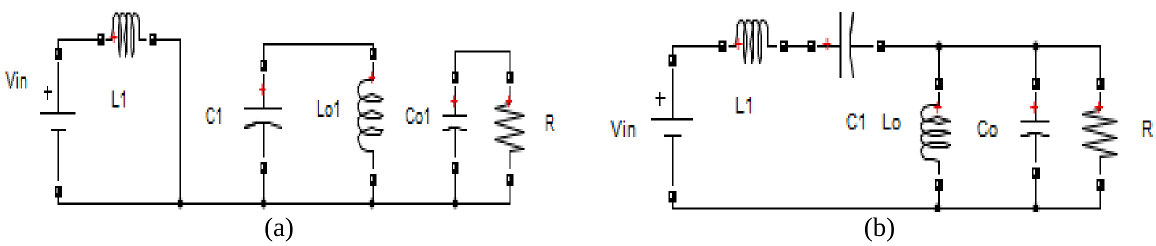

Figure 2. Equivalent circuit of Bridgeless SEPIC Converter, (a) During switch Q1 is ON; (b) During switch Q1 is OFF

2.2. Bridgeless SEPIC Converter Controlling Method

A current mode control (CMC) converter has two feedback loops, an inner loop that forces the current and an outer voltage loop that regulates the output voltage. The speed of BLDC motor has sense using hall sensor and the actual speed has compared with the reference speed. The speed difference is converted into voltage reference and compared with actual voltage to generate error signal. This error signal is given to fuzzy controller and voltage controller regulate the output voltage in desired value. The current controller is used to limit the high current and shape the input current waveform.This proposed system has to step down the Voltage and regulate the output voltage and input power factor.

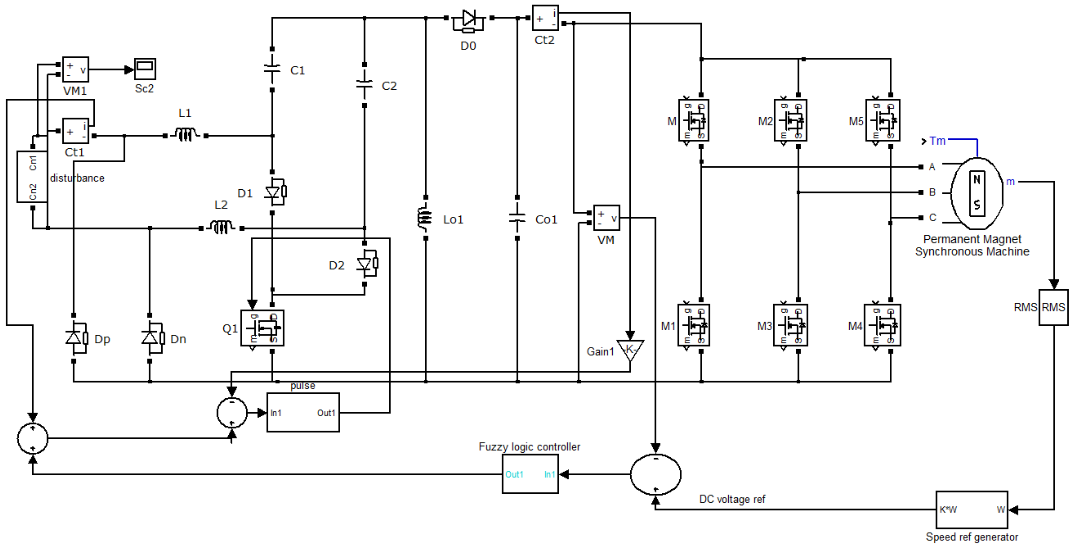

Figure 3. Proposed Bridgeless SEPIC converter fed BLDC motor under dynamic conditions

2.3. Fuzzy logic controller for Bridgeless SEPIC converter

The fuzzy logical controller in Figure 4 is an advanced controller using multi valued logical and it works on the principle of rule based system. It involves two processes namely fuzzification and defuzzification. Fuzzication involves the process of transforming a constant value into linguistic variable while defuzzification deals with hienstic variable conversion to constant value. The defuzzification is inverse process of fuzzification of each input in graphical form input. Bell shaped fuzzy membership functions are used in the proposed work. The inputs to the fuzzy logic controller are voltage error and rule of change of voltage error and output is reference current. Figure 5 shows Membership function of Fuzzy logic controller (FLC). The rule based system is incorporated in Simulink block of fuzzy logic controller. The membership function considered here are in triangular shape. The following are various linguistic terms for the FLC: (1) Negative Big (NB); (2) Negative Small (NS); (3) Zero (Z); (4) Positive Small (PS); (5) Positive Big (PB). FLC rule base truth table shown in table1.And also shown the surface view in Figure 6.

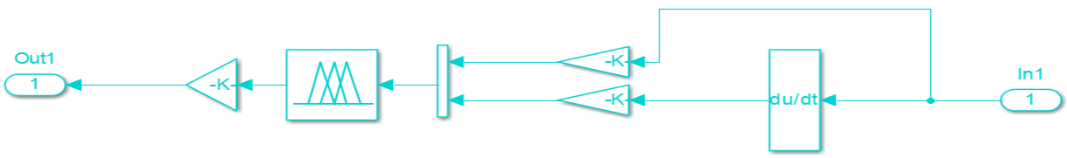

Figure 4. Proposed Bridgeless SEPIC converter Fuzzy logic controller circuit

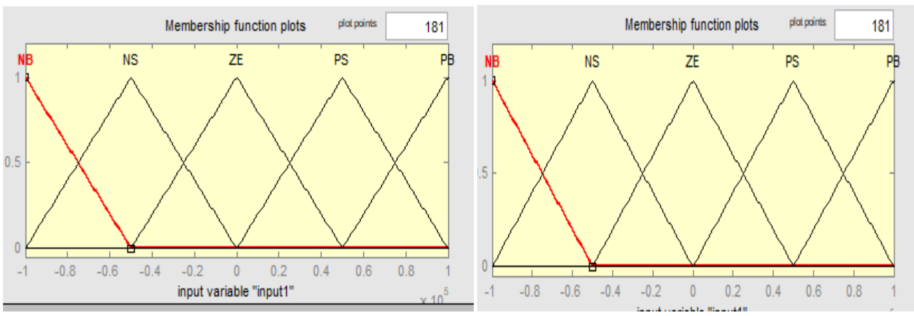

Figure 5. Membership function of Fuzzy logic controller circuit

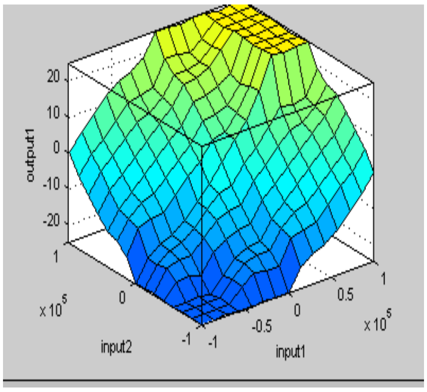

Figure 6. Fuzzy rule based system rule viewer diagram

Table 2. Rule based Fuzzy Controller for Bridgeless SEPIC converter system

E/dE	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	ZE
NS	NB	NB	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	ZE	PS	PB	PB
PB	ZE	PS	PB	PB	PB

2.4. PMBLDC Motor

The permanent-magnet Brushless DC(PMBLDC) motors with trapezoidal back EMF finds a variety of applications in aerospace, automotives, industries, military, computers, household products etc. due to higher efficiency, higher torque, higher power factor, increased power density, ease of construction, ease of control and ease of maintenance. The torque developed by a BLDC motor is constant. A conventional Brushless DC motor is excited by a six switch three phase inverter (SSTPI) where commutation is achieved through an inverter and a position sensor placed 120° apart on the stator.

The windings of a BLDC Motor modeled as a series combination of R L and speed depends on the voltage source, which is known as the back EMF The BLDCM has three phases and those phase voltages are given by the equations. A PMBLDC Motor has three stator phase windings connected in a stator manner. Figure 7 shows the equivalent circuit of a PM BLDC Motor.

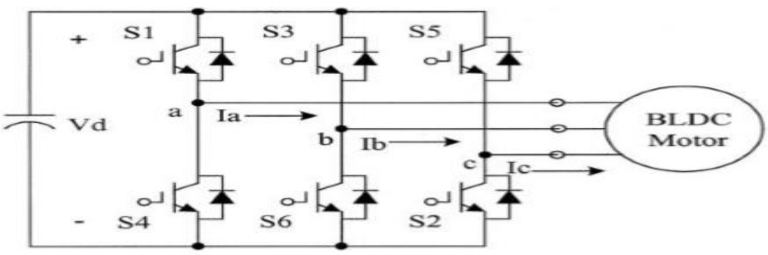

Figure 7. Basic PWM inverter fed PMBLDC motor

3. BRIDGELESS SEPIC WITH PMBLDC MOTOR PERFORMANCE

In this proposed system, the input voltage varies from 190V-220V, then the output voltage 48V in the Bridgeless SEPIC converter. The 48V is given to PMBLDC motor and the speed of the PMBLDC motor is controlled by the method of two loop control system with FLC.The change in input voltage occurs at 0.7sec and the waveform shows the output of the Bridgeless SEPIC converter is controlled. The input and the output waveform shown in Figure 8 and the input voltage and current waveform is shown in Figure 9.

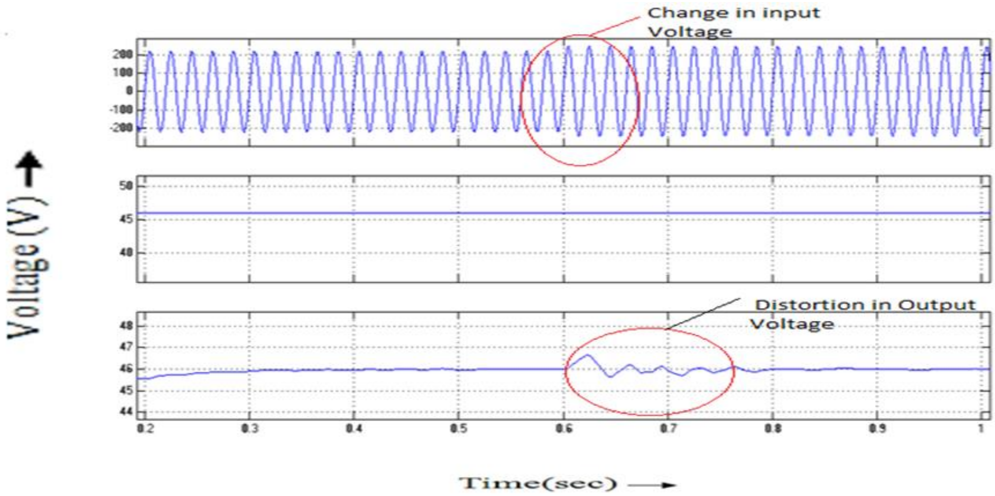

Figure 8. Input Voltage ,reference voltage and Output Voltage with disturbance

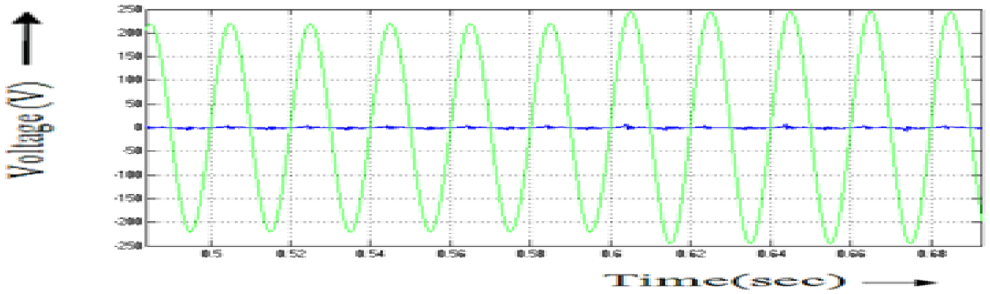

Figure 9. Input Voltage and Current of proposed system

The speed of the PMBLDC motor is controlled using Fuzzy controller and the speed curve shown in Figure 10 and 11. The change in the load current occurs at 0.7sec, but it immediately reaches the stable state in 0.8sec.

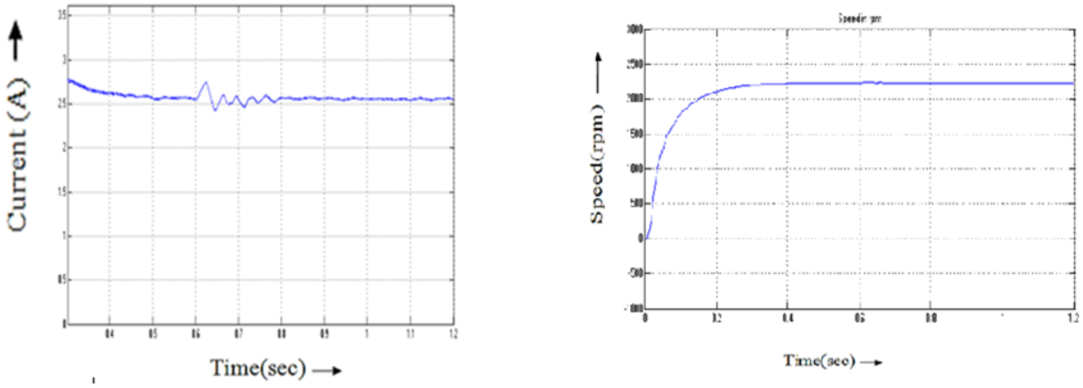

Figure 10. Output Current and speed of the PMBLDC motor with disturbance

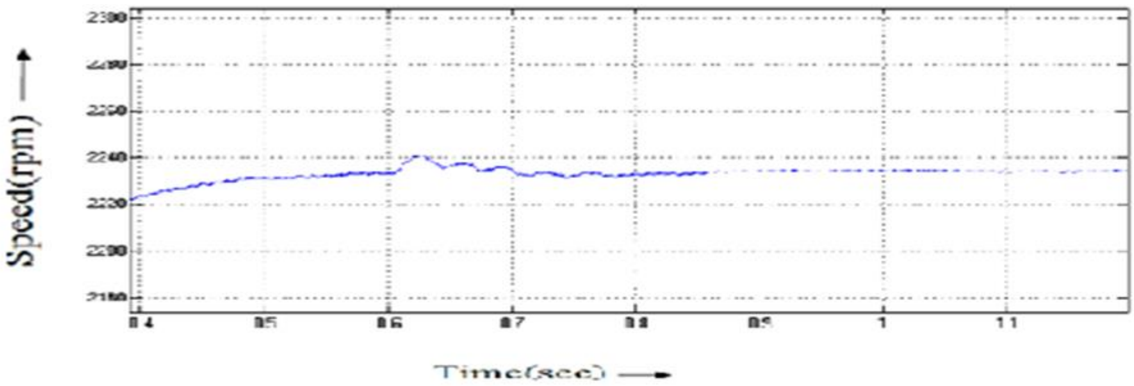

Figure 11. Output speed error of the PMBLDC motor with disturbance

Table 3. The Performance of Bridgeless SEPIC with FLC converter fed PMBLDC Motor

Parameters	Input voltage (v)	Input power factor	DC output voltage (v)	Speed (Rpm)	Input Current harmonic %THD	Load Current(A)
1	229	0.987	48	2430	10.2	2.7
2	225	0.984	48	2340	12.5	2.6
3	220	0.983	46	2230	10	2.6
4	210	0.976	46	2230	10.4	2.6
5	200	0.975	46	2229	10.6	2.6

4. CONCLUSION

In this paper, we have proposed a Fuzzy logic controller that include voltage and current controlling method for Bridgeless SEPIC converter fed PMBLDC motor. The fast dynamic response of the proposed system has proved that continuous conduction mode is good for load regulation. The speed of the BLDC motor did not get influenced during the parameters variation. The simulation results showed that, the design of the PFC Bridgeless SEPIC converter has enhanced the converter performance and also wide range of speed control is possible.

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