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Efficient figureconverter fed PMBLDC motor using artificial neural network

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ABSTRACT

In this paper, a new design of Bridgeless SEPIC (Single Ended Primary Inductance converter) with Artificial neural network (ANN) fed PMBLDC Motor drive is proposed to improve Power Factor. The proposed converter has single switching device of MOSFET, so the switching losses is reduced.ANN is used to achieve the higher power factor and fixed dc link voltage. Also the ANN methodology the time taken for computation is less since there is no mathematical model. The output voltage depends on the switching frequency of the MOSFET. The BLSEPIC act as a buck operation in continuous conduction mode. Detailed converter analysis, equivalent circuit and closed-loop analysis are presented for 36V, 120W, 1500rpm BLDC Motor drive. This proposed converter produces low conduction loss, low total harmonic reduction, low settling time and high power factor reaching near-unity. All the simulation work is verified with MATLAB – Simulink.

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1. INTRODUCTION

Power Quality of the AC system has become great challenge due to large increased in industrial. Power Quality like Power factor (PF), Total harmonic distortion(THD), Output voltage ripple are affected due to Power Electronic equipment [1, 2]. A PFC (Power Factor correction) converter places the input current in phase with input voltage waveforms. When Power Factor is 1.0, the input Current is perfectly in phase with the input Voltage [3, 4].

Brushless dc Motor are compact and energy saving machine with high efficiency. BLDC Motor used for various applications like pump, fan, electric vehicle, washing machine etc. The main advantage of BLDC motor is energy saver, less maintenance, greater speed range and better thermal efficiency.Single-Ended Primary Inductance Converter (SEPIC) AC-DC Rectifier has several advantages of step-up and step down capabilities. SEPIC converter has been operated in continuous conduction mode (CCM) has been proposed. The output of SEPIC converter is positive, hence this is recommended in applications such as battery chargers, fan, Air-conditioners, motor drive and home appliances [5-9].

Bridgeless PFC topologies are proposed topology can reduce conduction losses from rectifying bridges; thus, overall system efficiency can be increased. Unlike the boost, the SEPIC and bridgeless SEPIC converters have many several benefits in PFC applications, such as easier implementation of transformer isolation, input surge current limitation during startup and full-load conditions, lower input current ripple, and less electromagnetic interference [11-15].

More over Current Mode Control (CMC) architecture has been widely used for Power Factor correction. Based on different modulating schemes such as constant turn-on control method, constant-OFF time control method, average current control method, peak current control method and hysteresis current control method. In this paper proposed the average current controlling method. In this method very simple and high efficiency's CMC has been two feedback control. Outer is voltage control and inner loop is current control [16-10].

The Artificial neural network outputs the appropriate control signal for achieving the desired speed under variations in the motor load [17]. The ANN must learn the connection weight from available training pattern. Perform is improved over time by iterative updating the weight. In general, soft computing method can be used in all motor drive. In this modern technology, can increase performance and PMBLDC motor using ANN.

2. OPERATION OF THE BRIDGELESS SEPIC CONVERTER WITH ANN

2.1. Basic bridgeless SEPIC converter circuit

The basic single stage bridgeless SEPIC circuit is shown in Figure 1. In this system, there are two MOSFET switch replacing diode bridge rectifiers, which helps to reduce high conduction loss, but the controller circuit is complex to implement, and the size of the system too high.

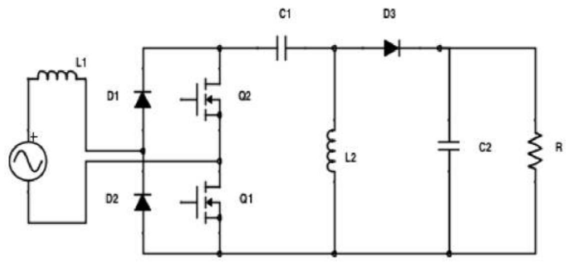

Figure 1. Basic bridgeless SEPIC circuit

2.2. Design calculation of bridgeless SEPIC converter circuit

The fundamental operation of the SEPIC converter is shown at the point when the switch S_1 is turned on, the inductance L_1 is charged; in the meantime the inductance L_2reads energy from the capacitance C_2. The output Capacitance Co supplies the load. At the point when the MOSFET switch S1 is turned off, L_1 charges C_1 and also supplies the current to load. L_2 is connected to the load.

Using the (1)-(6),the SEPIC Converter is designed for a constant link voltage V_{out}=36V, Vin=195V to 230V, I=3.5A, L1=L2=L=230mH, C1=171µF, C2=1000µF and fsw=20KHZ.

$$V_o= V_{in} * D / (1-D) \quad (1)$$

$$D= (1 + V_D) / (V_{in} + V_{out} + V_D) \quad (2)$$

$$L_1= L_2 = D * V_{in}/ \{fs (\Delta I\ L_1)\} \quad (3)$$

$$C_2 >= (I_{out} * D) / V_{ripple * 0.5}\ fs \quad (4)$$

$$\text{Voltage error} =V_{ref} - V_o \quad (5)$$

$$I_{ref} = V_{ref} - V_o) / r(t) * \sin\omega t \quad (6)$$

2.3. Proposed BRIDGELESS SEPIC converter modes operation

Figure 2 shows the Modes of Operation circuit diagram. In OFF state diagram for switch Q1, in which switch is off and the diode D1 is ON. Inductor L1charges the capacitance C2 and provides the load current. The Inductor Lois connected to load: it charges the output capacitance Co and provides the load current. Figure 6 shows the ON state diagram for switch Q1, in which switch Q1 is ON and the diode D1 is on. Inductor L1 charges the capacitor C 1 and provides the load current. The Inductor L2 is connected to the load: it charges the output capacitor Co and provides the load current.

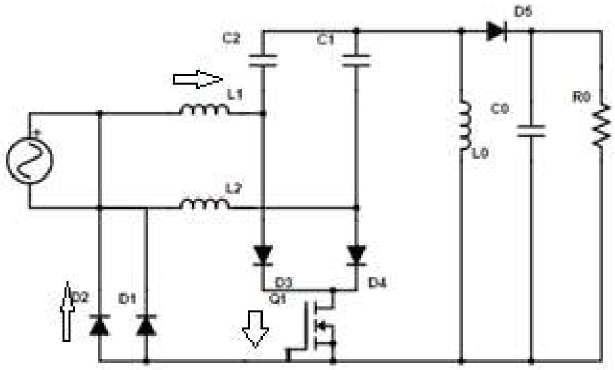

Figure 2. Modes of operation of bridgeless SEPIC circuit

2.4. Proposed BRIDGELESS SEPIC converter with ANN controller

Artificial Neural Network has very popular in many control application due to high computation rate and ability to handle the nonlinear load. In this proposed system with ANN controller used to control the speed of the BLDC motor. ANN system is reduced the steady state error and Peak overshoot. A trained neural network is required less computation time and memory. ANN has 3 layers, input layer, hidden layer and output layer. Inthis circuit diagram shown in Figure 3 and Modes of operation of bridgeless SEPIC circuit as shown in Figure 4.

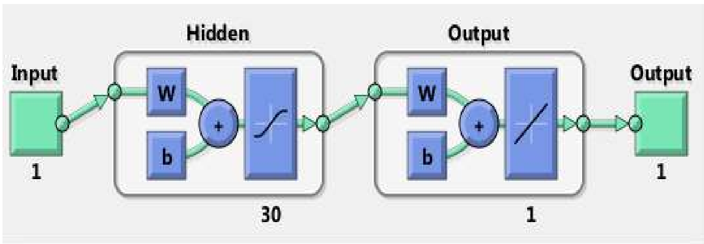

Figure 3. Input and output layer of ANN

Feed forward neural network is selected having 30 hidden layers, obtained by trial and error process. Tansig transfer function is used for hidden layers and by using back propagation method the network is trained using the data obtained.

$$A_i = \Sigma_{j=1}^{N} wijxj \; A_i = \Sigma_{j=1}^{N} wijxj \qquad (7)$$

where, ai is output of the neural network at node i; Wij is the weight between the nodes i and j; Xj are the states variables evaluated by activation functions.

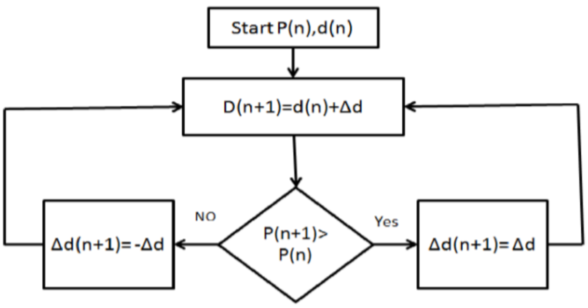

Figure 4. Modes of operation of bridgeless SEPIC circuit

3. OPERATION OF PROPOSED BRIDGELESS SEPIC CONVERTER FED BLDC MOTOR DRIVE

3.1. Block diagram of proposed system

The proposed topology consists of Bridgeless SEPIC Converter, ANN controller, reference current generator, PWM generator, filter, zero crossing detectors, VSI and the BLDC motor. The block diagram is given below Figure 5.

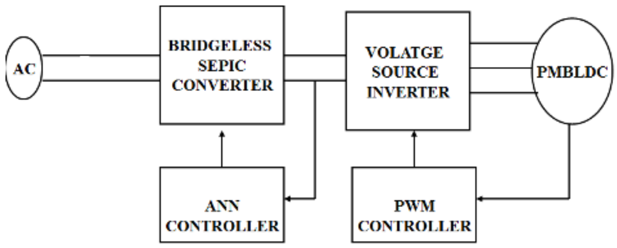

Figure 5. Block diagram of proposed system

3.2. Sumulation circuit diagram for proposed system

The Proposed System Bridgeless SEPIC with ANN circuit is shown in Figure 6. In this proposed system, there is single MOSFET switch replacing the two MOSFETs, which helps to reduce high conduction loss and reduce the size of the converter. In this proposed to reduce the complexity of controller circuit. Theclosed loop of Bridgeless SEPIC converter circuit shown in Figure 7. In this system has two loop control method. One is outer layer (voltage control) and another one is inner layer (current control). Voltage control is used to control the output voltage disturbance.

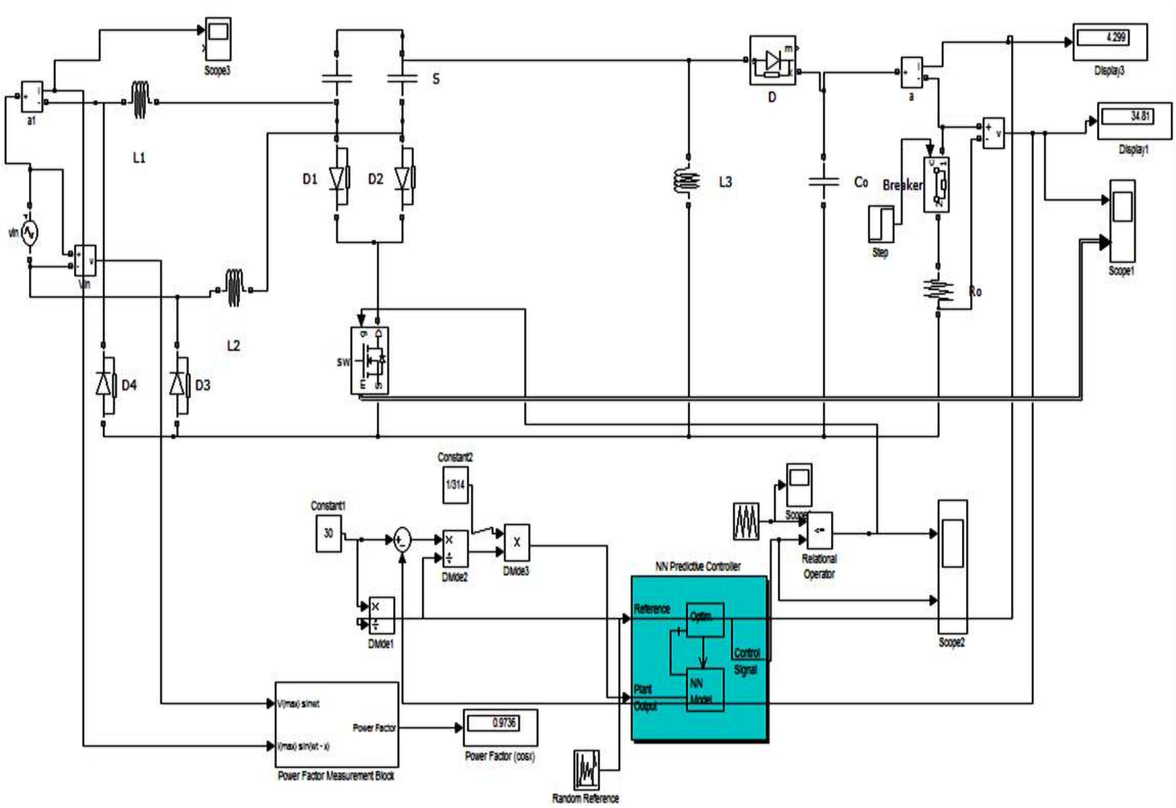

Figure 6. Proposed system bridgeless SEPIC with ANN circuit

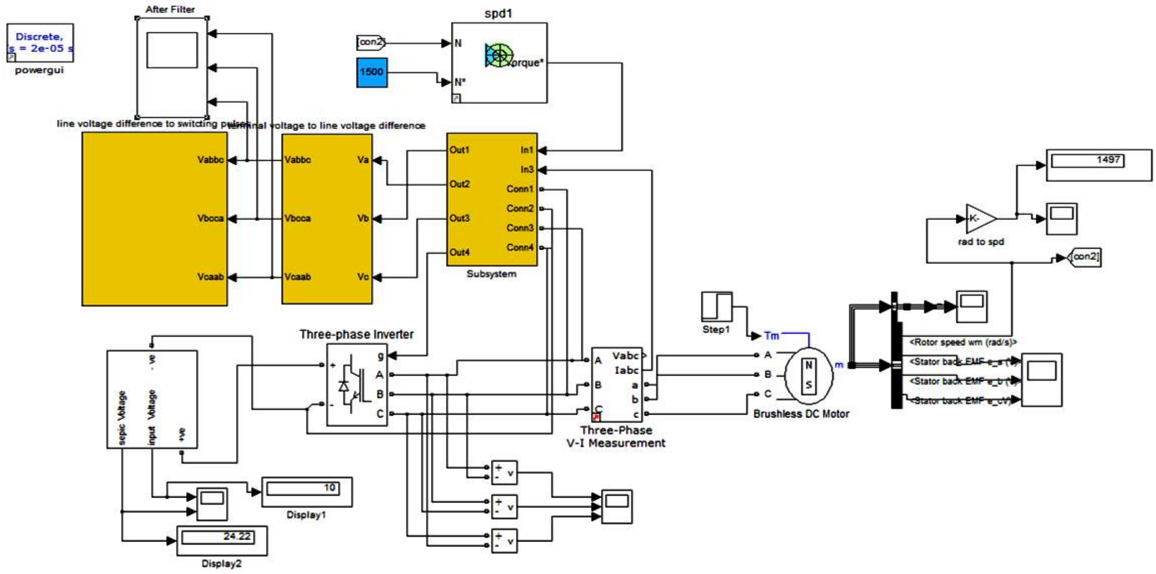

Figure 7. Proposed system bridgeless SEPIC fed PMBLDC motor

3.3. Bridgeless SEPIC with PMBLDC motor output wave form

Output wave form of Bridgeless SEPIC fed BLDC motor converter is shown in Figure 8. Output voltage ripple =0.3V current ripple = 0.3A and the Power Factor = 0.978with PMLDC motor drive. If change in the load occurs in 0.5msec at that time response shown in Figure 9 and also shown the input Current ant Voltage waveform in Figure 10. The Speed control of BLDC Motor shown in Figure 11.

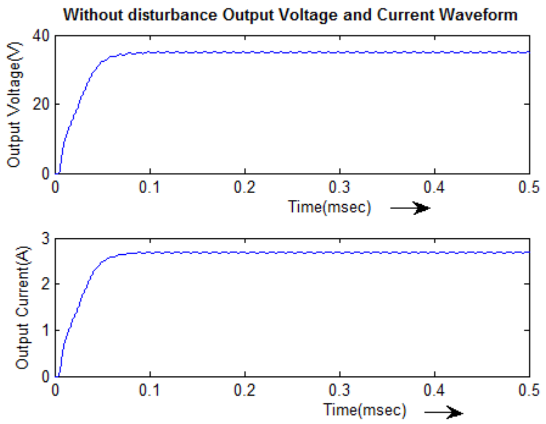

Figure 8. Output voltage and current waveform of BRIDGELESS SEPIC converter without disturbance

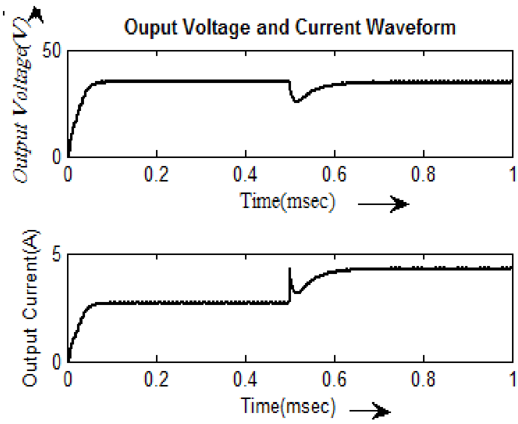

Figure 9. Output voltage and current waveform of BRIDGELESS SEPIC converter with disturbance

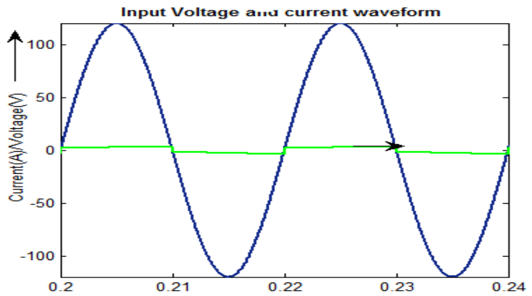

Figure 10. Input voltage and current waveform of BRIDGELESS SEPIC with ANN

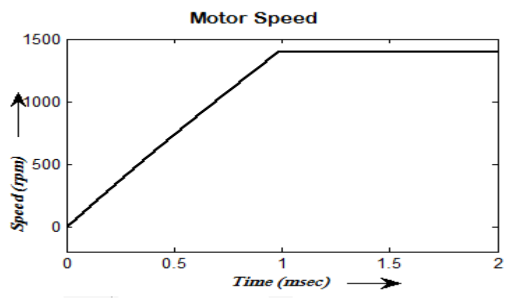

Figure 11. Speed of PMBLDC motor

3.4. Reading of proposed bridgeless SEPIC system

The proposed system is simulated using MATLAB / Simulink. The input voltage is changed from 195V to 230V (normal supply voltage) and the power factor, output voltage, output current and speed of the motor readings are taken and tabulated in Table 1. The tabulated values are clearly showing, the power factor is maintained near-unity with less voltage and current ripple using bridgeless SEPIC Converter with ANN.

Table 1. Reading of conveter parameter with varioous input voltage

Input Voltage (V)	Output Voltage(v)	Power Factor	Output Current(A)	Speed(rpm)
230V	35.5V	0.975	2.7A	1400
225V	35.4V	0.986	2.6A	1399
220V	35.2V	0.984	2.6A	1399
215V	35V	0.983	2.6A	1398
210V	35V	0.98	2.5A	1398
205V	34.9V	0.975	2.5A	1397
200V	34.9V	0.973	2.55A	1397
195V	34.8V	0.972	2.45A	1397
190V	34.8V	0.97	2.45A	1397

3.5. Comparative analysis of various converters

Comparative analysis of various converters refer Table 2. In this proposed Artificial Neural Network system has very fast responses compared with other controlling methods. The settling time of the system has 0.4msec.

Table 2. Comparison of PFC converter with various topologies

	SEPIC	Bridgeless SEPIC(ANN)
No. of switches	1	2
No. of components	Medium	Less
Power Factor	0.925	0.975
THD	35.2%	17.36%
Current Ripple	0.5A	0.3A
Voltage Ripple	3V	0.3V
Cost	Medium	Less
settling time	2	0.4msec

4. CONCLUSION

In this paper, single stage Bridgeless SEPIC converter with Artificial neural network controller fed PMBLDC Motor has been proposed and verified with MATLAB Simulink and the results are compared with traditional SEPIC fed BLDC Motor. The main advantage of the Bridgeless SEPIC with ANN Converter is provides, power factor reaching near-unity with low Voltage stress, low Total Harmonic Distortion and low settling time under input voltage variations and load variation. The study is also proving that, the proposed circuit would be more suitable for low power applications.

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