Performance and analysis of Sepic and Non-isolated DC- DC Converter using Fuzzy controller fed PMDC motor

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Abstract: *This paper presents the comparison of the controller in Sepic converter and Non-isolated Converter to decrease the ripple content, switching losses, conducting losses and enhanced the efficiency. Fuzzy logic (FL) control is recognized to be non-mathematical and flexible in nature that provides faster and more reliable performance under varying parameters and load disturbance, determining the member function. The output voltage is obtained at constant PWM generation from the fuzzy logic controller with Non-isolated and Sepic converter. These are simulated, fabricated and tested with R-load and Motor load. Closed loop system is also simulated. The hardware results with the simulation results are verified. The efficiency of the proposed Sepic converter is improved from 94% to 97.1%*

Keywords: Fuzzy controller, Sepic converter, Non-isolated Converter, PMDC motor, Microcontroller, Bidirectional DC-DC Converter and Voltage multiplier

1. INTRODUCTION

The progress of high voltage Sepic and Non-isolated Converters are significant investigation domain, which are due to the high demand of the technology for several applications provided by small power sources [1-2].Specific illustrations are non-conventional energy sources as small power photovoltaic (PV) modules and further applied as fuel-cells, Miniature D.C Motor and hospital equipment, uninterruptible power supply and battery powered equipment. Many factors are using fuzzy logic in these two converters, the main advantage being the adaptability offered by fuzzy logic. The strength of any FLC (Fuzzy Logic Controller) lies in a set of fuzzy rule. In conventional DC-DC converter, topologies play a vital role in the system. They guarantee the input of maximum power to the system with a minimum loss of energy in the circuits [3-5]. These two DC-DC converters produce some quantity of ripples, which are minimized by the use of filters at the output terminals. To maintain desired output voltage, effective cost expense and lifetime of the filter, Sepic converter and Non-isolated Converter are used. DC-DC converters are commonly used as low voltage and high voltage side between the voltage sources and the load. The proposed converter application can be applied in the solar power generation, in grid-connected systems using the Converter structure [6-10].

It was designed a bidirectional converter that can operate with a continuous inductor current, fixed switching frequency and switch stress of usual DC-DC converter which improves the efficiency of filter, regardless of the direction of power flow. Fuzzy logic controller can understand the dynamic characteristics of these two DC-DC Converters. This application of a fuzzy logic controller in DC-DC converter control is also observed in this work [11-17].

It fabricated a dual Non-isolated DC- DC Converter topology, which is improved to make the essential power rating using the required number of devices. Zero-voltage technic is applied in all switches, which is achieved in the bidirectional power flow with either a voltage clamping circuit or extra switching devices and quasi-resonant components. All these advantages are is allowed in high power rating, efficient power conversion, minimum component and condensed packaging [18-20].

In six basic zero-voltage transition PWM, converters like buck, boost, buck-boost, cuk, Sepic and zeta are described. The size of the Non-isolated Converter bidirectional DC-DC converter, minimize the number of devices switches and inductors The circuit uses a transformer based energy inductor magnetic coupling and also combines the output of these techniques as the integration of circuit to recover the energy captured in the snubber capacitors. [21-23]. It also covers the proposed inductor magnetic coupling, as a non-isolated converter as there is no such power transformer. It is easy to apply the soft switching in isolated bidirectional converter, as they tend to base on the conventional half bridge and full bridge structures [24-25]. This maximizes the use of inductor energy stored in the main power transformer to discharge the capacitance among the converter switches. The above literature does not

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deal with the comparison of closed loop controlled converter, comparison of Non-Isolated Converter and Sepic converter in the open loop. This work deals with the comparison of fuzzy controller, converters, identification of the best convertor topology and hardware implementation. The conventional Non-Isolated Converter and enhance all the performance features of Sepic converter which is used for the same power and it also operate in high voltage operation. It is utilized in the renewable energy sources [25-27].

2. SEPIC AND NON-ISOLATED CONVERTER

Sepic converter with π filters is shown in Figure 2.1. DC-DC converters are widely used in hospitals and in battery charging and discharging systems. This Sepic converter has two parts inclusive of main diode and main capacitor. This capacitor is charged to achieve high step up output voltage. Sepic converter operated in the C_S capacitor is inverted to achieve high voltage. It is used in high voltage operation. Zero voltage switching technique is applied in all the switches. The switch voltage is summation of the input voltage and output voltage.

Figure.2.1 Modified Sepic converter with π filter fed DC motor

The operation based on the boost converter with magnetic coupling and the voltage multiplier cell is used in the circuit to get high voltage gain and an improved efficiency as shown in the Output. Though the magnetic coupling is achieved with the input inductor in the boost mode operation, the input current ripple increases and relies on the inductor winding turn's ratio Non-isolated DC-DC Converter is shown in Figure 2.2. The circuit has two main switches, auxiliary switches, three inductors, π filter and DC motor. The two main switches are operated alternatively. Switch S1 functions like a boost mode switch and S2 functions like a buck mode [1].Current flows through the Inductor Lin in both directions at each switching cycle. The four components such as auxiliary switches S_a, capacitor Cr and inductor Lr1 and Lr2 make up a simple circuit that is based on well-established active clamp technology.

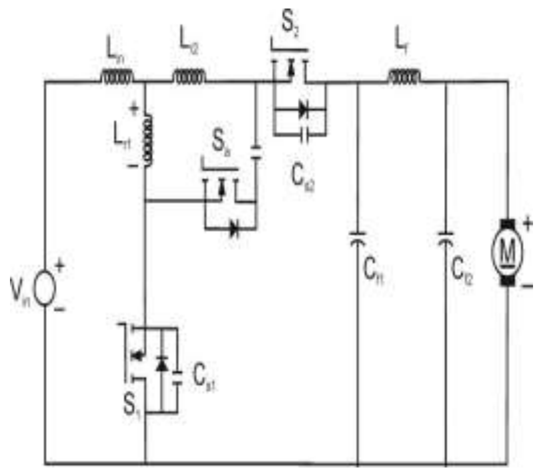

Figure 2.2 Non-isolated DC-DC converter fed PMDC motor

Non-isolated bidirectional converter is used for charging and discharging, depending on the operating condition. This converter can be used in either buck or boost mode [2]. The proposed non- isolated bidirectional converter is compared at the load side of C, LC and π filter, to produce the ripple content of each filter. The control requirements are normally needed to reduce the steady state error, settling time and allowable transient overshoots. Switching frequency reduces the switching losses [7]. When PWM is operated at constant frequency, the current stress is not observed in the main switch and so, there is no additional conduction loss. The zero voltage switching approach is applied in most of the semiconductor devices such as MOSFETS, and applied as an input.

3. FUZZY LOGIC CONTROL OF SEPIC AND NON-ISOLATEDCONVERTER

Fuzzy logic controller, which is needed for a good closed loop operation. It is operated in non-linear and adaptive in nature. Generally, the main use of these switches are non-linear and time varying in nature of the power converter. The output voltage is detected and matched with the reference voltage. The error signal is applied to a fuzzy logic controller. The output of the fuzzy logic controller is given to the MOSFET. The steady state error signal is reduced by properly tuning the fuzzy logic controller. Mamdani's technique is applied in the fuzzy logic controller circuit and simulated by

MATLAB and the results are presented. It has two inputs and an output is divided into seven fuzzy subsets that consist of Negative value of Big (NB), Medium (NM), Small (NS), Zero (ZE), Positive value of Small (PS), Medium (PM) and Big (PB). The MF (Member Function) is the conventional saw tooth shape with 50% overlap. The proposed fuzzy logic controller is dividing of fuzzy subsets and the shapes of MFs are shown in Figure 3.1. In various situations, for the above system whose output is fuzzy [3]. It is easier to take a hard decision if the output is represented as a numerical value. The rules are proposed to pass the value to the optimal PWM (Pulse Width Modulation) angles generator [9]. Each rule has spontaneous interpretation, and if the error signal is positively big and the change in error signal is zero, then the change in control action is positive big.

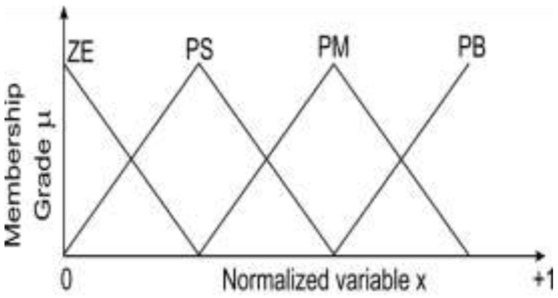

Figure 3.1Triangular shaped membership function

For comparison, different operating points covering the entire operating range of the converter have been selected. Mamdani's technique is applied in the fuzzy logic controller circuit. There are two inputs to the Mamdani's technique, which have been applied in the fuzzy logic controller. The resulting functionality is determined by the selection of inputs and definition of the fuzzy rule base [3]. This permits the system to be analyzed under varying control strategies and specifications using desirable hardware. The three sections have to be modified: the two are interfacing blocks, and the other is rule based. In this analysis, the output D.C. voltage of the rectifier is used as an input to the fuzzy logic controller [15].

The n Rule based (RB) is the primary criteria to be changed if the result is totally unparalleled with the control objective due to wrong sign in the output or the input. The minimum membership value is constant in every K^{th} fired rule which propagates through the consequent and truncates the membership functions for the corresponding consequent using min – operator. The closed loop system of Sepic converter consists of comparator and controller as shown in Figure 3.2.

Figure 3.2 Modified SEPIC converter with Fuzzy controller

4. SIMULATION RESULTS

This work designs a fuzzy controller, which can simulate various states of time Response, The most broadly used technique of analysis, and the fuzzy controller is through simulation. In this work, the fuzzy system is designed, analysed and simulated in several states as transient state response and steady state error. Fuzzy logic (FL) control is recognized to be nonlinear and adaptive in environment, which provides a quicker, and a more healthy performance below parameter dissimilarities and load disturbance, determining the member function. The output voltage is obtained at perpetual PWM generation from the fuzzy logic controller with Sepic converter [12].

The Sepic converter output voltage is 64Vin the closed loop system of fuzzy controller, which is shown in Figure 4.1. The output current increases but there is less ripple content in the fuzzy controller. Figure 4.2 shows a change in line current and load current of the converter to maintain constant current of 0.25A Figure 4.3 shows that the Sepic DC-DC Converter runs at the speed of 1200 rpm. At that time with the help of π filter, the ripple is reduced. The output voltage is 50V with the usage of fuzzy controller in Non-isolated Converter as shown in Figure 4.4. Output current with π filter is 1A as shown in Figure 4.5. There is a change in line current and load current of the converter to maintain constant current of 0.74A as seen in Figure 4.6,

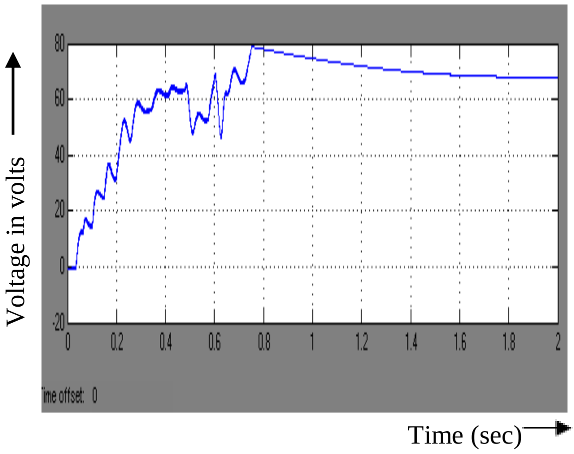

Figure 4.1 Output voltage of fuzzy controller in Sepic converter

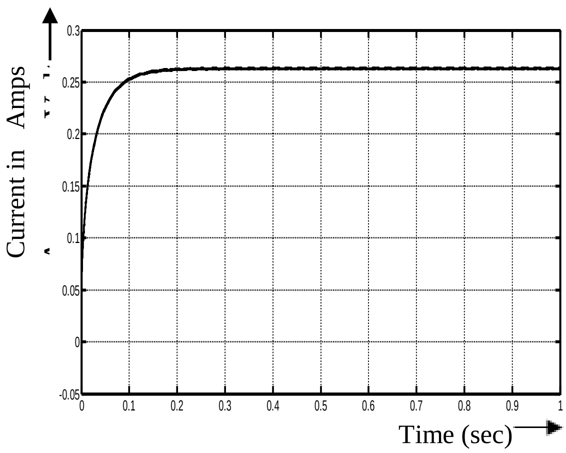

Figure 4.2 Output current (Input-12V)

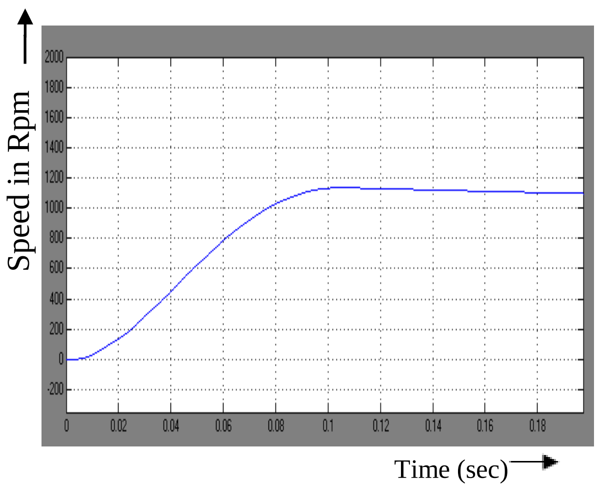

Figure 4.3 Armature speed in Sepic converter

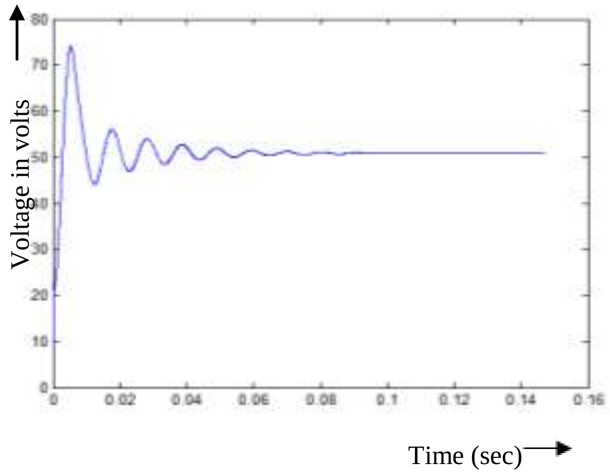

Figure 4.4 Output voltages with fuzzy controller in Non-isolated DC- DC Converter

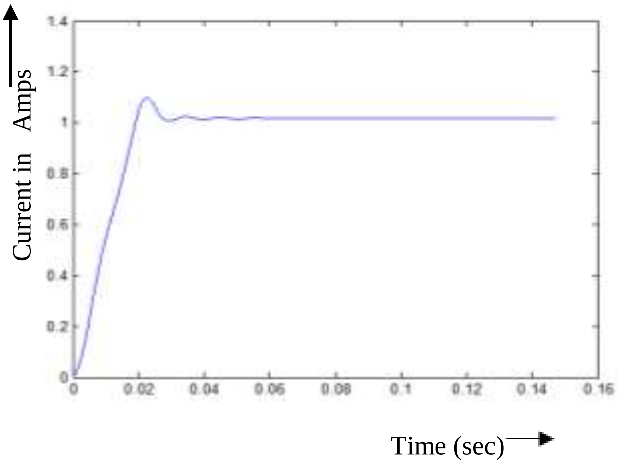

Figure 4.5 Output current with fuzzy controller in Non-isolated DC- DC Converter

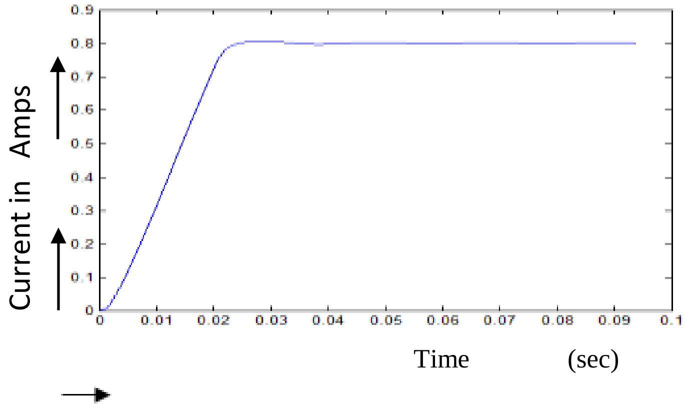

Figure 4.6 step change in current in Non-isolated DC- DC Converter

5 HARDWARE RESULTS

This IC chip is a low voltage, high Enhancement of microcontroller through 2K bytes flash programmable and volatile memory.

Table 1 variation of efficiency with 12V input with PMDC motor

Type	Efficiency	Speed(rpm)	Ripple (V)	Torque (Nm)
Conventional Sepic converter	94.4	1270	0.000275	1.5
Pi controller	96.3	1280	0.006050	1.8
Fuzzy Controller,Non Isolated converter	94.2	1290	0.006051	1.6
Fuzzy Controller,Sepic converter	97.1	1300	0.00032	1.9

Microcontroller is industrial by using ATMEL great-thickness non-volatile memory and is well matched through the production standard Trademark of 8-bit microcontroller instruction set. The microcontroller has the versatile feature of 8-bit CPU with flash on a solid Silicon chip [23]. The converter has designed the motor depending upon the duration of the dynamic operation with PMDC motor has allowed to carry out 2 to 3.5 times of the rated current the maximum permissible value of the torque is in Pi controller is 1.8 Nm to allow the motor torque capability for both the operation and braking.

Table 2: Performance Indices of NON-ISOLATED converter with 50 % Duty cycle: (SIMULATION MODE)

Input voltage (v)	Output voltage (v)	Output power (w)	Input powe r(w)	Efficiency (%)
12	50	58.52	55.32	93.04
13	54.8	68.8	64.98	93.25
14	55.3	79.62	75.44	93.52
15	56.1	91.73	86.71	93.58

Table.3 variation of ripple factor with different filters in Sepic converter (Input-12V)

Filters	Ripple factors	Input Power (W)	Output Power (W)	Efficiency (%)
Π	0.000275	58.77	56.11	93.04
LC	0.006050	59.38	53.13	93.25
RC	0.006051	59.31	53.14	93.52
L	0.00032	58.70	56.07	93.58

Table 4. Hardware Specification

Component	**Specification**
Microcontroller	AT89C2051,2.7VTO 6V,0hzTO 24Mhz
Crystal Oscillator	11.052Mhz
Diode	IN4007,0to 800V
Driver IC	IR2110,+500Vor+60 0V
Regulator	LM7805,LM7812,5to 24V
MOSFETM1,M3	IRF840,10A,10to500 V
MOSFETM2,M4	IRF210
Inductor	L1- 5 mH
Inductor	Lf - 15 H
Capacitor	Cf - 14.7 μf
Resistor	R – 100Ω
Minature Motor	Miniature motor Model 842,V=220V, A=2A and power 96W
Rated power	96w
Rated torque	0.5Nm
Rated speed	1500 r.p.m
Number of pole-pairs	4
Transformer	High ferrite core EDT 34

Voltage in volts

X-axis 1unit=18μsec, y-axis 1unit=20V

Figure 5.2 Output voltages in boost mode with motor load in Sepic converter

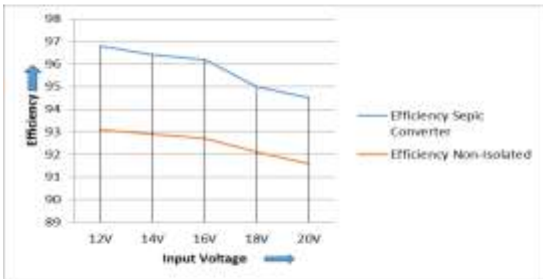

Figure 5.3 Input voltage versus %Efficiency

Table 6 Performance of Sepic and Non-isolated DC- DC Converter in fuzzy controller

Controller	Startup transient					
	Dead time (μ s)	Rise time (sec)	Peak time (sec)	Peak over shoot (%)	Settling time (sec)	Steady state ripple (V)
Fuzzy controller Sepic	0.71	0.002	0.0035	0.332	0.004	0.0555
Fuzzy Controller Non-isolated DC-DC Converter	0.82	5.57	6.1	1.10	1.089	0,0055

Technique	Line Disturbance		Load Disturbance	
Controller	Settling time (sec)	Steady state ripple (V)	Settling Time (msec)	Steady state ripple (V)
Fuzzy controller Sepic	0.042	0,055	0.052	0.0555
Fuzzy Controller Non-isolated DC- DC Converter	1.0154	1.085	0.041	0.088

Acknowledgement: This research development was supported by Adhiparasakthi Engineering College, Melmaruvathur

7. CONCLUSIONS

The performance of the Sepic and Non-isolated converter in open loop, with π-filter in the output side is superior to C and LC filters. Closed loop response is compared with fuzzy controller. Sepic converter and the Non-isolated Converter are simulated and analyzed. The best among the converters is Sepic converter, since it produces high output voltage with reduced ripple content and is also very quick to reach the steady state. Regulation of output voltage is demonstrated using closed loop of fuzzy controllers. Bidirectional power flow control, conversion capability, electrical isolation between the two sides through a transformer is evaluated for medium and high power applications. Simulation results match with the experimental results, thus representing an improved converter aimed at household and industrial applications. The circuit uses fuzzy controller to preserve a constant output voltage with various values of the input voltage. Experimental results of Sepic converter and Non-isolated Converter closely agree with the model results. PMDC motor can operate with torque for various converters among them fuzzy controller with sepic converter is best suited. The efficiency of the sepic converter increased from 94% to 97.1%

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