COMPARE THE PERFORMANCE OF CONTROLLERS IN NON-ISOLATED D.C TO D.C. CONVERTERS FOR DC MOTOR

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ABSTRACT

This paper compares controllers in non-Isolated d.c. – d.c. converter. To maintain a constant voltage is not possible in open loop. To achieve with the help of PI, neural and fuzzy controller. This paper shows three methods neural is the best among the other two. Neural network is giving more output voltage with free from ripple content. This circuit is operating without transformer, to reduce the size, space, weight cost and free from ripple. It is used in charging and discharging in buck mode, speed control of d.c. motor, UPS d.c. servo motor, telecom aircraft and automobiles. The open loop circuit is analyzed with all the passive filters. This circuit is different from other existing d.c.-d.c. step-up converters and possess many advantages including high output voltage with reduced ripple and wide range of control. The open loop is implemented with hardware and simulation results are verified. The performance evaluation of the controllers is tabulated.

Key words: Soft switching, microcontrollers, bidirectional dc-dc convertors, non isolated d.c.-d.c. converters, fuzzy logic controller, PI controller, Neural network controller, Boost converter.

I. INTRODUCTION

The standard non isolated bidirectional d.c.-d.c. converters are available without any passive filter [1]. The conventional controller requires two sensors with complex control algorithm. This paper closed loop circuit to provide only one sensor [2]. In the field of power electronics introduced the high frequency operating switching devices. Nowadays, this circuit is widely used in High voltage and extra voltage application. But in conventional circuit is not Economical and more reliable [3]. The proposed non isolated bidirectional d.c.-d.c. converter is compare at the load side of C, LC and π filter to produce the ripple content of each filter. In half bridge bidirectional d.c.-d.c. converter using Neural Network in dynamic response can be improved they are low switching stress; reduced component performance is excellent [4]. The back propagation is a multilayer feed forward network. The artificial neural network (ANN) algorithm trained with one input layer, five hidden layers and one output layer with standard purelin, Tansigmoid activation function [5]. This technique is adopted this paper to improve the dynamic response. The control requirements are normally needed to reduce the steady state error, settling time and allowable transient overshoots [6]. Fuzzy logic control are known to be non linear and adaptive in nature which gives faster response. This paper is utilized triangular shaped member functions in the range from – 1 to 1, but now this paper is utilized the range from 0 to 1 in triangular shape function [7]. Switching frequency is reduced the switching losses. Passive lossless soft switching is applied in all the switches [8-9]. Minimum Voltage and current stress in the zero voltage switching at turn ON and turn OFF period [10]. PWM operating at constant frequency there is no current stress on the main switch, so there is no additional conduction loss is not occurred [11]. The ZVS approach is applied in majority of semiconductor devices such as MOSFETS when being implemented as the input inverters [12]. To reduce the switching losses and increase the bidirectional energy conversion flexibly [13].

II. OPERATING PRINCIPLE

The non isolated Bidirectional d.c.-d.c. converter in standard circuit is very simple to boost the voltage (S1) and buck the voltage (S2). Two switches (S1, S2) can be used alternatively to reduce the switching losses as compared to the isolated d.c.-d.c. converter. Fig. 2 Proposed non isolated d.c.-d.c. converter With π - filter for dc Motor. The open loop system is applied with ripple input to provide the passive filter (L, LC, π - filter) on the load side. To calculate with the help of simulation which filter circuit is superior among other

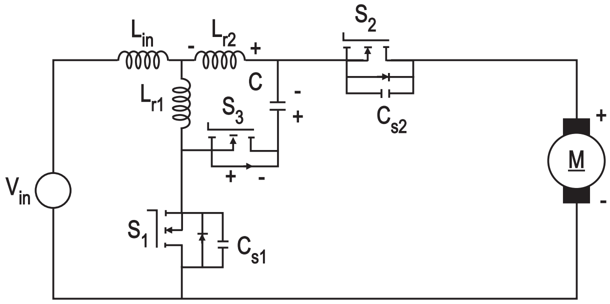


Fig. 1. Conventional non isolated d.c.-d.c. converter for dc Motor.

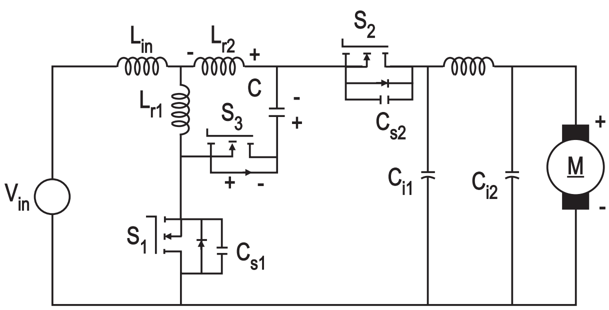


Fig. 2. Proposed non isolated d.c.-d.c. converter with π - filter for dc Motor.

filter. To review the best one is π - filter. To reduce more ripple content as compared to the other filter circuit is shown in Table 1. The input voltage is 12 V to produce the output is 24 v. Fig. 1 Conventional non isolated d.c.-d.c. converter for dc Motor.

Table 1.
Comparison of passive filter in Non isolated dc-dc converter

	π - filter	C - filter	LC - filter
Output Voltage	24.01 V	23.87 V	21.459 V
Ripple value	0.016 V	0.12 V	0.16 V

Table 2.
Performance of Boost converter efficiency

Input Voltage	Output Voltage	Efficiency
20	46.54	84.82%
24	54.43	85.20%
28	62.32	86.43%
32	88.65	89.95%

Table 3.
Performance of Buck converter efficiency

Input Voltage	Output voltage	Efficiency
40	9.36	84.24%
44	10.39	83.87%
48	11.3	82.51%
52	12.42	82.66%

III. TECHNIQUES ADOPTED

PI CONTROLLER

PI Controller is used for the closed loop control scheme for the standard non-isolated dc-dc converter. The control scheme is essentially consisting of only one voltage sensor with simple control structure when compared with conventional dc-dc boost converter which requires both voltage and current sensors. When the irrespective of the voltage is applied to the input. The output voltage is maintained constant. The output voltage is feedback and compared with Vdc reference voltage and the error is given to the PI (proportional integral) controller to stabilize the error and the signal is obtained from the controller is the modulating signal for the PWM scheme. Signal from the PI controller is compared with high frequency ramp signal to produce required pulse for the Mosfet Switch to obtain the reference DC voltage at the output side. The set value is fixed at constant voltage. In this paper for the above method of the converter [2]. Using the ziegler Nichols method –II is applied to design the PI Controller. Step input is applied to the method. The transfer function of a PI controller is often written in this form:

$$G_{pi}(S) = K_p + K_i/S \quad ...(1)$$

Step 1: Set $K_i = 0$. Increase K_p in steps until the closed loop response reaches a state of sustained oscillations. Mark this so called ultimate gain denoted as K_{pu} or K_{cr}. Measure the corresponding period of oscillation at the output, call it T_u or P_{cr}.

Step 2: Now set the parameters of the controller in accordance with Ziegler Nichols tuning criterion.

PI Controller : $K_p = 0.45 \times K_{cr} K_i = P_{cr} \times 1/1.2$ ...(2)

$T_u = P_{cr} =$ Ultimate period or Critical period

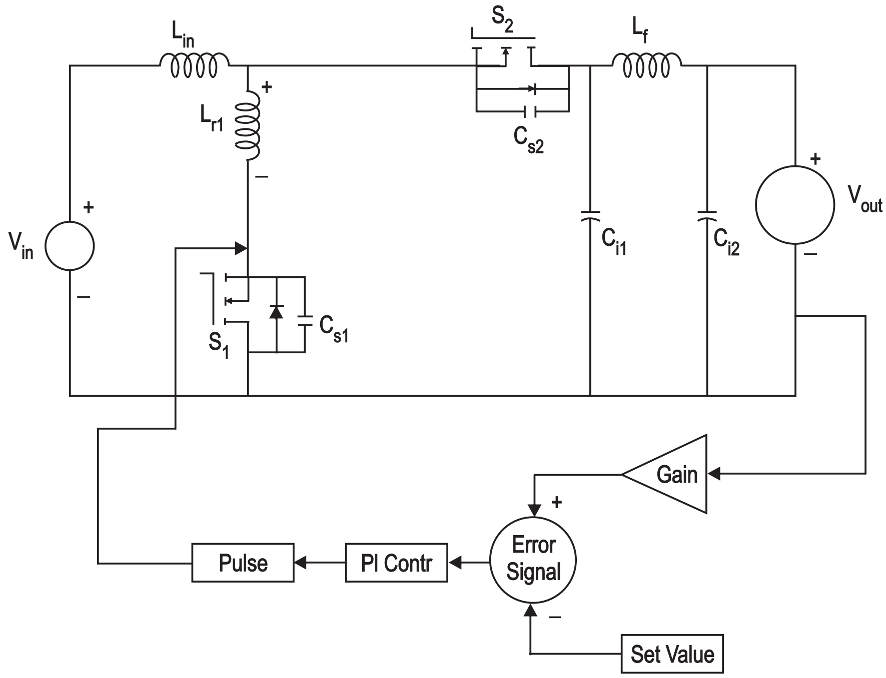


Fig. 3. Closed loop control of PI controller

$K_{pu} = K_{cr} =$ Ultimate gain or Critical gain

The performance of this non-Isolated dc-dc converter is superior to conventional (Isolated) dc-dc with the following advantages.

1. It performs similar to conventional dc-dc boost converter with comparatively high voltage without transformer.
2. Wide range of control, reduce the errors, more gain with smooth ripple at the output voltage is an added advantage of this converter.
3. High power density with high efficiency is compared to conventional (Isolated) converter.
4. Closed loop controller requires only one sensor.

(B) NEURAL NETWORK ALGORITHM (CONTROLLER OF NON ISOLATED DC-DC CONVERTER)

Neural networks with the abilities of real-time learning, parallel computation and self organizing make pattern classification more suitable to handle complex classification problems through their learning and generalization abilities. An artificial neural – network (ANN) based predictor was used along with a state predictor to greatly improve the performance of the rectifier regulator and shows a typical result where the impact of the prediction schemes on the dc bus voltage ripple is obvious. The feed – forward ANN was trained on line using standard back propagation as compared to most of the application of the feed forwarded neural nets where training is performed off line using pre – stored data. In general, each line training speech consists of propagating the ANN input vector to compute its output, compare the output with some reference to compute the training error, and finally modifying the ANN weights in such a way to reduce the magnitude of this error to obtain the optimum value similar training is done with all the patterns so that matching occurs for all the functions. This paper proposes and investigates the fast on – line training back propagation algorithm for feed – forward ANN.

Back propagation

Back propagation which is the most popular training method for a multilayer feed forward network is shown in fig. 4. The ANN with back propagation algorithm is trained with fifty thousand data for both voltage controllers. The topology is trained with one input layer, five hidden layer and one output layer with standard purelin tansigmoid activation function. In fig. 3.(a) the error data are set as PI sectors where m is the number of iterations. The vector V_j^{m-1} is the hidden layer activation function for the desired output. The input to the ANN is the error and the output is the desired proportional gain K_p and integral gain K_i for firing the dc line voltage. The training data for the neural controllers are derived from the appropriate PI controller gain valves for a typical load condition. The following steps are used for tuning the parameters of the controller using BP algorithms.

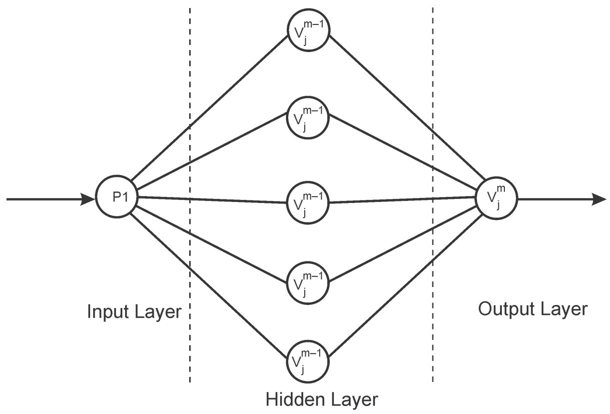


Fig. 4. Back propagation Network

1. Initially all the weights are set to small random value.

2. Present and input vector P and q desired output O and apply I to the input layer $(m = 0)$ so that $V_0 = 1$.

3. For other layers, namely $m = 1 \ldots M$ forward computation is performed using the equation (3).

$$V_i^m = f\left[\sum_i w_{ij}^m \; V_i^{m-1}\right] \quad \text{...(3)}$$

Where $w_{ij}^m \, V_i^{m-1}$ represent the connection weight from V_m^{m-1} to V_i^m

The error is updated making use of the equation (4) and fed to the output layer.

$$\delta_i^{(m)} = V_i^m (1 - V_i^m)(O_i - V_i^m) \quad \text{...(4)}$$

4. Then back propagation (BP) errors for the preceding layers $M - 1 \ldots I$ are calculated using the equation (5)

$$\delta_i^{(m-1)} = V_i^{m-1}(1 - V_i^{m-1}) \sum_j w_{ji}^m \, \delta_j^m \quad \text{...(5)}$$

5. Finally all the weights are adjusted for next iteration and is given by the equation (6)

$$w_{ij}^m (t+1) = w_{ij}^m (t) + \eta \, \delta_i^m \, V_j^{m-1} \quad \text{... (6)}$$

Where η is a gain parameter.

6. Repeat and go to step it until the desired epoch is achieved.

The load model is specified both linear condition. This model is easy to build and to simulate its performance is good. We build such a controller with an idealized load – current reference using the software tool matlab. In half bridge bidirectional dc – dc converter using Neural network control to claim the low stress on switches, Galvanic Isolation and reduced component count in dynamic behavior can be overcome this paper.

(C) FUZZY CONTROLLER

This paper designs a fuzzy controller and compares its performance at various operating points with local PI controller design and neural network controller for the operating point. The setting time, rise time, dead time, peak over shoot and steady state ripple. The most widely used method of testing a fuzzy controller design is by simulation. In this work the fuzzy system designs, analysis and simulation in various states such as transient state response and steady state error. Corresponding to each control goal. Fuzzy logic (FL) control are known to be nonlinear and adaptive in nature which gives its faster and more robust performance under parameter variations and load disturbance determining the member function, each universe of discourse for two inputs and an output is divided into seven fuzzy subsets that consists of Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (ZE), Positive Small (PS), Positive Medium (PM) and Positive Big (PB). The MFS (member function) are the classical triangular shape with 50% overlap. It is conventional. The proposed fuzzy logic controller is partition of fuzzy subsets and the shapes of MFs are shown in fig. 5. A set of rules is proposed to pass the valve to the optimal PWM (pulse width modulation) angles generator. Each rule has an intuitive interpretation. If the error signal is positive big (PB) and the change in error signal is zero (ZE) then the change in control action, do would be Positive Big (PB). General Guidelines from Fuzzy Control Rules.

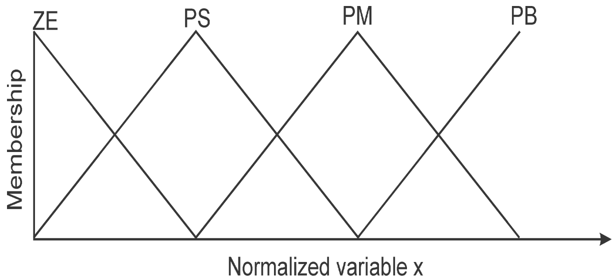


Fig. 5. Normalised Membership Function

Table 4. Knowledge base rules

Reference Points	Rules		Do	Notation
	e	*ce*		
*a*1, *a*2	*P*	*ZE*	*P*	(*P*, *ZE*, *P*)
(*b*1, *b*2)	*ZE*	*P*	*P*	(*ZE*, *P*, *P*)
(*c*1, *c*2)	*N*	*ZE*	*N*	(*N*, *ZE*, *N*)
(*d*1, *d*2)	*ZE*	*N*	*N*	(*ZE*, *N*, *N*)

The inference method of mamdam's max – min composition is chosen in the work is simplify the programming algorithm. Simulation was tested, the choice of mamdam's max – min composition or larsen's max product composition does not give much difference based on the result is obtained. Fig 6 shows the Response of Second Order system

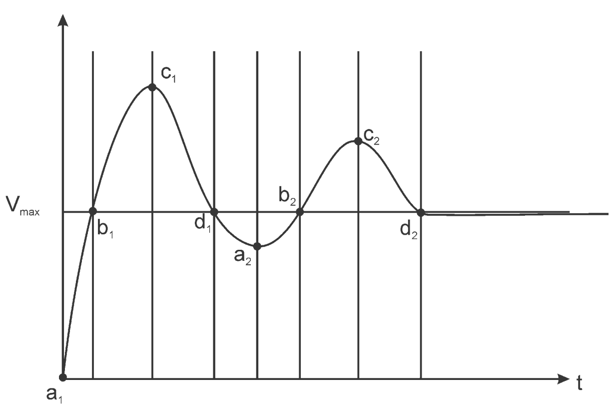


Fig. 6. Response of Second Order system

The minimum membership value for the antecedents does not give much difference based on the results obtained. The *n* Rule based (RB) is the first parameter to be tuned if the result is totally unmatched with the control objective because it may be due to the wrong sign in the output or input. The minimum membership value for the antecedents in every K^{th} fired rule propagates through to the consequent and truncates the membership functions for the corresponding consequent using min – operator. The membership functions chosen are the classical triangular shape with 50% overlap. Unlike the conventional PI controller local adjustment on control surface is possible for the FPIC. To ensure the controller operates in the defined range. The controller input and output are monitored.

IV. SIMULATION RESULTS

The non-isolated dc-dc converter performs the open loop and closed loop operation with *R*-load Fig 7. The passive filter is accommodated in the output side to reduce the ripple content in the load. The output voltage with π- filter to produce the higher output voltage is 24.01 v as compared to other passive filter is shown in fig. 8. Output current with π- filter is produce the current of 0.25 A is shown in fig. 9. The ripple content of voltage is 0.016 v is shown in fig. 10 voltage across switches in boost mode for π- filter *S*1 and *S*2 are shown in fig. 11. Output voltage with LC filter is 21.459 v is shown in fig. 12. Output current with LC filter is 0.24 A is shown in fig. 13. Ripple content with LC filter is least among the passive filter is 0.12 v is shown in fig. 14. The output voltage with C filter is 23.87 v. The output current with C filter is 0.243 A. The Ripple content with C filter is 0.16 v is highest among the C and LC filter. The output voltage with LC filter is 24.01 v. Output voltage is less than the input voltage in the Buck mode output current 0.15 A with π-filter of the Buck Mode. Driving pulses for *S*1 and *S*2 for applying pulses for switches in the circuit. The generation of pulse width modulation (PWM) for closed loop in general forms for all three closed loop in the controller to replace any controller to be provided. The closed loop response of the PI controller. Output current with π-filter the load side disturbance is available. The output voltage with disturbance of PI controller. The output voltage with fuzzy controller to get more steady state time. Output current is 0.2525 A in fuzzy controller. Load side disturbance of output current in fuzzy controller. the disturbance of output voltage of fuzzy controller. Output voltage with neural controller. Output voltage with neural controller. Output voltage with neural controller is available with ripple content. The output current with load disturbance neural controller.

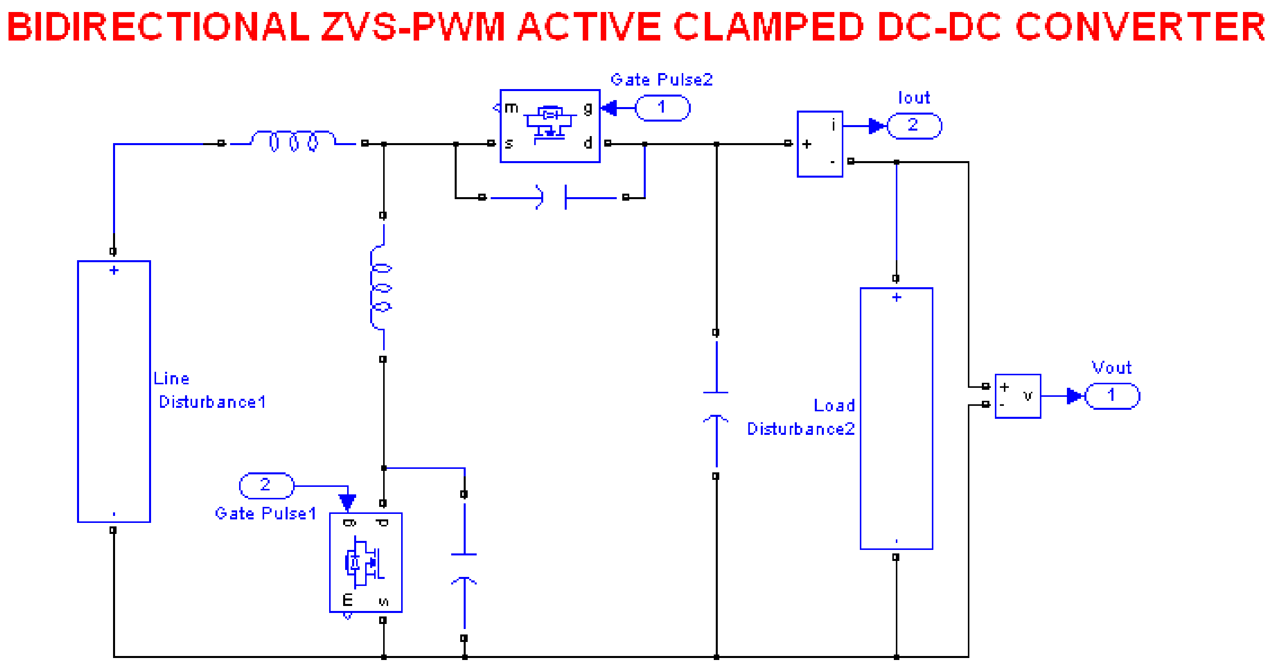


Fig. 7 Non isolated Bidirectional dc-dc Converter

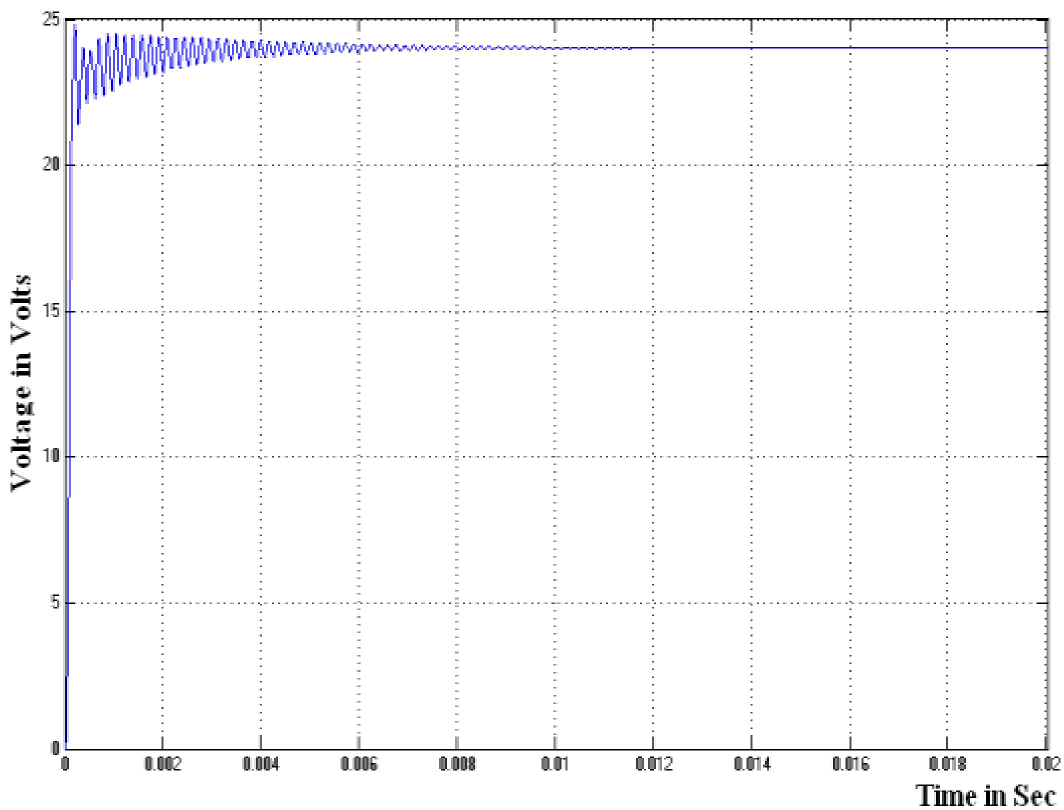


Fig. 8 Output Voltage with Pi filter

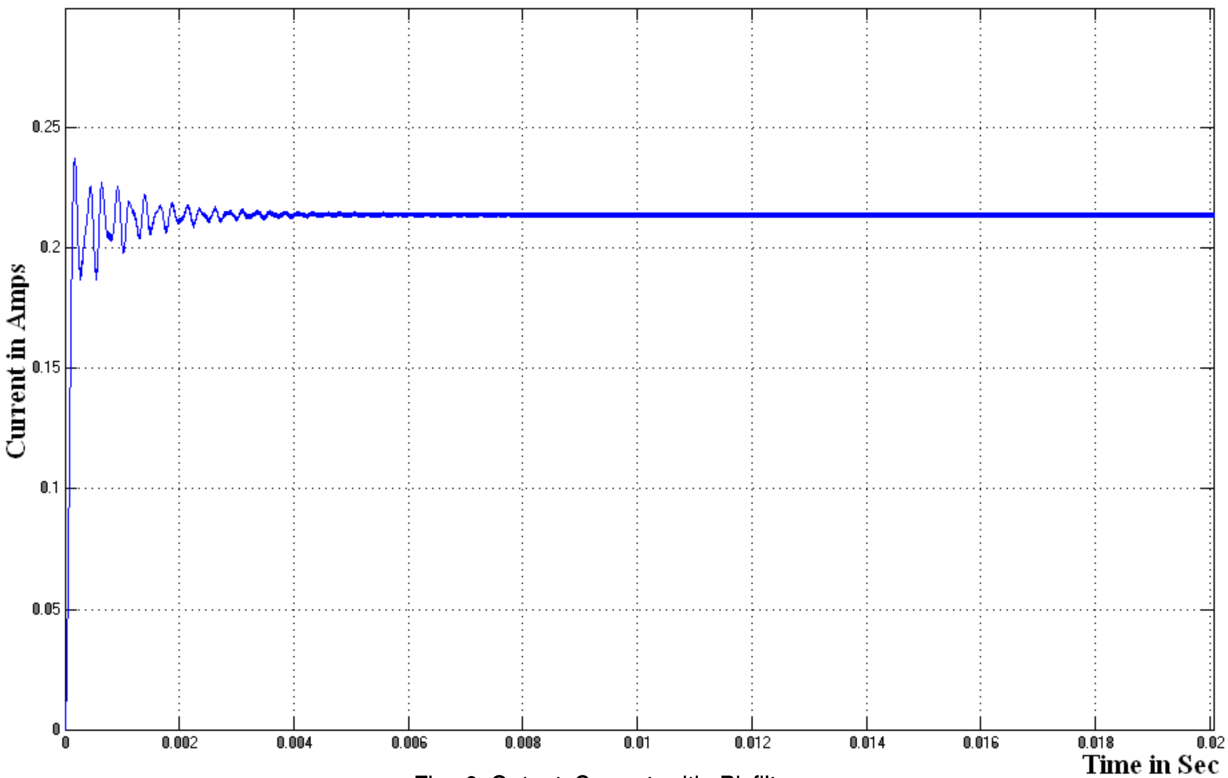


Fig. 9 Output Current with Pi filter

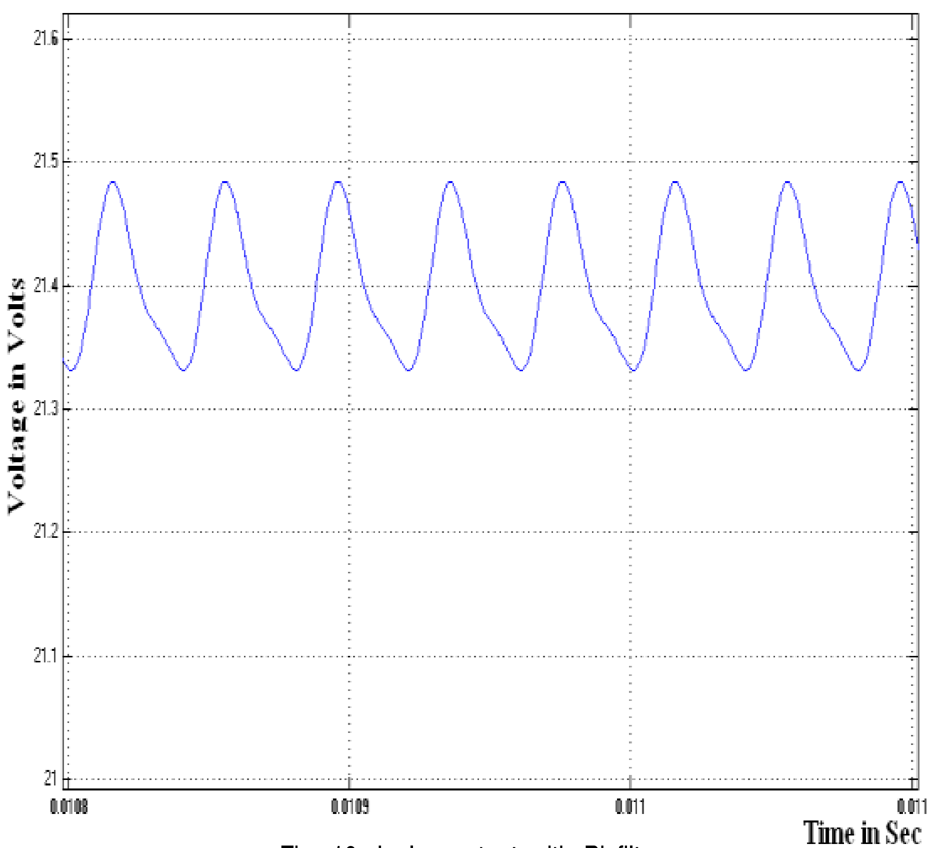


Fig. 10 ripple content with Pi filter

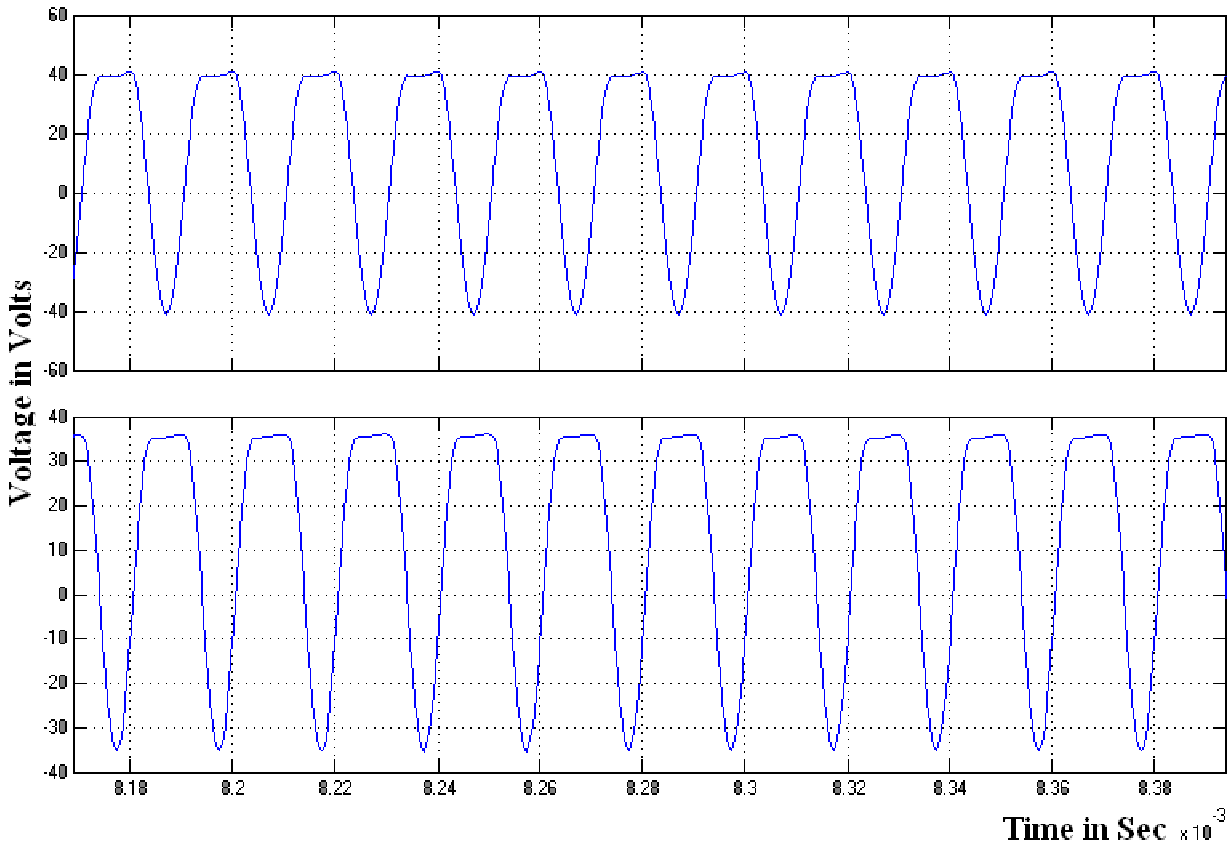


Fig. 11 Voltage across switches boost mode for Pi filter *S*1 and *S*2

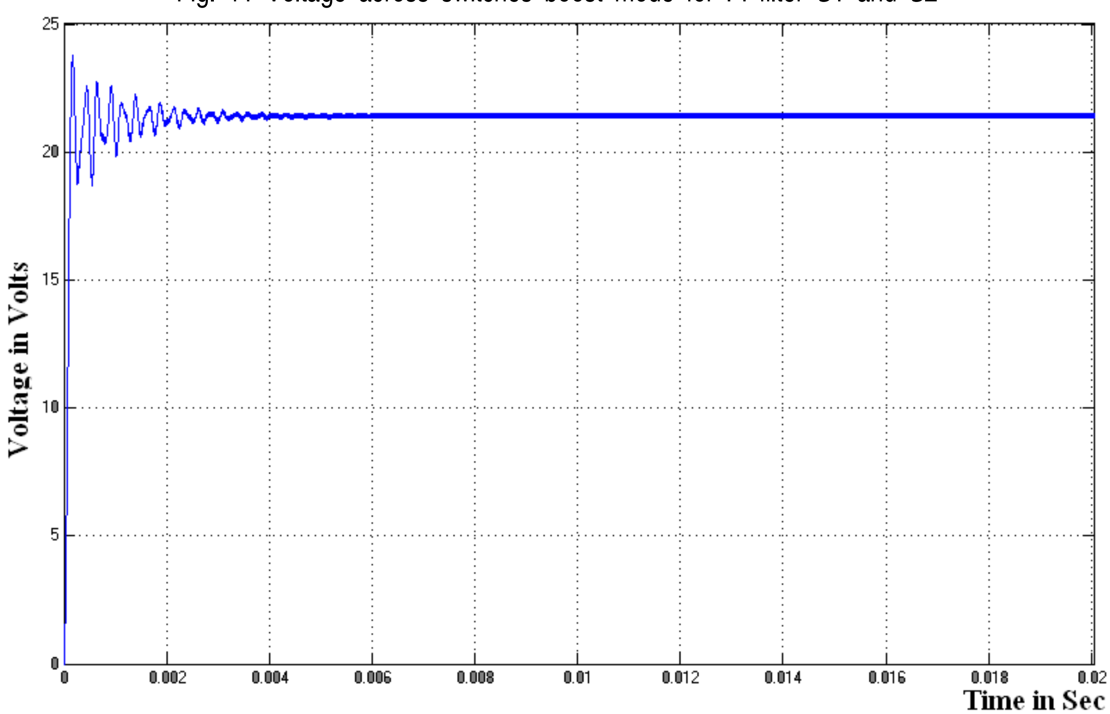


Fig. 12 Output Voltage with LC filter

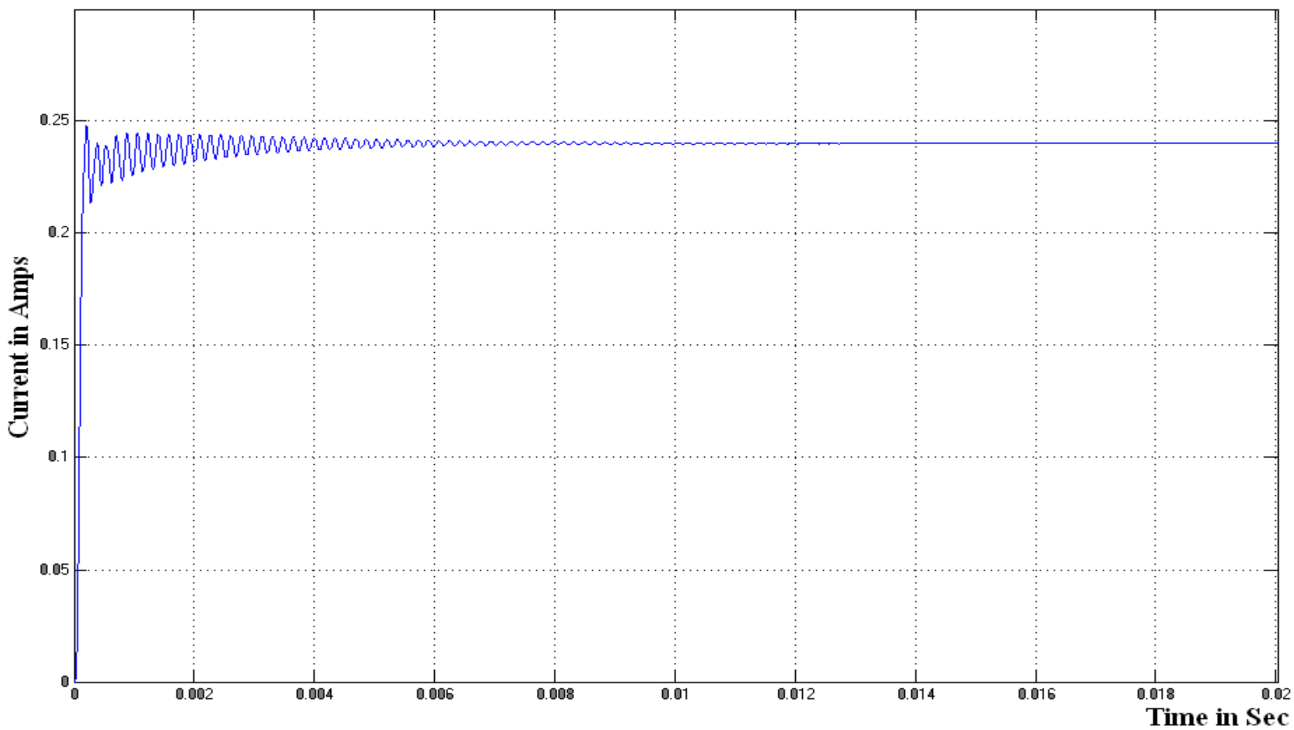


Fig. 13. Output Current with LC filter

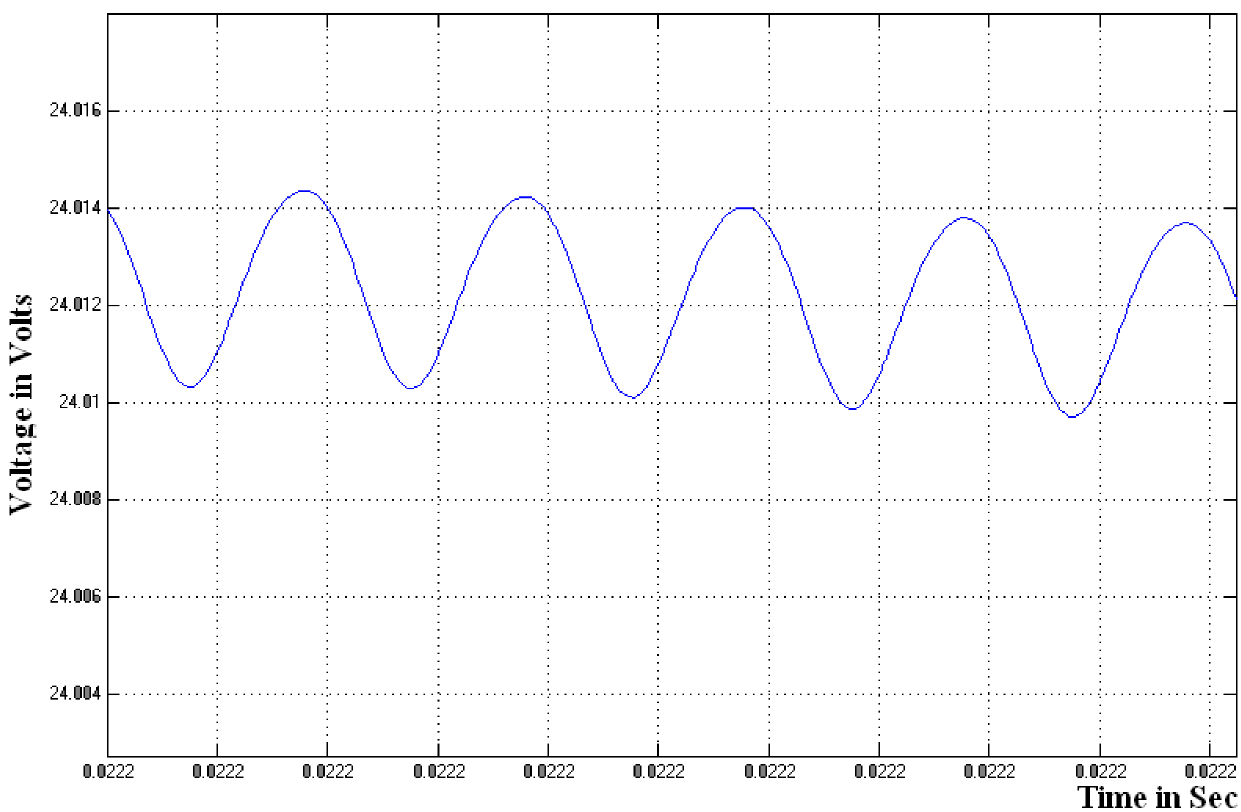


Fig. 14. Ripple Content with LC filter

Simulation Parameters

V_i = 12 V	V_0 = 24 v	L = 12.5 μH	C = 5 μH	R_L = 100 Ω

Table 5. Performance Evaluation of Controllers for Non-Isolated dc-dc converter with resistive load

Controller	Start up transient						Lune Disturbance		Load Disturbance	
	Deadtime	Risetime	Peak time	Peak over shoot	Settling time	Steady state ripple	Setting time	Steady state ripple	Setting time	Steady state ripple
PI	4 μ s	1.37 msec	1.76 msec	1.2%	8 msec	0.016 Volts	3 msec	0.016 Volts	3 msec	0.016 Volts
Neutral controller	0.5 e - 8 sec	3.38 msec	4 msec	1.13%	8 msec	0.0034 volts	1.25 msec	0.0034 volts	3 msec	0.0034 volts
Fuzzy controller	0.8 μ s	5.25 msec	6 msec	1.09%	1.85 msec	0.004 volts	1.25 msec	0.004 volts	1.25 msec	0.004 volts

IV. HARDWARE RESULTS

The AT89C2051 is a low-voltage, high performance CMOS 8-bit microcomputer with 2K Bytes of Flash programmable and erasable read only memory. The device is manufactured using ATMEL high-density nonvolatile memory technology and is compatible with the industry standard MCS-51 instruction set. By combining a versatile 8-bit CPU with flash on a monolithic chip, the Atmel AT89C2051 is a powerful microcomputer, which provides a highly flexible and cost effective solution to many embedded control applications.When *R*-load is simulated to this non-isolated bidirectional dc-dc converter, the efficiency is 89.58%. This proposed converter with *R*-load can be used in DC transmission of low power applications (about 20/40 V rating). Thus, the operation of the proposed converter was analyzed; Experimental results further demonstrated the feasibility of the proposed ideas. The boost mode output voltage is 43.7 V and the buck mode output voltage is 7 V is *R* Load arrangement The Motor load Operation the efficiency is reduced due to losses.

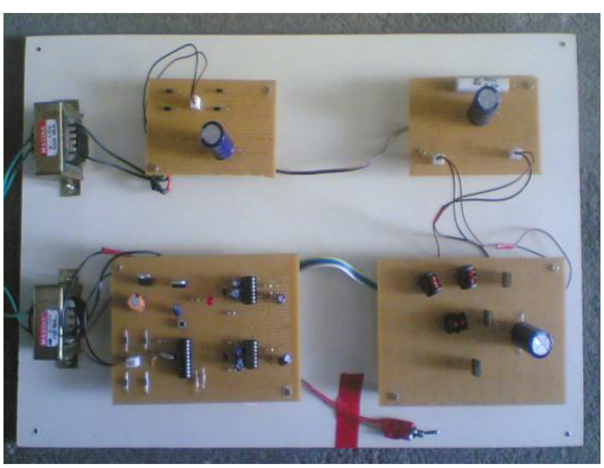


Fig. 15. Photograph of Proposed Converter Kit using with *R*-load

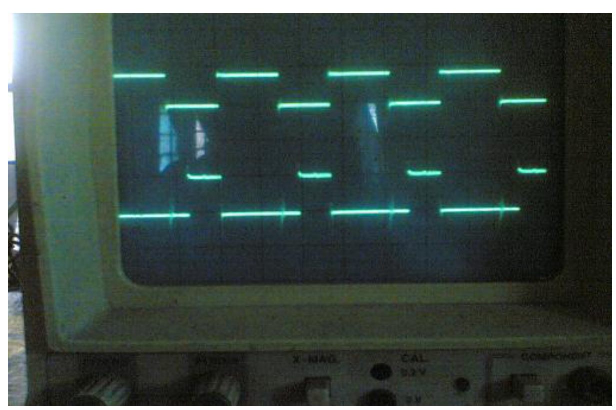


Fig 16. Photograph of Boost mode Output Diagram using *R*-load Boost Mode - Output Pulse

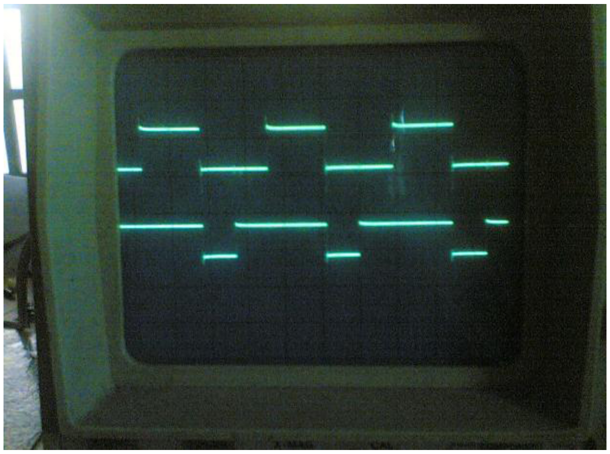
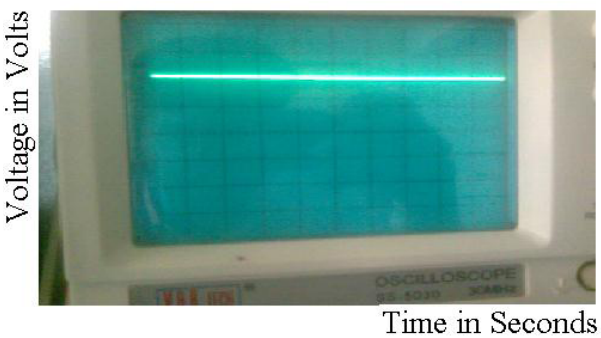


Fig. 17. Photograph of Buck Mode Output Diagram using *R*-Load Buck Mode - output pulses



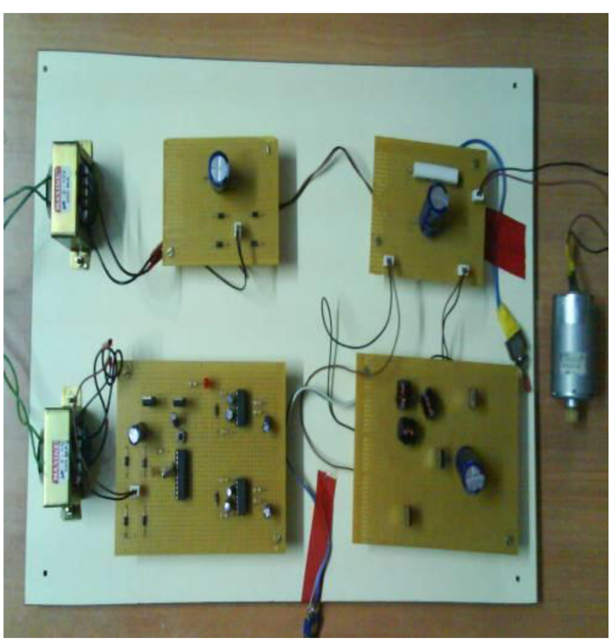


Fig. 18. Photograph of Proposed Converter kit using

Table 6

*M*1 - IRF 840
*M*2 - IRF 210
D - 0.5
*L*1 - 5 mH, *L*2 - 8 mH
R - 100 Ω
C_f – 14.7 μ f
L_r – 15 μ H
Miniature motor 1 A
Modle 842 V = 220 V
power 19 W

VI. CONCLUSION

Compared the performance of PI controller, fuzzy controller and neural controller are simulated and analyzed, the best among the controller is neural controller to produce high output voltage with reduced ripple content and quickly to reach the steady state response. Performance of controller is tabulated and passive filter in open loop to reduce the ripple content among the three filter is π- filter to achieve the efficiency is 89% at 50 Khz, to reduce the switching losses, eliminate transformer winding losses reduce the size and cost. To optimum utilize the standard non – Isolated dc – dc converter in computer application Hospitals, UPS, Recharging Battery and speed control of dc drives. The hadware is closely agreed with the simulation results.

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