NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581-4230
VOLUME 3, ISSUE 11, Nov. -2017

CLOSED LOOP CONTROL FOR MULTI LEVEL DC – DC CONVERTER USING NEURAL NETWORKS

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ABSTRACT:

Multilevel DC – DC converter system is the novel development system which may be used as a DC link where several levels of controlled voltages are needed with unidirectional current flow and self balancing. The concept Multilevel is able to be implemented for both Buck converter and Boost converter. For multiple outputs, multilevel converter topology can be extended. This proposed paper shows the method of neural network controller implementation for the Multilevel DC – DC converters. The purpose of this is to decrease the output voltage ripple content and to vanish peak overshoots due to transients in order to improve the system performance. And finally the output voltage of more accuracy is achieved in this method. The losses existing in the conventional DC-DC converter can be eliminated by using this proposed converter. In this paper the MATLAB simulation of control of multilevel DC – DC Buck boost converter with the help of neuro controller is obtained using the software MATLAB simulink model and then the final results of this converter for neuro controller is compared.

KEYWORDS*:* DC – DC converter; multi level DC – DC converters; transient Overshoots; Output ripples; Neuro controller.

I. INTRODUCTION:

In the last few years we can see the wide progress of power electronics industries. In particular DC power supplies are widely used in many areas starts from simple electronic devices like mobile phones, till even more advance application such as medical electronics and also the aerospace applications. Also increased development of communication devices and electric power drives increases the necessity of DC – DC converters. DC – DC converters can be utilized for both low and high power applications widely. To overcome the need of more number of converters, the multilevel DC – DC converters are introduced recently.

Utilization of Multi level DC – DC Buck Boost converters reduces the requirement of number of converter and also it can be often used for many applications with single input. Multi level DC – DC Buck Boost converters have more merits such as minimized voltage accentuate on the output capacitor, less interference due to electromagnetic, low frequency of switching and more efficiency. The main advantage of using this multi level DC- DC buck boost converter is that it needs less number of components for magnetization so the total system volume is very much diminished. There are several types of topologies that are available in multi level concept those topologies are: capacitor clamped, diode cascaded and clamped multi-cell.

This type of configuration can be made up by using multiple dc links. The diode clamped configurations are in need of more number of switches, which leads to increased switching losses. In this paper fly wheel capacitor or capacitor clamped multi level buck boost converter configuration is proposed. This configuration has minimized output voltage ripples as well as it possesses fast transient response. The main demerit of this configuration is capacitor balancing is somewhat difficult.

In the past few years, the PWM signal generation was done by utilizing the P, PI, PID controllers. These Buck boost converters can be utilized for controllers because of its coherence in design. Nevertheless, carrying out of these control strategies to the plants which are non linear will subject to dynamic response of the converter output terminal voltage replication. In general, all these types of controllers do produce long rise time when the peak overshoot in output voltages reduces.

Now days, there has been increased interest in the efficient control strategies development to improve the dynamic behaviour of the converters, by utilization of intelligent controllers like Neural networks. Effective implementation of Neuro controller aims to minimize the output ripple until zero and to extinguish the maximum peak overshoot voltage upto zero. And also the Neural network controller avoids the problem of balancing of capacitor. Multi leveling concept can be utilized for both buck converter as well as boost converter. The design of Neuro controller for multilevel DC – DC buck boost converter using MATLAB 9.0 simulink has been presented in this paper.

II. MULTILEVEL INVERTER:

The proposed multi level boost converter system can be operated on one inductor, one switch, number of diodes is 2N-1, number of capacitors is 2N-1 for N levels of operation. This converter is mainly operated based on the principle of conventional multi level converter. In this the DC link reference is used for various levels where unidirectional current flow and self balancing is needed.

This converter is can be extended upto N number of levels, but maintaining the same voltage in each and every level.

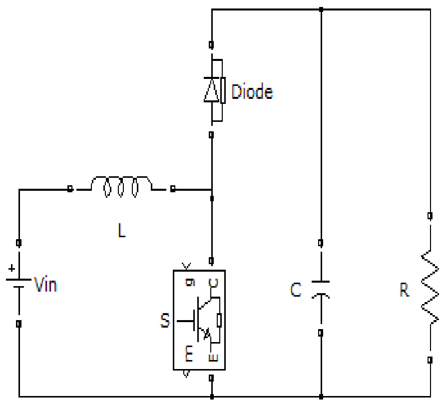

Fig. 1. Basic Boost converter

The fig 1 shows the basic Boost converter configuration. From this configuration a multi level buck boost converter can be designed by extending the dc links upto N levels.

The voltage across Inductor at steady state V_L is

$$V_L = D(V_{in}) - (1-D)(V_{in} - V_c) = 0 \quad 1$$

$$\frac{V_c}{V_{in}} = \frac{1}{(1-D)+\frac{R_L}{(1-D)R_O}} \quad 2$$

If we ignore the losses of inductor

$$\frac{V_c}{V_{in}} = \frac{1}{(1-D)} \quad 3$$

The fig. 2 shows the N level multi level converters. Here if the level of converter is increased the switch used will be the same but the number of capacitors and the diodes will be increased. The voltage of each level is given as the product of number of level (N) and the voltage drop across the capacitor (V_c) .

The difference between the nominal boost converter and the multilevel boost converter is that in the case of multilevel boost converter the output voltage is Vc times N, where N+1 denotes the number of levels of converter.

The output terminal voltage of the multilevel buck boost converter is then now by the equation

$$V_{out} = nV_c = \frac{nV_{in}}{(1-D)} \quad 4$$

If all the losses are also considered then the boost ratio of multilevel boost converter topology is given as

$$\frac{V_{in}}{V_{out}} = \frac{1}{\frac{(1-D)}{N}+\frac{NR_L}{(1-D)R_O}} \quad 5$$

Where R_o is given as the Switch resistance and R_L is the resistance of the inductor.

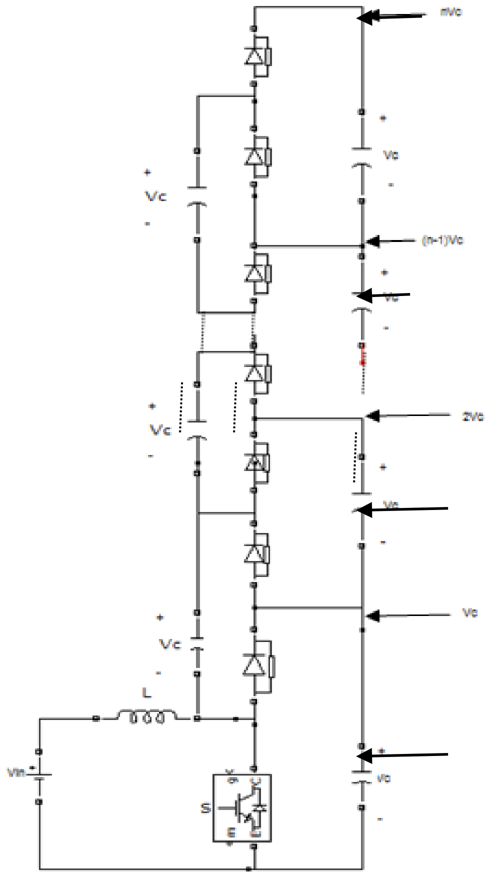

Fig. 2 Circuit diagram for Multilevel buck boost converter for level N

III. OPERATION OF FIVE LEVEL BOOST CONVERTER:

The detailed performance and operation of the five level boost converter can be explained with the help of fig 3. Let us consider that the duty cycle of the power switches (D) is 0.5. During the period converter switch S is ON, the inductor L is then connected to V in. If C_6's voltage is lesser than C_7's voltage then C_7 lifts C_6's voltage through diode D_6 and switch (S). At the same instant, if the voltage drop across C_4 +C_6 is smaller than the voltage drop across C_5 +C_7 , then capacitors C_7 and C_5 elevates the voltage across capacitors C_6 and C_4 through diode D_4 and Switch S. Similarly, voltage drop across C_2 , C_4 , and C_6 are clamped by the voltage across capacitors C_3 , C_5 , and C_7. When the switch (S) is turned off, the current losses of inductor diode D_7 , and switches all the diodes. When D_7 is closed, C_6 and the voltage in V_{in} plus the inductor's voltage clamp the voltage across capacitors C_7 and C_5 through D_5 . In the same way, the voltage drop across the inductive element plus V_{in} , C_4 , and C_6 clamp the voltage across capacitors C_3 , C_5 , and C_7 through D_3 . Finally, the voltage across capacitors C_1 , C_3 , C_5 , and C_7 is clenched by C_2 , C_4 , C_6 , V_{in}, and the inductor's voltage drop. Fig 3. Modes of operation of 5 level buck boost converter.

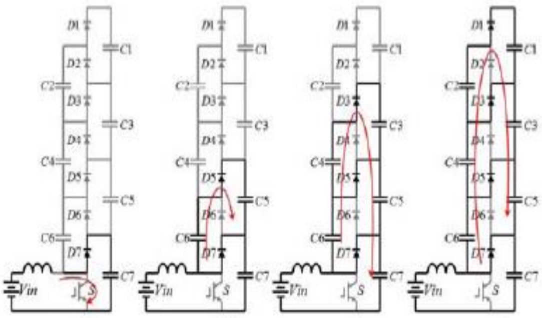

Fig 3. Modes of operation of five level boost converter

IV. BLOCK DIAGRAM OF PROPOSED SYSTEM:

The proposed Neural network controller for the multilevel buck boost converter is shown in the fig.4. The important blocks of the system is multilevel boost converter, Neural network controller, Pulse width modulation (PWM) generator and a voltage comparator. The total output terminal voltage of the multilevel buck boost converter is now compared with the help of voltage comparator block. The comparator produces an error signal 'e' which is the difference of the reference voltage and output at any stage. Then the error signal is fed to the neuro controller for the next stage of processing. The output signal that is fed from the neuro controller is the duty cycle to the switches of converter that is fed to the PWM frequency generator that produces the gating pulse train to the switch S.

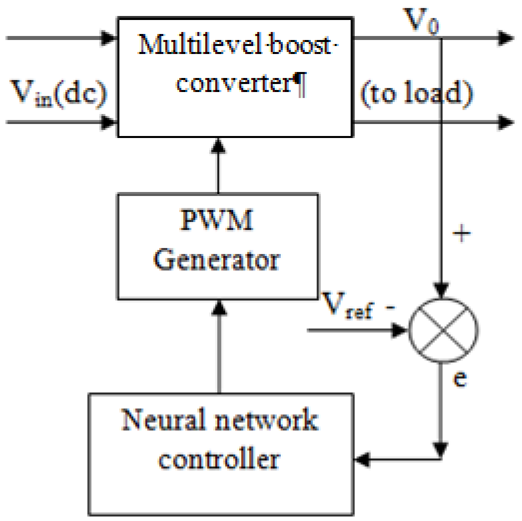

Fig. 4 Simplified block diagram for the proposed system

V. MATLAB SIMULINK MODEL DIAGRAM FOR THE PROPOSED CONTROLLER:

Design of Proposed model using MATLAB Simulink. Here IGBT is used as a switch for our proposed multilevel converter. In this proposed system there are totally three levels which are taken into account for the MATLAB simulation. Totally there are five diodes, each diode shares two levels and five capacitors that are connected across each two diodes. In this diagram scope two gives the output terminal voltage of first level, scope 3 gives the total output voltage. The gate signal to the switch is fed from neural network controller.

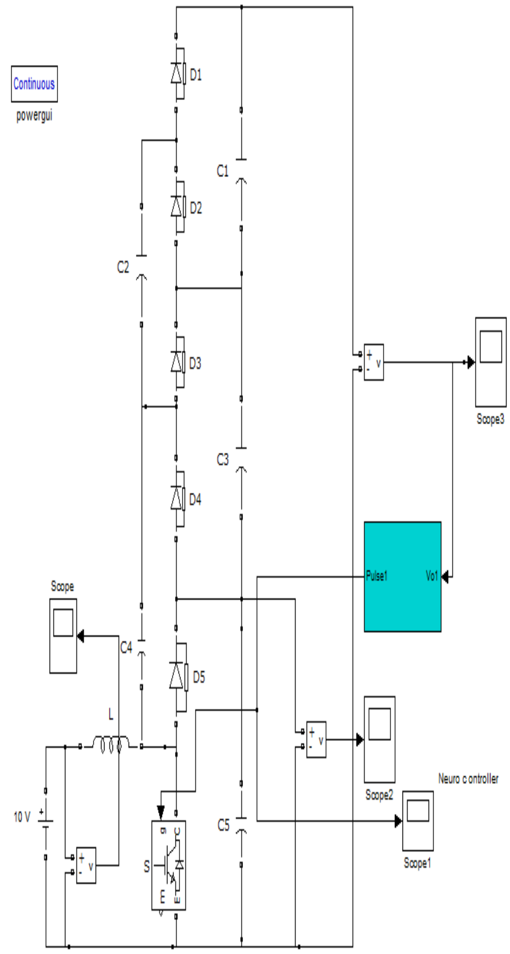

Fig 4 Design of Proposed model using MATLAB

VI. NEURO CONTROLLER:

Artificial intelligence neural network is a modern and useful technique in analyzing multi variable input conditions to optimize for the specific output conditions. They can be given training with the help of number of examples which are already known to gain clear knowledge about any kind of problem. Once if it is trained appropriately, that network is able to be put in to correct use of solving of unknown or untrained occurances of the problem. The input data mandatory for the off-line training of the neural network has been obtained in the present work using voltage transfer ratio of the proposed system.

Fig5 shows the conventional multilayer perceptron model. This consists of 3 layers, those are input layer, hidden layer and output layer.

This neuro controller is depicted as an third layer i.e. output layer,

$$\Delta u(k) = g_{NN}(I(k); w) \quad 6$$

Where g NN (I(k);w) is a function approximator, I(k) denotes the information that is accessible to the controller at the instantaneous value of k, and w denotes a vector of approximator parameters.

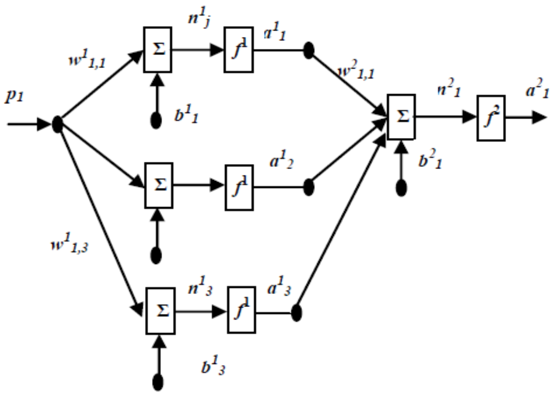

Fig. 5. Three layer neural network controller perceptron model

Quasi-Newton back-propagation algorithm is accomplished for the updation of the weights in this work in view of the following reasons: Quasi-Newton method is a one-dimensional (1D) minimization related numerical interpolation method which has a fast convergence property, which is called as convergence of quadratic and the super linear convergence near the target has been exhibited. This algorithm requires very less memory space when compared with other training algorithms. It is a famous supervised learning rule for the feed forward networks of multi-layer. With the assistance of this algorithm, the input data can be persistently fed to the neuro network. The neuro controller output is compared with the system's desired output with each presentation and the error is calculated. This error signal is then alimented back (back-propagated) to the neuro controller and it used to adjust the weights of controller such that the error gets minimized with each and every iteration and the output of the neuro gets more proximate and more proximate to the desired output.

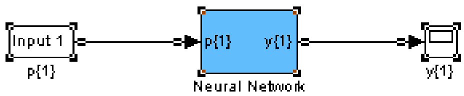

Fig. 6 Simulink model of Neural network controller

VII. SIMULATION RESULTS:

To conform the proposed multilevel DC – DC boost converter's validation the proposed neural network controller alimented multilevel boost converter is simulated with MATLAB 9 simulink software.

A. INPUT VOLTAGE:

The fig .7 shows the applied input voltage to the proposed multilevel DC to DC boost converter. Here the voltage at the input terminals applied to the converter is 10 V. From the simulation diagram it is clearly shown that a pure DC signal of 10 V is applied to the converter circuit. There is no transient overshoots in the input signal.

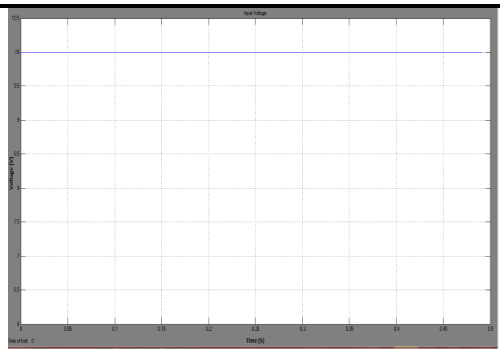

Fig 7. Input voltage to converter

B. TOTAL OUTPUT VOLTAGE:

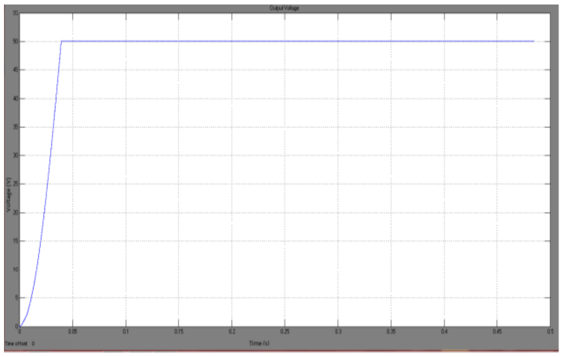

Fig. 8 Total output terminal voltage of the proposed converter

The fig 8 shows the total output terminal voltage of the proposed converter which was obtained from the system. The output voltage is measured as 50 V. From this figure it can be justified that there is no transient overshoots.

C. OUTPUT VOLTAGE OF FIRST LEVEL:

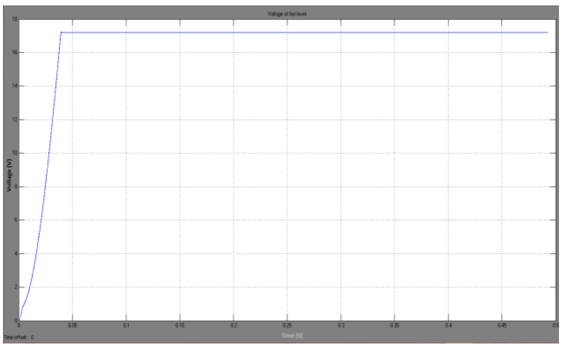

Fig. 9 Output voltage of first level of converter

Fig 9 describes the output terminal voltage of first level of the converter. In the proposed system the level used is three level. Therefore the first level voltage is 16.6 Volts.

D. GATING SIGNAL:

Fig 10 shows the output of our proposed neuro controller which is to be fed to the gate of the switch S_1.

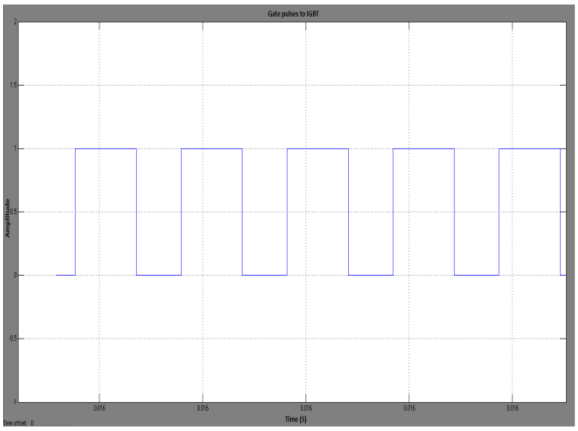

Fig 10 Gating pulse waveform to the switch S

TABLE 1. Specifications of the converter

Specification	**Ratings**
Input voltage (Vin)	10 V
Capacitors	120µF
Inductor	250mH
Reference Voltage	50 V
Output voltage	50 V
Output voltage of first level	16.6 V

VIII.CONCLUSION:

Thus the neural network controlled multilevel boost converter has been designed using MATLAB. The output was obtained accurately with that of the reference voltage which is 50 V. There is no ripples in the output voltage. The output terminal voltages of each level of our proposed converter is same of about 16.6 V. We can find no transient overshoots.

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