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Simulation of Boost Derived Hybrid Converter Using Fuzzy Logic Controller for EV Application

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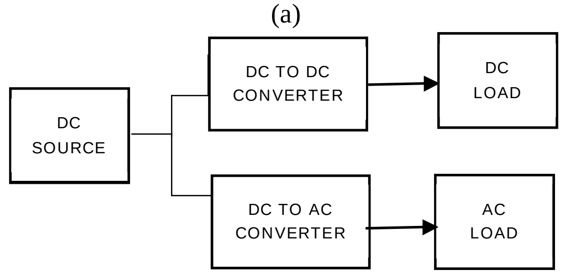
Abstract: A new control technique for hybrid converter topologies with a single DC input that simultaneously supplies DC and AC to appropriate DC and AC loads is presented in this paper. This is achieved by using Voltage Source Inverter (VSI) bridge instead of single step-up switch in a boost converter. This converter is known as Boost Derived Hybrid Converter (BDHC) because it is derived from the basic boost converter. Unipolar sinusoidal pulse width modulation (PWM) is used to control the BHDC. This BDHC utilizes less number of switches and furnishes DC and AC yield with higher reliability. Fuzzy logic controllers (FLC) are being used to replace the conventional PID controllers in this control technique. Since fuzzy controller is the best option for non-linear control technique, it is used to control BDHC which is has nonlinear dynamics. The input to the fuzzy logic controller is error and change in error from two different comparators which contrasts AC and DC voltages with their respective reference voltages. The simulation results of BDHC are done using MATLAB/SIMULINK.

Keywords: Boost Derived Hybrid Converter (BDHC), Voltage Source Inverter (VSI), Pulse Width Modulation (PWM), Fuzzy Logic Controller (FLC).

I. INTRODUCTION

DC loads are increasing day by day in this modern era. Furthermore, these DC loads must be used in combination with AC loads. EV battery chargers, fuel cell applications, hybrid electric vehicles, uninterrupted power supplies, and nano-grid architectures are all part of the modern power system, which utilizes efficient power electronic converters to supply loads from several types of energy sources. Typically, there is only one DC source available, and it must supply both AC and DC loads, depending on the requirements. Figure 1 shows a block schematic of such a system, in which a single DC input feeds both AC and DC loads. Figure 1 (a) depicts traditional architectures in which DC and AC loads are supplied by separate converters, whereas Figure 1 (b) depicts hybrid architectures in which DC and AC loads are driven by a single DC source. In Figure 1(b), the converter is referred to as a hybrid converter. A single stage converter performs both DC-DC and DC-AC operations with this type of converter. Boost Derived Hybrid Converters are a unique sort of hybrid converter (BDHC). This BHDC has a lower number of switches and is more reliable. This is owing to the inverter's built-in shoot-through protection. A single-stage architecture is described in this study for supplying hybrid loads. To avoid the shot through in traditional VSI, dead time circuitry is required. Miss-gating of switch turn-on may occur as a result of unwanted noise, which could lead to switch damage. [1]

(a)



(b)

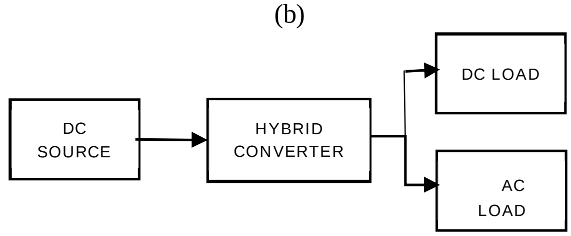


Fig 1. Architecture of Converters with AC and DC load. (a) Separate converters that supply AC and DC load. (b) Hybrid converter that supplies both AC and DC load.

II. BOOST DERIVED HYBRID CONVERTER

A. Proposed Circuit Modifications

Switches in the same leg that are complimentary. The duty cycle can be changed by manipulating one of the switches in the same leg and using a diode to control the other switch. In the boost converter, this mechanism is employed instead of a regulated switch. This converter architecture can be achieved by replacing the controlled switch with a single-phase or three-phase inverter bridge network.

B. Derivation of BDHC Topology

This suggested converter delivers simultaneous ac output (Vac out), similar to a VSI, as well as dc output (Vdc out), similar to a boost converter. The four switches S1–S4 can be used to control the BDHC outputs. To create the BDHC topology, the boost converter switches were replaced with bidirectional single-phase bridge network switches (S1– S4). As a result, BDHC faces the following challenges: As a result, BDHC faces the following challenges:

1) Choosing the duty cycle (Dst) for boost operation and the modulation index for inverter operation (Ma)
2) Voltage stresses and currents flowing through various components are calculated.
3) The total input power is controlled and distributed to DC and AC loads.

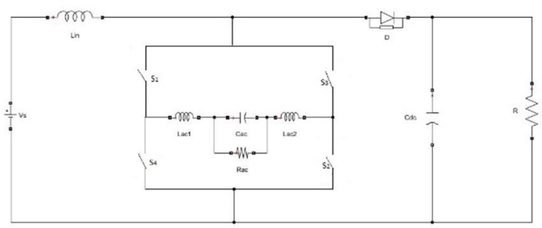


Fig 2. Schematic representation of the Boost derived hybrid converter.

III.OPERATION

Each of the four switches, S1 to S4, is a bidirectional switch. The proposed converter boost operation can be carried out by turning on both switches on selected leg switches at the same time (such as S1-S4 or S2-S3). This mode is analogous to the condition of shoot through operation in the case of VSI operation. The switching sequence of the boost derived hybrid converter is explained in the fig 3.

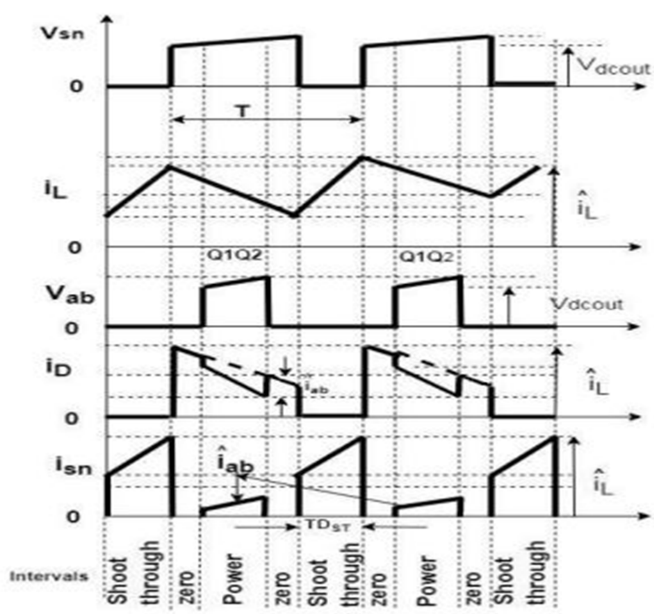


Fig 3. Switch node voltage (Vsn), load current (I_L), inverter output voltage (V_{ab}), diode current (I_D), inverter input current(Isn).

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The BDHC uses a modified unipolar sine PWM contol scheme to control the AC output which is described in section V.
The BDHC has following three switching operations:

A. Mode 1- Shoot-Through Mode

Fig 4 explains the shoot-through mode of operation on BDHC. The shoot-through mode of operation is carried out by turning on both the switches of specific leg (such as S_1-S_4 or S_2-S_3). This mode of operation helps us to decide the duty cycle of the boost converter. During this mode of operation, the diode D is reverse biased and there is dc output. In VSI, there is no such mode of operation. Hence the inverter current circulates the load.

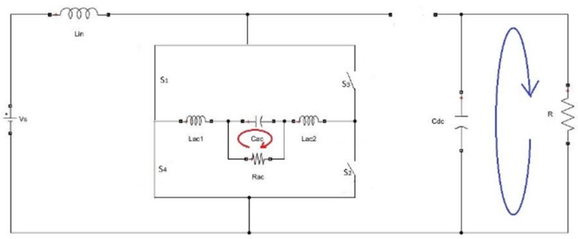

Fig 4. Shoot-through Interval circuit diagram.

B. Mode 2- Power Interval Mode

Fig 5 explains the power interval mode of operation on BDHC. In this mode operation, either of the opposite switches are turned ON (such as S_1-S_2 or S_3-S_4). Here the inverter current is either entering or leaving the switching nodes. During this mode of operation, the diode is forward biased and there is a flow of dc output. So, the power is transferred to both AC and DC loads during this interval.

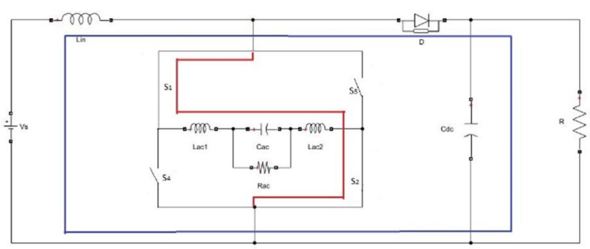

Fig 5. Power Interval switching diagram.

C. Mode 3- Zero Interval Mode

Fig 6 explains the zero-interval mode of operation of BDHC. During this mode of operation, all the switches of VSI is turned off (that is inverter is not connected to the source) and the diode is forward biased. Thus, the power transfer occurs only to the DC output.

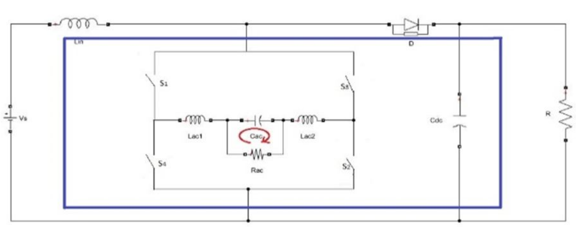

Fig 6. Zero-interval circuit diagram.

IV.STEADY STATE ANALYSIS

A. Expression of Voltage Gain for both AC and DC Outputs

The duty cycle (Dst) is the time interval between shoot throughs in a switching period that is used to control the dc output voltage. BDHC's voltage gain equation is as follows:

The BDHC's AC output voltage is provided by the modulation index (Ma), which is the same as that of VSIs. The maximum AC output voltage and the DC input voltage have the following relationship:

With a fixed duty cycle (Dst), the AC gain increases as the modulation index increases. Because the same switches control both outputs, the maximum duty cycle or modulation index is limited. The control of modulation index and duty cycle is constrained by the relationship described by equation (3).

As a result, the maximum value of AC gain is given by the requirement of relation (3). The maximum AC voltage value is identical to the input voltage and is independent of the duty cycle and modulation index. A higher order boost converter or the transformer is used to obtain an output voltage with voltage levels greater than the input voltage.

Thus, power equation for AC and DC are derived from equation (2) and (3). They are as shown below:

B. Passive Components Design

The output waveforms of the BDHC are identical to those of a VSI. Finally, the filter is designed using the VSI, L_{ac} (= L_{ac1} + L_{ac2}), and C_{ac} methods. LC filters are used in DC-DC converters to decrease ripples in currents and voltages. However, because both DC and AC outputs are created in the BDHC, the current through the inductor (i_L) and the voltage across the capacitor ($V_{dc\ out}$) contain a high and low frequency component.The low-frequency component of ripple content can be assessed in the following way. The bridge network's instantaneous input power consists of a DC value (equal to PAC) and a sinusoidal component that fluctuates at twice the power frequency.

V. CONTROL STRATEGY

A. Modified unipolar Pulse width Modulation

The inverter bridge must be connected to positive voltage during the power interval, according to the basic equations of BDHC operation. This means that when Vsn = 0, the inverter output must be controlled, and when Vab = 0, boost operation must occur. Because the inverter output voltage has three different values, the unipolar sine pulse width modulation approach is employed to generate the three output voltage levels.

The pulse width modulation is done as proposed in [3]. To achieve the shoot-through in this method, gate-on both switches on a single leg at the same time. During the shoot-through, the switching control involves turning on only one leg or turning on two legs by switching on all four switches. [4] and [5] have recommended this technique. As indicated in the diagram, turning on four switches in two legs during the shoot through time will result in additional switching during each switching phase, resulting in additional losses. Because the time between two consecutive switches is determined by tz, which can be near to zero, the circuit is less dependable. This system has been used to control the BHDC.

B. Implementation and Control of BDHC

The control logic circuit is used to implement a pulse width modulation control technique. Vm(t) and Vst are the switching logic or pulse width modulation generation circuit's reference signals (t). The controlled switches gates receive the S1–S4 signals, the shoot-through period is controlled by a DC signal Vst(t), which is also regulated by the duty ratio (Dst) for the boost converter's DC output, and the signal Vm(t) controls the inverter's amplitude modulation index (Ma).

VI.FUZZY LOGIC CONTROLLER:

The fuzzy control rules are determined by experience and are based on the following conditions:

When a substantial error is formed as a result of a disparity between the reference output and the actual output of the converter, the duty cycle must be changed dramatically to fast reduce the error to zero. When the converter's output is approaching the reference, duty cycle changes should be minimal; when the converter's output is extremely close to the reference and approaching it quickly, the duty cycle should not be adjusted to avoid overshoot. If the output changes after reaching reference, the controller must alter the duty cycle. The duty cycle must be constant when the output reaches reference and remains unchanged. When the output exceeds the reference, the duty cycle change must be negative, and vice versa.

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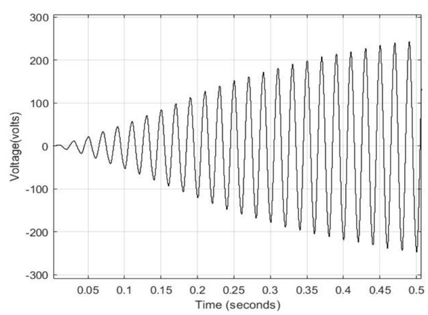
The rule basis is determined based on the conditions mentioned above. The major purpose of these regulations is to keep the BDHC's output voltage under control. The output voltage error and change in error are sent to the fuzzy logic controller. NH-Negative High, NL-Negative Low, ZO-Zero Area, PL-Positive Low, and PH-Positive High are the five groups of these two inputs. The P-Positive, Z-Zero, and N-Negative fuzzy control rules for ac output voltage will determine the amplitude of the sinusoidal reference signal.

VII. OPEN LOOP SIMULATION RESULTS:

The inductor current ripple and the capacitor current ripple is considered to be 25% and 3% respectively, at the rated power. The rating and parameters of the BDHC for open loop is as shown in the below table I. Simulation results are displayed in Fig 6 to 8.

TABLE I: PARAMETERS OF OPEN LOOP

COMPONENTS	ATTRIBUTES
INPUT DC VOLTAGE	48V
AC OUTPUT	210V
DC OUTPUT	900V
DC LOAD	10Ω
AC LOAD	500Ω
INPUT INDUCTOR	5mH
DC CAPACITOR	100mF
AC CAPACITOR	100mF
AC INDUCTOR	0.1mH



VIII. CLOSED LOOP SIMULATION RESULTS:

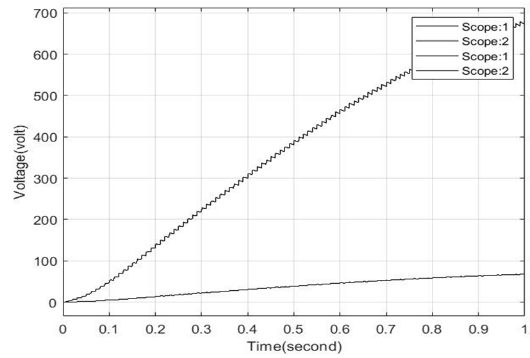
By calculating the modulation index for SPWM in a fuzzy controlled system using equations (1) and (2). With fuzzy regulated outputs, the relationship between modulation index and duty cycle can be seen. The implementation of fuzzy controller for controlling dc and ac outputs independently in BDHC obtains following simulation results of controlled outputs of the circuit as shown in Fig. 9 (a) and (b). The parameters for closed loop control are shown below table II:

TABLE II: PARAMETERS FOR CLOSED LOOP BDHC

COMPONENTS	ATTRIBUTES
INPUT DC VOLTAGE	48V
AC OUTPUT	210V
DC OUTPUT	700V
DC LOAD	10Ω
AC LOAD	500Ω
INPUT INDUCTOR	5mH
DC CAPACITOR	100mF
AC CAPACITOR	100mF
AC INDUCTOR	0.1mH

The total harmonic distortion is reduced from 3% to 1.45% in closed loop control of BDHC.

(a)



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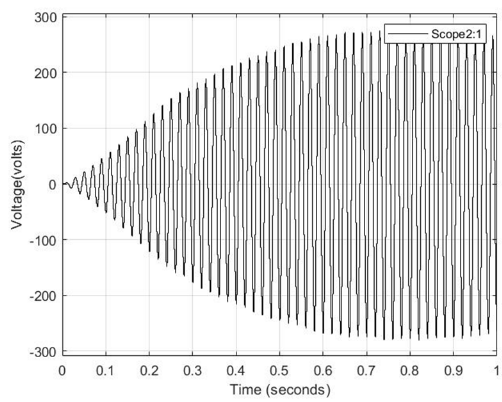


Fig 9. Simulation output. (a) DC voltage and Current waveform. (b) AC Voltage waveform.

IX. CONCLUSION

This work presents a fuzzy control method for a hybrid power converter that can provide dc and ac loads simultaneously from a single stage converter. The Shoot-through protection has been described and contrasted with traditional VSI. Total Harmonic Distortion has been reduced to 1.45 percent in fuzzy regulated closed loop BDHC. Which is lower than the IEEE 519 slandered limit. The design of a fuzzy logic controller for controlling the BDHC has been completed successfully. In comparison to PI and other controllers, an algorithm based on the fuzzy rules' parameter is proven to be more convenient for controlling the dc and AC voltages independently. It is demonstrated that instead of considering the error signal, the change in error provides us with more smooth DC voltage control.

REFERENCES

[1] O.Ray, S.Mishra, A.Joshi and A.Tiwari, "Implementation and control of a bidirectional high-gain transformer less standalone inverter," in Proc. IEEE Energy Convers. Congr. Expo., NC, USA, Sep.2012, pp.3233-3240.

[2] S.Upadhyay, R.Adda, "Inverse Watkins-Johnson topology-based inverter," IEEE Trans. Power Electron., vol. 27, no.3, pp.1066-1070, Mar.2012.

[3] R.Adda, S.Mishra, and A.Joshi, "A PWM control strategy for switchedboost inverter," in proc. IEEE ECCCE, Pheonix, USA, Sep.2011, pp.991- 998.

[4] F.Blaabjerg, Zcheng," Power electronics as efficient interface of in dispersed power generation systems," IEEE Trans. Power Electron., vol.19, no.5, pp.1184-1194, Sep.2004.

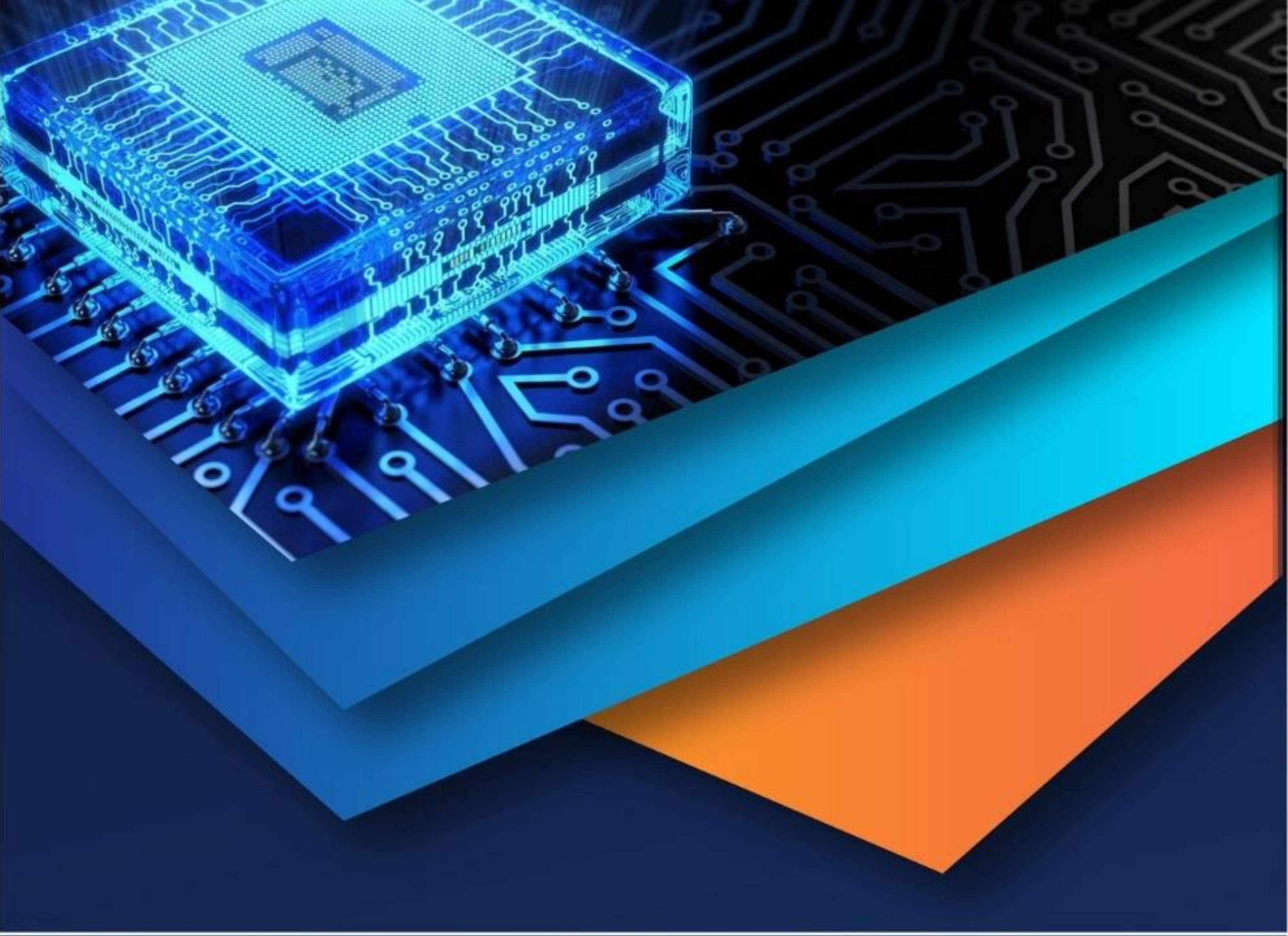
[5] S.H.Hwang and J.M.Kim, "Dead time compensation method for voltage fed PWM inverter," IEEE Trans. Energy Convers., vol. 25, no.1, pp.1- 10, Mar. 2010.

[6] Guang Feng, Yan-Fei Liu. "An adaptive current mode fuzzy logic controller for dc-to-dc converter". Applied Power electronics conference and exposition, 2003.APEC '03. Eighteenth Annual IEEE Volume 2, 9-13 Feb.2003 Pages: 983 989, vol.2

[7] Matsimovic D,Stankovic AM,Thottuveli , VJ.Verghese GC." Modelling and simulation of power electronic Converter", proceedings of the IEEE Volume 89, Issue 6, June 2001, Pages: 898-912.

[8] Ranganatham Gurunathan, "A zero voltage transition Boost Converter using a zero-voltage switching auxiliary circuit", Power electronics, IEEE transactions on Volume 17, Issue5, Sept.2002, Page: 658-668.

[9] W.C., Tse, C.K., &Lee, Y.S(1994). "A fuzzy logic controller for DC-DC converter". In IEEE Power electronics Specialist conference records.



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