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DC-DC Converter in Electric Vehicle

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Abstract: An integral part of any modern day electric vehicle is the Electric Electronic Circuit (PEC), which includes DC-AC Inverter and DC-DC converters. A DC-AC inverter supplies air conditioning systems such as high power electric motor and utility load, while DC-DC converter provides conventional low-power, low-voltage loads. However, the need for high power bidirectional DCDC converters in future electric vehicles has given rise to the development of several new topologies of DC-DC converters. This letter presents an overview of state-of-the-art DC-DC converters used in Battery Electric Vehicles (BEV), Hybrid Electric Vehicle (BEV), and Fuel Cell Vehicles (FCV). Many DC-DC converters, such as separate, non-isolated, half-bridge, FU-bridge, unidirectional and bidirectional topologies, and electric vehicles are presented in their applications

Keywords: Automotive Power Electronics, Bidirectional DC-DC Converters, Electric Vehicles, Fuel Cell Vehicles, Hybrid Electric Vehicles

I. INTRODUCTION

Power electronic circuits (PEC) have gained great importance in the past decade as the focus of vehicle technology towards electrical systems, as more and more mechanical, hydraulic, or pneumatic systems change. Increasing vehicle loads such as utility, entertainment, luxury and security weight have increased the demand for compact and efficient PEC. Commercial electric vehicles can be broadly classified: (1) Battery Electric Vehicle (BEV), (2) Hybrid Electric Vehicle (HVV), and FUEL Cell Vehicle (FCV). In addition, heavy duty electric vehicles meet industrial applications like deep mining. BEVs are fully electric vehicles (EVs), whereas HVV combines EVs and internal combustion engines (ICE). Using electricity from both FCV batteries and fuel cell stacks. The popularity of BEV has decreased, while the FCV has not yet gained popularity as both are not currently effective. On the contrary, HVV has influenced the market and will continue until the fuel cell technology becomes viable for commercialization.

Figure 1 shows the main components of PEC in the 2001 Toyota Prius hybrid vehicle . Components are DC-AC inverter, DC-DC converter, battery, and electric motor. OC-AC inverters supply electric motors from batteries and provide utility loads such as air conditioning and AC power outlets. DC-DC converters supply different vehicle loads set to operate on different voltages. In the near future, EVs require high power DC-DC converters because the requirements of vehicle power are increasingly increasing, due to the current 12-V / 14-V power system replaced by 42-V / 300-V architecture will be. DC-DC converters are well developed for low and medium power applications, while the development of highly efficient and cost-effective high-power DC-DC converters for the applications of vehicles is in continuous progress. It is also partly due to stringent electromagnetic interference (EMI) Standards and temperature related issues.

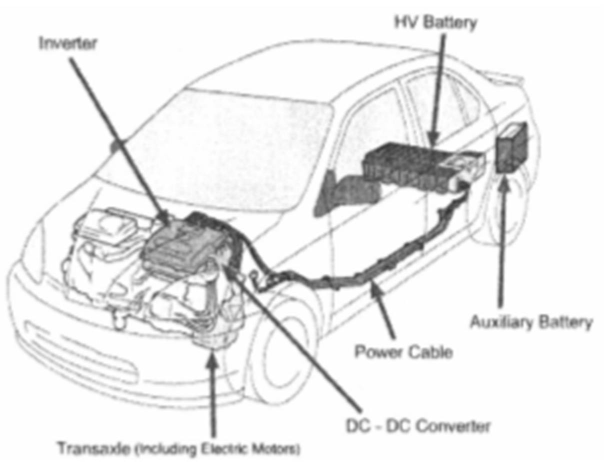


Fig. 1 shows the main components of PEC in the 2001 Toyota Prius hybrid vehicle

In this paper, a brief review of recently developed DC-DC converter topologies, especially for high power bidirectional isolated DC-DC converters, is suitable for electric vehicle applications. Design challenges and potential solutions are discussed. Section IT presents an overview of the original DCDC converters. The stream presents application of DC-DC converters in Ill EVS. Bidirectional DC-DC converters in EV are presented in Section IV. discuss about Follow high temperature electronics and design challenges respectively in section Follow high temperature electronics and design challenges respectively in section V and VI.

II. OVERVIEW OF DC-DC CONVERTERS

DC converters are used in portable electronic devices such as cellular phones and laptop computers, which are mainly supplied with electricity from the battery. Such electronic devices often have several sub-circuits, each of which requires its voltage level, which is provided by the battery or external supply (sometimes more or less than the supply voltage). In addition, the battery voltage decreased because its stored energy is dry. DC converters from switch DC provide a method to increase voltage by partially lower battery voltage, instead of using multiple batteries to complete the same thing, space is saved current through the LEDs, and simple charge pumps that doubles or triples the output voltage .

DC converters have been developed to maximize the energy harvest for photovoltaic systems and are called Power Optimizers for wind turbines.

Transformers used for voltage conversion at major frequencies of 50-60 Hz should be large and heavy for more powers than few feet. This makes them expensive, and they are subject to energy loss in their windings and are due to Edi currents in their core. DC-to-DC technologies that use transformers or inductors work on very frequent, only small, lightweight and cheap wound components are required. Consequently these techniques are used, even a major transformer can be used; For example, for home electronic appliances DC is better to improve the main voltage, use switch-mode technology to convert high voltage AC to the desired voltage, then usually, modify the DC.

III. DC-DC CONVERTER FOR ELETRIC VEHICLE

Various configurations of EV power supply show that at least one DC / DC converter is necessary to interface FC, battery or super capacitor module in DC-Link.

In electric engineering, DC to DC converter is a range of power converters and it is an electric circuit that temporarily stores the input voltage and then releases that voltage from one voltage level to another by releasing that energy is. Production on a different voltage. Storage can be either in magnetic field storage components (inductors, transformers) or electric field storage components (capacitors).

DC / DC converters can be designed to transfer power from input to output, in only one direction. However, almost all DC / DC converter topologies can be made bi-directional. A bidirectional converter can transfer power in any direction, which is useful in applications that require renaissance braking.

The amount of power flows between input and output can be controlled by adjusting the duty cycle (the ratio of the current / closed time of the switch). Generally, it is used to maintain the output voltage, input current, output current, or continuous power. Transformer-based converters can provide isolation between input and output. The main drawbacks of switching converters include complexity, electronic noise and high costs for some topologies. Several different types of DC / DC power converters are proposed in literature (Chiu and Lin, 2006) (Fengyan et al., 2006). The following DC / DC converters can be grouped as follows:

A. Non Separate Converters

Non-isolated converters type is usually used where voltage is required to take steps up or down by relatively small proportion (less than 4:1) and when there is no dielectric separation in output and input then there is no problem. There are five main types of converter in this non-isolated group, which are generally called deer, boost, dock-boost, cook and charge-pump converters. Bunk converter voltage is used for step-down, while Boost converter is used for voltage step-up. Deer-Boost and Q converters can be used either for step-by-step or step-up. Charge pump converter is used for either voltage step-up or voltage infra, but only in relatively less power applications.

B. Separate Converters

Typically, a high-frequency transformer is used in these types of converters. In those applications where the output should be completely separated from the input, a separate converter is necessary. There are many types of converters in this group including Half-Bridge, Full-Bridge, Fly-back, Forward and Push-pull DC / DC converters. All these converters can be used as bi-directional converters and the proportion of raising or voltage uptake is high.

C. Electric Vehicle Converters Requirements

In the case of interfacing the fuel cell, DC / DC converter is used to boost fuel cell voltage and control the DC-link voltage. However, an inverse DC / DC converter is required to interface the SC module. A wide variety of DC-DC converters topologies, in which structures with direct energy conversion structures, intermediate storage components (with or without transformer coupling) have been published. Although some design ideas are necessary for motor vehicle applications:

1) Light weight,
2) High efficiency,
3) Small quantity,
4) Low electromagnetic interference,
5) The low current wave drawn from the fuel cell or battery,
6) Step up converter function,
7) Control of DC / DC converter power flows under wide voltage variation on converter input.

The advantages and shortcomings of each converter topology are decreased. For example, the DC / DC boost converter does not meet the criteria of electrical isolation. In addition, large variation in the amount of input between the input and the output puts severe stress on the switch and this topology suffers from high current and voltage waves and large amounts and weight. A basic interleave multichannel DC / DC converter topology allows for input and output to reduce the current and voltage waves, in order to reduce the volume and weight of the indicators and increase the efficiency. However, these structures can not work efficiently when high voltage phase-up. ratio is required because the duty cycle is limited by circuit impedance, which has a maximum step-up ratio of approximately 4. Therefore, two series linked phase-up converters are required to obtain specific voltage benefits of the specification specification. A full-bridge DC / DC converter for fuel-cell power conditioning is the most applicable circuit configuration when required for power separation. The full bridge DC / DC converter is suitable for high power transmission because the switch voltage and current are not high. It has small input and output current and voltage waves. Full-bridged topology is preferred for zero-voltage switching (ZVS) pulse width modulation (PWM) technologies.

IV. BIDIRECTIONAL DC-DC CONVERTER

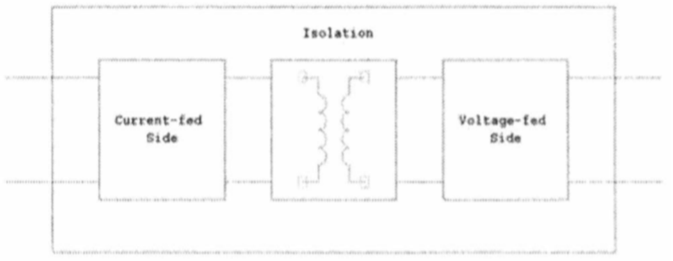


Fig no. 2 Bidirectional DC-DC converter

A bidirectional DC-DC converter can be divided into three main blocks, as shown in Figure 2. The primary side (low voltage side) generally has a buck or boost type half full bridle converter and secondary side is usually there is a half-full bridge system. Based on application, power level and frequency range, power is used as a MOSFET or IGBT switch. The mode of operation can be classified as energy storage and energy transfer mode

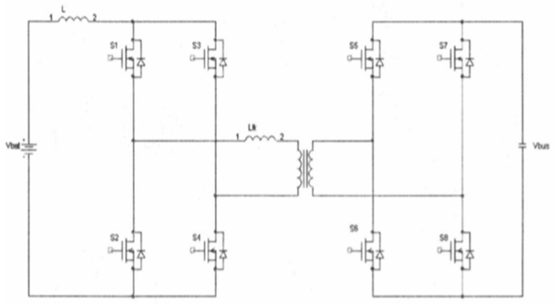


Fig no. 3 Conventional bidirectional full bridge isolated boost DC-DC converter

Due to the presence of Transformer leakage inductance L, shown in Figure 3, during transferring from primary to secondary, high-temperature voltage spikes are produced in the switch on the primary side (hard-switching).

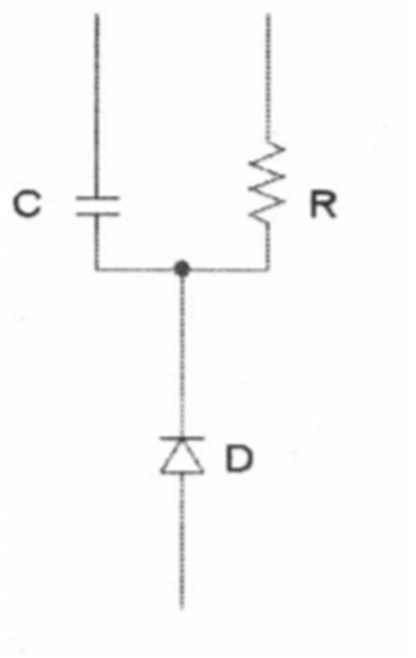


Fig no. 3(a) Passive snubber

Due to high leakage current due to high wastage loss, this leak shown in Figure 3(A) was inserted into energy passive resistant-diode snubber (RCD snubber).

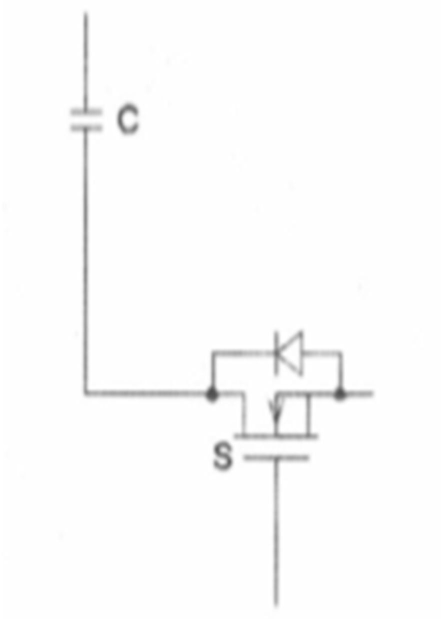


Fig no. 3(b) Active clamp

The active-clamp solution is shown in Figure 3 (B) in which the clamp capacitor is included and an additional switch can be used to achieve the switches of switching (ZVS). However, these circuits require very high voltage clamp capacitors and a complex drive circuit.

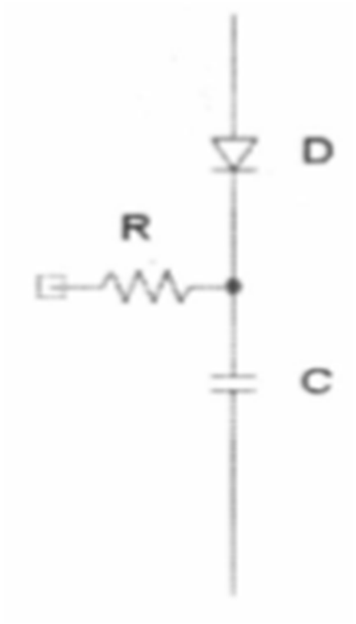
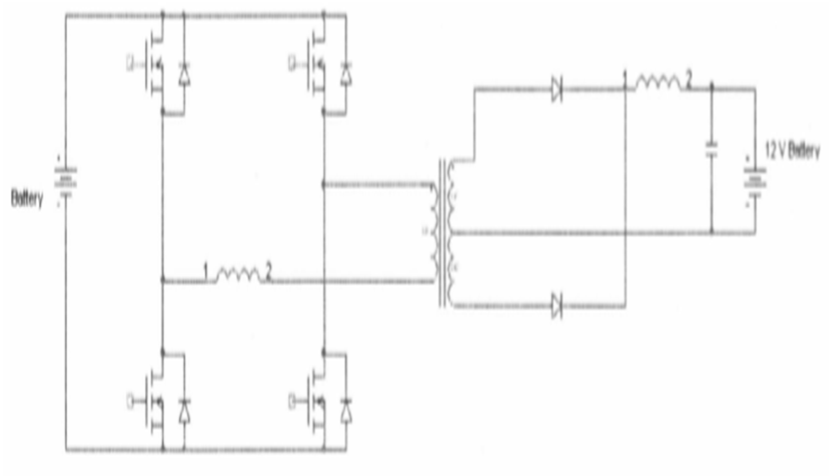


Fig no. 3(c) Active communication

The active communication control scheme is used in so that the primary side switch can be clamped using an inactive RCD clamp shown in Figure 3 (C). A Better Soft Commutating Plan of Active the commutation has been developed in some other converters use coupled industries to cancel the wave in the primary flow. This type of system is especially useful in providing purple free DC segmant in the primary form of the battery. A multi-stage (four-level, 12 MOSFET) non-isolated bidirectional DC-DC converter has been developed for dual voltage architecture in for this circuit, large quantity components and oscillator-based gate control schemes are required. Using a coupled inductors, a hybrid off acent-fed fullbridge has been recently published on primary and current half bridges on secondary with self-operated operated synchronous modification. This converter size is three times smaller than current-fed full-bridge counterpart.



DC-DC converter in electric vehicle
Fig no. 4(a) 12v DC-DC converter circuit

Some examples of DC-DC converters used in hybrid vehicles are shown in Figure 4. A 12-V output DC-DC converter was designed to include soft-switching four door Sedan Honda Civic hybrid (figure 4 (a)) and it was implemented. This soft switching resulted in 22% reduction in size, weight loss, and more Efficiency compared to hard-switched converter used earlier in Honda Insight. This enabled the manufacturers to use the cooler, which consume less electricity and space, thereby increasing fuel efficiency.

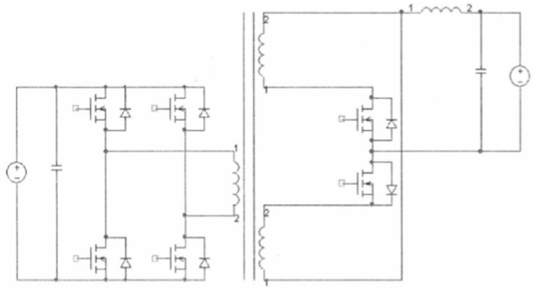


Fig no. 4(b) Battery recharging DC-DC converter circuit with automatic temperature circuit

Figure 4(B) shows DC-DC converter, which automatically feels the temperature and limits currents and voltages such as cut off temperatures are not exceeded. Note that the converters shown in Figure 4 are based on different bridge topologies.

V. HIGH TEMPERATURE ELECTRONICS

Operated electronic circuit high temperature electronics (HIEs) is believed to be in temperature above 125°C. Reliable operations of electronic operations used in automotive applications can be ensured by keeping them away from the load rather than keeping them under the hood (LIT) of the vehicle. For example, under the previous seat, having an electronic control of a transmission system and adding it through long wires and connectors may cause unsafe operation. This compels the designers to keep PEC or on the surface of the engine. The normal range of temperature around the engine varies between 105°C to 140°C. Apart from the surroundings PECs working at temperature, high power levels generate extra heat.

DC-DC converters in EVS will be placed around the vehicle propulsion system in which they will experience high temperatures. Therefore, DC-DC converters built for EV applications should be designed to operate effectively in high temperature. With the transition to the 42-V/300-V architecture of 14-V architecture, the operating power level of PEC is bound to increase. The result is in the high junction temperature of the operating equipment. Apart from this, PEC also has to operate in extreme weather conditions. Commercially available power are limited in MOSFET and IGBT ratings. For high power and high temperature applications, special MOSFET and IGBT are to be constructed. Anti-parallel and rectifier diodes used in converters suffer from reverse-recovery problems, especially when operated at high temperatures and high frequencies. To ensure the safety of the vehicle, reliable operation of PEC is required. To be reliable, PEC, which is kept in high ambient temperature, should have extra cooling system. This increases the cost and size of the vehicle. Wide band gap semiconductors are known for superior thermal conductivity, high breakdown power, and higher maximum operational junction temperatures than their silicon counterparts. Some examples of entire band interval semiconductor are silicon carbide (CIC) and gallium nitride (GaN). CIC and GN-based diodes, MOSFET, and IGBT will reduce the temperature related problems in the near future [28] - [29]. For example, in the [28], high-efficiency, CEC JFET and CIC scotty diode is designed and demonstrated on the basis of high-efficiency DC-DC converter Toyota Prius II converter model! It eliminates the secondary cooling system, thus saving space and cost.

Compared to the favourable electrical characteristics in the CI material, compared to the material, only the higher the level of power and the high temperature is operating. The table gives me some properties of SI and CIC content. As seen in Table 1, high thermal conductivity, the highest maximum junction temperature and lower internal carrier concentration of SIC material make them better for high temperature operation than C devices. However, in the current automotive applications, since the maximum constant temperature below the hood is not more than 150 ° C as the performance of C devices is satisfactory. Micro, electronic components are kept in high performance polymer cover almong with a cooling system. Along with the high operating power level of the vehicle and the large scale production of SIC-based equipment, the benefits of these devices can be used in automotive electronic.

VI. CHALLENGES IN DESIGN OF DC-DC CONVERTER

In addition: Finding solution to reduce and improve the device tension Many other challenges are faced for converter efficiency, electrical electronic circuit designers. DC-DC converters in EVS should be properly controlled for the safety of the passengers. Almost all DC-DC converters section IVhave presented complex drive control. In addition, the dynamics of each circuit should be studied and strictly tested before selecting the DC-DC converter topology, the efficiency of the converter should be evaluated against the overall efficiency of the EV. Depending on this assessment, hardswitch or soft-switch topology should be selected [26]. Good checking about DC-DC converters to meet standard rules! To ensure a safe and unreliable operation, temperature influences should be considered.

VII. CONCLUSION

An overview of high power DC-DC converters applied to electric vehicles was presented. The Requirements, problems and related solutions for bidirectional DC-DC converters were discussed. DC-DC converters play an important role in efficiently delivering electric power to vehicles. With the increasing demand of electricity electronics in electric vehicles, it can be concluded that DC-DC converters will play a major role in future technological advancement of vehicles.

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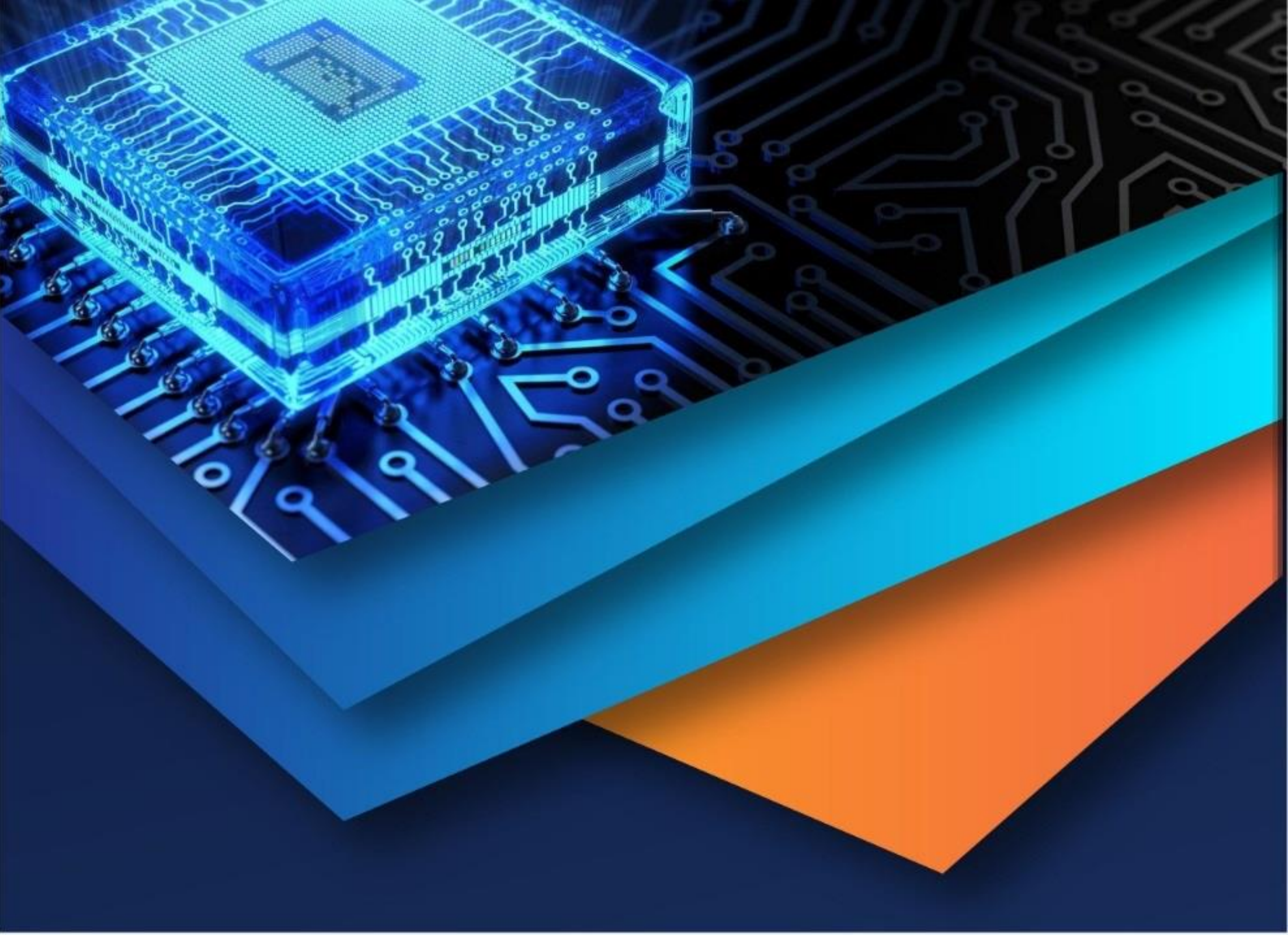

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