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Thermal Simulation of Cold Plate using CFD Analysis

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Abstract: Power electronics devices are now widely used to efficiently deliver electrical power in home electronics, industrial drives, telecommunication, transport, electric grid and numerous other applications. This paper discusses cooling technologies that have evolved in step to remove increasing levels of heat dissipation and manage junction temperatures to achieve goals for efficiency, cost, and reliability. Cooling technologies rely on heat spreading and convection. Applying integrated power electronics to electric drive

systems is causing the need to improve volumetric requirements, ruggedness, weight, reliability, noise levels, and thermal heat dissipation. Modern integrated power electronics have a much higher power density compared to past technologies and companies continue to innovate. The limiting factor in these electronic components is heat removal. In order to achieve adequate cooling at current power densities, design engineers are forced to look beyond standard forced-convection air cooling. Liquid cooling has become an accepted and necessary form of heat dissipation for integrated power electronic modules. A notable cooling technology that has evolved into an efficient and reliable means to dissipate heat is cold plates.

I. INTRODUCTION

In this paper a new design of heat sink for cooling of microprocessors is described. The most important feature of presented solution is that it fulfills two requirements: high thermal capacity (which comes off the use of PCM) and high heat transfer surface and heat transfer coefficient in basic mode of operation. Basic thermal characteristics were established and thermal performance of the heat spreader in unsteady conditions was analyzed by means of numerical methods and computer simulation.The high heat flux cooling of electronic equipments and devices with various methods is reviewed. Particularly heat sinks which are used for natural convection and forced convection as passive device is studied. Based on the papers reviewed, it revealed the research needs to be focused to investigate advanced cooling technology that uses high performance heat pipe, thermoelectric coolers, low acoustical novel micro fans for air cooling, and phase change material based cooling to satisfy the thermal technology needs.

The challenges of cooling electronic equipments may be expected to continue through the remaining of this decade. As the size of semiconductor is reducing day by day and power dissipation is increasing rapidly, so a breakthrough is needed in advanced cooling to reduce cost without sacrificing effectiveness of cooling. Advances in microelectronic processing led to miniaturization of components. According to Moore’s law, the number of transistors on integrated circuits doubles approximately every 18 months. This has resulted in an increase in CPU transistor density, causing rising heat fluxes. Why should this matter for a thermal engineer in the electronics field? What if thousands of data storage components with a working power range of 20W and maximum case temperature of 70^0C are closely packed together like in data centers? The advancements in microelectronics packaging and fabrication have led to the evolution of cooling techniques to meet the resultant high heat flux densities.

Thus, how fast a computer can process information depends directly on how efficiently the processors can be cooled. Thermal systems with air as the coolant are reliable, cheap and easy to maintain. As electronic components get smaller, air is no longer an effective coolant because of low thermal conductivity and thermal capacitance. Liquid cooling provides a means by which the thermal resistance can be reduced significantly. Liquid cooling can be classified as indirect liquid cooling, and direct liquid cooling. Using micro channels is a method of indirect liquid cooling. Micro channels can be machined onto the chip itself or machined onto a substrate and then attached to a chip or an array of chips. Although there are advantages with micro channels, factors like clogging and formation of local hot spots have not yet been resolved. Two phases boiling in micro channels is another indirect liquid cooling method. The flow inside the micro channels is highly unpredictable and can produce large voids and multiple flow regimes inside tubes.

II. INPUT PARAMETER

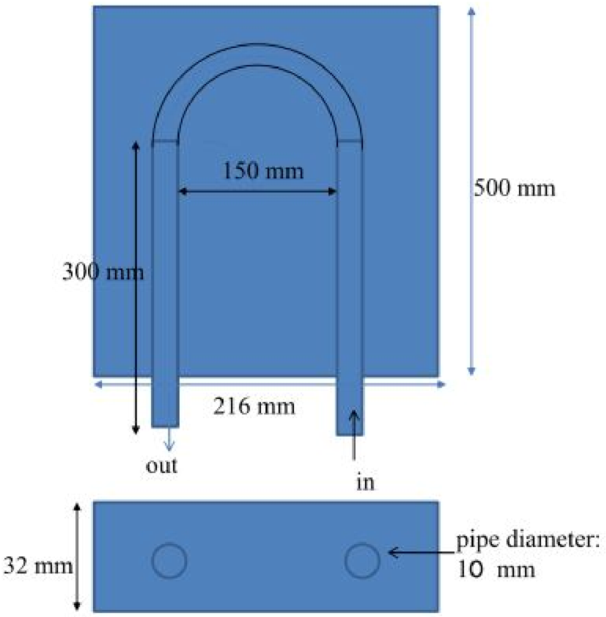

Fig 1 Cold Plate

A. Cold plate Specifaction

Length: 500 mm
Breadth: 216 mm
Width: 32 mm
Pipe length: 300 mm + 300 mm +200 mm = 800 mm
Pipe dia: 10mm
Distance between to pipe: 150 mm
Coolent Used: Ethylene Glycol
Ambient air velocity: 0.002m/s
Inlet Temp.: 20^0C

III. RESULT

A. FIrst Case: Liquid Flowrate with inlet velocity 0.02 m/s

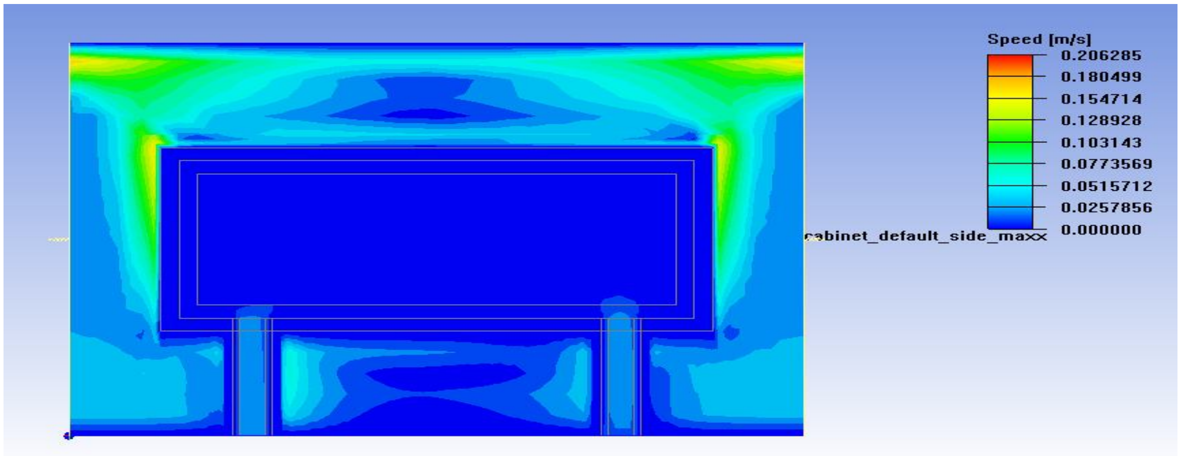

Fig 2 Velocity Profile

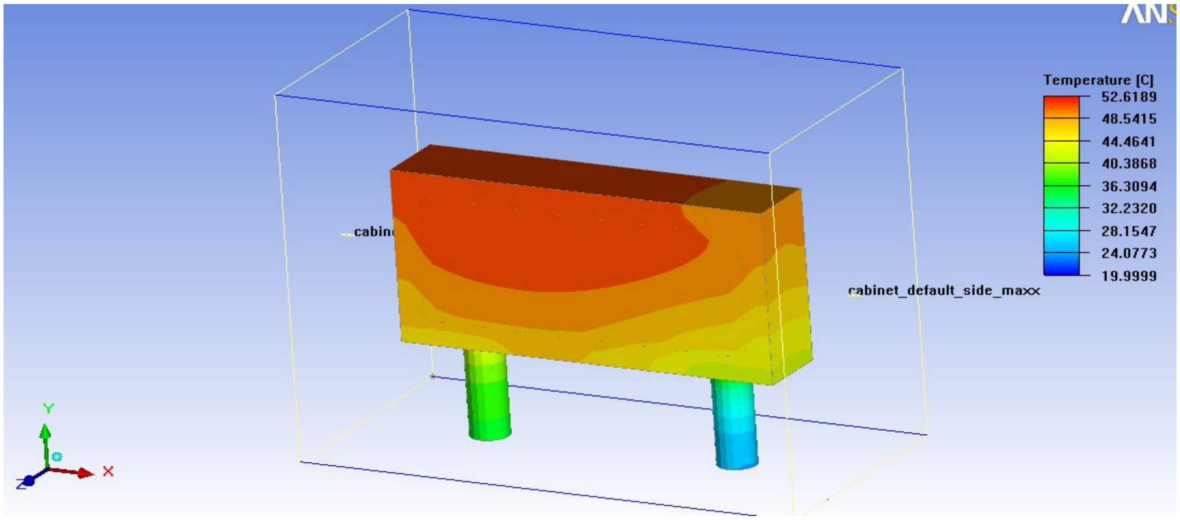

Fig 3 Temperature Profile

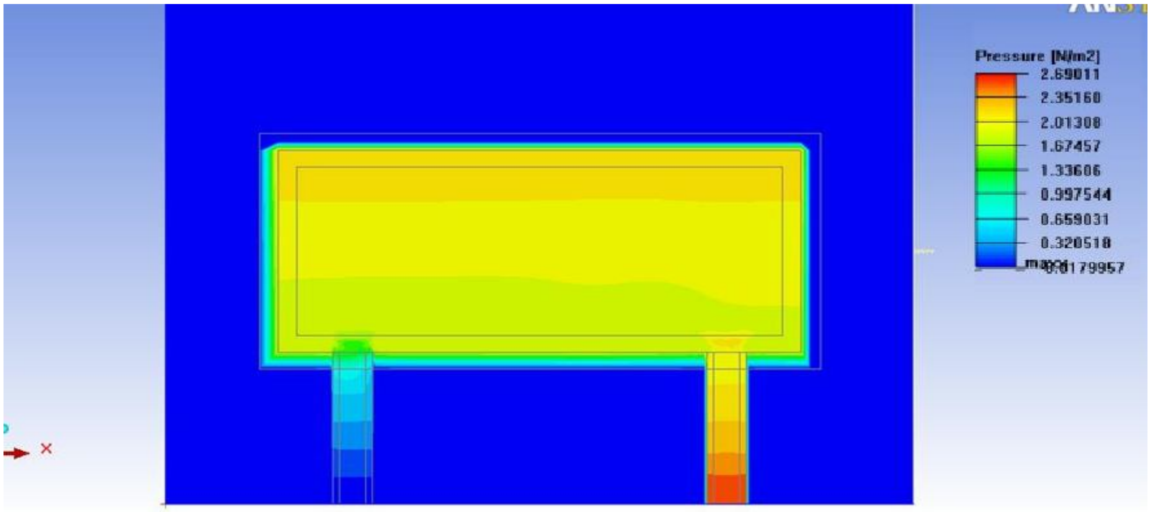

Fig 4 Pressure Profile

B. Second Case: Liquid Flowrate with inlet velocity 0.04 m/s

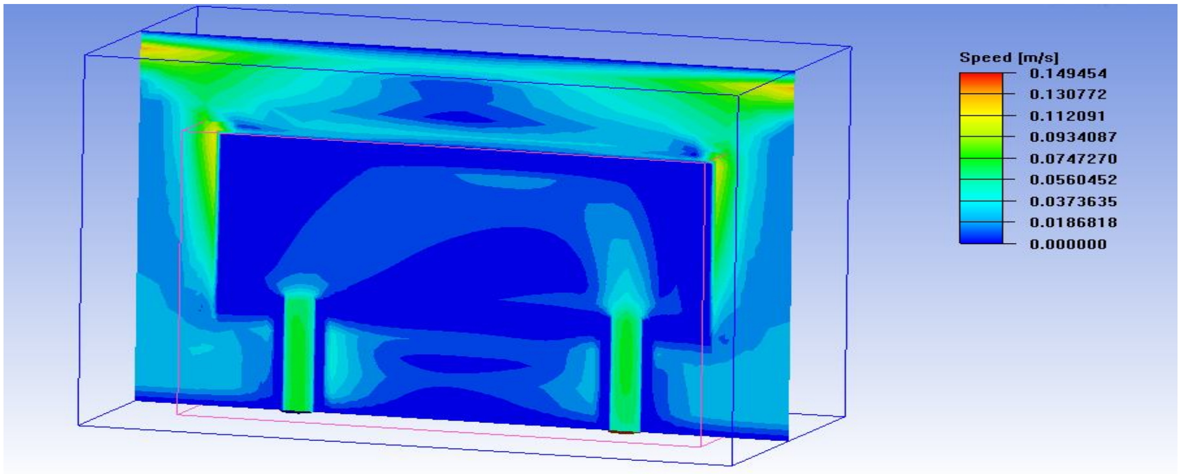

Fig 5 Velocity Profile

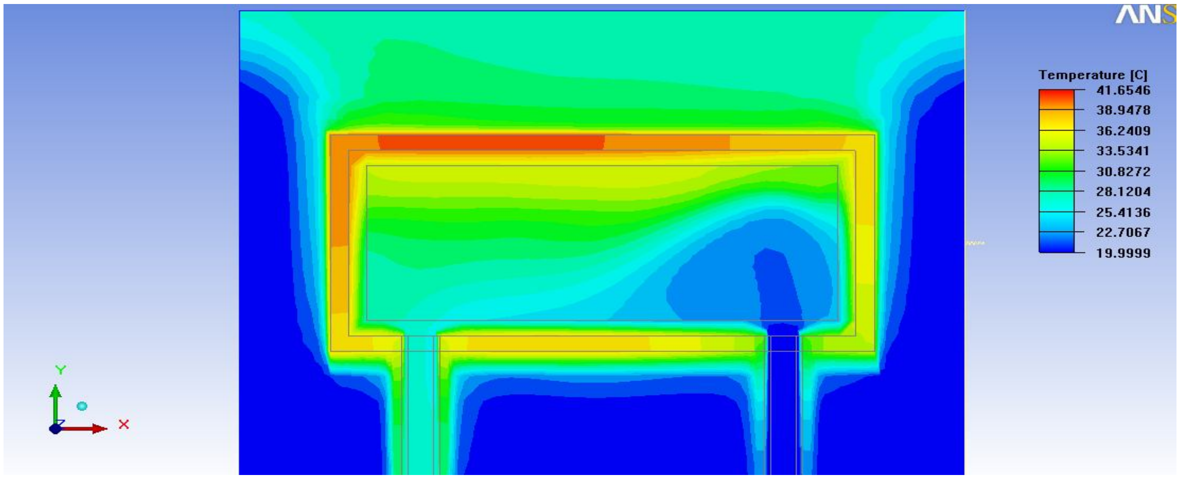

Fig 6 Temperature Profile

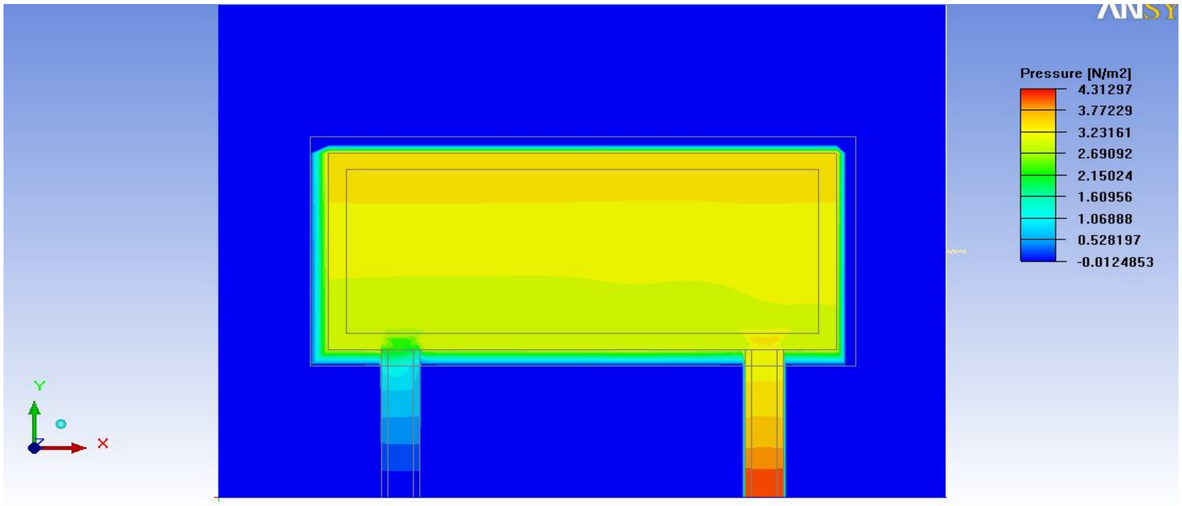

Fig 7 Pressure Profile

C. Third Case: Liquid Flowrate with inlet velocity 0.06 m/s

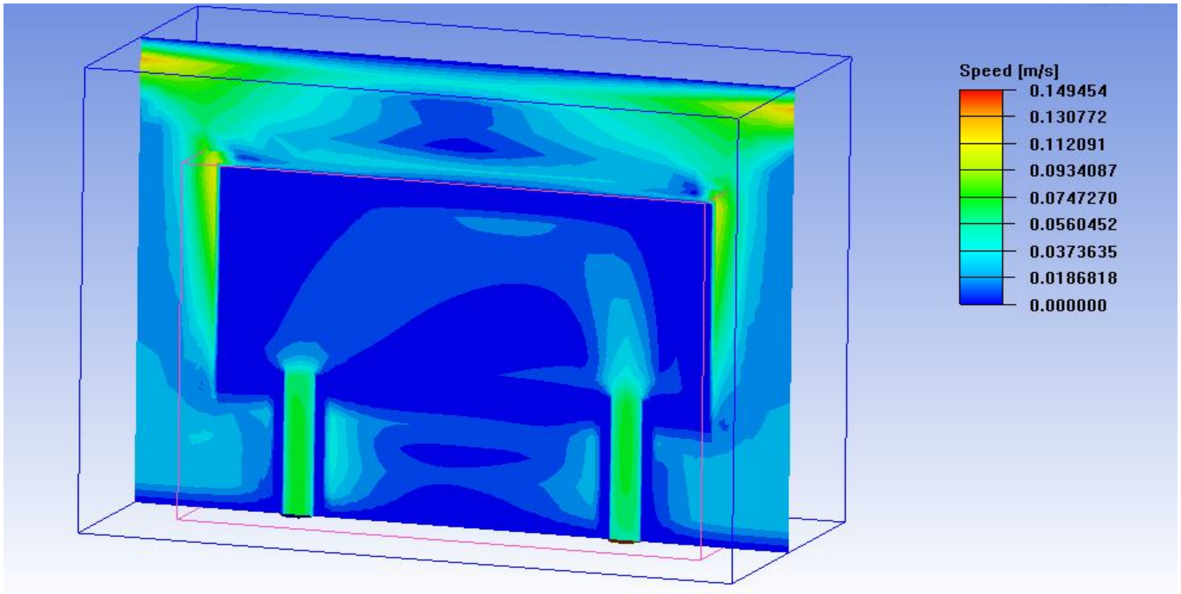

Fig 8 Velocity Profile

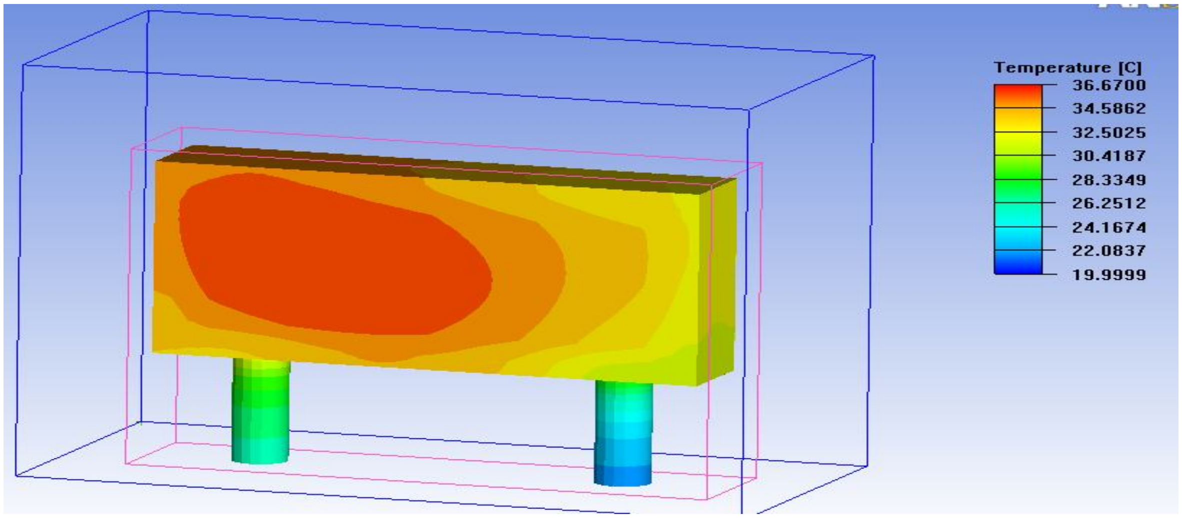

Fig 9 Temperature Profile

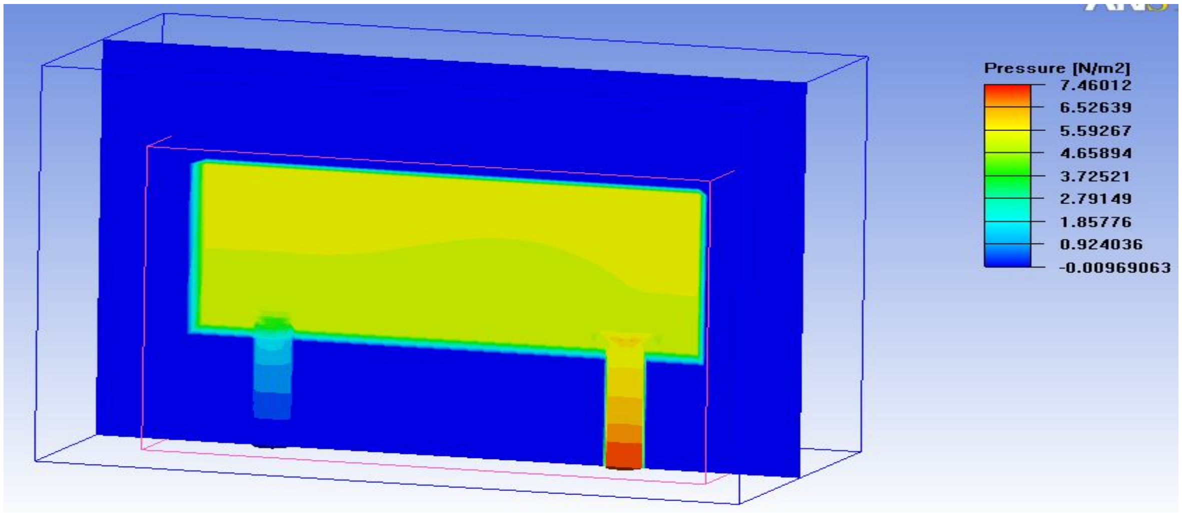

Fig 10 Pressure Profile

Case	FIrst Case: Liquid Flowrate with inlet velocity 0.02 m/s	Second Case: Liquid Flowrate with inlet velocity 0.04 m/s	Third Case: Liquid Flowrate with inlet velocity 0.06 m/s
Inlet Velo. (m/s)	0.02	0.04	0.06
Cold Plate Temp. (^{0}C)	52	41	36.6
Pressure (N/m^{2})	2.69	4.31	7.41
Inlet Temp. (^{0}C)	20	20	20
Outlet Temp. (^{0}C)	30	28	26

IV. **CONCLUSION**

As inlet velocity of etylyne glycol solution in pipe of cold plate increases from 0.02 m/s to 0.06 m/s, cold plate temperature decreases from 52^{0}C to 36.6^{0}C which is beneficial for life of cold plate but upto certain pressure. However as inlet velocity of etylyne glycol solution in pipe of cold plate increases from 0.02 m/s to 0.06 m/s with constant inlet temperature of 20^{0}C, the outlet temperature decreses from 30^{0}C to 26^{0}C which means ethylenlene glycol solution is not heated to extreme value which is also beneficial for life of cold plate.

Hence it concludes that inlet velocity of liquid flow rate increses upto certain limit with constant inlet temperature increases life of cold plate.

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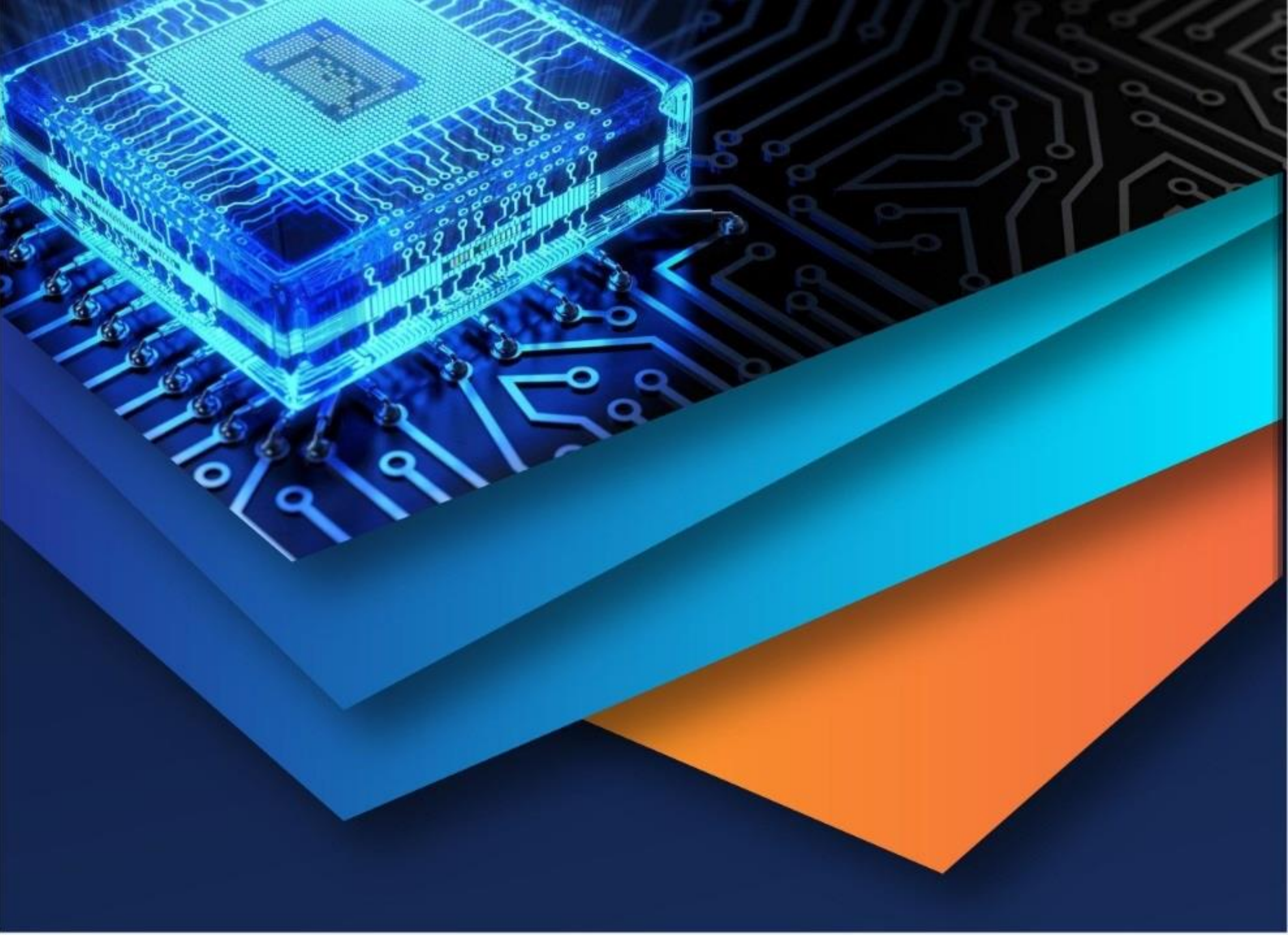

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