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A Review on DC Microgrid and Decentralized Approach

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Abstract: DC Microgrid is going to be a very important part of the Distribution system soon. The given circumstances have forced us to find how to utilize renewable energy sources in the integration to increase its reliability in our day-to-day life. This paper gives a good idea of the DC Microgrid and various methods being used for the controlling part of it. As day by day cost incurred in renewable energy generation is decreasing, we need to find out significant parts where this kind of DC Microgrid can be utilized to provide electricity in all parts of the country.
Keywords: DGUs, ImGs, DMA, OXD, DC Microgrid.

I. INTRODUCTION

In recent advancements, renewable energy is getting popular in India due to the rise in charges from distribution companies. One of the concerns that arise in installing renewable sources is the management system needed for it. For this scenario, The DC Microgrid has been introduced, and it provides several advantages for efficiently integrating renewable energy sources into the supply chain. Even in islanding mode, microgrids can be considered self-sustained electric systems. India has a very diverse demography and microgrids can play a vital role in electrifying them. Considering traditional ways, renewable energy sources have different characteristics which are difficult to tackle. For this reason, we need to have an efficient way of connecting distributed generators. In the case of the centralized method, we have few disadvantages like a failure of the central unit leads to make the entire control inefficient. To consider the distributed control strategy, we have to take into consideration that it is based on the communication system. The delay caused in the communication system might become a reason for the losses. In an AC system, we have a decentralized method which is called as Droop method. In this method, circulating current can be decreased and good load sharing can be achieved. But in this method, we need to know the circuit parameters otherwise scalability can be an issue. Though the distributed generator droop control is considered as the popular method for implementation still there are some drawbacks. One of the drawbacks is based on sharing of the load as it is considered negligible impedances. Second is the voltage regulator which is hampered due to load. An alternative method has been introduced for paralleling the DC converter based on fully decentralized current control. In Droop control, the system has been modeled concerning Thevenin's equivalent but in the proposed method, it has converted to Norton's Equivalent. To generate the current reference, it uses the power available at the distributed generation as well as a voltage which shows the gap between the reference voltage and present voltage

II. METHODOLOGY

Microgrids are small-scale electrical networks that are disconnected from the main grid and can run independently. Microgrids offer increased dependability, lower electricity prices, and better integration of distributed sources, among other advantages. Moreover, rectifiers already give DC power to the majority of loads, therefore DC-linked load can operate more smoothly. As a result of their efficiency, economy, and dependability, DC microgrids will become the best alternative for the small local electricity sector soon.

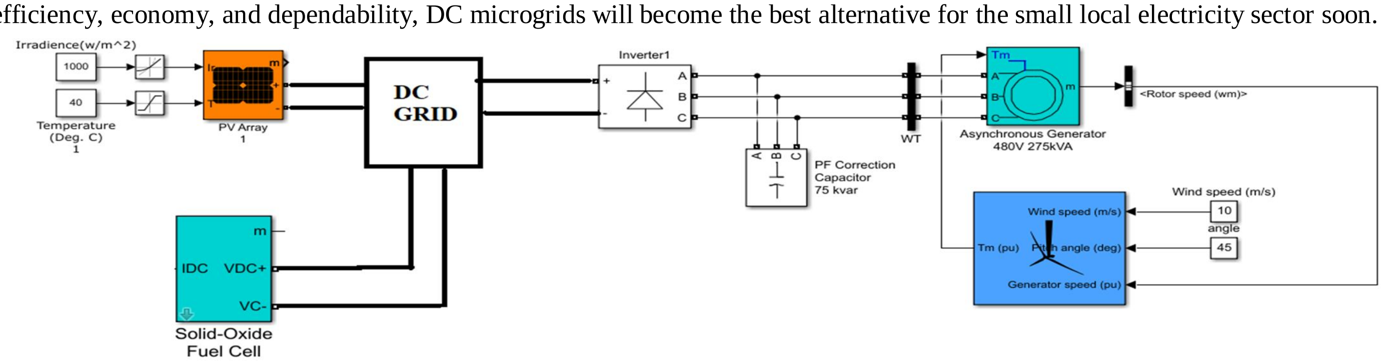

Fig. 1 DC Microgrid Model

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A. General Control Scheme For Dc Microgrid

This work proposes a control strategy for meeting the three basic needs of DC microgrid functioning in a wholly decentralized way. Matching the voltage at every DG's output to a reference voltage Vref is the first and most essential control goal. The second control purpose is to react proactively to the amount of input power and Microgrid loads, irrespective of many other parallel elements. Ultimately, the final control aim is to promote adequate current distribution to assure optimum power distribution and thermal management. In this part, the major components of the suggested control technique are presented. The Norton concept, depicted in Fig. 1 for the twin DGs scenario and recently updated for the n-instance, depicts the behavior of a power converter's endpoints when connected to a renewable energy source, limiting its reply between open and short circuit via the values of ISi and RNi. Also because the dielectric characteristics of the power circuit converter dictate ISi and RNi, it's assumed that RNi has a high operating value, whilst ISi can be given flexibly relying on the power source. A primarily closed-loop system for the DC microgrid is shown in Figure 2. The incorrect signal between a predetermined voltage reference for each DG's output, Vref, and the output voltage Vi is Vi = Vref –Vi. To establish the current reference INi for each converter in each DGi, the DCC block uses Vi and the power source connectivity PDGi. The coupling terms from other DGs and for the loads ILi affect each DGi, which are expressed by summing. As shown in the next subsection, the DCC is based on a switched current generator.

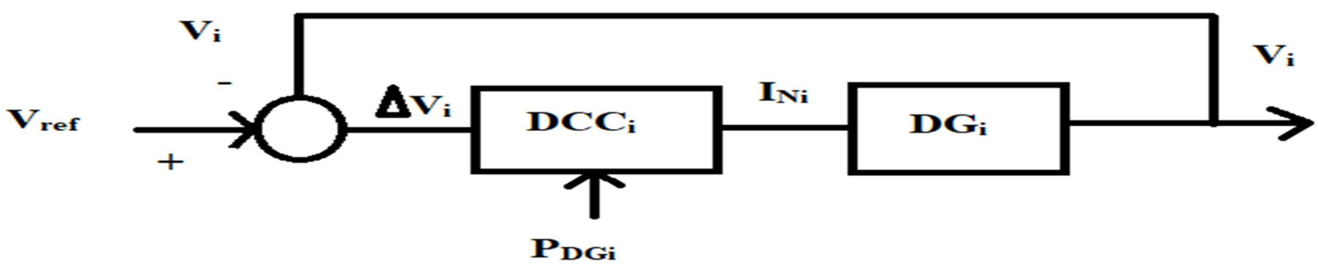

Fig.2 DC Microgrid Control Strategy

B. Centralized Approach

Figure 3 shows the centralized controller. In figure, the major portion shows the controller, non-moveable converter, and the DC Supply. The grid dc bus voltage is controlled by the master module, while the current is controlled by the slaves. Although the centrally managed load sharing, this control system has the disadvantage of requiring a fast communication link so because slave converters reference currents are provided by the master block. A broken communication link or a defective master block might bring the entire system to a halt. As a result, this system should be designed with some redundancy to avoid or lessen the likelihood of failure

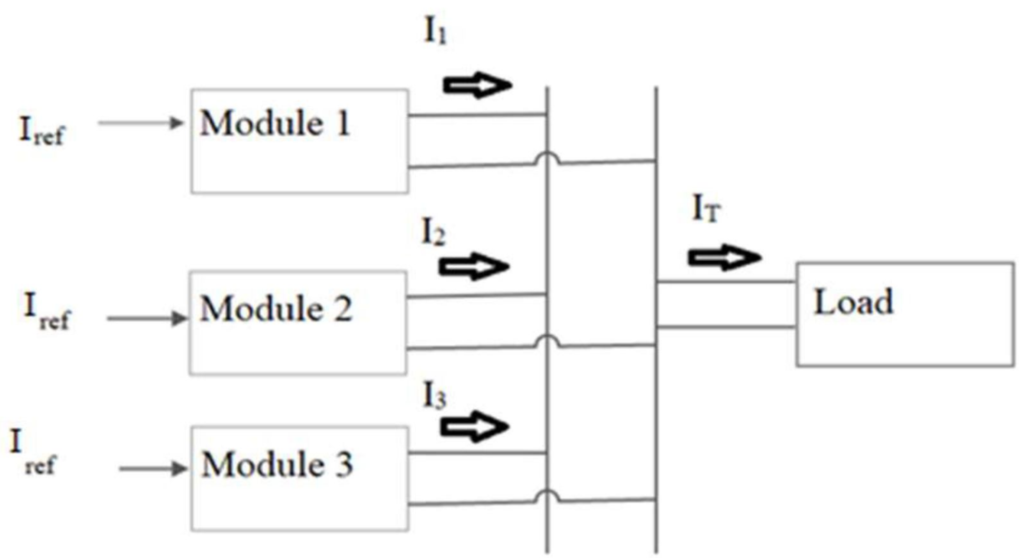

Fig.3 Centralized Approach for DC Microgrid

C. Decentralized Approach

The voltage droop control technique is depicted in Figure 2 is a block diagram. Each droop controller simulates an impedance response, lowering the converter output voltage as the input current increases. This method encourages current sharing among paralleled converters in a dc microgrid without the use of a central controller. The voltage controller of the dc-dc converter is done using the PWM technique.

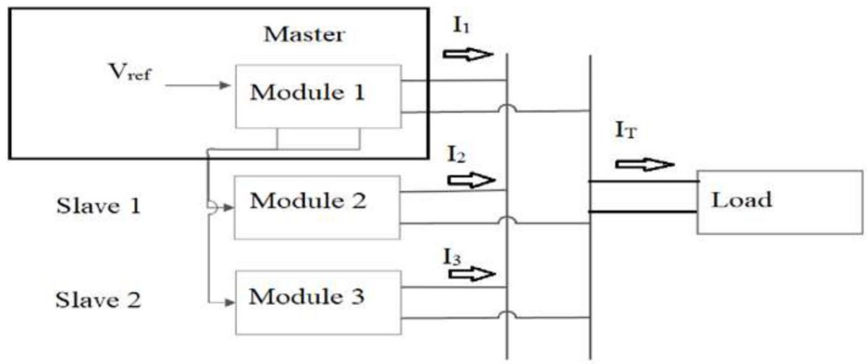

Fig. 4 Decentralized Approach for DC Microgrid

III. RELATED WORK

In the paper "A Decentralized Scalable Approach to Voltage Control of DC Islanded Microgrids." An innovative method is presented to connect all the islanded distributed generators. [1] The controller plays a vital role by setting all the distributed generators to a given set point. Offline controllers are set to operate in plug and play mode, which gives: 1) the ability to add/remove a DGU without affecting the stability of islanded microgrids considering the optimization problem; 2) in case one generator I have taken out then adjacent controllers are informed about their removal, and 3) in the same scenario their respective controllers are also provided with the information of the removal. Merely data from the associated DGU and lines associated with it is used in the synthesis of a local controller. As the ImG dimension expands or DGUs are changed, this ensures total scalability of control synthesis. Nonetheless, we essentially assure that the closed-loop system will remain within the set boundaries. By using the simulation we can assess the given controller performance. In this work, a decentralized approach is provided for maintaining the voltage stability of the microgrids. The key advantage of the suggested technique is that a very small number of the individual controller must be changed whenever DGUs must be plugged in or out. All the controllers must be provided with the linkage of a higher rank control layer to manage the power in the given flow. To this end, we'll see if and how principles from ImG secondary control may be applied to our situation. In this paper, "Distributed control of multi-time scale", DC microgrid based on ADRC N – source Hamiltonian concept controller for distributed controllers is proposed with a decentralized mode adaptive concept. [2] The droop control is widely used for the decentralized concept of microgrids. Droop controller can't decide whether to remove any source or not. These drawbacks can be removed with the help of a centralized controller to provide optimization in the system. A centralized controller provide optimization in the system. A centralized controller will not be able to deal with the failure in the main controller. The given system fills the difference between the droop control which is the traditional method and the centralized controller by providing a system away to help a particular system to maintain the fluctuations between the source and load, along with reducing centralized control's communication requirements, thereby increasing resiliency and scalability. The DMA's result is evaluated to that of a centralized optimal energy destruction power distribution approach and a Hamiltonian-based droop control architecture when it is ready to use.[3] Ultimately, the suggested decentralized, mode-adaptive technique is demonstrated to be an optimal and realistic alternative from both droop control and centralized control schemes for a significantly huge number of converters providing a microgrid. In the paper, "AC versus DC distribution systems: Did we get It right?" We now have a primarily AC electrical distribution system, with an engineering foundation that dates back over a century. [4] Because air conditioning distribution networks have functioned successfully, we should evaluate what opportunities we have seized or declined as a result of their dominance regularly. It need to verify the various benefits of adding a little bit of the DC distributed generator in the existing AC system. This paper provides the key benefits of the current AC system over the DC system. This study will concentrate on premise distribution and low-voltage distribution systems. It gives a brief idea of the cost incurred in the working of AC as well as DC system architecture In the study conducted it has been determined that the DC system is having poor efficiency of conversion than the AC system. With this condition, if houses or societies are powered by Fuel Cells then it might match the cost of the AC system. The framework has been laid for evaluating low voltage and premise power distribution networks that are both dc and ac. The benefits of both ac and dc systems were discussed, as well as just a few current issues that may have an impact on the commercial inclusion of dc distribution into our existing power systems. We looked at how series converting losses might affect the feasibility of premise dc distribution after incorporating the results of a study that revealed conductor losses in manufacturing premise ac and dc distribution systems. To provide a complete evaluation of such fictitious energy systems, a standardized technique was developed. Due to inefficiencies of the combination transformer rectifier able to transform bulk ac power to premise dc electricity, it was thought that using home dc distribution solely would have been unnecessary. However, negligible conversion losses have been demonstrated for fuel cells or other local dc generation that provides visibility into a premise dc bus. This was especially true when comparing to a basic dc generator which had to convert its energy to ac almost quickly. Lower voltage microgrids are widely used to power critical loads like data centers and distant communication devices. As a result, to support possible load demand rises, redundancy and enough energy capacity are required. This is accomplished by raising the number of distributed energy storage units in the energy storage system. When scattered energy storage units are employed, microgrid control becomes more challenging because stored energy must be decided to dodge deep discharge or overpricing from one of the energy storage units. To lessen voltage variance on the common dc link, the simulated resistance is also modified. Since these units are self-controlled just using local variables, the Microgrid can operate even without the utilization of communication systems. The hardware in the loop research shows the feasibility of the proposed technique. The suggested use of such a fuzzy control method to adjust the simulated resistance guarantees that the stored energy balance is maintained and that voltage variation is kept to a minimum. [5] Additionally, this method is flexible, adjustable, and does not require centralized control. When a new energy storage unit needs to be updated to the microgrid, it can be used with little alterations. Furthermore, when compared to traditional methods, the suggested model results in rapid charge in the batteries. Moreover, it is shown that the fuzzy controller prioritizes the stored energy balance, and once the stored energy balance is achieved, the fuzzy controller maintains to manage the voltage deviation. Because dc voltage is utilized for bus signaling, it's vital to note that a steady-state error is always desired in the dc bus. In general, the FIS proposed in this study has demonstrated its utility in addressing various control objectives. Another advantage of the fuzzy controller is that it is simple to scale the same FIS to different Rd values. Furthermore, the microgrid can run reliably in a variety of settings without the use of communications. An overview of current improvements in DC power systems is offered in the publication "DC microgrids and distribution systems: An overview. "Researchers explored numerous of the concerns that need to be considered during this transition interval from present conventional power systems to modern smart grids containing DC microgrids, due to the greatly increased interest that DC power systems have recently gained." These researchers focused their efforts on determining the feasibility of implementing DC distribution in a given application, as well as various design-related issues of DC distribution, such as the system architecture or voltage level, and the challenges involved with DC power system protection. In the given work categorized, presented, discussed, and assessed these research efforts. This study provided a comprehensive overview of research on DC systems as well as the given various DC microgrids. It can be considered as a true measure and seeing where we sit and what we all need to continue pushing forward with these efficient, smart, environmentally sustainable, and budget DC power systems. With this perspective, it is plausible to conclude that the viability of embracing DC systems has now become obvious, especially in light of advanced power electronics technology. The choice of DC system voltage, modeling, and grounding have all been extensively studied. Nevertheless, because this is a very interesting subject of research, there still is a great of remains to be undertaken. A whole system design, comprising all of its practical features and effects, must be properly investigated. a little more is necessary to conduct much more complete research into the DC equipment that was originally designed for AC operation. Scientific investigations could concentrate on DC power system structure and architectures to satisfy the special needs of various loads, such as pulse loads. Hierarchy Control—A Basic Strategy to Standardization for Droop-Controlled AC and DC Microgrids Microgrids (MGs) are essential parts for ensuring optimum and distributed energy resources, as well as distributed energy storage systems, in both AC and dc configurations.[6] Efforts were made to standardize these MGs during the last several years. This work presents centralized structures created from ISA-95 and electrical forecasting guidelines to give MGs intelligence and adjustability in this regard. The suggested hierarchical control system has three levels: 1) The primary control uses the droop approach, which includes an output-impedance virtual loop; 2) the secondary control allows the primary control to restore deviations, and 3) the tertiary control handles power flow between the MG and the external electrical distribution system. The feasibility of the suggested technique is demonstrated using results from a hierarchical-controlled MG. This paper provided a broad technique for hierarchical control for MGs. The hierarchical control is handled by ISA-95. Three levels of control are used to both ac and dc MGs. Mostly on one end, the control system of ac MG is comparable to that of a large-scale power system, ac grid, emphasizing the correlation between the two.

Hierarchical control of dc MGs, on the other hand, gives new features that can be useful in distributed power systems activities such as communications and dc-voltage networks. As a consequence, flexible MGs may be built that can provide full ac or dc communication with the ac or dc distribution model while also controlling power flow from the MG to all these systems.[7] Additionally, these MGs can operate for both island and stiff-source-connected states, with a smooth transition in between two. This proposed approach can be used to connect several microgrids, leading to an SG. In this method, the tertiary control might operate as the cluster's primary control by providing high-level inertias to link more MGs. In this aspect, MGs will operate like just a voltage source with high inertias. As an outcome, the cluster tier's secondary control may transmit all the references with each cluster of MGs to recover frequency and amplitude. Lastly, the tertiary group control can then either determine the active and reactive power that this group will provide or serve as the main controller to link other groups. As a consequence, the control structure could be scaled as desired. The system becomes much more adaptive and expandable as a result of this strategy, permitting it to include an increasing number of MGs with needing to alter the regional hierarchical control scheme with each MG.

IV. CONCLUSION

From the above discussion, the bottom line is the DC Microgrid plays a vital role in the distribution system as well. The various methods give a brief idea about how we can utilize the system with the best efficiency. As the scarcity of nonrenewable energy is among us, we need to find out other renewable options which can help us in the generation of electricity. The decentralized approach also provides a good idea of why one should opt for it. The main reason is it doesn’t hamper the whole system whenever a small fault occurs. The maintenance of such a system is easy and of great reliability. Integration of renewable sources is going to play an important role shortly. By this, we can understand how much importance is DC Microgrid is going to get soon.

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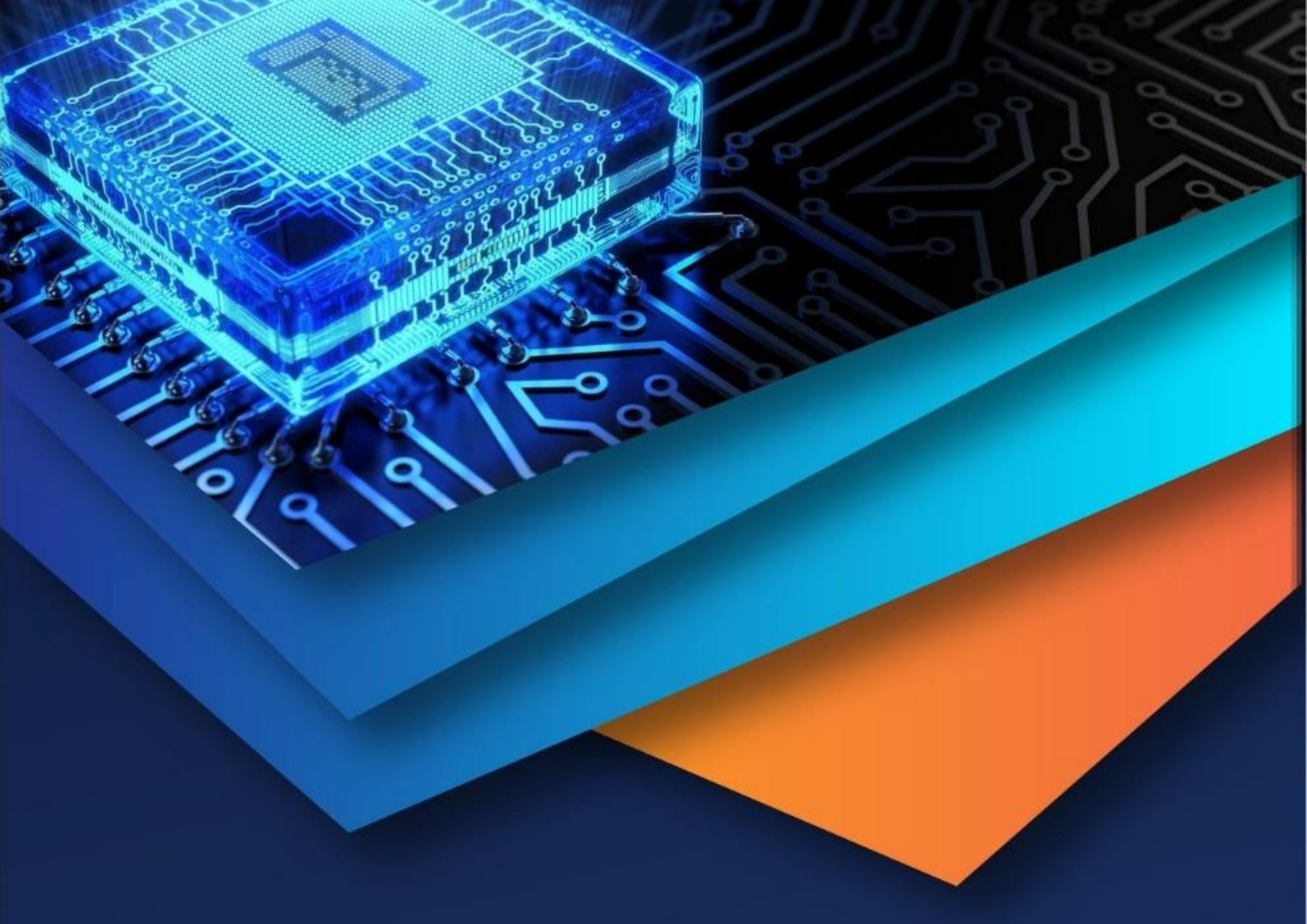

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