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Investigation of Sensitive Load Location for Incorporation of DG

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Abstract— In recent years with ever increasing load demand by customers and difficulties for construction of new power plants, transmission lines and substations, power distribution system is experiencing an urgent need of distributed generation (DG) sources. Employing DG in a distribution network has several advantages. While introducing DG in a network, it is essential to determine the adequate size, number and location of DG units. The poor selection of location would lead to higher losses than the losses without DG. There are several issues pertaining to interconnecting distributed generation to grid such as voltage rise, high losses, and negative impact on power quality, reliability and protection. All the issues can be eradicated only when a proper attention is given to find a suitable location of DG units. The poor selection of location would lead to higher losses than the losses without DG. Therefore, the aim of this paper is find a suitable location for the incorporation of distributed generation (DG) in a power system by carrying out a comprehensive study of the impact of load variation on active and reactive power losses. This will provide the information of those load sensitive location DG should be installed. The analysis of results shows that an increase in load always leads to an increase in losses but the degree of increase in losses is different for different load buses.

Keywords—Distributed Generation, Load Sensitivity, Newton-Raphson method, Active & Reactive losses, Load flow

I. INTRODUCTION

In recent years with ever increasing population, more load demand by customers and difficulties for construction of new power plants, transmission lines and substations [1], power distribution system is experiencing an urgent need of distributed generation (DG) sources [2]. DG also called decentralized generation, dispersed generation, and embedded generation and is defined as a small scale power generation system connected at distribution end in order to cater urgent electric demands of customers and to provide high quality electric power. Employing DG in a distribution network has several advantages such as reduction in line losses, emission pollutants and overall costs due to improved efficiency, and improvement of voltage profile, power quality, system reliability and security [3]. Both renewable and non renewable technologies can be used for DG.

Distribution system provides a final link between the high voltage transmission system and the consumer. Electricity networks are in the era of major transition from stable passive distribution networks with unidirectional electricity transportation to active distribution networks with bidirectional electricity transportation. Distribution networks without any DG units are passive since the electrical power is supplied by the national grid system to the customers embedded in the distribution networks. It becomes active when DG units are added to the distribution system leading to bidirectional power flows in the networks [4]. In an active distribution network the amount of energy lost in transmitting electricity is less as compared to the passive distribution network, because the electricity is generated very near the load centre [5].

While introducing DG in a network, it is essential to determine the adequate size, number and location of DG units. The DG units must be placed at most load sensitive points. These are those points which show a high rate of increase of losses as the load increases beyond certain limit. The poor selection of location would lead to higher losses than the losses without DG. The arbitrary introduction of DG alters the characteristics of the distribution network. There are several issues pertaining to interconnecting distributed generation to grid such as voltage rise, high losses, and negative impact on power quality, reliability and protection.

If DG is connected to a network section, it will alter the active and reactive flows and hence change the voltage drop along the lines. DG leads to a significant voltage rise at the end of the long, high impedance lines [6, 7]. A rise in voltage occurs if there is low demand and high generation, which leads to a large amount of power flow along lightly loaded lines with high impedance [8].

Generally, DG helps to decrease current flow in the feeders there by reducing the power losses. In electrical system, the line loss occurs when current flows through distribution systems. The amount of losses depends on current flow and line resistance, which can be reduced by decreasing line current or resistance or both. DG minimizes line loss because it decreases current flow in some part of the network. However, DG may increase or reduce losses, depending on the location, capacity of DG and the size of DG, as well as on the topology of the network and the system configuration [9].

DG can have a considerable impact on power quality within the distribution system. Voltage flicker refers to dynamic variations in the system voltage. It can be an issue with wind power, given the variable nature of its energy source. However, voltage quality can be improved by finding optimal points of connection with the network to minimize the inverse impact of the connection of DG to Medium Voltage distribution systems.

Reliability has always been an important issue in power system. Reliability of distribution system can be improved by connecting DG to the system but its improvement depends on the nature of connection of disconnects. If disconnects are installed properly then improvement will be more. But it will be maximum if the DG units are optimally located in the system. [10]

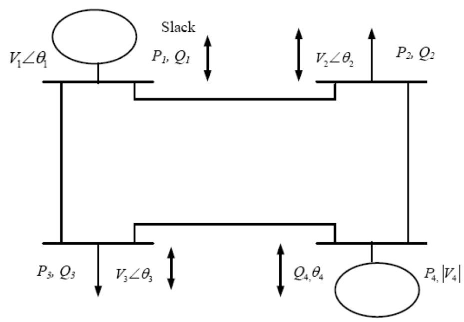

Fig. 1 Basic power distribution system [13]

The majority of protection systems for distribution network operate based on unidirectional power flows from the transmission network down through the lower voltage networks [11]. As DG changes the flows on the network, this can lead to problems with the operation of the protection system such as false tripping [12].

Thus, it is clear that several issues arise due to the incorporation of DG. All the issues can be eradicated only when a proper attention is given to find a suitable location of DG units. The poor selection of location would lead to higher losses than the losses without DG. Therefore, the aim of this paper is to locate a suitable location for the incorporation of distributed generation (DG) in a power system by carrying out a comprehensive study of the impact of load variation on active and reactive power losses. This will provide the information of those load sensitive points where DG should be located. The methodology is explained in Section II followed by results and discussion in Section III and finally conclusion in Section IV.

II. METHODOLOGY

In this paper, an investigation is carried out to find a suitable location for the incorporation of DG in a power system by study of the impact due to load variation. It will provide the information about the sensitive load location where DG should be installed. The study has been carried out on a 14-bus power system which includes one reference bus (R1), four generator (G2, G3, G6, G8) buses and nine load buses (L4, L5, L7, L9, L10, L11, L12, L13, L14). The investigation consists of two parts. In first part, each load bus is subjected to percentage load increase of 1%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50%. In this way, respective overall active and reactive losses are calculated by using Newton-Raphson method. In second part of investigation, all the load buses are subjected to overall percentage load increase simultaneously. And overall active and reactive losses are calculated by using Newton-Raphson method. Fig.2 shows the overall steps of investigation.

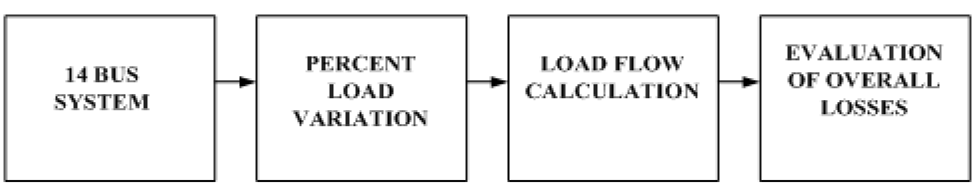

Fig. 2 Overall steps to study the impact of load variation.

III.RESULTS AND DISCUSSION

After subjecting the bus system to the percentage load increase in two different ways, respective active and reactive losses. Fig. 3 to Fig. 8 describes the results. In Fig. 3 and Fig. 4, x-axis shows load bus number while y-axis shows active losses for percent increase in load. Similarly, in Fig. 5 and Fig. 6, x-axis shows load bus number while y-axis shows reactive losses for percent increase in load. For Fig. 3 and Fig. 5 percent increase in load is from 1%, 5%, 10%, 15% and 20%, whereas Fig. 4 and Fig. 6 show present increase of load from 25%, 30%, 35%, 40%, 45%, and 50%. It is observed that for all the load buses, with an increase in load, both active and reactive losses increases.

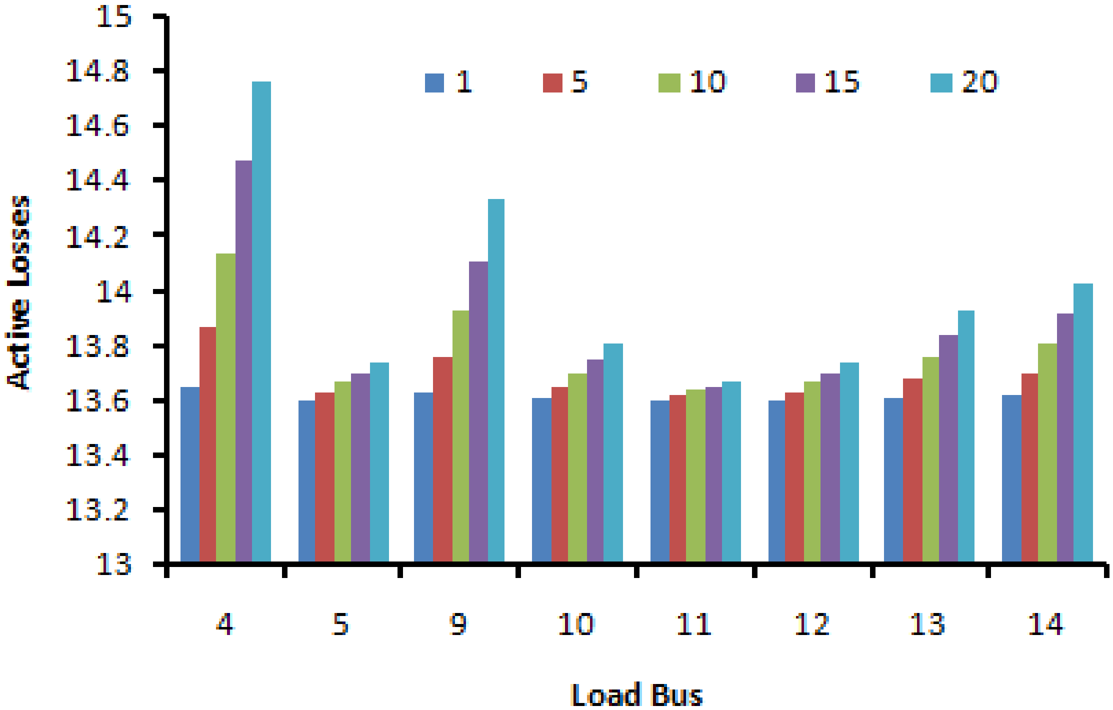

Fig. 3 Variation of active losses as the load increases on load buses from 1% to 20%

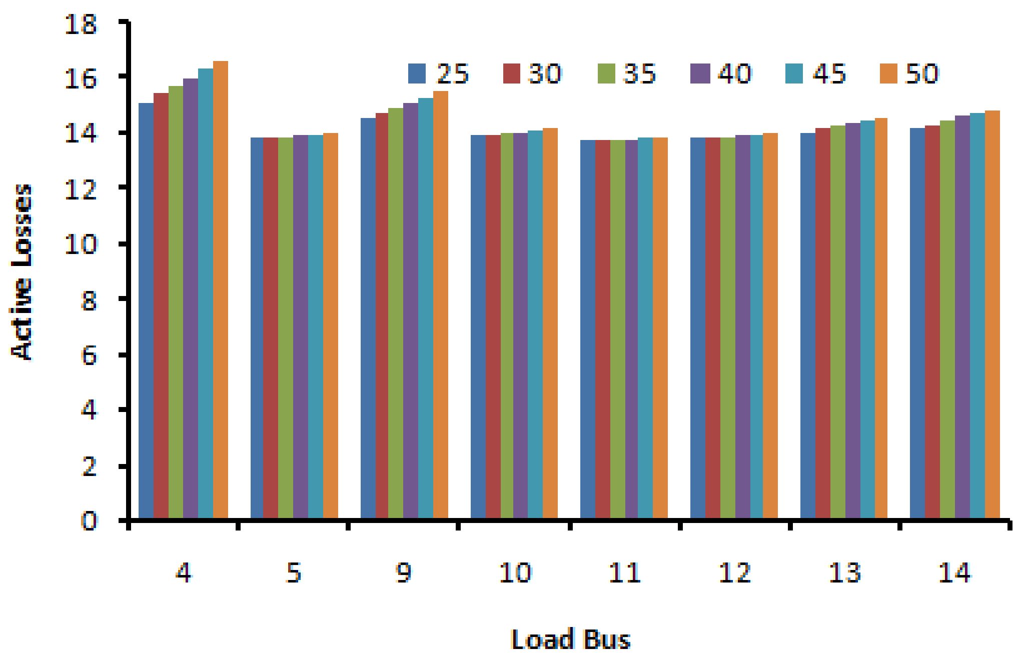

Fig. 4 Variation of active losses as the load increases on load buses from 25% to 50%

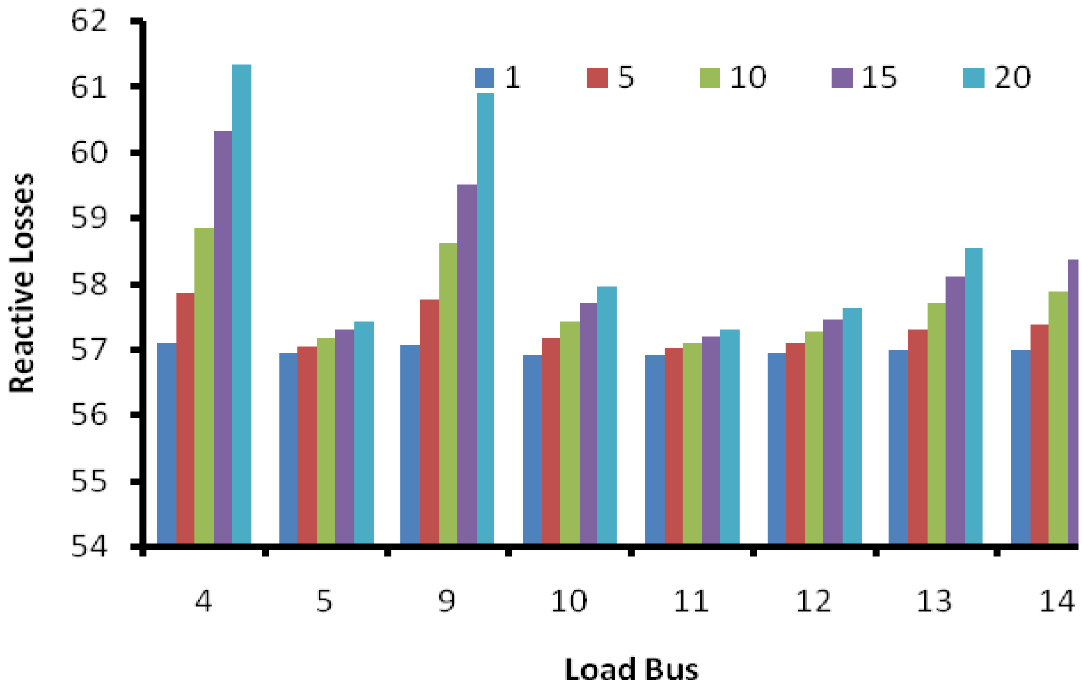

Fig. 5 Variation of reactive losses as the load increases on load buses from 1% to 20%

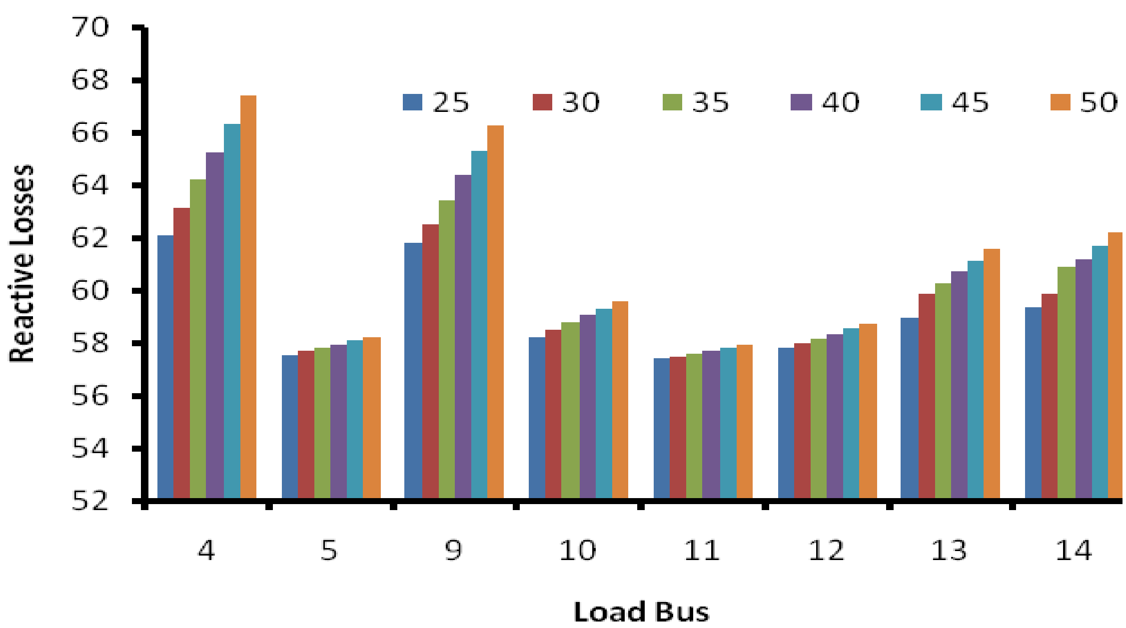

Fig. 6 Variation of reactive losses as the load increases on load buses from 25% to 50%

At particular bus location (L4), higher variations of losses are observed due to percent increase of load. It depicts that load sensitivity of bus no. 4 is higher. On the other hand at particular bus location (L11), lower variations of losses are observed due to percent increase of load. The y-axis of Fig. 7 and Fig. 8 show active and reactive losses respectively and x-axis shows the overall percentage load variation on all buses with percent increase in load by 10%, 20%, 30%, 40%, and 50%. From this it is also concluded that both active and reactive losses increase on increasing load at all the buses simultaneously. So, it can be observed that on average losses increases with increase in load. It is important to note that sensitive load location can be located out only by varying load at particular bus location rather than varying overall load.

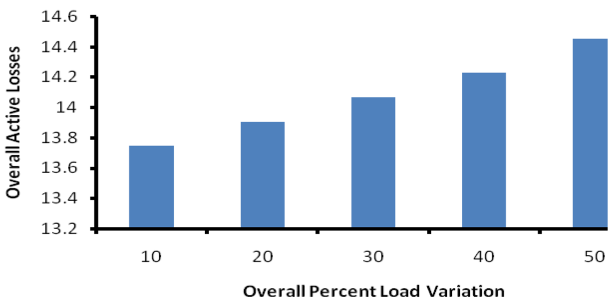

Fig. 7 Overall reactive losses by simultaneous percent load variation on all buses

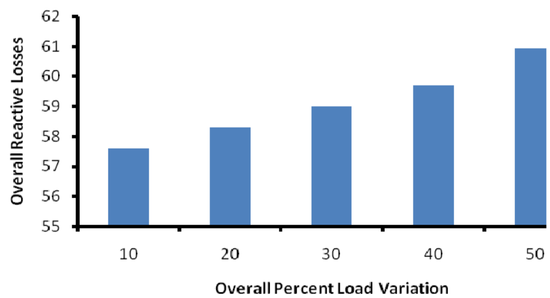

Fig. 8 Overall reactive losses by simultaneous percent load variation on all buses

IV. CONCLUSIONS

This investigation is done to find a suitable location for the incorporation of distributed generation (DG) in a power system by carrying out a comprehensive study of the impact of load variation on active and reactive power losses in a 14-bus system. It will provide the information of those load sensitive points where DG should be located. The analysis of results shows that an increase in load always leads to an increase in losses but the degree of increase in losses is different for different load buses. Out of all buses, the bus showing highest rate of increase in losses is deemed as a load sensitive bus, and requires an urgent penetration of distributed generation (DG) unit in order to curb losses and meeting customer demand.

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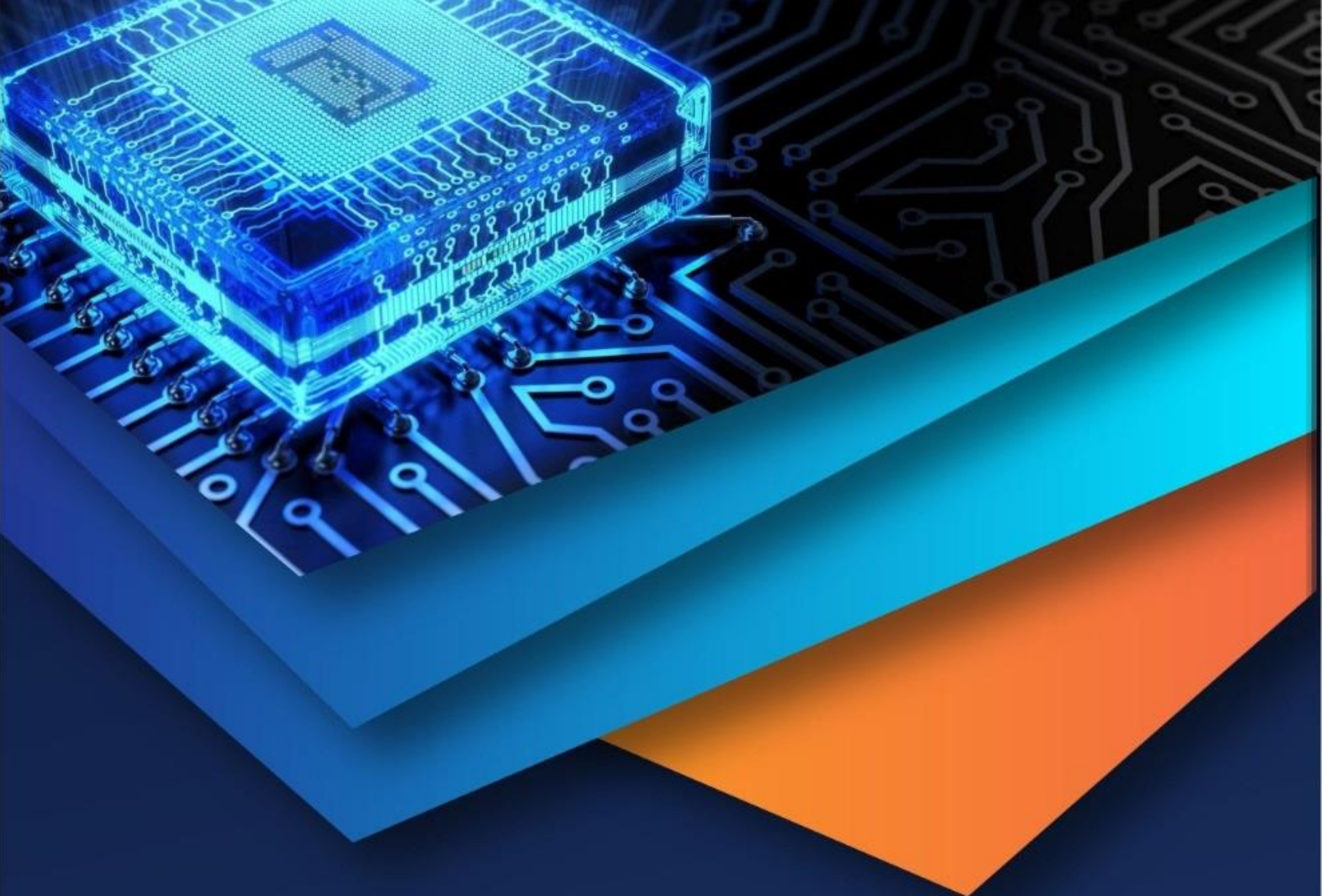

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