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Differential Protection of Power Transformer Using Simulink

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Abstract: ***In this research work we propose a simple and effective technique based on the Clark's transformation. Which avoiding the mal-operation of differential protection relays during inrush currents and trip signal generated during occurrence of other internal faults. This paper presents a technology to simulate differential relay in Simulink based environment for determining its behavior during various operating conditions. The results show that this simulation model works properly and it gives satisfactory results.***
Keywords: Transformer, Differential Protection, Simulink Model, Different Fault Conditions and Results.

I. INTRODUCTION

Transformer is the most important unit in an electrical transmission and distribution networks. The unexpected outage of a power transformer is costly for utilities and consequently requires sufficient protection [1]. It is essential to study the different working conditions of transformer to discover new protection method [2]. A power transformer functions as a node to connect two different voltage levels. Therefore, the continuity of transformer operation is of vital importance for maintaining the reliability of power supply. Any unscheduled repair work, especially replacement of faulty transformer is very expensive and time consuming. As a result, their protection is of great importance to assure stable and reliable operation of the whole system. Power Transformer is one of the most cost effective components in an electric power system. Any damage to it can cause irreparable damage resulting in replacement or high cost for repairs if possible. Thus protection of transformers becomes a critical issue related to power system. Thus it becomes very essential that the transformer is protected from various possible failures. Transformer protection has always been a challenging problem for protection engineers. The faults occur in transformer are open-circuit faults, earth faults, phase to phase faults, over heating faults and inter-turn faults. Inter phase short circuit are most frequent on leads of three phase transformer, while the inter phase short circuit within the winding are less frequent. Earth fault and inter-turn fault have the highest probability on the transformer. Winding short circuit also called as the internal faults, usually result from failure of insulation due to temperature rise or deterioration of transformer. The conventional technique used for transformer protection is current differential protection, which is used for protecting the transformer windings against internal faults [3].

II. DIFFERENTIAL PROTECTION

One of the most effective methods of protection to protect power transformers is the differential protection method by using differential relay circuits. This scheme is based on the principle of that the power input to the transformer under normal conditions is equal to the power out. By proper connection of the secondaries of current transformers, under normal conditions, no current will flow into the relay coil. On every occasion when a fault take place the current balance will no longer exist and relay contacts will close and release a trip signal to cause a certain circuit breakers to operate in order to disconnect the faulty equipment [4]. The Power Transformer protection scheme would be such that it avoid and block the tripping of differential relay during magnetizing inrush & over excitation and should speedily operate the relay tripping during internal faults. For this reason, it is required to choose an appropriate identification scheme which can make a distinction and discriminate the magnetizing inrush over excitation and internal fault current. Percentage restraint differential protective relays have been in service for many years [5]. Figure 1 shows the digital differential protection of power transformer.

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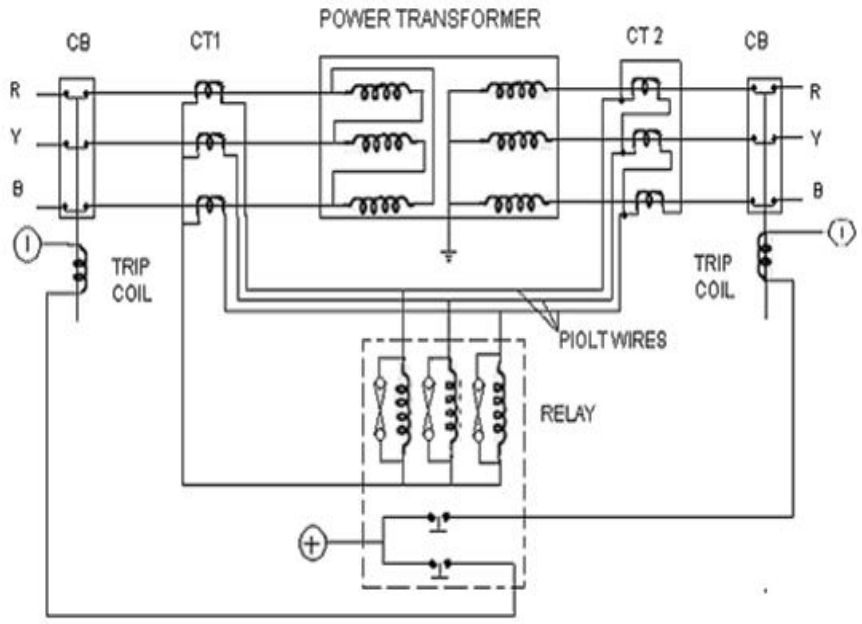

Fig. 1 Differential Protection scheme [6]

III. SIMULINK MODEL

In this model three phase star-star connected transformer is protected. Figure shows the simulated power system built in Matlab/Simulink environment.

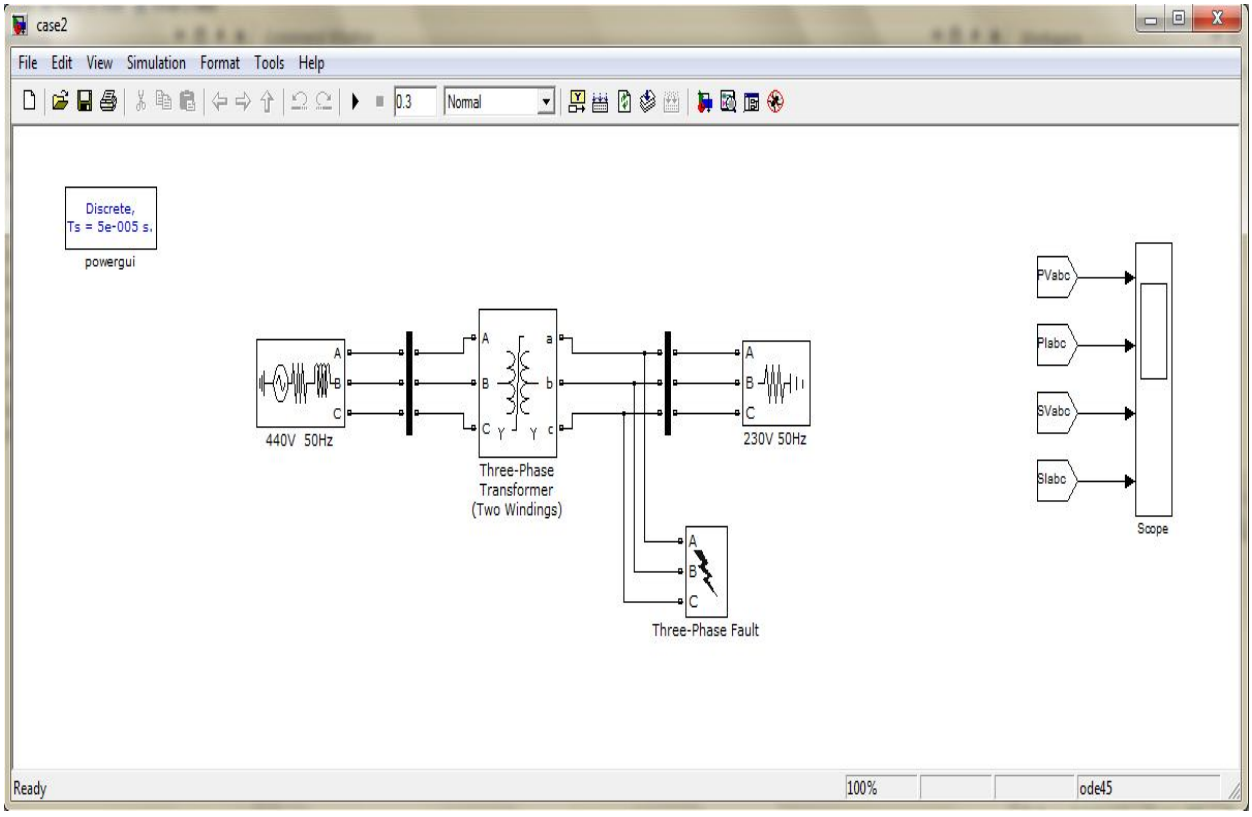

Fig. 2 Simulink Model for differential protection of transformer

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IV. RESULTS

There are various cases are studied in my research work. Like magnetizing inrush current, each phase to ground, phase to phase and three phase to ground. Here I discussed only three results.

A. For Phase to Ground Fault

Differential protection scheme when there is phase A to ground fault is occurred. It gives satisfactory results.

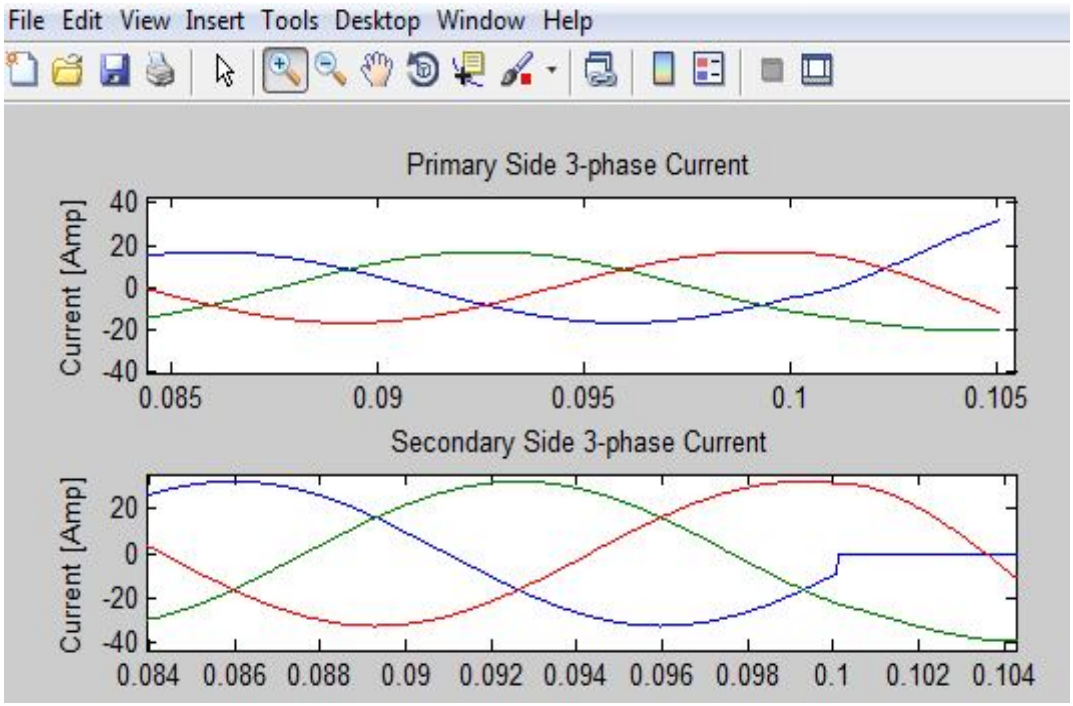

Fig. 3 Phase A to ground fault

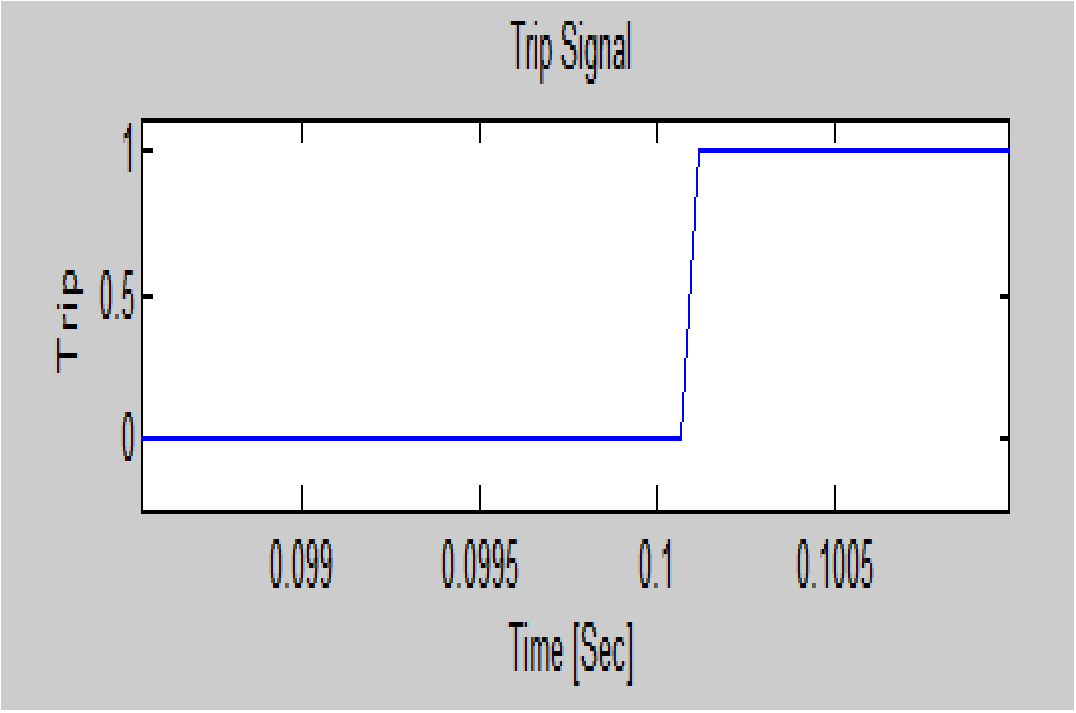

Fig. 4 Trip signal for phase A to ground fault

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B. For Phase-Phase Faults

Differential protection scheme when there is phase A to phase B fault is occurred and it gives satisfactory results.

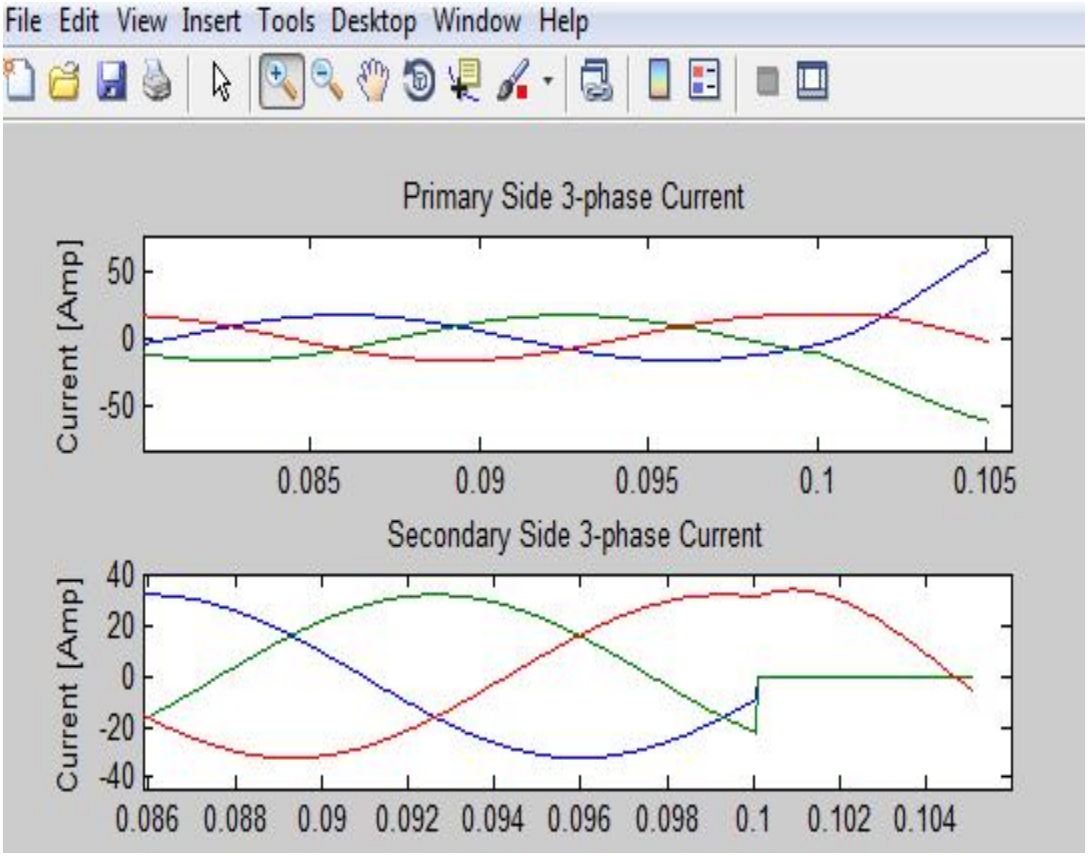

Fig. 5 Phase A to Phase B fault

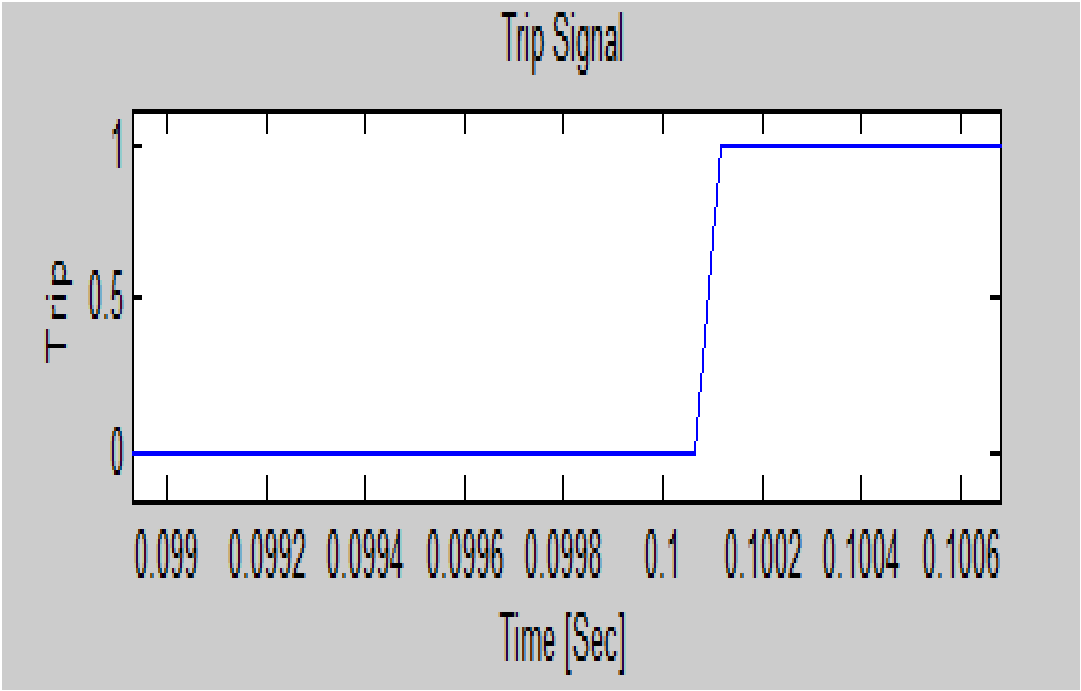

Fig. 6 Trip signal for phase A to phase B fault

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C. For Three Phase to Ground Faults

Differential protection scheme when there is phase ABC to ground fault is occurred and it gives acceptable results.

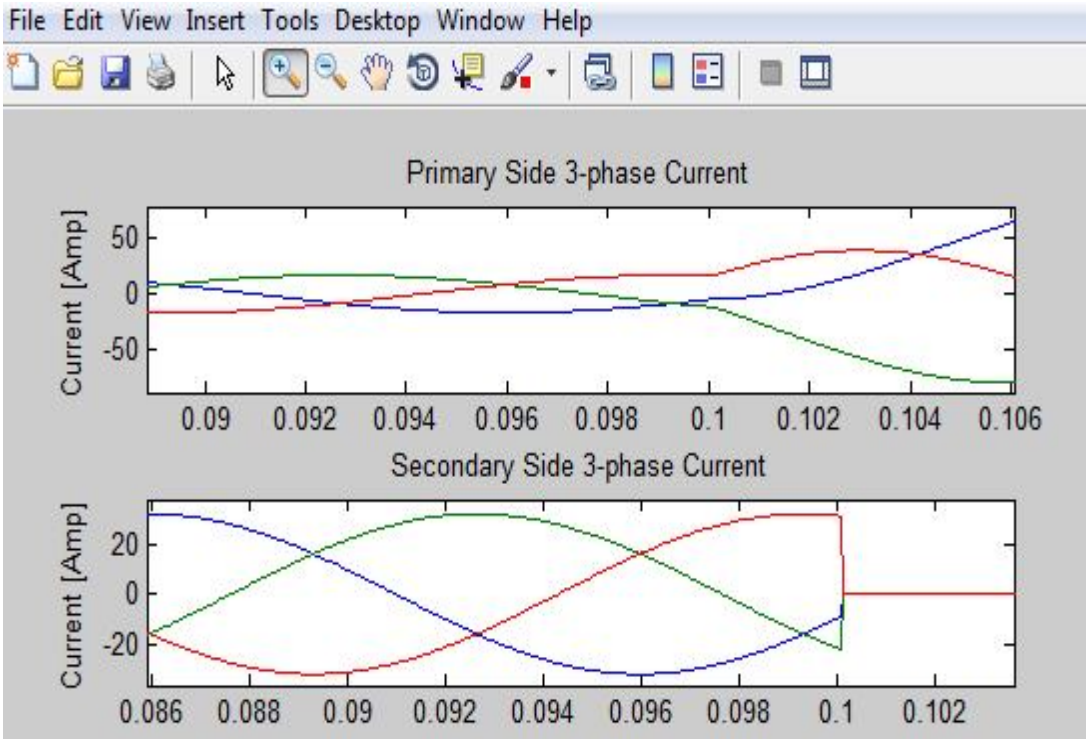

Fig. 7 Phase ABC to ground fault

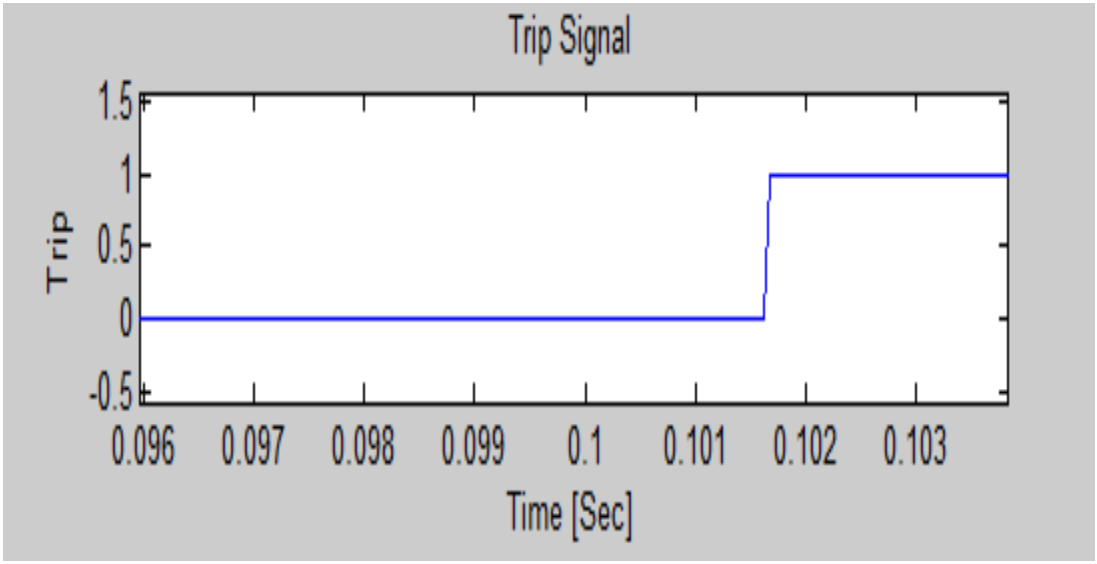

Fig 8. Trip signal of three phase to ground fault

V. CONCLUSION

This research paper presents a method for differential protection power transformer based on the application of Clarke's transformation which gives better performance over the conventional techniques. The obtained result shows that the proposed differential protection method avoids the tripping of the circuit during magnetizing inrush current situation and trips the protection scheme during the fault state. Thus the use of Clarke's transform can make it possible to increase reliability and sensitivity of differential relays for power transformer.

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A. Summary for All tested cases

Cases	Result
Inrush current	No trip
Phase to ground fault	Trip
Phase to phase fault	Trip

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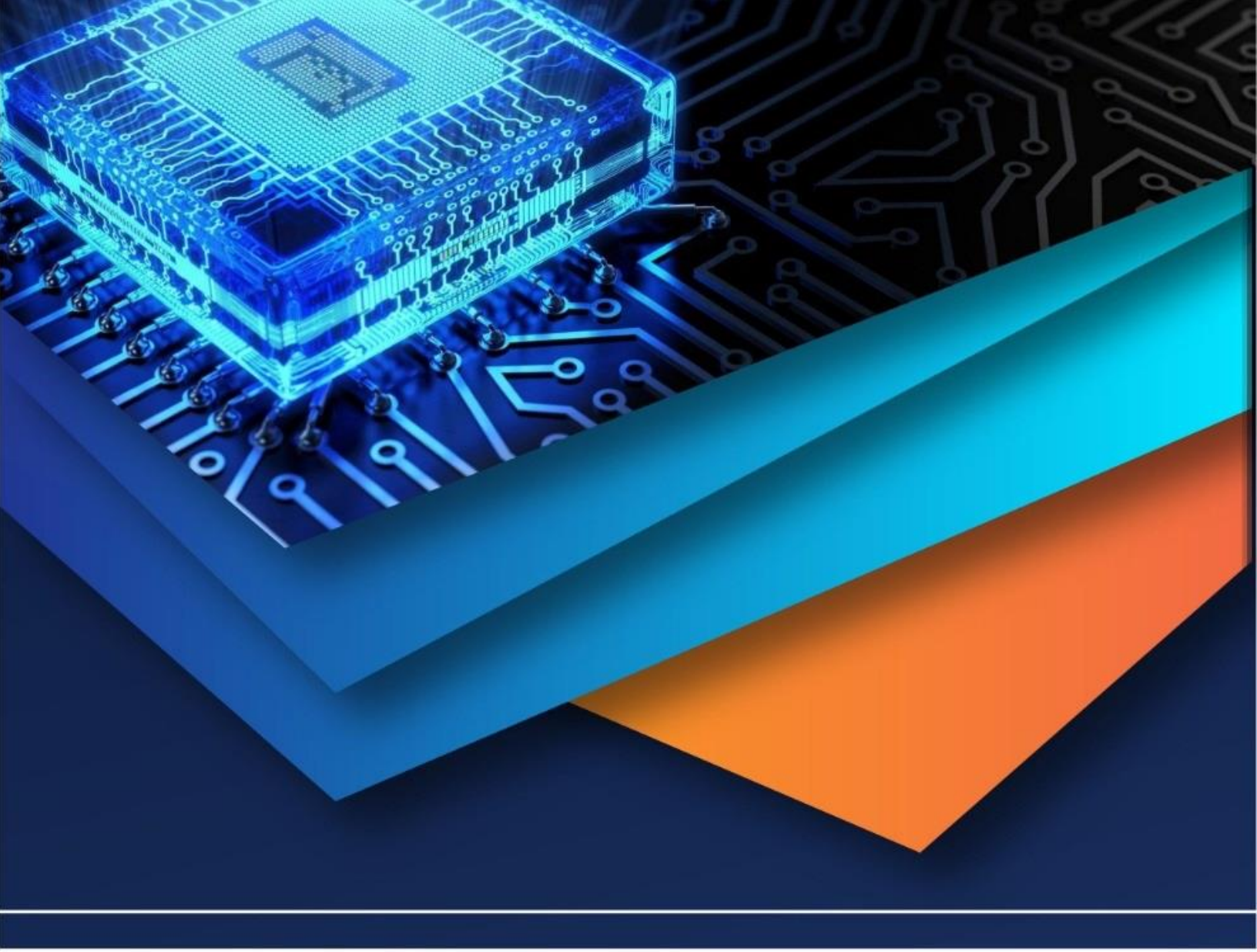

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