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Study of Particle Swarm Optimization Based Interconnected Automatic Generation Control System

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Abstract— This paper with help of controllers considering equal area to minimize errors in power system. The areas are equal in nature. The sources used here depicts with the automatic generation control of multisource interconnected power systems. The AGC optimized by particle swarm optimization technique are gas, thermal and hydro systems. The modelling is designed with the PID controller. The system parameters are taken into consideration here. The integral gain of AGC and PID controller parameters are determined taking various values. It is possible to decrease the area frequency and tie line power deviations by dynamic controlling series impedance with the PID controller.

Keywords— AGC, ALFC, GDB, GRC, PSO

I. INTRODUCTION

Power system deals with the conversion of natural energy to electrical energy. In the current scenario the demand for the electricity is heavily engrossing. The balance between the load side and generation side needs to be maintained always. Because a change in the load side leads to six times the change in generation side. It is known as the three phase AC is used to transportation of electricity. During the transportation both the active and reactive power must be balanced between the generation and utilization side. The automatic generation control (AGC) or automatic load frequency control (ALFC) is designed to control the system frequency of interconnected power systems. Different control strategies are proposed to maintain the control of system frequency and tie line power flow during the normal and distributive conditions. Such as proportional controller and different feedback form to develop optimal controller. Now a day's PID controllers, PI controllers, robust controllers are used. Governor Dead Band (GDB) and Generation Rate constraints (GRC) non-linearities are taken into consideration. The Particle swarm optimization (PSO) is a simple technique by which large scale non linear problems can be solved effectively by this technique without complications.

II. MODELLING OF POWER SYSTEM

It is very necessary to obtain the suitable models of the power systems for LFC studies. The model mentioned here is the integral control scheme of an interconnected power system.

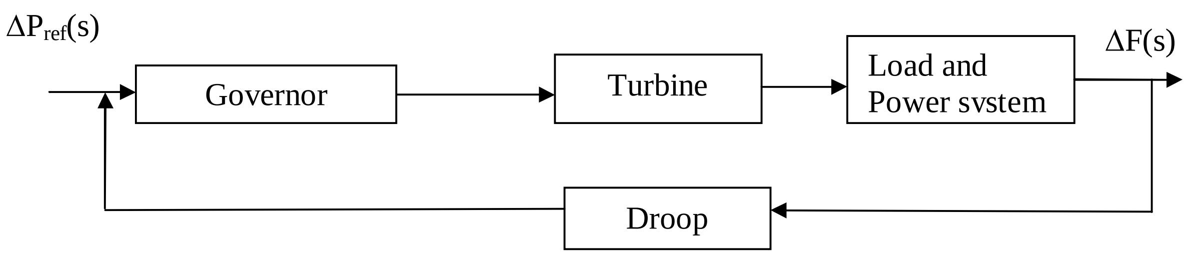

Fig.1 Block diagram of Automatic load frequency control

A. Speed Governor

Governors are employed in power systems for sensing the bias in frequency which is the result of the modification in load and eliminate it by changing the turbine inputs such as the characteristic for speed regulation (*R*) and the governor time constant (*Tg*). If the change in load occurs without the load reference, then some part of the alteration can be compensated by adjusting the valve/gate and the remaining portion of the alteration can be depicted in the form of deviation in frequency.

Mathematically,

$$\Delta P_g(s) = \Delta P_{ref}(s) - \frac{1}{R}\Delta F(s) \quad (1)$$

Where $\Delta P_g(s)$ = governor output
$\Delta P_{ref}(s)$ = the reference signal
R = regulation constant or droop, $\Delta F(s)$ = frequency deviation due to speed

B. Turbine

For the conversion of natural energy into mechanical power which can be conveniently supplied to the generator, turbines are used in power system. It can be hydraulic turbines near waterfalls, steam turbine whose energy come from burning of coal, gas and other fuels. There are three categories of turbines usually used in power systems: non-reheat, reheat in addition to hydraulic turbines, each and every one of which may be modelled and designed by transfer functions.

C. Generator

Generator receives mechanical power from the turbines and converts it to electrical power. When there is a change in load, it is reflected instantaneously as a change in the electrical torque output of the generator. This causes a mismatch between the mechanical torque and the electrical torque which in turn results in speed deviation as determined by equation of motion.

D. Single area ALFC

Change in the system load will result in a steady state frequency deviation, depending on the speed regulation of the governor. To reduce the frequency deviation to zero we need to provide a reset action by using an integral controller to act on the load reference setting to alter the speed set point. The frequency can be set to the desired value by making generation and demand equal with the help of steam valve controller which regulate steam valve and increases power output from generators. It serves the basic purpose of balancing the real power by regulating turbine output (P_T) according to the variation in the load demand (P_D).

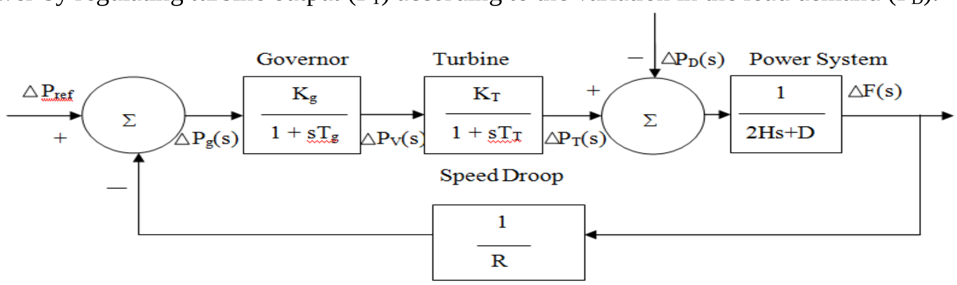

Fig.2 Model of single area ALFC without using secondary control

E. Tie-Line

Multiple areas can be connected with one another by one or more transmission lines in an interconnected power grid through the tie-lines. When two areas are having different frequencies, then there's an exchange of power between the two areas that are linked by the tie lines. The deviation in frequency in two areas: area 1 and area 2 can be represented by Δf_1 and Δf_2. The power due to tie-line trades is ΔP_{12} and the tie-line synchronizing torque coefficient (T_{12}).

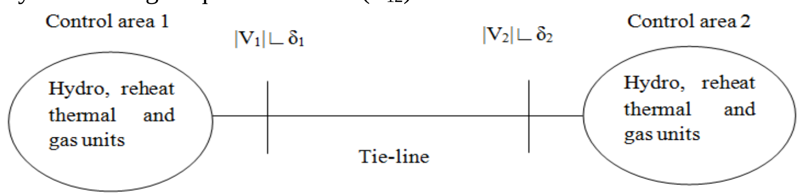

Fig.3 Two-area interconnected hydro, thermal, gas power system with TCSC in series with the tie-line

III. MULTI-SOURCE POWER SYSTEM MODELLING

The system under investigation consists of two area interconnected power system of gas, hydro and thermal plant in each area as shown in Fig. The system is widely used in literature for the design and analysis of automatic load frequency control of interconnected areas. Each area of the power system consists of speed governing system, turbine and generator as shown in Fig. Each area has three inputs and two outputs. The inputs are the controller input, load disturbances, and tie-line power error. The outputs are the generator frequency deviations and Area Control Error (ACE). To simplify the frequency-domain analyses, transfer functions are used to model each component of the area. All power plants in each area are lumped together to make a control area which is represented by an equivalent plant dynamics. Appropriate GRC models for the hydro and thermal units and GDB for the

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thermal units in both areas are considered.

The GDB is defined as the total magnitude of a sustained speed change within which there is no change in valve position of the turbine. The GDB of the backlash type can be linearized in terms of change and the rate of change in the speed. the rate of active power change, which can be achieved by thermal and hydro units, has a maximum limit. The appropriate GRC of 10% per minute for thermal unit is considered for both raising and falling rates. For the hydro unit, typical GRC of 270% per minute for raising generation and 360% per minute for falling generation are considered.

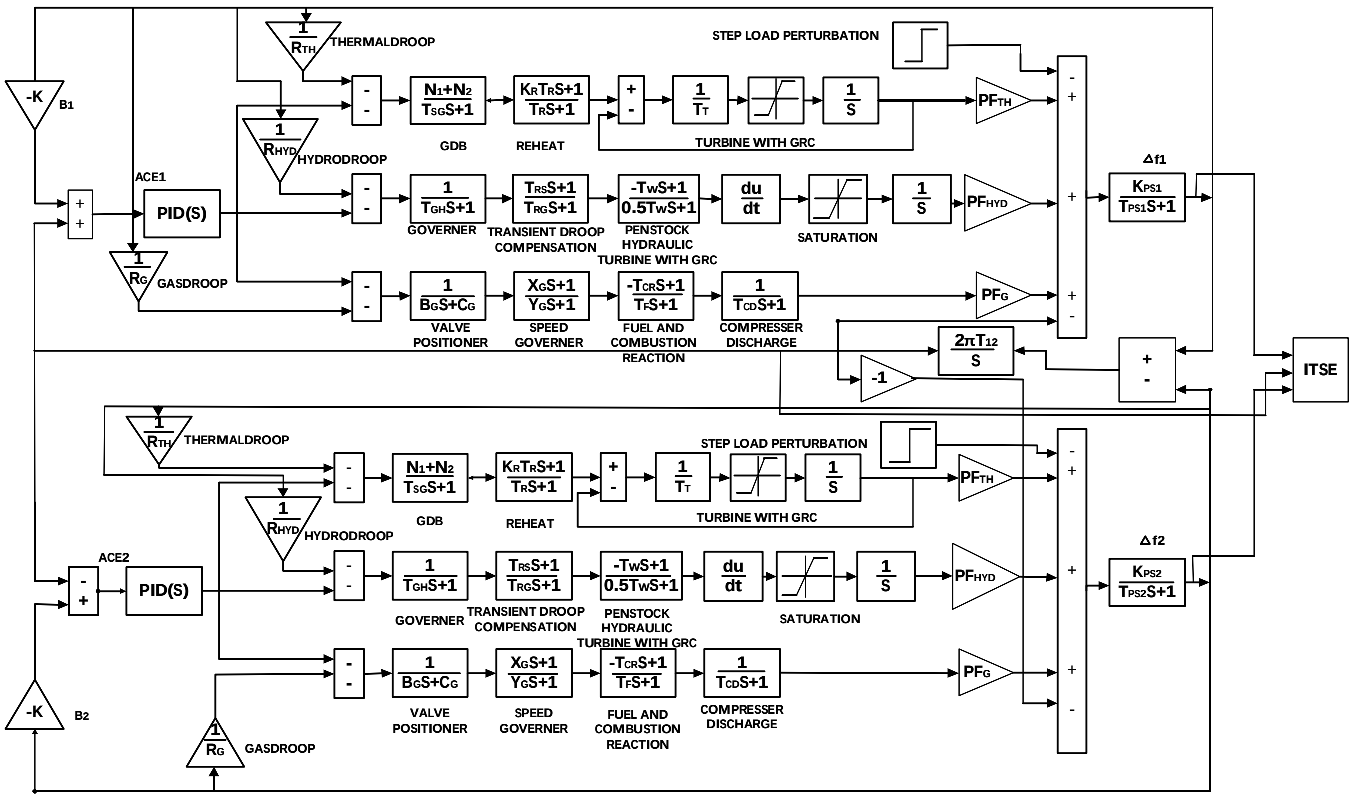

Fig.4 Transfer function model of proposed multi-source power system considering GRC and GDB

IV. PARTICLE SWARM OPTIMIZATION

The Particle swarm Optimization is an evolutionary computational technique based on the movement and intelligence of swarms looking for the most fertile feeding location .It was developed in 1995 by James Kennedy and Russell Eberhart. This technique is based upon simple algorithm, easy to implement and few parameters to adjust mainly the velocity and position. A "swarm" is an apparently disorganized collection (population) of moving individuals that tend to cluster together while each individual seems to be moving in a random direction. It uses a number of agents (particles) that constitute a swarm moving around in the search space looking for the best solution. Each particle is treated as a point in a D-dimensional space which adjusts its "flying" according to its own flying experience as well as the flying experience of other particles. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) that has achieved so far. This value is called ***pbest.*** Another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighbors of the particle. This value is called ***gbest***.

The PSO concept consists of changing the velocity(or accelerating) of each particle toward its *pbest* and the *gbest* position at each time step. Each particle tries to modify its current position and velocity according to the distance between its current position and *pbest*, and the distance between its current position and *gbest.*

$$v_{n+1} = v_n + c_1 rand1()*(p_{best,n} - \text{CurrentPosition}_n) + c_2 rand2()*(g_{best,n} - \text{CurrentPosition}_n)$$

CurrentPosition[*n+1*] = CurrentPosition[*n*] + *v*[*n+1*]

current position[*n+1*]: position of particle at *n+1th*iteration

current position[*n*]: position of particle at nth iteration

Volume 4 Issue VI, June 2016
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$v[n+1]$: particle velocity at $n+1th$ iteration
v_{n+1}: Velocity of particle at $n+1$th iteration
V_n: Velocity of particle at nth iteration
c_1 : acceleration factor related to gbest
c_2 : acceleration factor related to lbest
rand1( ): random number between 0 and 1
rand2( ): random number between 0 and 1
gbest: gbest position of swarm
pbest: pbest position of particle

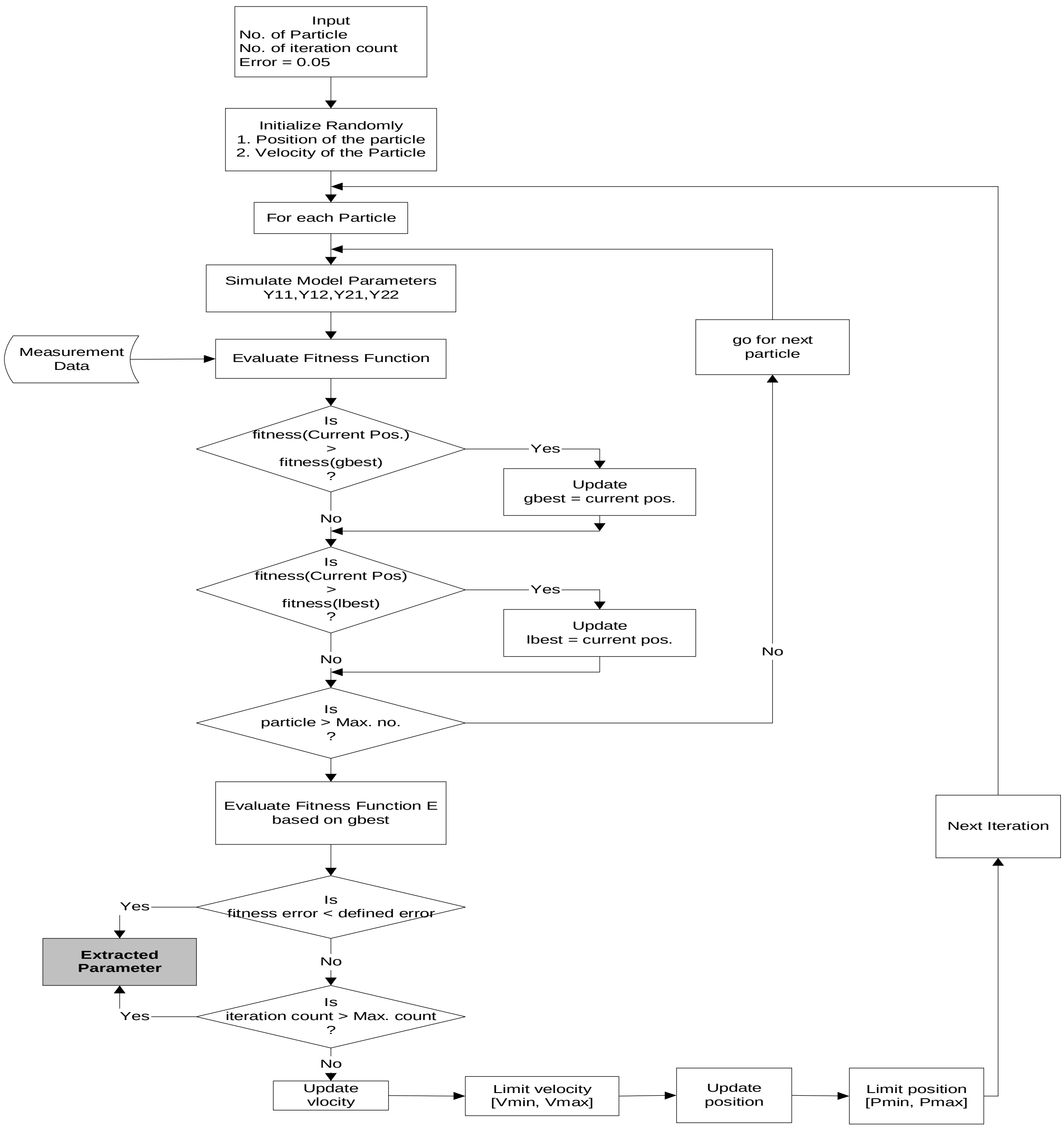

Fig.5 Flow Chart for PSO Technique

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V. SIMULATION RESULTS

The change in frequency of area 1, area 2 and the change in tie line power graphs are observed. The simulation time is taken as 100.0s. The results come to zero after oscillations.

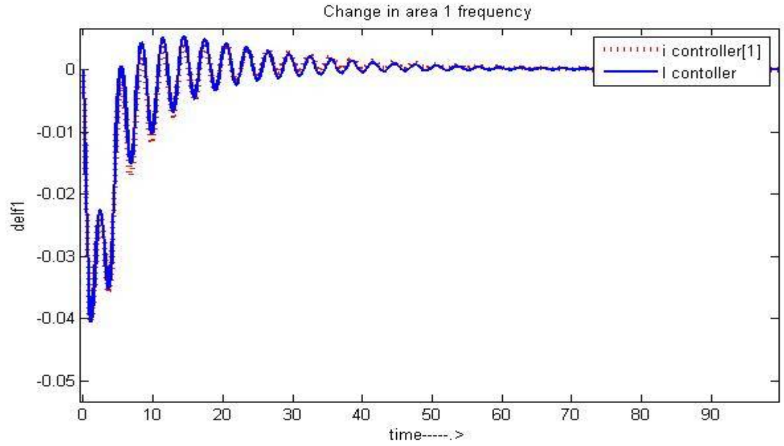

Fig.6 Change in frequency of area 1

Figure 6 shows the change in frequency of area1 with the time . After some oscillations it settles at zero.

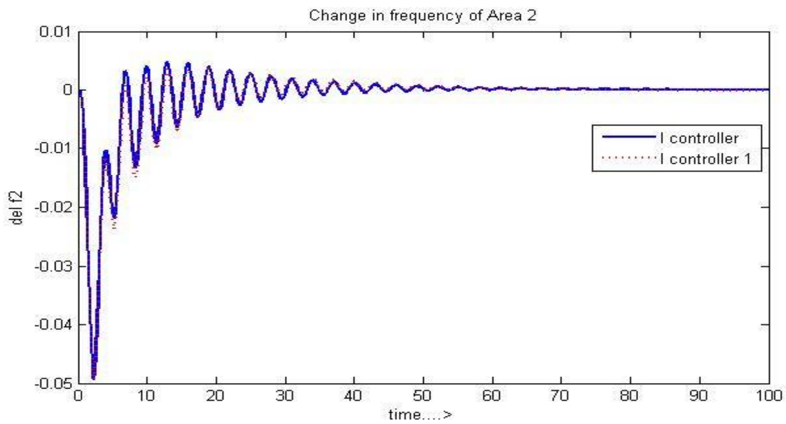

Fig.7 Change in frequency of area 2

Figure 7 shows the variations of change in frequency of area 2 with the time.

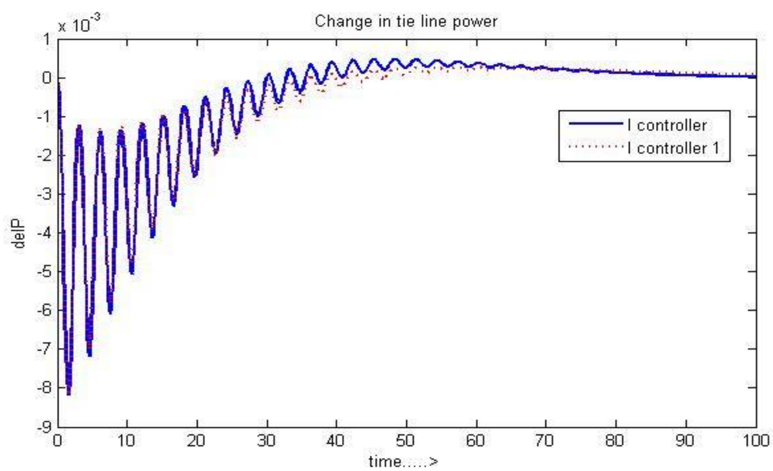

Fig.8 Change in tie-line power

Figure 8 shows the variations of change in tie line power with the time

Volume 4 Issue VI, June 2016
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TABLE 1 (Tuning parameters)

	KI_1	KI_2	ITSE
CONTROLLER 1	**0.0851**	**0.0478**	**0.03733**
CONTROLLER 2	**0.0916**	**0.0959**	**0.03438**

TABLE 2 (System damping characteristics using controller)

PARAMETERS	OVERSHOOT	UNDERSHOOT
ΔF_1	0.0042	-0.0406
ΔF_2	0.0037	-0.0494
ΔP	0.000267	-0.0082

VI. CONCLUSIONS

Controlling of power systems in order to meet the demands of consumers is a challenging task that motivates to design optimum controllers. They should have the capability of monitoring the power system like maintenance of frequency and voltage in no time. Many optimization techniques are used in the design of controllers. A two-area system is taken into consideration to show the method. The integral of time multiplied absolute error was used as objective function. Different plots of frequency deviation were obtained by varying the load demand of areas. Effects of parameter variation on system response were also plotted and observed. Its superiority over other methods used to tune the controller is justified by comparing the error values.

VII. ACKNOWLEDGMENT

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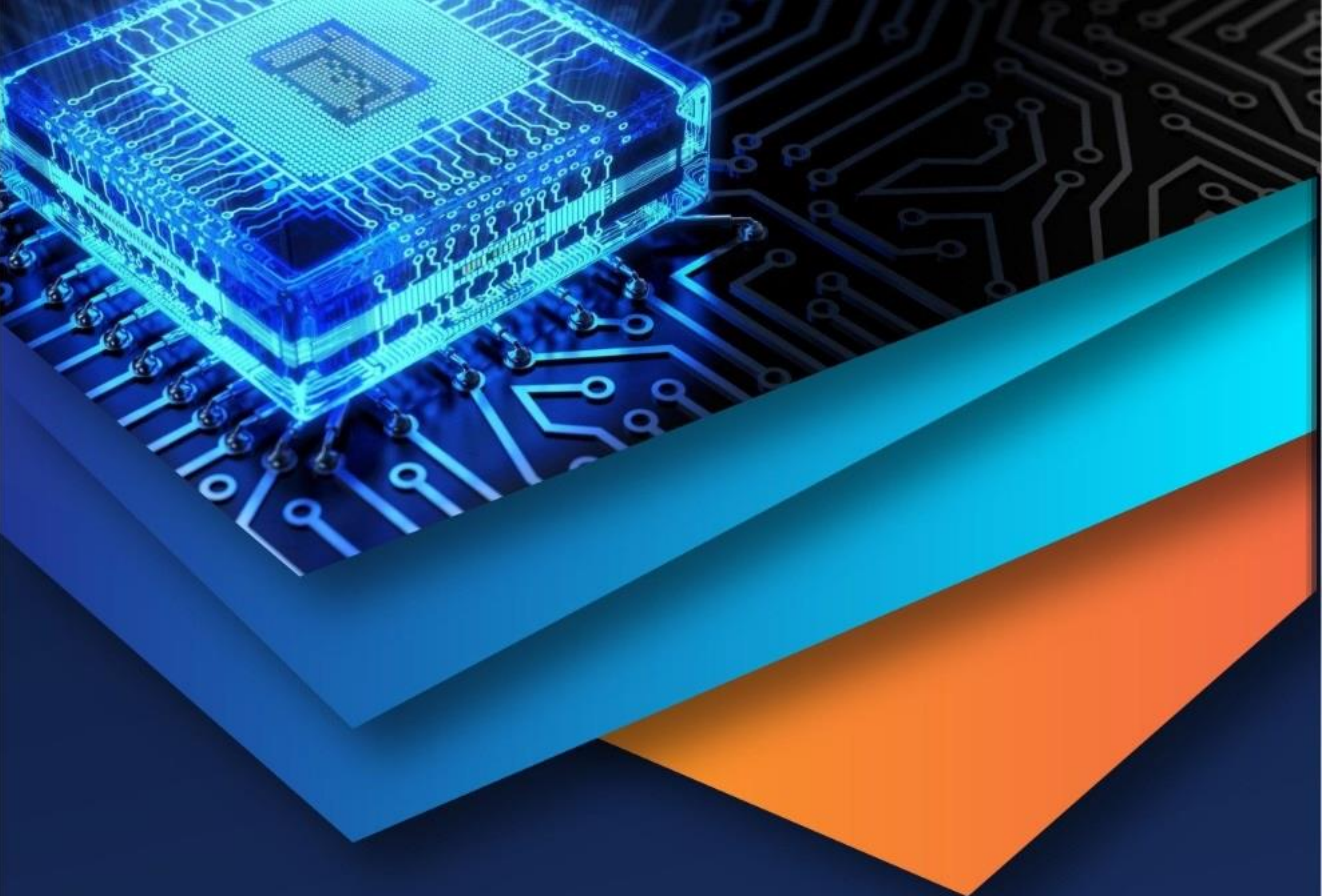

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