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Power Management of Solar Photovoltaic Based Microgrid with Demand Side Management

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Abstract: The use of modern solar photovoltaic system combined with efficient electrical appliances as load, storage battery, and demand side management strategies in the domestic sector, can significantly increase the PV value for the user and also manage the wastage of power. This paper presents an active demand side management system to manage the power of the solar photovoltaic based micro grid by the use of the MATLAB. In this way, the customer an "active customer" that can also cooperate with others and the grid, increasing even more the PV value for the electrical system. In conclusion, this paper presented a practicable method for the operation of a micro grid and DSM.
Keywords:-Distributed energy resources, Micro grid, DSM.

I. INTRODUCTION

Micro-Grid usage among consumers has become a new attraction due their several of advantage. MG technology can simply be defined as a low voltage network plus its load and several small modular generation systems connected to it, providing both power and heat to the local lads that calls Combined Heat and Power. One of the most important issues of micro-grid is when the grid become unavailable the micro-grids must be isolated itself from the grid and must not transfer the power to the grid. It is important in terms of safety to let to the utility grid to stay in normal operation and restore the power to the system. This phenomenon is called islanding or a stand-alone network. Smart micro-grid is an advanced framework based on the service-oriented architectures for integrating micro-grid modeling, monitoring and control. Given the importance of the Smart grid concept towards building a sustainable electricity system, many innovative concepts have been proposed by researchers. Demand Side Management is an important function that should be considered in the energy management of the smart grid system.

II. MICROGRID

The Congressional Research Service (CRS) gives different definition of a Microgrid:
A microgrid is any small or local electric power system that is independent of the bulk electric power network.
The U.S. Department of Energy (DOE) has offered the following description of microgrids:
A Microgrid, a local energy network, offers combination of distributed energy resources (DER) with local elastic loads, which can function in parallel with the grid or in an intentional island mode to produced a customized level of high reliability and resilience to grid disturbances.
A more concise definition by the Microgrid Exchange Group1 is as follows:
A microgrid is a group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that behave as a single tractable entity with respect to the grid. A Microgrid can disconnect and connect from the grid to allow it to operate in both grid-connected and island-mode.
According to inspection of sources for this report a distinctive attributes/aspects of a Microgrid include:

Operation in both island mode and grid-connected mode
Presentation to the Microgrid as a single tractable entity
Combination of integrated loads and co-located power generation sources
Provision of varied levels of power quality and reliability for end-uses
Designed to accommodate total system energy requirements

A. Operation Of Microgrid

The architecture of microgrid is shown in figure (1). This consists of a group of radial feeders, which could be part of a distribution system or a building's electrical system.

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A microgrid operate within a point of common coupling(PCC). Some feeders have sensitive loads, which require local generation. The uncritical load feeders don't have any local generation.

In our example there is Feeder D. Feeder A and Feeder C can island to the grid using the static switch which can disconnect in less than a period.

In this example their are four micro sources at nodes 8, 11, 16 and 22, which manage the operation using only local voltages and currents measurements. If there is a problem with the utility supply the static switch will open and isolating the sensitive loads from the power grid. Feeder D loads drive through the event.

It is assumed that there is sufficient generation to meet the loads' demand. When the Micro grid is grid-connected power from the local generation can be directed to feeder D.

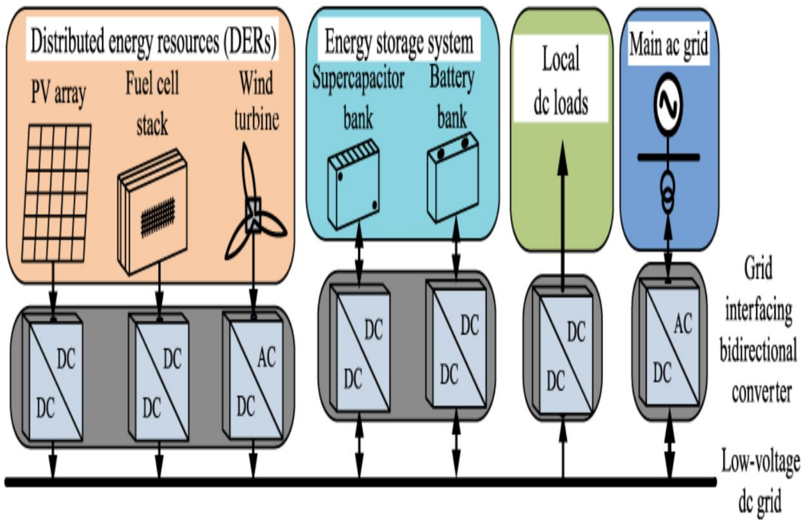

Fig 1. Architecture of Micro grid

III. DSM (DEMAND SIDE MANAGEMENT)

A. Demand Side Management

Such methods for controlling and influencing energy demand are part of demand response, which relies on the varying price of electricity to reduce the overall peak load demand, change the demand profile and increase the grid sustainability by decreasing the costing and carbon emission levels.

A different characteristic of smart grid had been done by usage of smart metering devices in the automatic metering framework is called smart pricing. It could lead to cost-reflective pricing based on the entire supply chain of delivering electricity at a certain location, quantity and period. Control the customer's energy usage will be influenced by real-time penalty and incentive schemes at all levels of the supply chain when the smart pricing is applied to the DSM. The rationale of the implementation is to promote the overall system efficiency, security and sustainability by maximizing the capacity of the existing infrastructure while facilitating the integration of low carbon technology into the system .

There are several DSM techniques and algorithm can be applied in context of reduction of system peak load demand and operational cost. Most of the techniques were developed by using dynamic programming and linear programming but these techniques cannot handle a large number of controllable devices from several types of devices which have several computation patterns and heuristics. In smart grid, these techniques cannot be applied because the DSM strategies need to handle a large number of controllable loads of several types. So, the strategies should be able to deal with the large number of a variety of controllable loads with all possible control durations. Furthermore, the operation of the smart grid requires two way communications between the central controller and various system elements which need to design the DSM system that able to handle the communication infrastructure between the central controller and controllable loads.

Then, there is a need to integrate demand response (DR) into the DSM in conjunction to manage the electricity market and power system within both planning and operational timescales. Demand responce refers to the changes in electricity usage by end-user consumers from their normal consumption patterns in response to changes in supply condition. Generally, DR can help in reducing the peak demand load of the consumers and reducing spot price volatility.

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There are two types of DR that had been classified into price-based DR and reliability-based DR. Price-based DR including real-time pricing (RTP), critical-peak pricing (CPP) and time-of-use (TOU) tariffs, refers to contract offered to consumers by retailers. Reliability-based DR including direct load control (DLC) and interruptible load contract (ILC) refers to technical load controls triggered by network operators in order to fix a grid reliability problem or a spot price spike.

B. Demand Side Management Strategy

In this part, the techniques that had been discussed are about DSM. In Heuristic Optimization the strategy is based on load shifting technique which can handle a large number of devices of several types by developing based on an evolutionary algorithm that can easily adapt its heuristics. DSM will focus on utilizing power saving technologies, electricity and tariffs in order to change the shape of the load demand curve by reducing the total load demand of the distribution system during peak periods and shift these loads to be served during more appropriate times in order to reduce the overall planning and operational cost of the network.

The load shapes will indicate the daily or seasonal electricity demands of domestic level consumers between peak and off peak times can be compared in six load shape: peak clipping, valley filling, load shifting, strategic conservation, strategic load growth and flexible load shape. These six types of load shape of DSM techniques are illustrated in fig 2. Based on the techniques stated, the suitable DSM techniques that can be applied for future micro grid is load shifting strategy that can be utilized by the central controller of the micro grid. The objective of DSM is to maximize the use of renewable energy resources, maximizing the economic benefits and also reduce the peak load demand of the consumers.

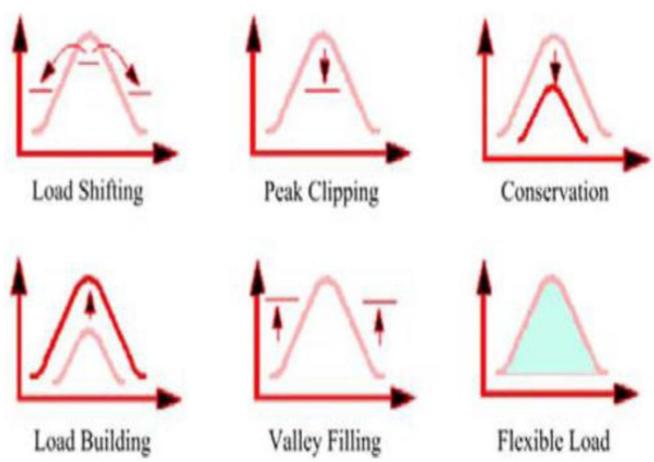

Fig 2: Demand side management techniques

The effective DSM can provide the benefits to the end users and also to the utilities. So, the proposed heuristic optimization is proposed to find the final load curve as close to the objective load curve as possible. it provides real time price information to customers through communication networks. Furthermore, consumers can only adjust their demands through setting the operating time of some of the home appliance with energy feature and also participate in the DLC program in the control centre of a micro grid based on the real time prices to shift their consumptions and save cost and energy also shifting system peak load.

Demand SideManagement Techniques	Demand Side Activities
Load Shifting	Shift loads from peak time to off-peak time
Peak Clipping	Reduction of the peak loads
Conservation	Achieve load shape optimization through application of demand reduction methods
Flexible Load	Controlled during critical periods in exchange for various incentives
Valley Filling	Off-peak demand by applying direct load control (DLC)
Load Building/ Load Growth	Increasing demand with processes for constructing

Table 1: Differentiate of demand side management techniques

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In the following section, some of the most discussed demand side management options are summarized.

C. Time-based demand side management

In a deregulated electricity market the electricity price depends both on the demand and production resulting in high electricity price when electricity demand is high and/or when there is shortage in production. Figure 1 shows the spot market price at the Nordic day-ahead market Nord pool in the whole year of 2008 as well as the prices in one winter day. As can be seen in Figure 3, the price varies both during the day and during the year.

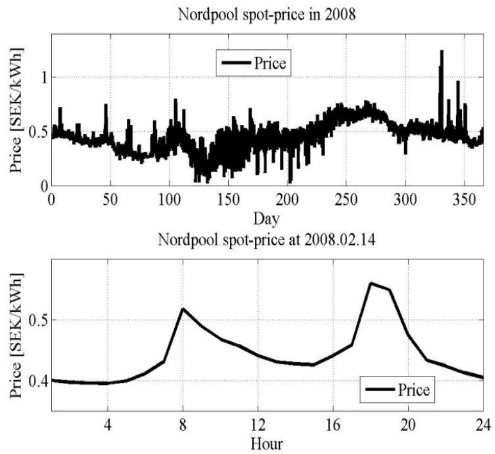

Fig 3: Spot-price at Nord pool spot in 2008

For most countries, household customers are not directly exposed to these price fluctuations resulting in no incentives to change their electricity usage pattern. This section presents some time-based demand response programs that reflect the demand/supply issue in different ways.

D. Real-time pricing

The main idea of a RTP program is to give the customer access to the above mentioned fluctuation in the electricity price. RTP scheme could be designed in several different ways. A simple way, which was proposed in, is to bill the customer on an hourly basis for all electricity the customer used during this hour. However, according to, many customers are worried that the high volatility in the electricity price would increase their total electricity cost. To reduce the anxiety, some RTP programs allow the customer to pay a fixed price for part of their consumption ("baseline consumption") and any consumption above that is billed according to the real time price.

One important aspect regarding the design of a RTP scheme is the time difference between the announcement of the price to the customers and the actual consumption. A long time lag, *e.g.* using day-ahead price, would result in a price that less accurately reflects the demand/supply, which may result in increased need for balancing power. A shorter time lag would result in better reflection of the demand/supply but with more difficulties for the customer to plan their electricity consumption, since they must forecast the electricity price for the coming day.

A number of studies on real-time pricing (RTP) has been conducted in different countries, *e.g*. Portugal , Spain, USA, Singapore and in the Nordic countries (Northern Europe). Most studies indicate that RTP would have a significant impact on the peak demand, even for power system with low price elasticity of demand. Many of these studies assume a short time lag between the price announcement and the implemented price or some kind of feedback from the customer, *e.g.* participations by the customers on the spot market, either on their owns or by a representative agent, so that equilibrium between demand and supply could be reached without increasing the need for balancing power. However, according to, most RTP schemes available today announce the prices one day in advance.

By designing the RTP program so that the customer price is based on the price at the day-ahead market, the total power system peak for each area may be reduced and/or the amount of renewable electricity generation that could be integrated to the power system may be increased. However, in the Nordic countries the price areas are large, *e.g.* Sweden is divided into four different areas, the total power system peak does not necessary occurs simultaneously everywhere in each area and certain parts of the

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power system may experience an increased peak demand. Additionally, the technical infrastructure,*e.g.* metering and communication, needed for RTP programs is extensive. Although about 95% of all meters in Sweden can handle hourly metering, only about 29% have the possibility to store their meter readings in a database, which is needed for a RTP program.

One way to avoid possible problems on a local level of the power system is to use different prices for different areas, *i.e.* industrial and residential area, or to combine the RTP with other measures.

IV. PROPOSED SIMULATION MODEL

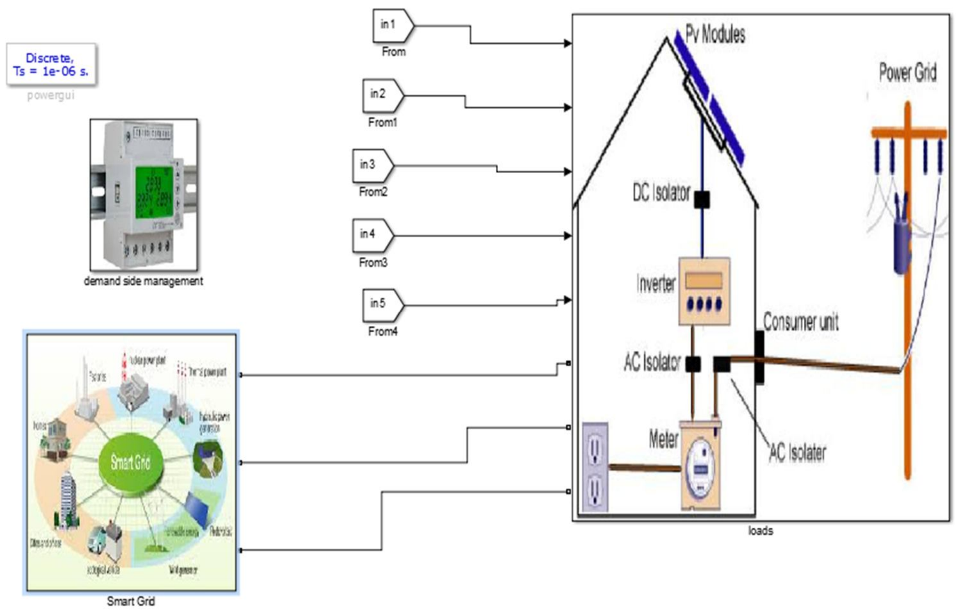

Fig 3(a) The overview of power management of solar photovoltaic based micro grid with demand side management.

The above diagram shows the overview of the proposed project with solar photovoltaic based micro grid with demand side management. In which micro grid connected with load and that load will feeded to the process of demand side management.

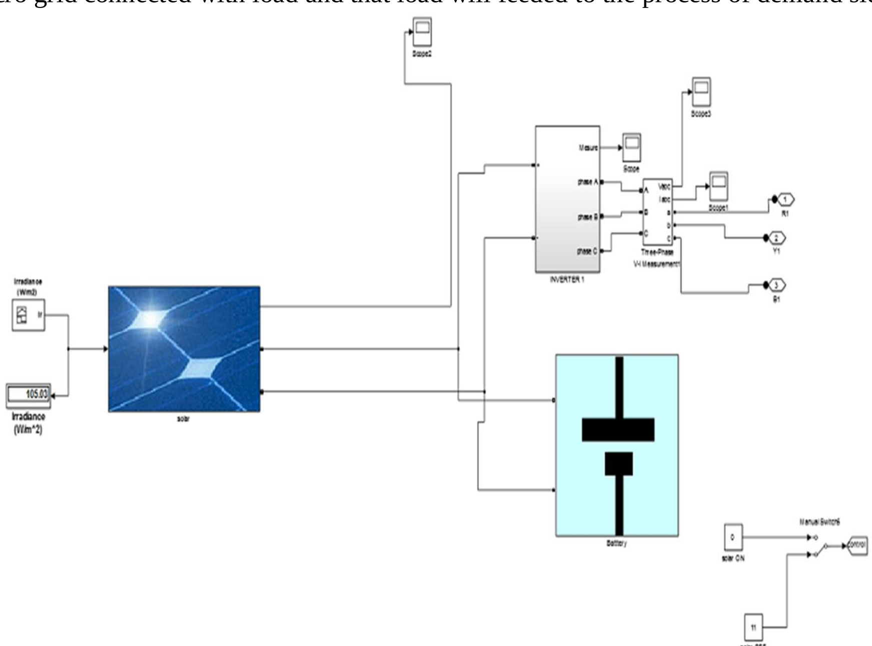

Fig.3(b):simulink model of solar pv with storage battery and loads

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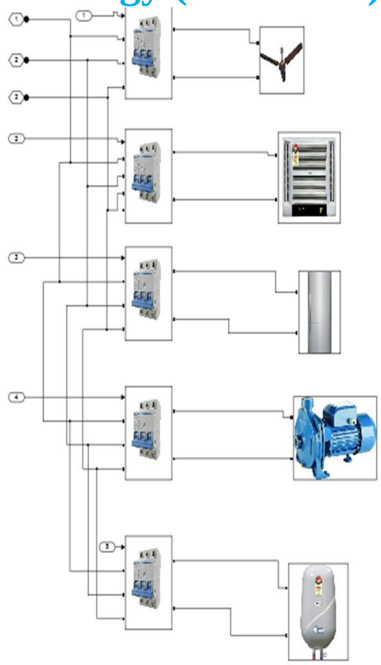

Fig 3(c):Model of loads connecting in the **project**

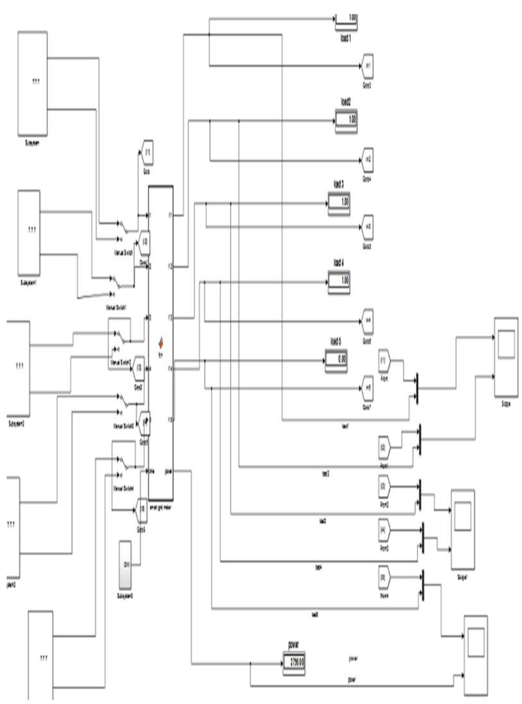

Fig 3(d) Model of demand side management

V. RESULTS OF TESTS AND DISCUSSIONS

The different results of proposed model are shown in this section. The number of cells are used in pv system is 96.In which number of cells in series are 5 and number of cells in parallel are 66.The different curves of the proposed model are describe the whole process which will perform in the MATLAB.

We can view what amount of power is consuming in and we can shut down any appliances or load in case it is running uselessly so as to avoid power comsumption and for the economic bill as well.

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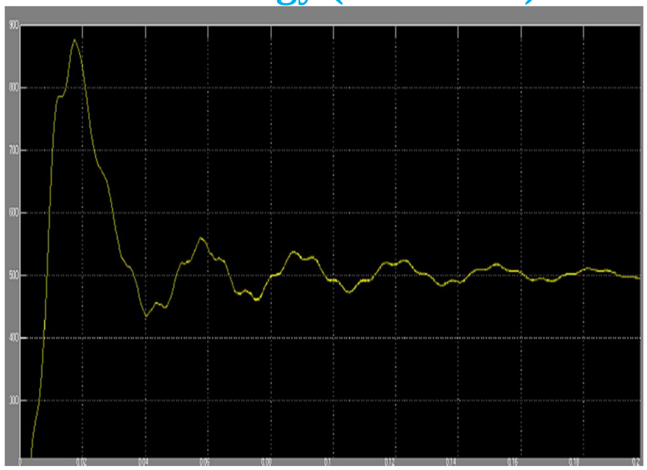

Fig 4: voltage verses time curve of pv array after boast convertor

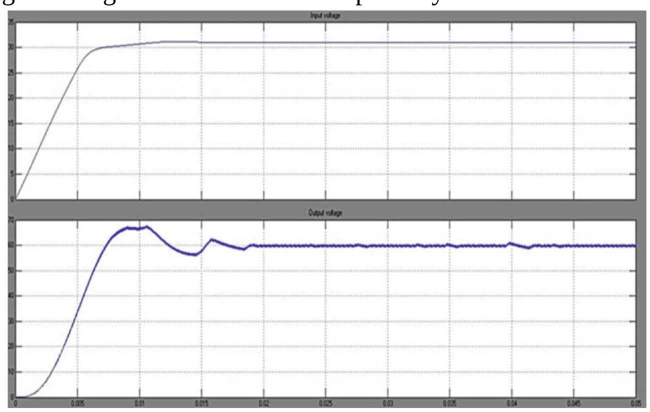

Fig. 5 Voltage versus time curve without MPPT technique at temperature 25 _C and irradiance 1,000 W/m2

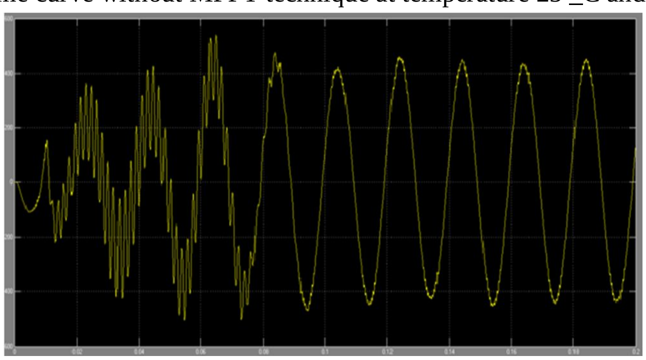

Fig 6: Inverter output in the form of voltage verses time curve

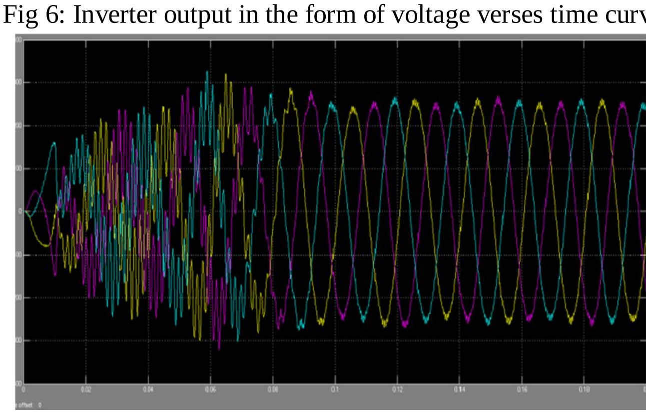

Fig 7: Voltage verses time curve in three phase system

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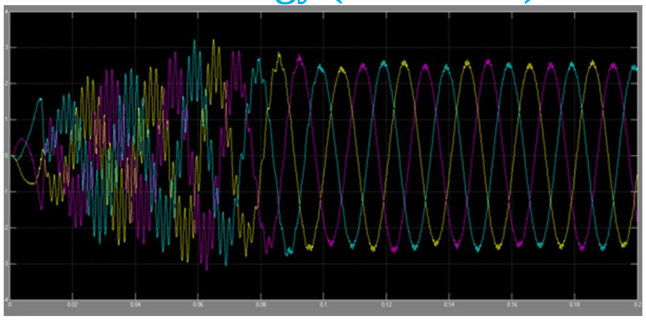

Fig 8: current verses time graph of three phase system

VI. CONCLUSION

An active power management system for the residential sector has been presented, which combines a new generation solar PV system with storage battery,different loads and with strategies of Demand Side Management performed. In this way, the system is able to displace the consumer's load curve in response to local and external conditions, thus optimizing the PV use and enhancing the PV value for the user and also minimize the wastage of power and it will use in the real time implementation also.

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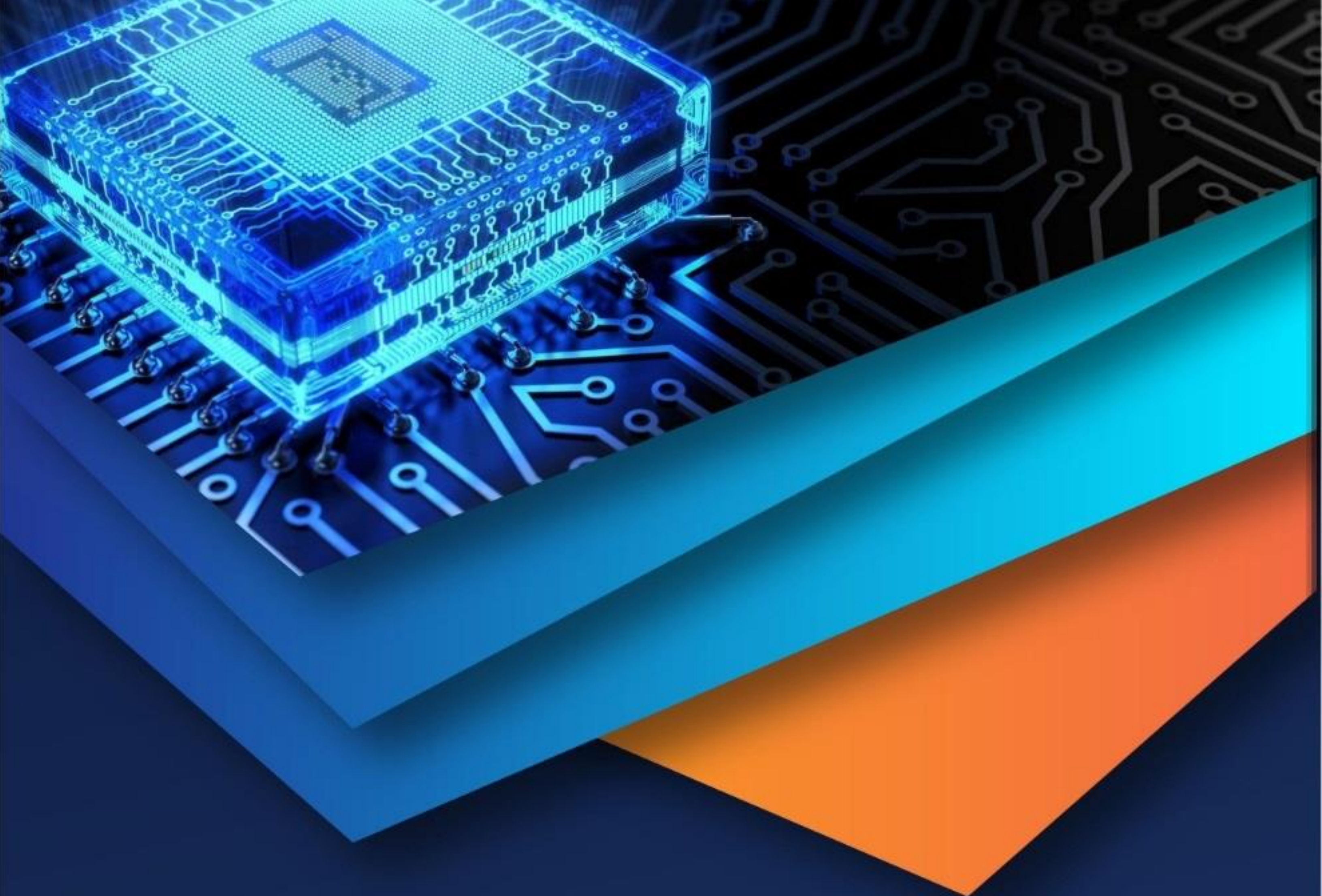

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