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Demand Response of Smart Homes Using State Flow Algorithm

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ABSTRACT –Nowadays power demand is increased by consumers. Usually peak demand is present in different seasons. During peak demand frequency drop and voltage dip are occurred. Due to these problems power system may block out and system reliability decreases. Generation demand and load demand should be maintained equally. Generation demand should be increased to maintain equal load demand and generation demand. Generation demand is increased by increasing generating plants. But generating plants cost is very high compared to DSM.Demand side management is the quickest response to reduce peak loads. So the peak demand can be reduced by load management.. Demand side management is facilitated to load management by state flow algorithm. State flow algorithm is made by conditions of system voltage and frequency and peak time or off peak time. By using Demand side management, consumers and energy providers get more benefits. DSM used to reduce expensive imports of fuel, energy prices and harmful emissions to the environment pollution are reduced. Simulation is done in MATLAB SIMULINK.

Index Terms: DSM, Peak Demand, State Flow Algorithm

I. INTRODUCTION

Peak demand is the major problem in the power system. Generation demand must be equal to load demand. If peak demand is not met properly with supply demand,frequency fluctuations and voltage dip and power quality and safety problems are occurred in peak hours [7]. This can lead to reduce system reliability and power system stability. Due to this problems power system may get blackouts. By using different ways to reduce peak demand are generation demand is increased by using renewable energy sources. We face some problems by interconnecting renewable energy sources to grid. These are [1]:

1. Reactive power management is very difficult.
2. System can't be predictable and low reliability.
3. Power quality problems are occurred.
4. Large fluctuations in power injected.

And also plants investment is very high. Demand side management is the quickest response to reduce peak demand and DSM cost is low. Further generation demand can be increased. These are:

1. Utilisation of more renewable energy sources.
2. Import power from another grid.

To increase power generation requires more investments. The best solution is Demand Side Management .

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Load Side Management is also called as Demand Side Management.

Demand Side Management is applied at loads side to manage loads in peak demand.

Therefore peak demand is reduced. Consumer and get more benefits i.e. consumer get low cost energy because utilising low energy consumption through DSM. Peak load can be minimised by utilities. To increase system reliability by improving operating reserve limits [4]. Consumer gets better quality power and also system reliability increases. By using DSM providers get benefits i.e. better supply capacity. Demand Side Management makes more profits and in some situations it makes least cost planning. Some commercial customers in the load management program demand dynamic or routine based power control to ensure the safety of their large equipment such as refrigeration unit [5]. Many literatures reveal that power system failures due to lack of power availability and lack of transmission corridors.These changes set higher demands to marketing decision-making made by electricity supply enterprises who are responsible for DSM implementation. This is changing from peak load shifting to improving energy efficiency [6]. Demand Side Management is used to reduce environment pollution and energy prices. Demand side management is facilitated to load management by state flow algorithm.Stateflow is a tool in Matlab that integrated with Simulink to model, simulate and analyze, combining finite state machine theory, flow diagram and state-transition diagrams [10]. State flow algorithm is made by conditions of system voltage and frequency and peak time or off peak time.The State flow machine is the collection of State flow blocks in a Simulink model. The Simulink model and the State flow machine work seamlessly together. Running a simulation automatically executes both the Simulink blocks and the State flow charts of the model. Loads are automatically operated according to the state flow algorithm. During peak loads some loads are OFF and important loads are ON.

II. DEMAND SIDE MANAGEMENT STRATEGY

Electricity demand is being increased in all over the world. Literately many papers are predicted that electricity demand would be double by 2030 year. Mainly DSM for residential, commercial and industrial energy users.Demand side management (DSM) has been applied to peak load shifting management, electricity saving and energy[8] [9].During peak time, it protects loads (or) devices and reduces energy demand. DSM used to describe energy auditing and routine data collection, monitoring and to indicate their benefits. DSM should be promoted because of various reasons. These are:

- Cost reduction
- Environmental and social improvement
- Reliability and network issues
- Improved markets

DSM means Planning and implementation of strategies designed to encourage customers to improve energy efficiency reduce energy costs.The main goal of DSM is to encourage the consumer to use less energy during peak hours. So consumer gets low price energy during off peak time. During peak hours energy cost is high.

The main types of DSM activities may be classified in three categories:

- Energy reduction programmes reducing demand through more efficient processes, buildings or equipment;
- Load management programmes changing the load pattern and encouraging less demand at peak times and peak rates;
- Load growth and conservation programmes.

Several studies have proposed peak shaving is to increase power utilization [3]. The difference between the peak power draw and the power shaving corresponds to energy savings.

Peak load is reduced by different types of load management technologies.

1. Load control load control where loads can be switched off or on often remotely by the utilities in particular time. Peak load is found in particular duration. It can be reduced by load management. Switching actions of loads are made by according to state flow algorithm. So homes can plan their use of energy in that period.
2. Peak clipping where the demand peaks (high demand periods) are “clipped” and the load is reduced at peak times. This form of load management has little overall effect of the demand but focuses on reducing peak demand by DSM.

Fig.1

3. Valley filling where the demand valleys (low demand periods) are “filled” by building off-peak capacities. This form of load management can be achieved by thermal energy storage (water heating or space heating) that displaces fossil fuel loads. During off peak demand, peak valley gap can be increased from 40%-50% by large industries cities [2].

Fig.2

Most of high rating loads are like motors and pumps etc. high rating devices contribute to the peak demand. Controllers are used to control peak demand in peak time. If high rating devices drawing power during peak time, Grid may be blocked out. By using peak shaving concept, we can control peak demand in peak hours. In peak hours, important devices should be on and unnecessary loads should be off.

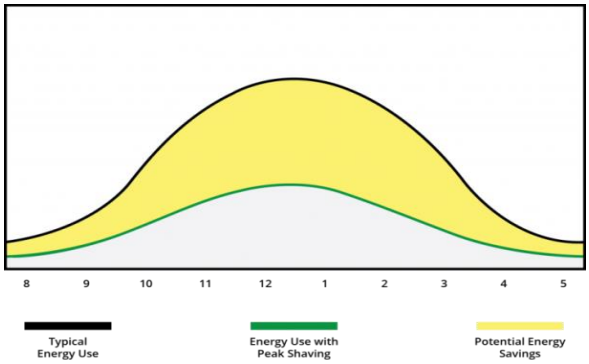

Fig.3

Due to load increases, the grid frequency will be changed. Changing frequency can be measured by different frequency measurements. But frequency measurement devices cost is high. Voltage sensors and timers are available at low cost in market. We are selected grid voltage and frequency and current and timer as key factors to identify peak time. While turning ON loads it checks importance of loads. In simulation we can monitor voltage and frequency and peak time.

III. METHODOLOGY&DESIGN

In this paper DSM facilitated to state flow algorithm to manage the peak loads. We introduce statecharts as a possible attempt at confronting these problems[11].Stateflow is a popular commercial model-based development tool for many industrial domains, such as power systems, aircraft, automotives and chemical plants[12]. When satisfied all conditions, suitable loads are operated. Voltage and frequency, status of loads and all other variables can be given as input to the model automatically. State flow is a graphical design and development tool for control and supervisory logic used in conjunction with Simulink. It provides clear, concise descriptions of complex system behaviour using finite state machine theory, flow diagram notations, and state-transition diagrams all in the same State flow diagram. State flow integrates with its Simulink environment to model, simulate, and analyze your system. State flow visually models and simulates complex reactive control and simulation based on finite state machinetheory. You design and develop deterministic, Supervisory control systems in a graphical environment.

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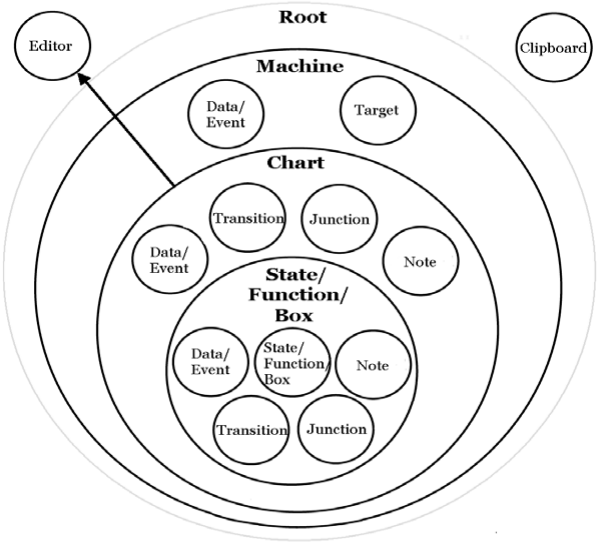
Flow diagram notation creates decision-making logic such as for loops and if then else constructs without the use of states. In some cases, using flow diagram notation provides a closer representation of the required system logic that avoids the use of unnecessary states.

Easily modify your design, evaluate the results, and verify the system's behaviour at any stage of your design.State flow automatically generates integer, floating-point, or fixed-point code directly from your design (requires state flow Coder) state flow brings system specification and design closer together.

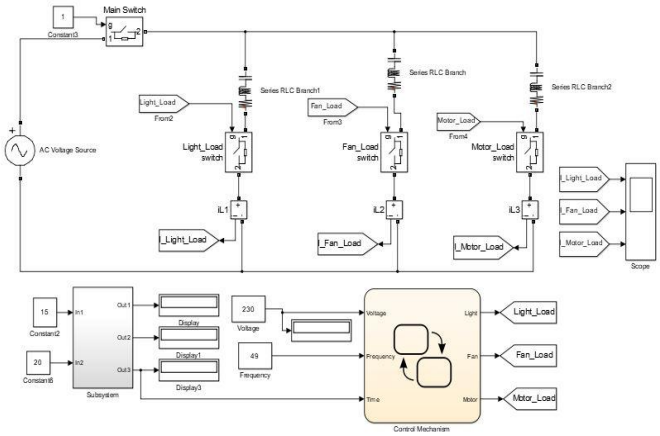


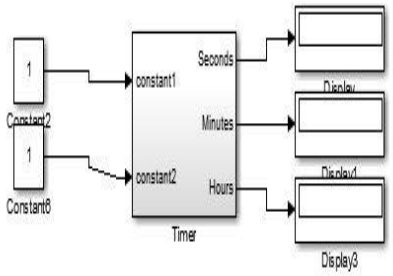
STATEFLOW DATA

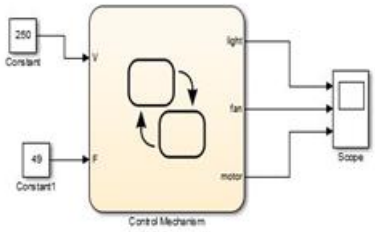
Fig.4

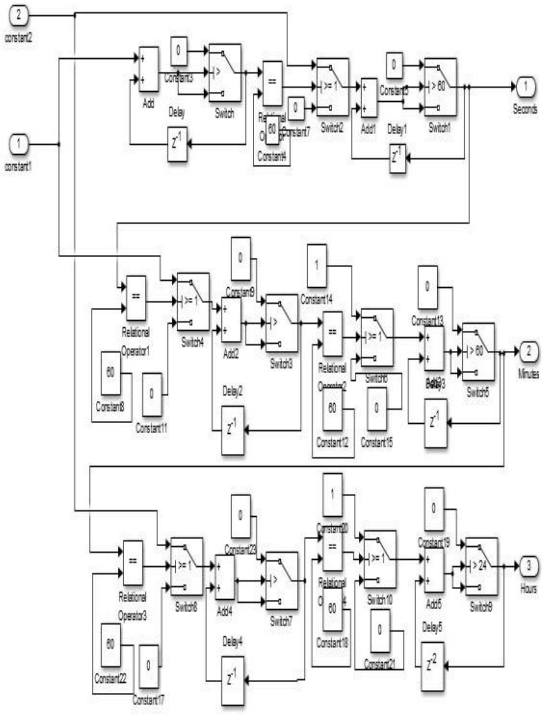
It is easy to create designs, consider various scenarios, anditerate until the state flow diagram models the desired behaviour. Voltage and frequency and peak time parameters are taken as input to the state flow. It makes decision according to the algorithm. It generates signal and satisfied

loads are operated.









MATLAB SIMULINK MODEL OF TIMER

In real time controller we can set time of peak demand. Usually in India peak demand duration is from 6 pm to 9 pm in different seasons. At the peak time some loads should be off position to maintain load demand is equal to power supply demand. During peak demand, the grid voltage is decreased. So voltage dip occurs if compare with set voltage.

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At the time loads are off. Important loads should be run. During off peak demands, loads should be run based state flow algorithm. The controller continuously monitors the variations in voltage and frequency and time of off peak demand and controller verifies them. If they are satisfactory to off peak loads, loads are on in position.

TheStateflow isthecollectionofStateflowblockSimulinkmodel. The state achartconsistsof

MATLAB SIMULINK MODEL OF STATE FLOW

graphicalobjects(states, boxes, functions, notes, transitions, connective junctions, and history junctions). The state flow inputs are given from grid voltage and frequency and real time. Loads switch switching action depends on state flow algorithm. If the conditions of voltage and frequency are satisfied, the suitable loads-1 and load-2 are turned on. For motor load, if the conditions of voltage and frequency and off peak time (from 6 pm to 9 pm) are satisfied with off peak load, load-1, load-2 and load-3 are turned on. The controller continuously monitors the variations in voltage and frequency and time of off peak demand and controller verifies them. If they are satisfactory to off peak loads, loads are on in position.

Algorithm:

Step-1: Start

Step-2: Check whether the switch is ON or OFF. If on go to Step 3Else go to Step 2.

Step-3: Read the voltage and frequency and whether it is Peak time orNot.

Step-4: Check V>=250v and V<=220v and F<=48Hz whether it is peak time or not. If it is YES go to step 5 else go to step 8.

Step-5: Load 1 an Load 2 and Load 3 are Off.

Step-6: Check V<=250v and V>=220v and f>=48Hz and peak time. If it is YES go to step 7 else go to step 6.

Step-7: Load 1 and Load 2 are ON and Load 3 is Off.

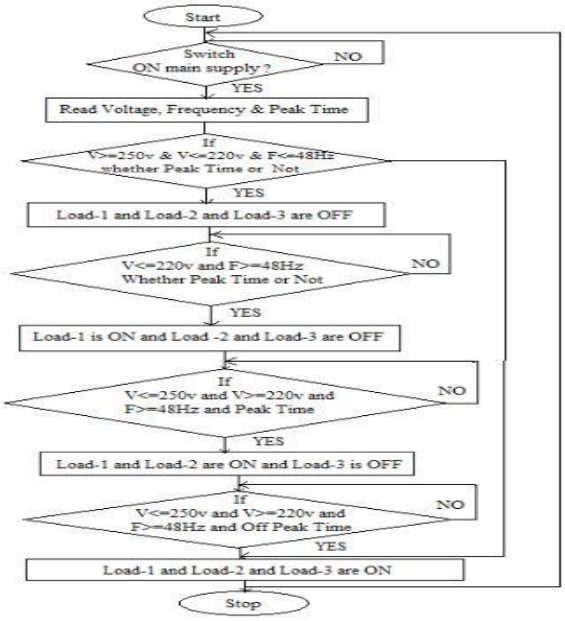
Step-8: Check V<=250v and V>=220v and f>=48Hz and off peak time. If it is YES go to step 9 else go to step 8.

Step-9: Load 1 and Load 2 and Load 3 are ON.

Step-10: Go to step2.

Step-11: Stop.

FLOW CHART:



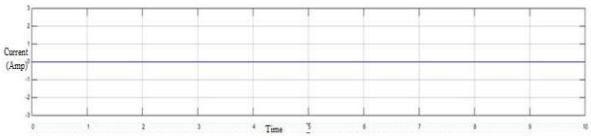
IV. RESULTS

MATLAB simulation model proposed for devices. Grid voltage and frequency and real time are given input to the controller. Controller makes signal according to the algorithm, and signal send to loads switch. Loads operation depends on its input.RLC loads are connected parallel with source.

Loads are operated only if the following conditions are satisfied.

- When the voltage <=220v or >=250v or frequency <=48Hz and whether it is off Peak Load or Not, the load switches will be turned OFF.

The Light load is OFF



The Fan load is OFF

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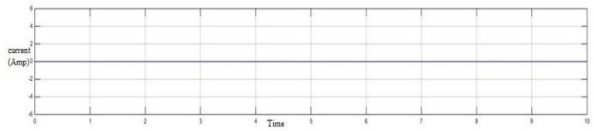
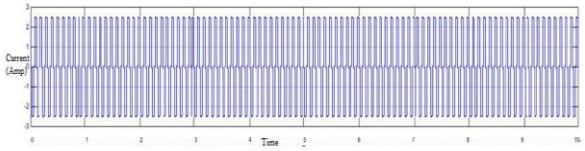
The Motor load is OFF

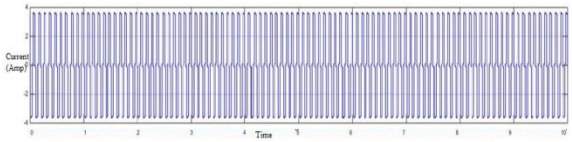


- When the voltage >=220v or <=250v and frequency >=48Hz and Peak Load, the load switches will be turned ON.

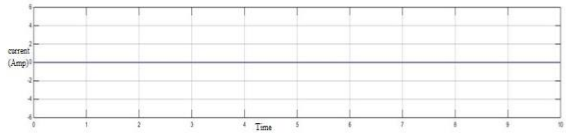
The light load is ON.



The Fan load is ON.

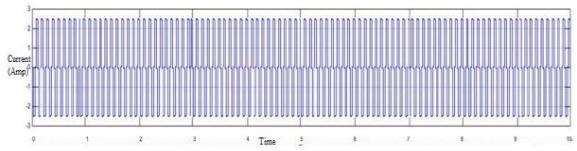


The Motor load is OFF

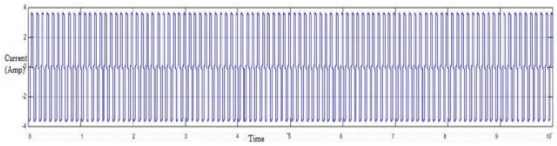


- When the voltage >=220v or <=250v and frequency >=48Hz and off Peak Load, the load switches will be turned ON.

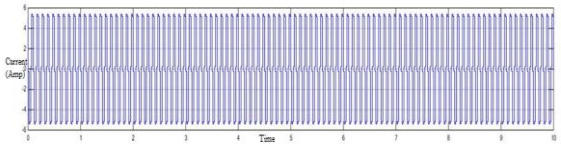
The light load is ON.



The Fan load is ON.



The Motor load is ON



V. CONCLUSION

Demand side management is implemented for domestic and industrial applications. Based on voltage and frequency and off peak demand time for maintain switching of the loads. In peak demands, which important loads are operated, so load demand will be decreased.Consumers get more benefits and environment pollution will be reduced by using demand side management.

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