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A Review and Study on Advancements in Smart Demand Side Management Systems for Reduced Scheduled Outages in Developing Countries

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Abstract: ***Increasing load demand combined with physical and geographical challenges in conventional power generation techniques has widened the gap between power generation and load demand. Demand based load side management, which is a method that does not affects on climate and free from pollution and also helps in improving power factor.DSM encourage to people for energy efficient equipments. In this paper we review the challenges in this area of research on demand side management to make energy efficient system by using the available raw material in Indian market. Also we studied about the load shedding and instead of going to the load shedding we turn off only heating element and remains on lighting element for effective energy saving. In this way, It can be helpful for villages and in city also in electricity saving. So by using this technique we use less electricity during peak hours and help to balance the load demand and generation. This can be achieved by applying bidirectional communication between substation and home. For this communication we use special device called smart device.***

Keywords: Smart DSM (Demand Side Management), IOT, Smart Grid, Substation Automation, Smart meter, Node MCU, Arduino Uno software.

I. INTRODUCTION

Science is universal but technology must be local. In many of the areas, present grids depends upon foreign technology. In consideration with future technology must be affordable and sustainable .So we investigated and works in the area where the local needs to be survive and also self dependent. To meet demands, reduce losses and transport electricity effectively present grid needs to be updated [7]. Total demand of load keeps on varying depending on time of day and season. Load factor is the ratio of average power to peak power. A high load factor means lower cost of generation as in fig.1.1New load management technologies are constantly underdevelopment.

DSM is a concept of changing consumers electricity use pattern. Load management has the purpose of improving effective utilization of generating capacity and encouraging best use of electricity by consumers. This paper, discusses about discuss about methods to reduce electricity bill by reducing energy consumption by consumers thereby contributing to minimize the gap between generation and load growth.

In majority of the developing countries, most of the times for load management one method is use i.e. Load shedding. In this paper we focuses on the different Demand Side Management (DSM) techniques apart from traditional load shedding method. DSM improves load profile shape with the help of controllable loads [6]. The graph shows the inverse relationship between fixed cost and operating cost.

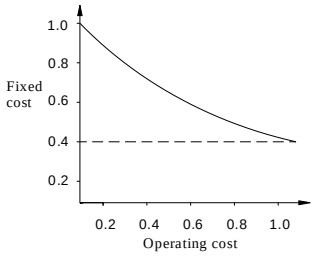

Fig.1.1 Variation of generation cost with load factor

Load based demand side management is implemented for direct load control to analyze over the maximum demand with its indicator. Tariff rate is decided by the respective authorities on the basis of power factor values. If the power factor is less than 0.894 then consumer has to pay penalty to the power suppliers. Power factor is in between the 0.955-1.00 then additional incentives are given to consumers for maintaining power factor within this limits. Consumer gets this notification about the penalty while paying the electricity bill. Assuming that a consumer is having n numbers of connected loads, where n=1, 2,3,.,N.
The power consumed by each appliance in time 't' is expressed as

$$Pn(t) = \sum_{n=1}^{N} Vn(t)In(t)\cos\varphi n \quad \ldots(1) \text{ subjected to constraint}$$

$$\iiint Pn(t) \leq Pc(t) \forall n>0 \quad \ldots(2)$$

where, Pn(t) is the power consumed by n number of appliances in time t given in hours. Pc(t) represents the contract demand of the consumer. Contract demand of the respective consumer may vary because of variation in the power factor due to operation of power electronic based devices. Another reason which can cause the violation of contract demand agreement is installation of extra loads which were not mentioned earlier. If the fluctuation in the value of power extends the tolerance range that is 110%-150% of Pn(t) for more than 5 minutes of the proposed scheme, the DLC algorithm initiates. In the case of poor power factor, consumers are advised to operate capacitor bank or penalty is imposed on consumer for degrading the power factor. Second case persists when load increases beyond the agreement values. If N loads are exceeded by x number of loads, power consumed in time t is

$$PN+x(t)>Pc(t) \quad \ldots(3)$$

$$Px(t) = PN+x(t)-Pc(t) \quad \ldots(4)$$

If equation (2) satisfies, it represents that no extra load is connected to the system and contract demand is within limits. If extra load is connected to system and contract demand is violated by power consumer then system is represented by equation (3) and (4).
Thus, the DSLM algorithm initiates and provides following options to the consumer to act according to the loading condition:

1) Curtail load till the equation (2) condition satisfy.
2) Make payment for exceeded demand Px(t)* penalized rate for defined duration.
3) If consumer did not opted for option (i) and (ii) in prescribed wait period, trip the load so that Pn(t)=0. Cost of energy tariff paid by user rely upon power in watts energy consumption time, pricing per unit, peak load requirements.

$$Cn = \int_{t}^{t1} [Vn(t)In(t)\cos\varphi n]Rtdt + \int_{t2}^{T} Px(t)rtdt \quad \ldots(5)$$

$$Ctot = \sum_{n=1}^{N} Cn \quad \ldots(6)$$

Where, Cn is the cost estimate for nth and x appliances, Rt and rt is the cost rate for given locality at time (t − t1) and (t2−T) respectively.Jaiswal et al.[6] as stated in their work that the N+x load is considered to be operating for time (t2 − T) hours. DSM promotes energy users to use in an efficient way during peak load time and it results in shifting of load demand from peak load time to off peak time such as nightmare & weekends. Reference book 'Generation of electric energy' by Gupta as stated in their work that Load shapes indicates the how much power consumed by the customers [12].
There are different load shapes as shown in fig.1.2
The application of load control includes the following methods:

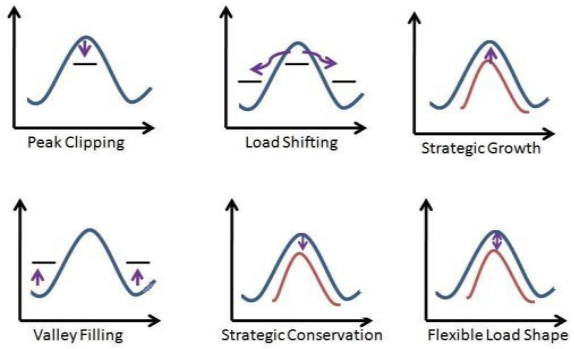

Fig.1.2DSM load shapes methods

a) *Peak Clipping:* In this application some of the consumer appliances are switched off by direct load control for some time. Eventually these appliances are those which consumes large power and whose disconnection for some time can tolerated, But the demand peaks (high demand period) are clipped & load is reduced at peak time. This form of load management has little overall effect of the demand focuses on reducing peak demand [2].

b) *Valley Filling:* The demand valley (low demand and periods) are 'Filled' by building off- peak capabilities. Load management can be achieved by thermal energy storage (water heating) or shifting to nonconventional methods Load shifting: Loads are "shifted" from peak to valley time. Shifting refers to change in costumers energy usage pattern from peak load time to off peak load time, whereas clipping is a method of isolating the load due to shortage of availability of required power to supply removed.

c) *Strategic load Conservation:* It aims encouraging the use of high efficiency equipment. Thus it leads to reduction in lower costs & lesser damage to environment.

d) *Strategic Load Growth:* These load are the one which produce a general increase in sales beyond valley filling it may achieved by increasing the market share of the connected loads served by other fuel as well as general economical development.

e) *Flexible Load Shape*: The utility is allowed to adjust the load shape to meet the reliability constraints. The consumer can get the incentives for the reduced level of service. Device are available which can limit the power & energy that individual consumer can draw. The main objective of consumers to minimize the electricity bill. For that purpose, the consumer designs a target load curve which is inversely proportional to the electricity market prices [6].

II. BLOCK DIAGRAM OF SMART DEMAND SIDE MANAGEMENT SYSTEM

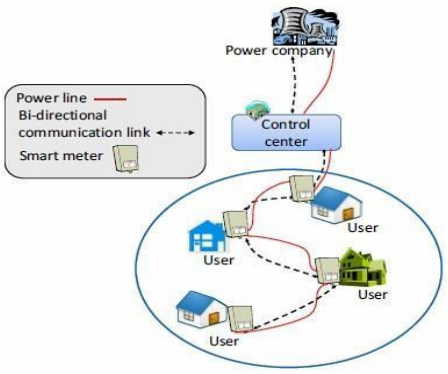

Fig.2.1 Block diagram

Figure.2.1 shows the functional block diagram of architecture of power system incorporated with smart and intelligent electronic devices. As shown in the above figure, for number of consumers in smart grid technology, Power is supplied to the consumers from Power Company using smart grid. In power system model, the load is taken as a consumer request and according to the load demand the power has to be shifted and control the power during peak hours. Due to this cost of energy consumption by consumer get reduced. Energy consumption by the equipments used in off peak hours has less cost as compared to the equipments used in peak hours. In that way by using this smart device it's helpful to balance generation and load demand during peak hours[7].

III. USE OF SOFTWARE SMARTTECHONOLOGIES

A. *IOT*

Fig.3.2 Internet of Things

IoT means Internet of Things .IOT aims to set modeling physical objects with an IP address which gives access of communication via telephonic internet activity.

B. What is IoT?

IoT is technique of controlling on and off c+6+onditions of connected devices and ongoing processes using internet based communication channel. IOT may be applied even for miniature applications like musical headphones, smart washing machine, coffee maker machine, etc.

C. How Does it Work?

IoT has the capacity to process Big Data. . IOT features users to control connected devices with ability to collect data and sending data from other connected network with proper hardware connectivity.

D. Arduino IDE for Node MCU

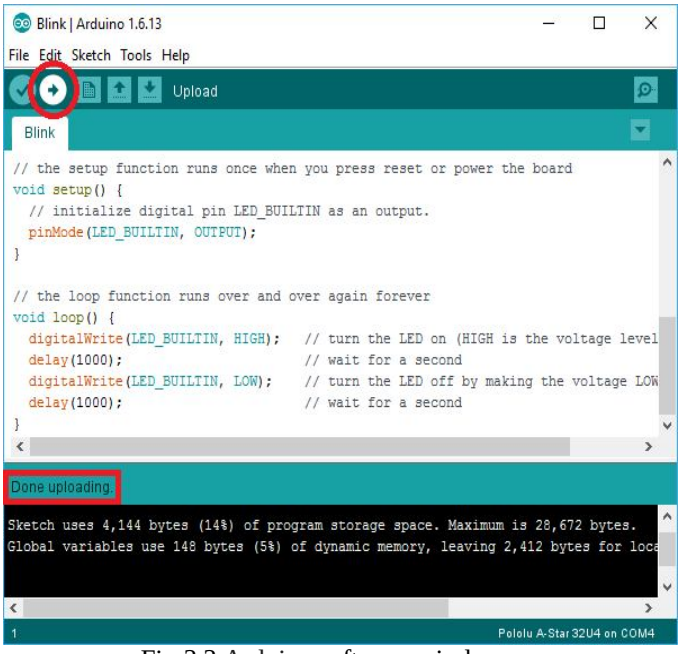

Fig.3.3 Arduino software window

We can use ARDUINO 1.6.13 is used for coding purpose. Here the Arduino IDE is used for this project work. For installation of Arduino IDE software, Google search for arduino.cc and go to download option and download latest version of software as per our working area as on windows, Mac, Linux and linux ARM etc. This software can be used with any arduino board and in this project work we use arduino NodeMCU with inbuilt Wi-Fi.

IV. DESIGN OF HARDWARE SETUP

A. Node MCU

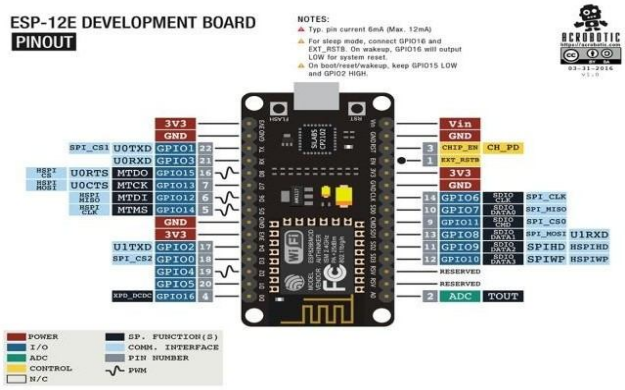

Fig.4.1Pin diagram of NodeMCU

The arduino project creates an open source hardware design & software for versatile IOT controller. Similar to NodeMCU the arduino h/w is a µc board with a ready USB control LED light & standard data pins it also define standard data pins it also standard interfaces to interact with sensors or other board General purpose input and output (GPIO) is a pin on an IC (Integrated Circuit). It can be either input pin or output pin, whose behavior can be controlled at the run time. For example, P0.0on the NodeMCU kit mapped to the internal GPI0 pin of ESP8266.

1) Advantages of NodeMCU

a) Low cost
b) Reduced size of board
c) Integrated support for wifi network.
d) Low energy consumption

2) Drawbacks

a) Reduced pin outs
b) Need to learn a new language and IDE.

B. Two channel Relay Switch

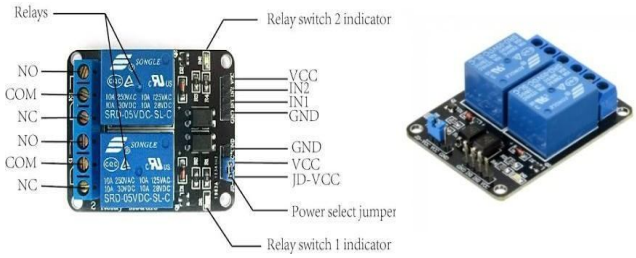

Fig. 4.2 Two channel relay switch

This works with 5V and 10 Amps, DC supply which has two channel relay interfacing board. It is use for controlling different appliances with high current ratings also. The control can be achieved through 3.3V or 5V logical signals from microcontroller. Microcontroller may be of Aurdino, PIC, arm, 8051, etc. based on applications..It has four pins of 2.54mm pitch for connecting power supplies of 5V and 0V which is also use to control relay switches. The marking of pins are given on the PCB.
GND is a ground connecting pin. Where 0V is to be supplied.
IN1 is connected to control relay 1, which will turn on when input voltage reduces less than 2V. Another pin IN2 is also very similar to IN1. Which is connected to another relay. A separate pin of 2.54mm pitch is used to connect relay terminals with PCB board. Main supply is connected to VCC terminal with 5V DC power supply. Under normal operations an intermediate jumper selects appropriate pins between pin1 and pin2 and supplies 5V DC for required pin. There is a second 1x3 (2.54mm pitch) pin header for supplying the "relay side" of the board with 5V.

1) Features: A high current relay is used with specifications of 10Amps, 30V DC supply. Indicating LED'S are used to indicate logical high level signals from 5V or 3.3V DC connected devices.

C. Current Sensor

Fig.4.3Current Sensor

These sensors can be used for measurement of different values like 5Amps, 20Amps, 30Amps, etc.

V. CONCLUSION

Electricity has particular characteristics that it cannot be stored in large amounts .Moreover its supply is under the control of the consumer.DSM today plays a crucial role in proper allocation, planning and utilization of available resources with reducing operating cost. The technologies are to be developed in a way to reduced present and future cost. This paper is an attempt to understand how to design a Smart device to control peak hour load on residential feeders in communication with Grid requirements. DSM helps to save money in terms of reducing electricity bill and also helps the electrical grid to operate more efficiently. The resources are developed in such way that to minimize present and future cost. This paper is an attempt to understand how to design a Smart device to control peak hour load on residential feeders in communication with Grid requirements. DSM helps to save money in terms of reducing electricity bill and also helps the electrical grid to operate more efficiently. DSM encourages people to use energy efficient equipments. In this paper we understand about the demand side management, to make use of energy efficient system by using the available raw material in. It helps to improve power factor and gives financial incentives. Low cost, flexible, accurate, energy saving.

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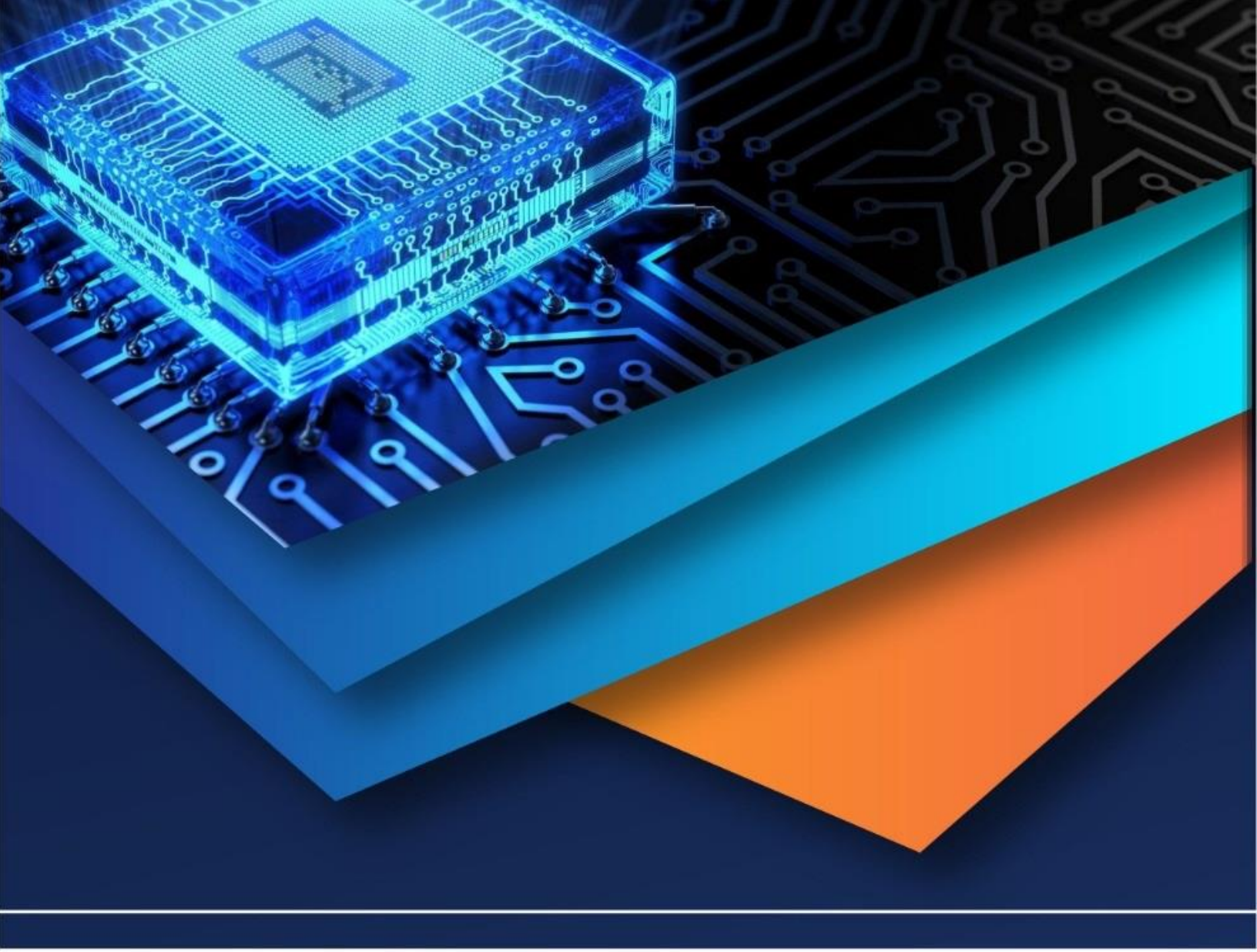

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