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IoT based Load Shedding

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Abstract: ***In the current scenario of increasing energy demand the utilities are struggling to meet the demand with existing generation. Utilities are forced into load shedding which is an unhealthy practice in the consumer point of view. This project aims to implement a system which limits the load that a single user can connect there by limiting the connected load of a large area. Allowing the user to connect a minimum amount of load enables the user to operate necessary loads for the duration of load shedding thus avoiding the discomfort that may be caused by total power cut. In our current scenario in case of any power failures utilities are notified of the fault through communication initiated by the consumers, in the project we are trying to minimize the time delay for communication by creating a dynamic system which informs the utility about the fault location in a greater accurate manner. The project also aims to implement a home energy consumption awareness interface that prompts the user to reduce energy consumption by means of pre assigned financial plan***.

Keywords: Power failure, Load shedding, IoT, Fault location

1. Introduction

India is experiencing an unprecedented increase in electricity consumption. Electricity has become one of the basic needs of the people irrespective of their jobs or status. Their daily activities, their daily routine, all depends on electricity one way or another. Thus, a proper system is required to provide an uninterrupted supply of electricity. It is necessary to make sure that there are low chances for the occurrences of fault, and in case a fault occurs there is an immediate response system for its recovery. Like all services the use of electricity also has cost. Which is required for proper maintenance and functioning of the service provider.
Through our project we aim at addressing these following basic functions and we suggest a better solutionn for implementing the same: -
1) Load shedding
2) Fault detection
3) Cost awareness

1.1. Load Shedding

A direct consequence of these increase demand is the enormous load burden that has been imposed on the national electricity grid, especially during peak demand periods. Load shedding is a measure of last resort to prevent the collapse of the power system country-wide. When there is insufficient power station capacity to supply the demand (load) from all the customers, the electricity system becomes unbalanced, which can cause it to trip out country-wide (a blackout), and which could take days to restore. When power is insufficient, Utility can thus either increase supply or reduce demand to bring the system back into balance. As the difference between supply and demand becomes large, this implies that action has to be taken to prevent the system from becoming unstable.

Utility normally takes a sequence of steps to keep the system stable and to avoid load shedding. By employing load scheduling for customers to reduce load voluntarily. However, if several power stationunitsfail unexpectedly, we may have to opt for a complete load shedding to prevent the system from becoming unstable. Scheduled load shedding is controlled by way of sharing the available electricity among all its customers. By switching off parts of the network in a planned and controlled manner, so the system remains stable throughout the day, and the impact is spread across wider base of customers. Load shedding schedules are drawn up in advance to describe the plan for switching off parts of the network in sequence during the days that load shedding is necessary. when load shedding isrequired, the networks are switched off according to the predetermined plan, to ensure that, as far as possible, customers experience load shedding in accordance with well informed schedules. In exceptional circumstances, if scheduled load shedding is not achieving the required load reduction or an unexpected fault occurs, then System Control Centres will shed load outside the published schedules by using emergency switching in order to protect the network.

Such events are rare, but if load shedding is declared, then all customers can expect to be affected at any time, and the planned schedules may not necessarily apply. During load shedding no matter which area, homes and cities are in total blackout. All loads are cut off and we have no means to meet our electricity demands during these times. Through this project we aim to limit the accessible load. Instead of cutting the entire load during load shedding period, a small portion of load is permitted to be used during the load shed period. We use IoT for a better implementation of this form of load shedding so that there are no complete blackout and people can do their basic needs.

1.2. Fault Detection

To transmit the electricity from the point of generation to the end user, an interconnected network of electric grid is used. The network of electric grid consists of countable number of generating stations, high-voltage transmission lines and distribution lines. The electricity generated from various sources is stepped up before transmission. This stepped-up power is transmitted to the substations through transmission network. In the substation the high voltage power is stepped down for various purposes according to the needs. From the

substation, low voltage electricity suitable for end users can be distributed.

Power distribution lines run though several natural conditions those results in various electrical faults caused by lightning, bird, tree and so on. Since these faults are possible to fail the power supply, they should be found out and rectified appropriately. To provide uninterrupted power supply. The distribution lines carry the electric power from step down transformer to consumers and need to be maintained properly with at most care. In our country the electric power line fault is a serious issue and conventionally, the users detect these visually and inform the utility about its location and is a very long process. In our project through the implementation of IoT we have a system in the module that connects every user to a central data base at the utility, which feeds in continuous data on status of the power line in its proximity whether it's live or not, the collected data from all the user base , as each module place at the user's premises has location Id and both data are compared to pinpoint the exact location and rectified immediately by the utilities officials rather than the consumers informing them of the faults.Also, such a data helps in understanding load patterns.

1.3. Cost Awareness

In the present metering system, we have no means to identify the energy used at a particular moment or the price amounted for the use of the same. In today's scenario we have the utility officials who travel to each of the consumer locations and record the details with respect to each consumer. Now there are various calculations to be done on these values based on slab and time of use pricing. The reason for their consideration is that energy consumed measured in units has different cost at various times and based on other factors. Thus, cost of energy need not be the same all the times. Thus, the bill must be made taking into these factors. Now presently in India we get our electricity bill at the end of two months. If a consumer has to minimize the money they spent on electricity, they have to go on an assumption that reducing the use of a particular load will help achieve their goal. This is effective and it canprovide energy saving. However, this is only a broad perspective and there is no means of knowing the amount of money they have saved on a real time basis and also the amount of money that has to be reduced on a regular basis to achieve energy savings.

Through our project we have set up a better method of cost awareness letting our consumers aware of the amount of energy they have used on a real time basis and also giving them the amount of energy that has to be used on a regular basis to achieve cost awareness. This part of our project is only an awareness mechanism and it does not forcibly shed or cut off any loads to achieve cost savings.

2. Review Stage

As a part of literature survey a few journals were referred and the following inferences were obtained, [1]This paper focuses on the importance of energymanagement during peakhours to avoid the burden ofload shedding, energyconsumption is also monitored on real time basis using IoT tobring about energyawareness to the consumer.

[2]This paper explains various types ofload shedding, thedivision of load sheddingsystem into parts, thecommon part and thefunction specific fault.

[3]In this system sensors are placed at variouspoints in transmission lines, these sensors detect physicalor electrical parameters, andgenerate data, these data aresent through IoT.

[4]The paper focuses on the design and realization of IoT current sensor, hardware architecture, connectivity, and protocols, IoT architecture(First step towards a cost effective IoT platform for customer's power consumption awareness).

[5]The system has a combination of smartdirect load control and load shedding to utilizeIoT for real time loadcontrol and generate dailyschedule for customersequipped a with IEDbased on their demandthermal comfort andforecast load model.

3. Working

3.1 IOT based load shedding

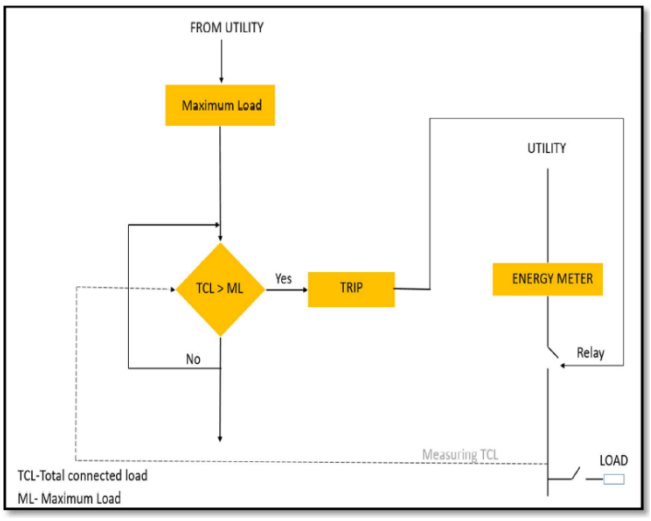

Figure 3.1: Flowchart

The figure3.1 shows the flow chart of IoT based load shedding. The load shedding is initiated by the utility from their webpage which has the options to control the maximum permissible load, load shedding period and set price for electrical unit consumed.

The load shedding module and the utility Domain have a continuous exchange of data, the webpage is designed to continuously send the maximum permissible load during normal operating conditions and during load shedding. During the initiation of load shedding from the utility, the webpage sends maximum permissible load to each load shedding module present in the consumer household, the module is in a constant cycle of checking the total connected load at the house hold and comparing it with the maximum permissible load received from the utility. If the module detects spike in thepermissible connected load during the

load shedding period, the relay in the module trips the relay thus cutting the supply. The system waits for few seconds before reconnecting the relay, this allows the user to shed the load and the module again rechecks the connected load whether it exceeded the permissible load if it does not exceed, the module continuously supply the consumer with permissible load, and if it exceeds the cycle repeats.

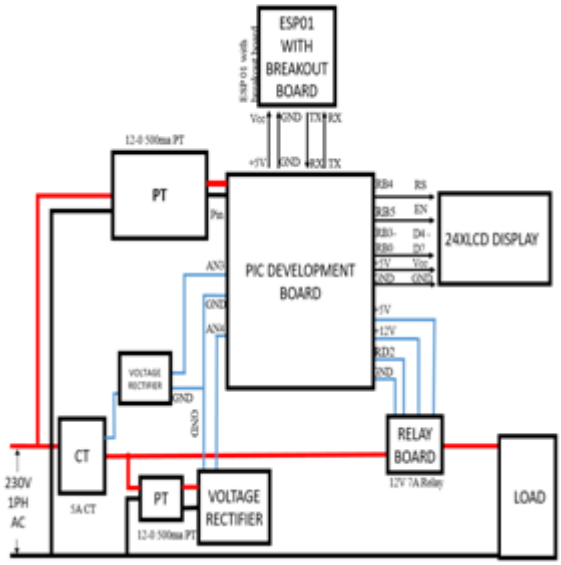

Figure 3.2: Block Diagram

The figure 3.2 shows the working block diagram of IoT based load shedding. It begins from the website which is connected to the pic microprocessor of our IoT module through ESP-01, a Wi-Fi module. The Wi-Fi module pins RX and TX pins are connected to the PIC's TX and RX pins respectively. This enables the two-way transfer of data between PIC and the website. The pins RS, ENABLE and D4-D7 is connected to the 20*4 LCD display. The connected load is measured by measuring the values of current and voltage in the circuit. This is done through a voltage and current transformer which measures the values of voltage and current. The CT and PT measures the respective quantities and these are passed to a voltage rectifier. The rectifier rectifies it to a voltage less than 5V. The unregulated signal is given to the ADC pins of the PIC IC. CT is connected to the pin AN3 and PT is connected to the pin AN4. The ADC converts these signals to their equivalent analog values and is given to the PIC. These analog values are converted back to voltage and current and power that is the connected load is measured which is the product of voltage and current. The PIC compares this value of load with the maximum permissible load provided by the website. If the measured load is higher the relay is triggered. A 7A relay is connect to the pin RD2 of the PIC IC. So, if the connected load is higher a signal "HIGH" is provide to the pin RD2 which operates the relay thus cutting off supply to the household. Now the consumer is provided a particular amount of time so that they can reduce the load and thus receive uninterrupted supply during load shedding. This refresh time is set for 6 seconds for our project prototype. After the refresh time a signal "LOW" is sent to the pin RD2 of the PIC IC. This turns on the relay thus providing electricity supply. Again, PIC compares the connected load with the permissible value and the cycle continues. The KSEB website is used to control and set up load shedding. The website has two adjustable load quantities, "NORMAL WATT" and "LOAD SHEDDING" watt which is set up by the utility. The normal watt is the maximum permissible load that can be used by the consumers during normal condition that is during the non-load shed period. This is usually set as a high value by the utility. Now, to initiate load shedding the "START TIME" and "END TIME" of the website is adjusted or set by the utility. During a time outside of this period the normal watt is sent to the Pic. When the time duration changes and load shed is initiated, instead of normal watt the load shed watt is provided to the pic and comparisons in the pic is based on this load shed watt. Again, after the end of the load shed period the signal that is sent to the microprocessor reverts back to "NORMAL WATT".

3.2 Fault Detection

Each and every household which is connected to the utility is provided with an IoT module. This module connects the households with the utility through an IoT network. So, when there is any fault and the supply to any household is interrupted, the Wi-Fi link to the household will be lost and the utility can pinpoint the exact location where the fault originated. Now each consumer is provided with a unique consumer number. The number will be different for different consumers. So, when supply is interrupted the unique consumer number will be sent to the utility when the fault occurs. The utility has a geographical map based on the consumer number knowing their exact location. The website will show a status "ONLINE" when the supply to the household is uninterrupted. The website has a refresh rate of 30 seconds that is within each 30 seconds the utility checks for any fault. If there isn't any then the status remains "ONLINE". Now when there is an occurrence of a fault. The website will identify the fault only after the completion of the 30 second refresh rate and once the fault is detected the status changes from "ONLINE" to the unique consumer number which is made available to each consumer. The new website shows the consumers number which will have a geographical location available to the utility. Thus, the need for the utility official to search each area for the fault or the consumers having to report to the officials can be eliminated.

3.3 Cost Awareness

The Cost awareness system includes an in-home display that is created to make the energy consumer aware about their consumption on a real rime basis so that they can take measures to reduce their consumption. The in-home display unit consist of Arduino Mega, 2.4-inch TFT LCD display, NodeMCU. The working block diagram of In-Home display unit is shown in fig:3.3 The IoT load shedding module calculates the energy consumed by the consumer and sends it to the consumer website via ESP-01 which is connected to the RX and TX pins of PIC microcontroller of the IOT module. The price of each unit of energy consumed is set by the utility in their website. This data is also transferred to the consumer website. The consumer website has a tab which allows the user to set the amount of money the consumer wishes to spent as their electrical bill for a month. The website then calculates the amount of money the consumer

can spent on a day for their energy consumption based on the cost of unit of electricity and the budget allocated for a month by the user. The data shown in the website to the consumer includes the cost per unit of electricity, total consumption of the user and its equivalent money, the amount of money provisioned for a day's consumption, the actual energy consumption of the day and its equivalent price. All these data are transferred to the in-home display. NodeMCU connected to the Arduino mega receives this information and transfer it to Arduino Mega through its TX pin. The TX pin of Arduino mega is connected to the RX1 of Mega. NodeMCU is powered by 5V supply from Arduino Mega and is provided to its VCC pin. The GND of both Arduino Mega and NodeMCU are also connected to each other. A piezo electric buzzer is connected to the pin 49 and GND of Arduino Mega to create beep sound for in-home display touch interface. The information in the consumer website is received by the NodeMCU via the internet provided from the consumer premises. This received data is filtered by the NodeMCU and serially transmitted via TX to the RX1 pin of Arduino Mega.

The Arduino Mega is programmed to create a touch interface with the LCD TFT display. The display is programmed to show the daily consumption of the user in a bar graph format so that the consumer becomes aware of their energy consumption as a visual representation creates a more striking impact rather than showing just data.The display is programmed to create a touch menu. The consumer can choose either of the options. When the consumer chooses the first option a bar graph will be shown that depicts the consumers' energy consumption.

When the second option is chosen, the same details available in the consumer webpage is replicated and displayed.

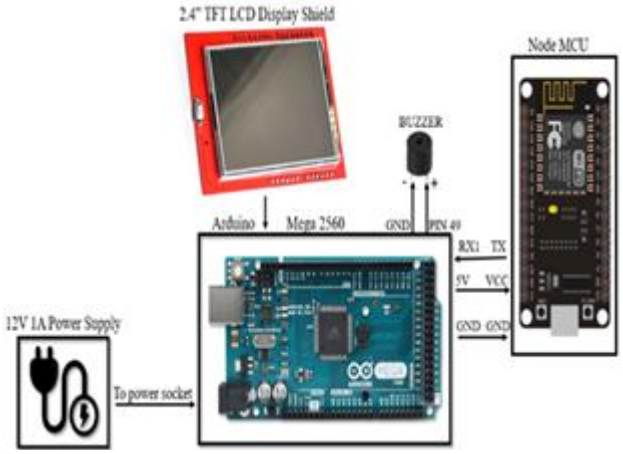

Figure 3.3: In-Home Display Block Diagram

4. Experimental Analysis

The load shedding module was assembled on a hylum body and is provided with three batten holders. These are provided with three 100W bulbs which acts as loads. The "NORMAL WATT" and "LOAD SHEDDING" watt on the utility's webpage is set as 5000W and 2500W respectively. The load is represented as a scaled value by the pic microcontroller. It was scaled by 10 that is when a 100W bulb is placed on one of the batten holders the connected load displayed will be 1000W. To simulate the operation of our project, we have set up a time period between which load shedding is to happen. This time period is set up in the utility's webpage by entering values into "START TIME" and "END TIME" boxes. When the device was tested all the three batten holders were provided with bulbs of 100W each. During load shedding when two of the bulbs were turned ON, a value of 2000W was shown on the display and there was no cut off of power but, when the third bulb was turned ON, the connected load shown on the display was 3000W which was well beyond the permissible watt of 2500W. Hence the supply was tripped off. Now one of the bulbs was turned OFF. After the refresh time supply was returned and the connected load value on the display was changed back to 2000W which is below the permissible watt, the supply to the load was sustained. Hence the operation of the load shedding module was successful. A Fault was simulated by turning OFF the power supply to load shedding module and the utility was able to pinpoint the exact point of the fault by displaying the consumers "consumer ID" on the utility webpage. The in-home display was operated and it was able to display the live data of the real-time cost and the units consumed. The bar graph showing the energy consumption increased with consumption of energy. Thus, the IoT based load shedding was a success

5. Future Scope

With the improvement in technology and increase ofliving standards the demand for energy will always increase. Thus, the chances of supply not able to meet the demand will be prominent. Load shedding will be an ever-occurring event. The proposed project we brought forward can be improved further with the technological advancements in network. The range of the WIFI system can be increased and also the transfer and refresh speeds can be increased substantially with the technological advancements in the coming years. The presently used overhead lines will be replaced by underground distribution system in the future and fault detection would be accurate with our proposed project. The project proposed is only aimed at load and power consumption monitoring there is no scope of shutting off non priority load during peak demand periods or turn them off when not in use. Also, the cost awareness interface can be only be accessed from the in-home display provided at our homes. Future advancements can be made so that the interface can be accessed from anyplace and anywhere also automatic load control can be done by the user. Smart home is an advancing technology that will have large applications and use in the future. The iot module and cost awareness system, we proposed can be integrated with smart home in future.

6. Conclusion

Our project tried to address the three basic functions such as the load shedding, fault detection and the cost awareness. From the customer point of view, we are able to see that the load shedding is a burden to the customer. After knowing the difficulties of total blackout, in this project, we tried to redefine the conventional load shedding strategy by load restriction. That is to restrict the total usage by allowing the

customer access for a limited amount of electric power during load shedding. This way consumer can use a small amount of load that's adequate for the basic needs. This helped in preventing the total blackout when the station capacity is very less in supplying the large demand of the consumers. This method helped in providing the required power to meet the necessary demands of the consumer. Thus, this project made to ensure that the system will be stable meeting the necessity. We brought the IoT in our project for proper implementation on restriction the total usage. IoT is a developing technology which has high future scopes. With the development of technology, the present IoT technology will flourish. These improvements when applied to our project will increase its functionality. The better method of fault detection is also put forward through our project. Earlier the fault point is detected manually and large amount of time is spent for the detection of the location of fault point. The officials have to either get a call from their consumers about the fault which will help determine the faulty points but the risks of a call being a prank is equally high. Whichever the case, the officials have to scan the area to find the faulty line. This is a time consuming and inefficient process costing time and money. We have brought up a new method for the exact and accurate location of a faulty point. Thus, if there is any power failure at a particular residence or a particular area can be detected automatically with the help of consumer identification numbers of the particular consumer that are affected by the power failure. So that the rectification of the fault and the restoration of the supply can be easily made by the utility officials.

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