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Prioritized Load Distribution system in Households

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Abstract - With increase in power demands there has been a continuous increase in power loading both in normal and peak hours. The power generation hasn't increased at such a pace so as to keep up with increasing demands thus resulting in power shortages and load shedding. This problem is maximally felt in third world countries and that too during peak hours of peak months like winters. Hence resulting in limited amount of power supply to households. This led us to design a solution for the same. We have proposed a smart load handling technique and an efficient household load management system. The system consists of priority based load distribution system (PLDS).the system drives the load appreciably which is of highest priority on the other hand limits the supply to the least priority loads, required for their operation. The overall system is designed around smart automatic voltage regulators (AVR), Arduino platform and sensor circuitry. The Arduino used in the system is Arduino mega which is Atmega 2560 family based embedded development and prototyping system. The system contains voltage sensors, current sensors, regulated power supply, step up/down transformers and relay board. The PLDS works on the concept of prioritizing the household appliances on the basis of need, voltage and current requirement. Whenever a particular priority load is connected to the system, it senses the device priority and routes the current and voltage to the device in such a way so that it runs smoothly. This routing is done at the cost of low priority devices keeping total power consumption constant. This system forms a complete efficient electrical system for household.

1. INTRODUCTION

According to survey in the distribution system, a 50 KWh distribution transformer is shared by about 50 households. Hence providing a 1KWh supply to each. But during peak hours of peak months the Household power consumption moves to tens of kilowatts which loads the distribution transformer and hence leads to power failures. Keeping in view the house hold power consumption scenario it is only 60% of the total power that is ideally used and rest 40% is either wasted or lost. There is a need to work on this problem on the both fronts, first to control the amount of power being wasted and then to manage the house hold consumption efficiently and the concept is realized by designing the Priority based Load Distribution System (PLDS). Therefore in detail, the main part of research has focused on household energy consumption as it's clear due to voltage and power losses, it is not be possible to satisfy the present power demand in household with a very low voltage supply. As per the survey carried out, it was revealed that during winters, the available voltage at mains is merely 90 Volts in most of the third world countries and rural areas but the required voltage for proper functioning of appliances like geysers, iron, AC's, electric heaters, ovens ,OTG's, induction heaters, rice cookers, room heaters, blowers, washing machines, refrigerators etc. is above 180 Volts . Considering the lay man solution to the problem, a household step up transformer should be installed in every home or office which would raise the voltage levels up to the appropriate values, but household transformers raise the voltage levels of the whole system that result in overloading .As the system gets loaded the output voltage from the household transformer automatically decrease in order to satisfy the current demands which can at times be such large that it could damage the transformer windings moreover damaging the voltage sensitive equipment . The proposed reformation helps to prioritize particular household's appliances. The appliances which require a minimum of 180 volts for the proper functioning are kept on priority first and the appliances which could work on voltages below 180 volts are put on other priorities. The prioritized system keeps an eye on the voltage fluctuations as well. In every room we keep three prioritized sockets each one differing in the voltage and current demands. The prioritized system is a dynamic system which changes voltages as per the requirements at a particular priority socket.

2. ORIGIN OF RESEARCH PROBLEM

Voltage irregularities are one of the greatest power quality issues faced today. In fact 95% of the problems revealed in electrical networks stem from voltage problems.
The following discusses some common voltage problems:

2.1 Over/Under Voltages

Technically speaking an over/under voltage condition is reached when the voltage exceeds / lags the nominal voltages by 10% for more than a 1 minute. Both of these conditions result in voltage that fall outside the acceptable power envelope as defined by CBEMA curve pictured in figure 1.

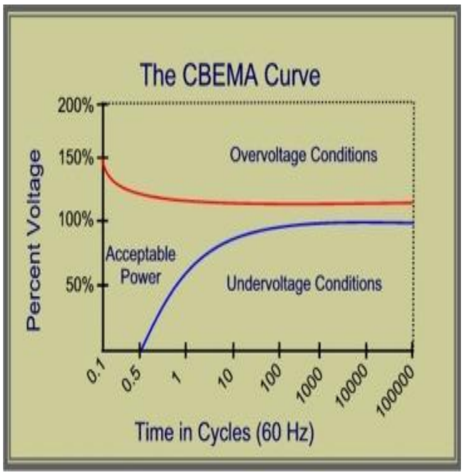

Figure 1. CBEMA Curve

2.2 Short Term Voltage Fluctuations

Short duration voltage events can occur such as transients, sags/dips & swells. Although shorter in duration, these events can reach a magnitude that falls outside the acceptable power envelope as shown in CBEMA curve. When this happens, events above the upper asymptote will lead to insulation breakdown, overvoltage tripping & over_ excitation. Events below the lower asymptote may cause loads to drop out all together.

2.3 Intermittent supply failures

Short duration intermittent supply failures can last anywhere from .5 cycles up to 1 minute and can be caused by a no. of occurrences such as supply systems faults (caused by lightening & other natural phenomenon), equipment failures or malfunctioning in control equipments.[6]

3. EXISTING TECHNOLOGIES

There have been various attempts to implement likewise system which include various research work done from various countries. They include Smart power management system for smart grid system consisting of five single steps: smart power system modelling, monitoring, database collection and management, grid condition check & maintenance and smart grid power system fault analysis. Smart power management system makes use of engineering data and provides a visualization which is to be effective in smart grid system.[1]
In another system for demand side management with a hardware solution for laboratory demonstration is proposed. Load of the consumer is divided into three categories: very critical, critical and non-critical. Power to the loads is fed through the microcontroller which is installed at home. System is proposed to control the load from the substation containing iPac 9302 single board computer and micro controller in the consumer premises using Zigbee technology i.e. IEEE 802.15.4 standard communication protocol. The method proposed does not take priorities from consumer as the load is controlled from substation on the bases of optimum load management and the critical conditions.[2]
Also Energy management system for efficient load management is presented .Proposed method consists of the two main parts. One is the energy management centre (EMC) consisting of graphical user interface. EMC shows the runtime data and also maintains the data log for the user along with control of the appliances. Second part of the method is load scheduling which is performed using the single knapsack problem. Results of the EMC are shown using LABVIEW while MATLAB simulations are used to show the results of load scheduling. Hardware model is implemented using human machine interface (HMI). HMI consists of PIC18f4520 of microchip family and Zigbee transceiver of MC12311 by Free scale. The microcontroller interface with the Zigbee transceiver is on standard RS232 interface. The method proposed requires HMI (human

machine interface) which makes the system manual in nature. It's not fully dynamic in nature as it takes only one load into consideration at a time while shedding other loads [3].

The problems with all the existing technologies related to this field are that the hardware and software implementation of these technologies is cost inefficient. In case of any fault in the system the whole system needs to be replaced thus increasing its troubleshooting cost. Another problem with these systems is that they are not fully dynamic in nature. The controlling mechanism requires human interference thus making the systems manual in nature.

All these problems have been nullified in our system design which is completely automatic, fully dynamic, cost efficient and user friendly system.

4. PROPOSED SYSTEM

The system consists of a local distribution transformer, automatic voltage regulators differing in priorities, input voltage sensor, output voltage sensors connected at the outputs of prioritized AVRs (automatic voltage regulators), and current sensors connected serially at the sockets differing in priorities as shown in the figure 4.1. The AVRs internally consist of a relay board, power transformer and a microcontroller (Arduino mega) for programming the system. The Mains input is fed to the local distribution transformer, The output of which is given to the AVRs. Also a voltage sensor is connected parallel to the output of local distribution transformer which is directly given to the microcontroller for checking the input voltage conditions. The microcontroller checks whether any of the appliances is connected to any of the prioritized sockets through the readings of current sensors. As per the demands at different prioritized sockets, the AVRs change the outputs depending on the requirement at the particular priority socket. The outputs of the AVRs are voltage sensed with the help of voltage sensors and are fed to the microcontroller for feedback purposes. If current sensor at priority first socket is not showing any value of current i.e. an indication that an appliance at priority first socket is connected, then the AVR feeding the priority first socket sets its output to a higher Voltage level that is required by the appliance to run smoothly and the other priorities are decreased in voltage levels to the minimum voltages required for their proper functioning through microcontroller which is already being programmed for the different voltage requirements at different priorities. The complete system is described with the help of an illustration diagram given in figure 4.1. Working and structure of AVR is described ahead which acts as the main brain behind the system. Figure 4.2 gives the description of the AVR i.e. the block diagram of the structure of AVR.

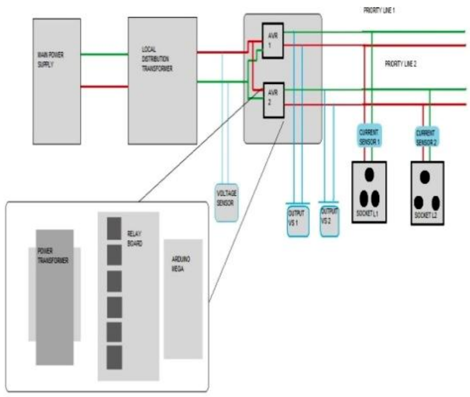

Figure 4.1 Illustration Diagram of the Whole System

AVR consists of a power transformer and a relay board (meant for switching various voltage levels of power transformers). Transformers can be used as step up as well as step down configurations depending upon the output of the local distribution transformer which is sensed by the voltage sensors. The voltage sensor designed by us consists of a full wave rectifier, a capacitor and a variable resistor whose value is set as per the requirement. The filtered rectified output has a peak voltage of 5v corresponding to the peak ac voltage of 230v.If the voltage at the output of the local distributer transformer which is input to the AVRs is less than 180v as sensed by the voltage sensor which is being fed to the controlling unit (microcontroller), the system then switches the AVRs in the voltage step up mode. While as if the incoming voltage is greater than 180v then the system switches the AVRs in the step down mode. Considering the AVR, the micro controller switches that relay which provides the required voltage of 180v to the priority 1 socket .On the other hand the other priorities are maintained at minimum voltages required for their operation.

Hence putting all the hardware components together our proposed system works successfully.

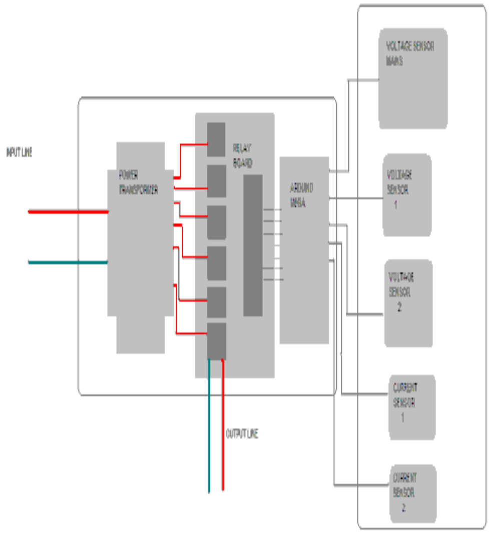

Figure 4.2 Illustration Diagram of the AVR (automatic voltage regulator)

Design of processing unit is illustrated with the help of implemented figure 4.3 which has been used within the system.

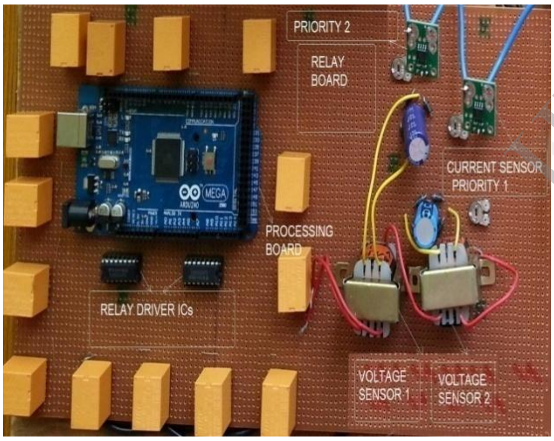

Figure 4.3 Illustration Implemented diagram of the processing unit.

5. IMPLEMENTATION

The system is implemented using the modules and circuits described in following section.

5.1 Processing module

Our processing module consists of Arduino mega development board belonging to Arduino family. Arduino is a single_ board microcontroller designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open source hardware board designed around an 8_bit Atmel AVR microcontroller, though a new model has been designed around a 32 bit Atmel ARM. The software consists of a standard programming language compiler & a boot loader that executes on a microcontroller. An Arduino board consists of an ATMEL 8 bit AVR microcontroller with complementary components to facilitate programming & incorporation into other circuits. An important aspect of Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. some shields communicate with the Arduino board directly over various pins , but many shields are individually addressable via an I2C serial bus, allowing many shields to be stacked & used in parallel official Arduino have used the mega AVR serial of chips specially the ATmega8, AT mega 168, AT mega 328,ATmega 1280, & AT mega 2560. A handful of other processors have been used by Arduino compatibles. Most boards include a 5v linear regulator & 16MHZ crystal oscillator (or ceramic resonator in some variants) although some designs such as the lily pad run at 8MHZ & dispense with the on _ board voltage regulator due to specific form factor restrictions. An Arduino microcontroller is also programmed with a boot loader that simplifies uploading of programs to the on_ chip flash memory, compared with other devices that typically need an extend program.[4]

5.2 Voltage sensors

Ideal for situations where power quality is an issue, voltage watch sensors facilitate monitoring of supply voltage levels. They identify under voltage concerns & help protect Critical motors and Electronics.
Our voltage sensor design consists of a bridge type full wave rectifier and a filter circuit calibrated over the scale using a potentiometer such that 230 volts of ac input refers to 5 volts of dc output which is input to the analog input pin of the microcontroller(Arduino). Any change in the ac input voltage is reflected at the analog input pin of the microcontroller which can be analyzed at the serial monitor of Arduino interface software. The
voltage levels sensed by these voltage sensors acts as a control signal to the microcontroller which accordingly decides the future course of action on the AVR's. Figure 5.1 gives the design of voltage sensor.

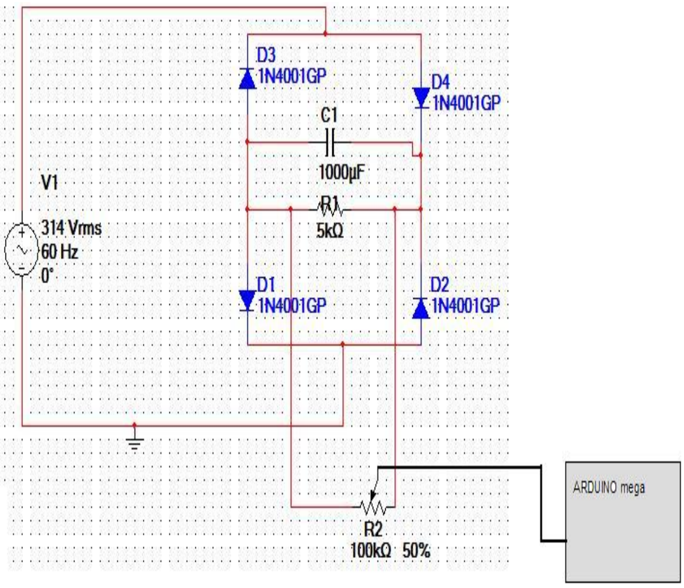

Figure 5.2 Illustration Diagram of voltage sensor.

5.3 Current sensor

It's a device that detects electrical current (AC or DC) in a wire & generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose. [5]

The sensed current & the output signal can be:

a) AC current input
b) Bipolar output
c) Unipolar output
d) DC current output
e) Digital output

Figure 5.3 gives the sketch of hall effect current sensor used in the system.

Figure 5.3 Illustration diagram of Hall Effect current sensor.

5.4 Relay module

Relay module is used in the system to switch between various steps of transformer windings in the automatic voltage regulator. The Combination of various high power relays are used to step u or step down the voltage automatically. This switching is done with the help of processing module of system. Figure 5.4 gives outline of relay module.

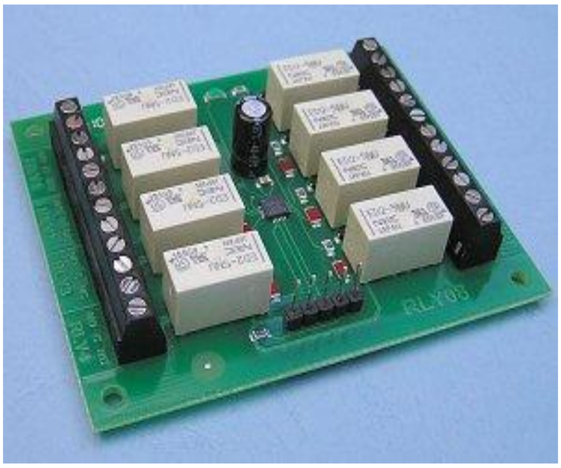

Figure 5.4 Illustration diagram of the relay board.

6. EXPERIMENTAL RESULTS

In the experiment we have analyzed two priority systems.

1. When current sensor of priority 1st does not show any reading i.e. when no device is connected to priority 1st, voltage level observed at priority 2nd is 220 volts.
2. When current sensor of priority 2nd does not show any reading i.e. when no device is connected to priority 2nd, voltage level observed at priority 1st is 220 volts.
3. When both the current sensors show some reading i.e. when both the priorities have devices connected to them the system behaves dynamically and the results observed are as under.

Table 6.1

Input voltage (volts)	P1 voltage (volts)	P2 voltage (volts)
<120	>= 180	110-150
120-190	>= 180	110-150
>190	>= 180	110-150

Figure 6.1 gives the experimental graphical results of the implementation of the system which come in synchronization with the expected results and thus testifying the successful implementation of the system.

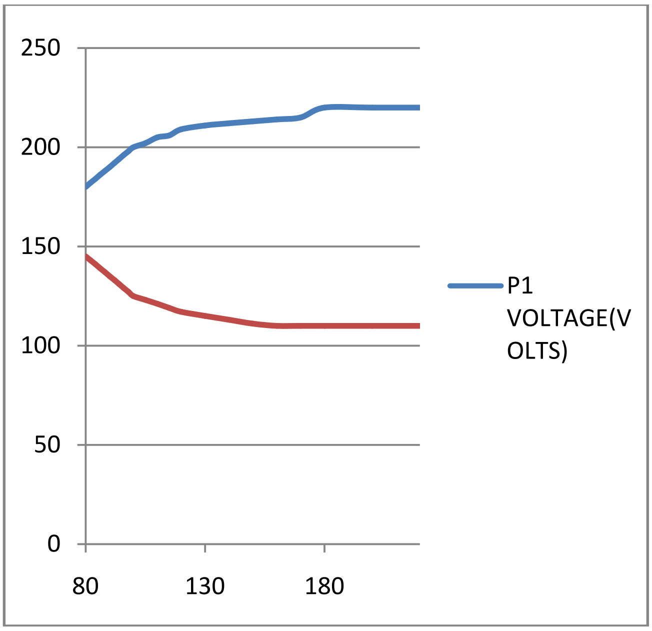

Figure 6.1 graphical Illustration graphical of the results.

7. CONCLUSION

1. Proposed method is encouraging and cost effective.
2. The system is fully dynamic and needs no user intervention.
3. All the voltage levels required by the priorities are automatically controlled by the AVR interface.
4. Consuming electrical energy efficiently results in reducing peak load, lowering electricity bills and minimizing the emission of green house gases (GHG).
5. The system also protects local distribution transformer from getting damaged due to overloading.
6. It also saves household appliances from over and under voltage conditions and also protects appliances from input voltage fluctuations.

8. REFERENCES

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