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AN ADVANCEMENT AND INVESTIGATION ON REAL TIME POWER MANAGEMENT FOR THE STREETLIGHT SYSTEM

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ABSTRACT
Street lighting in most of the rural and urban areas in India are not energy efficient. As it is the indispensable part of the rural and urban infrastructure. Hence there is tremendous potential for the improvement and proper maintenance without altering present street lighting system. This paper focuses on the problems like power saving, power theft, security, and immediate response to problems. Here we suggest a system which can monitor and control power continuously. An experimental system of wireless sensor network can be developed to study the feasibility for streetlight monitoring and control system. It also helps to design a highly secured and efficient system which can save power, as is the prime demand to meet the present increasing power needs. The important phenomenon of the paper is to consider the prime things while designing new system, that can read, corrects and as well as control utilization of power efficiently. This system consists of a base station (also called as control center) and a sensor node at each of the remote station (also called as feeder enable box). The base station monitors and controls all streetlights at real-time. This paper presents a modern and secured street lighting control system with embedded system based AC regulator system for lighting applications. The system guarantees energy savings due to power dimming options to avoid unnecessary glowing of bulbs during night hours according to traffic safety, lighting comfort and ON OFF timings in the morning & evening hours.

KEYWORDS: Power saving, Intelligent control, Base Station, Remote Station, GSM, GPRS, Embedded system, & SMS.

INTRODUCTION
India, generates about 1, 00,000 MW as per the present statistics. About 17-20% of which is used for the lighting systems, which operate at 220V ac at 50 Hz. Power qualities is rather poor in India. Interruptions both planned and unplanned are common. Line voltage variation of 30% or higher is also common, as are spikes and surges. All these problems are contributing for the reduced lamp life and lead to frequent lamp replacements and hence higher maintenance costs. This is over burden to the most of the sick municipalities in the country. In addition to the power quality problems, poor and inefficient design of the lighting systems also causing pain to the municipalities in the country. A well designed street lighting or public lighting or outdoor lighting should permit night movers the greatest possible safety and comfort, because the traffic capacity of the road at night is as much equal as possible that planned for the daytime. And the density of traffic will not be same evening to midnight, so a planed control system according to the density of the traffic is very much essential. Efficiently designed street lighting enables the driver to see distinctly without the use of dipped or driving headlights and helps to locate any traffic signs and possible obstacles on the road without much difficulty. It also helps pedestrian to see distinctly the edges of the footways, vehicles and obstacles. As street lighting system is the indispensable part of the town's infrastructure. Maintenance and control of the lighting systems and the production price of electricity by itself are the major expenses to the town's streetlight operation budgets. The system suggested here can help to solve the problems, about the draw backs of present system as fallows.

(I)There are thousands of streets connected in a common line, so it is very tedious work to maintain and control. The generated electricity can be improved by new technologies, as the demand for using electricity is increasing drastically. Hence energy savings is an important phenomenon to be considered while designing new equipment. In order to overcome this problem the street lighting controls are provided from a central control station using GPRS,

(II). Energy savings combined with reduced maintenance costs are prime benefits of remote energy tracking and control system. Energy savings through ON/OFF control, reduces maintenance costs by immediate reporting on defects and as well as monitoring of glowing hours are possible.

This work aims to develop an Energy efficient and low cost solution for street lighting system using Global System for Mobile communication [GSM] network using General Packet Radio Service [GPRS]. GSM and GPRS are used to establish a communication between the streetlights i.e., Remote Station Unit [RSU] at load side (streetlights) and the Base Station Unit [BSU] at the operator side. The whole setup provides the remote operator to turn off the lights when not required, regulate the voltage supplied to the streetlights and prepare daily reports on glowing hours. Power shut downs also can be intimated to the remote BSU operator through GSM and GPRS communication setup. The energy meter placed at the lighting system sends the readings to the remote BSU in the form of short message [SMS] during GPRS failure. From the data collected at BSU, energy report is prepared using front end software modules. This paper mainly focuses on remote monitoring and control of streetlights. Monitoring panel and energy report are designed using embedded system design.

THE PROPOSED SYSTEM

The need of automatic streetlight system is felt because, very few municipal corporations and municipalities in the country have metering facilities for streetlight consumption. Most of the municipalities pay the bill to respective electricity board based on the number of fittings in the municipal area. And there is no proper and efficient control system for the streetlight according to the needs. This practice not only creates revenue loss to the municipalities and electricity board but also increases the maintenance cost for the municipalities and overload problems to the electricity board.

The main reason for the poor and inefficient design of the street lighting system in any municipalities is due to,

- Improper management of power,
- Selection of energy inefficient equipment,
- Poor designing practice of street lights,
- Poor power quality,
- Higher overhead & maintenance costs, and
- Lack of skilled labor.

So the proposed system will take care of switching (ON/OFF), sensing the voltage and load conditions of the streetlights, along with dimming and antitheft identification to secure the system.

METHODOLOGY

The functional block Diagram shown in the figure.1 describes the concept of remote monitoring and control of streetlights. The system consists of two parts:

1) Base Station Unit [BSU] server side.

2) Remote Station Unit [RSU] Client side.

BSU SERVER SIDE

BSU server side illustrated in figure 2 provides the control commands. These commands are processed by GPRS modem or Broad band and sent to operate the loads (street lights) at client side remotely. The central or base station unit (BSU) includes a GSM modem (transceiver), interfaced to a PC, which is connected to a printer as shown in figure.2. Initially the BSU will switch on the lights by passing a message "all lights on" to all RSUs. Each receiving unit will have an ID, after receiving message from the BSU the RSU will send an acknowledgement to the BSU saying that it has received message. The BSU will check the acknowledgement from all RSUs, and if any RSU fails to send acknowledge, then the BSU will identify that RSU and it will send an mass message to the maintenance staff mobiles saying "please check ID……….".

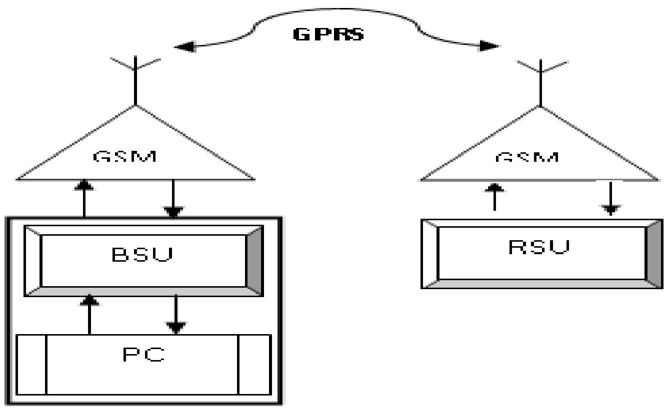

Figure 1. Functional block diagram of Remote Energy Monitoring System

After switching on the streetlights it has to check the health condition i.e., the voltage and load conditions. Like to know how much voltage the load it is getting and what is the current it is drawing. And it will check these parameters as per the predefined values. Whenever the BSU asks the RSU for checking RSU status then, it will send back the information to the BSU as fallows.

UNDER NORMAL CONDITIONS:

i) To turn on streetlights: By passing the command "switch on all" through GSM modem to all the RSUs, the street lights will be turned on and in response RSU will send "turned on" status message back to GSM modem.

ii) To turn off streetlights: By passing the command "switch off all" through GSM modem to all the RSUs, the street lights will be turned off and in response RSU will send "turned off" status message back to GSM modem.

iii) Turn off alternate bulbs: By passing the command "switch off alternate" through GSM modem to all the RSUs, the alternate street lights will be turned off and in response RSU will send "alternate turned off" status message back to GSM modem.

iv) Dimming the intensity: By passing the command "reduce intensity" through GSM modem to all the RSUs, the intensity of street lights will be reduced and in response RSU will send "intensity reduced" status message back to GSM modem. If BSU fails to send appropriate commands at predefined times both at morning and evening, then RSU will wait for half an hour and then will turn on and turn off the streetlights automatically both at morning and evening respectively. In this way RSU acts as BSU under BSU failure.

UNDER ABNORMAL CONDITIONS:

i) Modem Failure/ not functioning: If this condition exists in the morning, then the streetlights will continuously glow. Now it is required to replace modem or cutoff supply by sending service men. For that the service person will send a message to BSU asking to "Deactivate security system for 1hr". And after servicing "service done" message will be sent to BSU to resume the control immediately.

ii) Abnormality in R/Y/B: Phase problems are very frequent and as the BSU reads the status continuously, hence the problem can be immediately tracked. Then a mass message will be sent to RSUs maintenance staff. For that the service person will send a message to BSU asking to "Deactivate security system for 1hr". And after servicing "service done" message will be sent to BSU to resume the control immediately.

iii) Over load condition: When the command "switch on all" is sent to RSU, but status message received is "overload", that means either there is a leakage or theft of power and needs to be taken care off. Hence the BSU will send "overload" message to service person. Then for that the service person will send a message to BSU asking to "Deactivate security system for 1hr". And after servicing "service done" message will be sent to BSU. Likewise overload and power theft problems can be solved immediately.

In this way the status of the streetlights like switch on, switch off, under load, overload, and theft reports under normal and abnormal conditions can be maintained automatically

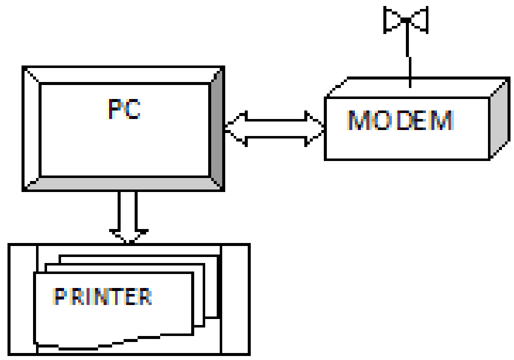

Figure 2. Functional Block of Base Unit (Server)

RSU CLIENT SIDE

Client side control system is shown in figure.3. The remote sensing unit involves a GSM system and a controlling circuitry which includes DSP controller, voltage sensing system, load sensing system, dimming and antitheft circuit. Power supply unit step down the 230V supply and rectifies it to power the micro controller. Crystal Oscillator unit provides the clock to the controller. LCD display setup is attached with the control unit to display the current status of the relays and voltage supplied to the streetlights. Communication between RSU and BSU server is setup through GSM/GPRS mobile communication. Commands given by the remote to BSU operator are received and processed by the micro controller at the client side. Controller issues the commands to operate the relay i.e. to turn the lights off when not required and to regulate the voltage supplied to the lights. Energy meter measures the energy consumed and sends the readings to the controller. Opto-isolator protects the controller from external disturbances. Through GPRS and GSM communication readings are sent to the server BSU operator. Two port serial communications is setup between the controller and GPRS modem using RS 232 network interface.

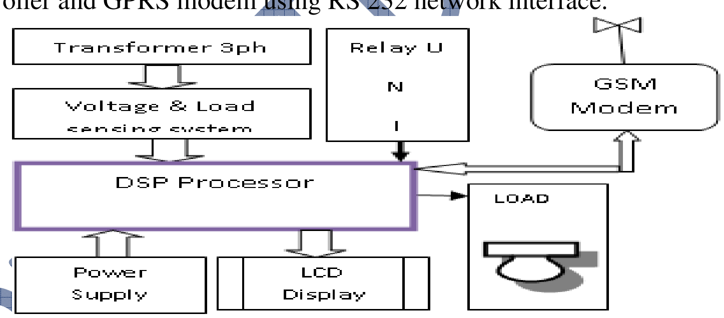

Figure 3. Functional Block of Remote Unit (Client)

RELAY UNIT

The block diagram of voltage regulator unit shown in figure 4 describes the voltage regulation done at the client side. Micro controller controls the main relay and tap changing relays according to the command sent by the BSU operator or timer set by the client. The relay connected with the secondary of the transformer is used to select the required voltage. The voltage above the rated value is controlled and maintained. The secondary of the tap changing transformer with relay is shown in figure 5 tapped by 180V, 220V, 230V, and 240V output for each phase R/Y/B. The Relays R1, R2, R3, and R4 operate corresponding to the command set by the micro controller. R-Main in the figure 5 indicates that the ON status of the main relay. R1 indicates the on condition of the first tap changer relay and continues the same for R2, R3, R4 etc. If R1, R2, R3, and R4 get turned off; no supply will be connected to the load. Hence load is in OFF condition. In case of relay R1 gets turned on; 180V of input supply will be connected to the load. Likewise all the relays are operated based on the signal given by the controller. The table 1 shows that the Glowing hours and relay status according to the time slot set by the program. During evening times (18.00hrs to 22.00hrs) maximum supply is connected with the load. During night hours (22.00hrs to 6.00hrs: can be adjustable at any time) voltage is regulated step by step according to the relay status.

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VOLTAGE SENSING

Voltage sensing is done to provide high voltage protections and , if any of the phase becomes absent then the supply will be provided to the load (i.e., street lights) uniformly through the rest of the two phases. Simultaneously input line voltage will be sensed and this information will be immediately sent to the BSU from every RSU for immediate action simultaneously.

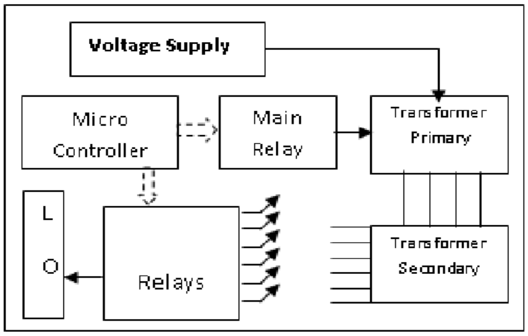

Figure 4. Voltage Regulator Block Diagram.

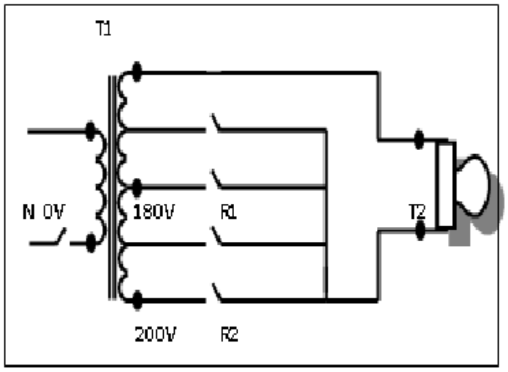

Figure 5. Tap Changing Transformer for each phase.

LOAD SENSING & POWER THEFT

In this case there are two conditions exists. One is overload and the second is under load condition. The load sensing system will inform BSU about the load condition i.e., the current consumption of the load under each RSU. Each RSU is designed to draw specific amount of load current. Sometimes due to failure of some of the streetlights and power theft it may draw low or high current respectively. Whenever load drawn is less then 20% of its predefined values, then RSU will send a message to BSU as its current status and predefined condition differs i.e., under load conditions. And in the same way, whenever there is power theft i.e., the RSU drawing 10% more current then its predefined values, RSU will send a message to BSU stating about the overload conditions.

ANTITHEFT

With this antitheft security system we can avoid any unauthorized activity at the RSU cabinet. i.e., whenever the cabinet of RSU and box or cap of the energy meter gets opened, then RSU will immediately send a message to BSU. Then in return BSU will send a alert message to the RSU's maintenance staff to look after the problem with client ID.

DIMMING

Dimming of street lights is another important & very much essential aspect to save energy at late nights. As the density of vehicles and public flow will be less at late nights, so it becomes unnecessary to glow the streetlights to their maximum intensity. In order to fulfill this requirement the input phase voltage will be decreased from 230v to 180v, which in turn decreases the power consumption up to 30% per phase.

Time slot (hr)	Voltage range (v)	Relay Status
18.00 – 22.00	221-240	R4 (ON)
22.01 – 24.00	201 – 220 or221 – 240	R3 (ON) or R4 (ON)
24.01– 06.00	181 – 200 or 201 – 220 or221 – 240	R2 (ON) or R3 (ON) or R4 (ON)
06.01	00	All OFF

Table 1. Glowing hours V/s Relay status of street lights

REMOTE MONITORING AT THE BSU SERVER SIDE

Monitoring and control panel is designed using embedded system on the BSU operator side. The control panel enables the current status of the load, which is being used. The programmer collects the information in terms of "base KWH", "load KWH", and relay status etc. Data are sent as SMS from the client side using GSM modem.

SMS SERVER

The System and the GSM module are serially connected via BSU (as shown in figure.1). Front end software module is used to enable communication between the mobile phone and the system. . The front end tool manager is used for managing the content and settings of a mobile phone from the personal computer. It can read, edit, store, load and rewrite the phonebook, import data from database. To initialize Front end software module control component, serial communication port address and Connection Mode properties of the system are to be set. Details of clients (area number, location of the street lights, SIM number of the client, glowing hours and current reading) are acquired and stored in a database. The SMS server first checks the area number, location and other details (as shown in the flow chart of figure.6). The SMS server first sends the request command to the controller at the client side. The RSU sends different parameter readings to BSU. Then the server authenticates the reading by checking with the SIM number from the database. From the readings, total amount of the units consumed, total glowing hours are calculated and updated in the database.

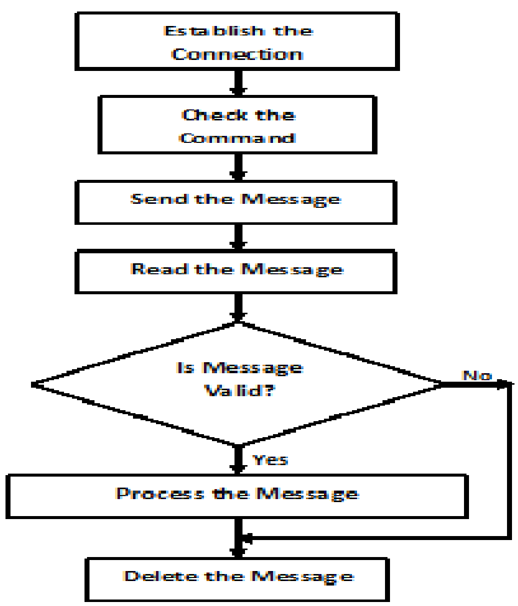

Figure 6. Flowchart for the SMS Server function

MONITORING PANEL SYSTEM DESIGN

The monitoring panel system is designed in such a way that it can display fallowing status.
MONITORING PANEL: displays current status of relays
SC NO: Indicates serial number of the current panel, which is monitored by the controller.
SIM NO: SIM Card number
ADD SERVICE: New connection establishment

VOLTAGE CONTROL: This panel indicates the current status of relays ON/OFF
KILO WATTS: Base /Actual input power in Kilo Watts (KW)
KWH: Base /Actual input power in KW/hour
LOAD KW: Load power in KW
SET TIME SLOT: Set time period for relay control
ENERGY REPORT: Gives details about the total load
power consumed in Kilo watts hour.
GET 24hrs READING: Gives the information about total load power consumed?

ENERGY REPORT

The amount of energy consumed by the load and percentage of energy saved is calculated using the following equations I and II.

Percentage of energy saving = Average power consumption by the load/Actual power to be consumed without relay for N days ------ * 100 -------------- (I)

Average power consumed = Sum of actual load condition based on the traffic density (using relays) for a period of N days ------------ (II)

i.e., Average = Sum of Power consumed for N days/N KW

Where, N is number of days

The panel shows the readings for 12 hours before enabling the relay unit at the client side and total power consumed is indicated as BASE KW. The readings for 12 hours after enabling the relay unit and total energy consumed are indicated as LOAD KW. From these two readings, the total energy consumed can be reduced by enabling the relay units.

RESULTS AND DISSCUSSION

Results are taken based on the assumption, that, if there are N numbers of Loads like florescent lamps, i.e., if 5no's of Sodium lamps connected with the client. Then N=5

The energy consumption before enabling the relay unit and after enabling the relay unit can be calculated. Before enabling the setup, the lighting system consumes 2 BASE KW for 12 hours. Next day after enabling the relays the same system consumes 1.52 KW for 12 hours because of relay actions based on the density of the traffic. From the two readings percentage of energy savings is calculated using equation.

If we take 5 samples of five days for 20 lights of 100watts each, hence total power required is 2KW.

i) First day with full intensity without using relays is 2.0KW.
ii) Second day with the use of relays based on traffic intensity is 1.75KW.
iii) Third day with the use of relays based on traffic intensity is 1.25KW.
iv) Fourth day with the use of relays based on traffic intensity is 1.40KW.
v) Fifth day with the use of relays based on traffic intensity is 1.50KW.

Then using equation II average power consumed is,
=2.00+1.25+1.40+1.50+1.70
=7.85/5
=1.57KW
Their fore the Percentage of energy saving = 1.57/20 =0.785KW
Energy Savings in percentage = (Total Units / BASE KWH) * 100 ------------ (III)
= (1.52 / 3.8) * 100
= 40%

The energy report also shows the information of total energy savings in percentage. The percentage of energy saving may vary between 33% and 40% according to the input supply fluctuations. 1000MW of electricity produces 7.5 million tons of CO_2 [at production], this solution contributes to save tons of CO_2 by reducing electricity consumption. The street light failure identification within hours can help in reducing a considerable percentage of average lamp downtime. Can be used to collect data's such as pollution ratio, air composition, humidity, temperature, traffic and noise levels. Further the power factor correction system also we are trying to implement, which may contribute another 10 to 15% power saving.

CONCLUSION

Power saving' which is one of the major factor of the present situation. So this study is important to expose this matter being serious and growing problem of any developing country. Significant focus of the paper is to discuss and solve these issues. Security of the system is another significant factor of the study. This work is crucial to develop as energy efficient and low cost solution for streetlight system using GSM and GPRS. Power is the means of developing countries, without which we cannot work. So the research will be useful for everybody who is surviving in this globalization. The benefit of this work occurs to protect the power which is been used unnecessarily or vested because of unplanned systems. Considering the demand of present situation, the study is significant to solve the problems like power cut, overload, under load etc., up to maximum extent. The test results show that the system can be used for the streetlight control. The system application in streetlight can extend control scope to each lamp; reduce in streetlight electricity and maintenance cost, and increase availability of streetlight.

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