Implementation of Energy Management Structure

for Street Lighting Systems

C.Maheswari (Corrosponding author)

Lecturer, Department of Mechatronics Engineering

Kongu Engineering College, Perundurai

Erode – 638 052, India

E-mail: maheswarimts@yahoo.co.in

R.Jeyanthi (Corrosponding author)

Lecturer, Department of Mechatronics Engineering

Kongu Engineering College, Perundurai

Erode – 638 052, India

E-mail: jeyanthi.ramasamy@gmail.com

Dr.K.Krishnamurthy

Professor & Head, Department of Mechatronics Engineering

Kongu Engineering College, Perundurai

Erode – 638 052, India

E-mail: krishmech@kongu.ac.in

M.Sivakumar

Senior Lecturer, Department of Mechatronics Engineering

Kongu Engineering College, Perundurai

Erode – 638 052, India

E-mail: amsivakumar@yahoo.co.in

Abstract

This work aims to develop an Energy efficient and low cost solution for street lighting system using Global System for Mobile communication [GSM] and General Packet Radio Service [GPRS]. GSM and GPRS are used to establish a communication between the streetlights and the Central Monitoring Station [CMS] 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 CMS operator through GSM and GPRS communication setup. The energy meter placed at the lighting system sends the readings to the remote CMS in the form of short message [SMS]. From the data collected at CMS, energy report is prepared using visual basic programming.

Keywords: Energy saving, GSM, GPRS, Embedded system, SMS

1. Introduction

Now day's street lighting systems are 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 (1). There are thousands of streets connected in a common line, so it is very tedious work to maintain and control. Dark roads deter people and well its surroundings attract people. The generated electricity is improved by new technologies; 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 (2). Energy savings combined with reduced maintenance costs are prime benefits of remote energy tracking and control system. Energy savings through ON/OFF control, reduced maintenance costs by immediate reporting on defects and by monitoring glowing hours are possible. This paper mainly focuses on remote monitoring and control of streetlights. Monitoring panel and energy report are designed using Visual Basic [VB] system design.

2. Methodology

The functional block shown in the figure 1 describes the concept of remote monitoring and control of streetlights.

The system consists of two parts:

1) CMS server side

2) Client side

2.1 CMS Server Side

CMS server illustrated in figure 2 provides the control commands. These commands are processed by GPRS modem and sent to operate the loads [street lights] at client side remotely.

2.2 Client Side

Client system control is shown in figure 3. Power supply unit steps 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 client and CMS server is setup through GSM/GPRS mobile communication. Commands given by the remote CMS 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 (6). Opto isolator protects the controller from external disturbances. Through GPRS and GSM communication readings are sent to the remote CMS operator. Two port serial communications is setup between the controller and GPRS modem using RS 232 network interface.

2.2.1 Relay unit

The block diagram of voltage regulator unit shown in figure 4 describes the voltage regulation done at the client side (4). Micro controller controls the main relay and tap changing relays according to the command sent by the CMS 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 unit is shown in figure 5 tapped by 0V, 180V, 220V, and 230Vand 240V output. The Relays R1, R2, R3, R4 and R5 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 gets turned off; no supply will be connected to the load. Hence load is in OFF condition. In case of relay R1 and R2 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 programmer. During evening times (18.00hrs to 21.00hrs) maximum supply is connected with the load. During night times (21.00hrs to 6.00hrs) voltage is regulated step by step according to the relay status.

3. Remote Monitoring At The CMS Server Side

Monitoring and control panel is designed using VB on the CMS 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, Relay status etc. Data are sent as SMS from the client side using GSM modem (8).

3.1 SMS Server

The System and the GSM module are serially connected via CMS (7). (Shown in figure 1). Oxygen software is used to enable communication between the mobile phone and the system. Oxygen phone manager is the software tool 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 Microsoft Access.

To initialize Oxygen Mobile ActiveX 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. This database is created using Microsoft access (shown in figure 9). Using VB the front end is developed and the database is accessed.

The SMS server first checks the area number, location and other details (shown in figure 6). The SMS server first sends the request to the controller at the client side. The energy meter sends the meter reading to SMS server via micro controller. Then the SMS 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.

4. Monitoring Panel System Design

Figure 8 shows that the monitoring panel of the remote operator. The list of comment boxes indicated the current status of the controller mode.

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 DAY READING: Gives the information about total load power consumed/ Day

4.1 Energy Report

The amount of energy consumed by the load and percentage of energy saved is calculated using the following equations 1 and 2.

Percentage of energy saving = current reading/ maximum reading *100   -------------   (1)

(or)

Percentage of energy saving = {(current reading / Maximum reading) *(maximum on time/ minimum on time)} *100   -----------   (2)

Where, Current Reading = LOAD KWh, Maximum Reading = Total KWh of previous day

Figure 9 shows the readings for 12 hours before enabling the relay unit at the client side and total power consumed is indicated as BASE KW. Figure 10 shows the readings for 12 hours after enabling the relay unit and total energy consumed is indicated as LOAD KW. From these two readings, the total energy consumed is reduced after enabling the relay unit.

5. RESULTS AND DISSCUSSION

Results are taken based on the assumption, that there are N numbers of Loads like florescent lamps, Sodium lamps and Motors etc connected with the client. Where N=0, 1, 2….

Figure 10 shows the data of energy consumption before enabling the relay unit and after enabling the relay unit. Before enabling the setup, the lighting system consumes 3.8 BASE KW for 12 hours (13.06.2007). After enabling the relays the same system consumes 1.52 KW for 12 hours (14.06.2007). From the two readings percentage of energy savings is calculated using equation 3

Energy Savings in percentage = (Total Units / BASE KWH) * 100   -----------   (3)

$$= (1.52 / 3.8) * 100$$

$$= 40\%$$

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.

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Table 1. Glowing hours Vs Relay status of street lights

Time slot (hours)	Voltage range (volts)	Relay status
18.00-21.00	221-240	R1 and R5
	>240	R1 and R5
21.00-23.00	201-220	R1 and R4
	221-240	R1 and R5
	>240	R1 and R5
23.00-06.00	181-200	R1 and R3
	201-220	R1 and R4
	221-240	R1 and R5
	>240	R1 and R5

Figure 1. Functional block diagram of Remote Energy Monitoring System

Figure 2. Functional Block of CMS Server

Figure 3. Functional Block of Client

Figure 4. General block of Voltage Regulator Unit

Figure 5. Tap Changing Transformer

Figure 6. Flowchart for the SMS Server functio

Figure 7. Monitoring Panel

Figure 8. Energy report **(**displays energy savings for 12 hours)

Figure 9. Energy report after enabling the relay unit for 12 hours