ENERGY CONSERVATION WITH VOLTAGE REDUCTION USING AUTOMATIC ON-OFF CONTROL IN LIGHTING SYSTEM

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Abstract- As per the saying ‘Money saved is money earned’ the economic development in energy saving becomes the economic growth. For achieving such growth energy saving and energy efficiency are the priorities of the nation. One area under study among the energy efficiency field is street lighting and industrial lighting. This paper presents a novel & efficient system of regulation and stabilization of luminous flux for public street lighting installations as well as industrial lighting. The main objective is to reduce their voltage supply, resulting in the improvement of energy efficiency in the installation. The system is basically composed of electromagnetic components and some basic electronic components which provide robustness and high performance to the device, as well as minimum maintenance requirements. This is based on the principle of CVR (conservation Voltage reduction) in lighting system.

Keywords- Energy Conservation, Street Lighting, CVR,

1. INTRODUCTION

1.1 What is energy conservation?
Energy conservation refers to reducing energy through using less of an energy service. Energy conservation differs from efficient energy use, which refers to using less energy for a constant service. For example, driving less is an example of energy conservation. Driving the same amount with a higher mileage vehicle is an example of energy efficiency. Energy conservation and efficiency are both energy reduction techniques.

1.2 Past Energy Scenario
Energy is prime factor for national economic development. India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations.

Per capita energy is use in India is much below compared to many countries.

Installed capacity of India: 110,000MW
Installed capacity of Maharashtra: 20,289.5MW
Available power: 13,375MW
Peak demand: 18,049MW
Power shortage: 4,774MW
Limited Fossil fuel stock up to 50 to 100 years only

Energy survey conducted by Ministry of Power in 1992 revealed that there is requirement of improvement in energy generation efficiency, improvement in energy transportation (transmission & distribution systems) and enhancing the performance efficiency of use end apparatus. Study of

‘Energy strategies for Future’ evolved two things - efficient use of energy, energy conservation and use of Renewable Energy.

1.3 Need of energy conservation
Today a significant amount of energy is wasted in power conversions. Conversion of power from one voltage to another, while a necessity in power distribution and usage, has inherent conversion losses resulting in wasted energy.

Higher conversion efficiency results in lower amount of wasted power, and this affect is multiplied if several conversions are used to create a required voltage. Significant energy savings can be achieved by not only having high efficiencies at full loads, but also by maintaining high efficiencies at light loads, low standby power and adaptive power controls via remote networked managed systems.

Energy conservation in lighting system is one of the important factors while considering the conservation of energy in electrical system. Huge amount of energy is wasted in street lighting because of neglecting factors like height of pole in required area, calculating area in sq.ft/sq.m, calculating luminance for particular area, number of lights required in that area which are actually cost reducing factors. Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 10% of the total power depending on the type of industry. Innovation and continuous improvement in the field of lighting, has given rise to tremendous energy saving opportunities in this area. Lighting is an area, which provides a major scope to achieve energy efficiency at the design stage, by incorporation of modern energy efficient lamps, luminaries and gears, apart from good operational practices.
1.4 Energy Conservation In Lighting System
Good lighting is required to improve the quality of work, to reduce humans / workers fatigue, to reduce accidents, to protect his eyes and nervous system. In industry it improves production, and quality of products / work. To view economy of lighting system, cost of initial installation cost, running cost, and effect on production / work are to be considered as main parameters. The power consumption by the industrial lighting is nearly 2 to 10 % of total power consumption, depending on type of industries.

Optimum use of natural light
Whenever the orientation of a building permits, day lighting has to be used in combination with electric lighting. The maxim use of sunlight can be get by means of transparent roof sheets, north light roof, etc.
Replacing incandescent lamps by Compact Fluorescent Lamps (CFL's)

CFL's are highly suitable for places such as Living rooms, Hotel lounges, Bars, Restaurants, Pathways, Building entrances, Corridors, etc.

Replacing conventional fluorescent lamp by energy efficient fluorescent lamp

Energy efficient lamps are based on the highly sophisticated technology. They offer excellent color rendering properties in addition to the very high luminous efficacy.
Replacement of Mercury/Sodium Vapor Lamp by Halides Lamp

MHL provides high colour rendering index and offer efficient white light. Hence for critical applications where higher illumination levels are required, these lamps are used. They are highly suitable for applications such as assembly line, inspection area, painting shops etc.

Replacing HPMV Lamps by High pressure sodium Vapour Lamp (HPSV)
Where color rendering is not critical for such applications e.g street lighting, yard lighting because CRI of HPSV is low but offer more efficiency.

Replacing filament lamps on panels by LED
LED lamps consumes less power (1 W lamp), withstand high voltage fluctuation in the power supply, longer operating life (>100,000 hrs). Hence nowadays they are also used in street lighting, signaling, advertising boards, even as replacement for tube light or CFL.

Replacement of conventional ballast by Electronic ballast
Installation of high frequency (28 –32Mhz) electronic ballast in place of conventional ballasts helps to reduce power consumption up to 35%.
Installation of separate transformer for lighting

In most of the industries, the net lighting load varies between 2 to 10%. If power load and lighting load fed by same transformer, switching operation and load variation causes voltage fluctuations. This also affects the performance of neighboring power load apparatus, lighting load equipments and also reduces lamps. Hence, the lighting equipment has to be isolated from the power feeders. This will reduce the voltage related problems, which in turn provides a better voltage regulation for the lighting this also increases the efficiency of the lighting system.

Periodic survey and adequate maintenance program
Illumination level reduces due to accumulation of dirt on lamps and luminaries. By carrying periodic maintenance i.e. cleaning, dusting of lamps and luminaries will improve the light output / luminance.
As part of maintenance program, periodic surveys of installation, lightning system with respect lamp positioning and illumination levels, proper operation of control gears should be conducted to take advantage of energy conservation opportunities as user requirements changes.

II. EXISTING LIGHTING SYSTEMS
Today, street lighting commonly uses high-intensity discharge lamps, often HPS high pressure sodium lamps. Such lamps provide the greatest amount of photopic illumination for the least consumption of electricity. However, when scotopic/photopic light calculations are used, it can be seen how inappropriate HPS lamps are for night lighting. White light sources have been shown to double driver peripheral vision and improve driver brake reaction time by at least 25%. When S/P light calculations are used, HPS lamp performance needs to be reduced by a minimum value of 75%. This is now a standard design criterion for Australian roads. New street lighting technologies, such as LED or induction lights, emit a white light that provides high levels of scotopic lumens allowing street lights with lower wattages and lower photopic lumens to replace existing street lights. However, there have been no formal specifications written around Photopic/Scotopic adjustments for different types of light sources, causing many municipalities and street departments to hold back on implementation of these new technologies until the standards are updated.

III. PROPOSED SYSTEM
This system is all about energy conservation in lighting system. This is done by Conservation Voltage
Reduction or Regulation (CVR). Conservation Voltage Reduction or Regulation has been identified by many utilities, organizations and individuals as a method of energy conservation. Utilities have been using, experimenting with or researching CVR for at least 25 years. Snohomish County PUD in Washington State has actively applied CVR to its system as part of its energy conservation program. One study estimated that in the Pacific Northwest alone CVR could provide up to 270 average megawatts of energy savings. California, in the summer of 2001, was actively pursuing widespread application of CVR to help alleviate its energy crisis. In its November 1982 newsletter, the Environmental Defense Fund published an article that described CVR and the potential savings associated with it [2][3].

3.1 Block diagram and circuit diagram
The proposed system as shown in figure 1 consist of
- Auto transformer
- Buck-Boost transformer
- Synchronous motor
- Control circuitry which includes the Dusk to dawn circuit and 555 Timer circuit.

![Figure 1 Proposed system Block Diagram](image)

![Figure 2 Circuit diagram of proposed system](image)

3.2 Operation of proposed circuit
The design is for the capacity of 700W. A 1-phase, 230V, 50Hz auto-transformer is used which is driven by servomotor control system and is center taped at 115V as shown in figure 2. The output of auto-transformer is connected to the input of buck-boost transformer whose output is further connected to the lighting load. In between auto-transformer and load in figure 1 there is a major closed loop control system with auto ON-OFF (Dusk to Dawn operation) system.

Initially, a light sensor will sense the climate light. Depending upon the climatic conditions it will vary the resistance i.e. when the light intensity is more the resistance is high and when the light intensity is less the resistance is low. The corresponding resistance provided by the sensing device is given to the control circuitry for further operation. The control circuit gives command to auto-transformer driving unit as well as to the timer circuit. At that time all the lights glows up at supply voltage 230V. After completing the timer circuit which is pre-set by user, gives command to servomotor to reduce the dimmer voltage as per the design meant for conservation.

3.3 Calculation
This system is designed for the load of 1700W which consumes 4.6W. This means that we can test on 6 lamps of 250W each.

Calculations for 1 sodium vapor lamp (Standard lamp used for test).

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Input Voltage (volt)</th>
<th>Load Wattage(watt)</th>
<th>Current (ampere)</th>
<th>Actual Wattage (watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>230</td>
<td>250</td>
<td>2.29</td>
<td>210.68</td>
</tr>
<tr>
<td>2</td>
<td>210</td>
<td>250</td>
<td>1.91</td>
<td>160.44</td>
</tr>
</tbody>
</table>

Table I Observations of load and wattage of 1 sodium vapor lamp

Power factor of the lamp = \( \cos \phi = 0.40 \)

Tariff rate for street lighting is Rs. 5/unit.

For 230 V

\[
\text{Power in watts per day} = \text{Voltage} \times \text{Current} \times \text{Power factor} \times \text{hours}
\]

\[
= 230 \times 2.29 \times 0.4 \times 12
\]

\[
= 1925.28 \text{ Watt/day.}
\]

For 210V

\[
\text{Power in watts per day} = \text{Voltage} \times \text{Current} \times \text{Power factor} \times \text{hours}
\]

\[
= 210 \times 1.91 \times 0.4 \times 12
\]

\[
= 160.44 \times 12
\]

\[
= 1925.28 \text{ Watt/day.}
\]

Saving for 1 lamp

\[
\text{Saving for 1 lamp} = \text{Power in watts for } 230 \text{V} - \text{Power in watts for } 210 \text{V}
\]

\[
= 2528.16 - 1925.28
\]

\[
= 602.88 \text{ watt/day}
\]

Actual saving for 1 lamp

\[
\text{Actual saving for 1 lamp} = \text{Saving for 1 lamps - system wattage}
\]

\[
= 602.88 \text{W} - 55.2 \text{W}
\]
= 547.68 watt/ day
Saving for 1 lamp per day in Rs. = [547.68 watt/(1000)]* 5
= Rs. 2.73/day
Saving for 1 lamp per year in Rs. = 2.73 * 365
= Rs. 999.51/year
Saving for 6 lamp per year in Rs. = 999.51*6
= Rs. 5997.06/year

Pay- back period calculations -
Per year saving = Rs. 5997.06/
Total cost of project = Rs. 15340/- Approx
Therefore,
Pay back period = 15340 / 5997.06
= 2.55 Years i.e. 2.5 year Approx

3.4 Advantages & Disadvantages

Every system has its merits and demerits. So needless to say our system also has some advantages and disadvantages which are discussed as follows.

1. By using this system life of lamp used in lighting system is increases .The main problem regarding lamp life is its heating as the applied voltage to lamp increases heating also rises according to ohms law V=IR for applied voltage 230 current is 4.5 A and as the voltage is reduced to 210 the current is 4.3 A also reduced according to joules law H=I*I RT so for current of 4.5 A the heating is more than for current of 4.3A obviously as with reduced voltage heating will also reduced .heating is a factor that determines the life of particular lamp hence with reduced heating life of lamp also increases.

2. Its implementation reduces cost. This lighting system requires less maintenance and inspection .overall maintenance of the lighting system where this system is employed is less. also because of automatic system the workmanship reduces.

3. Pay- back period is less Even though the initial cost of this system is high, considering the daily saving in wattage and in terms of money the payback period is less.

4. This circuit is not complicated As all the basic electrical and electronic component with their basic properties are used the circuitry becomes simpler. This system ensures continuous operation .After the first installation of this system it gives uninterrupted operation that is even after the power is off it starts automatically giving its continuous operation when power is on.

5. Versatility: The system is able to present one-phase or three-phase configurations

6. Reliability: In addition to ensuring high reliability levels, in case of system failure the regulator is connected in bypassed position and this provides a continuous and uninterrupted energy supply for lighting.

7. This system can work more efficiently if LED street lamps are employed.

Disadvantages

1. Preliminary cost is high due to the use of equipments like transformers, synchronous motor etc. makes the manufacturing costly.

2. As load increases the rating of equipments like transformer is increases and needless to say weight also increases and system becomes bulky.

3. This system is not applicable for fluorescent tubes.

IV. RESULT AND DISCUSSION

The lights are switched on for 12 hours a day; it would represent a consumption of 922.77 kWh a year. The consumption is reduced till 702.72 kWh. It means an energy saving of more than 220.04 kWh a year. Saving in rupees per year will be around Rs.5997.06/- and the cost of project is Rs.15, 340/- which will be recovered in approximately two and half years.

CONCLUSION

The proposed system had achieved 23.84% conservation in lighting system. Moreover, this conservation is achieved with the help of simple electronics components thus making the circuit less complicated. Also the payback period of this system is also less.

REFERENCES


