Energy saving in street lighting system

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Abstract. A street lighting system should be very efficiently designed to provide good visibility, safety and comfort to the users. It must be energy efficient with reduced cost. Generally Street lights are not operated robotically. During summer, the lights are on even during the day resulting in wastage of electricity. In the existing street lighting system, power consumption is more since the lamps glow with full illumination even in the nonappearance of vehicles or pedestrians. To overcome this, an attempt has been made to propose a system which is totally automatic. Thus an efficient and comprehensive scheme for energy saving in illumination is proposed in this paper. The energy saving is implemented using three main methods namely Dawn Dusk Method, Reduced voltage method and one phase cut off randomly and other two phases with reduced voltage method. This idea can exploit the capabilities of energy saving on the street light in well planned township in a systematic manner.

1. Introduction

Recently, the world is moving towards automation due to technological development. For a developing country energy conservation is the main necessitate. But energy is wasted through various means. Hence a new system is proposed which is very economical and requires less time to change the existing system[1,2].

Developing countries like India face difficulties with lack of power resources due to increase in population. The survival of the next generation is affected due to over dependency on fossil fuel. Hence energy consumption must be minimized by adopting various energy proficient techniques[3,4].

The existing street lights consume a huge amount of power since they are in operation in the entire night even in the absence of vehicles or pedestrians. So this became a most inefficient method. The main intention of this system is to save energy and man power. Energy Conservation means using energy more efficiently or with reduced wastage of energy. Industries are the biggest consumers of energy. In most industries the energy cost forms the large portion of manufacturing cost. So saving the electrical energy and reducing the wastage of energy is highly essential. Here the LDR sensor is used to turn ON-OFF the street light based on the ambient intensity level. This avoids unnecessary power waste during sufficient day light.[5,6]

In the existing street lighting system, three phase power supply is fed through load power contactors to the street lighting loads. These power contactors are controlled by the Light dependent Resistor (LDR). The LDR is installed at a height above the lighting system. Based on the light intensity on the LDR, it will response and give signals to the power contactors for ‘ON’ and ‘OFF’ the street lighting system. In this system the ‘ON’ and ‘OFF’ exact time of the street lighting system can’t be fixed because the LDR wholly depend on the natural light, i.e. the climatic condition of the place on a particular day. In this system there is no reduction of supply voltage, so full rated voltage is applied to energise the system [7,8].
2. Proposed street lighting system

In the proposed street lighting system as shown in Fig 1, power supplies are fed through Main power contactors, Bucking Transformers and load power contactors to the street lighting loads. The load power contactors are controlled by the Light dependent Resistor (LDR) and Programmed logic controller (PLC). The LDR is installed above the lighting system. Based on the light intensity on the LDR, it will respond and give signals to the power contactors for ‘ON’ and ‘OFF’ the street lighting system. The PLC is installed at the panel itself. Based on the preset timing, it will response and give signals to the load power contactors for ‘ON’ and ‘OFF’ the street lighting system. Also the PLC controls the voltage tapping contactors of the bucking transformer. From this control, the primary winding turns are varied and the secondary voltage of the bucking transformer is also varied, ultimately the voltage at the lighting system can be controlled [9,10].

Fig 1. Proposed lighting system

Fig 2. Proposed power circuit diagram – 1
Fig 2. shows the power circuit diagram with three phases, 415V, and 50Hz main power connected to the lighting load through the main power contactor, bucking transformer and load power contactors. Also it indicates that the lighting loads are connected in proper phase sequence.

![30KVA BUCKING TRANSFORMER PRIMARY 415V SEC 394.25/373.5V WINDING DIAGRAM](image)

Fig 3. Bucking transformer

Fig 3. shows the bucking transformer connected in subtractive polarity. The primary winding has three terminals. One terminal is common Neutral and connected to the load and another two terminals are provided with the tapings of the 95% & 90% output voltage with respect to the input voltage. It works on the principle of the transformer ratio i.e. \( V_1/V_2 = N_1/N_2 = K \). Also it shows the full load current will flow through the secondary winding only but not in primary winding. The primary winding can be designed with lower rating and the secondary winding can be designed with the rated load. So the size of the transformer will be reduced.

Fig 4. shows the control circuit diagram with single phase 230V, 50Hz AC supply connected to the double pole MCB. From that MCB output, LDR, PLC and other components shown in the figure are connected. The LDR will response based on light intensity. The LDR output is connected to the single pole 4 way selector switch. In that selector switch there are four output terminals. One terminal operates in the manual mode, second one in the LDR mode, third one in the PLC mode and final fourth one in the PLC with LDR mode. In the PLC output there are four output terminals of Q0, Q1, Q2 and Q3. The Q3 terminal is responsible for the voltage variation from 95% to 90% and the Q0, Q1 & Q2 terminals are responsible for the any one phase cut off with respect from the preset timing in PLC.
3. Methods and modes of operation

3.1 Methodology

Here the LDR sensor is used to ON-OFF the street light based on the ambient intensity level. This avoids unnecessary power wastage when sufficient sun light is available. The three main methods involved in energy saving are Dawn Dusk Method, Reduced voltage method (without interruption), one phase cut off randomly and other two phases with reduced voltage method.

3.2 Modes of operation

- Dawn dusk method
- Reduced voltage method
- Two phase operation instead of three phase operation

During day time (dawn) the lights are switched off by using timer in PLC so the system shall be in de-energized condition. When dusk arrives, the lamps are automatically “ON” using PLC programs. The system shall be energized and it will give signal to contactors to close. The street light circuit will be closed and the supply to the streetlights will be getting 95% voltage through the bucking transformer. The bucking transformer is in subtractive polarity. So 5% of supply Voltage will be...
saved from 6.00 PM to 10.00 PM. Energy saved is nearly 4 hours for all the three phases.

After 10.00 PM the supply to the street lights will be getting 90% of supply Voltage through the bucking transformer. So 10 % of supply will be saved from 10.00 PM to 12.00 AM. Energy saved nearly will be 2 hours in all the three phases. After 12.00 AM to 6.00 AM any one of the phase will be cutoff randomly. The sequence of operation will be controlled by PLC system. Energy saved nearly will be for 6 hours by using two phases instead of 3 phases.

When DAWN arrives, the PLC make the contactors to open. The system shall be in de- energized condition. The total assembly will be placed as an energy saving panel and it shall be wired for 95% & 90% tappings. By using bucking transformer even though the supply voltage changes from 95% to 90%, the lamp illumination will not get disturbed.

4. Calculation concepts - Model Calculation

Assume Resistance of the lamp is 100 ohms. Applied Voltage is 230V.

Power = \((V*V) / R\) Watts

\[\text{Power} = (230*230) / 100\]

\[= 529\text{ Watts}\]

**For 5% reduced voltage**

Power = \((V*V) / R\) Watts

\[\text{Power} = (218.5*218.5) / 100\]

\[= 477\text{ Watts}\]

Saving in power = 10%

**For 10% reduced voltage**

Power = \((V*V) / R\) Watts

\[\text{Power} = (207*207) / 100\]

\[= 429\text{ Watts}\]

Saving in power = 19%

For one phase switched ‘OFF’

Saving in power = 100%

For calculation purpose, take three 100W lamps glowing from 06.00 PM to 06.00 AM.

**Apply the full rated voltage for the whole time and it consumes,**

Energy = 12 * 100 * 3 WH

= 3600 WH (or) 3.6 Units.

**Apply the 95% of rated voltage for 06.00 PM to 10.00 PM and it consumes,**

Energy = 4 * 90 * 3 WH (Saving 10% of Power)

= 1080 WH (or) 1.08 Units.
Apply the 90% of rated voltage for 10.00 PM to 12.00 AM and it consumes,

Energy = 2 * 81 * 3 WH (Saving 19% of Power)

= 486 WH (or) 0.486 Units.

Apply the 90% of rated voltage for 12.00 AM to 06.00 AM and it consumes,

Energy = 6 * 81 * 2 WH (Saving 19% of Power with one Phase switched ‘OFF’)

= 972 WH (or) 0.972 Units.

So, total energy consumed with this energy saving system per day

Energy = (1.08 + 0.486 + 0.972) WH

= 2.538 WH (or) 2.538 Units.

So, Percentage of Energy saving per day = ((3600 - 2538) / 3600) * 100

= 29.5%

5. HARDWARE IMPLEMENTATION

Fig 5. shows 90% of supply Voltage measured at the load terminals i.e. 196V measured. In this mode Blue Phase switched ‘OFF’ and 90% of supply voltage applied to the load from 12.00 AM to 06.00 AM. Fig.6 shows 95% of supply Voltage measured at the load terminals i.e. 208V measured. In this mode 95% of supply voltage applied to the load from 06.00 PM to 10.00 PM. Fig.7 shows 100% of supply Voltage measured at the incoming supply terminals to the system i.e. 219V measured.

Fig 5. 90% of voltage measured
6. CONCLUSION

Energy demand in the country currently exceeds supply. The main benefit of the proposed system is saving of power. Only the cost for designing and installation is high but not for utilization. Hence, to reduce the consumption of conventional power, such systems can be adopted. Significant reduction of the power consumption is possible when implemented on a large scale. This initiative will save energy and meet the domestic and industrial needs. The circuit is simple and has flexibility in design. Necessary controlling actions could be taken depending on the intensity of traffic in a particular path. Moreover, the complete system can be made self-sufficient with renewable energy resources making this system more robust and reliable.
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