Performance of new generation pole light

K C Foo, S Karunanithi, G Thio
Centre of Communication Services Convergence Technologies, College of Engineering, Universiti Tenaga Nasional, Km 7, Jalan Ikram-Uniten, 43000 Kajang, Selangor, Malaysia.
Email: sarveswaren@uniten.edu.my

Abstract. This paper describes the design and implementation of a standalone photovoltaic power supply which caters for garden lighting scheme. New Generation Pole Light (NGPL) consists of three parts which are light dependent resistor (LDR) and pyroelectric infrared (PIR) sensors, microcontroller and light emitting diode (LED) and finally, solar charging system. During the night, LED is switched on with two operating modes which are ultra-bright lighting for a predetermine period (when human presence is detected) and dim lighting. Meanwhile, LED is switched off at day time and solar charging system will recover the capacity of discharged battery. NGPL provides portable, sustainable, environmental friendly and requires minimal maintenance for outdoor lighting scheme for both urban and rural areas.

1. Introduction
The alternating current (AC) power supply from TNB has provided great convenience to the customers. However, there are limitations as AC supply isn’t available at all locations. Outdoor lighting (for example garden area) using AC power supply is not feasible due to expensive cost of wiring installation. Nowadays, there are a lot of commercial off-the shelf solar powered garden light available. Disadvantages of these products is light is switched on and off at predetermine time rather than triggered by surrounding light intensity. Based on observation on street lights along Jalan Istana, the existing lighting scheme is less efficient with variation of sunrise and sunset timing throughout the year. Another disadvantage is the light is still switched on although there is no presence of human which addresses the need of sustainability and energy saving. Therefore, New Generation Pole Light (NGPL) was developed in order to address the need of intelligent outdoor lighting scheme. Light intensity detection and control is feasible with the usage of microcontroller, pyroelectric infrared sensor and light sensor [1] [2].

2. System Overview
NGPL consists of three parts which are light dependent resistor (LDR) and pyroelectric infrared (PIR) sensors, microcontroller and light emitting diode (LED) and finally, solar charging system as shown in Figure 1.
2.1. Sensors
Two PIR sensors were used to detect reflected infrared signals from the surrounding (human or animal). The PIR sensor used has a detection range of 7 m and deflection angle of 120°. The digital output pin of PIR sensor remains low (0), when there are no motions detected. When a warm body (human or animal) passes within the PIR detection range, output pin becomes high (1). Meanwhile, LDR was identified as a low cost solution for detecting light intensity (brightness). Resistance of LDR changes depending on amount of light shining on its surface. As light intensity decreases, the resistance of LDR will increase. LDR resistance measured at 7pm, 7.10pm and 7.20pm respectively are 60.5 k\( \Omega \), 0.343 M\( \Omega \) and 1.44 M\( \Omega \) as shown in Figure 2.

2.2. Microcontroller and Light Emitting Diode
Microcontroller, PIC16F690 receives signals from LDR circuitry and PIR sensors. During the day, the output voltage across the LDR is less than the predefined voltage level; which in return turns off the system (LED). Once the day is dark, voltage across the LDR is greater than the predefined voltage level where the LED is turned on. However, the voltage supplied to the LED is being limited in order to produce dim lighting. When PIR sensors detect presence of human, the microcontroller turns on the LED brighter for a predetermine duration. LED lighting was used instead of light bulb due to its low power consumption; thus, increasing the efficiency of the system without compromising the light intensity. 12 V, 3 W LED was used which emits warm white lighting without any UV or IR radiation. This is essential to avoid interference with PIR sensing.

2.3. Solar Charging System
LDR, PIR sensors, microcontroller and LED are powered using a 12 V, 4 Ah sealed-lead acid battery (manufactured by Innovation Battery Technology). Usage of sealed-lead acid batteries is common in standalone power supply due to its maintenance free nature. However, the battery will need constant charging depending on how frequent the system is being used. This raises the need of using renewable energy for battery charging purpose. Solar power was identified to be used for battery charging purpose as Malaysia is located along the equator line. Hence, SPM010-M monocrystalline
photovoltaic module with rating of 10 W, 18 V was used (manufactured by Solar Power Mart). A charge controller circuit was built to regulate solar panel voltage to the battery voltage.

2.4. System Integration
The solar panel was mounted on top of the pole in order to obtain maximum amount of sunlight as shown in Figure 3. LDR was placed in the mid-section of the pole which enable optimal light intensity sensing. Both PIR sensors were respectively placed on left and right side of the pole which maximizes detection of infrared signals. Finally, the rechargeable battery and circuitry were fixed into a lab scaled waterproof container.

![Figure 3. NGPL prototype.](image)

3. Preliminary Results
NGPL was tested in a lab scale environment where output of PIR circuitry was observed using an oscilloscope. PIR sensor outputs digital pulse when human presence is detected as shown in Figure 4; else, there is no change in output level. Current LED lighting used has a beam angle of 45° which limits the system application to narrow lighting area. By replacing the current lighting to surface mount ultra-bright LED, the system is able to be installed for wide area lighting scheme.

![Figure 4. Output of PIR sensor indicating motion.](image)

4. Conclusion
NGPL provides portable, sustainable and environmental friendly lighting scheme for both urban and rural areas. Using solar renewable energy is also cost efficient in the long run as it requires only annual maintenance to desulphate the battery terminals.

References
[1] Bai Y W and Ku Y T 2008 Automatic room light intensity detection and control using a microprocessor and light sensors *IEEE Trans. On Consumer Electronics* 54 issue 3 1173-76
[2] M Moghavvemi and C S Lu 2004 Pyroelectric infrared sensor for intruder detection *IEEE Region 10 Conf. (TENCON 2004) vol 4* p 656-659