Design of Modern Solar Street Light Intensity Controller: An Energy Saving Approach

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Abstract : Due to rapidly increase urban sector in India large volume of energy is required for it shows the answer is Renewal Energy in the form of Solar Energy which is presently used in urban sector of India whether it's used for domestic as well as the corporate sector. Now a days Light Emitting Diode (LED) based lamps are replacing the High Intensity Discharge (HID) lamps are used in the urban street light, thus intensity control is possible by pulse width modulation based on sensing the movement of vehicles. In the present text, in lighting the street light, as the vehicle moves the intensity goes on increasing for the few lights ahead and as it is passed away the intensity goes on reducing. This paper gives the basic ideas about the control the intensity of street light by the programmable micro controller to reducing as well as save the energy, as a result the programmable micro controller was engaged to provide different intensity at different condition.

GENERAL TERMS : Embedded System Design

Keywords : Solar system, Grid, Micro-controller, LED.

I. INTRODUCTION

Energy is the primary and most universal measure of all kinds of work ofhuman beings and nature [1] [2]. Energy is a crucial commodity in the process of economic, social and industrial development. As conventional energy sources are depleting day by day, utilization of alternative energy source is the only solution [3]. The increased power demand, depleting fossil fuel resources and growing environmental pollution have led the world to think seriously for other alternative source of energy and save this energy as much as possible. In this paper, we design an automatic dark detector and auto intensity control of street light [4] [5] [6] and it will take energy from the sun as well as from the local grid. Photodiodes (PD) are used on one side of the road. One Switching Transistor (ST) is meant for each PD. Each reversed biased PD is connection to the base of the ST. one Infra-Red (IR) diodes faces each PD on the other side of the road. When used no vehicle obstruction is there, the IR ray falls on the PD forcing the ST that conducts form controller toemitter like a switch. One variable resistor is used to control adequate base current of ST, as parameters of each conducting PD may be different from each other, while IR rays fall upon. The conducting ST develops a logic zero state at its collector that feeds one of the micro-controller pins that acts as an input. Eight such inputs are made by above arrangement.

II. COMPONENT DESCRIPTION

A. SOLAR CELLS

Solar cells are the building block of Photo Voltaic (PV) system. It is a form of photoelectric cell which, when exposed to light, can generate and support an electric current without being attached to any external voltage source. Solar cells produce direct current electricity from sunlight, which can be used to power equipment or to charge a battery. Solar cells require protection from the environments and are usually packaged tightly behind a glass sheet. When more power is required than a single cell can deliver, cells are electrically connected together to form photovoltaic modules or solar panels as shown in Fig. 1. Solar cells are often electrically connected and encapsulated as a module. Solar cells have many applications. They have been used in situations where electrical power from the grid is unavailable, such as in remote area power system as well as the urban area power system. The power produced by the PV cells fluctuates with the intensity of the sunshine. It is to be used to charge batteries first and then the batteries used.

Fig. 1. Solar Panel

B. CHARGE CONTROLLER

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added or drawn from the batteries. The term “charge controller” or “charge regulator” may refer to either a stand-alone device or to control circuitry integrated within a battery pack, battery-powered device or battery recharge. It prevents overcharging and may prevent against over voltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining (deep discharging) a battery [7]. The circuit diagram of a charge controller is shown in below Fig. 2.

(a) Off-Grid System

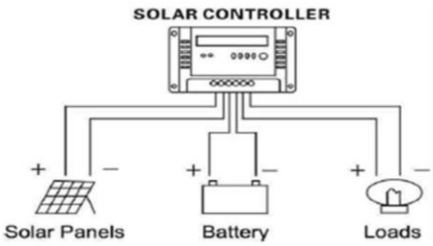
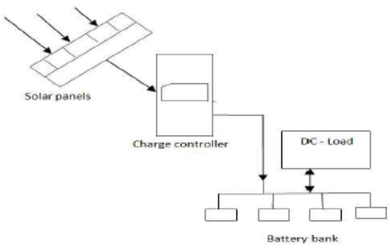


Fig. 2. Solar Charge Controller

Solar charge controller basically divided into two types: standalone charge controller and integrated charge controller. Stand-alone charge controllers are sold to consumer as separate devices, often in conjunction with solar or wind power generators, for uses such as PV, boat, and off-the grid home battery storage system. In solar application, charge controller may also be called solar regulators some charge controllers or solar regulators have added features, such as a low voltage disconnect, a separate circuit which power down the load when the batteries become overly discharged. Simply charge controller stop charging a battery when they exceed a set high voltage level and re-enable charging when battery voltage drop back below that level. Pulse Width Modulation (PWM) and Maximum Power Point Tracking (MPPT). Technology is charging rates depending on the battery level, to allow charging closer to its maximum capacity, but in case of integrated charge controller it functions as a charge regulator controller may consist of several electrical components or may be encapsulated in a single microchip. An integrated circuit (IC) usually called a charge controller IC.

(b) On-Grid System



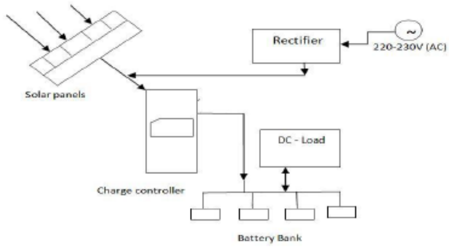


Fig. 3. Different Solar Power System

D. LDR (LIGHT-DEPENDENT-RESISTOR)

A photo resistor or Light-Dependent Resistor (LDR) or photocell is a light-controlled variable resistor, which is shown in Fig. 4. The resistance of a photo resistor decreases with increasing incident light intensity; in other words, it exhibits photo conductivity.

C. SOLAR POWER SYSTEM

Solar power system can be classified as two types depending on the connection to the system: on a grid system and off grid systems (stand-alone system). Grid connected photovoltaic power system is a power systems energized by photovoltaic panels which are connected to the utility grid [3]. The term off grid refers to not being connected to the grid, mainly used in terms of not being connected to the main and national transmission of electricity. In electricity off-grid can be Stand-Alone System (SAS) or mini grid typically to provide a smaller community with electricity. The term Off-The Grid (OTG) can refer to living in a self-sufficient manner without reliance on one or more public utilization [8] [9]. The different power system is shown on below Fig. 3.

Fig. 4. Light Dependent Resistor (LDR)

A photo resistor can be applied in light-sensitive detector circuits and light and dark-activated switching circuits. LDRs or Light Dependent Resistors are very useful, especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically to the base of the transistors. Consequently the LED does not light. However, when light shines onto the LDR its resistance falls and current flows into the base of the first transistor and then the second transistor. The resistor can be turned up or down to increase or decrease resistance, in this way it can make the circuit more or less sensitive. That means light must shine into the LDR for the circuit to be activated. But here a circuit design of the same components that activates when it is DARK.

E. LED (LIGHT EMITTING DIODE)

LEDs are semiconductor devices like transistors and other diodes. LEDs are made out of silicon. The small amount of chemical impurities that are added to the silicon such as gallium, arsenide, indium and nitride makes an LED lightened, which is shown in Fig. 5.

Fig. 5. Light Emitting Diode (LED)

When current passes through the LED. It emits photons as a by-product. LEDs produce photons directly; not via heat. An LED is usually a small area (less than $1MM^2$) light source. The color of the emitted light depends on the composition and condition of the semiconductor and the condition of the semiconducting materials. LEDs have a dynamic resistance that depending on how much current passes through them. Among the specifications for LEDs, a "maximum forward current" rating is usually given. LEDs consume a certain voltage known as the "forward voltage drop". A voltage source and a resistor are connected into drive an LED.

F. LIGHT SENSOR

Light Sensors often use an infra-red LED as a light source is shown in Fig. 6. Infra-red LEDs have a greater intensity than LEDs that emit visible light. When infra-red photo-diodes are used in the sensors, they become relatively insensitive to ambient light. The photoelectric light source is often modulated at a given frequency to prevent interference from ambient light, but flashes or reflection can be still full light-active ted sensors. This problem is solved by modulated receiver. Here the detector is synchronized to the light source frequency. Photoelectric sensors are the development of the modular devices. Sensor heads can be combined with a separate base and power supply and with various logic options. Also the logic options can be changed in the field without disturbing wiring or beam alignment. This minimizes downtime and allows unskilled personnel to repair equipment. Fiber optic is small; some are about 1/16 inch diameter and the fiber optic head usually just a little larger. As a result, it can fit into tight spaces.

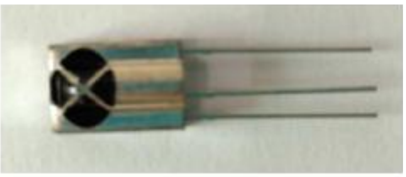


Fig. 6. Light Sensor

Fiber optic can also be used in explosive environments because all electrical signals are remote. Reflective Light Sensors (RLS) are frequently employee to sense an object present because they are easy to use. An RLS defers from other light sensors in that target doesn't simply break a light beam, but reflect the light to the detector. RLSs are less sensitive to ambient and detect minute or transparent objects. Some devices can even determine the distance between sensor and object, thereby offering an alternative to ultrasonic system. While in general RLSs are becoming smaller two divergent trends are emerging as well. One group of sensors is becoming simpler, basically containing only a light source and detector. Sensors output is a simple on or off signal and users provide the power supply and signal processing circuitry. The other group is becoming full featured. These contain a power supply and logic. A user programs the devices by setting switches or with a PC. Sensor manufactures are integrating advanced devices like solid state lasers. Usually the power supply for the lasers and an amplifier for the signal output are contained in a separate unit. An advantage of placing system functions in different packages is that the sensor is kept small.

G. IR TRANSMITTER

IR transmitters carries at round 40 KHz carrier frequency and are wildly used in TV remote controlling. The circuit can be control by using any TTL or RS-232C level control signal which makes the interfacing very simple.

H. TRANSFORMER

The transformer is a static device which converts AC from one voltage to another with little loss of power. Step-up transformer increase voltage, step-down transformers reduces the voltage. Most of the power supplies use a step-down trans-former to reduce high mains voltage to a safer low voltage.

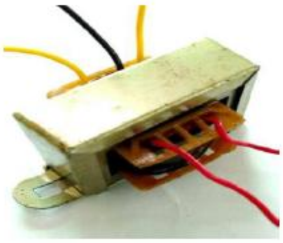
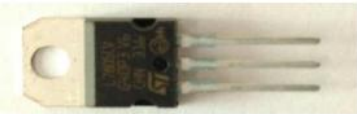


Fig. 7. Step-down Transformer

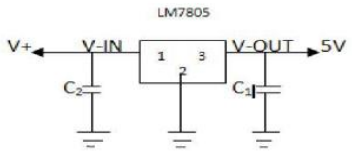
The input coil is called primary coil and the output coil is called secondary coil. The primary and secondary coils are linked by an alternating magnetic field created in the soft-iron core of the transformer. Transformer waste very little power, so the power output is almost equal to the power input. A Step-down transformer has a large number of turns of the its primary (input) coil which is connected to the high voltage main supply and a small number of turns on its secondary (output) coil to give a low output voltage, which is seen like below Fig. 7.

I. VOLTAGE REGULATOR 7805

The KA78XX/KA78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of application. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1 amp output current, although design primarily as fixed voltage regulators. These devices can be used with external components to obtain adjustable voltage and current. The specification of TO-220 is tabulated in Table-I.



(a) Voltage Regulator LM7805



(b) Layout Diagram of LM7805

Fig. 8. Voltage Regulator

As per the above Fig. 8(a) LM7805 voltage regulator is a linear regulator which comes in several types of packages. For output current upto 1A there may be two types of packages: TO-220 (vertical) and D-PAK (horizontal) with proper heat sink these LM78xx types can handle even more than 1A current. They also have thermal overload protection and short circuit protection. In case, the design does not exceed 0.1 amp current, then the regulator LM7805 may be chosen with smaller packages and lower maximum current up to 0.1 A. They come in three main types of packages SO-8, SOT-89 and TO-92. LM7805 has an input range of 7-25V and output of 5 V. Decoupling capacitors of 10F and 47 F connected to the input (V-IN) and output (V-OUT) respectively are grounded. There are negative voltage regulators marked as LM79xx that work in the same way. The circuit diagram of LM7805 is shown in Fig. 8(b).

TABLE- I : ABSOLUTE MAXIMUM RATTING OF T0-220.

Parameter	Symbol	Value	Unit
Input Voltage: (for V=5 to 18v) and (for V=24v)	VI and VI	35 and 40	V
Thermal Resistance Junction cases (T0-220)	^{R}LJC	5	◦C/W
Thermal Resistance Junction Air(T0-220)	^{R}JA	65	◦C/W
Operating Temperature Range (KA78XX/A/R)	^{T}OP R	0+125	◦C
Storage Temperature Range	^{T}ST G	- 65+150	◦C

J. 8-BIT MICRO-CONTROLLER WITH 4K BYTES FLASH, AT89C51

This application describes a PC-based programmer for the AT89C51 Flash-based Micro-controllers. The programmer supports all flash memory micro-controller function, including code read, the code writes, chip erase, signature read and lock bit write. It is connected to an IBM PC-compatible host computer through one of the host's parallel ports. Required operating voltages are produced by an integral power supply and external wall mounted transformer.

The AT89C51 is a low power, high-performance CMOS, 8-bit microcomputer with 4K bytes of flash programmable and Erasable Read Only Memory (PEROM). The on-chip flash allows the program memory to be reprogrammed in a system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective to many embedded control applications. The AT89C51 provides the following standard features: 4K bytes of flash, 128 bytes of RAM, 32 I/O lines, two 16 bit timer/counters, a five vector two-level interrupt architecture, full duplex serial port, on chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle modes stops the CPU while allowing the RAM, timer/counter, serial port and interrupt system to continue to function.The Power down Mode save the RAM contents, but freezes the oscillator which disabling all other chip functions until the next hardware reset.The Pin configurations of AT89C51 are as shown in Fig. 9.

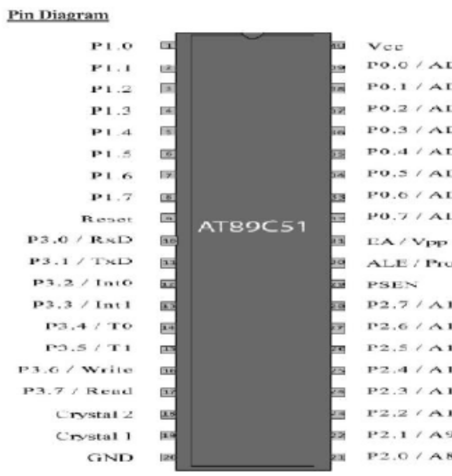


Fig. 9. Pin Configuration of AT89C51

The details of the parts are as follow:

Port1: Pin no. 1-8 is an 8-bit bidirectional I/O port with internal pull-ups. The port 1 output buffer can sink/source four Transistor-Transistor Logic (TTL) input. When 1s are written to port 1 pins they are pulled high by the internal pull-ups and can be used as inputs. Port 1 also receives the low-order address bytes during flash programming and verification. RST: pin no. 9 is reset pin. It is an active high input pin. The high pulse must be high at least 2 machine cycles.

Port 3:pin no 10-17 is port 3. Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The port 3 output buffers can sink/source four TTL inputs. When 1s are written to port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. Port 3 also serves the functions of various special features of the AT89C51 as listed in Table-II. Port 3 also receives some control signals for flash programming and verification.

TABLE-II : FUNCTION OF PORT 3 OF THE AT89C51.

Port Pin	Alternative Function
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	INT0 (external interrupt 0)
P3.3	INT1 (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	WR (external data memory write strobe)
P3.7	RD (external data memory read strobe)

CRYSTAL1: pin no 18 is crystal 1. Input to inverting oscillator amplifier and input to the internal clock operating circuit.

CRYSTAL2: pin no. 19 is crystal 2. Output from the inverting oscillator amplifier.

GND: pin no. 20 is ground.

Port 2: pin no 21-28 is port 2. Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The port 2 output buffers can sink/source four TTL inputs. When 1s are written to port 2 pins they are pulled high by the internal pull-ups and can be used as inputs. Port 2 emits the high order address bytes during fetches from external program memory and during accesses to external data memories that use 16-bit address (MOVX @ DPTR). In this application, it uses strong internal pull-ups when emitting is 1s. During accesses to external data memory, that use 8-bit addresses (MOVX R1). Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address bit and some control signals during flash programming and verification.

PSEN: pin no. 29 is Program Store Enable (PSEN). It is the read strobe to the external program memory. When the AT89C51 is executing code from external program memory, PSEN is activated twice in each machine cycle, except that two PSEN activation are skipped during each access to external data memory.

ALE/PROG: pin no. 30 is ALE. “Address Latch Enable” output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6th of the oscillator frequency and may be used for external timing or clocking purposes.ALE is active only during a MOVX or MOVC instruction; otherwise the pin is weakly pulled high. If the micro-controller is in the external execution mode, ALE-disable bit has no effect.

EV/VPP: pin no. 31 is External Access enables (EA). It must be strapped to GND in order to enable the device to fetch the code from external program memory locations starting at 0000H up to FFFFH. EA should be strapped to VCC for internal program executions. This pin also receives the 12-Volt Programming enable voltage (VP) during Flash programming, for the parts that require 12-volt VPP.

Port 0: pin no. 32-39 is port 0. It is an 8-bit open drain bidirectional I/O port. For an output port each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs. Port 0 may also be configured to be the multiplexed low order address/data bus during accesses to an external program and data memory. In this mode P0 has an internal pull-up. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pull-ups are required during the program verification.

VCC: pin no. 40 is a voltage source.

III. CONSTRUCTION AND WORKING

20 bright white LED (WL) representing as street light is fed from the micro-controller output pins that normally provide 10% duty cycle pulse (while no IR ray is blocked, simulating a no vehicle movement) that’s slows dimly. As the vehicle reaches the first IR, it blocks the ray falling on the P D that deprives the ST bias to result in the off condition at its pulled up collector that sends a logic high to the corresponding MC input. The program then takes effect inside the MC in making its output of few WLS ahead of set 99% duty cycle pulses to increase their intensity. Whenever vehicles enter into the road, the photo sensors which are placed on either side of the road will detect and the 10 LEDs which act as street light will go high to glow in one mode and will change from dimmed to full bright mode according to the program [10].

Existing automatic street light are only use conventional AC source of energy to save the energy [11] but our pro-posed automatic street light is used both conventional and non-conventional source of energy so that the robustness of the proposed model is better as well as save energy than the existing one as per our statistics.

As per the above Fig. 10, here we have used grid connected photovoltaic power system. First battery is energized by the PV panels and the batteries charge is control of the charge controller. If in case there is no sun is available due to bad weather then from the traditional way the battery is energized that is 230 volts AC mains is converted into 12 volts AC through a transformer. The 12 volt AC is then converted into 12 DC through a rectifier and finally through a charge

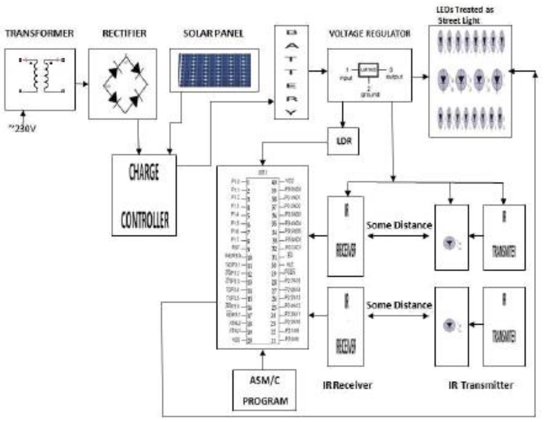


Fig. 10. Symmetric Representation of Grid Connected Density Sense Auto Intensity Control Street Light.

controller DC is stored in the battery. This 12 volt DC voltage is unregulated as called as pulsating DC, for obtaining 5 volts fixed DC, a voltage regulator (LM7805) which convert the pulsating DC to fix DC.The 5 volt DC is given to the MC, in between the MC and the voltage regulator. This is a LDR placed in such a way that if there is no light shine into the LDR, the circuit will be activated. An appropriate program is written in high level language or assembly language, which is converted into machine language. This is then loaded into the MC in HEX format.

As per the requirement of the load the program is loaded in the MC. The LEDs are treated as street light. The total circuit of the street light is first activated by the LDR then when the road is obstructed by the vehicle, LEDs from no. 1 to 10 starts glowing as per the program; when the vehicle crosses the first street light then the next 10 LEDs glows as driven by the program.

IV. FUTURE ASPECTS

1. Using wireless sensor with GPS module we will easily localized the bug poles and also fetches the timing from sensor for the passenger.

2. By adding some innovative sensor like object capturing sensor, speed measuring sensor we can sense and get information from the sensor and then we can store the data in cloud server when we need some data then we can directly find the same data from the cloud sever.

3. We can also use the street light pole for holding the module in smart city.

V. CONCLUSION

It is apparent from the current setup that two robust approaches can lead to save energy as far as the arrangement of the street light in the highways, traffic and parking are concerned. First of all the replacement of current fluorescent lamps by LEDs is cost effective and less voltage requirement. Secondly the arrangement can be achieved by low investment and in turn saves more energy by automatically dimming of LEDs in no traffic situation. Depending upon the easy visibility of the driver and average positioning of the lamps in the highways, the present arrangement that out of 20 LEDs 10 LEDs are simultaneous glow to avoid accident. However, due to the flexibility of the circuit the micro-controller can be reprogrammed to control any number of lamps at a time.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] R. Hargroves, “Road lighting,” IEE PROCEEDINGS, vol. 130, no. 8, pp. 420–441,november 1983.

[2] R. C. Barr, “Green power: A renewable energy resources marketing plan,” 32nd Intersocity Energy Conversion Engineering Conference, pp. 803–808, NOVEMBER 1983.

[3] M. K. Rout, N. D. Badgayan, S. K. Pattnaik, and M. K. Rout, “An empirical study on energy management standard (iso50000): Effectiveness performance evaluation for steel plants and comparison with iso 9000, iso 14000, iso 18000 and iso 22000,” International Journal of Engineering Research and Technology (IJERT), vol. 2, no. ISSN: 2278-0181, pp. 1329–1341, Dec 2013.

[4] H. Nakayama, E. Hiraki, T. Tanaka, N. Koda, N. Takahashi, and S. Noda, “Stand-alone photovoltaic generation system with combine d storage using lead battery and edlc,” 13th International Power Electronics and Motion Control Conference (EPE-PEMC), 2008.

[5] K. Yang, J. Song, and Y. Chen, “Secondary light distribute ion design for led street light,” International Conference on Electronics and Optoelectronic (ICEOE 2011), vol. 2, pp. 378–381, 2011.

[6] F. Argatu and C. Cepisca, “Modeling dynamic high intensity discharge lamp characteristics,” U. P. B. Sci. Bull.

[7] M. becherif, M. Y. Ayad, A. Henni, and A. Aboubou, “Hybridization of solar panel and batteries for street lighting by passivity based control,” IEEE International Energy Conference.

[8] M. Ali, M. Orabi, E, E. Abdelkarim, J. A. Abu, Q. Abdelali, and E. Aroudi, “Design and development of energy-free solar street led light system,” IEEE, 2011.

[9] M. A. Mahmud, H. R. Pota, and M. J. Hossain, “Dynamic stability of three-phase grid-connected photovoltaic system using zero dynamic design approach,” IEEE journal of Photovoltaics, vol. 2, no. 4, October 2012.

[10] C. M. D. Dominicis, A. Flammini, E. Sisimini, L. Fasanotti, and F. Floreani, “On the development of a wireless self-localizing street light monitoring system,” Sensor Applications Symposium IEEE, pp. 223–238, 2011.

[11] S. Srivastava, “Automatic street lights,” Advance in Electronic and Electric Engineering.

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