ПРИКЛАДНАЯ ЛИНГВИСТИКА: РАЗРАБОТКА КОНЦЕПЦИИ НАУЧНО-ОБРАЗОВАТЕЛЬНОГО КОМПЛЕКСА «ИНТЕЛЛЕКТУАЛЬНЫЕ ЭНЕРГОСИСТЕМЫ (SMART GRID)»

DESIGN AND IMPLEMENTATION OF A LOW-COST PHOTOVOLTAIC TRAFFIC LIGHT SIGNAL SYSTEM

A. Avazov, L. Sobinova
Tomsk Polytechnic University

Abstract: Power failures in roads and intersections can cause serious difficulties and dangers due to non-availability of electric power for traffic light signals. Application of solar energy has been increased to power-up the traffic light signals all over the world recently. This paper proposes the application of solar energy in powering traffic signal systems for rural areas with no power grid. A photovoltaic system is used to capture the solar energy. Three B.S. students have involved in this educational project. The implemented system is simple, low-cost and free of maintenance. Captured solar energy is saved into a 12 volts lead-acid battery. A circuit including IC regulator is used to control the flow of charge through the battery instead of a dc-dc converter that lower the price of system controller. Timing of the traffic light is carried out via AVR ATMEGA16 microcontroller. Some software tools that have been used in this project are: PROTEUS for simulation of the circuit, Code vision for programming AVR microcontroller, and Microsoft Excel for plotting the captured data. Experimental results for different angles of radiation at different times of the day are also shown in this paper.

Introduction. Solar energy technologies, which harness the sun’s energy to generate electrical power, are one of the fastest growing sources of renewable energy on the market today1. Engineers and scientists are collaborating to lower the material costs of solar cells, increase their energy conversion efficiency, and create innovative and efficient new products and applications based on photovoltaic (PV) technology around the world.

On the other hand, vehicular travel is increasing throughout the world, particularly in large urban area. Traffic control systems have also increased in installation as a result. However it is still economically difficult to provide traffic control in country and rural areas, primary due to cost of building power infrastructure over long distances. Solar traffic signs have many uses. They can be used in manufacturing facilities, for pedestrian safety, stop and yield signs, vehicle directions, emergency instructions, parking and school zone safety [1].

A solar traffic light system as shown in Fig. 1 composed of the four major components as following: (1) Solar panel that includes solar cells, (2) DC to DC converter to maintain the output voltage at a constant level, (3) Charge controller to control the flow of charge through the battery and charges it when needed, (4) Battery to store electric energy and use it during the absence of sunlight [2].

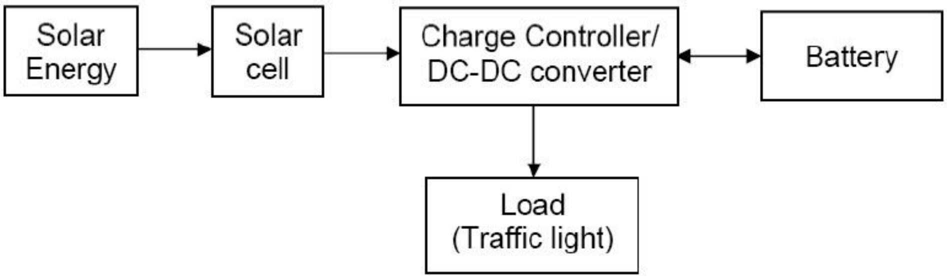

Fig 1. Energy flow in a solar powered system

Photovoltaic Cells. Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PV) cell, commonly called a solar or PV cell. PV cells are constructed out of semi-conducting materials so that when light shines onto the cells a certain amount of the light is absorbed. The energy of the absorbed light knocks the electrons loose from their atoms allowing them to flow through the compound [3].

The photovoltaic cell is the basic part of the building block of a PV system. PV cells can be arranged in a series configuration to form a module to supply electricity at a certain voltage, such as a common 12 volts system. Modules can then be connected in parallel-series configurations to form arrays. When connecting cells or modules in series, they must have the same current rating to produce an additive voltage output, and similarly, modules must have the same voltage rating when connected in parallel to produce larger currents. Fig. 2 shows a sample cell, module, and array.

The following factors are affected on the performance of a solar cell: [4]

- Sunlight and the angle that the sunrays hit the PV cell.
- Climate conditions such as clouds, fog, dust.
- The atmospheric layer's absorption and reflection.
- Temperature of the surroundings.

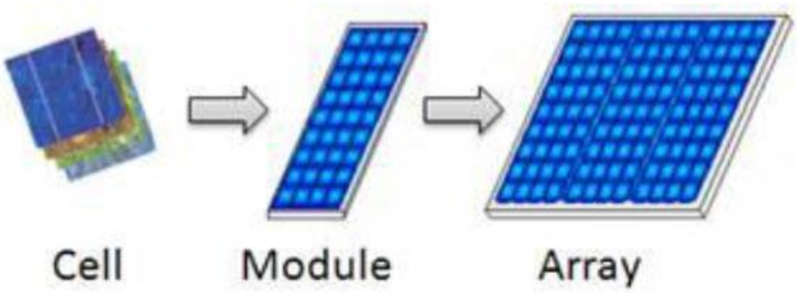

Fig 2. Solar panel configurations

Many types of solar cells are available in the market8 and the average selling price of solar modules these days is around US$4/W. The chosen solar array is FVG 10 P - FVG 25 M – 0106. The operating specifications of this type solar cell are Voc=21.8V, ISC=1.76A, V=17.1V, P=25W, I= 1.46A and its dimensions are 680×335×23 mm. Fig. 3 shows the schematic of implemented photovoltaic traffic light signal system with real components.

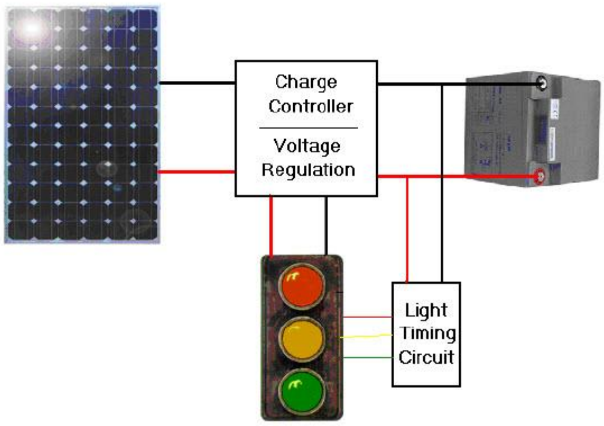

Fig 3. Schematic of implemented PV traffic light signal system

Energy Storage. Stand-alone PV systems require energy storage to compensate for periods without or within sufficient solar irradiation, such as during the night or during cloudy weather. Chemical batteries are the most candidates. The most suitable battery technologies to use in a standalone photovoltaic system are: lead acid batteries, Lithium-ion batteries, Ni-Cd batteries. Currently, the lead-acid battery is the most common form of energy storage in photovoltaic applications due to its low cost, low rate of self discharge and its ability to work at higher temperatures. Although, it has a low mass/energy ratio, that doesn't affect their performance in solar traffic light application as the battery is stationary [4; 5].

Traffic Light. Nowadays LED bulbs are replacing the old incandescent bulbs. LED's is very efficient, with low energy consumption and a long life span. The most recent technological innovation reached in the traffic industry is using solar traffic light systems. [6] In this paper, we have used LED traffic lights with rating 12 V, 8 W. It always is supplied from the battery.

Conclusion. A low-cost solar traffic light system was presented. The system has four major parts: PV fixed- array, charge controller, lead-acid battery and traffic light. Crystalline silicon solar cells were used in this project because it is the most favorable type for traffic stop light signals, due to its availability in the market, and its higher efficiency. The timing sequence of light signals was managed via an AVR microcontroller. In order to regulate voltage of PV array, IC regulator was employed instead of conventional buck-boost dc-dc converter which reduced the price of the control system. Lead acid battery was employed since these batteries are relatively inexpensive and have a longer lifetime compared to other batteries for energy storage. The LED stop light is energy efficient and has a long life span and low maintenance costs. The experimental results shows that angle of array, time of day and different days of the year are effective to capture the highest power, which were done by three undergraduate students. In order to capture maximum power, movable array that can changes the angle is more effective which can be used for high power applications.

REFERENCES

1. Kalingamudali S.R.D., Harambearachchi J. C. et al. Pedestrian and vehicular traffic friendly uninterrupted solar powered traffic signal light system // First International Conference on Industrial and Information Systems, 2006. – P. 208.
2. Moghbelli H., Ellithy K., Eslami Z., Vartanian R. et al. Investigation of Solar Energy Applications – Design and Implementation of Photovoltaic Traffic Light Signal System for Qatar // International Conference on Renewable Energies and Power Quality (ICREPQ'09).
3. Solar Power // Wikipedia. – [Электронный ресурс]. – Режим доступа: http://en.wikipedia.org/wiki/Solar_power (дата обращения: 04.09.2014).
4. Patel M.R. Wind and Solar Power Systems. – CRC Press, 1999.
5. Markvart T., Castaner L. Solar Cells: Materials, Manufacture, and Operation. – UK: Esevier, 2003.
6. Stop Light // Wikipedia. – [Электронный ресурс]. – Режим доступа: http://en.wikipedia.org/wiki/Stop_light# Introduction (дата обращения: 04.09.2014).