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A SOLAR TREE BASED ENERGY HARVESTING, TRACKING AND FAULT DETECTION SYSTEM

L. Glarida Amala*, Dr. M. Balasingh Moses, D. Pooja***, S. Senthamizhan***, R. Mathanraj*** & S. Karthikeshwaran*****

* Assistant Professor, Department of Electrical and Electronics Engineering, M.A.M College of Engineering and Technology, Siruganur, Trichy, Tamilnadu

** Senior Assistant Professor, Department of Electrical and Electronics Engineering, University College of Engineering, BIT, Anna University, Trichy, Tamilnadu

*** UG Student, Department of Electrical and Electronics Engineering, M.A.M College of Engineering and Technology, Siruganur, Trichy, Tamilnadu

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Abstract:

Solar tree project was initiated by the SB IEEEIAS (Student Branch IEEE Industrial Applications Society) at the University of Sarajevo. Solar tree is a metal construction that resembles a real tree. Solar panels are mounted on top of each branch. Generated energy will be available to everyone and it'll be used for charging batteries of mobile phones and portable computers. This paper describes the necessary steps required for a successful completion of this project. Additionally, this paper discusses benefits of this project for the students and the community. A part of this paper describes an original solution for the solar tree, along with necessary calculations, technical specifications, basic characteristics, working principle and 3Drendering of the chosen design at its future location. The area around the solar tree would become a place where students and their friends can gather to recharge their devices and, at the same time, while they wait, exchange ideas, advices and their experiences with each other.

1. Introduction:

Solar tree represents a metal construction that resembles a real tree. Solar panels are put on top of its "branches". Utilizing the sunlight energy, solar panels produce electric energy which is then used for charging batteries of mobile phones, tablets, laptops etc. and, additionally, as an element of street lighting. Its attractive and modern design will complement the public areas of our campus and it'll be integrated completely into the architectural design of the Faculty of Electrical Engineering (ETF) at the University of Sarajevo, thus allowing all students and visitors on campus freely use of energy efficient technologies i.e., LED street lighting.

2. Planned Activities:

Solar tree represents an autonomous photovoltaic system. It is equipped with a system of solar panels which, as long as they're illuminated by the sunlight, produce voltage at their respective endings. That voltage can then be used for charging batteries. Accumulated energy from those batteries is then used for various purposes. Neglecting the necessary replacement of the batteries every few years, electric energy produced by this system is completely cost free. Additional automatic control of charging and discharging process of the batteries can guarantee maximum lifetime of the batteries .Realization of the project compromises of many additional activities, all of which will be carried out by the members of our SB IEEE IAS (Student Branch IEEE Industrial Applications Society). This means that complete project will be done by the students and supervised by the assistants and professors at the Faculty of Electrical Engineering in Sarajevo. These activities range from writing documentation for the project and securing the necessary funding, to doing various calculations and making design choices.

3. Project Goals:

Although we are witnessing constant advancement of the technologies used in battery construction the problem of fast battery discharge in mobile phones and portable computers is still present. Unfortunately, as of today, we still don't have an adequate solution for this problem. The implementation of this project would, at least a little, simplify this problem for the majority of the population at our campus that uses these devices regularly. The area around the solar tree would become a place where students can gather to recharge their devices and, at the same time, while they wait, exchange ideas, advices and their experiences with other colleagues.

In accordance with everything that's been said previously, we divided our goals into two groups which are given below.

Goals Related to Community:

- Encouragement of the ideas that improve the quality of life of members in the community
- Promotion of students 'involvement in useful community work
- Promotion of their new able sources of electric energy

- Promotion of the ecological awareness in our community

Goals Related to Students:

- Practical application of theoretical knowledge
- Mastering all phases of project development
- Making project documentation
- Doing technical calculations
- Securing then necessary funding
- Final realization of the project
- Development of organizational skills
- Experience in working in a team
- Chance to express their creativity
- Broadening the horizons by being involved in extracurricular activities and overall, helping in creating a better, more able and ecologically aware future engineers and workers

By working on this project, students will get a chance to gain skills and knowledge they couldn't get in the classroom, in current educational system in Bosnia and Herzegovina. This is an excellent opportunity for the practical application of theoretical knowledge gained in the classes that couldn't otherwise be applied due to the lack of the necessary laboratory equipment and the overall financial crisis. Campus of the University of Sarajevo is an ideal location for the solar tree because of a large number of students passing through every day. Also, it is a good location because this solar tree could potentially become an inspiration for some future students. They could try to build similar or more challenging tasks as they will constantly bare minded that, by combining a little ingenuity with the knowledge gained at the university, it is possible to design and build useful projects.

4. Characteristics and Design:

It is a known fact that everyone today can utilize solar energy. Sunlight reaches Earth's surface regardless of weather conditions, but its intensity is reduced by passing through the clouds (we call it diffused light or indirect radiation). Direct radiation is a lot stronger, as sunlight reaches Earth's surface without being blocked by the clouds. Enough sunlight teaches Earth's surface to be used for electric energy production even at locations with a lot of foggy days.

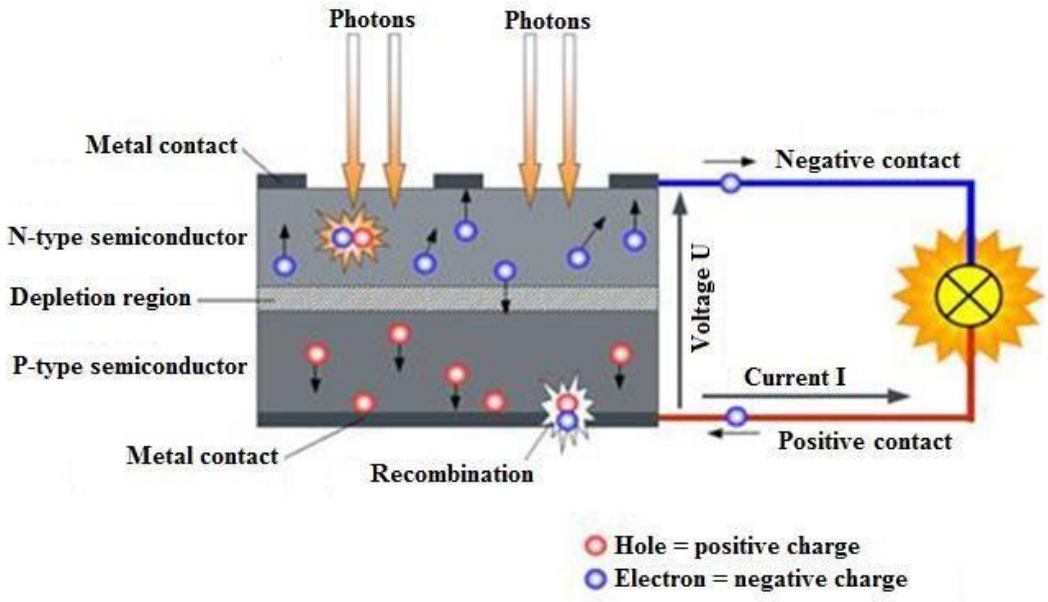


Figure 1: Working Principle of a Solar Cell

One photovoltaic cell is compromised of two or more thin layers of semi conducting material, usually made of silicon (Si). Under the silicon layer, there is a thin conducting layer made of metal. When silicon is exposed to sunlight, electrons are knocked loose from their atoms, causing electric potential difference. As a result, direct current (DC) starts to flow through the material in order to cancel out the potential difference (Figure 1). Due to the special composition of solar cells, the electrons are only allowed to move in a single direction. Photovoltaic modules will also function during cloudy days, but with reduced output power. Each branch ending will serve as a mechanical support for a number of mono crystalline solar panels, summing up to 10 overall. Single panel has an output of 80W, and the diameter of each panel is 1.02m.This type of panel is able to convert 1000 W/m2 of the sun's irradiation into 140W one very square meter of its surface. Panels are pointed to the south and their declination is 34° because these are the optimal settings for maximum efficiency at the current location. Figure 2 shows global irradiation levels and electricity potential in Bosnia and Herzegovina, as measured by ECJRC.

Figure 2: Global Irradiation and Solar Electricity

Potential in Bosnia and Herzegovina for optimally inclined photovoltaic modules Yearly production of the solar tree is approximately 1200kWh/m2.This is based on the available research on the subject of solar irradiance and solar electricity potential in Bosnia and Herzegovina more precisely in Sarajevo, where the solar tree will be located. The design of this solar tree is solely developed by the students of the Faculty of Electrical Engineering, University of Sarajevo.Figures3.and4.show 3Drendering of the design in day light and at night, respectively.

Figure 3: 3D Rendering, Daytime Variant

Figure 4: 3D Rendering, Night Time Variant

Solar tree will be compromised of 10 solar panels, spread across 3 symmetrical branches, 120° apart from each other. Each branch will have 3 panels mounted on top of it. One branch will be located at the center of the construction and it will support one additional panel. Table I shows efficiency calculation

and predictions of the consumption, as well as the list of parts that will be used during the construction of the solar tree.

Table 1: Specification of equipment that will be used for the project

Panels:
- 10 x 80W = 800W
- Connection type: 2 panels from every branch in series, then all 5 branches in parallel to achieve a 24V output
- Output: 25 A, 24 V

Batteries:
- 4 x 110Ah (12V), high deep discharge
- Connection type: 2 in series, then those groups of two in parallel
- Output: 24V, 220Ah

Regulator:
- PUBC30A with display

Inverter:
- 24V/900W

Cabling:
- Cable 2 x 4mm2, cca. 150 m
- Safety fuse g PV 10A and breaker switch
- Cable 1 x 16mm2
- Load switch 32A/500VDC
- Other small installation equipment (boxes, plugs etc.)

Control Switchbox:
- Monitoring of the generation and consumption on the basis of the ARDUINO platform
- Display showing current readings
- Remote control via GSM module

Other:
- Installation of Wi- Fi hot spot
- LED

We have developed a low cost solar panel monitoring system. The main goal was to create a monitoring system for solar panel energy production based on open source hardware. The system measures the voltage and current of a solar panel and battery. It also measures the current consumption. Everything is connected to the regulator. Current is measured using Hall's sensors, while the voltage is measured by opt couplers. The system is connected to the Internet via the local network at the ETF so that anybody can access and see the data. The data is stored on a 2 GB SD card in a specific, easily readable, format. We have also connected a temperature sensor, which is located near the solar panel to measure the temperature. This measurement can potentially serve as one of the variables in the analysis of the influence of weather conditions on the energy production levels. Also, a Windows application for result analysis, plotting and real time monitoring is currently being developed. This monitoring system can further be used for the optimal usage control of solar panels and for the collection of statistical data about solar energy potentials of selected areas.

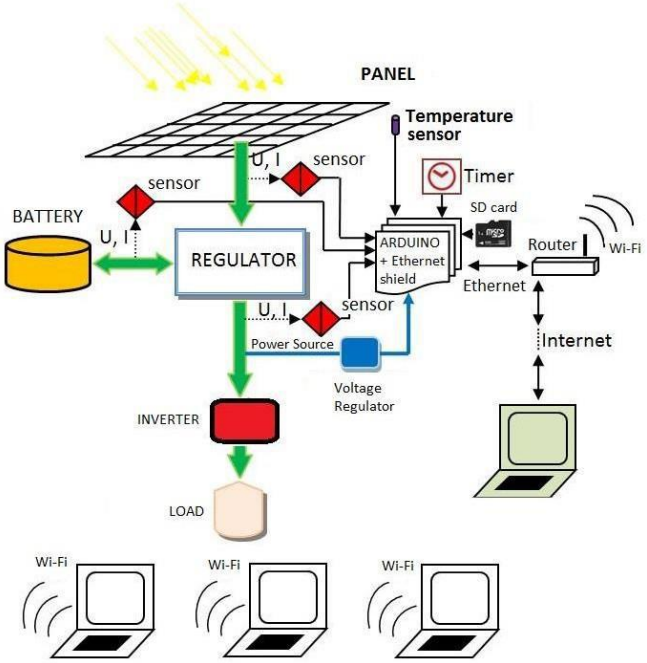
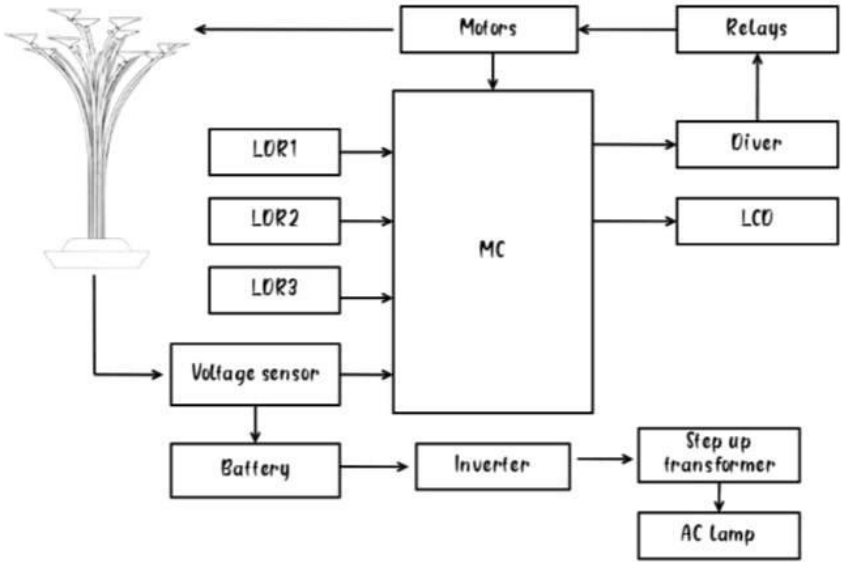


Figure 5: Schematic Illustration of the Whole System

Solar tree use scenario was worked out in order to address certain points raised during the discussions about the project. If we assume 4 hours of sunlight at the place of installation, and the irradiance of around 1000W/m2, we can expect the production of 3200 WH daily. Batteries can accumulate energy of approximately 5280Wh, which should be adequate for normal operation of solar tree in case of 3 or 4 cloudy days in arrow. Plan is to install 6 plugs. The assumed load of each plug is 60W, summi up to 36W overall. With full battery capacity, this consumption level and the consumption of the system itself (around150W), the solar tree could be sustained for about 10 hours (4 days of 2.5 have range use), which is considered as an acceptable autonomy time. Expected yearly production is around 1170 Wh approximately. Also, calculations of the lighting that will be used to illuminate the area around the tree were performed .Each of the six branches will produce cca. 1200 lx. This will be achieved by using 20 diodes (1WLED, color cool white), mounted on every branch.

5. Conclusion:



We expect that realization of this project will promote the idea of the use of renewable sources of energy, more precisely the solar energy. Our community doesn't value enough the use of renewable sources of energy. Because of that, it is very important to try to make an impact on the society through this project, more specifically on students, so that they can recognize the importance of the renewable energy sources and its positive impact on our environment. Students will also gain valuable practical skills by working on this project. They will be able to make connections between the theoretical background and the actual application of those principles. The plan is to build a complete system that will monitor current energy generation and consumption of the solar tree. This data will be displayed using a display mounted on the solar tree, and it will be accessible via web application or any Android device.

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