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# AUTONOMUS SOLAR ENERGY CONVERTER WITH REMOTE CONTROL AND SUPERVISION FOR ENERGY SUPPLY OF TELECOMMUNICATIONS FACILITIES

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## ABSTRACT
*This paper describes the design of the mobile autonomous solar generator for backup power remote telecommunication facilities. The system integrates information and communication technology in the form of android apps installed on your mobile phone and microcontroller-based devices arduino. The system has the possibility of remote monitoring of essential parameters for the generator, control and management of the work of the solar generator.*
**Keywords:** Autonomus solar generator, android, arduino, telecommunications facilities

## 1. INTRODUCTION
For power of telecommunications facilities in remote locations there is a need for emergency power supply. The standard method is to use diesel generators. A lack of these systems is a constant need to supplement fossil fuels , start the system in case of power failure, and the need for frequent services [1]. As an alternative to diesel generators was proposed solution with mobile solar generator with the option of monitoring and control of generator using mobile phone devices and microcontroller control/control subsystem based on a set of SainSmart Mega 2560 [1,5]. Software for the control and management of generator is based on an Android OS [5].

## 2. SYSTEM DESCRIPTION AND OPERATING PRICIPLES
Adjustable solar generator is composed of two photovoltaic panels power 240W mounted on a small car trailer. To control the charging solar battery provided is a solar regulator power 600W. With battery powered DC/AC power inverter 12V DC to 220V AC. In the figure 1.visible are the basic elements of the energy part of the solar generator. To monitor the operating parameters of generator (battery level, consumption) is designed on the basis of a set of SainSmart Mega 2560 devices. Communication between the control unit generators and users is realized through GPRS technology.
The picture shows the main elements of management and communication and energy part of the solar generator system:

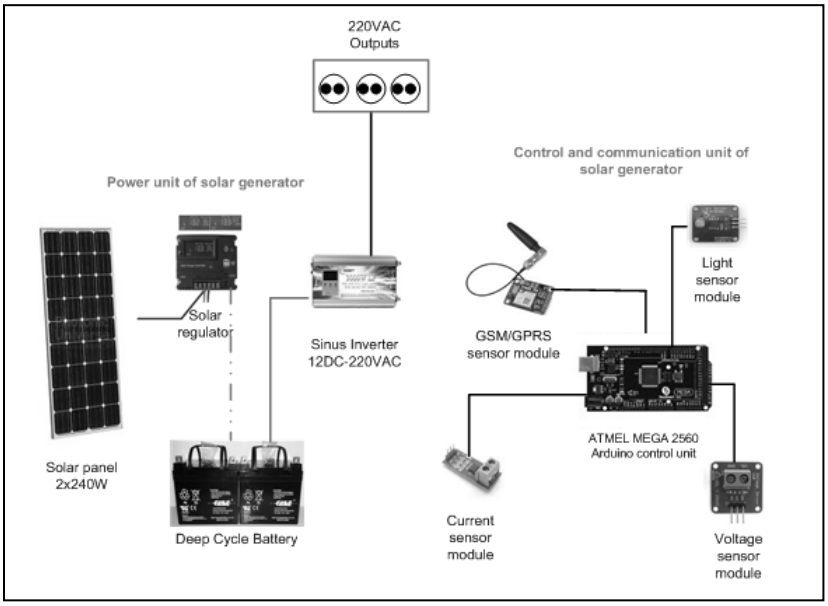


*Figure 1. Power unit and Arduino control and communication unit with sensors*

The main element of the solar system is a photovoltaic module, which is essentially a parallel or serial connection of solar cells.When solar cell or photovoltaic module is exposed to influence of solar light then comes to dependence of electronic photo component parameters on radiation intensity and on temperature because of warming up of cell and module [2,3]. Each individual solar cell has an output voltage value of about 600mV. These cells are connected in series to obtain the desired output voltage. Maximum current produced by the cell in the radiation intensity of $100mW/cm^2$ is about 30mA/cm2. It can be shown that the total current solar cell is equal to [2,3,4]:

$$I_c = I_{ph} - I_S(T)\cdot(e^{\frac{qVc}{\eta kT}} - 1) \qquad (1)$$

where is: $I_c$ – current of cell, q – elementary charge, k – Boltzmann constant, $I_{ph}$ – photocurrent dependent of solar radiation E $[W/m^2]$ (irradiance), $I_S$(T) - inverse current of saturation that is dependent on temperature T, $\eta$ - correction factor. Photo current $I_{ph}$ is proportional to solar radiation E: $I_{ph} = K_E \cdot E$, where $K_E$ is constant of proportionality.Voltage of solar cell is then given by [4]:

$$V_c = \frac{\eta kT}{q}\cdot ln\left(\frac{K_E E - I_c}{I_S} + 1\right). \qquad (2)$$

Power of solar cell as a function of temperature is described by [2,3,4]:

$$P_c = V_c \cdot \left[K_E \cdot E \cdot - I_S(T)\cdot(e^{\frac{qV_c}{\eta kT}} - 1)\right] \qquad (3)$$

The solar battery charge controller , one of the main elements of an autonomous solar system. It has multiple functions. Placed between the solar generator and the battery and protects the battery from overcharging and deep discharging . Batteries are used in autonomous solar systems as a form of backup power, and as devices to accommodate the excess electricity produced [6]. The most commonly used batteries are lead-based plate-acid, nickel cadmium, lithium-ion, nickel-metal-hydride. Converters (inverters) are used in cases where the autonomous photovoltaic system designed to power consumer alternating voltage 220V. Function DC/AC inverter converting the DC voltage of the solar modules or power accumulated in batteries to alternating voltage sinusoidal shape (or approximately sinusoidal) standard values 220V [6]. User communications with the system shown in figure 2.

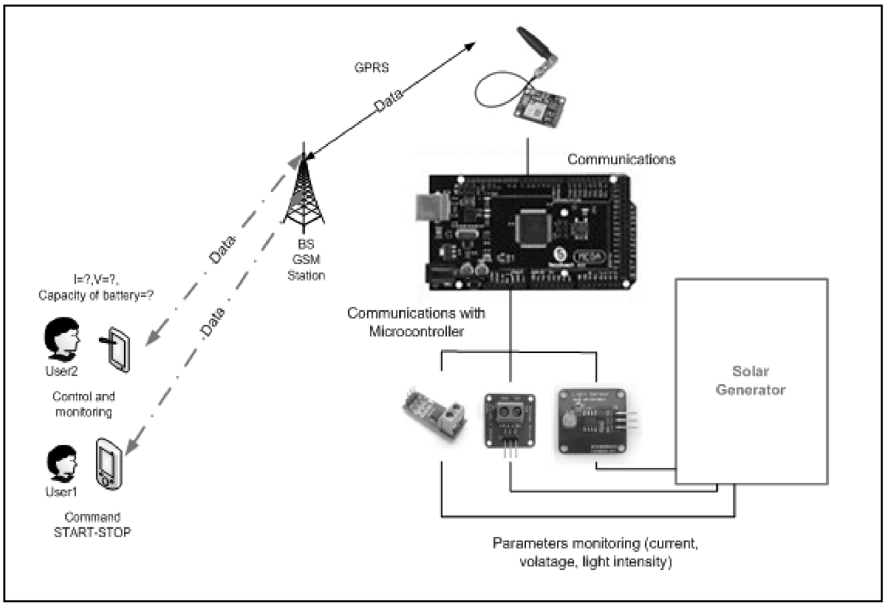


*Figure 2. User communications with the system*

In the figure 2 it is clear that users have the ability to remotely start and stop of the solar generator without having to go to the scene. Monitoring of generator operation is achieved through the application that was developed for the Android OS and installed on users' mobile devices [5]. By accessing the server application, the user has the ability to track the parameters of generators that are connected to the network unit. The server application is developed based on PHP ( Hypertext Preprocessor) scripting language [5]. The generators grid are shown in figure 3.

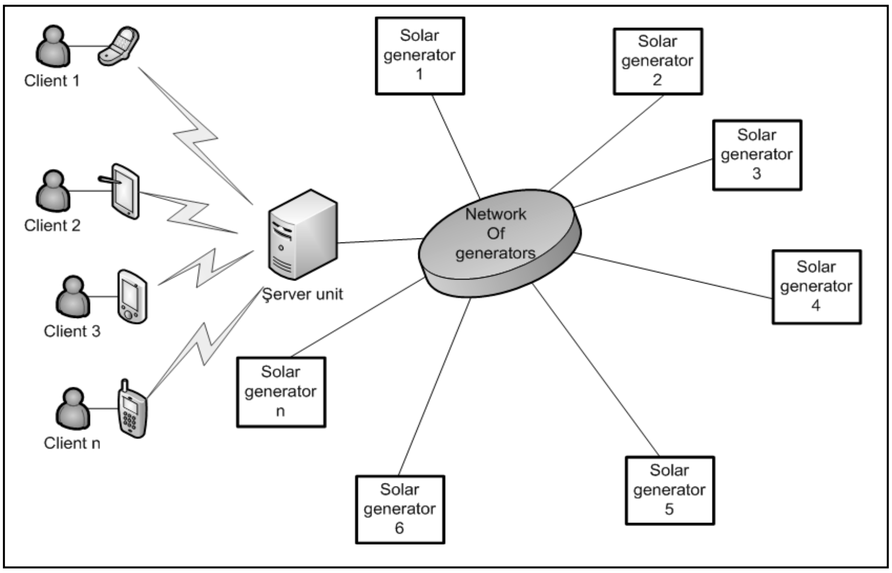


*Figure 3. Network of solar generators*

## 3. EXPERIMENTAL RESULTS

For the simulation of an autonomous solar generator used a software package PVsyst 5.20. The influence of temperature on the efficiency of the solar modules for different values of incident radiation. The figure 4 presents the dependence of the efficiency of the solar panels as a function of radiation intensity for different values of the temperature of the solar cell. The figure 5 displays the output current from the photovoltaic modules in the function of radiation intensity.

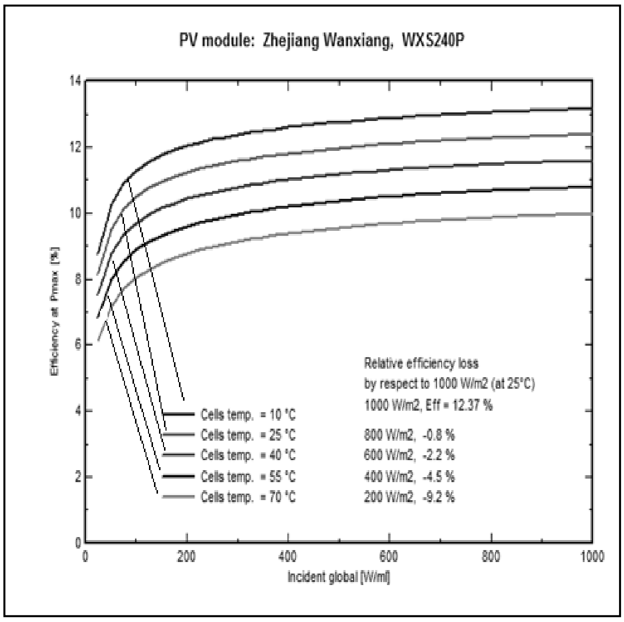


*Figure 4. Efficiency as a function of radiation intensity for different temperatures of the solar cells*

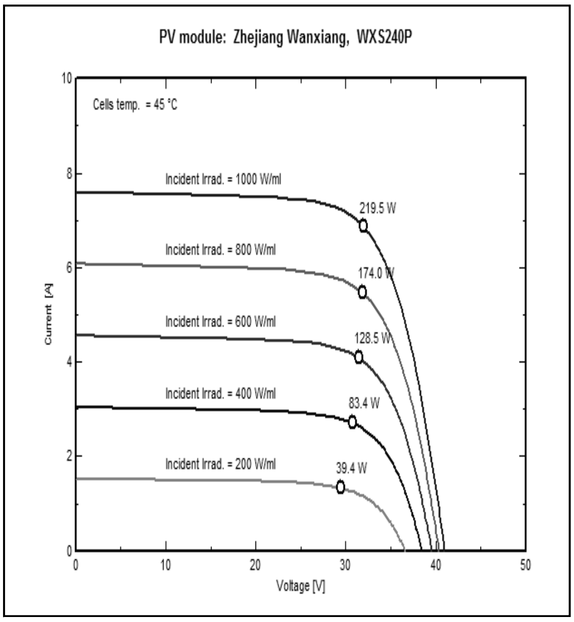


*Figure 5. Output current as a function of the output voltage for different radiation intensities*

It is evident from the figure 4 that increase in temperature decreases the efficiency of the solar generator. Figure 5 shows the dependence of the output current as a function of voltage for different intensity of solar radiation. As the reference temperature is assumed to be $45^0$C . Cell increase in temperature leads to the reduction of output power. To simulate selected WXS240P solar panel power output 240W .

## 4. CONCLUSIONS

This paper analyzes the autonomous power supply system for the removal of telecommunication facilities . Presented system is a network of solar generators, whose control and monitoring of the work is done from a remote location via the application installed on mobile user devices. For the monitoring, control and data distribution is responsible server application that is used to synchronize the operation of the network unit. To simulate the operation of the energy used is part of a software package Pvsyst , and analyzes the effects of temperature and intensity of the radiation incident on the output parameters of the solar generator.

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