JEDNA MOGUĆNOST IMPLEMENTACIJE MPPT-A

ONE POSSIBILITY OF MPPT IMPLEMENTATION

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Promenom temperature i iradijacije dolazi do promene oblika strujno-naponske karakteristike fotonaponskog sistema, a samim tim i položaja tačke maksimalne snage (MPP). Zato u okviru konvertora, sa strane fotonaponskog sistema (PVSC), treba da postoji implementiran algoritam za praćenje tačke maksimalne snage (MPPT). U ovom radu je predstavljen i objašnjen "Poremeti i prati" MPPT algoritam i mogućnost njegove primene u realnim PV sistemima. Takođe, prikazana je i simulacija ovog algoritma u programskom paketu MATLAB.

Ključne reči: *PV sistem; MPPT; MATLAB; monitoring; energetska efikasnost*

By changing the temperature and irradiation, the shape of the current-voltage characteristic of the photovoltaic system changes, and therefore the position of the maximum power point (MPP). Because of that, within the converter, on the side of the photovoltaic system (PVSC), there should be an implemented algorithm for maximum power point tracking (MPPT). This work presents and explains the "Perturb and Observe" MPPT algorithm and the possibility of its application in real PV system. Also, a simulation of this algorithm is presented in the MATLAB software package.

Key words: *PV system; MPPT; MATLAB; monitoring; energetic efficiency*

1 INTRODUCTION

Charge control devices controls the energy coming from solar panels. It adjusts the current and the voltage and then send it to batteries. Charge control device prevents over charge and over discharge of the batteries. Therefore, it protects the system. Each solar energy systems requires a charge control device. Charge control devices divided into two as PWM (Pulse Width Modulation) and MPPT (Maximum Power Point Tracking).

PWM stands for Pulse Width Modulation. PWM charge control devices can be explained as an electrical switch between batteries. The switch can be quickly switch on and switch off. Therefore, desired voltage can be obtained to charge the batteries. The charge current will be slowly decreased as the batteries charged.

MPPT stands for Maximum Power Point Tracking. MPPT is a technique to observe and regulates the energy going from solar panel to the batteries. Solar panels show changeable outputs according to weather conditions. MPPT charge control devices can match the solar panel voltage with battery voltage to maximize the charge efficiency. In these systems, the full power of solar panels can be used by balancing between voltage and current according to the P = V × A equation. For example, the amount of current drawn from the panels reduced to protect the voltage when the weather is cloudy. When the weather is sunny, it is allowed to draw more current [1].

An MPPT is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher/lower voltage DC output from solar panels down/up to the lower/higher voltage needed to charge batteries or other devices on the grid.

Maximum Power Point Tracking is electronic tracking - usually digital. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. Most modern MPPT's are around 93-97% efficient in the conversion. It's typically a 20 to 45% power gain in winter and 10-15% in summer. Actual gain can vary widely depending weather, temperature, battery state of charge, and other factors.

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An MPPT tracks the maximum power point, which is going to be different from the STC (Standard Test Conditions) rating under almost all situations. Under very cold conditions a 120-watt panel is actually capable of putting over 130+ watts because the power output goes up as panel temperature goes down - but if there is no way of tracking that power point, that power will be lost. On the other hand under very hot conditions, the power drops - power is lost as the temperature goes up. That is why there's less gain in summer [2].

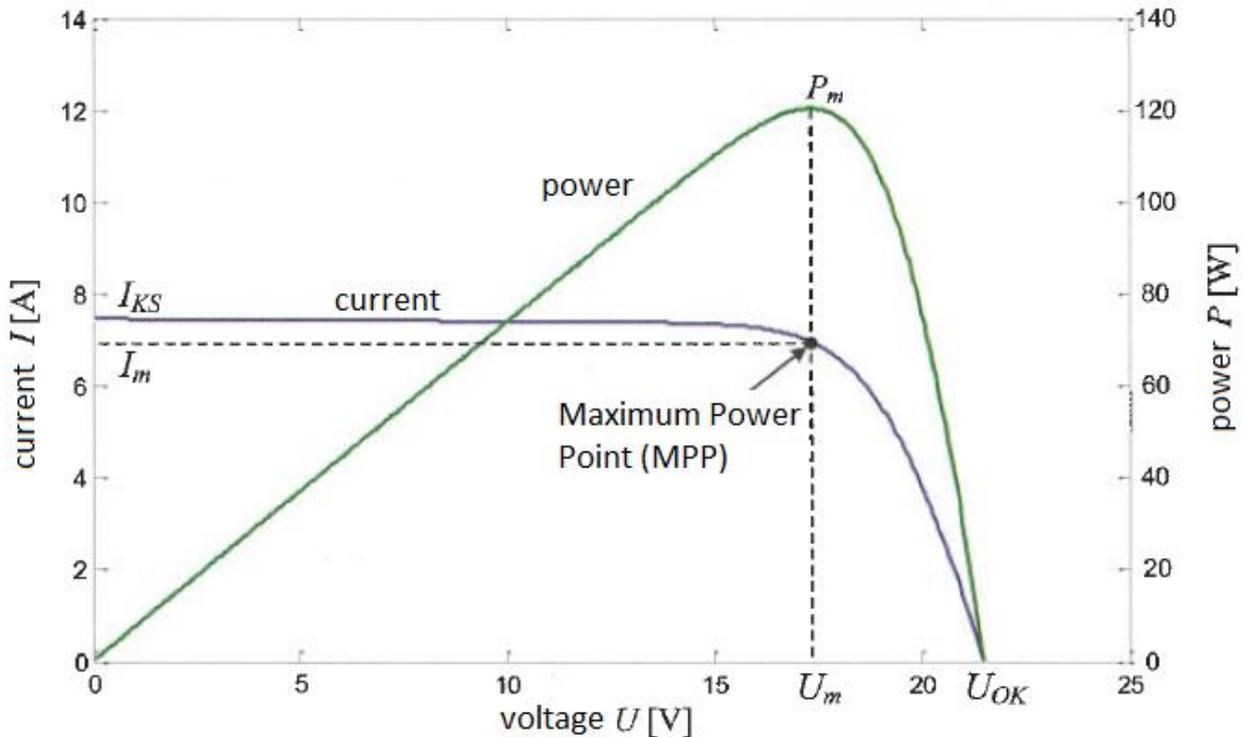On Figure 1 is shown current-voltage and power characteristic of PV panel together with the Maximum Power Point [3].

Figure 1: I-U characteristic of PV panel and Maximum Power Point (MPP)

2 MPPT ALGORITHM IN MATLAB

In MPPT devices, it's required to have appropriate algorithm for determination of duty cycle of a buck-boost converter. Algorithm implementation is possible with microcontrollers that are managing the work of a converter and sensors for measuring the current and voltage. Microcontoller periodically increases or decreases duty cycle and follows the output power with the goal of achieving the maximum of output power [3].

There are dozens of algorithms that can be used for MPP tracking. Some of them are simpler, but with low accuracy, and some of them are more complicated and more accurate.

In this case, we are using Perturb and Observer MPPT algorithm. It's more complicated than some algorithms, but has better efficiency. It's based on incremental change of duty cycle D by following the power and voltage. For example, if the increase of voltage led to increase of power, then it continues with the increase of a voltage until the power is increasing. Similarly, if the increase of voltage leads to decrease of power, then it decreases the voltage in order to increase the power, and so on. Perturb and observe algorithm is shown on Figure 2 [3].

Blemish of this algorithm is constant oscillation of operating point around MPP and problems if PV module is in shade, but it's efficiency is really high and that's the biggest advantage.

Logic of Perturb and Observe algorithm is shown on Figure 3 [3] and it's MATLAB Simulink model is shown on Figure 4 [4], respectively.
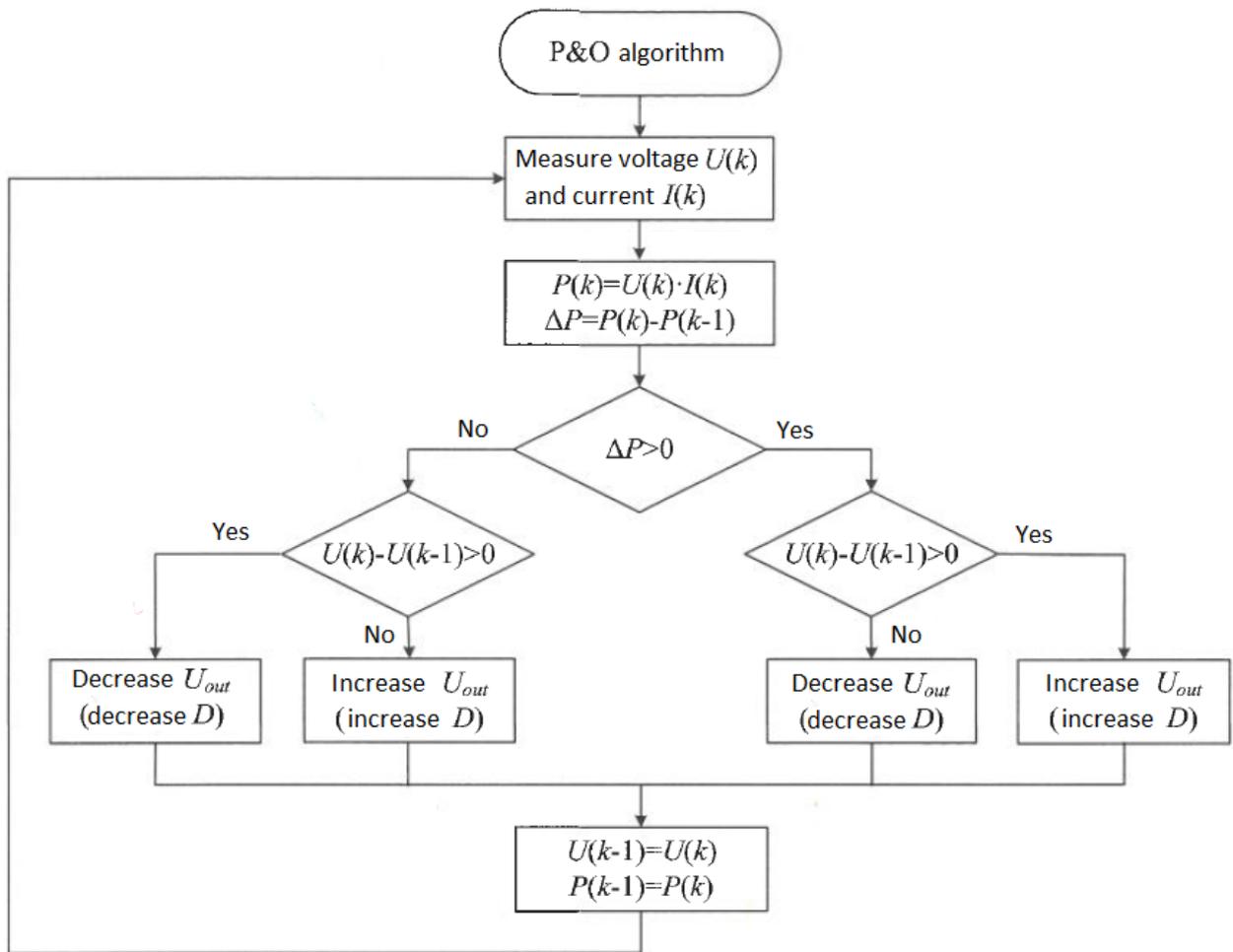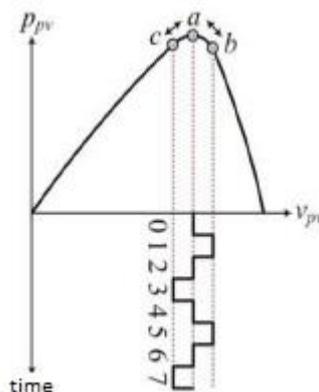
Figure 2: Perturb and observe MPPT algorithm

Figure 3: Logic of perturb and observe algorithm and oscillation around MPP

As it's shown on Figure 4, model input is PV module output power (P_{PV} [W]) and the model output is referent value of voltage at PV link (V_{ref} [V]).

Block Z^{-1} remembers the value of the last signal that was on his input. Part of the model marked in red line compares old and new value of P_{PV}, and gives 1 at the output if operating point goes in direction of power increase, or -1 in reverse case. Part of the model marked in blue line allows multiplication of current ΔV value with the switch output value. At the end, new ΔV is added at the last value of referent voltage (marked in yellow line).

Accuracy of this algorithm actually depends the most on ΔV. In other words, if ΔV is bigger it will take less time to determinate MPP, but power oscillation will be bigger. And if ΔV is smaller, it

will take longer time to determinate MPP, but power oscillations will be smaller. Which ΔV we will take usually depends on system size, and converter possibilities.
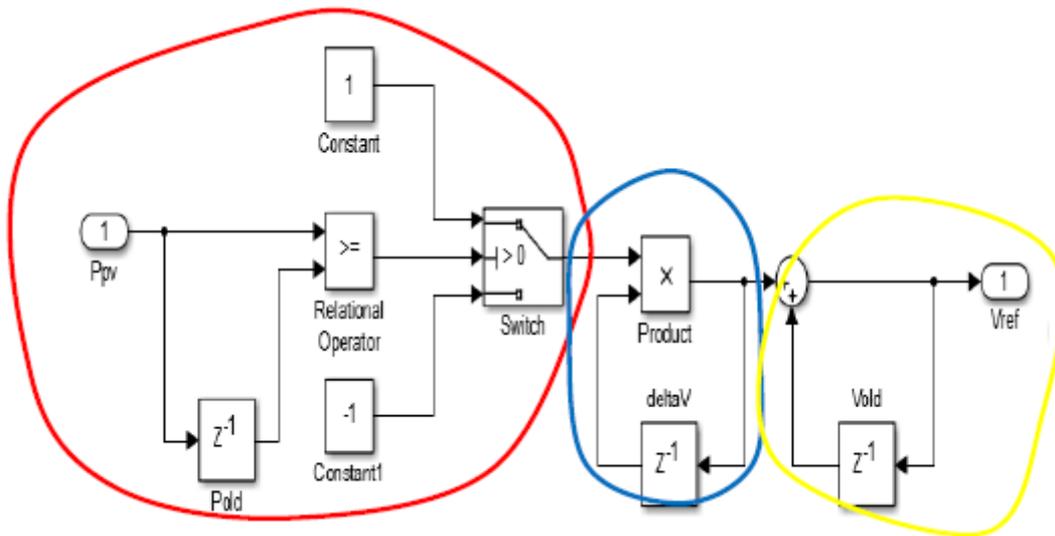

Figure 4: MATLAB Simulink model of MPPT algorithm

3 REAL PV SYSTEM

PV system analyzed in this work is placed on the rooftop of the Faculty of Electrical Engineering in Belgrade, Serbia. This system is hybrid, which means that it can be connected on distribution grid or work off grid with batteries (Figure 5). It contains 8 PV panels [5] with P_{max}=275W of which there are 4 parallel connections of 2 panels in a series connection (Figure 6). Also, there are converter/charger with PWM (Pulse Width Modulation) [6] and 8 batteries [7] with 200Ah capacity of which 4 batteries are series connected and then parallel connected with other 4 batteries in a series alongside with the battery balancer that is used for equalizing the state of charge of batteries, so they are even charged/discharged (Figure 7). The power obtained from this system is used for power supply of different devices at faculty of Architecture. Also, this system can work for few days without grid power.
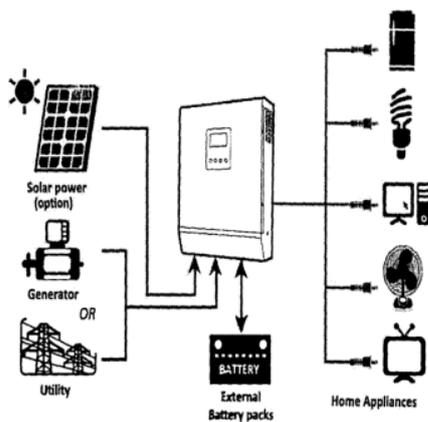

Figure 5: Hybrid PV system

Figure 6: PV panels on the rooftop

Figure 7: Safety fuses with converter, batteries and charge controller

4 PV SYSTEM SIMULATION IN MATLAB

In order to see the benefits of MPPT over PWM, MATLAB Simulink model with MPPT algorithm is made.

PV system from Chapter 3 could be presented with electrical scheme shown on Figure 8 and MATLAB Simulink model of the system is shown on Figure 9 [4].
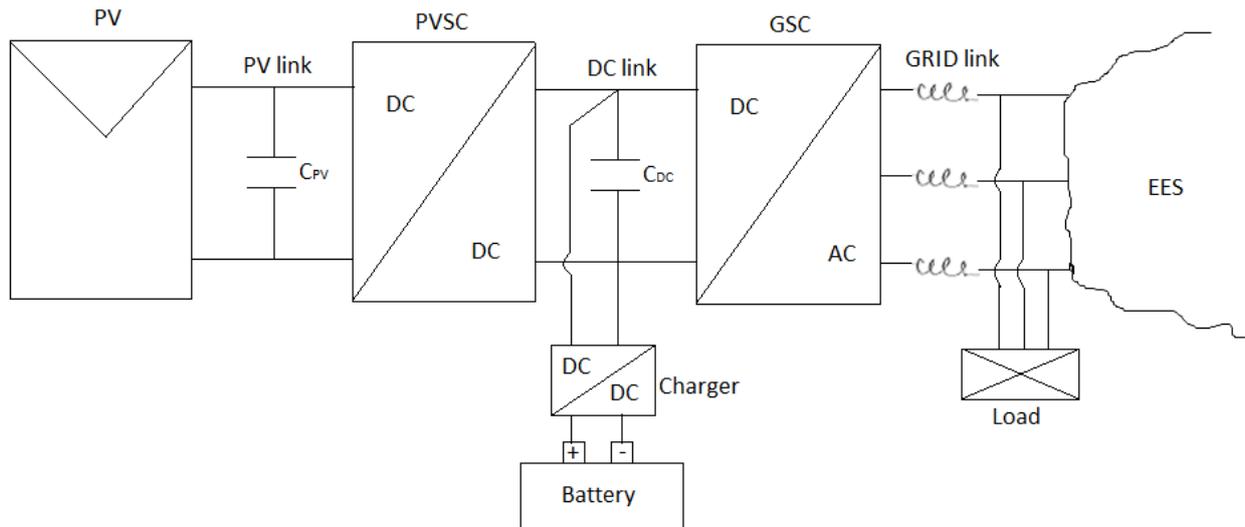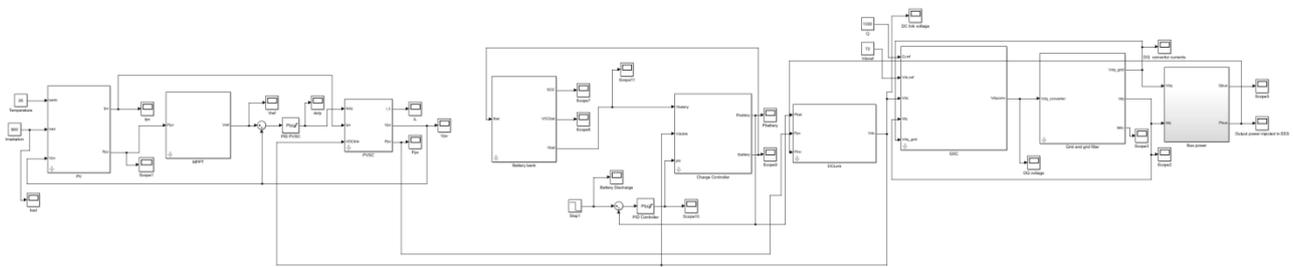
Figure 8: PV system electrical scheme

Figure 9: PV system in MATLAB

Under cloudy conditions, with irradiation on solar panels of 800 W/m^2 and ambient temperature of 25°C alongside with other input values given by manufacturer, the simulation is started.

The results of importance are shown down below.

The PV side converter or PVSC output power is shown on Figure 10, while change of Duty cycle D is shown on Figure 11.
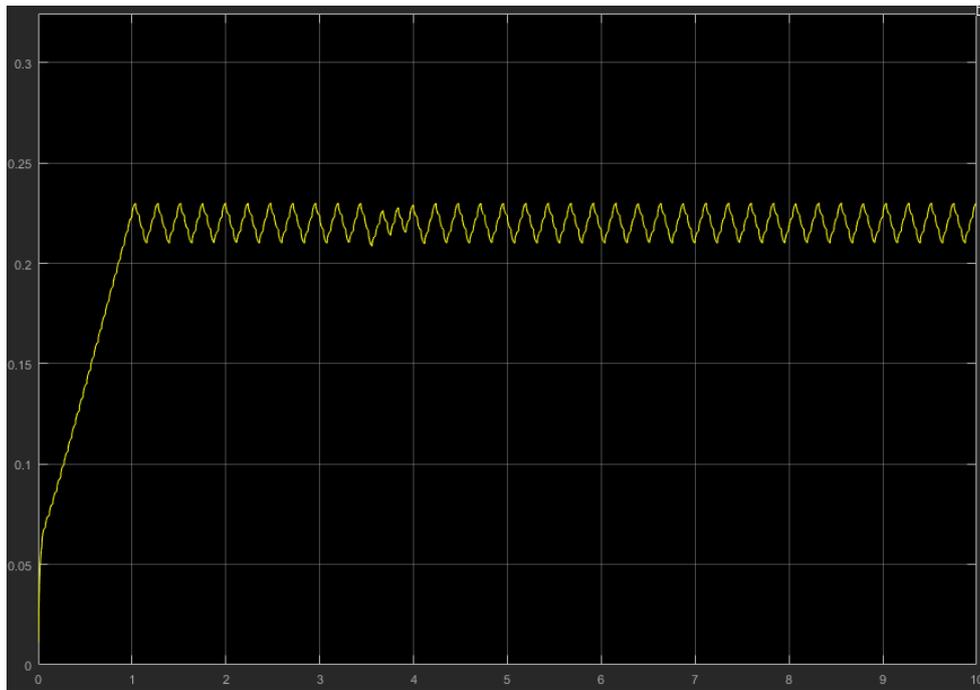

Figure 10: PVSC output power

Figure 11: Change of duty cycle

As we can see from Figure 10, the output maximum power is around 1550 W under given conditions and operating point is going around MPP and that's why there are little cogs around maximum power, or in other words there isn't a straight line on a graph of output power. That's the reason why on Figure 11 Duty cycle is increasing and decreasing, in order to maintain around MPP.

5 CONCLUSION

Under the similar weather conditions that are used in simulation, in real system with PWM, output power is measured around 1250W. That means that MPPT efficiency, in this case, is around 20% better than with PWM.

Generally, MPPT is 20-30% more efficient than PWM, which means that more power is used from PV modules. Should we use MPPT or PWM mainly depends on the PV system size.

If system is smaller and efficiency isn't critical, tendency is to use PWM controllers, because they are cheaper than MPPT ones. In other hand, if system is bigger and producer is giving power into the EES which means that distribution is paying him for the power, then it is recommended to use MPPT instead of PWM controllers.

6 References

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