



**5<sup>th</sup> International Youth  
Conference on Energy 2015**  
27th - 30th May, 2015 Pisa, Italy

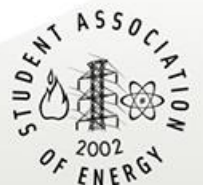
# ***Proceedings***

---

*2015 5th International Youth Conference on Energy*

***ISBN: 978 - 1 - 4673 - 7172 - 8***

**[www.iyce-conf.org](http://www.iyce-conf.org)**



## ***Authors***

### *2015 5th International Youth Conference on Energy*

Abu-Siada, A.	Berei, J.	Clauss, F.
Albert, B.	Bihari, P.	Coelho, T. S.
Amushembe, H.	Biner, D.	Commet, S.
Andolfatto, L.	Bitir-Istrate, I.	Conte, F.
Andrássy, Z.	Blanes, J.	Conti, P.
Anglani, N.	Boccito, A.	Cristofano, L.
Anunciação, B. B.	Bokor, T.	Crosa di Vergagni, M.
Arestova, A.	Borge-Diez, D.	Cselkó, R.
Asano, P. T. L.	Bouquain, D.	Csoknyai, T.
Atkinson-Hope, G.	Brabete, A.	Ćurevac, S.
Avellan, F.	Braciník, P.	Czifrus, Sz.
Baherník, M.	Brar, C.	Da Rocha, B. R. P.
Bajor, T.	Calcara, L.	Dhiman, M.
Balangó, D.	Canesso, B. C.	Dán, A.
Baldauf, Á.	Cardoso, G. S.	Dasila, N. K.
Baluev, D.	Carminati, M.	Davis, W.
Bank, M. R.	Carrillo-Caicedo, G.	De Almeida, T. H. S.
Bánóczy, E.	Caruso, G.	De Angelis, F.
Barzegar Ganji, H.	Casella, F.	De Luca, D.
Bashiri, B.	Cauzillo, B. A.	De Sá, J. A. S.
Batta, A.	Cavalieri, T.	De Simón-Martín, M.
Bechta, S.	Cherubini, M.	Dev, S.
Becirovic, V.	Chhetri, R.	Dib, E. A.
Bečvaříková, T.	Chung, I.-Y.	
Beisswenger, L.	Class, A.	
Bendfeld, J.		

Dietrich, P.	German, P.	Holst, A.
Diez de los Rios	Gherbi, A.	Homolya, E.
Ramos, N.	Gimenes, A. L. V.	Horák, B.
Djerdír, A.	Göcsei, G.	Horváth, M.
Dorsch, N.	Gorte, O.	Houda, A.
Đozić, N.	Gramulia Jr., J.	Hrabovszky-
Dubey, P.	Grasselli, U.	Horváth, S.
Duchene, G.	Grimoni, J. A. B.	Iftime, S.
Duus, H.	Griner, H.	Ilak, P.
Dvořáková, M.	Gróf, Gy.	Istrate, M.
Ekés, D.	Grzegorzczuk, L.	Ivanjko, M.
Eliasova, I.	Guilbert, D.	Jeong, M.-G.
ElSawy, A. E.	Guimarães, A.	Jiang, Q.
Erdmann, N.	Guzonas, D.	Jing, L. B.
Euzenat, C.	Hackel, K.	Jintanasombat, B.
Falcnik, M.	Hakim, A.	Josefová, T.
Farkas, Cs.	Halász Bálint, G.	Józsa, V.
Farkas, R.	Hambalkó, Z.	Kalló, P.
Feher, A.	Hanggraeni, D.	Kancijan, M.
Fehér, S.	Hanjalic, S.	Kang, H.-K.
Fiorelli, F. A. S.	Harabut, C.	Karchung
Fomichev, D. V.	Hasanić, M.	Kari, B. M.
Fosso, O. B.	Hasmatuchi, V.	Katona, B.
Freitas, T. T.	Hayashi, Y.	Katzenbach, R.
Friedrischková, K.	Hendley, J.	Kawano, S.
Fritz, T.	Henry, R.	Kékes, M.
Fujimoto, Y.	Hering, W.	Khaburi, D.
Gagro, M.	Hizam, H.	Khamaira, M.
Gaillard, A.	Hocke, E. K.	Kheradmand Saadi,
Gasperic, S.	Hofmeister, J.	M.
Gehlot, R.	Höger, M.	Khmelik, M.

Kim, C.-G.	Liu, L.	Muniz, R.
Kim, R.-G.	Loewen, A.	N. Đozić,
Kirincic, V.	Lóka, M.	Nagy, I.
Kiryanova, N.	Lóránt, B.	N'Diaye, A.
Klemenž, S.	Ludovici, G.	Necula, H.
Komoss, B.	Lutzemberger, G.	Nelles, M.
Kopriva, R.	Luz, R. C.	Németh, B.
Korsakas, A.	Mahavar, S.	Nikita, M.
Kovács, I. S.	Malozemova, O.	Nikolic, B.
Krajcar, S.	Mami, A.	Nobili, M.
Krauter, S.	Mandelli, S.	Nóbregas, A. P.
Krebs, S.	Mann, E.	Norouzianpour, H.
Kretschmar, F.	Mantrawadi, H.	Nowakowska, L.
Kronland, M. J.	Markin, V.	Nyerges, V.
Kryzia, D.	Matkovič, M.	Ognerubov, D.
Küller, P.	Mayer, M. J.	Olaszi Bálint, D.
Kűs, V.	Menzel, F.	Onea, A.
Kwon, D.	Miao, F.	Ordóñez-Plata, G.
Ladányi, J.	Miassoedov, A.	Orzechowska, M.
Lamedica, R.	Mihalic, R.	Otobe Jr., R. F.
Lamont, L. A.	Mikac, E.	Pacheco, R. R.
Lanfredini, M.	Mohammadi, A.	Pácsonyi, I.
Lascu, C.-E.	Mohanty, S.	Panasetsky, D.
Látková, M.	Mokou, C.	Papageorgiou, S.
Leak, N. B.	Molinas, M.	Papp, M. G.
Leite, P. T.	Monroe, A.	Pardikar, K.
Letite, P. T.	Moon, H.-L.	Parise, L.
Leung, L.	Moon, S.-I.	Pavel, C.
Lima, C.	Moraes, G. R.	Pavel, G. L.
Lipčsei, G.	Muhamad Mohd, I.	Pavić, I.
Listratov, Y.	Műnch-Alligné, C.	Pendieu, M. K.

Péter, N.	Schróth, Á.	Vagnoni, E.
Petruzzi, A.	Serna-Suárez, I. D.	Vajk, I.
Pintácsi, D.	Sharma, D.	Vala, D.
Pintér, L.	Shtork, S. I.	Vencl, M.
Pompili, M.	Sidorov, D.	Villanueva, W.
Pourmovahed, A.	Silva, M. S.	Vitale Di Maio, D.
Prankevich, G.	Skok, S.	Vogel, G. H.
Premrudeepreechacharn, S.	Skripkin, S. G.	Vogel, H.
Radzi, M. A. M.	Sljivac, D.	Wahab, M. I.
Ragaini, E.	Smohai, B.	A.Kim, Min-Hwan
Ragawino, O.	Sóki, R.	Weber, T.
Randall, J. E.	Solonin, V. I.	Weisenburger, A.
Rangacharyulu, C.	Somossy, E. S.	Weissmann, C.
Rapin, A.	Spiryaev, V.	Wirachowsky, B.
Razvan, A.	Stecher, L. C.	Womack, C. D.
Relva, S.	Steiner, N. Y.	Wongphat, M.
Ribeiro de Alencar, T.	Stumpf, P.	Xia, Y.
Ridley, C.	Sviridov, V.	Yakovlev, D.
Robertson, L. K.	Szente, Sz.	Yamaji, B.
Sabundjian, G.	Takács, B.	Yazdizadeh, A. R.
Sadati, A. M.	Tan, Z.	Ye, H.
Saib, S.	Tardy G. M.	Yoshizawa, S.
Salgado, R. S.	Thomas, D. F.	Zambon, K. L.
Samani, N.	Tiselj, I.	Zdunic, G.
Sartório Cardoso de Lima, G.	Tomásková, T.	Zeliang, C.
Scharfenberg, G.	Tomin, N.	Zhang, C.
Schegner P.	Topić, D.	Zheng, J.
Scherrer, S.	Tóth, T.	Zheng, Y.
Schickhuber, G.	Trnka, P.	Zhukov, A.
	Tsoy, M. A.	
	Udaeta, M. E. M.	



# Modelling of a dynamic cooperation between a PV Array and DC Boost Converter

M. Látková, M. Baherník, P. Bracíník, *Member, IEEE*, M. Höger, *Member, IEEE*

**Abstract**— Photovoltaic (PV) arrays are used in many applications such as water heating, battery charging, hybrid vehicles and grid connected photovoltaic power plants. Their main disadvantage is that their output strongly depends on weather conditions, mainly on a solar irradiance and temperature, thus influencing the operation of each system they feed. Since the changes of PV production could be very fast, it is necessary to use dynamic modelling to evaluate PV system's behavior during these changes. This could be quite challenging, especially if the application is modelled and analyzed from longer-term point of view. This paper describes partial results achieved during the process of building such a model. Simulation models of PV array and DC boost converter with MPPT controller created in software Ptolemy II by using synchronous data flow and finite state machine domain will be presented and evaluated.

**Index Terms**-- Finite state machine, mathematical model, maximum power point trackers, photovoltaic systems.

## I. NOMENCLATURE

$\lambda$	Solar irradiance ( $\text{kW}\cdot\text{m}^{-2}$ ).
$T$	Temperature (K).
$I$	PV array current (A).
$V$	PV array voltage (V).
$V_o$	DC boost converter output voltage (V).
$D$	Duty cycle (p. u.).
$I_D$	Diode current (A).
$I_S$	Diode saturation current (A).
$V_D$	Diode voltage (V).
$R_{SH}$	Shunt resistance of a PV cell ( $\Omega$ ).
$R_S$	Series resistance of a PV cell ( $\Omega$ ).
$N_P$	Number of parallel connected cells.
$N_S$	Number of series connected cells.
$I_{PH}$	Photo current (A).
$A$	Ideality factor.

$L$	Inductance of a DC boost converter (H).
$C$	Capacitance of a DC boost converter (F).
$f_S$	Switching frequency of a DC boost converter (Hz).
$R_L$	Load resistance ( $\Omega$ ).
$v_C$	Capacitor voltage (V).
$i_L$	Inductance current (A).
$V_{MPP}$	PV array voltage at the maximum power point (V).
$V_{OC}$	Open circuit voltage of a PV array (V).

## II. INTRODUCTION

WITH increasing concerns about the fossil fuel exhaustion and the environmental problems caused by the conventional power plants, renewable energy sources, as photovoltaic panels, are now in great need. Among several renewable energy sources, photovoltaic arrays are used in many applications such as water heating, battery charging, hybrid vehicles and grid connected photovoltaic power plants. Amount of energy produced by the sun is so large, that in one hour it can provide more than enough energy for human population for one year. However, due to the low efficiency of photovoltaic panels, conversion of irradiation energy into electrical power is very poor. This efficiency further decreases if there is no matching load, it means, that a PV array is not operated at its maximum power point (MPP) [1]. The MPP changes with the change of solar irradiance and cell temperature. Therefore an online tracking of the MPP of the PV array is essential part of any PV system. A MPP tracking algorithm is mostly the control part of DC boost converter, which is used to increase the voltage from PV array to a suitable form of energy accepted by the load [1], [2].

As it was mentioned, an output of PV system strongly depends on weather conditions (mainly on a solar irradiance and temperature). Since the changes of PV production could be very fast, it is necessary to use dynamic modelling to evaluate PV systems' behavior during these changes [3]. It could be quite challenging, when a larger part of a power system is modelled, especially if the influence is analyzed from a longer-term point of view. To solve this problem, it seems to be very useful to design PV systems models using finite state machines (FSM), to represent both steady state as well as dynamic characteristics in only one model. The building of such a model is a very complex task and has to be done step by step. So the partial results representing the modelling of the

---

This paper has been supported by the Educational grant agency (KEGA) Nr: 030ŽU-4/2014: The innovation of technology and education methods oriented to area of intelligent control of power distribution networks (Smart Grids).

M. Látková, M. Baherník, P. Bracíník and M. Höger are with the Department of Power Electrical Systems, Faculty of Electrical Engineering, University of Žilina, Žilina, Univerzitná 1, SK-01026 Slovakia (e-mail: [martina.latkova@kves.uniza.sk](mailto:martina.latkova@kves.uniza.sk)).

PV array and DC boost converter cooperation will be described in this paper.

### III. MATHEMATICAL MODEL OF PV SYSTEM

The model of PV system consists of mathematical models of a PV array, a DC boost converter loaded by constant resistive load and a maximum power point tracking (MPPT) controller (Fig. 1).

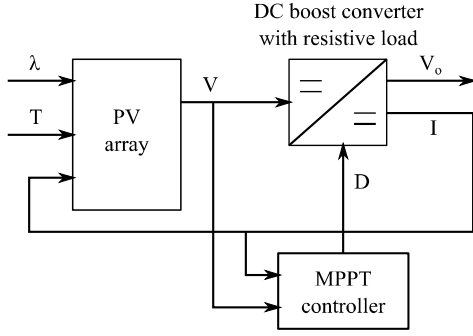


Fig. 1. A block diagram of modelled photovoltaic system.

The inputs of the PV array model are solar irradiance  $\lambda$  ( $\text{kW}\cdot\text{m}^{-2}$ ), temperature  $T$  (K) and load current  $I$  (A). They are used to calculate the PV array voltage  $V$  that is used as an input for the model of DC boost converter. Converter calculates the increased output voltage  $V_o$  and the load current  $I$ .

The switching of the DC boost converter is controlled by MPPT controller, which changes the duty cycle  $D$  of the converter according to the voltage from PV array and load current. The MPPT controller's algorithm determines the duty cycle needed to operate the PV array in a point of its maximum power.

#### A. Mathematical Model of a PV Array

Solar cell is basically a p-n junction and so the Shockley equation can be used for its mathematical description:

$$I_D = I_S \cdot \left[ e^{\left( \frac{q \cdot V_D}{k \cdot T} \right)} - 1 \right], \quad (1)$$

where  $I_D$  is a diode current,  $I_S$  is a diode saturation current,  $V_D$  is a diode voltage,  $q$  is an electron charge ( $1.6 \cdot 10^{-19}$  C),  $k$  is a Boltzman constant ( $1.38 \cdot 10^{-23}$  J/K) and  $T$  is a temperature dependence of the diode saturation current. An equivalent circuit of solar cell based on this equation is shown in Fig. 2. The circuit consists of the current source, a diode, a shunt resistance  $R_{SH}$  and a series resistance  $R_S$ , which represents an internal resistance of the cell [4].

Because a typical PV cell produces approximately 2 W, the cells have to be connected in series-parallel connection to produce enough power. The generalized equation for the solar array connected of  $N_p$  parallel and  $N_s$  series cell is [5]:

$$I = N_p \cdot I_{PH} - N_p \cdot I_S \cdot \left( e^{\left( \frac{q \cdot \left( \frac{V}{N_s} + \frac{I \cdot R_s}{N_p} \right)}{k \cdot T \cdot A} \right)} - 1 \right), \quad (2)$$

where  $A$  is an ideality factor.

Using (2) the voltage  $V$  can be expressed as:

$$V = N_s \cdot \left( \frac{k \cdot T \cdot A}{q} \cdot \log \left( \frac{N_p \cdot I_{PH} - I}{N_p \cdot I_S} + 1 \right) - \frac{I \cdot R_s}{N_p} \right). \quad (3)$$

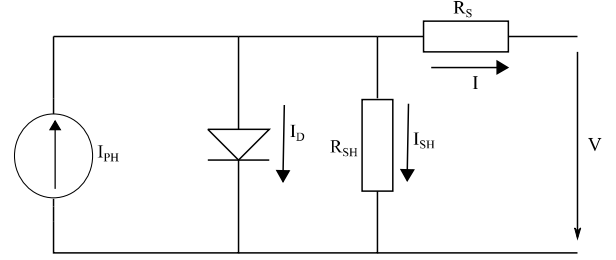


Fig. 2. Equivalent circuit of a photovoltaic cell.

#### B. Mathematical Model of the DC Boost Converter

A topology of the DC boost converter is shown in Fig. 3. It is modelled in two modes of operation, which are given by the operation state of the switch. The output variables are inductor current  $i_L$  and the capacitor voltage  $v_C$  [6].

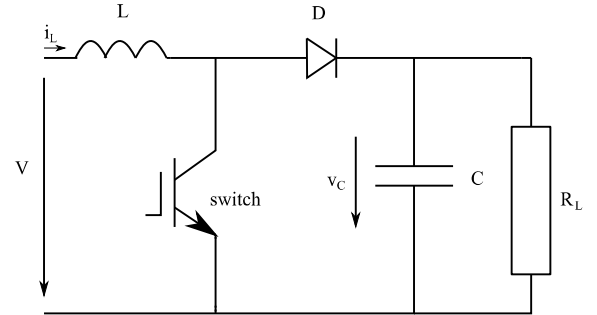


Fig. 3. Topology of a DC boost converter.

When the switch is on (closed), the inductor stores the energy from PV array and the load is supplied only by the capacitor (Fig. 4) [5].

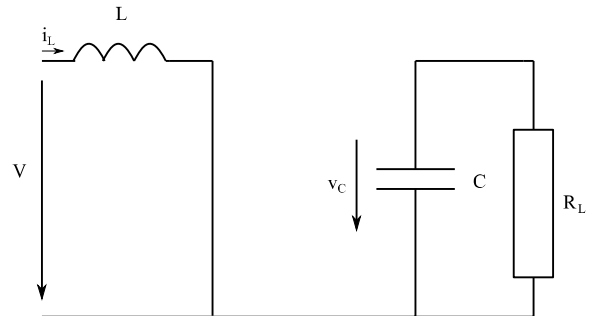


Fig. 4. ON operation mode of a DC boost converter.

This state can be described by following differential equations [5]:

$$V = L \cdot \frac{di_L}{dt}, \quad (4)$$

$$\frac{v_C}{R_L} = -C \cdot \frac{dv_C}{dt}. \quad (5)$$

When the switch is off (open), the inductor current flows to the load and the stored energy of the inductor is transferred to the capacitor and the load (Fig. 5) [5].

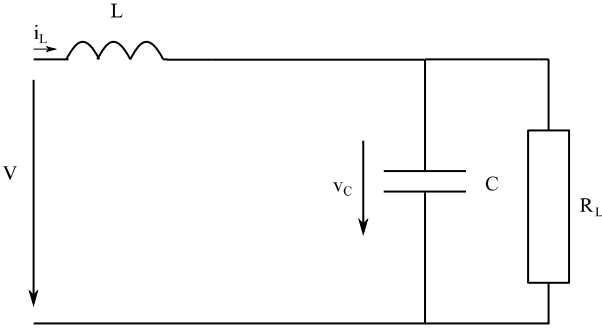


Fig. 5. OFF operation mode of a DC boost converter.

This state can be described by following differential equations [5]:

$$V = L \cdot \frac{di_L}{dt} + v_C, \quad (6)$$

$$i_L = C \cdot \frac{dv_C}{dt} + \frac{v_C}{R_L}. \quad (7)$$

### C. Algorithm of the MPPT Controller

The DC boost converter is controlled by MPPT controller to achieve maximum power point of the PV array. There are many methods for the MPPT, such as perturb and observe method, incremental conductance method or constant voltage, etc. Controller changes duty cycle  $D$  of the converter to achieve voltage at maximum power point and so the maximum power in all of these technique [7].

We use constant voltage method in our system, as the simplest and fastest method. The basis for the constant voltage (CV) algorithm is assumption that the ratio of the array's maximum power voltage  $V_{MPP}$  to its open-circuit voltage  $V_{OC}$  is approximately constant. This ratio has been empirically determined between 70 and 80 % [7].

The controller firstly calculates the open-circuit voltage and 80 % of its value (in our case) and this value is set as  $V_{MPP}$ . Then, if the voltage of the PV array is lower than the calculated value, the controller decreases duty cycle, what in consequences decreases current in the converter and therefore increases the voltage according to V-I curve of the PV panel and vice versa. Flowchart of this method is shown in Fig. 6.

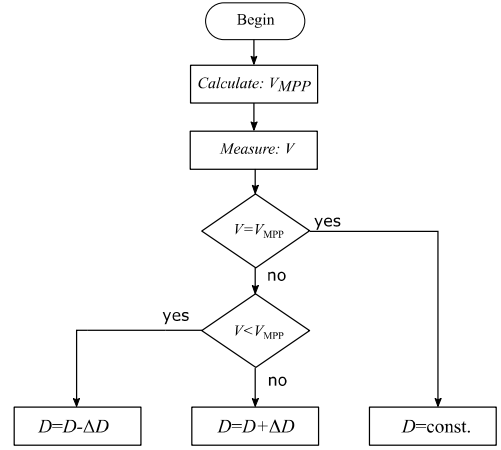


Fig. 6. Flowchart of the constant voltage method.

## IV. MODELLING OF PV SYSTEM OPERATION

### A. PV array with constant resistive load

Firstly, we created a model of the PV array with direct connected constant resistive load in the software Ptolemy II [8]. The model is shown in Fig. 7. It calculates the output voltage and the output current of the PV array according to:

$$I = \frac{N_S \cdot V_D}{\frac{N_S}{N_P} R_S + R_L}, \quad (8)$$

and the Ohm's law:

$$V = R_L \cdot I, \quad (9)$$

where  $R_L$  is the load resistance.

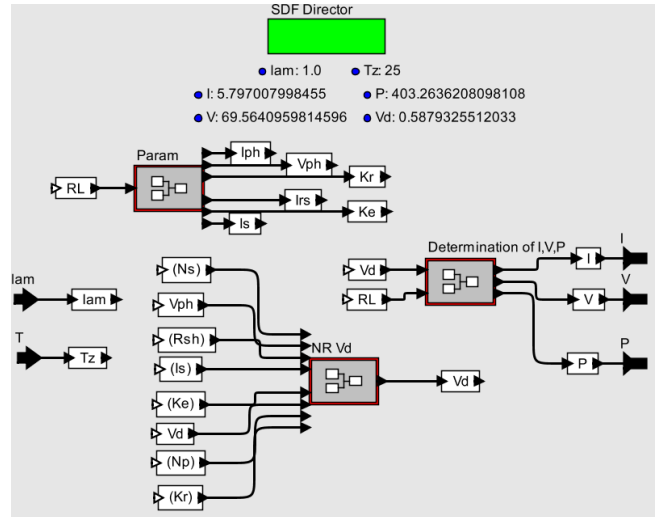


Fig. 7. Ptolemy II model of PV array with constant resistive load.

The model of PV array was parametrized to represent an installation of 8 PV panels interconnected in four parallel groups, each consisting of two in series connected PV panels. Table I presents parameters of the panels. The load was set to constant value of 12  $\Omega$ .



TABLE I  
TECHNICAL PARAMETERS OF USED PV PANELS

Parameter	Parameter name	Parameter value
$I_{sc}$	Short-circuit current	7.71 [A]
$K_1$	Cell temperature coefficient	0.11 [mA/C]
$K$	Boltzmann's constant	$1.38065 \cdot 10^{-23}$ [J/K]
$T_r$	Thermodynamic reference temperature	298.15 [K]
$q$	Electron charge	$1.6 \cdot 10^{-19}$ [C]
$E_g$	Bandgap voltage for silicon	1.11 [eV]
$A$	Ideality factor	1.3 [-]
$V_{oc}$	Open-circuit voltage	0.589 [V]
$R_s$	Serial resistance	0.01136 [ $\Omega$ ]
$R_{sh}$	Parallel resistance	116.8415 [ $\Omega$ ]

In order to minimize the execution time of future simulations, a static data flow (SDF) director (Fig. 7) was used in the model instead of a continuous time (CT) director [8].

Model inputs are values of the solar irradiance ( $\lambda$ ) and the temperature ( $T$ ), which are used to calculate relevant PV array operation parameters. They are then used to determine the diode voltage  $V_D$  by using Newton-Raphson method as well as the PV array output variables - current, voltage and power.

Two simulation cases were used to verify model functionality. During the first one, the value of solar irradiance  $\lambda$ , at the constant temperature of 25 °C, has been changed from 1.0 to 0.5 and then to 0.3 kW·m<sup>-2</sup>. The curve representing changes of solar irradiance is illustrated in Fig. 8. The PV array output current, voltage and power curves are shown in Fig. 9, Fig. 10 and Fig. 11, respectively.

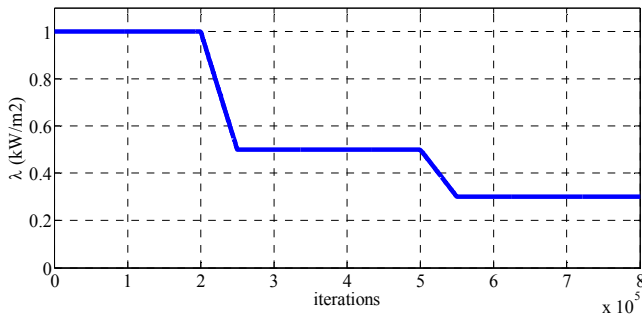


Fig. 8. Solar irradiance curve.

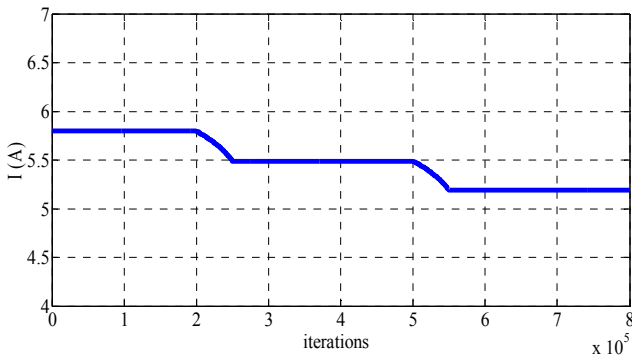


Fig. 9. PV array output current for different solar irradiances.

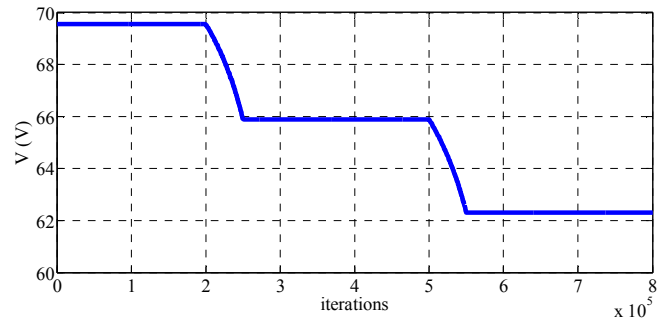


Fig. 10. PV array output voltage for different solar irradiances.

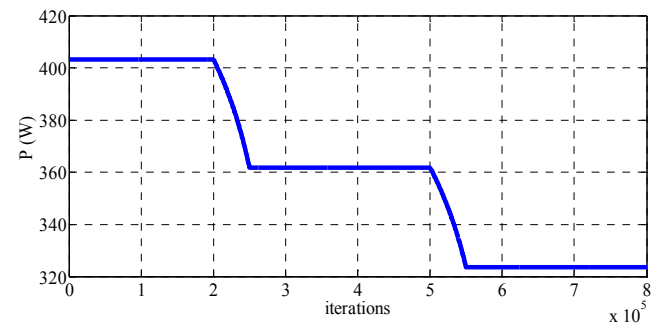


Fig. 11. PV array output power for different solar irradiances.

In the other case, the constant value of solar irradiance 1 kW·m<sup>-2</sup> was used, but the value of PV array temperature  $T$  has been changed from 23 to 25 and then to 27 °C. The curve representing changes of temperature is illustrated in Fig. 12. The PV array output current, voltage and power curves are shown in Fig. 13, Fig. 14 and Fig. 15, respectively.

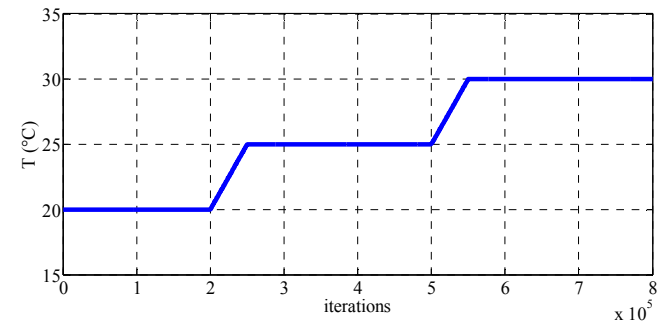


Fig. 12. PV array's temperature curve.

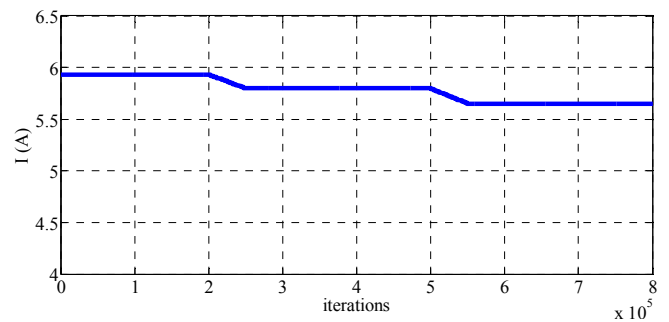


Fig. 13. PV array output current for different temperatures.

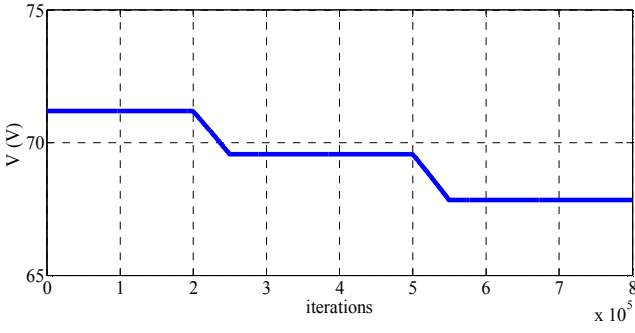


Fig. 14. PV array output voltage for different temperatures.

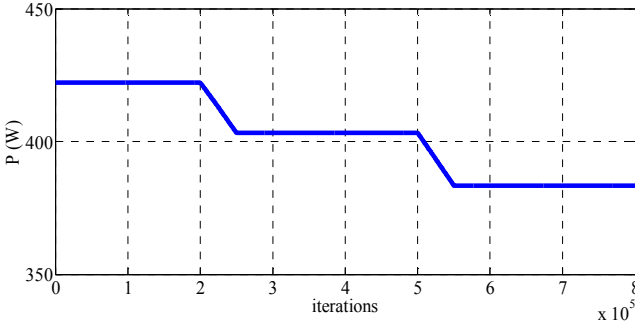


Fig. 15. PV array output power for different temperatures.

The model provided results according to theoretical expectations. The output power of the PV array decreases with decreasing solar irradiance as well as with increasing panels' temperature. Nevertheless, the achieved output power was very low in both cases, because the PV array was not loaded with the value of load resistance ( $R_L$ ) appropriate to the changes of input parameters. To eliminate this effect, the model of DC boost converter with MPPT controller was added to the PV array model.

### B. PV array with DC boost converter and MPPT controller

The extended model of PV array with DC boost converter and MPPT controller was created according to the block diagram in Fig. 1. It was also created in software Ptolemy II and by using SDF director. The model is shown in Fig. 16.

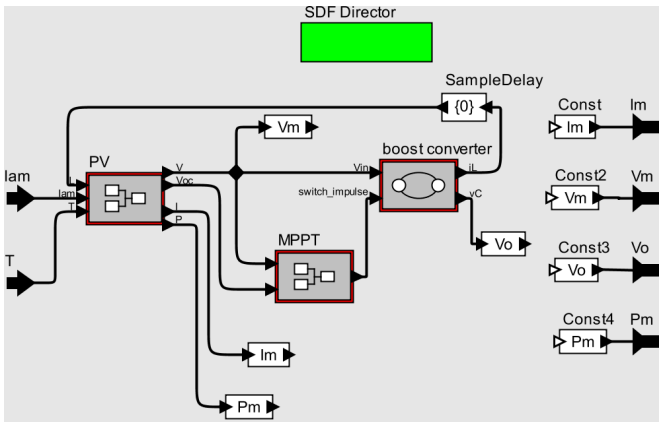


Fig. 16. Extended model with DC boost converter and MPPT controller.

The inputs of extended model are again the solar irradiance and temperature of the PV array, which are used to calculate

PV array output current, voltage, power and open-circuit voltage. The calculated values of PV array voltage and open-circuit voltage are used in the model of the MPPT controller, where the boost converter duty cycle  $D$  is set according to the flowchart presented in Fig. 6 and switching impulses controlling the DC boost converter operation are generated.

According to previously presented theoretical description, a DC boost converter operates in two basic states – ON and OFF. The change of one state to the other is caused by the switching impulses generated by MPPT controller. Each state is described by different set of differential equations representing its dynamics, (4) and (5) or (6) and (7), respectively. For such cases, the use of finite state machine model is very suitable, because it enables to combine different representations of model's object dynamic operation very easily, just by defining appropriate number of states and transitions between them. Therefore a finite state machine (FSM) domain in Ptolemy II was used to create the model of DC boost converter [8]. Table II presents used parameters. The load was set again to  $12 \Omega$ , as before.

TABLE II  
TECHNICAL PARAMETERS OF DC BOOST CONVERTER

Parameter	Parameter name	Parameter value
$f_s$	Switching frequency	50 [kHz]
$L$	Inductance	5 [mH]
$C$	Capacitance	60 [ $\mu$ F]

The same simulation cases were used as before. The current, voltage and power curves of the PV array for the changed value of solar irradiance (Fig. 8) and constant temperature are shown in Fig. 17, Fig. 18 and Fig. 19, respectively. The curve representing DC boost converter output voltage is shown in Fig. 20.

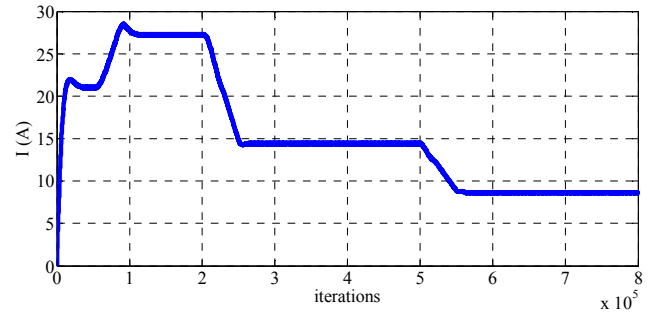


Fig. 17. PV array output current for different solar irradiances in extended model.

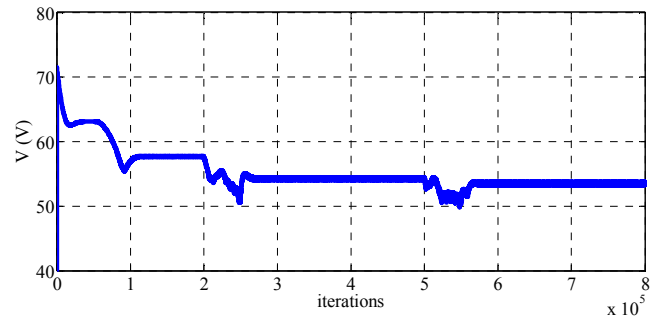


Fig. 18. PV array output voltage for different solar irradiances in extended model.

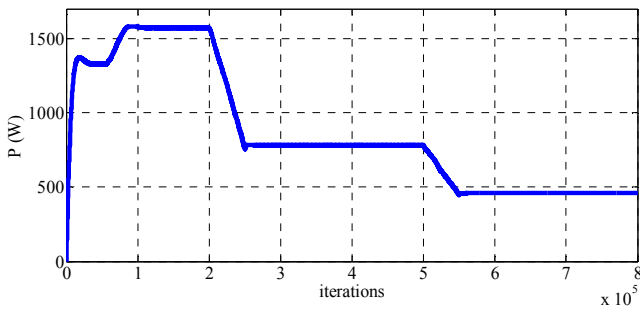


Fig. 19. PV array output power for different solar irradiances in extended model.

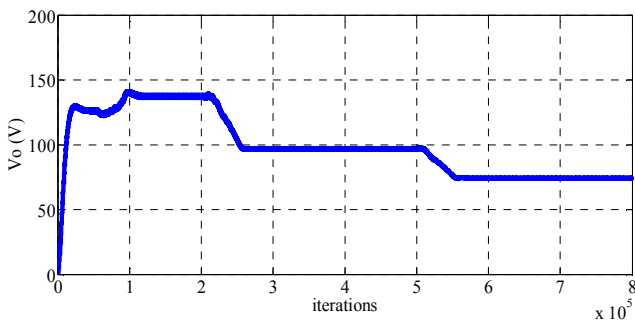


Fig. 20. DC boost converter output voltage for different solar irradiances in extended model.

The current, voltage and power curves of the PV array for the changed value of panels' temperature (Fig. 12) and constant solar irradiance are shown in Fig. 21, Fig. 22 and Fig. 23, respectively. The curve representing DC boost converter output voltage is shown in Fig. 24.

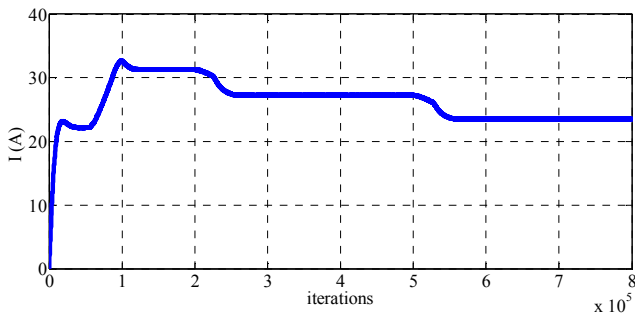


Fig. 21. PV array output current for different temperatures in extended model.

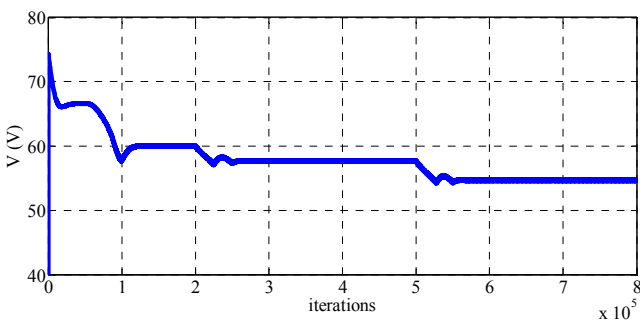


Fig. 22. PV array output voltage for different temperatures in extended model.

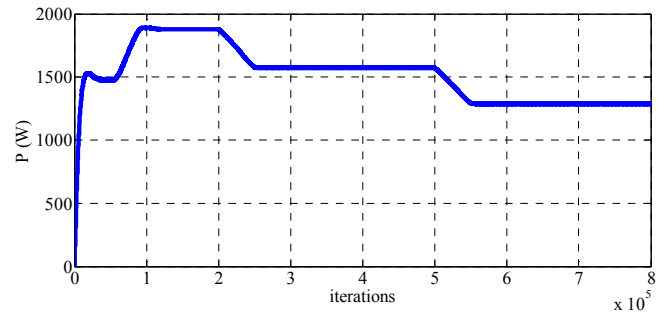


Fig. 23. PV array output power for different temperatures in extended model.

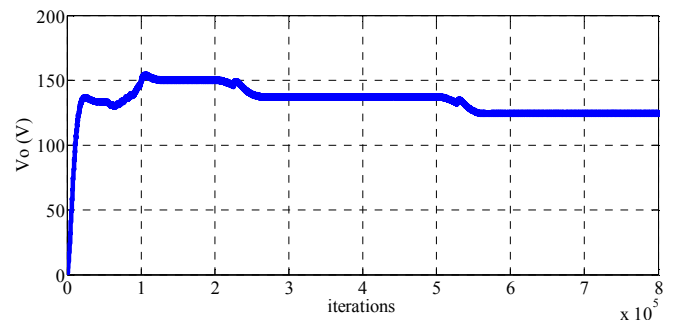


Fig. 24. DC boost converter output voltage for different temperatures in extended model.

The extended model provided results according to theoretical expectations and similar to results obtained by the simple PV array model, however the extended model reflects the positive effect of the DC boost converter with MPPT controller on the generated power that is almost four times higher than by the simple model.

## V. CONCLUSION

A photovoltaic (PV) technology has become very popular in many industrial applications, from small battery chargers up to big power plants generating electricity for the electric power system. Considered as a renewable energy source, PV applications seem to be a good solution for feeding future Smart Grids and Smart Cities. However, their operation has to be studied and their influence on power network has to be analyzed, due to the strong dependence of generated power on actual weather conditions. A solar irradiance and temperature are the main parameters, which determine how much power will be generated in a PV installation. Moreover, both parameters can change with different dynamics for different time periods.

To build a model that will sufficiently represent PV power plants characteristic for different operation modes, including transients, and enables to analyze PV system operation from longer-term point of view as well, is a quite challenging tasks. This paper describes partial results achieved during the process of building such a model. Simulation models of PV array and DC boost converter with MPPT controller created in software Ptolemy II by using synchronous data flow and finite state machine domain were presented and evaluated.

The created model (extended one) proved its ability to represent the PV array operation during the dynamic changes of solar irradiance and temperature. It will be now used in more complex model of PV power plant that will be used to model the operation of a distribution network with renewable energy sources.

## VI. REFERENCES

- [1] J. J. Nedumgatt, K. B. Jayakrishnan, S. Umashankar, D. Vijayakumar, D. P. Kothari, "Perturb and observe MPPT algorithm for solar PV systems-modeling and simulation," *India Conference (INDICON), 2011 Annual IEEE*, vol., no., pp.1,6, 16-18 Dec. 2011.
- [2] A. KHAMIS, M. N. KAMARUDIN, M. Y. LADA, M. SAIFUZAM, F. HANAFI, A. NAZMI, "Identification and Simulation of Dc-Dc Boost Converter for Charging Up PV Voltage for 24-Volts Battery," presented at The Asia-Pacific Symposium on Applied Electromagnetics and Mechanics, 2010.
- [3] P. KRÖMER, V. SNÁŠEL, J. PLATOŠ, A. ABRAHAM, L. PROKOP, S. MIŠÁK, "Genetically evolved fuzzy predictor for photovoltaic power output estimation," in *Proc. of 3<sup>rd</sup> IEEE International Conference on Intelligent Networking and Collaborative Systems*, 2011, pp. 41-46.
- [4] S. SAID, A. MASSOUD, M. BENAMMAR, S. AHMED, "A Matlab/Simulink-Based Photovoltaic Array Model Employing SimPowerSystem Toolbox," *Journal of Energy and Power Engineering*, Vol. 6, No. 12, 1965-1975.
- [5] H. TSAI, C. TU, Y. SU, "Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK," in *Proc. of the World Congress on Engineering and Computer Science*, 2008, San Francisco, USA.
- [6] Y. MA, D. CHENG, X. ZHOU, "Hybrid Modeling and Simulation for the Boost Converter in Photovoltaic System," presented at Second International Conference on Information and Computing Science, 2009.
- [7] A. W. Leedy, L. Guo, K. A. Aganah, "A constant voltage MPPT method for a solar powered boost converter with DC motor load," in *Proc.2012 of IEEE*, pp.1,6, 15-18 March 2012.
- [8] M. BAHERNÍK, M. HÖGER, P. BRACINÍK, K. DEZELAK, "Model of Photovoltaic Power Plant with Resistive Load," *ELEKTRO 2014*, pp. 252-255, 19-20 May 2014.
- [9] C. PTOLEMAUS, Editor, "*System Design, Modeling and Simulation using Ptolemy II*," Ptolemy.org, 2014, ISBN 978-1-304-42106-7, [Online]. Available: <http://ptolemy.eecs.berkeley.edu/books/Systems/>

## VII. BIOGRAPHIES



**Martina LÁTKOVÁ** was born in Czechoslovakia. She received her M.Sc. from University of Žilina in Electrical Power Systems. She is with the Department of Power Electrical Systems as a PhD student. Her research interests include distribution networks and renewable energy sources.



**Michal BAHERNÍK** was born in Czechoslovakia. He received his M.Sc. from University of Žilina in Electrical Power Systems. He is with the Department of Power Electrical Systems as a PhD student. His research interests include distribution networks and renewable energy sources.



**Peter BRACINÍK** was born in Czechoslovakia. He received his M.Sc. as well as PhD. from University of Žilina in Electrical Power Systems. He is with the Department of Power Electrical Systems as an associate professor. His research interests include distribution networks, fault location and operation of smart regions.



**Marek HÖGER** was born in Czechoslovakia. He received his M.Sc. as well as PhD. from University of Žilina in Electrical Power Systems. He is with the Department of Power Electrical Systems as an assistant professor. His research interests include distribution networks, fault location and operation of microgrids.

BROWSE ▾

MY SETTINGS ▾

GET HELP ▾

WHAT CAN I ACCESS? ▾

Enter Search Term

 Search

Basic Search

Author Search

Publication Search

Advanced Search

Other Search Options ▾

Browse Conference Publications - Energy (IYCE), 2015 5th Inter ...

[Back to Results](#)

# Modelling of a dynamic cooperation between a PV array and DC boost converter

 Full Text as PDF4  
Author(s)Latkova, M. ; Department of Power Electrical Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 1, SK-01026 Slovakia ;  
Bahernik, M. ; Bracinik, P. ; Hoger, M.

Abstract

Authors

References

Cited By

Keywords

Metrics

Similar

 Download Citations Email Print Request Permissions Save to Project

Photovoltaic (PV) arrays are used in many applications such as water heating, battery charging, hybrid vehicles and grid connected photovoltaic power plants. Their main disadvantage is that their output strongly depends on weather conditions, mainly on a solar irradiance and temperature, thus influencing the operation of each system they feed. Since the changes of PV production could be very fast, it is necessary to use dynamic modelling to evaluate PV system's behavior during these changes. This could be quite challenging, especially if the application is modelled and analyzed from longer-term point of view. This paper describes partial results achieved during the process of building such a model. Simulation models of PV array and DC boost converter with MPPT controller created in software Ptolemy II by using synchronous data flow and finite state machine domain will be presented and evaluated.

**Published in:**[Energy \(IYCE\), 2015 5th International Youth Conference on](#)**Date of Conference:**

27-30 May 2015

**Page(s):**

1 - 7

**Print ISBN:**

978-1-4673-7171-1

**Conference Location :**

Pisa, Italy

**DOI:**[10.1109/IYCE.2015.7180783](#)**Publisher:**

IEEE

