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EFFECT OF SLIDING MODE CONTROLLER ON DC-DC BOOST CONVERTER WITH DIFFERENT CONDITIONS

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Abstract: nowadays days, solar, wind and PV are regularly used for increases power as per necessity and generation. The power received from energy source required to be converted using AC- DC or DC-DC converters. The main converter used is Boost converter for step up this voltage. These sources are adjustable by nature, thus problem arises is to maintain constant required output in all conditions. Boost converter converts the low value of input voltage into higher value of output voltage as per the input is received. This problem of gaining constant output under variable conditions can be solved by using sliding mode control of the converter. There are many schemes to implement this technology with converter but the problem arises when the capacitance and inductance parameters changes as load varies. In proposed work is to resolve this problem whit the help of competitive analysis of Slide Mode controlled compared with PID controller in terms of transient characteristics, load and other parameters variations, these controllers are modeled and evaluated by MATLAB simulations. The input source is taken as DC source voltage at variable conditions. The modeling is done in MATLAB/Simulink software.
Keywords: DC/DC boost converter, SMC controller, PID controller.

I. INTRODUCTION

Switched mode DC-DC converters are electronic circuits which convert a voltage from one level to a higher or a lower one. They are more and more used in some electronic devices such as DC-drive systems, electric vehicles, smart grids, and distributed power supply systems. In modern years, DC-DC power converters must use in a number of applications like generation of energy through solar and wind system. The power composed from these sources is converted with help of AC-DC and DC-DC converters but energy gained from these sources are flexible in nature, so that to maintain continuous production from and get desired output voltage several controlled converters are used. Switching type dc-dc converters are commonly used and one the best power electronic circuits that convert unregulated electrical voltage from one level into regulated desired other level electrical voltage by switching technique and the eliminate the unfettered output issue can be solved via the converter's sliding mode control. There are many schemes to contrivance this technique with the converter, but then the difficult arises when fluctuations in the form of installation and capacitance and the load varies. The benefit of converters in the electricity system is to regulate the parameters giving to difference in load & maintains the essential creation voltage. for controlling the output voltage of the converter we can use to control the semiconductor device duty cycle. The idea of proposed work by the controlling method to control the duty cycle according to the variance in the several parameters of the structure by using sliding mode control. The parameter considered for control is voltage. A unique method has to be ready to control the duty-cycle of converter and increase system effectiveness for every parameter.

In this paper, performance of Slide Mode controlled DC-DC buck converter system is compared with PID feedback controller in terms of load and other parameters variations, these controllers are modeled and evaluated by MATLAB simulations. The planned control algorithm sustains the strength of predictable SMC against parameter disconcertion. In accumulation to this, the switching frequency variation during supply and load voltage deviations are remove over the usage of pulse width modulation(PWM) strategy. Here In after, section 2 deals with the theory of DC-DC buck converter. Section 3 explains the detail of controller design methodology. Section 4 presents the simulation results & brief discussion of the similar. Section 5 shows the conclusions.

II. BOOST CONVERTER

A boost convertor is a power convertor which convert small value of input voltage to higher value of output voltage.It's a category of switch mode power supply containing a minimum of 2 semi- conductors switches (a diode and a transistor) and a minimum of one energy storage part.

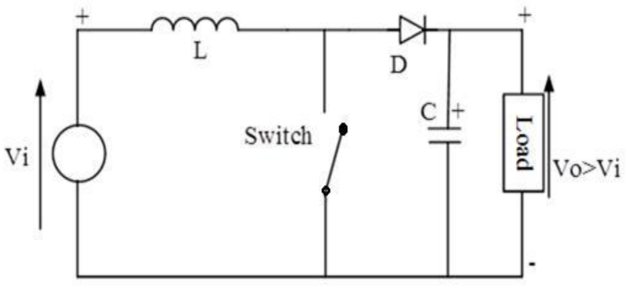

Fig.1. Schematic diagram of boost converter

A basic configuration of boost converter has controlled power transistor a Diode (D), switch (S), an inductor (L), a capacitor (C) and a load (R).
assume the converter is operating in continuous conduction mode as shown in Fig. 2 when switch is on input voltage (V_i) appears across inductor L. due to which change in inductor current ΔI_l over time t is given by:-

$$\frac{\Delta I_L}{\Delta t} \quad \frac{V_i}{L} \qquad \dots (1)$$

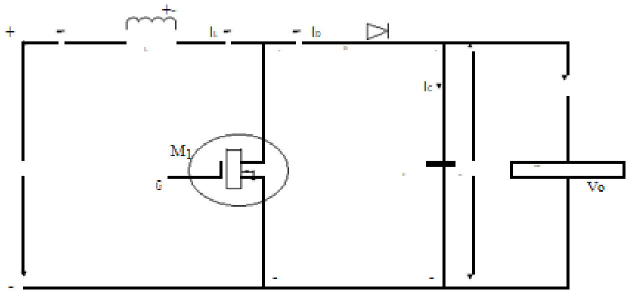

Fig.2 Circuit diagram of Boost Converter

When the on state end the increase in inductor current during on time is

$$\Delta I_{L\,on} = \frac{1}{L}\int_0^{DT} V_i dt = \frac{DT}{L} V_i \quad \ldots.(2)$$

Where D is duty cycle, it signifies how much of the duration of the conversion for the duration of which the switch is turned on. So, the D ranges from 0 to 1. When switch is off the load has inductor current across it which is shown in Fig.2 considering zero voltage drop across D, Maintains Capacitor great for its voltage to remain constant. The inductor current is

$$V_i - V_o = L\frac{dI_L}{dt} \quad \ldots.(3)$$

So, in switch Off-period the inductor current I_L varied to

$$\Delta I_{L\,off} = \int_{DT}^{T} \frac{(V_i - V_o)}{L} dt = \frac{(V_i - V_o)(1-D)T}{L} \quad \ldots.(4)$$

Hence, the inductor current should be same at the beginning and ending of the commutation cycle therefore the overall change the current is zero:

$$\Delta I_{L\,on} + \Delta I_{L\,off} = 0 \quad \ldots.(5)$$

Substituting $\Delta I_{L\,on}$ and $\Delta I_{L\,off}$ from (2) and (4) in (5). This can be written as:

$$V_o = \frac{V_i}{1-D} \quad \ldots(6)$$

(6) Give the relation between output voltage and duty cycle So it is clear that for control the output voltage through the duty cycle (D when it changes from 0 to 1 the output voltage is directly related to the duty cycle.

III. CONTROLLER DESIGN METHODOLOGY

The main aim of control in DC-DC boost convert to control the output dc-voltage (V0) t given reference value (Vref). One main concern in this process is that control must be accepted out in the existence of input voltage deviations and load disturbances. Conventional controller sliding mode control is proposed to regulate the output voltage V0 of the converter.

a) Proportional-integral-derivative controller

In industry for controlling the system commonly used Proportional-integral-derivative controller (PID) it is a feedback control loop mechanism. A PID controller is perfect the error among a measured and wanted variable set point, Shown in Fig.3 PID Controller control contains 3 different parameters; integral, Proportional and derived value controls the response to the current error, the integral bounds the response created on the sum of latest errors and controls the response to the derived rate at which the error is varying.

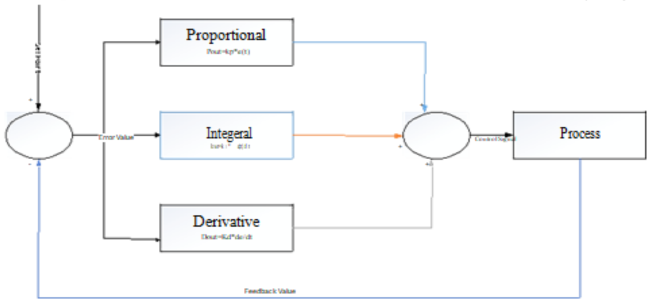

Fig.3 Control circuit of PID Controller.

b) Sliding mode controller

The sliding mode voltage controller is especially helpful, because of its easy implementation and high performance. the fundamental concept of sliding mode (SM) controller includes designing a sliding surface within the state space and a control law which can direct the system trajectory into the sliding surface . A sliding surface is predefined surface in the state space region. The control law is designed to steer the system trajectory in the sliding surface and also to ensure that the sliding mode starts at a finite time. The motion of the system on a discontinuity surface is called sliding mode. To design a Slide mode controlled converter assume that the Output voltage is control variable and the state variable of full order slide mode controller which are to be controlled can be expressed by variables x.

$$x = \begin{bmatrix} X1 \\ X2 \\ X3 \end{bmatrix} = \begin{bmatrix} V_{ref} - \beta v_o \\ \frac{d(V_{ref} - \beta v_o)}{dt} \\ \int (V_{ref} - \beta v_o) dt \end{bmatrix} \quad \ldots.(7)$$

Where X1, X2, and X3 are the voltage error, rate of change of voltage error, and integral of voltage error. V_{ref} Is reference voltage, βv_o is sensed output voltage, β is the gain/proportion of the sensed output voltage and M O S F E T M1 is the control switch.

in this system, a general Sliding mode control rule that use the control input or switching function u can be written as,

$$u = \begin{pmatrix} 1 & when\ S > 0 \\ 0 & when\ S < 0 \end{pmatrix} \quad \ldots(8)$$

Here, S is the instantaneous state variable trajectory. It can be represented as

$$S = a_1 x_1 + a_2 x_2 + a_3 x_3 = J^T x \quad \ldots.(9)$$

Where a_1, a_2 and a_3 are control parameters known as sliding coefficients.

For the SMVC boost converter, the derivations are as illustrated.

Equating $\dot{S} = J^T A x + J^T B u_{eq} = 0$ gives the equivalent control function

$$\mu_{eq} = -[J^T B]^{-1} J^T A x = \frac{\beta L}{\beta(V_o - V_i)} \times \left(\frac{a_1}{a_2} - \frac{1}{R_l C}\right) i_c - \frac{a_3 LC}{a_2 \beta (V_o - V_i)} (V_{ref} - \beta V_o) \quad \ldots (10)$$

Where μ_{eq} is continuous and $0 < \overline{\mu_{eq}} < 1$. Since $\mu = 1 - \bar{\mu}$, this also implies.
the equivalent control function is mapped onto the duty ratio control, where

$0 < d = \frac{V_c}{V_{ramp}} < 1$, gives the following relationships for ramp and the control signal V_c .

Where Signal V_c is

$$V_c = \mu_{eq} = -\beta L \times \left(\frac{a_1}{a_2} - \frac{1}{R_L C}\right) i_c - \frac{a_3 LC}{a_2} (V_{ref} - \beta V_o) + \beta(V_o - V_i) \quad \ldots (11)$$

The calculation of the control signal (11) can be done using modest summing utilities and gain. The parameters of these circuit can be simply calculated by known values of, and proper selections of a1, a2 and a3.

IV. SIMULATION AND RESULT ANALYSIS

This section explain design and modelling of DC/DC boost converter with controller.Modelling is based on mathematical calculations and designing and modifications of system provides the circuit design representation in MATLAB/ Simulink. This work show control and working of DC/DC boost converter with PID controller and slide mode controller, when the factors fixed on different conditions. Proposed system is give the output at all different conditions.

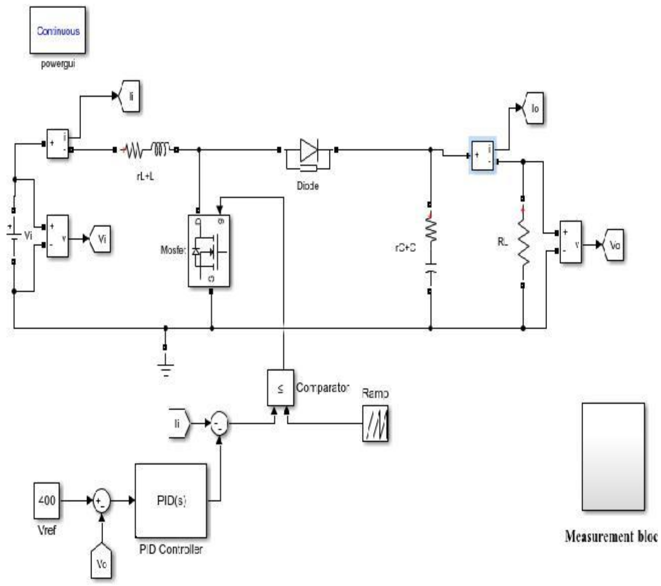

Fig. 4 MATLAB model for Boost converter using PID

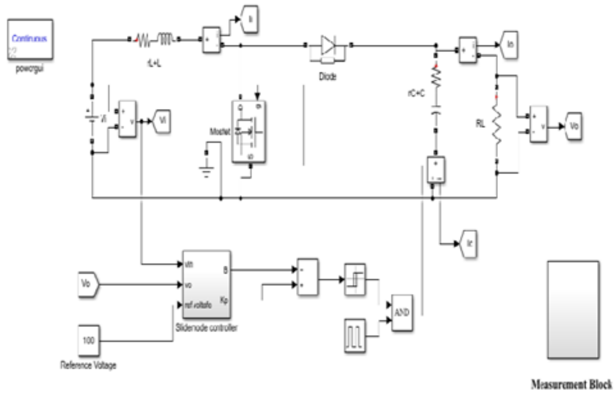

Fig. 5 Simulink Diagram for Boost Converter with SM controller at 200V to 400 V

a) DC – DC boost converter with 200v input
Fig 6 to Fig 9 Shows the experimental voltage and current waveform for the period of steady-state operation for the Boost converter with PID and Slide Mode controller with input voltage is 200Vand desired output voltage is 400V.

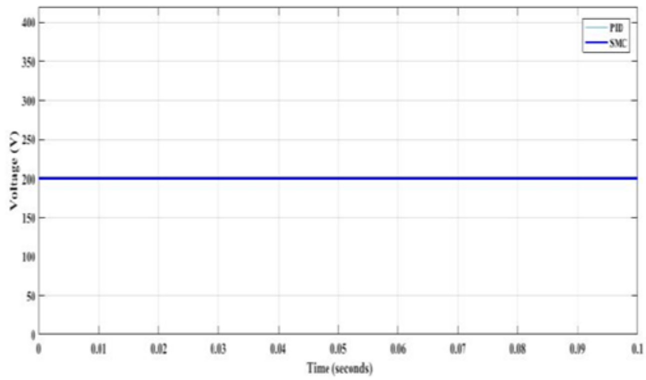

Fig.6 Input Voltage from Boost converter

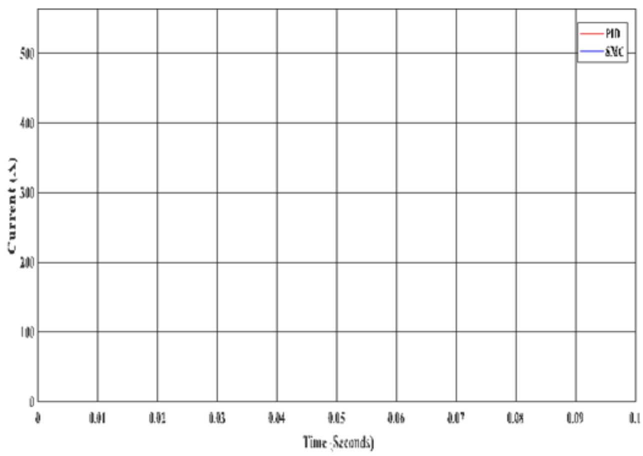

Fig.7 Input Current from Boost converter. Controller

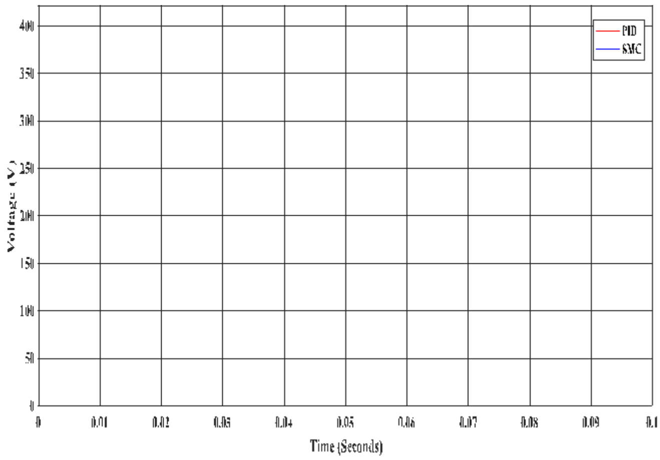

Fig.8 Output Voltage from Boost converter

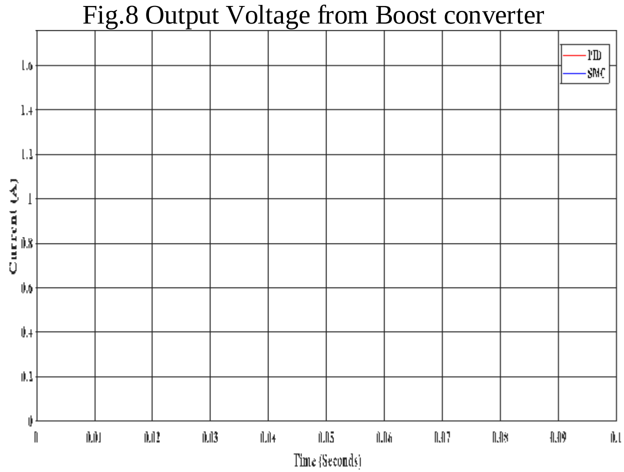

Fig.9 Output Current from Boost converter

Table.I
Comparison between Output responses of PID controller, SM controller

Parameter	PID	SMC
Output Voltage	400.9 V	399.9 V
Output Current	1.67 A	1.666 A
Settling Time	12.508 milliseconds	3.460 milliseconds

Table I shows the data analysis of DC/DC boost converter at 200 volt input.

b) DC – DC boost converter with different load resistance
Fig.10 and 13 represents the output waveform for voltage and current in Boost converter Using PID and SM controller operating at load resistance 120Ω and 480Ω mode here the boosting mode is from 200 V to 400 V.

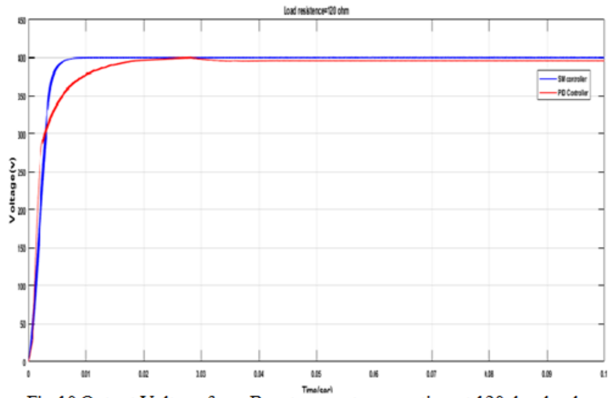

Fig.10 Output Voltage from Boost converter operating at 120ohm load

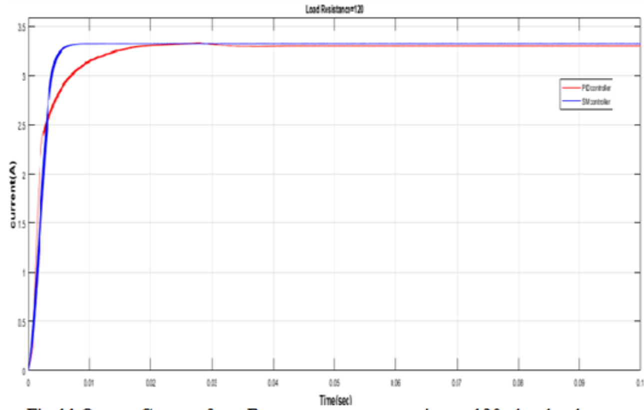

Fig.11 Output Current from Boost converter operating at 120 ohm load

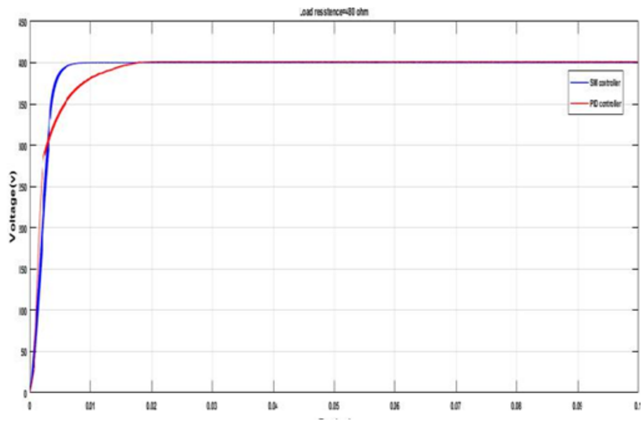

Fig.12 Output Voltage from Boost converter operating at 480 ohm load

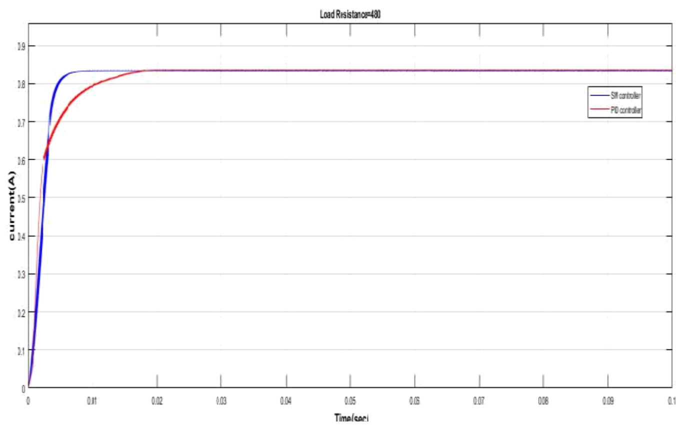

Fig.13 Output Current from Boost converter operating at 480 ohm load.

Table.II
Comparison between Output responses of PID controller, SM controller by varying Load

Controller	Load	Output Voltage	Output Current	Settling Time
Slide Mode Controller	120 Ω	399.6 V	3.33 A	3.489 ms
	480 Ω	400.1 V	0.83 A	3.440 ms
PID Controller	120 Ω	396.1 V	3.30 A	11.984 ms
	480 Ω	401 V	0.83 A	12.162 ms

Table II shows the data analysis of DC/DC boost converter at 120 ohm and 480 ohm resistive load.

V. CONCLUSION

This research shows the analysis between the two controllers. Proportional Integral derivative (PID) and sliding mode controller. Designed controllers are feeding resistive load and analysis the result of integrated converter with different conditions and controllers attained zero steady state error. . The proposed work is carried out by two different conditions first is when the operating mode is for 200 V to 400 V and another is operating at load resistance 120Ω and 480Ω.a system is designed in MATLAB and measure the increase time, overshoot and settling time from the graphical response of voltage which is achieved from the MATLAB simulation. The several comparative simulation output waveform between two controller shows that the system works more effective at higher voltage rating & decrease the output current. Compare the result of PID and Slide mode Controller in case of stability Slide mode Controller is more accurate and time is less as compare to PID. The data analysis shows in table all specific results with Sliding mode controller compared to PID controller.

REFERENCES

[1] handra Shekher Purohit, Geetha M., P. Sanjeevikumar, Pandav Kiran Maroti, Shruti Swami, Vigna K. Ramachandaramurthy ―Performance analysis of DC/DC bidirectional converter with sliding mode and pi controller,‖ in International Journal of Power Electronics and Drive System (IJPEDS) Vol. 10, No. 1, March 2019, pp. 357~365.

[2] Humam Al-Baidhani and Marian K. Kazimierczuk, ―PWM-Based Proportional-Integral Sliding-Mode Current Control of DC-DC Boost Converter,‖ IEEE Trans. Power Electron.2018.

[3] P. R. Mohanty and A. K. Panda, "Fixed-Frequency Sliding-Mode Control Scheme Based on Current Control Manifold for Improved Dynamic Performance of Boost PFC Converter," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 5, no. 1, pp. 576-586, March 2017.

[4] A. Martínez-Treviño, A. E. Aroudi and L. Martínez-Salamero, "Sliding-mode approach for start-up control and voltage regulation of a boost converter driving a constant power load," 2017 IEEE International Symposium on Circuits and Systems (ISCAS), Baltimore, MD, 2017, pp. 1-4.

[5] S. Ahmadzadeh, G. Arab Markadeh and F. Blaabjerg, "Voltage regulation of the Y-source boost DC–DC converter considering effects of leakage inductances based on cascaded sliding-mode control," in IET Power Electronics, vol. 10, no. 11, pp. 1333-1343, 9 9 2017.

[6] S. Barhoumi, A. Sahbani and K. Ben Saad, "Sliding Mode Control for a Boost converter with Constant Power Load," 2016 4th International Conference on Control Engineering & Information Technology (CEIT), Hammamet, 2016, pp. 1-5.

[7] M. E. Şahın, H. İ. Okumuş and H. Kahvecı, "Sliding mode control of PV powered DC/DC Buck-Boost converter with digital signal processor," 2015 17th European Conference on Power Electronics and Applications (EPE'15 ECCE-Europe), Geneva, 2015, pp. 1-8.

[8] Y. Massaoudi, T. Damak, J. P. Gaubert and D. Mehdi, "Sliding mode control of a boost converter using a non linear sliding surface," 3rd International Conference on Systems and Control, Algiers, 2013, pp. 299-302.

[9] A.H. ALQahtani and V. I. Utkin, "Control of photovoltaic system power generation using sliding mode control," 2012 IEEE International Conference on Power System Technology (POWERCON), Auckland, 2012, pp. 1-6.

