iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1335

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Controlling and Analysis of Boost converter using Sliding mode controller at variable Conditions

Sandeep Tyagi[1], Garima Verma[2]
[1,2]*Department of Electrical & Electronics Engineering Rajasthan Institute of Engineering & Technology, Bhakrota, Jaipur (India)*

Abstract: ***As the requirement of power increases, it is required to increase the generation on demand. Now a days, solar PV and wind are increasingly used for generation. The power collected from these energy source need to be converted using DC-Dc or AC- Dc converters. The main converter used is Boost converter for step up this voltage. These sources are variable by nature, so problem arises is to maintain constant required output in all conditions.***
Boost converter converts the input voltage into higher value of voltage but as per the input is received. This issue can be resolved by using sliding mode control of the converter. There are many theories to implement this technology with converter but the problem arises when the inductance and capacitance changes as load varies. The proposed work is to resolve this problem by using sliding mode controller with modified values of parameters and beta factor for precise values using feedback, close loop system. The input source is taken as DC source voltage at variable conditions. The modelling done in MATLAB/Simulink software.
Index Terms: Solar PV, Wind, Boost Converter, slide mode controller

I. BOOST CONVERTER

For example, applications for boost converter operations are DC Motor's rebounding breaking circuit and regulated DC power supply. In this type of converter, the output voltage is always greater than the input voltage. Therefore, the speed-up converter can be applied to the MPPT system where the output voltage should exceed the input voltage. Such as in the systems connected to the grid, where the boost converter holds a high output voltage, even if the PV array voltage falls at lower prices. Circuit topology of step-up converter as shown in Fig. 1 [1-3]

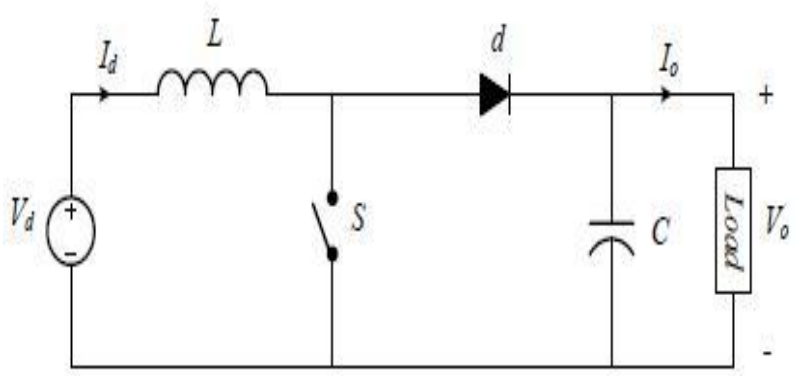


Fig.1. Equivalent Circuit of Boost Converter

$$D = 1 - \frac{V_d}{V_0} \quad (1)$$

$$L = \frac{V_d D}{2\Delta I_L f_s} \quad (2)$$

$$C = \frac{I_0 D}{\Delta V_0 f_s} \quad (3)$$

When the converter is working on the state of stable-state, then the duty ratio can be expressed by D, equation (1). Where D is the ratio of the voltages called duty ratio, and they indicate the output volts of input and converter output, respectively. From the above equation, it can be seen that, the increase in the duty ratio will increase the value of the voltage in the output of D, besides that, the change in duty ratio results in changes in current and output of the converter driven converter operated in continuous conduction mode. The filter inductor and capacitor can be calculated by following the equations.

©IJRASET (UGC Approved Journal): All Rights are Reserved

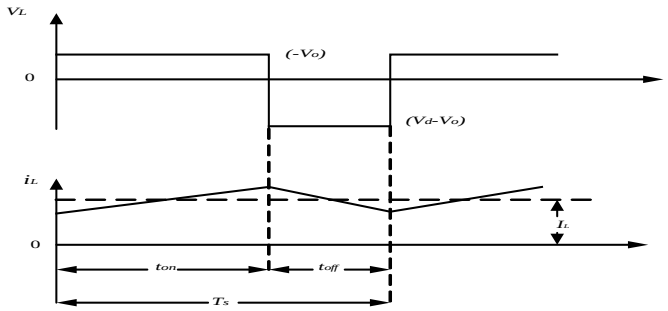


Fig.2. Triggering Pattern for Boost Converter Pulses

Designing Boost Converter made in MATLAB. This includes the inductor (L), input DC voltage, MOSFET, diode, capacitor and load resistance. Table 1 shows the basic parameters taken for analysis and designing.

Table.1. Parameters for Boost converters

Input Voltage (V)	L-R (mH-Ohm)	Load R(Ohm)	R-C(mOhm-μF)
200	300 – 0.14	240	69-2300

II. SLIDE MODE CONTROLLING OF BOOST CONVERTER

Technically, this controller has a time-separate state-response imbalance control law, in which due to the current situation of state variables in state, switching from one continuous structure to another is possible with high frequency. Its purpose is to control the system's mobility to follow the desired and predetermined.

Sliding mode has been applied to current controller technology to boost converter. Fig 3 represents the basic circuit diagram of the boost converter controlled by the sliding mode controller. This control plan for boost converter starts with selecting the sliding surface. At present, the continuous growth results in direct surface $v_o - V_{ref}$ almost zero. By the voltage error, the external voltage loop reference produces the current. The existence of stability criteria and sliding mode can be achieved by controlling the output voltage of the AC-DC converter. The inductor is currently controlled by the internal current loop through the sliding mode technology. Current SMC is used for regulation, due to which voltage loop high frequency switching and reference is currently highly sensitive to uncertainties. Therefore, the sliding surface is for better performance; [4-8]

$$S = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 \tag{4}$$

where α_1, and$\alpha_2\alpha_3$ are the control parameters, generally stated as sliding coefficients and x_1 , x_2 and x_3 are called as the desired state feedback variables which are to be controlled.

$$\begin{cases} x_1 = i_{ref} - i_g' \\ x_2 = V_{ref} - \beta v_o \\ x_3 = \int (x_1 + x_2) dt \end{cases} \tag{5}$$

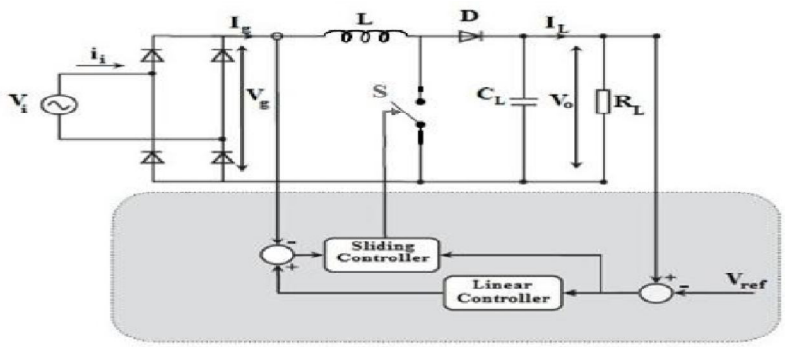


Fig. 3. Boost PFC Converter operated by Sliding Mode Controller

©IJRASET (UGC Approved Journal): All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

SM For the operation, there are three necessary conditions, the condition of the kill, survival and stability. The result of the control function to kill the situation;

$$u = \begin{cases} 1 =' ON' & when\ S > 0 \\ 0 =' OFF' & when\ S < 0 \\ unchanged & otherwise \end{cases} \quad (6)$$

Considering the continuous conduction of boost converter and by time differentiation, from equation 6, the system dynamic model is;

$$\begin{cases} \dot{x_1} = \dfrac{d\left[i_{ref} - i_g'\right]}{dt} = \dfrac{\beta K}{C} i_C - \dfrac{v_g - \bar{u} v_o}{L} \\ \dot{x_2} = \dfrac{d\left[V_{ref} - \beta v_o\right]}{dt} = -\dfrac{\beta}{C} i_C \\ \dot{x_3} = x_1 + x_2 = (i_{ref} - i_g') + (V_{ref} - \beta v_o) \\ \quad = (K+1)\left[V_{ref} - \beta v_o\right] - i_g' \end{cases} \quad (7)$$

Where $\bar{u}$= 1 – u, is considered as inverse logic of u.

By solving the equation $\frac{dS}{dt} = \alpha_1 \dot{x_1} + \alpha_2 \dot{x_2} + \alpha_3 \dot{x_3} = 0$ the equivalent control signal would be;

$$u_{eq} = 1 - \frac{K_2}{v_o} i_C - \frac{v_g}{v_o} + \frac{K_1}{v_o}\left[V_{ref} - \beta v_o\right] - \frac{K_3}{v_o} i'_g \quad (8)$$

Where, $K1$ and $K2$ are the fixed gain parameters.

$$\begin{cases} K_1 = \dfrac{\alpha_3}{\alpha_1} L(K+1) \\ K_2 = \dfrac{\beta L}{C}(K + \dfrac{\alpha_2}{\alpha_1}) \\ K_3 = \dfrac{\alpha_3}{\alpha_1} L \end{cases} \quad (9)$$

$u_{eq} = (0,1)$ And it can be represented in terms of the controlled state variable like as;

$$u_{eq} = 1 - \frac{K_2 \frac{v_o}{r_L} - v_i + K_3\left[V_{ref} - \beta v_o\right] - K_3\left(i_{ref} - i'_g\right)}{K_2 i'_g - v_o} \quad (10)$$

From the sliding surface 10, the controller is driven and is executed through a PWM, comparing $u_{eq} = d$ (duty ratio of the PWM controller). The control law equation is described as in fig.3, involving;

$$\begin{cases} \text{a control signal } v_C = G_S K_1\left[V_{ref} - \beta v_o\right] - G_S K_2 i_C - G_S K_3 i'_g + G_S[v_o - v_g] \\ \text{a ramp } v_{ramp} = G_S v_o \end{cases} \quad (11)$$

The factor $G_s = (0,1)$, is introduced purposefully to down scale the equation to a practical level of magnitude. To make the duty ratio of the output of the controller always below 1, a multiplier is incorporated for the multiplication of $u_{pwm}$and u_{CLK}. By a logic AND operator the impulse generator creates u_{CLK}. Based on equation 11, the controller is designed with assuming $\beta = G_s$.

The control law and the sliding gain coefficients should be designed in such to fulfill the stability condition. This is to make sure that the trajectory is directed by the desired sliding manifold and always towards a stable equilibrium point.

III. SIMULATION AND RESULTS

This section will explain the modelling and design of proposed work. Modelling includes the mathematical calculations and modifications of system and designing gives the description representation of circuit designed in MATLAB/ Simulink. The proposed work represents the working and control of boost converter with modified slide mode controller, when the parameters set on different conditions. Proposed system is to give required output at all variable conditions.

©IJRASET (UGC Approved Journal): All Rights are Reserved

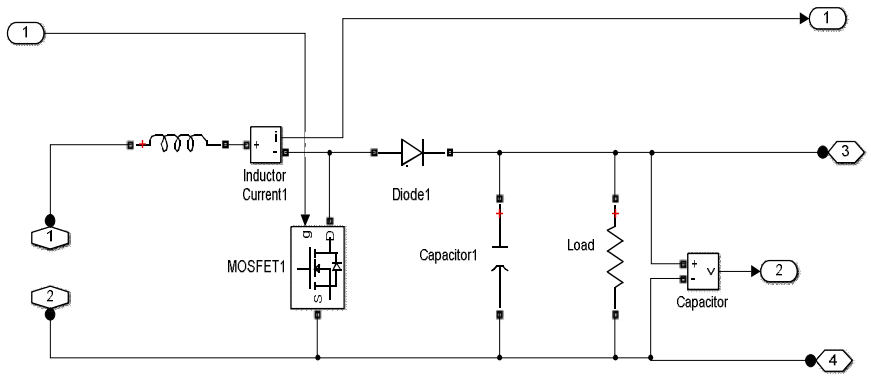


Fig.4. MATLAB model for Boost Converter

Mode of operation of Boost converter slide mode controller
In the proposed work, the sliding mode controller works for different conditions of Boost Converter as listed below:
Boosting mode 200 to 350 V
Booting mode 240V to 400 V

A. Boost Mode Of Slide Mode Controller For 200 To 350 V
In this mode of operation, slide mode controller controls the output to 350 V as the input DC power is 200 V. As shown in fig.5, MATAB model designed and the parameter for the same are:

Table.2. Parameters for Boost converters

S.NO	PARAMETER	RATING
1	Source Voltage(V)	200
2	Output voltage(V)	350
3	L-R (mH-Ohm)	300 – 0.14
4	R-C(mOhm-µF)	69-2300
5	Load R(Ohm)	240
6	Beta1	1/3.5
7	Beta	1/3.5
8	Reference Voltage(v)	100
9	Kp_1	0.12
10	Kp_2	2.7

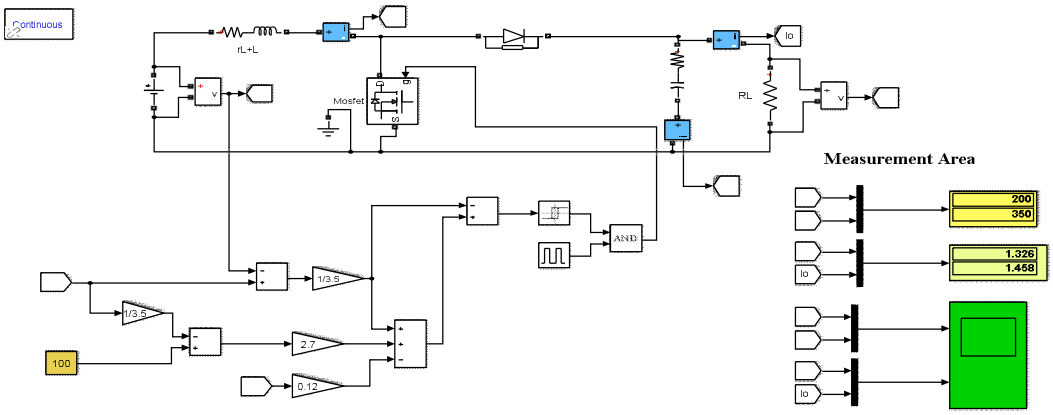


Fig. 5. Slide mode control of Boost Converter at 200 V to 350 V

©IJRASET (UGC Approved Journal): All Rights are Reserved

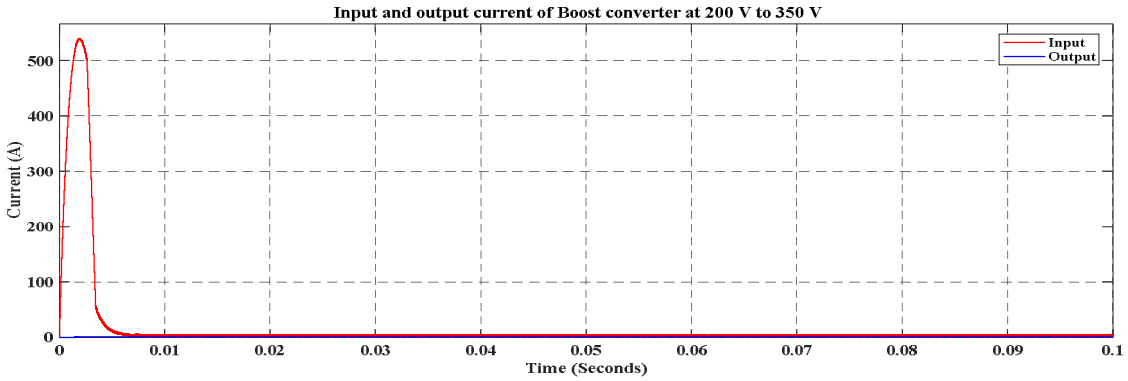


Fig.6. Input and output current of Boost converter at 200 V to 350 V

Fig.6 shows the current input and output waveforms for sliding mode controller of Boost converter when input DC is 200 V and required output is 350 V. as there is requirement of voltage step up and to maintain constant output, therefore the output current received is decreased. The input current is 1.326 A and output received is 1.458 A.

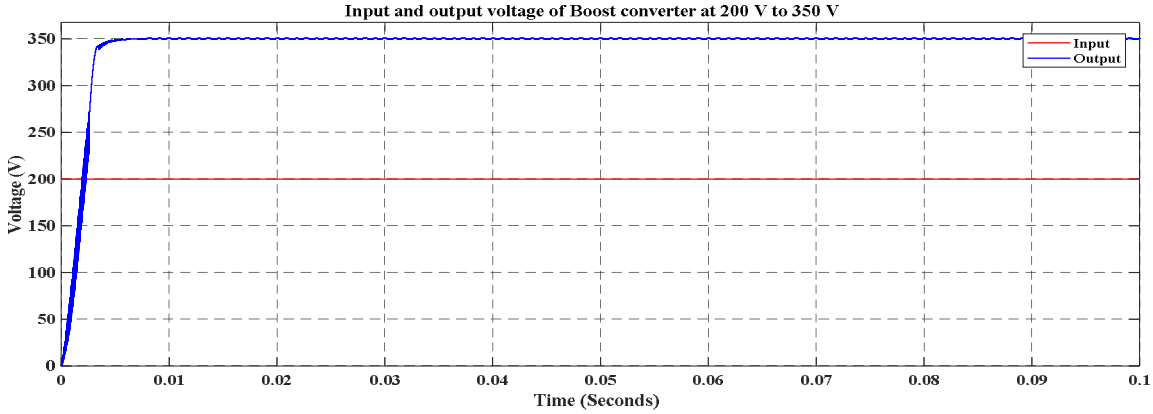


Fig.7 Input and output voltage of Boost converter at 200 V to 350 V

Fig 7 shows the voltage input and output waveforms for sliding mode controller of Boost converter when input DC is 200 V and required output is 350 V. input voltage is 200 V and output gain is 350V. the output is constant to 350 V approx..

B. Boost Mode Of Slide Mode Controller For 240 To 400 V

In this mode of operation, slide mode controller controls the output to 400 V as the input DC power is 240 V. As shown in fig.8, MATAB model designed and the parameter for the same are:

Table.4.2. Parameters for Boost converters

S.NO	PARAMETER	RATING
1	Source Voltage(V)	240
2	Output voltage(V)	400
3	L-R (mH-Ohm)	300 – 0.14
4	R-C(mOhm-µF)	69-2300
5	Load R(Ohm)	240
6	Beta1	1/4
7	Beta	1/4
8	Reference Voltage(v)	100
9	Kp_1	0.12
10	Kp_2	2.7

©IJRASET (UGC Approved Journal): All Rights are Reserved

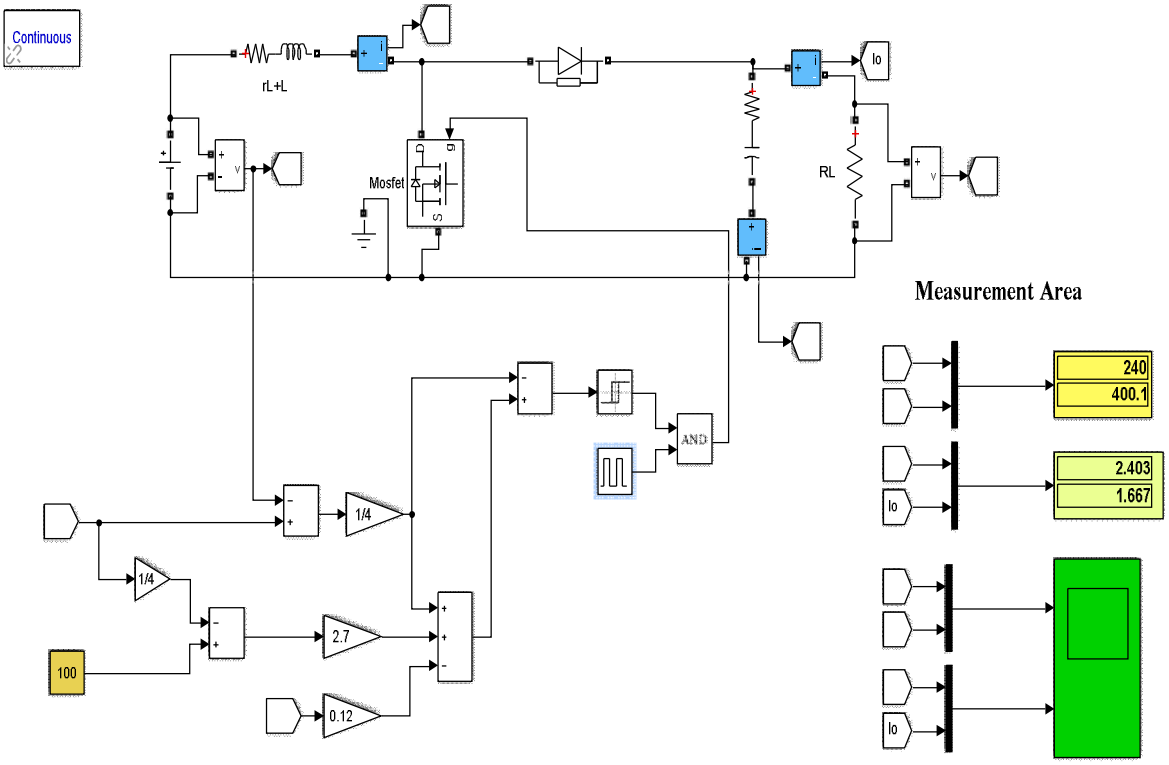


Fig. 8. Slide mode control of Boost Converter at 240 V to 400 V

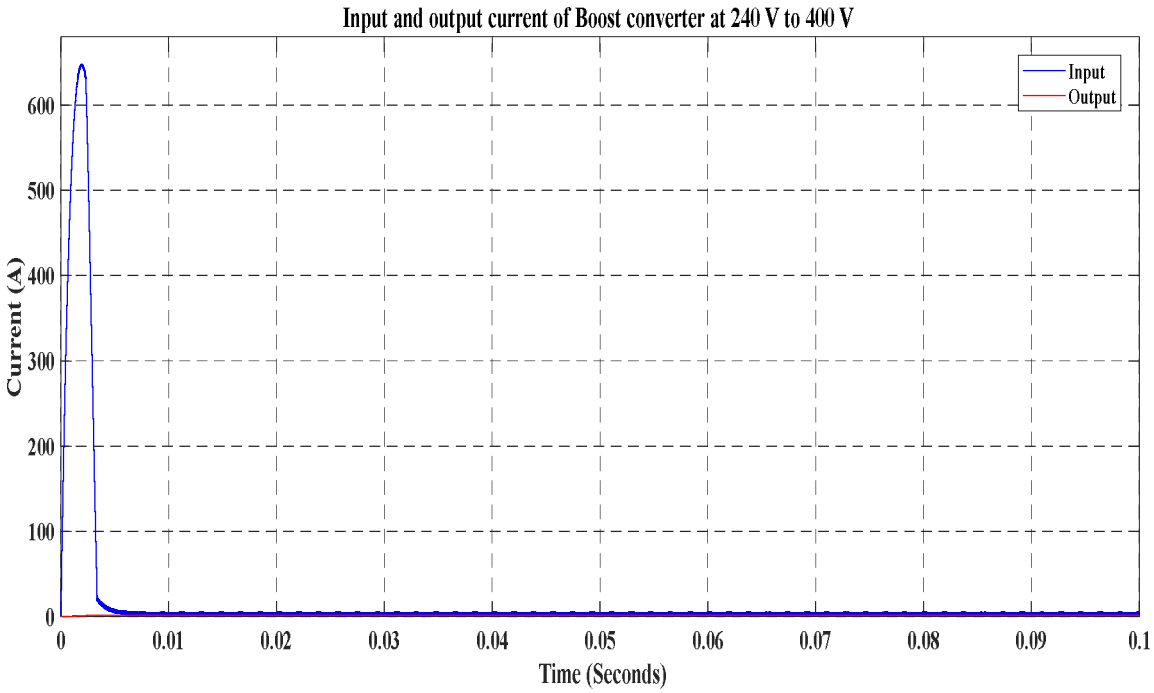


Fig.9. Input and output current of Boost converter at 240 V to 400 V

©IJRASET (UGC Approved Journal): All Rights are Reserved

Fig.9 shows the current input and output waveforms for sliding mode controller of Boost converter when input DC is 240 V and required output is 400 V. as there is requirement of voltage step up and to maintain constant output , therefore the output current received is decreased. The input current is 2.403 A and output received is 1.6667 A.

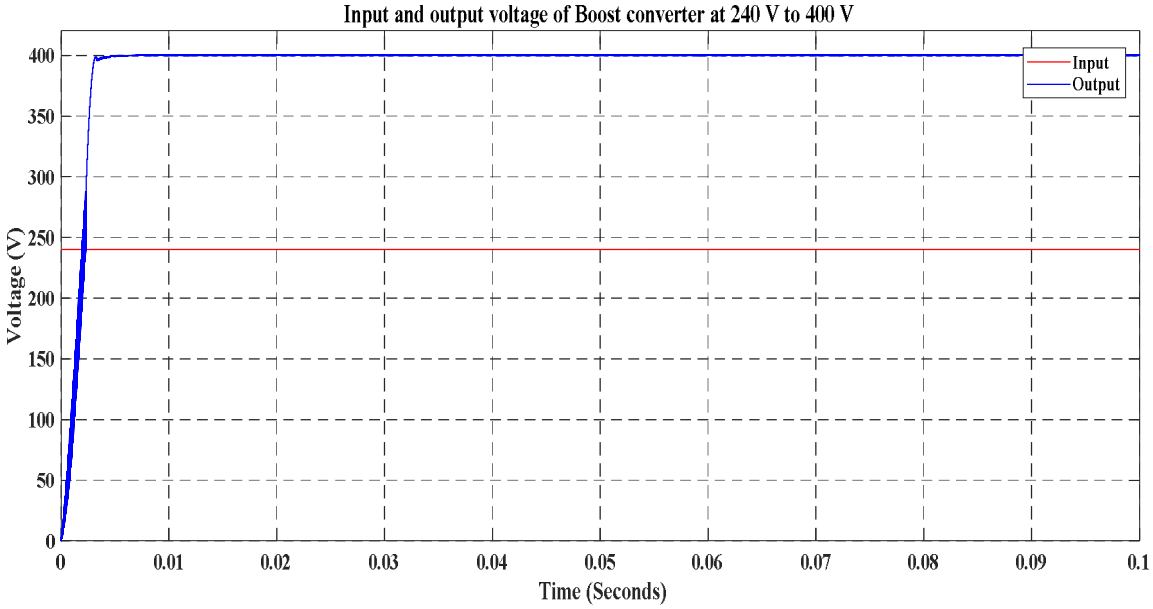


Fig.10. Input and output voltage of Boost converter at 240 V to 400 V

Fig 10 shows the voltage input and output waveforms for sliding mode controller of Boost converter when input DC is 240 V and required output is 400 V. input voltage is 240 V and output gain is 400.1 V.

III. CONCLUSION

The proposed system is slide mode controller for Boost converter using variable parameter and beta gain function. The analysis is performed on two different conditions of input 200 V and 240 V at required output of 350V and 400 V. a closed loop system is designed in MATLAB and output voltage and current are measured. The output waveforms describes that the system works more efficient at higher voltage rating and as a property of converter current output decreases. In both the conditions the output is maintained constant and as per feedback gain (beta) it gives controlled gate signals to MOSFET.

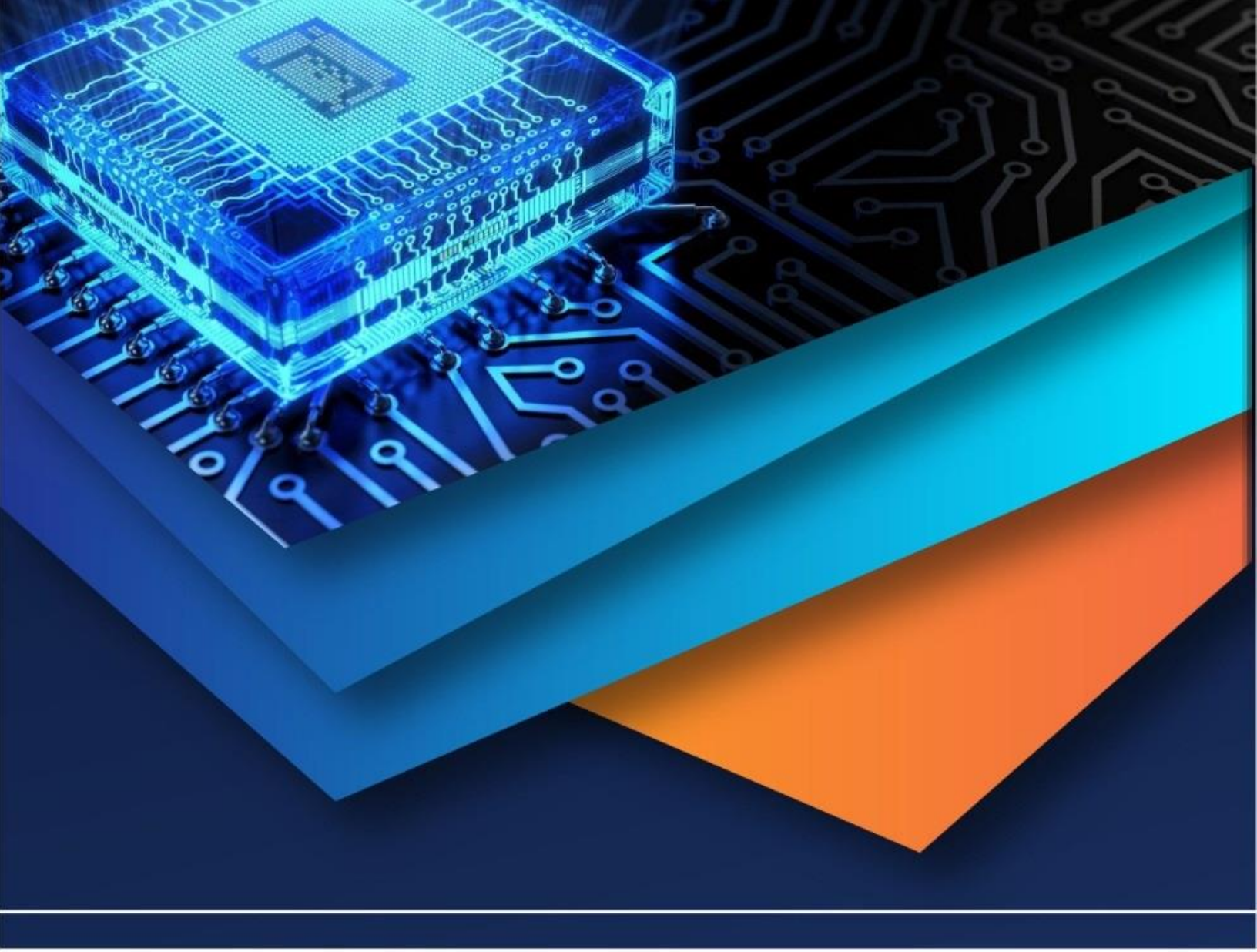
REFERENCES

[1.] 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.
[2.] C. Asma, Z. Abdelaziz and Z. Nadia, "Dual loop control of DC-DC boost converter based cascade sliding mode control," 2017 International Conference on Green Energy Conversion Systems (GECS), Hammamet, 2017, pp. 1-6.
[3.] B. 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.
[4.] A. Kihel, F. Krim and A. Laib, "MPPT voltage oriented loop based on integral sliding mode control applied to the boost converter," 2017 6th International Conference on Systems and Control (ICSC), Batna, 2017, pp. 205-209.
[5.] 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.
[6.] A. Ghasemian and A. Taheri, "Constrained Near Time-Optimal Sliding Mode Control of Boost Converters Based on Switched Affine Model Analysis," in IEEE Transactions on Industrial Electronics, vol. PP, no. 99, pp. 1-1.
[7.] S. K. Pandey, S. L. Patil and S. B. Phadke, "Comment on “PWM-Based Adaptive Sliding-Mode Control for Boost DC-DC Converters”," in IEEE Transactions on Industrial Electronics, vol. PP, no. 99, pp. 1-1.
[8.] Yanmin Wang, Yuqing Cao, Tienan Liu, Hongwei Xia and Bao Ding, "Terminal sliding mode control of boost converter using an energy storage function model," IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society, Florence, 2016, pp. 354-358.
[9.] Xuemei Zheng, He Li, Rui Song and Y. Feng, "Full-order terminal sliding mode control for boost converter," 2016 IEEE 8th International Power Electronics and Motion Control Conference (IPEMC-ECCE Asia), Hefei, 2016, pp. 2172-2176.

©IJRASET (UGC Approved Journal): All Rights are Reserved

[10.] 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.
[11.] İ. Yazici and E. K. Yaylaci, "Fast and robust voltage control of DC–DC boost converter by using fast terminal sliding mode controller," in IET Power Electronics, vol. 9, no. 1, pp. 120-125, 1 20 2016.
[12.] M. B. Debbat, H. A. Bouziane and R. B. Bouiadjra, "Sliding mode control of two-level Boost DC-DC converter," 2015 4th International Conference on Electrical Engineering (ICEE), Boumerdes, 2015, pp. 1-5.
[13.] A. Leon-Masich, H. Valderrama-Blavi, J. M. Bosque-Moncusí, J. Maixé-Altés and L. Martínez-Salamero, "Sliding-Mode-Control-Based Boost Converter for High-Voltage–Low-Power Applications," in IEEE Transactions on Industrial Electronics, vol. 62, no. 1, pp. 229-237, Jan. 2015.
[14.] O. Lopez-Santos, L. Martinez-Salamero, G. Garcia, H. Valderrama-Blavi and T. Sierra-Polanco, "Robust Sliding-Mode Control Design for a Voltage Regulated Quadratic Boost Converter," in IEEE Transactions on Power Electronics, vol. 30, no. 4, pp. 2313-2327, April 2015.
[15.] O. Lopez-Santos, L. Martinez-Salamero, G. Garcia, H. Valderrama-Blavi and T. Sierra-Polanco, "Robust Sliding-Mode Control Design for a Voltage Regulated Quadratic Boost Converter," in IEEE Transactions on Power Electronics, vol. 30, no. 4, pp. 2313-2327, April 2015.

©IJRASET (UGC Approved Journal): All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)