A Review on Full Wave Zero Voltage Switching Boost Converter using Sliding Mode Control

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Abstract— This paper is a study about zero voltage switching boost converter and there control mode. DC–DC converters are nonlinear systems, they represent a big challenge for control design. Since classical control methods are designed at one nominal operating point, they are not able to respond satisfactorily to operating point variations and load disturbance. The difficulties in the control of boost converters are due to the non-minimum phase structure since, the control input appears both in voltage and current equations. The result of both converters with and without SMC are compared and the increased efficiency of the proposed converter is confirmed. The ZVS Boost Converter with sliding mode controller shows acceptable performance than the conventional. Using the sliding mode controller, the non-linearity and un-stability have improved.

Key words: Non- Linear Converter, Resonant Converter, Zero Voltage Switch

I. Introduction

Power Electronics is the branch of Electrical Engineering which belongs partly to Power Engineering and partly to Electronics Engineering. Power Engineering is the mainly concerned with the generation, transmission, distribution and utilization of electric energy at high efficiency. Electronics Engineering on the other hand, deals with the distortion less production, transmission and reception of data and signals of very low power level. In addition, apparatus associated with power engineering is based mainly on electromagnetic principles whereas that in electronics engineering is based upon physical phenomenon in vacuum, gases/vapors and semiconductors. Power Electronics is the subject that concerns the applications of electronic principles into situations that are rated at low power level rather than signal level. It can also be defined as the subject that deals with the apparatus and equipment working on the principle of electronics but rated at power level than signal level.

Some Applications of Power Electronics are as follows:

1) Aerospace- Space shuttle power supplies, satellite power supplies, aircraft power systems
2) Commercial- Advertising, heating, air conditioning, central refrigeration, computer equipment, elevators, light dimmers and flashers, uninterruptible power supplies.
3) Industrial- Blowers and fans, pumps and compressors, textile mills, rolling mills, cement mills, welding, arc and industrial furnaces.
4) Residential- Air-conditioning, cooking, lighting, refrigerators, dryers, fans, vacuum cleaners, washing and sewing machines.
5) Telecommunication- Battery charger, power supplies.

A. Transportation- Battery chargers, traction control of vehicles, trolley buses, subways .

Power Electronics system consists of one or more power converters. A power electronic converter is made up of semiconductor devices that convert the power from the form available from the source to the form required by load. The load may be ac or dc, single phase or three phase. The source may be dc or ac (single phase or three phase), a battery, solar panel, electric generator or commercial supply.[6] Power Electronic converters can be classified into following categories:

1) Diode Rectifiers- converts ac input into a fixed dc voltage.
2) AC-DC Converters- converts constant ac input voltage to variable dc output voltage.
3) DC-DC Converters (Choppers) - converts fixed dc input voltage to controllable dc output voltage.
4) DC-AC Converters (Inverters)- converts fixed dc voltage to a variable ac output voltage

AC-AC Converters- converts fixed ac input voltage to variable ac output voltage.

B. Sliding Mode Control (SMC)

The Sliding Mode Control (SMC) technique is known as one of the efficient method to design robust controllers for complex high order nonlinear dynamic plant operating under uncertainty conditions. The phenomenon, “ sliding mode” may appear in dynamic systems governed by ordinary differential equations with discontinuous state functions in the right hand side.[27] SMC design involves two steps:

1) Selection of state hyper planes in state/error space on which motion should be restricted known as switching function.
2) Designing of control law which addresses the converter dynamics to the sliding surface.

The SMC provides robust, good dynamic performance and easy implementation for large load supply and load variations. It is low sensitive to plant parameters and disturbances thus eliminate the necessity of exact modeling. Sliding mode control implies that control actions are discontinuous state functions which may easily be implemented by conventional power converter with “ON-OFF” as the only admissible operation mode.

II. Literature review

A. Different Aspects of Converters

I have read many research papers before writing this paper.

1) In 2012, Jorge Luis Sosa, Miguel Castilla, Jaume Miret, Luis Garcia de Vicuna, and Luz Stella Moreno [1],

Presented the sliding mode input-output linearization controller for the dc-dc ZVS CLL-T resonant converter. He designed the model with DSSOM technique to obtain ZVS over for main switches in wide load range applications. The sliding surface of the proposed model is obtained in a systematic way that not only linearizes the original model and provides robustness and fast transient response against transient load changes.

2) In 2009, Rahul Shrivastava and Gaurav Saurabh [2],

Put the idea of zero voltage switching converter over basic boost converter. They studied ZVS and ZCS and showed that ZVS eliminates switching losses and dv/dt losses over ZCS. They also constructed a ZVS boost converter in the laboratory and proved that the output of ZVS boost converter can be used for high efficiency applications.

3) In 2004, Domingo Biel, Francesc Guinjaon, Enric Fossas and Javier Chavarria [3],

Presented a sliding mode control design of a buck-boost converter for a voltage step up dc-ac conversion without use of any transformer. They have applied the approach that combines the step-up/step-down conversion ratio capability of the converter with the robustness properties of sliding-mode control. The proposed control strategy is based on the design of two sliding control laws, one ensuring the control of a full-bridge buck converter for proper dc–ac conversion, and the other one the control a boost converter for guaranteeing a global dc-to-ac voltage step-up ratio. They have derived set of design criteria and a complete design procedure of the sliding-control laws from small-signal analysis and large-signal considerations. The experimental results show good accuracy and robustness in front of input voltage and load variations.

4) In 2014, Reham Haroun, Angel Cid Pastor, Abdelali El Aroudi, and Luis Martinez Salamaro[4],

Presented synthesis, modeling and stability analysis of interconnected systems using cascaded converters working under sliding mode control. They have introduced a systematic procedure to synthesize cascaded connection of dc-dc boost converters. They have considered three different elements, which are the dc power gyrator, the dc transformer, and the dc loss-free resistor. These canonical elements are designed by means of a sliding-mode control theory and then their dynamic behavior is studied in detail. The sliding-mode conditions for each case are derived in closed form to obtain design-oriented criteria for selecting the parameters of the system. The aforementioned canonical elements are compared to select the most suitable one for a distributed power system. Simulation results ensure the correctness of the proposed approach.

5) Sliding-Mode Control Design of a Boost-Buck Switching Converter for AC Signal Generation [5]

In this paper it is studied about the qualitative characteristic of aggregated wind and PV based power generation. This is also summarized the energy reserve capability of the storage system. This explains with the help of an urban area building with the renewable energy set up and production of the energy the nearby people. The paper concludes that this system is good to use the micro grid concept implement it with the wind and solar energy also with EV based system.

6) Xuesong Zhou, Tie Guo and Youjie Ma [2015] [6]

This paper proposed a DC-DC boost converter using sliding mode controller based on the averaging state space. It is elaborate to be easily implemented and has time-variant sliding coefficients. The proposed controller can effectively regulate the output voltage by controlling the switch states even when the input voltage, load or output command varies. The controller is independent of theload and inductor current and the load value is used when designing the sliding coefficients. The constant switching frequency is maintained thus simplifying the design procedure, enhancing the regulation properties and benefiting the filter design. The controller has good robustness, overshooting damping and dynamic response. Comparative simulations are carried in MATLAB/Simulink between the proposed approach and a widely used PID controller to verify the effectiveness and feasibility of the proposed method.

7) Sliding Mode Control of Wide input Wide output DC-DC Boost Converter [2013] [7]:

This paper is used the Coupled inductor based DC-DC converters for achieve high step up(or)step down voltage gains. These converters use fixed frequency PWM technique for controlling the output voltage. Many configurations are available for step up and step down DC-DC conversion operation. This sliding mode are suitable for switching operation and controllers are non-linear controllers references are provides sufficient literature about the stable operation of converter circuits. This converter is studied for different loads with indirect sliding mode controller. And case studies verified with the help of MATLAB SIMULINK software.

8) Dr Ghous Buxarejo, Fawad Azeem and Muhammad Yasir Ammar [2015] [8]

The author of the paper gives the explanation of the different methods for its efficient functioning and increase in the power quality production of the system. This paper elaborates the proper working as well as the failure related to the system across the globe.

9) Jinquan W., Pengfei H., Jianke Lie and Jun Yan [2015][9]

In the present study, this gives the advantages of DC system over the AC system. DC micro grid is more reliable, simpler control, higher power conversion efficiency and lower cost compared with the AC system.

This paper explains the autonomous control strategy of DC grid system. In autonomous control strategies the is no requirement of communication bus and reduce the cost of the system.

Finally this paper studied the problem of autonomous system which is non communication bus problem.

10) In 2011, H. Guldemir, presented a dc-dc buck- boost converter using sliding mode control. [10]

Firstly, he has done the modeling of the buck-boost converter and then he derived the dynamic equations describing the converter. Lastly, he has designed the sliding mode control for the converter. The converter is simulated on MATLAB/Simulink and were tested for step load changes and input voltage variations. The simulation results show fast dynamic response of output voltage and robustness to load and input voltage variations.

11) In 2013, S .S. Muley, and R. M. Nagarale [11]

Proposed a dc-dc boost converter operating in continuous conduction mode using pulse width modulation with sliding mode control. They have studied different control methods such as PI, PID and SMC. The converters are simulated on

MATLAB/ Simulink and results are studied. The results show that SMC is efficient control tool than PI and PID. It removes the nonlinearity and improves efficiency.

III. CONCLUSION

This paper studied about the zero voltage switching boost converter and its various controlling method. Sliding mode control of DC-DC converter is appropriate method. SMC provides various advantages over other control methods, Robustness, stability for even very large line and load variations. It is a good dynamic response and simple implementation.

The study shows that Boost converters are most widely used dc–dc converters in the world because no other topology is as simple.

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