Novel High Voltage Converter Applied Smooth Control of PMSM

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Abstract: ***This paper presents a new high efficiency buck boost dc-dc converter with low voltage renewable energy resources. The proposed converter utilizes a low voltage DC supply and boost it to required dc voltage. In this paper PI controller is used with snubber circuit. Therefore there is very les power loss and the efficiency of the system is high in comparison with the conventional buck boost converter. The output is then converted in 3 phase ac voltage and then fed to Permanent Magnet Synchronous Motor (PMSM). The vector control scheme of a PMSM drive has been implemented using the developed simulation model. In the developed model, speed and torque as well as the voltages and currents of voltage source inverters components can be effectively monitored and analyzed. The developed simulation model has been implemented using Matlab and the dynamic response of PMSM drive has been analysed for constant speed, varying torque and variable speed constant torque operation. Also, the simulation results have been presented. Therefore, it can be expected that the developed simulation model can be an easy to design tool for the design and development of PMSM drives for different control algorithms and topological variations with reduced computation time and memory size.***

Keywords: PMSM-Permanent magnet Synchronous Motor

1. Introduction

In modern world the cost of producing energy with nonrenewable energy source is increasing day by day and there is constant threat of limited amount of availability of it, so we have to switch to different energy sources like renewable energy sources. A dc-dc converter with is very essential now as it can be used to convert low voltage to required high voltage and we can say that conversion of a regulated dc voltage from unregulated dc voltage. An unregulated dc source may be from output of rectified solar cell or battery etc. the sources can be varied but the main objective is to get the input and convert it into required output with better efficiency and minimal loss of energy. There are many ways to convert dc-dc but buck boost dc-dc converter has a better current driving capability and has good efficiency. Although many different design have been proposed to improve the efficiency of the converter an to achieve high voltage gain such as using switched capacitor and a coupled inductor.

The basic circuit of buck-boost converter is shown in Figure.1. The output of converter is controlled by closed loop and alternating its MOSFET(switch) gate signal. PI controller is used as it is more widely used for industrial application. Conventional high voltage converter without transformer cannot provide such a high voltage. In high voltage dc-dc converter coupled inductor is used to improve the voltage gain , snubber circuit to absorb stray inductance. Now-a-days many DC drives were replaced by brushless AC drives. PMSM gained much attention and has become the most used drive in machine and modern control applications. The inherent advantages of the machine include high efficiency, high power factor, high power density, easy maintenance, fast dynamic response. PMSM replaces Induction motor(IM) and Synchronous motor(SM) in several applications due to its higher efficiency, higher power density and higher torque to inertia ratio. Rotor of PMSM is made up of permanent magnet. In PMSM rapid torque build up required by, variable speed and fast dynamic response drives, could be achieved by stator current control technique.

PMSM is a topic of interest for last twenty years. Vector control technique is one of the most common closed loop control technique used in a PMSM drive. Vector control eliminates oscillating flux, torque responses in inverter fed induction motor and synchronous motor drives. This method has further classification, which includes constant torque angle control, Unity power factor control, constant mutual air gap flux-linkage control, optimum-torque-per-ampere control and flux-weakening control. The choice of these methods depends on mainly on the type of application and the load characteristics.

Hence, it is always essential to perform a simulation study prior to designing a PMSM drive for choosing the appropriate control algorithm for a particular application. The mathematical model of PMSM as such has been well established. Incorporation of PMSM model along with the inverter model and load characteristics is essential to represent a complete drive system.

This paper proposes a system simulation model for a complete PMSM drive based on the mathematical model of an inverter fed PMSM implemented using MATLAB\Simulink, which could be used for simulating various control algorithms. In the developed model, speed and torque as well as the voltages and currents of voltage source inverters components can be effectively monitored and analyzed.

2. Circuit Configuration

There is widely use of power semiconductor in power electronics. Snubber circuits are used across the semiconductor devices to improve performance and to improve protection. It can do many things:

- Reduce or eliminate voltage or current spikes.

- Limit dI/dt or dV/dt.
- Shape the load line to keep it within the safe operating area (SOA).
- Transfer power dissipation from the switch to a resistor or a useful load.
- Reduce total losses due to switching.
- Reduce EMI by damping voltage and current ringing.

Out of vast variety of snubbers the two most common are the resistor-capacitor (RC) and the other is the resistor-capacitor-diode (RCD). They have been used in many industrial applications.

The widely used general conventional buck-boost is shown in Figure. 1. The output voltage of the converter is also regulated ted by the PWM control of the switch *S*. One is the continuous conduction mode (CCM) of dc current and another is the discontinuous conduction mode (DCM) of dc current. Specially, the turn-on of the switching device in the discontinuous mode is a ZCS. On the other hand, the device must be switched off at a maximum inductor current. Therefore, in order to relieve turn-off stress of the device, a snubber circuit is connected in parallel with the switch of the conventional converter. However, the efficiency of the conventional converter is very low due to the power loss of the snubber circuit.

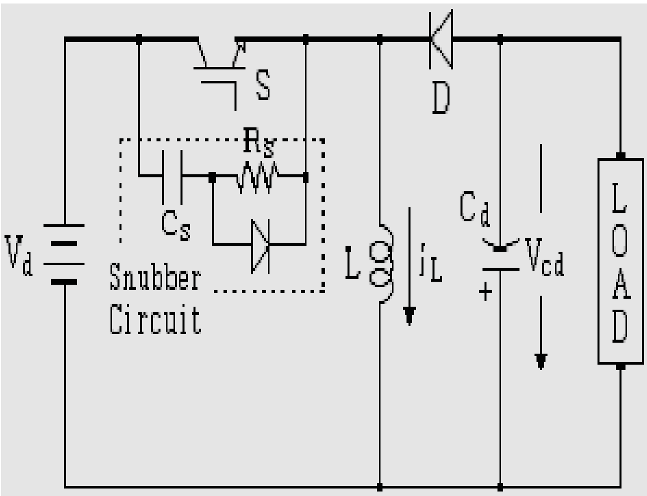
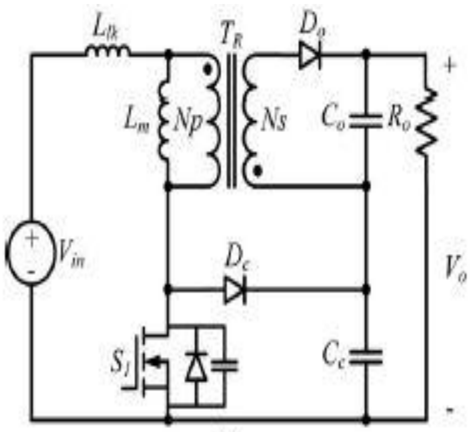
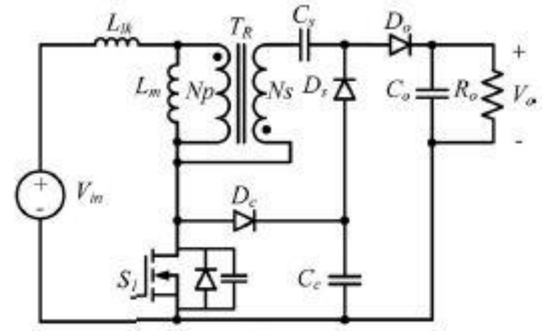


Figure 1: Conventional buck-boost dc/dc converter.



(a)



(b)

Figure 2: High step-up dc–dc converters using coupled-inductor and switched-capacitor techniques. (a) High-step coupled-inductor roboost dc-dc converter (b) High step-up dc-dc converter with coupled-inductor and switched-capacitor

To improve the efficiency, a new buck-boost dc/dc converter with high efficiency is proposed in this paper and is shown in Figure. 3. The proposed buck-boost dc/dc converter is composed of controlling devices, Series LCR and snubber circuit with MOSFET. It is considered that the snubber circuit in the conventional converter is partly replaced to a partial resonant circuit in the proposed converter.

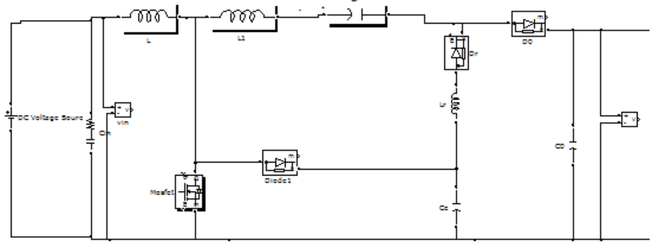


Figure 3: Proposed buck-boost dc/dc converter.

The switching devices in the proposed converter are operated with the soft switching in MOSFET. The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronic devices. The MOSFET is a three terminal device such as source, gate, and drain. The MOSFET is very far the most common transistor and can be used in both analog and digital circuit. The MOSFET works by varying the width of a channel along which charge carriers flow (holes and electrons). The charge carriers enter the channel from the source and exits through the drain. The channel width is controlled by the voltage on an electrode is called gate which is located between the source and drain. It is insulated from the channel near an extremely thin layer of metal oxide. There is a different type of MOSFET applications which is used as per the requirement.

Snubber Resister, R_s	500 Ω
Snubber Capacitor, C_s	250 µf
Resonent Inductor, L	2.5 mH
Resonent Inductor, L_r	0.5 mH

The inductive and capacitive energy can be transferred simultaneously to the high voltage dc bus increasing the total power delivered decreasing the losses in the circuit. As a result of the energy transferred through the hybrid transformer that combines the modes where the transformer operates under normal conditions and where it operates as a coupled-inductor, the magnetic core can be used more effectively and smaller magnetic can be used. The continuous input current of the converter causes a smaller current ripple than that of previous high boost ratio converter topologies that used coupled-inductors. The lower input current ripple is useful in that the input capacitance can be reduced and it is easier to implement a more accurate MPPT for PV modules. The conduction losses in the transformer are greatly reduced because of the reduced input current RMS value through the primary side. The voltage stress of the active switch is always at a low voltage level and independent of the input voltages. Due to the introduction of the resonant portion of the current, the turn-off current of the active switch is reduced. As a result of the decreased RMS current value and smaller turn-off current of the active switch, high efficiency can be maintained at light output power level and low-input voltage operation. Because of the resonant capacitor transferring energy to the output of the converter, all the voltage stresses of the diodes are kept under the output dc bus voltage and independent of the input voltage.

3. Operation

Figure 4 shows the Simulink Schematic of Buck- Boost converter with analog PI controller. The output of the proposed diagram is again send back to the PI-controller which again with the reference required is controlled and a switching pulse is generated to give the required output. In this proposed schematic diagram the input provided can be from any dc source either a storage devices or a continuous dc source provider through a generation or a grid for reference in this 100V dc sources in provided which is then converted to 500v dc.

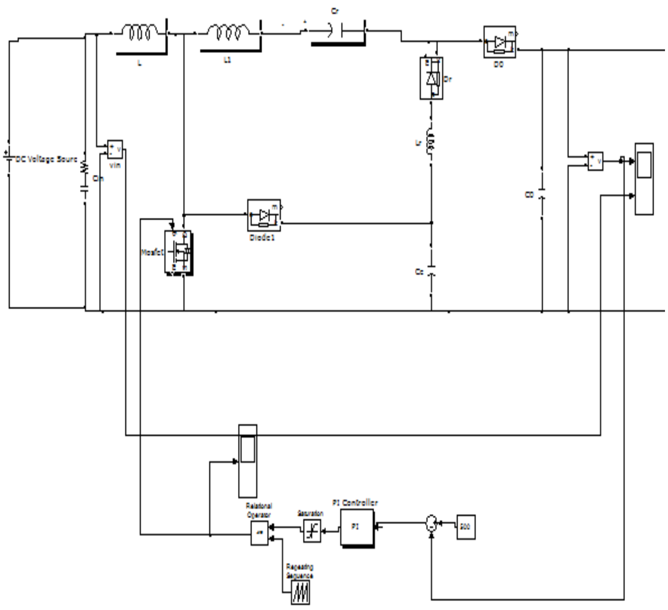


Figure 4: Converter with Pi controller

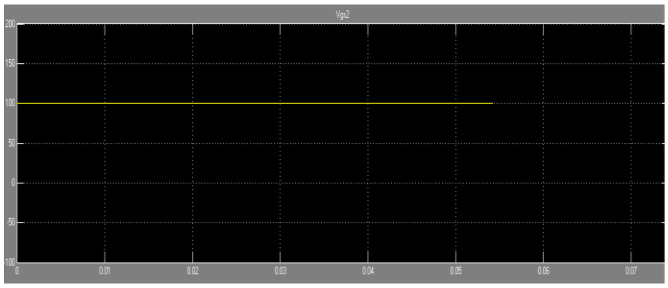


Figure 5: 100v DC input

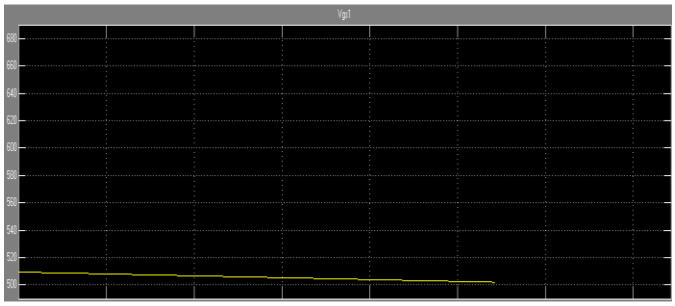


Figure 6: 500v DC output

Figure 5 shows the input provided to the proposed circuit diagram and Figure. 6 shows the output of the proposed diagram.

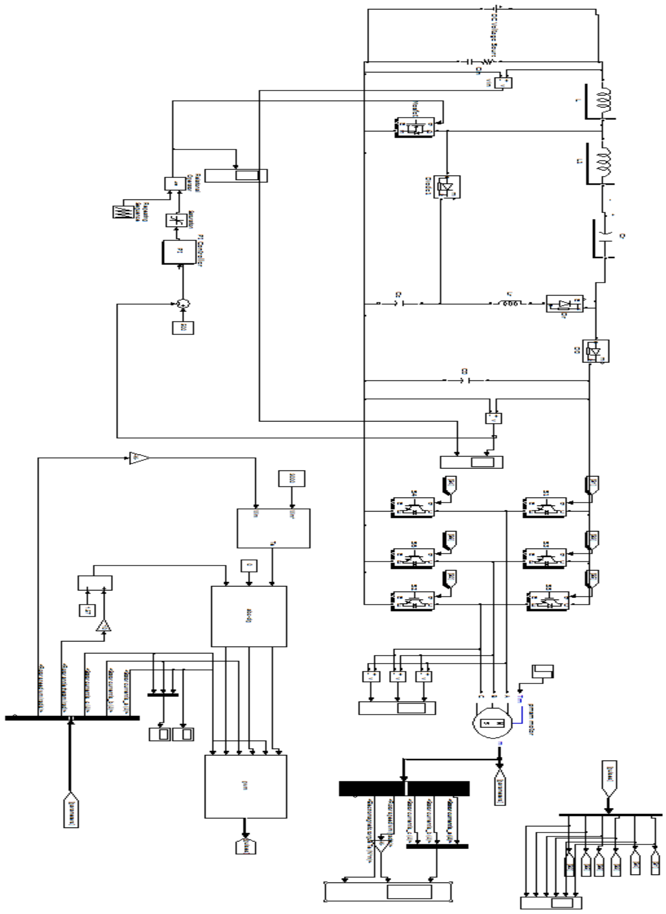


Figure 7: 500v Proposed Model

Figure 7 is the proposed model for the PMSM for smooth functioning with the required output. 100v dc voltage is provided which with the help of buck-boost converter, convert to 500v dc voltage which then convert to the 3-phase required ac voltage with the help of 6 IGBT. The required pulses for the IGBT is provided for the desired output voltage which is then fed to the PMSM. The parameter of the PMSM is then again send back to generate the pulses with reference of the desired rpm for smooth functioning of PMSM with desired speed.

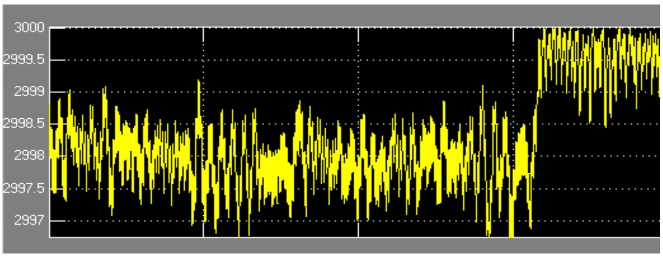


Figure 8: Output speed (AT 3000rpm)

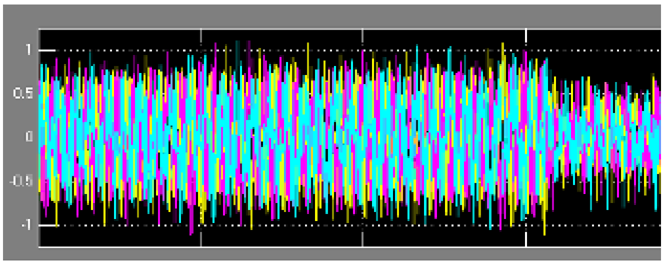


Figure 9: Stator current (a,b,c)

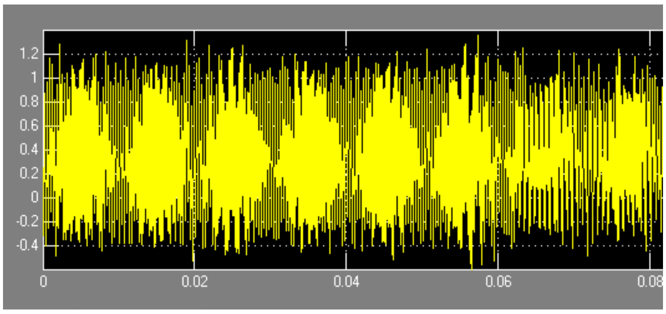


Figure 10: Torque

4. Conclusions

In this paper an advanced buck-boost converter is proposed which boost the low dc voltage to the required high dc voltage which is then fed to the inverter for proper functioning of the PMSM. AS it is closed loop model so for the required output the final output of buck-boost converter and speed of PMSM is again used to measure its value and get the continuous required output. The developed system simulation model has been validated by circuit simulation model of the same scheme which shows the accuracy of the developed model. This developed model can be well utilized in the design and development of closed loop PMSM drives system for experimenting with different control algorithms and topological variations but with a much reduced computational time and memory size.

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