DC-DC Converter Fed PMDC Motor Drive based on ZC Switching

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Abstract: The paper proposes a DC-DC converter dedicated for PMDC motor drive applications. Converter proposed is intended to aid in the speed control of the PMDC motor. PI controller is used for this purpose. The proposed converter ensures power conversion at high efficiency. This is attained by minimizing the switching losses. ZCS technique is applied here. Voltage stress are further reduced by using voltage divider circuits.

Index terms- Soft switching DC-DC converter, Zero Current Switching, PI controller. PMDC motor

I. INTRODUCTION

When it comes to power conversion through converter, type of switching and switching frequency play a huge role in deciding the output power. Also the same switching can cause power loss also due to high switching frequency, related conduction losses and EMI problems. The auxiliary snubbersand circuitry will add to the power loss and increased switching level. Hence we can adopt a phase shift control based switching to reduce the losses.

A method to keep the conversion efficiency high is proposed here. This is attained by keeping the switching losses to a minimum level.

To keep the switching loss to minimum value we adopt ZCS switching scheme for the switching devices in the resonant converter.

In this project mainly focuses on improving the conversion efficiency with help of reducing voltage stress occurs in power semiconductor switches and controlling the speed of PMDC motor with the help of PI controller. In high input voltage applications, the high voltage rated switching devices are commonly required to construct the conventional full bridge DC-DC converters. However, the conduction resistance of the switching devices increases exponentially as the voltage stress rises, which results in the severe conduction losses. Recently, many research contributions have been carried out to make the low voltage rated power devices available in the high input voltage conversion systems. One of the main concepts is to connect the switches in series to sustain the high voltage stress. A soft-switching DC-DC converter with secondary side phase shift control strategy is proposed to improve the conversion efficiency and minimize the primary switch voltage stress in the high input voltage applications. The normal DC to DC power converters, semiconductor switches are the major components.

stresses, this will leads to switching power losses. To solve these problems with help soft switching topologies to improve the efficiency as well as to allow for higher frequency operation. . Here one such topology is the zero voltage switching converter. In the DC-DC converters efficiency is very important during the energy conversion from high input voltage to low load voltage applications. Here primary voltage stress is reduced to half of the input voltage, which is important for high input voltage application. Input voltage divided with help of voltage divider, here input capacitance act as a voltage divider. PMDC motor finds more applications in current world industries due to it’s small size, lower manufacturing cost and higher efficiency. Here in this project the rectifier output voltage is effectively used supply PMDC motor, the speed of PMDC motor is controlled with the help of a PI controller.

II. CIRCUIT DESCRIPTION

The circuit diagram of the secondary side phase shift controlled ZCS dc-dc converter closed loop drive system for PMDC motor is shown above. Secondary side rectifier is the key here, converter output is utilized for driving the PMDC motor, and motor is controlled with the help of a PI controller. The phase shift controlled ZCS dc/dc converter closed loop drive system for PMDC operation is as following, let us assume all primary switches IGBT have the constant duty cycle. The switches $Sp1$ and $Sp4$ turns ON and OFF simultaneously, while the pair of switches $Sp2$ and $Sp3$

shares the same gate signal. The two pairs of the primary switches work in complementary pattern. The two secondary-side switches *Ss*1 and *Ss*2 also act with constant duty cycle complementarily. The output voltage and power is controlled by phase-shift angle between the primary and secondary active switches is employed. *LLk* stands for the transformer leakage inductance, which usually includes an external inductor if the practical leakage inductance is not large enough to realize the expected circuit operation. The input series capacitors *C*1 and *C*2 have the same capacitance it is act as a voltage divider. It is generally used to divide the supply voltage. The primary side switches share equal voltage level. *vp* and *vs* are the voltages on the primary side and the secondary side of the transformer and *ip* and *is* are the primary and secondary currents through the circuit. Vin, Vout and N is the input voltage, output voltage and transformer ratio. According to the work conditions of the primary current, the converter has three different operation modes, namely continuous current mode 1, continuous current mode 2, and discontinuous current mode, respectively. Considering only half of the input voltage is imposed on the primary side of the transformer, in order to simplify the analysis, the gain G is defined as G =2NVout/Vin.

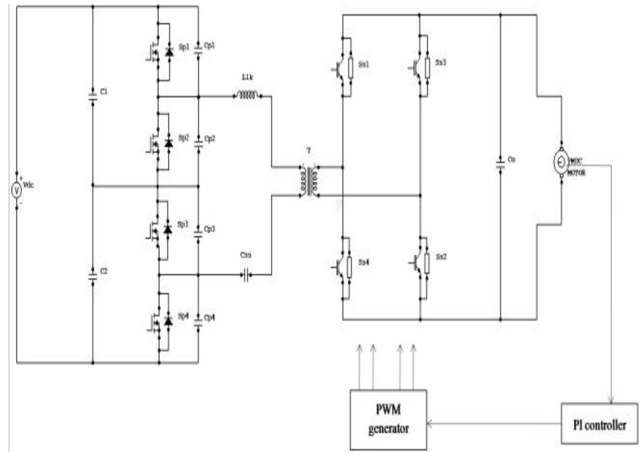

Fig 1. Main Circuit Diagram

The converter can work in the buck mode (G < 1), balance mode (G = 1), and boost mode (*G* > 1). Transformer turns ratio is the key parameter because it determines the converter operation mode. ZCS is achieved for the primary side active switch and the secondary side switch. Since all the primary switches work in the same pattern and both the secondary-side switches work symmetrically, ZCS is accomplished for all the primary and secondary active switches. and due to the soft switching, there are no voltage spikes on the primary switch.

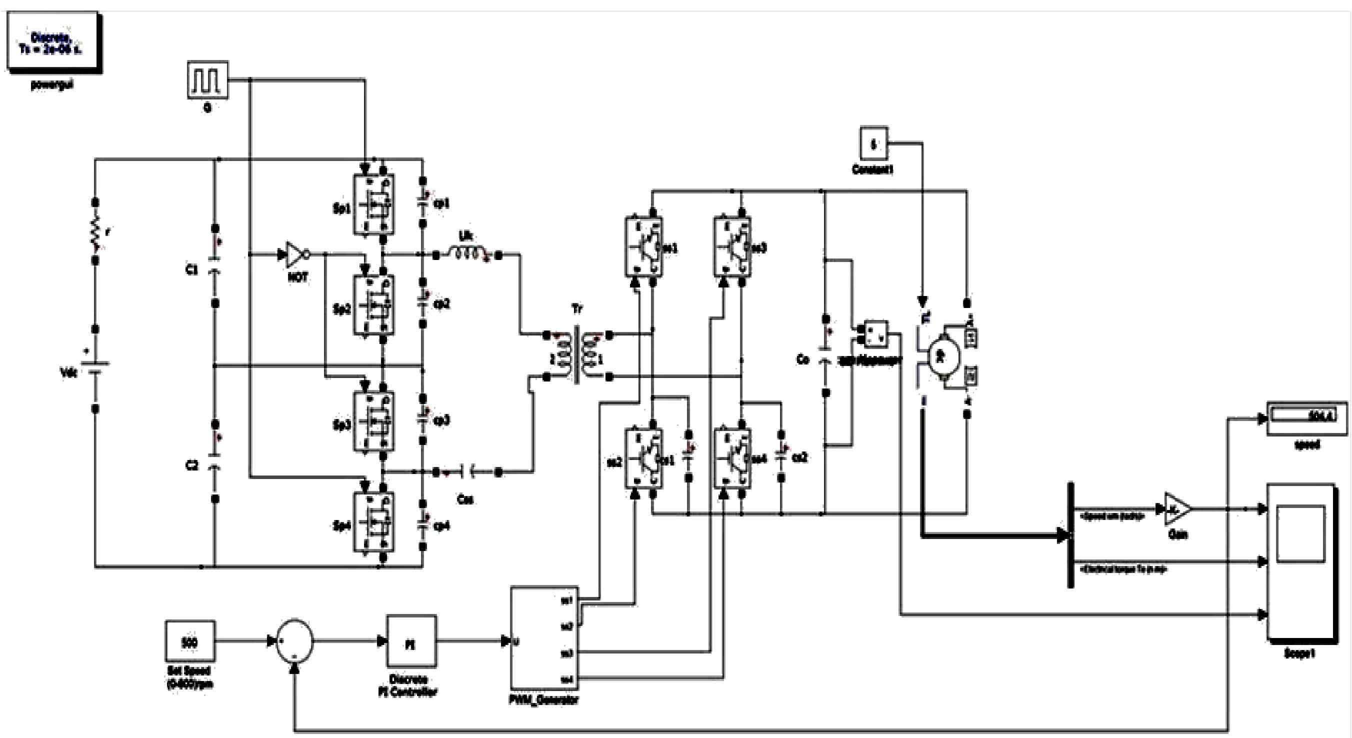

Fig.2 Main Simulation diagram

The low voltage rated power IGBTs with high performance can be employed to reduce the conduction losses and also reduce the voltage stress with help of soft switching technique. The voltage spikes on primary side IGBT switches and the secondary-side IGBT are effectively suppressed and output capacitor filter is used reduce the harmonics in regulated output voltage. The regulated output voltage is given to the PMDC motor. The actual data determined with help of feedback signal this signal is given to PI controller. It compare with the actual signal with reference set speed signal here some error signals is compensated with help of controller and controlled signal is given to the PWM generator. The phase shift controlled signal is given to the fully controlled rectifier. The general speed control of PMDC motor is following as, Speed is controlled by varying the voltage applied to the armature. Feedback devices sense motor speed and send this information to the control to vary its out-put voltage up or down to keep speed at or near the set value. Feedback techniques include voltage tachometers, optical encoders, electromagnetic pulse generators, and back EMF monitoring. Regulation is the ability of the motor and control system to hold speed constant over the torque range.

III. SOFT SWITCHING ANALYSIS

Let us consider primary switches of circuit here IGBT act as a primary switch, The ZCS turn-off of the primary switches is obtained due to the parallel capacitors. The larger the parallel capacitors are, the less turn-off losses would be caused. In the steady-state operation ZCS turn-on is achieved for all the primary power IGBTs, which reduces the switching losses greatly. When Sp1 and Sp4 turn OFF, the inductor Llk charges Cp1 and Cp4 , and discharges Cp2 and Cp3 . As a result, the ZCS turn-on for the switches Sp2 and Sp3 can be realized once Cp2 and Cp3 are discharged completely. The condition for the ZCS turn-on of another pair of primary switches is the same. Now consider the equivalent circuit when primary switch turn OFF. Cp is equal to one parallel capacitance of the primary switches, assuming the four parallel capacitors are all the same. That is Cp = Cp1 = Cp2 = Cp3 = Cp4 and Vcp equals to input voltage value, when the primary switches turn OFF.

IV. EXPERIMENTAL RESULTS

The circuit proposed is obtained and analyzed with MATLAB software tool for voltage stress reduction and speed control of PI controller.

MATLAB simulation circuit diagram, resultant waveforms for converter input voltage, output voltage, motor speed and torque is given below.

Fig.3 Input voltage waveform

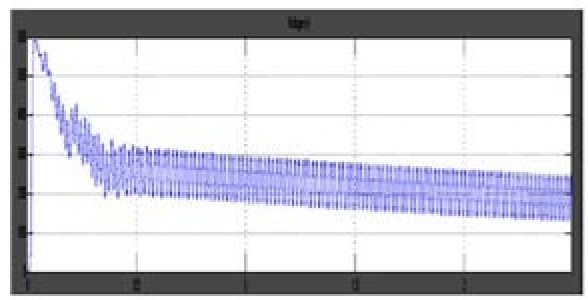

Fig.4 Output voltage waveform

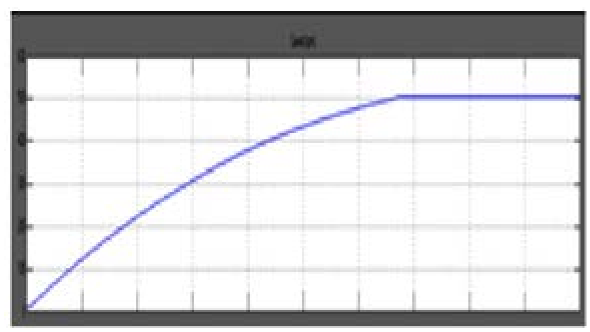

Fig.5 Speed waveform

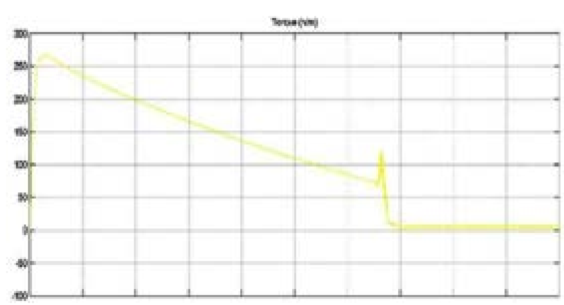

Fig.6 Torque waveform

V. CONCLUSION

A resonant switching converter to reduce the voltage stress and thus the losses in switches is proposed in the paper. The switching scheme adopted is zero current switching and this enables the reduction of losses considerably thereby improving the efficiency. This voltage stress reduction is enabled by the voltage divider arrangement followed by multilevel inverter configuration. A PI controller is used for the control of the PMDC motor drive. The resultant output waveforms are as given above.

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