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Improving the Performance of Dc Motor Drive Application for Dc-DC Converter by using Resistance Compression Network

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ABSTRACT:

In this paper improve the performance of DC motor by the resistance compression network. The output DC supply is dependence upon number of transformer winding ratio. If the DC input side voltage is two times of the output side voltage. The RCN maintains desired current waveforms over a wide range of voltage operating conditions. We implementing torque and speed characteristics are performed by the Resistance Compression Network (RCN). The validated results are verified by the MATLAB/SIMULINK Software.

***Index Terms*—DC/DC converter, high-efficiency power converter, ON–OFF control, resistance compression network (RCN), resonant converter, dc motor chopper drive.**

I. INTRODUCTION

High-voltage-gain dc/dc converters are found in a variety of applications [1]–[4]. For example, to connect photovoltaic panels to the grid, interface circuitry is needed. Some architectures for this purpose incorporate dc/dc converters to boost voltage of individual photovoltaic panels to a high dc-link voltage, with follow-on electronics for converting dc to ac (e.g., see, [5] and [6]). The step-up dc/dc converter is a critical part of this system, and must operate efficiently for a large voltage step up and for a wide voltage range (e.g., at the converter input and/or output depending upon the system). Furthermore, to be compact, it must operate at high switching frequencies. In conventional hard-switched power converters, the overlap of current and voltage is large during switching, resulting in significant power loss, especially at high frequencies. Soft switched resonant converter topologies providing zero-voltage switching (ZVS) or zero-current switching (ZCS) can greatly reduce loss at the switching transitions, enabling high efficiency at high frequencies (e.g., see, [7] and [8]). Unfortunately, while many soft-switched resonant designs achieve excellent performance for nominal operating conditions, performance can degrade quickly with variation in input and output voltages and Limitations on the efficient operating range of resonant converters are tied to both converter structure and control. Numerous control techniques are possible for compensating variations in input voltage, output voltage, and power level. These include frequency control [7], [8], phase-shift PWM control [11], asymmetric duty cycle PWM control [12], and ON–OFF or burst mode control [13]. Each of these control techniques in conjunction with conventional resonant tank structures imposes significant design limits. For example, the conventional half bridge series resonant converter (SRC) [8] requires wide-band frequency variation to control the power when output load or input voltage varies such that the magnetics cannot be optimally designed. Furthermore, to maintain ZVS, the frequency must increase to reduce power, hurting the efficiency at light load. For a full-bridge version of the SRC, phase-shift control can be used to control the power and reject conversion ratio variations (e.g., see, [11]). However, this results in asymmetrical current levels in the switches at the switching instants, with the switches in the leading leg turning OFF at high currents. The effective impedance of the rectifier in a resonant converter also often causes challenges, as it

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varies with operating conditions. This paper introduces a new high efficiency resonant dc/dc converter topology, the resistance compression network (RCN) converter, which seeks to overcome the aforementioned challenges. This converter operates with simultaneous ZVS and near-ZCS across a wide range of input voltage, output voltage, and power levels, resulting in low switching losses. This study represents an expansion on an earlier conference paper [14], and includes additional experimental results and estimates of loss breakdown. The remainder of this paper is organized as follows: Section II describes the topology and control of the proposed RCN dc/dc converter. The converter is analyzed and methodology for its design is presented in Section III. Section IV describes the design and implementation of a RCN dc/dc converter. The simulation results of dc motor chopper drive are present and discussed in Section V. Finally, Section VI summarizes the conclusion of the paper. The conventional phase shifted PWM converters are often used in many applications because their topology permits all switching devices to operate under zero-voltage switching by using circuit parasitics such as power transformer leakage inductance and devices junction capacitance. However, because of phase-shifted PWM control, the converter has a disadvantage that circulating current flows through the power transformer and switching devices during freewheeling intervals.

To decrease the circulating current to zero and thus to achieve zero-current switching, various snubbers, auxiliary circuits and/or clamps connected mostly at the secondary side of power transformer are applied [1] – [10]. The disconnection of the secondary windings is usually achieved by application of the reverse bias for the output rectifier or using controlled rectifier. The optimal switching for IGBTs is zero-voltage turn-on and mainly zero-current turn-off due to elimination of the current tail influence, which has considerable high involvement in creation of the IGBT turn-off losses.

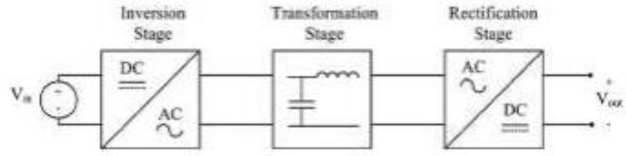

Fig. 1. Architecture of the proposed dc/dc converter.

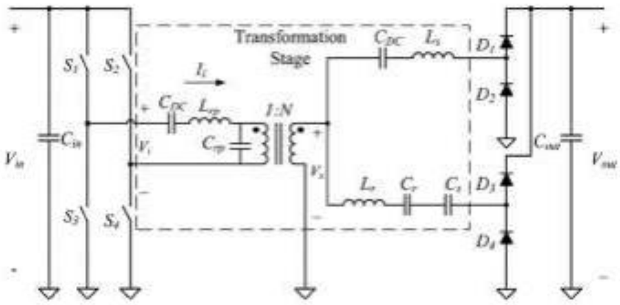

Fig. 2. Topology of the proposed RCN dc/dc converter.

II. RCN CONVERTER TOPOLOGY AND CONTROL

The dc/dc converter proposed here consists of an inversion stage, a transformation stage, and a rectification stage, as shown in Fig. 1. The inversion and rectification stages use standard designs. However, the transformation stage and the control of the converter are new. The topology of the proposed RCN converter is shown in Fig. 2. The converter as shown is designed to step-up voltage. The transformation stage consists of a matching network, a transformer, and an RCN. The matching network composed of Lrp and Crp acts as a filter and provides a voltage gain [17], hence reducing the transformer turns ratio requirement. One issue with high-turns-ratio step-up transformers that exists in many topologies is that the parasitic leakage inductance of the transformer can undesirably ring with its secondary side winding capacitance at the switching transitions. This creates large ringing in the current and voltage waveforms, and high-frequency losses. The matching network also eliminates this ringing by absorbing the transformer parasitics. The 1:N transformer provides additional voltage gain and isolation. The RCN (composed of Ls and Cs) is a special single input, multioutput matching network that provides desirable impedance control characteristics [15], [16], [23]. The RCN technique was originally

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proposed and applied for radio-frequency (RF) applications, such as very-high-frequency dc/dc converter systems [15] and RF power amplifiers [16]; here, we exploit if for high efficiency power conversion. The function of the RCN is to automatically regulate the converter operating power and waveformsin a desirable manner asthe input and output voltages vary. As applied here, the RCN also includes a series resonant tank (composed of Lr and Cr) [8]. Its purpose isto provide additional filtering. The inverterstage issimply a full-bridge inverter (composed of switches S 1 − S 4). A full bridge is used instead of a half bridge to reduce the voltage gain requirement from the matching network and the transformer. The rectification stage is composed of two half-bridge rectifiers. The capacitors Cin and Cout are for input and output filtering, respectively, and the two capacitors marked as CD C are for dc blocking purposes. The output power in the proposed converter isregulated using ON–OFF control, also known as burst-mode control or bang– bang control. The power is controlled by gating the converter ON and OFF at a modulation frequency that is much lower than the switching frequency [13], [15], [21]. The advantage of using ON–OFF control is that the magnetics are designed for only a single frequency (a high frequency), while the power is regulated by turning the converter ON and OFF at a lower frequency. Moreover, the power is transferred only in the fraction of the time the converter is ON, which results in high efficiency even at light loads. The output power is controlled by the duty ratio of the ON–OFF modulation. The ON–OFF control can be implemented through hysteretic control (e.g., see, [18]–[20]), through fixed-period ON–OFF PWM (e.g., see, [21]), or other methods. Additional care may be necessary in implementationsthat allow very short ON or OFF durations to maintain high efficiency and desired operation during ON–OFF transient conditions. The ON–OFF modulation has its own corresponding loss. The higher the modulation frequency the greater the loss. The output capacitance is sized according to the ON–OFF modulation frequency; with a lower modulation frequency, a larger capacitor has to be used. The duty ratio of the modulation also influences the loss. Very small or very large duty ratio results in greater loss asthe converter operatesin steady state for a shorter time. So, in order to minimize the total loss both the modulation frequency and the duty ratio have to be considered.

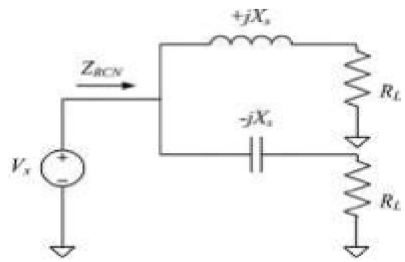

Fig.3. Fundamental frequency model of the RCN and the rectifiers

III. OPERATION PRINCIPLE

The switching diagram and operation waveforms are shown in Fig. 2. The basic operation of the proposed soft switching converter has six operating modes (intervals) within each half cycle. The switching diagram and operation waveforms are shown in Fig. 6. The DC/DC converter is controlled by modified pulse width modulation with phase shift between primary and secondary switches.

Interval (t0-t1): At the time t0 the primary transistors T1, T2 are turned on. The leakage inductance of the power transformer ensures that the emitter current of these transistors rises with a reduced di/dt, so the IGBT switches are turned on under zero current conditions. The rectifier switch T6 is turned on in the same interval and the capacitor CC6 is discharging to load through smoothing choke. At the end of this interval is the capacitor CC6 fully discharged.

Interval (t1-t2): During this period the secondary current rises with a slope that depends on the output filter inductance L0.

Interval (t2-t3):

At the time t2 the secondary transistor T5 is turned off. The transistor current is commutated to the snubber capacitor CC5. The rise of drain-source voltage UT5 is

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slowed by down capacitor CC5.and thus the zero voltage turn off of the secondary MOSFET is ensured. The maximum value of the voltage UT5 depends on the load current, leakage inductance and the secondary voltage of the high frequency power transformer. While the capacitor CC5 is charging, the capacitor current commutates to the freewheeling diode D0.

Interval (t3-t4):
Only negligible magnetizing current flows through primary winding of the transformer. The load current starts to flow through the freewheeling diode D0.

Interval (t3-t5):
The load current continues to flow through the freewheeling diode D0 during this period. Interval (t5-t6): The secondary transistor T5 is turned on at t5 a half period earlier then primary transistors T1 and T2. The capacitor CC5 starts discharging through T5, L0, R0, LS, and DS5. The rate of rise of discharging current of this capacitor CC5 is limited by the snubber circuit inductance LS, and thus zero current conditions of the MOSFET transistor T5 is achieved. Also the primary transistors T3, T4 are turned on at the beginning of this interval and the energy from the input source U is transferred to the load. But on the beginning of this transfer the power is supplied also from the snubbed circuit capacitance CC5. The waveforms of the primary and secondary currents are exactly the same like the current waveforms of the opposite transistors only with a half period phase shift. At the time t6 the discharge current stops to flow through the T5 transistor.

Interval (t6-t7):
The energy stored in snubber inductance LS is now flowing through DS5, DC5, L0, R0, LS. At the time t7 the whole load current flows through the transistor T6.

Interval (t7-t8): At the time t8 ends one period of the DC/DC converter operation and another period starts with the turning on of the transistors T1, T2.

IV.SIMULATION RESULTS

The RCN dc/dc converter has been tested using a dc power supply and a dc motor chopper drive. The tests were carried out and the results of output load with different input voltages(in the 25–40 V range) and different output voltages (in the 250–400 V range). Fig. 11 shows current and voltage waveforms for the converter over two switching periods, when operated at an input voltage of 25 V. In particular, it shows the current through the inductor of the matching network, which is also the output current of the inverter, the gate drive voltages of the inverter switches S 1 and S 3, and the drain– source voltage ofthe switch S 3. As expected, the current through the inductor of the matching network is approximately sinusoidal. Also, the switches achieve ZVS and near-ZCS, as can be seen from Fig. 12. Even with the slight distortion in currents that occur owing to limited tank Q, ZVS, and near-ZCS is still achieved as predicted with sinusoidal approximations. This owes in part to the fact that even with moderate damping of the resonant oscillation owing to the rectifier network, the current waveform still tendstoward zero (at a reduced slope) for the next switching transition. Fig. 12(a) shows a zoomed in view of the turn-off transition of switch S 3. The current through switch S 3 at turn-off issmall compared to both the peak and average of the current it carries (turn-off current is 15.7% of peak current and 27.5% of average current). Fig. 12(b) shows the turn-on transition of switch S 3. Notice that the switch turns ON under ZVS, as the voltage across the switch falls to zero before the switch is turned ON. Fig. 13 shows the current and voltage waveforms with an input voltage of 40 V and an output voltage of 400 V.

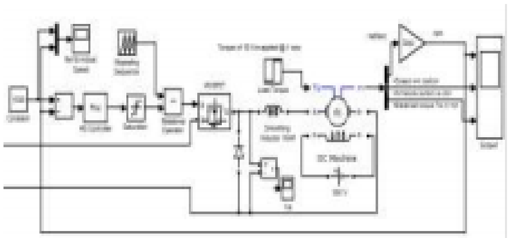

Fig.-simulink type chopper DC drive with fixed ref speed

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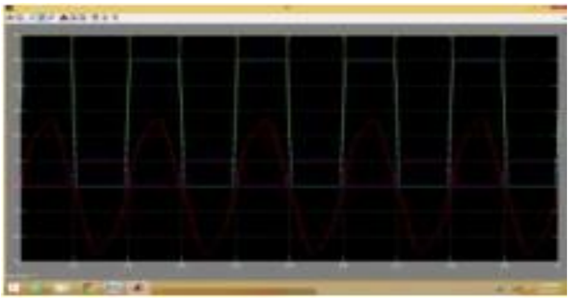
PERFORMANCE WAVE FORMS OF A DC MOTOR DRIVE



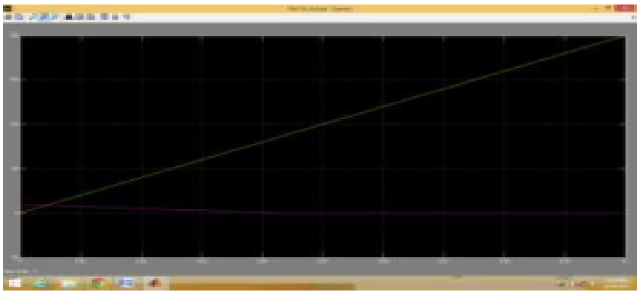


fig:-chopper dc motor drive actual and ref speed with clock

below fig:-speed, armature current and torque o/p of dc motor drive with ref clock i/n side

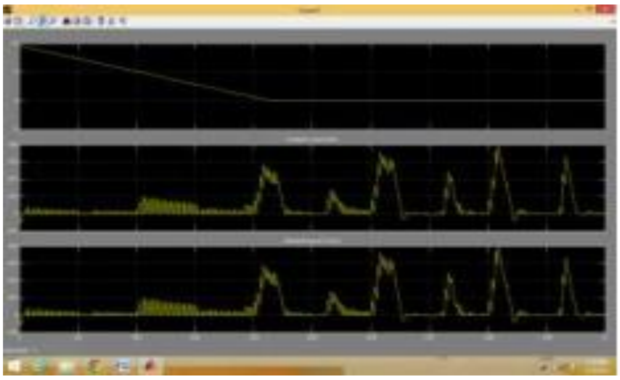


Fig:- RCN DC/DC converter output waveforms

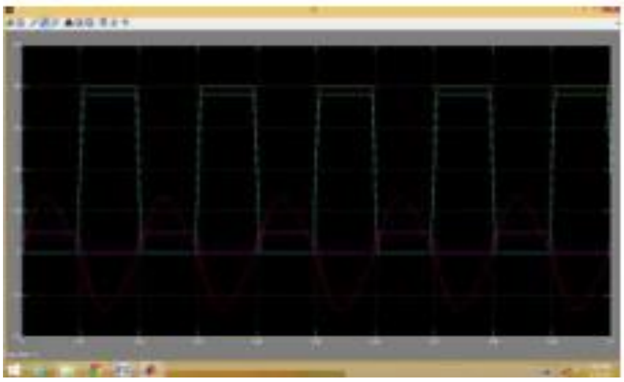


Fig:-reversing amplitudes switching of mosfets.

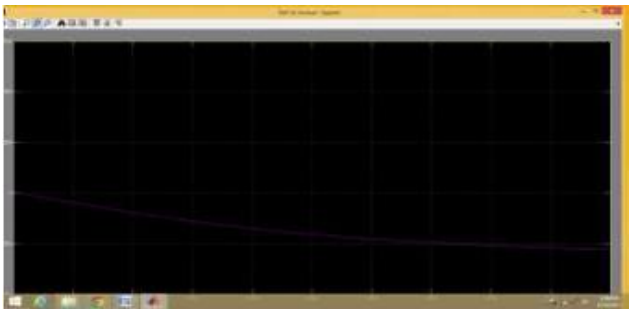


Fig:- chopper dc motor drive fixed ref speed(1500rpm) and actual speed

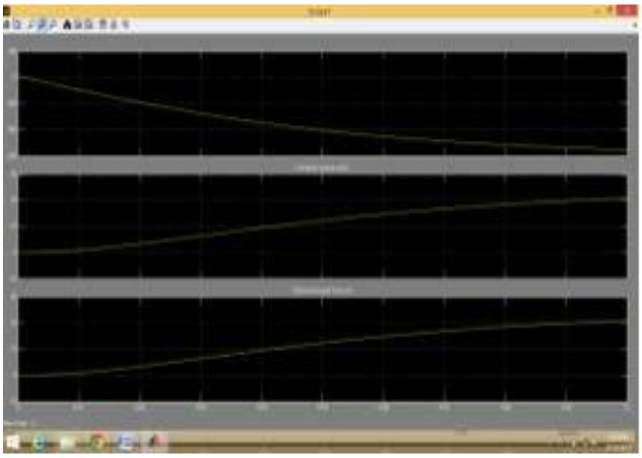


Fig:-chopper dc motor drive speed, amature current and armature torque with fixed referance speed(1500rpm)

V. CONCLUSIONS

Operation principle of the novel full-bridge PWM DC/DC converter with secondary energy recovery snubber is presented in the paper. Soft switching all of the power switches and reduction of circulating currents are achieved for full load range in the proposed converter. At proper design it is possible to utilize the magnetizing current of power transformer for charging or discharging output capacitances of the IGBT switches and thus zero-voltage turn-on of the IGBTs to achieve. The IGBT transistors are turned off almost under zero current. Only small magnetizing current of the power transformer is turned off by IGBT transistors, so the turn off losses are minimized. One of the main tasks of the proposed secondary snubber is transfer of the leakage inductance energy to the load at turn-off of the secondary switch. Moreover it ensures zero current turn-on and zero voltage turn-off of the secondary switch. For optimal utilization of the snubber circuit it is necessary to use a power transformer whose leakage inductance is minimized (planar transformer or coaxial transformer). A laboratory model of this converter is being developed to verify the theoretical and simulation analysis.

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