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Reduction of Switching Losses for a DC-DC Converter using RCD Clamp Circuit

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Abstract: A snubber for a buck-boost converter is presented. The proposed snubber uses a resistor, inductor and capacitor. This circuit is capable of resetting the transformer, as well as eliminating leakage inductance voltage spike across the power switch. The proposed snubber eliminates the losses due to switching by freewheeling action through the diode.

Key words: DC-DC converter · Isolation transformer · Demagnetization · Inverter

INTRODUCTION

Clamp Circuit: The RCD clamped buck-boost converter is a popular topology for low to medium power applications. The clamp voltage is dependent on a number of circuit parameters, including the magnetizing inductance, the parasitic capacitance of the power semiconductors and the switching frequency. An alternative method of buck-boost converter transformer reset is using a resistor, capacitor and diode (RCD) clamp. The RCD clamp circuit is simple and it consist of three components, a resistor, a capacitor and a diode and requires a simpler two winding transformer. The clamp absorbs the magnetizing inductor energy as well as provides a discharge path for the leakage inductance. Thus, with RCD clamp, the transformer is totally reset and the power switch experiences significantly less voltage stress than that with the reset-winding method. For these reasons, RCD clamp buck-boost converter is widely used in power supply industry. The main disadvantage of RCD clamp is that the recovered energy is dissipated and the overall converters efficiency decreases. The switch still experiences a hard turn-off in RCD clamp [1].

Buck-boost converter is a type of popular switched mode power supply (SMPS) circuit used for producing isolated and controlled dc voltage from the unregulated dc input.

In case of fly-back converter the input dc supply is derived after rectifying the ac voltage. The buck-boost converter is high energy efficient when compared with the fly-back circuit and is used for little higher power applications.

Block Diagram: Buck-boost converter is a DC-DC converter here single switch buck-boost converter is used to boost the input voltage obtained from the DC Source. In the single switch buck-boost converter, the magnetizing energy stored in the primary inductance is restored to the input source by a demagnetization winding. Most commonly, the primary and the demagnetization windings have the same number of turns. During turn off the switch has to withstand twice the input voltage during the time of demagnetization. In order to reduce the voltage spike more than the theoretical $2V_{in}$ occurring at turn-off across the power switches both the demagnetization winding and primary windings are tightly coupled.

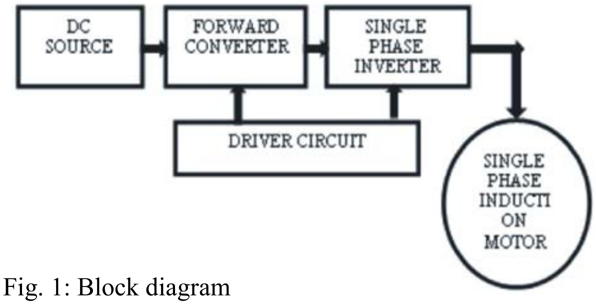

Fig. 1: Block diagram

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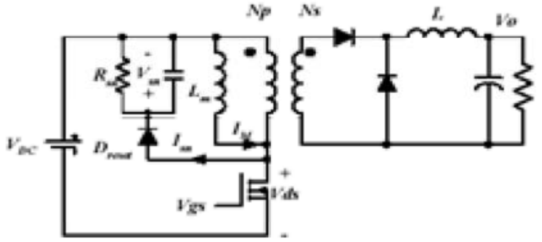

Fig. 2: RCD-Buck-boost converter

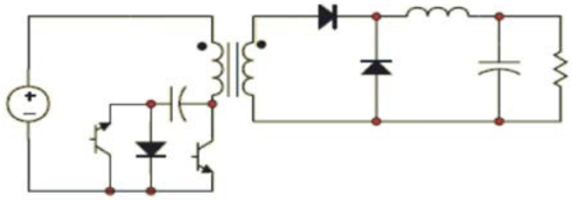

Fig. 3: Buck-boost converter

This boosted voltage is given to single phase inverter to convert the DC power into AC power connected with single phase induction motor.

Advantages of Buck-boost Converter:

- Reduced drain current by the ratio of Ns/Np,
- Less voltage ripple,
- Supports multiple outputs.
- Isolation between load and source.

Snubber Circuit: A snubber circuit is added to a DC-DC converter for suppressing stresses on semiconductor switches Type Dissipative Clamp/Reset technical Reset circuit design is very less cost with discrete components R C and D. Max operating duty could be slightly higher than 50% (up to 55~65%), depending the magnetizing current reset by RC constant Critical point. High consumption of the energy storage on “C” should dissipates bypassive component “R”. The transformer volt/second balance should trade off by adjusting the value of “C” and “R” for Clamp/Reset.

The snubber capacitor voltage is fixed and independent of the input voltage, the voltage stress across the switch can be reduced when compared with the reset winding when the converter is operated with a range of wide input voltage. One more advantage of RCD reset method is that it is possible to set the maximum duty ratio higherr than 50% with relatively low voltage stress on MOSFET compared to reset method auxiliary winding, which gives reduced voltage stress on the secondary side.

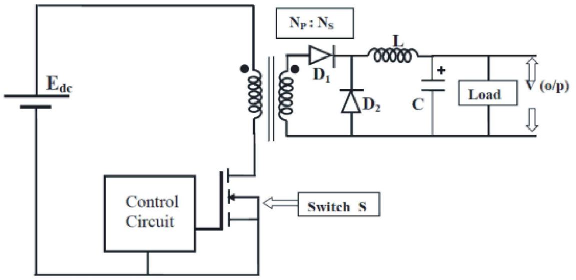

Fig. 4: Buck-boost converter with Inductive load

Proposed System

Buck-boost Converter: Buck-boost converters have been widely used in the power supply industry over 50 years due to its simplicity and high efficiency. Despite its long history, buck-boost converters are still evolving; in fact, many tradeoffs between switch stress and transformer reset are still necessary to meet the needs of various applications. As a result, new topological variations and innovations have been continuously emerging. With different transformer demagnetizing schemes, many buck-boost converters were reported in harmonic oscillation during large signal transients were experienced in these converters. Although the buck-boost converter has evolved many topology variations over the years, the search for simpler design, lower voltage stress and lossless reset mechanism is still a significant driving force in the power electronics research community.

Basic topology of the buck-boost converter is shown in the above Fig 3. It consists of a switching device ‘S’ which is fast along with its control circuit, primary winding of the transformer is connected in series with switch ‘S’ to the input supply and a rectification and filtering circuit for the transformer secondary winding. The rectified output of the transformer-secondary connected with load.

The transformer used in the buck-boost converter has no leakage fluxes, nil magnetizing current and losses. Finite magnetizing current in a practical transformer needs a tertiary winding to be connected with the transformer. In contrast, the buck-boost converter (which is based on a transformer with same-polarity windings, higher magnetizing inductance and no air gap) does not store energy during the conduction time of the switching element transformers cannot store a significant amount of energy, unlike inductors. Instead, energy is passed directly to the output of the buck-boost converter by transformer action during the switch conduction phase.

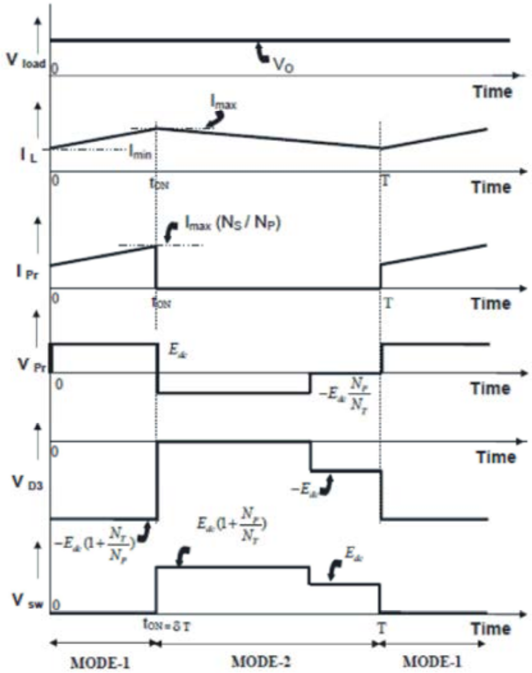

Fig. 5: Ideal Waveforms of Practical Buck-boost converter

RESULTS AND DISCUSSION

Buck-boost converter is supplied by 12V by using the dc source and this 12V is boosted to 200V by using the buck-boost converter connected to resistive load.

The output current obtained from the buck-boost converter is 1A which is shown in Fig 7.

The output voltage obtained is 200V. power obtained from buck-boost converter is also 200W which is shown Fig 8.

The buck-boost converter with the motor load is shown in Fig 10. where the single phase induction motor is connected through the single phase inverter.

The buck-boost converter is connected to single phase inverter and this single phase inverter is connected to the single phase induction motor and the speed-torque obtained from this single phase induction motor is shown in Fig 11 and Fig 12 repectively.

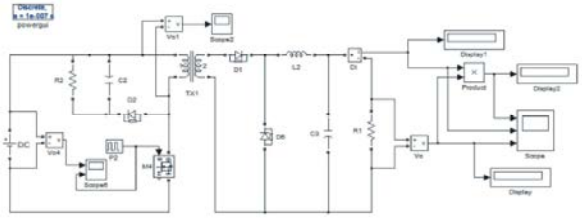

Fig. 6: Buck-boost converter with R load

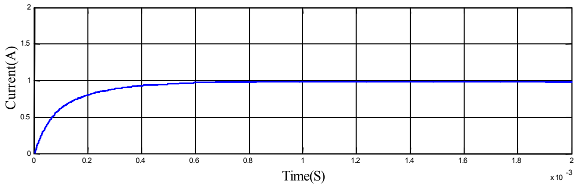

Fig. 7: Output Current

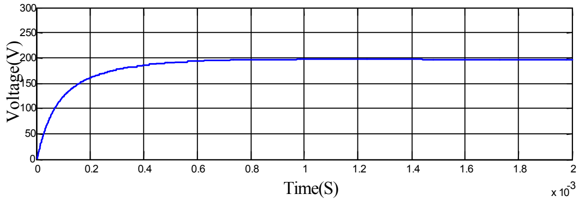

Fig. 8: Output Voltage

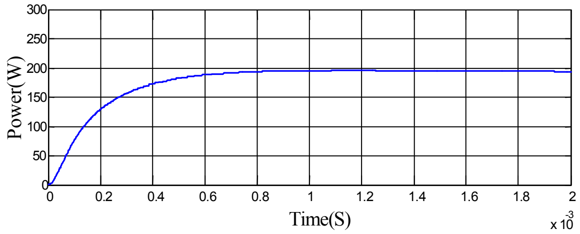

Fig. 9: Output Power

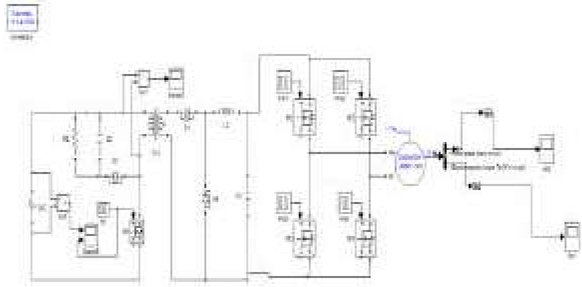

Fig. 10: Buck-boost converter with motor load

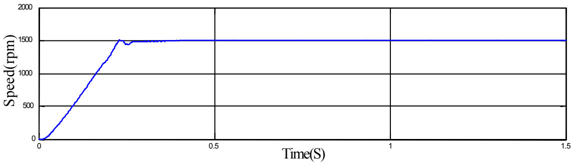

Fig. 11: Output Speed of the motor

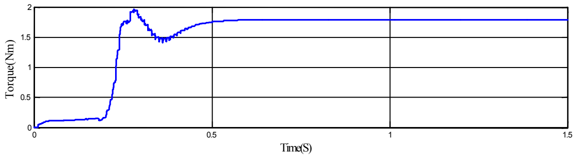

Fig. 12: Output Torque of the motor

Table 1: Parametrers and its values

S.No.	Parameter	Values
1.	Input voltage	12v
2.	Current	4.05a
3.	Capacitor(converter)	1200µf
4.	Inductor(converter)	60µh
5.	Capacitor(filter)	90µf
6.	Inductor(filter)	130µh

CONCLUSION

The nondissipating snubber reported in [2] uses a discrete inductor to perform the reversal of the snubber capacitor voltage and feed the energy back to the source. Recycling of the energy takes place during the clamp state. However, when the converter operates with low duty cycle, the magnetizing energy the capacitor absorbs may be insufficient to raise the capacitor voltage to the value of the source voltage. Consequently, the clamp state will not occur and the nondissipating snubber changes the operating mode. The under charged snubber capacitor cannot provide true ZVS condition for the power switch and The power stage efficiency deteriorates [3]. The nondissipating snubber provides no means to make any readjustments in order to improve the performance ratio introduces another degree of freedom and can be adjusted to ensure a complete precharge of the snubber capacitor to the full value of the source voltage. As a result, Contrary to that, the proposed regenerative snubber uses a tertiary transformer winding and bene?cially exploits the transformer leakage inductances. The tertiary winding turn mode changes can be avoided and perfect ZVS conditions for the power switch can be provided for a wide range of operation conditions. This is one of the most important advantages of the proposed snubber circuit over the previously reported counterpart.

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