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Isolated Switched Boost Push Pull DC-DC Step-up Converter

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Abstract

An isolated switched high step up boost DC-DC converter is discussed in this paper. The main objective of this paper is to step up low voltage to very high voltage. This paper mainly initiates at boosting a 30V DC into 240V DC. The discussed converter benefits from the continuous input current. Usually, step-up DC-DC converters are suitable for input whose voltage level is very low. The circuital design comprises of four main stages. Firstly, an impedance network which is used to boost the low input voltage. Secondly a switching network which is used to boost the input voltage then an isolation transformer which is used to provide higher boosting ability and finally a voltage multiplier rectifier which is used to rectify the secondary voltage of the transformer. No switching dead- time is required, which increases the reliability of the converter. Comparing with the existing step-up topologies indicates that this new design is hybrid, portable, higher power density and the size of the whole system is also reduced. The principles as well as operations were analysed and experimentally worked out, which provides a higher efficiency.
Keyword- Impedance Network, Switching Network, Isolation Transformer, Voltage Multiplier Rectifier, Micro-Controller, DC-DC Boost Converter

I. INTRODUCTION

A DC-DC converter is an electronic circuit and it is employed to modify DC electrical circuit from one potential difference stage to an added potential difference level. DC-DC converters are circuits which convert sources of DC from one voltage level to another by changing the duty cycle of the main switches in the circuits. DC-DC converters are widely used in switched-mode power supplies, adjustable speed drives, uninterruptible power supplies and many other applications to change the level of an input voltage to fulfil required operating conditions. The limitations of conventional boost DC-DC converter such as low boost ability and low power density can be removed using this proposed system. Some of its advantages includes continuity of input current, voltage boost stability, reduction in size, isolation, reliability and higher efficiency. There are various step-up DC-DC converters that are applicable in these systems. Step-up DC-DC boost converters are mostly used in low voltage level of input source. The applications of the proposed system are wide such as used in photovoltaic grid connected applications, integrated magnetics, input current shaping techniques, distributed power generations, micro grid systems, electrical vehicle drives, motor drives etc.

This paper discusses a major solution for the existing conventional DC-DC converters. This integrates the advantages of impedance network which uses the push pull switching network to ensure the continuity of the input current source moreover the isolation transformer and the voltage multiplier does adds the voltage boost ability of the converter to achieve high voltage gain.

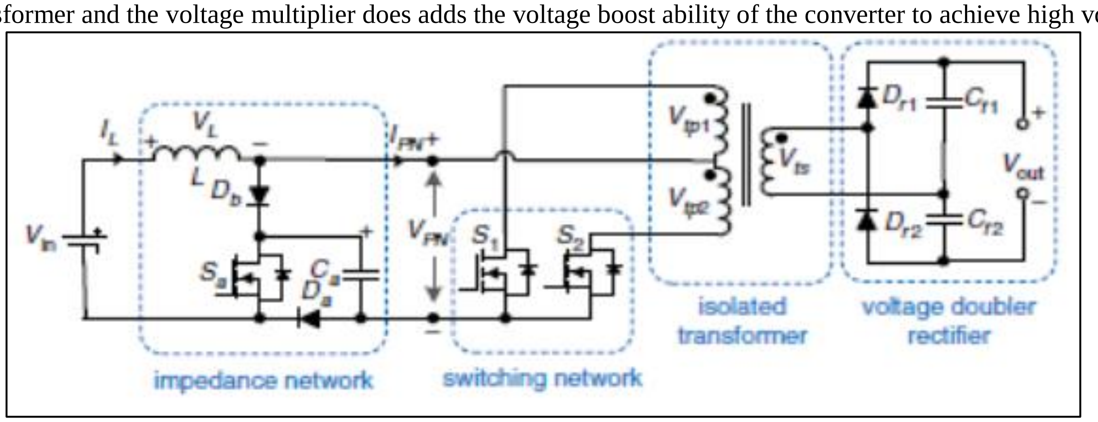

Fig. 1: Discussed Converter

Basic operating principles: The operating modes of the converter are, respectively, shown in Figs. 2. The operating states of the proposed converter are basically divided into three modes which are as follows.

Mode I: In this mode, the three power switches S1, S2 and Sa are conducting simultaneously, which confirms the high reliability of the converter since no switching dead-time is required. Referring to Fig. 2, diodes Da, Db, Dr1 and Dr2are reverse biased. During this interval time, the inductor L stores the energy, whereas the capacitor Ca is being discharged in the primary side. At the same time, the output capacitor Cf1 and Cf2 are discharged by supplying the load.

Mode II: In the switching network, the power switch S1 is turned on, while S2 is turned off. Meanwhile, Sa is also turned off. Referring to Fig. 2, the diodes Da, Db and Dr2 are conducting, while Dr1 is reversely biased. During this interval time, the inductor L transfers the energy, whereas the capacitor Ca is being charged by the power supply in the primary side. At the same time, the capacitor Cf2 is charged until it reaches the secondary voltage of the transformer, and Cf1 is discharged by supplying the load.

Mode III: Same as Mode II, Sa is turned off in this mode. S2 is turned on, while S1 is turned off. Referring to Fig. 2, the diodes Da, Db and Dr1 are conducting, while Dr2 is reversely biased. At the same time, the capacitor Cf1 is charged until it reaches the secondary voltage of the transformer, and Cf2 is discharged by supplying the load.

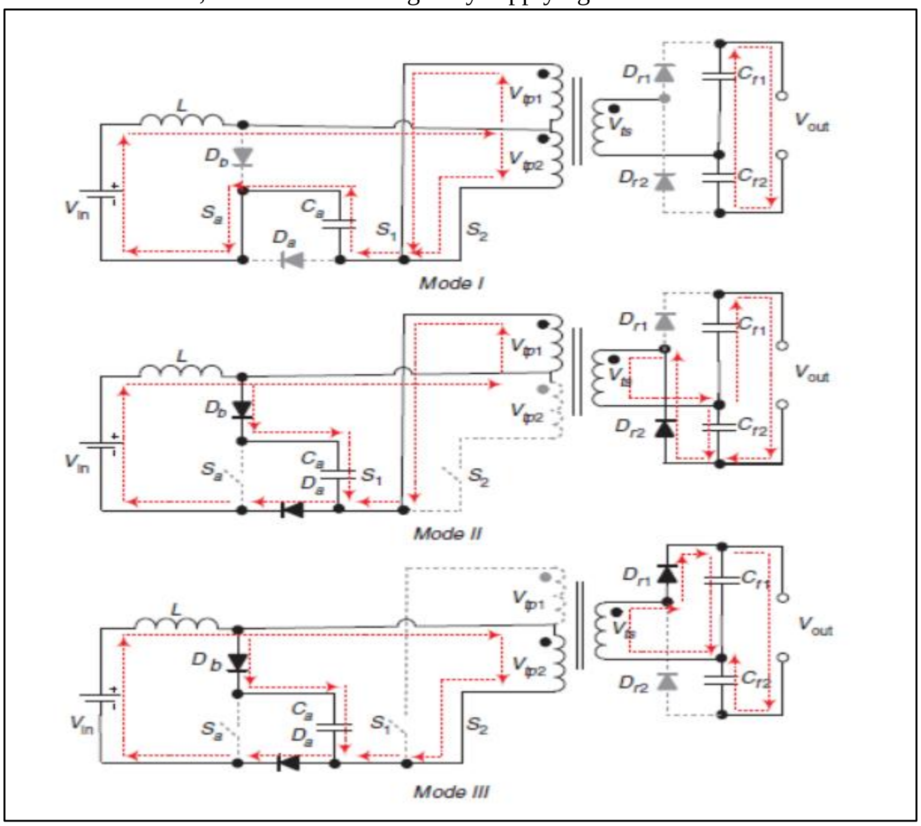

Fig. 2: Operation Mode Diagram

II. INDENTATIONS AND EQUATIONS

Design Equations;

Resistance for all LED, $R_{LED} = (V_{in} - V_{LED})/I_{LED}$

$$I_{LED\ nom} = 20\ mA$$
$$I_{LED\ nom} = 10 - 15mA$$
$$V_{LED}(RED) = 1.8V$$
$$V_{LED}(GREEN) = 2.5V$$
$$V_{LED}(NEON) = 60V$$

Resultant Current (C_4, R_1)& (C_4, R_7)

MCU

$$V_{MCLR} = V_0(1 - e^{-6/RC})$$

Oscillation Crystal (Q_c)

$C_L = \{(C_{x1} * C_{x2})/(C_{x1} + C_{x2})\} + C_{stray}$

Stray Capacitance = 0.7pF/P_{in}

$$C_{x1} = C_{x2} = \text{Load Capacitance}$$

(From Crystal Data)

Transistor Base Resistor $(R_3, R_{23}, R_{26}\ \text{etc.})$

$R_B = V_{cc} - V_{diode} - V_B/I_B$

$$I_B = I_c/\beta$$
$$I_c = V_{cc} - V_{BE}/R_{LOAD}$$
$$V_{Diode} = 0.6 * V_{BE}$$

Potential Terminals (R_{17}, R_{18} etc)

$$V_{out} = \frac{V_{in} * R_2}{R_1 + R_2}$$

T=0.44 RC
Zener Regulation (D_{10}, R_4, etc)

$$I_{zener} = P_{zener}/V_{zener}$$
$$P_{zener} = 1W$$
$$R_{zener} = V_{in} - V_{zener}/I_{zener}$$

µ0.1 Capacitor discharge units
(R_{28}, R_{29} etc)
Discharge Time Ʈ ≤ Base/10
Ʈ=RC
Where C= µ01 Capacitance
<u>Transformer</u>
Core = 500W

$$B_{max} = 1500\ wb$$
$$N_{primary} = \frac{V_{in} * 10^8}{4 * f * B_{max} * A_c}$$
$$A_c = \text{Core Section Area}(Cm^2)$$

f =Frequency

$$V_{in} = V_{out\,low} = 10.8$$

$V_{in\,P} = \frac{N_{sec}}{N_{pri}} * V_{sec}$

<u>Boost</u>

$$V_{out} = \frac{V_{in}}{(1 - D)}$$

D=Duty Cycle

$$I_{inductor} = 4 * I_{DC\,avg}$$
$$L_{inductor} = \text{must satisfy in continous mode}$$

III. FIGURES

The block diagram of the proposed system is shown below

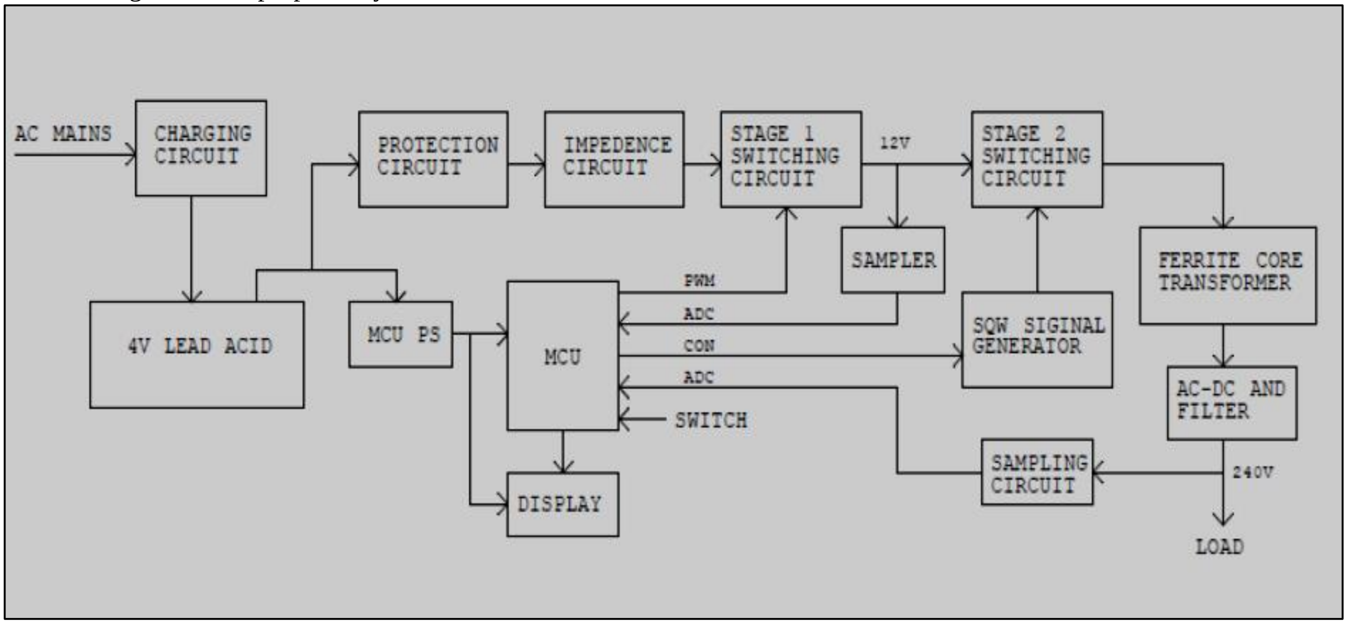

Fig. 3: Block Diagram

The modified diagram has much more advantages. It uses microcontrollers and several other units, thus increasing its overall efficiency. The detailed explanation of components of the block diagram;

Charging circuit is a charging circuit is for charging lead acid battery in parallel. Charging mechanism uses captive charging methods for low cost implementation. Protection Circuit contains some fly back protection and short circuit protection devices. Also include switches and indication circuit for powering up the module. MCU power supply is basically a boost power supply with a small micro controller for low noise power supply generation. This is storing energy while boost switch is turned on and will release energy while turned off. Stage1 switching circuit contain a high current transistor controlled by PWM of master controller and will boost 3V input supply to 12V output range. Sampler for taking feedback from output to MCU and contain a reference source and voltage dividers. Stage 2 switching circuit contain a push pull configuration and fly back RC Snubber circuits for protection. Signal generator give pulses to switching circuit and is carefully tuned for giving delay of equivalent rise and fall time of switching components. Ferrite core transformer is the basic thing which boost 12V input to 150V output with high switching frequency and output capability of 450W.AC-DC and Filter circuit will multiply the input AC voltage and convert to DC and filter the output. Output of this section will be 300V and feedback logic will hold output in 240V.

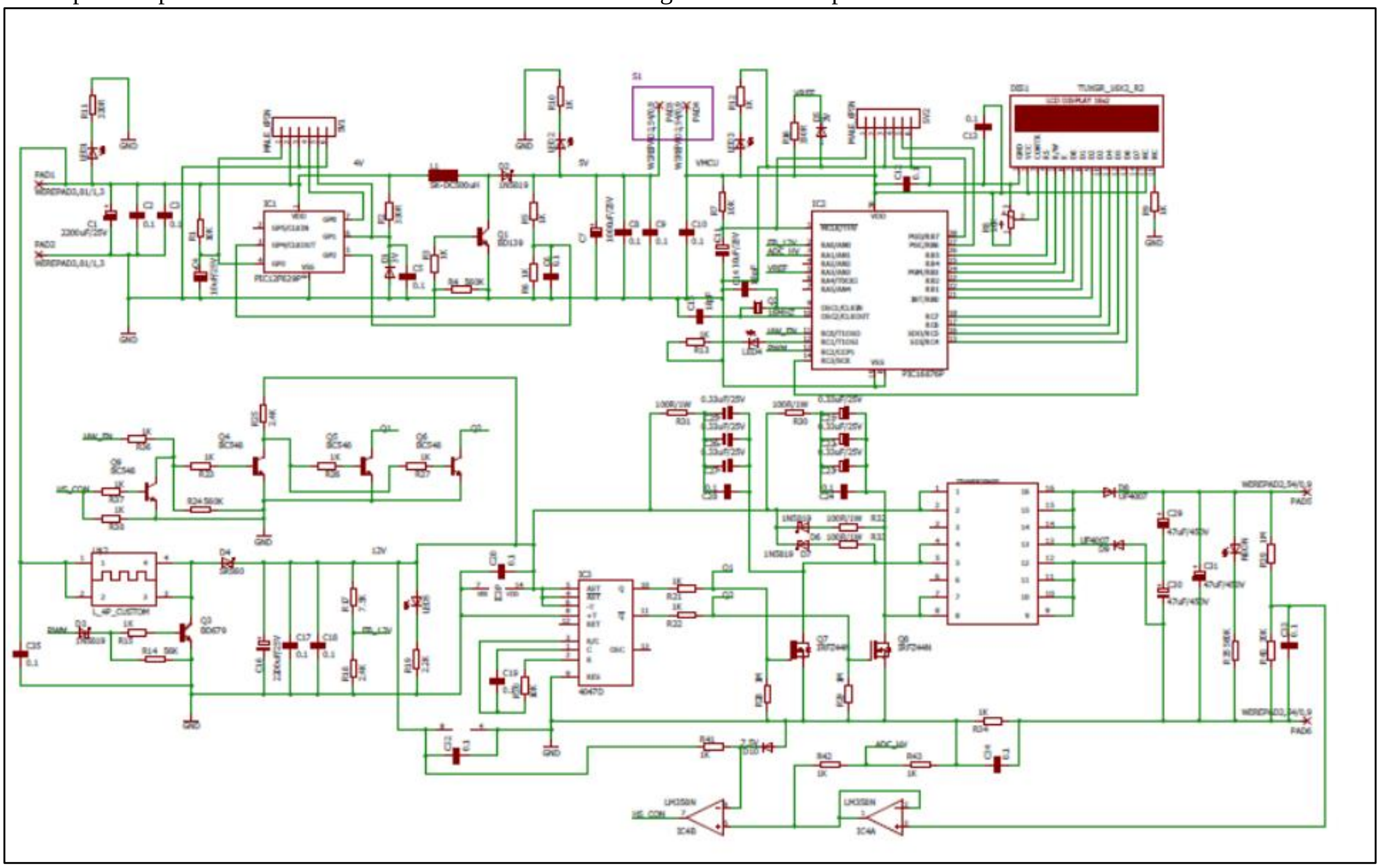

Fig. 4: Schematic Diagram

IV. CONCLUSION

This paper brings out the advantages of the newly setup isolated switched boost push pull DC-DC converter which is used in several step-up applications, where the continuity of the input current is a main concern. There are several advantages for the above discussed system such as voltage boost stability, reduction in size, isolation, reliability and higher efficiency. As the switches used in the system can be turned on or off simultaneously, there is no dead-time required and the reliability of the converter was improved. The design is executed experimentally and the output is verified.

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