High Efficiency Single-Input Triple-Output DC-DC Conversion with Zero Current Switching

R.Puvirajan*1, P.Uthayak Kumar*2, U.Akash*3, Dr.R.Narmatha Banu*4

*4Professor, Dept. of EEE, Velammal College of Engineering and Technology, Madurai, Tamilnadu, India
*1,2,3UG Students, Dept. of EEE, Velammal College of Engineering and Technology, Madurai, Tamilnadu, India

---

ABSTRACT: Multiple-output dc-dc converter has been widely used in many applications such as hybrid electric vehicles, spacecraft, uninterruptable power systems and so on. By dealing with the same issue of global warming, clean energies such as fuel cell, photovoltaic and wind energy etc., have been rapidly promoted. For the improvement of the global environment issue and lack of natural energy, the evolution of electric vehicles with renewable energy as the replacement of the fossil fuels vehicle has rapidly developed. In order to achieve high voltage-gain application with a low-voltage power source and the coupled-inductor based converters are used. This project especially develops a high efficiency single-input triple-output dc-dc converter with a soft switching technique for high step up applications Multiple output voltages with only one input source are generally required for renewable energy or electric vehicle applications. The proposed method has the high voltage conversion ratio to sustain the high voltage dc bus for the utilization of dc-dc inverter. Here the method uses coupled inductor with lower turn's ratios to achieve the high step-up voltage gain. Finally the proposed method is helpful to accomplish the high efficiency power conversion at three output voltage levels.

KEYWORDS: High-efficiency power conversion, Voltage clamping, Step-up voltage, Coupled inductor, Zero-current switching(ZCS).

I. INTRODUCTION

MULTIPORT dc/dc converters have recently attracted much research attention, which could be due to the increasing demand for renewable energy, the growth of electronic power systems and the increasing use of micro grids. Multiport dc-dc converters indicate a compact system with lower cost and fewer part counts as opposed to many separate dc-dc converters. At higher voltages, the switches experience the voltage stress which is a major challenge for dual output dc-dc converters. The reason for that are the issues such as the cost and the inaccessibility of high voltage switches, which could also have a negative effect on overall efficiency due to decrease in high forward voltage and resistance to ON-state. In addition, IGCT and high voltage IGBT are common semiconductors used in high voltage applications, but are not suitable solutions for multiport dc/dc converters. Their switching frequency is virtually limited to about 1 KHz due to the very high switching losses of those switches; hence the size of the passive components will increase dramatically. The goal of this study was to design a high-efficiency multiport dc-dc converter with reduced voltage stress across semiconductor devices and shrinking passive components. Multiple-output dc/dc converters have been widely used in many applications, such as hybrid electric vehicles, space crafts, uninterruptible power systems, and so on. In coping with the problem of global alert, renewable technologies, such as fuel cell, photovoltaic, and wind energy etc., have been quickly promoted. For the improvement of the global environmental issue and lack of natural energy, the evolution of electric vehicles with renewable energy as a replacement for the fossil-fuel vehicle has rapidly developed. In recent years, the coupled inductor-based converters have been investigated to achieve high voltage gain applications with a low-voltage power source. The requirement of high step-up converter with high-efficiency power conversion, a smaller volume, and a lower manufacturing cost has been achieved. The proposed a high-efficiency bidirectional dc/dc converter constructed by a coupled inductor with the interleaved topology. While the topology in can achieve high-efficiency power conversion, due to a low voltage gain many battery modules have been connected in series to form a high voltage bus. Moreover, the mega-watt level topology was demonstrated in with multilevel outputs and bidirectional operation for a wide power range. Although the topology in was utilized for ultra-high power applications, it had enormous control architecture for supporting the system stabilization, and the hard-switching operation will degenerate the power conversion efficiency. In addition, a high step-up dc/dc converter with the property of high-efficiency power conversion and wide operational range was constructed with low input-current ripple for renewable energy applications. Because an additional magnetizing inductor should be used for transferring the energy, the corresponding volume will be increased. It proposed an integrated dual-output converter with synchronous switches for decreasing conduction losses. However, two duty cycles for carefully designing the power switches will limit the range of output voltage.

II. LITERATURE SURVEY

1. K.Filsoof and P.W.Lehn in 2016 proposed a bidirectional multiple-input multiple-output dc-dc converter based on the triangular modular multilevel dc-dc converter. In this converter, the voltage stress on switches is shared amongst the levels. In addition to its complex control system, the converter is not capable of generating buck and boost output voltages at the same time. Consequently, two separate circuits with different topologies are needed to generate each voltage separately.

2. R.-J.Wai and K.-H.Jheng in 2013 proposed a non-isolated single-input dual-output dc-dc converter (SIDOC) is proposed, which one of its outputs is boost and the other one is buck at the same time. The converter's topology is achieved through the substitution of two series-connected switches with the control switch of the conventional boost converter. The voltage stress on each switch and the diode is equal to the boost output voltage, making the converter appropriate for low-voltage applications. In the meantime, switches were added due to high voltage stress on the diode and the series, and also due to the lack of a proper distribution of high input current, (which is typically the case in the single-input multiple-output converters) among the switches, the converter's both conduction and switching losses are high, which can lead to a fairly low system efficiency.

3. O.Ray, A.P.Josyula, S.Mishra, and **A.Joshi** in 2015 proposed an isolated SIDOC, which comprises four diodes and only one power switch. Nonetheless, in the experimental prototype, two parallel high-current switches with soft-switching system were used to improve the performance and cope with the high current-tension. A number of studies have been found proposing multiport multi-level converters.

4. S. Dusmez, X. Li, B. Akin in 2015 proposed a paper on "A new multi-input three-level integrated DC/DC converter for renewable energy systems" which is a combination of the SEPIC and five-level boost converters. The converter is composed of one switch and 10 diodes. The voltage stress on the switch is reduced to one-fifth of the high voltage side. Yet, high number of diodes may affect the reliability of the system. Moreover, reducing the passive components size.

5. Martin ET all in2013 proposed a paper on "Buck/Boost dc-dc converter topology based on the principle of auxiliary resonant commutated pole". In this paper EMI problem is very less due to proper design of auxiliary resonant converters. Both buck and boost mode is possible.

6. Hongfui et all in 2015 proposed paper on "Full-Range Soft-Switching Isolated Buck-Boost Converters With Integrated Interleaved Boost Converter and Phase-Shifted Control". This paper proposes conversion with single stage power. The supports for a wide variety of operations, and losses from switching are very low. Help for good power factor due to disrupted current mode.

III. PROPOSED SYSTEM

- The proposed HSTDC has three output ports with different voltage levels, and only one low-voltage input port. The output terminals are defined as the high-voltage dc bus (VO1), the auxiliary source (VO2), and the middle voltage output terminal (VO3), respectively.
- The proposed HSTDC has two essential characteristics for boosting input voltage and generating different voltage levels.
- The proposed HSTDC has an excellent stabilization under various experimental conditions and input voltage variations.
- The maximum power conversion efficiency is over 96% due to the soft-switching technique
- To achieve the objectives of high efficiency power conversion, zero-current-switching (ZCS)turned-on, and single-input triple-output features.
- The voltage stress of the power switch can be clamped to be a specific voltage level, the power switch with a lower turned-on resistor can be selected to decrease the conduction loss, and the switching loss will be alleviated via the soft-switching technique.
- The auxiliary source supplies energy for peripheral equipment instead of another power subsystems, and benefits as saving the manufacturing cost and simplifying complicated control systems.

- The output voltage levels independently, an active switch and a three-winding coupled inductor can be introduced to manipulate the output voltage levels with different duty cycles.

IV. BLOCK DIAGRAM & METHODOLOGY

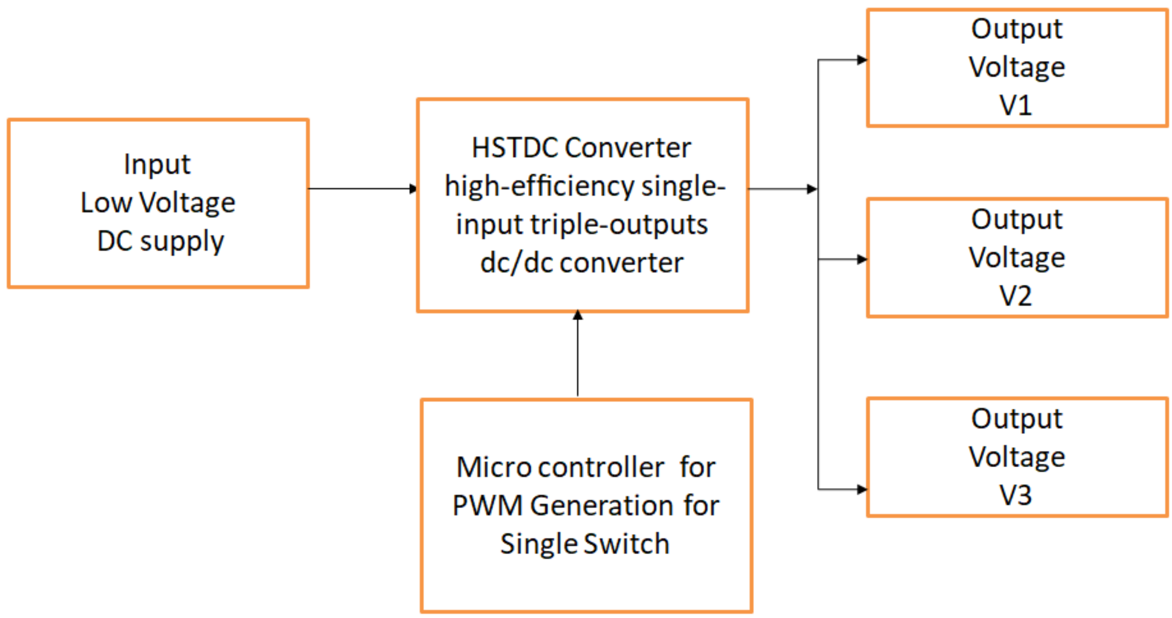

Fig 1. Block Diagram of HSTDC

- The proposed HSTDC has two essential characteristics for boosting input voltage and generating different voltage levels.
- The proposed HSTDC has an excellent stabilization under various experimental conditions and input voltage variations.
- The maximum power conversion efficiency is over 96% due to the soft-switching technique.
- To achieve the objectives of high efficiency power conversion, zero-current-switching (ZCS)turned-on, and single-input triple-output features.
- The voltage stress of the power switch can be clamped to be a specific voltage level, the power switch with a lower turned-on resistor can be selected to decrease the conduction loss, and the switching loss will be alleviated via the soft-switching technique.
- The output voltage levels independently, an active switch and a three-winding coupled inductor can be introduced to manipulate the output voltage levels with different duty cycles.

V. SIMULATION RESULTS AND DISCUSSION

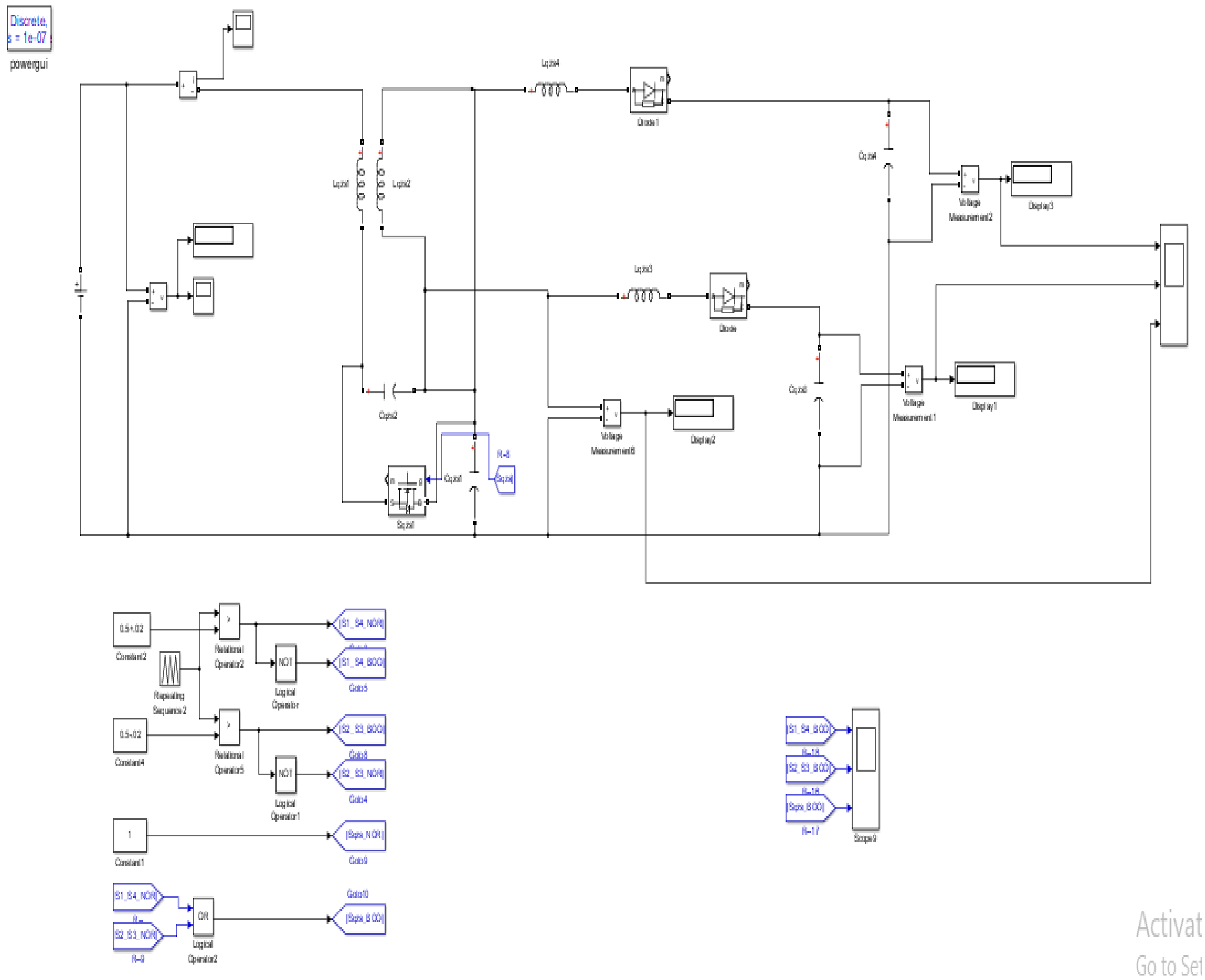

Fig 2. Simulation Circuit of HSTDC

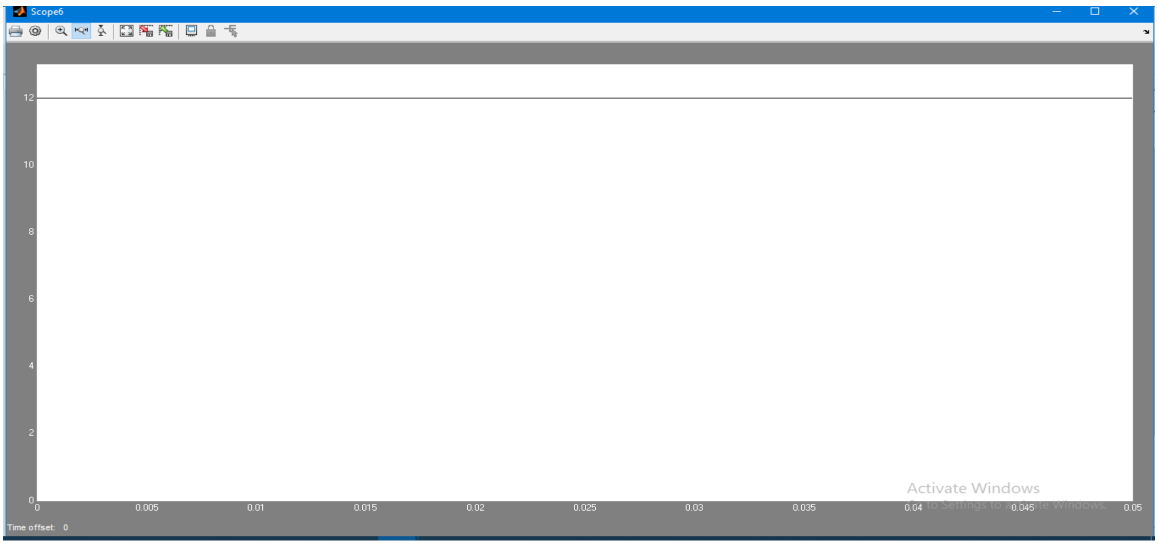

Fig 3. Simulation Input Voltage

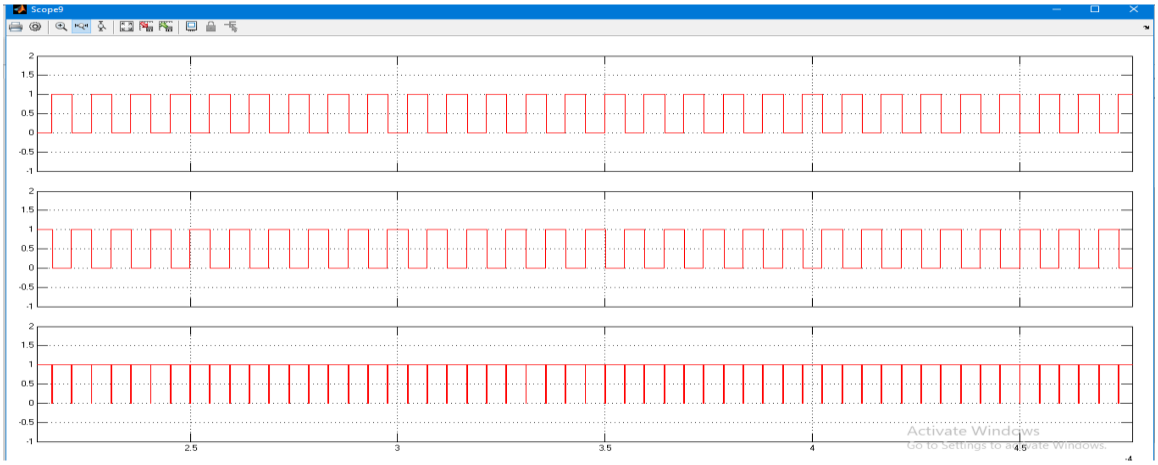

Fig 4. PWM Waveform

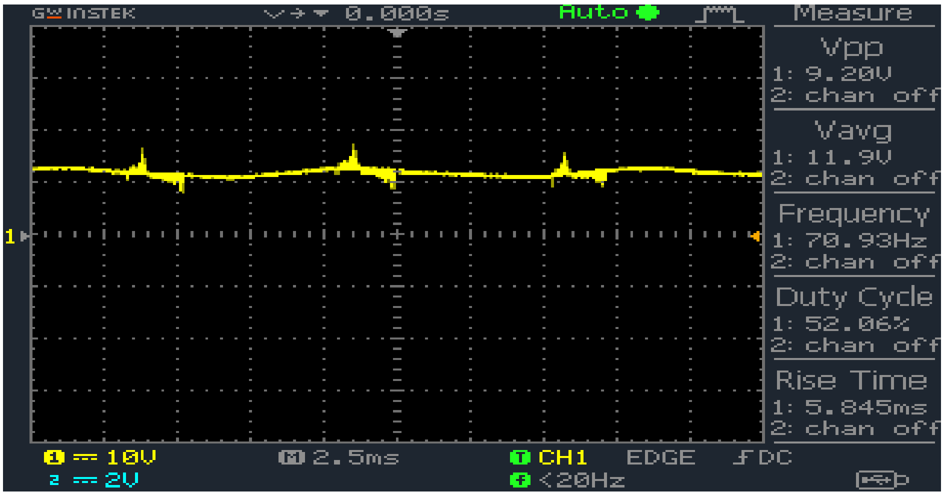

Fig 5. Hardware Input Voltage

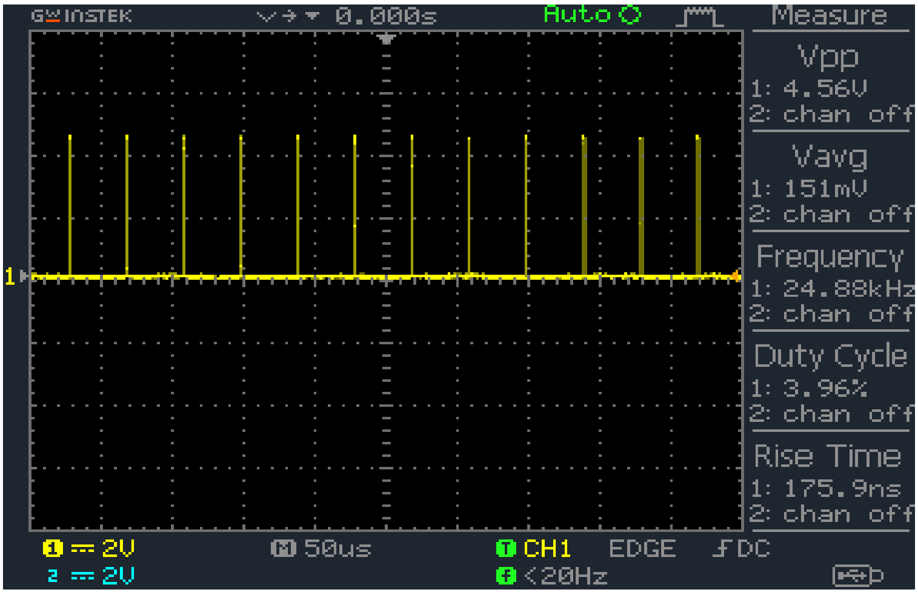

Fig 6. Pulse Waveform

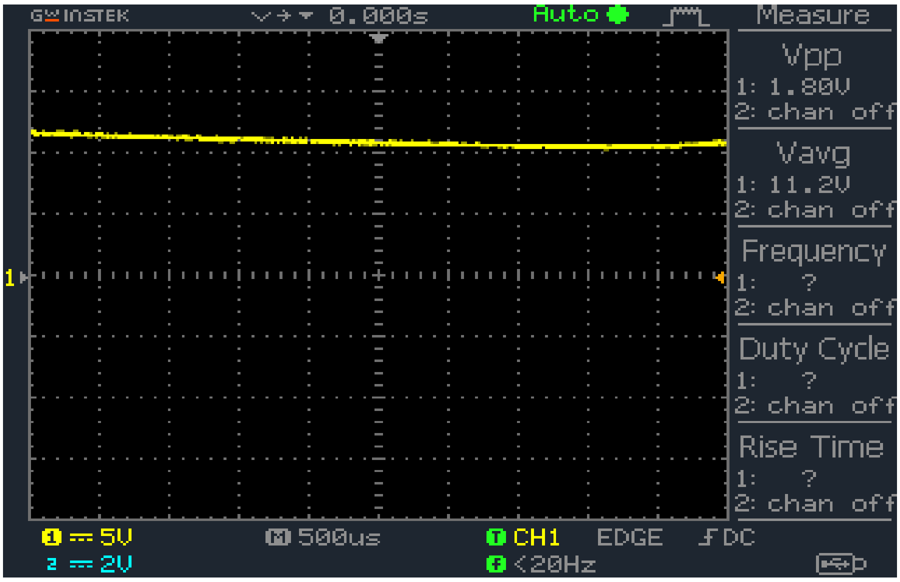

Fig 7.Output Voltage V1

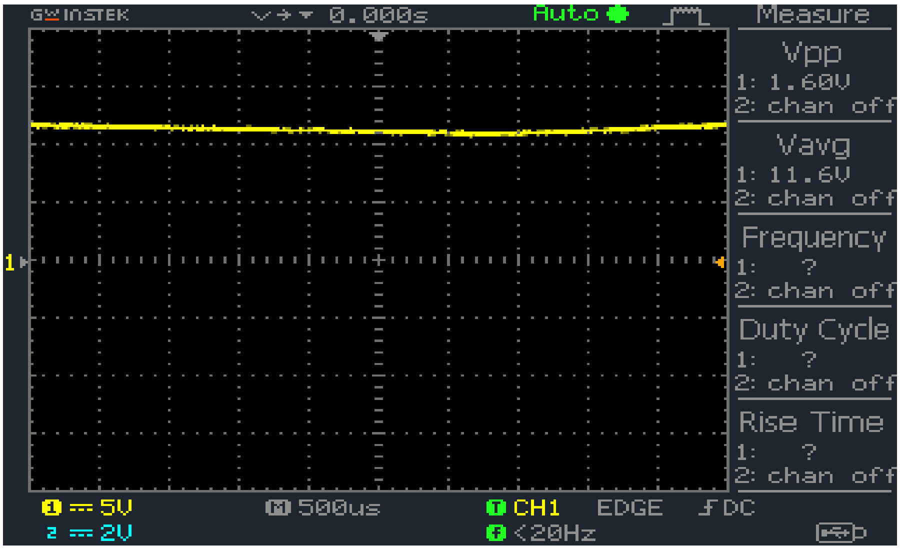

Fig 8.Output Voltage V2

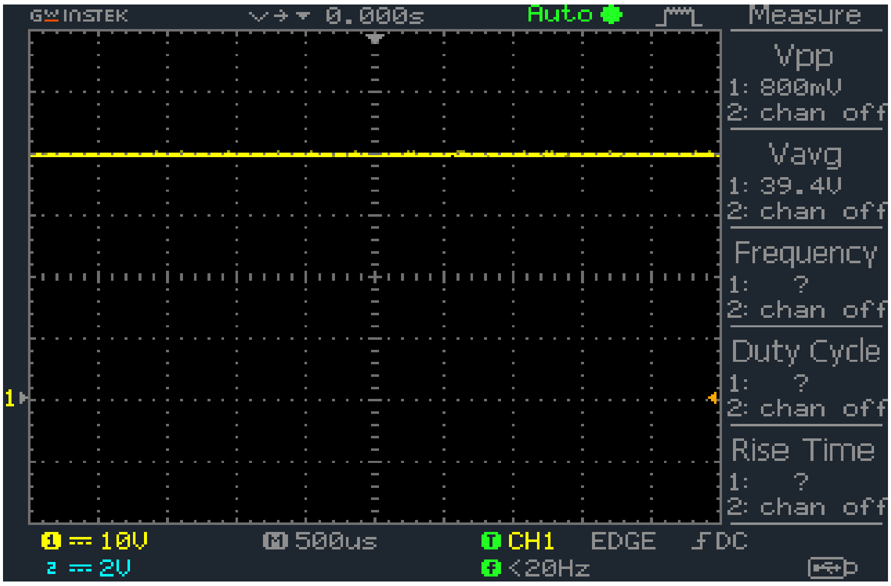

Fig 9.Output Voltage V3

The proposed HSTDC has an excellent stabilization under various experimental conditions and input voltage variations. From the experimental verification, the maximum power conversion efficiency is over 96% due to the soft-switching technique. In this study, the proposed HSTDC incorporates a coupled inductor, a power switch, four Schottky diodes, two metalized-polyester film capacitors, and one auxiliary inductor to achieve the objectives of high-efficiency power conversion, zero-current-switching (ZCS) turned-on, and single-input triple-outputs feature

In order to further regulate the output voltage levels independently, an active switch and a three-winding coupled inductor can be introduced to manipulate the output voltage levels with different duty cycles. By this case, the new circuit framework and multiple-input multiple-output (MIMO) dc/dc converter used in power systems also can be further investigated in the future research.

V. REFERENCES

[1] L. Albiol-Tendillo, E. Vidal-Idiarte, J. Maixe-Altes, S. Mendez-Prince, and L.Martinez Salamero,"Seamless slidingmode control for bidirectional boost converter for electric vehicle applications with output filter," IET Power Electron., vol. 8, no. 9, pp. 1808–1816, Jun. 2015.

[2] R. T. Naayagi, A. J. Forsyth, and R. Shuttleworth, ‘‘Performance analysis of extended phase-shift control of DAB DC-DC converter for aerospace energy storage system,’’ in Proc. IEEE 11th Int. Conf. Power Electron. Drive Syst., Jun. 2015, pp. 514–517.

[3] J.M.Shen, H.L.Jou, and J.C.Wu, ‘‘Transformerless single-phase three wire line-interactive uninterruptible power supply,’’ IET Power Electron., vol. 5, no. 9, pp. 1847–1855, Nov. 2012.

[4] Z. Amjadi and S. S. Williamson, "Conception concept and hybrid controller implementation electric vehicle batteryultra-capacitor energy storage system," IEEE Trans.Smart Grid, vol.3,no. 1,pp. 332–340, Mar. 2012.

[5] J.Cao and A.Emadi, "A new hybrid battery / ultracapacitor for hybrid electric vehicles," IEEE Trans. Power Electron., vol . 27, no. 1, pp. 122–132, Jan. 2012.

[6] Wang, "a ripple-free low frequency input current fuel cell power conditioner Using control oriented decoupling strategy for power pulsation, "IEEE Trans Power Electron., vol. 29, no. 1,pp. 159–169, Jan. 2014.