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A New Multi-Output DC-DC Converter for Electric Vehicle Application

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Abstract: Electronics on the go and EVs rely heavily on multiport converters. Various SIMO converter configurations have been reported in academic literature. Duty ratio and inductor charging are the parameters under which the majority of SIMO converters produce their outputs. The problem of cross-regulation is still present in SIMO converters. To circumvent these issues, this study recommends a SIMO design. The creation of the three separate output voltages is not constrained by any constraints on the duty cycle or inductor currents (iL1 > iL2 > iL3, or iL1 iL2 > iL3). Because the proposed topology sidesteps cross regulation problems, variations in the output current i03 (i02) (i01) do not impact the load voltage V01 (V02) (V03). Keeping the loads separate is an important aspect of regulation. In order to build the proposed system, MATLAB/Simulink is utilised to validate the simulation findings.

Keywords: Converters, EV, SIMO, PV System.

1. INTRODUCTION

There is a growing need to identify alternative energy sources because to the rising worldwide demand for electricity and the environmental and economic limitations of traditional energy sources like fossil fuels and nuclear power. In the realm of alternative energy, renewable sources have garnered a lot of attention. A result of this is the explosion of ideas surrounding smart grids and distributed generators (DGs). Due to their diminutive size and significant potential integration in future smart grids, distributed generation (DG) systems cannot be economically or practically served by the traditional optimum power flow (OPF) model. A practical approach to managing and controlling such distributed, small-scale generators is to arrange them in microgrids. The smart grid's innovation zone is microgrids, which allow for the control of distributed generation (DGs) and the realisation of smart grid goals due to their scalability and adaptability. The PCC is the connection point between a

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microgrid and the larger grid. The microgrid may be linked to motors, capacitor banks, generators, and DGs via a number of buses. Cleaner and more efficient energy extraction methods are highly sought after because to the growing demand for energy and the mounting environmental strain on conventional concentrated power generating methods based on fossil fuels, coal, and nuclear power.

Normally, electric vehicles' auxiliary electrical systems would take care of the load requirements. The cross-regulation problem and the absence of load separation while operating are the key downsides of this approach, despite its seeming simplicity. Having many loads turned on while charging the battery increases the likelihood of grounding issues. The circuitry will get even more intricate with the addition of a buck-boost mode to one of the output's negative voltages. Most of the research is going to be devoted to the onboard power converter. Instead of sharing the power stored in the inductor with all of the outputs during management, the circuit is constructed such that just one output may use it. This makes it possible to regulate the output voltages independently of each other in relation to duty cycles. Importantly, the cross-regulation problem is substantially eliminated since the loads split during control. Additionally, grounding is not a problem, even while filling the battery & ground at the same time, thanks to the onboard power converter.

Ev Applications

To power its electric drive system, an electric vehicle can draw electricity from a variety of sources, including batteries, fuel cells, and supercapacitors. One or more energy storage devices work in tandem with the primary energy source in electric vehicles. This allows for a considerable improvement in performance while simultaneously reducing the system's cost, mass, and volume. The two most common methods of storing energy are SCS and batteries. Several methods exist for connecting them to the fuel cell stack. Based on the various EV power supply arrangements, it is evident that connecting the FC, battery, or super capacitors module to the DC-link requires a DC/DC converter. An electrical circuit that briefly stores the energy input and then releases it to the output at a different voltage is known as a direct current to direct current (DC to DC) converter. These converters fall under the category of power converters in electric engineering. Both electric field storage components (capacitors) and magnetic field storage components (inductors, transformers) can be used for the storage. There is a single direction of power transmission that DC/DC converters can be configured to handle. It is possible to make nearly any DC/DC converter topology bidirectional, though. For applications that call for regenerative braking, a bi-directional converter's ability to transfer power in both directions comes in handy.

Proposed System

Figure 3.1(a) shows the suggested DC-DC setup with a single input and three outputs. Voltage differential (VDC), switches (S1–S3), diodes (D1–D3), and passive components (L1–C1, L2-C2, and L3–C3) make up this setup. It is capable of producing three distinct voltages as an output: boost (V01), buck-boost (V02) with a positively charged voltage polarity, and buck (V03). You may use the duty cycles D1, D2, and D3 to individually control the output voltages with the converter that is being suggested. Figure 3.1(b) shows the

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assumed waveforms of the circuit components. Traditional configurations that combine buck, boost, and buck-boost in parallel are different from the one that is presented. To ensure that the circuit can handle many loads at once, they are isolated during design. Mode-1 functioning is depicted in Figure 3.2(a), and the pictures that follow show that S3 is the single connection between the input power source and load R3. The remaining cargoes are kept separate. Figure 3.2(b) shows that in mode-2, the input source is connected to just load R1 through D1. The remaining cargoes are kept separate. No matter what the mode of functioning is, the proposed control approach keeps the loads separate. Having said that, this quality is not achievable with the conventional configuration of buck, boost, and buck-boost converters functioning in tandem. It may not look like much, but this circuit configuration is really quite clever and practical.

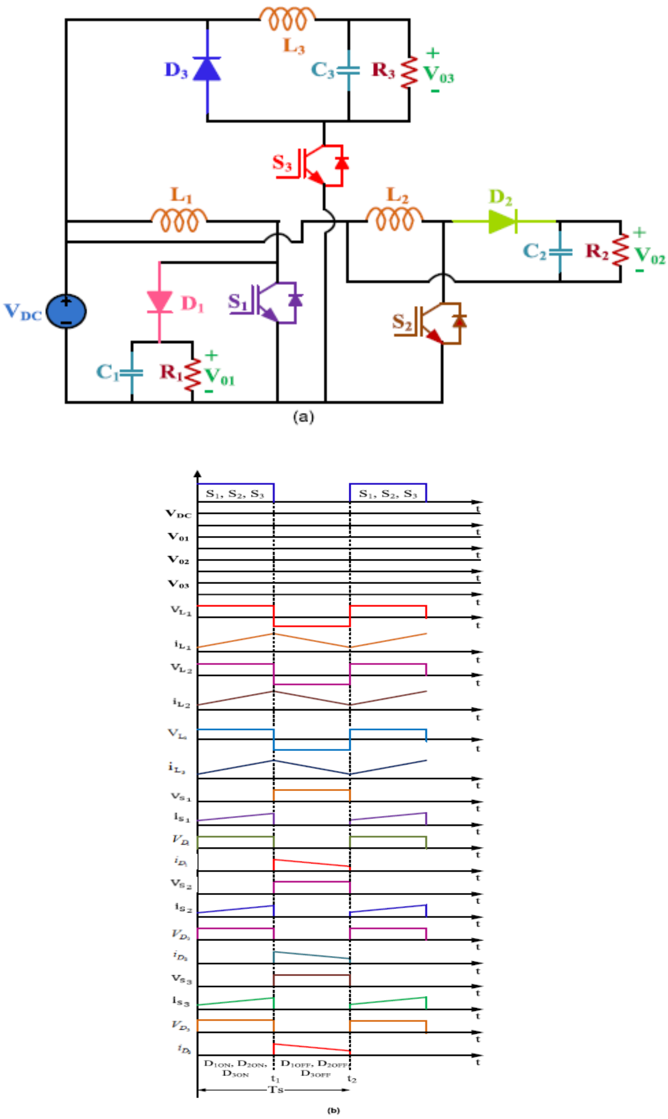

Fig.1.1: Proposed configuration: (a) SIMO configuration, (b) Theoretical waveforms.

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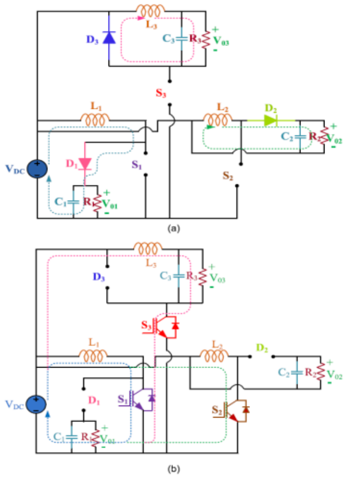
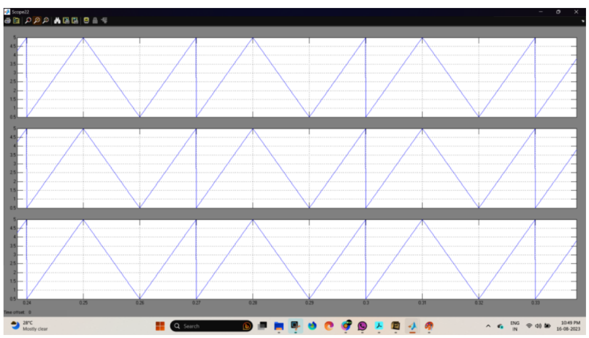


Fig.1.2: Operating states: (a) Switching state-1 and (b) Switching state-2.

As illustrated in Figure 3.2(a), it is noticeable that while switching state-1 operation, only load (R3) is linked to the ground through S4. However, all other loads remain isolated, even while the ground is involved in the battery charging process. As shown in Figure 3.2(b), in switching state-2, only load (R1) is linked to the earth through D1. All other loads are separated from both the ground and R1. Regardless of the mode of operation, the loads are kept separate in the suggested control method. In addition, the circuit's design permits independent control of the output voltages with respect to duty cycles by connecting the inductor's stored energy to a single output rather than sharing it with the other outputs. Consequently, the change in load current i03 (i02) (i01) has no effect on the load voltage V01 (V02) (V03). Therefore, all concerns regarding crossregulation are eliminated in the suggested configuration using this control strategy, even when the ground is engaged in the battery charging process. Moreover, the straightforward design allows for the generation of three separate outputs devoid of assumptions regarding operational duty cycle and inductor currents (iL1 > iL2 > iL3 or iL1 < iL2 < iL3 or iL1 D iL2 D iL3).

2. SIMULATION RESULTS

In order to test the suggested system with VDC D 50 V, frequency 50 kHz, and duty ratio 50%, the model was created in the MATLAB environment.



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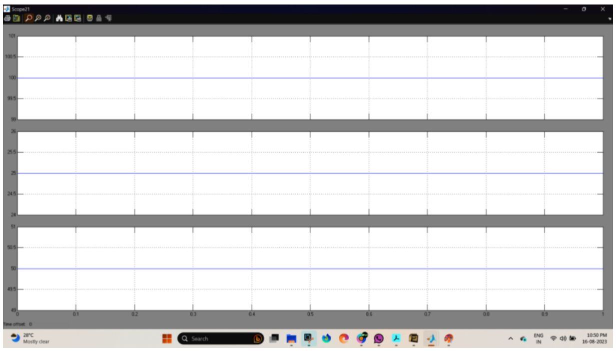


Fig.2.1: Voltages and Currents (V01, iL1, V03, iL2, V0, iL3). (Existing system)

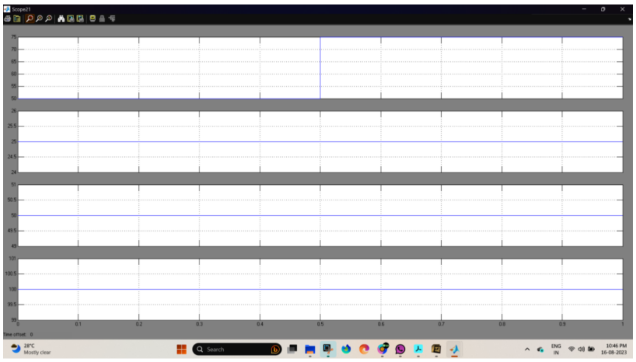
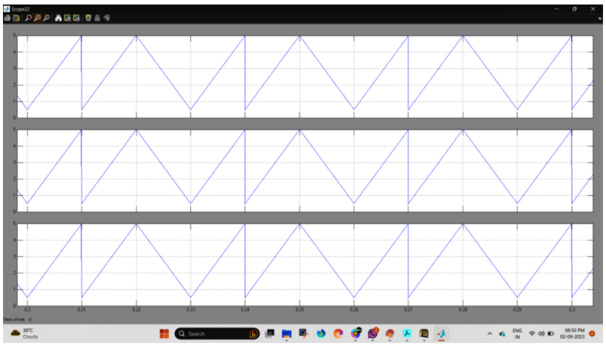


Fig.2.2: Performance of closed-loop control for a sudden variation in input voltage (VDC) at 0.5 sec. (Existing system)



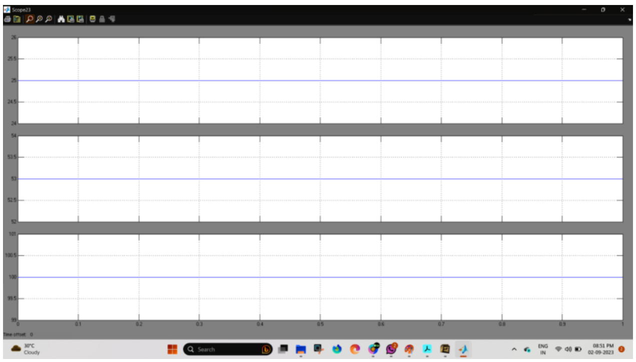


Fig.2.3: Voltages and Currents (V01, iL1, V03, iL2, V0, iL3). (Proposed system)

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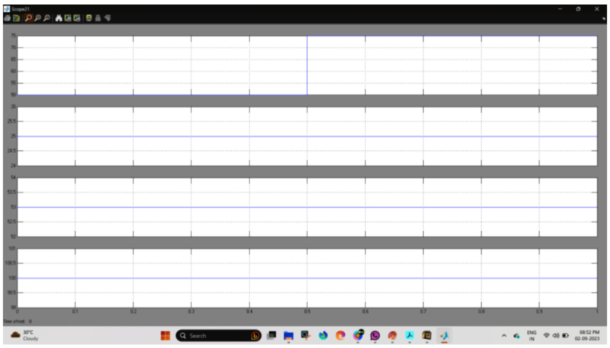

Fig.2.4: Performance of closed-loop control for a sudden variation in input voltage (VDC) at 0.5 sec. (Proposed system)

Figure shows the appropriate inductor currents (iL1, iL2, and iL3) and output voltages (V01, V02, and V03). The suggested setup makes use of closed-loop control, and the system's dynamic performance is checked for an abrupt shift in the input voltage. Figure displays the closed-loop control simulation outcome for a half-second input voltage (VDC) spike from 50V to 70V. Kp D 0.1 and Ki D 15 are the PI control gains for the Buck output, while Kp D 0.005 and Ki D 0.5 are the values for the Boost and Buck-Boost voltages, respectively. The outcomes demonstrate that the suggested setup produces robust, independent voltage outputs and is immune to the impact of a rapid shift in power source.

3. CONCLUSION

In this work, we present the SIMO converter's suggested structure. There has been an extensive explanation of the working principle and modalities of action. The suggested setup is straightforward and doesn't presume anything about the inductors' charging or running duty cycle. It has three separate controlled voltage outputs: buck, boost, and buck-boost. The output voltages are unaffected by the abrupt change in inductor and load currents since the suggested topology does not have cross regulation issues. The operating and performance of the suggested converter are finally validated by the results of the MATLAB/Simulink simulation.

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