Novel Design of VLT CUK Converter

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ABSTRACT: The main purpose of this paper was to create a novel topology of CUK dc/dc converter. This thesis talks about the importance of dc-dc converters and why CUK converters are used instead of all other dc-dc converters. This project also goes into detail about analysis of CUK converter with novel voltage lift technique optimization and control. All the basic converters results are compared with novel topology by using PROTEUS software.

Keywords: VLT (Voltage Lift Technique), CUK converter, PROTEUS.

I. INTRODUCTION:

DC to DC converters are essential in portable electronic gadgets such as cellphones, laptop, computers, car auxiliary power supplies, industrial applications and medical equipment which are supplied from batteries. Such electronic devices had several sub circuits which require unique voltage like higher or lower than the battery voltage, or even negative voltage.

DC to DC converters offers multiple controlled DC output voltages from a single variable battery voltage, instead of using multiple batteries to supply different parts of the electronic devices.

These converters will be widely used in computer peripheral equipment and industrial applications, especially for high output voltage projects. In recent years, the DC-DC conversion technique has been greatly developed. The main objective is to reach a high efficiency, high power density and topology in a simple structure. There are 5 main types of dc-dc converters.

Buck converter, Boost converter, Buck-boost converter, CUK converter, SEPIC converter.

Buck converters can only reduce voltage, boost converters can only increase voltage, and buck-boost, CUK, and CUK converters can increase or decrease the voltage. Another issue that can complicate the usage of buck-boost converters is the fact that they invert the voltage. CUK converters solve both of these problems by using an extra capacitor and inductor.

However, both CUK and buck-boost converter operation cause large amounts of electrical stress on the components, this can result in device failure or overheating. CUK converters solve both of these problems. The CUK converters are good topologies which have been developed. Because of the effect of parasitic elements, the output voltage and power transfer efficiency of all DC-DC converters is restricted.

The voltage lift technique is a popular method widely applied in electronic circuit design [1-9]. It can lead to improvement of DC-DC converter characteristics. After long term research, this technique has been successfully applied to DC-DC converters.

![Figure 1.1(a): Triple lift](image1.png)  1.1(b) Multiple lift

Figure 1.1(a): Triple lift  1.1(b) Multiple lift
2. ANALYSIS OF DC – DC CONVERTERS

Features of a buck converter:
It requires input filter with pulsed current. It delivers continuous output current. It leads to lower voltage ripple.

Features of a boost converter:
In boost converter no need for input filter. It increases the voltage ripple. Load voltage is always greater than input supply voltage.

Features of a buck - boost converter:
Pulsed input current, requires input filter. Pulsed load current increases voltage ripple. Load voltage can be either greater or lesser than supply voltage.

Features of CUK converters:
Continuous input and output current. Load voltage can be either greater or lesser than input voltage.

Features of SEPIC converters:
Like buck-boost converters, SEPIC have a pulsating output current. Since the SEPIC converter delivers all its power via the input series capacitor. The capacitor with high capacitance and current handling capability is required.

3. VOLTAGE LIFT TECHNIQUE:
Voltage lift technique is an efficient method widely applied in design of electronic circuits. In recent years it has been successfully employed in DC-DC converter applications, and builds a way to design high-voltage gain converters. VLT converters [8-9] are different from any other DC-DC step-up converters. It has many advantages including the high output voltage with smooth ripples. But existing converters are not economical. Because of the effect of parasitic elements, the output voltage and transfer gain of converters is limited. In order to overcome these limitations and to make efficient converter with a simple new technique called voltage lift technique. The performance of VLT converter is superior with the following credits.

(i) It can perform similar to classical boost converter with high-voltage transfer ratio.
(ii) Wide range of control with smooth ripple at the output voltage.
(iii) High power density
(iv) Comparatively high efficiency than classical boost converter.

In this proposed method all the components that are ideal and the capacitors values are large enough and also assume that the circuits operate in continuous conduction mode. This circuit consists of passive components: one static switch (Power MOSFET), two diodes, four inductors and two capacitors perform the characteristics to lift the output voltage.

The basic principle of this circuit is enhance the output voltage by charging and discharging reactive elements into a load, and consequently controls the output voltage by switching the source in and out of the circuit at very high frequencies. They had a freewheeling diode to protect the active switch from the inductors reverse currents.

There are many topologies available
i) Self-lift circuit [8][12]
iii) Multiple-lift circuits[2][5][9] (e.g. triple-lift and multiple-lift circuits) showed in Figs. 1.1(a) & (b) respectively.

This project introduces the skills to design new lift dc–dc converters using voltage lift technique. Lift converters are a group of new dc–dc step-up converters, which are developed from the basic prototypes [1]–[7].

The conventional method which have been already implemented are,

i) Self-lift converter
ii) Self-lift positive output converter.
iii) Self-lift negative output converter.
iv) Self-lift CUK converter.

The above listed methods are described with following Schematic representations.

![Fig 3.1 Self-lift converter.](image1)

![Fig 3.2 Self-lift positive output converter.](image2)
4. PROPOSED MODEL:

The proposed methods develop a new series of DC-DC step-up (boost) converters namely modified CUK Converters which eliminates the auxiliary switch in the original Positive Output Converters yet perform the same functions.

Thus modified CUK converters (Fig 4.1) have been used in high voltage regulated power supply. Detailed analysis is given in the following sections. The elementary circuit (CUK or Zeta converter) which can perform both step-down and step-up DC-DC conversion.

5. DESIGN OF NOVEL TOPOLOGY CUK CONVERTER

Inductor Selection:

A good rule for determining the inductance is to allow the peak-to-peak ripple current to be approximately 40% of the maximum input current at the minimum input voltage.

Input Capacitor Selection

Similar to a boost converter, the CUK has an inductor at the input. Hence, the input current waveform is continuous and triangular. The inductor ensures that the input capacitor sees fairly low ripple currents. The input capacitor should be capable of handling the RMS current. Although the input capacitor is not so critical in a CUK application, a 10μF or higher value, good quality capacitor would prevent impedance interactions with the input supply.

6. SPECIFICATIONS:

The converter should meet certain standards

<table>
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<td>12V</td>
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<tr>
<td>2</td>
<td>Vout</td>
<td>-15.2V</td>
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<td>3</td>
<td>Duty cycle</td>
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<td>4</td>
<td>Iout</td>
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Table 6.1 design specifications of Modified CUK converter
7. SIMULATION AND EXPERIMENTAL RESULTS OF SELF-LIFT CUK CONVERTER

Modified CUK converter with Voltage Lifting technique has been designed and compared with basic DC- DC (Buck, boost, CUK) converters model and simulated using PROTEUS software and the results were obtained are discussed in this chapter.

I) Buck converter

Figure 7.1: Simulation Model of Buck Converter

Figure 7.2: Waveform of Buck Converter

II) Boost converter

Figure 7.3: Simulation Model of Boost Converter

Figure 7.4: Waveform of Boost Converter

III) CUK converter

Figure 7.5: Simulation Model of CUK Converter

Figure 7.6: Waveform of CUK Converter (31%)

Figure 7.7: Waveform of CUK Converter (81%)
IV) Modified CUK converter

The modified CUK topology fig 4.1 shows that it can be act as both buck and boost converter whenever the duty cycle below 50% CUK converter act as buck converter but in this case the modified CUK converter delivers the output power higher than the input when the duty cycle is 31%.

From that we conclude that lifting the voltage even below the 50% duty cycle. Lifting topology can be varied like triple lift, multiple lift. Whenever the lifting components L-D-C-D increase the switching loss can be minimized. Here the value of lifting component L=500uH and C=22uF connected parallel with input inductance which stores and deliver the power to the load. During On condition it stores the energy and During Off condition it Lifting the energy and deliver to the load. This topology has been simulated under the switching frequency about 50K and duty cycle varied about 31% to 71%.

8. CONCLUSION:

The consequences on implementation of a Modified Converter with Voltage lifting technique and compare with basic buck-boost converters are investigated in this thesis. This paper introduced an implementation method of the VL technique in the traditional CUK converter. The simulation model is developed for Modified CUK converters with voltage lifting component. From the analysis and simulation results, it is seen that the proposed novel VL-type converters can greatly increase the voltage conversion ratios without resorting to higher values of duty ratio. The Modified CUK converter simulation results and waveforms has been verified and compared with buck, boost, and normal CUK converter.

REFERENCE:


[13] Luo, F.L., "Negative output Luo converters: voltage lift technique" ISSN: 1350-2352

[14] Online Reference:
http://libra.msra.cn/Publication/50121476/luo-converters-voltage-lift-