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# A Cuk Converter with Hysteretic Transition Method for Avoiding Dead-Zone Effect and Sub Harmonics

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**Abstract—This project deals with a Hysteretic transition method for Cuk converter is a common choice when designing highly efficient power conditioning units for applications which require buck-boost features along with low current and voltage ripple. Its advantageous features include high power conversion efficiency, low voltage ripple, and low stress on both the active and passive components within the circuit. The Cuk converter affect with dead zone problem during mode changes. As a result it produce voltage ripple, sub-harmonics in the output voltage, poor regulation and instability during operating mode transitions. A new hysteresis window method is proposed as a solution for avoiding the operational dead-zone that exists at the transition between buck and boost operating modes in all Cuk converters. In addition, this method also eliminates the discontinuities in the converter's steady-state output voltage transfer characteristic, which is a function of the duty cycle. The converter's output voltage function is subjective and therefore smooth mode transitions are achieved. The dead-zone avoidance technique proposed in this paper eliminates all these issues while at the same time ensures highly efficient operation of the converter. An additional advantage of the technique is its simplicity, which allows for implementation into low-cost digital signal controllers, as well as into analog control circuits. The features of the proposed approach are evaluated by using MATLAB / Simulink and the experiment output will be evaluated by a prototype Hardware.**

***Index Terms*—DC-DC power converters, non-inverting buck boost converter, dead-zone avoidance, digital control, and buck-boost transitions.**

## I.INTRODUCTION

Dead zone effects are an important issue at the time of transition between buck boost operating modes. Due to dead zone effect, efficiency of a converter is reduced and it should be eliminated. Hysteretic transition method is used to avoid the dead-zone effects. It allows for implement into both digital signal controllers, as well as into analog control circuit. Hysteretic transition method is used to avoid the dead-zone effects. It allows for implement into both digital signal controllers, as well as into analog control circuit.

Hysteresis is the dependence of the output of a system not only on its current input, but also on its history of past inputs. The dependence arises because the history affects the value of an internal state. To predict its future outputs, either its internal state or its history must be known. If a given input alternately increases and decreases, a typical mark of hysteresis is that the output forms a loop. Such loops may occur purely because of a dynamic lag between input and output. This effect disappears as the input changes more slowly. This effect meets the description of hysteresis but is often referred to as rate-dependent hysteresis to distinguish it from hysteresis with a more durable memory effect.

Hysteresis occurs in ferromagnetic materials and ferroelectric materials, as well as in the deformation of some materials in response to a varying force. In natural systems hysteresis is often associated with irreversible thermodynamic change. Many artificial systems are designed to have hysteresis, for example, in thermostats and Schmitt triggers, hysteresis is used to avoid unwanted rapid switching. Hysteresis has been identified in many other fields, including economics and biology. Hysteretic band is available which consist of two limits, upper limits and lower limits. The upper limits are used to turn on the switches and lower limit is used to turn off the switches within band. For the alternating operation of switches so it is called as hysteretic transition method. Therefore, a so-called dead-zone is formed around the transitions between the buck and boost operating modes.

The dead-zone represents a discontinuity in the converter's dc voltage transfer function and causes pulse skipping and random jumps in the output voltage when operating close to the border between buck and boost operating modes. The converter exhibits increased output voltage ripple, sub harmonics in the output voltage, poor regulation, and instability during operating mode transitions.

## II. SYSTEM STRUCTURE AND ANALYSIS

### *A.BLOCK DIAGRAM*

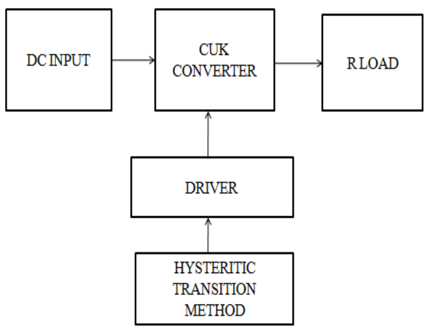



Fig 2.1 Block diagram of Cuk converter

This project involves with a Hysteretic transition method. This method also eliminates the discontinuities in the converter's steady-state output voltage transfer characteristic, which is a function of the duty cycle. The converter's output voltage function is subjective and therefore smooth mode transitions are achieved. The dead-zone avoidance technique proposed in this paper eliminates all these issues while at the same time ensures highly efficient operation of the converter. An additional advantage of the technique is its simplicity, which allows for implementation into low-cost digital signal controllers, as well as into analog control circuits.

## III. CIRCUIT DIAGRAM

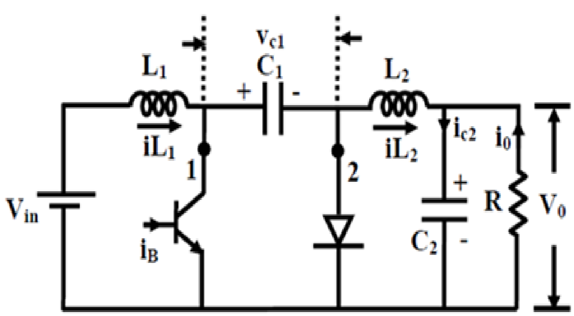
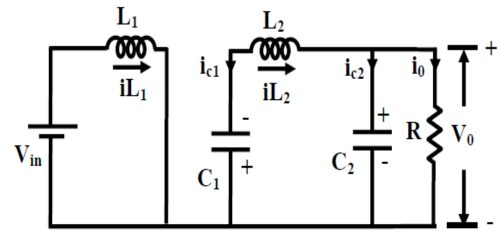



Fig 3.1 Circuit diagram of Cuk converter

Transfer energy from source to load both during ON\OFF period. Capacitor work as an energy storing element. Polarity of output voltage is reversed .The Cuk converter is a capacitive energy fly back converter. Cuk converter provides an output voltage which is less than or greater than the input voltage but the output voltage polarity is opposite to that of the input voltage.

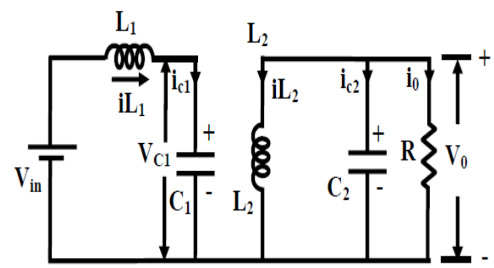
## IV.MODES OF OPERATION

MODE 1:




When switch is under ON condition, $L_1$ is under charging condition. At that time $C_1$ charging $L_2$ at the same time carry the load.

MODE 2:




When switch is under OFF condition .$V_{in}$ and $L_1$ charge C1, the load will be carry by Vin, C1 and L2.

## V. DEADZONE AVOIDANCE

The impulse is on at high level off at low level. The dead-zone time, off time and on time of the switching tube are $T_d$,$T_{off}$ and Ton respectively. The purpose of adding dead-zone time is that when one switching tube is off the other tube on after the dead-zone time .Consider the on and off time of the switching tube, the time error introduced by the delayed on time is expressed in

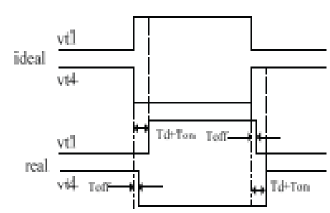


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Fig 5.1 Diagram showing deadzone effect

*A. Dead-Zone Avoidance*

The following subsections present and analyze several of the more common and simple dead-zone avoidance techniques with aim of stabilizing a firm ground for evaluating the novel technique proposed in this paper. All the dead-zone avoidance techniques discussed in this paper are evaluated on the basic of power conversion efficiency, output voltage ripple, and ability for eliminating the discontinue operation mode transitions. All other losses can be assumed as equal when using different dead-zone avoidance techniques at a fixed switching frequency and a given operating point. There is a close relation between the converter output voltage ripple, sub harmonics and discontinuities in the dc voltage conversion ratio characteristics.

## VI.SIMULATION RESULT

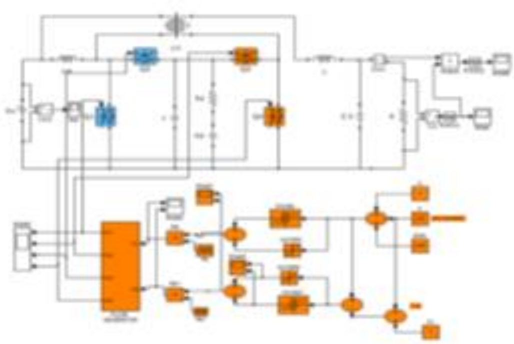

Fig 6.1 Simulation circuit of Non-Inverting Buck-Boost Converter

The Simulation done by MATLAB\SIMULINK to verify the practical implementation of the Existing Non-inverting Buck-Boost converter for the Hysteretic Transition Method.

*A. With Dead-Zone Effect and Sub Harmonics In A Non Inverting Buck-Boost Converter*

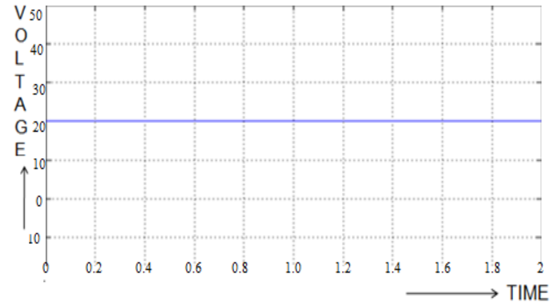


Fig 6.2 Input Voltage Waveform

The input voltage of Non-inverting Buck-Boost converter using Hysteretic Transition Method is shown in Fig 6.2. This input waveform is between voltage $v_s$ time and for this the Non-inverting Buck-Boost converter input is 20v.

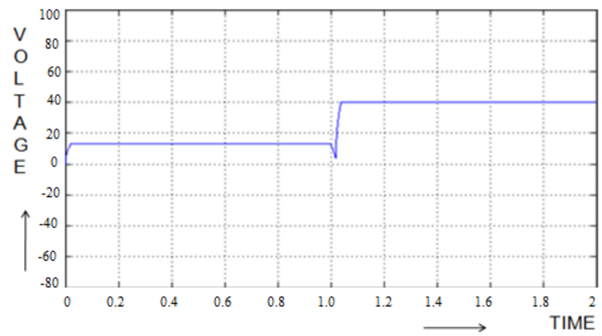


Fig 6.3 Output Voltage Waveform of Non-inverting Buck-Boost converter

The output voltage of Non-inverting Buck-Boost converter using Hysteretic Transition Method is as shown in Fig 6.3.This output waveform is between voltage $v_s$ time and the Non-inverting Buck-Boost converter output is 13 V in buck mode and 40V in boost mode.

*B. Avoiding Dead-Zone Effect and Sub harmonics In A Non-Inverting Buck-Boost Converter*

The output voltage of Non-inverting Buck-Boost converter using Hysteretic Transition Method is as shown in Fig 6.4.

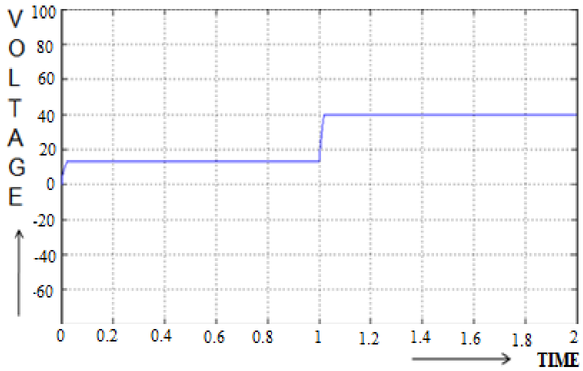


Fig 6.4 Output Voltage Waveform of Non-inverting Buck-Boost converter

This output waveform is between voltage $v_s$ time and the Non-inverting Buck-Boost converter output is 13 V in buck mode and 40V in boost mode.

*C. Cuk Converter With Dead-Zone Effect And Sub harmonics*

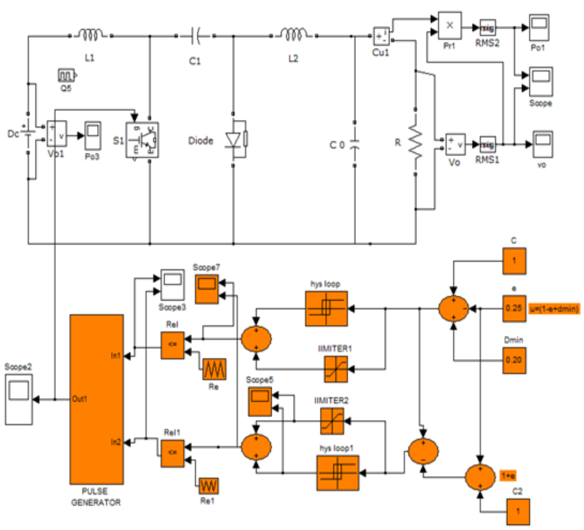


Fig 6.5 Simulation circuit of Cuk converter

The input voltage of Cuk converter using Hysteretic Transition Method is shown in Fig 6.5.The input voltage $V_s$ is shown and the Cuk converter voltage is 20.

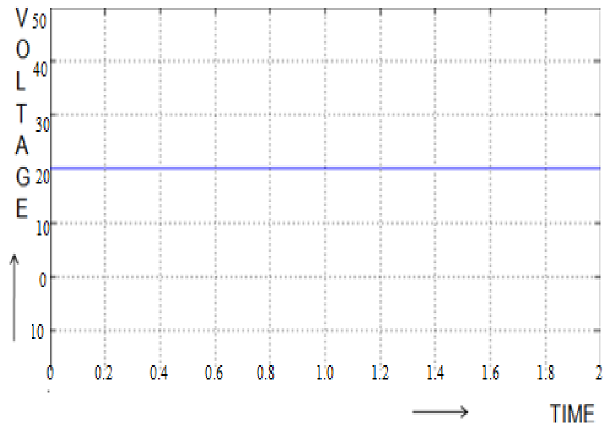


Fig 6.7 Input Voltage Waveform of Cuk converter

The waveform is between voltage $v_s$ time and for this the Cuk converter input is 20v between voltage $v_s$ time.

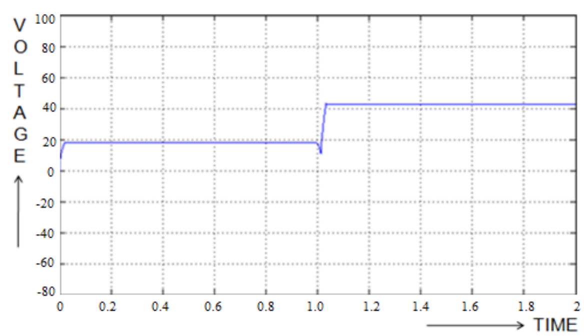


Fig 6.8 Output Voltage Waveform of Cuk converter

The output voltage of Cuk converter using Hysteretic Transition Method is as shown in Fig 6.8.This output waveform is between voltage $v_s$ time and the Cuk converter output is 18 V in buck mode and 43V in boost mode.

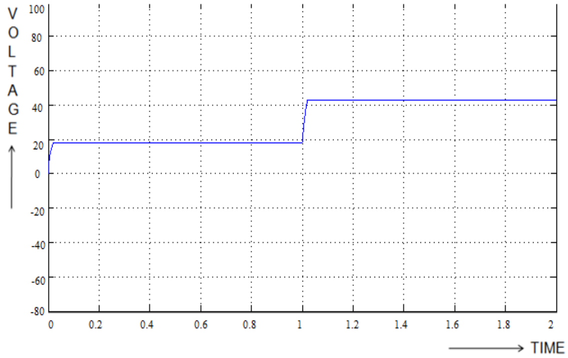


Fig 6.9 Output voltage waveform of Cuk converter

## VII. COMPARISION RESULT

| INPUT VOLTAGE | BUCK-BOOST CONVERTER | | CUK CONVERTER | |
|---|---|---|---|---|
| 20V | BUCK MODE | 13V | BUCK MODE | 18V |
| | BOOST MODE | 40V | BOOST MODE | 43V |

Table 7.1 Comparison Results

## VIII. CONCLUSION

In this project a Cuk converter with Hysteretic Transition Method for avoiding the dead-zone effect and sub harmonics model is done. The DC-DC converter affected with dead-zone problem during mode changes. By using the hysteresis window method is developed based on that the dead-zone effects is eliminated. This simulation is done for both Buck-Boost and Cuk converter based on Hysteretic Transition Method. The simulation results are shown for input and output voltage with and without the effect of dead zone. The results are analyzed for both the converters and found Cuk converter output is efficient

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