CUK CONVERTER AND SEPIC CONVERTER

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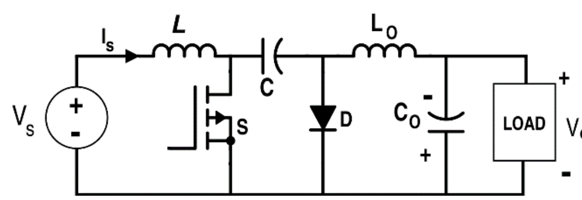
Abstract: In the realm of power electronics, DC-DC converters play a pivotal role in efficiently regulating and converting voltages to meet the diverse requirements of modern electronic systems. Among the myriad of DC-DC converters, the Cuk and SEPIC converters stand out for their unique topologies and versatile capabilities. In this report, we delve into the intricacies of these two converters, exploring their operational principles, advantages, limitations, and key applications.

Keywords: Cuk Converter, Sepic Converter, Current Voltage Waveforms, Voltage Control.

1. Introduction

The Cuk converter, named after its inventor Slobodan Ćuk, and the SEPIC (Single-Ended Primary Inductor Converter) converter, exhibit distinct characteristics that make them well-suited for diverse applications. These converters are particularly valued for their ability to provide stable output voltages from input sources that may vary widely

2.Cuk Converter Working Analysis:



1.During t(on) (Switch-On State):
a)At the beginning of t(on), the switching element (usually a transistor or a MOSFET) is turned on, connecting the input voltage source to the circuit.

b)As the input voltage is applied, current flows through the primary inductor (L1) and charges the inductor.

c)During this time, energy is stored in the inductor in the form of magnetic flux. The current flowing through L1 increases linearly with time.

d)Simultaneously, the capacitor connected to the output (C2) discharges through the load, providing a continuous output voltage.
The voltage across L1 is positive during t(on), and it aids in storing energy in the inductor.

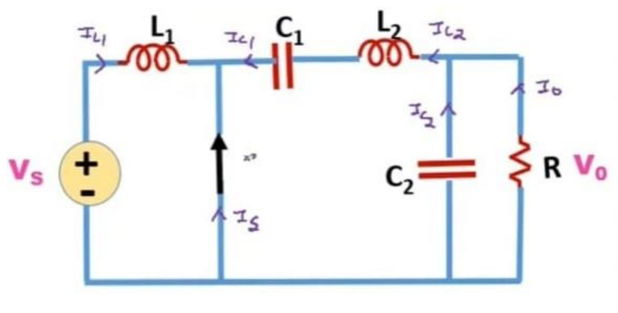


Fig: Schematic diagram of Cuk Converter during ON State(0<=t<=DT)

a)During t(off) (Switch-Off State):
At the end of t(on), the switching element is turned off, disconnecting the input voltage source.
b)As the input voltage is removed, the voltage across L1 reverses polarity. Now, the voltage across L1 aids in delivering energy to the output.
c)The current flowing through L1 starts to decrease, inducing a voltage across it in the opposite direction.
d)This induced voltage forces the current to continue flowing through the load, despite the switch being off.
e)The stored energy in the inductor now discharges through the load and the output capacitor, maintaining a continuous output voltage.
f)The capacitor connected to the input (C1) also discharges through the load, completing the energy transfer cycle.
The voltage across L1 is negative during t(off), and it assists in transferring energy to the load.

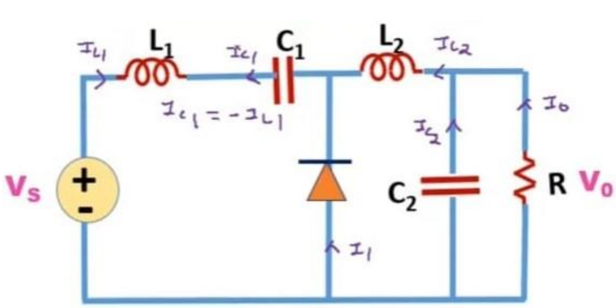


Fig: Schematic diagram of Cuk Converter during OFF State(DT<=t<=T)

Calculations :

GIVEN PARAMETERS :

V(SOURCE) = 5 V
R c1 = 1%
V(OUTPUT) = 12 V
f = 50000Hz
Ro = 1%
LOAD (P_S)= 200W

1.CALCULATING DUTY RATIO:

D = -Vo/(Vs-Vo) = -(-12)/(5-(-12)) = 0.7058 =70.58%

2. CALCULATING AVERAGE INDUCTANCE CURRENT :

$I_{L1}= P_S/V_S$ =200/5 = 40A

3.CALCULATING AVERAGE INDUCTANCE CURRENT :

$I_{L2}= P_S/-V_o$ =200/-(-12) = 16.67A

4.CALCULATE RATE OF CHANGE OF INDUCTOR CURRENT :

$^{\Delta i}{}_{L1} = I_{L1}$ X 10% = 8A

5.CALCULATE RATE CHANGE OF INDUCTOR CURRENT :

ΔiL1 = IL1 X 10% = 3.332A

6. CALCULATE INDUCTANCE L_1 :

$L_1 = VsD/ f\Delta i_{L1}$ = 5(0.7058) /50000(8) = 8.82uH

7. CALCULATE INDUCTANCE L_2 :

$L_2 = VsD/ f\Delta i_{L2}$ = 5(0.7058) /50000(3.332) = 21.18uH

8. CALCULATING CAPACITENCE C_2 :

$C_2 = (1 - D)/8rL2F^2 = 1 - 0.7058/ 8(0.01)(21.18)(50000)^2 = 69.45$ uF

9. CALCULATE LOAD RESISTANCE R :

$R = Vo^2/Ps = (12)^2/200 = 0.72\Omega$

10. CALCULATE RATE OF CHANGE OF CAPACITOR VOLTAGE :

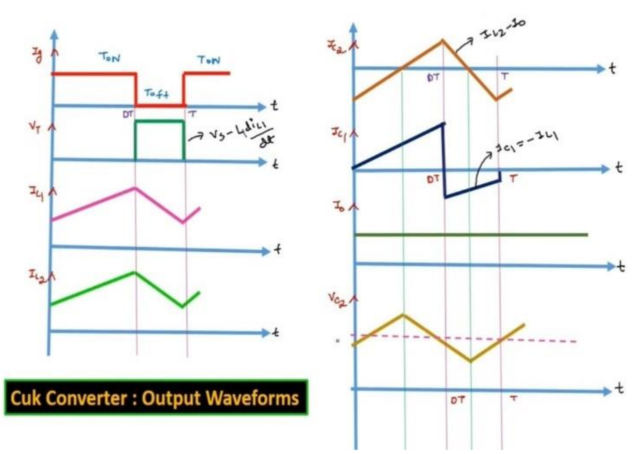
$\Delta Vc_1 = (Vs - Vo) R_{C1} = (5 - (-12))(0.01) = 0.17$

11. CALCULATING CAPACITENCE C_2 :

$C_1 = VoD/ Rf\Delta v_{C1} = 12(0.7058) / 0.72(50000)(0.17)$

$= 1383.92$uF

Waveforms of Cuk Converter:



Mat Lab Simulation for Cuk Converter :

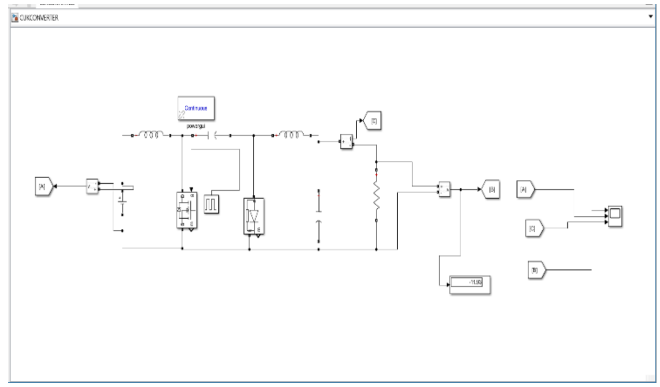


Fig: Simulation of Cuk Converter in OPEN LOOP

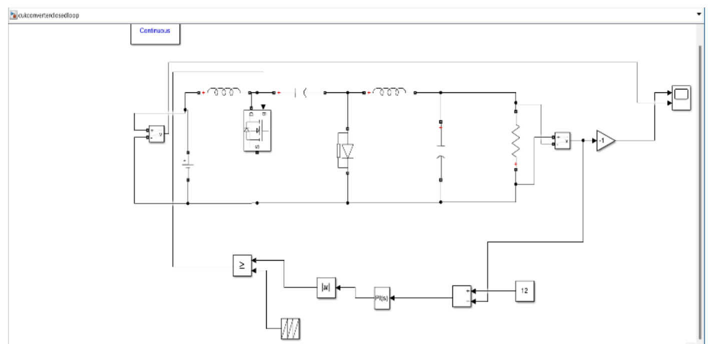


Fig: Simulation of Cuk Converter in CLOSED LOOP

Output Waveforms :

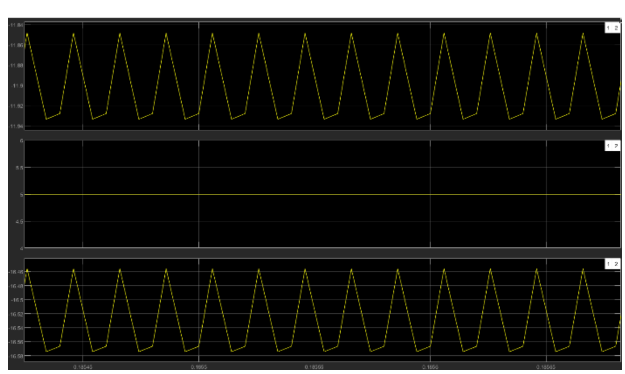


Fig: Graphs of Input Voltage ,Output Voltage and Output Current For OPEN LOOP

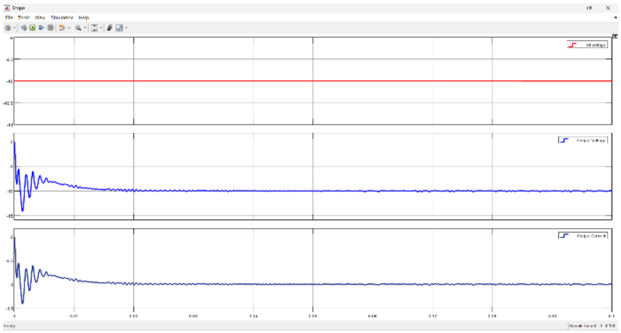
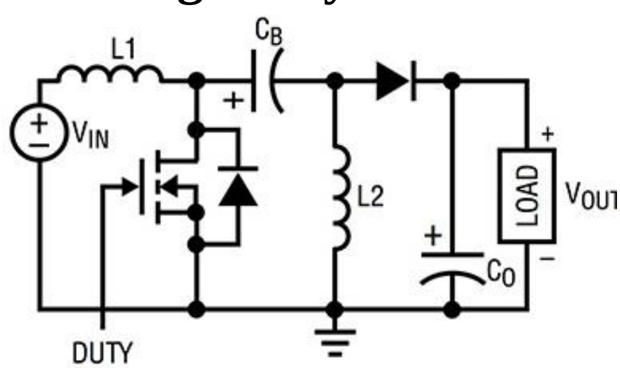


Fig: Graphs of Input Voltage ,Output Voltage and Output Current For CLOSED LOOP

3.Sepic Converter Working Analysis:



During t(on) (Switch-On State):

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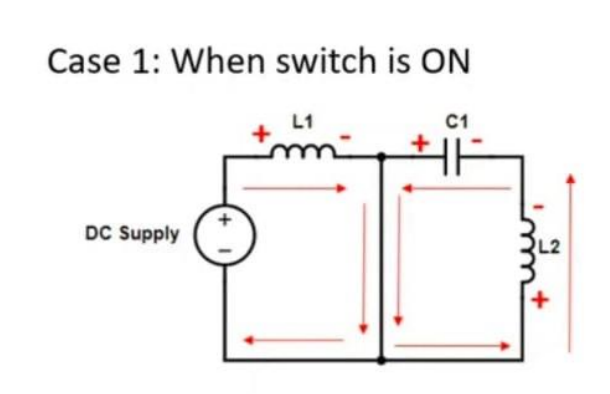
b)As the input voltage is applied, current flows through the primary inductor (L1) and charges the inductor.

c)During this time, energy is stored in the inductor in the form of magnetic flux. The current flowing through L1 increases linearly with time.

d)Simultaneously, the capacitor connected to the output (C2) discharges through the load, providing a continuous output voltage.

e)The voltage across L1 is positive during t(on), and it aids in storing energy in the inductor.



During t(off) (Switch-Off State):

a)At the end of t(on), the switching element is turned off, disconnecting the input voltage source.

b)As the input voltage is removed, the voltage across L1 reverses polarity. Now, the voltage across L1 aids in delivering energy to the output.

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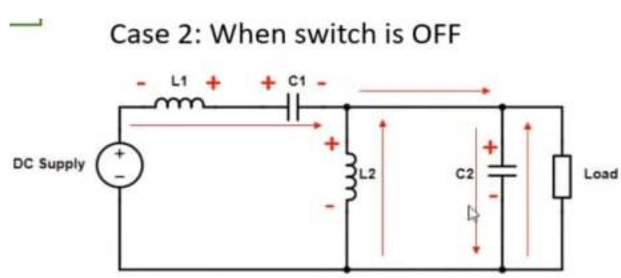
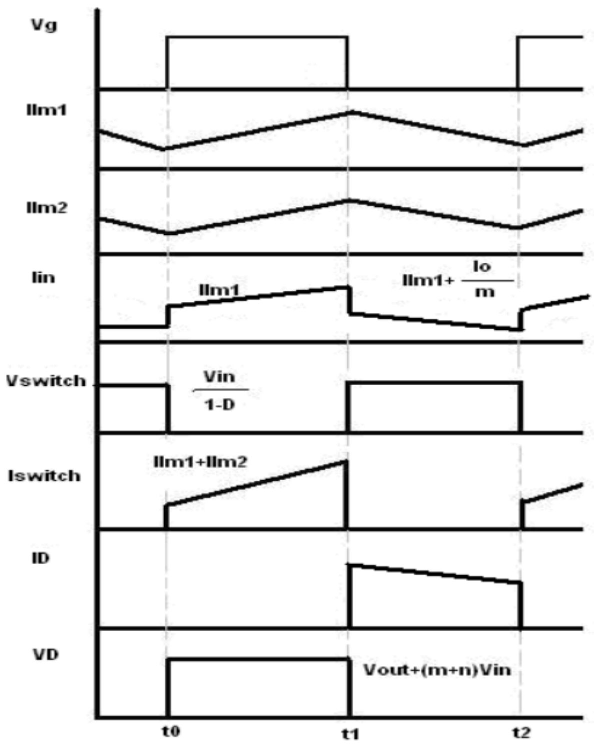
g)The voltage across L1 is negative during t(off), and it assists in transferring energy to the load.



Waveforms of Sepic Converter:



Mat Lab Simulation for Cuk Converter :

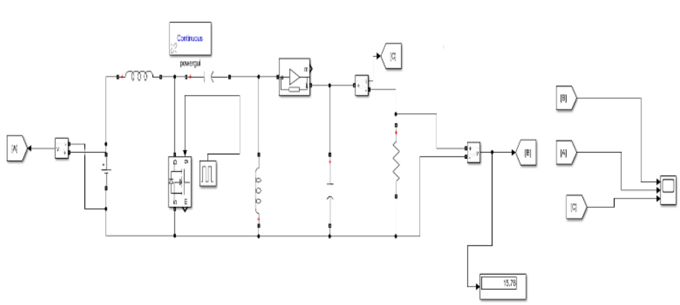
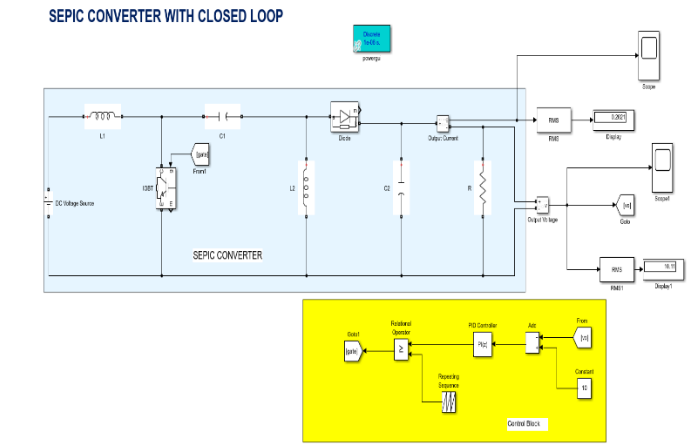


Fig: Simulation of Sepic Converter in OPEN LOOP



. Fig: Simulation of Sepic Converter in CLOSED LOOP

Output Waveforms :

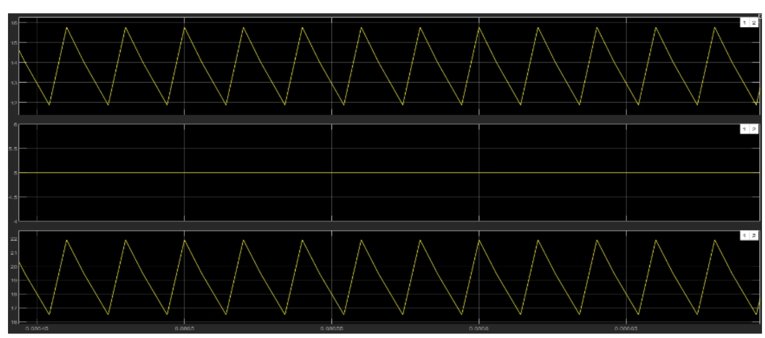


Fig: Graphs of Input Voltage ,Output Voltage and Output Current For OPEN LOOP

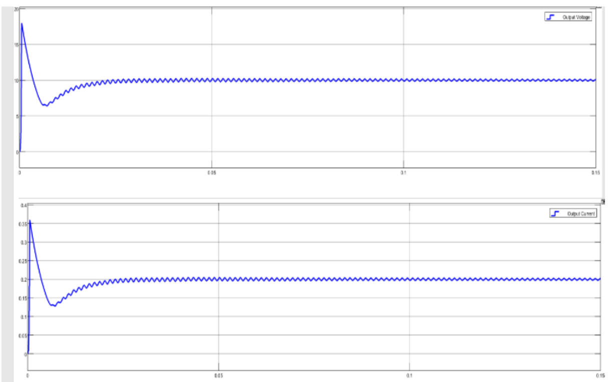


Fig: Graphs of Output Voltage and Output Current For CLOSED LOOP

Applications :

1.Battery-Powered Devices: DC-DC converters are widely used in battery-operated devices such as smartphones, laptops, tablets, and portable medical devices.

2.Automotive Electronics: In vehicles, DC-DC converters are used to power various electronics and subsystems, including infotainment systems, navigation systems, LED lighting, and sensors.

3.Renewable Energy Systems: DC-DC converters play a crucial role in renewable energy systems such as solar and wind power.

4.Industrial Automation: DC-DC converters are used in industrial automation and control systems to regulate voltage levels for various components, sensors, and actuators

5.Telecommunications: In telecommunications infrastructure, DC-DC converters are essential for powering networking equipment, base stations, antennas, and other communication devices.

6.Aerospace and Defense: In aerospace and defense applications, DC-DC converters are used in avionics, radar systems, communication systems, and missile guidance systems.

7.Consumer Electronics: DC-DC converters are found in various consumer electronics beyond just portable

CONCLUSION:

In conclusion, the exploration of Cuk and SEPIC converters has shed light on their operational principles, advantages, limitations, and applications in the realm of power electronics. Both converters offer unique capabilities that make them valuable assets in various electronic systems requiring efficient voltage regulation and conversion

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