DC-DC CONVERTER

CUK CONVERTER

REPORT

Submitted by

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1. Introduction

The DC-DC converter's input is fixed, and its output is controlled and regulated, with a buck converter stepping down the voltage and a boost converter ramping it up. A Buck-Boost converter, which can either step up or down the voltage, may be used to create a DC-DC converter with an adjustable topology. The Buck-Boost converter is a one-of-a-kind gadget that generates output that is polarised in the opposite direction.

The Cuk converter employs the same duality idea as the buck-boost converter, with the exception that the Cuk converter's output reverses polarity. One capacitor, one inductor, one diode, and one semiconductor switch are present in typical DC-DC converters such as buck, boost, and buck-boost. Two inductors, two capacitors, a diode, and a semiconductor switch comprise the Cuk converter. The Cuk converter architecture uses two inductors, which reduces voltage ripple on both the input and output sides.

2. Cuk Converter

Buck Converter, Boost Converter, Buck-Boost Converter, Cuk Converter, and SEPIC Converter are non-isolated DC-DC converters.

A buck converter is a type of step-down converter that transforms a fixed DC input into a regulated, controlled, and adjustable DC output. Because the buck converter's output voltage is smaller than the input voltage, it is referred to as a step-down converter. The input current is increased by stepping down the input voltage, and the output current ripple is increased in the buck converter. The buck converter has a lower output current ripple.

In the same way, a boost converter raises the input voltage while lowering the input current. In the boost converter, the input current ripple is less, but the output current ripple is larger.

Due to the disadvantages of buck and boost converters, a buck-boost converter combination is preferable since input and voltage level needs vary depending on the application. Depending on the duty ratio, a buck-boost converter steps up and down the input voltage level in the same architecture. A buck-boost converter offers the step up and steps down of input voltage inside the same architecture with the same component count. The buck-boost converter's output is reversible, although the output current ripple remains considerable in the topology. The capacitor's input and charging currents are both discontinuous, causing EMI problems. Cuk Converter was created to address these flaws.

When compared to buck, boost, and buck-boost converters, the cuk converter has a higher component count. Two inductors, two capacitors, one diode, and one switch make up the Cuk converter. Cuk converter is a hybrid of buck and boost converters, with the input side resembling a boost converter and the output side resembling a buck converter in a disconnected inverted manner connected by a single capacitor. In comparison to the input voltage, the Cuk converter's output voltage is inverted.

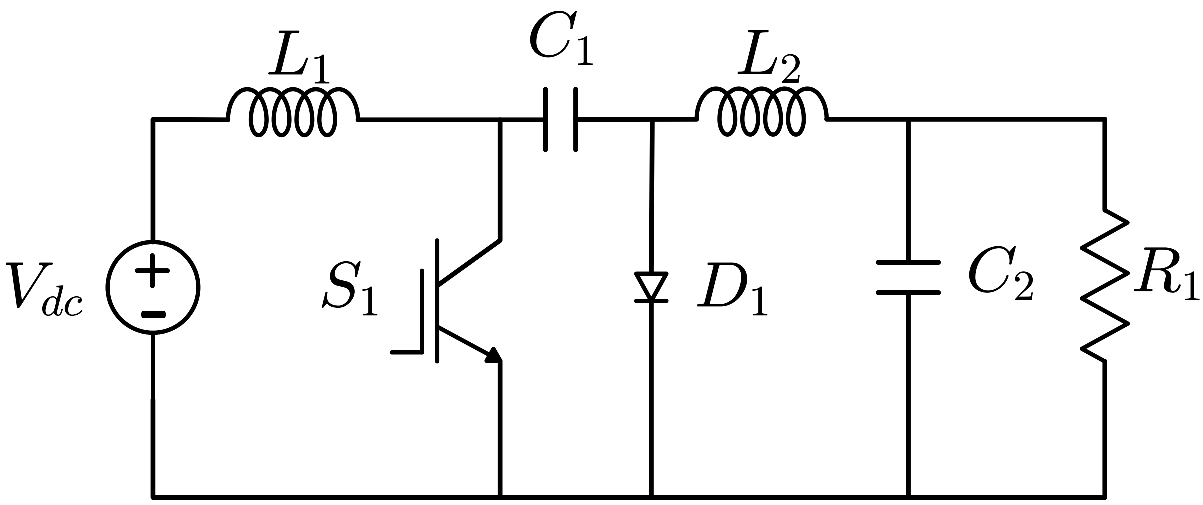

Fig. 1: Cuk Inverter

3. Basic Operation

Cuk the converter, as indicated in Figure, is made up of six components: L1, L2, C1, C2, diode D, and switch S. Before we look at how it works, we'll look at the ideal circumstances for the components, which are that L1, L2, C1, and C2 don't have any charge in them. The operation of the Cuk converter words for 4 Cases has been simplified.

3.1. When the switch is ON

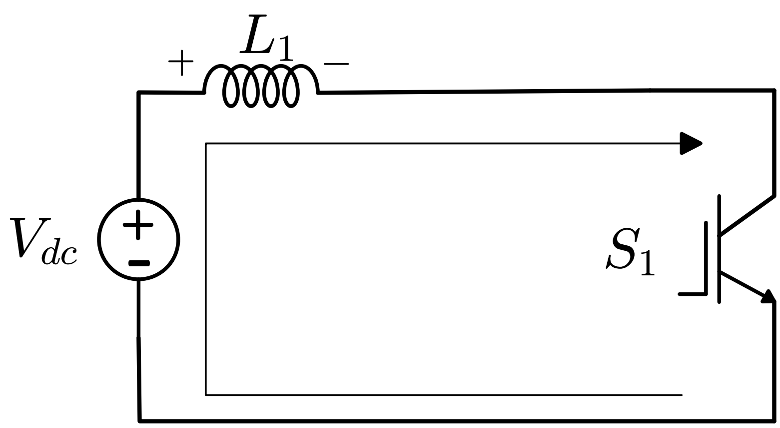

Fig. 2: When switch ON

Because there is no current in the capacitor and inductor when the switch is switched on, the source will charge the inductor, and the current will flow from L1 to the switch and back to the source, as illustrated in Figure. The inductor L1 is charged and operates as a storage element with positive and negative polarity. C1 will technically have a little quantity of stored voltage. There is no current flowing to the load.

3.2. When the switch is turned OFF

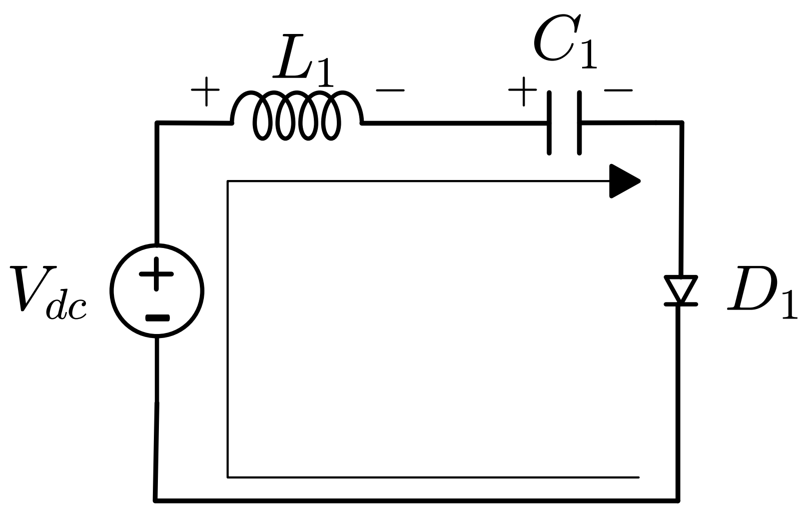

Fig. 3: When switch OFF

When the switch is switched off, the inductor L1 dissipates the stored energy by reversing its polarity, as illustrated in Fig.3. A current will flow from the source to the inductor L1, in addition to the stored energy dissipating from L1. The current flow in the inductor is caused by the fact that the current coming from inductor L1 is not totally DC.

When the switch is turned off, current will travel from the source to the inductor L1, the capacitor C1, the diode, and then back to the source. In this situation, capacitor C1 will also store the voltage. When the switch is turned off, voltage is given to the load.

3.3. When the switch is turned ON

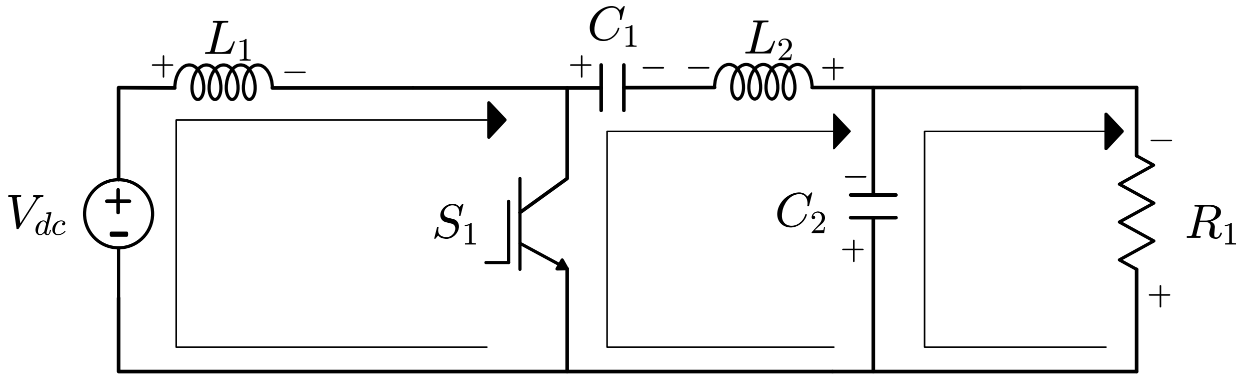

Fig. 4: When switch ON

When the switch is switched on, the inductor L1 is charged, much like in instance 1, and current travels from the source to the inductor L1, capacitor C2, and load, as illustrated in Fig.4. However, the voltage-holding capacitor C1 now loses its energy to the load. The voltage held in capacitor C1 serves as a voltage source, allowing current to flow from C1 to C2 and Load. In this procedure, when diode d is reverse biassed, it also charges the inductor L2.

3.4. When the switch is turned OFF

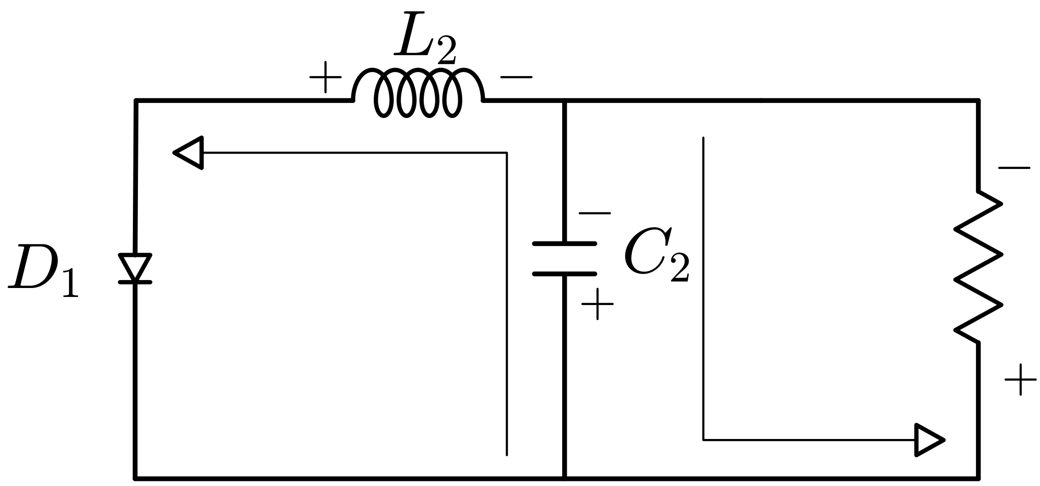

Fig. 5: When switch OFF

Case 2 is repeated when the switch is turned off, with capacitor C1 dissipating its energy and inductor L2 dissipating its energy to the load, resulting in the stored energy being dissipated to the load using capacitors C1 and L2. The diode is forward biassed when the output voltage is reversed, and energy is dissipated via capacitors C2 and L2. Because to the ON/OFF mechanism's construction, we get reversed polarity at the output when compared to the input side voltage.

Because we studied how a Cuk converter works in ideal conditions using these four criteria, the Cuk converter's mechanism will be as follows when the switch is turned on and off.

When the switch is switched on, the inductor L1 charges up, and the energy stored in the capacitor C1 is used to power the load. The capacitor C1 is energized or supplied with energy by the inductor L2. The voltage source for the load is C1.

Inductor L1 discharges the energy and delivers power to the capacitor C2 when the switch is switched off. And L2 is in charge of supplying power to the load that was ignited when the switch was flipped on.

4. Simulation results

The simulation is performed in the MATLAB software. The results has been shown in the figures below.

Converter Parameters	
Parameters	Values
Input Voltage	70 V
Output Voltage	151V
Duty cycle	0.69
Fundamental frequency	50 Hz
Switching frequency	10 kHz
Inductance L_1	0.857 mH
Inductance L_2	2 mH
Capacitance C_1	65 μ F
Capacitance C_2	1.66 μ F
Load Resistance R	10ω

Table 1: Parameters

The results obtained are shown in figures below.

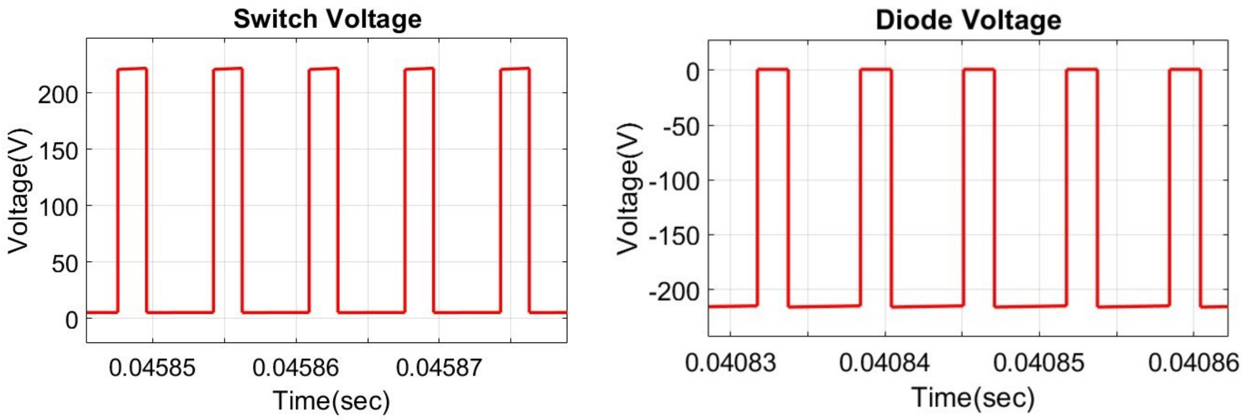

Fig. 6: Switch and diode voltage

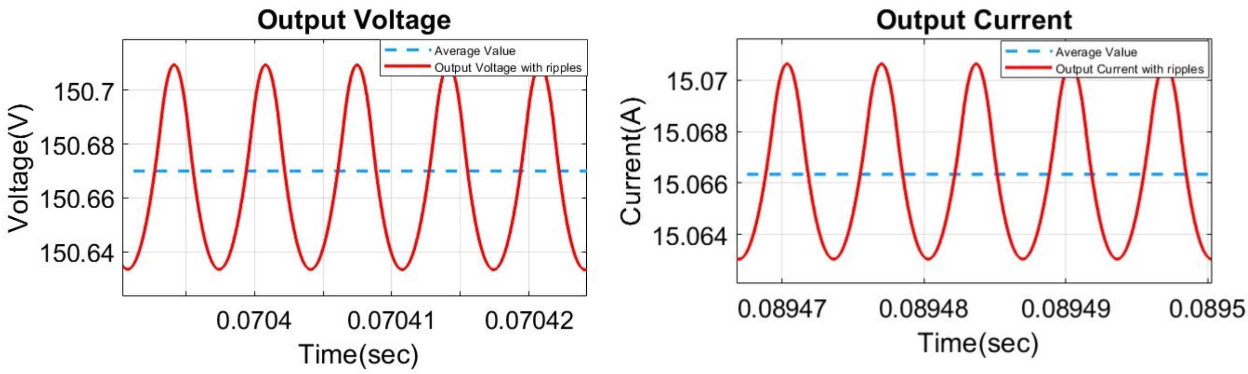

Fig. 7: Output Voltage and current

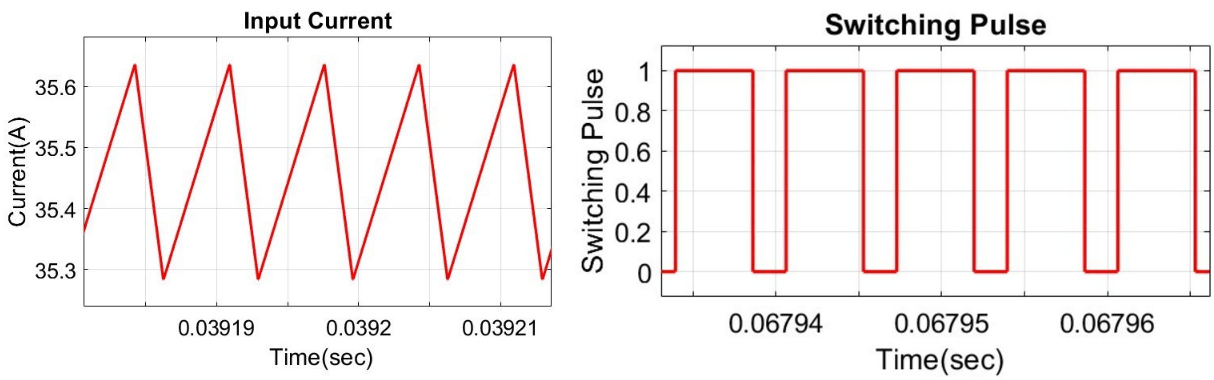

Fig. 8: Input current and switching pulse

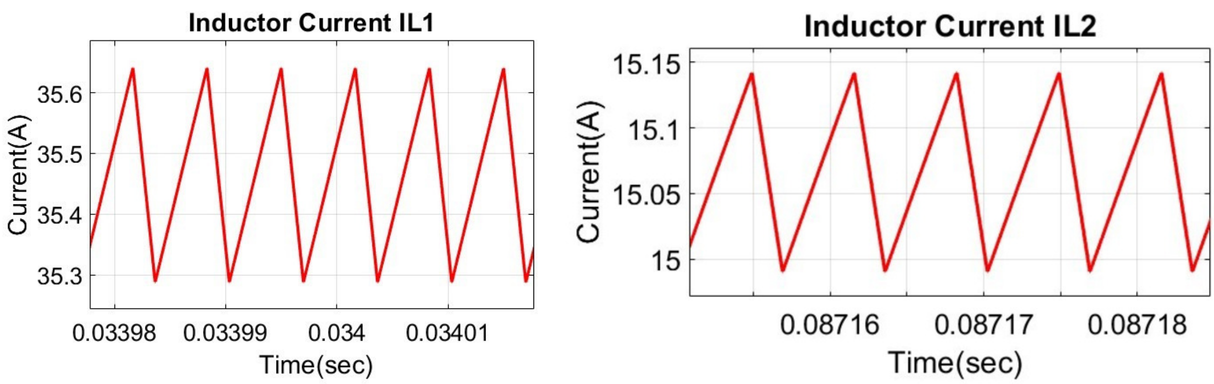

Fig. 9: Inductor currents

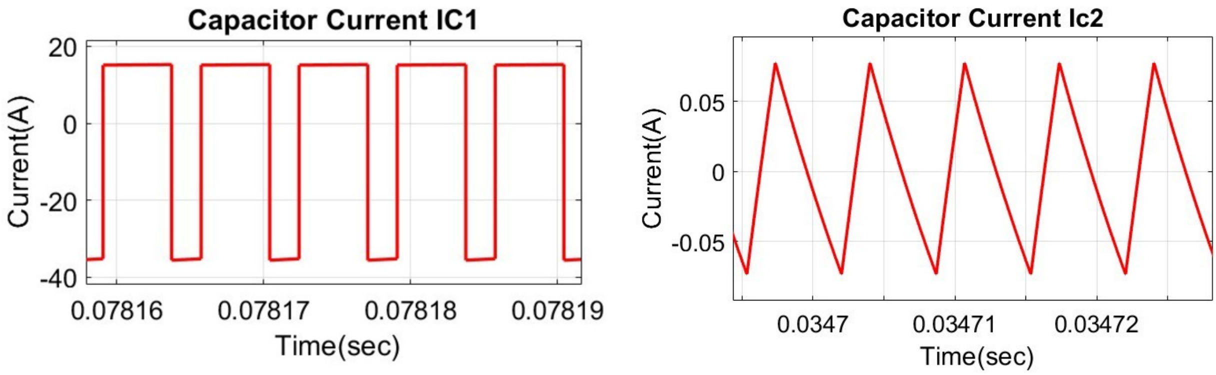

Fig. 10: Capacitor Currents

6. PCB Design

The PCB design has been implemented using Altium Designer. The components used are shown in the table 2.

Components	
Components	Part no.
Terminal Block	277-1667-ND
IGBT	IHW20N120R5
Diode	1N4007-T
Electrolytic Capacitor	ALC10A471DF450
Resistance	SFR25H0001509FR500
Ceramic Capacitor	C322C101K3G5TA7301
Linear Regulator	L7805CV
DC-DC Converter	CRE1S0515SC
Optocoupler	FOD3182

Table 2: Components

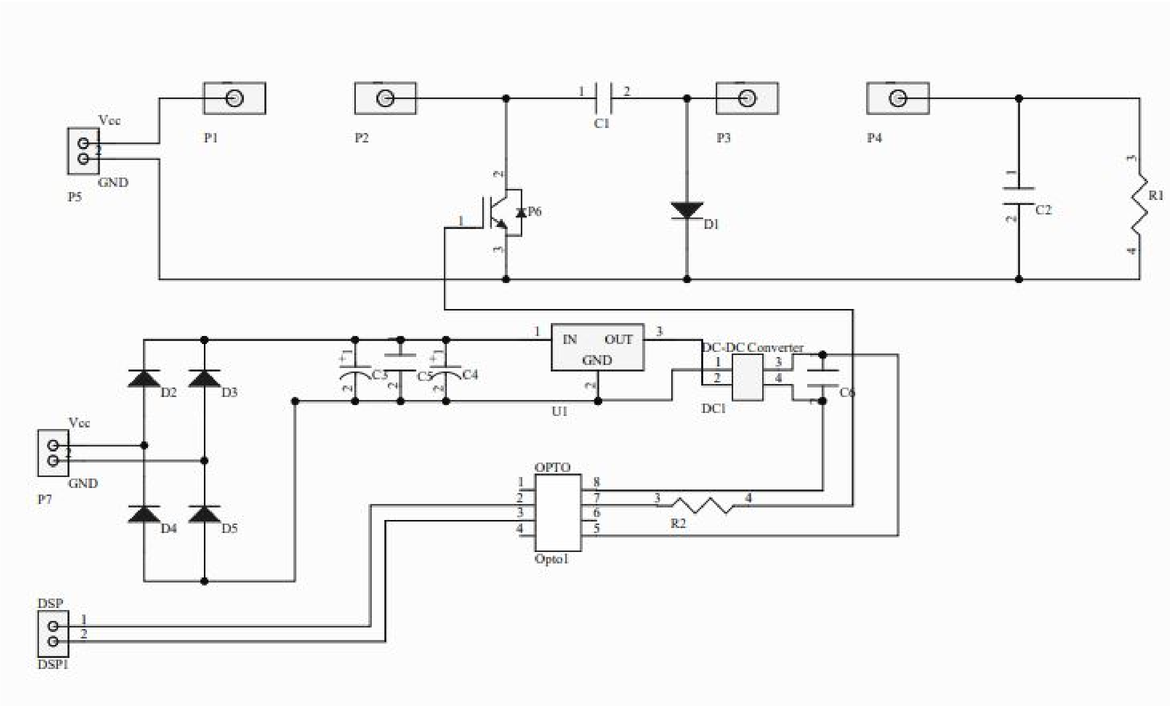

Fig. 11: Schematic Diagram

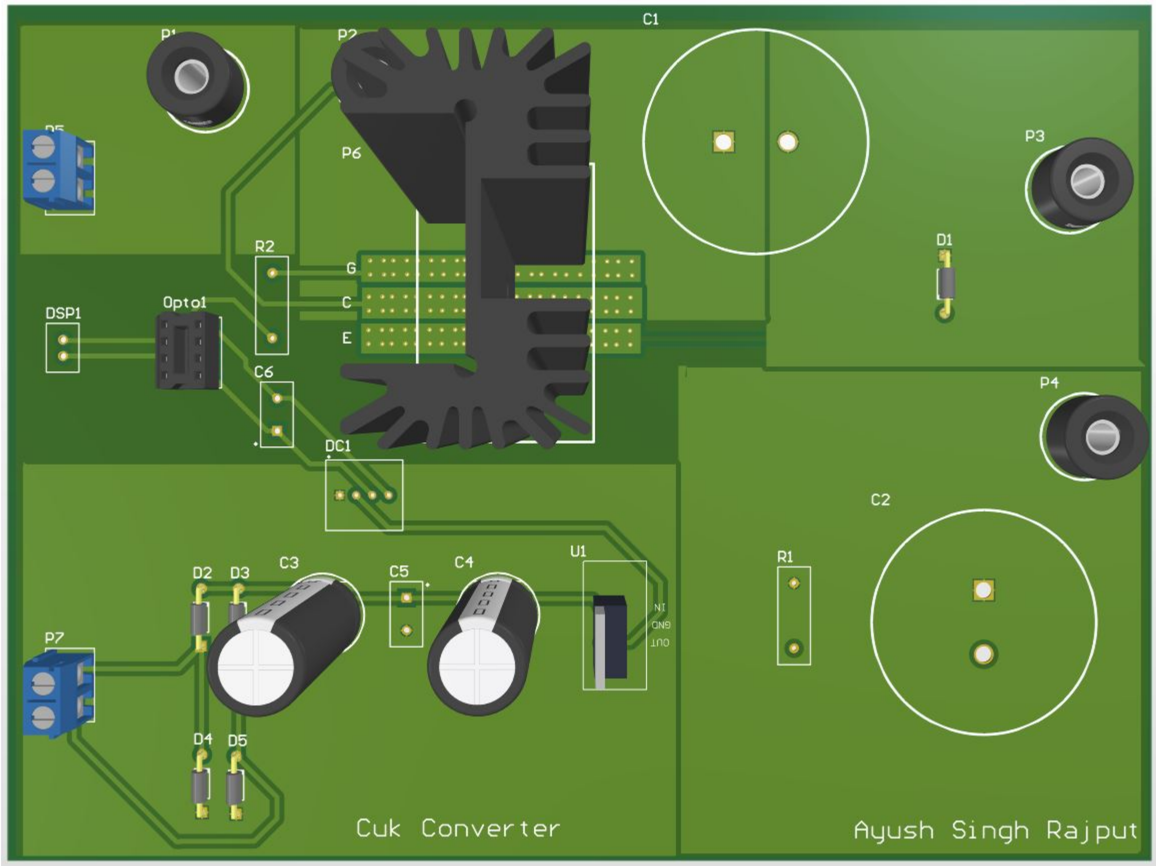

Fig. 12: PCB Top view

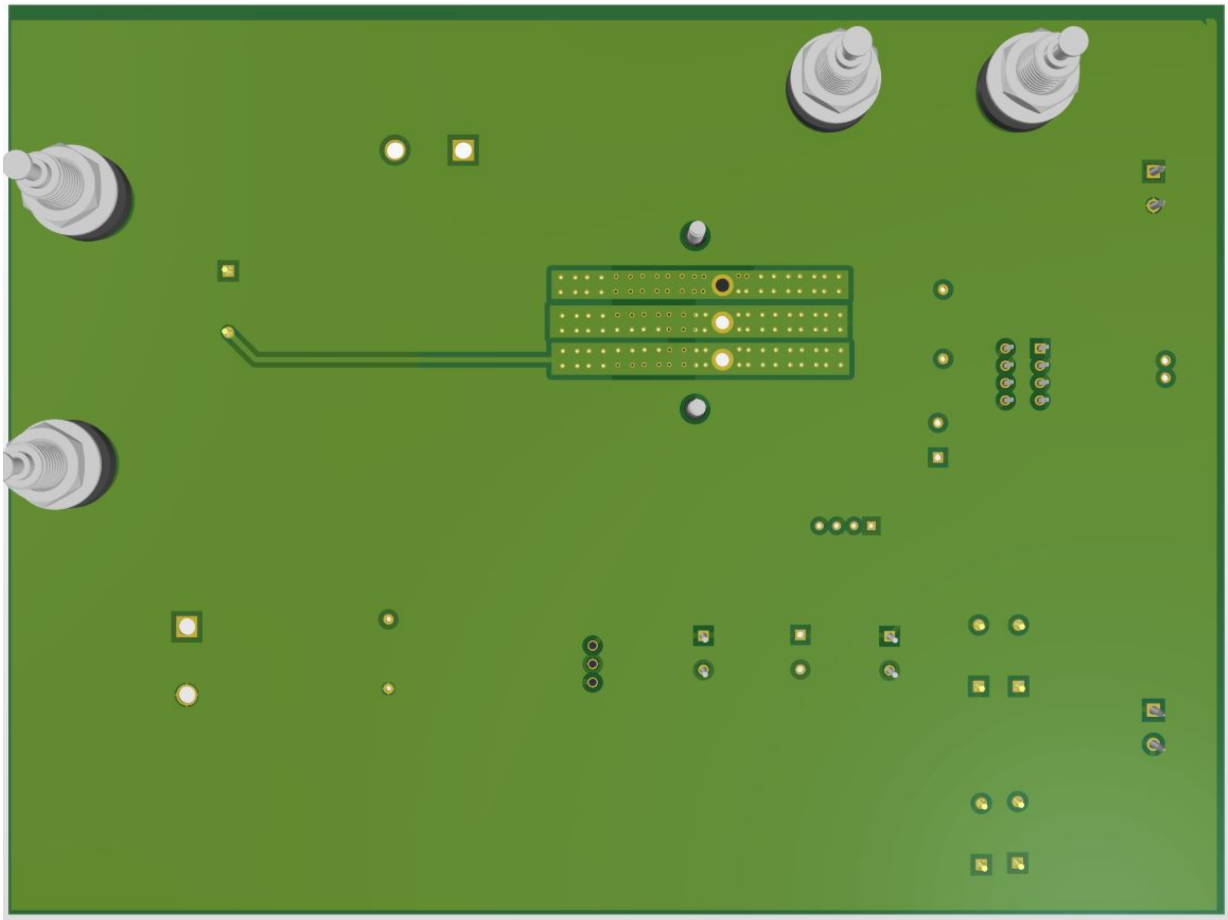

Fig. 13: PCB Bottom View

7. References

1. R.W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd ed., Kluwer Academic Publishers, 2001.

2. F. L. Paukner, C. Nardi, E. G. Carati, C. M. O. Stein, R. Cardoso and J. P. da Costa, ”Inductive filter design for three-phase grid connected power converters,” 2015 IEEE 13th Brazilian Power Electronics Conference and 1st Southern Power Electronics Conference (COBEP/SPEC), Fortaleza, Brazil, 2015, pp. 1-5, doi: 10.1109/COBEP.2015.7420189.