University of North Carolina at Charlotte  
Department of Electrical and Computer Engineering

Junior Design Lab 2-0

**DC-DC BUCK CONVERTER**

Lab 2-0

Team 5: Andrew Nicola, Christian Salitre, Daniel Jolin, John Saavedra, and Nathan Waters

Date: 09/11/2023

**Objective:**

In this lab, the team was provided a schematic of a DC-DC Buck-converter using two MOSFETs and needed to simulate the design, following the design parameters to provide constant voltage at the load with less than 1 percent ripple and provide a current at the inductor with less than 10 percent ripple with a 70 - 85 percent duty cycle.

**Relevant Theory:**

A DC-DC buck converter has a cycle of two stages, the "on" and "off" phases. In the "on" stage, the top MOSFET acts like a gate, allowing current to flow from the input voltage source through an inductor and into the load, where you want to power. This stores energy within the inductor. In the "off" stage, the top MOSFET turns off, and the bottom MOSFET turns on. The switch between these stages happens rapidly, with the duty cycle determining how much time is spent in each stage. This precise control allows you to efficiently convert a higher input voltage into a lower output voltage.

**Design Elements:**

Two MOSFETS

One 218 µH Inductor

One 23.6 µF Capacitor

One 1.96 Ω Resistor

DC Voltage Supply (Capable of 40V)

PWM Generator

Other elements needed to run the simulation (not essential in the converter operation)

**Design Parameters**

Power rating: 200W- 400W

DC voltage supply (input): 30V-40V

Switching frequency: 10kHz – 50kHz

Set the duty cycle between 70% and 85%.

Current ripple in the inductor: less than 10% of the max current

Output voltage ripple measured at the load: less than 1% at the max load

**Schematic:**

A diagram of a computer

Description automatically generated

**Questions:**

**1- Define your nominal operating conditions and specifications, i.e. switching frequency, input**

**voltage, duty cycle, load resistance value, inductor and capacitor values, etc.**

**Provide a justification on how to pick your inductor and capacitor values. Use standard values for**

**capacitor values. I suggest using ceramic capacitors for filtering, voltage rating of about 100VAC.**

**If you need bigger capacitance for filtering you can use Film capacitors.**

|  |  |
| --- | --- |
| **Design Specifications:** | **Values:** |
| Switching Frequency (*f)* | 27,000 Hz |
| Input Voltage (DC) (V­in) | 40 Volts |
| Duty Cycle (D) | 70% |
| Power Rating (P) | 400W |
| Load Resistance value (Ω) | 1.96 Ω |
| Inductor (H) | 218 µH |
| Capacitor (F) | 23.6 µF |

**Inductor:**

L = \* = \* = 218 µH

**Capacitor:**

C = = = 23.6 µF

**Load Resistance:** We set the power rating to 400 Watts to account for our system to withhold the highest power rating in the design parameters.

P =  RLoad = = = 1.96 Ω

**2- Provide the theoretical input-output voltage relationship. This is sometimes called conversion**

**ratio. With your simulation, include a plot showing the input and output voltage. Does it follow**

**the theoretical (calculated) value?**

**Load Voltage:** We chose a Duty Cycle of 70 percent, to account for low quality MOSFETS.

VLoad = Vin (D) 40V(0.70) = 28 V

A screen shot of a graph

Description automatically generated

A graph with lines and lines on it

Description automatically generated

**3- Measure the current ripple in the inductor and voltage ripple across the output (capacitor) at your nominal operating point? With your simulation include a plot with your measurements.**

**Voltage Ripple:**

Vripple = ΔVCapacitor = VLoad(Ripple%) = 28V(0.01) = 0.28 V

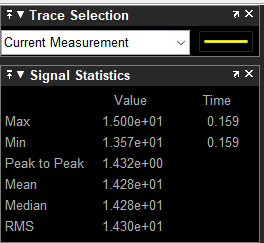
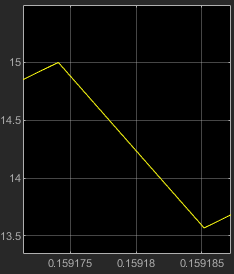
**Maximum Output Current:**

ILoad = = = 14.286 A

**Ripple Current:**

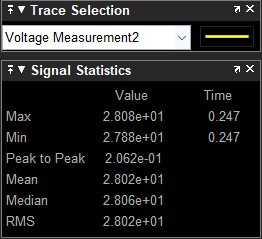
IRipple = ΔILoad = Iout (Ripple%) = 14.286A (0.10) = 1.428 A

**Current Ripple: (Needs to stay between 12.857 A to 15.714 A) (10%)**

****

**Voltage Ripple: (Needs to stay between 27.72 V to 28.28 V) (1%)**

A graph with yellow lines on a black background

Description automatically generated

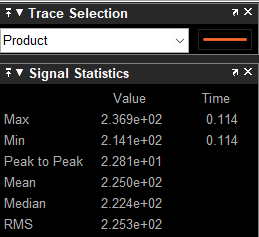
**4- Change the input voltage ±10V and run your simulation.**

1. **In one plot, measure the output voltage, output current, and output power**

A screen shot of a computer

Description automatically generated

A screenshot of a computer

Description automatically generated ****

1. **In another plot, show the inductor current and output voltage. Measure the inductor**

**current ripple and output voltage ripple. Compare them with your nominal operating**

**point.**

A screen shot of a graph

Description automatically generated

A screen shot of a graph

Description automatically generated