Group 7

LAB 2-0

9/12/2023

Leif Dixon, Leslie Deras, Ryan Guthrey, Emmanuel Mvutu, Swayam Mehta

OBJECTIVES

The purpose of this experiment is to simulate a DC-DC buck converter in Simulink. The goal is to calculate the capacitor and resistor values after selecting the duty cycle, switching frequency and input voltages.

MATERIALS/EQUIPMENT NEEDED

Matlab: Simulink

Equipment used in simulation:

-Two Mosfets

-One Inductor

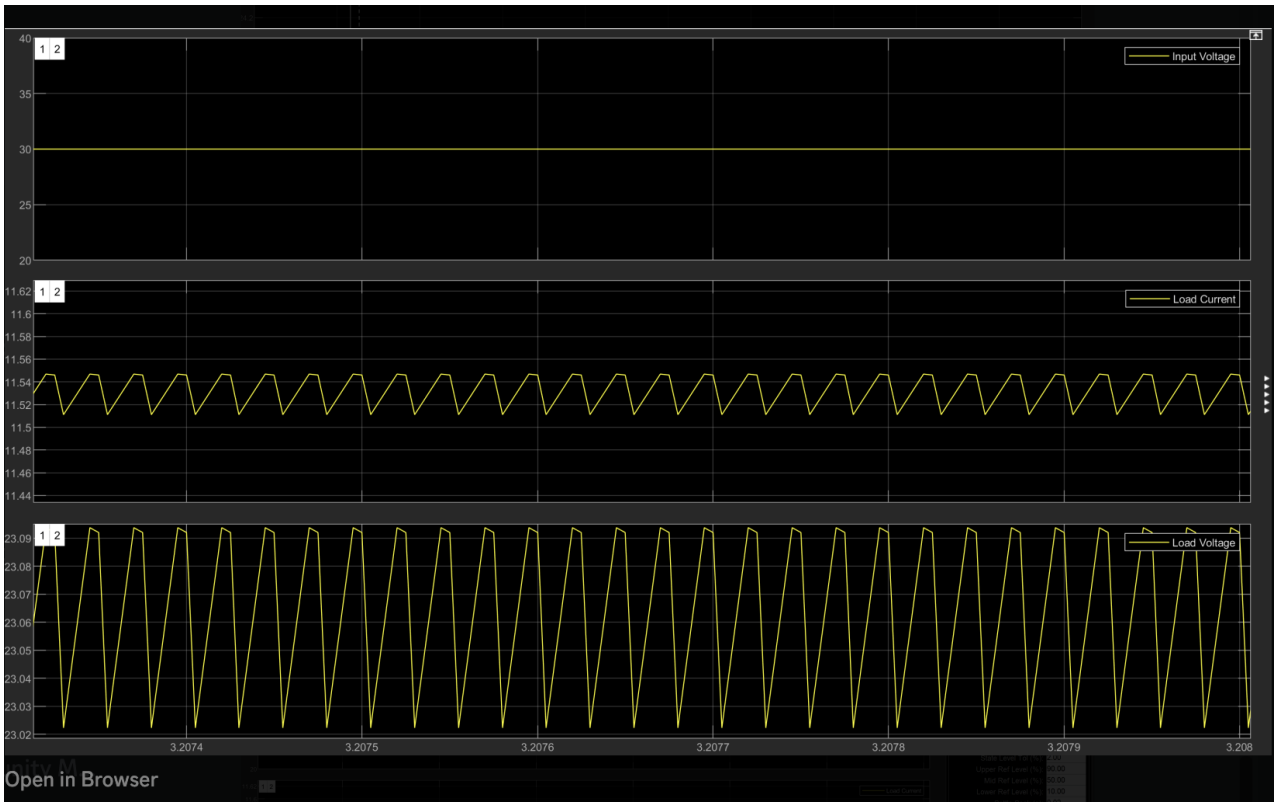
-One Capacitor

-One Resistor

-DC voltage Supply

-PWM Generator

Results:



Group 7

PostLab

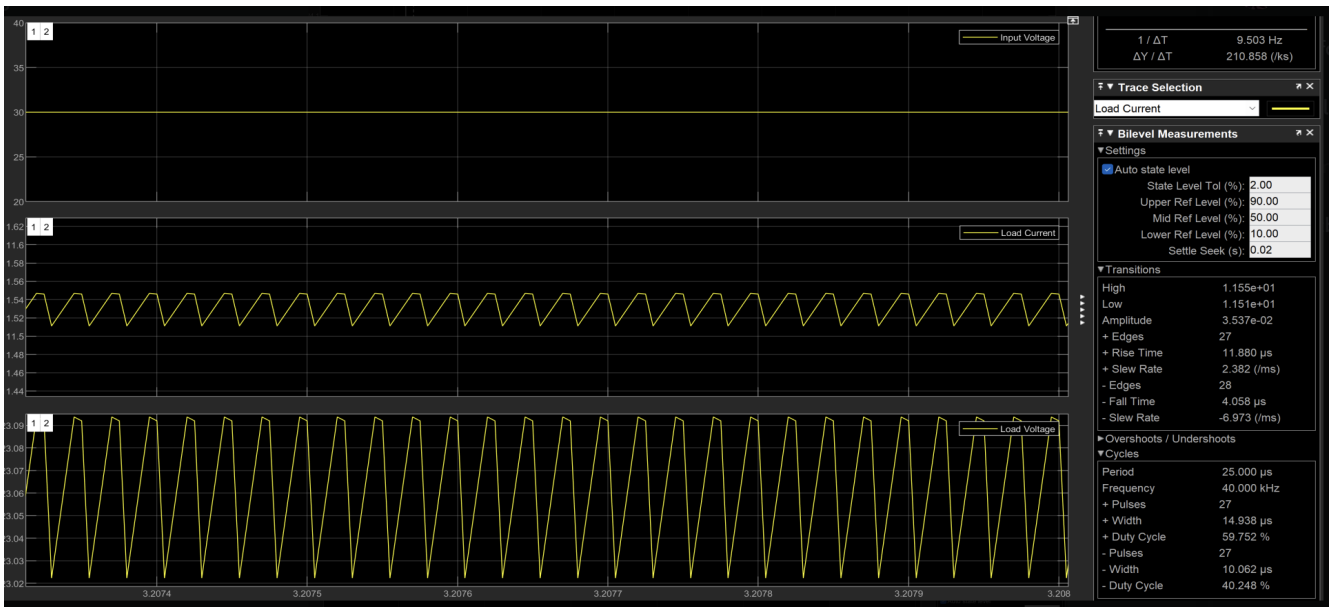
Questions:

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. I suggest using ceramic capacitors for filtering, voltage rating of about 100 VAC. If you need bigger capacitance for filtering you can use Film capacitors.
    - **In our experiment, the selection of components was a function of the choice of voltage, duty cycle, and estimated power output parameters. In this, we selected a duty cycle of 80%, an input voltage of 30 volts, and a switching frequency of 40 kilohertz. Based on a 300W output requirement the calculation for the resistor came out to 2 ohms. Using the equation: $(1\text{-}D)(R)/2f = L_{min}$ which was used to calculate the minimum inductance needed. The inductance came out to be 25uH. After finding inductance, the capacitance was found by utilizing the inductance found previously in this formula: $C = (1 - D) / 8*[L*(RipplePercent)*(f)^2] = 125uF$.**

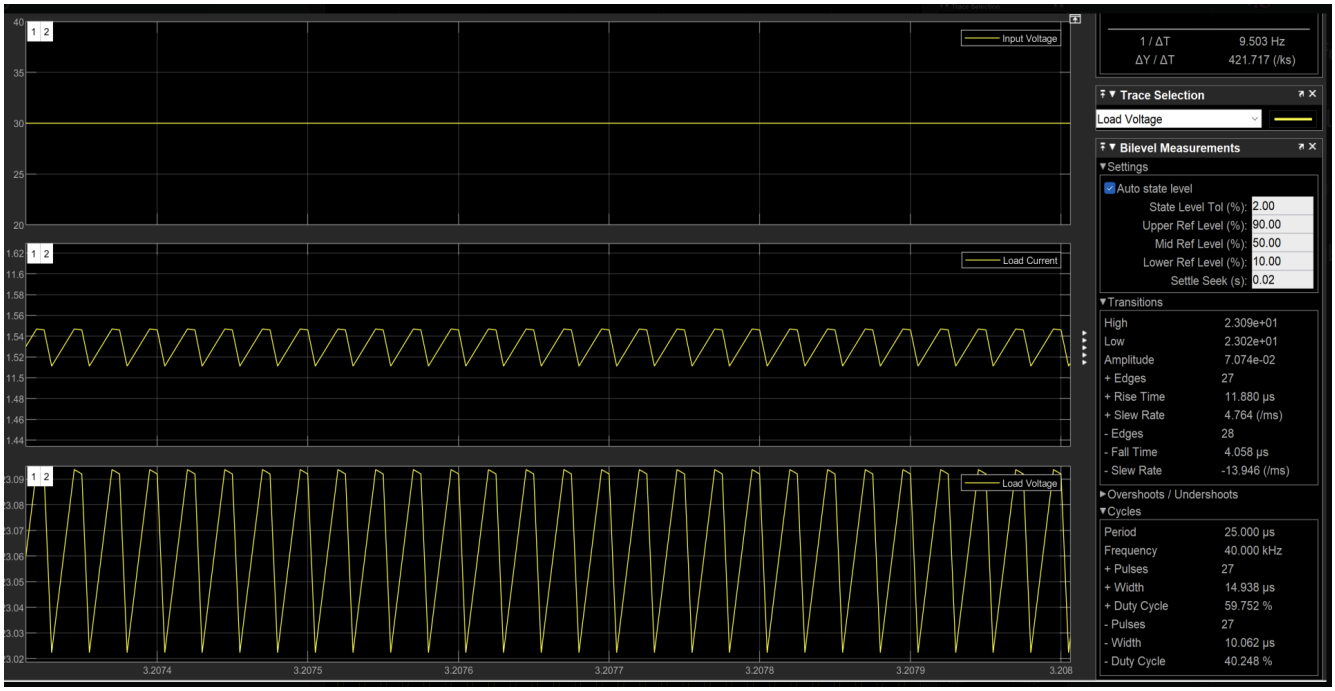
2. Provide the theoretical input-output voltage relationship. This is sometimes called conversion ratio. With your simulation, include a plot showing the input and output voltage. Does it follow the theoretical (calculated) value?
    - **For our experiment, the conversion ratio was 0.8 Vout/Vin, or in the case of this experiment, it was an input of 30V and an output of 24V. See Figure A below for the plot showing the input and output, (load), and voltages of the system.**

3. Measurement 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.
    - **This ratio fluctuates between 23.09 and 23.02 leading to a ripple of 0.07 V. The load voltage parameters need to be within 23.09 * .01 = 0.2309V. The load current ripple fluctuates between 11.55 and 11.51 leading to a ripple of .04 A. The parameters for this experiment needed to be within 10% so 11.55 * .10 = 1.155 A.**

(Figure A)

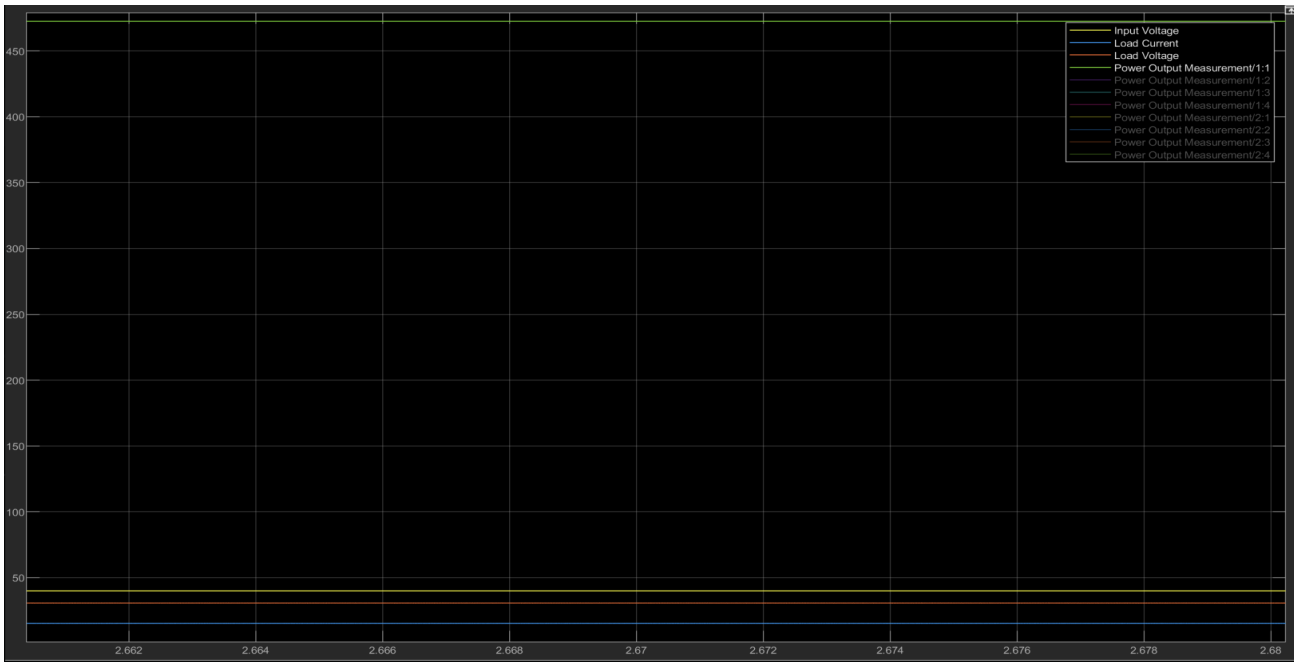


(Figure B)

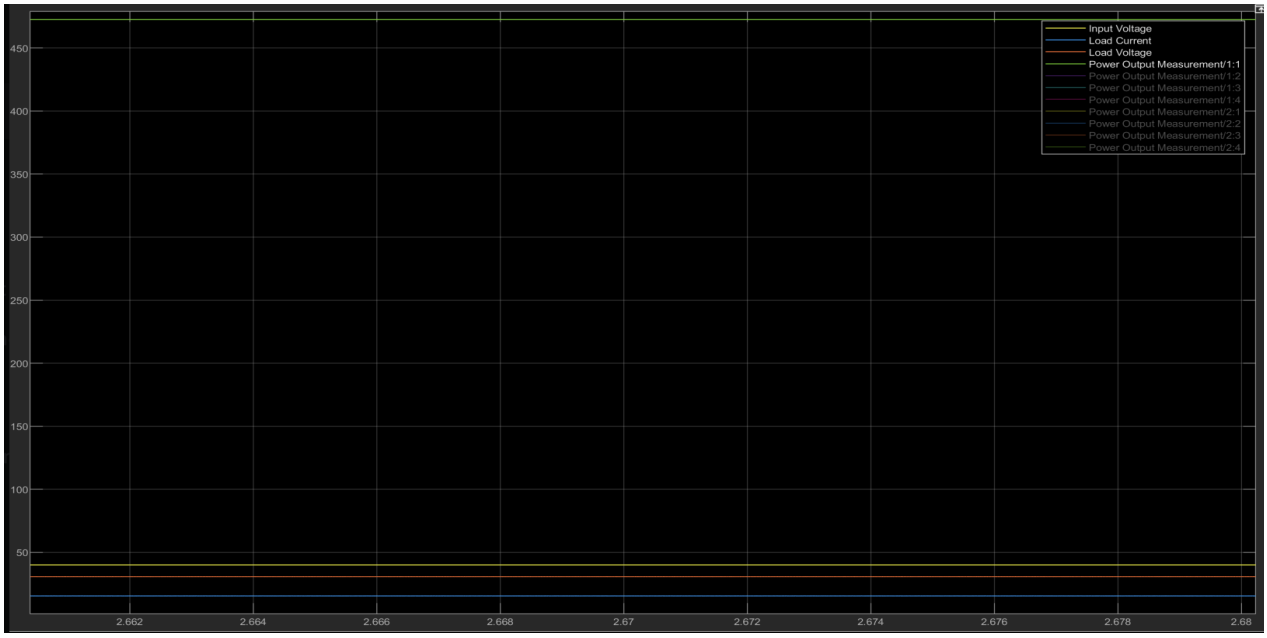


4. Change the input voltage ±10V and run the simulation.
    a. In one plot, measure the output voltage, output current, and output power.

+ 10V : 30V + 10V = 40V



-10V : 30V - 10V = 20V



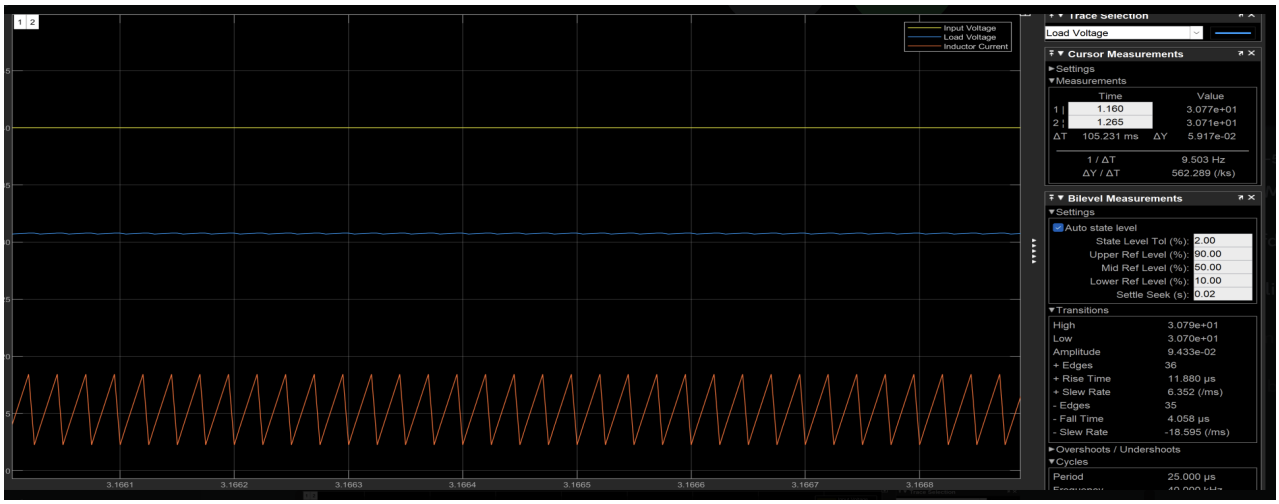
b. In another plot, show the inductor current and output voltage. Measure the inductor current ripple and output voltage ripple. Compare them with your nominal operating point.

- **Compared to the nominal operating point, the inductor current ripple has a significantly larger amplitude when the input voltage is varied from the original specification of 30V by plus or minus 10 volts, 1.532 compared to 0.03537. This quadrupling of the ripple factor highlights how important circuit design is to the demands of the circuit. The inductor and capacitor would need to be sized correctly in order to compensate for the change in input to maintain a quality DC output.**
- **As for the effect on the output voltage ripple, the change in voltage by subtracting 10 volts (-20V) leads to 0.05 ripple whereas the change to 40V leads to an increase to 0.09 voltage ripple. This indicates that the circuit is not as effective at these modified voltages.**
- **The circuit is designed for 30V specifically, to maximize the reduction in ripple there would need to be a change in the capacitor and inductor values. By adjusting these values for each voltage change and desired power output, the correct corresponding components can be selected.**

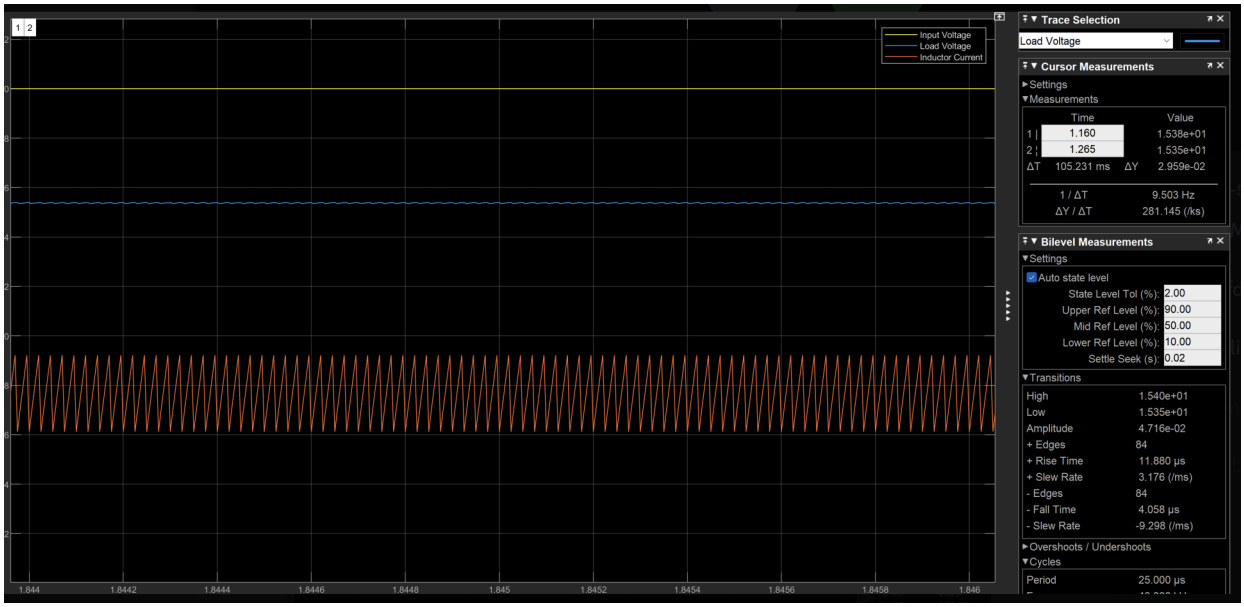
Group 7

Output Voltage ripple:

+ 10V : 30V + 10V = 40V



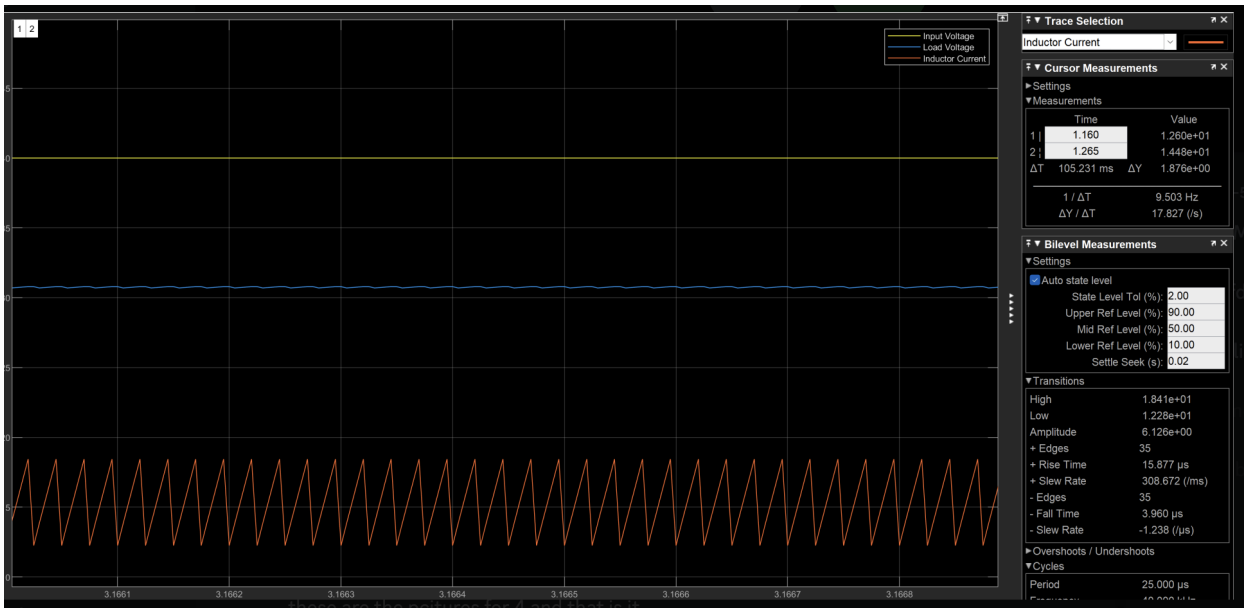
-10V: 30V - 10V = 20V



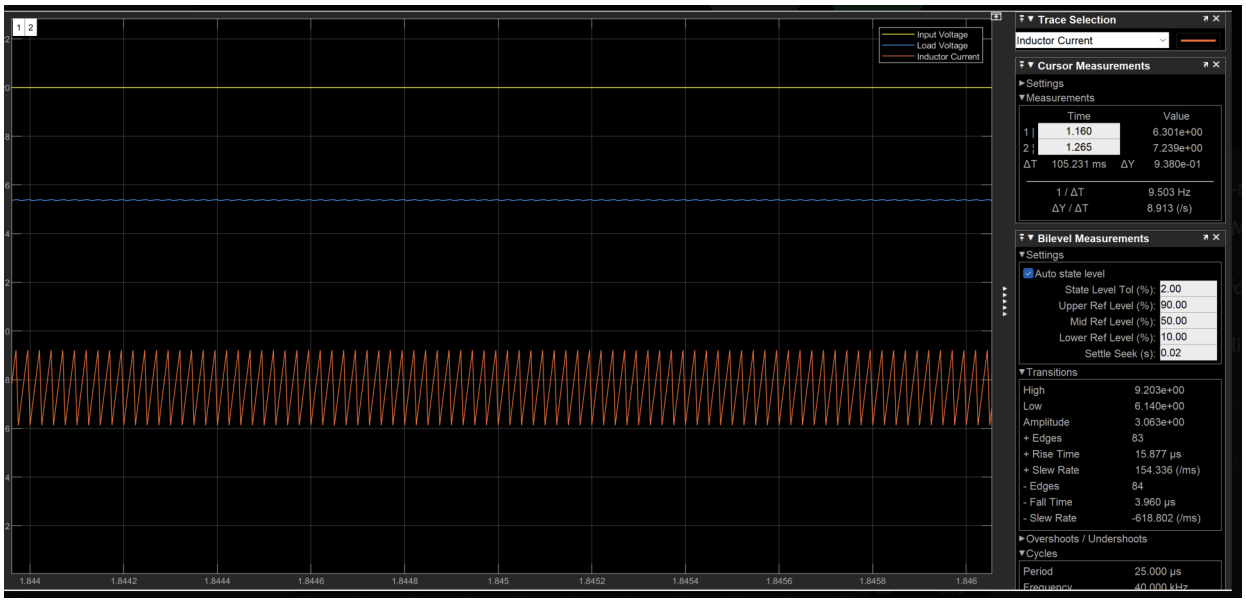
Group 7

Inductor Current Ripple:

+ 10V: 30V + 10V = 40V



-10V: 30V - 10V = 20V



CONCLUSION:

The buck converter allows the production step down DC to DC voltage. When designed appropriately, the converter will output the desired voltage with little deviation from a flat line. This deviation is known as a ripple. In terms of our simulation, we had an output current ripple of 0.04 and a voltage ripple of 0.07. This was well within the confines of the given parameters. Upon varying the voltage on the input side of our circuit by ±10 volts, the ripple varied by as much as 1.6, this fourfold increase in ripple demonstrates why designing the circuit-specific parameter, voltage in this case, is paramount. Given our results, the calculations of the 125 uF capacitor were an excellent choice for the power levels specified.