metin içeren bir resim

Açıklama otomatik olarak oluşturuldu

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**EE463 STATIC POWER CONVERSION I**

**Homework 2: DC/DC CONVERTERS**

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**Deadline:** 18/01/2023 23:59

**Lecturer:** Assoc. Prof. Ozan Keysan

**Assistant:** Ogün Altun

# INTRODUCTION

In this homework, Buck and Boost converters which are DC/DC converters, will be examined. The continuous current mode, power in the ideal case, and nonidealities in the real world will be examined for both converter types.

# SOLUTIONS

1. **Buck Converter**

**a)**

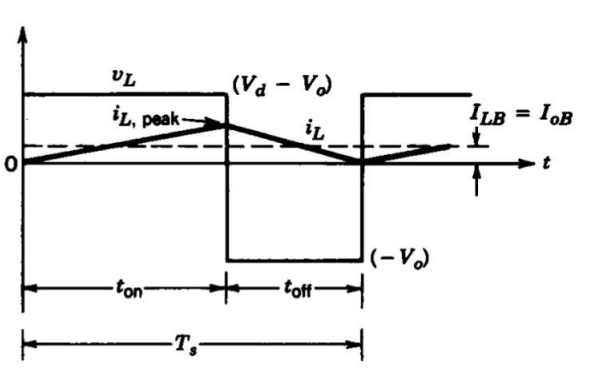


Figure 1: VL and IL graph for transition to the discontinuous current mode

In Figure 1, the boundary output current graph for DCM can be seen.

Since this boundary means the minimum current, we need to find the lower value. So the input voltage is chosen as 12V for the calculation.

**b)**

The output voltage is fixed and 5V. So



saat, kol saati, ölçü aleti içeren bir resim

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To find maximum ripple, the maximum input voltage must be chosen.







**c)**

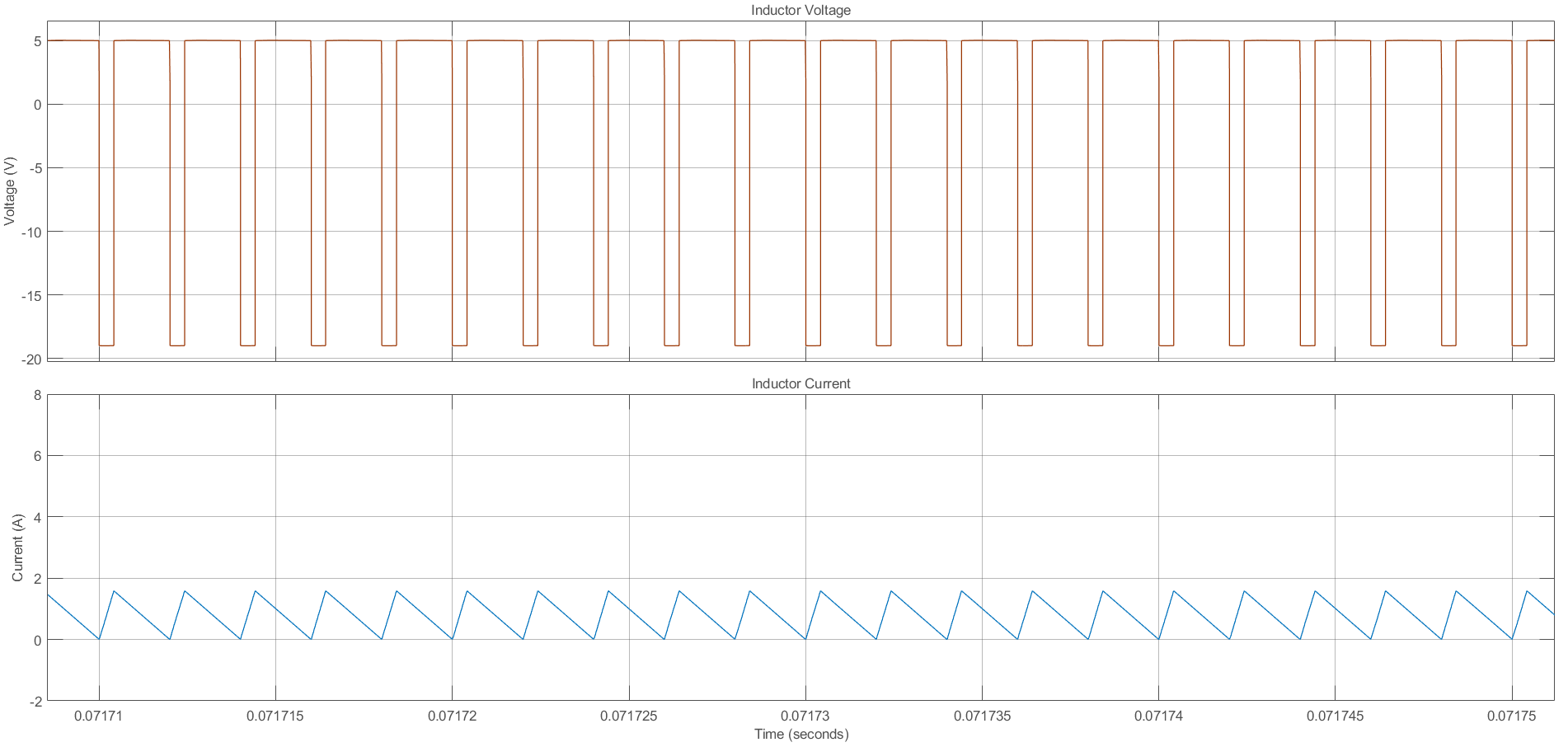


Figure 2: Inductor Voltage and Current Graph

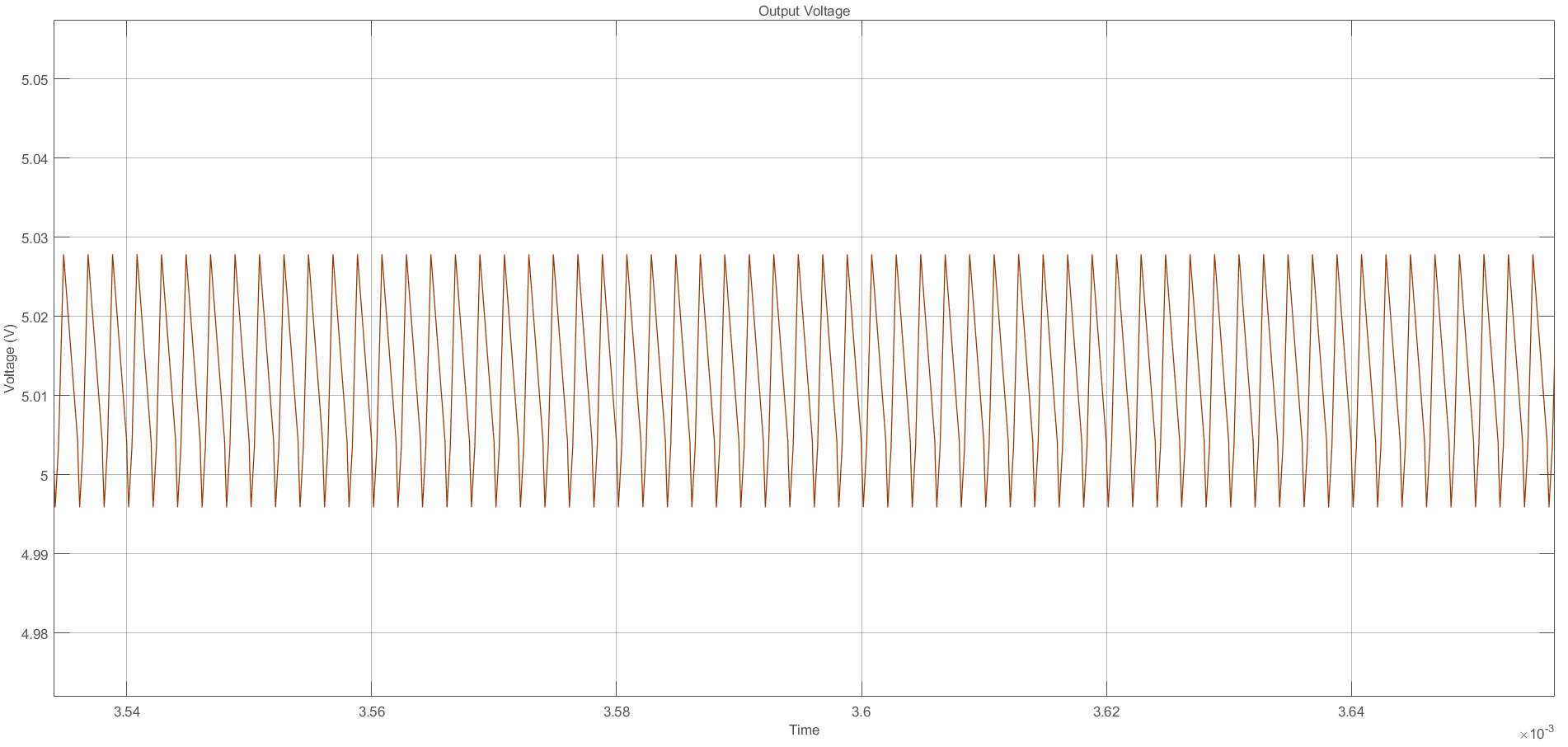


Figure 3: Output Voltage Graph

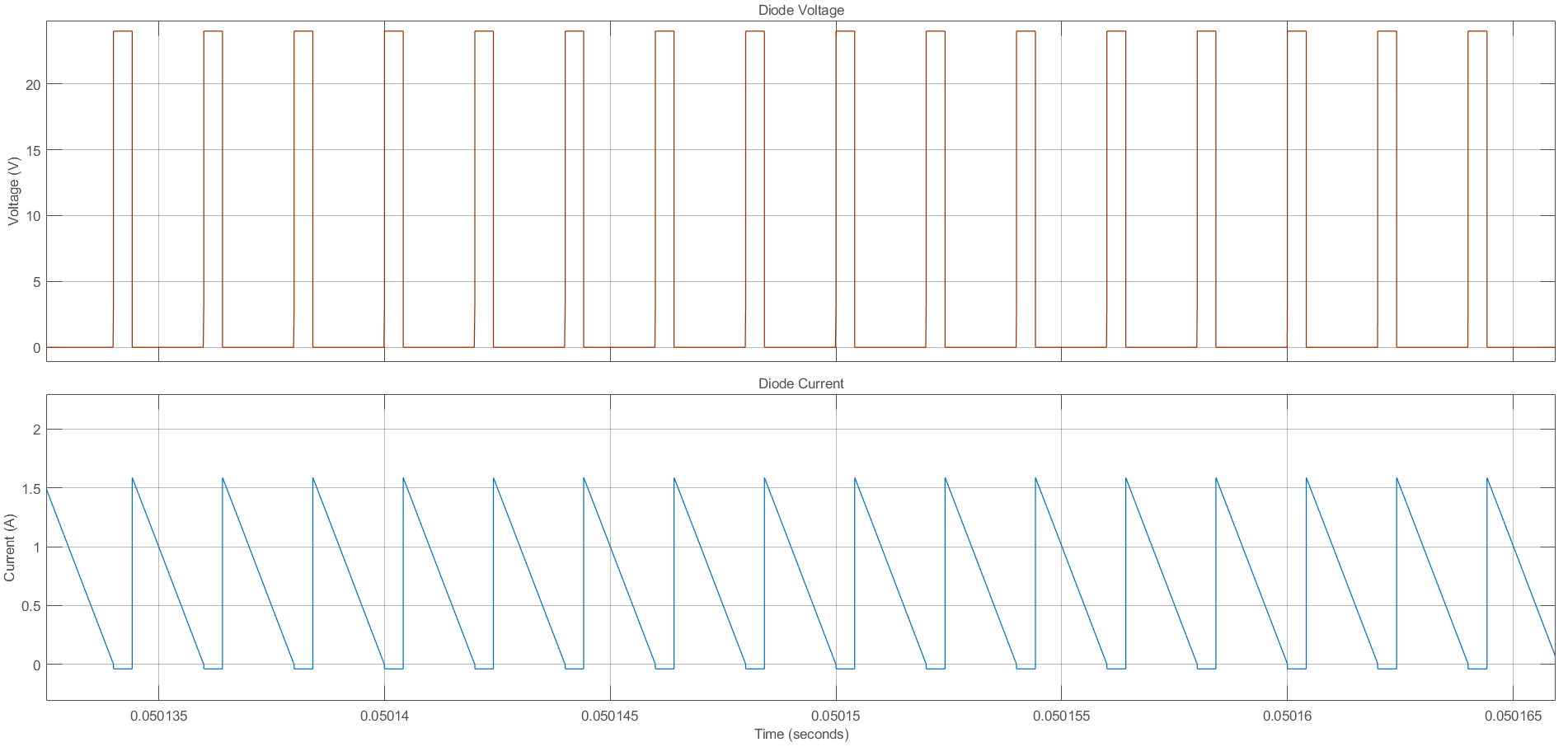


Figure 4: Diode Voltage and Current Graph

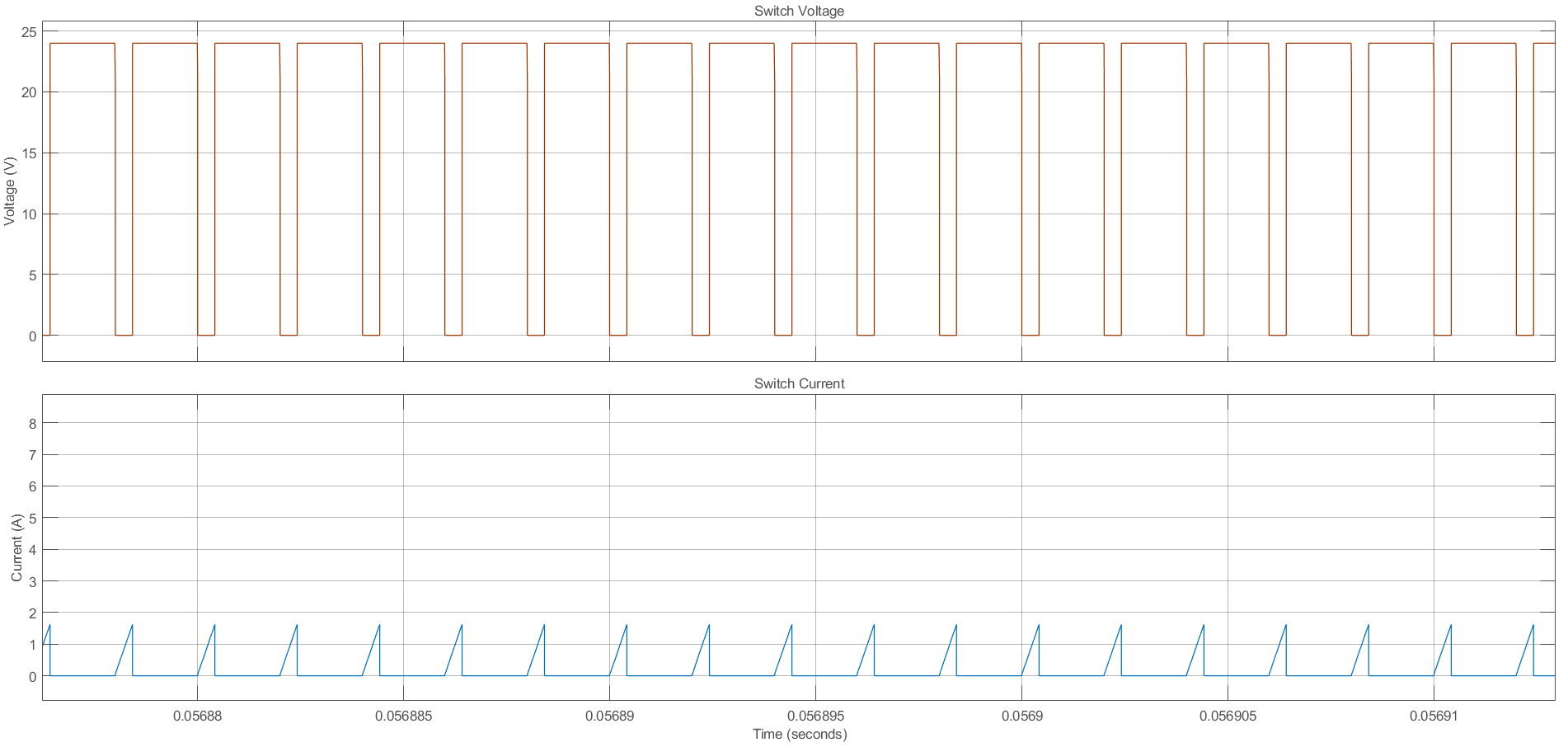


Figure 5: Switch Voltage and Current Graph

In this part, the continuous current mode of the buck converter was observed. When the inductor current graph was examined, it can be seen that the current does not remain zero; it goes down to zero and goes up.

In addition, the peak current value that guarantees CCM operation was 1.6A in part a. In this part, it can be seen that peak was 1.6A, and this is suitable for part a.

**d)**

In the simulation, the output voltage was 7.2V with a 41.67% duty cycle. As a result, D was decreased to 24.4% to obtain a 5V output voltage.

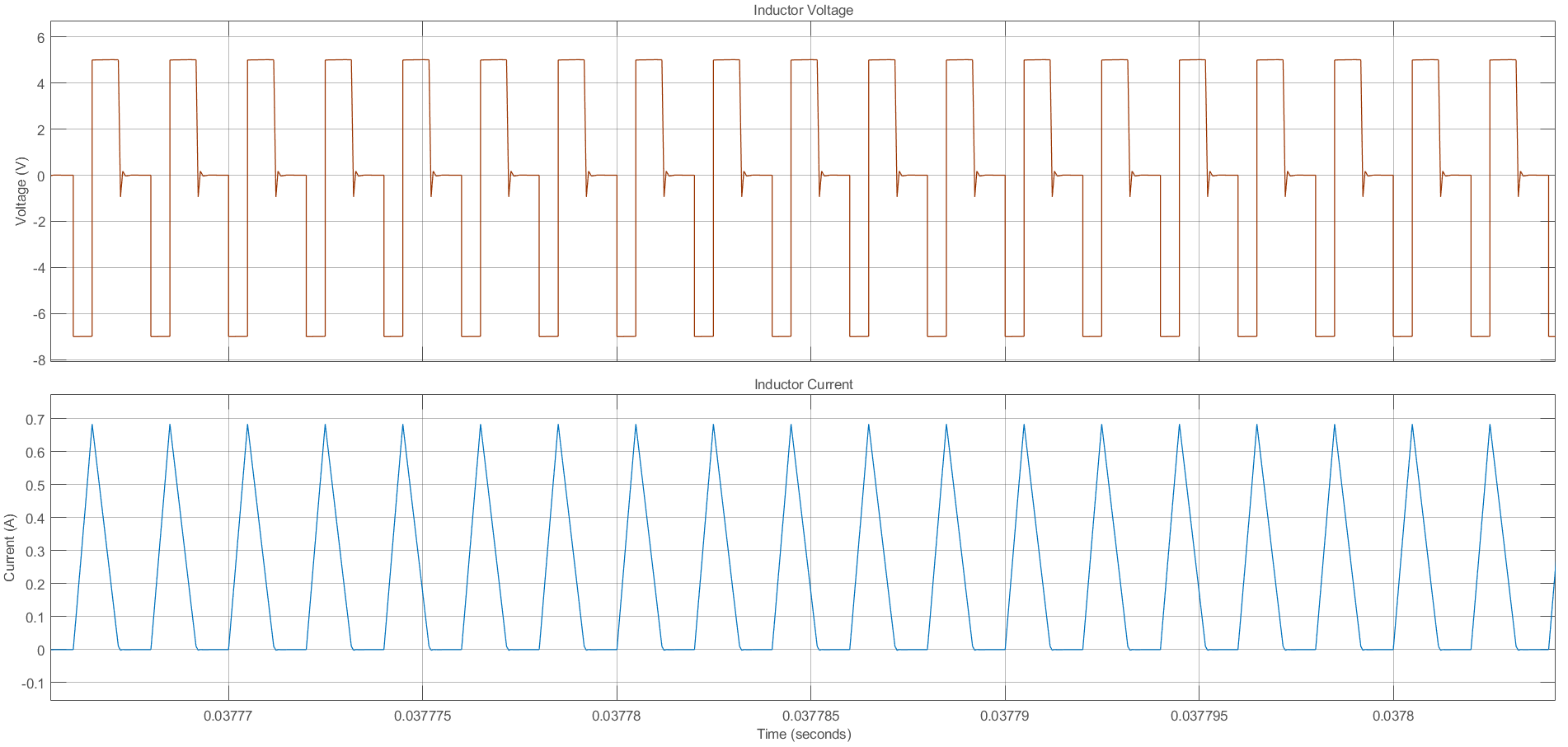


Figure 6: Inductor Voltage and Current Graph

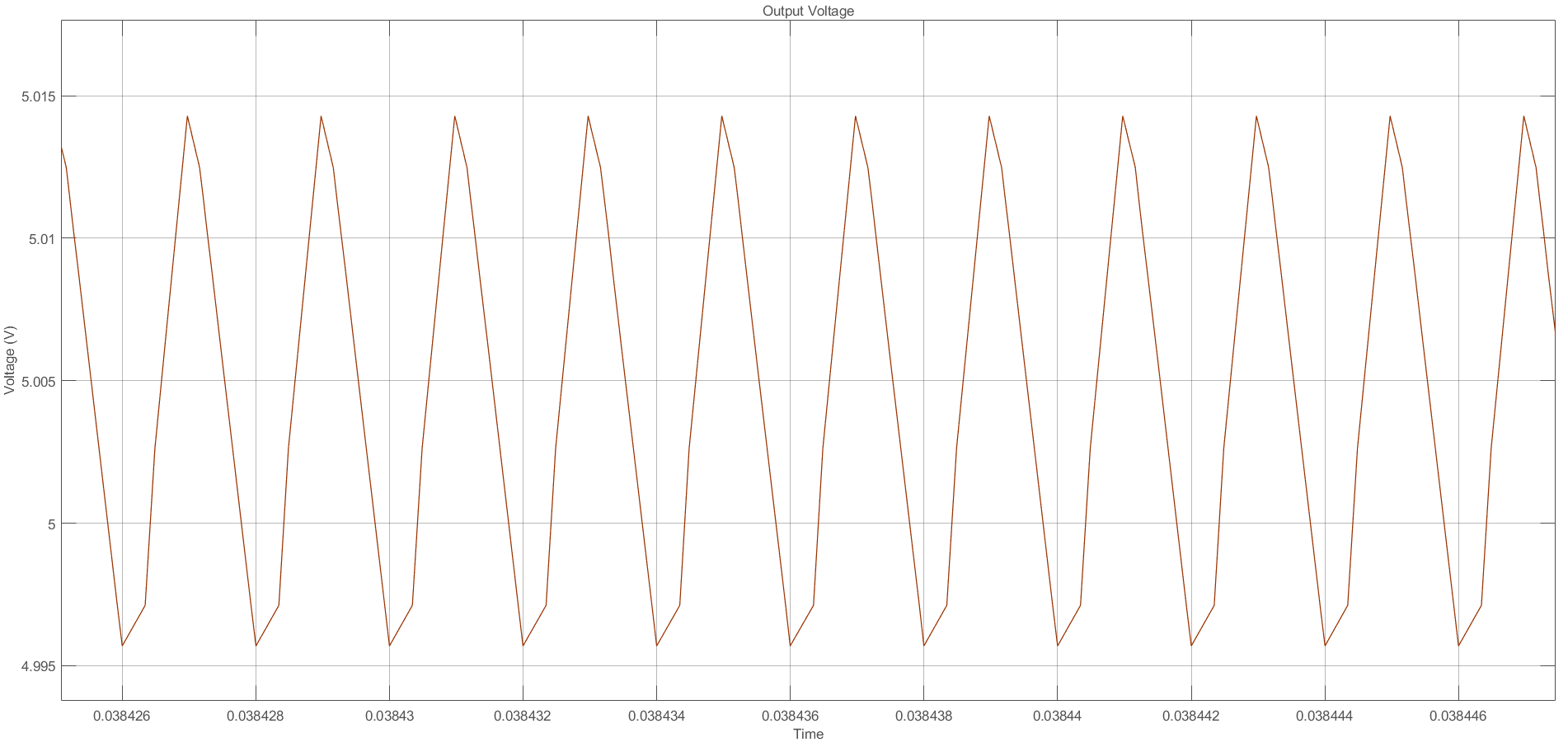


Figure 7: Output Voltage Graph

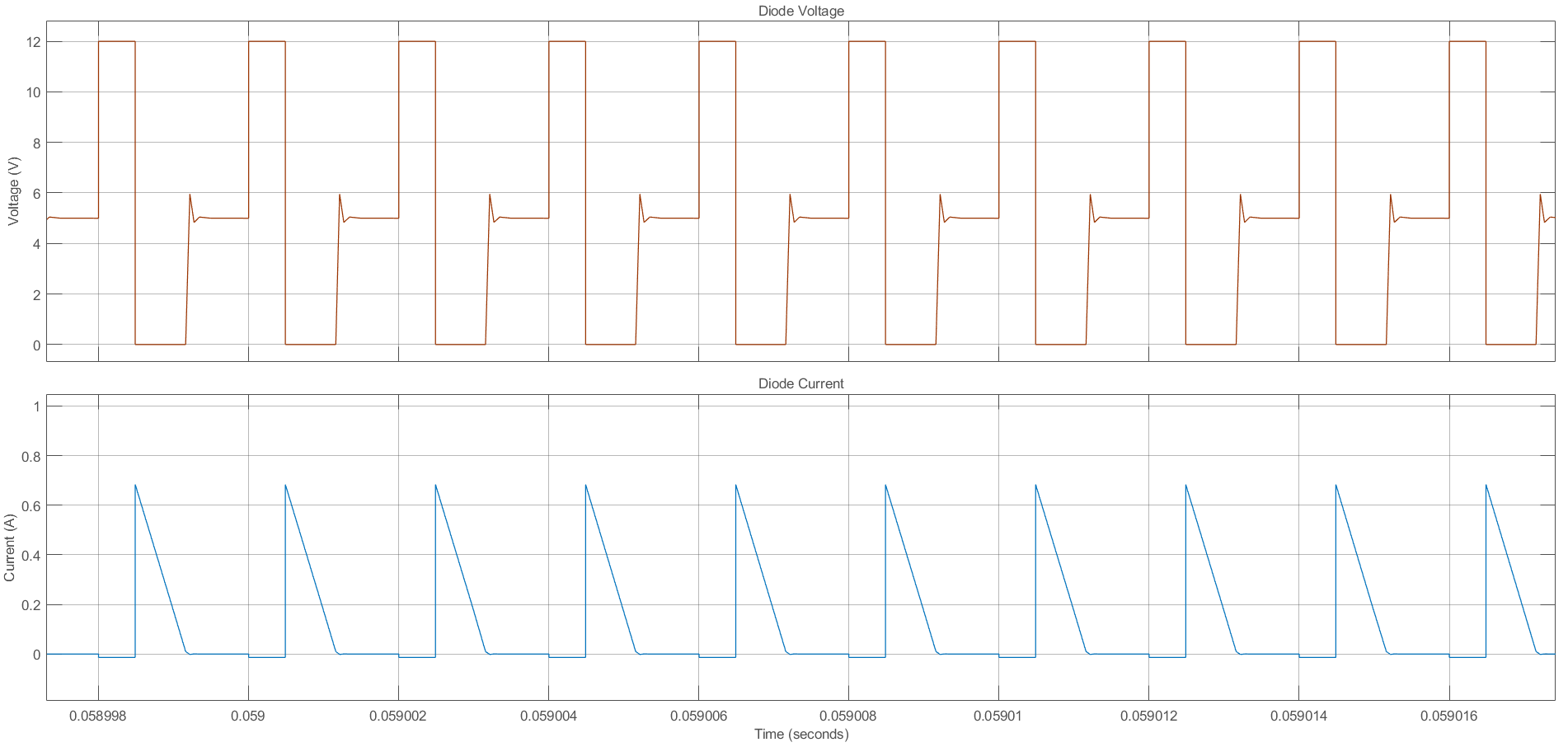


Figure 8: Diode Voltage and Current Graph

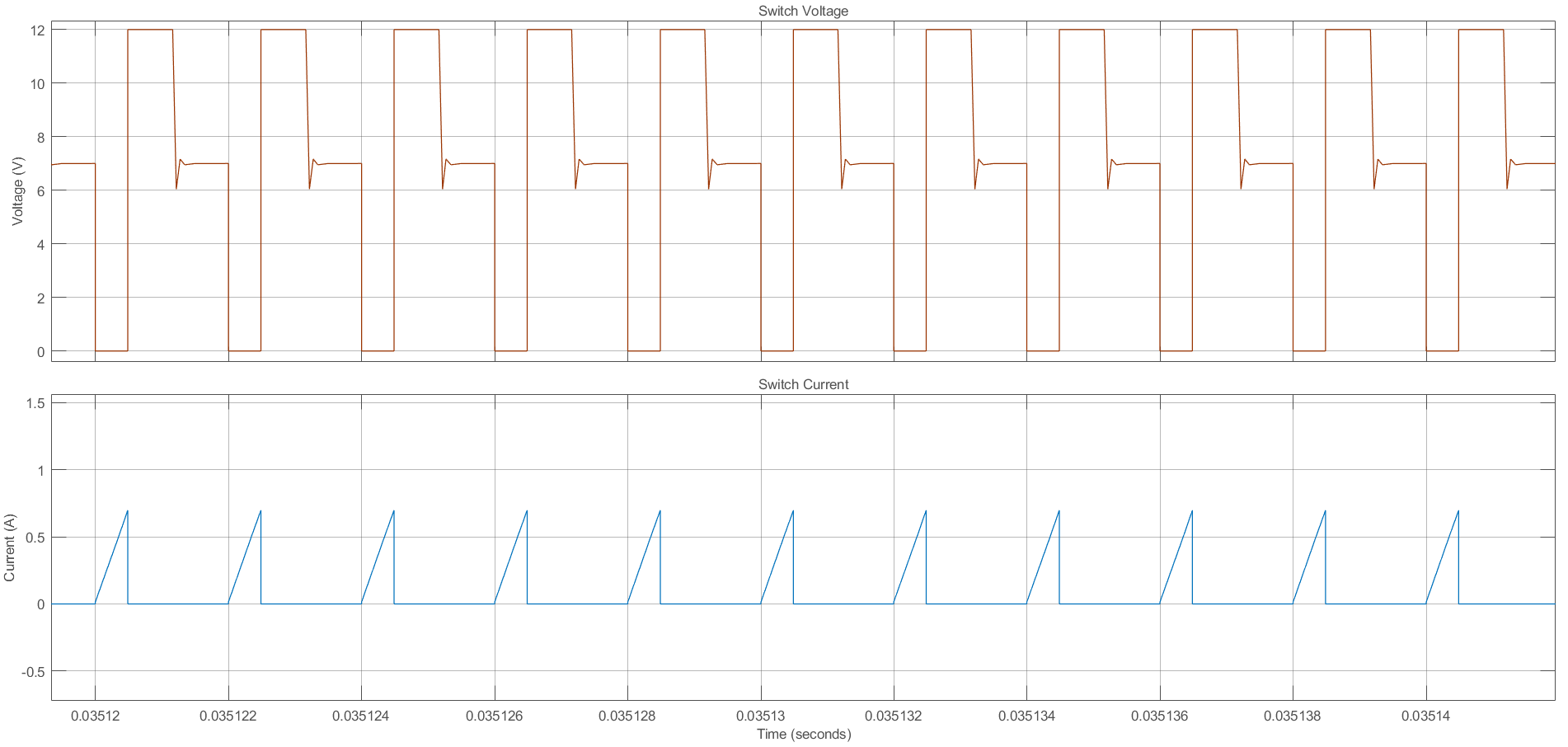


Figure 9: Switch Voltage and Current Graph

In this part, the discontinuous current mode was observed. When the inductor current graph was examined, the inductor peak current was 0.68A which is smaller than the boundary current value found in part a.

When compared with part c, it can be seen that the output voltage ripple and inductor current ripple decreased.

**e)**

The inrush current is the spike in the current when the supply is turned on. Since the capacitor is not charged, there is a need for a high current to charge them. It can be higher than the rated current of the component, so the components may be damaged.

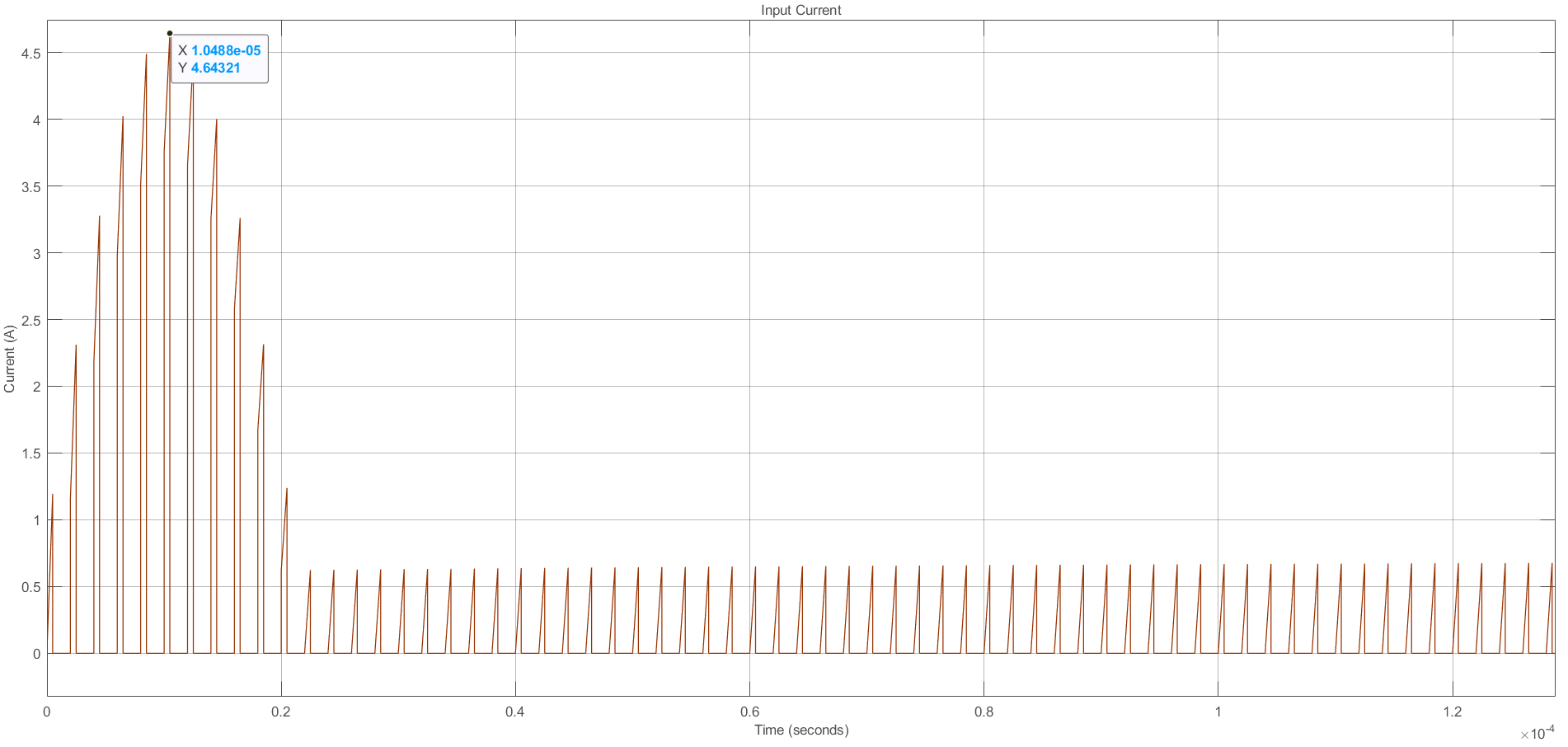


Figure 10: Input Current Graph without Applying Any Methods

It can be seen that the input current reached 4.64 A, which was approximately 6.5 times higher than the operating current.

To prevent high inrush current, soft starter can be used. With a soft starter, the duty cycle increased slowly. As a result, the current cannot reach high values.

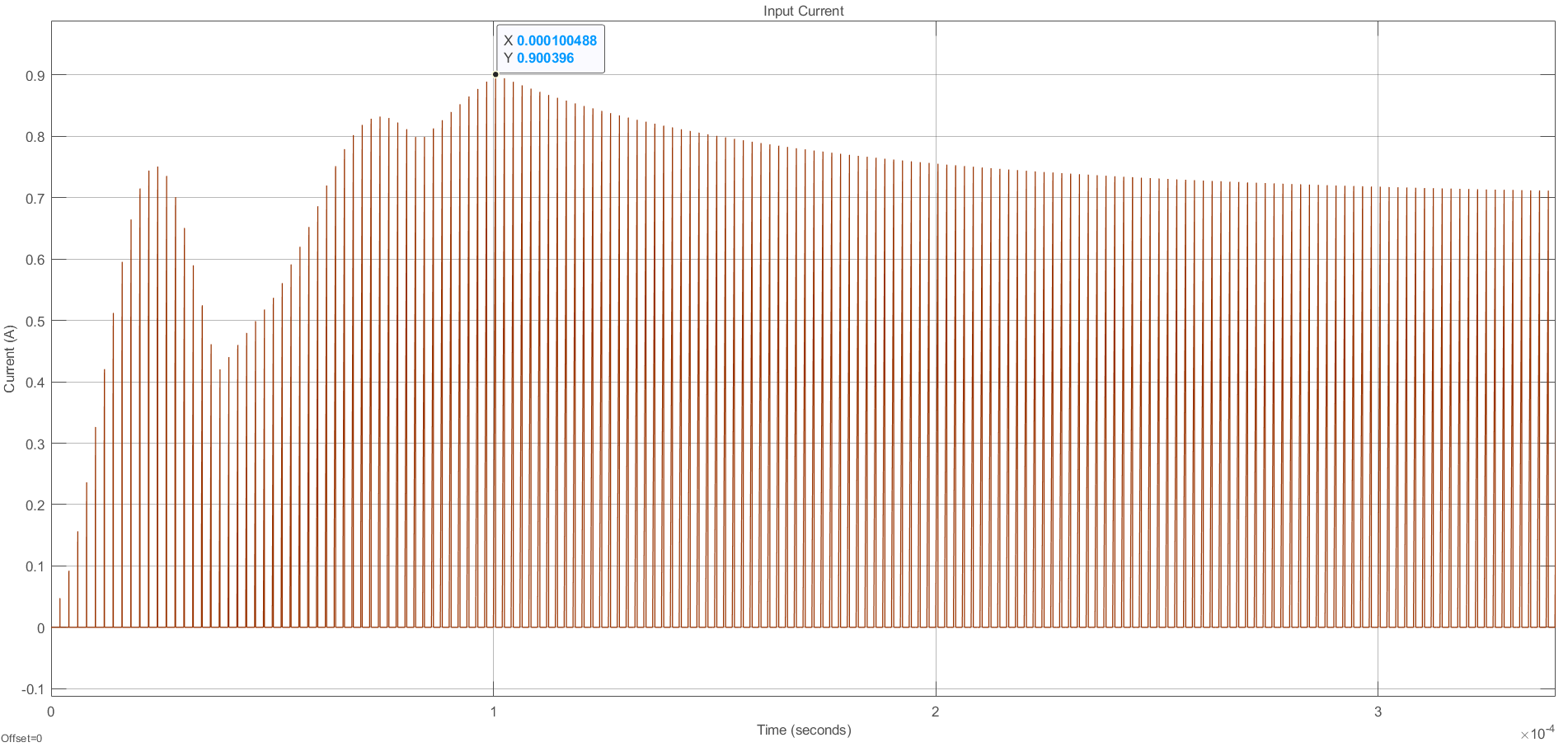


Figure 11: Input Current Graph When Soft Starter is Used

**f)**

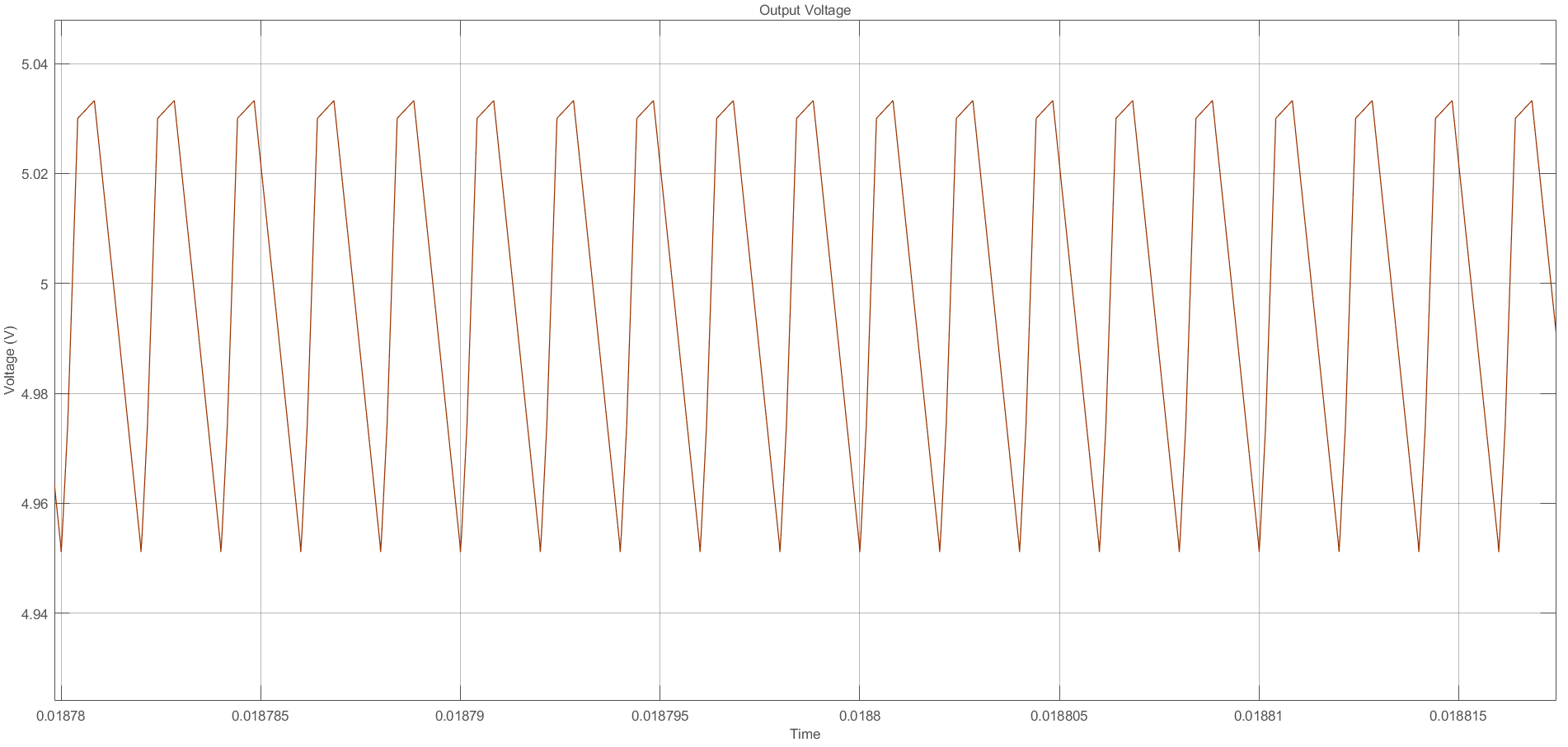
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Figure 12: Output Voltage Graph When the Input is 24V, and there is ESR

ESR affected output voltage ripple. The output ripple voltage was 82.24 mV which was 1.64% of the average output voltage in this case. In part c, it was 31.98 mV which was 0.64% of the average output voltage. To decrease ripple voltage, a smaller ESR is needed. To do that, capacitors can be connected in parallel.

1. **Boost Converter**

**a)**

**b)**

**c)**

**d)**

**e)**

**f)**

**g)**

# CONCLUSION

In this homework assignment, buck and boost converters were examined. In a buck converter, continuous and discontinuous current modes were investigated. The boundary current that ensures CCM operation was found by analytical calculation. In simulations, it can be seen that the converter that has a lower output current than the boundary current sometimes has zero inductor current. In addition, in DCM operation, when the duty cycle was calculated, it could not be found by using Vo/Vin formula because there is zero output current time in DCM operation. The inrush current was observed in the output current. This caused due to the capacitor is not charged. By adding a soft starter, the duty cycle was increased slowly, and the inrush did not occur. Also, the effect of ESR was observed. ESR increased the output voltage ripple, and a lower ESR was needed for a more stable output voltage. To do that, capacitors with lower ratings can be connected in parallel. As a result, the same capacitance value capacitor with lower ESR can be obtained.

# APPENDIX