EEE 148 Buck Converter in Simulink

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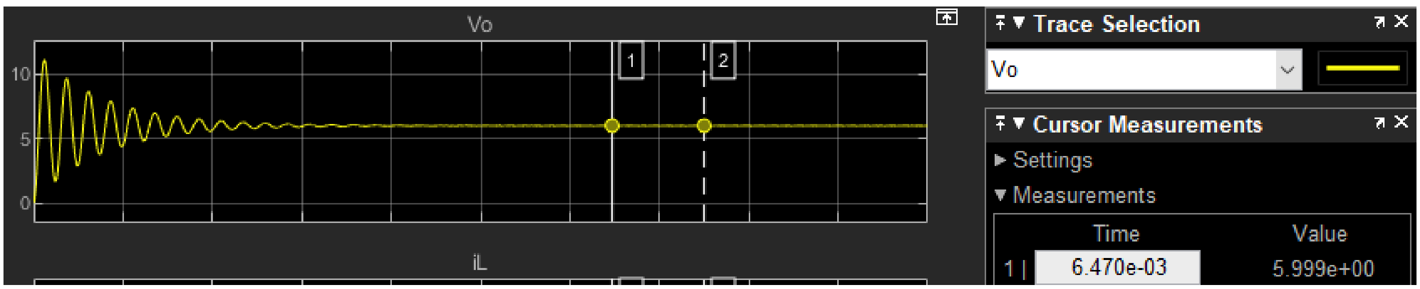
Collaborated with:		

GENERAL INSTRUCTIONS: Provide the required information in the spaces provided. If you run out of room for your answer, feel free to adjust the template as necessary.

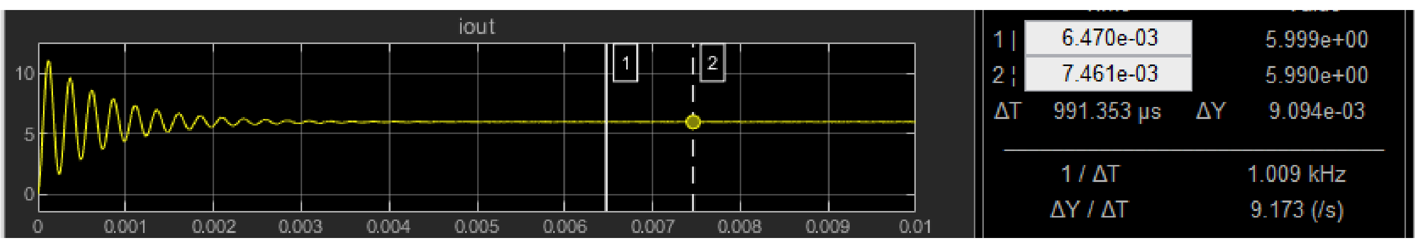
Learning Activity: Open-Loop Buck Converter

1. **Open-loop Buck Converter.** Implement the open-loop buck converter in Figures 4 and 5.

(a) v_o waveform. v_o at steady - state = 6V

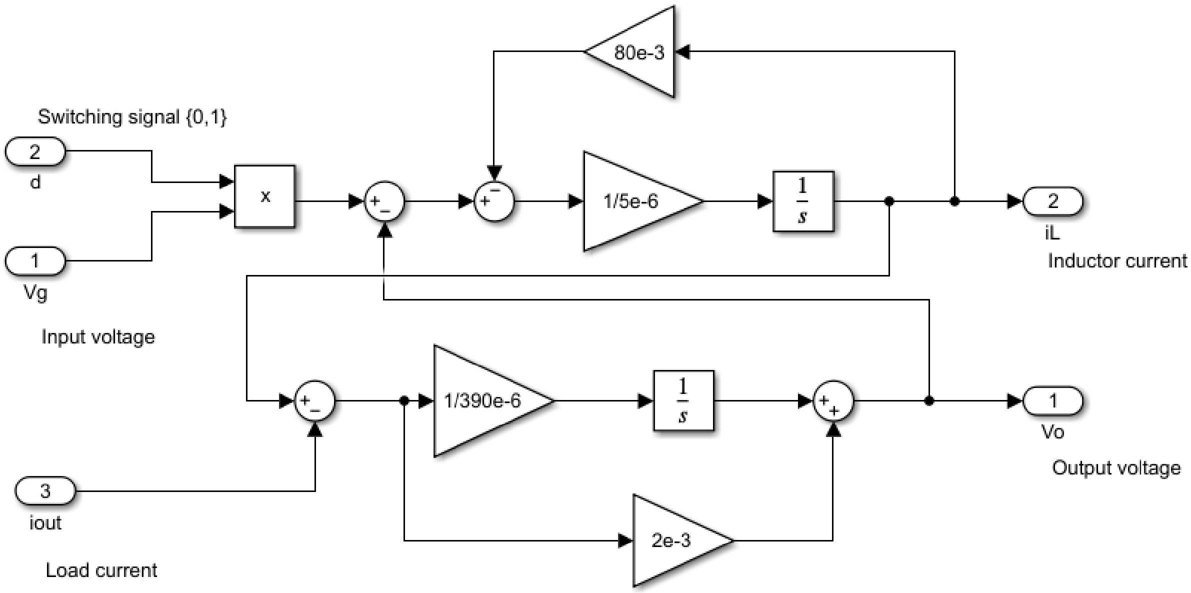


(b) i_{out} waveform.



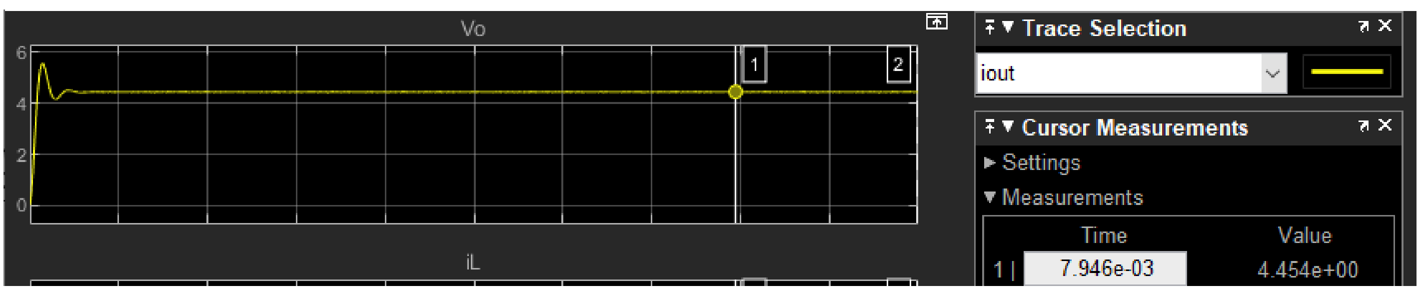
2. **Buck Converter with Resistances.** Modify the buck converter in Fig. 4 using the following values: $L = 5\mu H$, $R_L = 80m\Omega$, $C = 390\mu F$, $R_{esr} = 2m\Omega$.

(a) Block Diagram of the buck converter itself (similar to Fig 4; not the overall diagram).

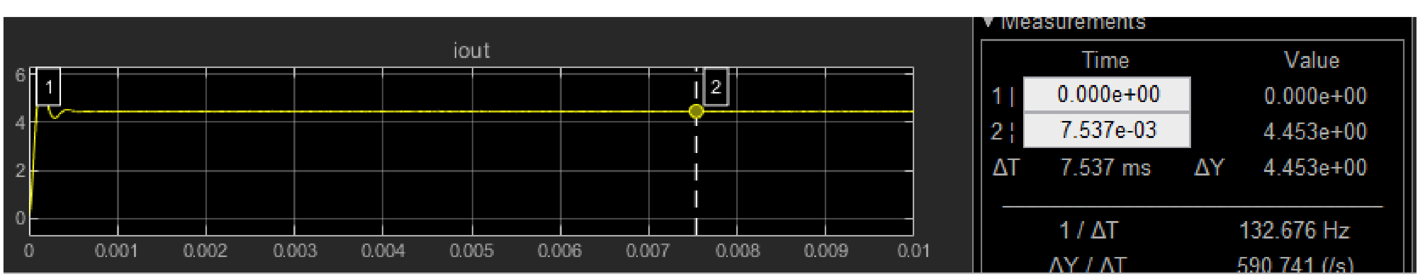


3. **PWM.** Set d=0.4

(a) v_o waveform. v_o at steady - state = 4.45V



(b) i_{out} waveform. i_{out} at steady - state = 4.45V

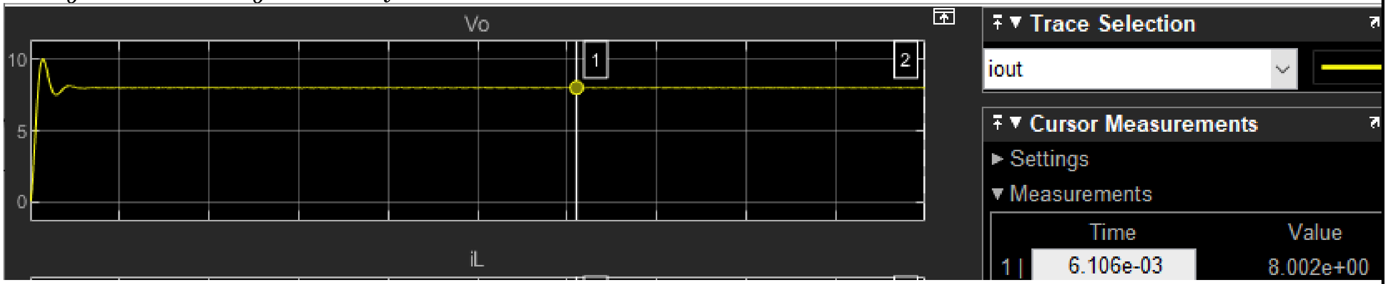


4. **Varying the duty cycle.** Change the duty cycle iteratively to get the desired output of $v_o = 8V$.

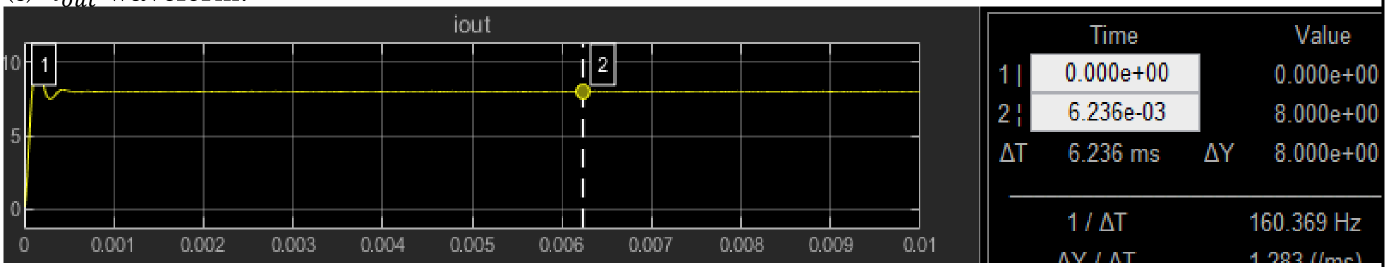
(a) What is the duty cycle d needed to get $v_o = 8V$?

$$d = 0.72$$

(b) v_o waveform. v_o at steady - state = $8.002V$



(c) i_{out} waveform.

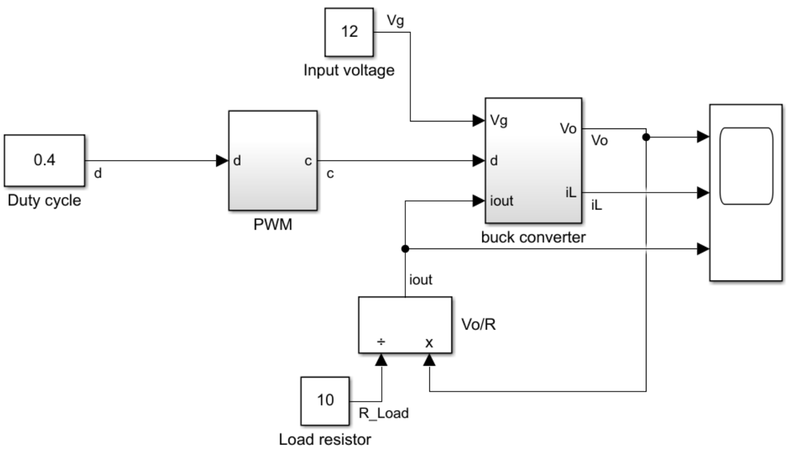


(d) What is your process for varying the duty cycle? How does the output of the buck converter affect your decision whether to increase or decrease the duty cycle?

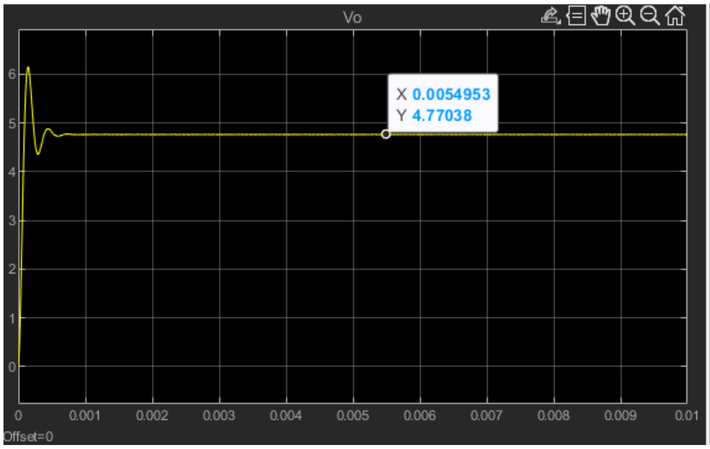
- Increasing the duty cycle also increases the steady – state output voltage. I increase or decrease accordingly.

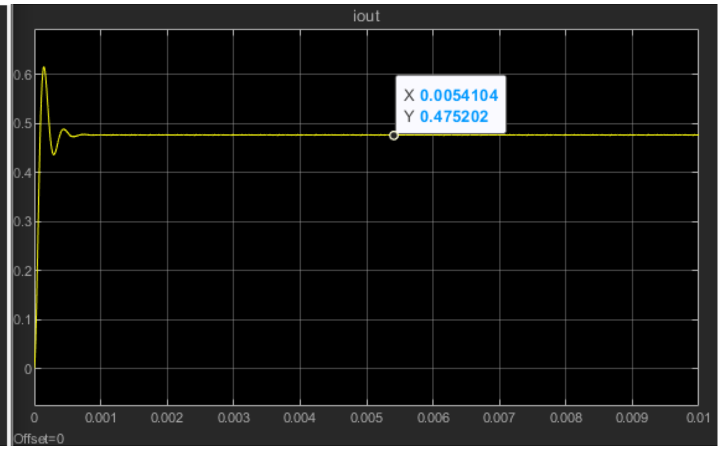
5. **Changing the load resistance**

(a) Show the new block diagram of the open-loop system.



(b) What is the value of v_o and i_{out} at steady state? $v_o = 4.77\text{V}$, $i_{out} = 0.47\text{A}$





(c) How does the load affect v_o and i_{out}? Explain.

- The load scales v_o $linearly. At\ the\ same\ time, the\ load\ scales\ \ i_{out}\ inversely.$
- This follows Ohm's law. With the same v_o, i_{out} changes depending on the load resistance.

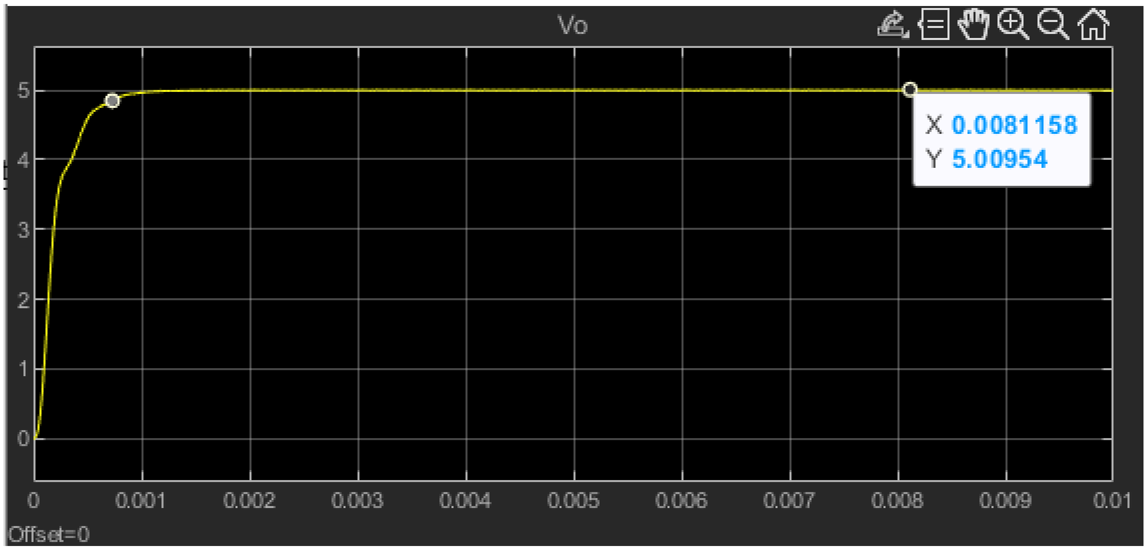
(d) How can you get back a desired value for $v_o$when using a different load?

- Since the duty cycle and v_o $are\ related\ proportionally, we\ can\ define\ a\ constant\ k\ where$
- $k = \frac{v_{o1}}{d_1} = \frac{v_{o2}}{d2}$
- This k holds for every value of v_o, d

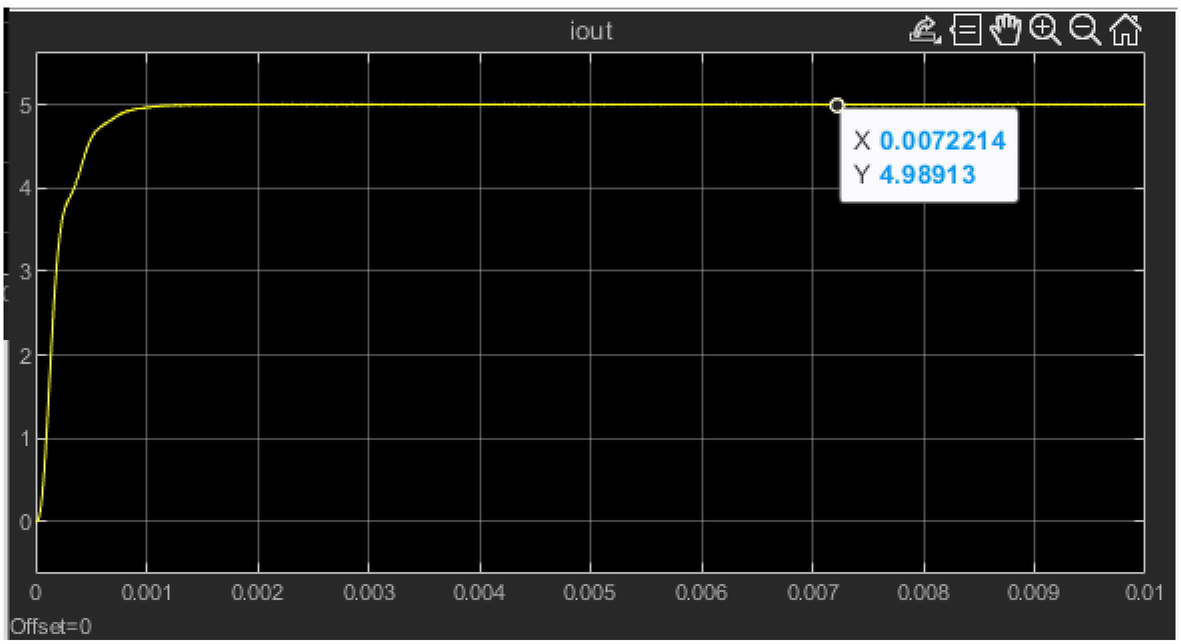
Learning Activity: Closed-Loop Buck Converter

1. **Closed-loop Buck Converter.** Implement the open-loop buck converter in Figures 7.

(c) v_o waveform. v_o at steady - state = 5V

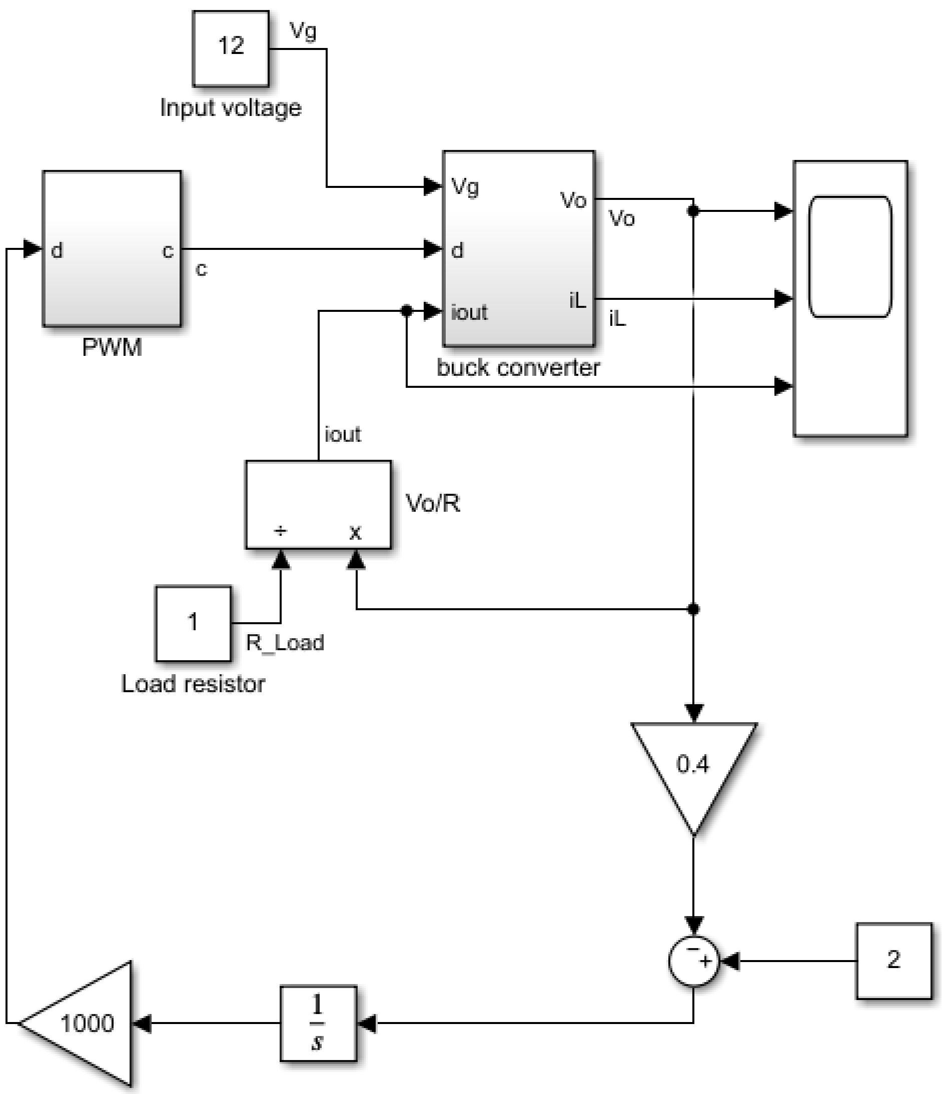


(d) i_{out} waveform.

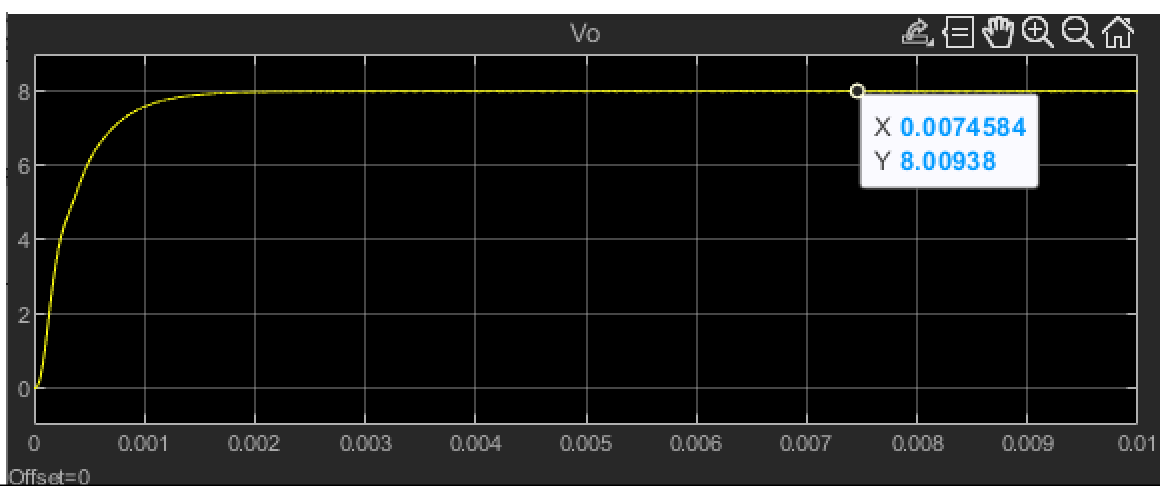


2. **Changing the output v_o.** Modify the closed-loop buck converter such that $v_o = 8V$.

(a) Block Diagram of the closed-loop buck converter



(b) What variable must be changed? What should be its value? Voltage divider gain = 0.25



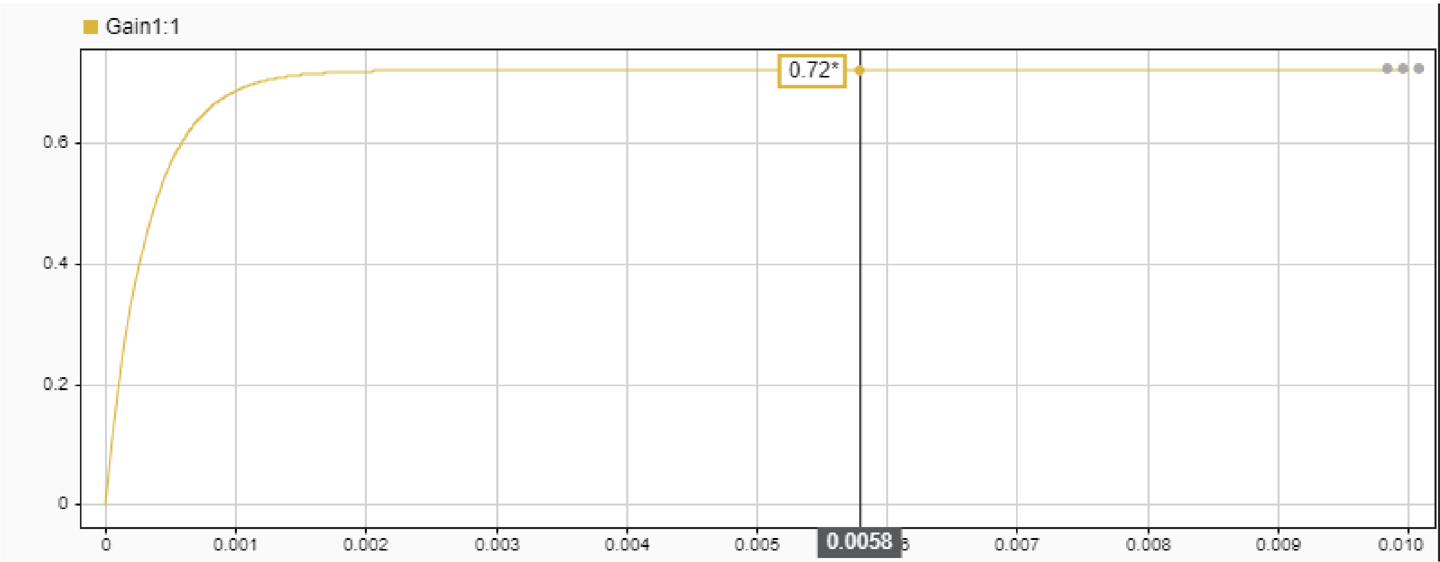
(c) Explain how this works. Include both equations and explanations.

$$A_{v,divider} = \frac{V_{ref}}{v_o}$$

- With $V_{ref} = 2, and\ v_o = 8,\ A_{v,divider} = 0.25$

(d) Probe the value of the duty cycle d. What is the value at steady - state? 0.72

Compare this with the duty cycle value that you got in the open-loop exercise to also get $v_o = 8V$. Explain.



- This is the same as the d value for the open loop setup.

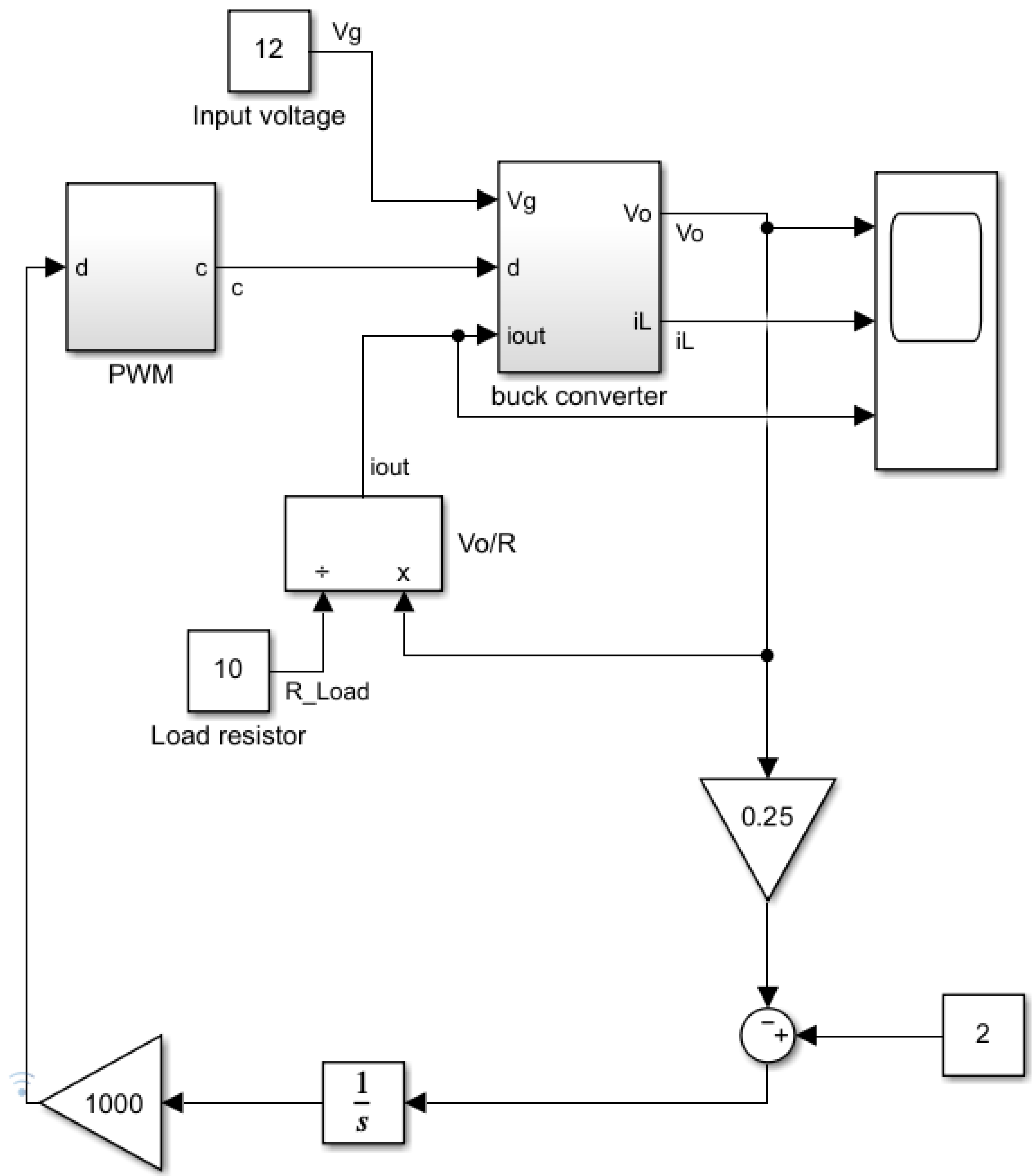
3. How can you implement V_{ref} without using another voltage source? Note that we only have a single input voltage source V_g available to us.

- We can always use the V_g and a gain block. The gain will have a value:

$$G = \frac{V_{ref}}{V_g}$$

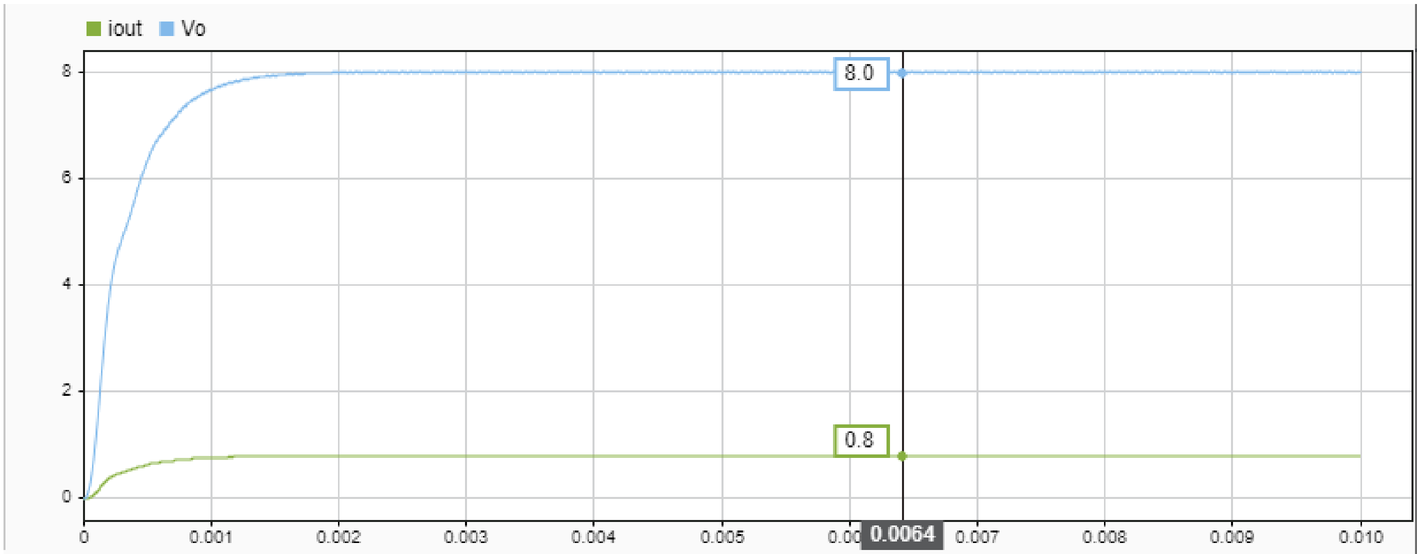
4. **Changing the load resistance.** Replace the load with $R_{load} = 10$.

(a) Show the new block diagram of the closed-loop system.



(b) Show the waveforms. What is the value of v_o and i_{out} at steady state?

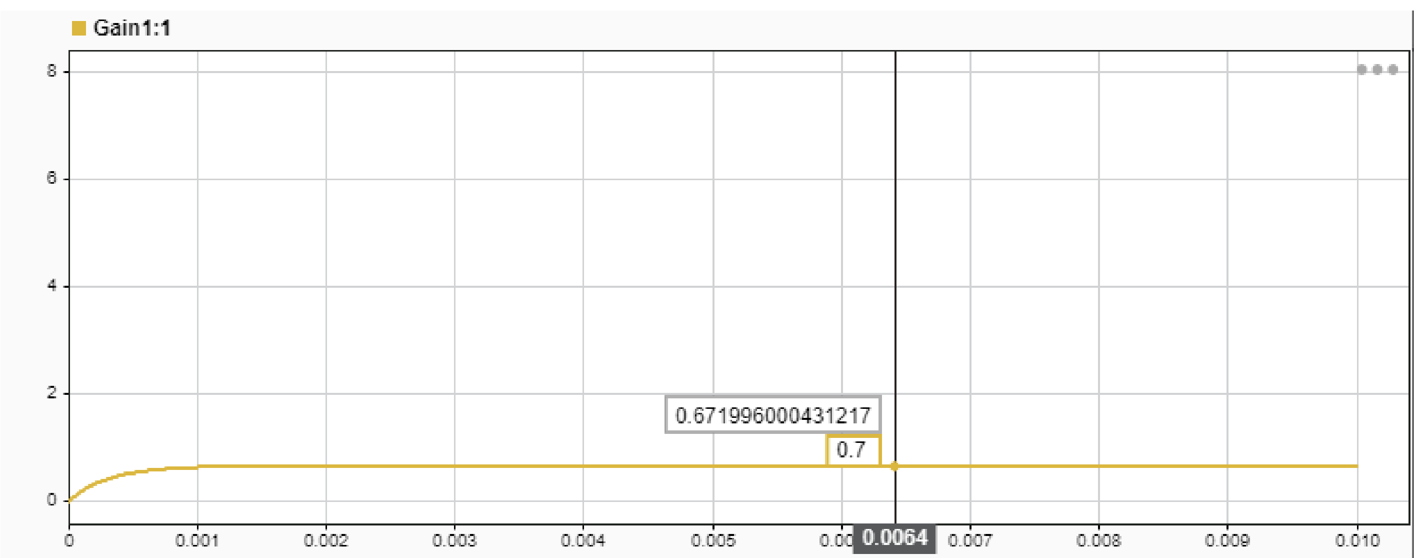
$v_o = 8.0\text{V}$, $i_{out} = 0.8\text{A}$



(c) How does the load affect v_o and i_{out}? Explain.

- The load current and voltage is governed by Ohm's law. Here, with the same v_o, the current should decrease if we increase the resistance.

(d) Probe the value of the duty cycle d. What is the value at steady - state? Did the value change when compared to when $R_{load} = 1$? Why or why not?



- The value of d decreased.
- I think this has something to do with the load resistance having an effect to the current.

5. Explain how an open-loop system would get a desired v_o, and how it differs from a closed-loop system.

- For an open loop system, the $v_o\ is\ governed\ by\ some\ constant, say, k\ where$

$$k = \frac{v_o}{d}$$

- With this, we can obtain any $v_o\ by\ just\ varying\ d$.
- For a closed loop system, $v_o\ follows$

$$v_o = \frac{V_{ref}}{A_{v,divider}}$$

- The duty cycle is not manually set in a closed loop system. It can vary since it has a feedback path.

6. Explain the advantages and disadvantages of using an open-loop vs. using a closed-loop system.

- The gain may be high on the open-loop system but is it not as stable when compared to the closed-loop system
- A closed-loop system is generally harder to design since the system also needs to use controllers.