INDUSTRIAL APPLICATIONS OF POWER ELECTRONICS

QUIZ 1 – 12 OCTOBER 2012

QUESTION

A Buck converter is given with $48V$ input and $24V$ output voltages. Switching frequency of the converter is $100kHz$. A variable resistive load is supplied by this converter.

1. Assume that $R = 4\Omega$ and CCM operation.
   a. Find duty cycle and output current of the converter.
   b. Find L for peak-to-peak inductor current ripple to be 20% of average inductor current.
   c. Find C for peak-to-peak output voltage ripple to be $0{,}1V$.
2. Assume that R is increased (converter is unloaded) .
   a. Find R_{crit} where the converter operates at boundary between CCM and DCM.
   b. Find a new duty cycle for $R = R_{crit} + 5\Omega$.

SOLUTION

1. For CCM operation;
   a. $D = V_o/V_d = 24/48 = 0{,}5 \qquad I_o = 24/4 = 6A$
   b. For a Buck converter, inductor average current is equal to output current.

      $\Delta i_L = I_o \cdot 20\% = V_o(1-D)/(L\, f_s) \;\rightarrow\; 6 \cdot 0{,}2 = 1{,}2 = 24 \cdot (1-0{,}5)/(100000\, L)$

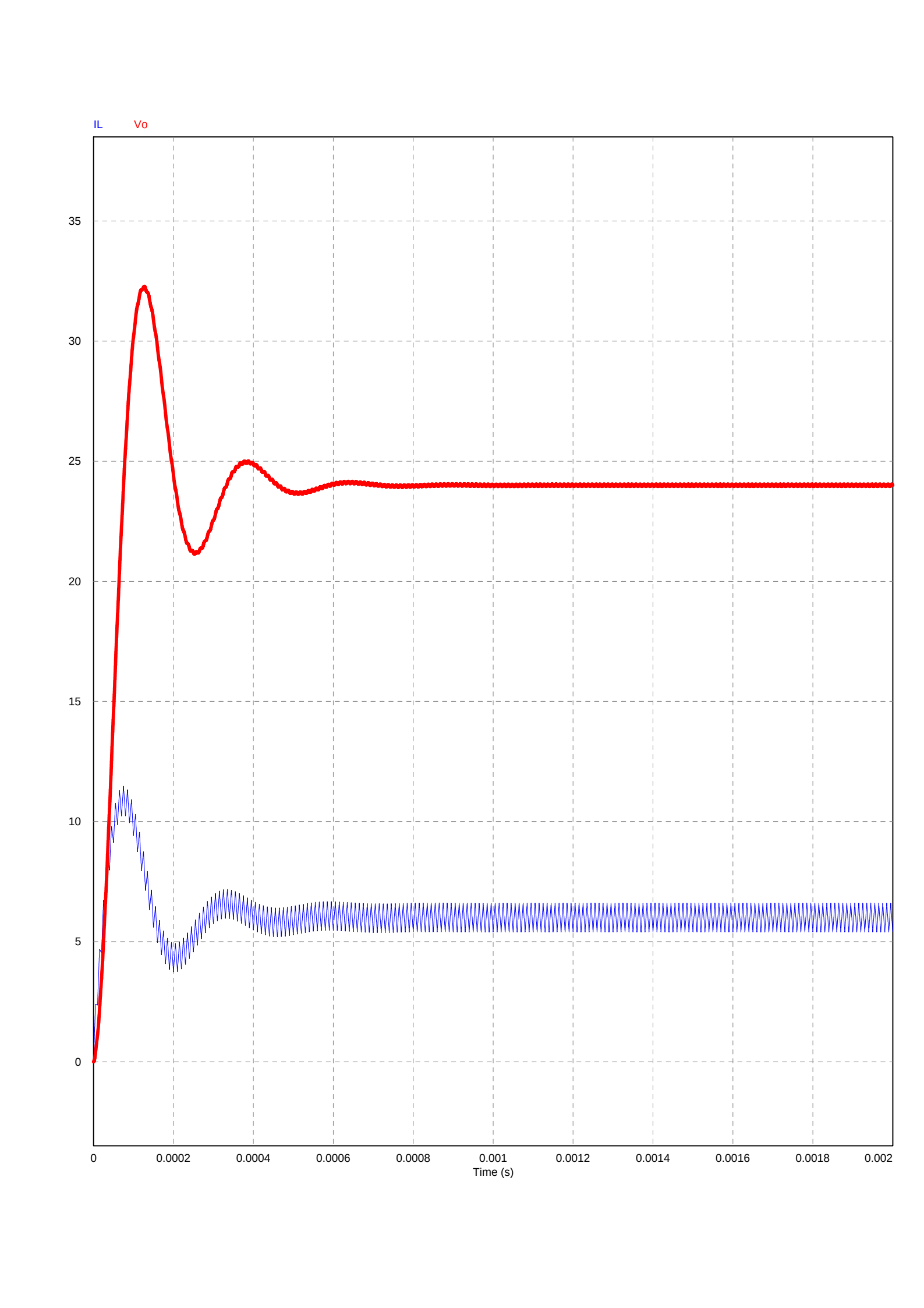
      $L = 100\mu H$
   c. $\Delta v_o = V_o(1-D)/(8\, L\, C\, f_s^2) \;\rightarrow\; 0{,}1 = 24 \cdot (1-0{,}5)/(800\mu\, C\, 100000^2)$

      $C = 15\mu H$
2. Unloading a converter makes operation mode going from CCM to DCM.
   a. At a specific R, converter operates at BCM (boundary point between CCM and DCM).

      $R_{crit} = 2\, L\, f_s/(1-D) = 200\mu \cdot 100000 \,/\, 0{,}5 = 40\Omega$
   b. For a R value greater than R_{crit} makes the converter operating at DCM. For DCM;

$$\frac{V_o}{V_d} = \frac{2}{1+\sqrt{1+4K/D^2}} \quad where \quad K = \frac{2\, L\, f_s}{R} \quad \rightarrow \quad K = \frac{200\mu\, 100000}{40+5} = \frac{20}{45} = 0{,}444$$

$$\frac{24}{48} = \frac{2}{1+\sqrt{1+4\cdot 0{,}444/D^2}} \quad \rightarrow \quad \sqrt{1+\frac{1{,}777}{D^2}} = 3 \quad \rightarrow \quad D = 0{,}471$$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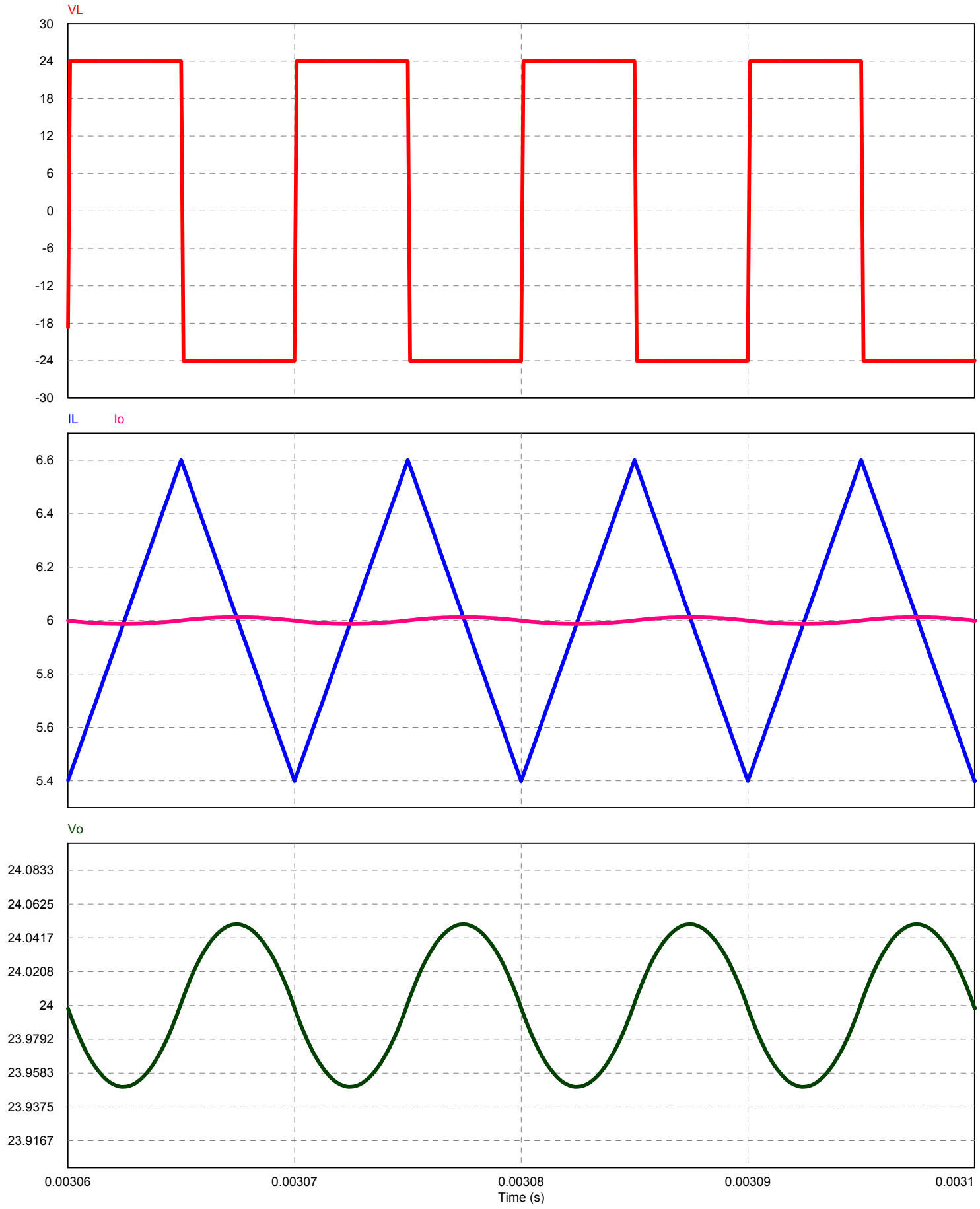
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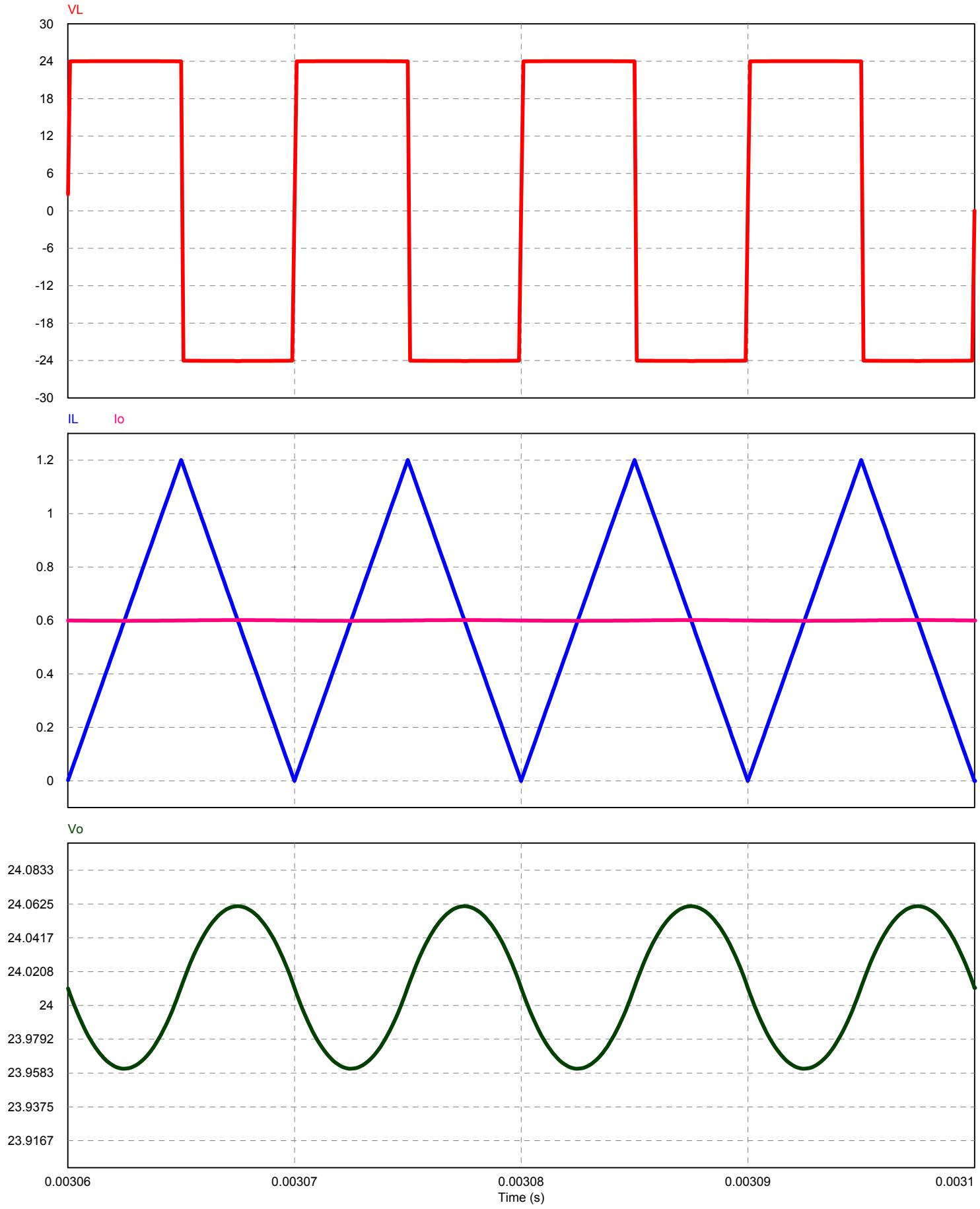
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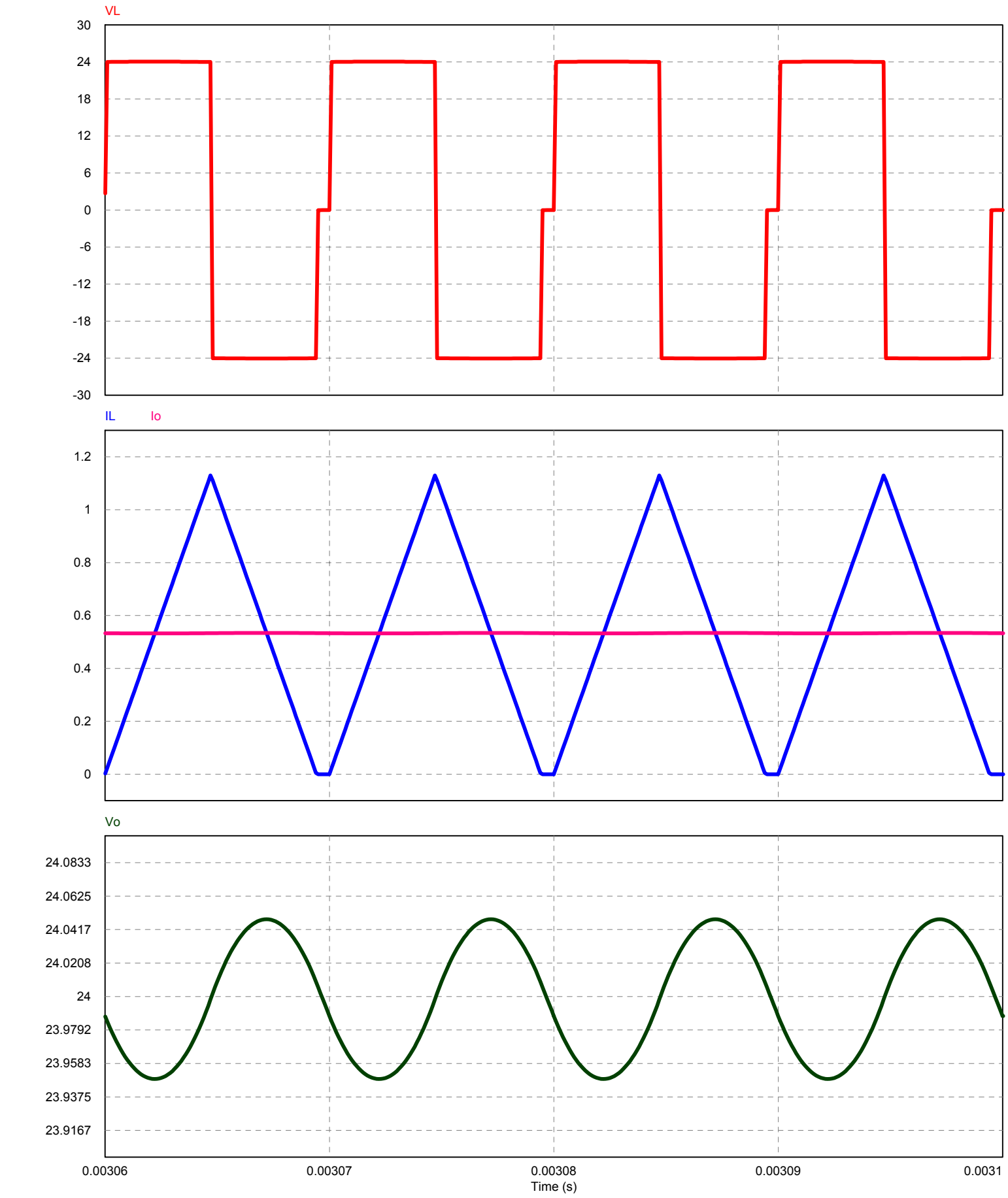
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