# Analog Lab
## Experiment 7: Buck Converter

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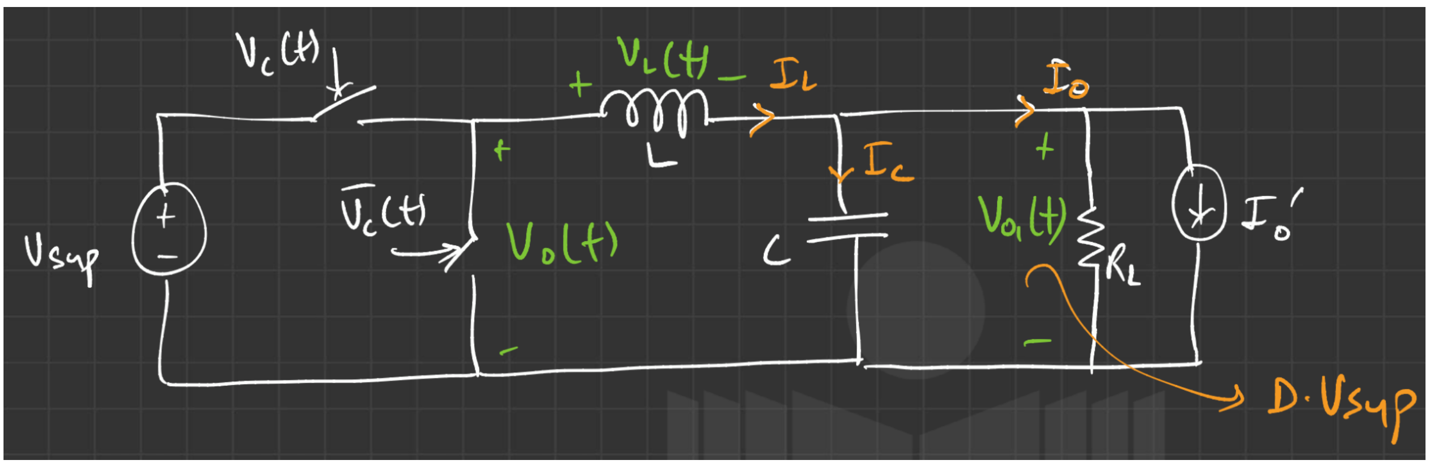
**1. To design a Buck converter with the following specifications**

Input Supply: $V_{sup} = 5V$
Output Voltage: $V_{01, avg} = 2.5V$
Switching Frequency: $f_s = 1MHz$
Load: $R_L = 100\Omega$ resistor with $I_o = 100mA$ current source
Output Ripple Voltage $\leq 10mV$
Quality factor: $Q = 3$

Circuit Used




Now the average voltage of $V_{01}$ is $DV_{sup}$ where D is duty cycle and $V_{sup}$ is 5V. Given the average of $V_{01}$ as 2.5V, we get the duty cycle D as 0.5

Relation between peak-to-peak voltage of $V_{01}$ is-

$$V_{01, PP} = \frac{(1-D)DV_{sup}}{8LCf_s^2}$$

Using the given condition that $V_{01, PP} \leq 10mV$ and substituting values of D(0.5), $f_s$(1MHz) and $V_{sup}$(5V) we get-

$$LC \geq \frac{5\times10^{-10}}{32} \rightarrow \text{Eq 1}$$

Quality factor for LC circuit is given as-

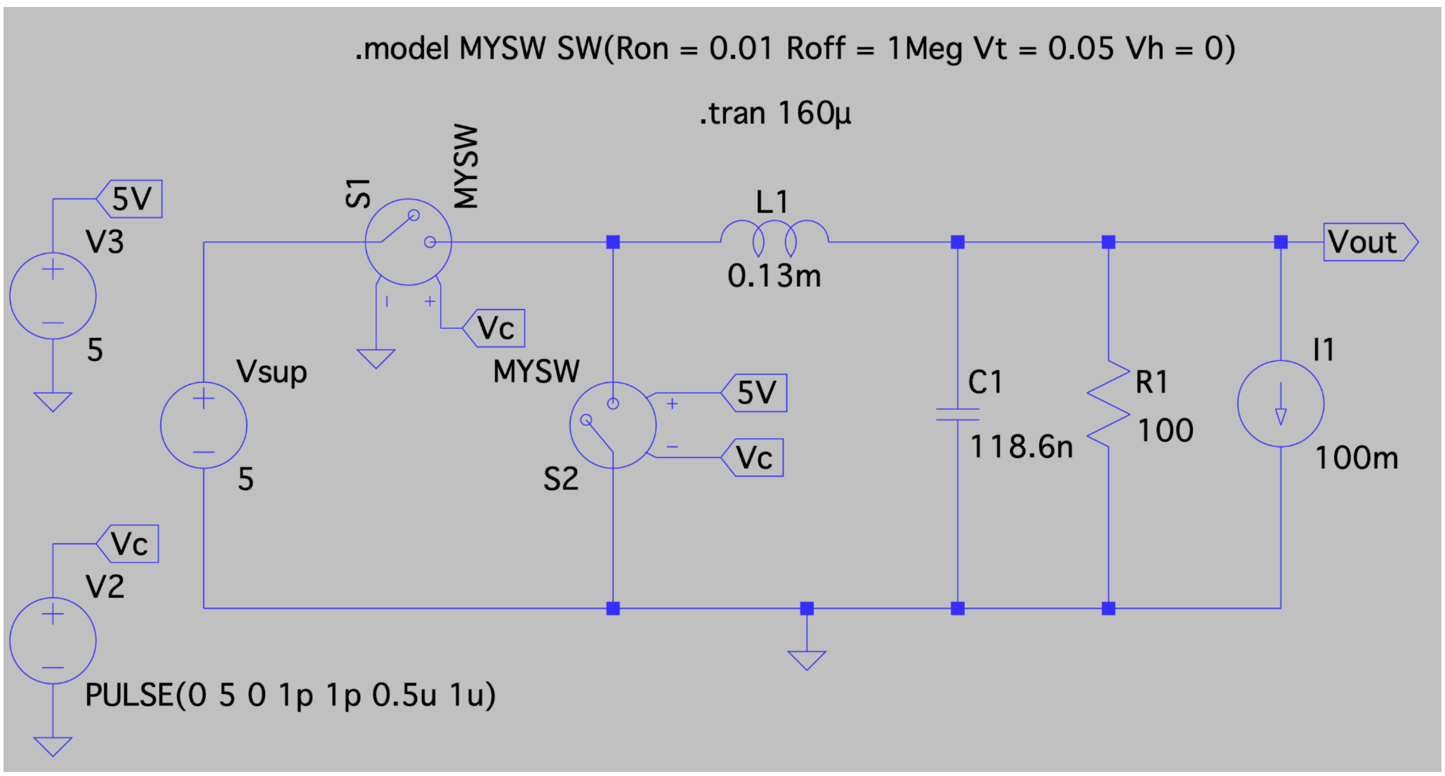
$$Q = R_L\sqrt{\frac{C}{L}}$$

Substituting values of Q(3) and $R_L$(100Ω) we get-

$$\frac{C}{L} = 9 \times 10^{-4} \rightarrow \text{Eq } 2$$

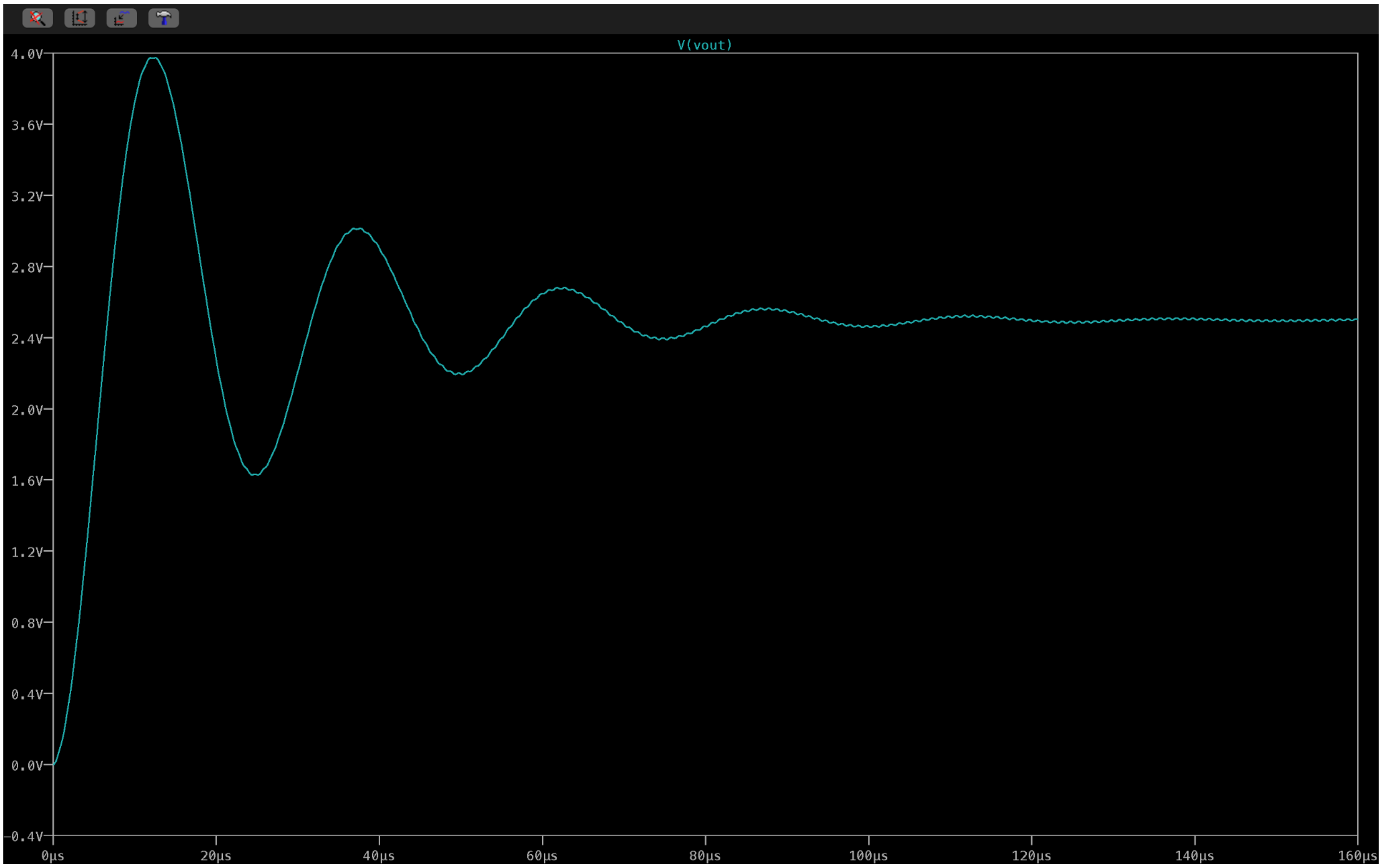
Taking equality in equation 1 and dividing with equation 2 we get L as 0.1317 mH and C as 118.59 nF.
In this experiment I have taken L as 0.13 mH and C as 118.6 nF.
All these formulas and circuits are from Analog Electronics lecture 18 and 19.

Implementation in LTSpice

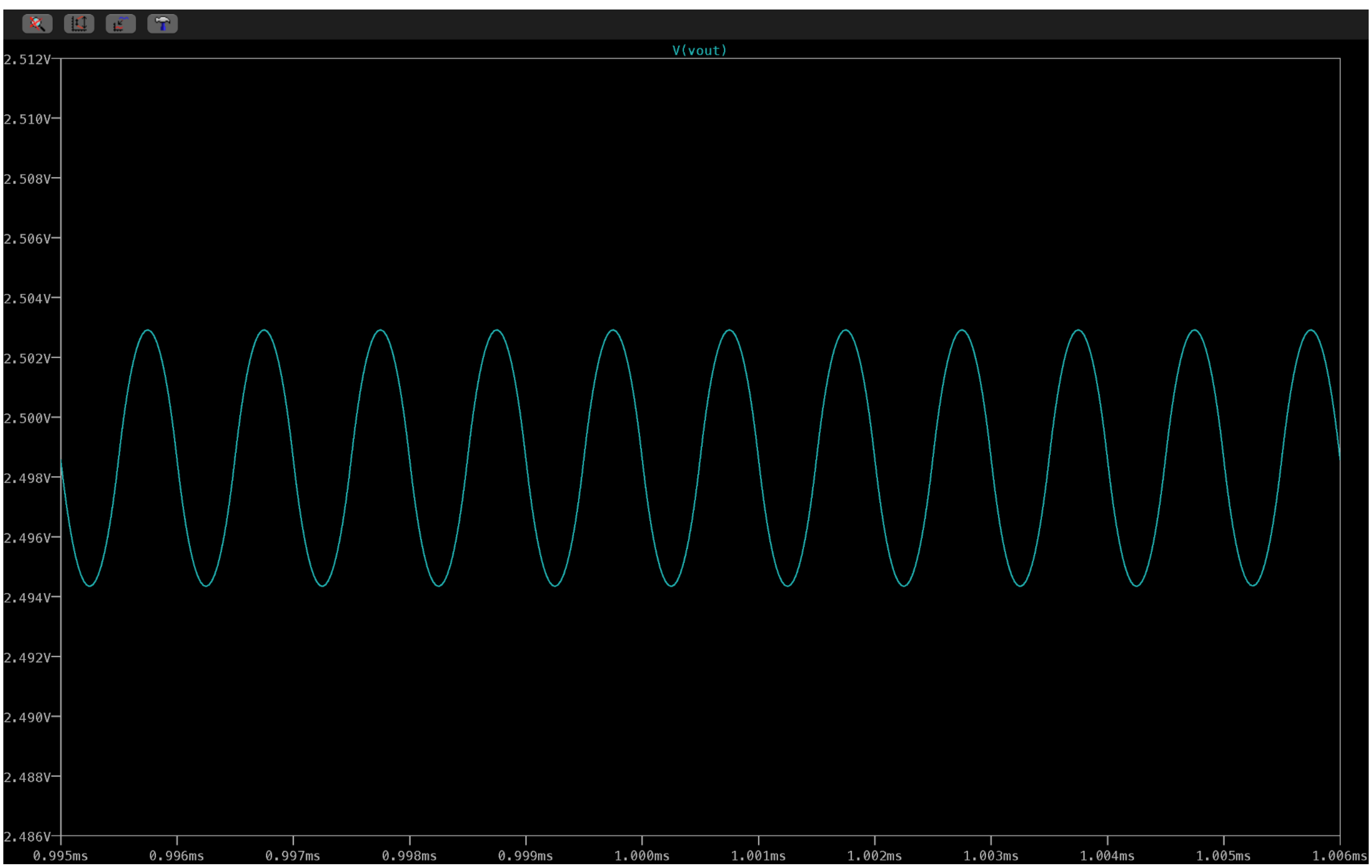



Here we used the voltage controlled switch to implement the switching mechanism. The specifications of the switch are as follows: $R_{on}$ = 0.01Ω, $R_{off}$ = 1MΩ, $V_T$ = 0.05V and $V_H$ = 0V. A low value of $R_{on}$ and high value of $R_{off}$ helps in keeping the switching mechanism to near ideal condition.
In S1, $V_C$ is compared to ground, i.e. $V_C - 0 = V_C$ and in S2, $V_C$ is compared to 5V, i.e. $5 - V_C = \overline{V_C}$.

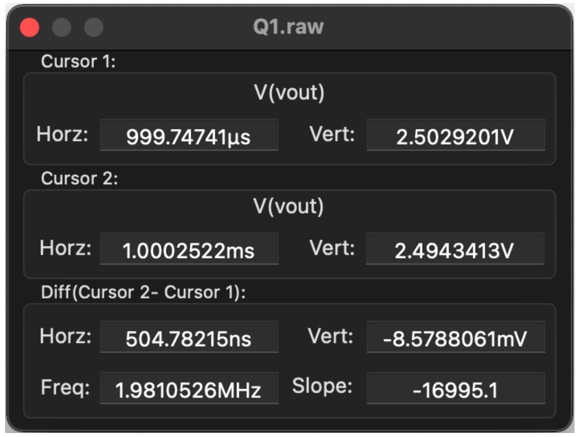
Transient Simulation




Steady State Simulation



Finding Ripple Voltage using Cursor in LTSpice




From the above measurements, ripple voltage is $8.57 \text{ mV} \leq 10 \text{ mV}$.

2. **Some observations**

   2.1 The ripple voltage is as expected.

   2.2 The transient response is similar to an under-damped system.

   2.3 We can control the ripple voltage by varying L and C.

   2.4 The above circuit acts as a DC to DC step down voltage transformer.