A step down converter is used to charge a set of batteries at 12v and a constant power flow of 10w. The input voltage varies between 20 and 40 v. The converter is operating at a 50 kHz switching frequency.

. a) Design an inductance such that the inductance current ripple doesn't exceed 50% of the average current at all times.

. b) Design the output capacitor for an output voltage ripple of 5%.

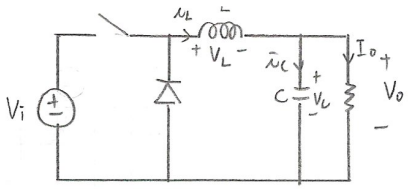
step down ⇒ Buck converter.

$V_o = 12V$.

$P_{out} = 10W \Rightarrow P_o = I_o V_o \Rightarrow I_o = 0.83\ A$

$20V \le V_i \le 40V \qquad P_o = \frac{V_o^2}{R} \Rightarrow R = 14.4\ \Omega$

$f_s = 50\ kHz \Rightarrow T = 2\times10^{-5}$ sec



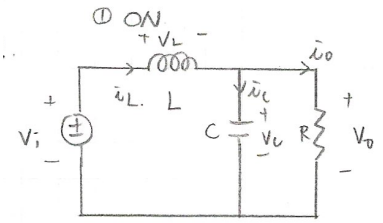
(a)

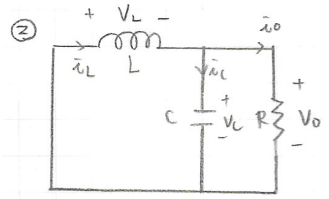
$\Delta i_L \le 50\%\ I_{L\,avg.} = 0.415$

$I_{L\,avg} = I_R = 0.83$

$V_L = L\frac{di_L}{dt} \Rightarrow \Delta i_L = \frac{V_L}{L}\Delta t = \frac{V_o}{L}(1-D)T$

$\Rightarrow L = \frac{V_o(1-D)}{f_s \Delta i_L}$





① for $V_i = 20V$.

$D = \frac{12}{20} = 0.6$

$\Delta i_L = \frac{12 \times (1-0.6)}{L \cdot 50\times10^3} \le 0.415$

$\Rightarrow L \ge 2.313\times10^{-4}\ H$

② for $V_i = 40V$.

$D = \frac{12}{40} = 0.3$

$\Delta i_L = \frac{12(1-0.3)}{L \cdot 50\times10^3} \le 0.415$

$\Rightarrow L \ge 4.048\times10^{-4}\ H$

$\Rightarrow \underline{L \ge 4.048\times10^{-4}\ H}$

Assume : $L = 5\times10^{-4}\ H$.

(b)

$$\frac{\Delta V_o}{V_o} = 5\%$$

$$C = \frac{1-D}{8 f_s^2 L (\Delta V_o / V_o)} = \frac{1-D}{L \times 10^9}$$

① for $V_i = 20V$

$\Rightarrow D = 0.6$

$\Rightarrow L \geq 2.313 \times 10^{-4}\ H$

$\Rightarrow C \leq 1.729 \times 10^{-6}\ F$

② for $V_i = 40V$

$\Rightarrow D = 0.3$

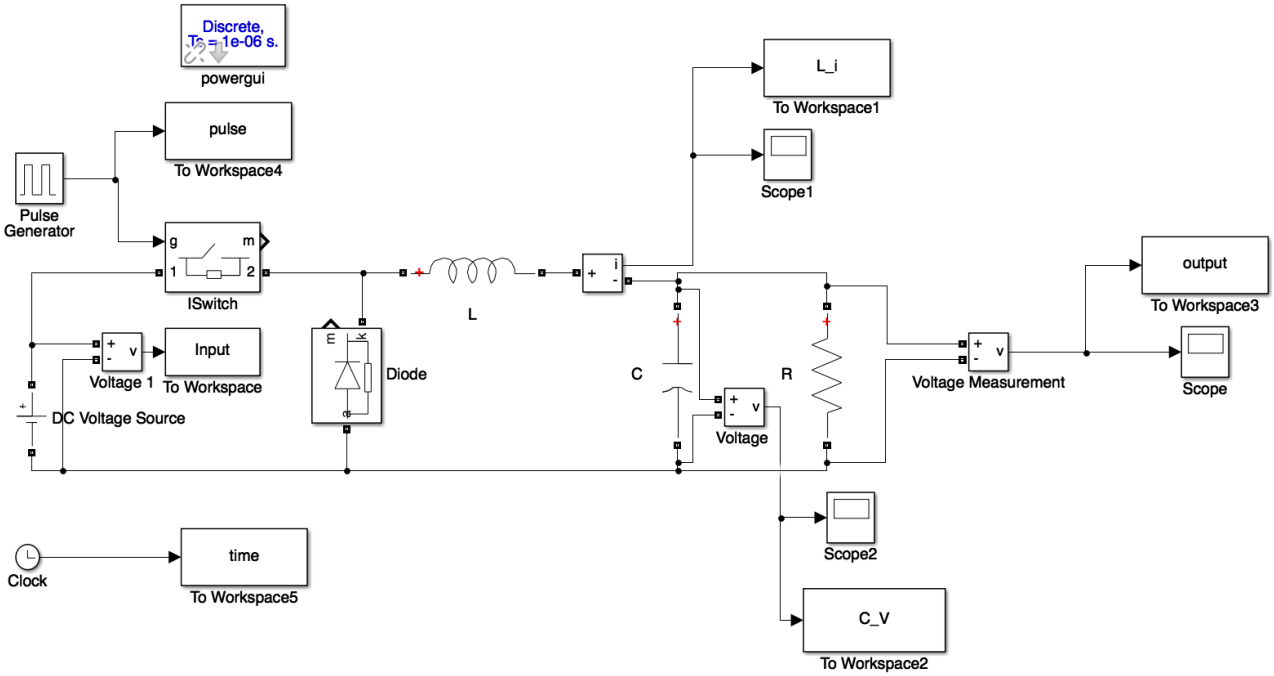
$\Rightarrow L \geq 4.048 \times 10^{-4} H$

$\Rightarrow C \leq 1.729 \times 10^{-6}\ F$

$\Rightarrow C \leq 1.729 \times 10^{-6}\ F$

Assume $C = 1.73 \times 10^{-7}\ F$

Figure1-1 Simulated configuration for Buck converter.



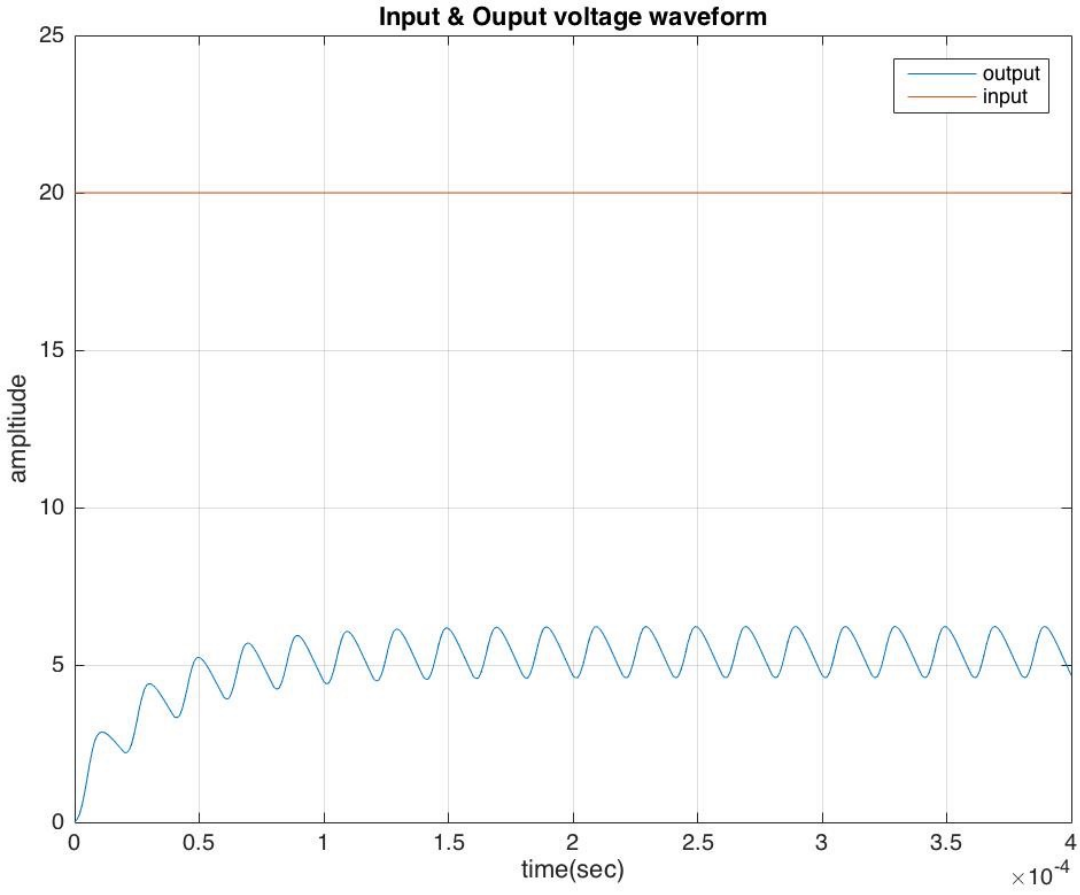


Figure1-2 20V input and output voltage waveform.

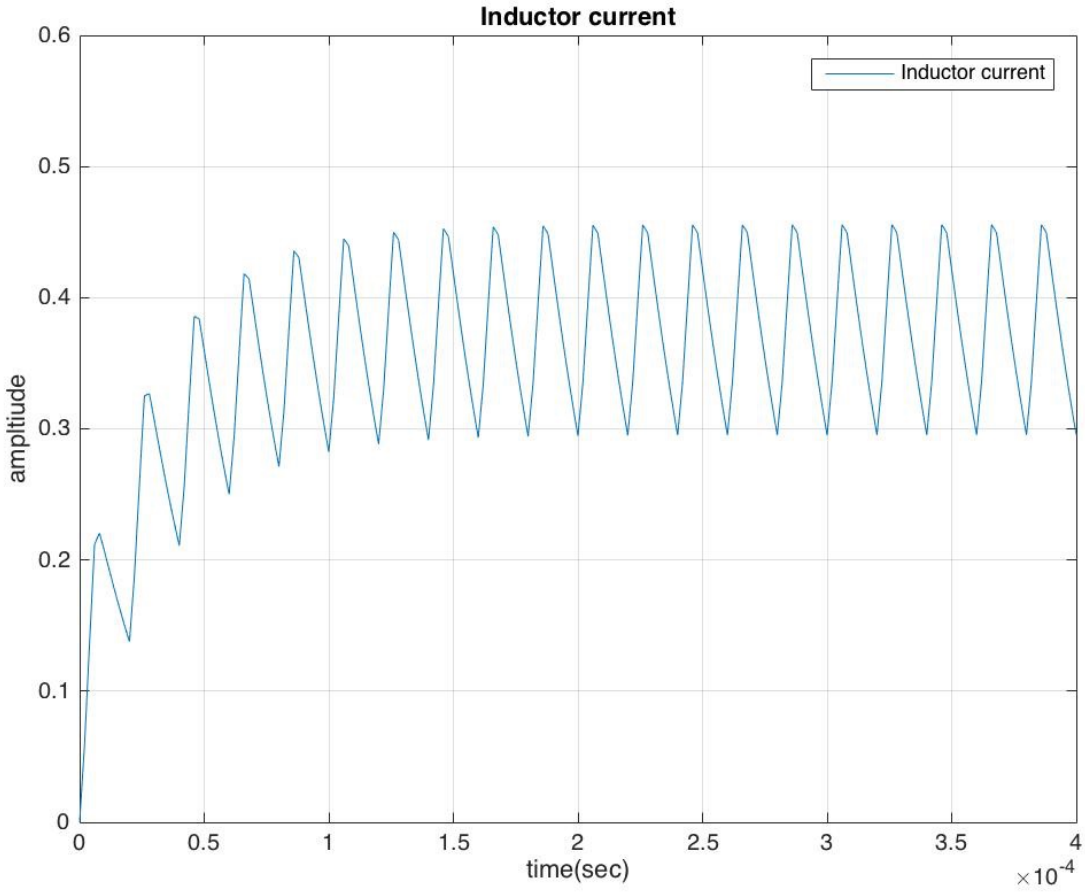


Figure1-3 the inductor current waveform for 20V input.

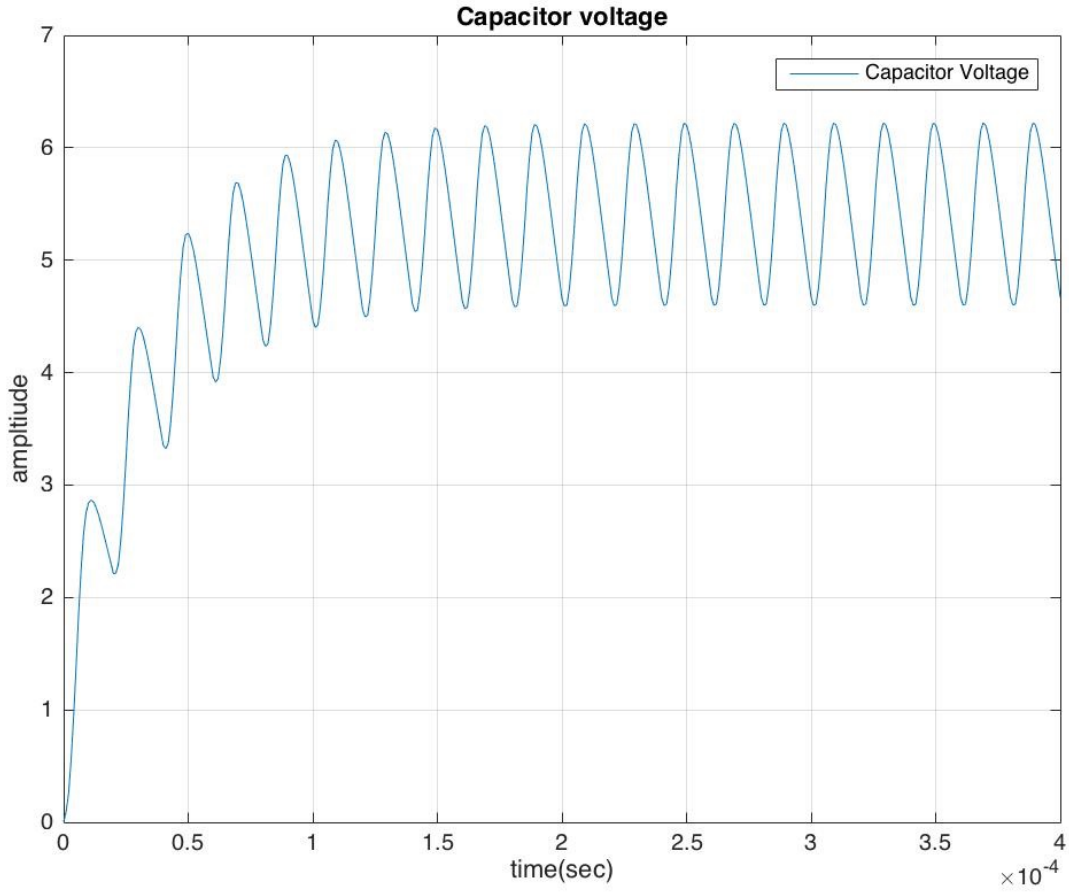


Figure1-4 the capacitor voltage waveform for 20V input.

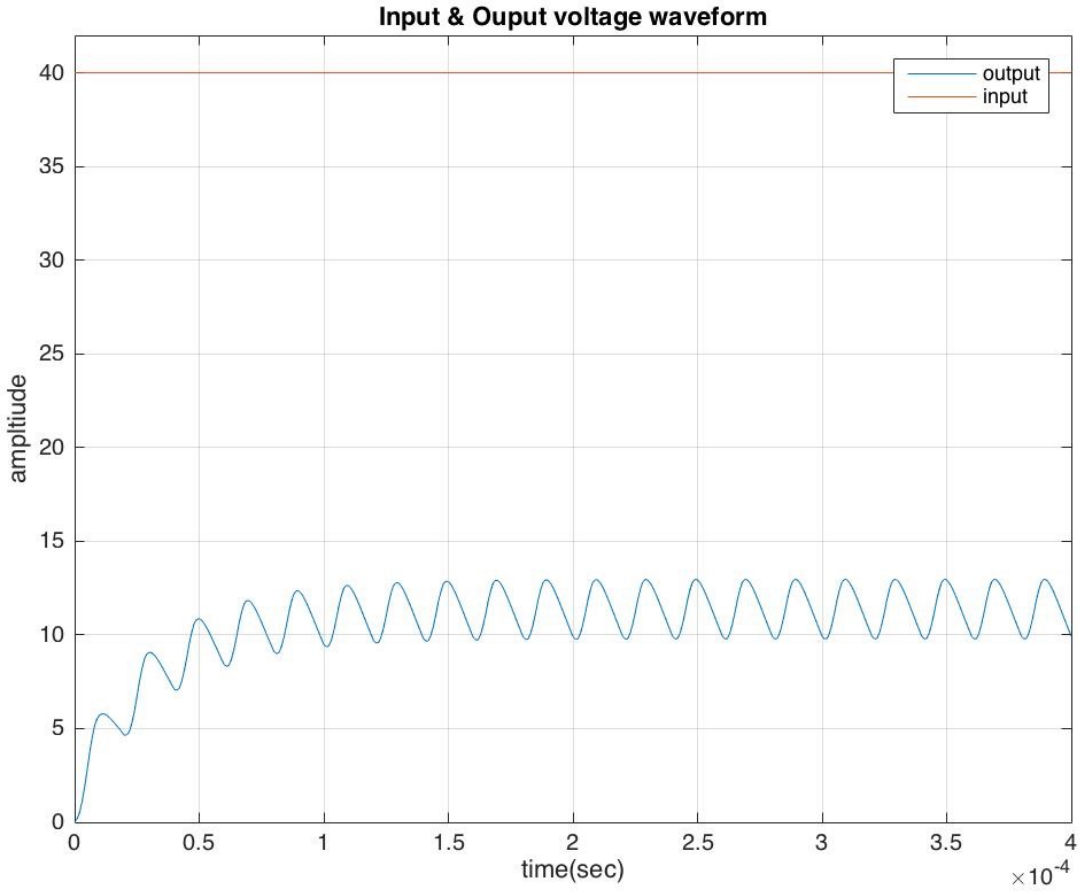


Figure1-5 40V input and output voltage waveform.

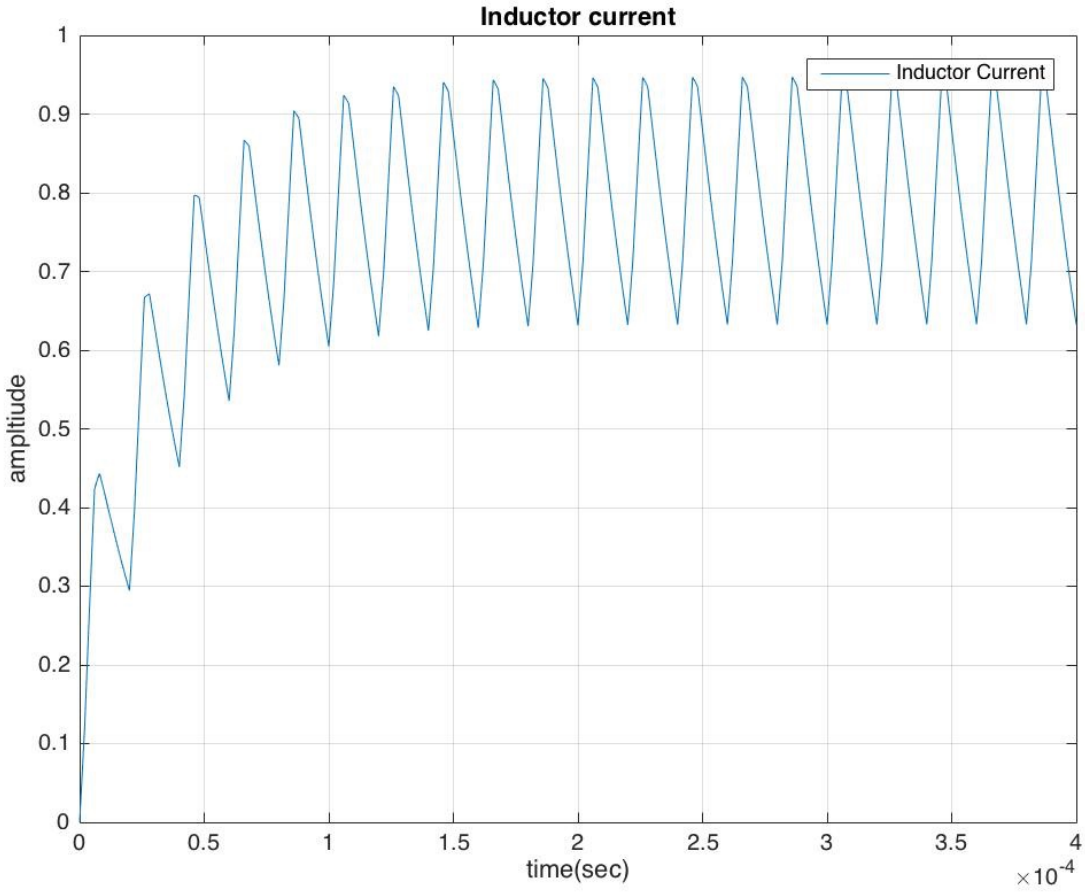


Figure1-6 the inductor current waveform for 40V input.

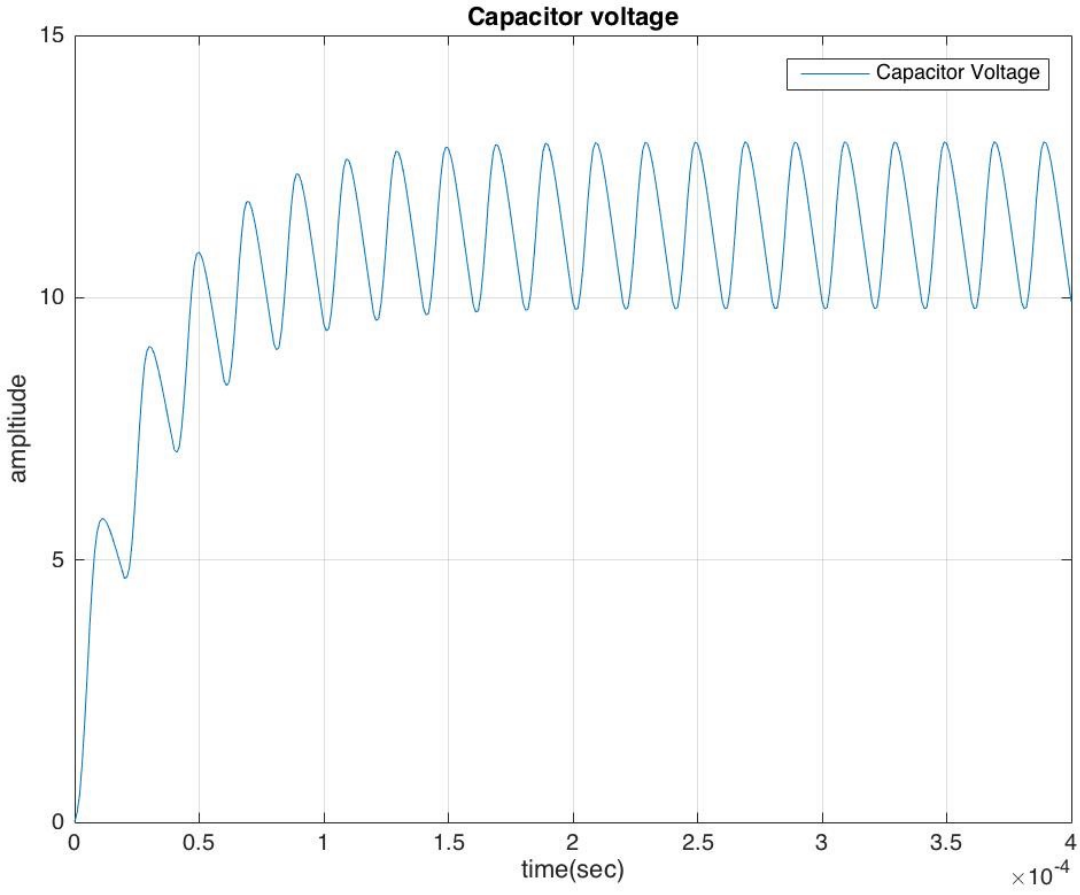


Figure1-7 the capacitor voltage waveform for 40V input.