Sample Exam Part 2 Solution

Here are a few dc-dc converter related questions:

1. You are given a buck converter. You measure the input voltage to be 15 V from a 100W source, and have an output current of 4 A. Assuming no power losses determine: average inp current, output voltage, duty ratio. The filter inductance is 100 μH and the switching frequen is 10 kHz. Will this converter be in continuous conduction. If not suggest two options to mo it to continuous conduction.

$Vd := 50V$ $\qquad$ $L := 100\mu H$

$Io := 4A$ $\qquad$ $fs := 10kHz$

$Po := 100W$ $\qquad$ $Ts := \frac{1}{fs}$

Therefore we find:

$Vo := \frac{Po}{Io}$ $\qquad$ $Vo = 25\,V$ $\qquad$ $D := \frac{Vo}{Vd}$ $\qquad$ $D = 0.5$ $\qquad$ $Id := Io \cdot D$ $\qquad$ $Id = 2\,A$

As a check: $Pd := Vd \cdot Id$ $\qquad$ $Pd = 100\,W$

$ILB := \frac{D \cdot Ts}{2 \cdot L} \cdot (Vd - Vo)$ $\qquad$ $ILB = 6.25\,A$

This converter will not be in discontinuous conduction. Options to make it continuous:

1. Increase L

$Lmin := \frac{D \cdot Ts}{2 \cdot Io} \cdot (Vd - Vo)$ $\qquad$ $Lmin = 156.25\,\mu H$ $\qquad$ $ILBn := \frac{D \cdot Ts}{2 \cdot Lmin} \cdot (Vd - Vo)$

$ILBn = 4\,A$

2. Increase switching frequency (keep the original L), recall: $f_s = 1/T_s$

$fsnew := \frac{D}{2 \cdot Io \cdot L} \cdot (Vd - Vo)$ $\qquad$ $fsnew = 15.625\,kHz$ $\qquad$ $Tsn := \frac{1}{fsnew}$

$ILBn2 := \frac{D \cdot Tsn}{2 \cdot L} \cdot (Vd - Vo)$ $\qquad$ $ILBn2 = 4\,A$

2. Short Answer:

A. Why is it important to always provide an alternate current path when opening a switch in se
with an inductor? What happens if you don't?

Solution: The inductor will act as a current source in the short term (you can't change the curre
through an inductor instantaneously). Therefore, if you open a switch in series with an inducto
the switch in a buck converter), you need an alternate path (like the diode in the buck converte
will pick up the current.

If this is missing, there will be a large voltage from

$$v = L \cdot \frac{d}{dt} i$$

This will be large enough to cause insulation to fail, most likely the swit
itself.

B. Why isn't the current through the inductor in the buck converter constant (since the averag
output current is constant)?

Solution: While the switch is on, the voltage across the inductor is Vd - Voave, while the swit
is open, it is -Voave. Since neither voltage is zero, the current will ramp up while the switch i
closed, and down while it is open. Increasing L or increasing the switching frequency will ma
the variations smaller, but not zero (unless the switch is always closed or always open).