Robert Bara Assignment 2:

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Assignment #2: PWM and Converter Implementation

- ~~Question #1~~

  - Given that the duty cycle of a lossless boost converter changes following d = 0.002·sin(ωt) + 0.3, t represents time and ω represents angular frequency that equals $2\pi \cdot f_{ripple}$, f_{ripple} = 120 Hz, and output voltage V_o is fixed at 100 V,

  1. Please show the feasible range of input voltage V_{in}

  2. For 20 s $\leq t \leq$ (20 s + 3·T_s) (T_s is the switching period and $1/T_s$ = 10 kHz), calculate and draw the equivalent duty cycle over the triangle carrier wave and also draw the corresponding PWM signal. Summarize the results in a scanned document or a Word document.

  $T_s = 1/f_s$

  Draw the equivalent duty cycle (one sample point per switching period)

  Draw the corresponding PWM signal

$t_0 = 20$ s t_0 $t_0 + T_s$ $t_0 + 2T_s$ $t_0 + 3T_s$

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$\omega = 2\pi 120 = 240\pi$ $V_0 = 100 V$ $T_s = \frac{1}{f_s} = \frac{1}{120} = .0083$ sec

$d = .002 \sin(240\pi t) + 0.3$

1) For a Boost converter, the transfer function $\frac{V_0}{V_{in}} = \frac{1}{1-D}$

Solving for V_{in}:

$$V_0(1-D) = V_{in}(1)$$

$$\Rightarrow V_{in} = 100v(1-(0.002\sin(240\pi t) + 0.3))$$

$$\Rightarrow V_{in} = 100v - 0.02\sin(240\pi t) - 30$$

$$\Rightarrow V_{in} = 70v - 0.2\sin(240\pi t)V$$

Therefore since the amplitude will be a peak voltage, V_{in} ranges from $[70v - 0.2v] = 69.8v$ and
$[70v + 0.2v] = 70.2v$, translating

to $69.8v \leq V_{in} \leq 70.2v$ or

$0 \leq V_{in} \leq 1$ at a

frequency of $\sin(240\pi t) \approx \sin(754t)$

dependent on time.

2) For $20s \leq t \leq (20s + 3T_s)$

$$\Rightarrow 20s \leq t \leq (20s + 3(\frac{1}{10KHz}))$$

$$\Rightarrow 20s \leq t \leq 20s + .003$$

$$\Rightarrow 20s \leq t \leq 20.003s$$

From the Duty Cycle

$D = .002\sin(240\pi t) + .3$, the graph will always
be amplified by .002 and shifted up .3. Since
the signal is a sinewave, there will be a positive and
negative peak, respectively at $-.002 \leq V \leq .002$, therefore
when including the shifts, the sinewave will peak at,

$$0.002 + .3 = .302 \quad \text{and}$$
$$-0.002 + .3 = .298$$

For a PWM implementation,

$$M = \frac{V_{m\,max}}{V_{c\,max}} = \frac{.302}{1} = .302$$

$$m = \frac{f_n}{f_c} = \frac{120Hz}{10kHz} = .012$$

$T_s = 1/f_s$

1

.302
.298

0

Ref is duty cycle

Vpwm

1

0

$t_0 + T_s$ $t_0 + 3T_s$

$t_0 = 20\ s$ t_0 $t_0 + 2T_s$