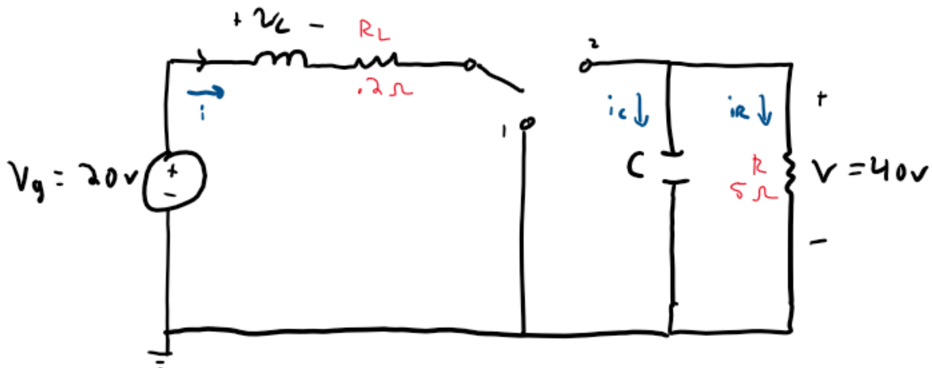
Robert Bara Assignment 1-Boost Converter Analysis

Friday, January 28, 2022 10:43 AM

Assignment #1

- Assignment #1: For the boost converter shown below (considering losses at inductor resistance),
- 1) If f_s = 10 kHz, V = 40 V, V_g = 20 V, R = 5 Ω, R_L = 0.2 Ω (inductor resistance), D < 80%, please draw the waveforms of v_L and i_C (voltage and current ripples are not considered, the values of v_L and i_C should be shown in the waveforms).



Find The Period from the Sample frequency

$$T_S = \frac{1}{f_S} = \frac{1}{10e^3} = .001 \text{ sec}$$

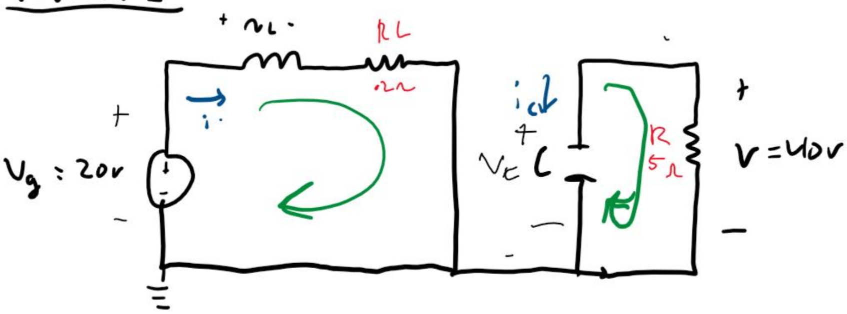
Find D from Voltages $V = M(D)V_g$

$$M = \frac{V}{V_g} = \frac{40}{20} = 2 \qquad M = \frac{1}{1-D} \text{ for Boost Converter}$$

$$M = \frac{1}{1-D} = 2 = \frac{1}{1-D} = 1-D = \frac{1}{2} = -D = \frac{1}{2} - 1 \Rightarrow D = 1 - \frac{1}{2}$$

$$\Rightarrow \boxed{D = \frac{1}{2}} \qquad \boxed{D' = 1-D = 1-\frac{1}{2}}$$

Position 1:



$V = IR$

KVL: $-V_g + v_L(t) + v_{R_L}(t) = 0$

$v_L(t) = V_g - i(t)R_L$

Small Ripple approximation: $v_L(t) \approx V$ $\quad i(t) \approx I$

$i_c(t) \approx I_c$

$V_L = V_g - IR_L$

$V_L = 20v - IR_L$

$V_L = 20v - I(.2\Omega)$

$I_0 = \frac{V}{R} = \frac{40v}{5\Omega} = 8A$

$\boxed{V = M(D)V_g \quad I_g = M(D)I}$

Finding I since $M(D) = 2$:

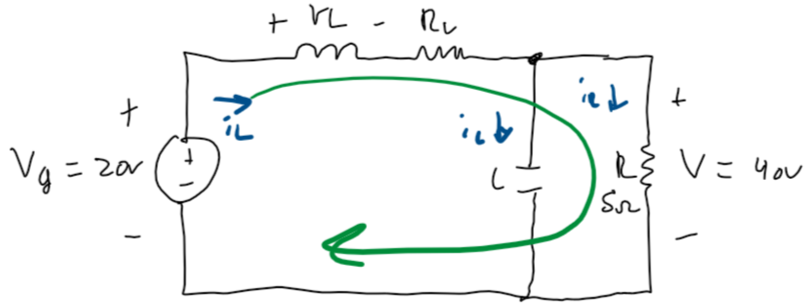
$I = (2)(8A) = 16A$

KCL: $I_c = I - I_0 = 16A - 8A = 8A$

$\therefore V_L = 20 - (16A)(.2\Omega)$

$V_L = 16.8v$

Position 2:



KVL: $-V_g + v_L(t) + v_{RL}(t) + V = 0$

Small ripple approximation

$\Rightarrow V_L = V_g - V_{RL} - V \Rightarrow V_L = V_g - IR_L - V$

Small ripple approx: $I_c = I - \frac{V}{R} \Rightarrow I_c = I - \frac{40V}{5\Omega} = I_c = I - 8A$

$0 = \langle v_L(t) \rangle = \frac{1}{T_s}\int_0^{T_s} v_L(t)\,dt = D(V_g - IR_L) + D'(V_g - IR_L - V)$

$\Rightarrow D(V_g - IR_L) + (1-D)(V_g - IR_L - V)$

$0 \Rightarrow V_g - IR_L - D'V$

$0 = \langle i_c(t) \rangle = D(-\frac{V}{R}) + D'(I - \frac{V}{R})$

$\Rightarrow D(-\frac{V}{R}) + (1-D)(I - \frac{V}{R})$

$0 \Rightarrow D'I - \frac{V}{R}$

$\Rightarrow D'I - \frac{V}{R} = V_g - IR_L - D'V$

Plug in values: $\frac{1}{2}I - 8A = 20v - 0.2I - \frac{1}{2}(40v)$

$0.5I - 8A = \cancel{20v} - 0.2I - \cancel{20v}$

$.5I - 8A = -.2I$

$.7I = 8A$

$I = 11.43A$

$\therefore I_c = I - \frac{V}{R}$

$I_c = 11.43 - 8A$

$I_c = 3.43A$

$\therefore V_L = V_g - IR_L - V$

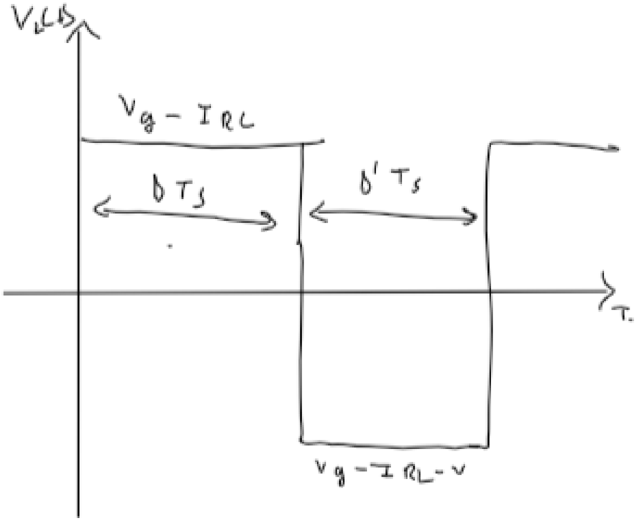
$= 20 - (11.43)(.2) - 40$

$V_L = -22.29v$

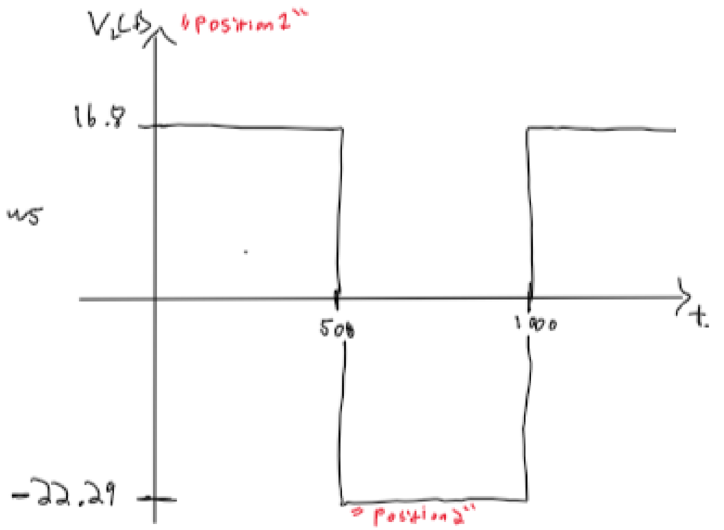
Find the Period of the signal

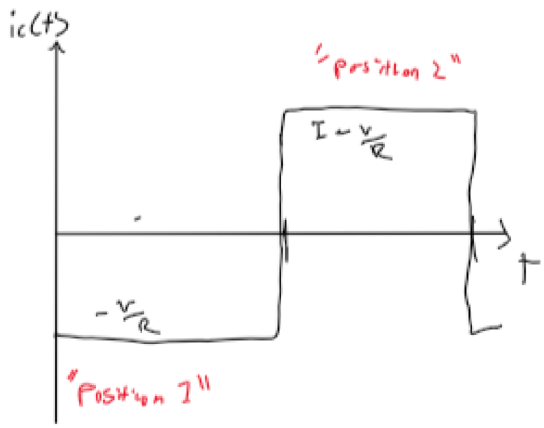
$DT_S = \frac{1}{2}\left(\frac{1}{0.001}\right) = 500$

$D'T_S = \left(1 - \frac{1}{2}\right)\left(\frac{1}{.001}\right) = 500$



Plug in equations/values $\Rightarrow$





plug in values $\Rightarrow$