2

CHALMERS

Anonymous code 2016-11-21
Anonym kod

Points for question (to be filled in by teacher)
Poäng på uppgiften (ifylles av lärare)

Consecutive page no. Löpande sid nr 1
Question no. Uppgift nr

Solution ENM061 Midterm Exam

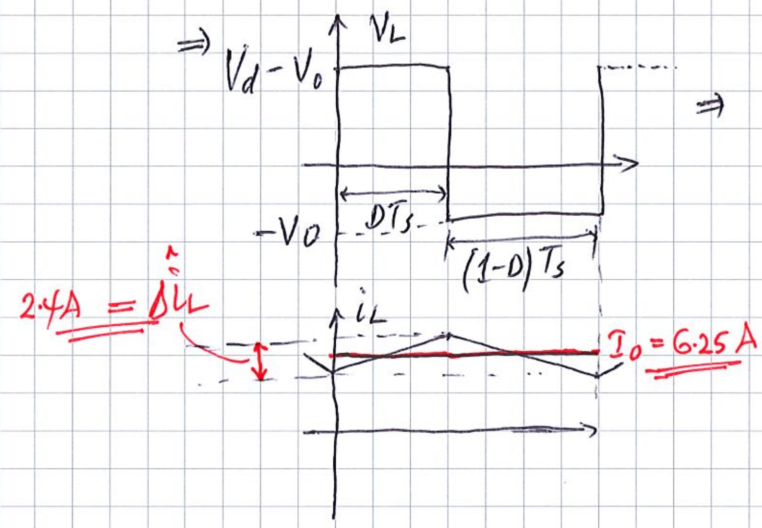
Q#1. Refer to the lecture notes for the answers.

Q#2. $V_0 = 8V$ $\quad f_{sw} = 20\,kHz$ $\Rightarrow T_s = \frac{1}{f_{sw}}$

$V_d = 20V$ $\quad L = 100\mu H$

$P_0 = 50W$ $\quad C = 500\mu F$

(a) Assume CCM



$$\Rightarrow V_L = \frac{1}{T_s}\int_0^{DT_s}(V_d - V_0)d\tau + -\int_{DT_s}^{T_s}(1-D)V_0 = 0$$

$$\Rightarrow V_L = 0 \Rightarrow \frac{V_0}{V_d} = D$$

$$\Rightarrow D = 0.4$$

during switch on. $v_L = V_d - V_0 = 12V = L\frac{\Delta\hat{i}_L}{DT_s}$

$$\Rightarrow \Delta\hat{i}_L = \frac{DT_s(V_d - V_0)}{L} = \frac{(0.4)(12)}{20(10^3)\cdot 100(10^{-6})} = 2.4\,A$$

$$I_L = \frac{1}{T_s}\int_0^{T_s} i_L(t)\,dt = I_0 = \frac{P_0}{V_0} = \frac{50}{8}A = 6.25\,A$$

$\frac{\Delta\hat{i}_L}{2} < I_L \Rightarrow$ the assumption of CCM is correct

(b) $I_0 = 6.25A$ from part (a)

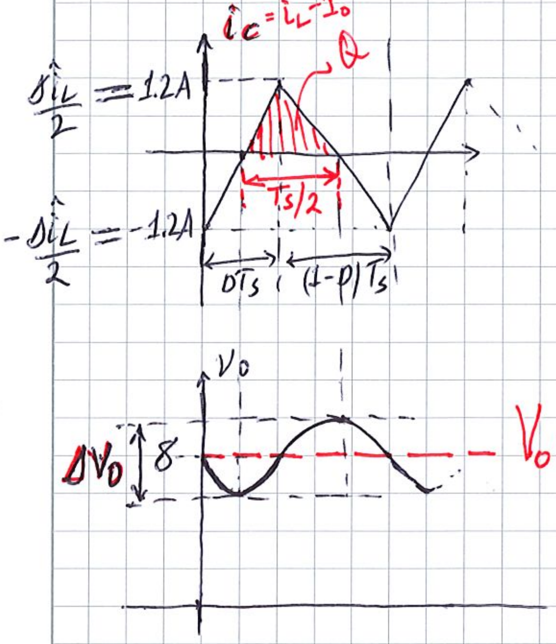
From energy conservation (100% efficiency of converter)

$P_{in} = P_0 \Rightarrow V_d I_d = P_0$

$\Rightarrow I_d = 50/20\,A = 2.5A$

Answer only one question on this page. Do not write on the back of this paper
Behandla endast en uppgift på detta blad. Skriv ej på baksidan

(c) $i_c(t) = i_L(t) - I_o$, from previous result we have



$$\Rightarrow \Delta V_o = \frac{Q}{C} = \frac{1/2 \cdot \frac{\Delta \hat{i}_L}{2} \cdot T_s/2}{C}$$

$$= \frac{\Delta \hat{i}_L}{8 C f_{sw}} = \frac{2.4}{8(500 \cdot 10^{-6}) \cdot 20 \cdot 10^{3}} V$$

$$\Rightarrow \underline{\underline{\Delta V_o = 0.030 V}}$$

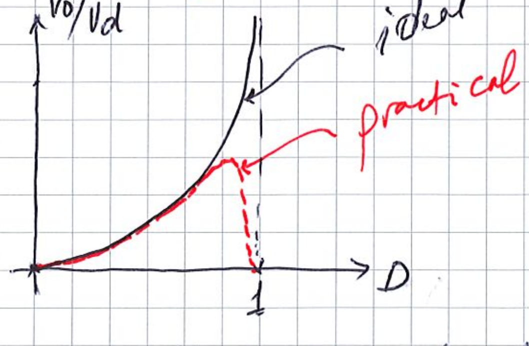
$\Delta V_o \ll V_o \Rightarrow$ the filters (L & C) are designed well !

Q#3. $V_L = \frac{1}{T_s}\int_0^{T_s} V_L dt = \frac{1}{T_s}\int_0^{DT_s} V_d \cdot dt + \frac{1}{T_s}\int_{DT_s}^{T_s} (V_d - V_o) dt = 0$

switch on switch off

CCM

$$\Rightarrow \underline{\frac{V_o}{V_d} = \frac{1}{1-D}} \quad \text{(ideal converter)}$$



Due to the parasitic elements in the converter, the expression $\frac{V_o}{V_d} = \frac{1}{1-D}$ is not followed for a practical converter.

Q#4. (a) For DCM, energy Stored in L_m is transferred to the load

$$\Rightarrow \frac{1}{2} L_m (\Delta \hat{i}_m)^2 = \frac{V_0^2}{R_{load}} \cdot T_s$$

(energy exchange in one switch cycle)

$$\Rightarrow \frac{1}{2} L_m (\Delta \hat{i}_m)^2 = \frac{V_0^2}{f_{sw} \cdot R_{load}}$$

when the switch S is on, $V_1 = V_d = L_m \frac{\Delta \hat{i}_m}{DT_s}$

$$\Rightarrow \Delta \hat{i}_m = \frac{DT_s \cdot V_d}{L_m} = \frac{DV_d}{f_{sw} L_m}$$

$$\frac{1}{2} L_m \left\{ \frac{DV_d}{f_{sw} L_m} \right\}^2 = \frac{V_0^2}{f_{sw} R_{load}}$$

$$\Rightarrow \frac{V_0}{V_d} = \sqrt{\frac{R_{load}}{2 L_m f_{sw}}} \cdot D$$

(b) During on, $V_1 = V_d$, $i_d = i_m$, $i_D = 0$

During off, $V_3 = -V_0 \Rightarrow V_1 = -\frac{N_1}{N_3} V_0$ until $i_m = 0$ / $i_d = 0$, $i_m = i_D \cdot \frac{N_3}{N_1}$

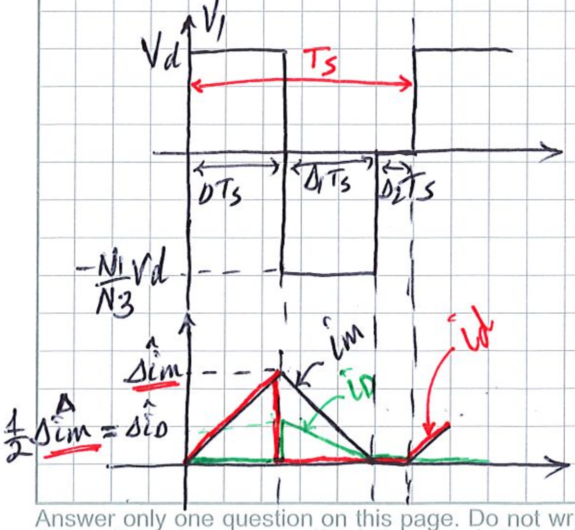
$$\Downarrow$$

$$i_D = \frac{N_1}{N_3} \cdot i_m$$

$V_3 = V_1 = 0$ when $i_m = 0 = i_D = i_d$

the above expression is for no current in N_2

$\rightarrow$ V_0 remains within the maximum voltage of $\frac{N_3}{N_2} V_d = 2V_d$



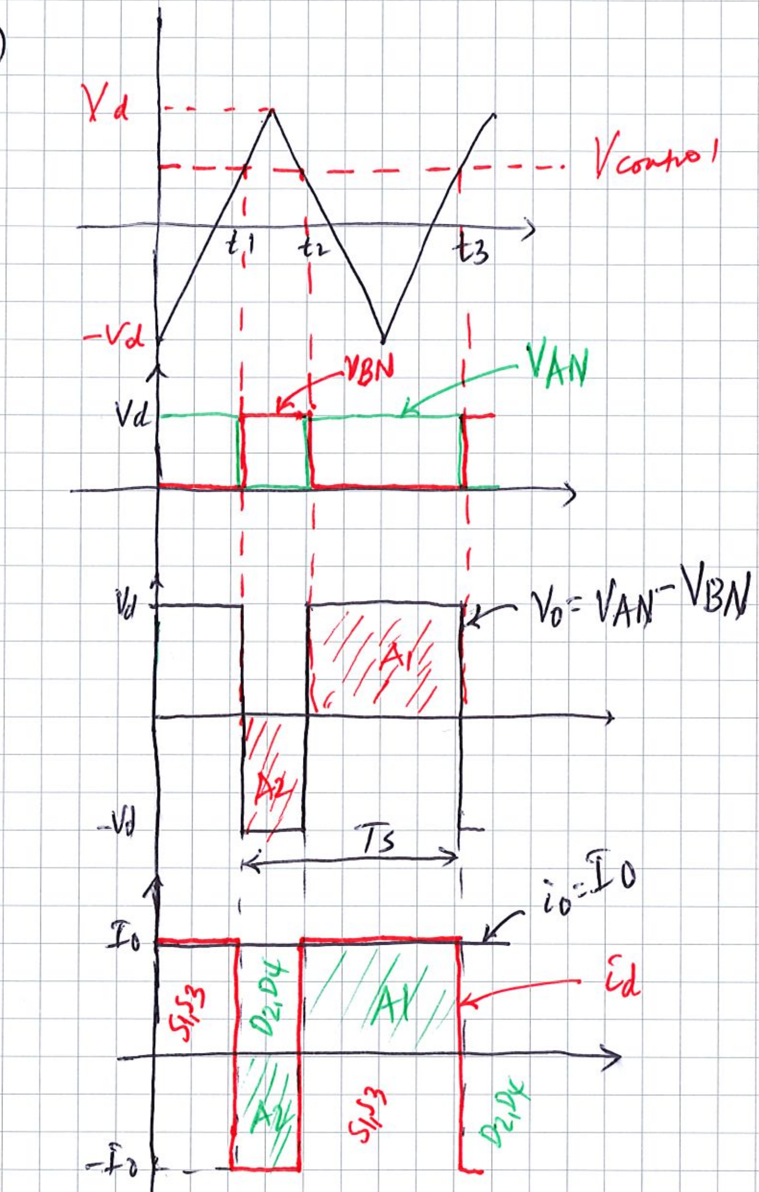
(c) if $R_{load} \rightarrow \infty \Rightarrow V_0 \rightarrow$ very high from results of part (a)

$\Rightarrow$ when $V_0 > \frac{N_3}{N_2} V_d$, D_2 will be forward biased which provides a path for the demagnetization

$\Rightarrow$ Diode D will be reverse biased and V_0 will be limited at $\frac{N_3}{N_2} V_d$

Q#5.

(a)



(b) $V_0 = \frac{A_1 + A_2}{T_s} = V_{control} = \underline{10V}$

$I_d = \frac{A_1 + A_2}{T_s}$: but from 100% efficiency

$P_{in} = V_d I_d = V_0 I_0 = 10(5) \Rightarrow \underline{I_d = 2.5A}$

(c) $t_1 \le t \le t_2$, $V_{control} < V_{tri} \Rightarrow S_2, S_4$ on ; due to positive current i_o $\underline{D_2, D_4}$ are conducting.

$t_2 \le t \le t_3$, $V_{control} > V_{tri} \Rightarrow S_1, S_3$ on ; due to positive current i_o $\underline{S_1, S_3}$ are conducting.