Demonstration 6

Equations used from previous lectures

Steady state

The average voltage over an inductor $V_L = 0$
The average current through a capacitor $I_c = 0$

Step down and forward converter

Continuous conduction mode (CCM)

$I_L \geq \Delta i_L/2$

Discontinuous conduction mode (DCM)

$I_L < \Delta i_L/2$

Energy stored in an inductor

$$W = \frac{1}{2}Li^2$$

Fourier analysis

$$g(\theta) = f(t)\,,\ \theta = \omega t$$

$$g(\theta) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left[a_n \cos(n\theta) + b_n \sin(n\theta)\right]$$

$$a_n = \frac{1}{\pi}\int_{\theta_0}^{\theta_0+2\pi} g(\theta)\cos(n\theta)d\theta \quad n = 0,1,2,3,...$$

$$b_n = \frac{1}{\pi}\int_{\theta_0}^{\theta_0+2\pi} g(\theta)\sin(n\theta)d\theta \quad n = 1,2,3,...$$

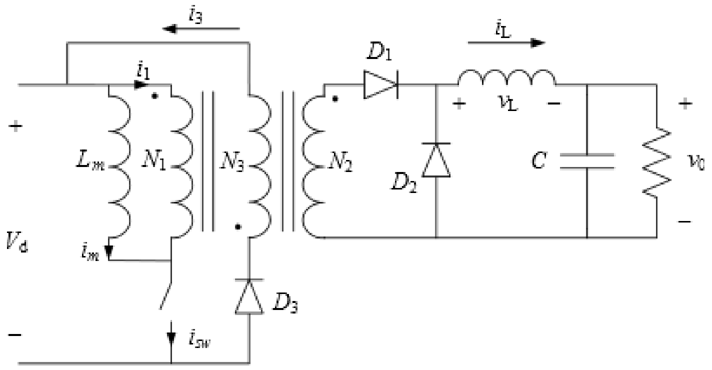
Table 3-1 Use of Symmetry in Fourier Analysis

Symmetry	*Condition Required*	a_h and b_h
Even	$f(-t) = f(t)$	$b_h = 0 \quad a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\, d(\omega t)$
Odd	$f(-t) = -f(t)$	$a_h = 0 \quad b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\, d(\omega t)$
Half-wave	$f(t) = -f(t + \frac{1}{2}T)$	$a_h = b_h = 0$ for even h $a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\, d(\omega t)$ for odd h $b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\, d(\omega t)$ for odd h
Even quarter-wave	Even and half-wave	$b_h = 0$ for all h $a_h = \begin{cases} \frac{4}{\pi}\int_0^{\pi/2} f(t)\cos(h\omega t)\, d(\omega t) & \text{for odd } h \\ 0 & \text{for even } h \end{cases}$
Odd quarter-wave	Odd and half-wave	$a_h = 0$ for all h $b_h = \begin{cases} \frac{4}{\pi}\int_0^{\pi/2} f(t)\sin(h\omega t)\, d(\omega t) & \text{for odd } h \\ 0 & \text{for even } h \end{cases}$

Literature: Undeland book Chapter 7, Chapter 10

Tutorial exercises

Problem 1 Forward converter



$N_1 : N_3 : N_2 = 1:1:1$

$V_d = 50V$

$D = 0.4V$ $\quad L_m = 22\mu H$

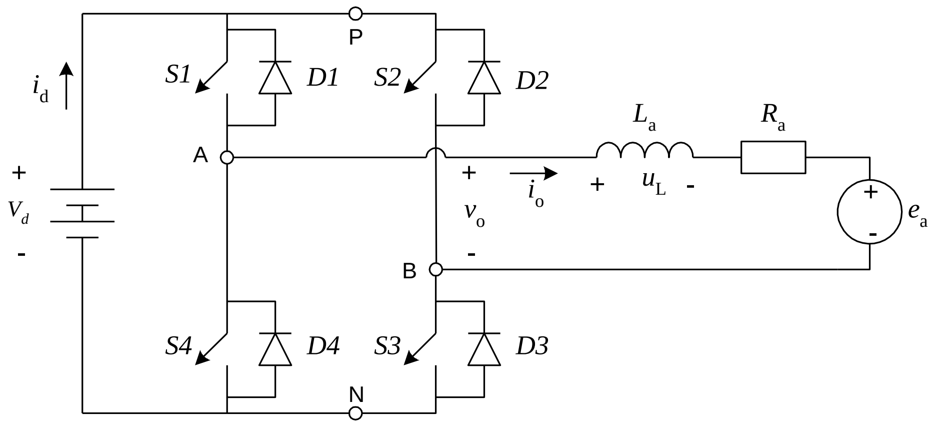
$C = 470\mu F$ $\quad f = 200kHz$

$R_{load} = 1\Omega$ $\quad L_{out} = 7.5\mu H$

1.1. Derive an expression for the ratio of the input and output voltage.
1.2. Plot the currents through all three diodes and the switch.
1.3. Calculate the power that is circulating to magnetize the transformer.
1.4. Derive an expression for the maximum allowed duty cycle.
1.5. Assume that each winding consists of 10 turns, $N_1 = N_2 = 10$, and calculate the maximum number of turns in the third winding, N_3, when the duty cycle is adjusted to achieve an output voltage of 30V.

Problem 2 (P7-18 in Undeland book)

In a full-bridge DC/DC converter using PWM bipolar voltage switching, $v_{control} = 0.5\hat{V}_{tri}$. Obtain V_o and I_d in terms of given V_d and I_o. Assume $i_o \cong I_o$.



By Fourier analysis, calculate the amplitude of the switching-frequency harmonics in the output voltage (v_o) and in the input current (i_d).

Self-study exercises

From Undeland book:
P7-19, P7-22, P10-5, P10-6, P10-7