Demonstration 7

Equations used from previous lectures

Modulation Index

$$m_a = \frac{\hat{v}_{ref}}{V_d}, \quad m_f = \frac{f_{sw}}{f_1}$$

Fourier analysis

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

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

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

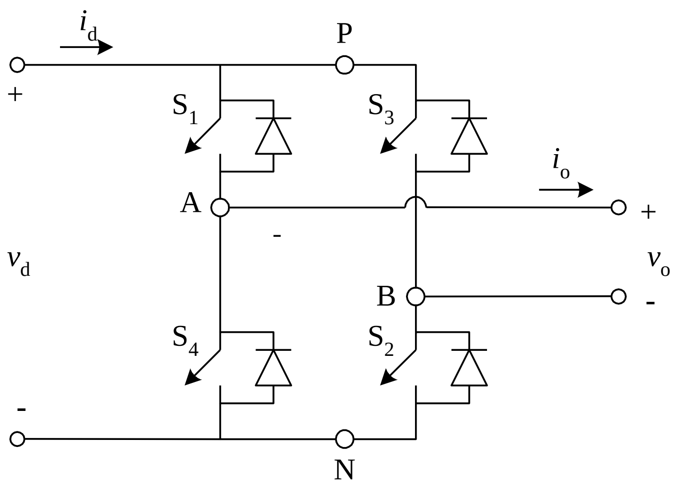
$$b_n = \frac{1}{\pi}\int_{\theta_0}^{\theta_0+2\pi} g(\theta)\sin(n\theta)d\theta \quad n = 1,2,3,...$$

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 8

Tutorial exercises



Problem 1 (P8-1 in Undeland book)

In a single-phase full-bridge PWM inverter, the input dc voltage varies in a range between 295V and 325V. Because of the low distortion required in the output (v_o), the modulation index is lower than 1 ($m_a \leq 1.0$).

What is the highest voltage of the fundamental frequency ($V(1)$) that can be possible obtained? What is the voltage rating that should be stamped on the nameplate?

Problem 2

The single phase inverter above is operating in square wave mode with a load that consists of an inductor ($L = 50mH$) in series with a sinusoidally shaped back-emf voltage source $\left(e_o = \sqrt{2} \cdot E_o \cdot \sin(\omega_1 t)\right)$. The output fundamental voltage is $V_{o(1)}$ has a frequency of 40Hz and the same amplitude and phase as the back-emf. The input dc voltage is kept constant at 300V.

2.1. Calculate the fundamental voltage $V_{o(1)}$.
2.2. Sketch the current (ripple) waveform to the load.
2.3. Calculate the peak value of the current.

Problem 3

The single phase inverter above is operating in square-wave operation mode with a purely inductive load. For one switching period, draw the output voltage and the output current. Clearly mark which transistor/diode that conducts the current.

Self-study exercises

From Undeland book:
P8-2, P8-3, P8-4