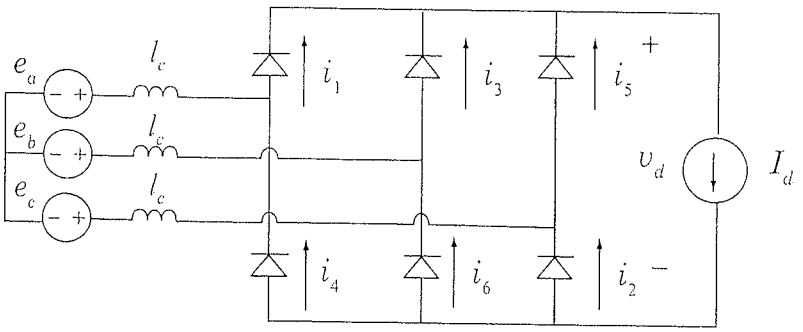
1. Consider the three-phase bridge rectifier.



$$e_a = E\cos\theta_e$$
$$e_b = E\cos\left(\theta_e - \frac{2\pi}{3}\right)$$
$$e_c = E\cos\left(\theta_e + \frac{2\pi}{3}\right)$$
$$\theta_e = \omega_e t$$

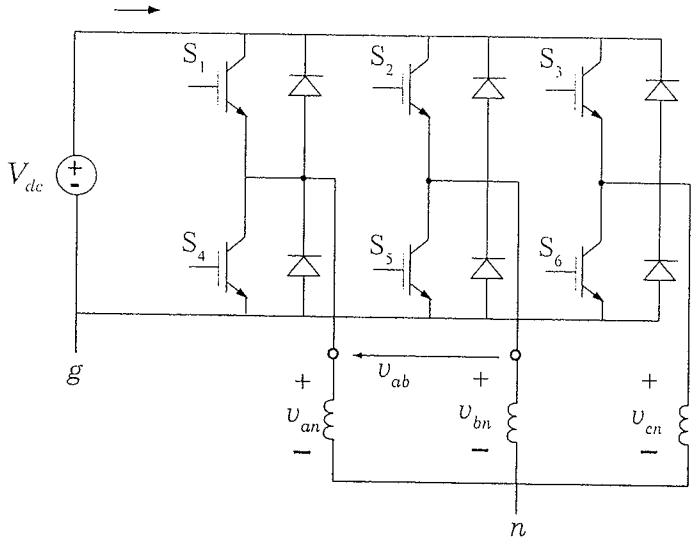
(10) (a) The converter is operating in the steady state in mode 1 (1-2, 1-2-3, 23. ...). At a certain instant of time, only diodes 1 and 2 are on. At what value of θ_e does valve 3 begin to conduct?

(15) (b) At what value of θ_e does diode 1 shut off after diode 3 turns on? Express answer in terms of l_c, E, ω_e, and I_d.

(10) (c) Express instantaneous v_d (as a function of θ_e) during the interval in which diodes 1 and 2 are on.

(15) (d) Express instantaneous v_d (as a function of θ_e) during the interval in which diodes 1, 2, and 3 are on.

The following circuit diagram applies to problems 2-4.



(25) 2. Sketch the line-to-neutral voltage v_{an} for basic six-step operation [the upper (lower) switch of each phase leg is closed (open) for 180° of the switching period and open (closed) for the other 180° - the switching of each phase leg is displaced 120° relative to the other phase legs]. Assume time zero is selected so that v_{an} approximates a cosine function. ***Derive*** the magnitude of the fundamental component in terms of V_{dc}. Exploit symmetry to minimize effort[1].

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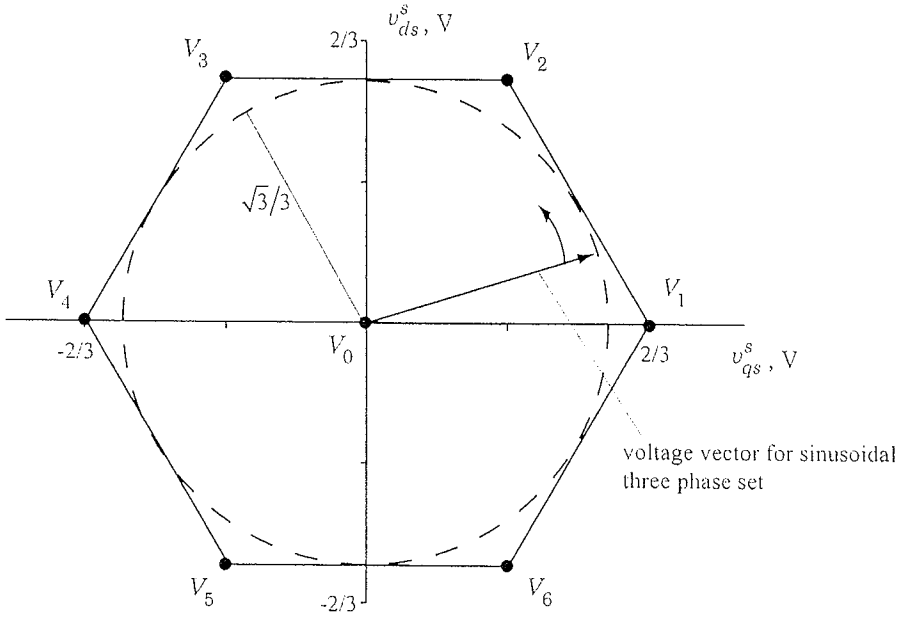
1. $f(\theta) = a_0 + \sum_{n=1}^{\infty} a_i\cos(n\theta) + b_i\sin(n\theta)$; $a_i = \frac{1}{\pi}\int_0^{2\pi} f(\theta)\cos(n\theta)d\theta$, $b_i = \frac{1}{\pi}\int_0^{2\pi} f(\theta)\sin(n\theta)d\theta$

(10) 3. Suppose a space vector modulator is used. The achievable voltage vectors (in the stationary reference frame) are depicted below for $V_{dc} = 1$ V. What is the maximum peak line-to-neutral voltage that can be achieved for arbitrary V_{dc} without introducing significant low-order harmonic distrortion?.

Achievable voltage vectors with V_{dc} = 1.0 V



(15) 4. Suppose a hysteresis modulation current control strategy is used with balanced sinusodal current reference signals. Sketch the time-domain block diagram using summers, comparators, etc. Label all signals. What is the maximim line-to-neutral voltage (peak value of fundamental component) that the inverter can be expected to supply?