ET4119 Electronic Power Conversion 2009/2010
Homework assignment 1

1. In the single-phase rectifier circuit shown in Figure 1, V_s = 230V at 50Hz, L_s = 1mH and V_d = 270V.
Sketch the waveform for the dc-side current i_d and calculate:

- The duration of the time interval in which the diode pair D_1, D_2 or D_3, D_4 are conducting;
- The peak value of the dc current, $I_{d, peak}$;
- The average value of the dc-current, I_d.

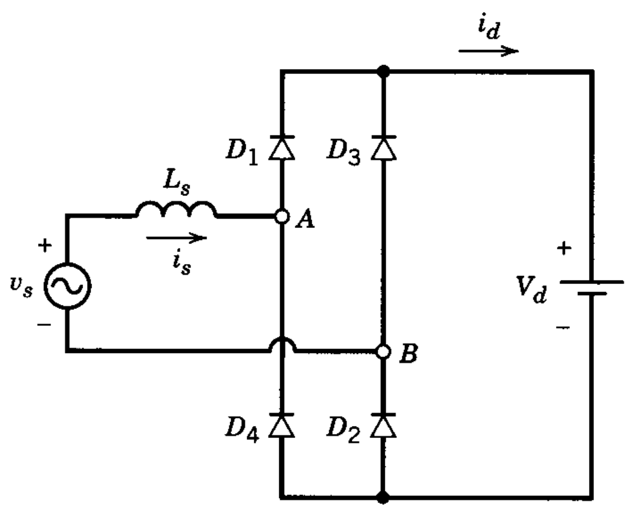


Figure 1

2. Figure 2 shows a single-line diagram of a power system with power electronic load. The utility power source (dashed block) is represented by sinusoidal voltage sources v_s in series with an inductance L_s in each phase. The nominal rms value of the phase-to-neutral voltage is V_s=230V and its fundamental frequency is f_s=50 Hz.
The power electronic load is a large industrial three-phase diode rectifier as shown in Figure 2. The load of the rectifier is represented by a constant DC current source I_d.

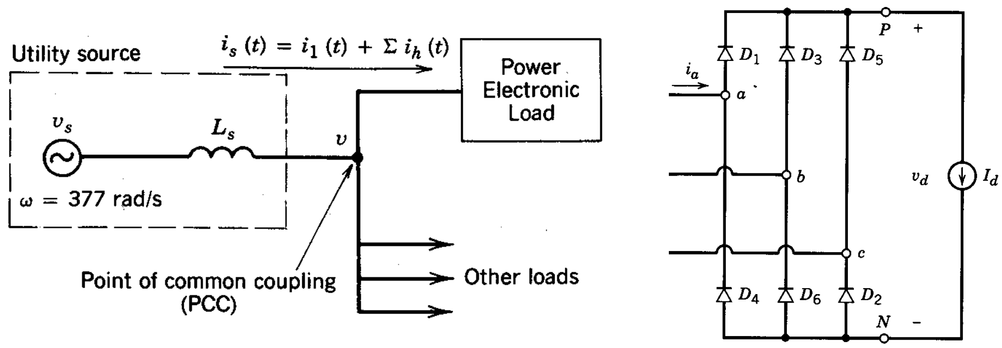


Figure 2

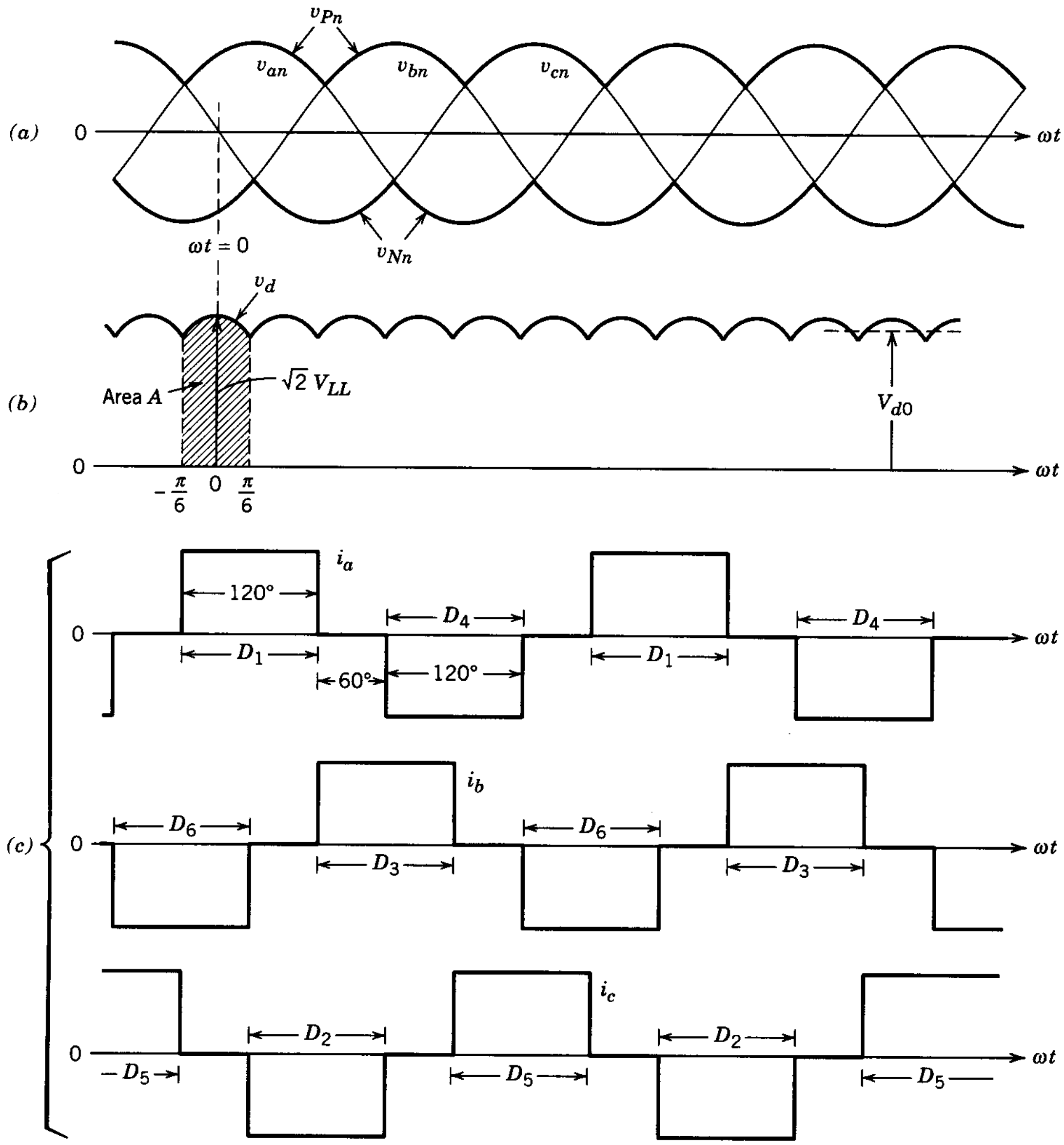
2.1 Calculate the average rectifier output voltage V_d as a function of V_s, L_s and I_d.
2.2 Sketch i_a and v_d and calculate the total harmonic distortion (THD) of the input current i_a for L_s=0.
2.3 Describe qualitatively the effect of $L_s \neq 0$ instead of L_s=0 on the input current harmonics. Consider both high-order harmonics and low-order harmonics.

Solutions:

2.1 See book fig. 5-33, eq. 5-60 to 5-71

$$V_d = V_{d0} - \Delta V_d = 1.35 V_{LL} - \frac{3}{\pi}\omega L_s I_d = 1.35 \cdot \sqrt{3} \cdot 230V - \frac{3}{\pi} g 2\pi \cdot 50Hz \cdot L_s \cdot I_d$$

2.2 See book Fig 5-32. eq. 5-60 to 5-71



$$I_s(I_d) := \sqrt{\frac{2}{3}} \cdot I_d$$

$$I_{s1}(I_d) := \frac{1}{\pi} \cdot \sqrt{6} \cdot I_d$$

$$THD(I_d) := \frac{\sqrt{I_s(I_d)^2 - I_{s1}(I_d)^2}}{I_{s1}(I_d)}$$

$$THD(I_d) = 0.311$$

2.3 All harmonics are more or less reduced, including the fundamental. Higher harmonics are attenuated more than the lower harmonics, because steep edges on currents are removed. Lower harmonics are only slightly affected.