# ET4119 Electronic Power Conversion 2011/2012
# **Exam 27 January 2012**

Remarks:
In front of every question the maximum rating that can be obtained is indicated.

First solve the problems on draft paper and make a neat version subsequently.

Start each problem on a separate piece of paper.

Always show the formulas that you used to make the calculations.

You can give your answers in Dutch or in English.

It is allowed to use a (self-made) single sided piece of paper (1xA4) with formulas and figures from the textbook.

1. In the single-phase rectifier shown below in Fig 1a., $L_s$ = 1mH and $I_d$ = 10A. The input voltage $v_s$ has the pulse waveform shown in Fig 1b with the amplitude of 200V at 50Hz.

a) (10) Sketch the waveform of voltage $v_d$ and calculate the commutation interval $u$,
b) (5) Calculate the voltage $V_d$,
c) (5) Calculate the average power delivered to the load $P_d$,
d) (5) What is the percentage voltage drop in $V_d$ due to $L_s$?

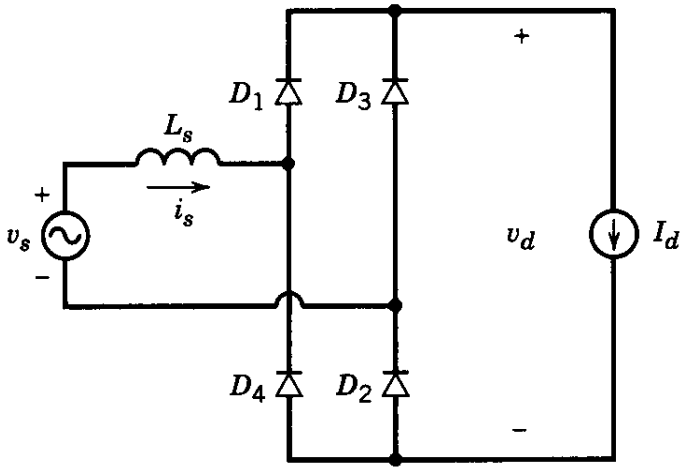



Figure 1a.

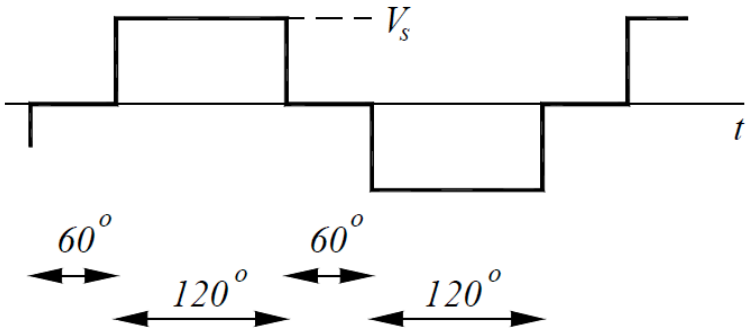



Figure 1b. Input voltage $v_s$

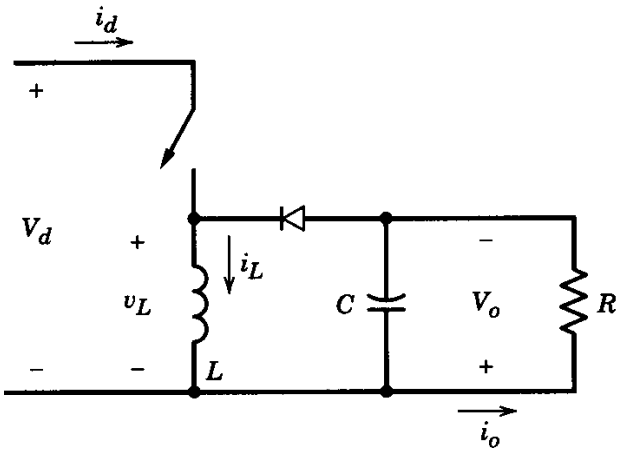
2. The ideal buck-boost converter is shown in figure below. The converter is operating in the continuous conduction mode (CCM). The converter's operating specifications are as follows:

- input voltage $V_d$ = 30V,
- output voltage $V_o$=20V
- load resistor R=4Ohm
- switching frequency $f_s$=40kHz.

a) (10) Calculate the steady-state ratios $V_d$ / $V_o$ and $I_L/I_o$.
b) (10) Calculate the required values of the filter components L and C so that converter operates as follows:

- Peak-to-peak ripple of the inductor current is 20% of the average value of the inductor current, $I_L$
- The output voltage peak-to-peak ripple is lower than 0.2V.

c) (5) Sketch the transistor current waveform for the operating point outlined above. How would the waveform change if the design criteria is that the converter operates on the border of the CCM/DCM mode?



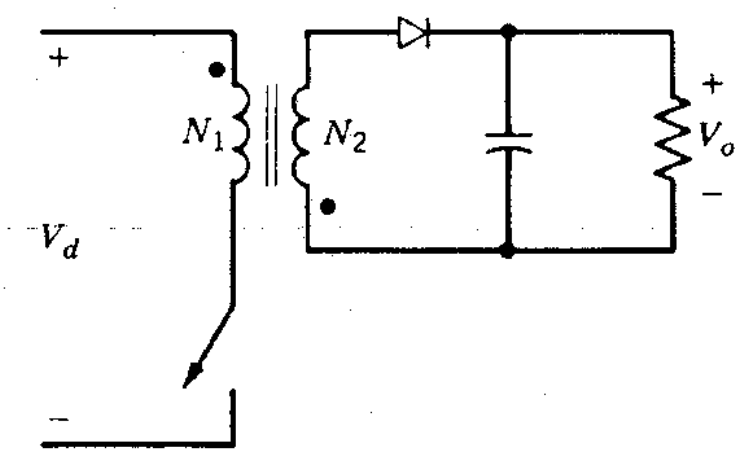
3. Design a flyback converter operating in the discontinuous conduction mode with the following specifications:

- Input voltage $300V \leq V_d \leq 400V$ (nominal value 400V)
- Output power $0V \leq P_o \leq 50W$ (nominal value 50W)
- Output voltage $20V \leq V_o \leq 30W$ (nominal value 27V)
- Switching frequency $f_s$=50kHz
- Peak –to-peak voltage ripple $\Delta V_{0p\_p}$=20mV.

a) (15) Select the transformer turn ratio $N_2/N_1$, the magnetising inductance $L_m$ and the output capacitance C. You may assume that the maximum duty cycle value is 0.5. The voltage drop across the diode when it is in on-state is 1V.

b) (5) Sketch the waveforms and calculate RMS and DC values of the transistor and output diode current at the nominal operating point.

c) (5) Sketch the waveforms and calculate the maximum voltages across the transistor and output diode.



4. Figure 4 shows the inverter that contains a full-bridge voltage source converter.

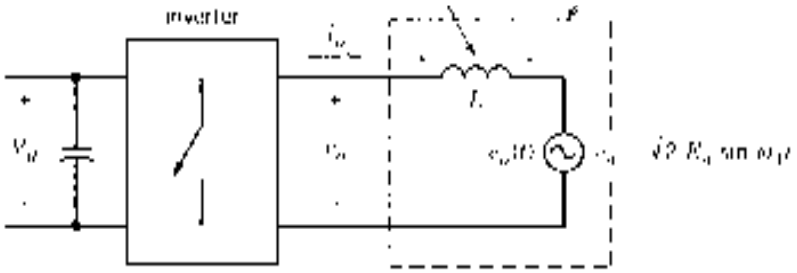



Figure 4

The output voltage $v_0$ of the inverter is obtained by unipolar voltage switching.

Given is further: $V_d = 350V$

$\omega_1 = 2\pi 50$

$L = 15$ mH

In the following questions 4.a and 4.b the ripple that is caused by the switching can be neglected.

a) (5) What is the highest value of the rms of the first harmonic of the output voltage, $V_o$ that can be obtained with $V_d = 350V$?

b) (10) Calculate the expression for the dc side current in the inverter (low frequency components only). Assume that the input capacitor is very large so that $V_d$ is pure dc.

c) (10) Calculate the expression for the peak-to-peak ripple in the output current caused by switching as a function of the duty cycle.