ET4119 Electronic Power Conversion 2012/2013
Exam 25 January 2013

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 ONE (self-made) single sided piece of paper (1xA4) with formulas and figures from the textbook.

1. In the circuit shown above, the diodes and the current source may be considered ideal. The following is given:

V_s=230V
L_s=5mH
I_d=10A
f=50Hz

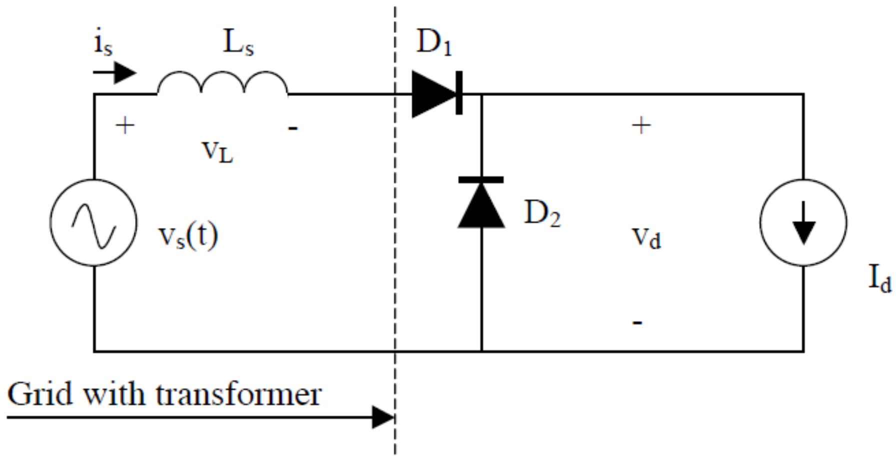


Figure 1 a. rectifier circuit b. input voltage waveform

1.1 (10) Sketch the voltages $v_d(t)$ and $v_L(t)$ and the input current as a function of time. Indicate relevant values on the graphs.

1.2 (5) Because of the grid inductance L_s, when $v_s(t)$ has a positive zero crossing there will be a voltage loss in $v_d(t)$ compared to the ideal value. This voltage loss is called commutation voltage loss. Why is there not a similar voltage loss at the negative zero crossing?

1.3 (10) Calculate the angle of commutation u, the average value of the dc voltage value V_d and power delivered to the load P_d.

2. A 1 kW, 48V output step-down converter is to be evaluated. Consider all the components to be ideal. The output capacitor C is so large that the output voltage can be considered to be constant. The input voltage is 100V, and the switching frequency is 80 kHz.

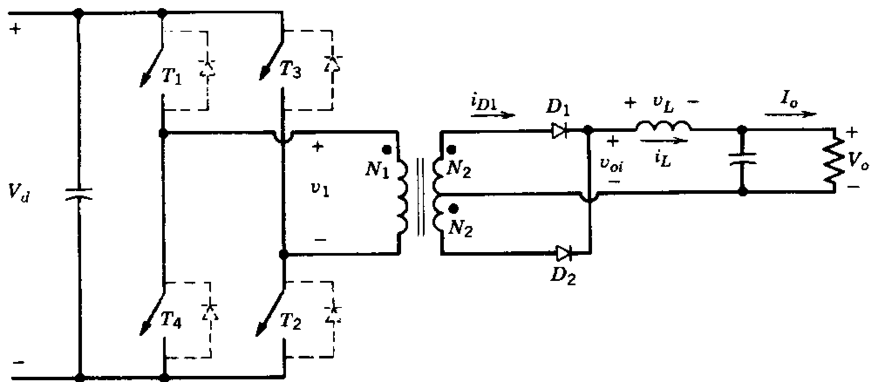
2.1 (10) For L=40μH calculate $I_{L,rms}$ and $I_{L, peak.}$

2.2 (10) Repeat 2.1 with L=5μH.

2.3 (5) Assume that the cost of an inductor varies linearly with the product of inductance, peak and rms current through the inductor. Calculate the ratio of the cost between the two inductors. Compare it with the inductance ratios. Could you draw any conclusions?

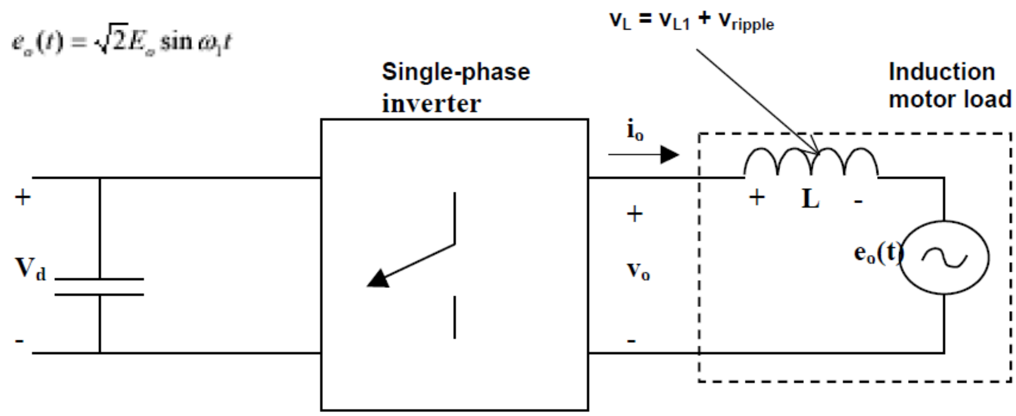
3. Design a full bridge converter to operate in continuous conduction mode (CCM) for the following specifications:

$360V < V_{in} < 400V$ (nominal 400V)
$200W < P_o < 500W$ (nominal 500W)
$V_o = 54V$
$f = 100kHz$
$\Delta i_{Lp\_p} < 20\%$ of nominal load current
$\Delta v_{Op\_p} < 20mV$
$L_M \sim 4mH$



3.1 (5) Select transformer turns ratio N_1/N_2
3.2. (10) Calculate L and C
3.3 (10) Sketch the waveforms of the switch current, diode currents, transformer primary current, magnetizing current and inductor current. Indicate relevant values on the graphs.

4. The problem with ripple in the output current from a single-phase full bridge inverter is to be studied. The first harmonic of the output voltage is given by V_{o1}=220V at f = 47 Hz. The load is given in the figure as L = 100 mH in series with an ideal voltage source $e_o(t)$. The converter works in square wave mode.



4.1 (5) Calculate the value of V_d which gives V_{o1} = 220V.
4.2 (10) Calculate the peak value of the ripple current.
4.3 (5) What are advantages and disadvantages of this mode of operation?
4.4 (5) What modifications can you envisage to address some of the disadvantages?