ET4119 Electronic Power Conversion 2012/2013
Exam 19 April 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. A single-phase diode rectifier is shown in the figure below. The rms value of the grid voltage is Vs = 230V. Assume that the load is represented by a constant dc current, I_d = 10A. The grid frequency is equal to 50 Hz.

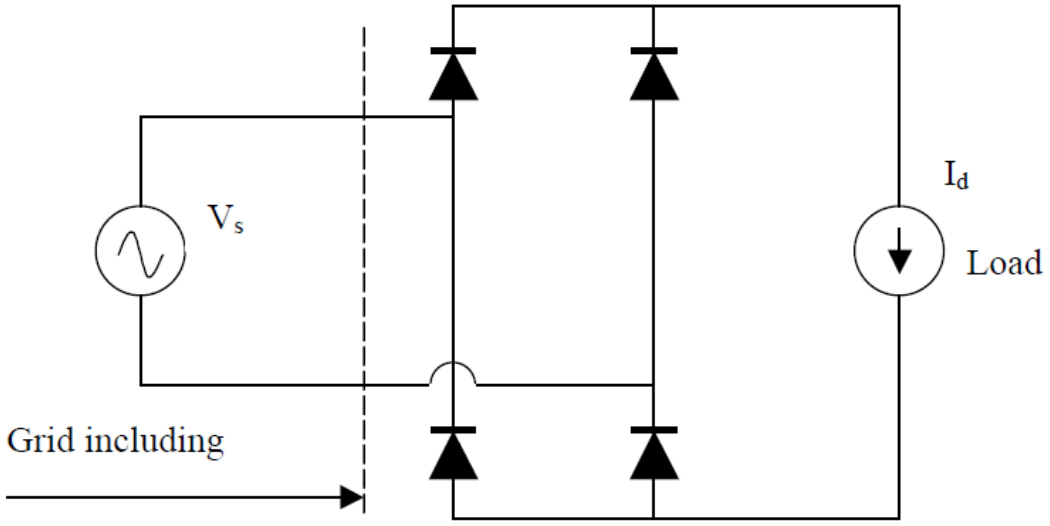


Figure 1 Rectifier circuit

Assume an ideal grid (L_s=0).

1.1 (7) Sketch the dc voltage v_d and calculate its average value.

1.2. (10) Calculate power factor (PF).

Assume the grid inductance is L_s=1mH.

1.3 (8) Calculate voltage drop in output voltage.

Note: Fourier series formulae

$$f(t) = F_0 + \sum_{h=1}^{\infty} f_h(t) = \frac{1}{2} \cdot a_0 + \sum_{h=1}^{\infty} \{a_h \cdot \cos(h\omega t) + b_h \cdot \sin(h\omega t)\}$$

$$a_h = \frac{1}{\pi} \int_0^{2\pi} f(t) \cos(h\omega t) d(\omega t) \qquad h = 1, \ldots, \infty$$

$$b_h = \frac{1}{\pi} \int_0^{2\pi} f(t) \sin(h\omega t) d(\omega t) \qquad h = 1, \ldots, \infty$$

2. In a buck converter, consider all components to be ideal. The inductance of L is 50 mH and C is so large that the output voltage can be considered to be constant. The switching frequency is 50kHz.

Note: Derive the formulae from circuit waveforms, do not use pre-made formulae.

2.1 (5) For V_{in} = 40V and V_{out} = 10V, calculate the duty cycle and the output current when the converter is operating on the edge of the continuous conduction mode.

2.2 (10) For output current one tenth of that in 2.1, calculate the duty cycle to keep the output voltage constant.

2.3 (5) Keep the duty cycle from (b). For ± 1% variation in output current, calculate the variation in output voltage.

2.4 (5) Sketch the output voltage vs. output current characteristic of the converter for the duty cycles of 2.1 and 2.2.

3. Design a flyback converter operating in the discontinuous conduction mode (DCM) shown shown in figure below for the following specifications:

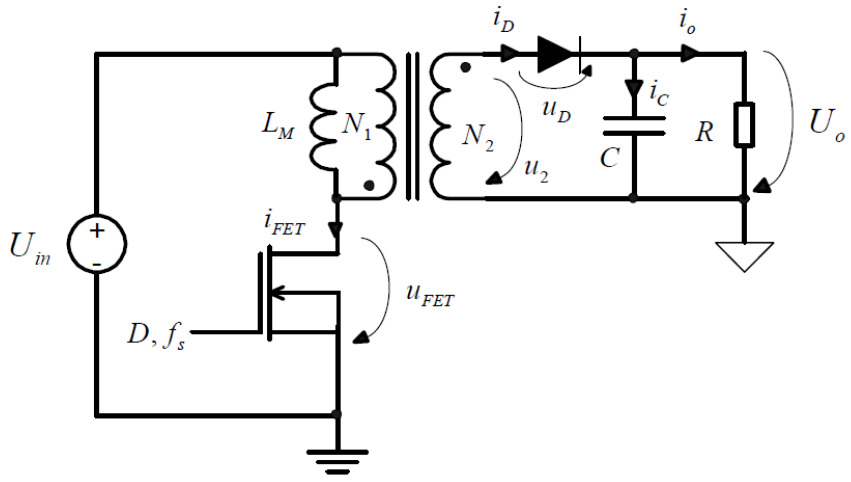
300V<V_{in} <400V (nominal 400V)

0W <P_o <50W (nominal 50W)

V_o =27V

f_s=50kHz

$\Delta v_{Op\_p} \leq$ 20mV

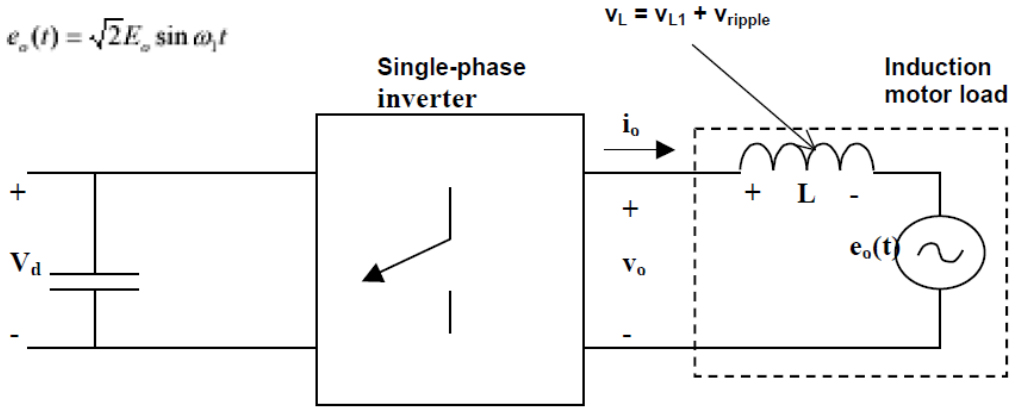


3.1 (5) Select transformer turns ratio N_1/N_2.

3.2. (10) Calculate magnetising inductance L_M and output capacitance C.

3.3 (15) Sketch the waveforms of i_{FET}, i_D, i_C, u_{FET} and u_D at the nominal operating point. 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. The converter operates in sinusoidal PWM-mode, bipolar modulation m_f =21 and m_a = 0.8.



4.1 (5) Sketch the relevant circuit waveforms to illustrate operation of the inverter. Indicate relevant values on diagrams and which switches are conducting at what interval.
4.2 (5) Which value of V_d gives V_{o1} = 220 V?
4.3 (10) Explain why the ripple current has its peak value at the zero crossing of the first harmonic voltage, and find this value.