UNIVERSITETET I AGDER
FAKULTET FOR TEKNOLOGI OG REALFAG

ENE229 Fornybar energi i kraftnettet

Eksamen 15. mai 2013

Duration: 0900 – 1300

Permitted: Approved calculator, Haugans tabeller and
Bastians elektroteknisk formelsamling
No PC or mobile phone

The Exam consists of 4 problems with sub problems.
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You can write your solutions in Norwegian or English.

Do read and analyze the problems thoroughly before you start solving them!! Apply method and explain if you do not have time to calculate.

Question 1. (25% marks)

A DC-DC buck (step-down) converter is shown in Fig. 1. The filter capacitor is large enough to achieve the output voltage nearly DC. In this buck converter $L = 24$ μH and assume ideal components. It is operating in DC steady state under the following conditions: DC input voltage $V_{in} = 20$ V, duty ratio $D = 0.6$ $\left\{D = \frac{T_{on}}{T_s}\right\}$, T_{on} is the switch on time, switching frequency $f_s = 200$ kHz $\left\{f_s = \frac{1}{T_s}\right\}$ and $P_o = 14$ W.

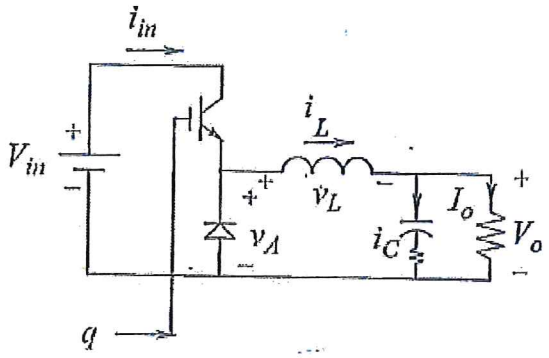

Fig. 1 The buck converter

(a) Plot the waveforms for (i) v_A, (ii) v_L, (iii) i_L and (iv) i_{in} with respect to the time.

(b) In this DC-DC converter, if the inductance $L = 0$, the filter capacitor is disconnected and the load is resistive (R Ω), then (i) what is now the role of the free-wheeling diode? (ii) plot the waveforms for output voltage and current (iii) find expressions for average output voltage and current (iv) show that the rms output voltage is $V_{in}\sqrt{D}$ and rms output current is $\frac{V_{in}\sqrt{D}}{R}$

Question 2. (25% marks)

A load is connected to 250 V, 50 Hz power supply. It takes 6 250 kW at 0.5 power factor lagging.

(a) Calculate the capacitance required in parallel with the load in order to bring the combined power factor to 0.9 lagging.

(b) How does the capacitance affect the line and load currents? Write comments on the results.

Apparent power $S = P + jQ$, where P is active power and Q is reactive power.
$P = VI\cos\emptyset$ and $Q = VI\sin\emptyset$, where $\cos\emptyset$ is power factor angle.

Question 3. (25% marks)

(a) Describe the formation of bus admittance matrix Y_{BUS} in a power system network. Explain why the admittance matrix Y_{BUS} is preferred in comparison to the bus impedance matrix Z_{BUS} in load flow studies.

(b) A single line diagram of a simple four-bus power system is given in Fig. 2. Table 1 gives the line impedances in p.u. identified by the buses on which these terminate. The shunt admittance at all the buses is assumed to be negligible.

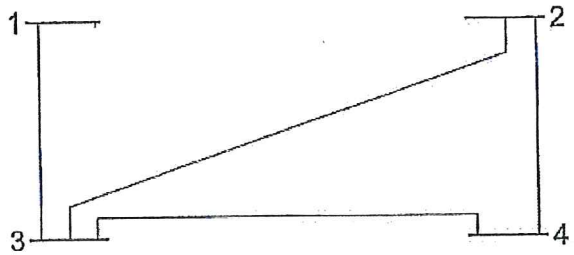

Fig. 2 Single line diagram of four-bus system

Table 1 Line impedances in pu

Line, bus to bus	R (pu)	X (pu)
1-3	0.10	0.30
2-3	0.15	0.45
2-4	0.10	0.30
3-4	0.05	0.15

Find the Y_{BUS} matrix for this four bus power system network.

Question 4. (25% marks)

Solve **any three** out of the following five questions.

(a) Explain the operation of a DC-DC converter application for maximum power point tracking in a solar photovoltaic system.

(b) Draw an electrical schematic diagram of a grid-connected variable speed wind turbine generator and briefly explain its operation.

(c) Explain surge impedance loading of a transmission line.

(d) Explain load buses, generator buses and slack bus in a power system network. Why is one of the buses taken as a slack bus in load flow studies?

(e) In a three-phase power line system with equilateral spacing D and conductor radius r, show that the inductance of each phase (per-unit length) is $L = \left(\frac{\mu_0}{2\pi}\right) ln\frac{D}{r}$ $(in\ H/m)$. Neglect the flux linkage due to internal flux in a conductor and use the balanced load currents.