TSTE19
Power Electronics

Examination (TEN1)

Time:	Thursday 12 April 2012 at 8.00 - 12.00
Place:	U10
Responsible teacher:	Kent Palmkvist, ISY, 28 13 47, 0705 23 31 59 (kentp@isy.liu.se) Will visit exam location at 9 and 11.
Number of tasks:	5
Number of pages:	4
Allowed aids:	Calculator
Notes:	A pass on the exam requires approximately 30 points. Remember to indicate the steps taken when solving problems.
Exam presentation:	Thursday 26 April 2012 11.00-13.00 (Kent Palmkvist's office)

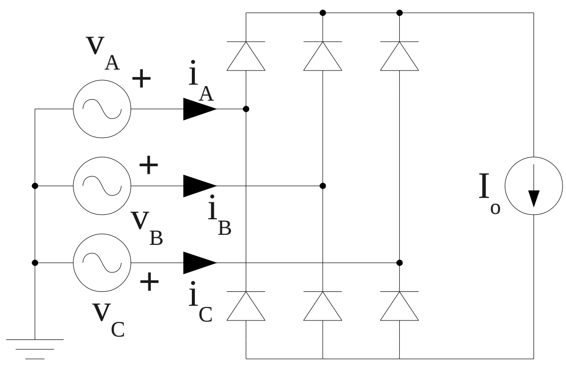
1. a) Why do an increase of the switching frequency in a step-down converter make it possible to use an inductor with smaller physical size? (2)

b) Is the speed of the synchronous motor dependent on the voltage or frequency of the driving voltage? (2)

c) Can the fundamental component of a signal be larger than the peak value? Motivate your answer. (2)

d) What does the acronym IGBT stand for? (2)

e) Does the Cúk dc-dc converter produce a positive or negative voltage? (2)



2. The 3-phase AC->DC conver above have load I_0 of 10 A. Assume the diodes are ideal. The AC input voltages v_A, v_B and v_C are 240V rms, with a 50 Hz fundamental frequency.

a) Draw the waveforms of $v_A(t)$ and $i_A(t)$. Indicate angles/time and voltages/currents. (6)

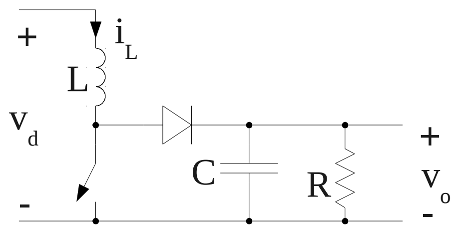
b) Calculate the amplitude of the 1st and 2nd harmonic of the current $i_A(t)$. (6)

3. An AC-DC converter consists of 4 thyristors. These are mounted onto one common heat sink. The input voltage is 400V rms, input current 4 A rms, output voltage is 250V, output current 6 A.The ambient temperature can reach a maximum of 50 degrees. The thermal resistance between junction and case is 2 °C/W, and the case to ambient thermal resistance is 0.8 °C/W. Assume all power loss occur in the thyristors and are equally distributed between them.

a) What is the efficiency of the converter? (4)

b) What is the switch utilization ratio? (6)

c) What is the maximum temperature in the junction of the thyristors? (6)

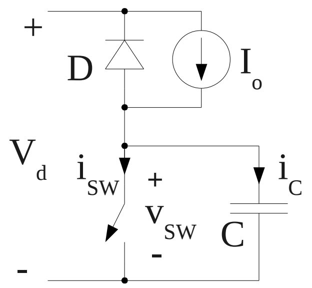


4. The step-up (boost) converter above is working in the continous conduction mode. The switching rate D = 0.75, input voltage V_d = 12 V. C is large, R = 80 Ω, and L = 50 µH. The switching frequency is 50 kHz.

a) Calculate the output voltage v_O. (6)

b) Draw the waveform for $i_L(t)$ and indicate when the switch is on and off. (6)

c) Calculate the maximum current through the inductor L. (4)



5. The circuit above describes a turn-off snubber consisting of the capacitance C. The flywheel diode D have a reverse recovery time of 0.2 us, The input voltage V_d is 380V, and the current I_0 is 10 A. The switch have a turn-off time of 0.5 µs (linear current decrease), and a turn-on time of 0.5 us (linear current increase). The voltage across the snubber capacitance should reach the input voltage after the same time as the switch current reaches zero.

a) Draw the waveforms of i_C, i_{SW}, and v_{SW} at the switch turn-off. (4)

b) Draw the waveforms of i_C, i_{SW}, and v_{SW} at the switch turn-on. (6)

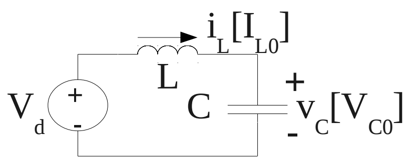
c) Compute the peak value of i_{SW} at switch turn-on. (6)

Formula collection TSTE19 Power Electronics

Fourier series coefficients using symmetri, Table 3.1

Even	$f(-t)=f(t)$	$b_h=0 \quad a_h=\frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\,d(\omega t)$
Odd	$f(-t)=-f(t)$	$a_h=0 \quad b_h=\frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\,d(\omega t)$
Half-wave	$f(t)=-f(t+\frac{1}{2}T)$	$a_h=b_h=0$ for even h $a_h=\frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\,d(\omega t)$ for odd h $b_h=\frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\,d(\omega t)$ for odd h
Even quarter-wave	Even and half-wave	$b_h=0$ for all h $a_h=\frac{4}{\pi}\int_0^{\frac{\pi}{2}} f(t)\cos(h\omega t)\,d(\omega t)$ for odd h $a_h=0$ for even h
Odd quarter-wave	Odd and half-wave	$a_h=0$ for all h $b_h=\frac{4}{\pi}\int_0^{\frac{\pi}{2}} f(t)\sin(h\omega t)\,d(\omega t)$ for odd h $b_h=0$ for even h

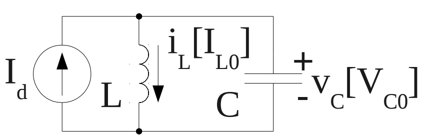
Undamped series resonant circuit, equations 9-3, 9-4



$$i_L(t)=I_{L0}\cos\omega_0(t-t_0)+\frac{V_d-V_{c0}}{Z_0}\sin\omega_0(t-t_0) \qquad (9\text{-}3)$$

$$v_c(t)=V_d-(V_d-V_{c0})\cos\omega(t-t_0)+Z_0 I_{L0}\sin\omega_0(t-t_0) \qquad (9\text{-}4)$$

Undamped parallel resonant circuit, equations 9-20, 9-21



$$i_L(t)=I_d+(I_{L0}-I_d)\cos\omega_0(t-t_0)+\frac{V_{c0}}{Z_0}\sin\omega_0(t-t_0) \qquad (9\text{-}20)$$

$$v_c(t)=Z_0(I_d-I_{L0})\sin\omega(t-t_0)+V_{c0}\cos\omega_0(t-t_0) \qquad (9\text{-}21)$$

Integration rules

$$\int_a^b f(ax)\,dx=\int_A^B f(g(t))g'(t)\,dt \quad \text{if } a=g(A) \text{ and } b=g(B)$$

$$\int_a^b \sin(x)\,dx=[-\cos(x)]_a^b$$

$$\int_a^b \cos(x)\,dx=[\sin(x)]_a^b$$