TSTE19
Power Electronics

Examination (TEN1)

Time:	Saturday 17 December 2011 at 14.00 - 18.00
Place:	TER3
Responsible teacher:	Kent Palmkvist, ISY, 28 13 47, 0705 23 31 59 (kentp@isy.liu.se) Will visit exam location at 15 and 17.
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:	Friday 13 January 2011 13.00-14.00 (Kent Palmkvist's office)

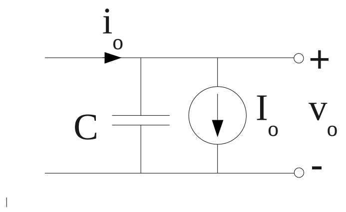
1. a) Can the displacement power factor (DPF) be larger than 1? Motivate your answer. (2)

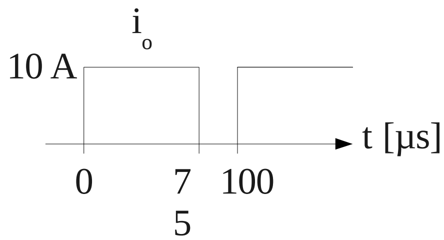
b) How is the fill factor for a solar cell defined? (2)

c) Is it necessary to have a common ground wire in a 3-phase system with a linear resistive load? Motivate your answer. (2)

d) Will an ideal capacitor connected to a 220V 50Hz line outlet voltage get warm due to the current flowing through it? Motivate your answer. (2)

e) Why is it sometimes better to use a transistor instead of a diode in a full bridge rectifier, even if the behavior (on and off times) is exactly the same. (2)





2. The output current from a power supply is shown above. The average output voltage V_o is 12V. The capacitor size is 7500 µF. The switching frequency is 10 kHz.

a) Calculate the average output current I_o. (4)

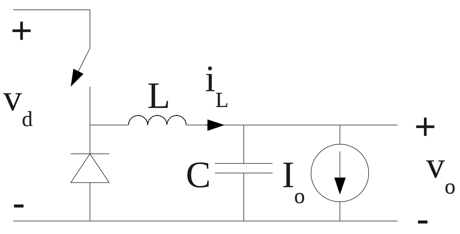
b) Draw the waveform of the output voltage $v_o(t)$. Indicate timing and voltage values. (6)

3. A full bridge DC->AC inverter is controlled using voltage cancellation with a waveform overlap angle of $\alpha = 45°$. The output fundamental frequency is 50 Hz, and the input voltage is 310V.

a) Draw the output voltage waveform of the converter. Indicate voltage levels and phase angles. (6)

b) Calculate the output voltage rms value? (6)

c) Calculate the amplitude (peak value) of the output voltage fundamental $v_{o1}(t)$. (6)

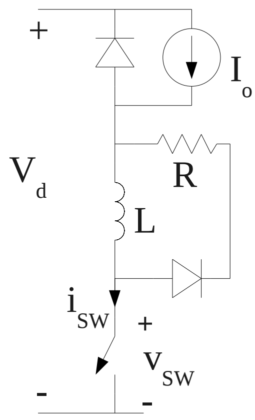


4. The step-down (buck) converter above is operating at the boundary between discontinuous and continuous current conduction mode. Switching ratio D = 0.3. The input voltage is 24V. The inductance L is 0.12 mH. The switching frequency is 10 kHz. The capacitance C is very large.

a) What is the output voltage? (6)

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

c) What is the average output current i_L? (4)



5. The snubber circuit above is designed to reduce the di/dt over the switch at turn-on. The switch have a t_{ri} of 5 µs. The input voltage V_d is 300 V, and the output current I_o is 20 A. The turn-on snubber shall be designed so that the switch voltage at turn on is 5% of the V_d voltage, and that the switch current I_{SW} is equal to I_o after t_{ri}. The switching frequency is 1 kHz. Assume the snubber time constant is much larger than the transistor turn-off time.

a) How large would the turn-on power dissipation be in the switch if there was no turn-on snubber (that is, L = 0)? (4)

b) Calculate the value of L. (6)

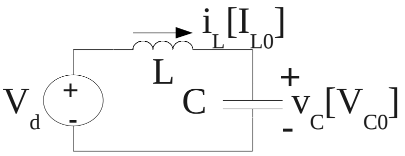
c) Assume the turn-off switch voltage v_{SW} is not allowed to be larger than twice the value of V_d. What is the largest allowed value of R? (6)

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

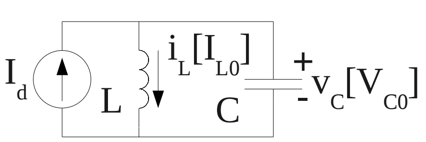
Undamped series resonant circuit, equations 9-3, 9-4



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

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

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

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

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

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