TSTE19
Power Electronics

Examination (TEN1)

Time:	Friday 21 December 2012 at 8.00 - 12.00
Place:	KÅRA
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:	6
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 18 January 2013 12.30-13.30 (Kent Palmkvist's office)

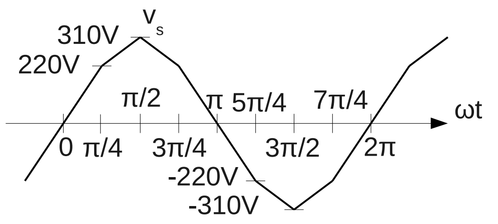
1. a) Describe two ways a battery charger may determine if a battery cell is fully charged. (2)

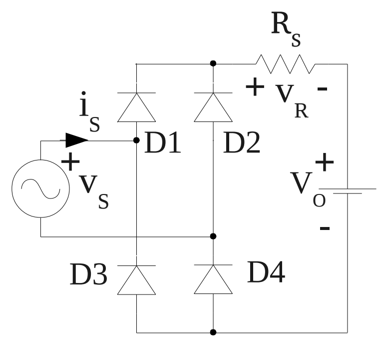
b) What type of motor have a permanent magnet as a rotor? (2)

c) Why must the dv/dt be limited when applying a positive voltage across the thyristor, that is, what will happen if dv/dt is to large? (2)

d) What is a GTO? (2)

e) What type of load (resistive, inductive, or capacitive) can sometimes be modeled as a current source? (2)



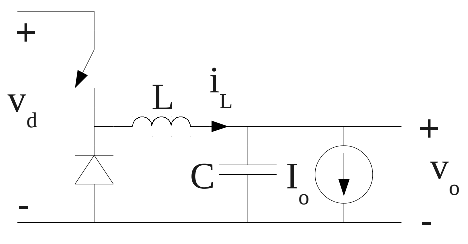


2. The rectifier above to the right have a source voltage v_S as shown above to the left. The output voltage V_O is 265V. The series resistance R_S is 15 Ω.

a) Draw the input voltage v_s, resistor voltage v_r, and input current i_s shapes, indicate where each diode is on (conducting) or off (not conducting), and at what angles current and voltage changes happen. (4)

b) Calculate the peak i_s source current. (4)

c) Calculate the i_s source current rms value. (6)



3. The DC-DC converter above is working in continuous conduction mode, $V_d = 12V$, $L = 37.5\ \mu H$, $D = 0.25$, $I_O = 1.5A$. Assume C is large.

a) Calculate the output voltage V_o. (4)

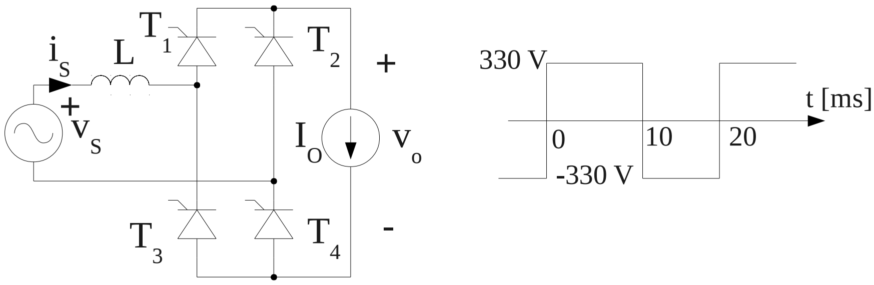
b) Calculate the minimum switching frequency to keep continuous conduction mode. (6)

4. A computer processor power supply have a 12V input, and the processor dissipates 45W when running at 1.5V (this is the output of DC-DC converter). The efficiency of the DC-DC converter is 90%. The ambient temperature is at most 25 degrees, and the maximum case (processor casing) temperature is 55 degrees.

a) How large is the average input current to the DC-DC converter? (4)

b) How much power is dissipated by the DC-DC converter? (4)

c) What is the largest thermal resistance Θ_{ca} allowed for the heat sink. (4)



5. The thyristor based inverter above have the input voltage v_s shown above to the right. The thyristors have a 30 degree firing angle. The current source load I_O is 3A, and the inductor L = 110 mH.

a) Draw the output voltage v_o and the source current i_s, indicating which thyristor is on (conducting) and off (not conducting). (6)

b) Calculate the average output voltage. (6)

c) Calculate the displacement power factor (DPF) for the input power. (4)

6. A full-bridge single-phase inverter is controlled using voltage cancellation. The output fundamental frequency should be 50 Hz. The input voltage is 310V. The waveform overlap angle α is 60 degrees.

a) What are the switching frequency and duty ratio (t_{on}/T_{sw} ratio) of the switches? (2)

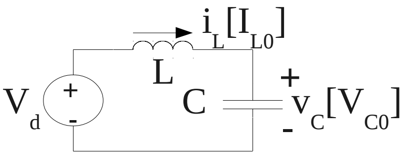
b) Calculate the amplitude of output voltage fundamental, v_{o1}. (6)

Formula collection TSTE19 Power Electronics

Fourier series coefficients using symmetri, Table 3.1

Even	$f(-t)=f(t)$	$b_h=0$	$a_h=\frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\,d(\omega t)$
Odd	$f(-t)=-f(t)$	$a_h=0$	$b_h=\frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\,d(\omega t)$
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	

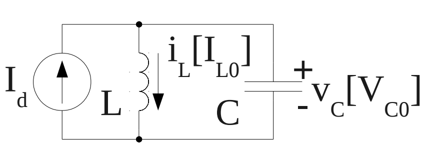
Undamped series resonant circuit, equations 9-3, 9-4



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

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

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

$$\int_a^b f(x)dx=\int_A^B f(g(t))g'(t)dt \quad \text{if } a=g(A),\ b=g(B), \text{ and } g \text{ is monotone in } [A,B]$$

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

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