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Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
ET027G	T101	2018-03-19
Kursnamn	Elektroteknik GR (B), Kraftelektronik	
Provnamn	Skriftlig tentamen	
Ort	Sundsvall	
Termin	V18	
Ämne	Elektroteknik	

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Examination in Power Electronics (ET027G)

Date and Time: 19th March 2018 and 8:00 – 13:00 (alt 09:00 – 14:00)

Responsible Teacher: Kent Bertilsson, Tel: 010-142 8915, Email: Kent.Bertilsson@miun.se

Permitted aids: *Scientific Calculator, Eng-Swe Lexicon, Formula collection attached*

Maximum points: 55p

Preliminary grading levels: A ≧49p, B≧44p, C≧39p, D≧33p, E≧27p; F<27p

- *Start every new exercise on a blank paper*
- *Written text and figures should be clearly drawn and graphs in scale with labeled axes.*
- *The solution should be logically written and used equations should be motivated.*
- *The calculations should be sufficiently complete to show how the final result was obtained.*
- *Each task must be concluded with a clearly written answer (underline the obtained answer).*
- *If you don't get an answer in one part of the exercise that is required for continuing calculations in later sections you can calculate with variables only.*

Good Luck

Kent

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1) Short questions.
   a. What is a shunt resistor most commonly used for (1p)
   b. List three reasons to use a transformer in a converter instead of a converter with just inductors. When the application require... (3p)
   c. Explain the concept of synchronous rectification. What is the benefit? (1p)
      i. Why is that? (1p)
   d. Which one of a thyristor based bidirectional converter and a full bridge bidirectional converters can be used in regeneration braking? (1p)
      i. Why is that? (1p)

Tot 8p

2) Which of the two answers in the table best fulfills each statement. Every correct answer gives 0.5 points. Wrong answer gives -0.5points (No answer (-) 0 points). The total points cannot be less than 0. Answer as a list from 1 to 16 with A / B / -

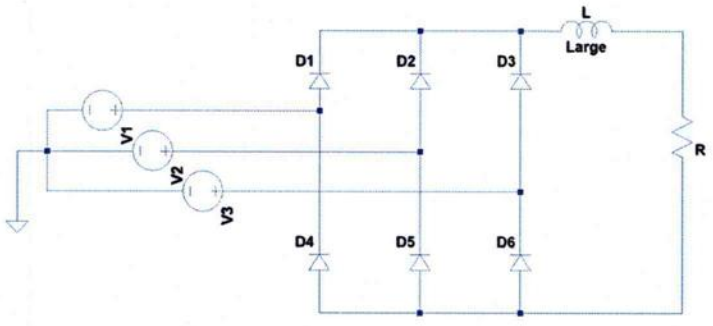
Q		A	B
1	Reduce transistor turn on losses	ZVS	ZCS
2	Reduce transistor turn off losses	ZVS	ZCS
3	Step up down	Buck	Boost
4	Isolated	Buck	Flyback
5	Energy storage	Half Bridge	Flyback
6	Lowest forward voltage drop	PN diode	Schottkty diode
7	Best performance for high voltage rectification	PN diode	Schottkty diode
8	Fastest Switching	PN diode	Schottkty diode
9	Suitable for parallelization	BJT	MOSFET
10	Lowest forward voltage drop	MOSFET	IGBT
11	Best performance for high voltage switch	MOSFET	IGBT
12	Fastest Switching	MOSFET	IGBT
13	Best switching performance	IGBT	Thyristor
14	Smallets	Switched	Linear
15	Lowers EMI	Switched	Linear
16	Cheapest in production	Switched	Linear

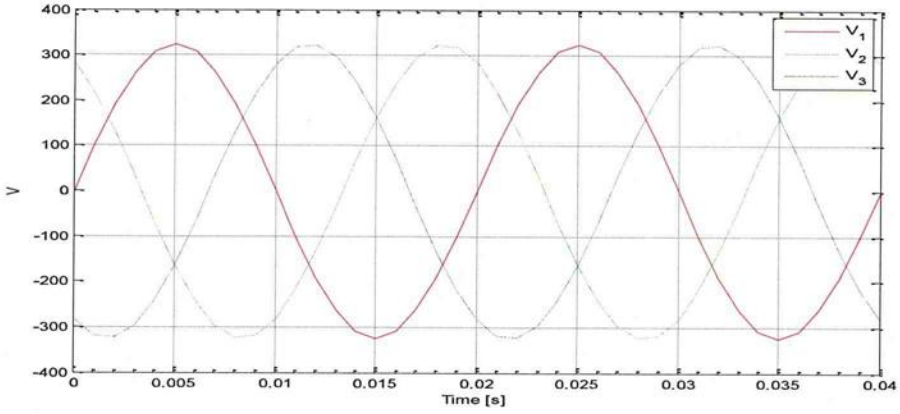
Tot 8p

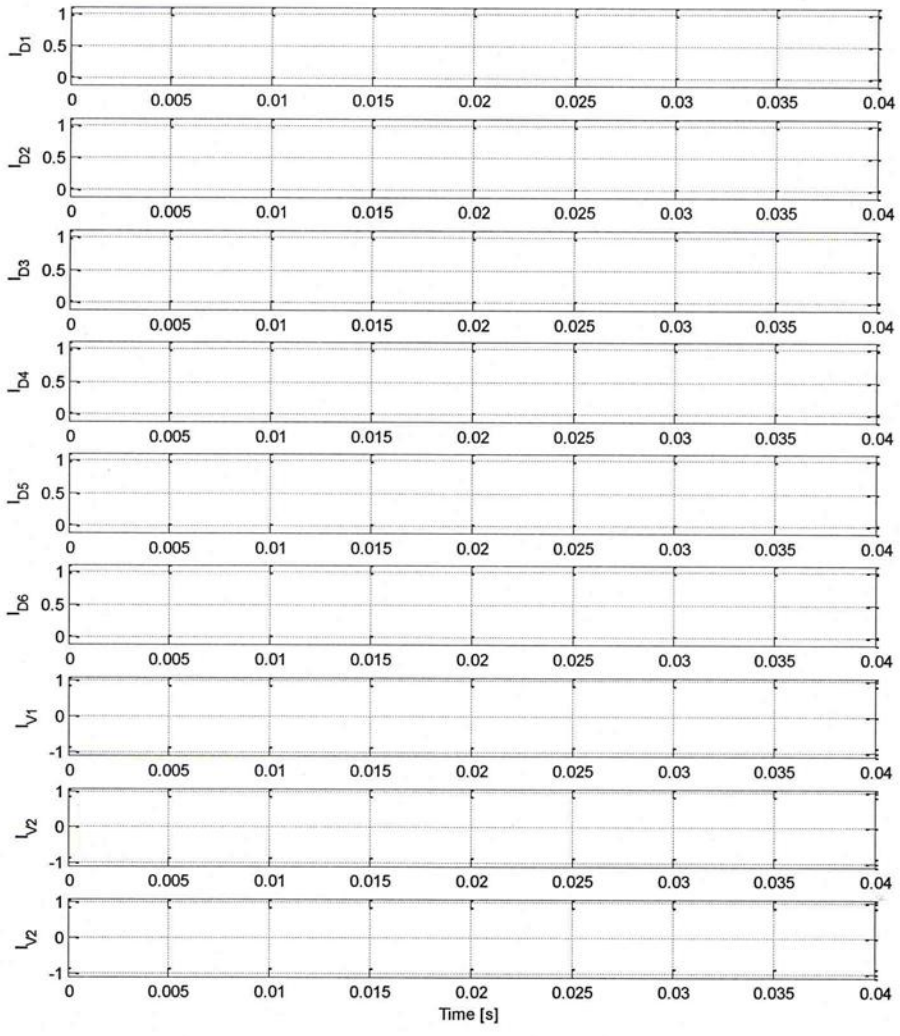
3) A three phase rectifier according to the figure below is connected to a grid with the voltages according to the graph (also available on separate page). The rectifier is connected to a resistive load R though a large inductor so that the load current is 1A DC.

a. Draw the current in the six diodes and in the grid connection. Use the separate page and hand it in with the exam. (4p)
b. What is the rated RMS voltage of the grid. (1p)
c. Determine the power factor of the rectifier load combination (2p)
d. Determine the mean output voltage, approximately (2p)
e. Calculate resistance value, R (1p)

Tot 10p




V1
V2
V3
V
Time [s]


ID1
ID2
ID3
ID4
ID5
ID6
VV1
VV2
VV2
Time [s]

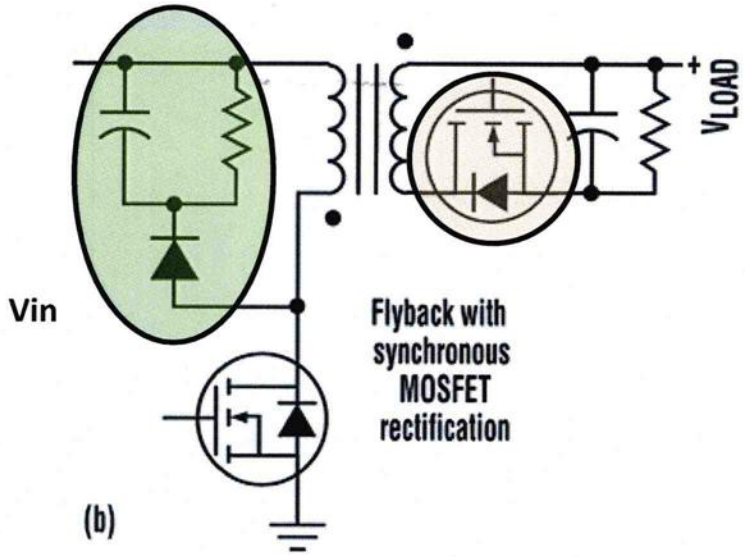
4) Assume a constant current of 10A in diode rectifier is switched with duty cycle of 40% with a forward voltage drop of 0.8V. How much is the losses reduced replacing this with a synchronous rectifier with a MOSFET with r_{dson}=10mΩ (3p)

Tot 3p

5) The converter below has Vin=200V, Duty cycle=40% is working in continuous conduction mode. The primary winding have 100 turns and the secondary 10 turns and the converter is loaded with 10Ω.

a. What type of converter is shown (1p)
b. Calculate the output voltage, V_o (1p)
c. What is the functionality of the transistor in the right circle (1p)
d. What is the functionality of the circuit elements in the left oval (1p)
e. Sketch the waveforms for the primary switch current, I_{Sw}, Rectifier current, I_{Rect}, Switch voltage, V_{Sw}, The amplitude for the voltages should be clearly shown. The mean currents should be correct and clearly visible. (6p)

Tot 10p



6) A transistor is dissipating 10W in losses under steady state. According to datasheets for the transformer and heatsink the thermal resistances are $R_{Th\ junction-case} = 0.5K/W$, $R_{Th\ case-sink} = 1.5K/W$, $R_{Th\ sink-ambient} = 3K/W$. The ambient is expected to be at most 30°C.

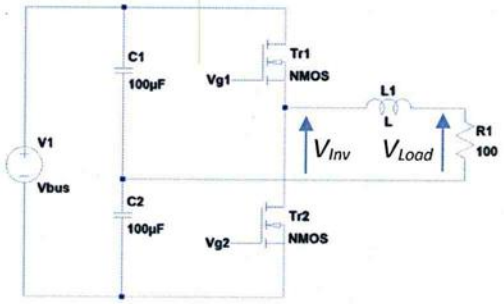
a. Draw a thermal schematic of the situation. (2p)
b. What is the highest junction temperature of the transistor (2p)

Under a surge event the losses can reach 1000W for 10us. Assuming that it is only the chip temperature that response to the surge and the corresponding thermal capacitance is 0.01 J/K.

c. Estimate the temperature the chip reach during such surge (2p)

Tot 6p

7) A single phase inverter according to the figure below is driving a 100Ohm load. A triangular and sinusoidal shown waveform (1st graph) are used to generate the switching pattern for the two switches (2nd and 3rd graph). The 4th graph shows the output from the inverter before and after the inductor and the resulting current is shown in the 5th graph.



a) Determine the switching frequency (1p)
b) Determine the inverter output frequency (1p)
c) Determine the amplitude and frequency modulation ratios, m_A and m_f (1p)
d) Determine the bus voltage, V_{Bus} (2p)
e) Determine the size of the inductor L1 used. (3p)
f) A single phase synchronous motor marked 60Hz, 1400rpm is connected to the driver. Determine the motor speed in rpm. (2p)

Tot 10p