Mittuniversitetet
MID SWEDEN UNIVERSITY

Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
ET027G	T101	2019-03-18
Kursnamn	Elektroteknik GR (B), Kraftelektronik	
Provnamn	Tentamen - Sundsvall	
Ort	Sundsvall	
Termin	VT2019	
Ämne	Elektroteknik	

Power Electronics Exam (ET027G)

Date and Time: 18th March 2019 and 8:00 – 12:00

Responsible Teacher: Sobhi Barg, Tel: 010-142 79 91, Email: sobhi.barg@miun.se

Maximum points: 55

Preliminary grades: A≥ 53pt, B≥ 48pt, C≥ 43pt, D≥ 38pt, E≥ 33pt , F< 28pt

Introduction:

- The exam includes two answer sheets, please return them with your answer sheets.
- The exam includes 4 parts, which are completely separate.
- The first part contains Yes or No type Questions. Full mark will be given for correct answer and zero for incorrect answer.
- The second part is a problem about the full-bride rectifier.
- The third part is a problem about the boost converter.
- The fourth part is a problem about the three phase inverter.
- Each numerical result has to be preceded by full and clear development of the analytical expression.
- The exam includes a formula sheet.
- The use of scientific calculator is allowed.
- English to Swedish dictionary is allowed.

I. Part One (15 pts)

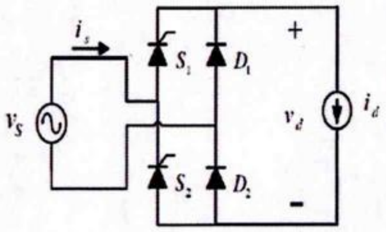
Complete the following sentences by Yes or No

- In switching mode power supply, the transistor is operated in the active region: ....
- The power Bjt transistor has better switching capability than the power MOSFET: ....
- The conduction loss depends on the switching frequency: ....
- At high frequency, the switching loss are higher than the conduction loss: ....
- The power MOSFET is a current controlled device: ....
- The maximum output voltage of the full bridge diode rectifier is 207 V: ....
- The average output voltage of the three phase diode rectifier is ....
- The AC line input inductance increases the average output voltage of the rectifier: ....
- The harmonics currents are part of the active power: ....
- The output voltage of a buck converter is dependent on the load current: ....
- In buck converter, the inductance is proportional to the output current ripple: ....
- For DC-DC converters, the inductance for DCM is bigger than that for CCM : ....
- In flyback converter, the magnetic core operates in the first and third quadrant: ....
- The Mosfet voltage stress in boost converter is higher than that in flyback: ....
- The ZVS can be realized during the turn-off: ....

Note: Please include this page with your exam answer sheet.

II. Part Two (16pts)

Consider the single phase semi-controlled rectifier below. Vs is the AC line voltage V_s=230 V, f=50 Hz.



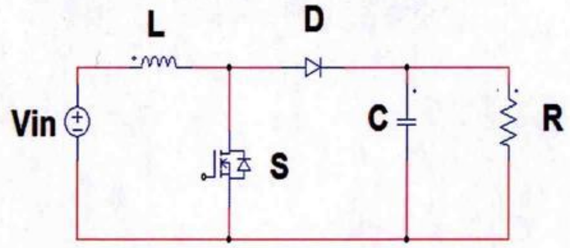
1- Determine the on-state and off-state conditions of each semi-conductor components in the circuit. (1pt)
2- Draw in the same figure, V_s, I_s, V_d for the firing angle α=45°, 90 °. (1pt)
3- In the same figure but in different x-axis draw, the current and the voltage across each components (use different colors). (1pt)
4- Determine the expression of the average output voltage V_d and calculate its value for the different firing angles. (2pt)
5- Suppose that V_{dc} is the average output voltage when α=0°. Calculate the firing angle that gives V_d=0.5 *V_{dc}. (2pt)

Suppose that you have a dc voltage source (Vc= 60 V)in series with the high inductive load (id).

6- Draw the new circuit. (1pt)
7- What is the average output voltage when the firing angle is equal to 5° (suppose that the triggering pulse is very short (some nano-second). (2pt)
8- Determine the minimum firing angle to get an input voltage higher than Vc. (3pt)
9- Determine the firing angle to get an average output voltage V_d 30% higher than V_c. (3pt)

III. Part Three (16 pts)

Consider the circuit of a boost converter below. We would like to operate the converter in CCM. V_{in}=2.3-8 V, Vo=12 V, f=200 kHz, Po=3.6 W, η=90



1- Explain the operation of this converter and draw the equivalent circuit for the two cases. (2pt)
   - The switch S is on.
   - The switch S is off.
2- Determine the minimum and maximum duty cycle D to get the required output voltage. (2pt)
3- Demonstrate that the expression of the output current ripple as function of Vo, D, L and f is equal to: (1pt)

$$\Delta I_o = \frac{V_o D(1-D)}{Lf}$$

4- Calculate $\frac{\Delta I_o}{dD} = 0$ and determine the critical duty cycle for which the current ripple is maximum. (3pt)
5- Calculate the critical input voltage that leads to the maximum output current ripple. (2pt)
6- Determine the required inductance to get an output current ripple equal to 20% the output DC current at the critical duty cycle. (2pt)
7- For the calculated inductance determine the minimum output current ripple that can be achieved. (2pt)
8- For D=0.5, the calculated inductance and the given frequency, sketch in the same figure: the input voltage, the switch voltage V_{ds} in the first x-axis. In the second x-axis, draw the output current and the switch current. (2pt)