

NAME:

STUDENT NUMBER

1. List three of the semiconductor switches commonly used in switch-mode power electronics?
2. During testing, the value of the gate-drive resistor for a MOSFET in a switcher is increased from  $50\ \Omega$  to  $75\ \Omega$ . Will the switching losses for the MOSFET increase, decrease or remain constant with  $R_G = 75\ \Omega$  compared to  $R_G = 50\ \Omega$ ? Briefly state why.
3. Which capacitance of the MOSFET is the Miller capacitance?
4. Instantaneously during switching a power MOSFET, of threshold voltage  $V_{GS(th)} = 4\text{ V}$  and transconductance  $g_{fs} = 10\text{ S}$ , has  $v_{GS}(t) = 12\text{ V}$  and  $v_{GS}(t) = 3\text{ V}$  while conducting  $I_D = 10\text{ A}$ . Is the device in the cutoff, active or ohmic region of operation? Briefly state why.
5. An IGBT module has a transconductance  $g_{fs} = 100\text{ S}$  and a threshold voltage,  $V_{GS(th)} = 4\text{ V}$ . What gate voltage is required to conduct a drain-source current of  $200\text{ A}$  in the active region?
6. A MOSFET has  $V_{GS(TH)} = 4\text{ V}$ ,  $g_{fs} = 10\text{ S}$ ,  $C_{GS} = 500\text{ pF}$ ,  $C_{DS} = 50\text{ pF}$ , and is driven by a  $0$  to  $12\text{ V}$  gate drive with a gate resistor  $R_g = 50\ \Omega$ . Given a delay time of  $11\text{ ns}$ , what is the current rise time when conducting a drain-source current of  $10\text{ A}$ ?
7. An IGBT is switching at  $10\text{ kHz}$ . Turn-on energy loss equals the energy turn-off loss equals  $5\text{ mJ}$ , and the conduction loss equals the combined switching loss. The maximum temperature of the attached heatsink is  $70\text{ degC}$ . What is the maximum thermal resistance allowable ( $\theta_{J-C} = ?\text{ degC/W}$ ) if the junction is not to exceed  $110\text{ degC}$ .

8. An IGBT operates in a H-bridge converter with a 320 V dc bus, and experiences an additional 50 V spike due to leakage inductance. Using typical derating guidelines, what voltage silicon would you recommend to the nearest 100 V?
9. In terms of n, n+, n-, p, p+, p-, sketch the three layers of the power diode going from anode to cathode?
10. Sketch the electrical symbol of the n-channel IGBT and identify the terminals of the device?
11. The power MOSFET and IGBT have similar construction – simplistically the addition of a *p* layer. Why does the IGBT have a tail current at turn off?
12. A power IGBT has a threshold voltage  $V_{GS(th)} = 4.5$  V, and conducts drain current  $I_D = 600$  A at  $V_{GS(th)} = 6$  V. Under short circuit conditions what magnitude drain current will the device conduct when a gate voltage of 15 V is applied?
13. What is the term for the undesirable characteristic of the power diode at turn off?
14. An IGBT has a maximum specified junction temperature of 150 degC. The part is dissipating 50 W and is attached to a heatsink with a total thermal resistance  $\theta_{JC} = 1$  degC/W. Under typical derating guidelines, what would you recommend as the maximum heatsink temperature?