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QUESTION WORKBOOK

Discrete semiconductor devices

Electronics · Year 13

AQA 3.13.1.1, 3.13.1.2, 3.13.1.3, 3.13.1.4 · CIE 20.3.4

17 questions · 51 marks

PRINT EDITION

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SECTION A · Warm-up

A1 Explain why the gate of a MOSFET draws no steady current, and state what a logic output must supply in order to switch one. [2]

A2 State what happens to the drain current of a MOSFET below its threshold voltage and above it. [2]

A3 A zener diode is used to hold a supply rail steady. State how the diode is connected and what the series resistor does. [2]

A4 State how a photodiode is biased in a light meter, and state how its photocurrent depends on the illumination. [2]

A5 State what a Hall probe measures, and explain why the probe is rotated before a reading is taken. [2]

A6 Give two reasons a photodiode is preferred to a light-dependent resistor at the receiving end of an optical fibre. [2]

SECTION B · Standard

B1 A MOSFET has a threshold voltage of 2.0 V and passes a drain current of 0.10 A when the gate-source voltage is 3.0 V. Its drain current follows $I_D = k(V_{GS} - V_T)^2$. Calculate k, and the drain current when the gate-source voltage is 4.5 V. [3]

B2 A MOSFET switches a 6.0 Ω heater across a 9.0 V supply. With the gate at 5 V the channel resistance is 0.12 Ω. Calculate the current, the pd across the heater and the power dissipated in the MOSFET. [3]

B3 A 5.1 V zener diode is fed through a 390 Ω series resistor from a supply of 15 V, and the load draws 12 mA. Calculate the current in the resistor, the current in the zener and the power dissipated in the zener. [3]

B4 A reverse-biased photodiode delivers a photocurrent of 24 µA at a certain illumination, and its current is passed through a 75 kΩ load resistor. Calculate the pd across the resistor, and the pd when the illumination is trebled. [3]

B5 A Hall effect sensor carries a constant current and gives an output of 2.4 mV when the flux density through its face is 0.20 T. Calculate its sensitivity in mV T^{-1} and its output in a field of 0.55 T. [3]

B6 A 5.1 V zener diode is fed through a 390 Ω series resistor from a supply that can fall as low as 9.0 V. Calculate the resistor current at 9.0 V and hence state the largest load current the regulator can supply. [3]

B7 A MOSFET with a threshold voltage of 2.0 V passes 0.10 A when the gate-source voltage is 3.0 V. Without calculating k, deduce the drain current at a gate-source voltage of 6.0 V. [2]

SECTION C · Stretch

C1 A 5.1 V zener regulator must supply a load drawing up to 15 mA from a supply that wanders between 9.0 V and 15.0 V. The zener needs at least 5.0 mA to stay in breakdown and is rated at 400 mW. Calculate the largest series resistance that meets the specification, choose the preferred value 180 Ω, and check the design at both ends of the supply range, including the power rating needed for the resistor. [7]

C2 A logic output that can supply 4.0 mA drives the gate of a MOSFET. The gate behaves as a 1.5 nF capacitor and must be taken to 5.0 V to switch the transistor on. Estimate the switching time, and state the current the logic output supplies once the MOSFET is on. [4]

C3 A Hall sensor giving 2.4 mV in a flux density of 0.20 T is mounted beside a rotating shaft carrying four small magnets, each bringing a peak flux density of 0.45 T past the slab. A counter registers 120 pulses in 2.0 s. Calculate the peak output voltage and the rotation rate of the shaft in revolutions per minute. [4]

C4 A photodiode gives a photocurrent of 20 µA per unit of illumination. It is to produce 2.5 V across a load resistor at an illumination of 3 units. Calculate the resistance required, state the pd obtained with the nearest preferred value of 43 kΩ, and explain why a light-dependent resistor could not replace the photodiode in a fibre-optic receiver working at 1 MHz. [4]