Version 1.0: 0807

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Electronics 5431/6431

ELE2 Further Electronics

Mark Scheme

2007 examination - June series

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Dr Michael Cresswell Director General

1 (a) **D** to $\overline{\mathbf{Q}}$ ✓
$\overline{\mathbf{Q}}$ to next clock ✓
C to AND gate input ✓
D to AND gate input ✓
AND output connected to all resets ✓

(max 4 marks)

(b) (i) Each term represents one line within the truth table for which the output is 1 ✓
Each letter within each term represents the logic state of the counter outputs ✓

(ii) Correct use of either Karnaugh Map of Boolean algebra ✓
At least one piece of simplification ✓
Simplification to $\overline{\mathbf{D}}\mathbf{.C.A} + \mathbf{D.}\overline{\mathbf{C}}\mathbf{.B}$ ✓

(5 marks)

(Total 9 marks)

2 (a) Voltage divider gives 6V at non-inverting input of op-amp ✓
So inverting input will also be approx 6V for non saturated output of op-amp because of large open loop voltage gain of op-amp ✓

(2 marks)

(b) Correct formula $G_v = -R_2/R_1$ ✓
$G_v = -2200/10 = -220$ ✓

(2 marks)

(c) $G_v = 3/220 = 13.6\text{mV}$ ✓

(1 marks)

(d) e.g. variable resistor ✓
to replace R_2 (or R_1) ✓

(2 marks)

(e) $X_c = 1 / (2 \pi f C) \Rightarrow C = 1 / 2 \pi f X_c = 1 / 2 \pi\ 20\ 10^4 = 0.796\mu F$ ✓✓

(2 marks)

(Total 9 marks)

3 (a) logic 1 ✓
The input to the NAND gate must be logic 1 for the output to be anything other than logic 0 ✓

(2 marks)

(b) Output of first NAND gate goes low, output of astable goes high ✓
Capacitor discharges and charges in opposite direction ✓
Until voltage at input to first NAND gate (<)+V_S/2 ✓
Output of astable switches state ✓
Capacitor charges in opposite direction ✓
Process repeats as long as motion sensor is at logic 1 ✓

(max 4 marks)

(c) $f \approx 1 / 2RC \Rightarrow 22 \times 10^3 \approx 1 / 2 \times 15 \times 10^3 \times C \Rightarrow C = 1.52\text{nF}$ ✓✓

(2 marks)

(d) The NOT gates are driven by opposite sides of NAND gate 2, which is configured as a NOT gate. Therefore when A is logic 1, B is logic 0 etc ✓

(1 mark)

(Total 9 marks)

4 (a) very large open loop voltage gain ✓
so there must only be a very small difference in inputs if output is not to be saturated ✓

(2 marks)

(b) If 200mA passes through battery it must also pass through R ✓
$R = V / I \Rightarrow R = 5/0.2 = 25\Omega$ ✓

(2 marks)

(c) (i) source follower (or equivalent) ✓

(ii) The op-amp will not supply such a large current ✓

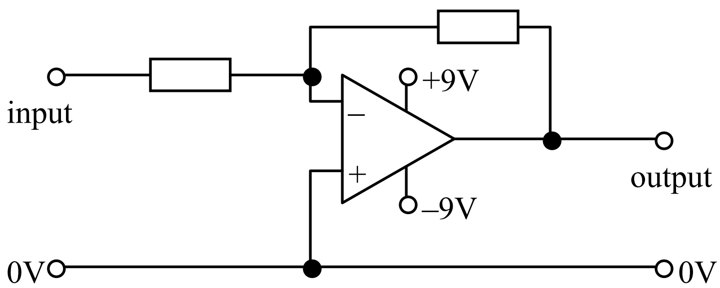
(2 marks)

(d) As the battery voltage rises, the output of the op-amp will also rise ✓
so as to ensure that there is 200mA passing through the battery and R ✓
and so maintaining the 5V across R and hence 5V at its own input terminals ✓

(3 marks)

(Total 9 marks)

5 (a) correctly connected inputs, ✓
feedback resistor in correct place, ✓
realistic values of R - accept between 1kΩ and 1MΩ, ✓
both Rs the same. ✓



(4 marks)

(b) (i) Any appropriate place associated with inverting input of op-amp ✓
(Accept if not X!)

(ii) Appropriate calculation leading to answer ✓
e.g. $-10^6\left(\frac{v}{10^4}+\frac{v}{10^4}\right)$
Output voltage = (+)200*v* ✓

(3 marks)

(c) (i) Calculation leading to answer of 1.99kg ✓

(ii) Resolution of meter is 0.01V
=> smallest change in weight is 0.01kg or 10g ✓

(2 marks)

(Total 9 marks)

6 (a) (i) CKs all connected together, ✓
Resets all connected together, ✓
D to proceeding Q ✓
Input to D_A ✓

(ii) switch to $+V_s$, ✓
pull down resistor to 0V ✓

(6 marks)

(b) 12 => 1100 => C => appropriate symbol for C ✓
13 => 1101 => D => appropriate symbol for d ✓
15 => 1111 => F => appropriate symbol for F ✓
OR ✓ ✓ ✓

(3 marks)

(Total 9 marks)

7 (a) (i) $G_v = V_{out} / V_{in} = 15 / 0.075 = 200$ ✓

(ii) $6 \times 10^5 = f \times G_v = f \times 200$
$\Rightarrow f = 6 \times 10^5 / 200 = 3000\text{Hz}$ ✓

(2 marks)

(b) (i) 1MΩ ✓
Assuming input impedance of capacitor is negligible
(or input impedance of op-amp is very large) ✓

(ii) Assume source followers have a voltage gain of 1 ✓
$G_v = 1 + R_f / R_1$ ✓
$200 = 1 + R_f / 10^4$ ✓
$R_f = 1.99 \times 10^6$ (allow 2MΩ) ✓

(6 marks)

(c) (i) X-over distortion is non-linearity in the characteristic of the amplifier ✓
when the signal changes from positive to negative or vice versa ✓

(ii) No - because the MOSFETs are biased into conduction ✓
(mention of 50mA drain current)
(because of the negative feedback loop)

(3 marks)

(d) (i) $P_{out} = V_s^2 / 2 \times R = 15^2 / 8$ ✓
$= 28.125\text{W}$ ✓

(ii) Output of op-amp does not reach saturation at the supply voltages ✓
MOSFETs have V_{gs} when conducting ✓

(4 marks)

(e) Dark colour (to aid radiation) ✓
Large surface area (to aid radiation and convection) ✓
Made of metal (to aid conduction) ✓
(fan (to assist convection) ✓)

(max 3 marks)

(Total 18 marks)