AQA A-LEVEL PHYSICS · 7408

PHYSICS



MARK SCHEME

3.13 ELECTRONICS: CAPACITOR CIRCUITS

SCORE	PERCENTAGE
/31	%

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Q1.

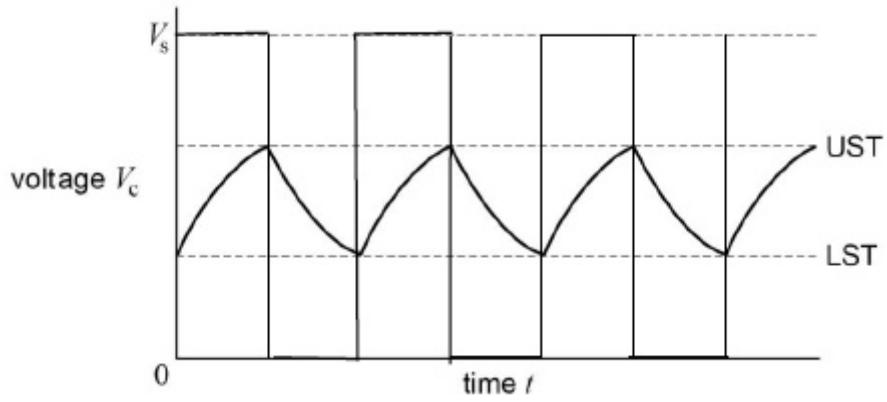
(a) PRF = 1 / (1.4 RC)

= 1 / (1.4 × 5.1 × 10^3 × 10 × 10^{-9})

14 kHz ✓

1

(b) Square wave with correct phase and amplitude ✓



1

(c) New resistor calculated and stated to be 1.7 kΩ ✓

New resistor placed in parallel with original resistor ✓

Ecf from part (a)

2

(d) $T = \frac{1}{f} = \frac{1}{5 \times 10^3}$ = 0.2 ms (200 μs)

t_C = 0.2 × 10^{-3} × $\frac{3}{4}$ = 150 μs

t_D = 0.2 × 10^{-3} × $\frac{1}{4}$ = 50 μs

$R_2 = \frac{t_D}{0.7 \times C} = \frac{50 \times 10^{-6}}{0.7 \times 10 \times 10^{-9}}$ = 7.1 kΩ (Accept 7kΩ)

$R_1 = \frac{t_C}{0.7 \times C}$ – R2 = 14.3 kΩ (Accept 14kΩ)

1 mark for significant calculation

Eg showing $R_1 = 2R_2$

OR

Calculation for t_C or t_D

1 mark for values of R_1 and R_2

2

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(e) Two properties per mark – (max mark 2)✓✓

- A square wave
- Amplitude of 0 V to 5 V
- Periodic time of 0.2 ms
- High for 0.15 ms – Low for 0.05 ms

2

[8]

Q2.

(a) $f = 1 / (2\pi \sqrt{LC})$

$C = 1/ f^2 4\pi^2 L$

$C = 1/ (910 \times 10^3)^2 \times 4 \times \pi^2 \times 1.1 \times 10^{-3}$

$C = 27.8$ pF (accept 28pF)

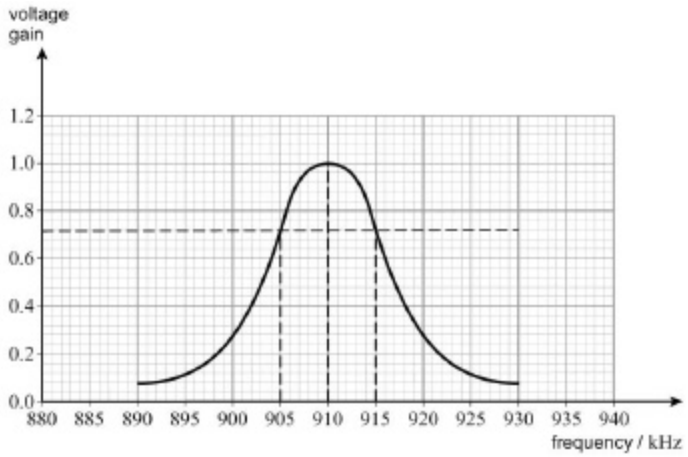
Formula with correct substitution / evidence of correct working

Answer

1

1

(b)



General shape around f_0 and to max of 1.0 on relative voltage gain axis

1

10 kHz bandwidth

at 0.71 gain

1

Frequencies (905 – 910 – 915) kHz (identified / used)

1

(c) Smaller Q factor leads to:

(Any **two** from)
(i) Broader bandwidth
(ii) More noise / (hiss) detected
(iii) Less selectivity
(iv) More susceptible to crosstalk from neighbouring stations on the frequency spectrum.
(v) Less gain due to energy loss / loss of signal detail

2

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[7]

Q3.

(a) No pd across 100 kΩ (since no current through it) so both inputs are 0 V / logic 0 and output there for logic 1.✓

1

(b) $\left(V = V_0\left(1 - e^{-\frac{t}{RC}}\right)\right)$ and RC = 10 s gives $2.5 = 5.0\left(1 - e^{-\frac{t}{10}}\right)$ ✓

Solution gives t = 6.93 s.✓

2

(c) Any appropriate time delay application that leaves a device switched ON or OFF for a short time after activation or deactivation.✓

e.g. Car interior light as driver leaves vehicle, intruder alarm exit delay.

1

[4]

Q21.

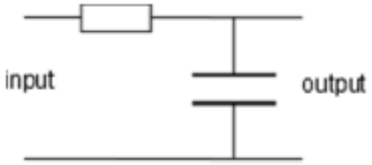
(a) range of frequencies in signal ✓
reference to frequency at which signal drops by
e.g. power 3dB (50%) / voltage 6dB (71%) ✓

2

(b) low pass / treble cut ✓

1

(c) (i) RC filter circuit, with input & output labelled ✓
correct R & C positions ✓



2

(ii) substitute values into f = 1 / 2πRC ✓

rearrange for C ✓

40 (39.7) nF ✓

3

(d) (i) gain > 1 ✓

1

(ii) 100Hz ✓

1

(iii) gain = 0.2 ✓ output = 0.4V ✓

2

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[12]

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Q1.

(a) Most students found the calculation to be quite straight forward with very few '*power of ten*' issues. 84% arrived at the correct answer.

(b) Just under half of the students (46%) were able to transfer the written properties from the stem into the voltage-time diagram.

(c) A surprising number of students did not open with a statement to say that '*if the PRF is x4, then the effective R must be ¼ value*'. This should then have triggered a parallel resistor calculation as a means of adding a resistor to reduce the total resistance. 50% of students gained at least one of the two marks available. *In general, it is important that multi-step calculations are carefully set out and explained to make sure that students can target all marks*.

(d) This question proved to be quite demanding and required students to pull in information from a number of areas. The key was to appreciate that the t_C = ¾ T and t_D = ¼ T
For many, the calculation evolved without a clear plan. However, one mark was available for making significant headway towards the solution. Only 24% of students gained both marks here.

(e) The graph was generally drawn well, although still only accessed by 56% of the students. Some missed out on a mark either because they forgot that the amplitude was 5 V, or got the mark–space ratio wrong.

Q2.

(a) Some students struggled with extracting C from the formula, and one or two lost some powers of ten. Again, it is recommended that students always show all stages of their working, so that some credit can be gained even if the final answer is wrong.

(b) Most students answered this question well, although a significant number failed to show on the graph the appropriate frequencies matched to the ~ 0.7 voltage gain point.

(c) Some students were rather 'clinical' in their response to this question and forgot to relate their answer to the context of the 'listener'.

Q21.

(a) A precise meaning of bandwidth, referring to power or voltage, should be known.

(b) Most were able to name the appropriate filter.

(c) Some attempted active filters, but the question asked for a passive filter. Most were able to rearrange the formula to find breakpoint frequency, with some power of ten errors.

(d) Interpretation of the graph was disappointing. Few were able to identify a filter with a gain >1 as active. Many thought that the frequency at which the gain first dropped from maximum was the breakpoint. Many could not read the gain at 5kHz.

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