A-Level Physics

Analogue Signal Processing

Mark Scheme

Time available: 59 minutes
Marks available: 57 marks

1.

(a) Numerical value for capacitor = 6.9 pF ✓

Substitution of values into formula alone – not sufficient for mark.

1

(b) Y and X most suitable / (W and Z out of range) ✓

Y better than X as value falls within centre of range. ✓

implied choice – 1 mark

reason – 1 mark

2

(c) Evidence of reading at 0.7 V_{max} (350 mV) ✓

Bandwidth 20 kHz ✓ Allow range (19–21 kHz)

1 mark only for:

Evidence of reading at 0.5 V_{max} (250 mV)

Bandwidth 25 kHz ✓ Allow range (24–26 kHz)

2

(d) $Q = f_0 / f_B$ = 198 kHz / 20 kHz = 9.9 ✓

Allow ecf from (c)

1

(e) **Either:**

Listener hears overlapping stations - due to increase in bandwidth. ✓

Or

Listener hears station more faintly - due to energy loss / wider energy distribution ✓

Accept S/N argument as weaker stations become more prominent and can be considered as noise.

1

[7]

2.

(a) f = 1 / (2π √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)

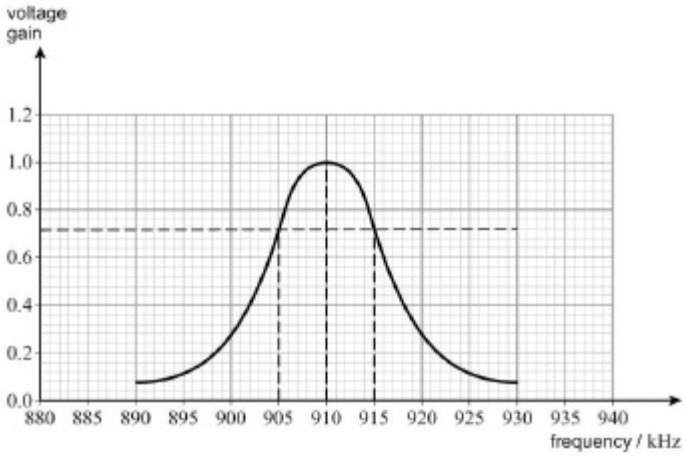
Formula with correct substitution / evidence of correct working

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

[7]

3. (a) (i) Log graph enables a wide range of values to be displayed on the same axis.

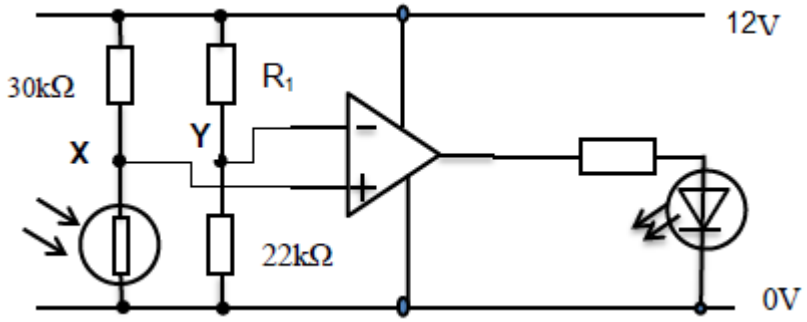
Allow − (enables values to be displayed as straight line)

1

(ii) 7 lux

1

(b)



1 mark for connections correct way round

1

(c) (i) 60 kΩ / (60kΩ + 30kΩ)) × 12V = 8V

Working − 1

Answer − 1

2

(ii) R_1 = 11kΩ to give same value at Y as switching voltage at X (2:1 ratio) (No ecf on value)

Reason / calculation − 1

Answer − 1

2

(d) The op-amp is not ideal and will saturate above 0V

Saturation − 1

Need to drop voltage

Voltage drop − 1

Acceptable method

Method − 1

3

(Total 10 marks)

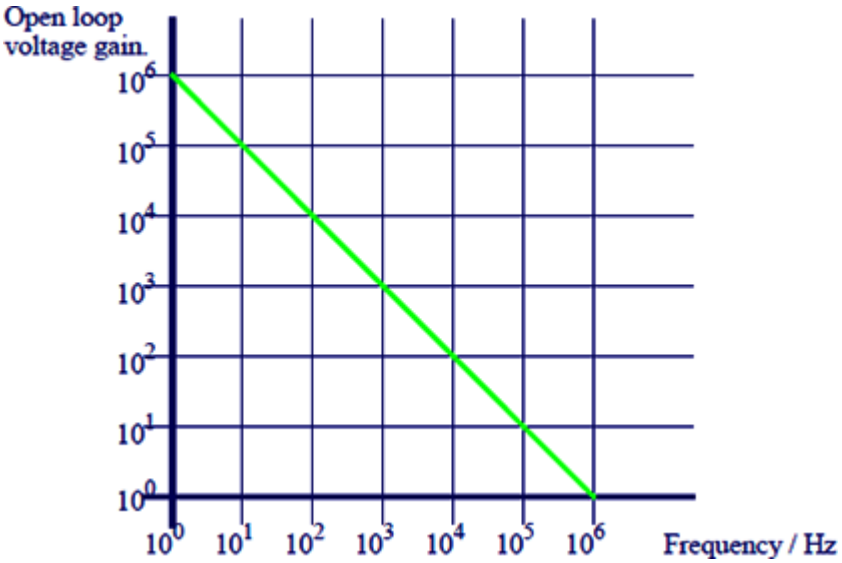
4. (a) Feedback resistor from output to –ve input
Correct inverting or non-inverting amplifier circuit
For inverting, 4.7kΩ and 470kΩ in the correct place
For non-inverting, 4.7Ω input resistor AND two resistors in ratio of 99 / 100

4

(b) Formula
120mV
0.12V
(No unit error if obvious)

2

(c)



Positive gradient = no marks
Correct intercept on vertical axis
Correct intercept on horizontal axis
Straight line joining

3

(d) (No possible ecf from (c))
Calculation
10kHz

2

[11]

5. (a) use of $f = 1 / 2\pi\sqrt{LC}$, change subject to $L = 1 / 4\pi^2 f^2 C$
substitute values, calculation , leading to 6.9μH ✓✓✓✓

4

(b) use of $\lambda = c / f$, substitute values leading to 22.1m ✓
dipole = 11.05m ✓
too large for desk operation ✓

3

(c) 13.56 / 0.1 = 136✓ (could be rounded down to 135)

1

(d) 1KB = 8192 bits (allow 8000)✓
8192 / 100000 = 0.082s
(or allow values based on 8000, 0.08s) regardless of these variations, time to download centres on 80ms✓

2

[10]

6. (a) Two input resistors to the inverting input ✓,
feedback resistor to the inverting input from the output ✓,
non-inverting input to 0V ✓

3

(b) All resistors the same value ✓,
1kΩ<R<4MΩ ✓

2

(c) Two input resistors, one to each op-amp input ✓,
feedback resistor to the inverting input from the output ✓,
resistor from non-inverting input to 0V ✓

3

(d) All resistors the same value ✓,
1kΩ<R<4MΩ ✓

2

(e) (L + R) + (L - R) = 2L ✓,
(L + R) - (L - R) = 2R ✓
or equivalent by diagram or description

2

[12]