Mark schemes

1. (a) difference amplifier ✓

1

(b) $V_{out} = (V_+ – V_–) \times (R_f / R_{in})$

$V_{out} = (0\text{ V} – 150\text{ mV}) \times (1\text{ M}\Omega / 100\text{ k}\Omega)$ ✓

$V_{out} = –1.5\text{ V}$ ✓

1 mark for the correct resistor substitution / resistor ratio (10)

1 mark for −1.5 V (must have correct sign)

2

(c) Signal 2 is subtracted from signal 1 by the difference amplifier ✓

Noise is common to both so will be reduced / eliminated when subtracted ✓

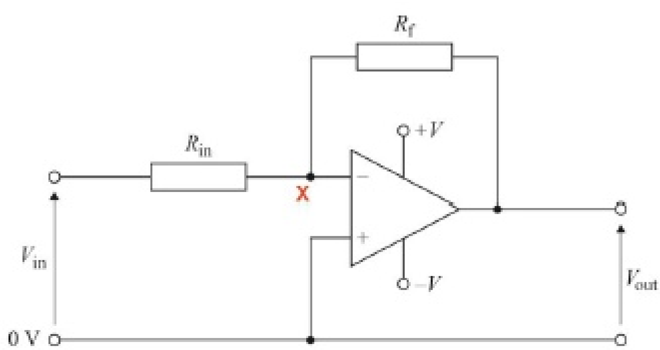
Signals will also be subtracted resulting in an addition (re-enforcement) of the signal. ✓

Accept arguments based on the ‘phase’ relationship

3

[6]

2. (a)



Correct position of X:

1

(b) The non-inverting input

(non-inverting)

1

(c) $I = (V_{in} – V_x) / R_{in} = (V_x – V_{out}) / R_f$

But $V_x = 0$ V (a virtual earth)

$I = V_{in} / R_{in} = – V_{out} / R_f$

Making use of: $I_{in} = - I_F$

$$\frac{V_{out}}{Vin} = \frac{R_f}{R_{in}}$$

Making use of virtual earth concept

2

(d) Voltage gain (Channel 1) = $-R_f / R_{in}$ 1

$-(150\ k\Omega / 7.5\ k\Omega)$

-20

*Both number **and** sign must be correct*

1

(e) $V_{out} = -R_f (V_{in\ Ch1} / R_1 + V_{in\ Ch2} / R_2)$

$= -150\ k\Omega\ ((15mV / 7.5k\Omega) + (-100\ mV / 30\ k\Omega))$

$= -((0.3) + (-0.5)) = 0.2$ Volts

Evidence of correct method

*Answer **and** correct sign*

1

(f) By using variable resistors

The gain can easily be changed
or
the relative levels of the two channels can be set
or
the required balance between the two signals can be made

One relevant point made

1

[6]

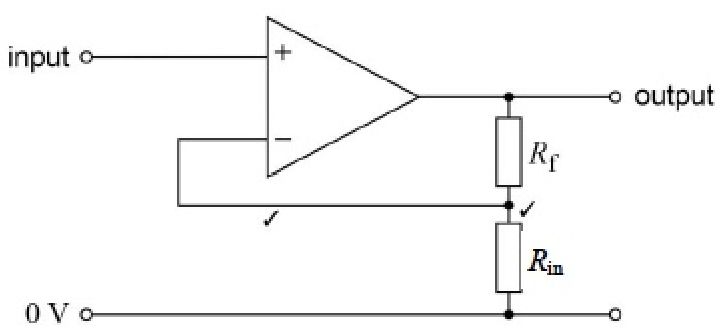
3. (a) Voltage in = Voltage out / Voltage gain

= 3 V / 40

$= 75 \times 10^{-3}$ V ✓

1

(b)



Two resistor chain, correctly labelled connected between output and ground

Inverting input connected to mid-point of resistor chain

2

(c) $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_{in}}$

$40 = 1 + \frac{R_f}{R_{in}}$ calculation to give resistor ratio of 39 ✓

R_{in} = 1 kΩ ; R_f = 39 kΩ ✓

2

(d) Desired gain × bandwidth is 40 × 50 kHz = 2 MHz ✓

The Op Amp can only provide ½ the amplification needed. Not suitable. ✓

1 mark - relevant calculation

1 mark - reference to only providing ½ require amplification / gain so not suitable

2

[7]

4. (a) Photoconductive mode

Accept 'reverse bias'

1

(b) Dark currents will become a source of noise – need to keep S:N as high as possible OWTTE

OR

Need to have a large difference in signal when detector is in light and dark ✓

Must include idea of 'noise'

OR

Must include concept of large signal change to represent digital signal

1

(c) At 850 nm, R_λ = 0.50 A/W ✓

Reading from graph

Allow 0.49 A/W to 0.51 A/W

Using $R_\lambda = \frac{I_p}{P}$ $I_p = R_\lambda \times P$ $0.50 \times 4 \times 10^{-6} = 2\ \mu A$ ✓ ecf

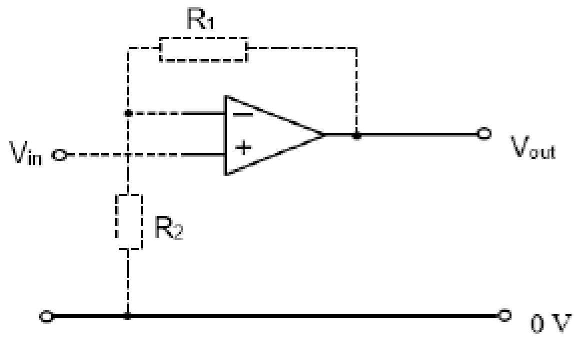
$V_{out} = I_p \times R$ 2 μA × 560 kΩ = +1.12 V ✓

Accept voltage in range of 1.10 V to 1.14 V

Accept value without + sign

3

(d)



Correct configuration of R_1 and R_2 ✓

R_1 : R_2 ratio 3 : 1 in suggested range ✓

Label the input point which must have a direct connection to the non-inverting input ✓

One mark only

An inverting op amp configuration with a voltage gain –4.

3

[8]