



GCE A LEVEL



A490U10-1

TUESDAY, 23 MAY 2023 – AFTERNOON

ELECTRONICS – A level component 1

Principles of Electronics

2 hours 45 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 2 _____

For Examiner's use only

Question	Maximum Mark	Mark Awarded
1.	9	
2.	16	
3.	10	
4.	11	
5.	8	
6.	6	
7.	14	
8.	8	
9.	13	
10.	20	
11.	16	
12.	9	
Total	140	

ADDITIONAL MATERIALS

You will require a calculator and a DATA BOOKLET.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

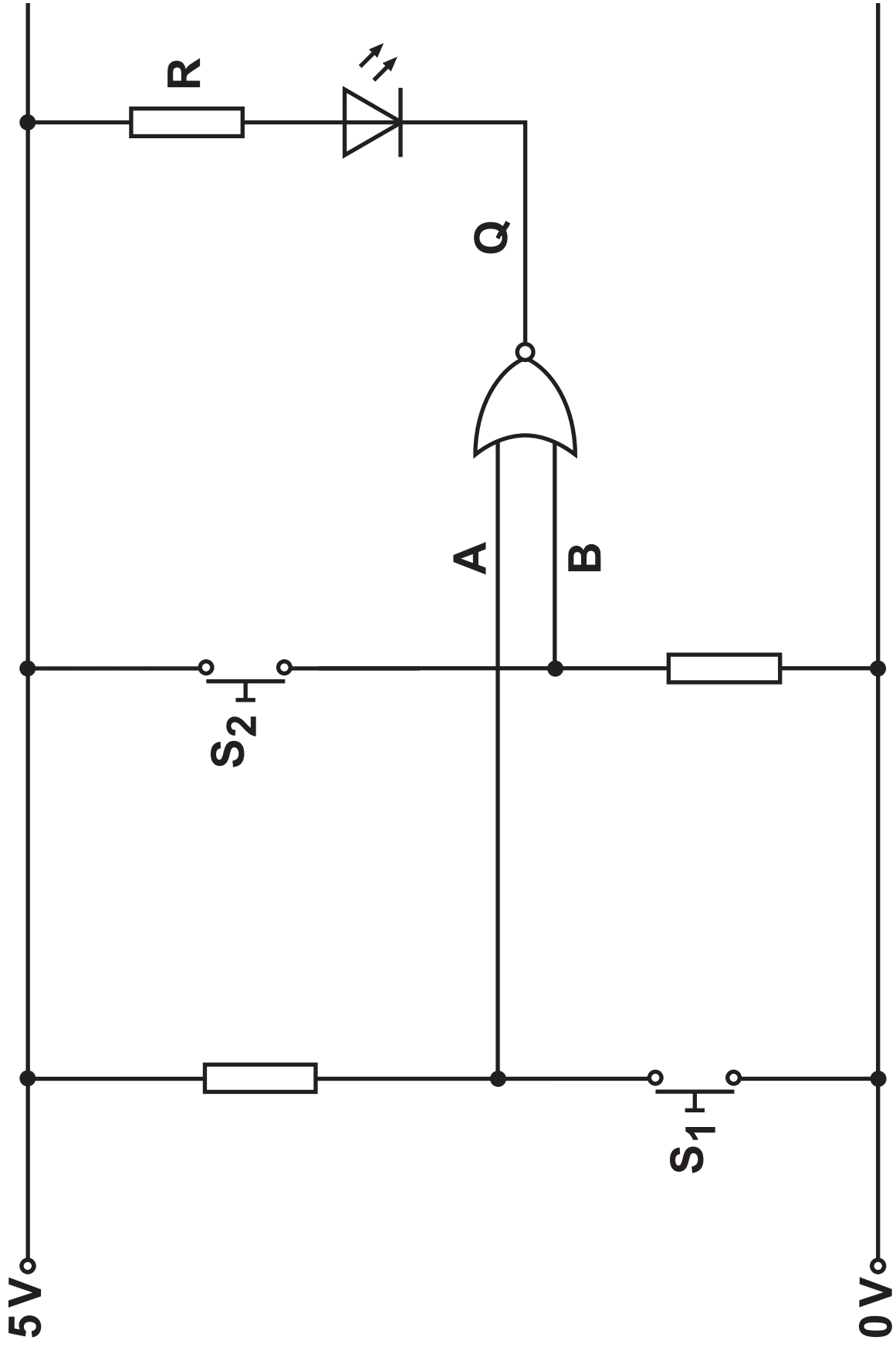
Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

(Turn over)

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 10 (a) (ii).



Answer ALL questions.

1. The LED in the circuit opposite is controlled by two switches S_1 and S_2 .

(a) (i) Name the type of logic gate in the circuit.

[1 mark]

(ii) Complete the table for the circuit opposite.

[4 marks]

S_2	S_1	B (1/0)	A (1/0)	Q (1/0)	State of LED (ON/OFF)
OPEN	OPEN				
OPEN	CLOSED				
CLOSED	OPEN				
CLOSED	CLOSED				

(Turn over)

1 (b) The LED has a forward voltage drop of 2V and a maximum current of 14 mA. The output Q of the logic gate is 5V for a logic 1 and 0V for a logic 0. Determine the ideal value of R required and select the most appropriate value from the E24 series.

[4 marks]

Preferred value _____

2. A logic system is shown opposite.

(a) (i) Give the Boolean expressions for J, K and Q in terms of inputs A, B and C. [3 marks]

J = _____

K = _____

Q = _____

(ii) In the space opposite draw the equivalent logic system using NAND gates only. [3 marks]

(iii) CROSS OUT ALL redundant gates. [1 mark]

2 (a) (iv)

Describe an advantage of converting logic systems to a NAND gate equivalent circuit. [1 mark]

2 (b) Another logic system has the following equation.

$$Q = \overline{\overline{A \cdot B \cdot A}}$$

Apply de Morgan's theorem to the equation and then simplify the result. [3 marks]

Q = _____

C	B	A	Q
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

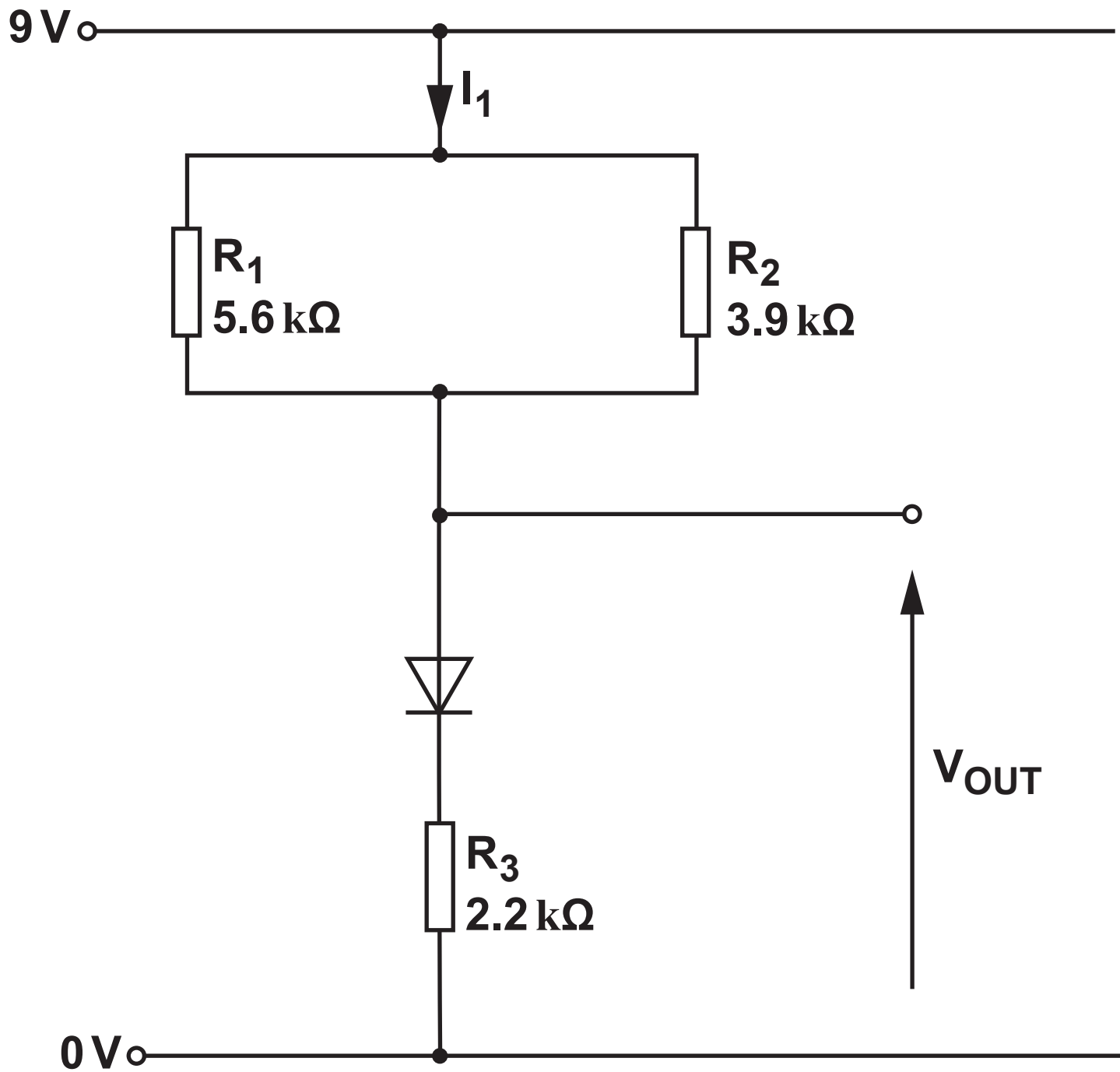
2 (c) The truth table for a different logic system is shown opposite.

- (i) Use the truth table to complete the Karnaugh map below. [2 marks]

		B.A			
		00	01	11	10
C	0				
	1				

- (ii) Use the Karnaugh map to obtain the simplest Boolean expression for the system. [3 marks]

Q = _____



3. Use the information in the circuit diagram opposite to answer the questions below.

(a) Calculate:

(i) the combined resistance of R_1 and R_2 ; [2 marks]

(ii) the current I_1 ; [3 marks]

3 (a) (iii)

the voltage V_{OUT} ; [2marks]

(iv) the power dissipated in R_3 . [2 marks]

(b) Determine the value of V_{OUT} when the diode is reversed. [1 mark]

- 4. A multiplexer can be used in both logic and communication systems.
 - (a) The circuit opposite contains a multiplexer used in a logic system.
 - (i) Describe the behaviour of the LED for each of the following combinations of A and B. Indicate the frequency when applicable. [6 marks]

B = 0, A = 0 _____

B = 0, A = 1 _____

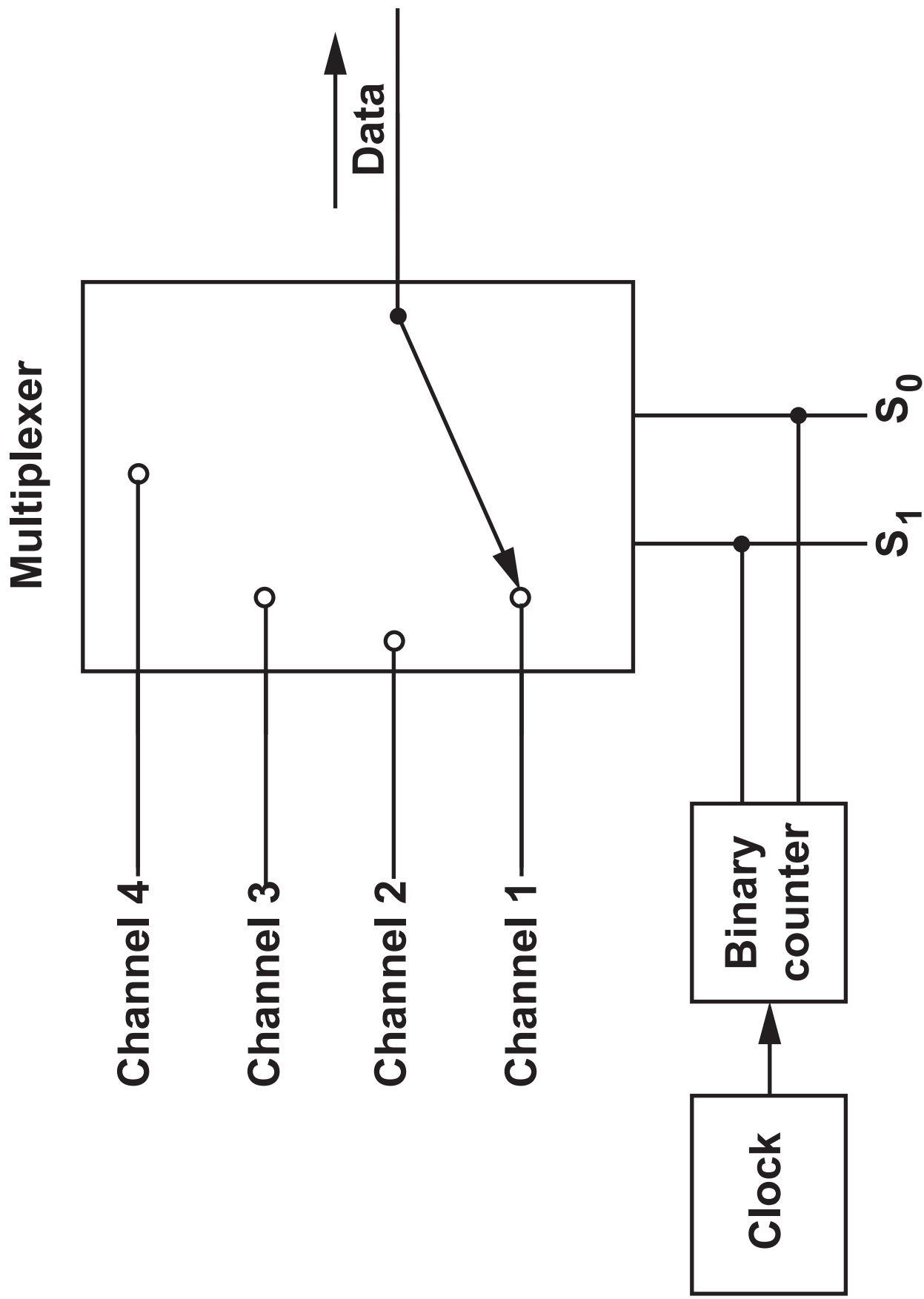
4 (a) (i)

B = 1, A = 0 _____

B = 1, A = 1 _____

4 (a) (ii)

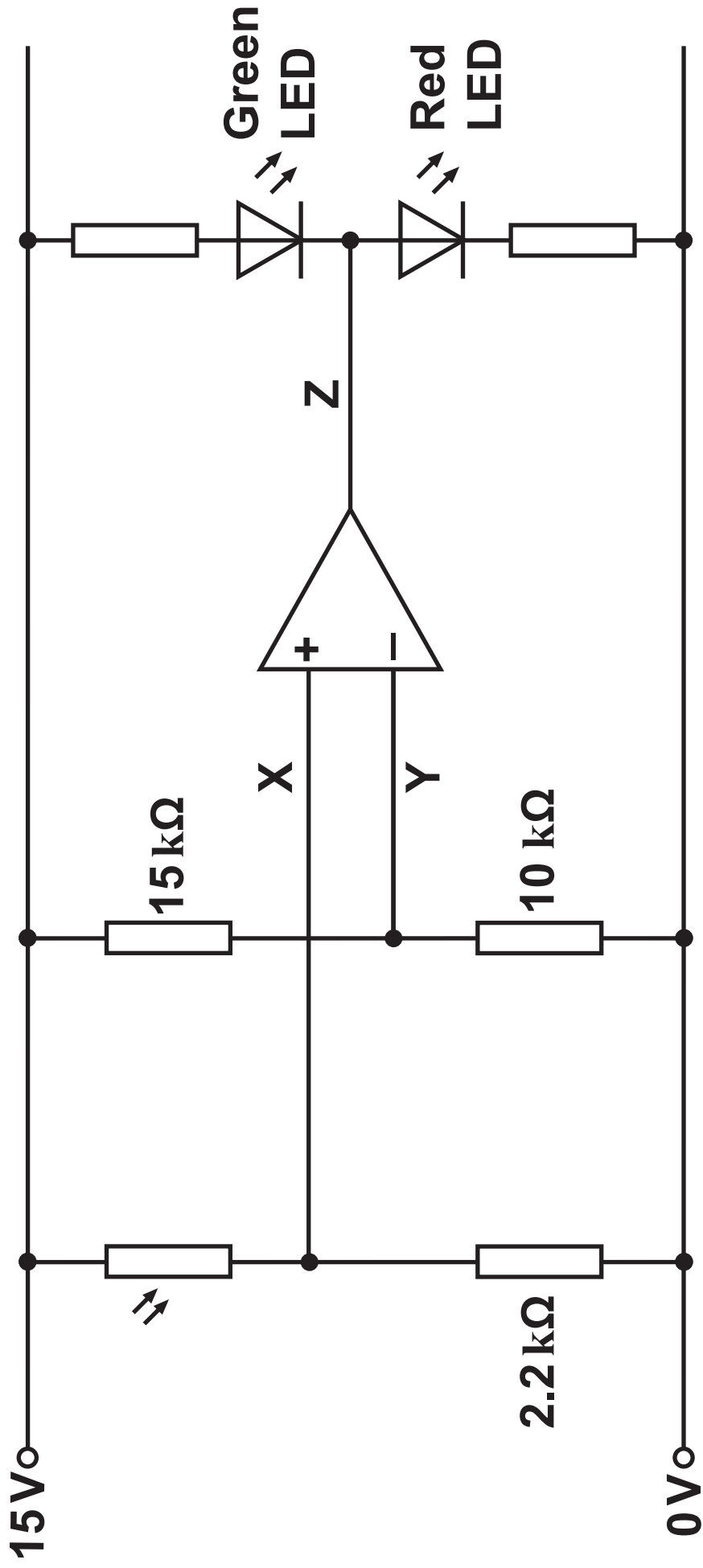
Give an advantage of using a multiplexer in this way. [1 mark]



4 (b) The block diagram opposite shows the multiplexer in a TDM communication system.

(i) What does TDM stand for? [1 mark]

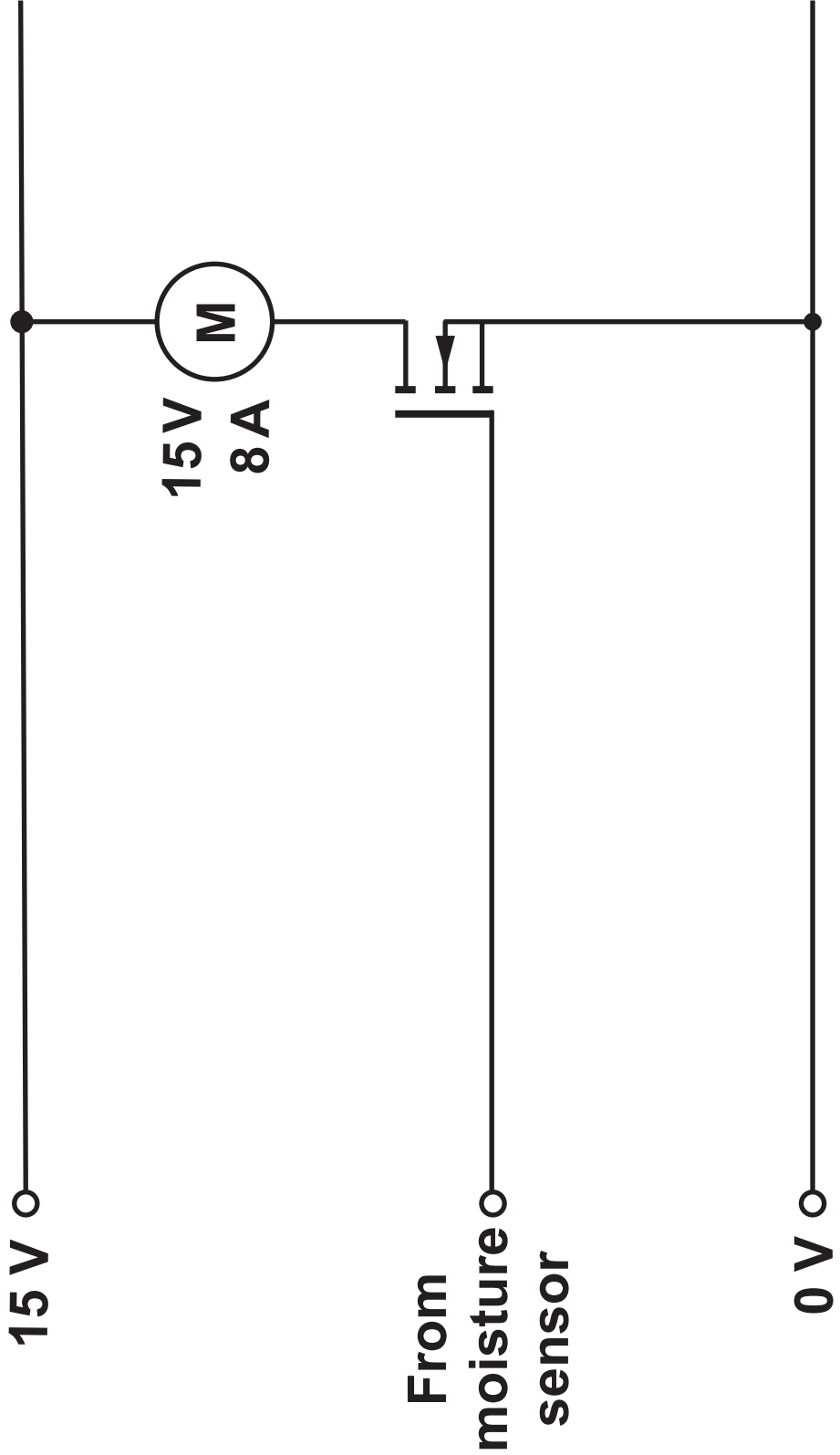
(ii) Explain how this communication system achieves TDM. [3 marks]



5. Opposite is a circuit for a light level indicator. The op-amp saturates at 0V and 15V.

(a) Calculate the voltage at Y. [2 marks]

(b) Calculate the resistance of the LDR that makes the output of the op-amp switch states. [3 marks]



6. A MOSFET uses a signal from a moisture sensor to control a motor for a dehumidifier.

An extract from the MOSFET data sheet is shown below.

V_{DS}/V (max)	V_{GS}/V (max)	I_D/A (max)	P_{TOT}/W (max)	r_{DSon}/Ω	g_M/S (typical)
60	20	12	100	0.32	1.4

- (a) COMPLETE THE DIAGRAM opposite by adding a component that protects the MOSFET when the motor switches off. [1 mark]

- (b) Calculate the power dissipated in the MOSFET when the motor is operating at its rated current.

[2 marks]

(Turn over)

6 (c) Calculate the minimum value of V_{GS} to allow the motor to operate at its rated current. [3 marks]

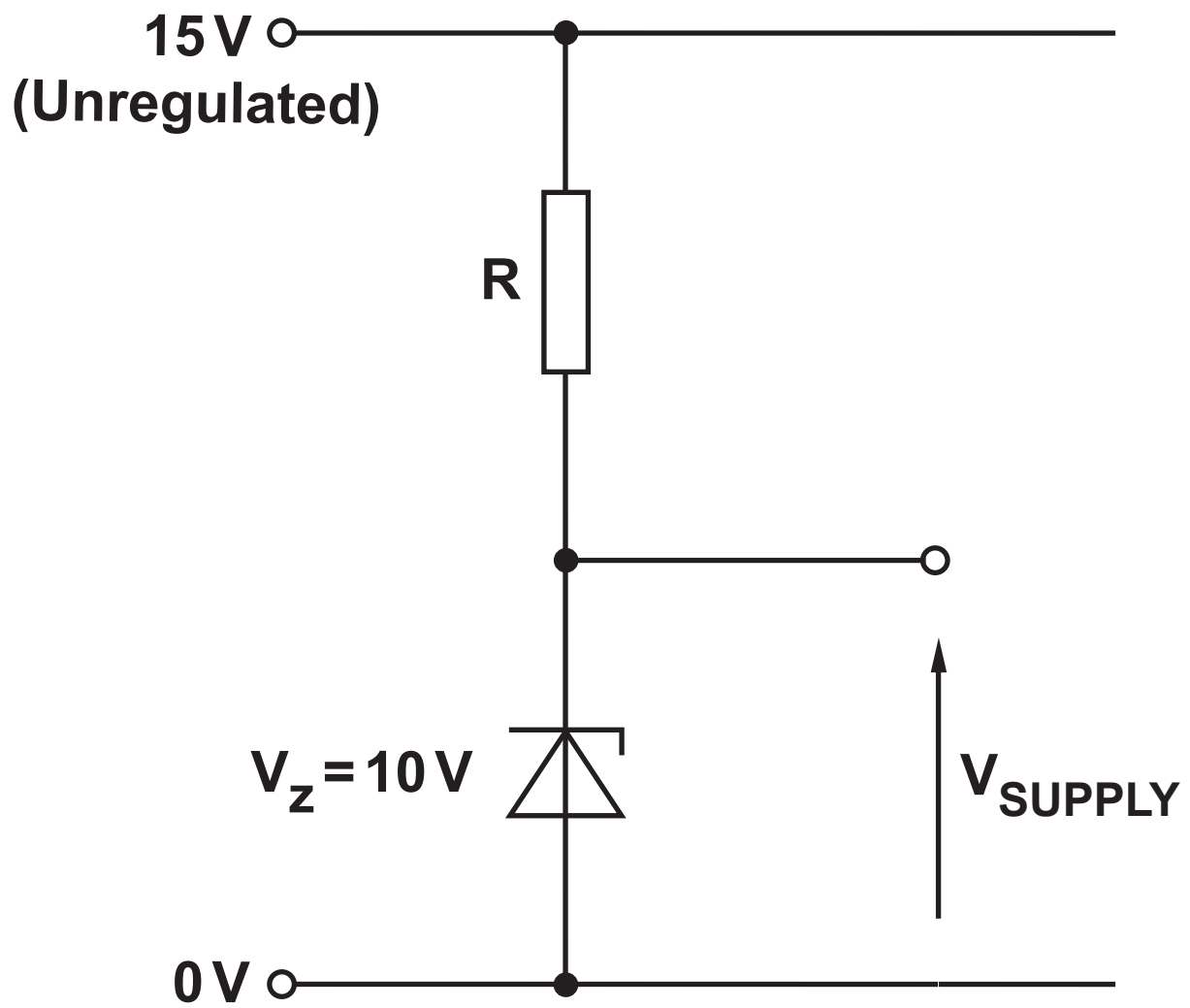
6

(Turn over)

7 (a) (ii)

The circuit is connected to a display of input resistance $5.6\text{ k}\Omega$. Draw the equivalent circuit with this load and calculate the voltage across the load. [3 marks]

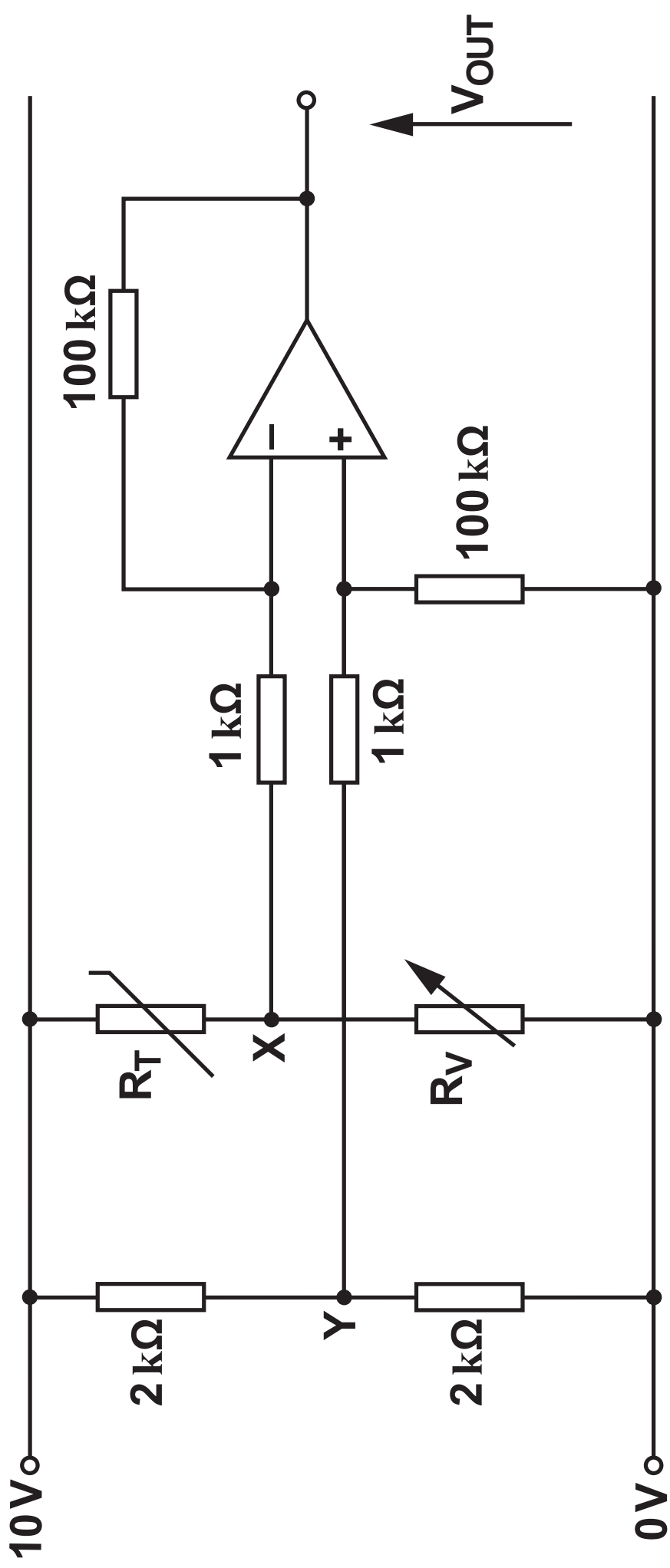
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7 (b) The system requires a 10V regulated supply capable of providing a maximum load current of 200 mA. The circuit design for the regulated power supply is shown opposite.
The holding current for the zener diode is 10 mA.

Calculate the ideal value for the resistor, R.

[3 marks]



8. The diagram opposite shows a 3-bit digital-to-analogue converter (DAC). The op-amps have a power supply of $\pm 13\text{ V}$ and saturate at $\pm 12\text{ V}$. Input A is the LSB.

<p>Input logic 1 = 8 V Input logic 0 = 0 V</p>
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- (a) Calculate:
- (i) the value of V_X when the binary input is 001; [2 marks]

8 (a) (ii)

the value of V_{OUT} when the binary input is 001;

[1 mark]

(iii) the value of V_{OUT} when the binary input is 110.

[2 marks]

(Turn over)

- 8 (b) A Gray code counter is connected to the DAC inputs. On the axes opposite draw the graph of V_{OUT} for the given Gray code inputs. [3 marks]

8

(Turn over)

Transmitter



Earth

Receiver

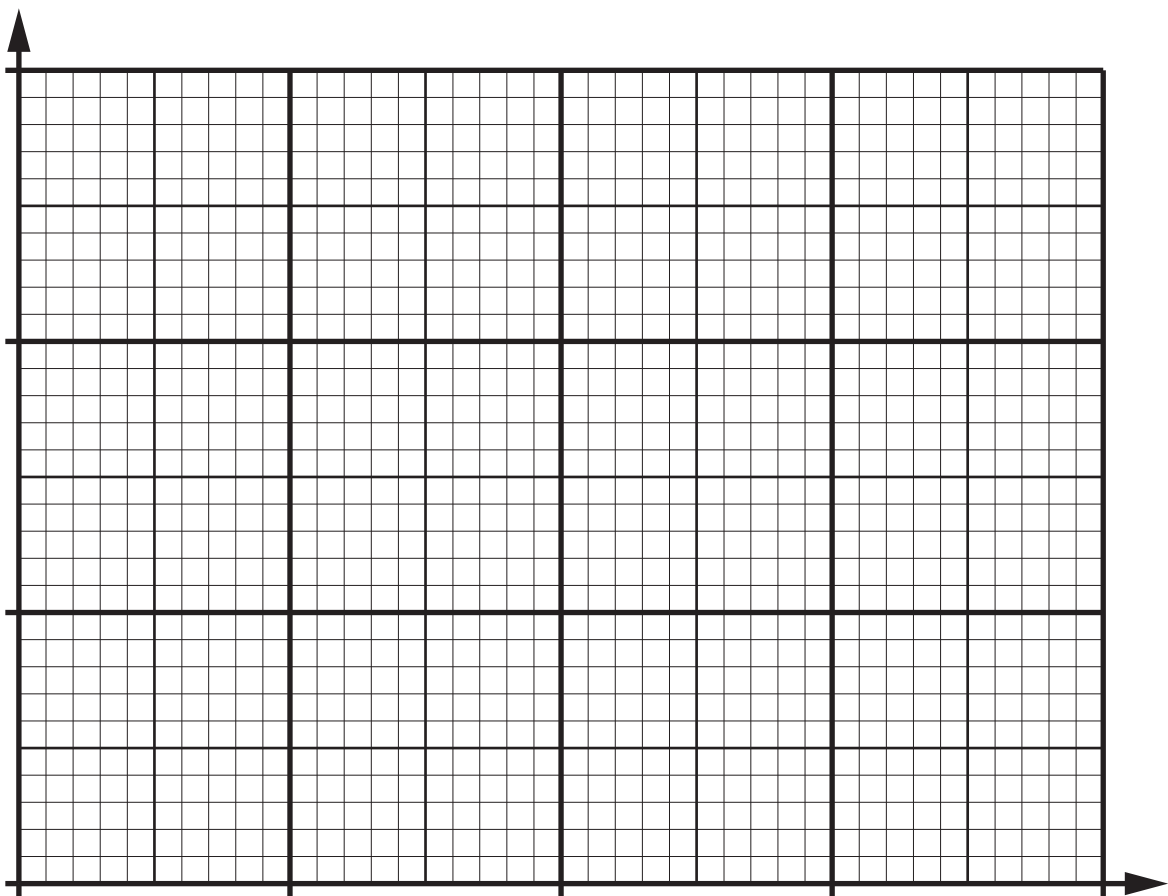
9. Radio waves can be transmitted using amplitude modulation (AM) or frequency modulation (FM).

(a) (i)

Use the diagram opposite to illustrate the difference between surface wave propagation and space wave propagation. [2 marks]

(ii) Calculate the wavelength of a 400 kHz surface wave travelling at $3 \times 10^8 \text{ m s}^{-1}$. [2 marks]

Amplitude



Frequency / kHz

9 (b) A radio station uses a carrier frequency of 200 kHz to transmit an audio signal with frequencies in the range of 40 Hz to 4 kHz using AM.

- (i) Using the axes opposite sketch the frequency spectrum for the modulated signal. Label significant frequencies. [2 marks]**

- (ii) Determine the bandwidth of this transmitted signal. [1 mark]**

9 (c) A different radio station uses FM to transmit the same audio signal in the range of 40 Hz to 4 kHz on a carrier frequency of 60 MHz, with a maximum frequency deviation of 65 kHz.

(i) Calculate the modulation index. [2 marks]

(ii) Calculate the bandwidth of the modulated FM signal. [2 marks]

9 (d) State and describe an advantage of AM over FM.

[2 marks]

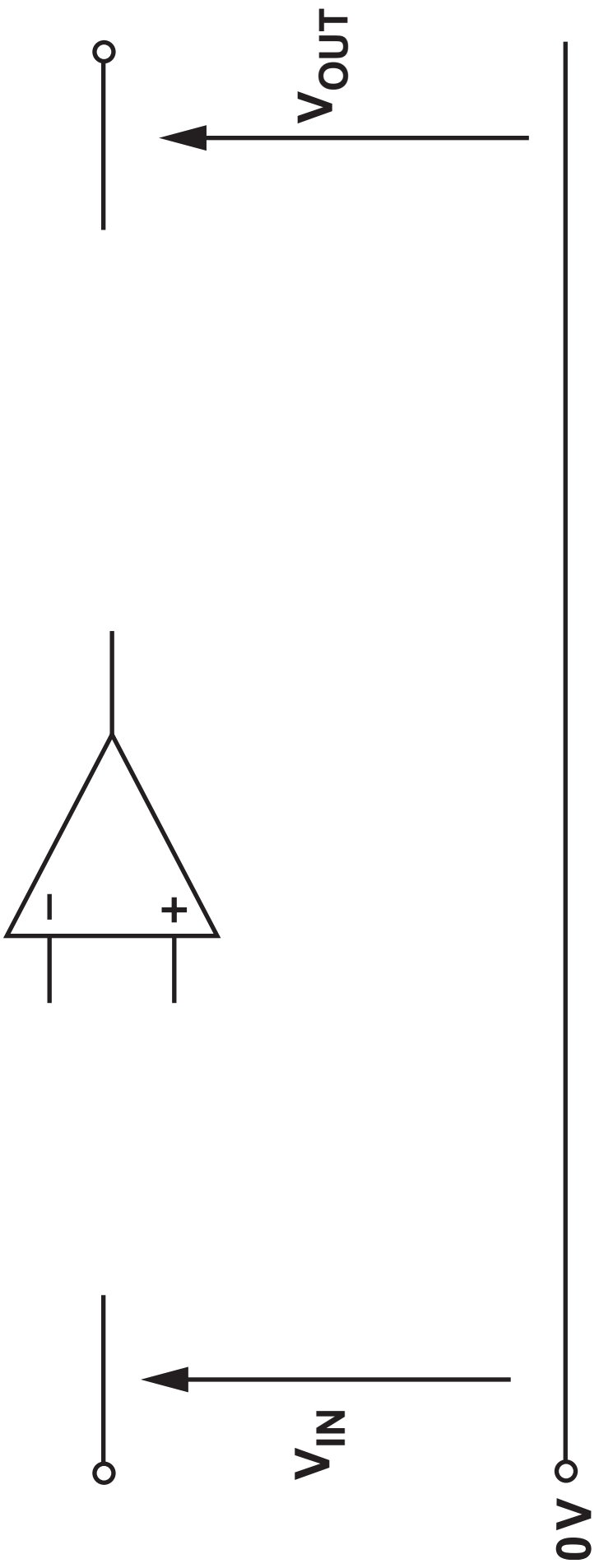
10 (a)

The table shows some of the parameters of an ideal op-amp.

Parameter	Ideal value
Input impedance	Infinite
Output impedance	_____
Open loop gain	_____
Slew rate	Infinite
CMRR	_____
Gain-bandwidth product	Infinite

(i) COMPLETE THE TABLE. [2 marks]

(Turn over)



10 (b)

A non-inverting amplifier is required to have a gain of 25.

(i) Complete the design of the circuit opposite for this amplifier. Include all component values.

[5 marks]

10 (b) (ii)

The op-amp has a power supply of $\pm 14\text{ V}$ and saturates at $\pm 13\text{ V}$. Determine the maximum input voltage that avoids clipping distortion. [2 marks]

10 (b) (iii)

The amplifier has the signal opposite applied to its input. Complete the graph opposite to show the output voltage. The op-amp has a slew rate of $5\text{V}\mu\text{s}^{-1}$. [2 marks]

(iv) An AC signal is applied to the input of the circuit that results in a peak output voltage of 12.5V. Determine the maximum frequency to avoid slew rate distortion. [3 marks]

11. A university installs a communications system for transmitting audio signals using frequency division multiplexing (FDM) on twisted-pair cables.
- (a) Each channel has a signal bandwidth of 3.4 kHz and a 0.5 kHz guard band, giving a channel bandwidth of 3.9 kHz. Each twisted-pair has a bandwidth of 250 kHz.
- (i) Twisted-pair cables reduce crosstalk. What is meant by crosstalk? [1 mark]

11 (a) (ii)

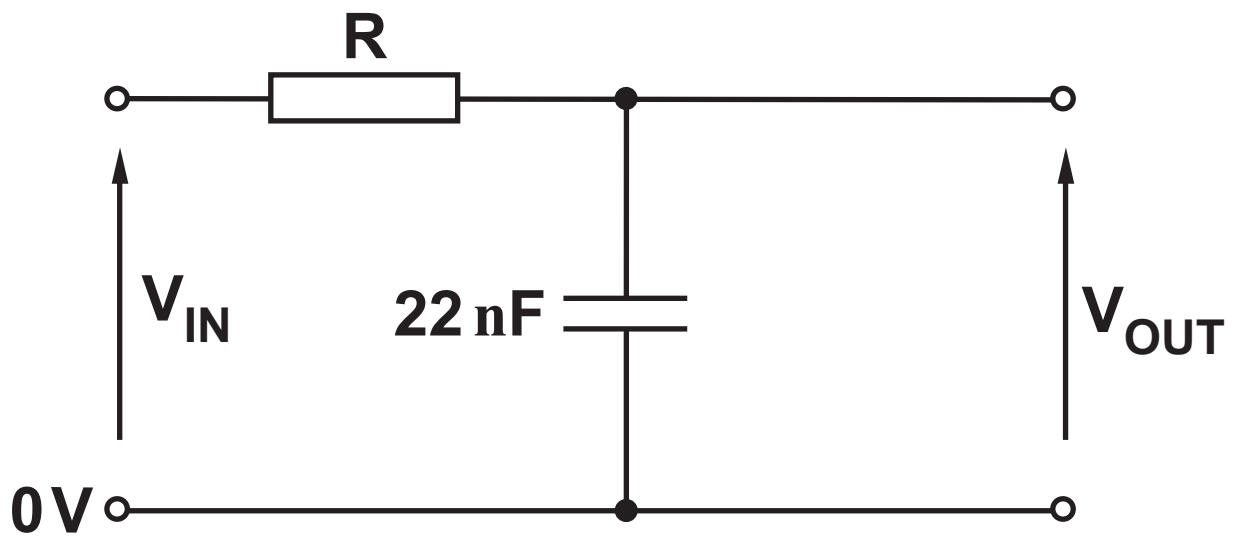
How many channels can be transmitted simultaneously along one twisted-pair? [2 marks]

11 (b)

The noise output from the twisted-pair link is $93\ \mu\text{W}$ with no signal present. What signal power is required at the output of the link if the minimum acceptable signal-to-noise ratio (SNR) is 38 dB?

[5 marks]

(Turn over)



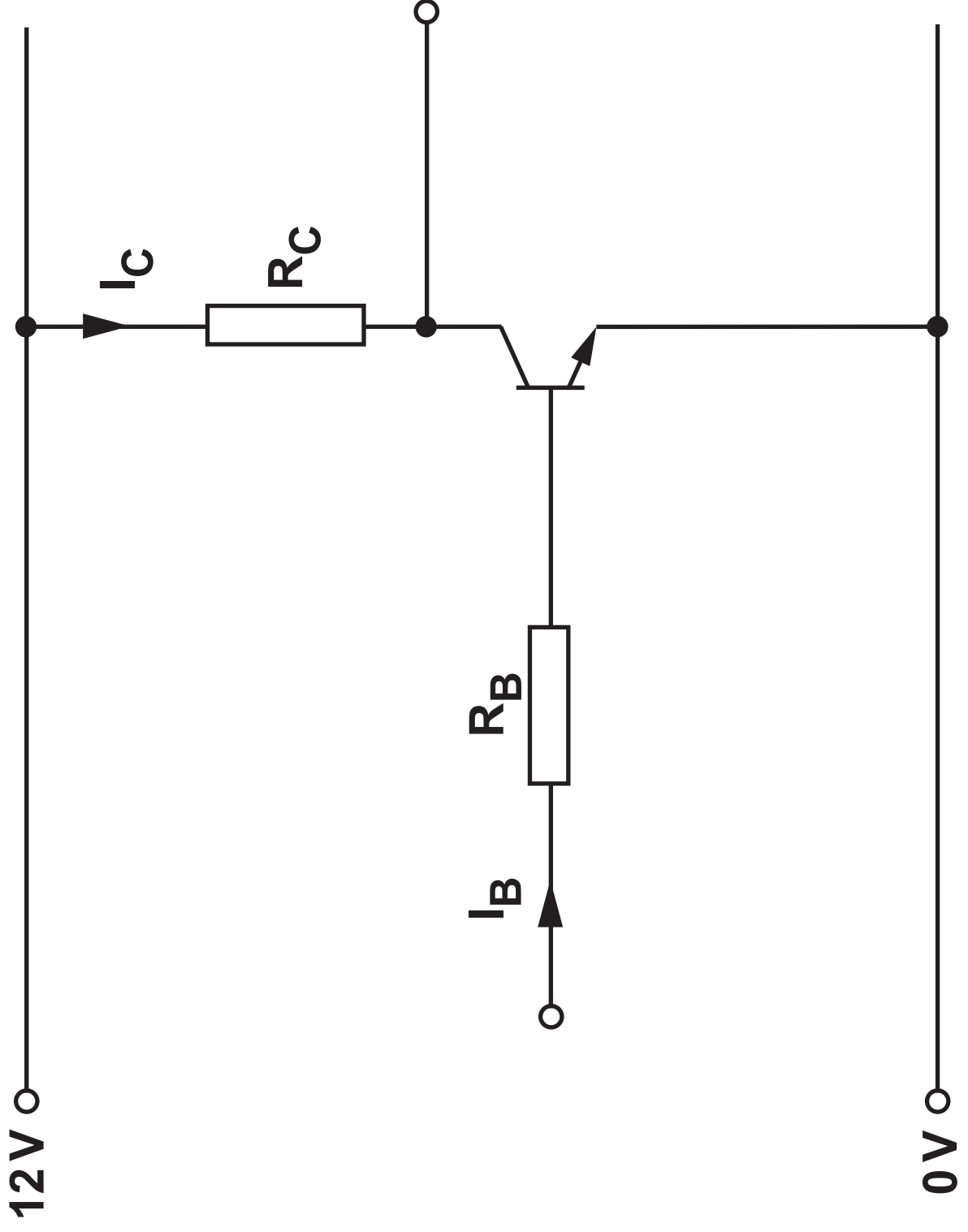
11 (c)

Channel 1 uses a low-pass filter to meet the 3.4 kHz bandwidth requirement. The circuit opposite is one solution.

(i) Calculate the ideal value for R to achieve a break frequency of 3.4 kHz. [3 marks]

11 (c) (ii)

A 2 kHz sinusoidal test signal of peak value 9 V is applied to the input V_{IN} . Calculate the resulting reactance of the capacitor and the peak output voltage V_{OUT} . [5 marks]



12. The circuit opposite was set up to determine the current gain of a transistor.

12 (a)

To find the current gain (h_{FE}) of the transistor, values of I_B and I_C were found and are tabulated below.

I_B /mA	I_C /mA
0.06	7
0.10	12
0.22	26
0.28	34
0.34	41
0.40	48

- (i) Use these values to plot a graph on the axes opposite. [2 marks]
- (ii) Use your graph to determine the current gain of the transistor. [2 marks]

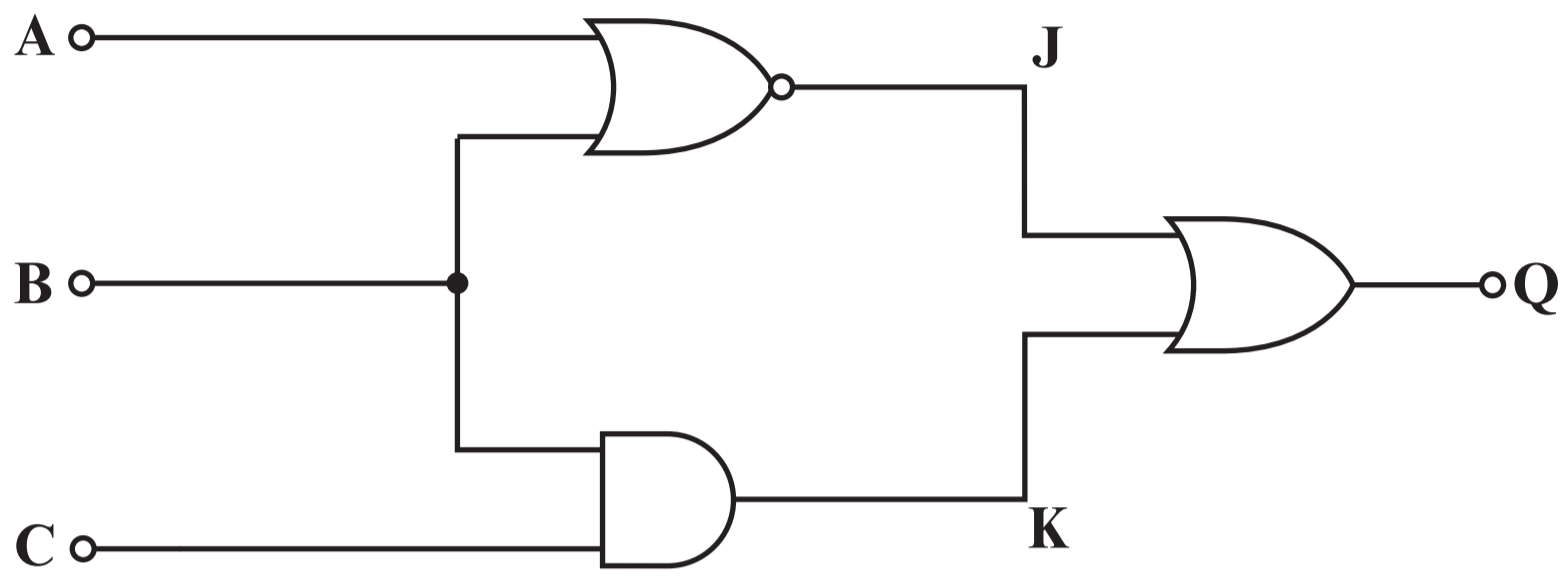
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12 (b)

A different transistor is used in the circuit opposite. The graph shows how V_{OUT} changes as V_{IN} is varied.

- (i) Use the graph to determine the minimum value of V_{IN} required to saturate the transistor. [1 mark]

(Turn over)



A ○ —

B ○ —

C ○ —

— ○ Q

