OCR
Oxford Cambridge and RSA

# Friday 17 June 2016 – Morning

## A2 GCE ELECTRONICS

**F615/01** Communication Systems

Candidates answer on the Question Paper.

**OCR supplied materials:**
None

**Other materials required:**
- Scientific calculator

**Duration:** 1 hour 40 minutes

| Candidate forename | | Candidate surname | |
|---|---|---|---|

| Centre number | | | | | | Candidate number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

### INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

### INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **110**.
- Quality of written communication will be assessed in this paper.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

**A calculator may be used for this paper**

## Data Sheet

Unless otherwise indicated, you can assume that:

- op-amps are run off supply rails at +15V and –15V
- logic circuits are run off supply rails at +5V and 0V.

| | |
|---|---|
| resistance | $R = \frac{V}{I}$ |
| power | $P = VI$ |
| series resistors | $R = R_1 + R_2$ |
| time constant | $\tau = RC$ |
| monostable pulse time | $T = 0.7\,RC$ |
| relaxation oscillator period | $T = 0.5\,RC$ |
| frequency | $f = \frac{1}{T}$ |
| voltage gain | $G = \frac{V_{out}}{V_{in}}$ |
| open-loop op-amp | $V_{out} = A(V_+ - V_-)$ |
| non-inverting amplifier gain | $G = 1 + \frac{R_f}{R_d}$ |
| inverting amplifier gain | $G = -\frac{R_f}{R_{in}}$ |
| summing amplifier | $-\frac{V_{out}}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} \ldots$ |
| break frequency | $f_0 = \frac{1}{2\pi RC}$ |

| | |
|---|---|
| Boolean Algebra | $A.\overline{A} = 0$ |
| | $A + \overline{A} = 1$ |
| | $A.(B + C) = A.B + A.C$ |
| | $\overline{A.B} = \overline{A} + \overline{B}$ |
| | $\overline{A + B} = \overline{A}.\overline{B}$ |
| | $A + A.B = A$ |
| | $A.B + \overline{A}.C = A.B + \overline{A}.C + B.C$ |
| amplifier gain | $G = -g_m R_d$ |
| ramp generator | $\Delta V_{out} = -V_{in}\dfrac{\Delta t}{RC}$ |
| inductor reactance | $X_L = 2\pi f L$ |
| capacitor reactance | $X_C = \dfrac{1}{2\pi f C}$ |
| resonant frequency | $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$ |

Answer **all** the questions.

**1** The incomplete circuit of Fig. 1.1 provides a test signal for a small single-colour display.

The screen displays a series of vertical black or white bars.

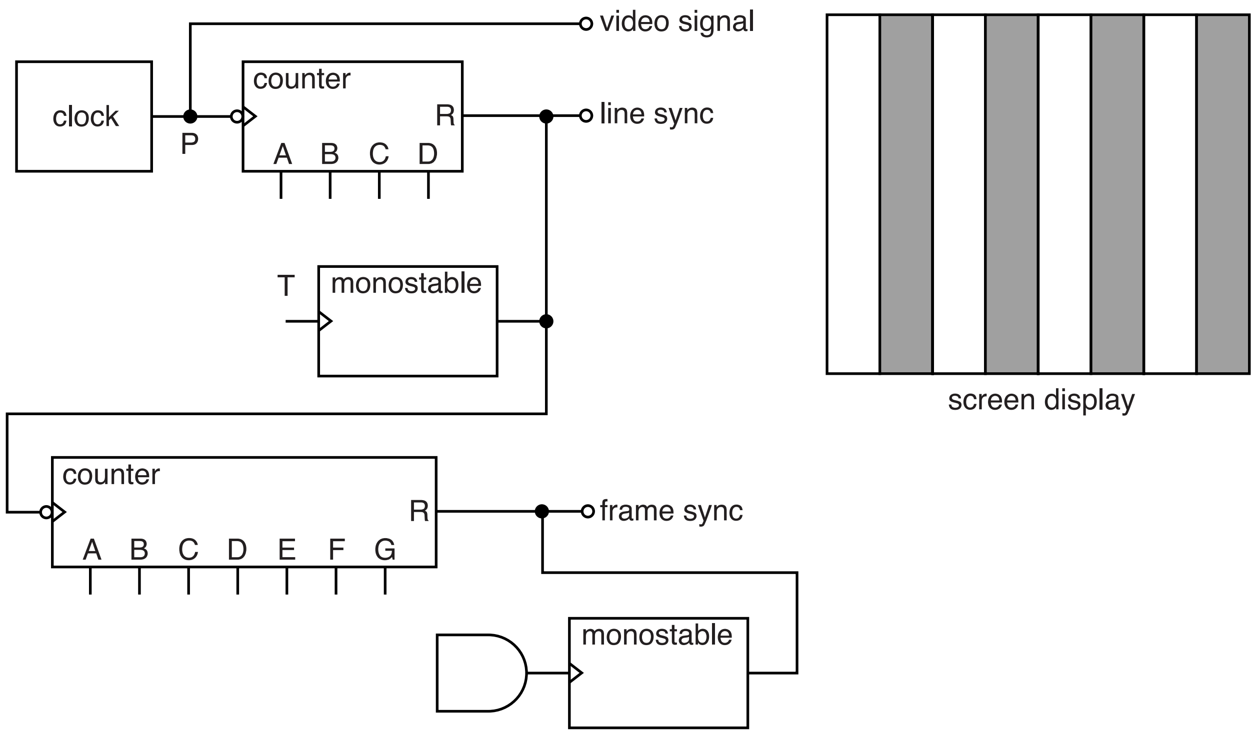


**Fig. 1.1**

**(a)** The line sync signal is generated by a monostable whose input T is connected to one of the outputs of the four-bit counter.

Draw on Fig. 1.1 to show the connection from the four-bit counter to T.

Use the screen display to justify your answer.

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**(b)** The video display has 128 columns of pixels arranged in 100 rows.

Draw on Fig. 1.1 to show how the seven-bit counter should be connected to the AND gate. Justify your answer.

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**(c)** The bandwidth of the video signal is 384 kHz.

**(i)** Calculate the frame refresh rate of the display and comment on its value.

refresh rate = ........................................................ $s^{-1}$

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**(ii)** Explain the effect on the display of using a cable which has a bandwidth of 50 kHz for the 384 kHz video signal.

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**(d)** Each rising edge at T makes the line sync signal pulse high for 28 μs.

Draw a suitable NAND gate circuit for the monostable in the space below.

Include all component values and justify them with calculations.

**[4]**

**[Total: 16]**

**2** Fig. 2.1 is the oscilloscope trace of an amplitude modulated (AM) carrier.

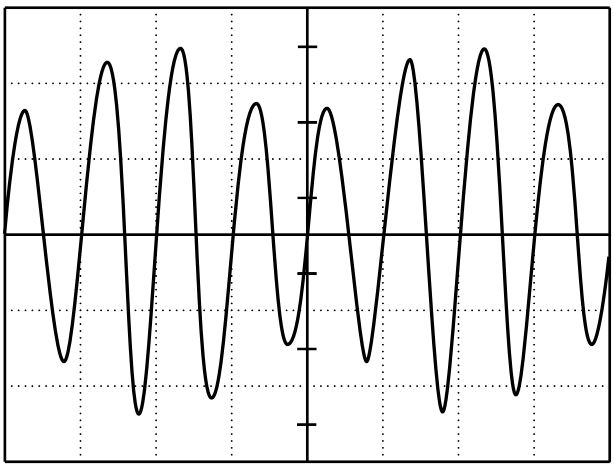

**Fig. 2.1**

**(a)** The settings of the oscilloscope are as follows:

- timebase setting 20 μs / div
- vertical scale 500 mV / div.

**(i)** Calculate the amplitude and frequency of the **modulating signal**.

amplitude = ........................................................ mV

frequency = ........................................................ kHz

**[3]**

**(ii)** Complete the amplitude-frequency graph of the AM carrier shown in Fig. 2.1.

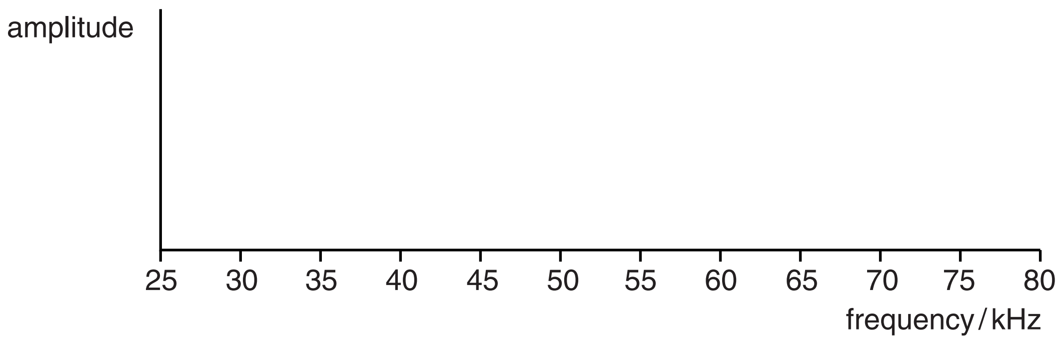


**Fig. 2.2**

**[3]**

**(b)** In the space below, draw a suitable demodulator for the amplitude modulated carrier shown in Fig. 2.1. Show all component values and justify them with calculations.

**[3]**

**[Total: 9]**

**3** This question is about the use of wireless microphones.

In the UK, wireless microphones can be used without a licence in the broadcast frequency range 173.8 MHz to 175.0 MHz. Each microphone uses frequency modulation (FM), with a bandwidth of 200 kHz.

**(a)** **(i)** Suggest the maximum number of microphones which can operate simultaneously at a single venue without a licence.

Justify your answer with calculations.

maximum number = ........................................................ **[2]**

**(ii)** A greater range of frequencies is available for wireless microphones in the frequency range 854 MHz to 862 MHz, but their use requires a licence from the government. Suggest why a licence is required.

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**(b)** The number of microphones can be increased by using amplitude modulation (AM) instead of FM.

**(i)** Describe the difference between AM and FM.

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**(ii)** Calculate the maximum number of microphones which can be used without a licence at a venue with AM.

maximum number = ........................................................ **[2]**

**(iii)** Explain the advantage of using FM instead of AM for a wireless microphone.

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**[Total: 13]**

**4** The circuit of Fig. 4.1 is a modulator for pulse-width modulation (PWM) systems.

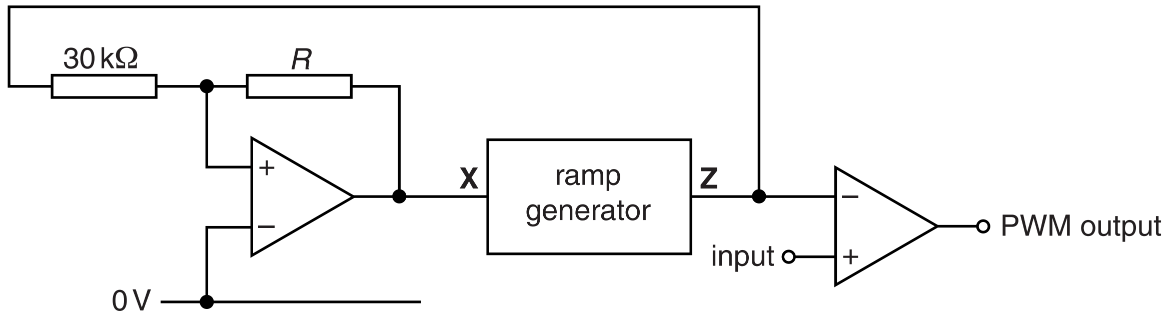


**Fig. 4.1**

**(a)** The signal at **Z** is a triangle wave with the following properties:

- amplitude 7.5 V
- frequency 20 kHz.

**(i)** Draw a voltage-time graph for the signal at **Z** on the axes of Fig. 4.2.
Label it **Z**. **[3]**

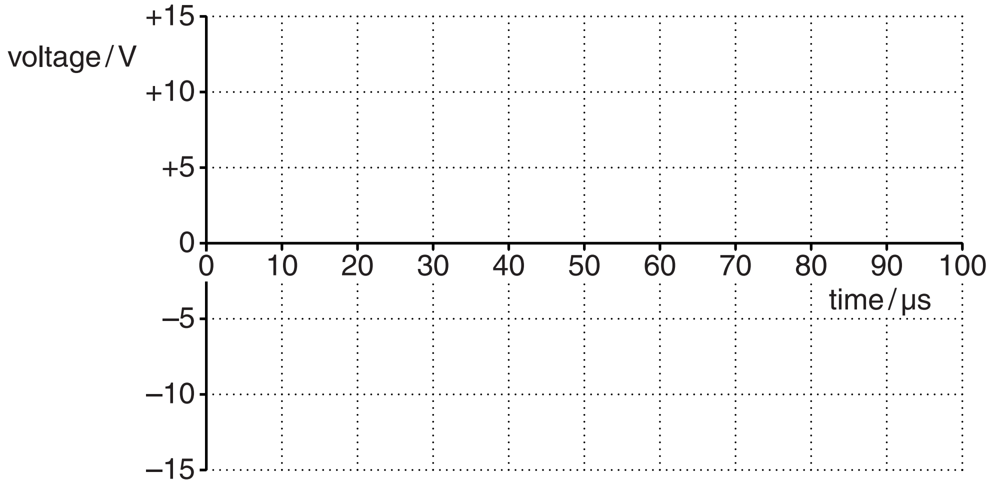


**Fig. 4.2**

**(ii)** Draw a voltage-time graph for the signal at **X** on the axes of Fig. 4.2.
Label it **X**. **[3]**

**(iii)** Calculate a suitable value *R* for the resistor.

*R* = ................................................... kΩ **[2]**

**(b)** Explain why the system of Fig. 4.1 only operates correctly for signals whose amplitude and frequency are less than 7.5V and 10kHz respectively.

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**(c)** Complete the circuit of Fig. 4.3 to show how a filter with a gain of 2.5 can be used as a PWM demodulator for signals in the range 0 to 2kHz.

Show all component values and justify them with calculations.

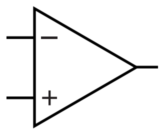


**Fig. 4.3**

**[5]**

**[Total: 15]**

**5** On their way from the transmitter to the receiver, radio waves pick up interference.
This reduces the quality of the information extracted by the receiver.

**(a)** What is interference?

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**(b)** Explain the effect of increasing the distance between transmitter and receiver on the quality of information extracted by the receiver.

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**(c)** Suggest **two** other ways that modulated carriers can be sent over large distances which are less affected by interference than radio waves.

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**[Total: 8]**

**6** Fig. 6.1 is an incomplete block diagram for a simple AM radio receiver.

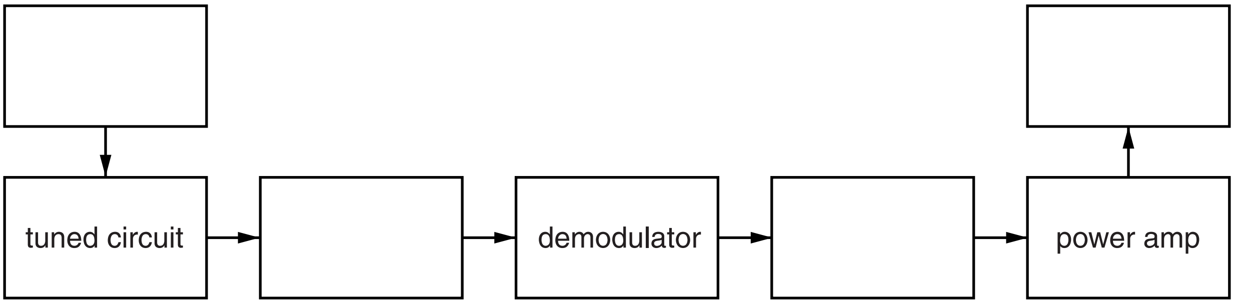


**Fig. 6.1**

**(a)** Complete the block diagram of Fig. 6.1. **[4]**

**(b) (i)** Complete the tuned circuit of Fig. 6.2, labelling the input and output.

Give component values appropriate for a carrier frequency of 470 kHz.

Justify them with calculations.

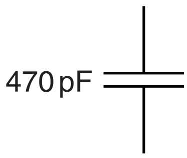


**Fig. 6.2**

**[4]**

**(ii)** Explain how the tuned circuit performs its function in the radio receiver.

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**[Total: 13]**

7 Fig. 7.1 shows an incomplete circuit for a 2-bit analogue-to-digital converter (ADC).

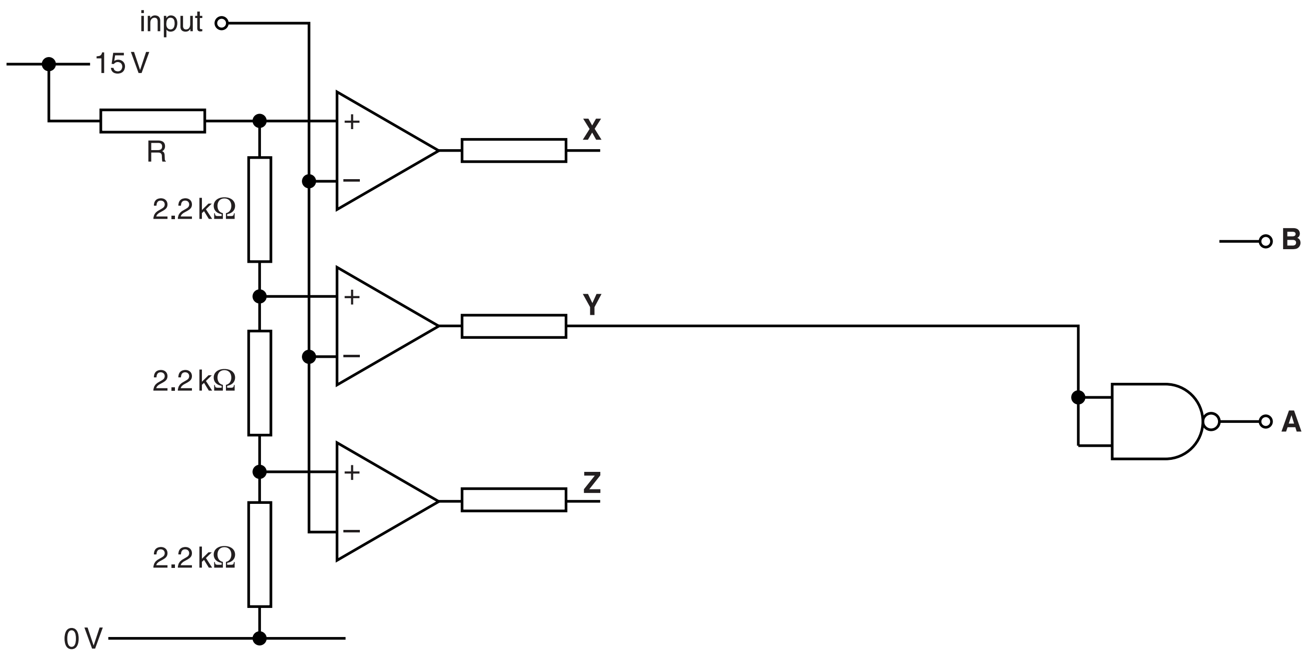


**Fig. 7.1**

**(a)** The converter is required to have a resolution of 0.5 V.

Calculate a suitable value for the resistor **R** of Fig. 7.1.

**R** = ................................................ kΩ **[3]**

**(b)** The missing part of the circuit of Fig. 7.1 is required to obey this incomplete truth table.

| **Input range / V** | **X** | **Y** | **Z** | **B** | **A** |
|---|---|---|---|---|---|
| 1.50 to 1.99 | | | | 1 | 1 |
| 1.00 to 1.49 | | | | 0 | 1 |
| 0.50 to 0.99 | | | | 1 | 0 |
| 0.00 to 0.49 | | | | 0 | 0 |

**(i)** Complete the table with the words **high** and **low**. **[2]**

**(ii)** Write down a Boolean expression for **B** in terms of **X**, **Y** and **Z**.

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**(iii)** On Fig. 7.1, draw a NAND gate circuit to generate **B**. **[3]**

**(c)** Fig. 7.2 is an incomplete digital-to-analogue converter.

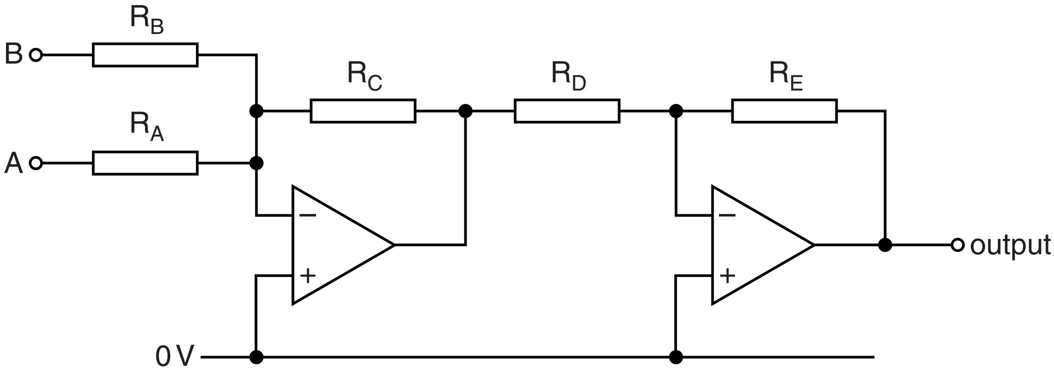


**Fig. 7.2**

Select component values for it to have a resolution of 0.5 V.

Justify your values with calculations.

$R_A$ = ........................................................ kΩ

$R_B$ = ........................................................ kΩ

$R_C$ = ........................................................ kΩ

$R_D$ = ........................................................ kΩ

$R_E$ = ........................................................ kΩ
**[3]**

**[Total: 12]**

**8** Fig. 8.1 is an incomplete block diagram of a digital transmission system which sends four different analogue signals from one place to another across a link.

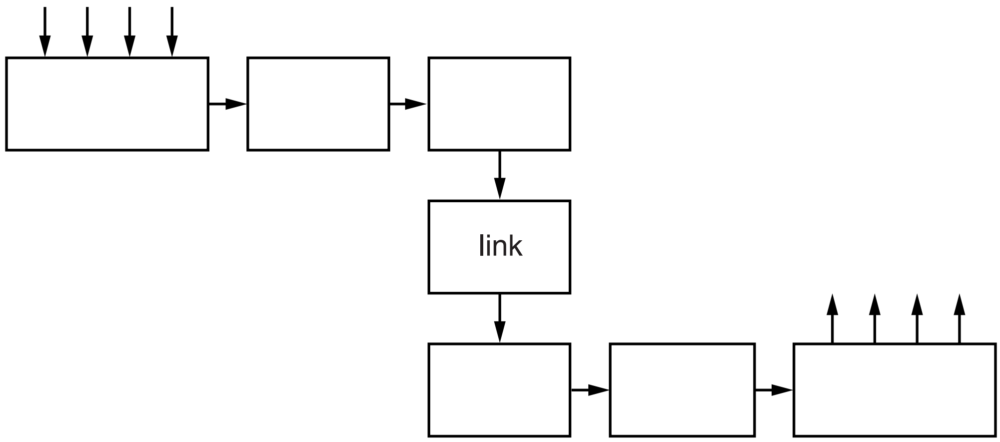


**Fig. 8.1**

**(a)** Complete the block diagram. Use symbols from this table of names.

| Name of block | Symbol |
|---|---|
| multiplexer | MUX |
| demultiplexer | DMUX |
| Schmitt trigger | ST |
| bandpass filter | BF |
| serial-to-parallel converter | SPC |
| parallel-to-serial converter | PSC |
| analogue-to-digital converter | ADC |
| digital-to-analogue converter | DAC |

**[6]**

**(b)** The link carries 12-bit words, each of which starts with 0 and ends with 1.

**(i)** Explain the function of the bits at the start and the end of each word.

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**(ii)** Each of the four analogue signals being transmitted has a frequency in the range 150 Hz to 15 kHz.

Calculate the minimum bandwidth required to send all of the information across the link.

bandwidth = ................................................ kHz **[3]**

**(iii)** Each of the four analogue signals being transmitted has a maximum amplitude of 1.2 V.

Calculate the resolution of the analogue-to-digital converter.

resolution = ................................................ mV **[3]**

**[Total: 15]**

9 Fig. 9.1 shows a four-input multiplexer for analogue signals placed at the inputs $S_0$ to $S_3$.

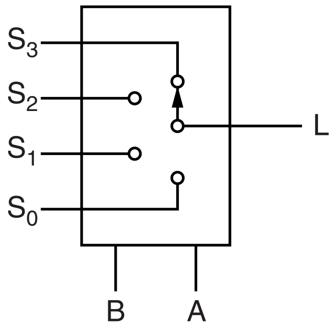


**Fig. 9.1**

**(a)** The multiplexer is part of a system which uses time division multiplexing (TDM) to send four different analogue signals down a single link.

Describe the transfer characteristic of the multiplexer.

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**(b)** Explain what is meant by the term TDM.

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**[Total: 6]**

**Quality of written communication [3]**

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