

Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1145/01



S16-1145-01

ELECTRONICS – ET5

A.M. FRIDAY, 17 June 2016

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	14	
2.	8	
3.	6	
4.	8	
5.	5	
6.	9	
7.	9	
8.	11	
Total	70	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 70.

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

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

INFORMATION FOR THE USE OF CANDIDATES

Preferred Values for resistors

The figures shown below and their decade multiples and sub-multiples are the E24 series of preferred values.

10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

Standard Multipliers

Prefix	Multiplier
T	$\times 10^{12}$
G	$\times 10^9$
M	$\times 10^6$
k	$\times 10^3$

Prefix	Multiplier
m	$\times 10^{-3}$
μ	$\times 10^{-6}$
n	$\times 10^{-9}$
p	$\times 10^{-12}$

Alternating Voltages

$$V_o = V_{\text{rms}} \sqrt{2}$$

Silicon Diode

$$V_F \approx 0.7\text{V}$$

Operational amplifier

$$G = -\frac{R_F}{R_{IN}}$$

Inverting amplifier

$$G = 1 + \frac{R_F}{R_1}$$

Non-inverting amplifier

$$V_{\text{OUT}} = V_{\text{DIFF}} \left(\frac{R_F}{R_1} \right)$$

Difference amplifier

$$V_{\text{OUT}} = -R_F \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$$

Summing amplifier

$$V_L \approx V_Z \left(1 + \frac{R_F}{R_1} \right)$$

Stabilised power supply

Emitter follower

$$V_{\text{OUT}} = V_{\text{IN}} - 0.7\text{V}$$

Filters

$$f_b = \frac{1}{2\pi RC}$$

Break frequency for high pass and low pass filters

$$X_C = \frac{1}{2\pi fC}$$

Capacitive reactance

Thyristor phase control

$$\phi = \tan^{-1} \frac{R}{X_C}$$

$$\tan \phi = \frac{R}{X_C}$$

Signal conversion

$$\text{resolution} = \frac{\text{i/p voltage range}}{2^n}$$

ADC

Power amplifier

$$P_{\text{MAX}} = \frac{V_S^2}{8R_L}$$

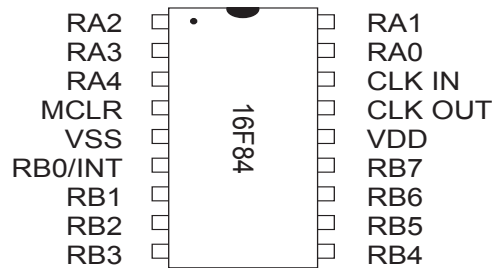
where V_S is the rail-to-rail voltage

PIC Information

The PIC programs include 'equate' statements that define the following labels:

Label	Description
PORTA	input / output port A
PORTB	input / output port B
TRISA	the control register for port A
TRISB	the control register for port B
STATUS	the status register
INTCON	the interrupt control register
W	the working register (= h '0')
F	the file register (= h '1')
RP0	the register page selection bit 0
Z	the zero flag status bit
GIE	the global interrupt controller bit
INTE	the external interrupt enable bit

Pinout for 16F84 PIC IC:



List of commands:

Mnemonic	Operands	Description
bcf	f, b	Clear bit b of file f
bsf	f, b	Set bit b of file f
btfs	f, b	Test bit b of file f, skip next instruction if bit is set
call	k	Call subroutine k
clrf	f	Clear file f
goto	k	Branch to label k
movf	f, d	Move file f (to itself if d = 1, or to working register if d = 0)
movlw	k	Move literal k to working register
movwf	f	Move working register to file f
retfie		Return from interrupt service routine and set global interrupt enable bit GIE

Comparison of TASM and MPASM languages:

Version		TASM	MPASM
Number system notation	Decimal	153	d'153'
	Hex	\$2B	h'2B' or 0x2B
	Binary	%10010110	b'10010110'
Opcode Notation		.equ	equ
		.org	org
		.end	end
		label:	label

Structure of the INTCON register

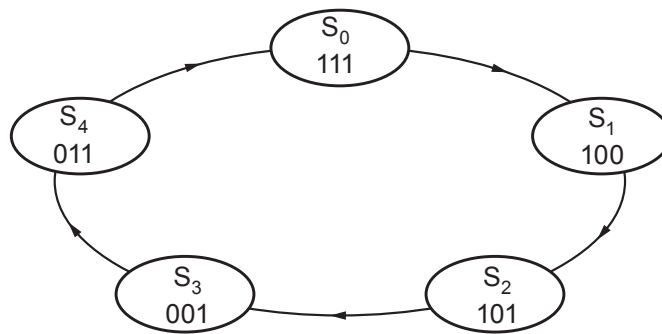
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
GIE	EEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF

Structure of the STATUS register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IRP	RP1	RP0	TO	PD	Z	DC	C

Answer **all** questions.

1. The main sequence for a sequence generator is shown in the following incomplete state diagram.



- (a) Use this information to complete the truth table for this sequence generator.
(The unused states have already been entered. There are no stuck states in this system.)

[3]

Current Outputs				Next Outputs		
State	C	B	A	D _C	D _B	D _A
0						
1						
2						
3						
4						
5	0	0	0	1	1	1
6	0	1	0	1	1	1
7	1	1	0	1	0	0

(b) **Complete** the state diagram opposite by adding the unused states. [1]

(c) What is meant by the term '*unused state*'? [1]

.....

.....

(d) What is meant by the term '*stuck state*'? [1]

.....

.....

(e) (i) Determine the simplest Boolean expressions for the inputs D_B and D_C in terms of the outputs C, B and A. [3]

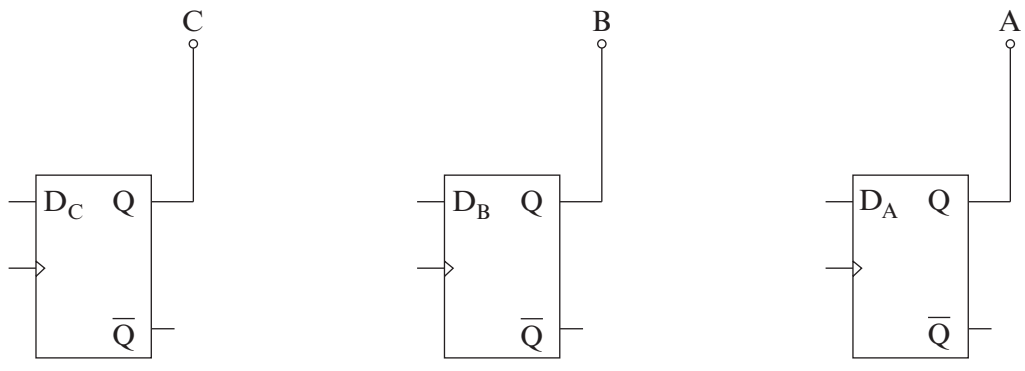
$D_B =$

.....

$D_C =$

.....

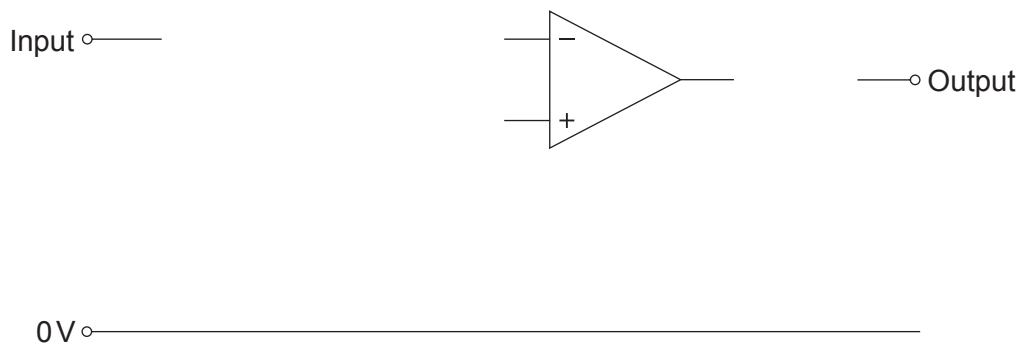
(ii) The Boolean expression for D_A is: $D_A = \overline{B.C}$. Complete the circuit diagram by adding appropriate logic gates and connections. [5]
(Extra credit will be given for using the smallest number of gates possible.)



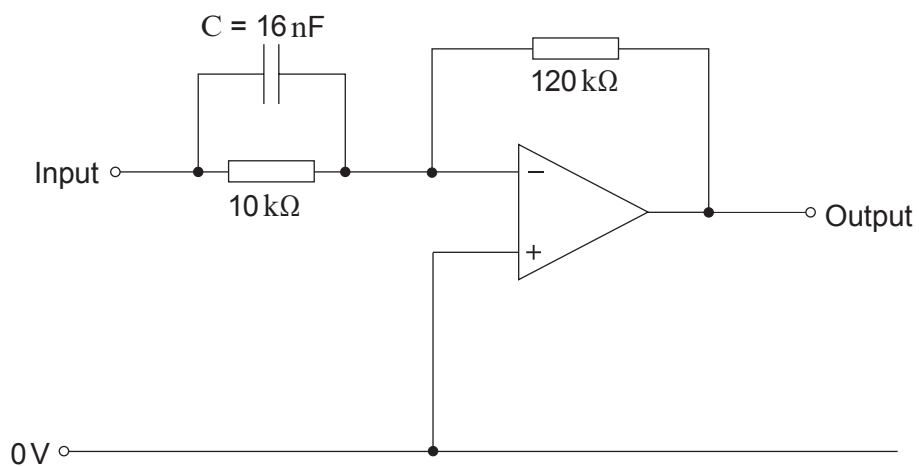
Clock input

2. (a) Complete the circuit diagram for an active bass cut filter.

[3]



- (b) Here is the circuit diagram for a different type of active filter.



(i) Calculate the break frequency of this filter. [2]

.....

.....

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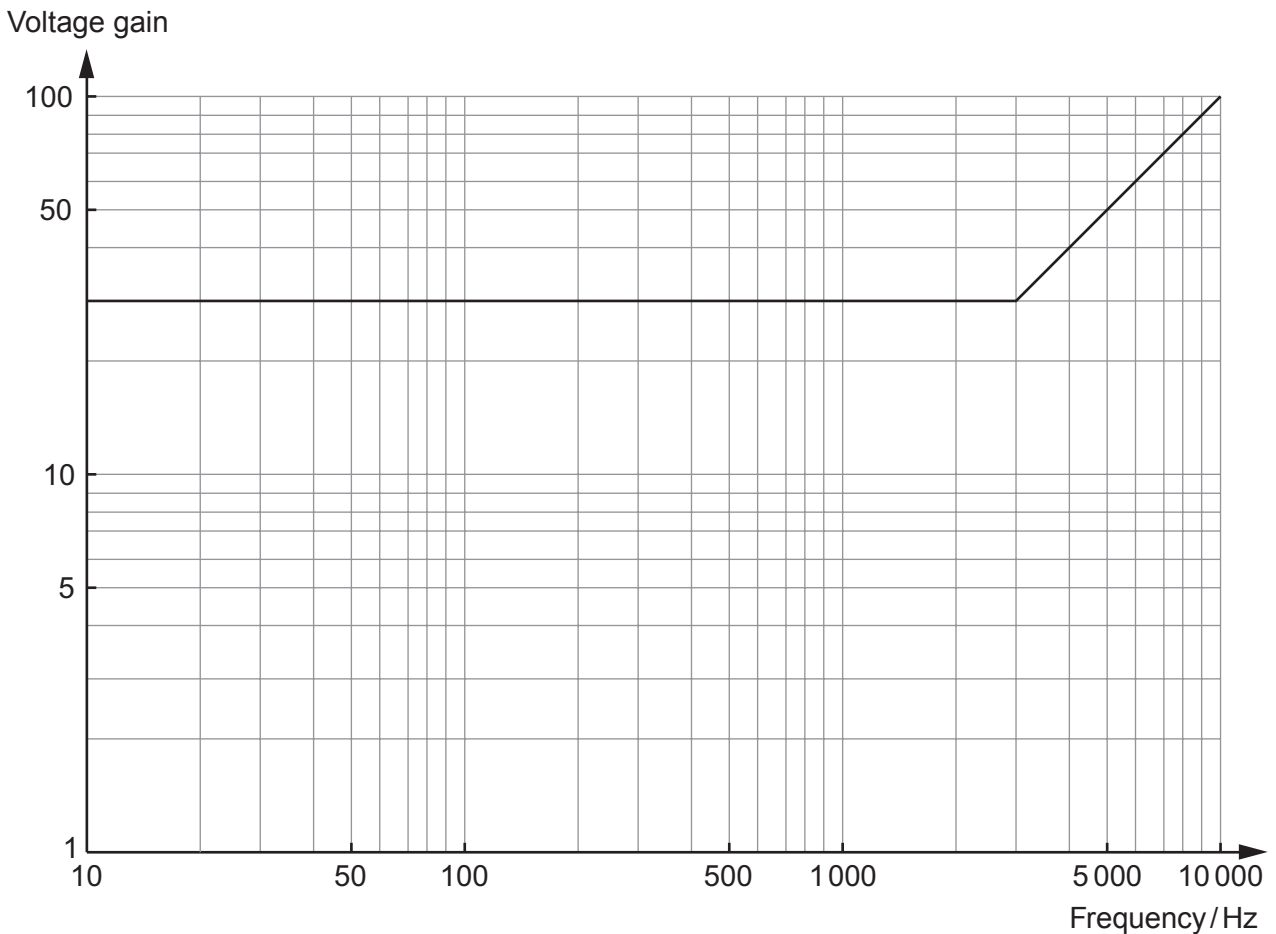
(ii) Calculate the low frequency voltage gain of this filter. [1]

.....

.....

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(c) The graph shows the characteristics of another active filter.



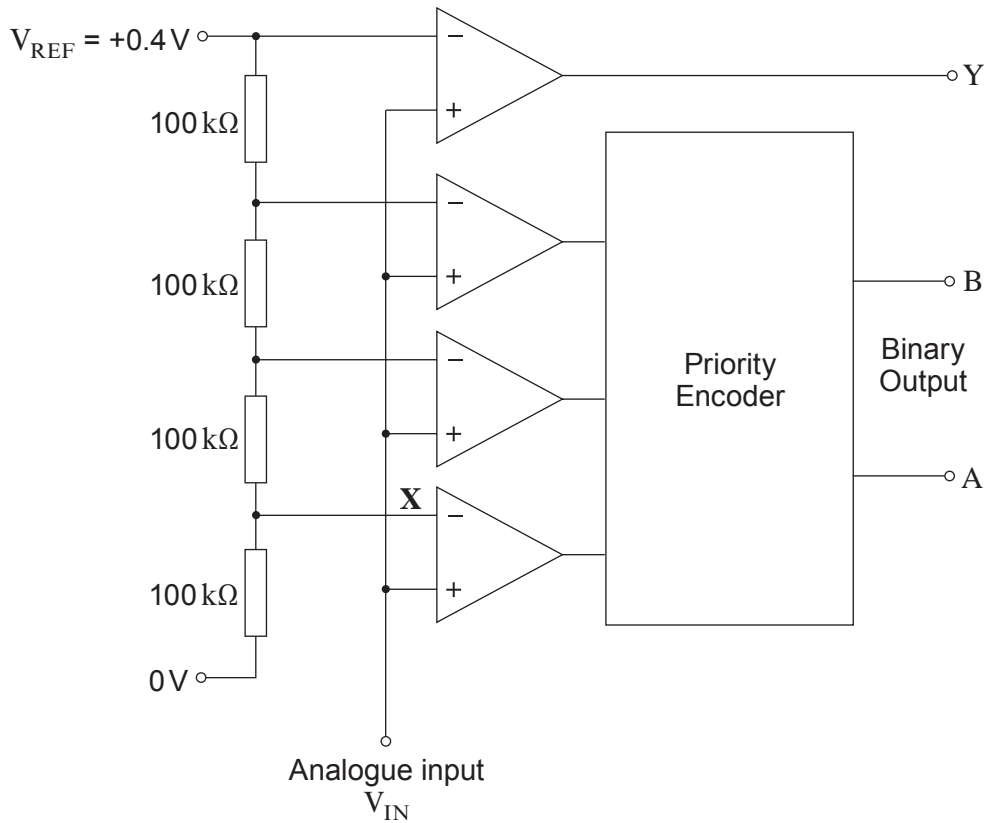
(i) What type of filter does the graph represent? [1]

.....

(ii) What is the break frequency for this filter? [1]

.....

3. (a) The circuit diagram for a two-bit flash ADC is shown below. The binary output increases uniformly as V_{IN} increases.



- (i) What is the voltage at input X? [1]

- (ii) A light sensing unit connected to the analogue input produces an output voltage of $0.25V$. What binary output is produced by the ADC? [1]

- (iii) What is the smallest value of V_{IN} that causes output Y to go to logic 1? [1]

(b) A **different** flash ADC has an input voltage range of 1 V and a four-bit output.

(i) Calculate the resolution of the new ADC.

[1]

.....

(ii) What reference voltage V_{REF} will be needed?

[1]

.....

(iii) How many resistors are needed in the resistor chain?

[1]

.....

4. A microcontroller system controls security in a bank. As part of this, it monitors the bank vault door using a magnetic switch. When the door is opened without authorisation, an interrupt service routine is activated. A buzzer sounds until a security guard cancels it by pressing a reset switch.

The system is set up as follows:

- the buzzer is connected to Port A bit 2;
- the reset switch is connected to Port A bit 0;
- other input and output devices are connected to other bits of the microcontroller.

- (a) Which one of the following binary numbers should be loaded into register TRISA to configure Port A appropriately? [1]

- A. 11100
 B. 11000
 C. 11010
 D. 00011
 E. 00111

Answer

- (b) Complete the following code to configure the INTCON register to enable an external interrupt on Port B bit 0, **while disabling all unused interrupt sources**. [2]

```
movlw    b'.....'
movwf   INTCON
```

- (c) The Interrupt Service Routine is outlined below, including line numbers. It includes a subroutine called **tensec**, which causes a ten second delay. Complete lines 220 to 224, using the comments and the commands given in the Information Sheet. [5]

```
220 alarm .....; store contents of W in register called 'protect';
221 .....; output logic 1 to switch on buzzer;
222 .....; call ten second delay subroutine;
223 .....; test reset switch – ignore next instruction if pressed;
224 .....; jump back to line 220;
225 bcf    INTCON, 1
226 movf   protect,0
227 retfie
```

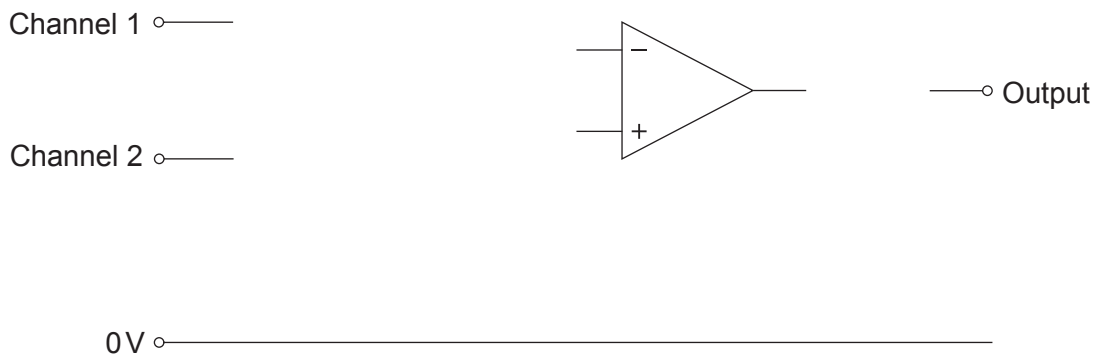
5. Here is part of the specification for a two-channel mixer:

Channel	Minimum input impedance	Maximum voltage gain
1	10 kΩ	-2
2	10 kΩ	-1

The circuit for the mixer is based on a summing amplifier. It has a fixed resistor in the feedback circuit and a series combination of a fixed and a 250 kΩ variable resistor in each channel input.

(a) Complete the circuit diagram for a mixer that meets this specification. Label all components with their values.

[3]



(b) The mixer is tested by applying DC signals to the inputs. Channel 1 and channel 2 are both set to give maximum voltage gain. A DC signal of +10 mV is applied to channel 1 while a DC signal of -4 mV is applied to channel 2. Calculate the output voltage, **showing all working**.

[2]

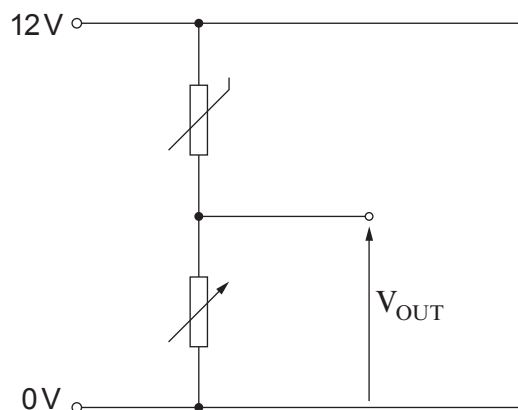
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6. A temperature control system for a small furnace uses two identical thermistors.

(a) This first diagram shows one of these connected in a simple voltage divider circuit.



At 60°C , the thermistor has a resistance of $1\text{ k}\Omega$ and the variable resistor is set to a resistance of $1.5\text{ k}\Omega$.

(i) Calculate the output voltage V_{OUT} at 60°C . [1]

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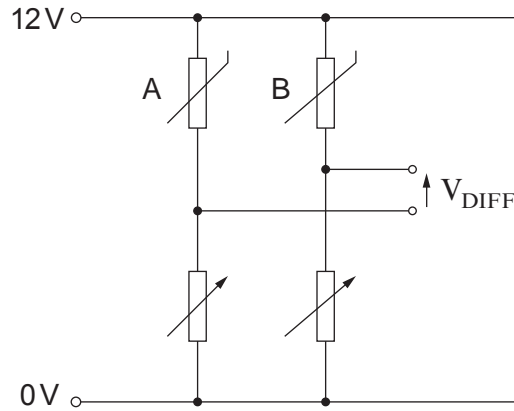
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(ii) The power supply voltage changes to 11.6V . What is the new output voltage at 60°C ? [1]

.....

.....

(b) The next diagram shows both thermistors connected in a bridge circuit.



(i) Calculate the output voltage, V_{DIFF} , when:

- thermistor A has a resistance of $1\text{ k}\Omega$, and its variable resistor has a resistance of $1.5\text{ k}\Omega$;
- thermistor B has a resistance of $1.5\text{ k}\Omega$, and its variable resistor has a resistance of $1.5\text{ k}\Omega$. [2]

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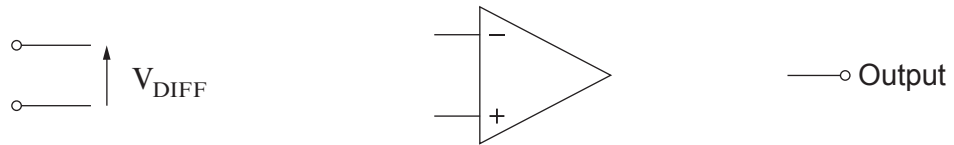
(ii) The power supply voltage drops to 11.6 V . What is the new value of V_{DIFF} ? [1]

.....

(c) The calculations in part (b) show that a bridge circuit is less susceptible to changes in power supply variations. Describe **one other** advantage. [1]

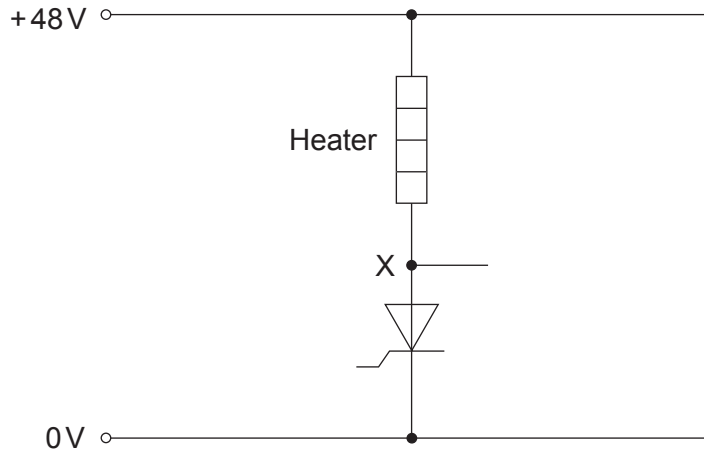
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- (d) Draw the circuit diagram for a difference amplifier that would amplify the output, V_{DIFF} , with a voltage gain of 100. Label all resistors with appropriate resistance values. [3]

Examiner
only

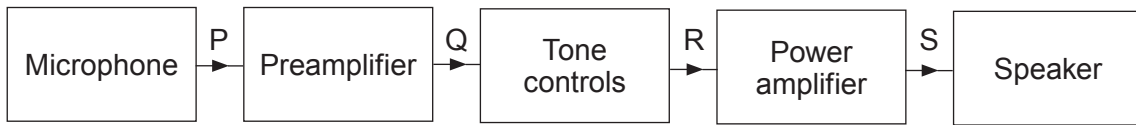
0V ○ —————

7. The diagram shows the incomplete circuit for a switching sub-system used to control a high-power heater.



- (a) Complete the circuit diagram by adding:
- (i) a push-switch and a resistor to switch on the heater. **Label the switch 'A'**. [1]
 - (ii) a second push-switch, a capacitor and any other components needed to switch off the heater using capacitor commutation. **Label this switch 'B'**. [3]
- (b) (i) What is the voltage at point 'X' when the heater is switched on? [1]
-
- (ii) Use your answer to (b)(i), and the voltage drop across the capacitor to explain how pressing switch 'B' turns off the heater. [3]
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-
-
-
- (c) What is the advantage of using a thyristor to control the heater rather than using a relay? [1]
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8. The block diagram for an audio system is shown below:

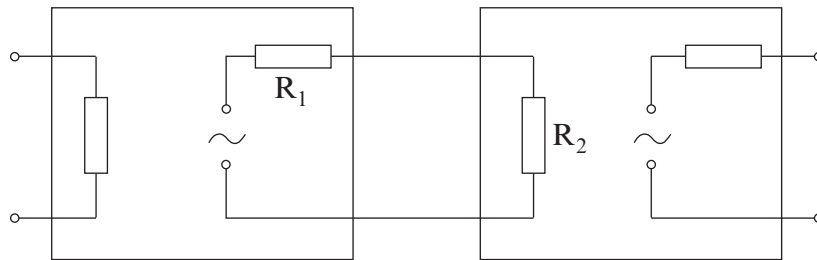


The links between sub-systems are labelled P, Q, R and S.

- (a) Which link(s) should be designed to maximise power transfer between sub-systems? [1]

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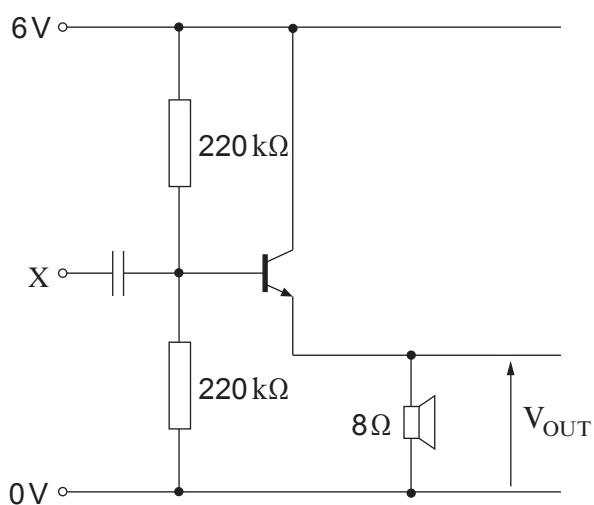
- (b) The diagram shows the equivalent circuit for two sub-systems within this audio system.



What is the relationship between R_1 and R_2 in order to maximise power transfer between the sub-systems? [1]

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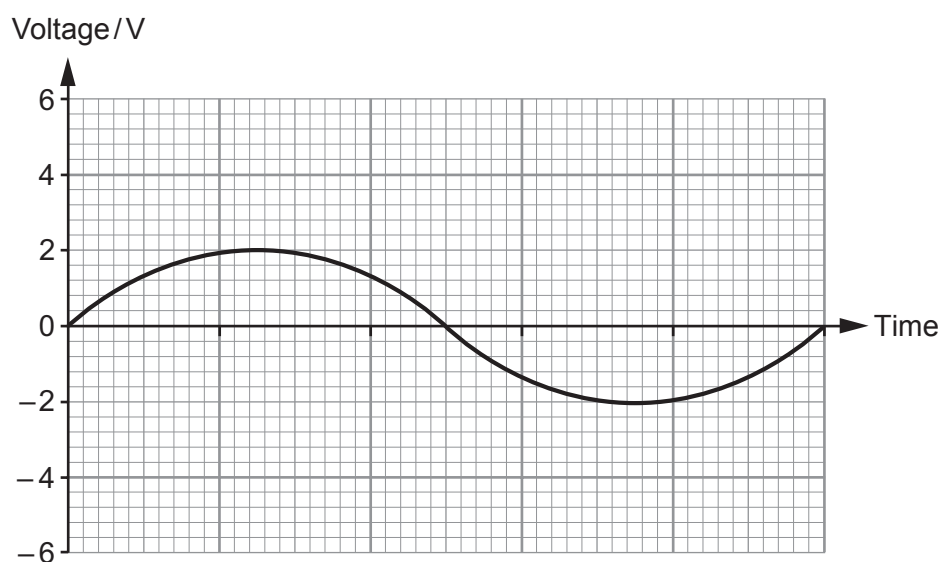
(c) An emitter follower circuit is shown below.



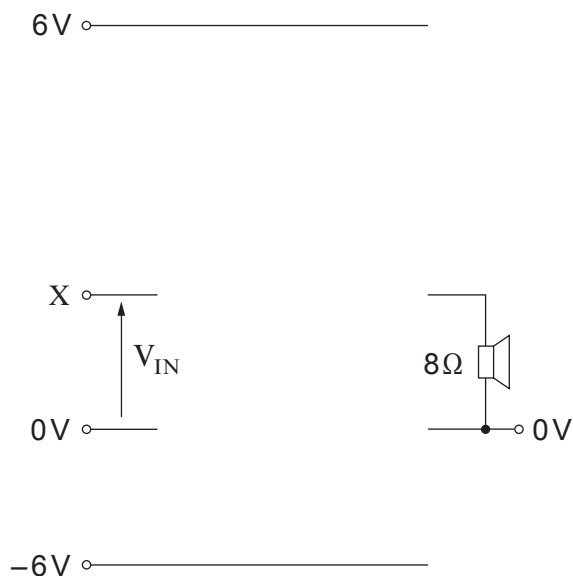
(i) With no signal present at X, calculate V_{OUT} . [1]

(ii) With no signal present at X, calculate the power dissipation in the 8Ω loudspeaker. [1]

(iii) The AC signal shown in the graph is now applied to X. On the same axes, **draw** the new output signal, V_{OUT} . [2]



- (d) (i) The emitter follower is replaced by a push-pull power amplifier. Complete the circuit diagram. [3]



- (ii) Calculate the maximum power dissipation in the 8Ω loudspeaker. [1]

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- (e) Describe one advantage of a push-pull power amplifier over an emitter follower power amplifier. [1]

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END OF PAPER

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