Surname	Centre Number	Candidate Number
Other Names		0

GCE A level

1145/01

ELECTRONICS

ET5

P.M. THURSDAY, 31 May 2012

1½ hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**9**	
3.	**8**	
4.	**6**	
5.	**8**	
6.	**4**	
7.	**8**	
8.	**8**	
9.	**7**	
10.	**6**	
Total	**70**	

1145
010001

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

Silicon Diode $V_F \approx 0{\cdot}7V$

Operational amplifier

$G = -\dfrac{R_F}{R_{IN}}$ Inverting amplifier

$G = 1 + \dfrac{R_F}{R_1}$ Non-inverting amplifier

$V_{OUT} = V_{DIFF}\left(\dfrac{R_F}{R_1}\right)$ Difference amplifier

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

$V_L \approx V_Z\left(1 + \dfrac{R_F}{R_1}\right)$ Stabilised power supply

Emitter follower $V_{OUT} = V_{IN} - 0{\cdot}7V$

Filters

$f_b = \dfrac{1}{2\pi RC}$ Break frequency for high pass and low pass filters

$X_C = \dfrac{1}{2\pi fC}$ Capacitive reactance

Thyristor phase control

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

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

Signal conversion $\text{resolution} = \dfrac{\text{i/p voltage range}}{2^n}$ ADC

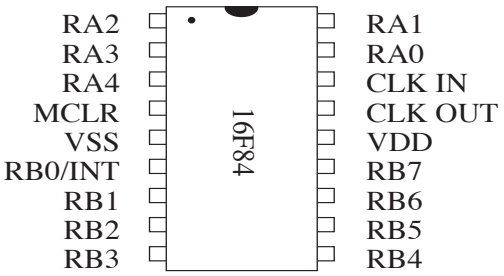
Power amplifier $P_{MAX} = \dfrac{V_S^2}{8R_L}$ where V_S is the rail-to-rail voltage

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

Pin out 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
btfss	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

Examiner only

1. *(a)* Each stage in a synchronous counter is clocked at the same time. What advantage does this give synchronous counters over ripple counters? [1]

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(b) Synchronous counters are prone to a problem caused when unused states are also stuck states.

(i) Explain what is meant by:

unused states; [1]

.....

.....

stuck states. [1]

.....

.....

(ii) **When** does the problem caused by stuck states occur? [1]

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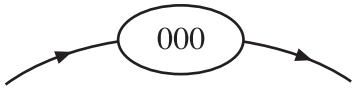
.....

(c) The behaviour of a synchronous counter is defined by its state diagram.

Use the table below to draw the state diagram for this 3-bit synchronous counter.

[2]

	Current Output			Next Output		
State	C	B	A	D_C	D_B	D_A
0	0	0	0	0	0	1
1	0	0	1	0	1	1
2	0	1	1	1	1	0
3	1	1	0	1	0	0
4	1	0	0	0	0	0
5	0	1	0	0	0	0
6	1	0	1	1	1	1
7	1	1	1	1	0	0



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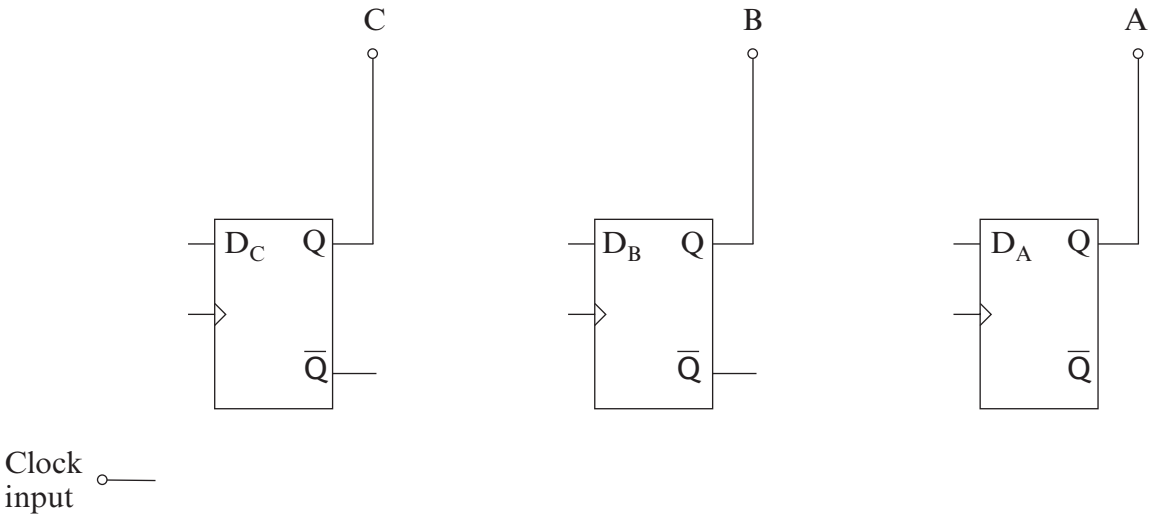
2. A sequence generator is controlled by the following Boolean expressions.

$D_C = \overline{C.A}$

$D_B = C \oplus A$

$D_A = \overline{A} + C.\overline{B}$

(a) Complete the circuit diagram for this sequence generator.
(Credit will be given for using the minimum number of gates.) [5]



(b) Complete the table to show the sequence of outputs generated by these Boolean expressions: [4]

	Current Output			Next Output		
State	C	B	A	D_C	D_B	D_A
0	0	0	0			
1						
2						
3						
4						
5						
6						
7						

Examiner only

3. *(a)* The following code is written to the data direction registers of a PIC microcontroller:

```
bsf     STATUS,RP0
movlw   b'00111'
movwf   TRISA
movlw   b'00000000'
movwf   TRISB
bcf     STATUS,RP0
```

Describe the effect of this code on PORT A of the microcontroller. [1]

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(b) How does the microcontroller locate the Interrupt Service Routine? [1]

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(c) The PIC microcontroller has LEDs attached to all bits of PORT B. A three second delay subroutine called 'threesec' is available.

A Reset switch is connected to PORT A bit 0.

Here is the Interrupt Service Routine. The numbers in the first column are line numbers in the program listing.

```
101  inter   movwf   Wstore
102  loop    movlw   b'11001100'
103          movwf   PORTB
104          call    threesec
105          clrf    PORTB
106          call    threesec
107          btfss   PORTA,0
108          goto    loop
109          movf    Wstore,W
110          retfie
```

(i) What is the purpose of the instructions in lines 101 and 109 in this program? [1]

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(ii) Describe exactly what is observed at the output when lines 102 to 106 of the program are executed. [3]

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(iii) State the purpose and effect of the instructions in lines 107 and 108 in this program. [2]

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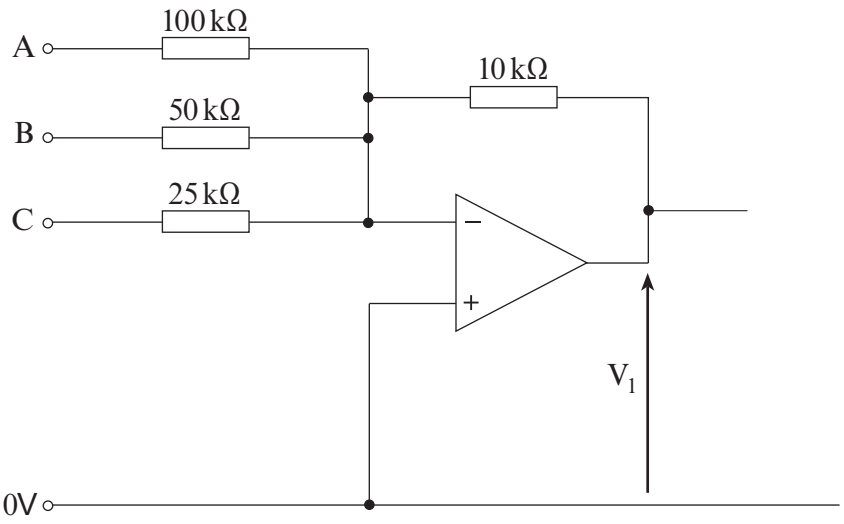
Examiner only

4. Here is the circuit diagram for a Digital-to-Analogue Converter (DAC).
This system uses a 10 V signal to represent logic 1 and a 0 V signal to represent logic 0.
The output of the op-amp saturates at +10 V and –10 V.



(a) Calculate voltage V_1 when the digital number 001 is applied to the inputs. [1]

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.....

V_1 = ...

(b) What is the value of V_1 when the input is the binary number 111? [1]

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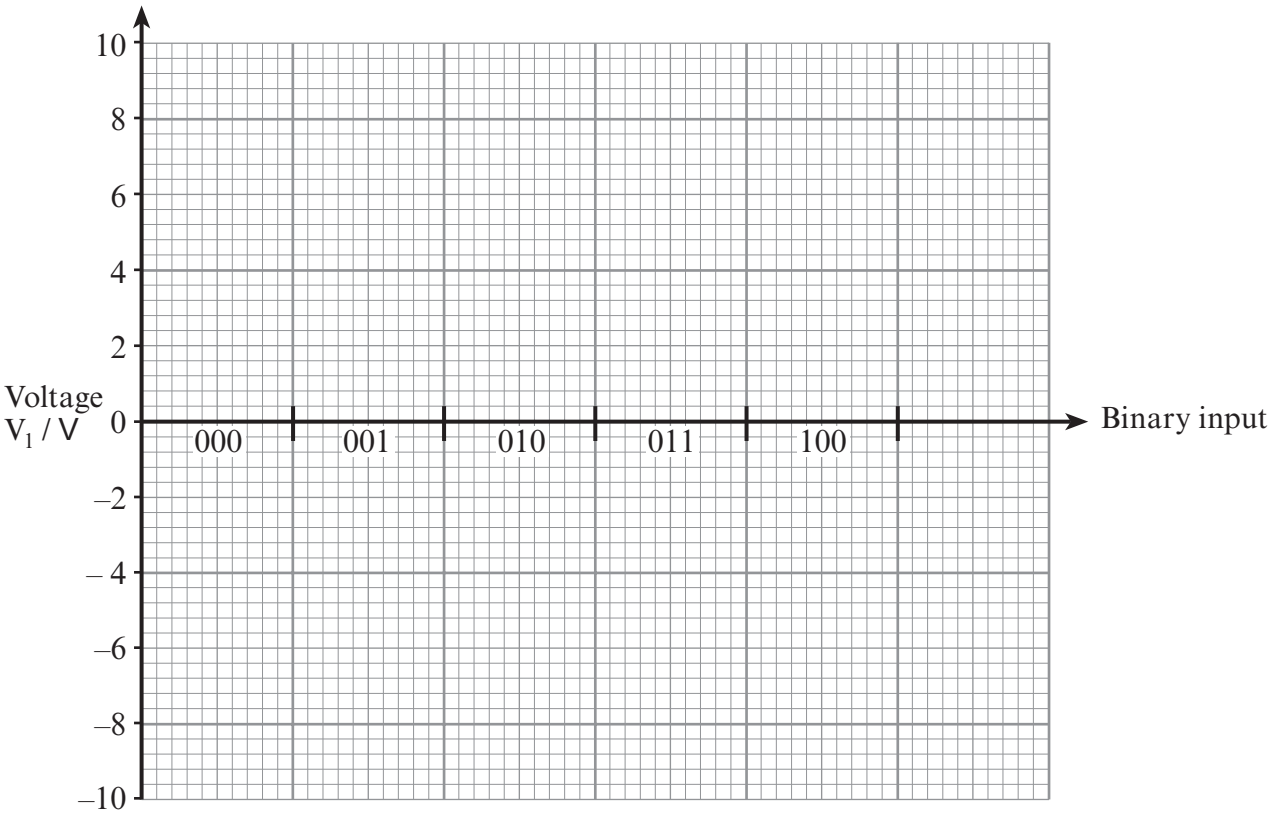
.....

V_1 = ...

(c) Use the axes provided to draw a graph to show how voltage V_1 changes as the binary input increases, in steps, from 000 to 100. [2]



(d) Modify the circuit diagram by adding a second amplifier, with a gain of –1, to invert the signal V_1.
Label any resistors used with suitable values. [2]

Examiner only

5. A high quality power supply incorporates *line* and *load regulation*.

(a) Explain what is meant by line regulation and load regulation. [3]

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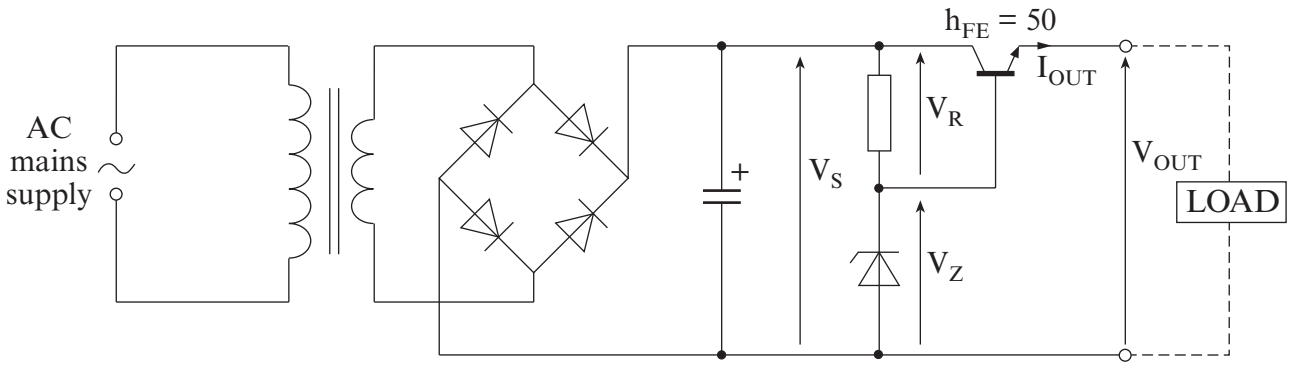
(b) The diagram shows the circuit for a power supply.



Calculate the output voltage V_{OUT} when

- $V_S = 14\,V$
- $V_Z = 9.2\,V$ [1]

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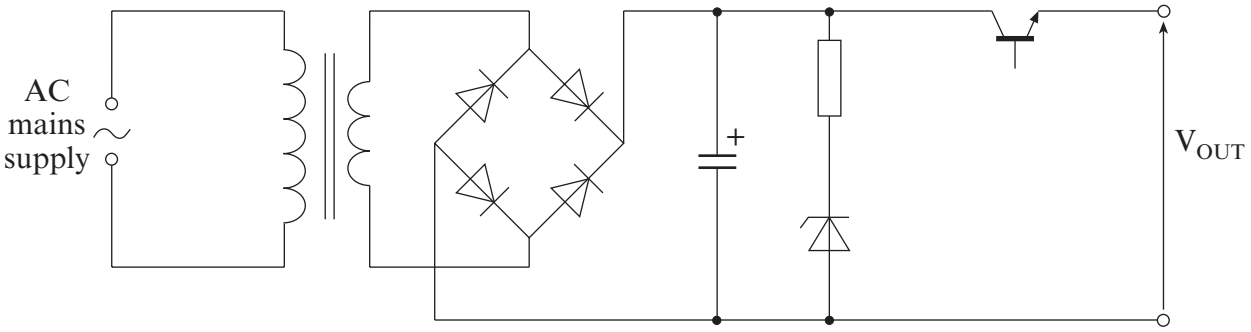
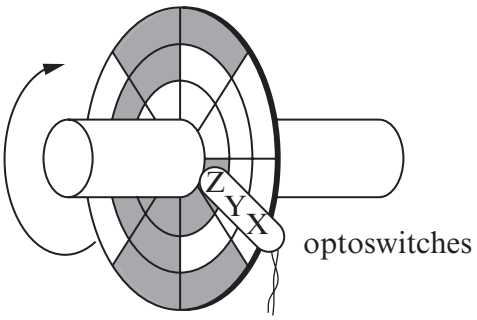
(c) The performance can be improved by adding an op-amp voltage amplifier to the circuit.
Show how this is done by modifying the following circuit diagram.
Your modification should make it possible to vary the output voltage, V_{OUT}.
No component values are needed. [4]



Examiner only

6. A machine tool control system uses an encoded disc to monitor how far a shaft has rotated. The disc is encoded using Gray code, and is read by three reflective optoswitches X, Y and Z. The arrangement is shown in the diagram.



(a) What is the advantage of using Gray code instead of pure binary code in this application? [1]

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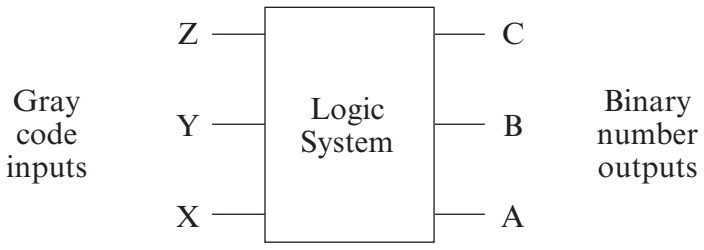
(b) A logic system is needed to convert the Gray code output from the optoswitches into binary numbers.



The conversion table is shown below:

Gray code			Binary number		
Z	**Y**	**X**	**C**	**B**	**A**
0	0	0	0	0	0
0	0	1	0	0	1
0	1	1	0	1	0
0	1	0	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1
1	0	1	1	1	0
1	0	0	1	1	1

Obtain Boolean expressions for the binary number outputs, C and B, in terms of the Gray code inputs Z, Y and X. Output A has been done for you. Credit will be given for simplification. [3]

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C = ...

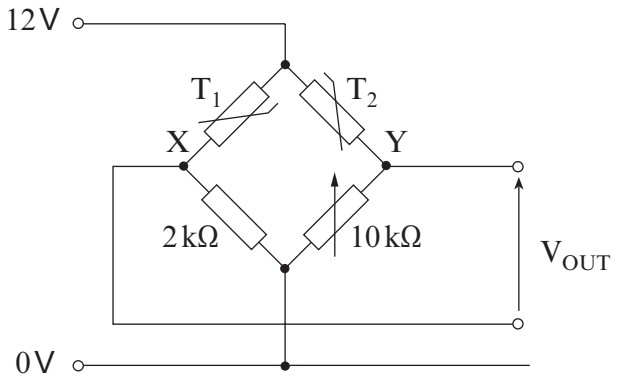
B = ...

$A = \overline{Z}.(Y \oplus X) + Z.\overline{(Y \oplus X)}$

Examiner only

7. The following system is used to detect small temperature differences inside an enclosure. The circuit contains two thermistors, T_1 and T_2, a 2 kΩ precision resistor and a variable resistor.

The circuit diagram is given below.



Initially, the resistances of the two thermistors are exactly 1.5 kΩ.

(a) What is the value of V_{OUT} when the variable resistor has a value of 2.00 kΩ? [1]

V_{OUT} = ...

(b) Calculate the output voltage V_{OUT} when:

- thermistor T_1 has a resistance of 1.43 kΩ
- thermistor T_2 has a resistance of 1.20 kΩ
- the variable resistor has a resistance of 2.00 kΩ [2]

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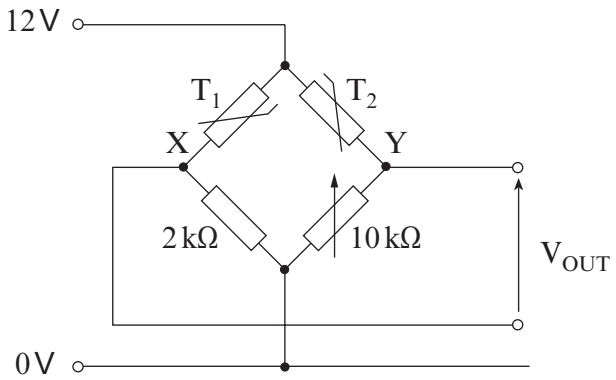
V_{OUT} = ...

Examiner only

(c) **Modify the circuit diagram** by adding a difference amplifier connected to amplify V_{OUT}. [2]



(d) Calculate suitable resistor values so that the amplifier has a voltage gain of 40.
Label **all** resistors used in the amplifier with their ideal values. [3]

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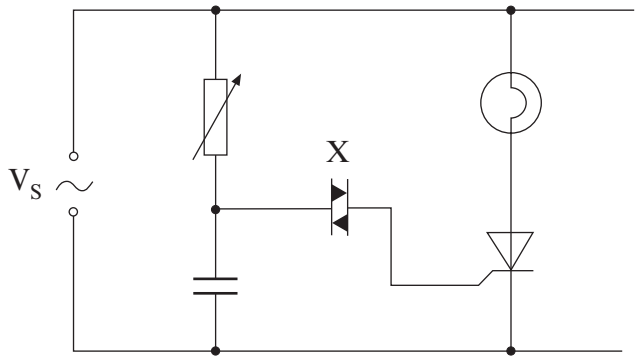
8. A thyristor is used to control the brightness of a lamp, using phase control.
The circuit diagram is shown below:



(a) (i) Identify component X. [1]

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(ii) What is its function in this circuit? [1]

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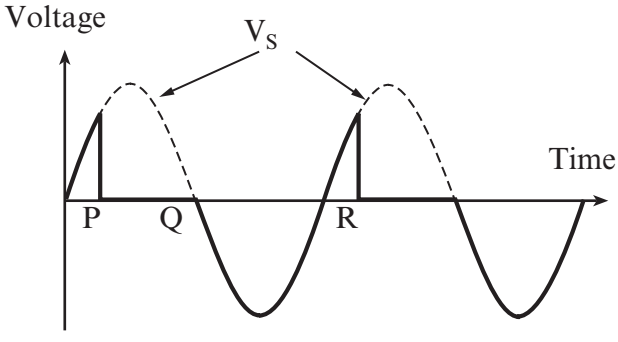
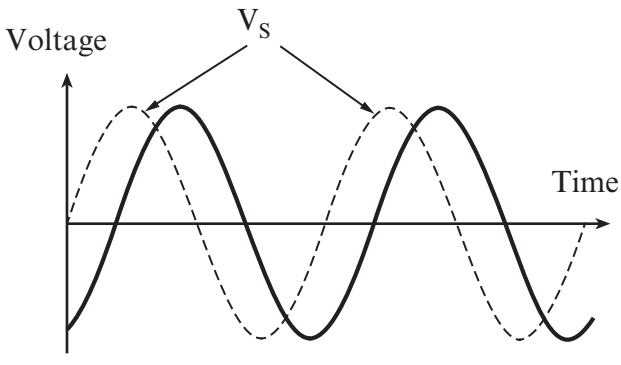
(b) The graphs show two signals obtained from parts of the circuit:



Signal Y



Signal Z

(i) Signal Y appears across which component? [1]

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(ii) State what is happening to the lamp:

- between P and Q [1]

.....

- between Q and R [1]

.....

(iii) Signal Z appears across which component? [1]

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(iv) Name the effect shown in signal Z and state how it arises. [2]

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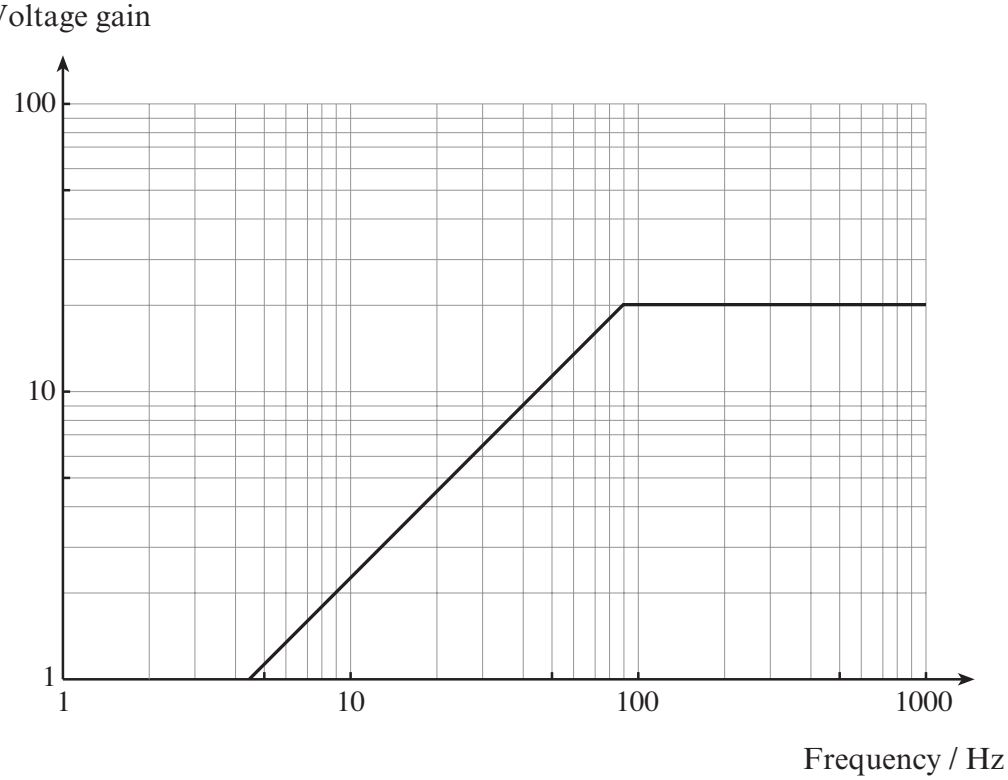
Examiner only

9. *(a)* The graph shows the frequency response of an active filter.



(i) What kind of filter is this? [1]

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

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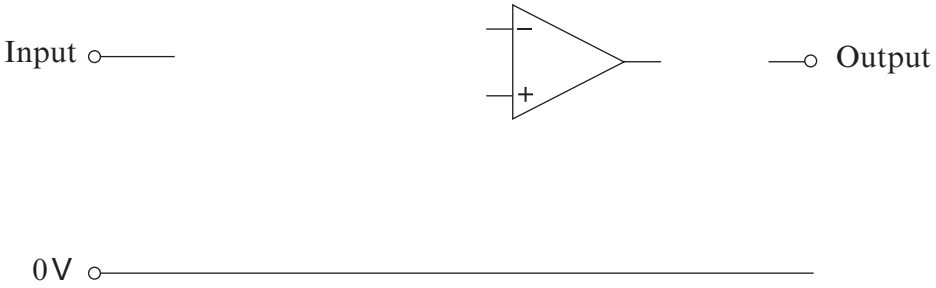
(iii) Complete the circuit diagram for the type of filter which produces the frequency response shown in the graph.

Component values are not needed. [3]



(iv) Why is this filter called an active filter? [1]

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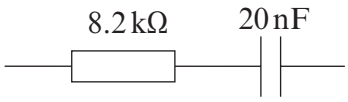
(b) The circuit for a **different** filter includes the RC combination shown below.



Calculate the break frequency of this filter. [1]

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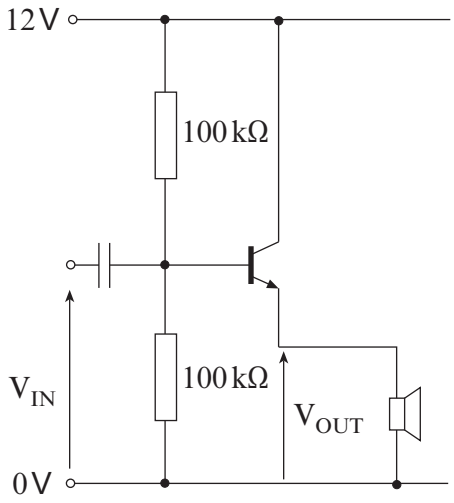
Break frequency = ... Hz

Examiner only

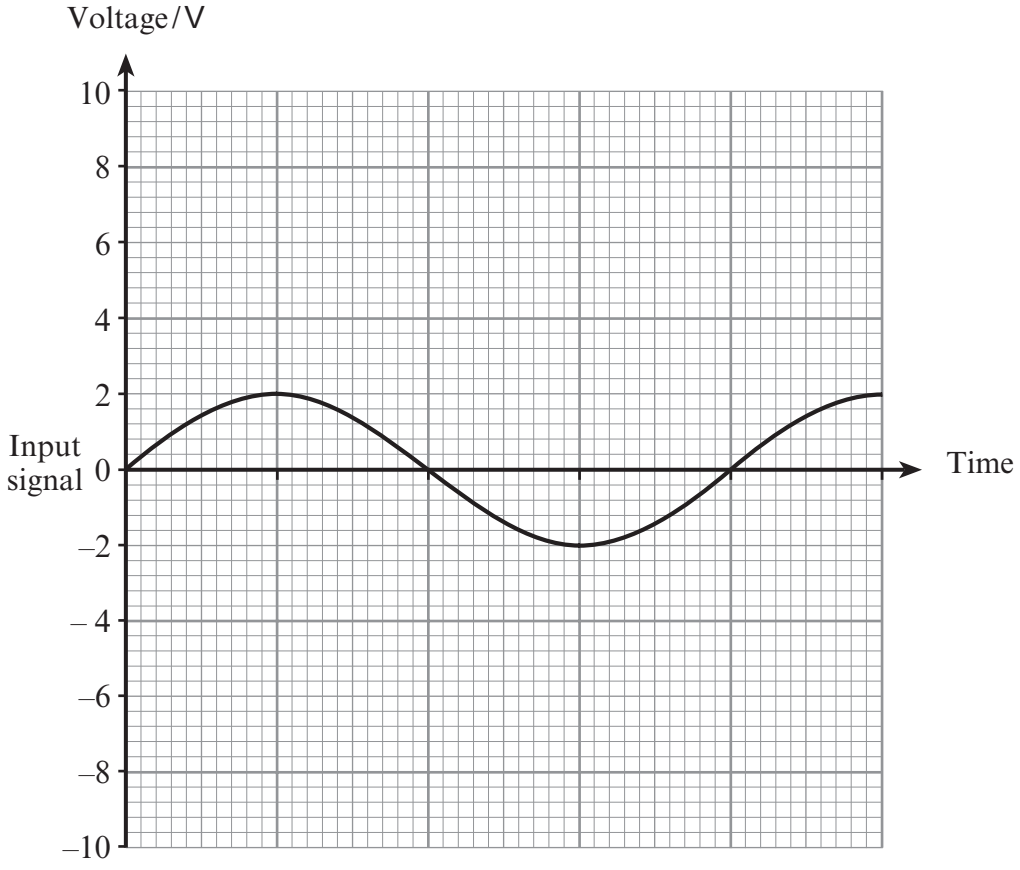
10. An audio system uses a power amplifier to drive the loudspeaker output stage.

Two possible choices for a power amplifier are the emitter follower and the push-pull amplifier.

(a) An emitter follower circuit is shown below.



The signal shown in the graph is applied to the input.
Draw the output signal on the same axes. [2]



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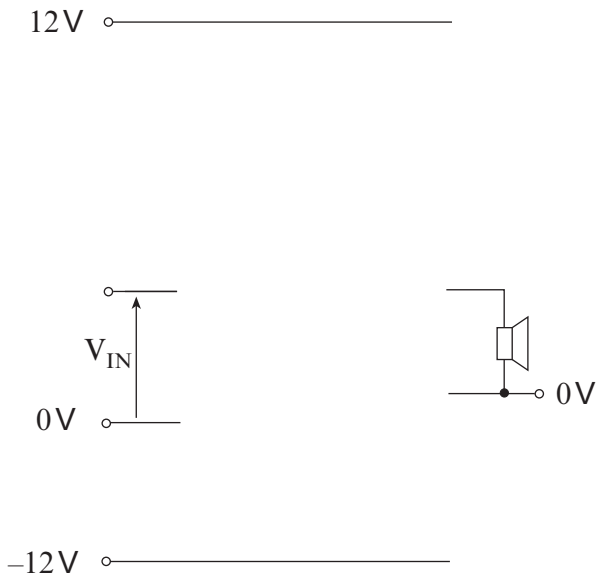
(b) Complete the circuit diagram for a push-pull power amplifier. [3]



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

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION

Examiner only