Candidate Name	Centre Number	Candidate Number
		2

WJEC CBAC

GCE A level

385/01

ELECTRONICS
ET5

P.M. TUESDAY, 10 June 2008

1¾ hours

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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 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.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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.

RC networks	$V_C = V_O\,(1 - e^{-t/RC})$	for a charging capacitor
	$V_C = V_O\,e^{-t/RC}$	for a discharging capacitor
	$t = -RC\ln\left(1 - \frac{V_C}{V_O}\right)$	For a charging capacitor
	$t = -RC\ln\left(\frac{V_C}{V_O}\right)$	For a discharging capacitor
Alternating Voltages	$V_o = V_{rms}\sqrt{2}$	
	$X_C = \frac{1}{2\pi fC}$	Capacitive reactance
	$X_L = 2\pi fL$	Inductive reactance
	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	Resonant frequency
	$f_{co} = \frac{1}{2\pi RC}$	Cut-off frequency for high pass and low pass filters
	$\phi = \tan^{-1}\frac{R}{X_C}$	Phase shift between V_R and V_S.
Silicon Diode	$V_F \approx 0{\cdot}7V$	
Bipolar Transistor	$h_{FE} = \frac{I_C}{I_B}$	Current gain
	$V_{BE} \approx 0{\cdot}7V$	in the on state
MOSFETs	$I_D = g_M V_{GS}$	

Operational amplifier

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

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

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

$$\text{Slew Rate} = \frac{\Delta V_{OUT}}{\Delta t}$$ Slew rate

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

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

Power Amplifier

$$P_{MAX} = \frac{V_S^2}{8R_L}$$ where V_S is rail-to-rail voltage

555 Monostable

$$T = 1{\cdot}1\ RC$$

555 Astable

$$t_H = 0{\cdot}7\ (R_A + R_B)C$$

$$t_L = 0{\cdot}7\ R_B C$$

$$f = \frac{1 \cdot 44}{(R_A + 2R_B)C}$$

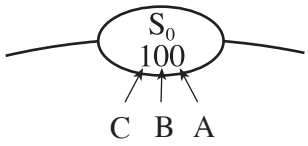
Schmitt Astable

$$f \approx \frac{1}{RC}$$

1. *(a)* (i) The table shows the behaviour of a 3-bit synchronous counter.

State	C	B	A	D_C	D_B	D_A
S_0	1	0	0	0	1	0
S_1	0	1	0	0	0	1
S_2	0	0	1	1	1	0
S_3	1	1	0	0	1	1
S_4	0	1	1	1	0	0
S_5	0	0	0	0	1	0
S_6	1	0	1	1	1	0
S_7	1	1	1	1	1	0

Use this information to complete the state diagram for the counter to show the main sequence and any unused states. [3]



(ii) Use the table to generate **simplified** Boolean expressions for the inputs D_C, D_B and D_A in terms of outputs C, B and A. [5]

D_C = ...

C \ B.A	0.0	0.1	1.1	1.0
0				
1				

D_B = ...

C \ B.A	0.0	0.1	1.1	1.0
0				
1				

D_A = ...

C \ B.A	0.0	0.1	1.1	1.0
0				
1				

(b) (i) Each stage of an 8-bit ripple counter has a propagation delay of 80 ns.
Show how this limits the maximum frequency of counting to around 1 MHz. [2]

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(ii) Why are synchronous counters not limited in this way by propagation delay? [1]

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(iii) Give one other advantage that synchronous counters have over ripple counters. [1]

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2. A sequence generator produces an output sequence governed by the following relationships:

$\mathbf{D_C = \overline{A}}$

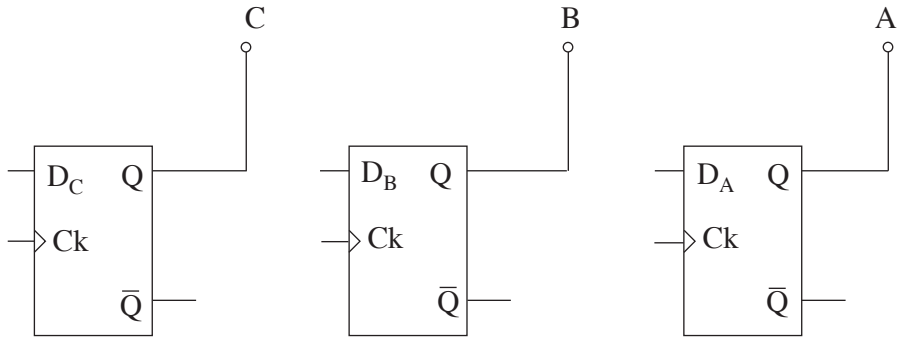
$\mathbf{D_B = A \,.\, \overline{C}}$

$\mathbf{D_A = B \oplus C}$

Complete the circuit diagram by:

(a) adding the correct clock connections; [1]

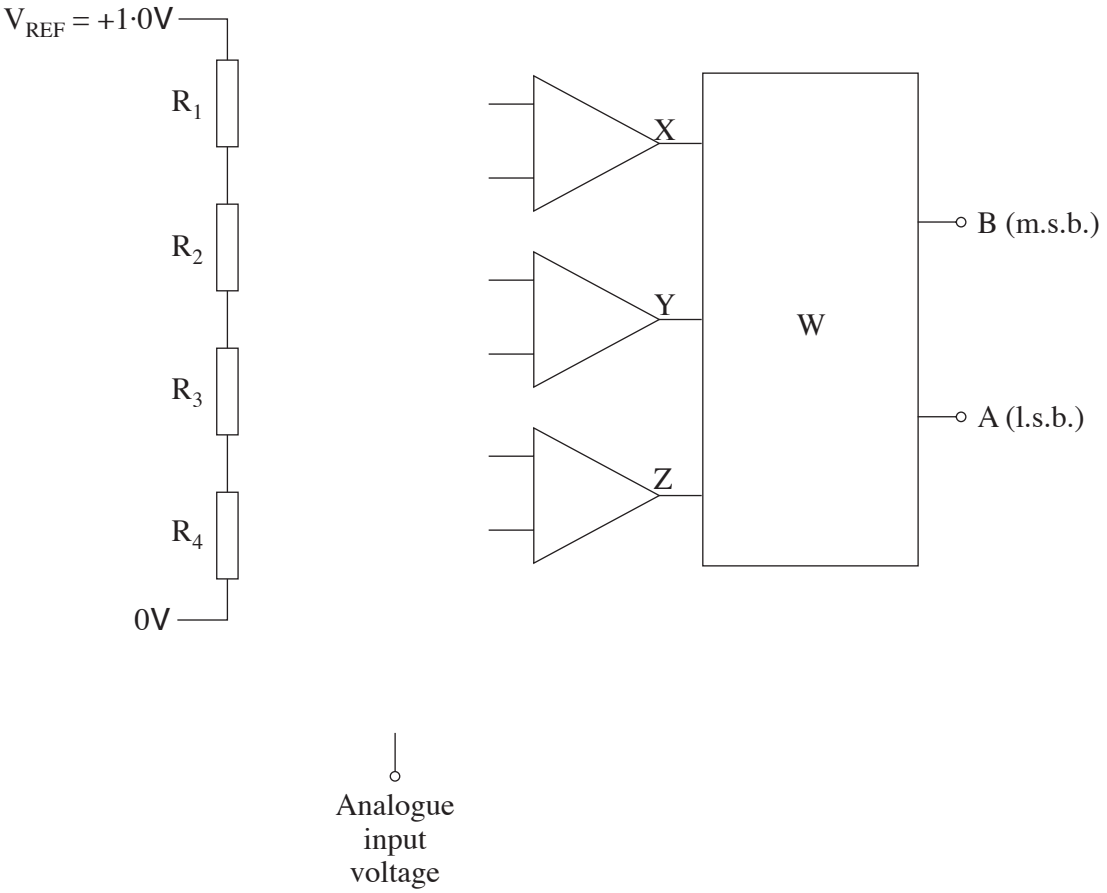
(b) adding logic gates to generate the required input signals. [4]
(Credit will be given for minimizing the number of logic gates needed.)



Clock input

Examiner only

3. *(a)* The diagram shows part of the circuit for an ADC.



(i) What is the name of the sub-system W, used to convert the output signals from the op-amps into a binary sequence? [1]

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The system meets the following specification:

Analogue input voltage	Voltage at X	Voltage at Y	Voltage at Z	Binary output	
				B	A
0·0 to 0·1V	10V	10V	10V	0	0
0·1V to 0·2V	10V	10V	0V	0	1
0·2V to 0·3V	10V	0V	0V	1	0
>0·3V	0V	0V	0V	1	1

(ii) Complete the circuit diagram by:

- adding the connections needed;
- labelling the inverting inputs of the op-amps with a '–' and the non-inverting inputs with a '+'. [3]

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(iii) Calculate suitable values for resistors R_1, R_2, R_3 and R_4. [3]

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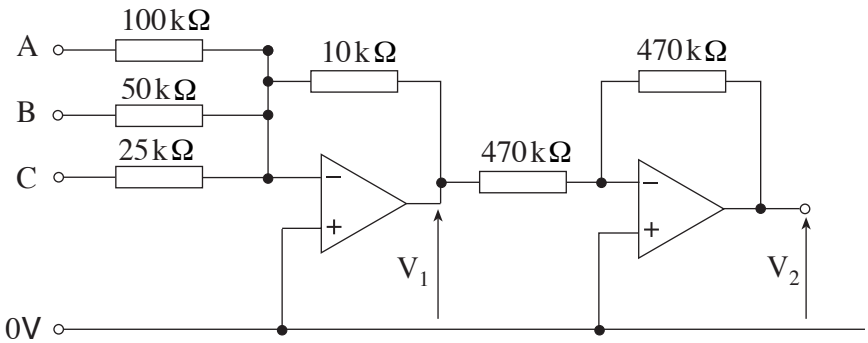
Resistor R_1 = ...

Resistor R_2 = ...

Resistor R_3 = ...

Resistor R_4 = ...

(b) Here is the circuit diagram for a digital-to-analogue converter (DAC).



In this system, logic 1 signals are represented by 10V, and logic 0 by 0V.
The op-amps saturate at +10V and –10V.
Input A is the least significant bit (lsb).

(i) The digital signal 001 is applied to the input of the DAC. Calculate the size and polarity of the voltage V_1. [2]

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(ii) What is the maximum value of output voltage V_2 that this 3-bit DAC will produce? [1]

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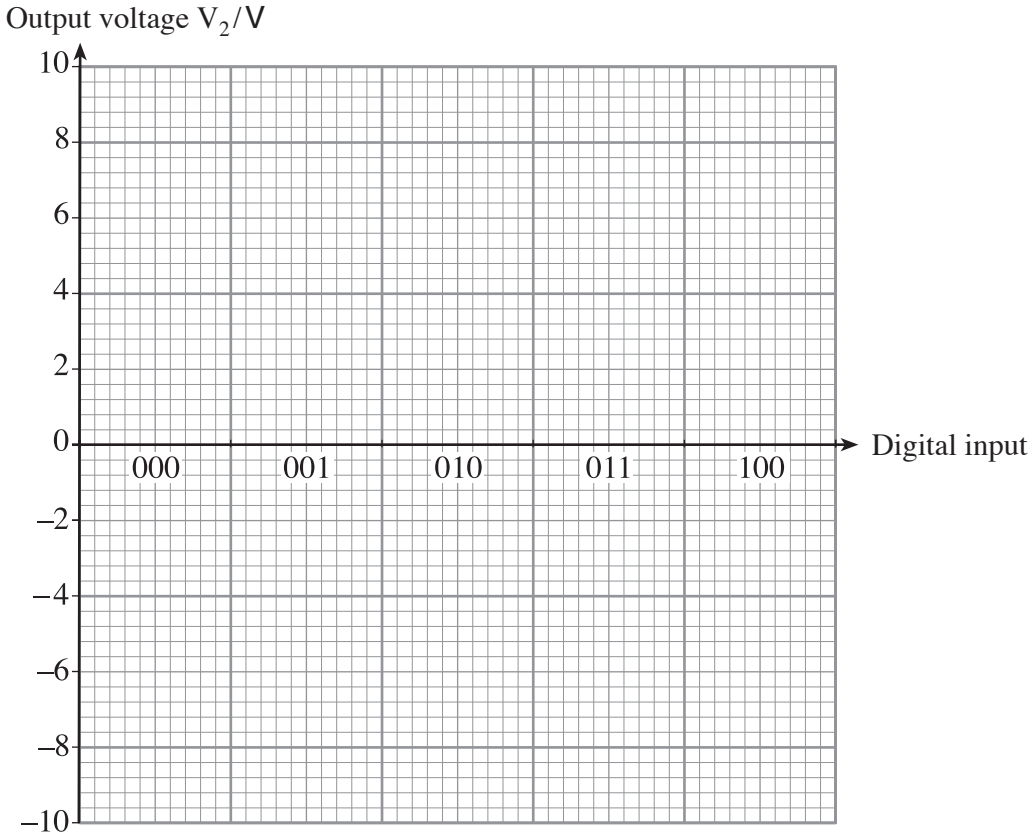
(iii) Use the axes provided to show output voltage V_2 when the given digital inputs are applied. [2]



4. *(a)* (i) What is the difference between the performance of an active filter and a passive filter? Give your answer in terms of voltage gain. [1]

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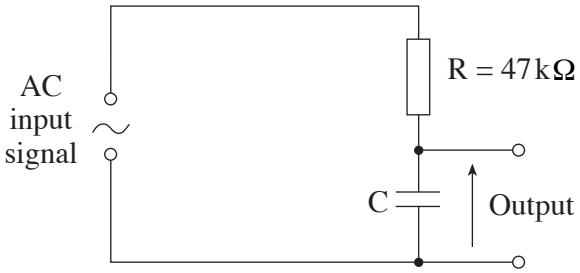
(ii) The term *break frequency* is often used in describing the performance of a filter.



In the filter circuit shown above, what is significant about the value of the reactance of the capacitor at the break frequency? [1]

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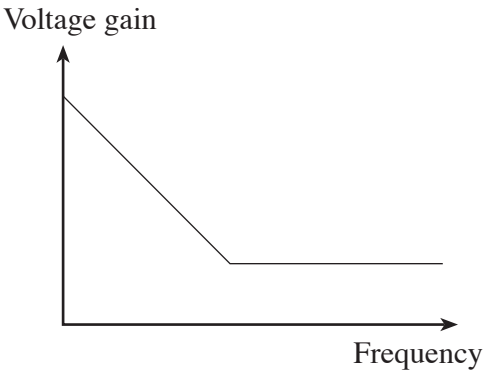
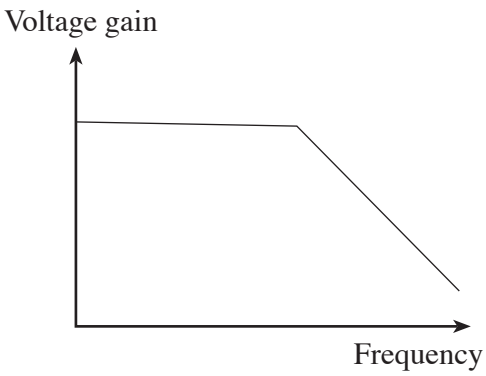
(b) The following sketches show the behaviour of two active filters.
Identify each filter, from the following list: [1]

treble boost *treble cut* *bass boost* *bass cut*



Filter A

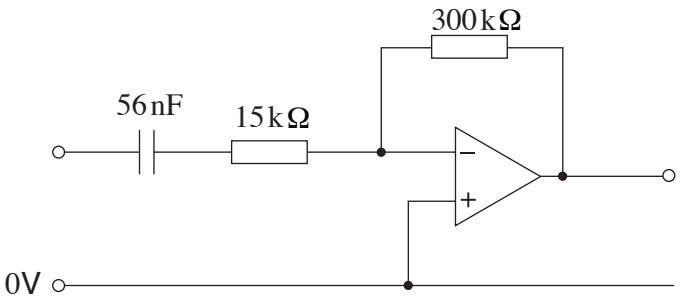


Filter B

Filter A = ...

Filter B = ...

(c) An audio system includes the following tone control circuit.



(i) What type of filter is this – treble boost, treble cut, bass boost or bass cut? [1]

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(ii) Calculate the break frequency of this filter. [3]

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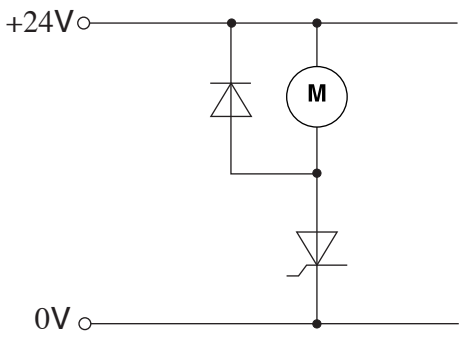
5. *(a)* In a paper mill, a guillotine is operated by a high-powered DC motor, **M**. Part of the circuit diagram for the control system is shown below.

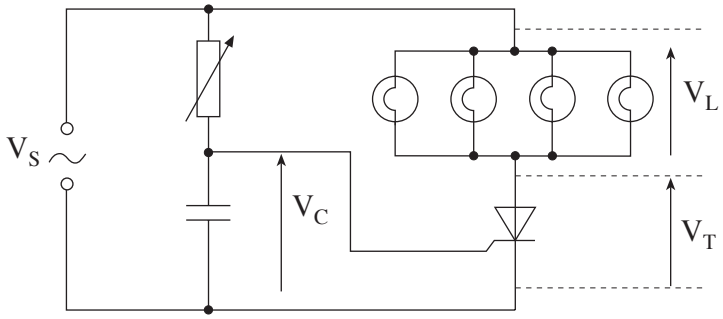


(i) Modify the circuit diagram by adding switches **A** and **B**, and a resistor so that the thyristor is switched on when either switch is pressed.
Label the switches with the letters **A** and **B**. [2]

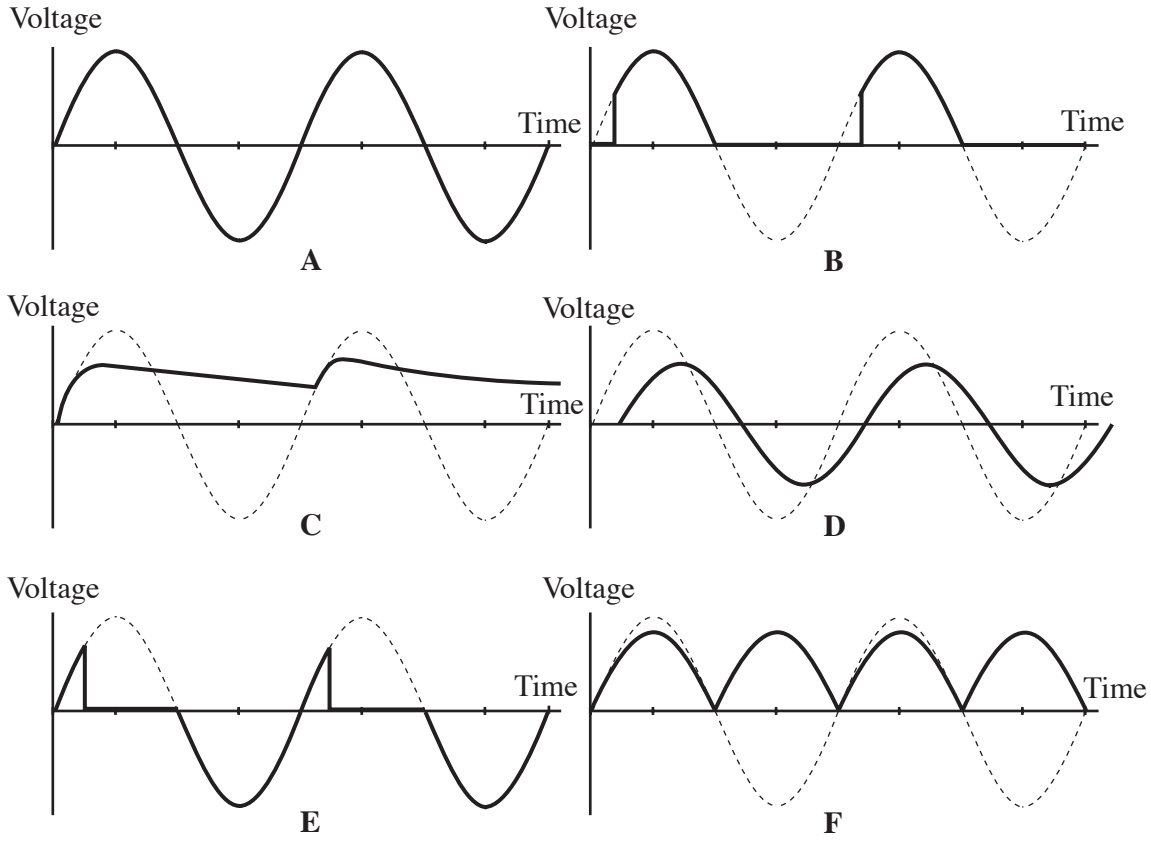
(ii) The thyristor is switched off using capacitor commutation.

Complete the circuit diagram by adding a third switch **C**, and other necessary components, so that the thyristor is switched off when switch **C** is pressed.
Label this switch with the letter **C**. [3]

(b) The AC lighting in the factory is controlled by a dimmer, using the following circuit:



Here are six graphs, labelled **A** to **F**, showing AC signals. The mains supply voltage is shown as a dotted line.



(i) When the lamps are at full brightness, which graph shows the signal V_C across the capacitor? [1]

Answer = ...

(ii) When the lamps are dimmed, which graph shows the signal V_C across the capacitor? [1]

Answer = ...

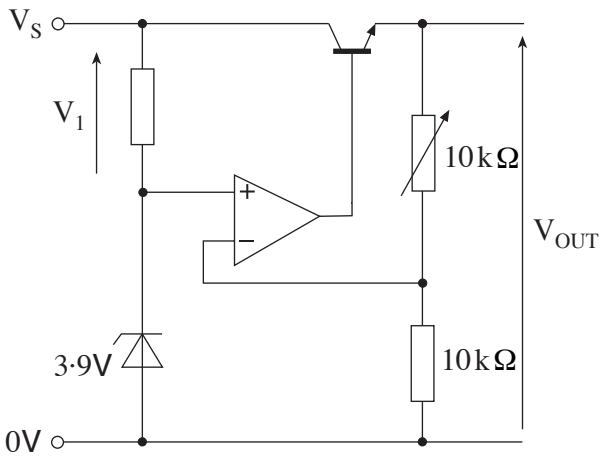
(iii) When the lamps are dimmed, which graph shows the signal V_T across the thyristor? [1]

Answer = ...

(iv) When the lamps are dimmed, which graph shows the signal V_L across the lamps? [1]

Answer = ...

6. The following subsystem is part of a power supply unit.



(a) V_S = 12·0V. Calculate:

(i) the maximum value of output voltage V_{OUT}; [1]

.....

(ii) the minimum value of output voltage V_{OUT}. [1]

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(b) (i) What is meant by the term *line regulation*? [1]

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(ii) By considering what happens if V_S changes to 12·2V, explain how this subsystem provides line regulation. [1]

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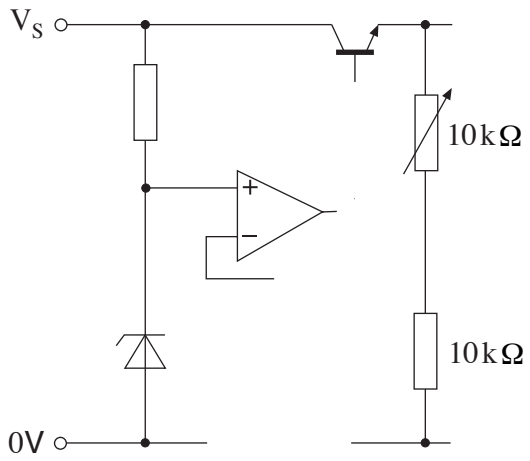
(c) (i) Modify the circuit by adding a second transistor and any other components needed to provide short-circuit protection. Complete the following diagram to show your modification. [2]



(ii) This modification must prevent an output current greater than 0·5 A when the output is short circuited. Calculate suitable values for any resistors used. [1]

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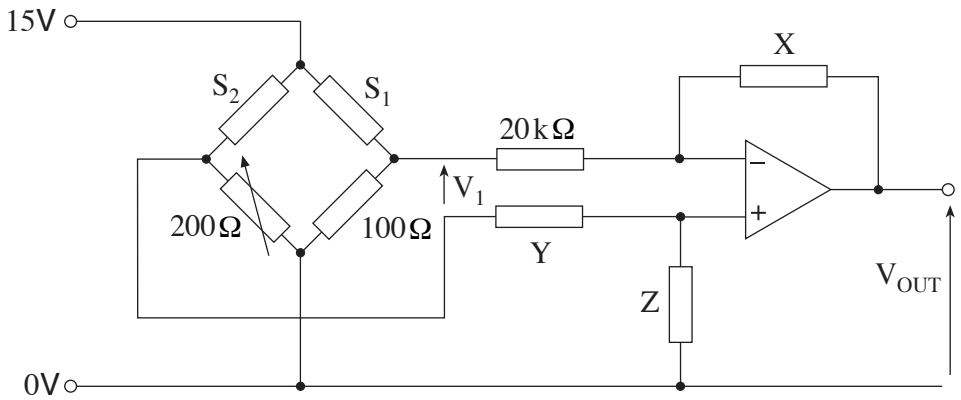
7. The circuit diagram for a strain monitoring system includes two identical strain gauges S_1 and S_2 and a precision 100Ω resistor.



(a) S_2 is the dummy strain gauge. What is its purpose in this circuit? [1]

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(b) Calculate the voltage V_1 when S_1 has a resistance of 100·27Ω , S_2 has a resistance of exactly 100Ω and the variable resistor is set to a resistance of exactly 100Ω .
Give your answer correct to two decimal places. [3]

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(c) The difference amplifier has a voltage gain of 100. Choose suitable values for the resistance of X, Y and Z to give this gain. Label the resistors with these values. [2]

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(d) Calculate the output voltage V_{OUT} of the system under these conditions. [1]

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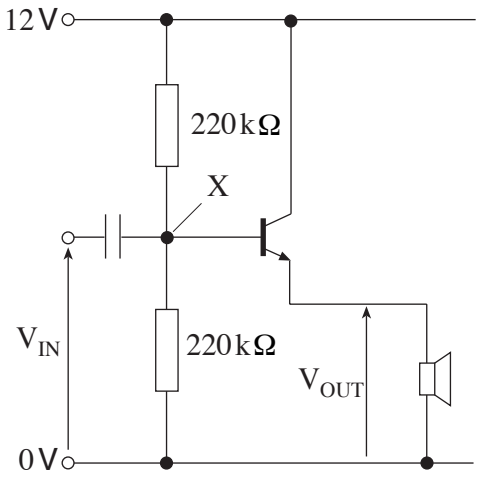
8. This question contrasts power dissipation in emitter followers and push-pull followers under quiescent conditions, (i.e. when $V_{IN} = 0V$).

(a) The circuit diagram for a compensated emitter follower is shown below.



No AC signal is applied to the input, i.e. $V_{IN} = 0\,V$,

(i) Calculate the DC voltage at point X. [1]

.....

(ii) Calculate the DC output voltage V_{OUT}. [1]

.....

(iii) Calculate the DC voltage drop across the transistor (i.e. collector-emitter voltage). [1]

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(iv) A current of 500 mA flows through the speaker when $V_{IN} = 0$.
Calculate the power dissipated in the transistor when no AC signal is applied. [1]

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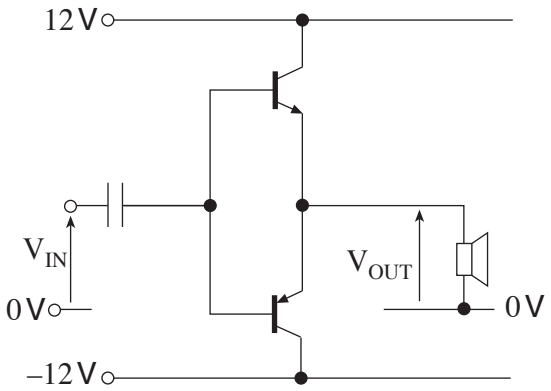
(b) The circuit diagram for a push-pull follower is shown below.



No AC signal is applied to the input, i.e. $V_{IN} = 0\,V$.

(i) What is the output voltage V_{OUT}? [1]

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(ii) What is the total power dissipation in the transistors when no AC signal is applied? [1]

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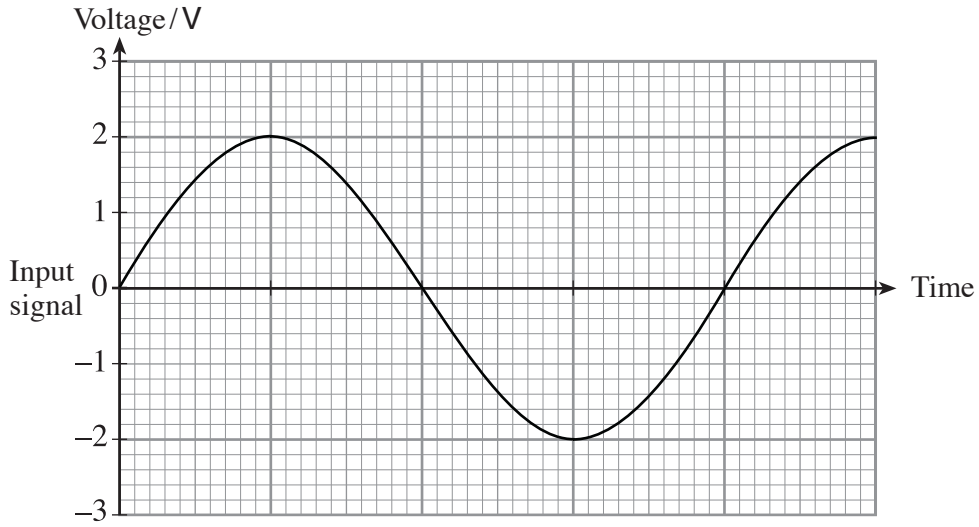
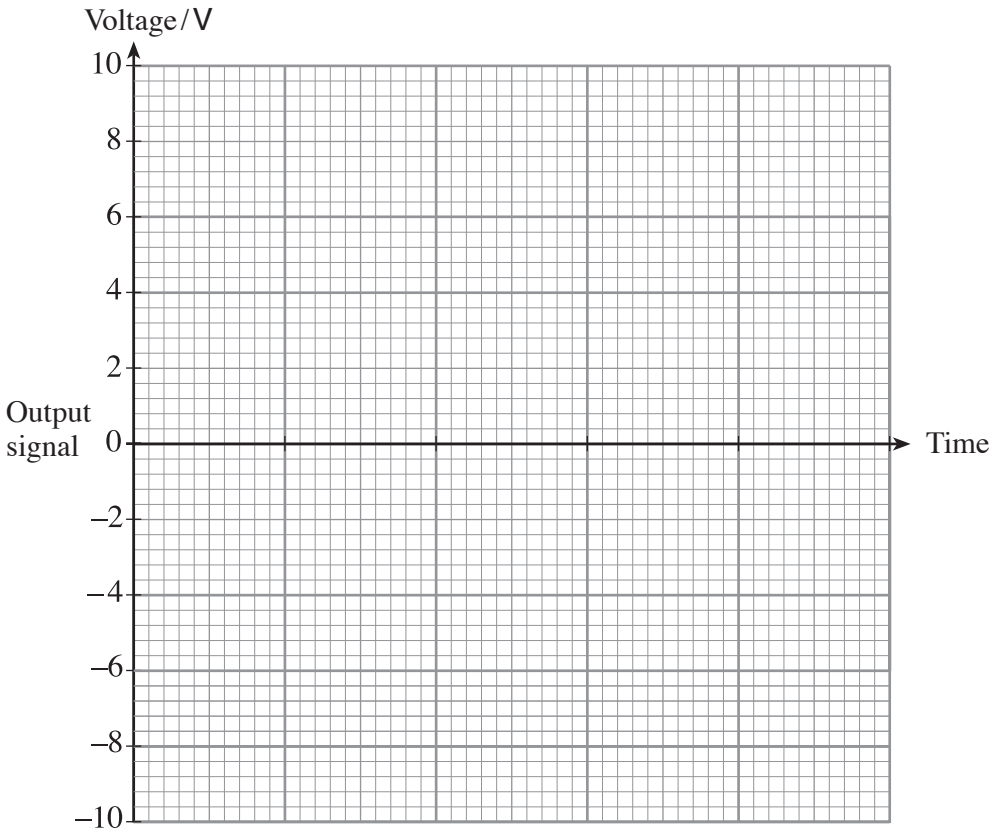
(iii) The test signal shown in the following graph is applied to the input of the push-pull follower.
Use the axes provided to sketch the output signal V_{OUT}. [3]





(iv) The loudspeaker has an impedance of 8Ω.
Calculate the maximum power that is dissipated in this loudspeaker. [2]

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Examiner only

FOR USE ONLY IF YOU HAVE MADE SUBSTANTIAL DELETIONS IN PARTS OF YOUR ANSWERS OR NEED MORE SPACE TO COMPLETE THEM. BE SURE TO INDICATE THE QUESTIONS CONCERNED.