OCR
Oxford Cambridge and RSA

Wednesday 17 January 2024 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 4: Principles of electrical and electronic engineering

Time allowed: 1 hour 30 minutes
C304/2401

C304 – 2401

You must have:
- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a scientific calculator

0582 2 – 04

Please write clearly in black ink. **Do not write in the barcodes.**

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

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

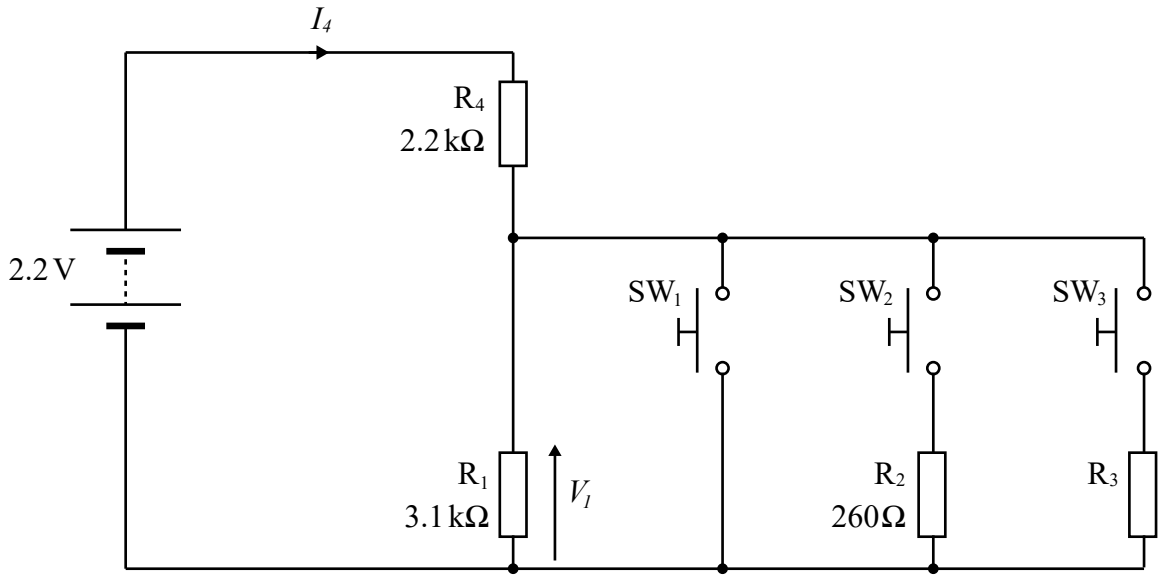
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working.
- Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

1 The diagram in **Fig. 1** shows the circuit for the control switches on a mobile phone.

Fig. 1



(a) Draw on **Fig. 1** to show how an ohmmeter should be connected to measure the value of R_3.

[1]

(b) Give **one** reason why switch SW_3 should not be pressed when measuring the resistance of R_3 with an ohmmeter.

.....

..... **[1]**

(c) Calculate the current I_4 when **no** switches are pressed.

I_4 = ... A **[2]**

(d) Find the current I_4 when **only** switch SW_1 is pressed.

$I_4 =$ ..... A **[1]**

(e) Calculate the voltage V_1 when **only** switch SW_2 is pressed.

$V_1 =$ ..... V **[3]**

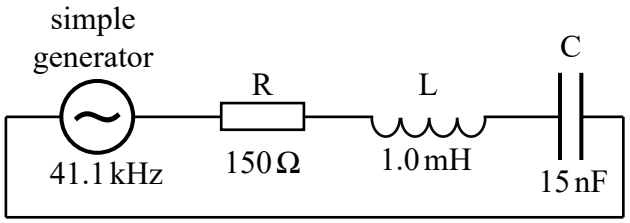
(f) When **only** switch SW_3 is pressed the voltage V_1 is 0.387 V.

Calculate the value of R_3.

value of $R_3 =$ ..... Ω **[2]**

2 The diagram in **Fig. 2** shows a circuit connected to a simple generator. The AC waveform from the generator is a sine wave with amplitude $V = 0.6\,\text{V}$ and frequency $f = 41.1\,\text{kHz}$.

Fig. 2



(a) State the function of a simple generator.

.....

..... **[1]**

(b) Calculate the period (T) of the signal from the simple generator.

period, T = ... s **[1]**

(c) Calculate the angular frequency (ω) of the signal from the simple generator.

Give the units for your answer.

angular frequency, ω = ... **[2]**

(d) Use the equation $v = V \sin \omega \tau$ for an AC waveform to calculate the voltage at time $\tau = 14\,\mu\text{s}$ in the simple generator.

voltage, v = ... V **[2]**

(e) Calculate the reactance of each component in the circuit at $f = 41.1$ kHz.

Write your values in the table.

Component	**Reactance / Ω**
Capacitor	
Inductor	
Resistor	

[3]

(f) Calculate the impedance of the circuit at $f = 41.1$ kHz.

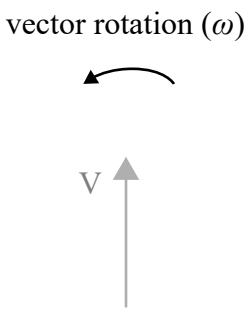
impedance, $Z =$ ..... Ω **[1]**

(g) Calculate the phase angle (f) in degrees between the voltage and current from the simple generator on **Fig. 2.**

Phase angle, $f =$ ..... ° **[1]**

(h) Complete the phasor diagram below to show the phase relationship between the voltage and current from the simple generator.

Draw an arrow for the current vector, I.



[1]

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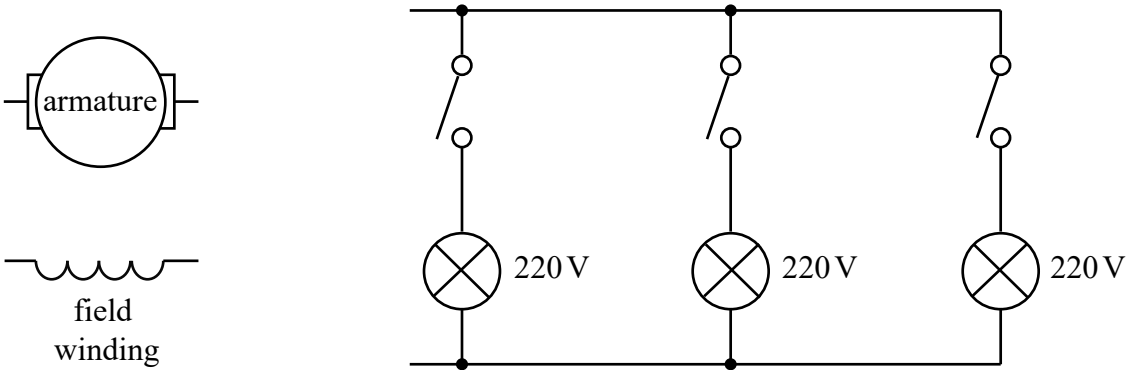
Turn over for the next question

3 A shunt-wound self-excited DC generator is used to provide power for a set of 220 V lamps.

The armature resistance is 4 Ω and the field winding resistance is 300 Ω.

(a) Complete the diagram in **Fig. 3** to show how the field winding, the armature and the lighting circuit are connected.

Fig. 3



[2]

(b) The generator needs to supply 220 V to the lamps when one, two or three lamps are switched on.

Explain why a shunt-wound self-excited DC generator is suitable for this application.

.....

.....

.....

..... **[2]**

(c) Calculate the current in the field winding (I_f) when the voltage from the generator is 220 V.

I_f= ..... A **[2]**

(d) Calculate the current in the armature (I_a) when the voltage from the generator is 220 V and the current to the lamps is 1.36 A.

I_a = ... A **[1]**

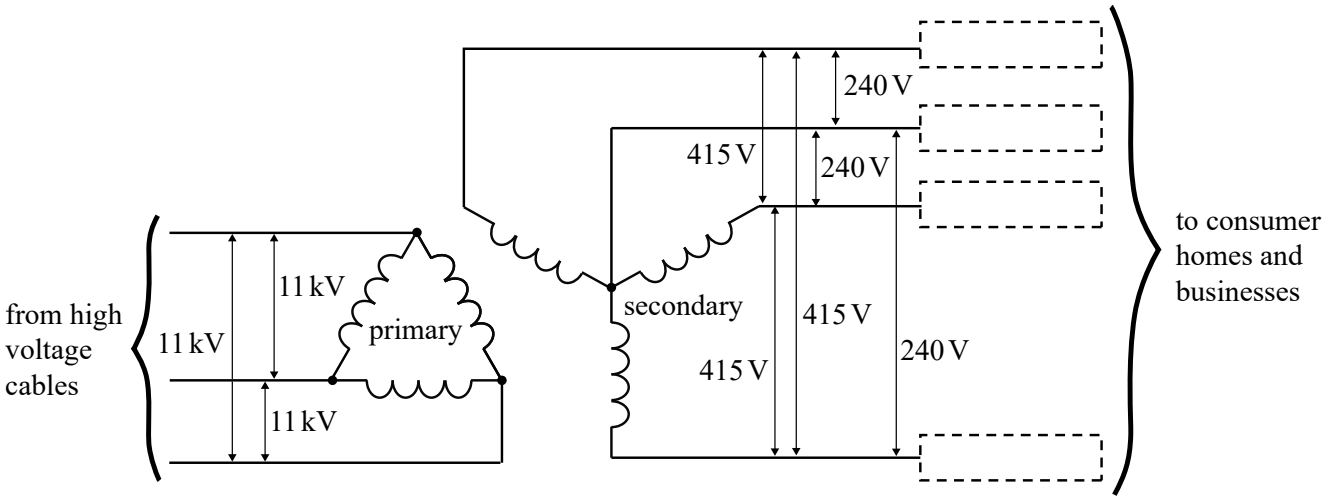
(e) Calculate the EMF (E) generated in the armature when the voltage from the generator is 220 V and the current to the lamps is 1.36 A.

Give the units for your answer.

E = ... **[3]**

4 The diagram in **Fig. 4** shows a system for supplying electricity to a local area from the higher voltage supply power lines.

Fig. 4



(a) Correctly label the wires from the secondary windings in **Fig. 4** by writing 'neutral' or 'phase' in each box.

[1]

(b) Complete the sentences below about the system in **Fig. 4** using the most appropriate term in each gap.

Choose terms from the following list.

Each term may be used once, more than once or not at all.

bridge

delta

line

phase

star

The system has a ……..... connected primary and

a ……..... connected secondary.

The ……..... voltage of the secondary is 415 V.

The ……..... voltage of the secondary is 240 V.

[4]

(c) Circuit breakers are often used in electricity supply circuits.

(i) Describe the function of circuit breakers.

.....

.....

.....

..... **[2]**

(ii) Describe **one** advantage of a circuit breaker over a fuse.

.....

.....

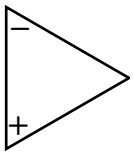
.....

..... **[2]**

Turn over for the next question

5 Part of the circuit symbol of an op-amp is shown in **Fig. 5**.

Fig. 5



(a) Add connections to op-amp symbol in **Fig. 5** for:

- the inputs
- the output
- the power supply.

Label all the connections.

[3]

(b) Draw components and connections on **Fig. 6** to show how to make a summing amplifier from an op-amp.

Connect the inputs to V_1 and V_2 and the output to V_{out}.

You do not need to show the power supply pins for the op-amp.

Fig. 6

V_1 ———

V_2 ———

——— V_{out}

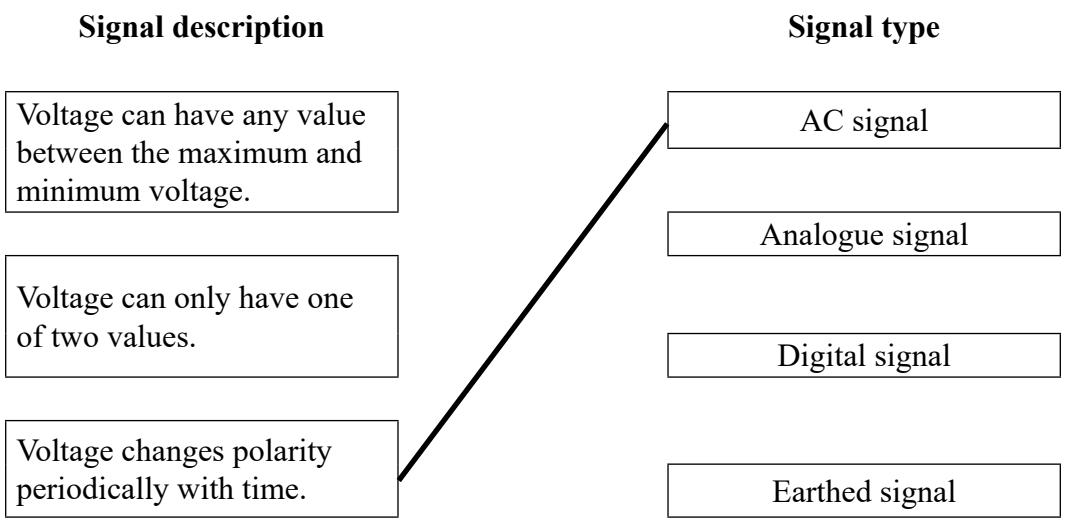
0 V ———————————————————————————

[5]

(c) Draw lines to join each signal description box to the most appropriate signal type box.

One of the lines has already been drawn for you.

You must only draw **two** lines.



[2]

Turn over for the next question

6

(a) Draw the symbol for a NOT gate.

[1]

(b) Draw a truth table for the NOT gate.

[2]

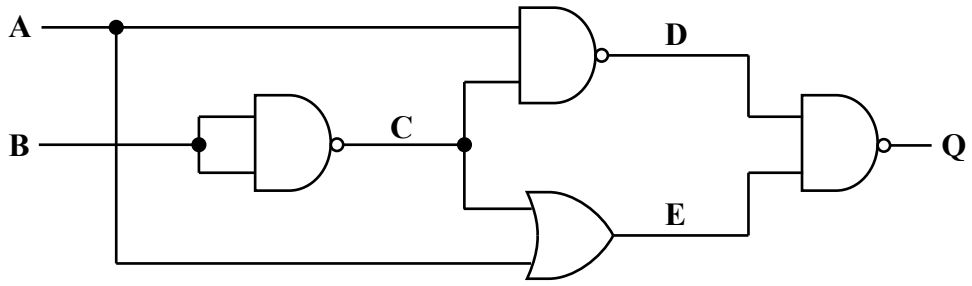
(c) Describe the function of the NOT gate.

.....

..... **[1]**

(d) A logic circuit is shown in **Fig. 7**.

Fig. 7



(i) Complete the truth table for the circuit in **Fig. 7**.

A	B	C	D	E	Q
0	0				
0	1				
1	0				
1	1				

[4]

(ii) The circuit in **Fig. 7** can be replaced by a single logic gate that would have the same function.

Draw the symbol of the single logic gate that could replace the circuit in **Fig. 7**.

Label the inputs **A** and **B** and label the output **Q**.

[1]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.