NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2022

ELECTRICAL TECHNOLOGY: ELECTRONICS

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, an Answer Sheet of 2 pages (i–ii) and a Formula Sheet of 1 page (i). Please check that your question paper is complete.
2. **ALL questions** must be answered.
3. Read the questions carefully.
4. Please start **each question** on a **new page** in your Answer Book.
5. **NB:** Use the given Answer Sheet to answer **Question 5.5.2**, **Question 5.7.2** and **Question 6.1.4**.
6. Do not write in the margin.
7. **Number your answers exactly** as the questions are numbered in the paper.
8. You may use a non-programmable calculator.
9. Use the attached Formula Sheet.
10. ALL **formulae and calculations** must be **shown**.
11. ALL **sketches and diagrams must be in proportion and labelled**. **Use a pen.**
12. **Round off** your final numerical answers to a **MINIMUM of TWO** decimal places.
13. Write neatly and legibly.

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

For each question, choose the most correct answer by indicating your choice in the given Answer Book. NB: Only one choice per question is acceptable. If more than one choice is indicated, the relevant answers will be marked as incorrect.

1.1 Identify the unsafe action from the given statements.

A Wet floors in the workplace.
B Using a file without a handle.
C A workshop with closed windows.
D Floor tiles of passages that are loose. (1)

1.2 The first-aid treatment for a burn with a soldering iron is to ...

A immediately switch off supply voltage to the soldering iron.
B immediately switch off the main switch of the building.
C rinse the wound with cold running water.
D break the blister that forms and put a plaster on. (1)

1.3 Which one of the statements is not a function of the occupational health and safety representative?

A Check the efficiency of health and safety measures.
B Identify potential threats and potential serious incidents at the workplace.
C Investigate, in coordination with the employer, the causes of incidents at the workplace.
D Repair machines and equipment that are unsafe, so that the workers can work safely. (1)

1.4 In terms of the occupational health and safety legislation (OHS Act), employees in the workplace should ...

A obey safety rules that are applicable to them personally only.
B do work that is unsafe when they receive a specific instruction.
C look after their own safety only and not that of other people.
D consider the safety of other people in their environment while they are working. (1)

1.5 What should be your very first reaction when a person in the workplace is being shocked electrically?

A Immediately report it to the supervisor.
B Immediately raise alarm.
C Immediately switch off the main switch.
D Activate the emergency stop. (1)

1.6 Identify the piece of equipment that should rather be used to strip the insulation from a conductor.

A 	C 
B 	D 

(1)

1.7 Identify the component that is used exclusively to generate square waves at a constant rate.

A 555-timer DC (IC)
B LM358 op-amp DC (IC)
C RS-latch DC (IC)
D JK-latch DC (IC) (1)

1.8 The discharge terminal of the 555-timer is found on terminal ...

A 6
B 2
C 7
D 5 (1)

1.9 The plus (+) and minus (–) signs within the symbol of the 741-operational amplifier are used to ...

A determine the output signal's polarity.
B indicate the polarity of the supply voltage terminal.
C indicate the wave amplification and wave diminishing input terminal.
D indicate the inverting and non-inverting terminals. (1)

1.10 This circuit is used to prevent switch bounce.

A Astable multivibrator
B Monostable multivibrator
C Bistable multivibrator
D Hartley oscillator (1)

1.11 Identify the circuit whose input and output waves are in phase with each other.

A 741-inverting amplifier
B 741-comparator
C 741-non-inverting amplifier
D 741-phase-shift amplifier (1)

1.12 The function of a pull-up resistor is to keep the terminal to which it is connected ...

A permanently switched on through a positive voltage.
B permanently switched off through a negative voltage.
C high until a +Vcc voltage is applied to it.
D high until a 0 V voltage is applied to it. (1)

1.13 The JFET will control the current flow through the channel by using a ...

A gate current on the gate terminal of the JFET.
B base current on the base of the JFET.
C voltage on the gate terminal of the JFET.
D voltage on the base of the JFET. (1)

1.14 The terminals of the UJT are known as the ...

A base, emitter and collector
B base 1, base 2 and emitter
C anode, cathode and gate
D HT1, HT2 and gate (1)

1.15 Positive feedback is used in amplifier circuits to ...

A obtain positive gain control in the circuit.
B create negative gain control in the circuit.
C create an oscillation frequency in the circuit.
D create signals with positive values only. (1)

[15]

QUESTION 2 SAFETY

2.1 Define the term "user" as contained in the Occupational Health and Safety Act 85 of 1999 (OHS Act). (2)

2.2 Discuss what an unsafe condition in the workplace is. (2)

2.3 Each manufacturer has duties towards the user of operational equipment. Name and explain TWO duties of the manufacturer towards the user of operational equipment. (4)

2.4 The employee has the duty to inform. Describe this duty in terms of the Occupational Health and Safety Act 85 of 1999 (OHS Act). (2)

[10]

QUESTION 3 RLC

3.1 How would the capacitive reactance react when the supply frequency to the circuit is halved? Substantiate your answer. (2)

3.2 Draw a neatly labelled graph that shows the reaction of an inductor across a wide range of frequencies. (3)

3.3 Define the term *impedance*. (2)

3.4 Describe the term *bandwidth* as applicable to RLC circuits. (2)

3.5 Study the RLC circuit shown in FIGURE 1 and then answer the questions that follow.

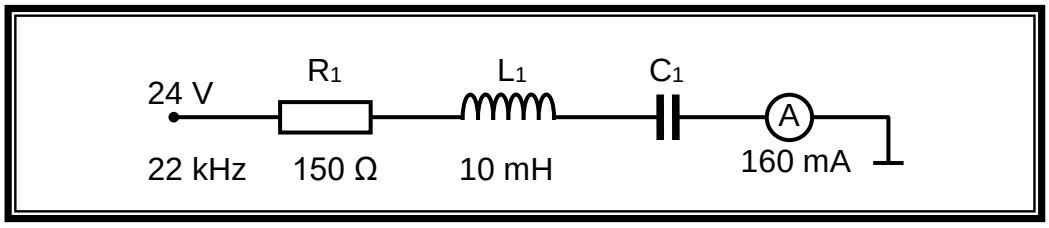

FIGURE 1

3.5.1 Calculate the inductive reactance of the inductor in the circuit. (3)

3.5.2 Determine the value of the capacitor when the circuit resonates at the given frequency. (3)

3.5.3 The voltage drop during resonance across the capacitor is 221,12 V. Find the Q factor of the circuit. (3)

3.5.4 What is the impedance of the circuit during resonance? (1)

3.6 The incomplete phasor diagram of a parallel RLC circuit is shown in FIGURE 2. Study the phasor diagram and then answer the questions that follow.

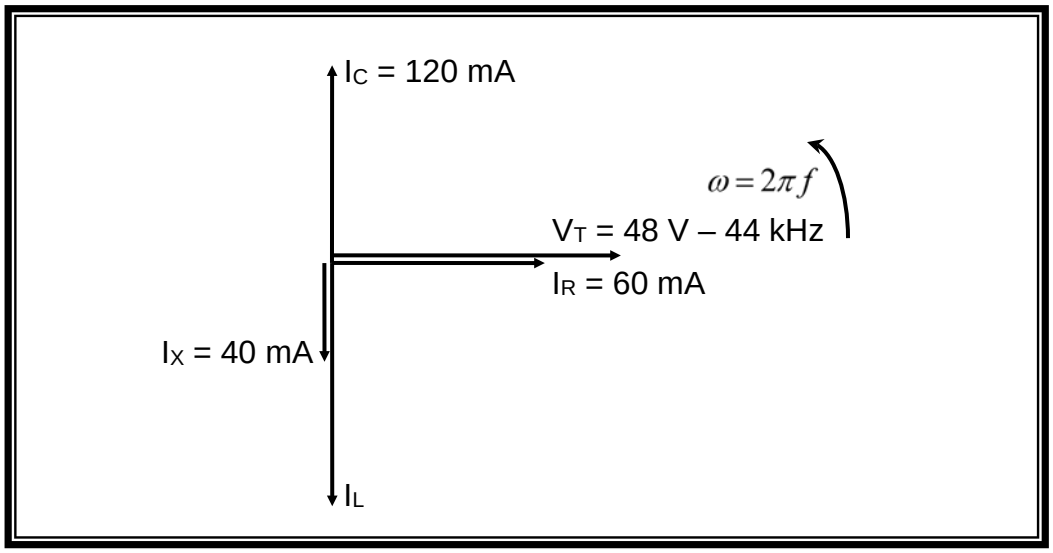

FIGURE 2

3.6.1 Calculate the total current flow that is present in the circuit. (3)

3.6.2 Determine the phase angle of the total current flow against the supply voltage. (4)

3.6.3 What is the value of the current flow through the inductor in the circuit? (3)

3.7 A series RLC circuit that was used in a practical experiment is shown in FIGURE 3. Study the circuit and the values shown and then draw the phasor diagram of the circuit.

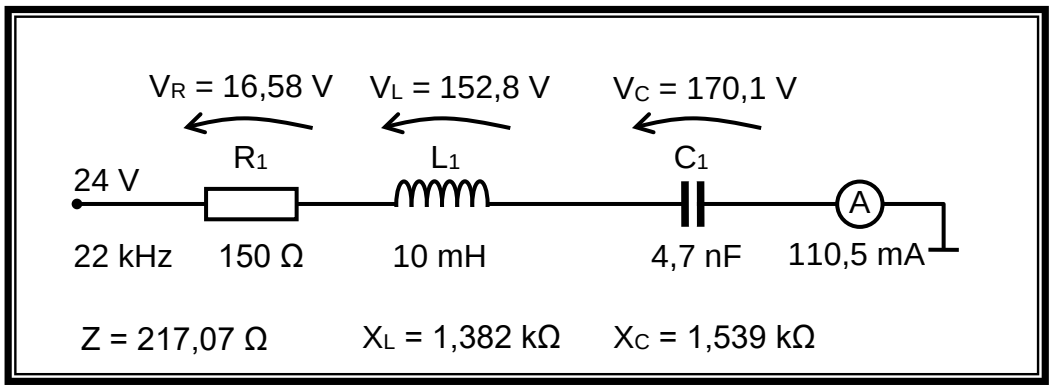

FIGURE 3

(6)
[35]

QUESTION 4 SEMICONDUCTORS

4.1 Draw a neatly labelled IEC symbol of the 741-operational amplifier. (5)

4.2 Explain what a double-polarity voltage supply (split power supply) is when using a 741-operational amplifier. (3)

4.3 A 741-operational amplifier is used as an inverting amplifier to provide an output voltage of 8,5 V_{AC}. The value of the input resistor to the circuit is 180 Ω. Determine the value of the feedback resistor in the circuit when the input voltage to the circuit is 10 mV. (3)

4.4 The IEC symbol of a 555-timer is shown in FIGURE 4. Study the figure and then provide the labels of the indicated terminals of the component by writing down only your answer next to the relevant number in your Answer Book.

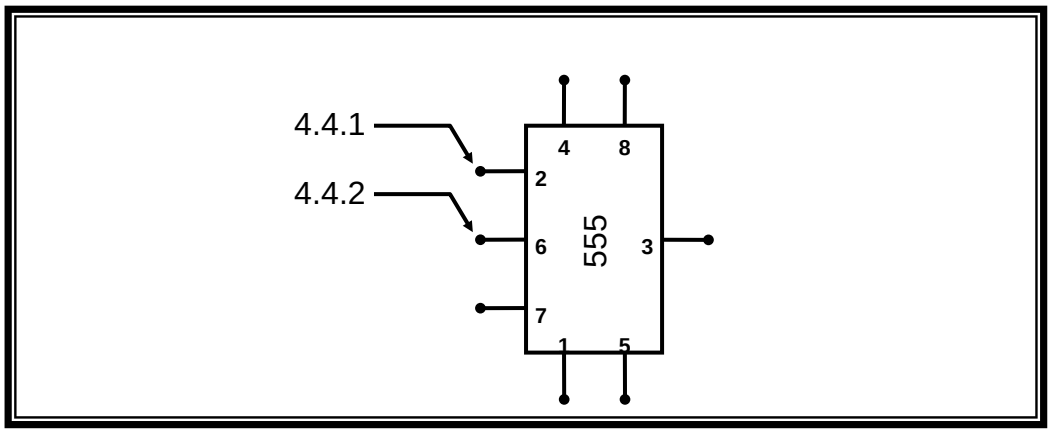

FIGURE 4

(2)

4.5 Explain the function of the three 5 kΩ resistors that are connected internally in series between terminals 1 and 8 of the 555-timer. (4)

4.6 Describe the purpose of the trigger terminal with regard to the operation of the 555-timer. (3)

4.7 The cross-sectional view of an N-CHANNEL JFET is shown in FIGURE 5. Complete the sketch of the JFET by writing down the missing labels in your Answer Book next to the relevant number.

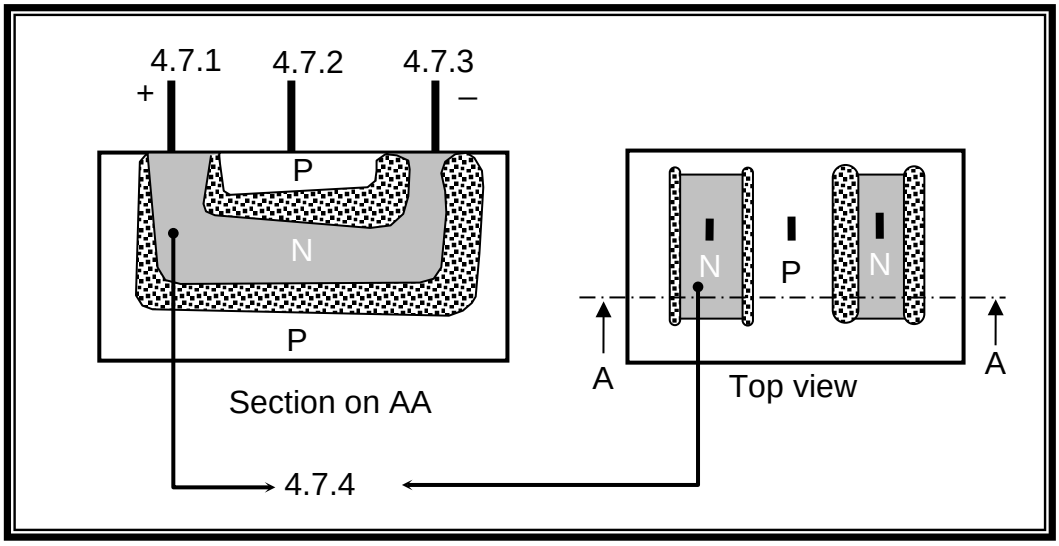

FIGURE 5

(4)

4.8 Discuss the operation of the unijunction transistor (UJT) as an electronic component. (8)

4.9 A non-inverting operational amplifier is used to amplify an input signal of 150 mV. The value of the input resistor is 1,5 kΩ and that of the feedback resistor is 33 kΩ. Determine the output voltage of the circuit. (3)

4.10 The input signal to an inverting operational amplifier is shown in FIGURE 6. Study the circuit and then answer the questions that follow.

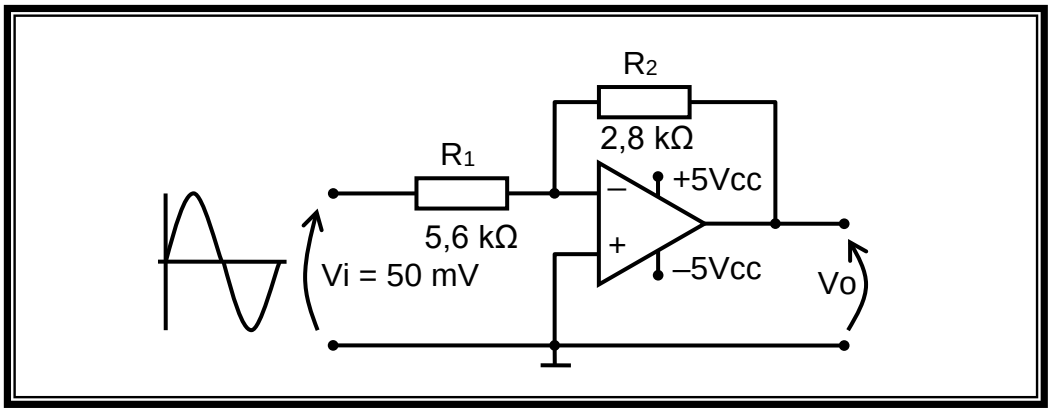

FIGURE 6

4.10.1 Calculate the gain of the circuit. (3)

4.10.2 The supply voltage of the circuit is increased from 5 V and –5 V to 9 V and –9 V. How would the output signal react to the change? Substantiate your answer. (2)

4.11 An operational amplifier circuit is shown in FIGURE 7. Study the circuit and then answer the questions that follow.

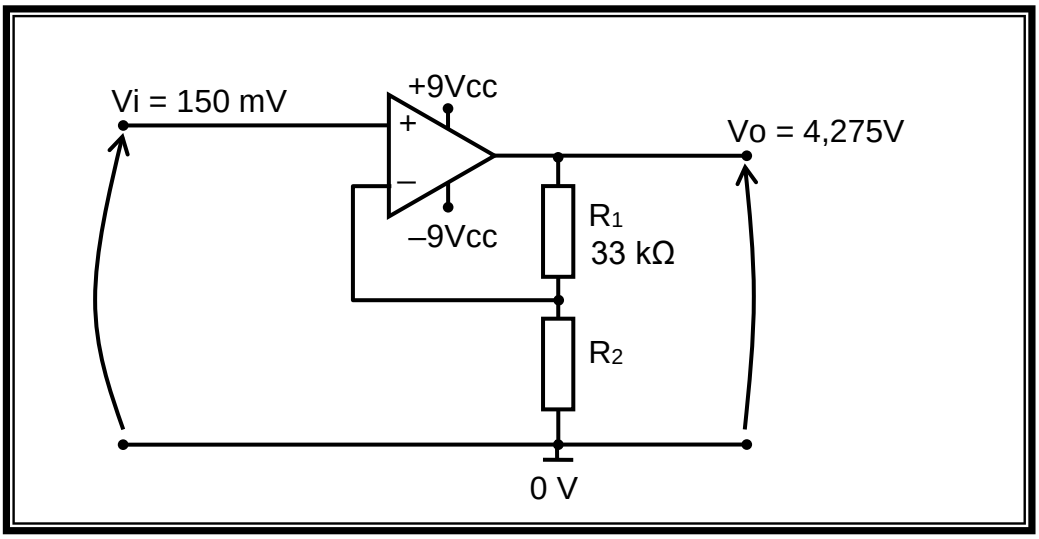

FIGURE 7

4.11.1 Identify the circuit that is shown in FIGURE 7. (1)

4.11.2 Calculate the value of resistor R_2 in the circuit. (3)

4.11.3 How would the output voltage react when the value of resistor R_1 is doubled? (1)

[45]

QUESTION 5 SWITCHING AND CONTROL CIRCUITS

5.1 Draw a neatly labelled circuit diagram to show the circuit of a monostable multivibrator that uses a 741-operational amplifier. (5)

5.2 Study FIGURE 8 showing the 741-operational amplifier where it is used as a comparator and then answer the questions that follow.

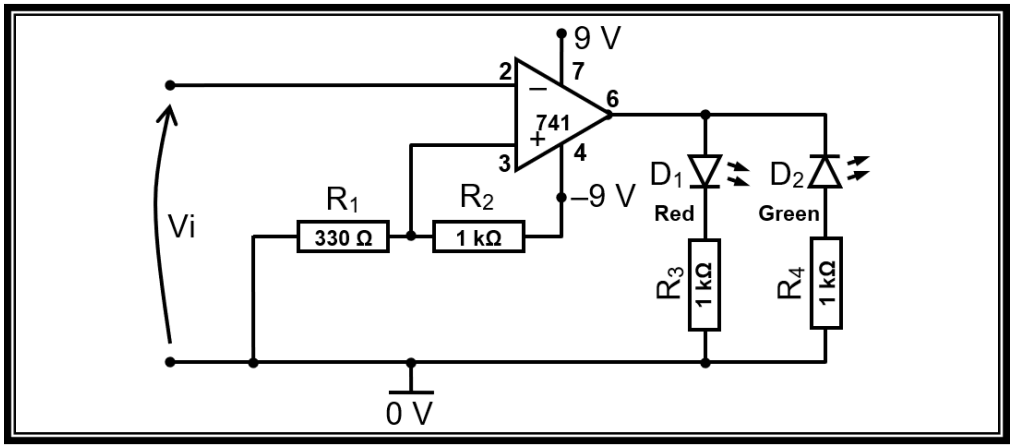

FIGURE 8

5.2.1 Explain the function of resistors R_1 and R_2 in the circuit. (2)

5.2.2 The reference voltage of the circuit is –2,2 V. Describe how the circuit would react when a –3 V input signal is applied to the circuit (4)

5.3 A 741-operational amplifier circuit is used as an adder in FIGURE 9. Three input voltages of V_1 = 10 mV, V_2 = 15 mV and V_3 = −12 mV, respectively, are applied to the inputs of the circuit. Calculate the output voltage of the circuit.

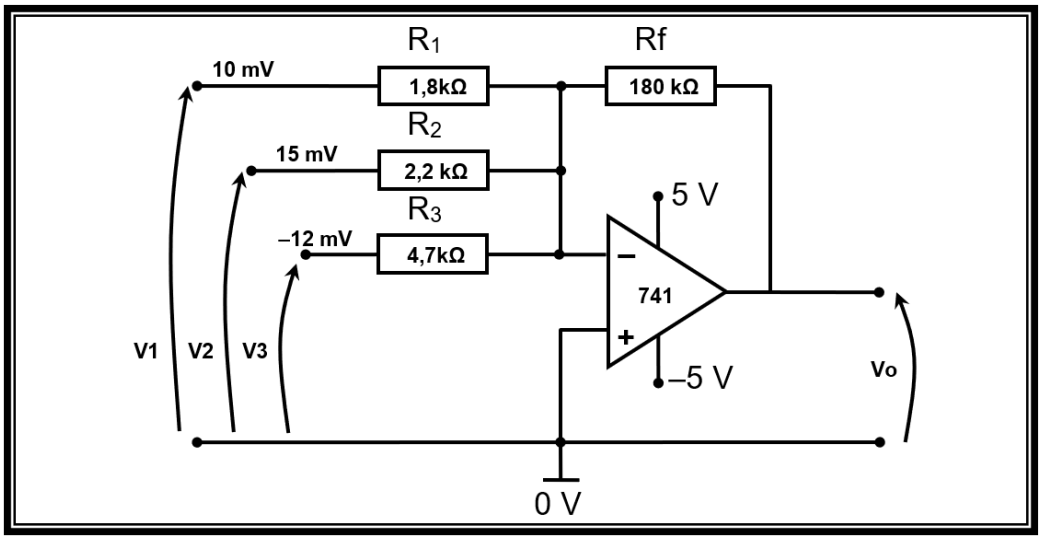

FIGURE 9

(3)

5.4 Calculate the time constant of the unstable state of a monostable 741-operational amplifier circuit when the value of the feedback resistor is 680 kΩ and that of the capacitor in the circuit is 12 ηF. (3)

5.5 A 741-operational amplifier, shown in FIGURE 10, is used to monitor the switching between two extreme values. Study the circuit and then answer the questions that follow.

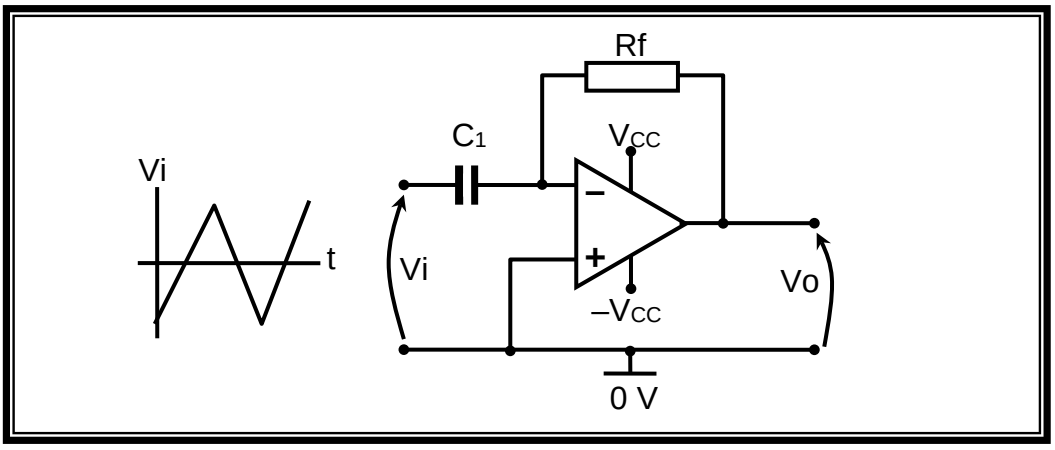

FIGURE 10

5.5.1 Identify the circuit that is shown in FIGURE 10. (1)

5.5.2 The input wave to the circuit is shown on **Answer Sheet Question 5.5.2**. Draw the expected output waves of the circuit when the RC time constant equals the pulse duration of the input wave. (2)

5.6 A 555-timer circuit is shown in FIGURE 11. Study the figure and then answer the questions that follow.

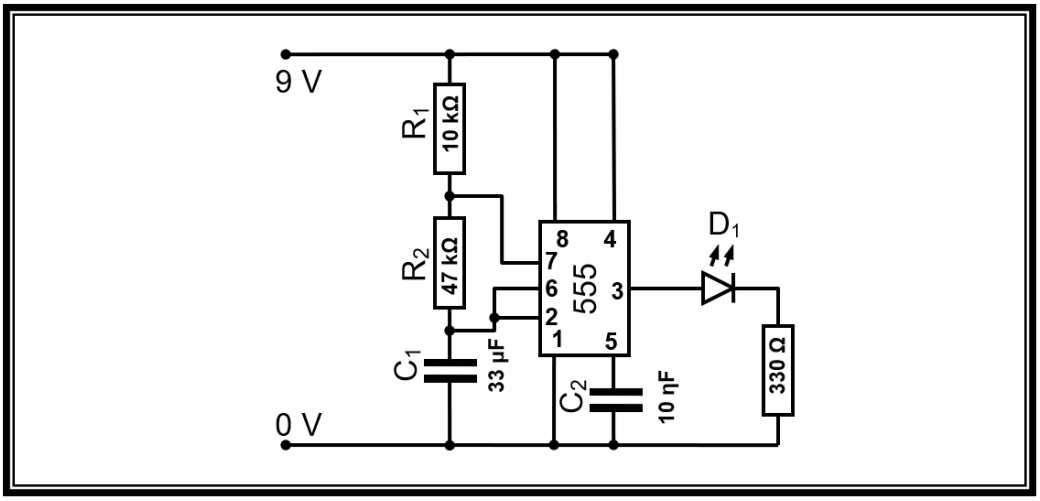

FIGURE 11

5.6.1 Identify the 555-circuit that is shown in FIGURE 11. (1)

5.6.2 Calculate the time that the LED is on. (3)

5.6.3 Describe how the circuit would switch off the LED. (5)

5.6.4 Discuss the function of resistor R_2 in the circuit. (3)

5.7 A bistable circuit that is put together using a 555-timer, consists of two resistors of 10 kΩ, two push-to-make switches and a resistor of 470 Ω and an LED on the output. The circuit is supplied with a 9 V supply voltage.

5.7.1 Draw a neatly labelled circuit diagram to show the composition of the circuit. (8)

5.7.2 FIGURE 12 shows the incomplete wave diagram of the circuit. Complete the diagram on the **Answer Sheet Question 5.7.2** by drawing the input waves for the relevant output wave of the circuit.

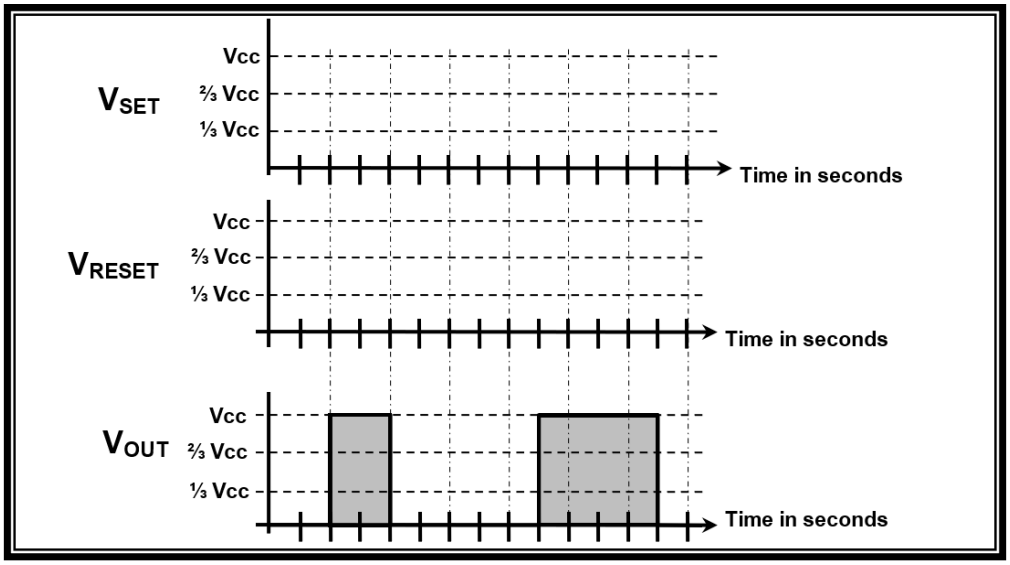

FIGURE 12

(5)

5.7.3 Explain the working principle of the bistable 555-timer circuit. (5)

[50]

QUESTION 6 AMPLIFIERS

6.1 Study the amplifier circuit that is shown in FIGURE 13 and then answer the questions that follow.

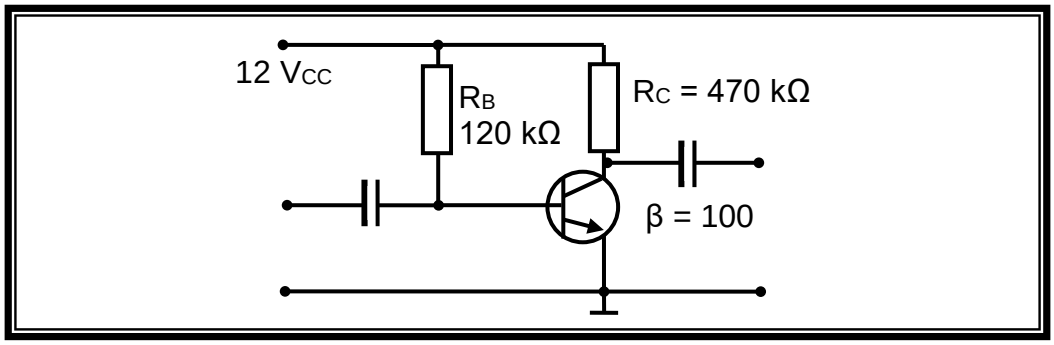

FIGURE 13

6.1.1 Calculate the maximum collector current flow in the circuit. (3)

6.1.2 Determine the maximum collector-emitter voltage that can develop across the transistor when I_C = 0A. (2)

6.1.3 Calculate the value of the base current that is applied to the transistor. (3)

6.1.4 Draw the direct-current load line and also indicate the Q point (Class A amplification) of the circuit on the direct-current load line on the common-emitter output curve that is provided on **Answer Sheet Question 6.1.4**. (3)

6.2 List THREE advantages of using negative feedback in amplifier circuits. (3)

6.3 Draw a neatly labelled frequency-response curve that shows the gain in decibels across a wide range of frequencies of the resistor-capacitor-coupled amplifier. (3)

6.4 The input signal to a resistor-capacitor-coupled amplifier is measured as 250 mV when the output of the amplifier is 3,5 V. Calculate the gain in decibels of the amplifier. (3)

6.5 The gain-frequency characteristic curve of the transformer-coupled amplifier is shown in FIGURE 14. Study the graph and explain why the gain suddenly increases at point A and then decreases.

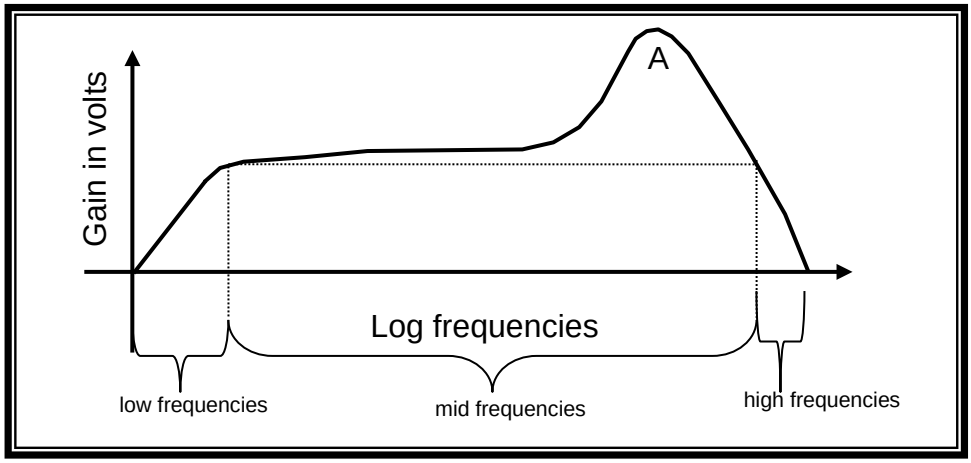

FIGURE 14

(6)

6.6 Describe the basic operation of the transformer-coupled amplifier by referring to signal amplification. (8)

6.7 A phase-shift oscillator circuit is shown in FIGURE 15. Study the circuit and then answer the questions that follow.

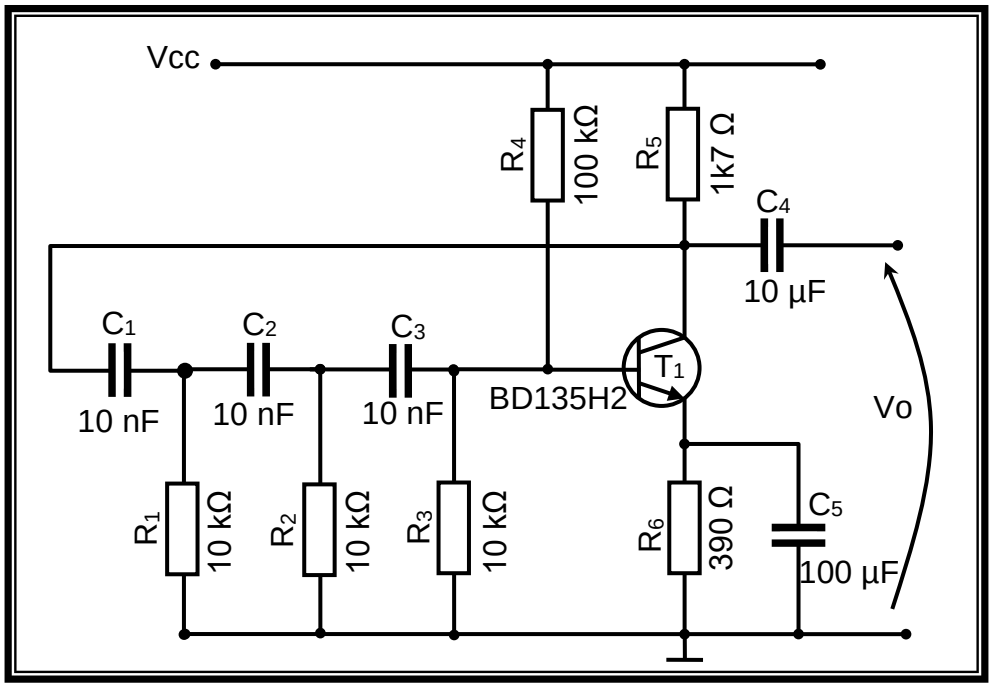

FIGURE 15

6.7.1 Determine the resonant frequency of the signal on the output of the circuit. (3)

6.7.2 Explain the operation of the circuit. (8)

[45]

Total: 200 marks