NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2021

ELECTRICAL TECHNOLOGY: ELECTRONICS

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 18 pages, an Answer Sheet of 3 pages (i–iii) 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 4.6**, **Question 5.5.4**, **Question 5.7 and Question 6.7.3**.
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 GENERAL 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 A faulty electronic circuit that causes a short circuit may lead to an electrical fire in the workplace. Which type of fire extinguisher or method of firefighting may be used on the fire?

A Wet chemical fire extinguisher

B Foam fire extinguisher

C CO_2 fire extinguisher

D Fire hose (1)

1.2 When the drill press is used, safety equipment must be used. Identify the safety equipment that is used with the drill press.

A Safety shoes, overall and hard hat.

B Safety shoes, overall, hearing protection and leather gloves.

C Safety glasses, drill vice and spark shield.

D Safety glasses and drill vice. (1)

1.3 The insulation of an electrical conductor is removed with a utility knife and the worker deeply cuts himself in the palm of his hand. What is the very first step that the first-aider should follow?

A Obtain permission to help.

B Tell the injured person to put pressure on the wound himself.

C Put on first-aid gloves.

D Rinse the wound with water. (1)

1.4 Safety signs are very important and help inform people in the workplace about safety. Which answer is the correct way to indicate the **evacuation route** of a building?

A 

B 

C 

D 

(1)

1.5 Identify the formula that would be used to determine the power factor of a series RLC circuit.

A $\cos\varnothing = \frac{Ir}{It}$

B $\cos\varnothing = \frac{Vr}{Vt}$

C $\cos\varnothing = \frac{Z}{R}$

D $\sin\varnothing = \frac{Ir}{It}$ (1)

1.6 To which input terminal of a 741 operational amplifier would a signal be connected if the output signal is out of phase with the input signal?

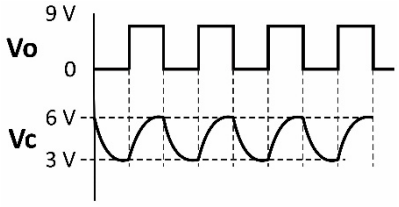
A Terminal 2

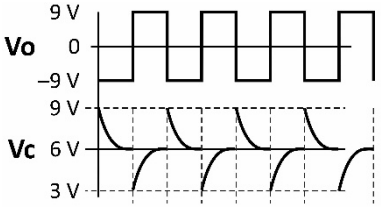
B Terminal 3

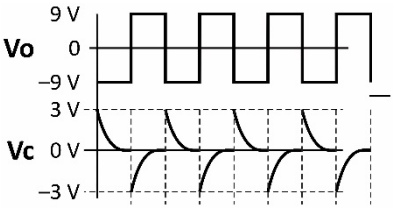
C Terminal 1

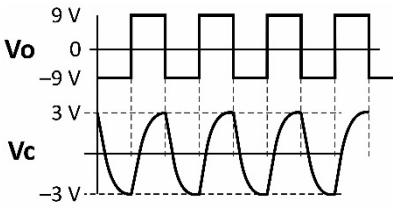
D Terminal 4 (1)

1.7 Select the correct waveform for a 555-timer astable multivibrator circuit.

A 

C 

B 

D 

(1)

1.8 Which 741 operational amplifier circuit would amplify an input signal in phase without distorting the output signal?

A Inverting amplifier

B Non-inverting amplifier

C Voltage-follower amplifier

D Schmitt trigger amplifier (1)

1.9 What is the function of a bistable multivibrator?

A To switch on a circuit.

B To generate a controlled clock pulse.

C To form a debounce circuit.

D To set and reset the output of a multivibrator circuit. (1)

1.10 What is a simple balanced amplifier also known as in practice?

A A Class B amplifier.

B A common-emitter amplifier.

C A Darlington pair.

D A push-pull amplifier. (1)

1.11 Which of the following advantages does not match **negative feedback**?

A Reduce noise and distortion.

B Improve stability.

C Increase bandwidth.

D Increase amplification. (1)

1.12 State the characteristic curve whereby the resonance of the output-matched impedance of transformer-coupled amplifiers may be observed.

A The input characteristic curve.

B The output characteristic curve.

C The frequency-response curve.

D The hysteresis curve. (1)

1.13 Oscillators can be classified into two broad groups. Name them.

A Colpitts and Harley oscillators

B Crystal and radio-frequency oscillators

C Sine-wave oscillators and relaxation oscillators.

D RC and Wien bridge oscillators. (1)

1.14 The basic circuit of an oscillator mainly consists of the following well-known circuits:

A Amplifiers

B RCL circuits

C Feedback circuits

D All of the above (1)

1.15 Amplifiers are part of oscillators. Which one is the most correct description of such an amplification?

A Amplifiers connect as Class A, Class B or Class AB amplifiers.

B Amplifiers that are connected as symmetry amplifiers.

C Amplifiers with negative feedback and a gain of 1.

D Amplifiers with positive feedback and a gain of 1. (1)

[15]

QUESTION 2 OCCUPATIONAL HEALTH AND SAFETY

2.1 Define *qualitative risk analysis*. (2)

2.2 Describe **THREE** standard treatments for electric shock after the electricity supply has been removed. (3)

2.3 Explain why you should protect yourself when you are assisting a person who is being shocked by electricity. (1)

2.4 Explain why a person should not misuse or fiddle with the safety equipment that is provided for safety or health in the workshop. (2)

2.5 Explain why poor ventilation is an unsafe condition in the workshop. (2)

[10]

QUESTION 3 RLC CIRCUITS

3.1 Define the term *impedance* by referring to RLC circuits. (3)

3.2 **FIGURE 1** below shows an RLC series circuit consisting of a 12 Ω resistor, a 30 mH inductor and a 150 µF capacitor all connected to a 120 V/60 Hz input.

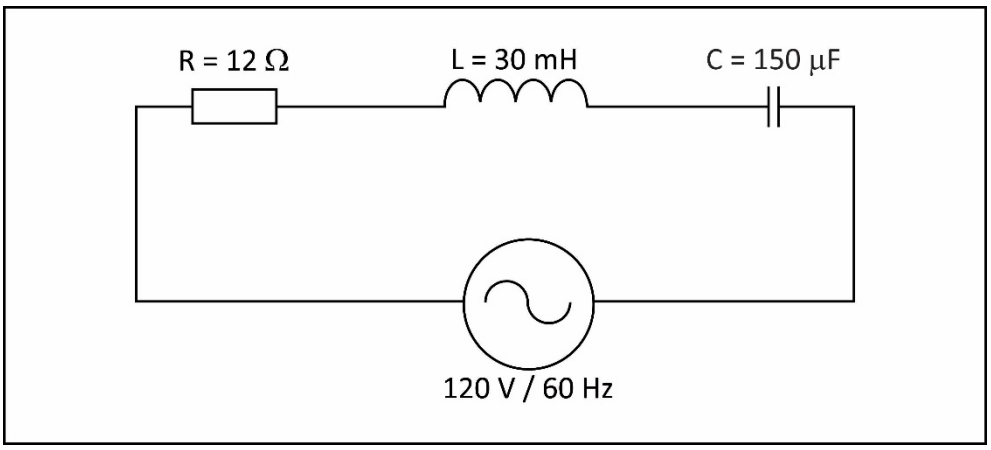


FIGURE 1

Calculate the:

3.2.1 Inductive reactance (3)

3.2.2 Capacitive reactance (3)

3.2.3 Impedance (3)

3.2.4 Total flow of current (3)

3.2.5 Power factor (3)

3.2.6 Indicate whether the phase angle is leading or lagging. (1)

3.3 Explain how the value of the *inductive reactance* would be affected if the input frequency is doubled. (2)

3.4 **FIGURE 2** below shows an RLC parallel circuit consisting of a 40 Ω resistor, an inductor with unknown inductance and a capacitor with a capacitive reactance of 60 Ω all connected to a 220 V/60 Hz input. Answer the questions that follow.

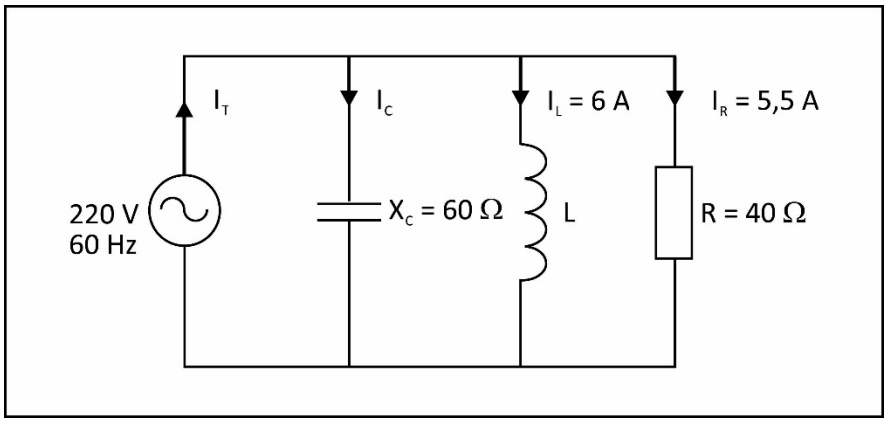


FIGURE 2

3.4.1 Calculate the current through the capacitor. (3)

3.4.2 Calculate the reactive current. (3)

3.4.3 Indicate, giving a reason, whether the phase angle is leading or lagging. (2)

3.5 **FIGURE 3** shows an RC circuit. Draw neatly labelled **output curves** showing the voltage and the current of the circuits in questions 3.5.1 and 3.5.2.

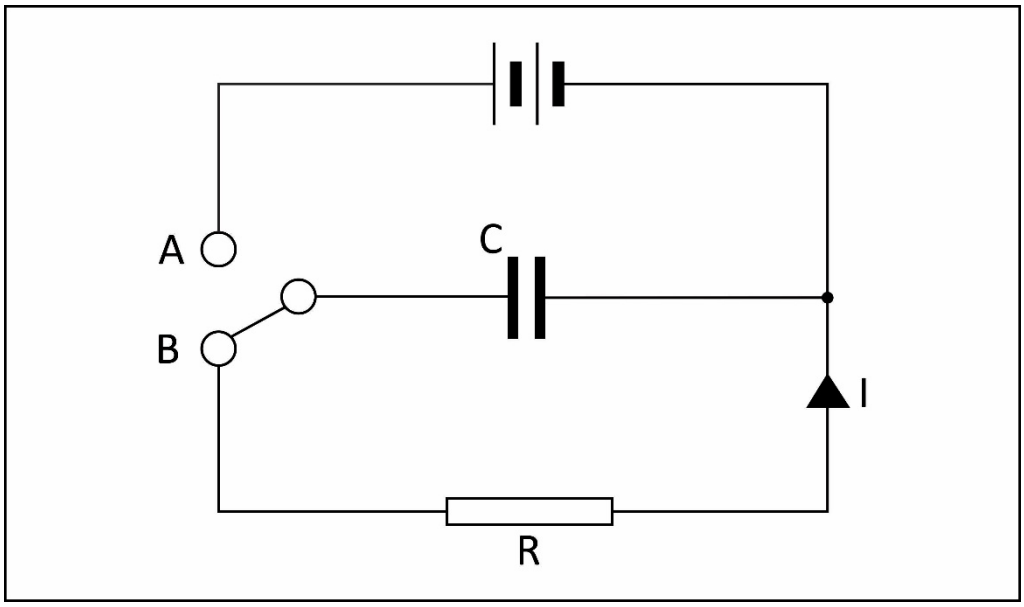


FIGURE 3

3.5.1 Capacitor-charging circuit (4)

3.5.2 Capacitor-discharging circuit (4)

3.6 List **THREE** characteristics of an RLC series circuit at resonance. (3)

[40]

QUESTION 4 SEMICONDUCTOR DEVICES

4.1 Draw a fully labelled symbol of a P-channel JFET. (3)

4.2 Name **TWO** applications of a FET. (2)

4.3 Refer to **FIGURE 4** below and answer the questions that follow.

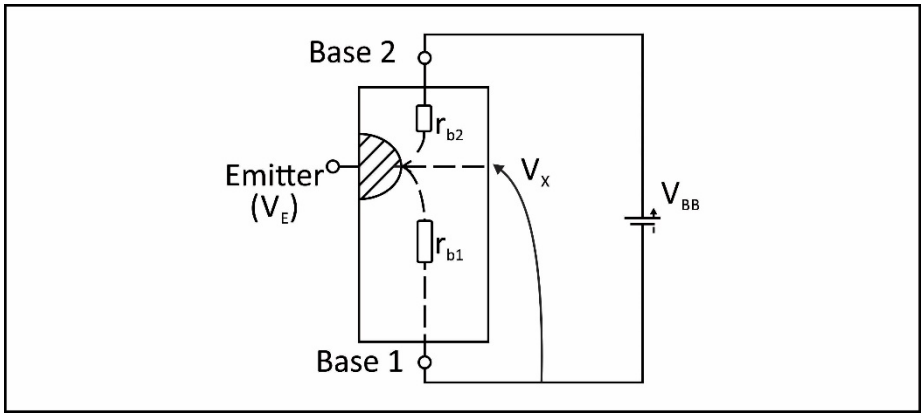


FIGURE 4

4.3.1 State how the intrinsic stand-off ratio is determined. (2)

4.3.2 Explain what happens when the voltage on the emitter terminal (V_E) is increased above V_X. (2)

4.4 A Darlington pair is an "amplifier using two transistors". Answer the following questions:

4.4.1 Draw a fully labelled circuit diagram of a two transistor Darlington-pair transistors. (3)

4.4.2 Calculate the total gain (β) if each transistor has a gain of 50. (2)

4.5 **FIGURE 5** below shows the 741 operational amplifier (op-amp). Answer the questions that follow.

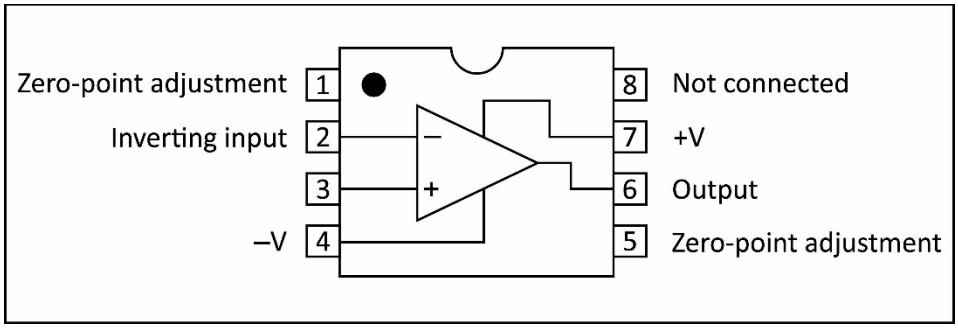


FIGURE 5

4.5.1 Label pin 3. (1)

4.5.2 State the type of package in which the integrated circuit (IC) above would be built. (1)

4.6 On **Answer Sheet 4.6**, draw the output signal if the input signals in **FIGURE 6** below are applied to the inputs of an op-amp.

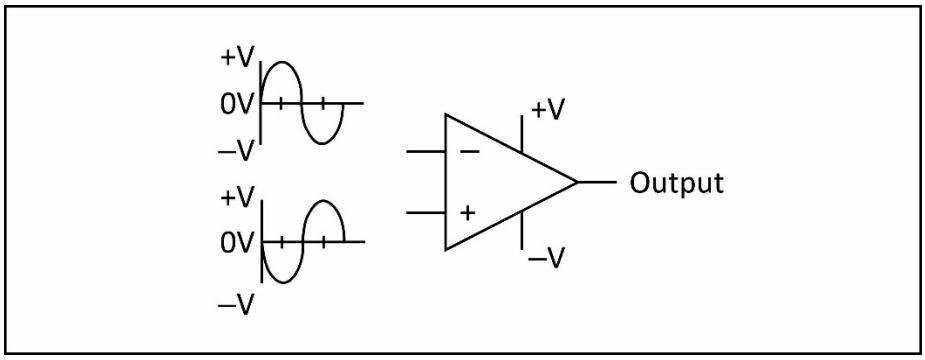


FIGURE 6 (2)

4.7 **FIGURE 7** below shows the internal block diagram of the 555 IC. Answer the questions that follow.

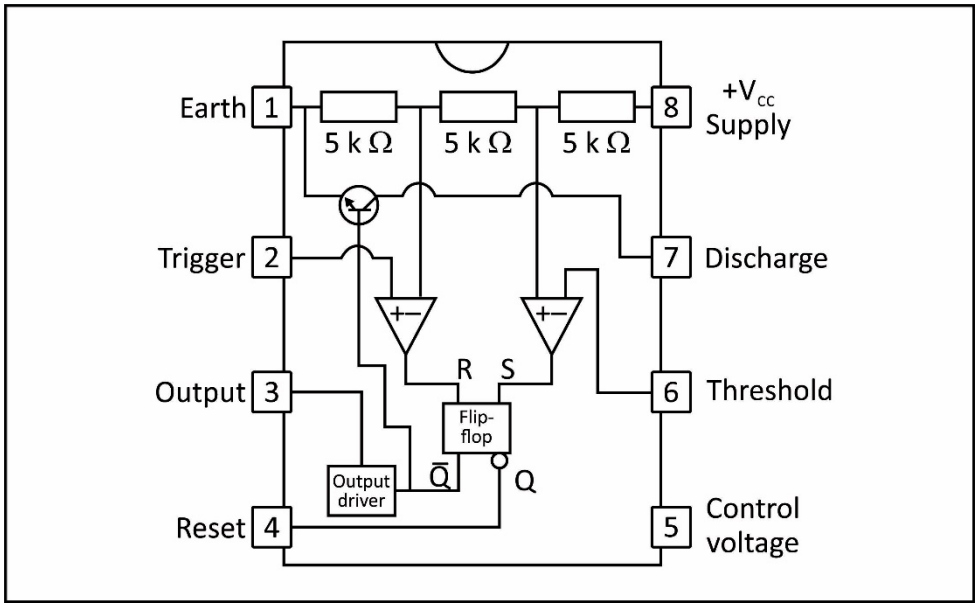


FIGURE 7

4.7.1 List the **THREE** primary building blocks of the 555 IC. (3)

4.7.2 Explain the function of the three 5 kΩ resistors. (2)

4.7.3 Explain what would happen to the output of an NE555 IC when the trigger voltage exceeds the maximum threshold-voltage level. (2)

[25]

QUESTION 5 SWITCHING CIRCUITS

5.1 Refer to **FIGURE 8** below and answer the questions that follow.

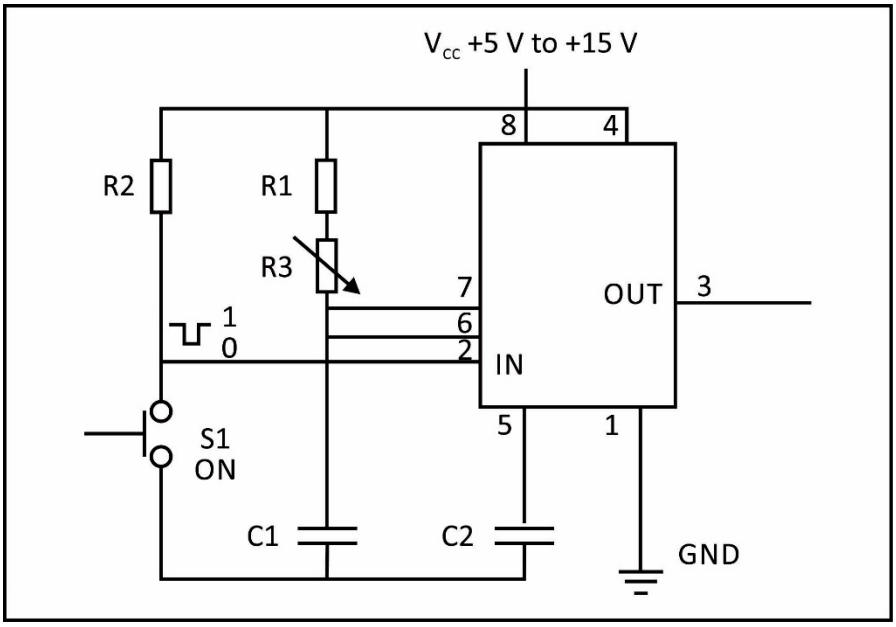


FIGURE 8

5.1.1 Explain the function of R_1 in the circuit. (2)

5.1.2 State **TWO** methods to vary the time period of the circuit. (2)

5.1.3 State the effect on the output waveform if R_3 is changed from 10 kΩ to 27 kΩ. (1)

5.2 Define the term *bistable multivibrator*. (3)

5.3 **FIGURE 9** below shows typical waveforms of the 741 op-amp that is connected as a monostable multivibrator. Answer the questions that follow.

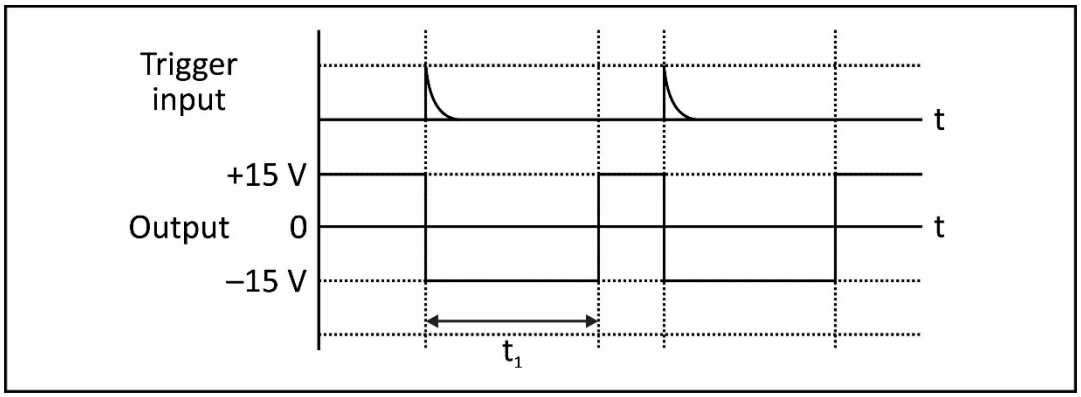


FIGURE 9

5.3.1 Explain what happens to the output with regard to t_1 when a trigger input is received. (3)

5.3.2 State how the time period t_1 can be varied. (2)

5.3.3 Explain the voltage-swing process that takes place at the output when a trigger pulse is received. (3)

5.4 Draw a fully labelled circuit of an *astable multivibrator* by using an operational amplifier (op-amp). (8)

5.5 Refer to **FIGURE 10** below and answer the questions that follow.

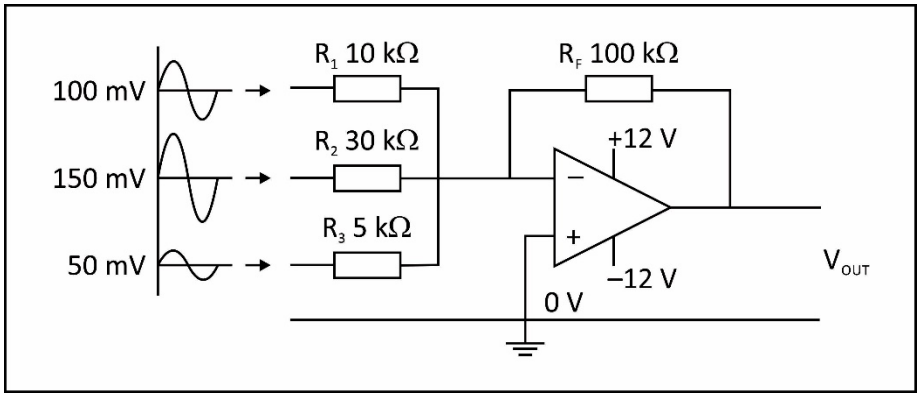


FIGURE 10

5.5.1 Calculate the output voltage. (3)

5.5.2 Explain how this circuit can be modified to independently control the input voltage of each signal. (2)

5.5.3 Explain how this circuit can be modified to prevent DC from being fed back to the input-voltage sources. (2)

5.5.4 Draw the output signal of the circuit on your **Answer Sheet 5.5.4**. (2)

5.6 Refer to **FIGURE 11** below and answer the questions that follow.

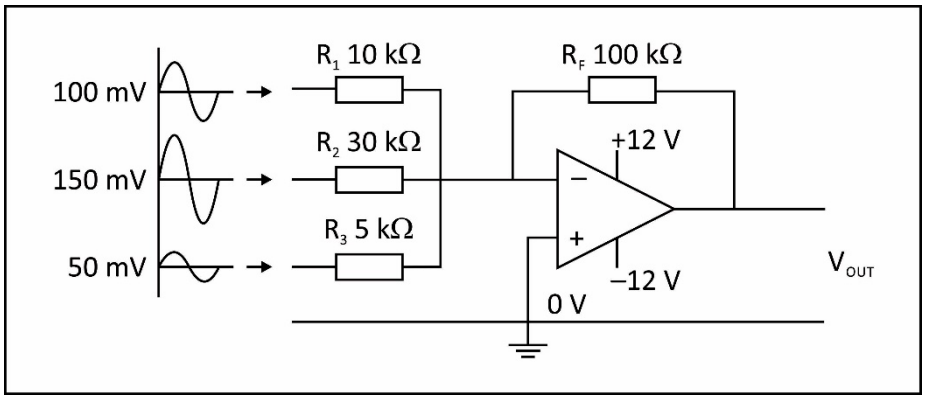


FIGURE 11

5.6.1 Identify the amplifier in **FIGURE 11**. (2)

5.6.2 Name the type of feedback that is provided by R_F. (1)

5.6.3 Calculate the output voltage of the amplifier. (3)

5.7 **FIGURE 12** below shows an operational amplifier (op-amp) as a differentiator. On **Answer Sheet 5.7**, draw the output signals of the amplifier when the following signals are applied to the circuit:

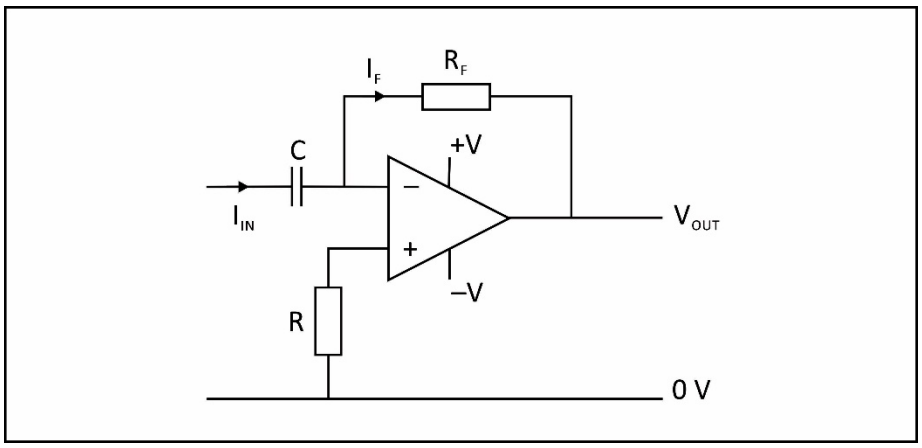
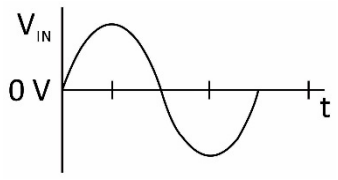


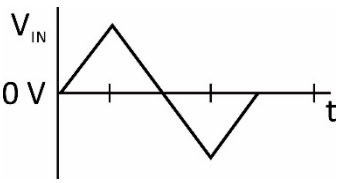
FIGURE 12

5.7.1 Sine wave



(3)

5.7.2 Triangular wave



(3)

5.8 Refer to **FIGURE 13** below and answer the questions that follow.

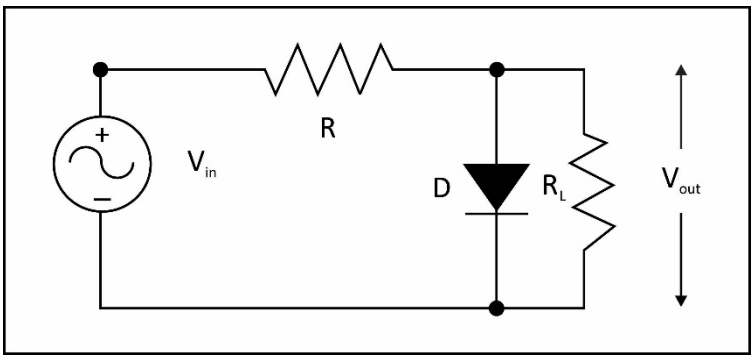


FIGURE 13

5.8.1 Identify and briefly describe the purpose of the circuit diagram in **FIGURE 13**. (3)

5.8.2 Draw the output wave of the circuit diagram in your **Answer Book**. (3)

5.9 Draw a labelled circuit diagram of a positive *clamping circuit*. (4)

[55]

QUESTION 6 AMPLIFIERS

6.1 Refer to **FIGURE 14** below and answer the questions that follow.

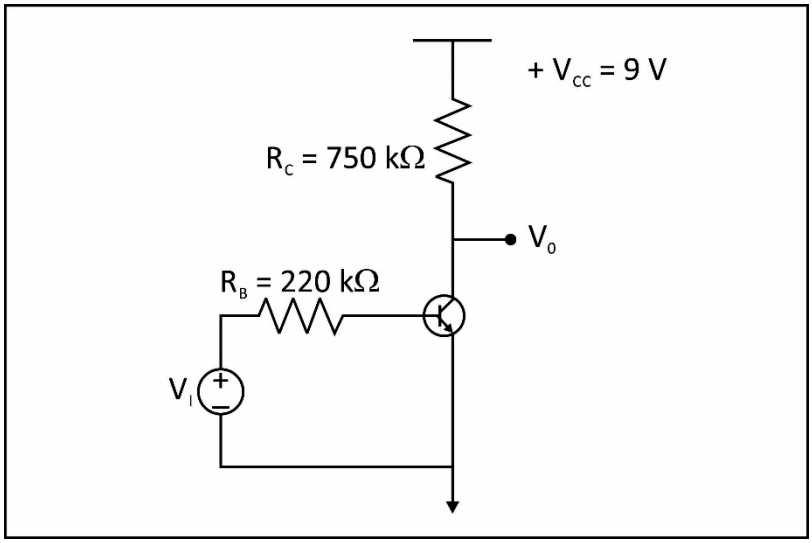


FIGURE 14

6.1.1 Calculate the maximum collector voltage. Give a reason for your answer. (4)

6.1.2 Calculate the maximum collector current. (3)

6.2 Use the given information to answer the following questions:

6.2.1 Calculate the voltage gain of an amplifier if voltage of 4 V was measured across the input terminals and 6,2 V across the output terminals. (3)

6.2.2 An 850 mW signal is applied to the input of an amplifier. The output signal is amplified to 29 W at the output. Calculate the gain of the amplifier. (3)

6.3 Refer to **FIGURE 15** below and answer the questions that follow.

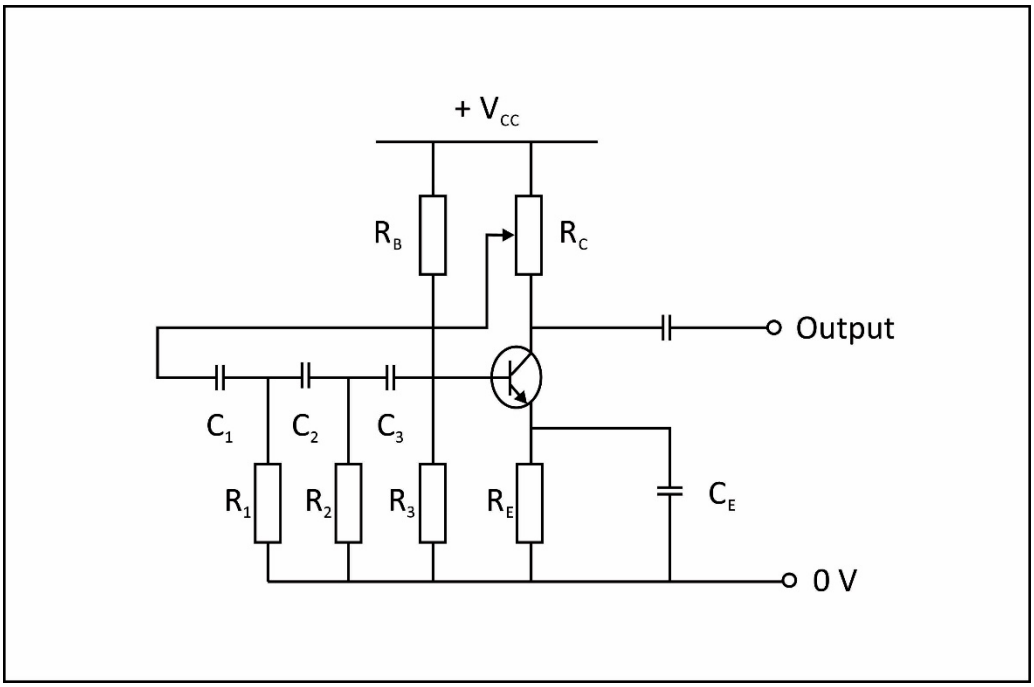


FIGURE 15

6.3.1 Give the type of feedback that is used in the circuit diagram above. (1)

6.3.2 Name ONE application of the RC phase-shift oscillator. (1)

6.4 **FIGURE 16** below shows a radio-frequency amplifier. Answer the questions that follow.

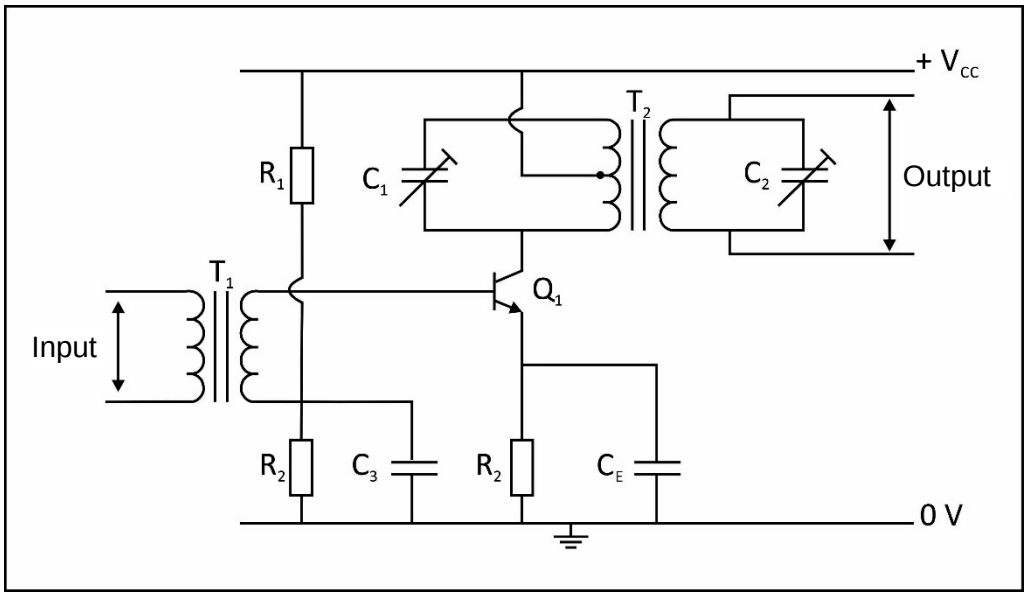


FIGURE 16

6.4.1 Explain how the radio-frequency amplifier differs from other amplifiers by referring to frequency. (2)

6.4.2 Discuss the function of the tuned circuit that is formed by the second transformer (T_2) and capacitors (C_1 and C_2). (3)

6.4.3 Describe how the radio-frequency amplifier circuit can be modified to handle a series of frequencies instead of letting through only a single frequency. (3)

6.5 **FIGURE 17** below shows a FET-LC oscillator. Answer the questions that follow.

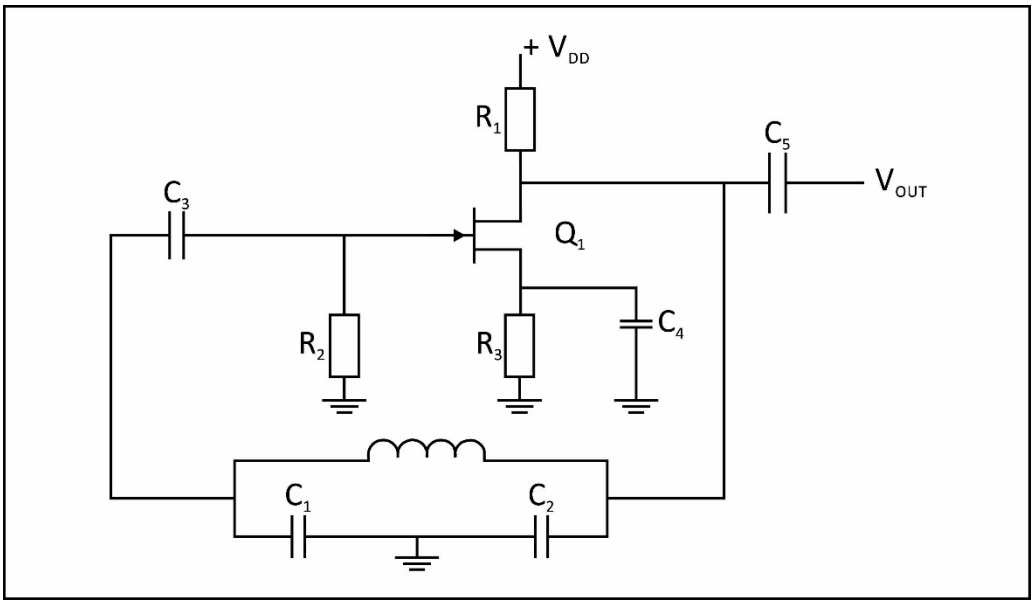


FIGURE 17

6.5.1 Define the term *oscillator*. (2)

6.5.2 Differentiate between the voltages that would develop across C_1 and C_2. (2)

6.5.3 Name the function of the following components in **FIGURE 17**:

(i) R_2 (1)

(ii) C_4 (1)

6.6 Refer to **FIGURE 18** below, showing an RC phase-shift oscillator that uses a FET. Answer the questions that follow.

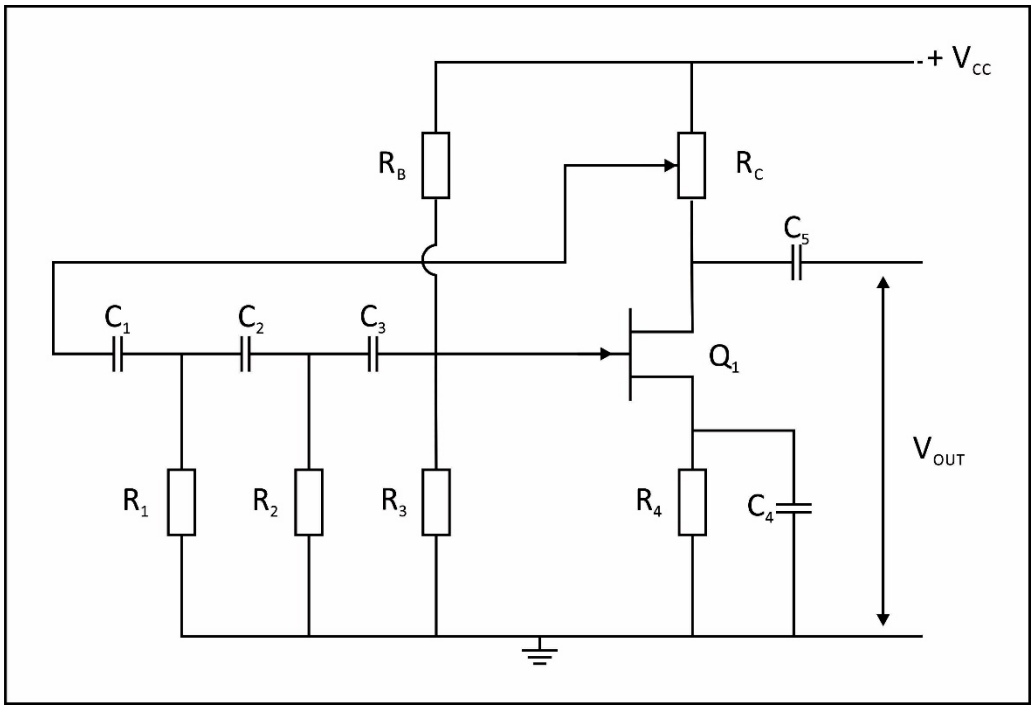


FIGURE 18

6.6.1 Name TWO functions of the *RC network*. (2)

6.6.2 Describe how the frequency of the *phase-shift oscillator* can be adjusted. (3)

6.7 Refer to **FIGURE 19** below and answer the questions that follow.

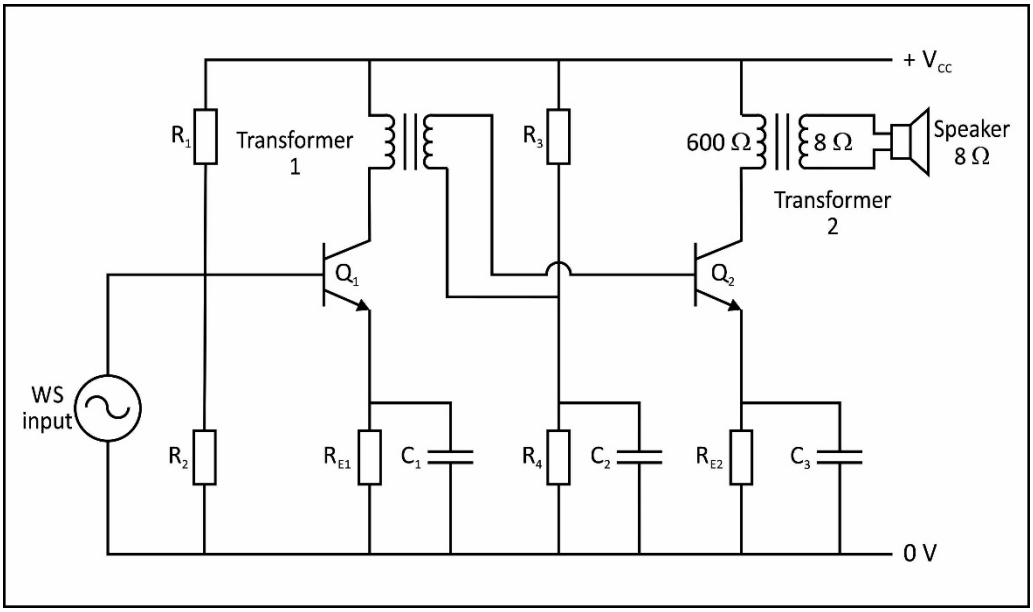


FIGURE 19

6.7.1 Describe how proper impedance matching between the transistor of the first stage and the transistor of the second stage can be obtained. (2)

6.7.2 Explain why a *transformer* is used at the output of the amplifier. (3)

6.7.3 Draw the *output-frequency-response curve* of the amplifier circuit on **Answer Sheet 6.7.3**. (6)

6.8 Table 1 indicates information on a **push-pull-amplifier circuit**. Answer the questions that follow.

Input power	3 015 watt
Output power	1 200 watt
Input voltage	230 V
Output voltage	219 V
Output current	5.48 A
Output impedance	40 Ω

TABLE 1

Calculate the following:

6.8.1 Power gain in dB (3)

6.8.2 Voltage gain in dB (3)

6.9 State TWO advantages of a *transformer-coupled amplifier*. (2)

6.10 *Radio-frequency (RF) amplifiers* have various uses. Give TWO. (2)

[55]

Total: 200 marks