NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2020

ELECTRICAL TECHNOLOGY: ELECTRONICS

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 20 pages, a Formula Sheet of 1 page (i) and an Answer Sheet of 6 pages (i–vi). Please check that your question paper is complete.

2. Read the questions carefully.

3. ALL questions must be answered.

4. Answer the following questions on the attached ANSWER SHEET:
   - Question 2.7
   - Question 4.3.2
   - Question 4.4.1
   - Question 4.5.2
   - Question 4.9.1
   - Question 5.2.1
   - Question 5.2.2
   - Question 5.6.4
   - Question 5.6.5
   - Question 5.7.3
   - Question 5.8.3

5. Start each of the rest of the questions on a new page in your Answer Book.

6. Do not write in the margin.

7. Number your answers exactly as the questions are numbered.

8. You may use a non-programmable calculator.

9. All formulas and calculations must be shown.

10. Round off final answers to a MINIMUM of TWO decimal places.

11. It is in your own interest to write legibly and to present your work neatly.

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QUESTION 1 OCCUPATIONAL HEALTH AND SAFETY

1.1 Describe how teamwork improves work ethics. (2)

1.2 Explain why horseplay in the workshop is an unsafe act. (2)

1.3 Name TWO functions of a health and safety representative. (2)

1.4 Define the term *accident* with reference to the Occupational Health and Safety Act (No. 85 of 1993). (3)

1.5 Name ONE unsafe condition that can cause accidents in a workshop. (1)

[10]

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QUESTION 2 RLC CIRCUITS

2.1 Define the term *quality factor* (Q) with reference to a parallel resonant circuit. (2)

2.2 List THREE factors that affect the impedance of an RLC circuit. (3)

2.3 During series resonant frequency of an RLC circuit, there are specific states that occur. Indicate any TWO. (2)

2.4 An RLC circuit is shown in FIGURE 1 below. The circuit consists of a 20 Ω resistor, an inductor with an inductive reactance of 30 Ω and a capacitor with a capacitive reactance of 40 Ω connected across a 120 V/60 Hz supply voltage. Answer the questions that follow.

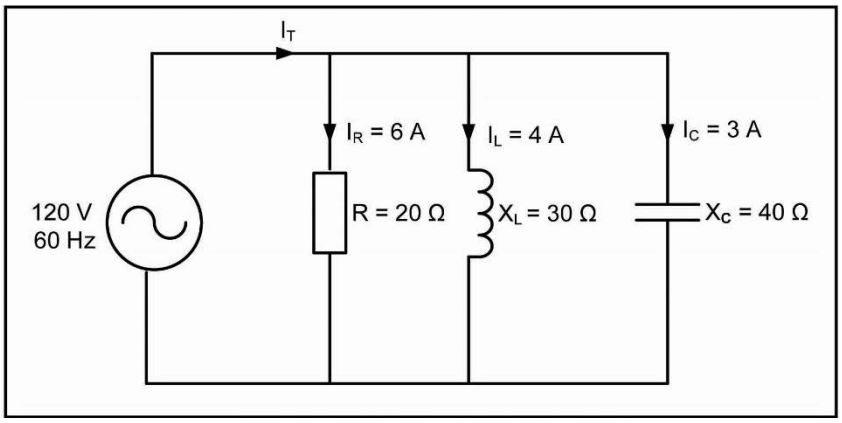

FIGURE 1

2.4.1 Calculate the total current in the circuit. (3)

2.4.2 Calculate the phase angle. (3)

2.4.3 Is the phase angle leading or lagging? Motivate your answer. (3)

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2.5 A coil with a negligible resistance has an inductance of 80 mH and is connected in series with a 33 µF capacitor and a 30 Ω resistor. The circuit is then connected to a 120 V alternating current supply with a variable frequency.

Calculate the following:

2.5.1 Resonant frequency. (3)

2.5.2 Current at resonance. (3)

2.5.3 Voltage drop across the inductor at resonance if the inductive reactance is 49,24 Ω. (3)

2.6 An RLS phasor diagram is shown in FIGURE 2. Answer the questions that follow.

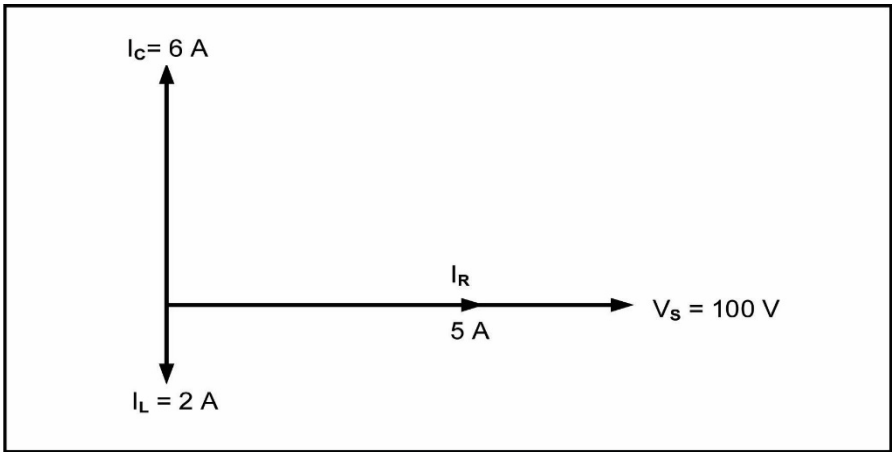

FIGURE 2

2.6.1 Calculate the following:

(a) Inductive reactance (3)

(b) Capacitive reactance (3)

(c) Reactive current (3)

(d) Total current (3)

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

2.7 Draw the current and voltage wave forms of a pure capacitive circuit on page i of the **ANSWER SHEET** to show the phase relationship. (2)

[40]

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QUESTION 3 SEMICONDUCTOR DEVICES

3.1 State whether field-effect transistors are current-controlled or voltage-controlled devices. (1)

3.2 Refer to FIGURE 3 below that shows the output characteristic curve for both enhancement- and depletion-mode field-effect transistors. Answer the questions that follow.

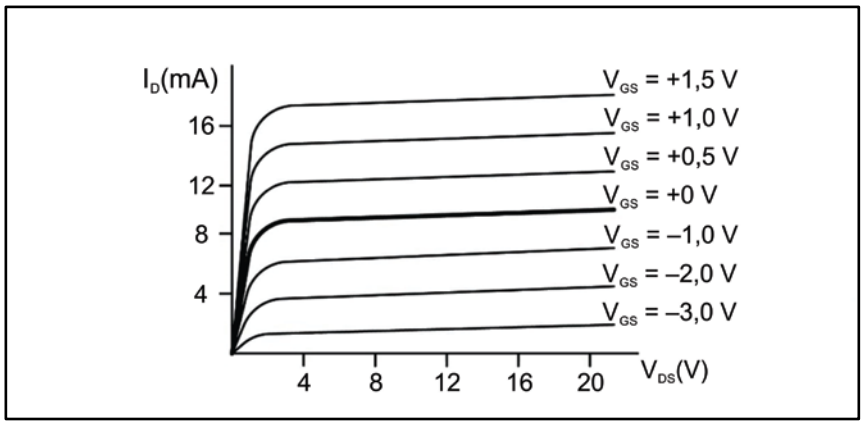

FIGURE 3

3.2.1 State the mode in which the MOSFET will operate for VGS > 0 V. (1)

3.2.2 Determine the drain-source current (IDS) of the curve when the drain-source voltage (VDS) is 12 V and the gate-source voltage (VGS) is –2 V. (1)

3.2.3 Explain why the gate material represented by the output characteristic curve in FIGURE 3 above is a p-type material. (4)

3.3 Study the symbol in FIGURE 4 below and answer the questions that follow.

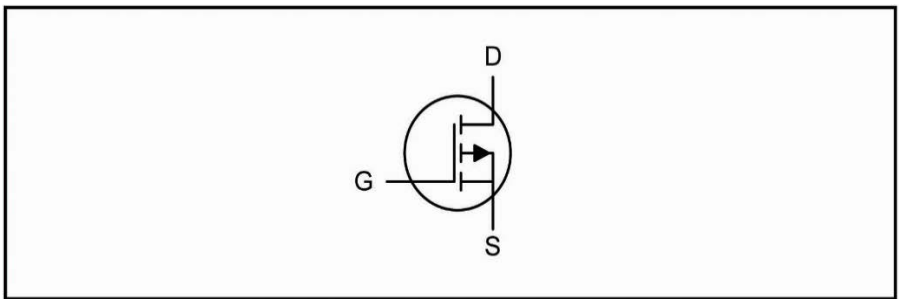

FIGURE 4

3.3.1 Identify the field-effect transistor (FET). (1)

3.3.2 List THREE states for the correct biasing of the transistor in the figure. (3)

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3.4 FIGURE 5 below shows the characteristic curve of a unijunction transistor (UJT). Study the curve and answer the questions that follow.

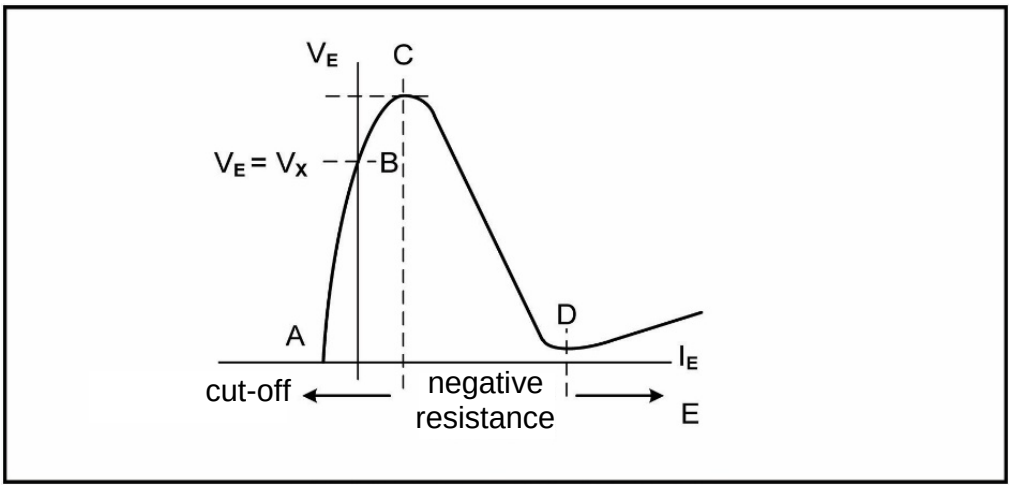

FIGURE 5

3.4.1 Identify region E. (1)

3.4.2 Explain what happens in the UJT between points C and D of the characteristic curve. (3)

3.5 Refer to FIGURE 6 below and answer the questions that follow.

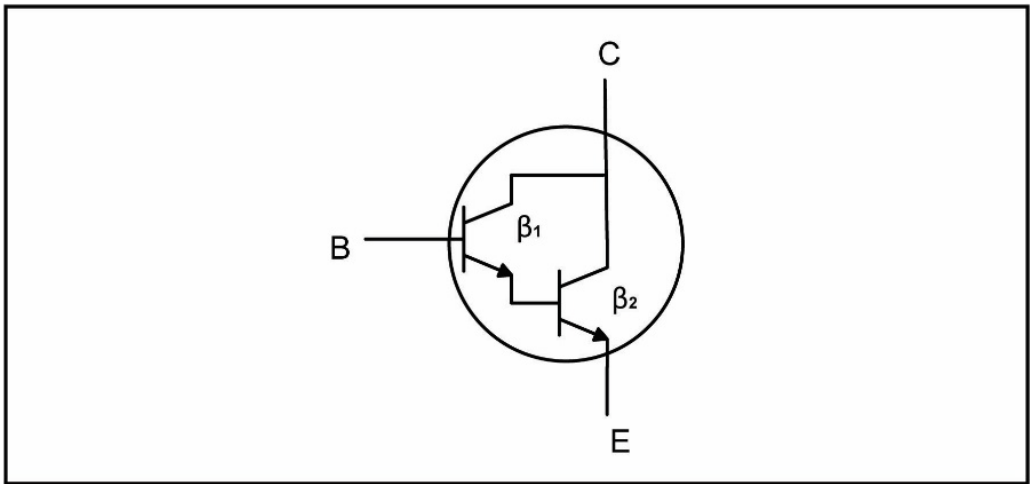

FIGURE 6

3.5.1 Identify the configuration in which the transistors are connected. (1)

3.5.2 State TWO advantages of the transistor configuration in FIGURE 6. (2)

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3.6 FIGURE 7 below shows an op-amp connected as an inverting amplifier. Answer the questions that follow.

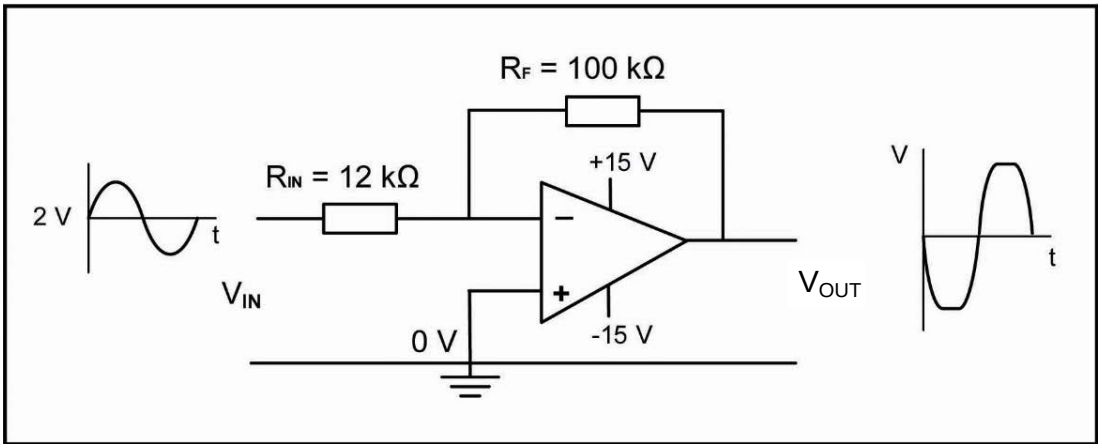

FIGURE 7

3.6.1 Calculate the output voltage based on the data in FIGURE 7. (3)

3.6.2 Explain why the shape of the output waveform is NOT an exact replica of the input waveform. (2)

3.6.3 Determine the maximum output voltages (V_{out}). (2)

3.7 State TWO uses of the 555 integrated circuit (IC). (2)

3.8 Explain the purpose of the three internally connected series resistors in a 555 IC. (3)

[30]

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QUESTION 4 SWITCHING CIRCUITS

4.1 With reference to the Schmitt trigger, draw a fully labelled hysteresis output characteristic curve that describes the principle of backlash. (6)

4.2 A 555 time regulator is connected as a bistable multivibrator in FIGURE 8. Refer to the multivibrator and answer the questions that follow.

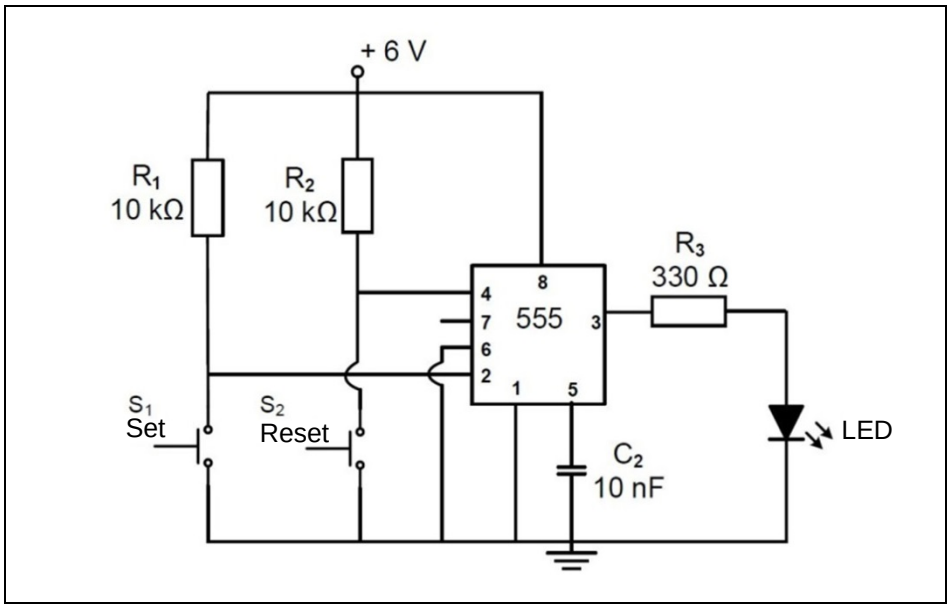

FIGURE 8

4.2.1 State the function of resistors R_1 and R_2. (2)

4.2.2 Describe what happens when the set switch, S_1, is pressed. (3)

4.2.3 Explain why threshold pin 6 is connected directly to ground. (3)

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4.3 The 555 DC astable multivibrator circuit with a voltage graph of capacitor C_1 is shown in FIGURE 9. Answer the questions that follow.

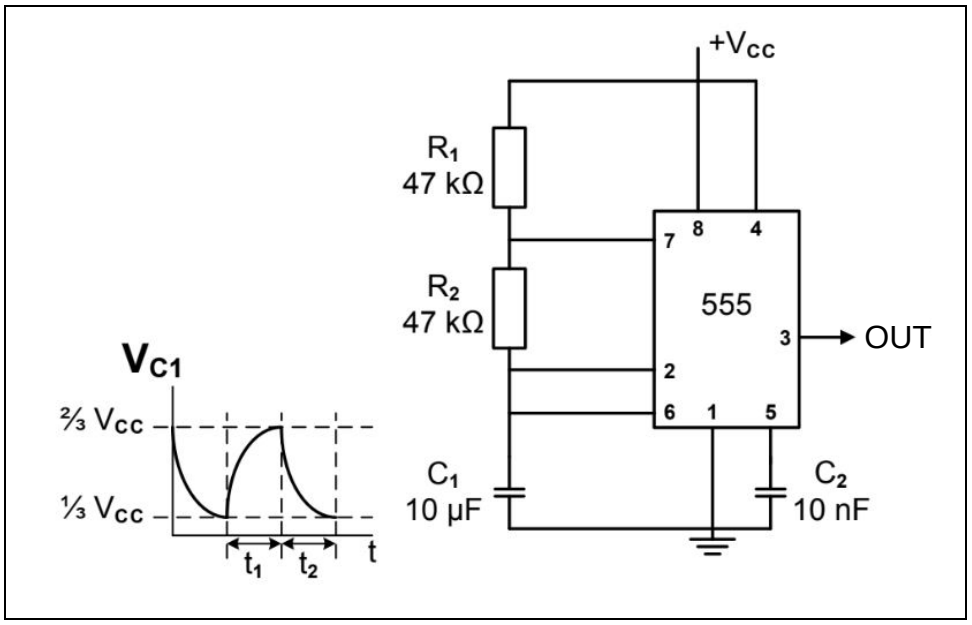

FIGURE 9

4.3.1 Name ONE application of an astable multivibrator. (1)

4.3.2 Draw the output signal with reference to signal V_{C1} on page ii of the **ANSWER SHEET**. (2)

4.3.3 Describe how an increase in the value of resistor R_1 will affect the output signal. (3)

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4.4 FIGURE 10 below shows a 555 monostable multivibrator's input trigger pulse with two pulses A and B. Study the inset pulses and answer the questions that follow.

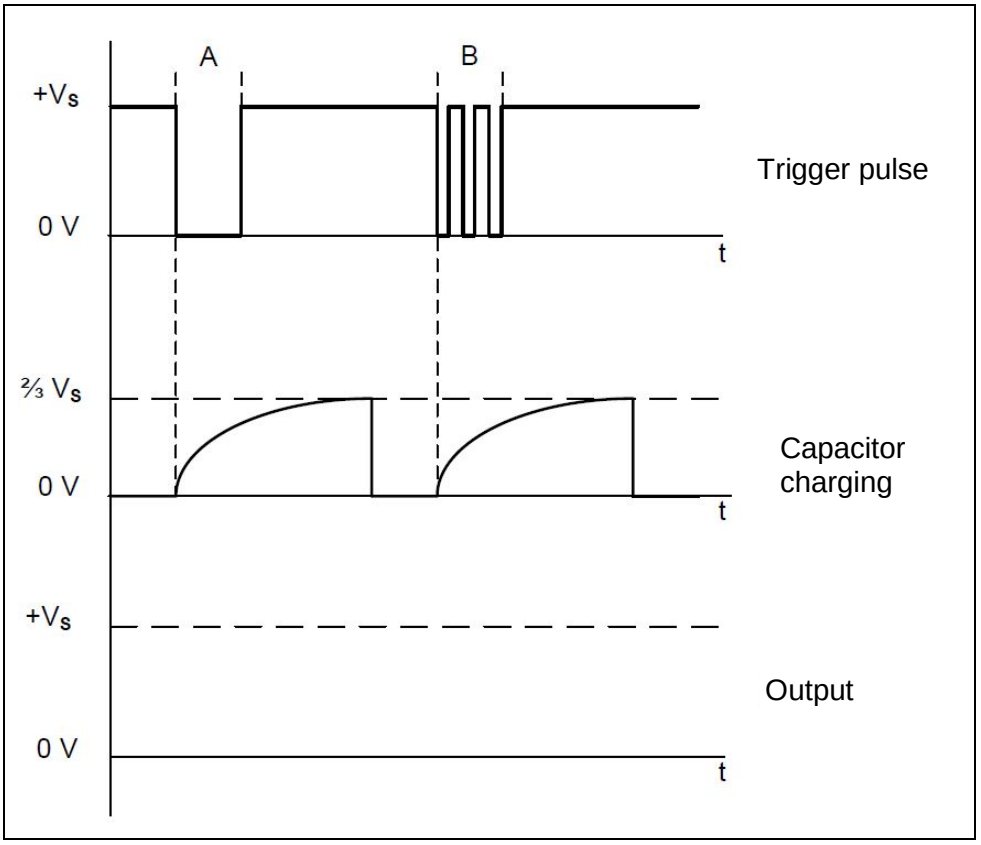

FIGURE 10

4.4.1 Draw the output signal on page ii of the **ANSWER SHEET**. (4)

4.4.2 Describe the condition that occurs at trigger pulse B. (2)

4.4.3 Explain why the condition that occurs at trigger pulse B does NOT affect the capacitor charging. (3)

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4.5 Refer to FIGURE 11 where a circuit is connected as an inverting Schmitt trigger and answer the questions that follow.

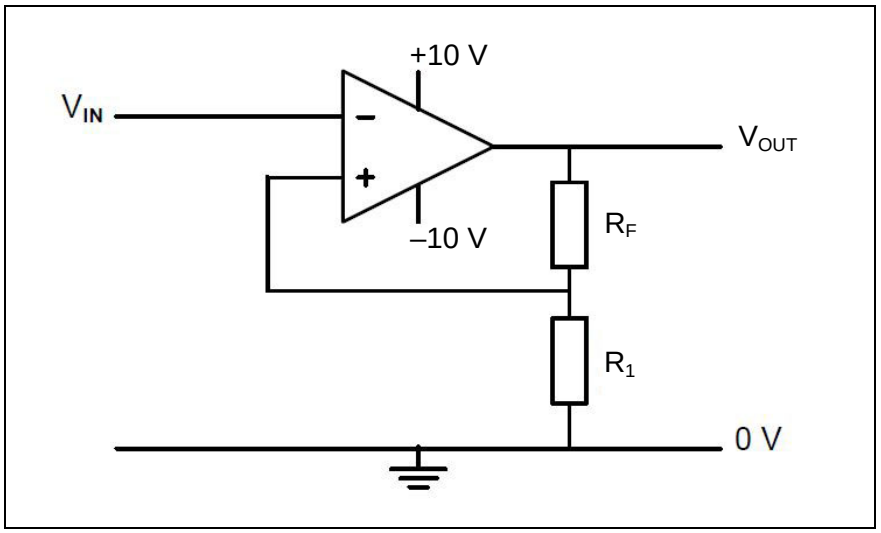

FIGURE 11

4.5.1 Explain the function of resistors R_F and R_1. (3)

4.5.2 Draw the output signal on page iii of the **ANSWER SHEET** if the signal in FIGURE 12 below is applied to the input of the Schmitt trigger.

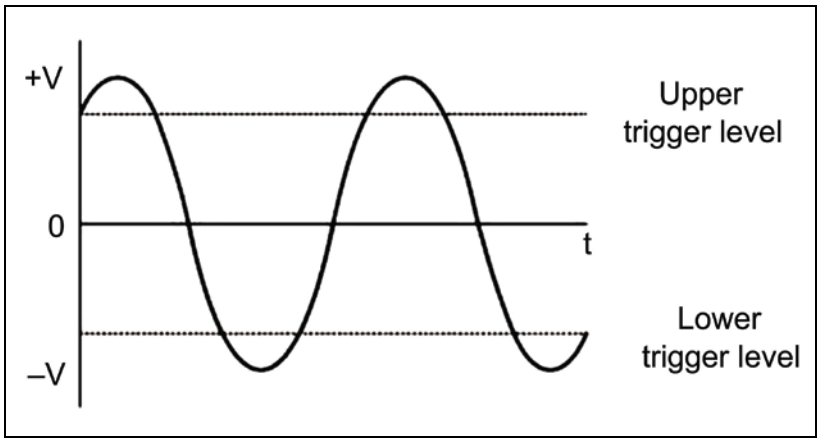

FIGURE 12

(3)

4.5.3 Describe how an increase in the value of R_F will affect the trigger voltage. (3)

4.6 Name TWO applications of the Schmitt trigger. (2)

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4.7 An inverting summing amplifier is shown in FIGURE 13. Consider the amplifier and answer the questions that follow.

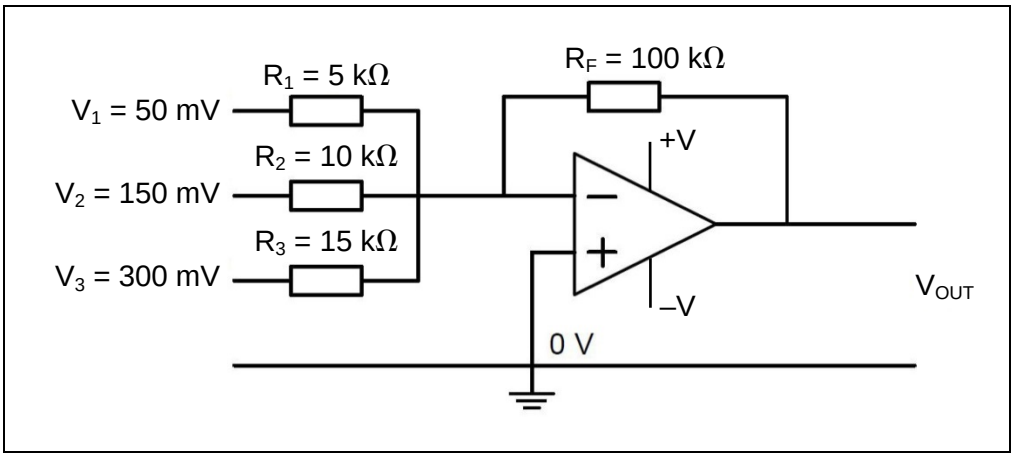

FIGURE 13

4.7.1 State how an additional input signal can be added to the summing amplifier to enlarge the summing amplifier. (1)

4.7.2 Calculate the output voltage for the inverting summing amplifier above. (3)

4.7.3 State why the answer to QUESTION 4.7.2 is negative. (1)

4.8 FIGURE 14 below shows a 741 op amp connected as a comparator. Answer the questions that follow.

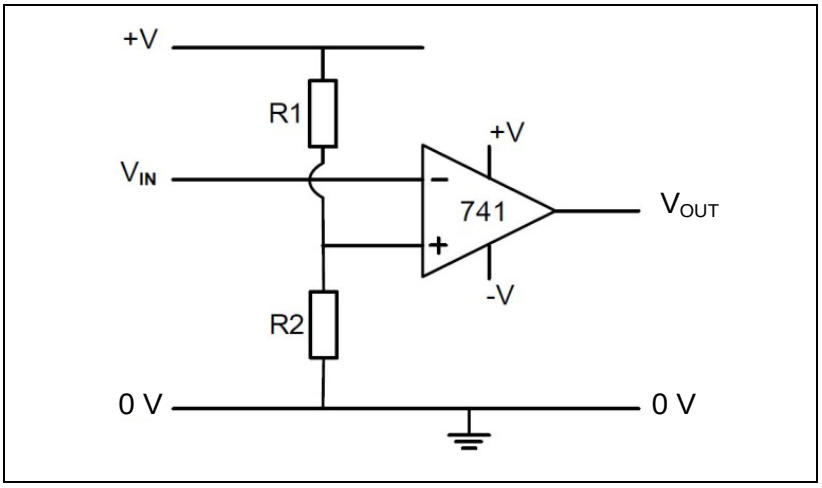

FIGURE 14

4.8.1 State the function of resistor R_2 in the circuit. (1)

4.8.2 Describe the operation of the comparator. (6)

4.8.3 Explain how the circuit can be modified to make the reference voltage adjustable. (1)

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4.9 Refer to FIGURE 15 which shows an op amp connected as an integrator. Answer the questions that follow.

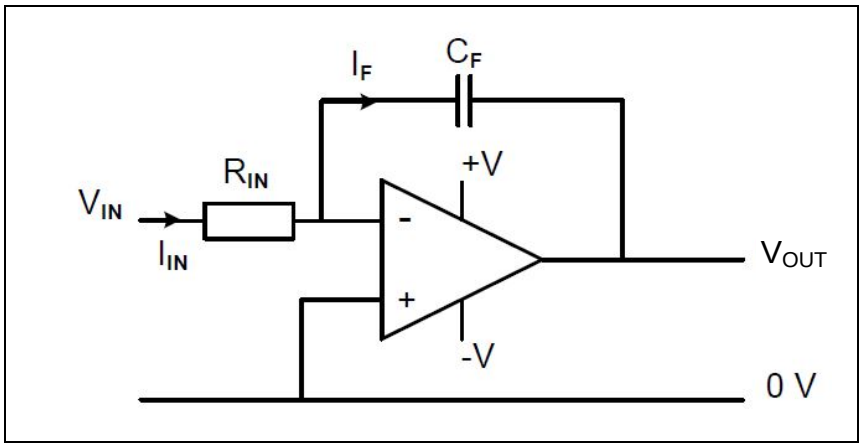

FIGURE 15

4.9.1 The input signal of the integrator is shown in FIGURE 16. Draw the output signal of the integrator on page iii of the **ANSWER SHEET**.

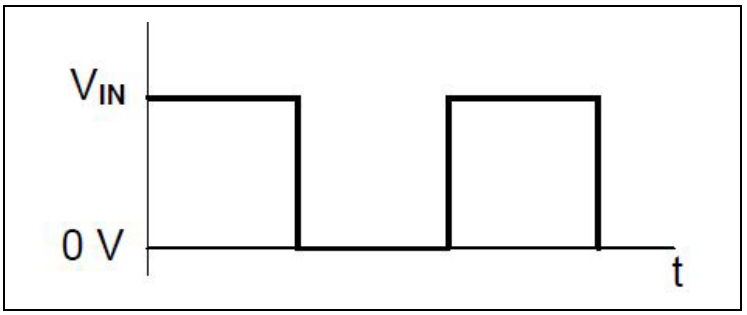

FIGURE 16

(3)

4.9.2 Describe what will happen to the output signal if the RC time constant is short. (4)

[60]

QUESTION 5 AMPLIFIERS

5.1 Compare Class A and Class B amplifiers with reference to the following:

5.1.1 Q-point (2)

5.1.2 Efficiency (2)

5.2 A biased NPN transistor circuit is shown in FIGURE 17 below. Answer the questions that follow.

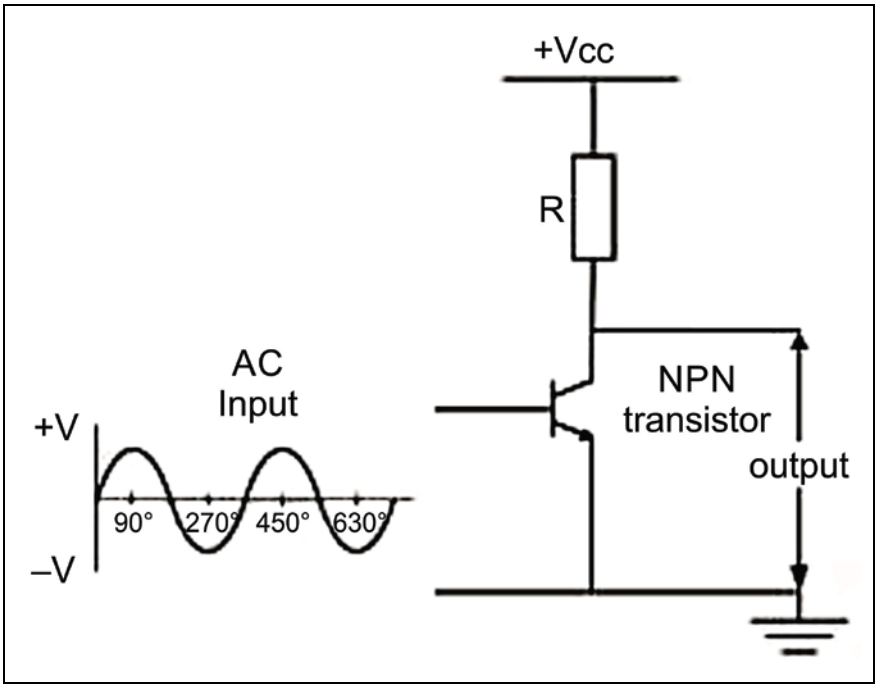

FIGURE 17

5.2.1 Draw the output waveform on page iv of the **ANSWER SHEET** when the transistor is operating as a Class B amplifier. (2)

5.2.2 Draw the output waveform on page iv of the **ANSWER SHEET** when the transistor is operating as a Class AB amplifier. (2)

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5.3 FIGURE 18 shows an RC-coupled amplifier. Study the circuit and answer the questions that follow.

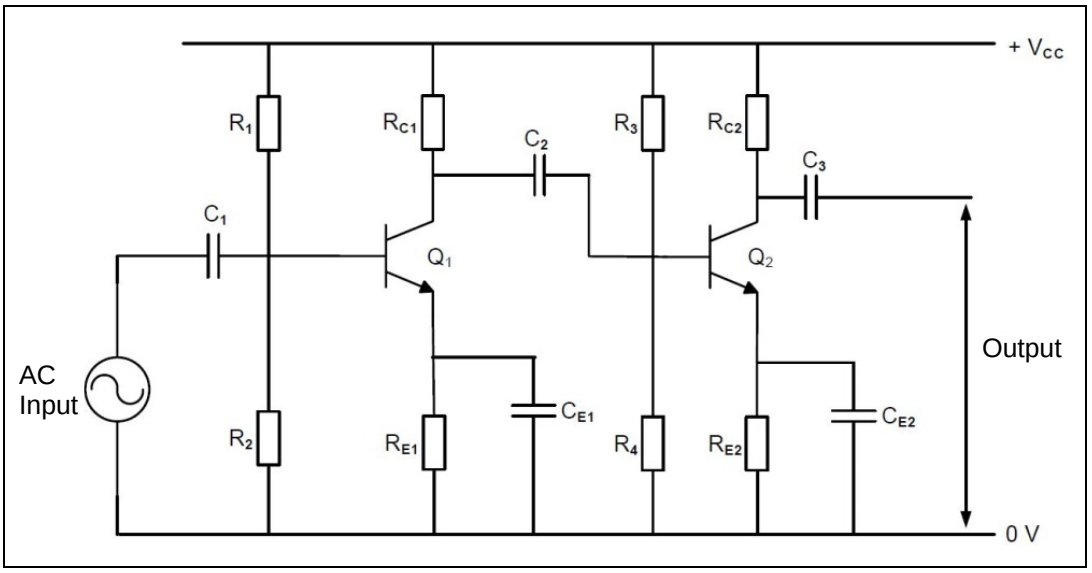

FIGURE 18

5.3.1 What is the purpose of capacitor C_2? (2)

5.3.2 Fully describe the operation of an RC-coupled amplifier. (6)

5.3.3 What is required for the coupling of amplifier stages? (2)

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5.4 Analyse the frequency response characteristic curve of an RC-coupled amplifier as shown in FIGURE 19 by answering the questions below.

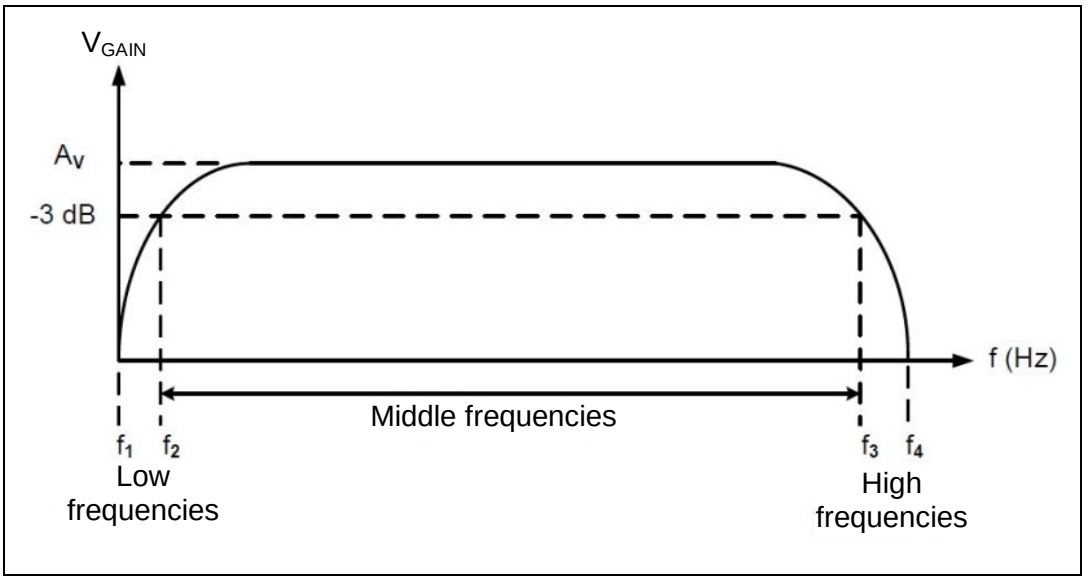

FIGURE 19

5.4.1 Define the term *frequency response* with reference to amplifiers. (2)

5.4.2 Explain the term *half-power points* with reference to a frequency response curve. (2)

5.4.3 Describe how the voltage gain of an RC-coupled amplifier is affected at low frequencies. (3)

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5.5 Answer the questions below with reference to FIGURE 20 that shows a transformer-coupled amplifier.

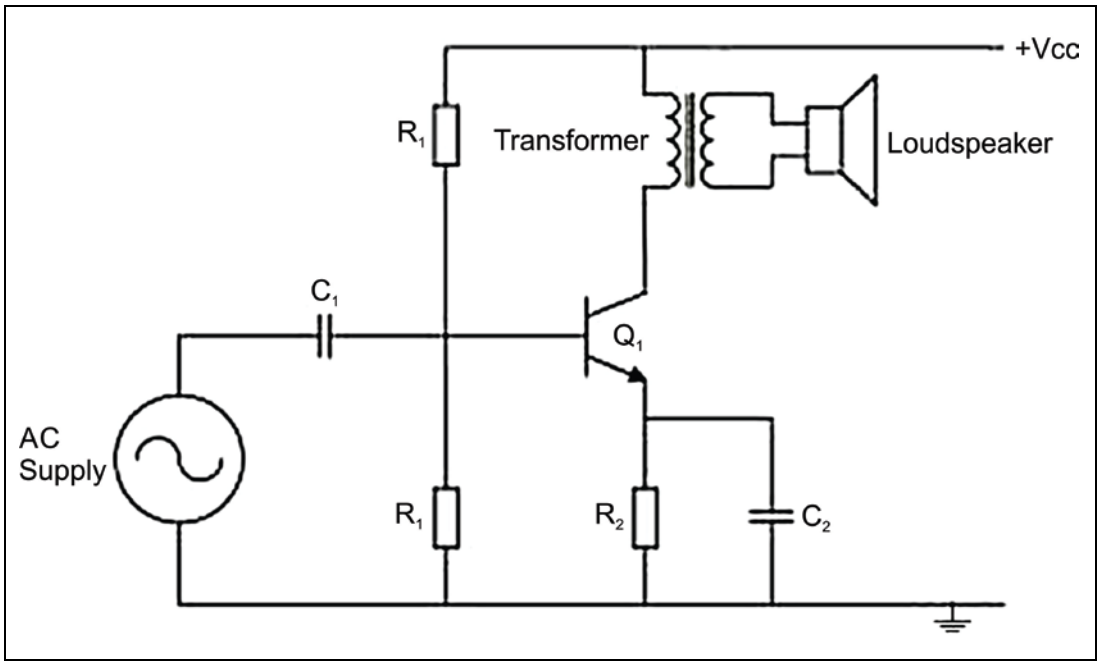

FIGURE 20

5.5.1 State TWO disadvantages of a transformer-coupled amplifier. (2)

5.5.2 Briefly describe how the circuit must be modified if the loudspeaker is changed to a lower-impedance loudspeaker. (3)

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5.6 A common emitter amplifier is shown in FIGURE 21. Consider the amplifier and answer the questions that follow.

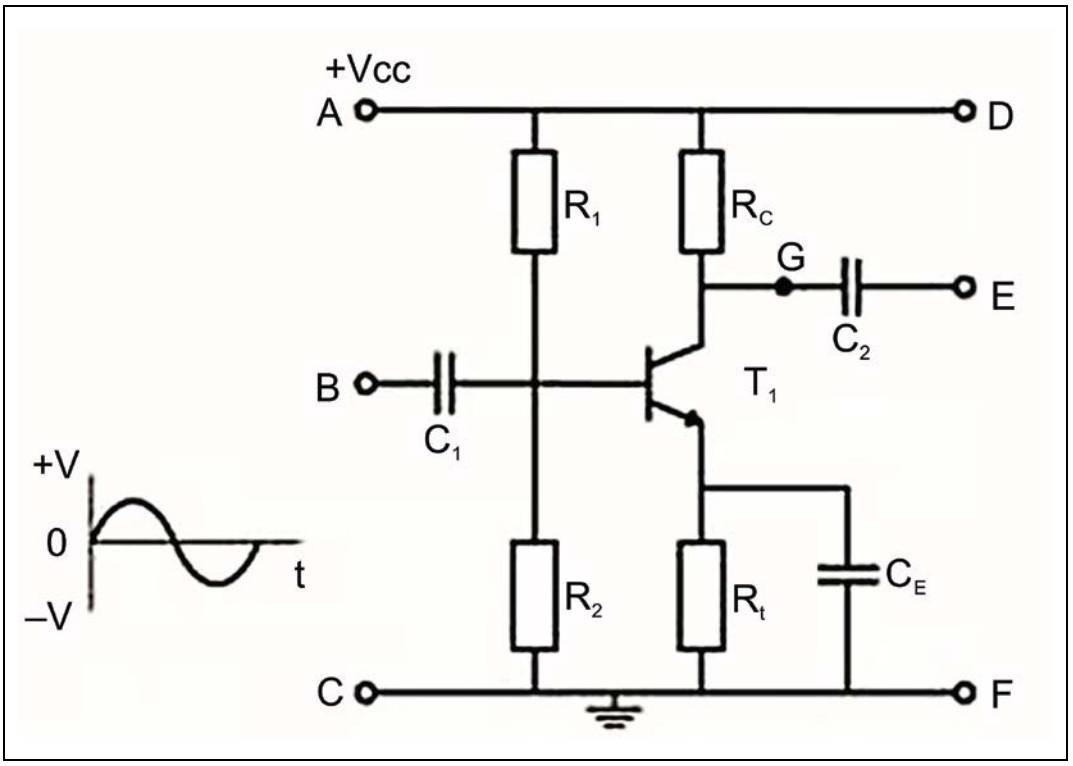

FIGURE 21

5.6.1 Explain why the circuit is called a common emitter amplifier. (2)

5.6.2 To which points will the input signal and the load be connected? (2)

5.6.3 Identify the TWO components that protect the transistor against thermal runaway. (2)

5.6.4 Draw the waveform that would appear between points G and F on page v of the **ANSWER SHEET**. (3)

5.6.5 Draw the output waveform that would appear between points E and F on page v of the **ANSWER SHEET**. (3)

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5.7 FIGURE 22 below shows an amplifier circuit. Answer the questions that follow.

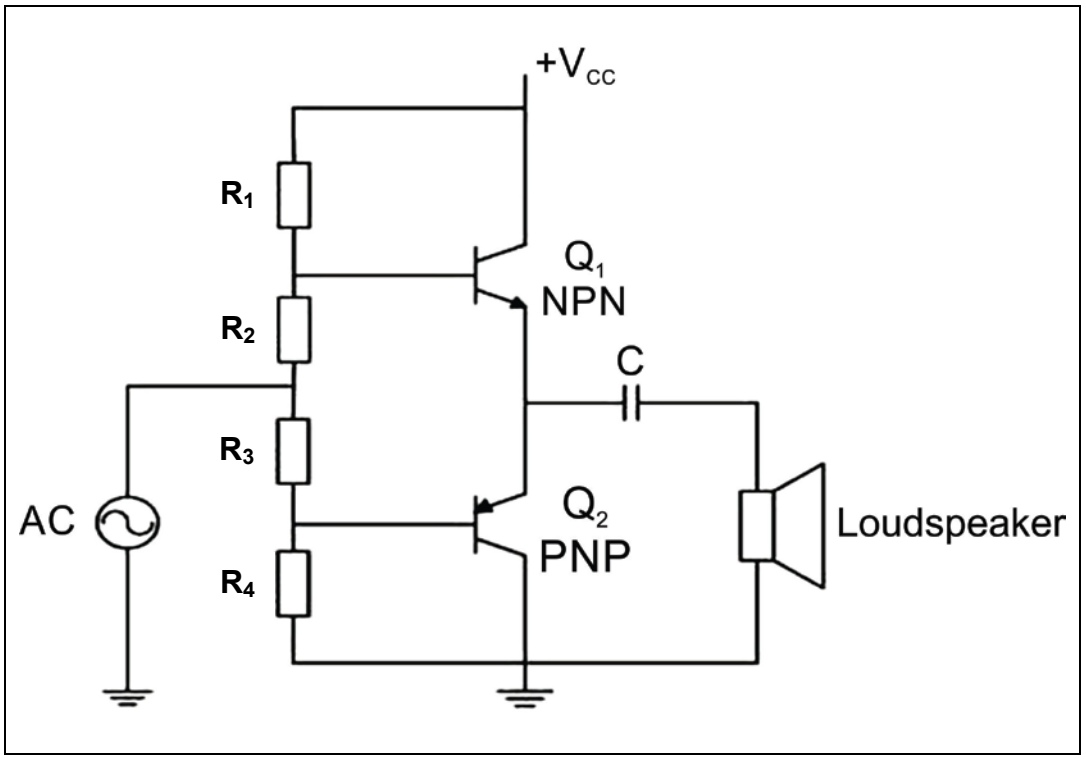

FIGURE 22

5.7.1 Identify the circuit. (2)

5.7.2 Explain how cross-over distortion can be eliminated in the circuit. (2)

5.7.3 Draw the output waveform on page vi of the **ANSWER SHEET**. (2)

5.7.4 Explain the function of resistors R_1 and R_2. (2)

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5.8 A Hartley oscillator is shown in FIGURE 23. Study the circuit and answer the questions that follow.

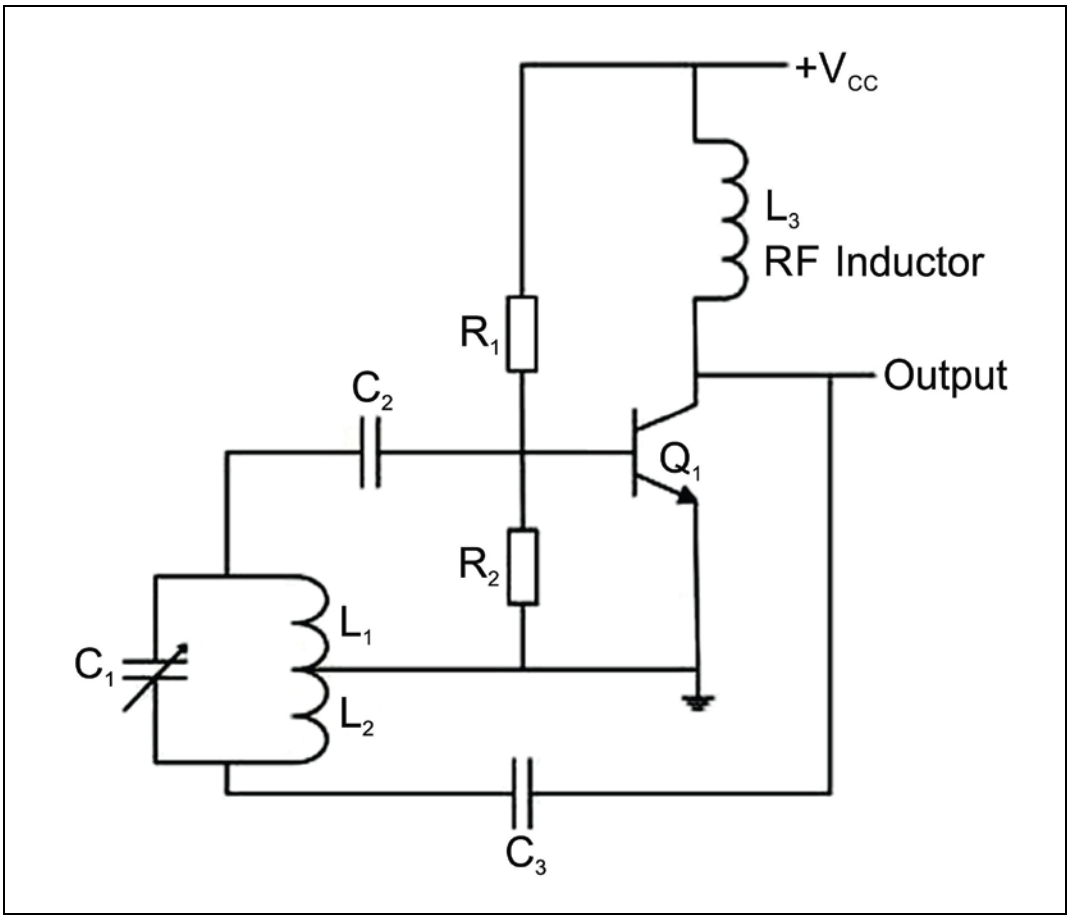

FIGURE 23

5.8.1 Describe the function of the RF coil in the oscillator circuit. (2)

5.8.2 What is the purpose of the tank circuit in the Hartley oscillators? (2)

5.8.3 Draw the output waveform of the Hartley oscillator on page vi of the **ANSWER SHEET**. (2)

5.8.4 Differentiate between the Hartley oscillator and the Colpitts oscillator with reference to their tank circuits. (2)

5.9 Indicate TWO advantages of negative feedback with regard to oscillators. (2)

[60]

Total: 200 marks

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