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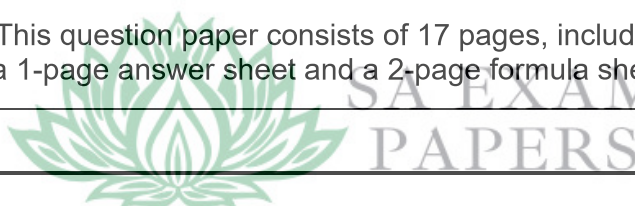
SEPTEMBER 2024

ELECTRICAL TECHNOLOGY: ELECTRONICS

MARKS: 200

TIME: 3 hours

This question paper consists of 17 pages, including
a 1-page answer sheet and a 2-page formula sheet.



INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. Show ALL calculations and round off answer correctly to TWO decimal places.
4. Number the answers correctly according to the numbering system used in this question paper.
5. You may use a non-programmable calculator.
6. Show the units for ALL answers of calculations.
7. A formula sheet is provided at the end of this question paper.
8. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.15) in the ANSWER BOOK, for example 1.16 D.

- 1.1 The purpose of the Occupational Health and Safety Act is to ...
- A provide for the health and safety of persons at work.
 - B provide for the health and safety of persons at home.
 - C prevent wear and tear on machinery.
 - D prevent workers from using machinery. (1)
- 1.2 The reference of a phasor diagram for a series RLC circuit is ...
- A apparent power.
 - B resonate frequency.
 - C current.
 - D voltage. (1)
- 1.3 In a pure capacitive circuit, the capacitive reactance is ... to the frequency.
- A proportional
 - B equal
 - C indirectly proportional
 - D all of the above (1)
- 1.4 Which ONE of the following are NOT true regarding a series RLC circuit at resonance?
- A The capacitive reactance is equal to the inductive reactance.
 - B The current is 0 A.
 - C The resistance of the circuit is equal to the impedance of the circuit.
 - D The phase angle is 0° . (1)
- 1.5 The most important feature of a FET is ...
- A the ability of its input gate voltage to control output drain current.
 - B the ability of its input gate current to control the output drain voltage.
 - C the ability of its input gate voltage to control its output drain voltage.
 - D the ability of its input gate current to control its output drain current. (1)
- 1.6 Pin 3 of a 741 op-amp is ...
- A inverting input.
 - B negative supply voltage.
 - C non-inverting input.
 - D offset null. (1)

- 1.7 Which ONE of the following is NOT a characteristic of an ideal op-amp?
- A The ideal op-amp has infinite gain.
 - B The input impedance of an ideal op-amp is almost non existing low.
 - C The output impedance is extremely low, between 50Ω and 100Ω .
 - D The ideal op-amp will have a very wide bandwidth in order to amplify almost any frequency signal. (1)
- 1.8 An op-amp differentiator with a triangular input waveform, will always have a(n) ... output.
- A square wave
 - B non inverted sine wave
 - C inverted sine wave
 - D sawtooth wave (1)
- 1.9 With reference to FIGURE 1.9 below, the function of R_1 is ...

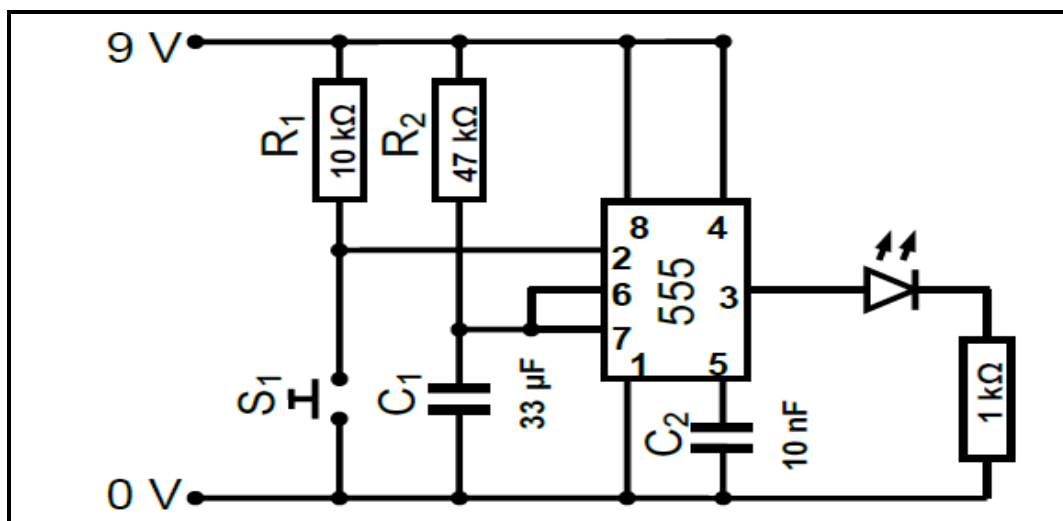


FIGURE 1.9

- A to protect the LED from over current.
- B to protect the 555 timer IC from over current.
- C a pull-up resistor to prevent the voltage from floating.
- D a pull-down resistor to prevent the voltage from floating. (1)

1.10 With reference to FIGURE 1.10 below, the function of C_1 is ...

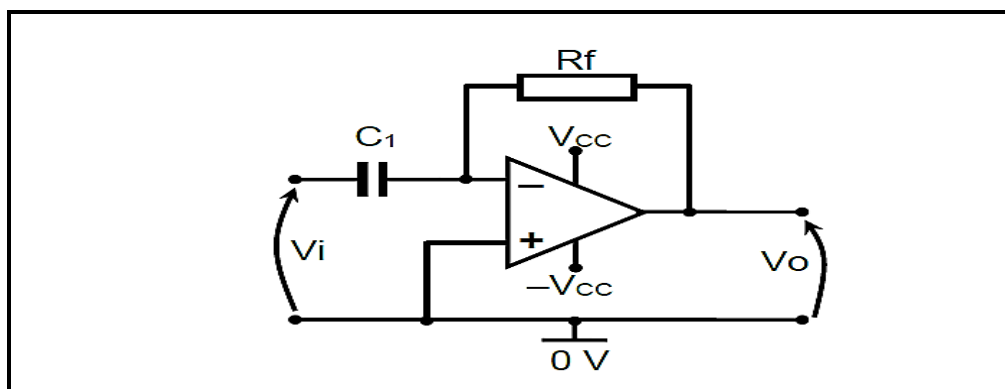


FIGURE 1.10

- A to allow only negative signals to pass and block positive signals.
- B to allow only positive signals to pass and block negative signals.
- C to allow AC signals to pass and block DC signals.
- D to allow DC signals to pass and block AC signals. (1)

1.11 The operating voltage range of the 555 timer IC is ...

- A 0 V to +20 V.
- B +5 V to +15 V.
- C -15 V to +15 V.
- D +5 V to +9 V. (1)

1.12 In a class A biasing of an amplifier, the Q point is chosen to lie ...

- A right at the bottom of the load line right at the cut-off point.
- B just within the active operating region of the amplifier.
- C right down below the cut-off region of the amplifier.
- D in the centre of the active region of the amplifier. (1)

1.13 Identify the type of amplifier circuit shown by FIGURE 1.13.

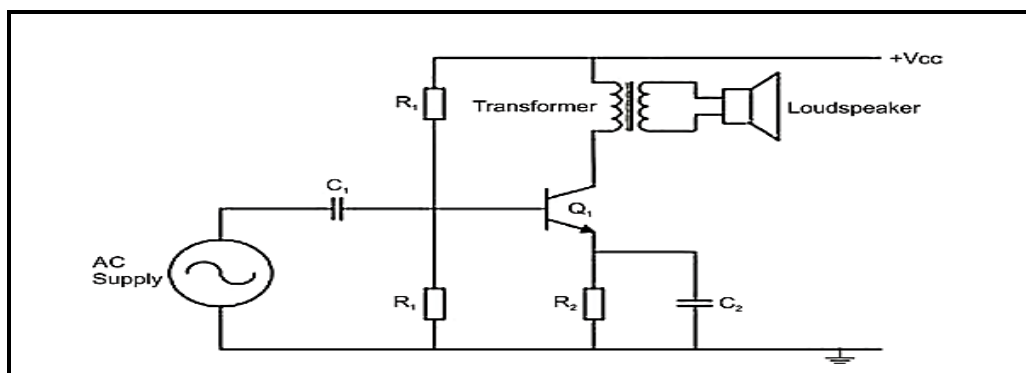


FIGURE 1.13

- A Resistor capacitor coupled amplifier
 - B Push-pull amplifier
 - C Transformer coupled amplifier
 - D Radio frequency (RF) amplifier
- (1)

1.14 Which ONE of the following is NOT an application of a RC coupled amplifier?

- A Servo motor amplifier
 - B RF communications
 - C Public address systems as pre-amplifiers
 - D Optical fibre communications
- (1)

1.15 The output waveform generated by a Colpitts oscillator will be a ... wave.

- A sawtooth
 - B sinusoidal
 - C triangular
 - D square
- (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Describe how teamwork in a workshop environment improves work ethics. (2)
- 2.2 Horseplay in a workshop is often said to be an unsafe act. Explain why this statement is true. (2)
- 2.3 Give ONE example of an unsafe condition found in a workshop. (1)
- 2.4 Name ONE human right with reference to work. (1)
- 2.5 Name TWO categories of dangerous practices which you could encounter in an electrical workshop. (2)
- 2.6 Explain what the concept of *quantitative risk analysis* entails. (2)
- [10]**

QUESTION 3: RLC CIRCUITS

- 3.1 Define the following terms with reference to RLC circuits:
- 3.1.1 *Phase Angle \emptyset* (2)
- 3.1.2 *Resonance* (2)
- 3.2 List TWO factors that will influence the capacitive reactance (X_C) of a RLC circuit. (2)
- 3.3 Explain why a change of frequency in a RLC circuit will have no influence on the resistance value of the circuit. (2)
- 3.4 Name THREE conditions that are met during resonance with reference to a parallel RLC circuit. (3)
- 3.5 A coil has an inductance of 80 mH and is connected in series with a 33 μ F capacitor and a 30 Ω resistor. The circuit is connected to a 120 V alternating current supply with a variable frequency.
- Calculate:
- 3.5.1 Resonant frequency (3)
- 3.5.2 Current at resonance (3)
- 3.5.3 Voltage drop across the inductor at resonance if the inductive reactance is 49,24 Ω (3)

- 3.6 A RLC phasor diagram is shown in FIGURE 3.6. Answer the questions that follow.

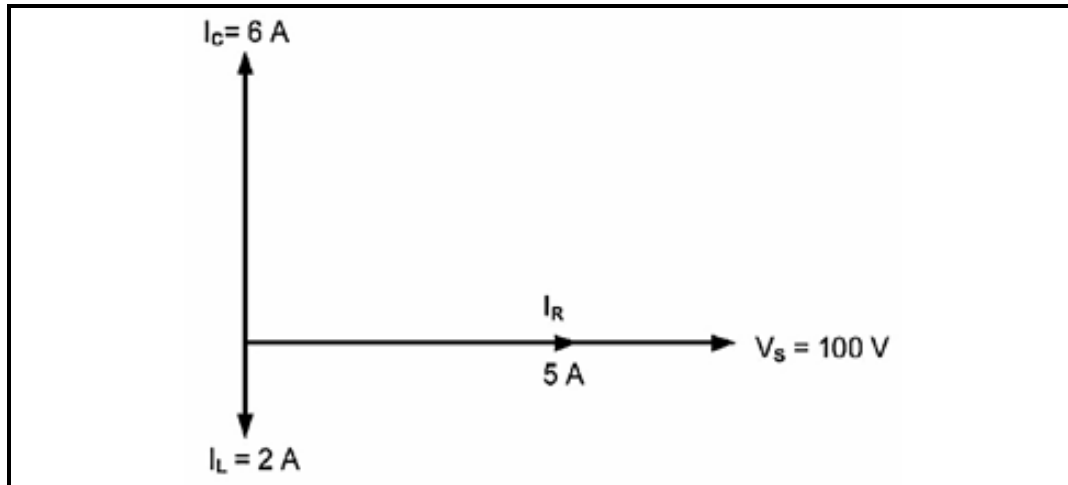


FIGURE 3.6: PHASOR DIAGRAM

Calculate:

- 3.6.1 Inductive reactance (3)
- 3.6.2 Capacitive reactance (3)
- 3.6.3 Total current (3)

- 3.7 A RLC circuit is shown in FIGURE 3.7 below. The circuit consists of a $20\ \Omega$ resistor, an inductor with an inductive reactance of $30\ \Omega$ and a capacitor with a capacitive reactance of $40\ \Omega$ connected across a $120\ \text{V}/60\ \text{Hz}$ supply voltage. Answer the questions that follow.

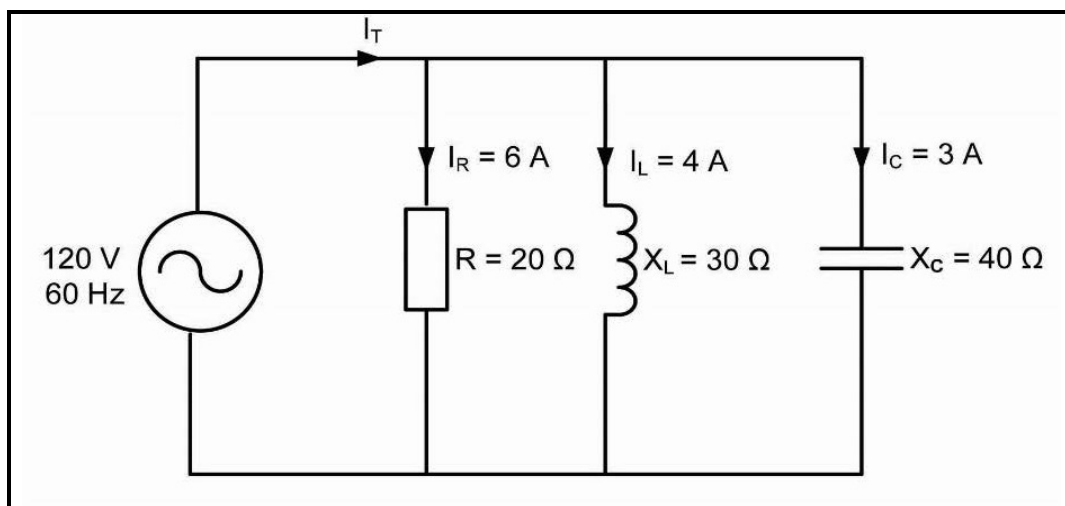


FIGURE 3.7: RLC CIRCUIT

Calculate:

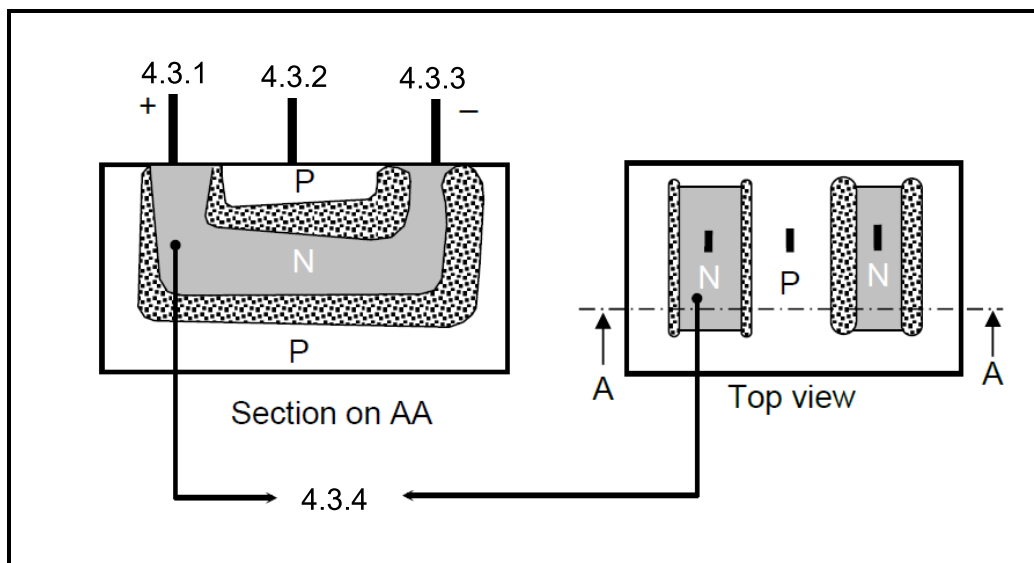
3.7.1 The total current in the circuit (3)

3.7.2 The phase angle (3)

[35]

QUESTION 4: SEMICONDUCTOR DEVICES

- 4.1 State what the abbreviation FET stand for. (1)
- 4.2 Unlike the BJT, the FET is a uni-polar device. Explain what is meant with this statement. (2)
- 4.3 The cross-sectional view of an N-CHANNEL JFET is shown in FIGURE 4.3.

**FIGURE 4.3: N-CHANNEL JFET**

- Label parts 4.3.1 to 4.3.4. (4)
- 4.4 State the abbreviation for metal-oxide-silicon field effect transistor. (1)
- 4.5 With reference to a 741 op-amp, explain what a double-polarity voltage supply (split power supply) is. (4)
- 4.6 A 741 op-amp is connected as an inverting amplifier to provide an output voltage of $8,5 V_{AC}$. The value of the input resistor is 180Ω . Determine the value of the feedback resistor when the input voltage is $10 mV$. (3)

- 4.7 An operational amplifier circuit is shown in FIGURE 4.7. Study the circuit and answer the questions that follow.

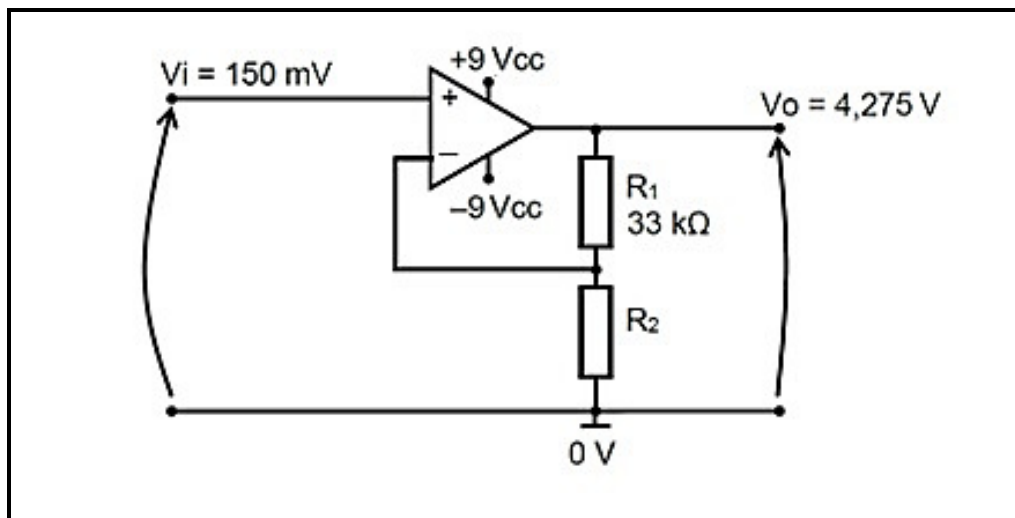


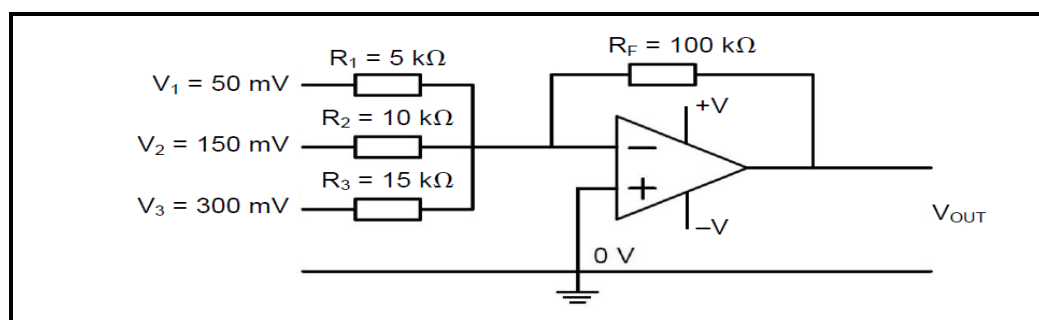
FIGURE 4.7: OP-AMP CIRCUIT

- 4.7.1 Identify the op-amp circuit that is shown in FIGURE 4.7. (1)
- 4.7.2 Calculate the value of resistor R_2 in the circuit. (3)
- 4.8 Explain the term *Common Mode Rejection Ratio* with reference to an op-amp. (4)
- 4.9 Explain the use of the 741 op-amp as a buffer amplifier. (3)
- 4.10 Explain the principle of operation of the trigger pin (Pin 2) with reference to the 555-timer. (3)
- 4.11 The 555-timer basically consists of two primary building blocks, two comparators and one S/R flip flop. Explain the principle of operation of the comparator. (4)
- 4.12 Explain the function of the three $5\text{ k}\Omega$ resistors that are connected internally in series between terminals 1 and 8 of the 555-timer. (4)
- 4.13 Discuss the operation of the unijunction transistor (UJT) as an electronic component. (8)

[45]

QUESTION 5: SWITCHING CIRCUITS

- 5.1 With reference to the THREE classes of multivibrators, answer the questions that follow.
- 5.1.1 Explain the bistable multivibrator in terms of inputs and stable states. (2)
- 5.1.2 Explain the monostable multivibrator in terms of inputs and stable states. (2)
- 5.1.3 Explain the astable multivibrator in terms of inputs and stable states. (2)
- 5.2 State ONE application of the monostable multivibrator. (1)
- 5.3 Explain the term *switch bounce* with reference to the action of a switch. (2)
- 5.4 State the output waveform of an astable multivibrator. (1)
- 5.5 Explain the term *hysteresis*. (2)
- 5.6 Explain FOUR applications for the Schmitt Trigger. (8)
- 5.7 An amplifier is shown in FIGURE 5.7. Answer the questions that follow.

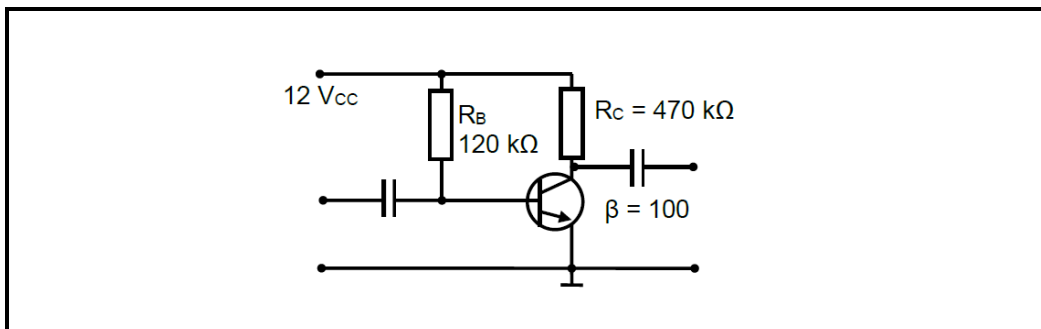
**FIGURE 5.7: ELECTRONIC CIRCUIT**

- 5.7.1 Identify the type of electronic circuit shown in FIGURE 5.7. (1)
- 5.7.2 State how an additional input signal can be added to the amplifier to enlarge the amplifier. (1)
- 5.7.3 Calculate the output voltage for the amplifier above. (3)
- 5.7.4 Explain why the answer to QUESTION 5.7.3 will render a negative answer. (2)
- 5.8 Draw the fully labelled circuit diagram of a passive RC differentiator. (4)
- 5.9 Draw a fully labelled typical hysteresis characteristic curve. (8)
- 5.10 Explain how you can vary the time period with reference to a monostable multivibrator. (3)
- 5.11 Discuss the principle of operation of a dark sensor. (8)

[50]

QUESTION 6: AMPLIFIERS

- 6.1 Compare class A and class B amplifiers with reference to the following:
- 6.1.1 The Q-point of the amplifiers (2)
- 6.1.2 Efficiency of the amplifiers (2)
- 6.2 List THREE advantages of using negative feedback in amplifier circuits. (3)
- 6.3 Explain the function of a small signal amplifier. (4)
- 6.4 Explain the term *a transistor is biased* with reference to amplifiers. (3)
- 6.5 State the THREE regions an amplifier operates in. (3)
- 6.6 Explain how amplifiers are classified into the different classes. (1)
- 6.7 Study the amplifier circuit that is shown in FIGURE 6.7. Answer the questions that follow.

**FIGURE 6.7: AMPLIFIER**

- 6.7.1 Calculate the maximum collector current flow in the circuit. (3)
- 6.7.2 Determine the maximum collector-emitter voltage that can develop across the transistor when $I_C = 0\text{ A}$. (2)
- 6.7.3 Calculate the value of the base current that is applied to the transistor. (3)
- 6.7.4 Draw the direct-current load line and indicate the Q point of the circuit on the direct-current load line on the common-emitter output curve that is provided on the ANSWER SHEET QUESTION 6.7.4. (3)
- 6.8 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. (4)
- 6.9 Discuss why decibel was introduced to measure gain. (4)

- 6.10 Refer to FIGURE 6.10 below and fully describe the operation of a RC-coupled amplifier.

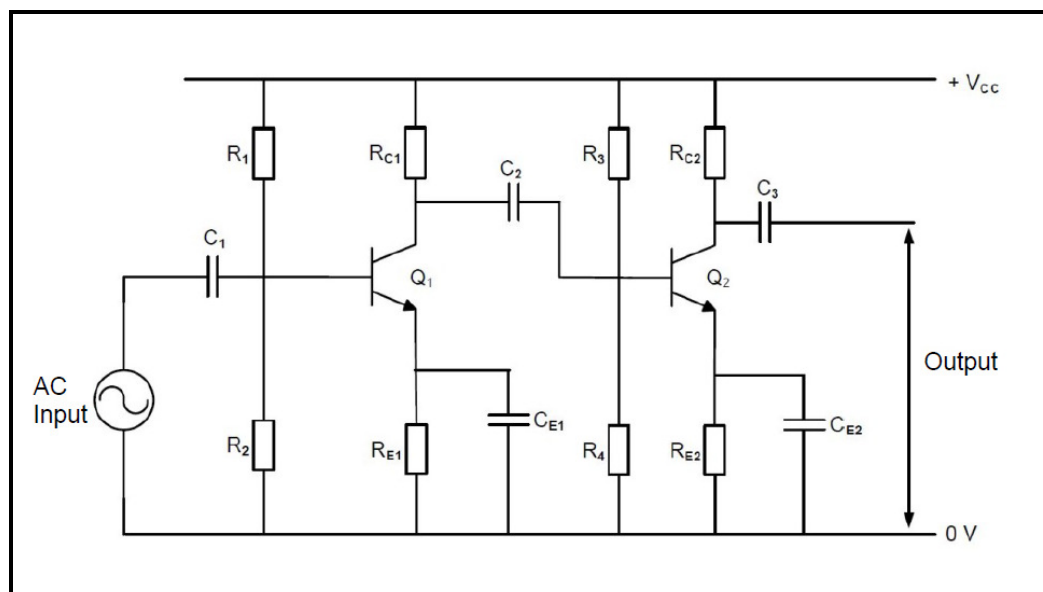


FIGURE 6.10: RC-COUPLED AMPLIFIER

(8)
[45]

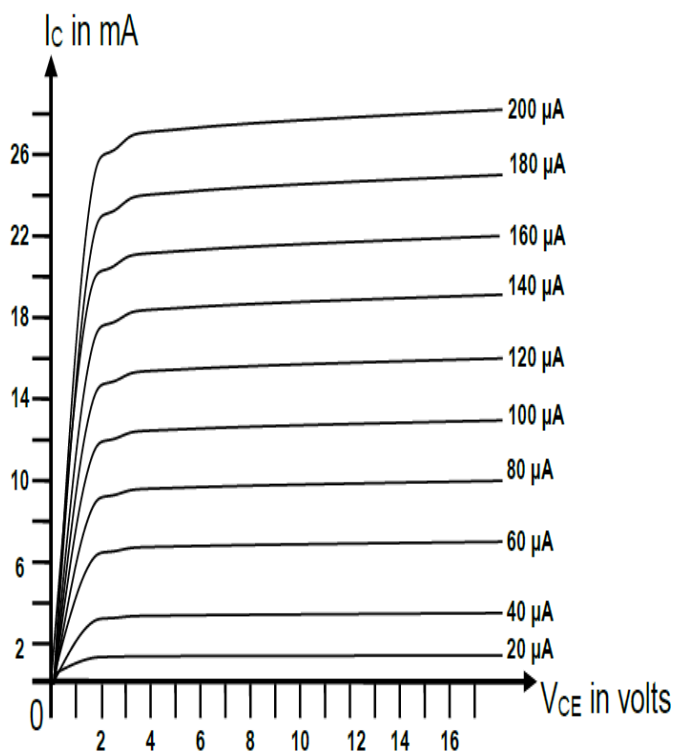
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LEARNER'S NAME: _____

ANSWER SHEET

QUESTION 6: AMPLIFIERS

6.7.4



FORMULA SHEET

RLC CIRCUIT

$$X_L = 2\pi FL \text{ and } X_C = \frac{1}{2\pi FC}$$

SERIES

$$I_T = I_R = I_C = I_L$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V_L = IX_L \text{ and } V_C = IX_C \text{ and } V_T = IZ$$

$$\cos\theta = \frac{R}{Z}$$

$$\cos\theta = \frac{V_R}{V_T}$$

$$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R} \sqrt{\frac{L}{C}}$$

PARALLEL

$$1. V_T = V_R = V_L = V_C$$

$$2. I_R = \frac{V}{R} \text{ and } I_L = \frac{V}{X_L} = I_C = \frac{V}{X_C}$$

$$3. I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$4. \cos\theta = \frac{I_R}{I_T}$$

$$5. Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{1}{R} = \sqrt{\frac{L}{C}}$$

SEMI-CONDUCTORS DEVICES

$$A_V = \frac{V_{out}}{V_{in}} = \frac{R_F}{R_{IN}}$$

$$V_{OUT} = V_{IN} = \left(-\frac{R_F}{R_{IN}}\right)$$

$$A_V = 1 + \frac{R_F}{R_{IN}}$$

$$V_{OUT} = V_{IN} \left(1 + \frac{R_F}{R_{IN}}\right)$$

$$\beta_{super} = \beta_1 \times \beta_2$$

AMPLIFIERS

$$V_{CE} = V_{CC}$$

$$I_{Cmax} = \frac{V_{CC}}{R_C}$$

$$A' = \frac{A}{1 + \beta A}$$

$$\text{Power Gain } A_P = \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

$$A_V = 20 \log_{10} \frac{E_{out}}{E_{in}} \text{ dB}$$

$$A_I = 20 \log_{10} \frac{I_{out}}{I_{in}}$$

$$F_0 = \frac{1}{2\pi\sqrt{L_T C}}$$

$$Fr = \frac{1}{2\pi\sqrt{LC}}$$

$$F_0 = \frac{1}{2\pi\sqrt{6} RC}$$



SWITCHING CIRCUITS

1. Gain $A_V = \frac{V_{OUT}}{V_{IN}} = -\left(\frac{R_f}{R_{in}}\right)$ inverting operational amplifier
2. Gain $A_V = \frac{V_{OUT}}{V_{IN}} = 1 + \left(\frac{R_f}{R_{in}}\right)$ non-inverting operational amplifier
3. $V_{OUT} = V_{IN} \times \left(-\frac{R_f}{R_{in}}\right)$ inverting amplifier
4. $V_{OUT} = -(V_1 + V_2 + V_3)$ summing up op-amp
5. $f_r = \frac{1}{2\pi\sqrt{LC}}$
6. $f = \frac{1}{2\pi\sqrt{6RC}}$