THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

083 ELECTRONICS AND RADIO REPAIR

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2000**

Instructions

1. This paper consists of TWELVE questions.

2. Answer six questions in section A and four from section B.

1

(a) Explain what is meant by the term free electrons.

Free electrons are electrons that are not bound to an atom or molecule and are free to move within a material. In conductors such as metals, free electrons are found in the outermost shells and can move freely through the atomic lattice, enabling electrical conductivity.

(b) Explain the behaviour of free electrons in presence of an electric field.

When a conductor is placed in an electric field, the free electrons experience a force opposite to the direction of the field. This causes them to accelerate and move, resulting in a drift current. The movement of these electrons constitutes an electric current.

(c) (i) Mention the two types of current flow through a semi-conductor crystal under the influence of an electric field.

The two types of current flow are electron current and hole current.

(ii) List two common types of donor and acceptor impurities.

Common donor impurities: Phosphorus, Arsenic

Common acceptor impurities: Boron, Gallium

2

(a) Mention two types of bi-polar transistors.

NPN transistor and PNP transistor.

(b) Name three electrodes of the transistor.

Emitter, Base, Collector

(c) A transistor exhibits a change of 0.995 mA in its collector current for a change of 1 mA in emitter current. Calculate

(i) the common base short-circuit current gain (α)

$\alpha = \Delta I\_C / \Delta I\_E = 0.995$ mA / 1 mA = 0.995

(ii) the common-emitter short circuit current gain

(β) $\beta = \alpha / (1 - \alpha) = 0.995 / (1 - 0.995) = 0.995 / 0.005$

= 199

3

(a) The meter scale has 30 divisions. What is the current measured by the milliammeter if the number of divisions indicated on the milliammeter is:

(i) 18 divisions for 1 mA range

Current = (18/30) × 1 mA = 0.6 mA

(ii) 10 divisions for 10 mA range

Current = (10/30) × 10 mA = 3.33 mA

(iii) 21 divisions for 10 mA range
Current = (21/30) × 10 mA = 7.0 mA

(iv) 27 divisions for 50 mA range
Current = (27/30) × 50 mA = 45 mA

(b) A milliammeter with a meter resistance of 50 ohms and full-scale deflection current of 1 mA has its range of 3 mA and 10 mA. Calculate (i) shunt resistance on each range For 3 mA range:
I_{total} = 3 mA, I_{meter} = 1 mA, I_{shunt} = 2 mA
$V = I_{meter} \times R_{meter}$ = 1 mA × 50 Ω = 0.05 V
$R_{shunt} = V / I_{shunt}$ = 0.05 V / 2 mA = 25 Ω

For 10 mA range:
I_{total} = 10 mA, I_{shunt} = 9 mA
R_{shunt} = 0.05 V / 9 mA ≈ 5.56 Ω

(ii) input resistance on each range For
3 mA range:
$R_{input} = (R_{meter} \times R_{shunt}) / (R_{meter} + R_{shunt})$ = (50 × 25) / (50 + 25) = 1250 / 75 ≈ 16.67 Ω

For 10 mA range:
R_{input} = (50 × 5.56) / (50 + 5.56) = 278 / 55.56 ≈ 5 Ω

4
(a) Draw the ohmmeter circuit.
(Mchoro huu utatolewa kama picha ukihitajika)

(b) Find the e.m.f. of the battery.
Given: full scale current I = 10 mA, resistance of meter R = 10 Ω, series resistance R_s = 490 Ω
Total resistance = $R + R_s$ = 500 Ω
$E = I \times R_{total}$ = 0.01 A × 500 Ω = 5 V

(c) What is the percentage deflection of the pointer on the scale for supply voltage of 4 V?
$I = V / R_{total}$ = 4 V / 500 Ω = 8 mA
Percentage deflection = (8 / 10) × 100 = 80%

5
(a) Name five types of capacitors.
Ceramic capacitor, Electrolytic capacitor, Tantalum capacitor, Film capacitor, Mica capacitor

(b) Two capacitors having capacitance of 10 µF are connected in series across a 200 volt d.c supply.

Calculate

(i) the charge on each capacitor

For capacitors in series, the equivalent capacitance C_eq = (C × C) / (C + C) = (10 × 10) / (10 + 10) = 100 / 20 = 5 μF

Q = C_eq × V = 5 μF × 200 V = 1000 μC

In series, charge on each capacitor is same = 1000 μC

(ii) the p.d. across each capacitor

V = Q / C = 1000 μC / 10 μF = 100 V

Each capacitor has 100 V across it

6

A tuned circuit is required to cover the frequency range 3.7 MHz to 7.0 MHz. The capacitor is variable and the maximum value of circuit capacitance is 50 pF.

(a) What is the required value of inductance? Use the resonance formula:

$f = 1 / (2\pi\sqrt{(LC)})$ Rearrange to find L:

$L = 1 / (4\pi^2f^2C)$

Use $f = 7.0$ MHz $= 7 \times 10^6$ Hz, $C = 50$ pF $= 50 \times 10^{-12}$ F

$L = 1 / (4 \times \pi^2 \times (7 \times 10^6)^2 \times 50 \times 10^{-12})$

$L = 1 / (4 \times 9.87 \times 49 \times 10^{12} \times 50 \times 10^{-12})$

$L \approx 1 / (4 \times 9.87 \times 49 \times 50)$

$L \approx 1 / (96630)$

$L \approx 10.35$ μH

(b) What is the required maximum value of capacitance?

Use $f = 3.7$ MHz $= 3.7 \times 10^6$ Hz and $L = 10.35 \times 10^{-6}$ H

$C = 1 / (4\pi^2f^2L)$

$C = 1 / (4 \times \pi^2 \times (3.7 \times 10^6)^2 \times 10.35 \times 10^{-6})$

$C = 1 / (4 \times 9.87 \times 13.69 \times 10^{12} \times 10.35 \times 10^{-6})$

$C \approx 1 / (5600000)$

$C \approx 178.57$ pF

7

(a) What is the difference between power and energy? Give one unit of each as used in Electrical Engineering.

Power is the rate at which energy is used or transferred per unit time. Its SI unit is the watt (W).

Energy is the capacity to do work, and it is the total work done or heat generated. Its SI unit is the joule (J) or kilowatt-hour (kWh) in electrical usage.

(b) An electric bulb is rated at 200 V, 75 W. Calculate
(i) the current when the bulb is used on 200 V supply
P = VI
I = P / V = 75 W / 200 V = 0.375 A

(ii) the cost of running the lamp for 500 hours, if electric energy costs TShs 10 per kilowatt hour.
Energy consumed = P × time = 75 W × 500 h = 37500 Wh = 37.5 kWh
Cost = 37.5 × 10 = TShs 375

8. (a) Draw a block diagram of the frequency modulated transmitter. Label each stage and show the signal waveform at each stage.

The block diagram of a frequency modulated (FM) transmitter consists of the following main stages in order:

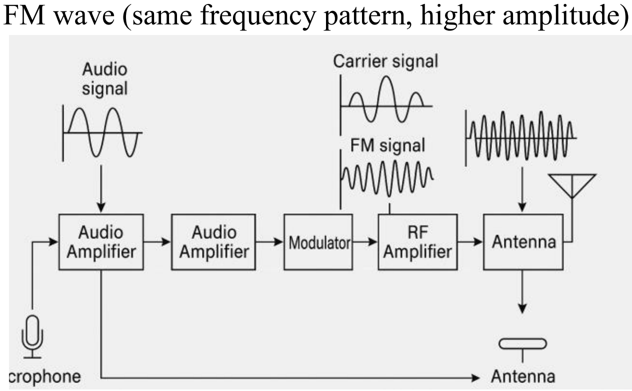
1. Microphone – Converts sound into electrical audio signal.
   Waveform: Analog audio waveform (low frequency)

2. Audio Amplifier – Amplifies the weak audio signal.
   Waveform: Stronger audio signal (same shape, larger amplitude)

3. Oscillator (RF Carrier Generator) – Generates a high-frequency carrier wave. Waveform: Sinusoidal carrier wave

4. Modulator – Combines the audio signal and carrier wave to produce frequency-modulated signal. Waveform: FM wave (frequency of the carrier varies with the amplitude of the audio signal)

5. RF Amplifier – Increases the power of the modulated signal for transmission. Waveform: Stronger FM wave (same frequency pattern, higher amplitude)



6. Antenna – Radiates the FM signal as electromagnetic waves.

Waveform: Electromagnetic transmission of FM signal

(b) State two advantages of frequency modulation (F.M.) as compared with amplitude modulation (A.M) transmission.
Frequency modulation has better noise immunity compared to amplitude modulation. FM provides higher sound quality due to wider bandwidth and less signal distortion.

9. (a) Explain the term "television"
Television is a system for transmitting visual images and sound that are reproduced on screens, primarily used for entertainment, information, and education. It works by converting optical and audio signals into electrical signals, which are transmitted and then converted back into visuals and sound.

(b) A picture has 400 horizontal and 300 vertical picture elements. Calculate the total number of details in the picture.
Total number of details = $400 \times 300 = 120000$ picture elements

10. (a) Give the speed of television waves in free air.
The speed of television waves in free air is approximately 3×10^8 m/s (speed of electromagnetic waves in vacuum or air).

(b) A television antenna must be equal to half the wavelength of the signal received. Calculate the length of antenna when the television receiver is tuned to a television station transmitting at 300 MHz.
Wavelength $\lambda = v / f = 3 \times 10^8$ m/s / 300×10^6 Hz = 1 m
Length of antenna = $\lambda / 2 = 1$ m / 2 = 0.5 m

11. In accordance with the Tanzania television system, fill in the missing word or number in the following statements:
(a) Picture frames are repeated at the rate of 25 per second.
(b) The number of scanning lines is 625 per frame.
(c) The television channel bandwidth is 8 MHz.
(d) Light is converted to video signal by the camera tube.
(e) The number of scanning lines is 15625 per second.

12. The block diagram in Fig. 1 is of a television broadcasting system. The numbered items and blocks represent stages of the system. Write what each block (item) stands for.

1 - Camera tube (converts light into video signal)
2 - Microphone (converts sound into audio signal)
3 - Transmitting antenna
4 - Picture tube (converts video signal back into light/image)
5 - Loudspeaker (converts audio signal into sound)