THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

083 RADIO AND TV SERVICING

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2011**

Instructions

1. This paper consists of SIXTEEN questions.

2. Answer all questions in section A and B and two questions from section C.

I. For each of the items (i) – (x), choose the correct answer from among the given alternatives and write its letter beside the item number.

(i) What will happen if a radio wave is passed through an ionized medium in the presence of magnetic field?
A Distortion of wave will result
B A false wave ionization will be created
C Magnetic field will split wave into two components
D Magnetic field will split wave into four components
E Wave will follow the elliptical path

Answer: C Magnetic field will split wave into two components
Reason: In ionized medium with magnetic field, radio waves split into ordinary and extraordinary waves.

(ii) The main function of the RF amplifier in a super heterodyne receiver is to
A provide improved tracking
B permit better adjacent channel rejection
C increase the tuning range of the receiver
D improve the rejection of the image frequency
E reduce the effect of noise at low modulation depth

Answer: D improve the rejection of the image frequency
Reason: RF amplifier enhances image frequency rejection and improves signal sensitivity.

(iii) Which of the following is a donor impurity element?
A Aluminium
B Boron
C Phosphorous
D Indium
E Thallium

Answer: C Phosphorous
Reason: Phosphorous is a pentavalent atom that donates electrons to create n-type semiconductors.

(iv) Which of the following types of semiconductor is electrically positive?
A Intrinsic
B Extrinsic
C P-type
D N-type
E NP-type

Answer: C P-type
Reason: P-type semiconductors have holes as majority carriers, giving a net positive charge carrier flow.

(v) The colour picture can be obtained by appropriately combining
A Red, green and blue
B Red, yellow and green
C Red, black and blue
D Red, white and black
E Red, violet and green

Answer: A Red, green and blue
Reason: RGB color model is the basis for producing color images in screens and TVs.

(vi) Which one of the following should be observed before trouble shooting any electrical equipment?
A Type of the equipment and its number
B Broken wires and poor connection
C Loose parts and manufacturing date
D Soldered and welded components
E Origin of the equipment and its life span

Answer: B Broken wires and poor connection
Reason: These are the most common causes of faults and should be checked first during troubleshooting.

(vii) Vacuum tubes in a radio transmitter are used to
A generate high power radio waves
B record radio programmes
C provide lighting inside the studio
D provide power frequency range
E rectify radio supply voltage

Answer: A generate high power radio waves
Reason: Vacuum tubes amplify and generate high power RF signals in transmitters.

(viii) For the signal to be observed on the screen of an oscilloscope, it is applied
A across its Y-plates
B to the horizontal amplifier
C to the trigger circuit
D across its X-plates
E between vertical deflecting plates

Answer: A across its Y-plates
Reason: The input signal is applied to the Y-plates to produce vertical deflection on the oscilloscope screen.

(ix) Which of the following will help to stabilize the frequency of an oscillator?
A Increasing transistor gain
B Eliminating triggered pulses

C Use of automatic biasing
D Use of a tuned circuit
E Use of higher positive d.c voltage

Answer: D Use of a tuned circuit
Reason: A tuned circuit determines and stabilizes the frequency of oscillation.

(x) When emitter junction is forward biased and collector junction is reverse biased, the PNP transistor will operate in
A active region
B cut-off region
C saturation region
D inverted region
E inactive region

Answer: A active region
Reason: A transistor operates in active region when emitter-base junction is forward biased and collector-base junction is reverse biased.

SECTION B

2. Draw the symbols of the following components:
(a) Choke
(b) IC timer 555
(c) Potentiometer

(a) Choke: Coiled inductor symbol
(b) IC Timer 555: Rectangle box labeled 555 with 8 pins
(c) Potentiometer: Resistor symbol with an arrow pointing to the center

3. Briefly explain three advantages of digital instruments over analogue instruments.

Digital instruments provide higher accuracy as they display exact numerical values.
They are less prone to reading errors due to the elimination of parallax.
They often include additional functions such as auto-ranging, data hold, and digital memory storage.

4. Sketch the waveforms of the load current and voltage for silicon rectifier circuit in the figure below. Show the peak values.

Sketch should show a half-wave rectified waveform across the resistor R_L (voltage and current only present during positive half-cycles). Peak value is equal to the peak of the input sine wave minus the diode's threshold voltage.

If input peak voltage is V_{peak}, then:
$V_{RL(peak)} = V_{peak} - 0.7$ V (for silicon diode)

5. (a) What is the difference between a junction diode and a photodiode?

A junction diode allows current flow when forward biased and blocks it when reverse biased, mainly used in rectification. A photodiode is a light-sensitive diode that operates in reverse bias and generates current proportional to incident light.

(b) Draw the NPN and PNP transistors and specify their leads.

[Both symbols should show emitter (arrow), base (middle terminal), and collector. For NPN, arrow points out of emitter. For PNP, arrow points into emitter.]

6. (a) What is a radio system?

A radio system is a system that transmits and receives information wirelessly using radio waves.

(b) Give the function of the following sections in a radio receiver:
(i) Tuner section
(ii) Detector (demodulator) section

(i) The tuner section selects the desired radio frequency signal from among many using resonance.
(ii) The detector section extracts the original audio or data signal from the modulated carrier wave.

7. (a) Draw a transfer characteristic curve for a common emitter mode of a transistor.

[The curve should show collector current (I_C) on Y-axis vs base-emitter voltage (V_{BE}) on X-axis. The graph rises exponentially after the threshold (~0.7 V).]

(b) A transistor is biased with a constant base current of 10 μA and the value of beta (β_{ac}) at the operating point is 124. Find the collector current.

$I_B = 10\ \mu A$
$\beta = 124$
$I_C = \beta \times I_B = 124 \times 10 \times 10^{-6} = 1.24$ mA

Answer: 1.24 mA

8. Briefly explain three different methods in which radio waves travel from transmitter aerial to the receiver aerial.

Ground wave propagation – waves follow the curvature of the Earth and are suitable for low-frequency communication.
Sky wave propagation – waves are reflected back to Earth by the ionosphere, suitable for long-distance communication.
Space wave propagation – waves travel in a straight line from transmitter to receiver, suitable for VHF, UHF, and satellite communication.

9. (a) Explain what is meant by the term 'modulation'.

Modulation is the process of varying a property of a carrier wave (amplitude, frequency, or phase) in accordance with the information signal.

(b) Explain two possible effects of transmitting audio frequency signals directly without modulation.

The audio signal would not be able to travel long distances effectively.
It would result in interference as multiple audio signals occupy the same frequency range.

10. (a) Define the word 'decibel' as used in electronics and electrical circuits.

A decibel is a logarithmic unit used to express the ratio of two quantities, especially power or intensity, in electronics.

(b) Express in decibel a power of 10 W with reference to standard power levels of 1 mW and 100 W.

Relative to 1 mW:
$dB = 10 \log(10 / 0.001) = 10 \log(10{,}000) = 10 \times 4 = 40$ dB

Relative to 100 W:
$dB = 10 \log(10 / 100) = 10 \log(0.1) = 10 \times (-1) = -10$ dB

11. Express mathematically three kinds of gain as applied in the amplifier.

Voltage gain (A_v) = V_{out} / V_{in}
Current gain (A_i) = I_{out} / I_{in}
Power gain (A_p) = $P_{out} / P_{in} = A_v \times A_i$

SECTION C

12. (a) For the circuit shown in Figure 1, determine its quiescent point.

[Calculate V_B, V_E, and I_E using voltage divider rule and KVL. Since the image is schematic, computations would depend on component values shown in the circuit.]

(b) A transistor used as a class A audio frequency power amplifier takes a collector bias current of 5 mA from 10 V supply. When a sinusoidal signal is applied to the amplifier the collector voltage varies between −2 V and −18 V and the collector current is between 8 mA and 2 mA. Calculate the:
(i) d.c power taken from the supply
(ii) a.c power output
(iii) collector efficiency

(i) $P_{dc} = V_{cc} \times I_c = 10\ V \times 5\ mA = 50\ mW$
(ii) $I_{ac(p-p)} = 8 - 2 = 6\ mA \rightarrow I_{rms} = 6 / (2\sqrt{2}) = 2.12\ mA$
$V_{ac(p-p)} = 18 - 2 = 16\ V \rightarrow V_{rms} = 16 / (2\sqrt{2}) = 5.66\ V$
$P_{ac} = V_{rms} \times I_{rms} = 5.66 \times 2.12 \times 10^{-3} = 12\ mW$
(iii) Efficiency = $(P_{ac} / P_{dc}) \times 100 = (12 / 50) \times 100 = 24\%$

(c) Identify each device shown below and explain its function in an electronic circuit.

(i) LED – emits light when forward biased
(ii) Zener diode – maintains constant voltage in reverse bias
(iii) Tunnel diode – used in high-speed switching and microwave oscillators
(iv) Photodiode – converts light into electrical current
(v) Schottky diode – fast-switching diode with low forward voltage
(vi) Varactor diode – used as variable capacitor in tuning circuits
15. (a) Draw a well-labeled block diagram of feedback loop of amplifier.

[Diagram should include:
Input → Summing Point → Amplifier → Output → Feedback Network → back to Summing Point
Labels: A (open-loop amplifier), β (feedback network), v_{in}, v_{out}, feedback signal.]

(b) Give five advantages of negative feedback amplifier.

Improves gain stability against component variations
Reduces distortion in the output signal
Increases bandwidth of the amplifier
Improves input and output impedance characteristics
Reduces noise and enhances linearity

(c) In the series-parallel feedback amplifier shown in Figure 4, calculate:
(i) open-loop gain of the amplifier
(ii) gain of the feedback network
(iii) closed-loop gain of the amplifier
(iv) sacrifice factor, S

From Figure 4:
$v_{in} = 1\ mV$, $v_{out} = 10\ V$

(i) $A = v_{out} / v_{in} = 10\ V / 1\ mV = 10{,}000$
(ii) $\beta = v_f / v_{out} = 250\ mV / 10\ V = 0.025$
(iii) $A_f = A / (1 + A\beta) = 10{,}000 / (1 + 10{,}000 \times 0.025) = 10{,}000 / 251 = 39.84$
(iv) Sacrifice factor $S = A / A_f = 10{,}000 / 39.84 \approx 251$

16. (a) An amplifier having a gain of 500 without feedback has an overall negative feedback applied which reduces the gain to 100.
(i) Calculate the fraction of output voltage feedback.
(ii) Due to usage of components, the gain without feedback falls by 20%. Calculate the percentage fall in gain with feedback.

(i) $A_f = A / (1 + A\beta) \rightarrow 100 = 500 / (1 + 500\beta)$
$1 + 500\beta = 5 \rightarrow 500\beta = 4 \rightarrow \beta = 0.008$

(ii) New open-loop gain = 500 − 20% = 400
New $A_f = 400 / (1 + 400 \times 0.008) = 400 / 4.2 = 95.24$
Percentage fall = $(100 - 95.24) / 100 \times 100 = 4.76\%$

17. (a) (i) Describe the effect of rise in temperature on resistance of metallic conductors and non-conductors (insulators). Give four examples of material in each category.

As temperature rises, resistance in metallic conductors increases due to increased lattice vibrations. In non-conductors, resistance decreases due to increased charge carrier mobility.

Metallic conductors: Copper, Aluminum, Silver, Iron
Non-conductors: Glass, Rubber, Plastic, Mica

(ii) One of the resistors in your circuit is defective, you want to replace it, but the value is not readable. How are you going to obtain the value of the resistor so that you can replace it with the proper value?

Use an ohmmeter to measure its resistance directly if not open
Refer to circuit diagram if available
Compare with identical component in same circuit
Check for part number and datasheet
Use color code from unburnt resistors

(b) In principle a transistor can be considered as being made up of two diodes joined as shown in Figure 5.
(i) What type of transistor is represented by the diagram?
(ii) Assume it is a low power transistor that has low leakage. With the aid of a diagram, show six arrangements of checking if the transistor is in order by using an ohmmeter.

(i) The diagram shows an NPN transistor (arrow points out of emitter).
(ii) Using a multimeter, check the following six junctions:

- Base to emitter (forward bias: low reading)
- Emitter to base (reverse bias: high reading)
- Base to collector (forward bias: low reading)
- Collector to base (reverse bias: high reading)
- Collector to emitter (both directions: high reading)
- Emitter to collector (both directions: high reading)

Each check shows whether junctions are working or short/open.

18. (a) Consider the circuit below.

(i) What type of circuit is represented in Figure 2?

Answer: Full-wave rectifier with capacitor filter

(ii) Give the function of the circuit shown in Figure 2.

Answer: Converts AC input voltage into DC output voltage

(iii) With the help of diagrams explain how the circuit works.

[Explain: Transformer steps down AC, diodes conduct alternately to produce full-wave rectification, capacitors smooth the ripple.]

(iv) Sketch the input and output waveform filtered by a shunt capacitor C_2.

[Sketch input: sine wave
Output: DC with minimal ripple]

(b) (i) If the peak voltage across the primary winding of transformer is 340 V, what voltage would you expect across C_2?

Assuming full-wave and ideal diodes:
Secondary peak voltage = 340 V
$V\_C_2 \approx V\_peak - \text{diode drops}$
Assuming two 0.7 V drops: $V\_C_2 = 340 - 1.4 = 338.6$ V

(ii) What will the polarity of the voltage across C_2 be?

Positive terminal at the top (connected to anode of D_1 and cathode of D_2)

(iii) If D_1 is an open circuit, how will the output voltage from the circuit be affected?

It will become a half-wave rectifier; output voltage will drop and ripple increases.

(c) A half-wave rectifier has a peak output voltage of 12.2 V at 50 Hz and feeds a resistive load of 100 Ω. Determine:
(i) the value of the shunt capacitor to give one percent ripple factor
(ii) the resulting dc voltage across the load resistor

(i) Ripple factor r = 1% = 0.01
Use formula: $r = 1 / (fRC) \rightarrow C = 1 / (fRr) = 1 / (50 \times 100 \times 0.01) = 0.2$ F

(ii) $V_{dc} \approx V_{peak} - 0.7 = 12.2 - 0.7 = 11.5$ V

19. (a) What is meant by tuning in receivers?

Tuning is the process of adjusting the receiver's resonant frequency to match the frequency of the desired radio signal.

(b) Briefly explain the function of the following circuits in a super heterodyne AM receiver:
(i) RF amplifier
(ii) IF amplifier
(iii) Audio amplifier
(iv) Mixer
(v) Antenna

(i) RF amplifier: amplifies incoming radio signals before mixing
(ii) IF amplifier: amplifies fixed intermediate frequency signals with high gain
(iii) Audio amplifier: boosts recovered audio signals to drive a speaker
(iv) Mixer: combines RF and oscillator signals to produce IF
(v) Antenna: receives electromagnetic signals from space

(c) (i) What is an automatic gain control (AGC)?

AGC is a system that adjusts the gain of the receiver automatically to maintain constant output despite varying signal strength.

(ii) Describe the function of AGC in a radio receiver.

AGC maintains stable audio output and prevents overloading of amplifier stages.

(iii) The intermediate frequency (IF) of the receiving system is a compromise. Explain the effects of choosing inappropriate IF in receivers.

Too low IF: poor selectivity, image frequency interference
Too high IF: poor gain, circuit instability

(d) Figure 3 shows the tuned circuit of the receiver.
When L = 200 μH and C = 507 pF, determine tuned frequency.

$f = 1 / (2\pi\sqrt{(LC)})$
$= 1 / (2\pi\sqrt{(200 \times 10^{-6} \times 507 \times 10^{-12})})$
$= 1 / (6.2832 \times \sqrt{1.014 \times 10^{-10}})$
$= 1 / (6.2832 \times 3.183 \times 10^{-6})$
$= 1 / 1.999 \times 10^{-5}$
= 50025 Hz = 500.25 kHz

Answer: The receiver tunes to 500 kHz (BBC station).