THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING AVIONICS (COMMUNICATION AND NAVIGATION OPTION)

TELECOMMUNICATION PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Smith chart;
Mathematical tables/Scientific calculator.
*Answer any **FIVE** of the **EIGHT** questions in this paper.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.

This paper consists of 8 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

1. (a) For the diode clipper circuit shown in figure 1:

(i) describe its operation;
(ii) sketch the output voltage waveform for a sinusoidal input voltage.

Assume negligible diode forward drop. (6 marks)

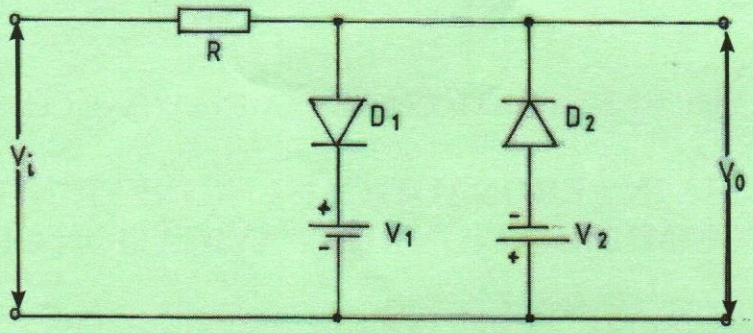

FIG. 1

(b) Obtain the expression for the cutoff frequency of the filter circuit shown in figure 2. (4 marks)

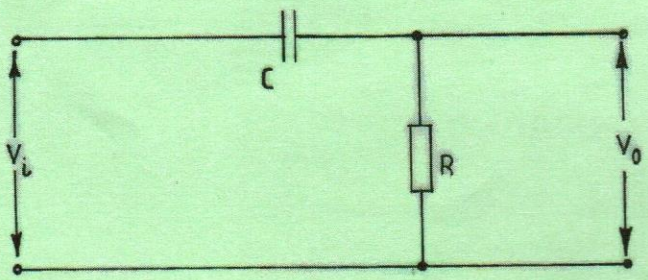

FIG. 2

(c) (i) Draw the circuit diagram of a transistor R-C phase-shift oscillator and describe its operation.

(ii) The oscillator in c(i) has a collector resistor, Rc = 10kΩ , resistance seen looking into the base, R = 8kΩ and phase shift capacitors $C_1 = C_2 = C_3 = C$. Determine the value of the:

I. capacitor C to provide oscillating frequency of 2kHz;

II. transistor current gain, hfe, to provide sufficient loop gain for oscillations to start.

(10 marks)

2. (a) (i) State any **three** areas of application of varactor diodes.

(ii) Sketch the characteristic curve of the diode in a(i) and explain its shape. (8 marks)

(b) With the aid of a labelled diagram describe the operation of a capacitive transducer employed in liquid level measurement. (6 marks)

(c) A copper-constantan thermocouple, with reference junction temperature of 0°C, has a linear calibration between 0°C to 400° C with e.m.f. at maximum temperature equal to 20.68mV. If the reference junction temperature changes to 25°C, determine the:

(i) sensitivity of the thermocouple in mV/°C;

(ii) temperature of the hot junction if the indicated e.m.f is 8.92mV. (6 marks)

3. (a) (i) State any **two** advantages of diode - over transistor - detectors in amplitude modulated (AM) systems.

(ii) Describe the operation of the circuit shown in figure 3. (7 marks)

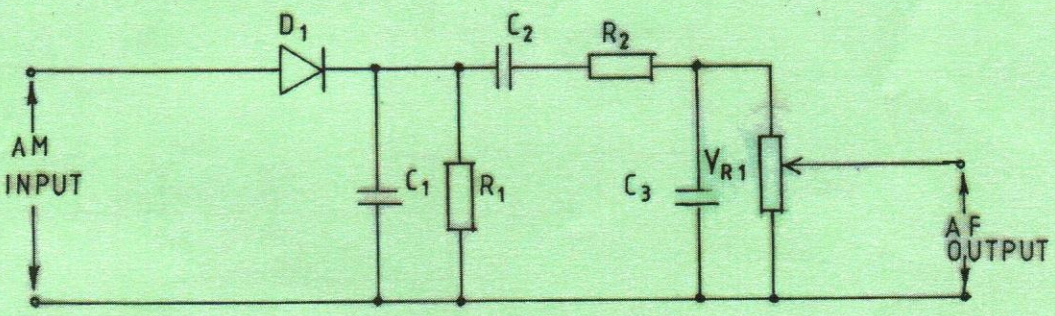

FIG. 3

(b) For an AM wave, obtain the expression for the total power in terms of the carrier power and the modulation index. (7 marks)

(c) An AM transmitter radiates 8.91 kW with the carrier unmodulated and 10.25 kW when the carrier is sinusoidally modulated. If the carrier is modulated to a depth of 40% by another sine wave, determine the:

(i) total modulation index;
(ii) total power radiated;
(iii) percent saving in power when the carrier and one sideband are suppressed.

(6 marks)

4. (a) (i) State any **two** advantages of frequency modulation (FM) over amplitude modulation (AM) systems.

(ii) With the aid of a labelled block diagram describe the operation of a direct-modulation FM transmitter employing automatic frequency control (AFC). (9 marks)

(b) Describe the operation of the Foster-Seeley detector circuit shown in figure 4, hence sketch its response curve. (5 marks)

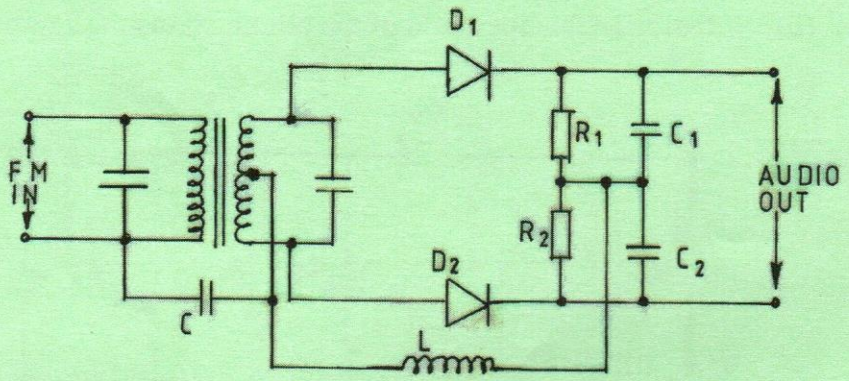

FIG. 4

(c) A carrier wave, when frequency modulated by a 2.4V, 500Hz sinusoidal signal, gives a deviation of 4.8 kHz. If the modulating signal voltage is increased to 7.2V, determine the:

(i) new deviation;
(ii) change in modulation index.

(6 marks)

5. (a) For the small signal amplifier shown in figure 5,

(i) draw the h-parameter equivalent circuit ignoring hre and hoe;

(ii) determine the voltage gain for the circuit in a(i) given that hfe = 50 and hie = 1kΩ

(8 marks)

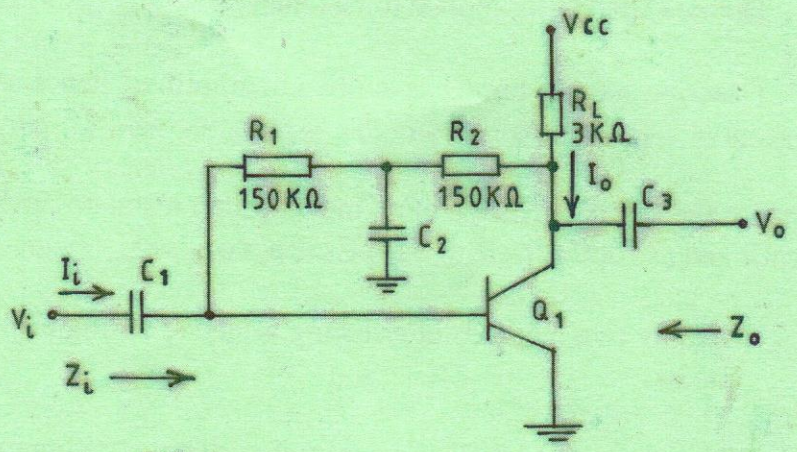

FIG 5

(b) (i) State any **two** advantages of push-pull over single-ended operation of power amplifiers.

(ii) Figure 6 is a circuit diagram of a complementary-symmetry class B power amplifier. Given that the input signal voltage, Vi = 12 Vrms and the voltage gain, Av = 1, determine the:

I. a.c. output power;
II. d.c. input power;
III. amplifier efficiency.

(12 marks)

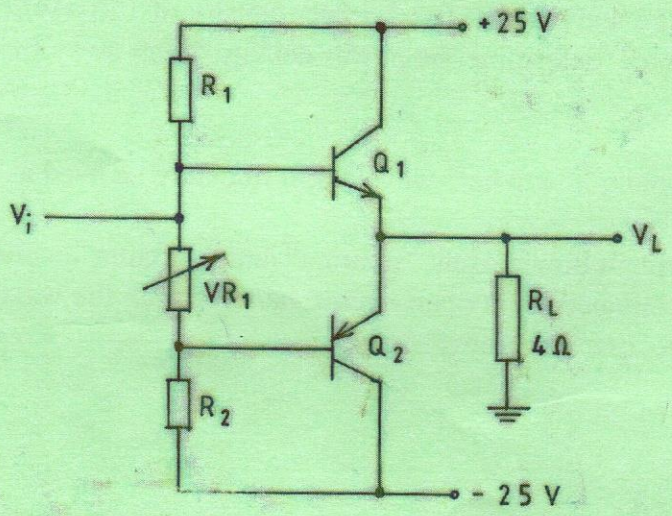

FIG. 6

6. (a) (i) State any **two** effects of applying negative feedback to amplifiers.

(ii) An amplifier has a voltage gain of 1000 without feedback. If 3% of the output voltage is applied as negative feedback, determine the change in gain with feedback when the gain without feedback falls by 50%. (6 marks)

(b) (i) Define Q-factor as applied to resonant circuits.

(ii) Describe stagger-tuning as applied to amplifiers hence sketch the response curve. (7 marks)

(c) Determine the self capacitance of an inductor that resonates at 500kHz with a 100pF capacitor and at 1000 kHz with a 20pF capacitor. (7 marks)

7. (a) (i) State any **two** methods of reducing selective fading in sky wave communication systems.

(ii) With the aid of a labelled diagram describe the fading in a(i). (7 marks)

(b) With the aid of a labelled diagram explain atmospheric ducting with respect to radio wave propagation. (5 marks)

(c) (i) An electromagnetic wave travelling in free space is refracted when it enters the ionosphere such that the original angle of 35° changes to 25°. Determine the:

I. refractive index of the ionosphere;

II. velocity of the wave in the ionosphere.

(ii) If the wave in c(i) has a power density of 150 $\mu W/m^2$ at 30km from a point source, determine the power density 40km away from the source. (8 marks)

8. (a) (i) Explain how a half-wavelength line may be used as a band-stop filter.

(ii) Explain how current "minima" and "maxima" occur in a transmission line terminated in an open circuit, hence sketch the wave pattern. Assume a loss free line, one wavelength long. (8 marks)

(b) A 50Ω transmission line has a voltage standing wave ratio of 2 when an unknown load is connected to its output terminals and produces voltage minima 30cm apart. When the unknown load is removed and replaced by a short-circuit, the voltage minima moves by 7.5cm. Using the Smith chart, determine the impedance of the unknown load.

(4 marks)

(c) If the load in (b) is now connected to a 75Ω transmission line, determine the following using the Smith chart:

(i) point, nearest the load, at which $\frac{\lambda}{4}$ transformer may be inserted to provide correct matching;

(ii) characteristic impedance of the transformer. (8 marks)

IMPEDANCE OR ADMITTANCE COORDINATES