2207/302
TELECOMMUNICATION PRINCIPLES
June/July 2018
Time: 3 hours

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:
Mathematical tables/Non-programmable scientific calculator;
Graph paper;
Drawing instruments.
*Answer **FIVE** of the **EIGHT** questions in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

This paper consists of 6 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) Figure 1 shows a circuit diagram of an emitter follower amplifier.

(i) Draw the h-parameter equivalent circuit ignoring hoe and hre.

(ii) From the equivalent circuit in a(i) determine the input impedance of the amplifier if the transistor has hie = 1kΩ and hfe = 50.

(8 marks)

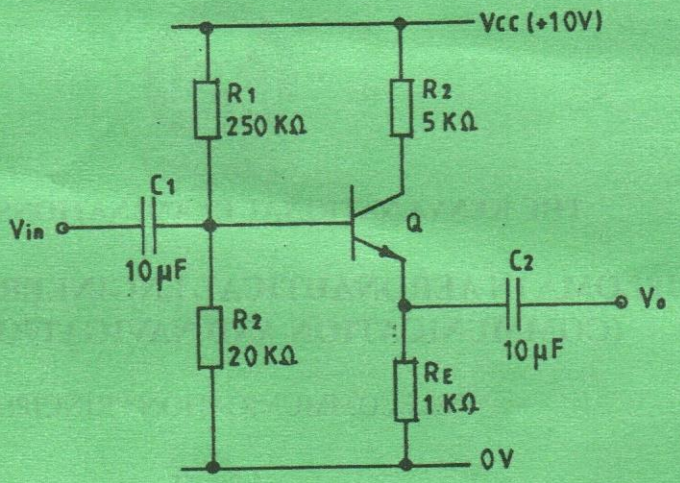

Fig. 1

(b) A transistor used in a single-ended transformer-coupled class A power amplifier has the data given in table 1. The load resitor = 5 Ω, transformer turns ratio = 3.464:1, supply voltage = 20V and the quiescent base bias current = 10 mA.

(i) plot the characteristic curves.

(ii) construct the a.c loadline.

(iii) use the loadline in (ii) to determine the:

(I) a.c power output;
(II) d.c power input
(III) efficiency. (12 marks)

Table 1

Vce (V)	Ic (A)				
	I_b = 2 mA	I_b = 6 mA	I_b = 10 mA	I_b = 14 mA	I_b = 18 mA
1	0.02	0.20	0.40	0.60	0.80
40	0.20	0.40	0.60	0.80	1.00

2. (a) (i) State **two** ways of improving the frequency stability of sinusoidal oscillators.

(ii) With the aid of an electrical equivalent circuit diagram, explain how resonance occurs in a piezoelectric crystal and sketch its response curve.

(10 marks)

(b) An amplifier has a gain of 50 dB. A fraction $\frac{1}{50}$ of the output voltage is fed back as negative feedback.

(i) Determine the:

(I) change in gain in dB;
(II) reduction in harmonic distortion.

(ii) Sketch, on the same axis, the response curves of the amplifier without feedback and with feedback.

(10 marks)

3. (a) (i) Define the following with respect to tuned circuits:

(I) selectivity;
(II) Q-factor.

(ii) Sketch the curve of current against frequency in a series resonant circuit and explain its shape.

(7 marks)

(b) With the aid of a circuit diagram, explain how high frequency compensation is achieved in wideband amplifiers. (5 marks)

(c) A parallel-resonant circuit consists of 20 pF capacitor in parallel with a 50 μH inductor of resistance 10 Ω. Determine the:

(i) resonant frequency;
(ii) dynamic impendance;
(iii) Q-factor;
(iv) bandwidth. (8 marks)

4. (a) (i) State **three** applications of unijunction transistors.

(ii) Describe the operation of a varactor diode and sketch its characteristic curve.

(8 marks)

(b) Figure 2(a) and 2(b) shows circuit diagrams of diode clippers. Sketch the output waveform for each clipper assuming a sinusoidal input whose peak value is greater than V_1 and V_2. (4 marks)

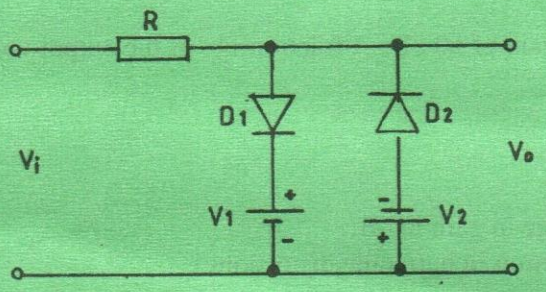

Fig. 2(a)

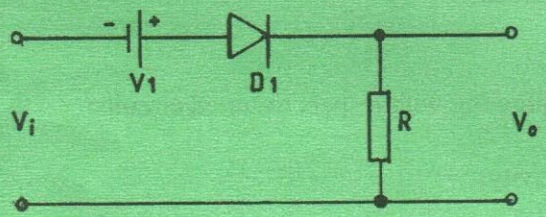

Fig. 2 (b)

(c) The output of a linear variable differential transformer (LVDT) is connected to a 5 V voltmeter through an amplifier whose amplification factor is 250. An output of 2 mV appears across the terminals of the LVDT when the core moves through a distance of 0.5 mm. The voltmeter scale has 100 divisions and the scale can be read to $\frac{1}{5}$ of a division. For the set up, determine the:

(i) sensitivity;
(ii) resolution. (8 marks)

5. (a) (i) Define amplitude modulation (AM).

(ii) With the aid of a circuit diagram, describe the operation of a Cowan modulator. (7 marks)

(b) Figure 3 shows a block diagram of the phase-shift method of generating single sideband (SSB) signal. Obtain the expression for the output voltage, V_o. (6 marks)

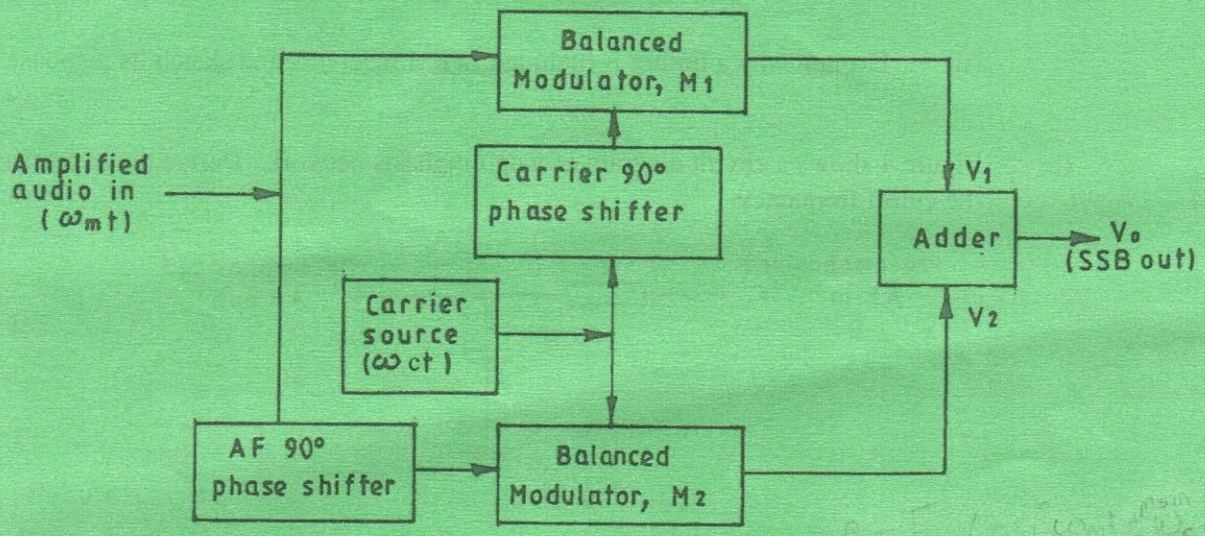

Fig. 3

(c) An AM signal has a carrier power of 2 mW and each side frequency is $\frac{1}{5}$ the carrier voltage. Determine the:

(i) modulation index;
(ii) total power;
(iii) side frequency. (7 marks)

6. (a) (i) State **two** losses that occur in transmission lines.

(ii) Draw the equivalent electrical circuit diagram for each of the following transmission lines:

(I) short circuited $\frac{\lambda}{4}$ lines;

(II) open circuited $\frac{\lambda}{4}$ lines.

(6 marks)

(b) With the aid of a labelled diagram, describe double-stub matching as used in transmission. (5 marks)

(c) The sending end of an open wire line is connected to a generator having an open circuit e.m.f of 10 V at a frequency of 1 kHz. If the line primary constants are R = 8 Ω, L = 3mH, C = 7500 pF and G = 0.25 μS, determine the:

(i) characteristic impedance;
(ii) sending-end current;
(iii) propagation coefficient;
(iv) phase shift coefficient. (9 marks)

7. (a) (i) State **three** advantages of frequency modulation (FM) over amplitude modulation (AM) systems.

(ii) Explain why a limiter is included in FM receivers and sketch its response curve. (9 marks)

(b) Figure 4 shows a circuit diagram of a de-emphasis network. Derive the expression for the cutoff frequency. (4 marks)

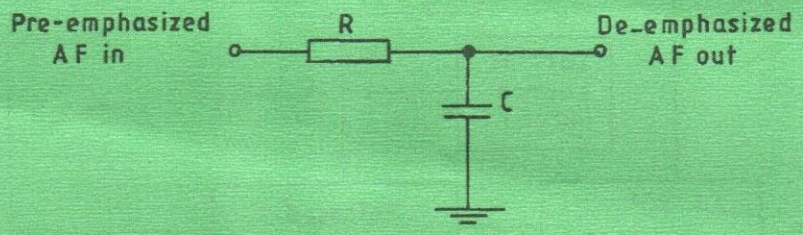

Fig. 4

(c) A 10 V, 65 MHz carrier is frequency modulated by a 200 Hz audio sine wave and the maximum deviation is 10 kz.

(i) Determine the:

(I) angular frequency of the carrier;
(II) angular frequency of the modulating signal;
(III) modulation index.

(ii) Write down the expression for the instantaneous voltage of the modulated wave. (7 marks)

8. (a) (i) With the aid of a labelled diagram, describe selective fading of sky waves.

(ii) State **two** methods of minimizing the fading in a(i). (8 marks)

(b) A p.c.m system uses 128 quantization levels with each sample signalled to the line accompanied by one synchronization bit. If the bandwidth required for transmission is 32 kHz, determine the:

(i) bit rate;
(ii) sampling frequency. (6 marks)

(c) An ionospheric layer has a maximum electron density of 5×10^{11} electrons/m^3. If the angle of incidence is 40° and angle of refraction is 60°, determine the:

(i) critical frequency;
(ii) maximum usable frequency;
(iii) refractive index of the layer.

(6 marks)

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