2207/302
TELECOMMUNICATION PRINCIPLES
Oct./Nov. 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;
Smith chart;
Drawing instruments.
*Answer any **FIVE** of the following **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 7 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) (i) List any **two** factors considered when selecting an RF oscillator.

(ii) With the aid of a circuit diagram, describe the operation of a tuned collector oscillator. (10 marks)

(b) Figure 1 shows the block schematic diagram for a voltage - negative feedback amplifier. Derive the expression for the feedback factor, β. (3 marks)

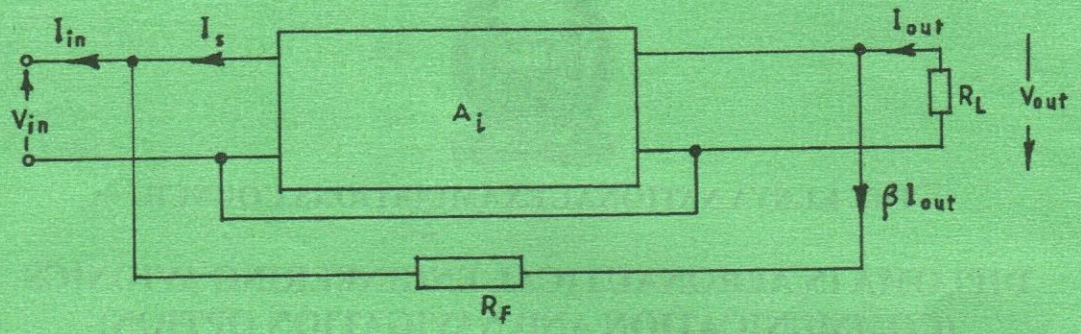


Fig. 1

(c) An amplifier has an open loop voltage gain of 60 dB and a closed loop voltage gain of 30 dB. If the open loop gain changes to 55 dB, determine the:

(i) feedback factor;
(ii) new closed loop gain in dB. (7 marks)

2. (a) Sketch, on the same axes, the response curves for the following coupled circuits:

(i) under-coupled;
(ii) critically coupled;
(iii) over-coupled. (6 marks)

(b) A common - emitter transistor amplifier has the following hybrid parameters: $h_{ie} = 1.1\,k\Omega$, $h_{fe} = 50$, $h_{re} = 50 \times 10^{-4}$, $h_{oe} = 25\,\mu S$. The source and load resistances are $1\,k\Omega$ and $10\,k\Omega$ respectively. Determine the:

(i) current gain;
(ii) voltage gain;
(iii) output resistance;
(iv) power gain. (8 marks)

(c) A class A power amplifier draws a collector current of 30 mA at a collector voltage of 9 V. When an a.c. signal is applied, the voltage swings from 16 V to 2 V while the current swings from 40 mA to 12 mA. Determine the:

(i) power drawn from the supply;
(ii) output power;
(iii) efficiency. (6 marks)

3. (a) Define each of the following with respect to silicon controlled rectifiers (SCR):

(i) holding current;
(ii) forward blocking region. (2 marks)

(b) (i) Figure 2 shows a circuit diagram of an SCR - based light dimmer control. Describe its operation.

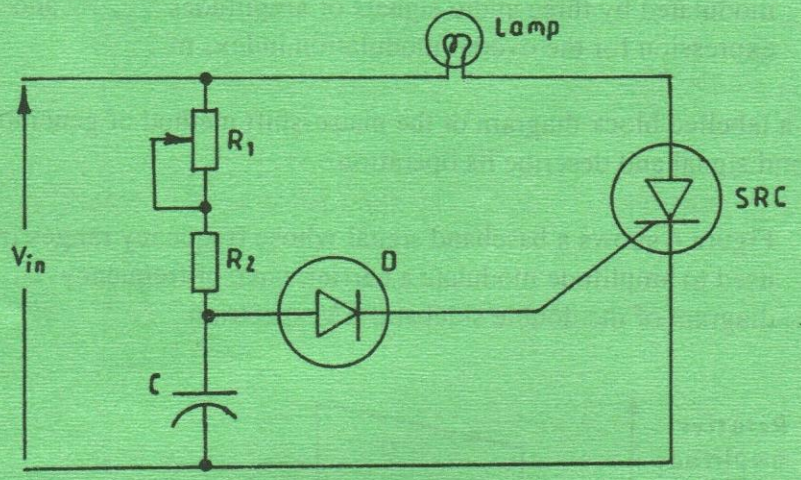


Fig. 2

(ii) With the aid of a response curve, describe the operation of a unijunction transistor. (11 marks)

(c) Figure 3 shows an input voltage, V_{in}, fed to a triac. The firing angle is θ while conduction angle is ϕ.

(i) draw the output voltage waveform;
(ii) describe the triac operation. (7 marks)

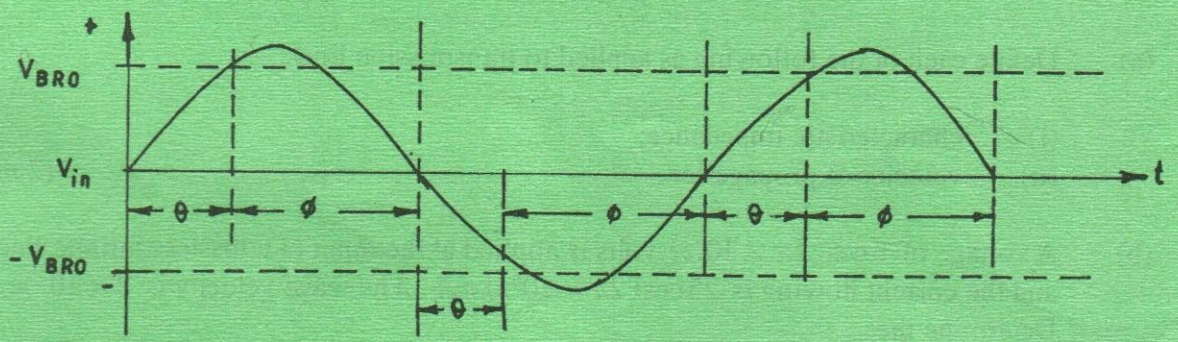


Fig. 3

4. (a) (i) Define each of the following with respect to amplitude modulation (AM) systems:

I. efficiency;
II. modulation index.

(ii) A sinusoidal carrier wave of amplitude V_C is simultaneously amplitude modulated by three audio signals of amplitudes V_1, V_2 and V_3. Derive the expression for the overall modulation index, m_t. (6 marks)

(b) Draw a labelled block diagram of the phase-shift method of generating a single sideband signal and describe its operation. (6 marks)

(c) (i) Figure 4 shows a baseband signal whose frequency ranges from f_1 to f_2. It is used to amplitude modulate a carrier wave of frequency f_c. Draw a labelled diagram of the double sideband AM spectrum.

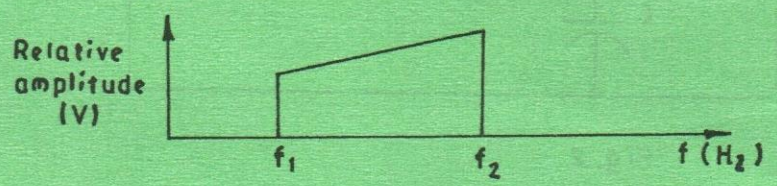


Fig. 4

(ii) The output power of a DSB AM signal is 150 kW when the depth of modulation is 0.78. Determine the:

I. carrier power;
II. power of each sideband. (8 marks)

5. (a) Define each of the following as applied to transmission lines:

(i) characteristic impedance;
(ii) velocity of propagation. (2 marks)

(b) A voltage of $6\cos(2\pi \times 10^6 t)$ volts is applied at the input of a lossless infinite line and the current flowing is $25\cos(2\pi \times 10^6 t)\, mA$. The wave velocity is $2 \times 10^6\, m/s$. Determine the:

(i) characteristic impedance;
(ii) signal wavelength. (4 marks)

(c) A transmission line has a characteristic impedance of $600\,\Omega$ and is terminated by a load of $300 + j450\,\Omega$. Using the Smith Chart, determine the:

(i) voltage standing wave ratio;
(ii) magnitude and phase angle of the reflection coefficient. (8 marks)

(d) With the aid of a circuit diagram, describe the operation of a discrete component monostable multivibrator. (6 marks)

6. (a) (i) List any **two** telecommunication services that use Pulse Code Modulation (PCM).

(ii) Figure 5 shows a block diagram of a pulse modulating system.

I. Describe its operation.
II. Draw the waveforms at points 1, 2 and 3. (11 marks)

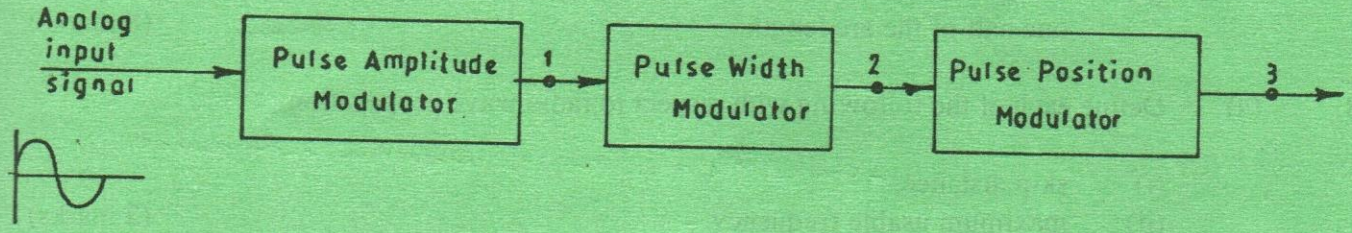


Fig. 5

(b) (i) With the aid of a circuit diagram, describe the operation of a silicon diode clipper whose sinusoidal input is $10\,V$ and output is $\pm 7.7\,V$.

(ii) Draw the output waveform for the clipper in (b)(i). (7 marks)

(c) Sketch the ideal response curve of a bandpass filter. (2 marks)

7. (a) (i) List any **two** advantages of closed-loop-over open loop control systems.

(ii) With the aid of a labelled diagram, describe the operation of an E-I displacement transducer. (9 marks)

(b) Figure 6 shows a circuit diagram of an a.c. servomotor. Describe its operation. (3 marks)

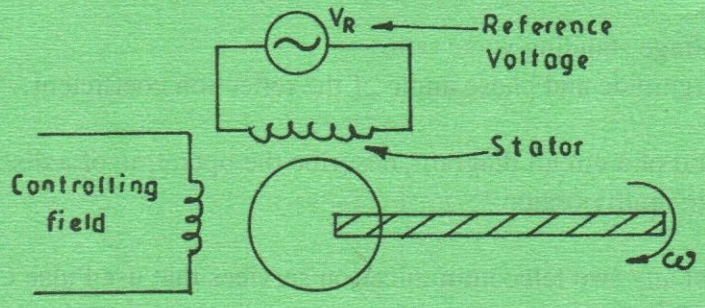


Fig. 6

(c) A 120 kΩ potentiometer with an arc length of 300° is connected to a 12 V d.c supply. Determine the:

(i) potentiometer constant in volts/radian;
(ii) output voltage when a load of 80 kΩ is connected to the slider which is set at one half of the arc length. (8 marks)

8. (a) Define each of the following with respect to radio wave propagation:

(i) skip distance; - Shortest distance from tx measured on earth surface
(ii) maximum usable frequency. - (2 marks)

(b) **Table 1** shows data for a space wave communication link.

(i) Plot the response curve.
(ii) Determine the:

I. received signal strength at 45 km;
II. distance at which the signal strength is 20 mV. (7 marks)

Table 1

Distance (km)	0	10	20	30	40	50	60	70	80
Signal strength (mV)	35	47.5	33	45	22.5	35	15	25	5

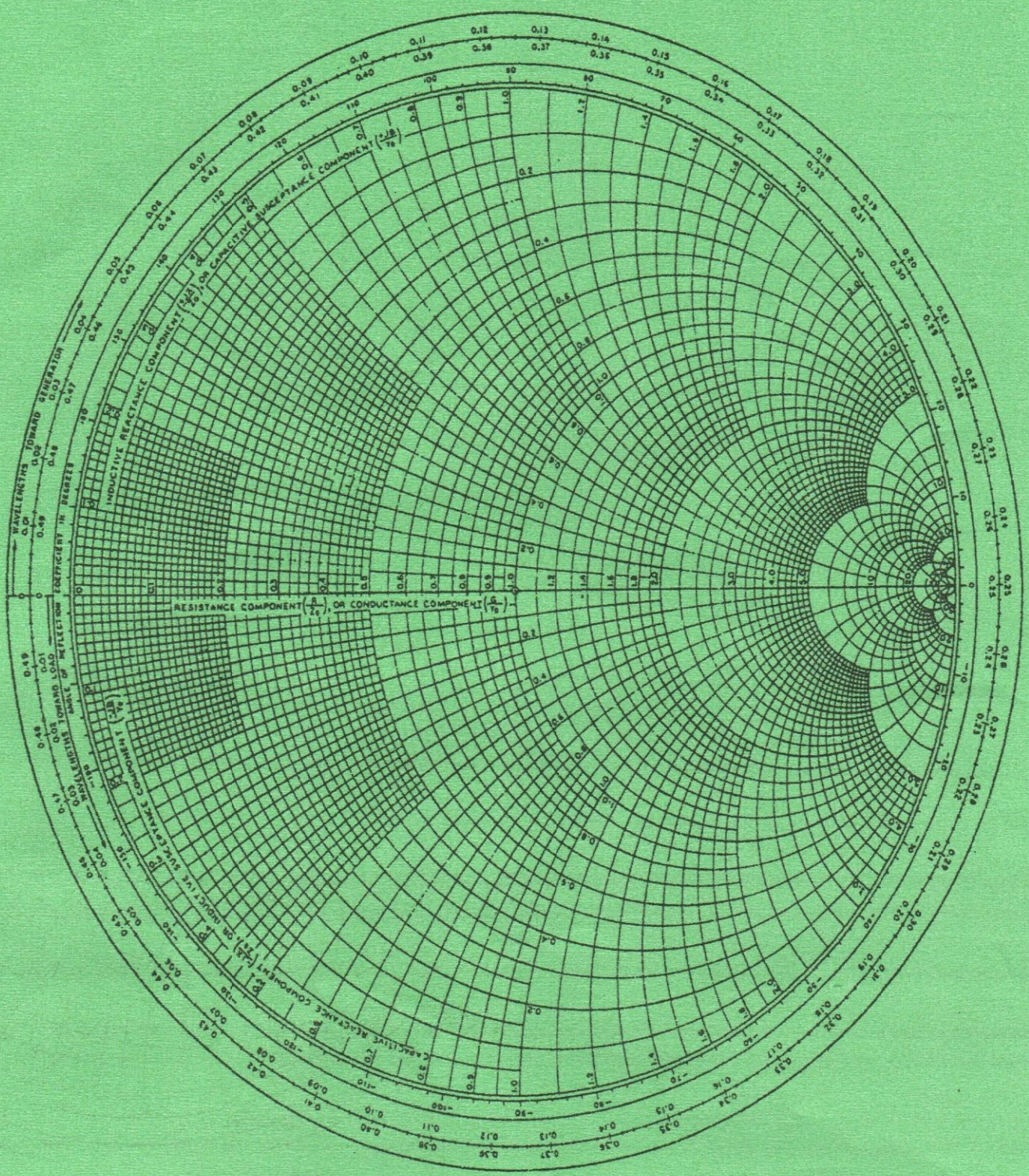
(c) (i) With the aid of a labelled diagram, describe surface duct with respect to ground wave propagation.

(ii) The electron density of the F_1 layer of the ionosphere is 2.8×10^{12} electrons/ m^3 at a virtual height of 250 km. Determine the:

I. critical frequency;
II. maximum usable frequency. (11 marks)

NAME:_____ INDEX NO: _____

IMPEDANCE OR ADMITTANCE COORDINATES



THIS IS THE LAST PRINTED PAGE.