2207/302
TELECOMMUNICATION PRINCIPLES
Oct./Nov. 2019
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:
Answer booklet;
Mathematical tables/Non-programmable scientific calculator;
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 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) Define each of the following with respect to tuned circuits:

(i) resonant frequency;
(ii) selectivity.

(2 marks)

(b) A class-A r.f. amplifier has a load circuit consisting of an indicator of 100 μH in parallel with a lossless capacitor of 200 pF. The effective Q-factor of the inductor is 56 and the output voltage at resonance is 10 V. Determine the:

(i) resonant frequency;
(ii) bandwidth;
(iii) lower cutoff frequency;
(iv) upper cutoff frequency;
(v) output voltage at the cutoff frequencies.

(10 marks)

(c) (i) State **two** effects of applying negative feedback to an amplifier.

(ii) A voltage amplifier has a gain of 47 dB without negative feedback. Determine the:

(I) voltage gain without feedback as a ratio:

(II) voltage gain when 25% of the output voltage is fed back as negative feedback;

(III) reduction in harmonic distortion when negative feedback is applied.

(8 marks)

2. (a) (i) State **three** applications of silicon controlled rectifiers.

(ii) Sketch the characteristic curve of a unijunction transistor and explain its shape.

(8 marks)

(b) With the aid of a circuit diagram, describe the operation of a synchro system for detecting angular misalignment between two shafts. (6 marks)

(c) A thermocouple is made up of tellurium having sensitivity of 500 μV/°C and bismuth having a sensitivity of –72μV/°C. The measuring junction is subjected to an increase in temperature of 150°C. The total circuit resistance is 320 Ω. Determine the:

(i) sensitivity of the thermocouple;
(ii) maximum output voltage;
(iii) maximum output current.

(6 marks)

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

(I) side frequency;
(II) modulation envelope.

(ii) Figure 1 shows a circuit diagram of an AM modulator. Describe its operation.

(6 marks)

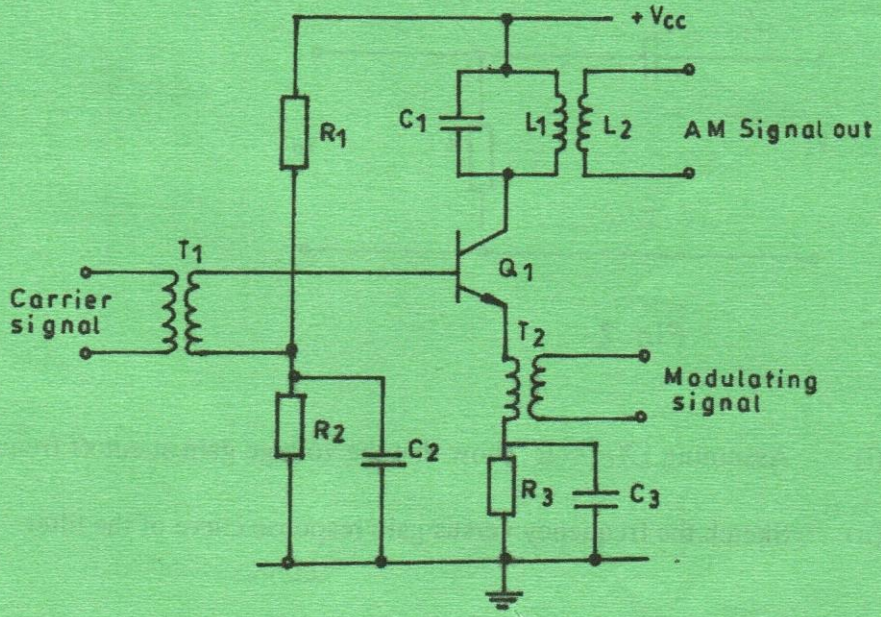

Fig. 1

(b) A 10V, 1MHz carrier signal is amplitude modulated by a sinusoidal signal. The amplitude of the lower side frequency is 4 V at 980 kHz. Determine the:

(i) modulation index;
(ii) amplitude of the modulating signal;
(iii) frequency of the modulating signal;
(iv) bandwidth required to transmit the modulated signal.

(8 marks)

(c) (i) Distinguish between pulse width modulation and pulse position modulation.

(ii) A pulse code modulation system has a bit rate of 72 kilobytes per second at a sampling frequency of 8 kHz. If each sample is accompanied by one synchronization bit, determine the:

(I) quantization level, in bits;
(II) bandwidth.

(6 marks)

4. (a) (i) State **two** factors that determine the natural frequency of a piezoelectric crystal.

(ii) With the aid of a labelled block diagram, describe the operation of a sinusoidal oscillator.

(8 marks)

(b) Figure 2 shows a circuit diagram of an R-C filter.

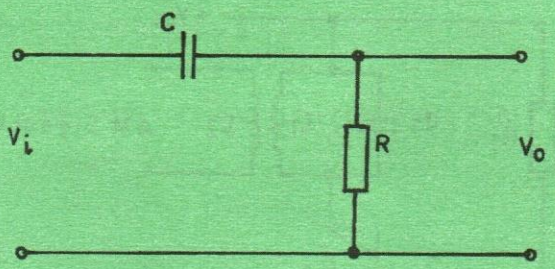

Fig. 2

(i) Assuming $|X_C| = R$, show that the voltage gain at cutoff frequency is –3 dB.

(ii) Sketch the frequency versus gain response curve of the filter.

(6 marks)

(c) The tuned circuit of an oscillator consists of a 22 pF capacitor in parallel with a 50 μH, 12 Ω inductor. For the tuned circuit, determine the:

(i) resonant frequency;
(ii) Q-factor;
(iii) dynamic impedance.

(6 marks)

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

(I) fading;
(II) ionosphere.

(ii) With the aid of a ray diagram, explain radio horizon for space waves.

(6 marks)

(b) Figure 3 shows a circuit diagram illustrating a generator, having an impedance Z_O, connected to the input terminals of a transmission line which is terminated in an impedance Z_R. Assuming the Z_O is not equal to Z_R, show that the reflection coefficient, ρ, is given by the expression

$$\rho = \frac{Z_O - Z_R}{Z_O + Z_R}$$

(8 marks)

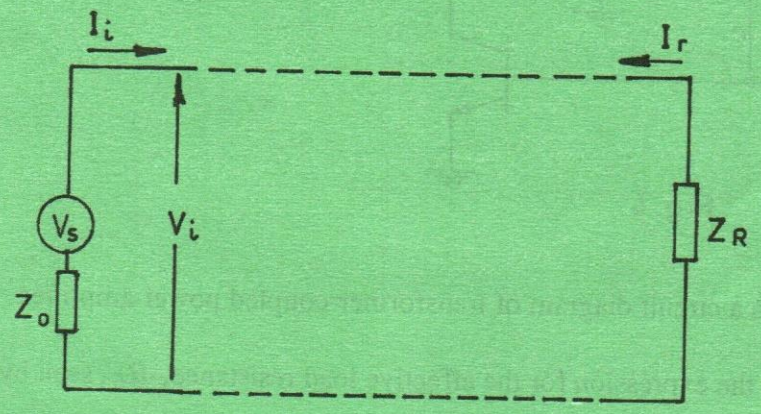

Fig.3

(c) A transmission line has inductance of 6 mH/km and capacitance of 0.056 μF/km. The frequency of operation is 1.5 kHz. Determine the:

(i) phase delay;
(ii) wavelength;
(iii) velocity of propagation.

(6 marks)

6. (a) Figure 4 shows a circuit diagram of a common-emitter amplifier in which the values of hre and hoe of the transistor are negligible.

(i) Draw the h-parameter equivalent circuit.

(ii) Taking hfe = 50 and hie = 1 kΩ, determine the:

(I) voltage gain;
(II) current gain;
(III) input impedance;
(iv) output impedance.

(12 marks)

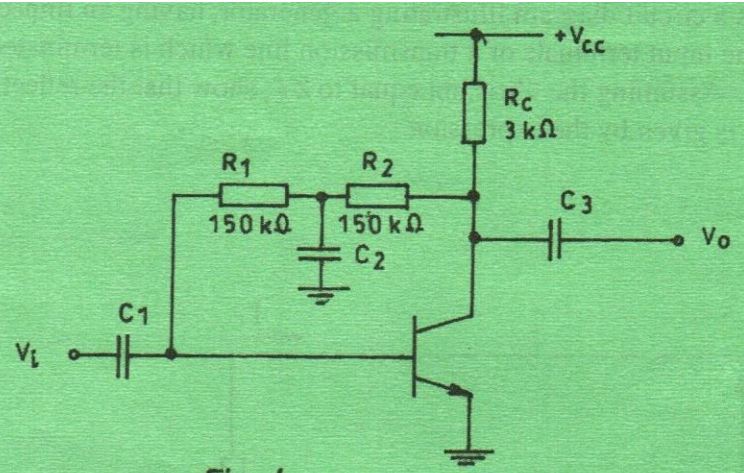

Fig. 4

(b) Figure 5 shows a circuit diagram of transformer-coupled power amplifier.

(i) Obtain the expression for the effective load resistance, $R_L^{'}$, seen by the collector circuit.

(ii) Determine the transformer turns ratio required to match a 16 Ω load to the amplifier so that $R_L^{'} = 10\ k\Omega$.

(8 marks)

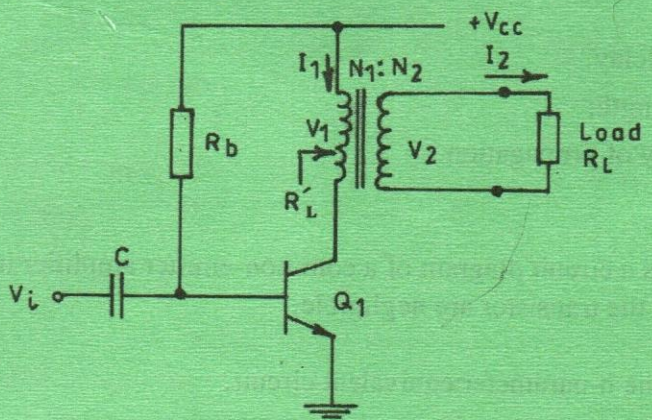

Fig. 5

7. (a) (i) State **two** services that use narrowband FM.

(ii) With the aid of a circuit diagram, describe the operation of a varactor diode FM modulator.

(8 marks)

(b) Figure 6 shows a circuit diagram of a balanced slope FM demodulator.

(I) Describe its operation.
(II) Sketch its response curve.

(6 marks)

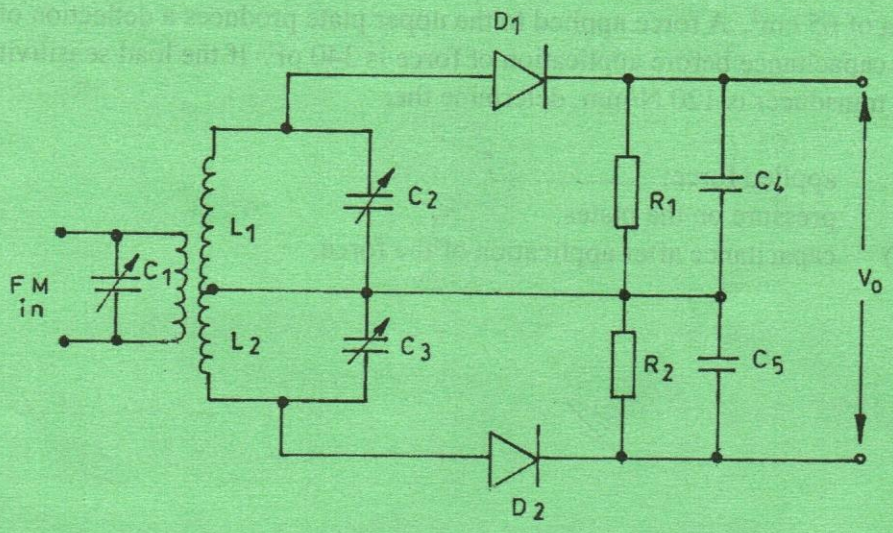

Fig. 6

(c) A 3V, 600 Hz audio modulating signal produces a frequency deviation of 5 kHz in an FM system. If the amplitude of the audio signal is increased to 8 V, determine the:

(i) sensitivity of the system;
(ii) new frequency deviation;
(iii) new modulation index.

(6 marks)

8. (a) State:

(i) **two** areas of application of wideband amplifiers;

(ii) **two** effects of cascading tuned amplifiers.

(4 marks)

(b) Table 1 shows various frequency bands and their classifications. Complete the table.

(4 marks)

Frequency	**Classification**
	Very low frequency
300 kHz - 3,000 kHz	
	Very high frequency
3 GHz - 30 GHz	

(c) With the aid of a labelled block diagram, describe the filter method of generating a single sideband signal. (6 marks)

(b) A capacitive transducer uses two plates separated by an air gap of 3 mm and effective area of 65 cm^2. A force applied to the upper plate produces a deflection of 0.8 mm and the capacitance before application of force is 340 pF. If the load sensitivity of the transducer is 120 N/mm, determine the:

(i) applied force;
(ii) pressure on the plates;
(iii) capacitance after application of the force.

(6 marks)

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