2207/302
TELECOMMUNICATION PRINCIPLES
June/July 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.
*This paper consists of **EIGHT** questions.*
*Answer any **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) (i) Define each of the following h-parameters of a transistor:

(I) hf;
(II) hr.

(ii) A transistor used in a common-emitter amplifier has the following h-parameters: hie = 700 Ω; hoe = 50 μS and hfe = 50. The amplifier has a load resistor of 1.5 kΩ. Determine the:

(I) current gain;
(II) input impedance;
(III) voltage gain;
(IV) power gain.

(10 marks)

(b) (i) With the aid of a transfer characteristic curve, describe class - B operation of an amplifier.

(ii) A class - A power amplifier takes a quiscent collector current of 5.5 mA from a 12 V supply. When a sinusoidal signal is applied, the collector - emitter voltage varies between 1.8 V and 19.2 V while the collector current varies between 7.9 mA and 1.6 mA. Determine the:

(I) dc power input;
(II) ac power output;
(III) efficiency of the amplifier.

(10 marks)

2. (a) (i) State the **two** methods used to minimize internal feedback in tuned amplifiers.

(ii) Sketch the gain/frequency response curve of a single-tuned amplifier and explain its shape.

(7 marks)

(b) An i.f. transformer has two identical windings which are critically coupled, the coupling coefficient being 0.031. Each winding has a self-inductance of 420 μH and is tuned to resonate at 580 kHz by a capacitor. Determine the:

(i) Q-factor;
(ii) 3 dB bandwidth;
(iii) mutual coupling.

(6 marks)

(c) With the aid of a block schematic diagram, show that the gain of an amplifier with negative feedback, A_f, is given by the expression:

$$A_f = \frac{A}{1 + A\beta}$$

where A = gain without feedback and β = feedback factor. (7 marks)

3. (a) (i) Distinguish between monostable and bistable modes of operation of multivibrators.

(ii) Figure 1 shows a circuit diagram of a monostable multivibrator. Describe its operation. (7 marks)

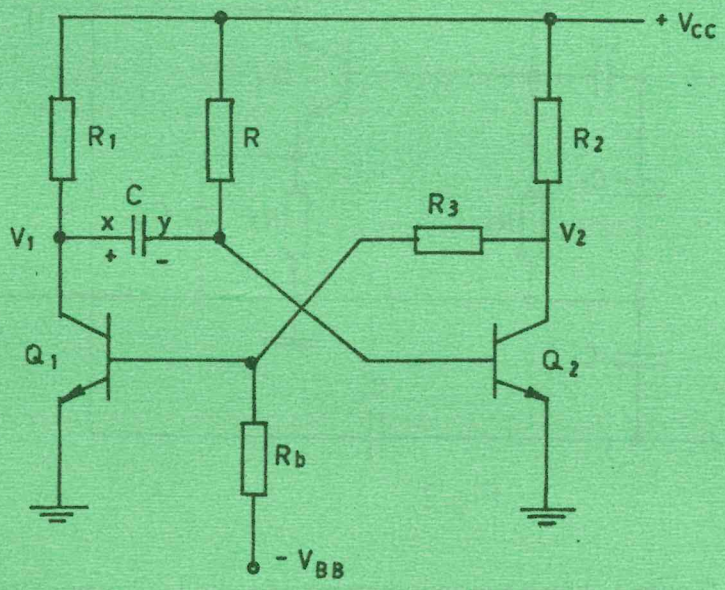

Fig. 1

(b) (i) State **three** factors that determine the choice of an oscillator.

(ii) Figure 2 shows a circuit diagram of a Colpitts oscillator. Show that its resonant frequency, fr, is given by the expression:

$$fr = \frac{1}{2\pi\sqrt{L.\frac{C_1C_2}{C_1+C_2}}}$$

(7 marks)

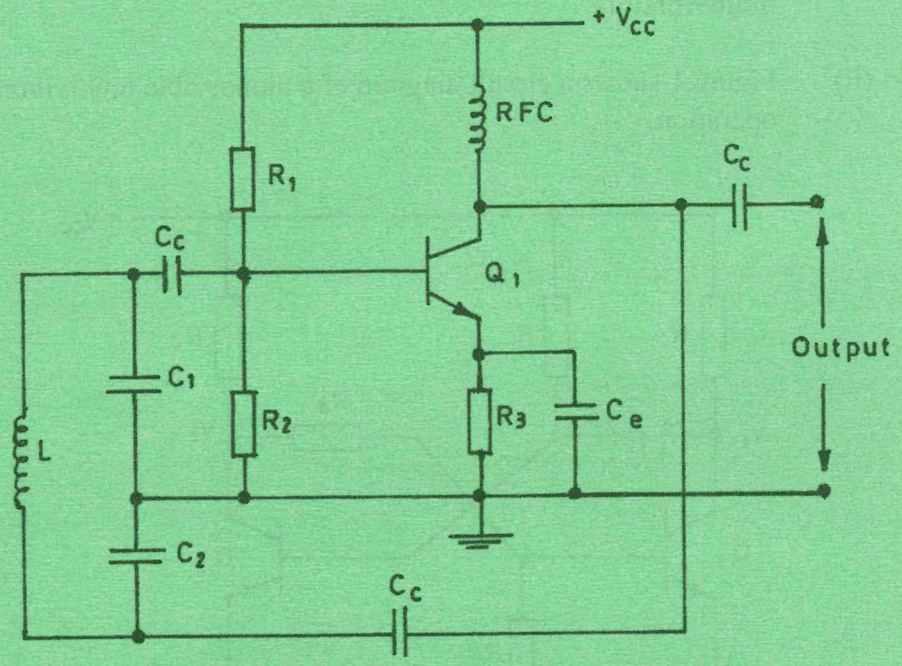

Fig. 2

(c) (i) Figure 3 shows a circuit diagram of a diode clipper. Draw the output waveform for a sinusoidal input of amplitude 10 V.

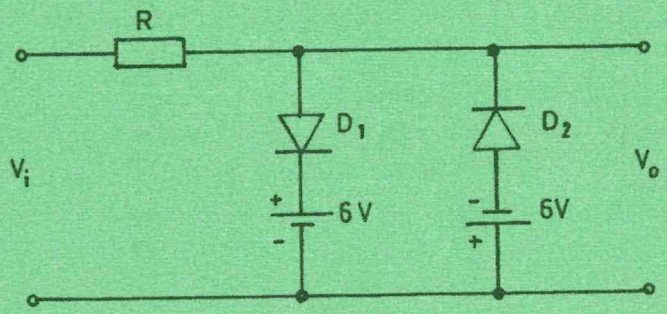

Fig. 3

(ii) Sketch the ideal response curves for each of the following filters:

(I) low pass;
(II) high pass.

(6 marks)

4. (a) (i) State **two** areas of application of varactor diodes.

(ii) Sketch the characteristic curve of a Zener diode and explain its shape.

(7 marks)

(b) (i) With the aid of a circuit diagram, explain the principle of operation of a thermocouple.

(ii) A variable reluctance type proximity inductive transducer has a coil of inductance 1200 μH when a target of ferromagnetic material is placed 1.2 mm away from the coil. If the target is moved 0.4 mm towards the coil, determine the new inductance of the coil. (9 marks)

(c) Draw labeled block diagrams, illustrating the following control systems:

(i) closed loop;
(ii) open loop.

(4 marks)

5. (a) (i) Define the following with respect to Amplitude Modulation (AM):

(I) sideband;
(II) modulation index.

(ii) Draw a circuit diagram of a Cowan AM modulator and describe its operation.

(7 marks)

(b) Figure 4 shows a circuit diagram of a diode AM detector.

(i) state **two** demerits of the detector;
(ii) sketch the waveform at point X.

(4 marks)

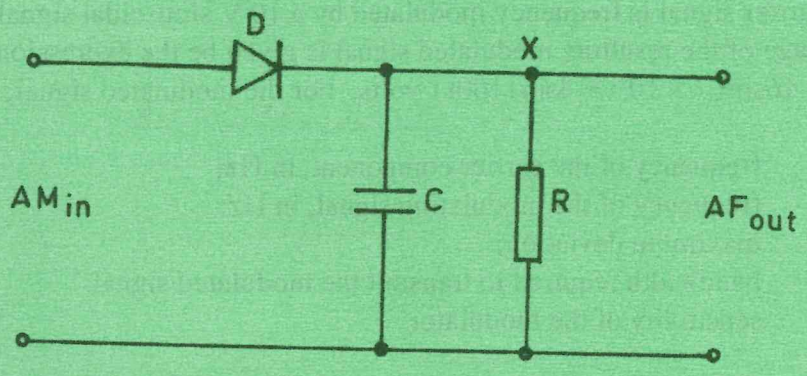

Fig. 4

(c) A carrier signal is amplitude modulated by a sinusoidal signal of 6 V to a depth of 30%. Determine the:

(i) carrier voltage;
(ii) sideband voltage.

(4 marks)

(d) In an AM system, the carrier and one of the sidebands are suppressed. Determine the percentage power saving in the transmitted wave if the modulation index is 0.6.

(5 marks)

6. (a) (i) Define the following with respect to frequency modulation (FM):

(I) frequency deviation;
(II) modulator sensitivity.

(ii) Sketch, on the same axes, response curves for de-emphasis and pre-emphasis networks in an FM system. (6 marks)

(b) Figure 5 shows a block diagram of an FM modulator. Describe its operation.

(4 marks)

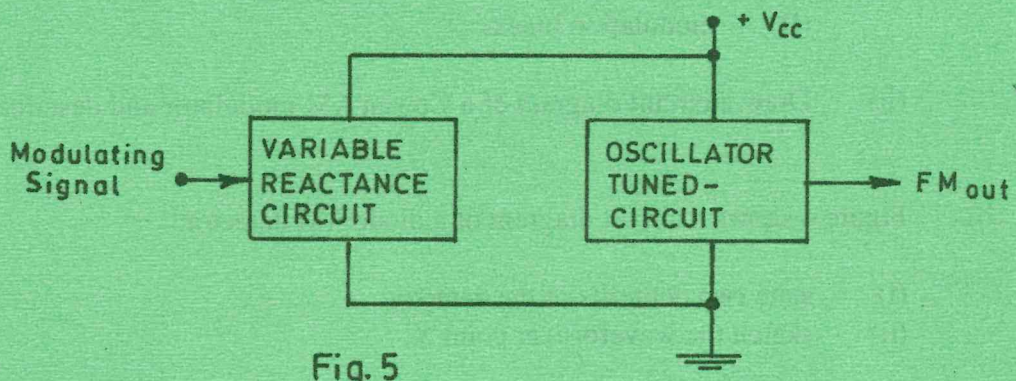

Fig. 5

(c) A carrier signal is frequency modulated by a 10 V sinusoidal signal. The instantaneous voltage of the resulting modulated signal is given be the expression $v = 16\sin(7 \times 10^8 t + 4\sin 1100t)$ volts. For the modulated signal, determine the:

(i) frequency of the carrier component, in Hz;
(ii) frequency of the modulating signal, in Hz;
(iii) maximum deviation;
(iv) bandwidth required to transmit the modulated signal;
(v) sensitivity of the modulator.

(10 marks)

7. (a) (i) Define the following with respect to transmission lines:

(I) phase delay;
(II) mismatch.

(ii) Figure 6 shows a circuit diagram of a T-section representation of a transmission line terminated in an impedance Zo. Obtain the expression for the impedance, Zo, seen looking into terminals 1-1. (7 marks)

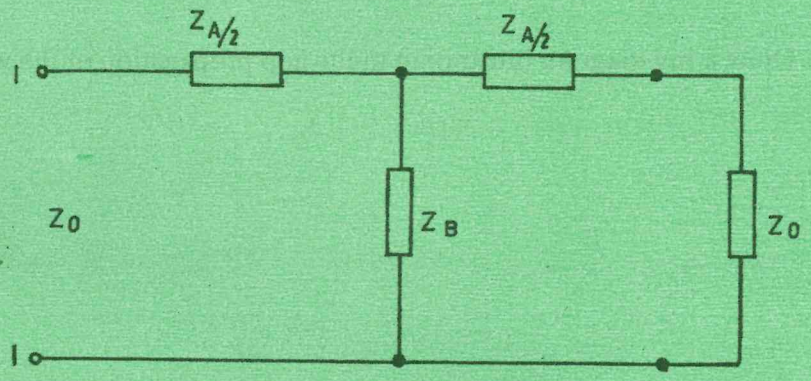

Fig. 6

(b) Explain the effects of open-circuit and short-circuit terminations on a traveling wave in a transmission line. (5 marks)

(c) A loss-free transmission line has primary line constants L = 0.68 mH/km and C = 0.15 μF/km. For an operating frequency of 550 kHz, determine the:

(i) characteristic impedance;
(ii) propagation coefficient;
(iii) wavelength on the line;
(iv) velocity of propagation.

(8 marks)

8. (a) (i) State the frequency range for each of the following frequencies:

(I) very high frequency;
(II) extra high frequency.

(ii) Explain reasons for determining Fresnel zones in radio wave propagation. (6 marks)

(b) Describe the generation of a pulse amplitude modulated signal. (4 marks)

(c) A sky wave enters an ionospheric layer at an angle of incidence of 30° and is refracted at an angle of 55°. The electron density of the layer is 5×10^{11} electrons/m^3. Determine the:

(i) refractive index;
(ii) critical frequency;
(iii) maximum usable frequency;
(iv) optimum working frequency.

(8 marks)

(d) Draw a ray diagram illustrating multi-hop propagation of the wave in (c). (2 marks)

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