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/Calculator
Smith chart

*Answer any **FIVE** of the following **EIGHT** questions.*
All questions carry equal marks.

Take: Earth radius R= 6370km

This paper consists of 6 printed pages.

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

1. (a) (i) State any **two** ways of improving the frequency stability of an oscillator.

(ii) With the aid of a circuit diagram, describe the operation of a colpitts oscillator. (9 marks)

(b) An oscillator tuned circuit consists of a capacitance, C, in parallel with a series arm of inductance, L, and resistance R. Derive an expression for the resonant frequency, f_o of the oscillator. (5 marks)

(c) The maximum voltage gain of an amplifier without negative feedback is 1000 and the variation of gain over its bandwidth is 4dB. Determine the resultant variation of gain (in dB) if 0.1 of the output voltage is negatively fedback. (6 marks)

2. (a) (i) List any **two** areas of application of silicon controlled rectifiers (SCR).

(ii) With the aid of a characteristic curve, describe the operation of an SCR. (8 marks)

(b) (i) With the aid of a circuit diagram, explain the operation of an a.c. motor speed controller using a diac and a triac.

(ii) Draw the input and output waveforms of the controller in b(i). (9 marks)

(c) A controlled full-wave rectifier of 300v a.c. drives a 100Ω load which dissipates 45w. Determine the firing angle. (3 marks)

3. (a) Define the following as applied to pulse code modulation (PCM):

(i) quantization noise;
(ii) encoding. (2 marks)

(b) (i) With the aid of waveforms, describe Pulse Amplitude Modulation (PAM).

(ii) For the circuit of Fig.1:

I. Describe its operation.
II. Determine the pulse width of the output signal if $R_2 = R_3 = 15k\Omega$ and $C_1 = C_2 = 1\mu F$. (11 marks)

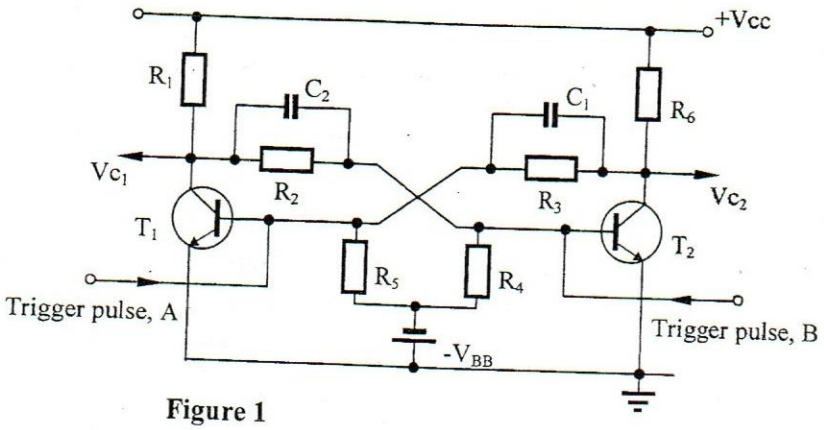

Figure 1

(c) (i) With the aid of a circuit diagram, derive the expression for the lower cut-off frequency, f_L, of an RL highpass filter.

(ii) An RL highpass filter has a lower cut-off frequency of 1.6KHz with a resistor of 2.8kΩ. Determine the circuit inductance. (7 marks)

4. (a) (i) List any **two** advantages of a thermistor over other temperature transducers.

(ii) With the aid of a circuit diagram, describe how thermistors are used to indicate three levels of a liquid. (7 marks)

(b) With the aid of a labelled schematic diagram, describe the operation of **two** phase a.c. servomotor. (6 marks)

(c) A linear 50kΩ potentiometer with an arc length of 300° is connected to a 12v stabilized d.c. supply. Determine:

(i) the potentiameter constant (in v/rads);

(ii) the output voltage when a 50kΩ load resistor is connected to the slider which is set at one half of the arc length. (7 marks)

5. (a) (i) State **two** reasons for using single sideband suppressed carrier (SSBSC) for point-to-point communications.

(ii) With the aid of a circuit diagram, describe the operation of a ring modulator. (8 marks)

(b) A phase-shift SSB modulator is driven by the signals $\upsilon_c = V_c \text{Sin}\omega_c t$ and $\upsilon_m = V_m \text{Sin}\omega_m t$. Derive the expression for the generated lower sideband signal. (4 marks)

(c) A varactor diode frequency modulator has the capacitance - voltage characteristic $Cd = 260/\sqrt{V}$ pF. When the d.c. reverse voltage is 5V, the circuit resonates at 5MHZ and has a Q-factor of 25. When a 30mV peak sinusoidal modulating signal is applied to the circuit, determine:

(i) the frequency deviation;
(ii) the peak phase deviation. (8 marks)

6. (a) Define the following as applied to transmission lines:

(i) phase change coefficient;
(ii) characteristic impedance. (2 marks)

(b) (i) With the aid of a waveform, explain "voltage standing wave ratio" with respect to a mismatched transmission line.

(ii) A mismatched transmission line of characteristic impedance, Zo, has a signal voltage, Vs, applied at its input. If the source current is Is, derive an expression for the sending-end impedance, Zs, in terms of the voltage reflection coefficient. (9 marks)

(c) A transmission line of characteristic impedance of 50Ω is terminated by a load impedance of 40 -j50Ω. Using the Smith chart, determine the:

(i) voltage standing wave ratio;
(ii) voltage reflection coefficient;
(iii) input impedance of a 0.18λ length of this line. (9 marks)

7. (a) (i) State any **two** properties of tuned power amplifiers.

(ii) With the aid of a voltage-current characteristic curves, explain how cross-over distortion is minimized in push-pull amplifiers. (7 marks)

(b) (i) From first principles, derive an expression for the output power of a common emitter transistor amplifier.

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

I. power drawn from the supply;
II. efficiency. (7 marks)

(c) A common emitter transistor amplifier driven by a source resistance of 500Ω, derives a load of 5kΩ. If its h-parameters are $h_{re} = 3.5 \times 10^{-5}$, $h_{ie} = 1.5k\Omega$, $h_{fe} = 50$ and $h_{oe} = 50\mu s$, determine the:

(i) current gain;
(ii) voltage gain;
(iii) output impedance. (6 marks)

8. (a) (i) Define the following with respect to propagation of radio waves:

I optimum working frequency;
II virtual height.

(ii) With the aid of a labelled diagram, describe multi-hop transmission of low-frequency radio waves. (7 marks)

(b) With the aid of a labelled diagram, derive the expression for the radius of the first Fresnel zone of a space wave. (9 marks)

(c) A line-of-sight link uses radiating and receiving antennae of 120m height. If the refractive index decreases at the rate of 0.05×10^{-6}/m, determine the length of the link. (4 marks)