2506/202
2507/202
ELECTRONICS AND CONTROL SYSTEMS
June/July 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AIRFRAMES AND ENGINES OPTION) (AVIONICS OPTION)

MODULE II

ELECTRONICS AND CONTROL SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non-programmable scientific calculator.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **THREE** questions from section **A** and **TWO** questions from section **B**.*
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.

SECTION A: ELECTRONICS

*Answer **THREE** questions from this section.*

1. (a) Perform the following conversions:

(i) $(1101.11)_2$ into decimal;

(ii) $(47C30.19)_{HEX}$ into binary. (7 marks)

(b) Figure 1 shows a logic circuit diagram. Derive the Boolean expression for the output.

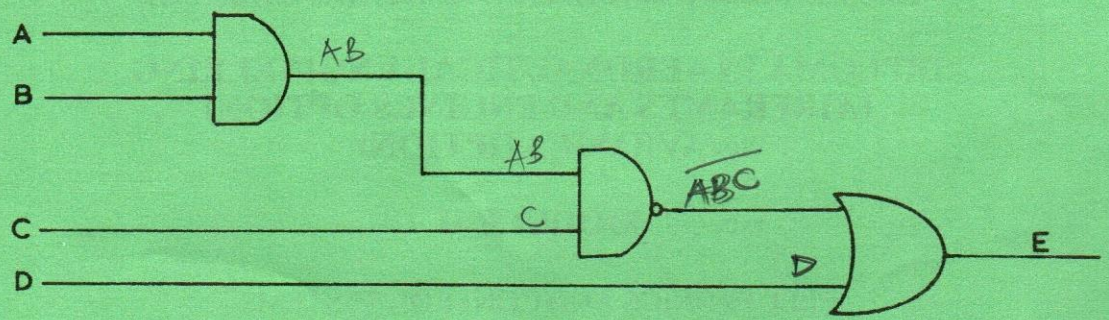

Fig. 1

(3 marks)

(c) Prove the following Boolean identity:

$A+\overline{A}B=A+B$ (4 marks)

(d) With the aid of a circuit diagram, explain the operation of an RTL logic circuit. (6 marks)

2. (a) State the essential conditions for maintaining oscillations in an oscillator. (2 marks)

(b) A quartz crystal resonating at 450 kHz has an equivalent inductance of 4.2 H, an equivalent capacitance of 0.0297 pF, connected in series with a resistance of $60\,\Omega$. Determine the:

(i) equivalent impedance in ohms;
(ii) Q factor. (8 marks)

(c) With the aid of a two transistor analogy of the silicon controlled rectifier, explain the regeneration of current in the device. (6 marks)

(d) A tunnel diode has the following data:

Ip = 2 mA at Vp = 60 mV.
Iv = 0.15 mA at Vv = 350 mV.

Determine the resistance of the tunnel diode. (4 marks)

3. (a) With the aid of energy band diagrams, explain conductivity in each of the following:

(i) conductor;
(ii) insulator;
(iii) semiconductor. (9 marks)

(b) (i) Define an intrinsic semiconductor. - pure semi-conductors without doping

(ii) With the aid of a lattice diagram, explain the formation of an N-type semiconductor. (7 mark)

(c) Figure 2 shows a fixed bias silicon amplifier circuit diagram. Determine the DC voltages at point:

(i) TP_1;
(ii) TP_2. (4 marks)

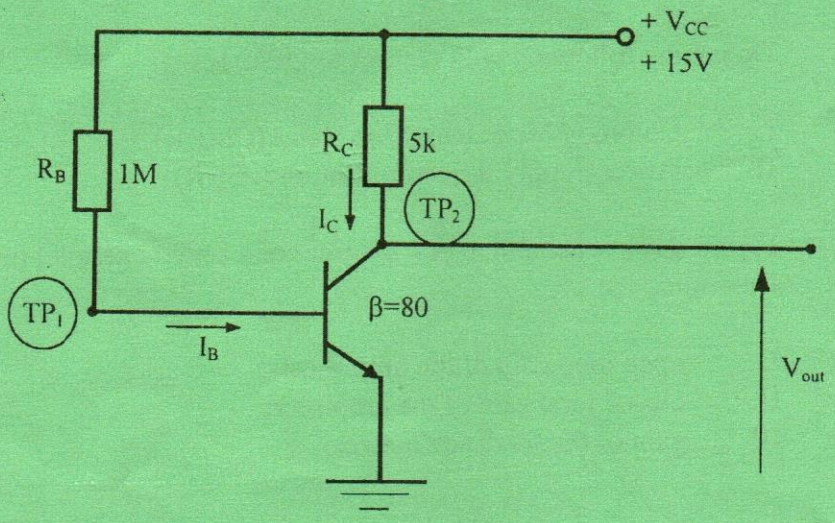

Fig. 2

4. (a) With the aid of a diagram, describe the construction and operation of N-junction Field Effect transistor. (6 marks)

(b) State **three** advantages of FETs over Bipolar transistors. (3 marks)

1. High input impedence
2. Ruggedness
3. Small size

(c) Figure 3 shows a circuit diagram of a voltage stabilizer. The zener diode used in the regulator circuit has a voltage V_{in} that can be varied from 20 V to 30 V. Determine the:

(i) minimum and maximum currents in the zener;
(ii) the minimum and maximum power dissipated in the diode;
(iii) maximum rated power dissipation that R_S should have.

Assume the zener diode remains in breakdown. (11 marks)

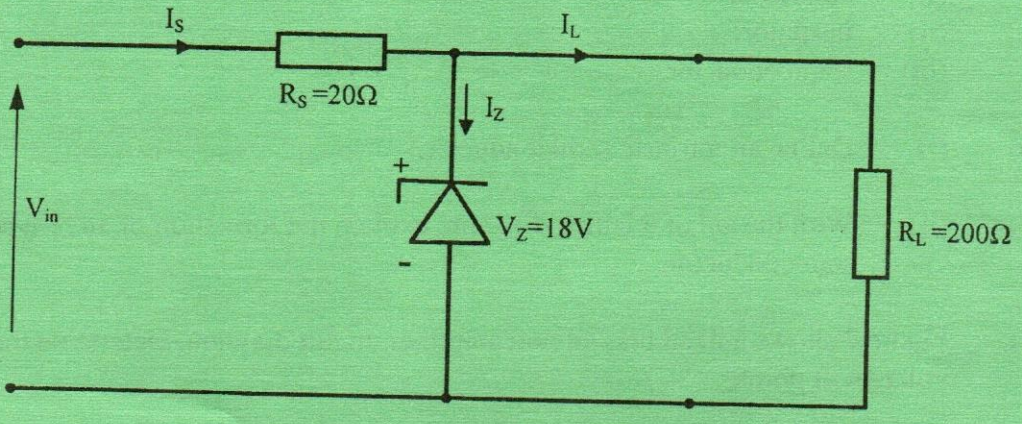

Fig. 3

5. (a) List **four** characteristics of an ideal operational Amplifier (OPAMP). (4 marks)

(b) (i) Define the following with respect to OPAMPs:

I. Common Mode Rejection Ratio (CMRR);
II. Power Supply Rejection Ration (PSRR). (4 marks)

(ii) Figure 4 is a schematic block diagram of a series - parallel feedback amplifier. Determine the:

I. open loop gain of the amplifier;
II. closed loop gain of the amplifier;
III. gain of the feedback network. (6 marks)

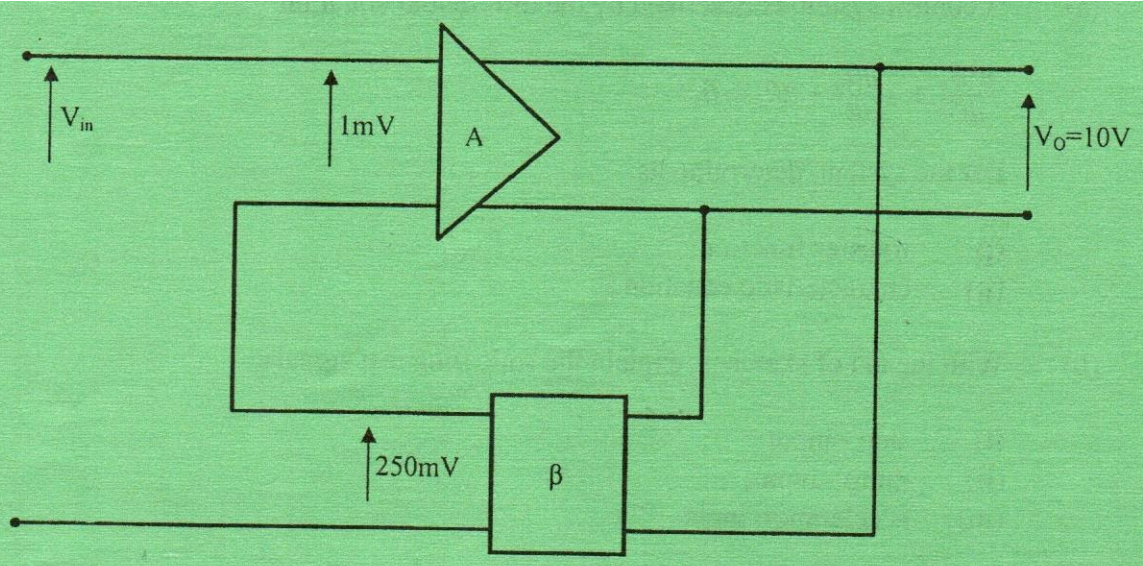

Fig. 4

(c) With the aid of a circuit diagram, explain the operation of a controlled full wave rectifier. (6 marks)

SECTION B: ENGINEERING CONTROL SYSTEMS

*Answer **TWO** questions from this section.*

6. (a) With the aid of block diagrams, explain each of the following control systems:

(i) open loop;
(ii) closed loop. (8 marks)

(b) Highlight **four** merits of using closed loop control systems. (4 marks)

(c) (i) Define 'Transfer Function' as used in control systems.

(ii) Explain the following as applied in control systems:

I. signal flow graphs;
II. forward path;
III. loop gain. (8 marks)

7. (a) A control system is described by the differential equation:

$$\frac{d^2\theta_0}{dt^2} + 4\frac{d\theta_0}{dt} + 3\theta_0 = \theta_i$$

For the system, determine its:

(i) transfer function;
(ii) characteristic equation. (6 marks)

(b) With the aid of sketches, explain the following test signals:

(i) step - input;
(ii) ramp - input;
(iii) acceleration input. (6 marks)

(c) (i) Define the following as applied to control systems in system response:

I. settling time;
II. overshoot.

(ii) The characteristic equation of a second order system is given by:

$$S^2 + 0.6S + 9 = 0$$

Determine the:

I. natural frequency;
II. damped natural frequency. (8 marks)

8. (a) Figure 5 shows a circuit diagram of a summing amplifier computing different level voltages. Determine the output, e_0.

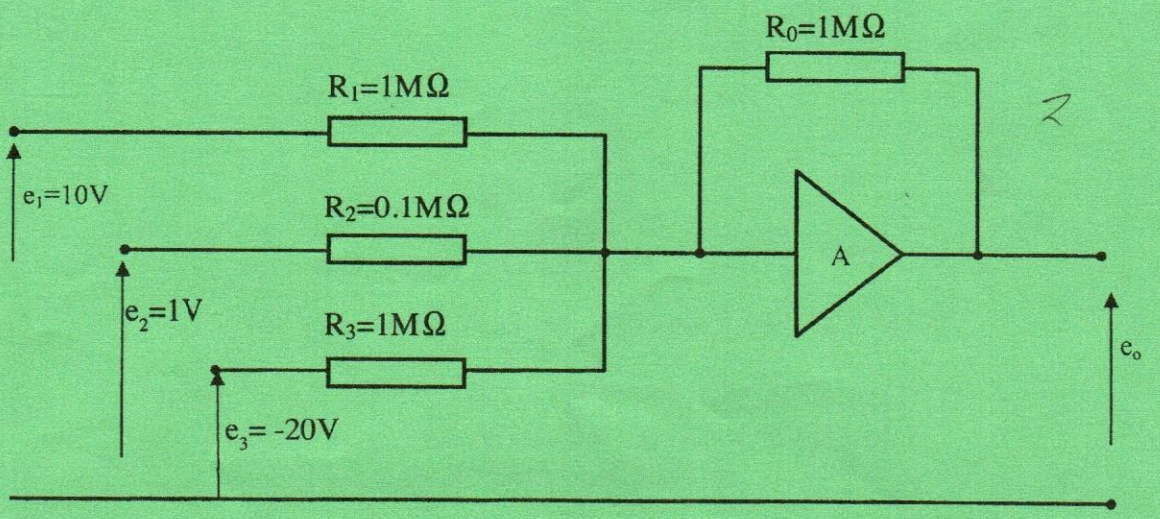

Fig. 5

(4 marks)

(b) A control system is represented by the equation:

$$\tau\frac{dx}{dt} + x = y;$$

Draw a computer simulation diagram for the system. (6 marks)

(c) (i) Define the following with respect to control system stability:

I. gain margin (G_m) – This the point on the Gain plane where $G(j\omega)H(j\omega)$ has a unity magnitude

II. phase margin (ϕ P_m). – How much the locus is less than −180 at the gain cross-over (4 marks)

(ii) With the aid of a diagram, describe the construction of a synchro transmitter - receiver system. (6 marks)

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