

2501/302    2503/302  
2502/302    2509/302  
CONTROL SYSTEMS AND  
INSTRUMENTATION  
Oct./Nov. 2016  
Time: 3 hours



**THE KENYA NATIONAL EXAMINATIONS COUNCIL**

**DIPLOMA IN MECHANICAL ENGINEERING  
(PRODUCTION OPTION), (PLANT OPTION),  
(CONSTRUCTION PLANT OPTION)  
DIPLOMA IN AUTOMOTIVE ENGINEERING**

**MODULE III**

**CONTROL SYSTEMS AND INSTRUMENTATION**

**3 hours**

**INSTRUCTIONS TO CANDIDATES**

*You should have the following for this examination:*

*Answer booklet;*

*non programmable scientific calculator;*

*This paper consists of TWO sections; A and B.*

*Answer any FIVE questions choosing at least TWO questions from each section.*

*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 6 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: CONTROL SYSTEMS (40 marks)**

*Answer at least TWO questions from this section.*

1. (a) State **three** features of an open loop control system. (3 marks)
- (b) With aid of a block diagram explain the elements of a closed loop control system. (10 marks)
- (c) Figure 1 shows a block diagram of a control system. Reduce the block diagram to canonical equivalent and determine the:
  - (i) feedback transfer function;
  - (ii) open loop transfer functions.(7 marks)

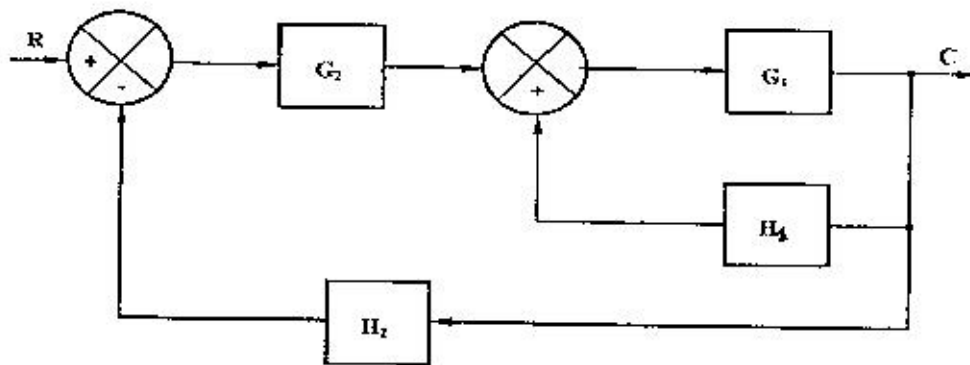


Fig. 1

2. (a) Explain the following in relation to signal flow graphs:
  - (i) feedback path;
  - (ii) self loop;
  - (iii) path gain.(3 marks)
- (b) Figure 2 shows a block diagram of a control system.
  - (i) convert the block diagram to a signal flow graph;
  - (ii) determine the transfer function of the signal flow graph in b(i).(12 marks)

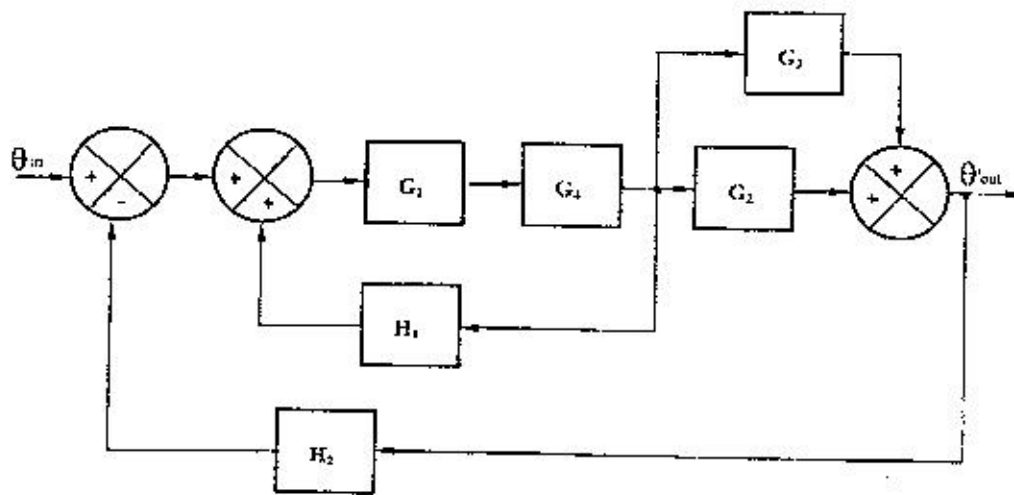


Fig. 2

(c) Figure 3 shows an R-C circuit. Derive its transfer function.

(5 marks)

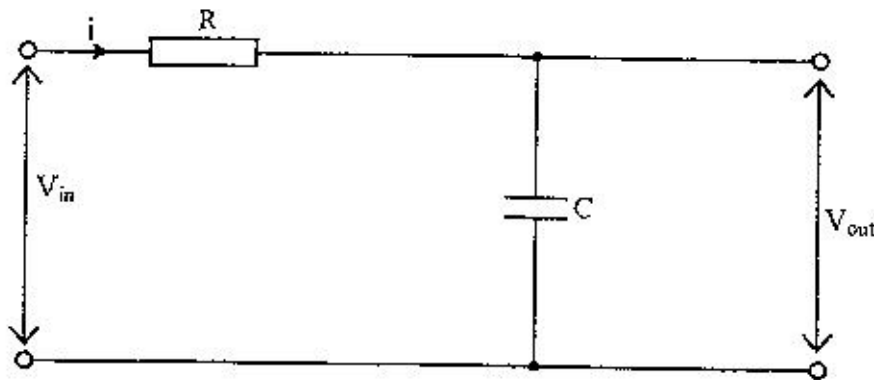


Fig. 3

3. (a) Explain the following terms as used in process control.

- (i) process load;
- (ii) process lag.

(4 marks)

(b) (i) State the importance of integral control in control systems.

- (ii) Figure 4 shows a circuit used in integral control. If  $R_2$  is assumed to be very small compared to  $R_1$ ; derive the expression for the output voltage using the Laplace transforms.

(7 marks)

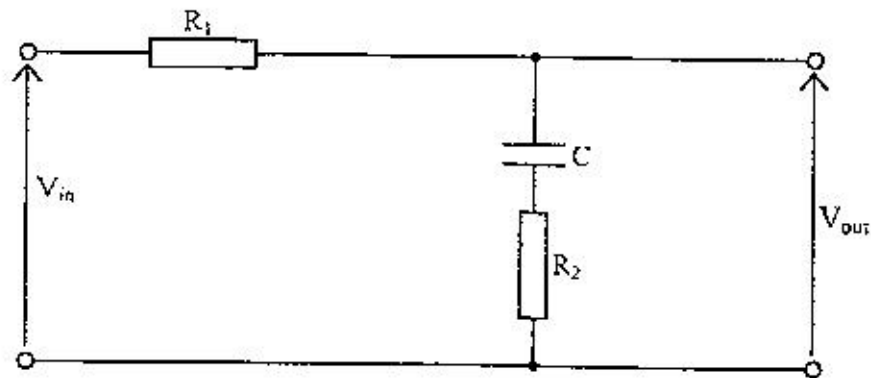


Fig. 4

- (c) (i) State any **two** types of actuators.
- (ii) A conveyor belt motor speed varies from 700 rpm to 1200 r.p.m. If the motor speed is controlled by 20 V to 40 Vd.c. signal, determine the speed when the signal is 25 Vd.c.
- (9 marks)
4. (a) With aid of a labelled block diagram describe the elements of a process control system. (9 marks)
- (b) With reference to programmable logic controllers, outline three functions of the:
- (i) input/output devices
- (ii) processor. (6 marks)
- (c) Sketch the torque/speed characteristics of an a.c. servomotor. (5 marks)

## SECTION B: INSTRUMENTATION

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

5. (a) State **three** components of an instrumentation system. (3 marks)
- (b) Explain the following errors in measuring instruments:
- (i) environmental errors;
  - (ii) observational errors;
  - (iii) instrumental errors.
- (6 marks)
- (c) With the aid of a schematic diagram describe angular velocity measurement using the d.c. tachometer generator. (6 marks)
- (d) A quartz piezo-electric transducer has a thickness of 1.8 mm, voltage sensitivity of 0.054 Vm/N and a permittivity of  $40.2 \times 10^{-12}$  F/m. If the transducer is subjected to a pressure of 1.2 MN/m<sup>2</sup>; determine:
- (i) the output voltage generated;
  - (ii) the charge sensitivity.
- (5 marks)
6. (a) State **four** merits of semiconductor thermometers in temperature measurements. (4 marks)
- (b) (i) With aid of a diagram explain temperature measurement using a thermocouple.
- (ii) A copper thermometer at 25 °C has a resistance of 20 Ω and is used to indicate the temperature of the surface of a d.c. machine. The resistance temperature coefficient of copper is 0.00393 Ω/°C. Determine the resistance of the thermometer if the maximum surface temperature is not to exceed 125 °C. (10 marks)
- (c) With aid of a diagram describe liquid level measurement using the capacitive voltage divider method. (6 marks)
7. (a) Define the term 'humidity'. (2 marks)
- (b) Outline **three** properties of a fluid considered when carrying out flow measurements. (3 marks)

- (c) (i) State **three** advantages of semiconductor strain gauges over bonded metal wire strain gauges.
- (ii) A strain gauge is bonded to a steel beam 20 cm long and has a cross-sectional area of 4 cm<sup>2</sup>. The strain gauge has an unstrained resistance of 200 Ω and a gauge factor of 2.01. When a load is applied the resistance of the gauge changes by 0.012 Ω. If Young's modulus for steel is 200 GN/m<sup>2</sup>; determine the:
- (I) change in length of the steel beam;  
 (II) amount of force applied to the beam.
- (10 marks)
- (d) (i) Explain the following terms as applied in pressure measurements:
- (I) static pressure;  
 (II) head pressure.
- (ii) A tank holds water with a depth of 8 m. Determine the pressure at the bottom of the tank. Take density of water as 10<sup>3</sup> kg/m<sup>3</sup>.
- (5 marks)
8. (a) Explain the operation of the following light detectors:
- (i) photoconductive;  
 (ii) photovoltaic.
- (4 marks)
- (b) (i) State **two** properties of fluids considered when measuring viscosity.
- (ii) With aid of a schematic diagram explain measurement of viscosity using rotating cylinder viscometer.
- (9 marks)
- (c) With aid of a diagram describe the operation of a disappearing filament optical radiators pyrometer.
- (7 marks)

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