2601/201
2602/201
2603/201
CONTROL SYSTEMS AND PROGRAMMABLE
LOGIC CONTROLLERS
Oct./Nov. 2018
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING
(POWER OPTION)
(TELECOMMUNICATION OPTION)
(INSTRUMENTATION OPTION)

MODULE II

CONTROL SYSTEMS AND PROGRAMMABLE LOGIC CONTROLLERS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
- *Answer booklet;*
- *Drawing instruments;*
- *Polar curve;*
- *Non-programmable scientific calculator.*

*This paper consists of **TWO** sections; **A** and **B**.*
*Answer any **THREE** questions from section **A** and any **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 6 printed pages and 1 insert.

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

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

1. (a) State **three** demerits of open loop control system. (3 marks)

(b) An automatic oven is set to maintain a temperature of 100°C. Draw a labelled block diagram of the control system. (5 marks)

(c) Figure 1 shows a block diagram of a control system.

(i) Draw its equivalent signal flow graph (SFG) .
(ii) Using the signal flow graph in (i), derive its overall transfer function.
(12 marks)

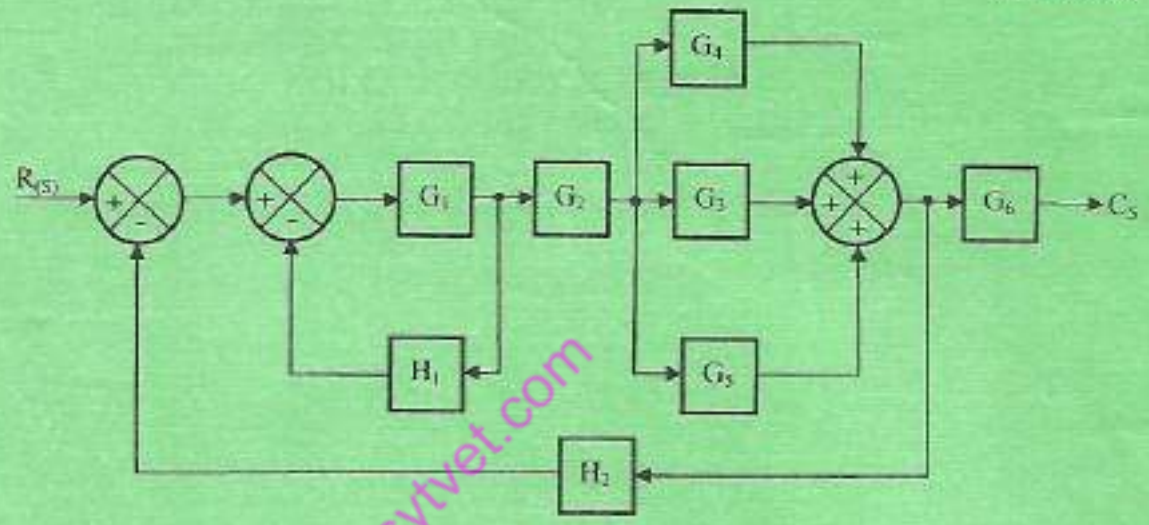

Fig. 1

2. (a) (i) Define servomechanism as used in control system.
(ii) With the aid of block diagram, describe the elements of a servo sytem.
(7 marks)

(b) A stepper motor with a step angle of 15° rotates 64 steps in the clockwise direction. Determine its final position. (3 marks)

(c) Figure 2 shows an equivalent circuit of a d.c. generator, show that its transfer function is given by.

$$\frac{E_{2(s)}}{E_{1(s)}} = \frac{K_r R_2}{(R_f + SL_f)(R_a + R_2 + SL_a + SL_2)}$$

where Kr = constant (10 marks)

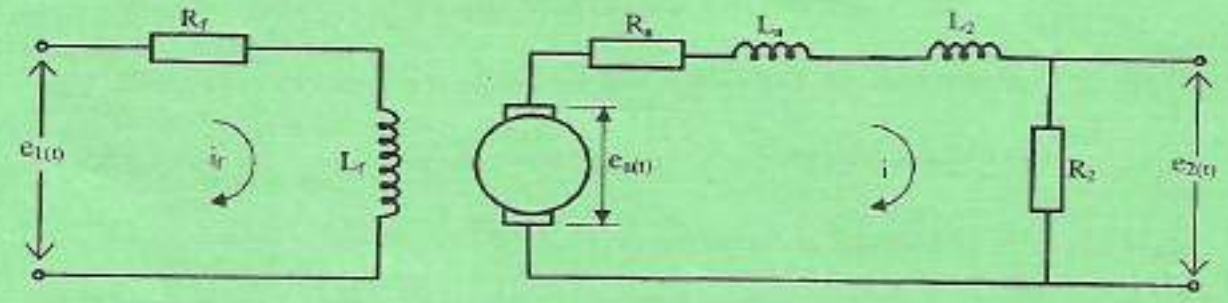

Fig. 2

3. (a) (i) State **two** effects of phase lead networks in a control system;

(ii) Figure 3 shows a circuit diagram of a compensating network;

I. identify the type of compensator.

II. derive its transfer function, $\frac{E_{o(s)}}{E_{i(s)}}$. (8 marks)

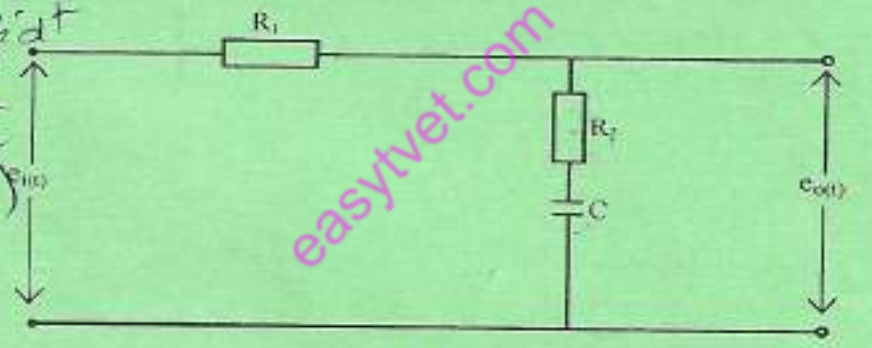

Fig. 3

(b) Table 1 shows test values of an open loop control system.

(i) Plot the polar curve;

(ii) Using the curve in (i), determine the:

I. phase margin;

II. gain margin;

III. Phase cross-over frequency;

IV. Stability of the system. (12 marks)

Table 1

ω (rad/s)	2.5	3	3.5	4	5	7	10	20
gain (dB)	12	8.9	6.7	5.2	3.3	1.6	0.69	0.11
$< 0°$	-155	-163	-169	-175	-185	-199	-214	-237

4. (a) (i) Outline the four steps involved when solving differential equations using analogue computer.

(ii) A differential equation representing a control system is given as:

$$\frac{d^2y}{dt^2} + 6\frac{dy}{dt} + 4y = 5$$

Draw an analogue computer flow diagram to solve the equation.

(12 marks)

(b) A second order control system is described by the equation:

$$1.5S^2 + 6S + 60 = 60$$

For this system, determine the:

(i) Natural frequency;
(ii) damping ration;
(iii) Percentage overshoot;
(iv) time to reach first overshoot.

(8 marks)

5. (a) (i) Define "actuators" as applied in automatic control.

(ii) List **three** categories of actuators used in control systems. (5 marks)

(b) The asymptotic approximation of log-magnitude versus frequency plot is shown in figure 4. Derive the transfer function. (10 marks)

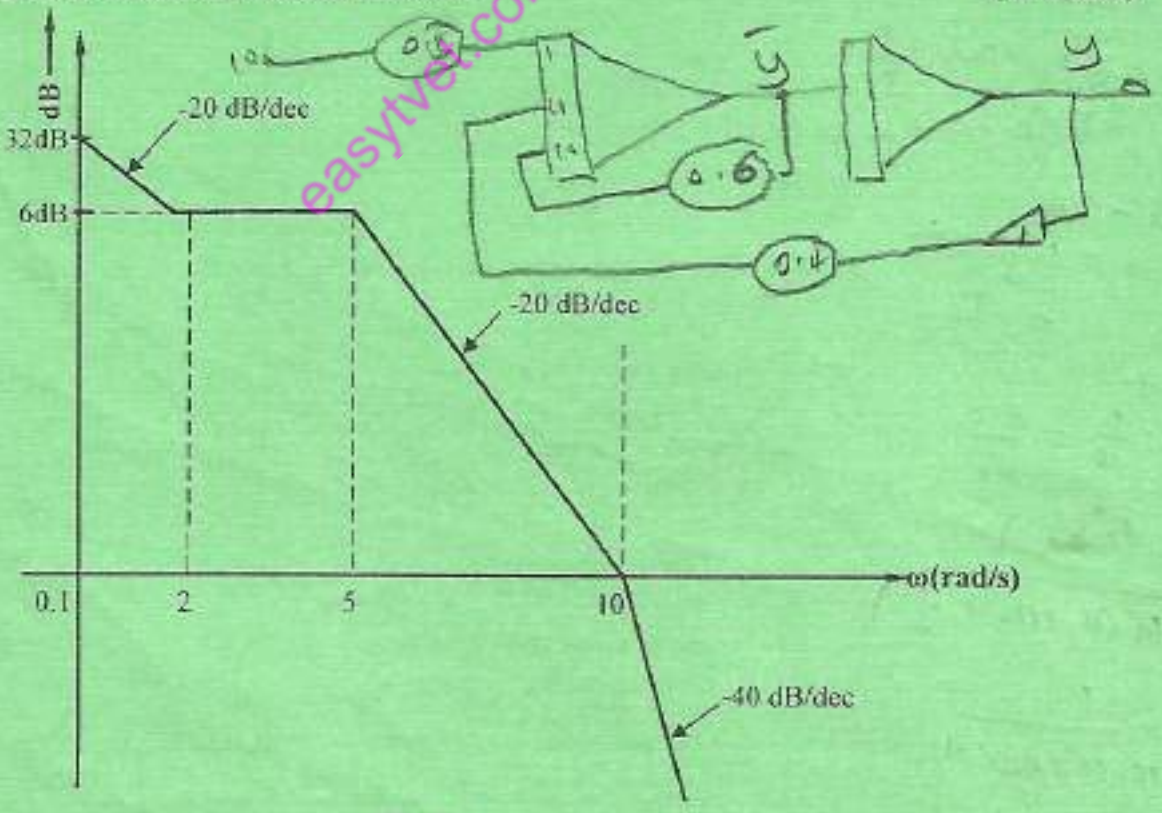

Fig. 4

(c) For a system whose open loop gain is given by

$GH_{(S)} = \frac{60}{(S+2)(S+10)}$, a step input of 5% is applied. Determine the:

(i) steady state error;
(ii) error coefficient. (5 marks)

SECTION B: PROGRAMMABLE LOGIC CONTROLLERS

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

6. (a) State **three** programmable logic controller (PLC) programming devices. (3 marks)

(b) With the aid of a block diagram, describe the elements of a programmable logic controller. (10 marks)

(c) The program listing shows a section of bottle filing plant control program. Draw its equivalent ladder diagram. (7 marks)

```
LD X400
OR Y430
AND X401
LDI X404
ORI X405
ANB
OUT Y430
LD Y430
OUT 431
LD X402
OR M100
AND X406
OUT M100
OUT Y432
END
```

7. (a) With the aid of diagrams, describe the **three** generations of SCADA system. (9 marks)

(b) With the aid of a block diagram, describe the components of a multi-channel computer data logging system. (8 marks)

(c) Define the following with respect to SCADA system:

(i) human machine interface;
(ii) master station;
(iii) multiplexer. (3 marks)

8. (a) (i) State **two** topologies used in wireless networks.
(ii) With the aid of sketches, describe the following network topologies:

(I) Star;
(II) bus;
(III) Mesh. (11 marks)

(b) (i) With aid of a labelled diagram, explain the construction of a fibre optic cable.
(ii) State **two** merits of fibre optic cable. (7 marks)

(c) State **two** types of calibration systems. (2 marks)

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