2521/302   2602/302
2601/302   2603/302
MICROCONTROLLER TECHNOLOGY
AND MICROPROCESSOR SYSTEMS
June/July 2021
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

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

MODULE III

MICROCONTROLLER TECHNOLOGY AND MICROPROCESSOR SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
   Answer booklet;
   Non-programmable scientific calculator;
   Drawing instruments;
   Intel 8080/8085 microprocessor instruction set;
   Intel 8051 microcontroller instruction set.
This paper consists of EIGHT questions in TWO sections, A and B.
Answer any THREE questions from section A, and any TWO questions from section B
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 10 printed pages.

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

Turn over

SECTION A: MICROPROCESSOR SYSTEMS

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

1. (a) Define each of the following with respect to microprocessors:

    (i)   Bus;
    (ii) word length.   (2 marks)

    (b) Describe each of the following microprocessor registers:

    (i)   program counter (PC);
    (ii) accumulator.   (4 marks)

    (c) With the aid of a timing diagram, describe an op-code fetch machine cycle.
                                                                          (8 marks)

    (d) Perform the following number system conversions:

    (i) $(13.375)_{10}$ to binary;
    (ii) $(73.75)_{10}$ to octal.   (6 marks)

2. (a) Define each of the following with respect to subroutines:

    (i)   parameter passing;
    (ii) nesting.   (2 marks)

    (b) With the aid of a flow chart, describe the interrupt driven mode of data transfer.
                                                                          (8 marks)

    (c) Four bytes of data are stored in consecutive memory locations 3500 H to 3503 H. Write an assembly language program to add the data and store the result at memory location 3504 H to 3505 H, starting with the lower byte.   (6 marks)

    (d) The accumulator contains data C4H. Determine the contents of the accumulator after each of the following shift operations:

    (i)   arithmetic right shift;
    (ii) logical right shift.   (4 marks)

3. (a) Describe each of the following microprocessor addressing modes citing an example in each case:

    (i)   implicit;
    (ii) register indirect;
    (iii) page zero.   (6 marks)

(b) Table 1 shows instruction listing of a delay program. The clock frequency is 5 MHz.

Table 1

Label	Mnemonic	T-states
	LX1 B, 1000 H	10
LOOP:	DCX B	6
	XTH L	16
	XTH L	16
	NOP	4
	NOP	4
	MOV A , B	4
	ORA C	4
	JNZ LOOP	10/7
	HLT	5

Determine the:

(i)   program delay time;
(ii) number of memory locations occupied by the machine code program.

(11 marks)

(c) State **three** CPU signals used in Direct Memory Access (DMA) data transfer technique.

(3 marks)

4.   (a) State **three** advantages of assembly language-over machine language-programming.

(3 marks)

(b) Explain each of the following microprocessor system development tools:

(i)   compiler;
(ii) cross-assembler.

(4 marks)

(c) With the aid of a flowchart, describe 'handshaking' input/output data transfer.

(6 marks)

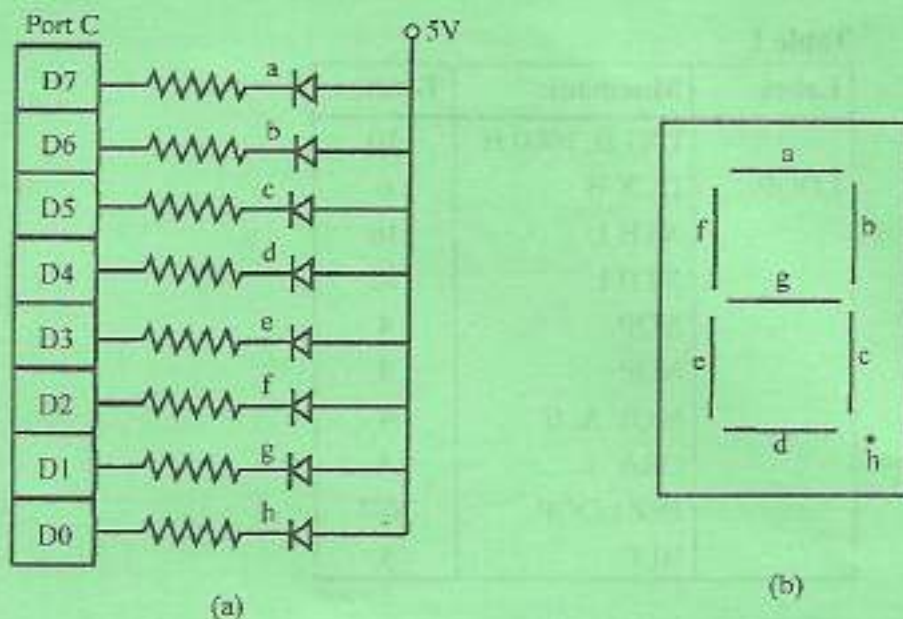(d)   Figure 1 shows an interfacing of 8085 microprocessor to a seven-segment display.

Fig. 1

(i)   state with reason the logic level that turns on a segment;
(ii)   determine the binary word that will display digit 4;
(iii)   write an assembly language program to display the digit in d (ii).

(7 marks)

5.   (a)   Table 2 shows a machine code program.

Table 2

Address (Hex)	OP-code(Hex)
8000	21
8001	00
8002	25
8003	7E
8004	23
8005	96
8006	23
8007	77
8008	76

(i)   translate the machine code into 8085 mnemonics;
(ii)   explain what the program accomplishes.

(8 marks)

(b)   (i)   State two reasons of disabling buffers when not in use.
       (ii)   With the aid of a diagram, describe the operation of a tri-state data buffer.
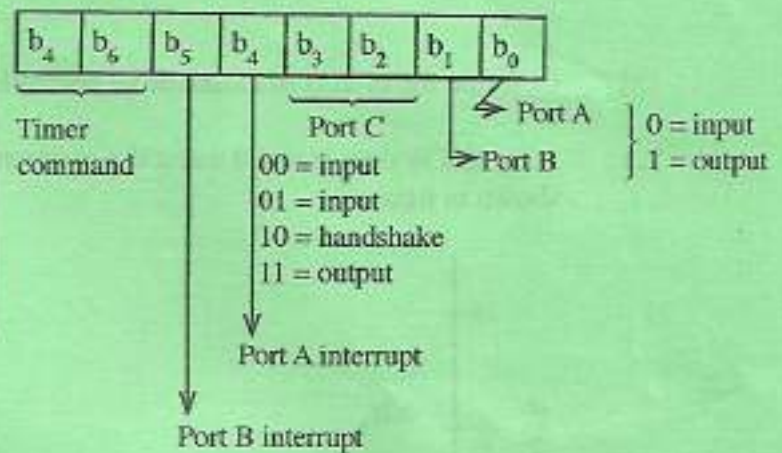
(7 marks)

(c)   Table 3 A and 3 B shows an intel 8155 programmable input/output (PIO)port register addresses and the command status bits respectively.

Table 3A

Port Register	Address
CSR	40 H
PORT A	4I H
PORT B	42 H
PORT C	43 H
High order timer	44 H
high order time	45 H

Table 3B

b_4	b_6	b_5	b_4	b_3	b_2	b_1	b_0

Timer command

Port C
00 = input
01 = input
10 = handshake
11 = output

Port A
Port B

0 = input
1 = output

Port A interrupt

Port B interrupt

Write a program segment to configure:
*   port A as an input port;
*   port B as an output port;
*   port C as a handshake port.

(5 marks)

SECTION B: MICROCONTROLLER TECHNOLOGY

Answer TWO questions from this section.

6.   (a)   With the aid of a memory map, describe the intel 8051 microcontroller register banks.

(7 marks)

(b)   Write an 8051 assembly language program to compute, $1 + 2 + 3 + \text{--------} + 15$, and store the sum at memory location 70 H.   (7 marks)

(c)   Explain each of the following intel 8051 microcontroller instructions, stating the addressing mode in each case:

(i)   MOV A, 60H;
(ii)   MOVC A, @A + PC;
(iii)   ADD A, @RI.

(6 marks)

7.   (a)   Define each of the following with respect to process controllers:

        (i)   tuning;
        (ii)   lag time.

                                                    (2 marks)

   (b)   Describe the effects of a derivative controller on a process control system.   (4 marks)

   (c)   A control system is tuned using the reaction curve method. The resulting output is shown in figure 2.
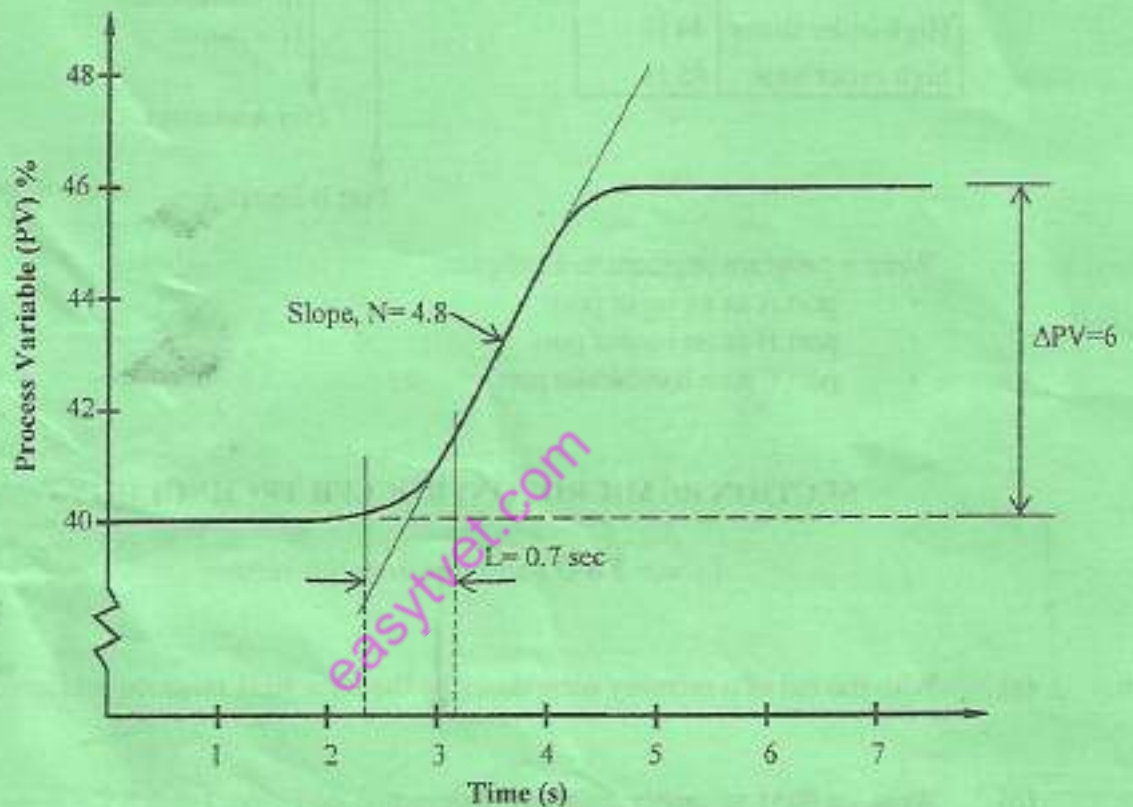

Fig. 2

Determine the:

        (i)   proportional gain, K_p;
        (ii)   integral gain K_i;
        (iii)   derivative gain, K_D.

                                                       (6 marks)

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(d)   Figure 3 shows a diagram of a PLC-controlled pick and place robot that picks up parts from one conveyer belt and places them on another belt. When a part moving on the lower conveyor belt activates switch 1, the motor turns in anticlockwise direction to move the gripper to the pick-up position. When the gripper reaches switch 2, the motor stops and the solenoid powered gripper clamps on the part. After 2 seconds, the motor turns in the clockwise direction to move the gripper to the drop-point. When the gripper reaches switch 3, the gripper's solenoid is de-energized to drop the part onto conveyor 2.

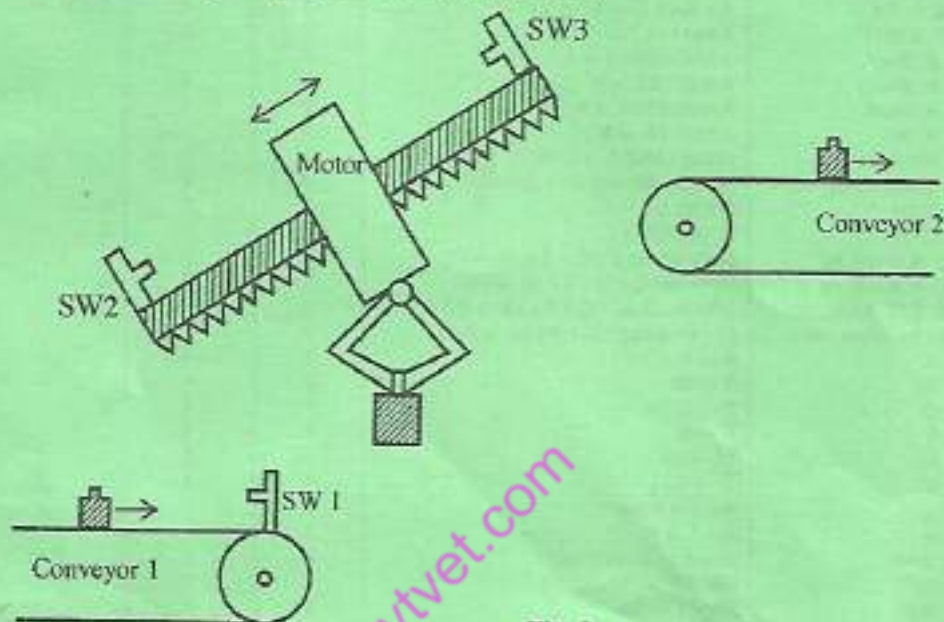Draw a ladder diagram program for this operation.   **(8 marks)**

Fig. 3

8.   (a)   (i)   Define aperture time with respect to data loggers.

         (ii)   A data logger has an analog input signal of 40 KHz and a qauntizer of 12-bits. Determine its aperture.

                                                       (3 marks)

   (b)   With the aid of a diagram, describe the operation of a counter-type analog-to-digital converter.   **(7 marks)**

   (c)   Describe the three rotational forces in a robotic arm.   **(6 marks)**

   (d)   Describe each of the following robot programming methods:

         (i)   lead through;
         (ii)   off-line.

                                                        (4 marks)