# International Institute of Information Technology, Hyderabad

(Deemed to be University)

## EC2.101 – Digital Systems and Microcontrollers

## End Semester Examination

**Max. Time: 3 Hr** **Max. Marks: 70**

**CALCULATORS ARE NOT ALLOWED**

Numbers in square brackets [x] after a statement show the marks for that question.
Numbers in {} brackets are for administrative use. Please ignore.

Q1. Let's say we are working in the ternary system (radix = 3). However, we need to create circuits using Boolean logic for the operations. A simple operation is to add two numbers. Given two 1-digit ternary numbers, design a circuit that produces their sum. [Hint: you will require 2 wires to represent 1-digit of ternary].

[12 marks]{CO-1}

Q2. We are given a serial stream of bits. Within this bit stream, we want to see if there is a 4-bit prime number. Design a circuit that outputs '1' if there is a 4-bit prime number in a given bit stream. The output should be active for one clock cycle upon detection of the prime number. If the next combination of 4 bits is also prime, the output should remain '1'. For example, bit stream 10111 will produce output '1' for two cycles, because 0111 and 1011 are both prime.

[12 marks]{CO-3}

Q3. Most of the arithmetic happens in a computer using 2's complement notation. Suppose we are given two 4-bit numbers in signed 2's complement representation (A and B). Design a circuit to compare them and output (A>B), (A<B), and (A=B).

[12 marks]{CO-2}

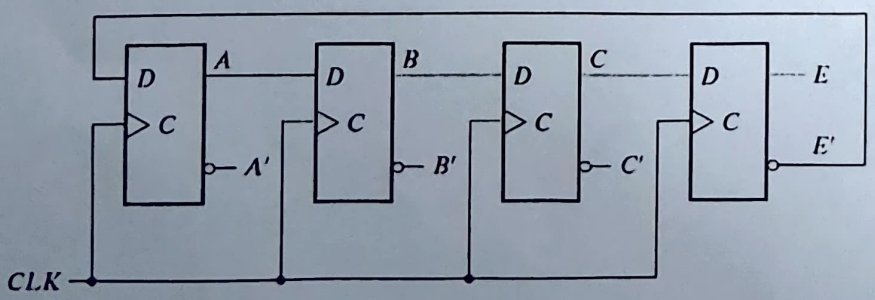
Q4. Perform the following conversions:

1) $(978)_{10} = (?)_{16}$
2) $(73)_8 + (5BC)_{16} = (57)_8 + (?)_{16}$
3) $(1011)_8 = (?)_{10}$
4) $(110)_2 \times (11011)_2 = (?)_{16}$
5) $(3.78)_{10} = (?)_2$

[2x5 = 10 marks]{CO-1}

Q5. What is the behaviour of the following circuit if clock pulses are applied from a reset state (when all FFs are at zero) [4]? Draw the complete state diagram for the 16 distinct states (including starting in any other state) [4]. In general, if there are *k* flip-flops in this chain and any arbitrary starting state is chosen, how many clock cycles does it take to make sure we return to the original state [4]?

[4+4+4 = 12 marks]{CO-3}



Q6. We are required to find the sum of a set of N numbers located in a block of memory starting from location "0x200". The number N itself is stored in location "0x220" (assume N<0x20). Write an assembly level program that computes this sum using our simple 8-bit microcontroller. (Concise instruction set is provided below). Assume your own code starts at memory location "0x000". Provide reasoning for your code.

[12 marks]{CO-4}

| Instruction | Opcode | Clk | Control Signals | Select Signals |
|---|---|---|---|---|
| adi xx | 01 | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$ | - |
| | | 4 | RD, $L_{OR}$ | - |
| | | 5 | $E_{AR}$, $L_{AR}$, End | $S_{ALU} \leftarrow$ ADD |
| sbi xx | 02 | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$ | - |
| | | 4 | RD, $L_{OR}$ | - |
| | | 5 | $E_{AR}$, $L_{AR}$, End | $S_{ALU} \leftarrow$ SUB |
| xri xx | 03 | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$ | - |
| | | 4 | RD, $L_{OR}$ | - |
| | | 5 | $E_{AR}$, $L_{AR}$, End | $S_{ALU} \leftarrow$ XOR |
| ani xx | 04 | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$ | - |
| | | 4 | RD, $L_{OR}$ | - |
| | | 5 | $E_{AR}$, $L_{AR}$, End | $S_{ALU} \leftarrow$ AND |
| movs <R> | 70-7F | 3 | $E_{RG}$, $L_{AR}$, End | $S_{RG} \leftarrow$ <R>, $S_{ALU} \leftarrow$ PASSO |
| movd <R> | 80-8F | 3 | $E_{AR}$, $L_{RG}$, End | $S_{RG} \leftarrow$ <R> |
| movi <R> xx | 90-9F | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$ | - |
| | | 4 | RD, $L_{RG}$, End | $S_{RG} \leftarrow$ <R> |
| stor <R> | A0-AF | 3 | $E_{AR}$, $L_{MR}$ | - |
| | | 4 | $E_{RG}$, WR, End | $S_{RG} \leftarrow$ <R> |
| load <R> | B0-BF | 3 | $E_{AR}$, $L_{MR}$ | - |
| | | 4 | RD, $L_{RG}$, End | $S_{RG} \leftarrow$ <R> |
| jumpd<FL> xx | E0-E7 | 3 | $E_{PC}$, $L_{MR}$, $I_{PC}$, $E_{FL}$, End if <FL>' | $S_{FL} \leftarrow$ <FL> |
| | | 4 | RD, $L_{PC}$, End | - |
| jmpr<FL> | E8-EF | 3 | $E_{FL}$, End if <FL>' | $S_{FL} \leftarrow$ <FL> |
| | | 4 | $E_{AR}$, $L_{PC}$, End | - |