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}

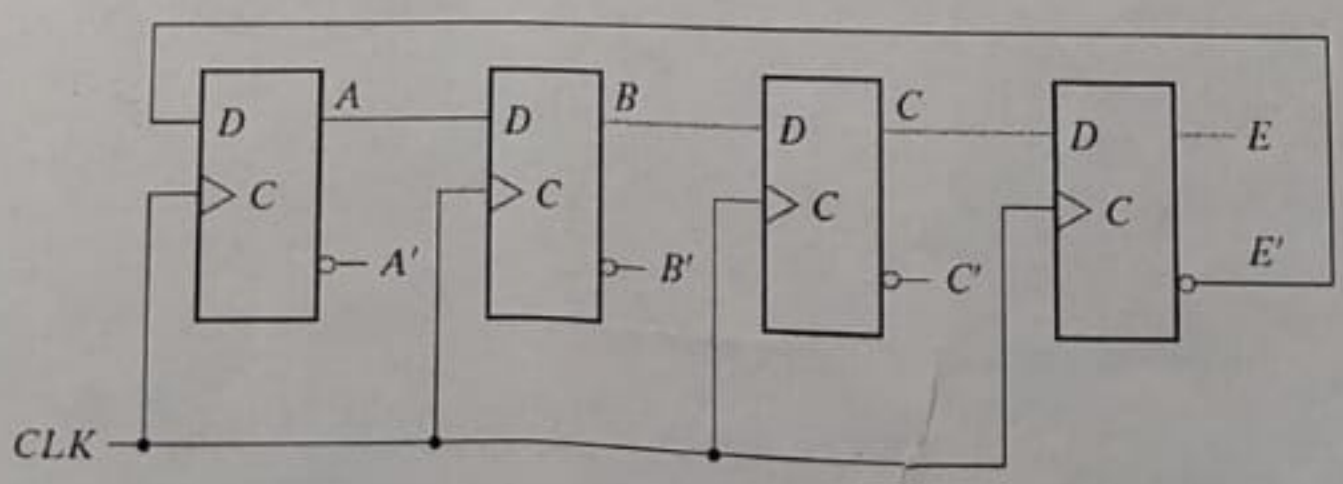
Q4. Perform the following conversions:

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