

**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}

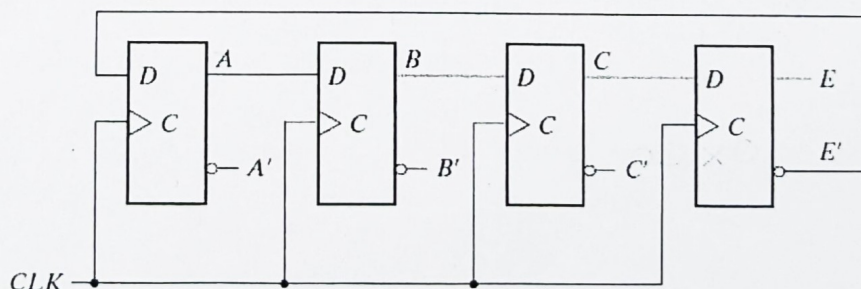
*Q4.* Perform the following conversions:

- 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	EPC, LMR, IPC	-
		4	RD, LOR	-
		5	EAR, LAR, End	SALU $\leftarrow$ ADD
sbi xx	02	3	EPC, LMR, IPC	-
		4	RD, LOR	-
		5	EAR, LAR, End	SALU $\leftarrow$ SUB
xri xx	03	3	EPC, LMR, IPC	-
		4	RD, LOR	-
		5	EAR, LAR, End	SALU $\leftarrow$ XOR
ani xx	04	3	EPC, LMR, IPC	-
		4	RD, LOR	-
		5	EAR, LAR, End	SALU $\leftarrow$ AND
movs <R>	70-7F	3	ERG, LAR, End	SRG $\leftarrow$ <R>, SALU $\leftarrow$ PASS0
movd <R>	80-8F	3	EAR, LRG, End	SRG $\leftarrow$ <R>
movi <R> xx	90-9F	3	EPC, LMR, IPC	-
		4	RD, LRG, End	SRG $\leftarrow$ <R>
stor <R>	A0-AF	3	EAR, LMR	-
		4	ERG, WR, End	SRG $\leftarrow$ <R>
load <R>	B0-BF	3	EAR, LMR	-
		4	RD, LRG, End	SRG $\leftarrow$ <R>
jumpd<FL> xx	E0-E7	3	EPC, LMR, IPC, EFL, End if <FL>'	SFL $\leftarrow$ <FL>
		4	RD, LPC, End	-
jmpr<FL>	E8-EF	3	EFL, End if <FL>'	SFL $\leftarrow$ <FL>
		4	EAR, LPC, End	-

0xA0



0xC0