International Institute of Information Technology, Hyderabad

(Deemed to be University)

EC2.101 - Digital Systems and Microcontrollers
Model End Semester Examination

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

CALCULATORS ARE NOT ALLOWED

Numbers in square brackets [x] show the marks. Numbers in curly brackets {CO-x} are for administrative use.

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1. **Base System Concepts:** In the decimal system (Base-10), we determine if a number is even or odd by looking at the Least Significant Digit (LSD).

   (a) Prove whether this "check the LSD" method works for determining if a number is even/odd in Base-5 (Quinary system). [5]

   (b) Design a combinational logic circuit that takes a 2-digit Base-3 (Ternary) number (A_1A_0) as input (where each digit is represented by 2 binary bits) and outputs a logic '1' if the ternary number is divisible by 4. [10]

   [15 Marks] {CO-1}

2. **Arithmetic Circuit Optimization:** We wish to design a circuit that calculates the absolute difference between two 2-bit numbers, A and B. i.e., Output $Y = |A - B|$.

   (a) Design the optimal logic circuit for this operation using K-Maps. [8]

   (b) Implement this circuit using CMOS logic style. Count the total number of transistors required and compare this to an implementation that uses a standard 2-bit Full Adder/Subtractor followed by selective inversion. [7]

   [15 Marks] {CO-2}

3. **Sequential Design (Sequence Detector):** Design a synchronous counter using JK flip-flops that counts through the **Fibonacci sequence** for 4-bit numbers (i.e., 0, 1, 1, 2, 3, 5, 8, 13).

   (a) After reaching 13, the counter should reset to 0. [10]

   (b) Ensure the design is self-correcting: if the counter powers up in an unused state (e.g., 4 or 6), it should return to a valid state within 1 clock cycle. [5]

   [15 Marks] {CO-3}

4. **Circuit Analysis:** Consider a chain of 4 D-Flip-Flops connected in a shift-register configuration. The output of the last flip-flop (E) is inverted and fed back to the input of the first flip-flop (A). Additionally, the output of the second flip-flop (B) is inverted and connected to the clock input of the third flip-flop (C).

   (Note: This refers to the standard Johnson/Twisted ring configurations seen in previous years).

   (a) If the circuit starts in a reset state (0000), draw the timing diagram for the first 8 clock cycles. [4]

   (b) Draw the complete state diagram. How many distinct cycles exist? [4]

   (c) In general, for a standard Johnson counter (without the clock gating modification) with k flip-flops, what is the modulus of the counter? [2]

   [10 Marks] {CO-3}

5. **Microcontroller Programming:** We are required to search for a specific value V (stored at memory location `0x200`) within an array of N numbers starting at `0x201`. The size of the array N is stored at `0x220`.

   Using the concise 8-bit microcontroller instruction set provided in class (Load, Store, Add, Sub, Jump, Branch if Zero, etc.):

   (a) Write an assembly program that outputs '1' to register R_0 if the value is found, and '0' otherwise. [10]

   (b) Comment your code explaining the logic.

   [10 Marks] {CO-4}

6. **Conversions:** Perform the following conversions. Show steps where applicable.

   (a) $(45.6)_{10} = (?)_2$ (upto 4 decimal places) [1]

   (b) $(123)_5 = (?)_8$ [1]

   (c) Subtract $(1011)_2$ from $(1001)_2$ using 2's complement representation. [1]

   (d) Represent $(-15)_{10}$ in 8-bit Signed Magnitude and 8-bit 2's Complement. [2]

   [5 Marks] {CO-1}