

International Institute of Information Technology, Hyderabad
(Deemed to be University)

EC2.101 – Digital Systems and Microcontrollers – Make up Exam
End Semester Examination

Max. Time: 3 Hr

Max. Marks: 50

Numbers in square brackets [x] after a statement show the marks for that question.

Q1. In base-10, you can determine the divisibility of a number by 3 or 9 simply by adding up all the digits in the number; if the results are divisible by 3 or 9, then the numbers are divisible by 3 or 9, respectively. What is the smallest base n such that we can do the same trick for all the numbers from 2 to 6? In other words, what is the smallest integer $n > 1$ such that for any number written in base n , we can determine the divisibility by all integers m , ($2 \leq m \leq 6$), by adding up all the digits of the number and, if the result divides by m , we conclude that the original number is divisible by m ? [15 marks]

Q2. Even and odd numbers are an interesting concept. In decimal and binary, it is very easy to recognize even and odd numbers just by observing the last digit – if that is even/odd, the entire number is even/odd. What is the mathematical basis for this? We are not so lucky in the ternary number system (radix = 3). Design a simple mathematical method to determine whether a given n -bit ternary number is even or odd ($A_{n-1}A_{n-2}A_{n-3} \dots A_0$), ($A_i \leq 2$). Explain the derivation of this method. Now, design a digital circuit that accepts a 4-digit ternary number as input (total 8 binary lines because each digit will need two lines as 00, 01, 10 for 0, 1 and 2), and outputs 1 if the number is odd and 0 if the number is even. Explain the design procedure and choices you make. [15 marks]

Q3. Let's say we are asked to design a circuit for a vending machine that dispenses candy for Rs. 2. The input consists of a coin slot that can accept Rs. 1 and Rs. 2 coins. The deposit of these coins by the user is detected by a circuit that gives out two outputs x and y – when Rs. 1 is inserted, y goes to one, and when Rs. 2 is inserted, x goes to one, for one clock cycle. x and y stay at zero by default. Only one coin can be entered at once. Once the user has finished inserting the coins, she can press a button to obtain the candies and change (if any). This button also generates a pulse of 1 when pressed and remains zero otherwise. Design a circuit such that it takes x , y and button press as inputs and outputs the count of candies to be provided, and if Rs. 1 change is to be dispensed or not. The circuit should be able to hold information of up to Rs. 30, i.e., at any time after inserting between 0 and 30, if the button is pressed, we should know how many candies to dispense, and whether to dispense change. [20 marks]