EE214 Digital Circuits Laboratory

Wadhwani Electronics Laboratory
Electrical Engineering IIT Bombay

Total Marks : 40 | MID-SEMESTER EXAM - Part A (4 Marks) | Total Duration: 2.5 hrs | Date: September 27, 2023

1. **Objective**
   Design an unsigned **BCD Adder-Subtractor circuit** using X-code.

2. **Theory**

   In BCD-code, each decimal number (0-9) is represented by 4 bits (0000 to 1001). The rest of the binary codes are treated as invalid cases (1010 to 1111). X-code is obtained by adding $(3)_{10}$ [decimal no. 3] to the respective BCD code. We have to perform single-digit BCD addition and subtraction using the X-code.

   Let A and B be two single-digit BCD numbers. A_X and B_X are X-codes respectively. Below are the 4 cases which can occur:

   - **Addition :** Addition A + B has to be performed by converting it to $A_X + B_X$.
     - **Case-1:** The output $A_X + B_X$ may overflow if addition exceeds $(15)_{10}$. In BCD addition $(6)_{10}$ is added as a correction factor. Since in X-code method, $(3)_{10}$ is added two times already, correction is done. The answer is 5 bits. MSB represents the ten's digit.
     - **Case-2:** The output $A_X + B_X$ may not overflow. Since in X-code method, $(3)_{10}$ is added two times already thus subtract $(6)_{10}$. Discard the final carry to get the correct answer.

   - **Subtraction :** Subtraction A - B has to be performed by converting it to A_X + 2's complement of B_X.
     - **Case-1:** A - B is positive then A_X + 2's complement of B_X will overflow. The final answer is with discarding carry.
     - **Case-2:** A - B is negative then A_X + 2's complement of B_X will not overflow. The answer evaluated will be in 2's complement form. Take 2's complement of the evaluated answer excluding carry bit to get the correct magnitude. Remember, the sign will be negative. Example: $(4)_{10}$ - $(6)_{10}$ = -$(2)_{10}$. Here, the final output should be $(2)_{10}$, and the sign flag should be set appropriately indicating a negative number.

3. **Exercise** **[4 marks]**
   For your understanding reference example is provided below for the Addition case-2.

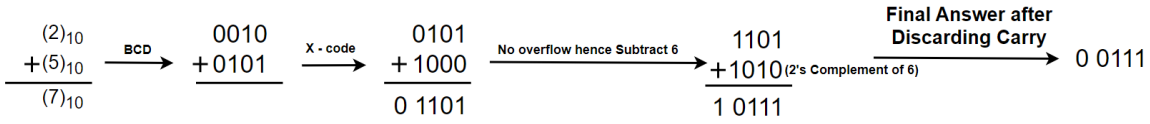

Figure 1: Addition case-2

Solve the other four questions given below in your answer sheet in a similar format as the reference example provided. Marks will not be awarded if the format is incorrect.

- Addition case-1: $(7)_{10}$+$(8)_{10}$
- Addition case-2: $(3)_{10}$+$(6)_{10}$
- Subtraction case-1: $(9)_{10}$-$(3)_{10}$
- Subtraction case-2: $(6)_{10}$-$(8)_{10}$