Assignment I

Under the Hood

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Aditya Tanwar

Akhil Agrawal

Question 1

Suppose in the upcoming technology, computers change their way of performing addition/subtraction of 4 numbers. The function of key importance for the addition 4-bits is given (represented in *PoS* form)

$$f(A, B, C, D) = \prod (1, 3, 4, 6, 9, 11)$$

The resulting bit in the addition is given by $r = f(b_1, b_2, b_3, c_{in})$ and the bit for carry out is determined by $c_{out} = f(c_{in}, b_1, b_2, b_3)$.

1. Implement an adder that takes three inputs X, Y, Z (each being 8 bit-numbers) and returns X + Y + Z as output.
2. Implement a calculator that can perform the following calculations, for three 8-bit numbers, A, B, C,
   - A + B + C
   - -A + B + C
   - A - B + C
   - A + B - C

   You may assume A, B, C to be positive numbers and 2's complement representation system to be used throughout the task.

   HINT for part 2: In your module take a 2-bit *"opcode"* as input.

Question 2

Implement a positive edge-triggered flip-flop which takes in two bits as inputs and outputs a single bit. The truth table of the flip flop is as follows-

B_1	B_2	Q_t	Q_{t+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

Question 3

Construct a heating system in the form of an *FSM* which has three states, Heating mode *(10)*, Cooling mode *(01)*, and a Neutral mode *(00)*. The initial state of the system is Neutral mode. If the system is currently in-

- Heating mode: It shifts to neutral mode if the current temperature exceeds 20 units, and to cooling mode if the temperature exceeds 26 units.
- Cooling mode: It shifts to neutral mode if the current temperature drops below 14 units and to heating mode if it drops below 8 units.
- Neutral mode: It shifts to heating mode if the temperature drops below 12 units, and to cooling mode if it exceeds 18 units.

Assume the temperature to be a *5-bit* unsigned integer. You may also assume strict inequalities in each statement. The output of the *FSM* is the same as the next state, it will adopt.
Print the input, output pairs for at least *10* temperatures.