

### 1) Number representation

Given  $X$  and  $Y$  below that are 5-bit numbers in 2's complement form, fill in the table of what  $S$  should be as a 5-bit number in 2's complement form (**even if the result causes an overflow**). Indicate whether or not there is an *overflow* and what  $S$  is as a number (if  $S$  results in an overflow, then just put an "x" under the  $S$  column).

Also, in the last two columns, specify how the binary vector of  $X$  should be interpreted as an Octal number and a Hexadecimal number, respectively?

(First two rows provide examples.)

| $X$<br>$x_4x_3x_2x_1x_0$ | $Y$<br>$y_4y_3y_2y_1y_0$ | $S = X + Y$<br>$s_4s_3s_2s_1s_0$ | Overflow? | $S$ in 2's<br>complement | $X$ in<br>Octal | $X$ in<br>Hexadecimal |
|--------------------------|--------------------------|----------------------------------|-----------|--------------------------|-----------------|-----------------------|
| 11101                    | 10001                    | 01110                            | yes       | x                        | 35              | 1D                    |
| 00001                    | 00111                    | 01000                            | no        | 8                        | 01              | 01                    |
| 00111                    | 01001                    |                                  |           |                          |                 |                       |
| 00111                    | 10111                    |                                  |           |                          |                 |                       |
| 11001                    | 10111                    |                                  |           |                          |                 |                       |
| 11001                    | 01001                    |                                  |           |                          |                 |                       |

Note:  $X = 11001$  is the same for the last two rows. Hence  $X$  in Octal should be the same for the last two rows as well. Same with  $X$  in Hexadecimal.

## 2) Two-level logic minimization

$$F(A, B, C, D) = \sum m(0, 1, 5, 6, 7, 8, 12, 13, 15)$$

$$d(A, B, C, D) = \sum m(3, 10, 11)$$

| AB \ CD | CD |    |    |    |
|---------|----|----|----|----|
|         | 00 | 01 | 11 | 10 |
| 00      |    |    |    |    |
| 01      |    |    |    |    |
| 11      |    |    |    |    |
| 10      |    |    |    |    |

a) Identify all the prime and essential prime implicants.

| Prime | Essential |
|-------|-----------|
|       |           |
|       |           |
|       |           |
|       |           |
|       |           |
|       |           |
|       |           |
|       |           |
|       |           |

b) Find the minimum two-level logic implementation.

$F =$

### 3) Multi-level logic minimization

Given following logic equations, minimize the number of literals, e.g. by using common subexpressions, Boolean rules, etc. You can introduce new immediate equations for common sub-expressions if it helps to reduce the number of literals. Put a box around your final answer, and indicate the number of literals in your final answer.

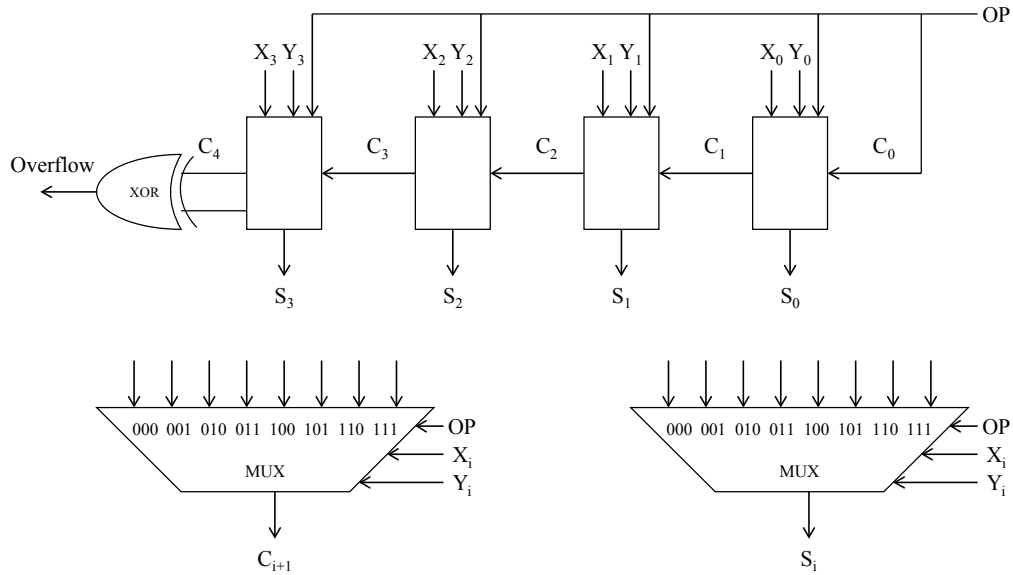
$$M = A\bar{C}\bar{D}FG + \bar{B}\bar{C}\bar{D}FG + A\bar{C}\bar{E}FG + \bar{B}\bar{C}\bar{E}FG + \bar{A}B\bar{F} + \bar{A}B\bar{G} + C\bar{F} + C\bar{G} + DE\bar{F} + DE\bar{G}$$

$$N = ABC + FG + \bar{A}F + \bar{B}F + \bar{C}F$$

$$P = \bar{A}BF + CF + DEF + \bar{A}B\bar{F} + C\bar{F} + DE\bar{F} + \bar{C}H + FH$$

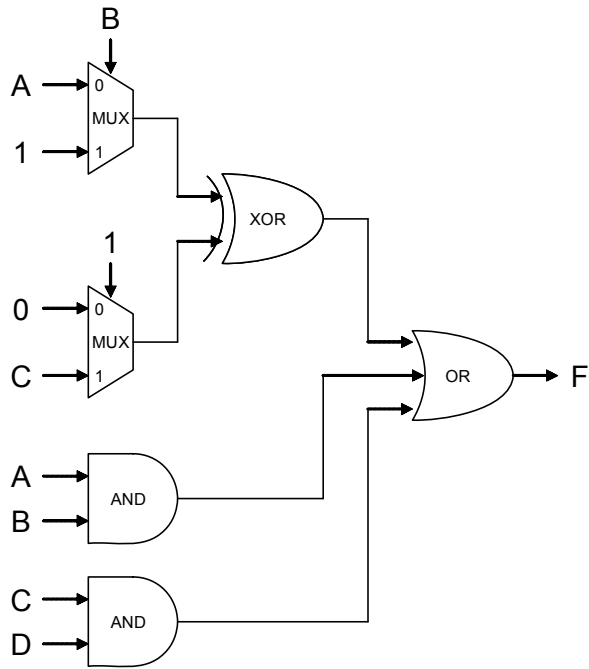
#### 4) Multiplexor/Adder/Subtractor

Consider the following 4-bit 2's complement adder/subtractor. When  $OP = 0$ , do an addition. Else (when  $OP = 1$ ), do a subtraction. Specify how to implement each  $S_i$  and  $C_{i+1}$  using only the following 8:1 multiplexors.



### 5) Multiplexors and XOR gates

Given the following logic diagram, fill out the K-map.



| AB \ CD |    |    |    |    |
|---------|----|----|----|----|
|         | 00 | 01 | 11 | 10 |
| 00      |    |    |    |    |
| 01      |    |    |    |    |
| 11      |    |    |    |    |
| 10      |    |    |    |    |