Name: ..............................................................................  Student ID: ..............................................................

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# Laboratory 5

# Binary Adders and Subtracters

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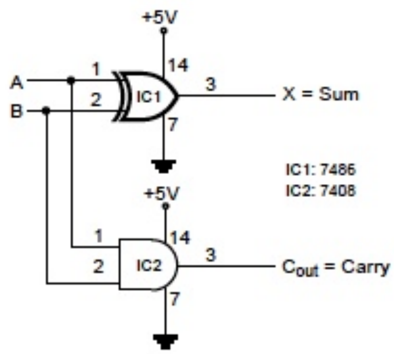
**1. Half Adder:**

1.1 Connect a circuit as shown in the following figure. Use the logic switches to supply inputs signals as specified and connect the output signals to the logic monitor.




1.2 Record the result in the following truth table.

| A | B | X | $C_{out}$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

1.3 Find the Boolean expression for the given circuit in 1.1.

$x = \bar{A}B + A\bar{B}$

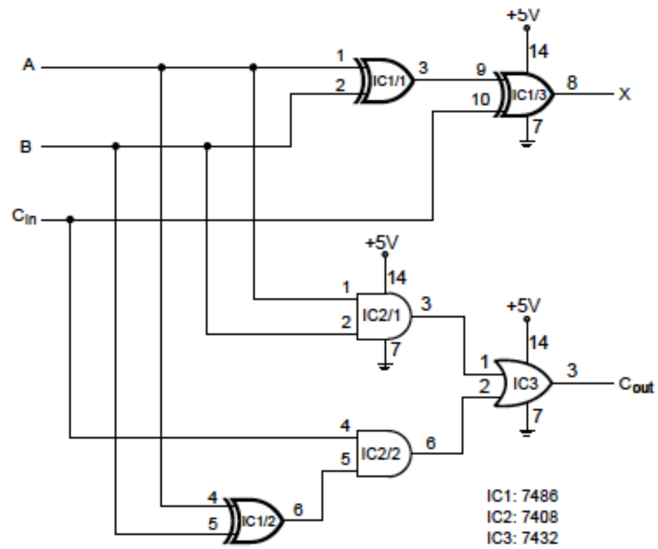
$= A \oplus B$ #

$C_{out} = AB$ #

Instructor's signature

**2. Full Adder:**

2.1 Connect a circuit as shown in the following figure. Use the logic switches to supply inputs signals as specified and connect the output signals to the logic monitor.




2.2 Record the results in the following truth table.

| A | B | $C_{in}$ | X | $C_{out}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |

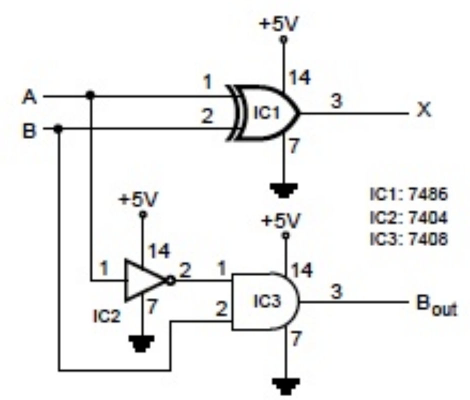
2.3 Find the Boolean expression for the given circuit in 2.1.

$$X = A\overline{B}\overline{C}_{in} + \overline{A}B\overline{C}_{in} + \overline{A}\overline{B}C_{in} + ABC_{in}$$
$$= (A \oplus B)\overline{C}_{in} + \overline{A}\overline{B}C_{in} + ABC_{in}$$
$$= (A \oplus B)\overline{C}_{in} + (\overline{A+B})C_{in} = (A+B) \oplus C$$
$$C_{out} = A\overline{B}\overline{C}_{in} + \overline{A}B\overline{C}_{in} + \overline{A}\overline{B}C_{in} + ABC_{in}$$
$$= (A \oplus B)\overline{C}_{in} + \overline{A}\overline{B}C_{in} + ABC_{in}$$

Instructor's signature

## 3. Half Subtractor:

3.1 Connect a circuit as shown in the following figure. Use the logic switches to supply inputs signals as specified and connect the output signals to the logic monitor.




3.2 Record the results in the following truth table.

| A | B | X | $B_{out}$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |

3.3 Find the Boolean expression for the given circuit in 3.1.

$x = \bar{A}B + A\bar{B}$

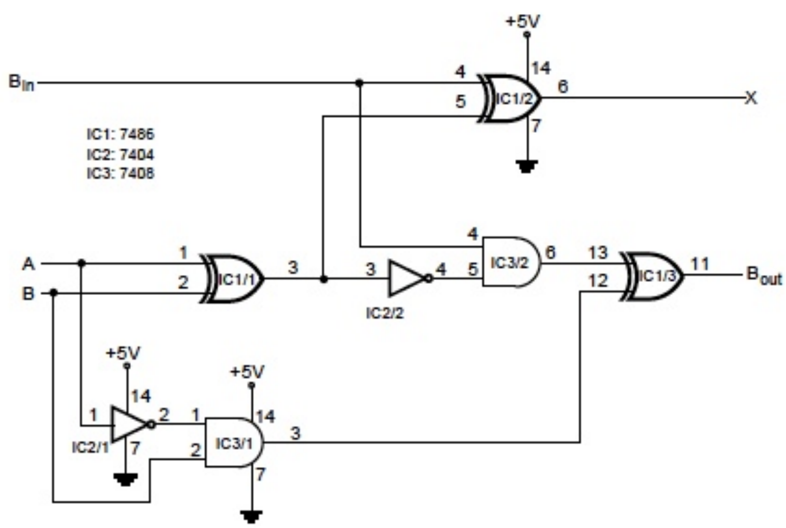
$= (A \oplus B)$

$B_{out} = \bar{A}B$

Instructor's signature

**4. Full Subtractor:**

4.1 Connect a circuit as shown in the following figure. Use the logic switches to supply inputs signals as specified and connect the output signals to the logic monitor.




4.2 Record the results in the following truth table.

| A | B | $B_{in}$ | X | $B_{out}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 |

| A | B | $B_{in}$ | X | $B_{out}$ |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 |

4.3 Find the Boolean expression for the given circuit in 4.1.

$$X = \bar{A}\bar{B}B_{in} + \bar{A}B\bar{B}_{in} + A\bar{B}\bar{B}_{in} + ABB_{in}$$
$$= \bar{A}(B \oplus B_{in}) + A(\overline{B \oplus B_{in}}) = A \oplus (B \oplus B_{in})$$
$$B_{out} = \bar{A}\bar{B}B_{in} + \bar{A}B\bar{B}_{in} + \bar{A}BB_{in} + ABB_{in}$$
$$= (\overline{A \oplus B})B_{in} + \bar{A}B$$

Instructor's signature

## 5. Assignments:

5.1 Design the circuit, which will add the two binary numbers. The numbers can be both positive and negative. The numbers are presented in 2's complement form. The circuit should be able to apply for 3-bit binary number. Use the following test cases to test your circuit.

| Test Cases | A | B | A+B |
|---|---|---|---|
| 1 | 010 | 001 | 011 |
| 2 | 010 | 010 | 100 |
| 3 | 010 | 111 | 001 |
| 4 | 110 | 001 | 111 |
| 5 | 110 | 111 | 101 |
| 6 | 110 | 110 | 100 |

Instructor's signature

5.2 The results obtained from the previous problem are not always correct since some results are overflow. Construct a circuit, which detects occurrence of overflow. The output LED should be ON when the overflow from occurs.

Instructor's signature

5.3 Design the circuit, which will subtract the two binary numbers. The numbers can be both positive and negative. The numbers are presented in 2's complement form. The circuit should be able to apply for 3-bit binary number. Use the following test cases to test your circuit.

| Test Cases | A | B | A-B |
|---|---|---|---|
| 1 | 010 | 001 | 001 |
| 2 | 010 | 010 | 000 |
| 3 | 010 | 111 | 011 |
| 4 | 110 | 001 | 101 |
| 5 | 110 | 111 | 111 |
| 6 | 110 | 110 | 000 |

| Instructor's signature |
|---|
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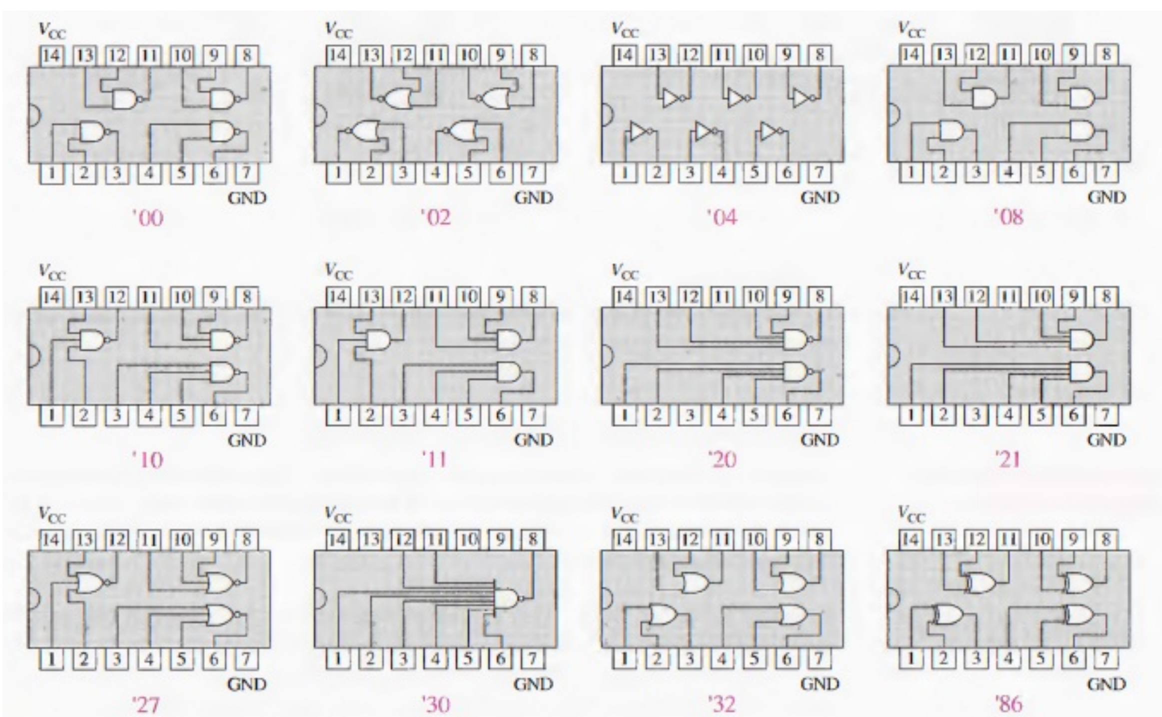
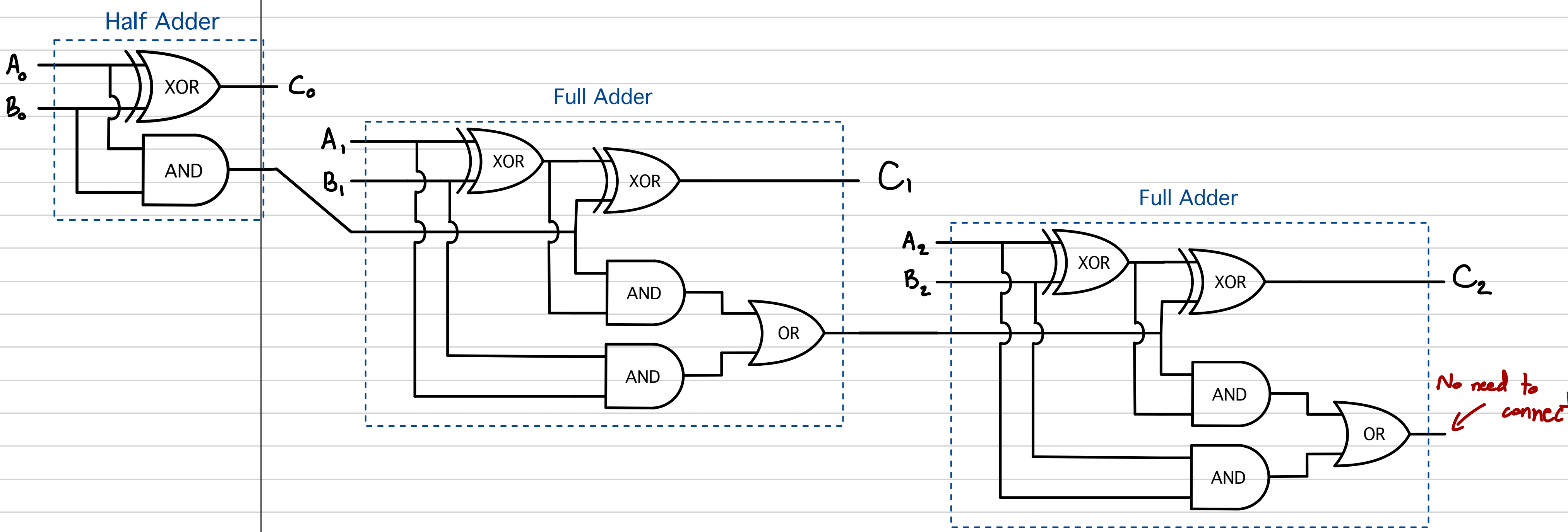
## Logic Diagram of frequently used gates



5. Assignments:

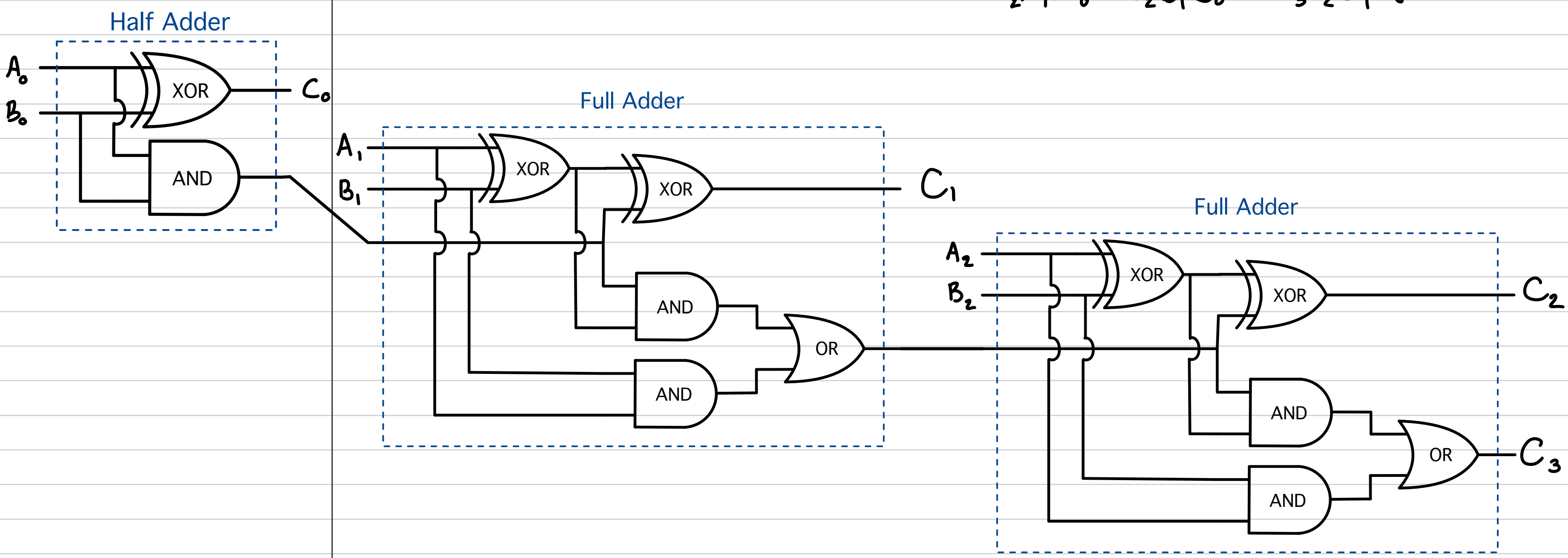
5.1 Design the circuit, which will add the two binary numbers. The numbers can be both positive and negative. The numbers are presented in 2's complement form. The circuit should be able to apply for 3-bit binary number. Use the following test cases to test your circuit.

| Test Cases | A ($A_2A_1A_0$) | B ($B_2B_1B_0$) | A+B ($C_2C_1C_0$) |
|---|---|---|---|
| 1 | 010 | 001 | 011 |
| 2 | 010 | 010 | 100 |
| 3 | 010 | 111 | 001 |
| 4 | 110 | 001 | 111 |
| 5 | 110 | 111 | 101 |
| 6 | 110 | 110 | 100 |



5.2 The results obtained from the previous problem are not always correct since some results are overflow. Construct a circuit, which detects occurrence of overflow. The output LED should be ON when the overflow from occurs.

$$A_2A_1A_0 + B_2B_1B_0 = C_3C_2C_1C_0$$



5.3 Design the circuit, which will subtract the two binary numbers. The numbers can be both positive and negative. The numbers are presented in 2's complement form. The circuit should be able to apply for 3-bit binary number. Use the following test cases to test your circuit.

| Test Cases | A | B | A-B |
|---|---|---|---|
| 1 | 010 | 001 | 001 |
| 2 | 010 | 010 | 000 |
| 3 | 010 | 111 | 011 |
| 4 | 110 | 001 | 101 |
| 5 | 110 | 111 | 111 |
| 6 | 110 | 110 | 000 |

$A_2A_1A_0 - B_2B_1B_0 = C_2C_1C_0$