

Subsystems

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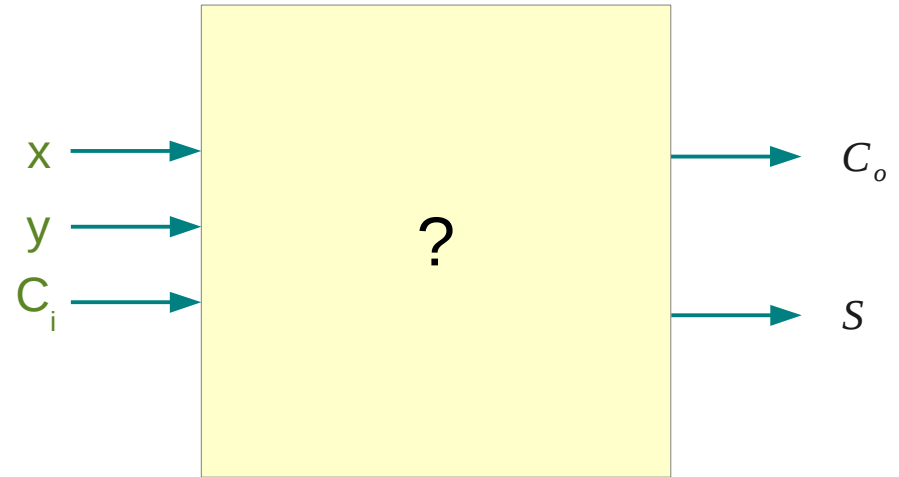
Subsystem Examples

Adders
Multipliers
Memories
Clock
PLL
DLL
I/O

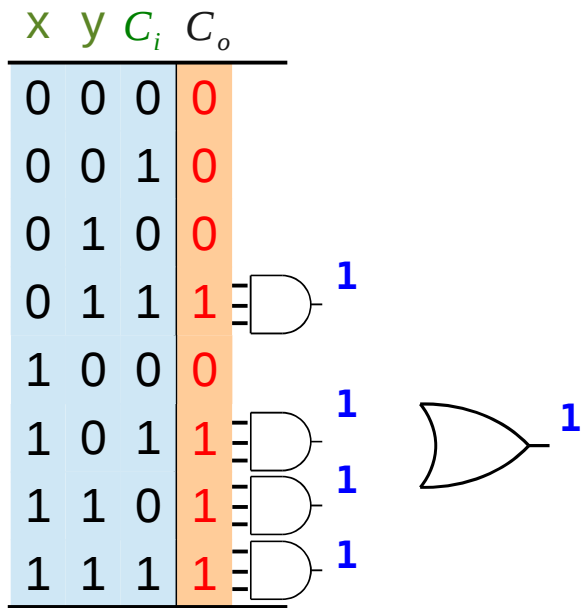
Truth Table

| x | y | C_i | C_o | S |
|-----|-----|-------|-------|-----|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

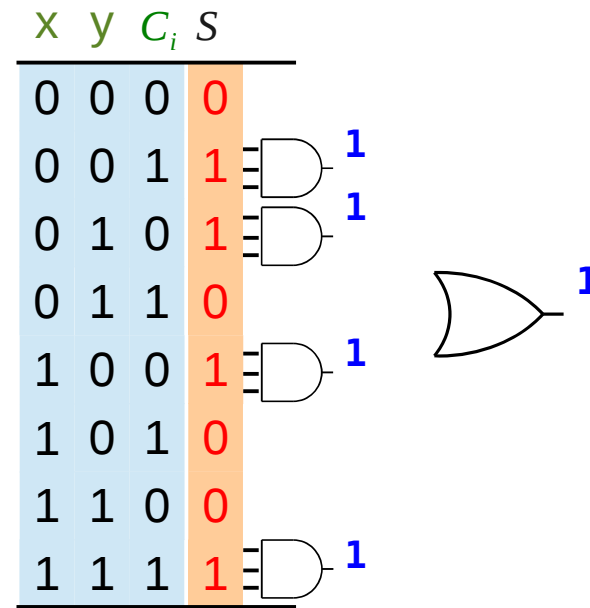
inputs output



Sum of Product



$$C_o = \bar{x}yC_i + x\bar{y}C_i + xy\bar{C}_i + xyC_i$$

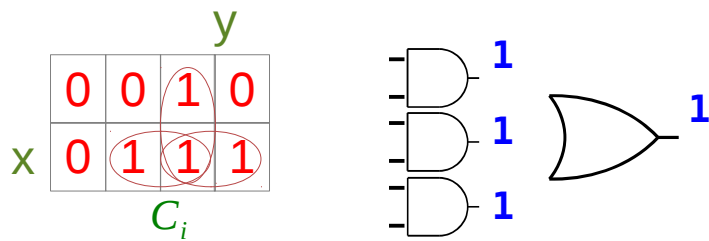


$$S = \bar{x}\bar{y}C_i + \bar{x}y\bar{C}_i + x\bar{y}\bar{C}_i + xyC_i$$

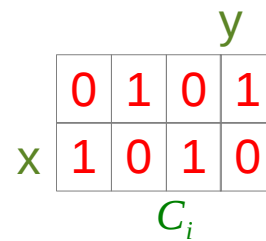
K-Map

| x | y | C_i | C_o |
|---|---|-------|-------|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

| x | y | C_i | S |
|---|---|-------|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

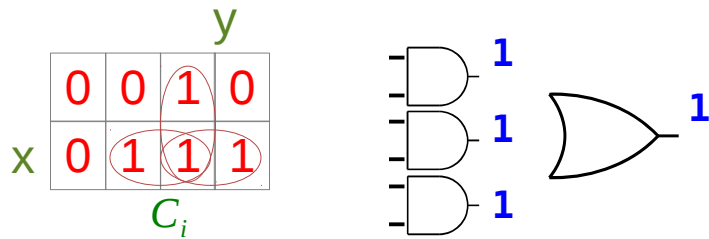


$$C_o = yC_i + xC_i + xy$$



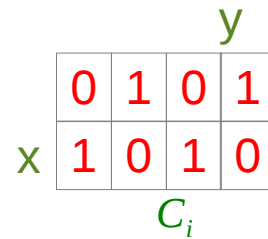
$$S = \bar{x}\bar{y}C_i + \bar{x}y\bar{C}_i + x\bar{y}\bar{C}_i + xyC_i$$

Boolean Algebra



$$C_o = yC_i + xC_i + xy$$

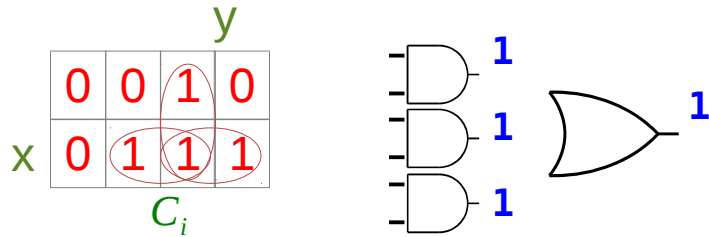
$$\begin{aligned} C_o &= (x + y)C_i + xy \\ &= (\bar{x}y + x\bar{y} + xy)C_i + xy \\ &= (\bar{x}y + x\bar{y})C_i + xy(C_i + 1) \\ &= (x \oplus y)C_i + xy \end{aligned}$$



$$S = \bar{x}\bar{y}C_i + \bar{x}y\bar{C}_i + x\bar{y}\bar{C}_i + xyC_i$$

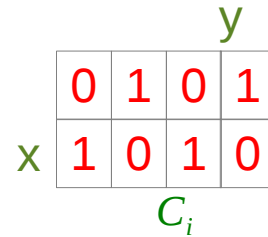
$$\begin{aligned} S &= (\bar{x}\bar{y} + xy)C_i + (\bar{x}y + x\bar{y})\bar{C}_i \\ &= \overline{(x \oplus y)}C_i + (x \oplus y)\bar{C}_i \\ &= (x \oplus y) \oplus C_i \end{aligned}$$

Boolean Algebra



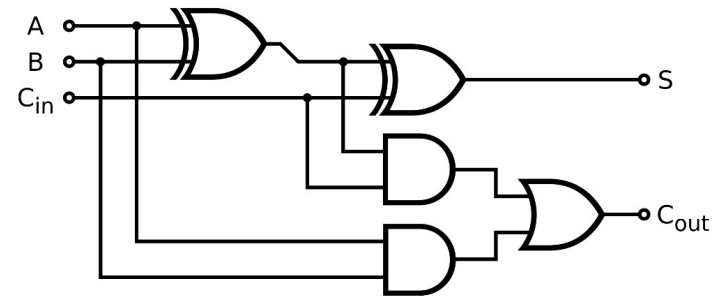
$$C_o = yC_i + xC_i + xy$$

$$\begin{aligned} C_o &= (x + y)C_i + xy \\ &= (\bar{x}y + x\bar{y} + xy)C_i + xy \\ &= (\bar{x}y + x\bar{y})C_i + xy(C_i + 1) \\ &= (x \oplus y)C_i + xy \end{aligned}$$

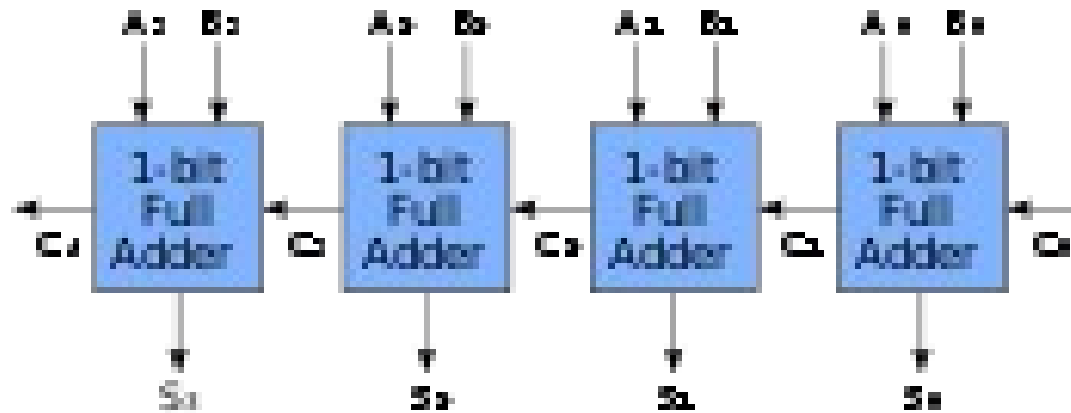
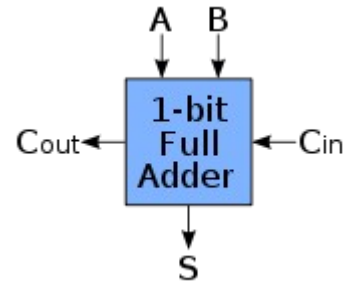
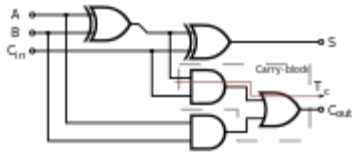


$$S = \bar{x}\bar{y}C_i + \bar{x}y\bar{C}_i + x\bar{y}\bar{C}_i + xyC_i$$

$$\begin{aligned} S &= (\bar{x}\bar{y} + xy)C_i + (\bar{x}y + x\bar{y})\bar{C}_i \\ &= \overline{(x \oplus y)}C_i + (x \oplus y)\bar{C}_i \\ &= (x \oplus y) \oplus C_i \end{aligned}$$



4-bit Binary Adder

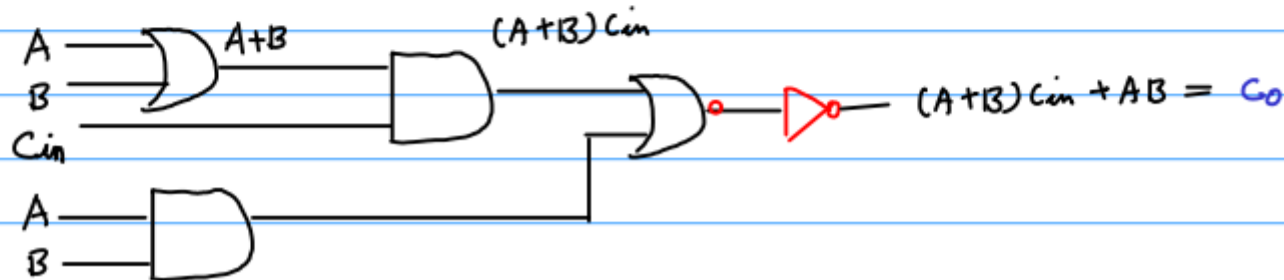
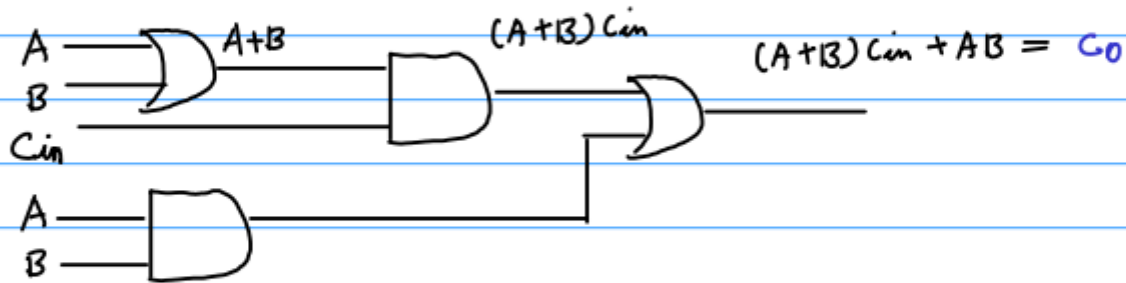


[https://en.wikipedia.org/wiki/Adder_\(electronics\)](https://en.wikipedia.org/wiki/Adder_(electronics))

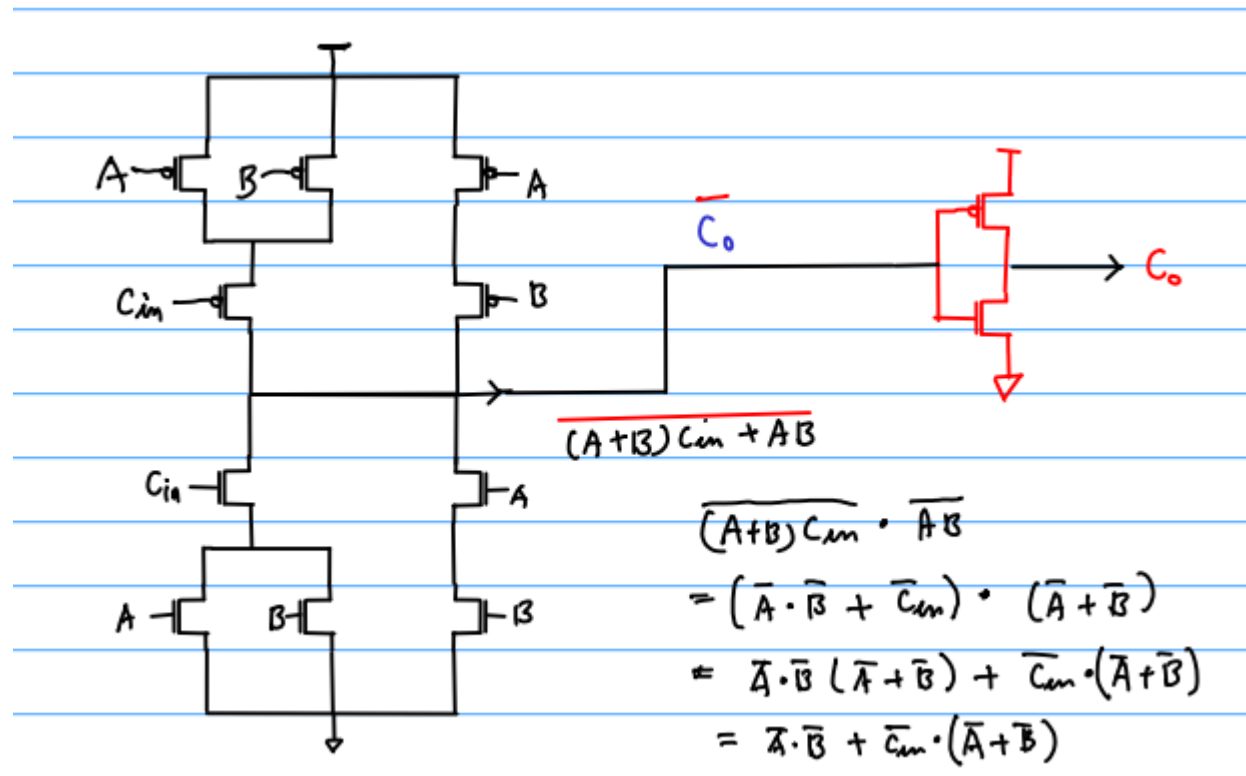
4-bit Binary Adder

$$C_0 = A C_i + B C_i + AB$$

$$S = \bar{C}_0 \cdot (A + B + C_i) + A \cdot B \cdot C_i$$



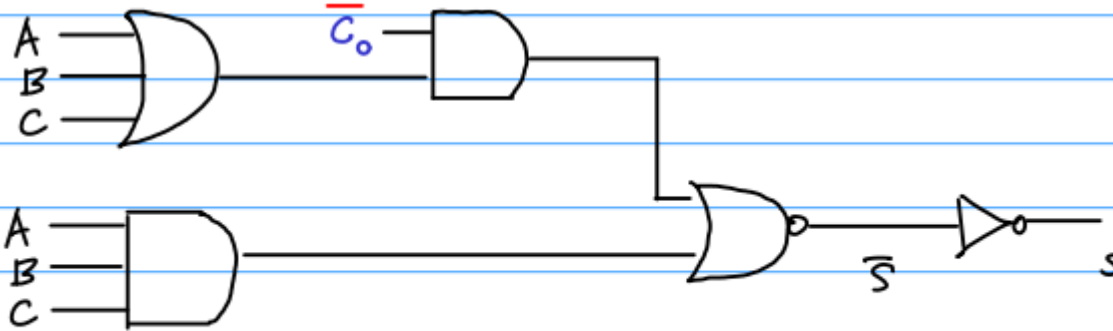
4-bit Binary Adder



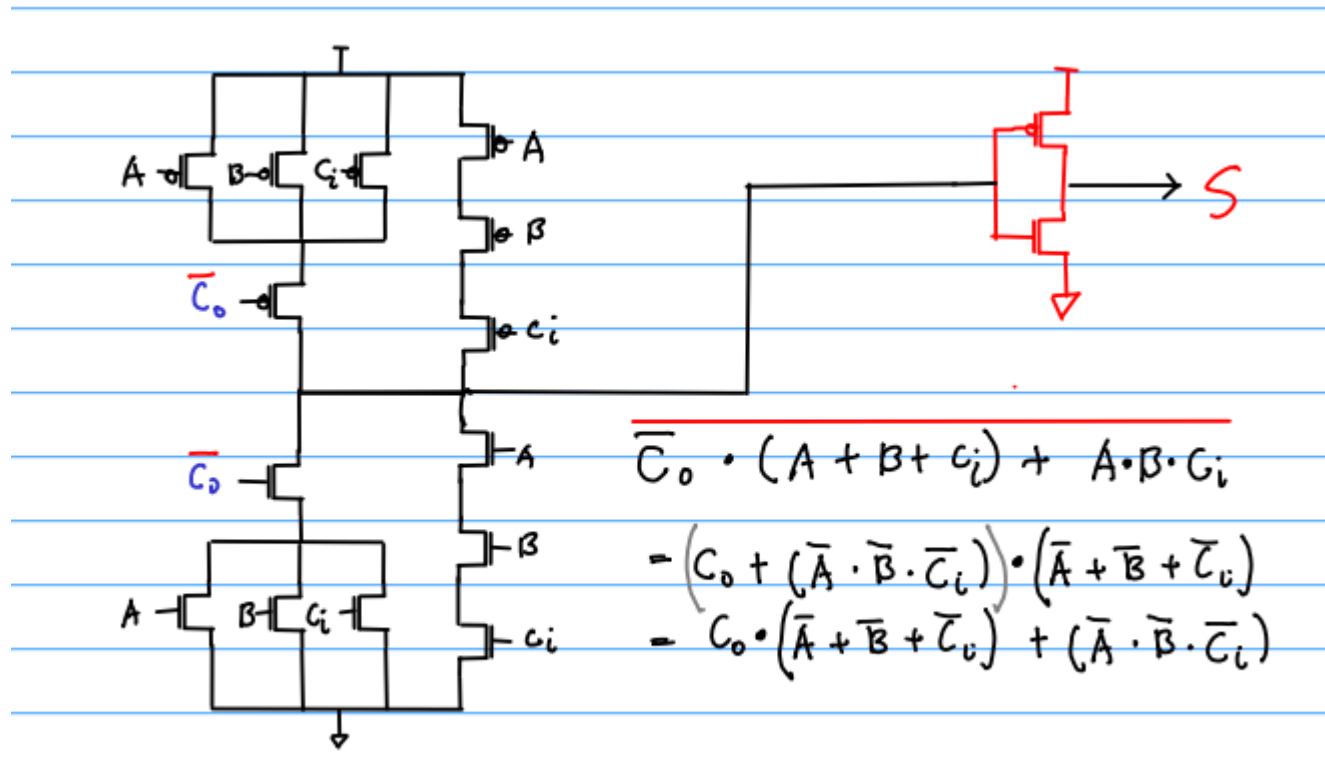
4-bit Binary Adder

$$C_o = A C_i + B C_i + AB$$

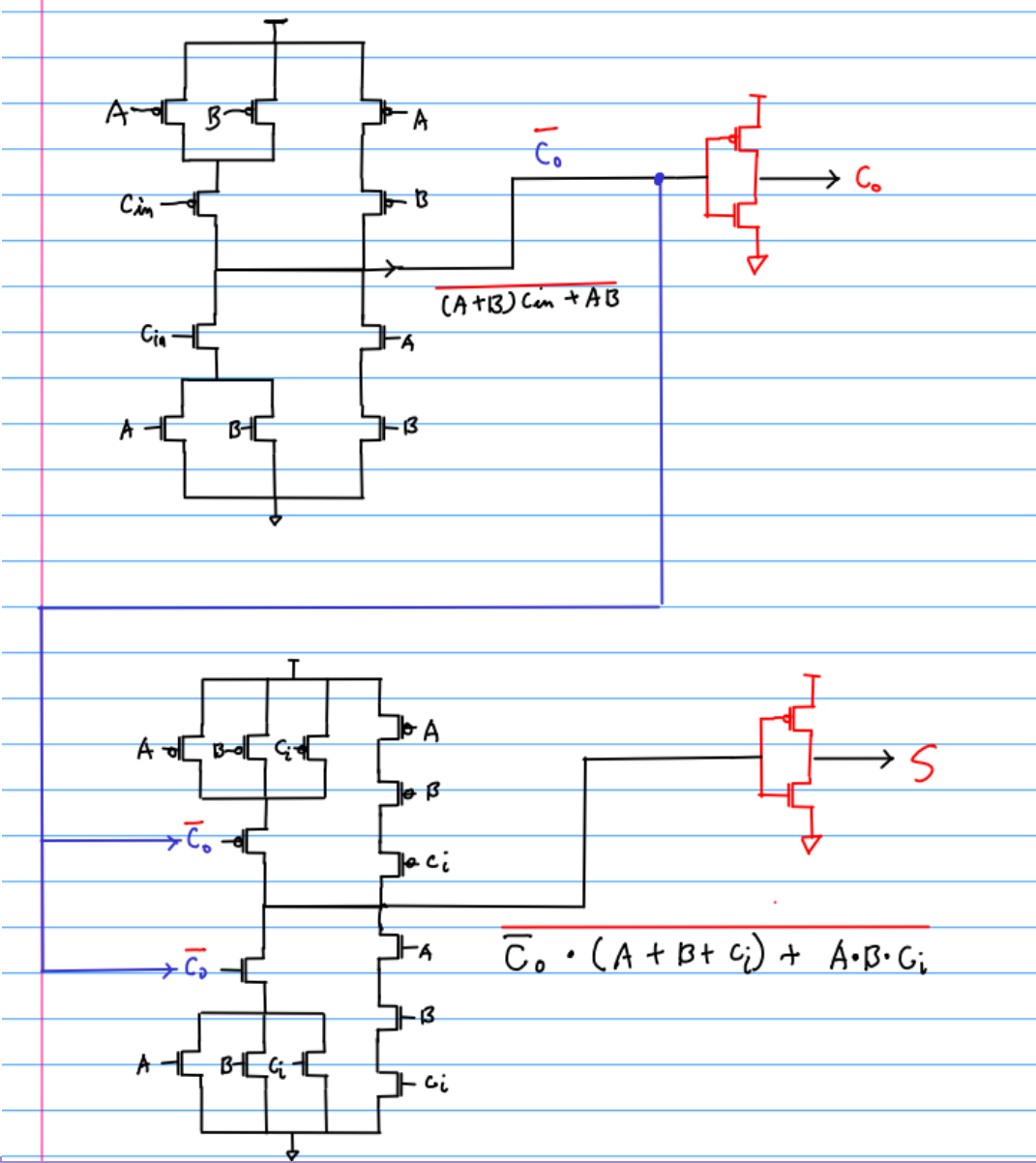
$$S = \bar{C}_o \cdot (A + B + C_i) + A \cdot B \cdot C_i$$



4-bit Binary Adder



4-bit Binary Adder



4-bit Binary Adder

4-bit Binary Adder

References

- [1] <http://en.wikipedia.org/>
- [2] <http://www.allaboutcircuits.com/>
- [3] W. Wolf, "Modern VLSI Design : Systems on Silicon"
- [4] N. Weste, D. Harris, "CMOS VLSI Design: A Circuits and Systems Perspective"
- [5] J. P. Uyemura, "Introduction to VLSI Circuits and Systems"