EE1001 4 bit add theory

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Binary Addition

- *Review of Binary addition*
- Use binary addition to compute 5+7

Write 5 in binary as: 101

Write 7 in binary as: 111

We have:

$$\begin{array}{ccccccc} & & 1 & & 0 & & 1 \\ + & {\color{red}1} & 1 & {\color{red}1} & 1 & {\color{red}1} & 1 \\ \hline 1 & & 1 & & 0 & & 0 \end{array}$$

Add column by column!

1 + 1 = 2 = 10 — 0 is the sum, 1 is the carry

0 + 1 + 1= 2 = 10 — 0 is the sum, 1 is the carry

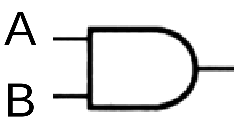
1 + 1 + 1= 3 = 11 — 1 is the sum, 1 is the carry

Therefore, the answer is 1100(12)

In other words 1 + 1 creates a carry.

Recall the Truth Tables in Engineering

Convert **Truth/False** (**T/F**) to **binary number** (**1/0**)

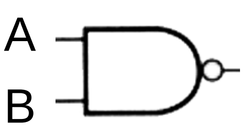


AND Gate

Input		Output
A	B	A ∧ B
1	1	1
1	0	0
0	1	0
0	0	0

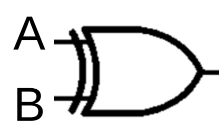
OR Gate

Input		Output
A	B	A ∧ B
1	1	1
1	0	1
0	1	1
0	0	0



NAND Gate

Input		Output
A	B	~(A ∧ B)
1	1	0
1	0	1
0	1	1
0	0	1



XOR Gate

Input		Output
A	B	A ⊕ B
1	1	0
1	0	1
0	1	1
0	0	0

More details will be studied in the section of Boolean Algebra, and you will exploit them during the labs

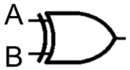
logic circuits

- This problem can be solved with *the logic circuits*
- Consider we have two terms A and B, and compute A+B. Both of A and B can only take the value 1 or 0.

Add One more value C which equals to 1

A	B	A + B	
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0
Input		*Carry* Output	*Sum*

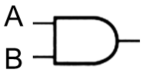
For the sum, we introduce



XOR Gate

Input		Output
A	B	A ⊕ B
1	1	0
1	0	1
0	1	1
0	0	0

For the carry, we introduce



AND Gate

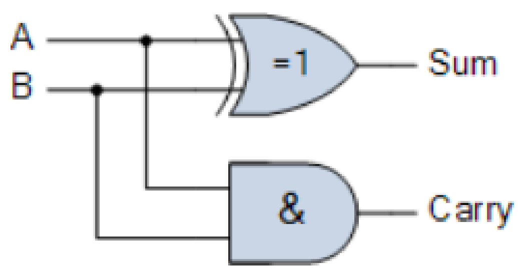
Input		Output
A	B	A ∧ B
1	1	1
1	0	0
0	1	0
0	0	0

- SUM = A XOR B = A ⊕ B
- CARRY = A AND B = A.B

Half Adder Circuit

- A **half adder** is a logical circuit that performs an addition operation on two binary digits. The half adder produces a **sum** and a **carry** value which are both binary digits.

Symbol



Truth Table

B	A	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Full Adder Circuit

- Apart from A and B, let consider another C which equals to 1.
- *C* also can be regarded a carrier from the previous stage.

C	A	B	A + B + C		A + B	
1	0	0	0	1	0	0
1	0	1	1	0	0	1
1	1	0	1	0	0	1
1	1	1	1	1	1	0

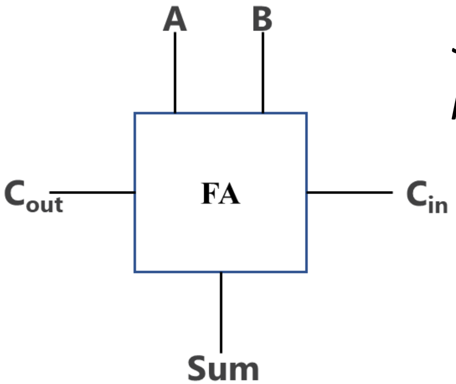
Carry-in Input *Carry-out* *Sum*

Output

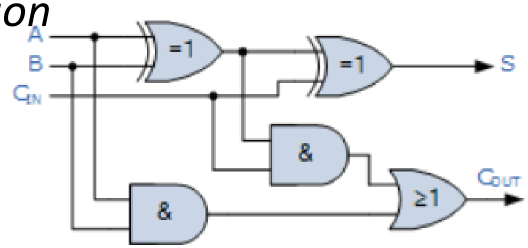
- *Compared with the result of A+B+C with A+B, it can be found:*
  - SUM = (A XOR B) XOR C= (A $\oplus$ B)$\oplus$ C= A $\oplus$ B $\oplus$ C
  - CARRY-OUT = A AND B OR C_{in}(A XOR B) = A.B + C_{in}(A $\oplus$ B)

Full Adder Circuit

- The **Full Adder** is an adder has ***three*** inputs. The same two single bit data inputs A and B as before plus an additional Carry-in (C_{in}) input to ***receive the carry from a previous stage***.



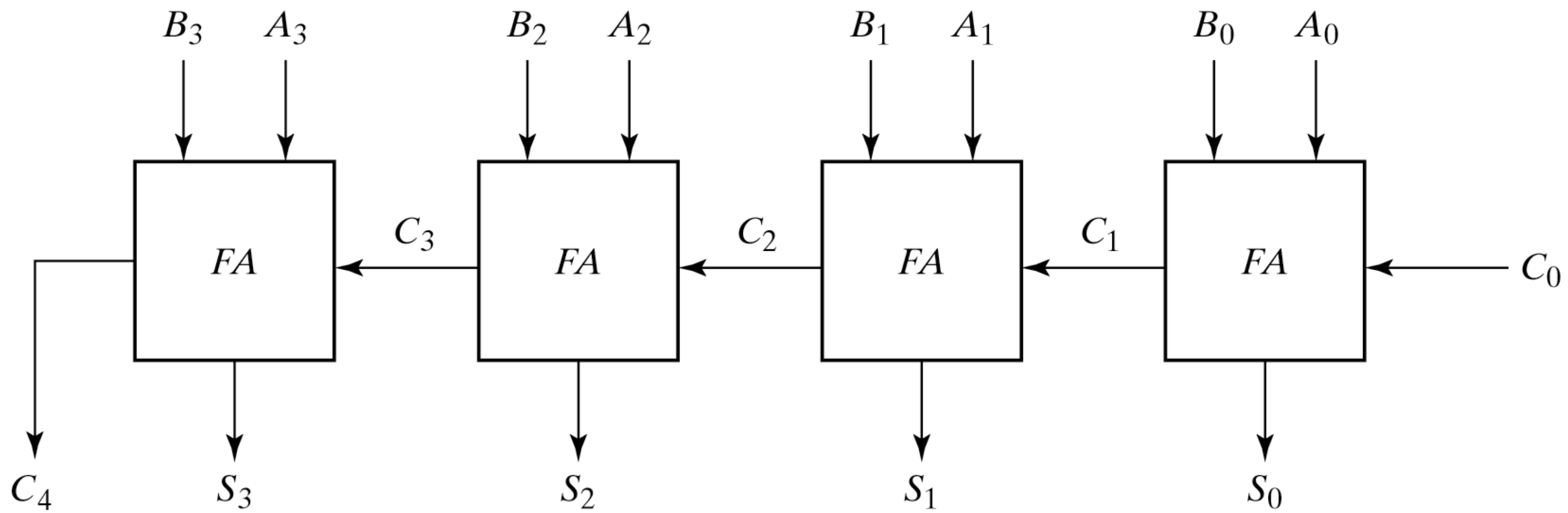
Simplify the presentation



Symbol	Truth Table				
	C-in	B	A	Sum	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

4-bit Adder Implementation

- Let's consider two 4-bit binary numbers A and B as inputs to the Digital Circuit for the operation with digits:
  A0, A1, A2, A3 B0, B1, B2, B3



- n-bit binary adder requires n full adders.
- The sum of each stage will be the output of the stage;
- The carry-out in this stage will be the carry-in in the next stage;
- The carry-out of the final stage will also be the output;

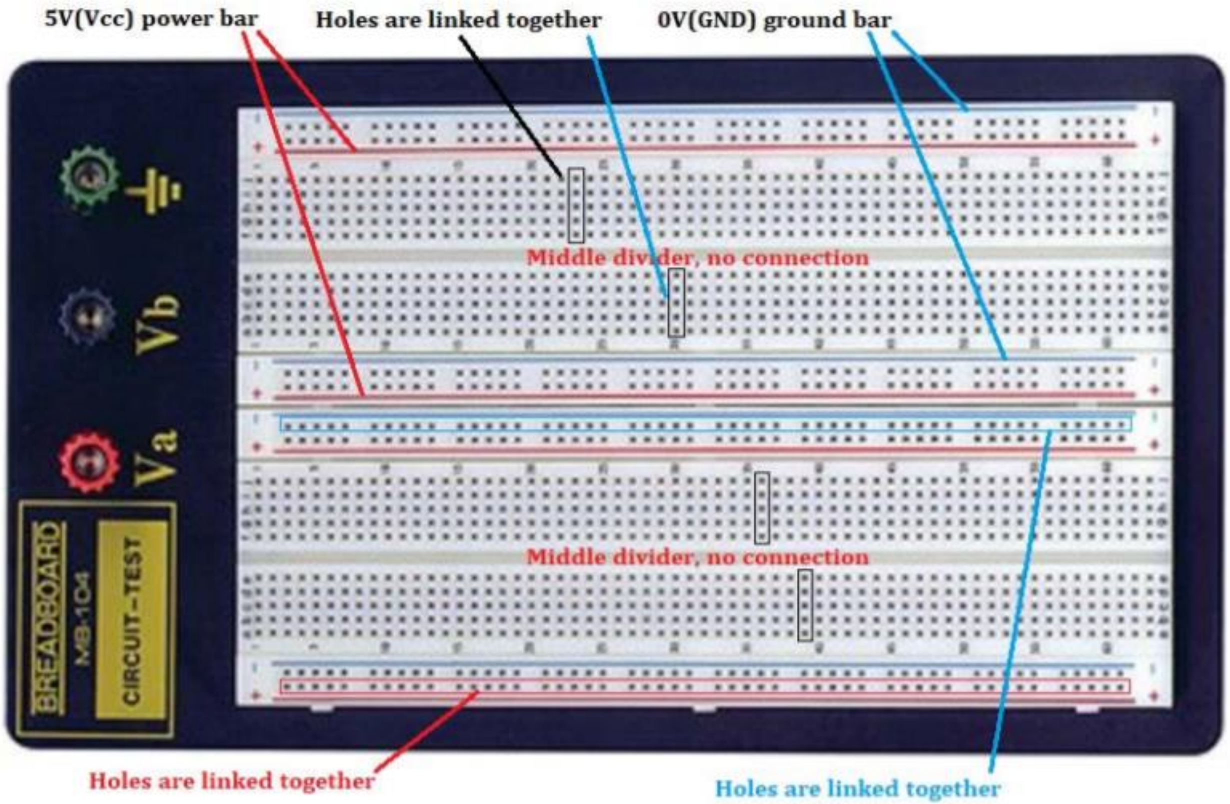
Implementation

- Components provided:

Breadboard		1
2-input AND gate	74LS08	2
3-input AND gate	74LS11	1
2-input OR gate	74LS32	1
2-input XOR gate	74LS86	2
LEDs (Red x 4, white x4)		8
4-ways DIP switch		2
470Ω resistor (color ring: yellow, purple, black, black)		10
1kΩ resistor (color ring: brown, black, black, brown)		10
5V USB wire (option: lab at home)		1
Breadboard red wire (option: lab at home)		0.5M
Breadboard black wire (option: lab at home)		0.5M
Breadboard yellow wire (option: lab at home)		2M
Breadboard green wire (option: lab at home)		2M

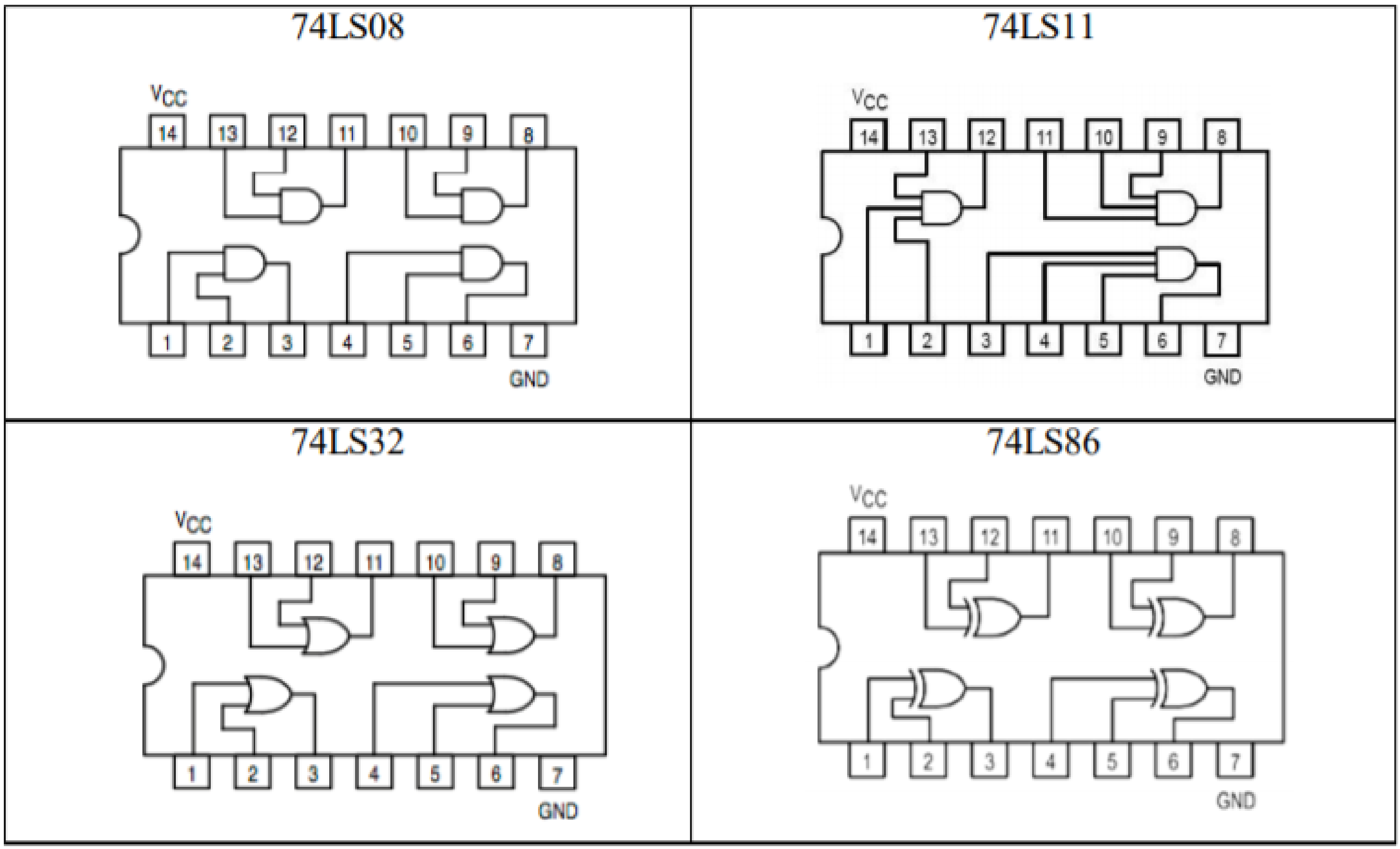
Introduction to bread board

- Equipment provided:



Introduction to Chipset

- Each Chipset contains 4 Gates



Before implementing on the bread board, please read carefully the Laboratory Manual to make sure you are safe and hopefully also avoid damaging equipments.

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