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LOGIC GATE CALCULATOR

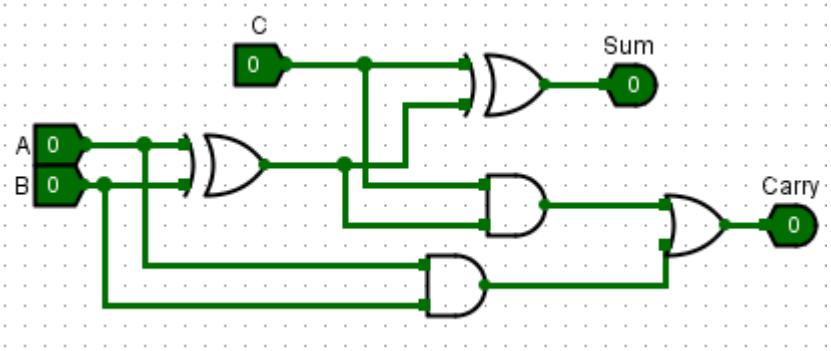
Goal of the Project

The prime purpose of a calculator is to provide a calculated result in response to a given set of input. The possible number of calculations is pre-defined. The range for input is [0,15] numbers in decimal for both A and B. Hence, the maximum input is 4 bits binary number while the output is based on the inputs inserted but still the maximum output can only contain 5 bits binary number in the range of [0,30] for adder operation. This calculator main function is to perform two basic operation which is addition and subtraction.

Detailed Design Process

The main components to create my logic gate calculator, I use full adder and full subtractor circuits as the basis.

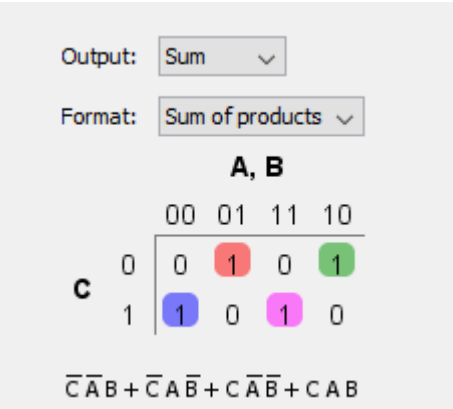
Full Adder Circuit

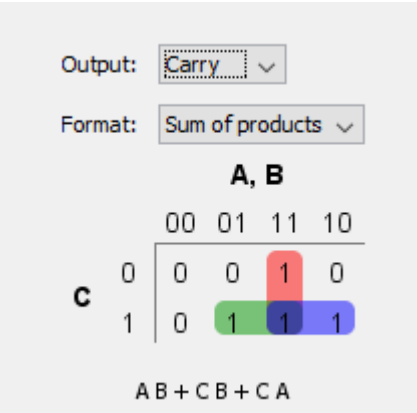


Truth Table

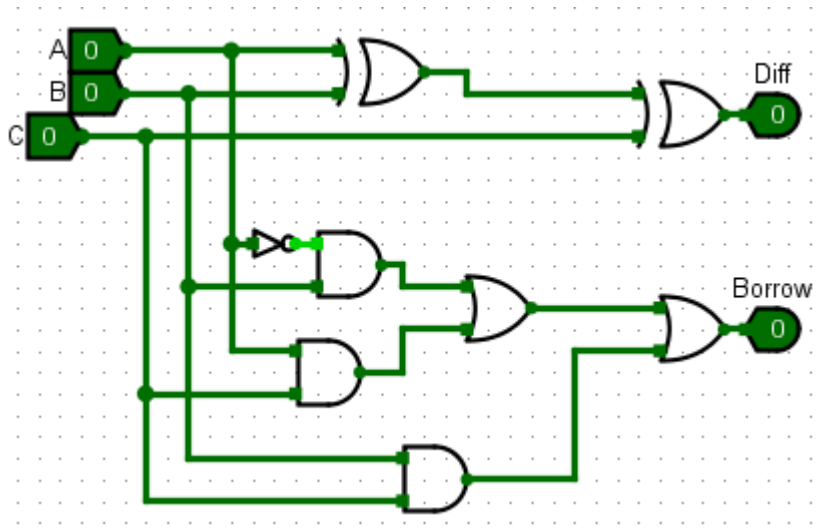
C	A	B	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

K-map and Boolean Expression





Full Subtractor Circuit

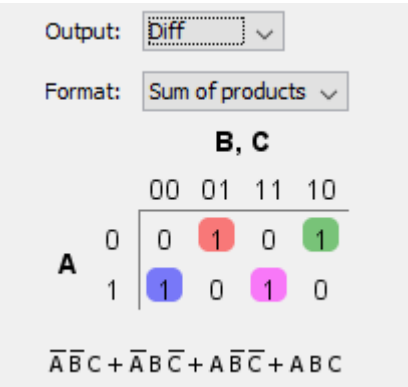


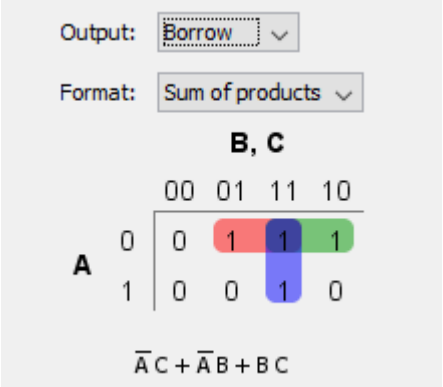
A full subtractor is very similar to a full adder, but it contains two inverters that a full adder does not. When configured to subtract, an adder/subtractor circuit adds a single inverter (in the form of an XOR gate) to one input of a full adder module.

Truth Table

A	B	C	Diff	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	0
1	0	0	0	1
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

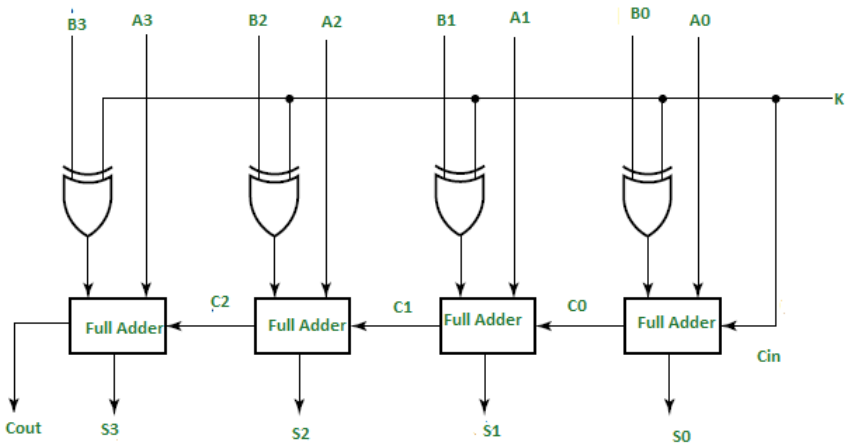
K-map and Boolean Expression



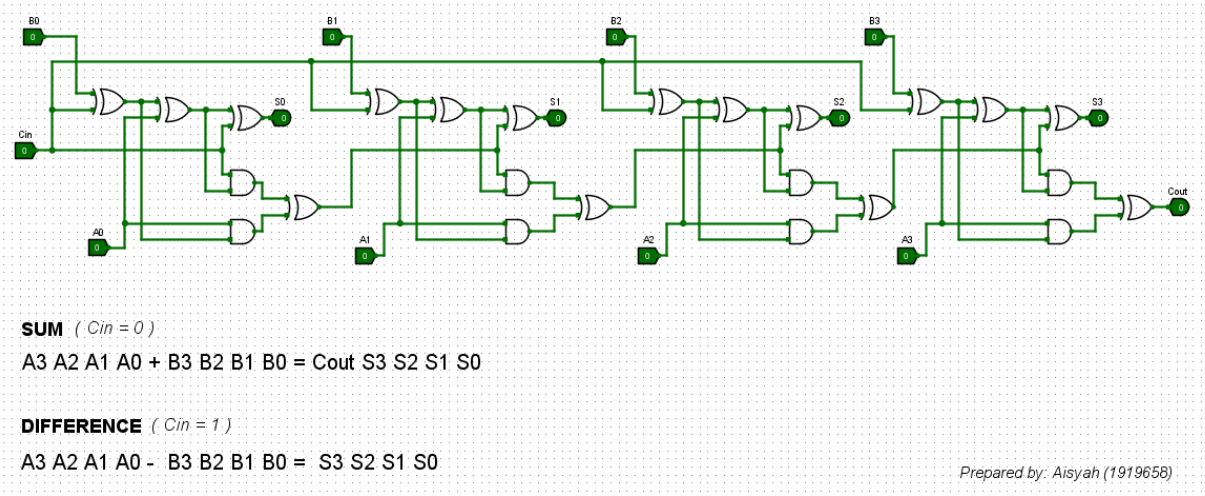


To create the calculator, we combined both circuits and will result in a new circuit which known as 4 bit adder subtractor circuit that consist of 4 full adder and 4 XOR gate. Just using this circuit, we can perform both operation by switching the input in Cin.

Draft

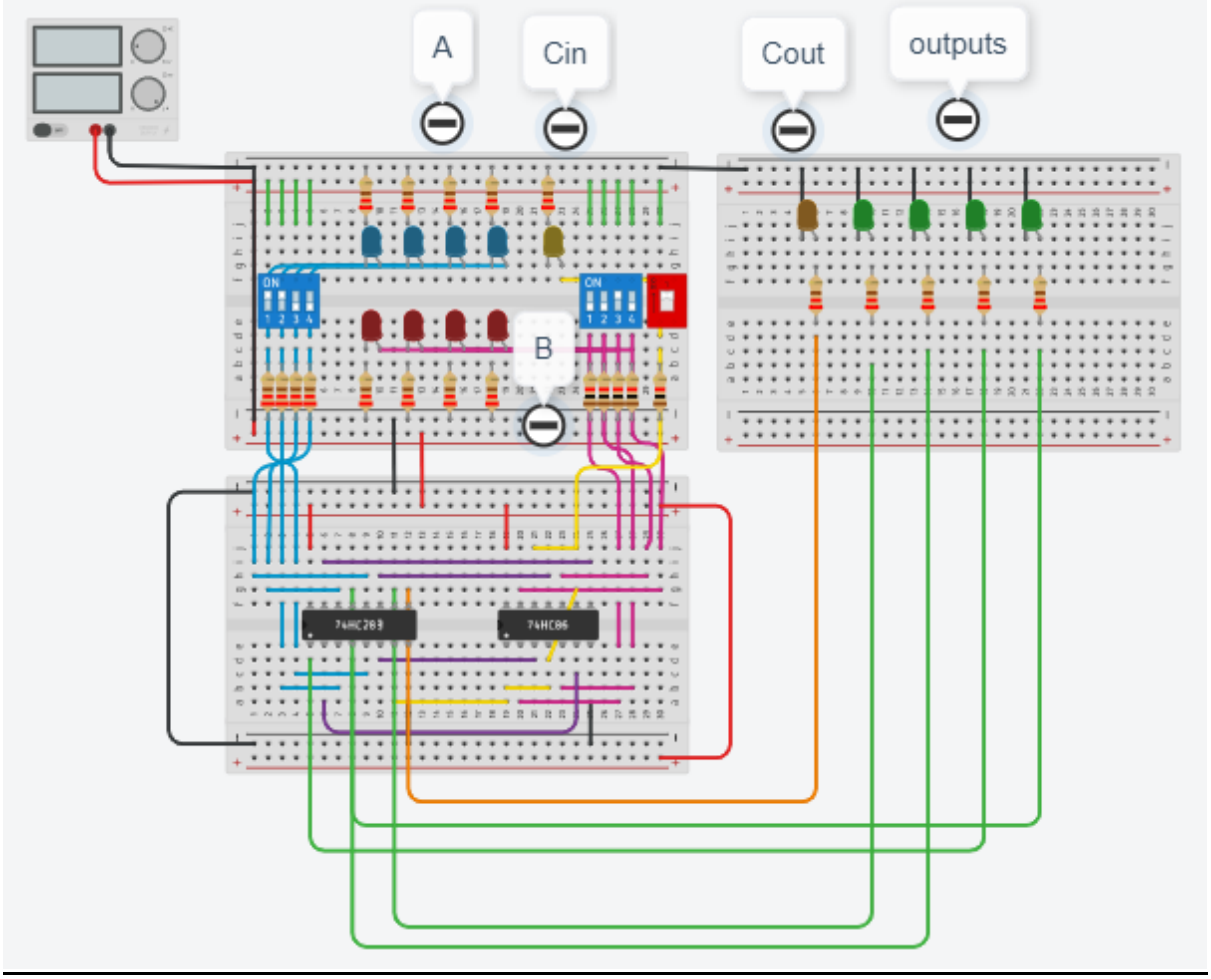


Circuit Diagram in Logisim



To operate as adder, make Cin = 0 while for subtract change Cin=1. For subtract operation, Cout=1 means it is positive number while Cout=0 means it is negative number. Take in mind that if the answer is negative than we have to make the 2's complement of the answer in order to get the real one.

Design Verification



Example of Summation Result

	A				B				Sum				Carry
Cin	A3	A2	A1	A0	B3	B2	B1	B0	S3	S2	S1	S0	Cout
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	1	0	0	1	0	0
0	0	0	1	0	0	0	1	0	0	1	0	0	0
0	0	0	1	1	0	0	1	1	0	1	1	0	0
0	0	1	0	0	0	1	0	0	1	0	0	0	0
0	0	1	0	1	0	1	0	1	1	0	1	0	0
0	0	1	1	0	0	1	1	0	1	1	0	0	0
0	0	1	1	1	0	1	1	1	1	1	1	0	0
0	1	0	0	0	1	0	0	0	0	0	0	0	1
0	1	0	0	1	1	0	0	1	0	0	1	0	1
0	1	0	1	0	1	0	1	0	0	1	0	0	1
0	1	0	1	1	1	0	1	1	0	1	1	0	1
0	1	1	0	0	1	1	0	0	1	0	0	0	1
0	1	1	0	1	1	1	0	1	1	0	1	0	1
0	1	1	1	0	1	1	1	0	1	1	0	0	1
0	1	1	1	1	1	1	1	1	1	1	1	0	1

How to read the output;

⇨ Cout S3 S2 S1 S0

How to read the output for Difference;

⇨ S3 S2 S1 S0

How to Calculate 2's Complement for a Binary Number;

First, find the one's complement by inverting 0s & 1s of a given binary number. Then, add 1 to the one's complement provides the two's complement.

For example of subtraction result, I don't make a table because it's a bit complicated as if its result in negative number, we need to convert to 2s complement to get the real value. But rest assured as I will show some example on how to do it in my video. I hope for your understanding madam, thank you.

Conclusion

This report discussed on an example of engineering design as applied in the digital logic design project. The design is known as logic gate calculator that specified on doing addition and subtraction of 4 bit binary number. The design is very beneficial as it helps the students to calculate the 4 bit number easier. This project can be used to measure students' understanding of the various digital logic design concepts such as logic gates and principles normally covered in the digital system and microprocessor course.

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