CIRCUIT SIMULATION PROJECT

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Title: Full Subtractor circuit using Full Adder Subcircuit

THEORY/DESCRIPTION:

In this project, Output Waveforms of Full Subtractor circuit using a Full Adder in eSim is analysed. A full subtractor is a combinational circuit that performs subtraction of two bits, one is minuend and other is subtrahend, taking into account borrow of the previous adjacent lower minuend bit.

This circuit has three inputs and two outputs. The three inputs A, B and Bin, denote the minuend, subtrahend, and previous borrow, respectively. The two outputs, D and Bout represent the difference and output borrow, respectively.

Bin is set when the previous digit is borrowed from A. Thus, Bin is also subtracted from A as well as the subtrahend B. Or in symbols: A-B-Bin.

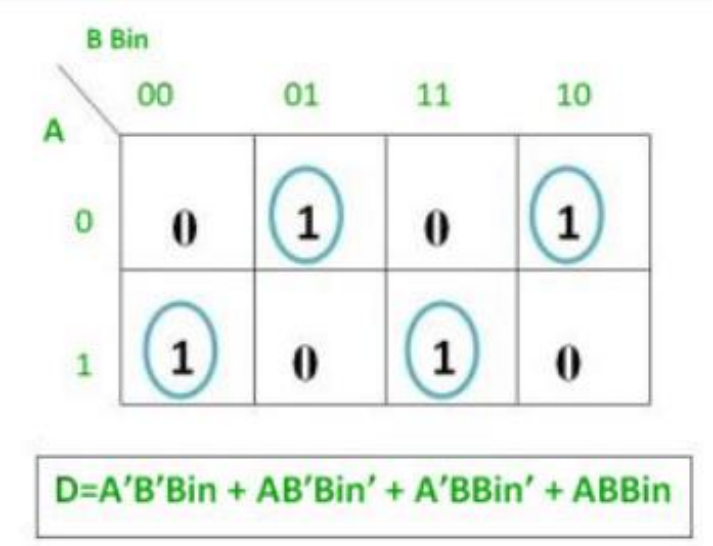
The full subtractor generates a borrow out when it needs to borrow from the next digit. Since we are subtracting B and Bin from A, a borrow out needs to be generated when A<B+Bin.

When a borrow out is generated, 2 is added in the current digit. (This is similar to the subtraction algorithm in decimal. Instead of adding 2, we add 10 when we borrow.) Therefore, D=A-B-Bin+2Bout.

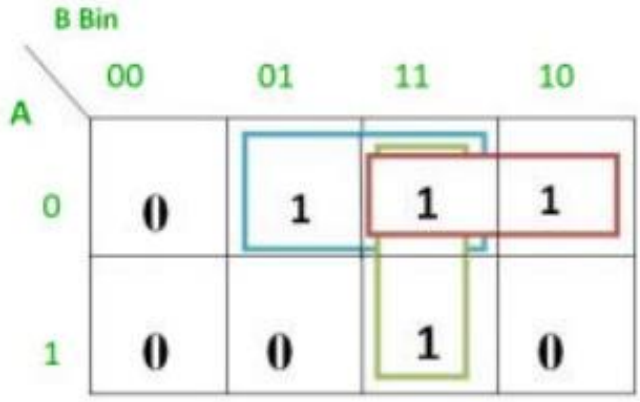
TRUTH TABLE:

INPUT			OUTPUT	
A	B	Bin	D	Bout
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
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

From above table we can draw the K-Map as shown for “difference” and “borrow”.



D=A’B’Bin + AB’Bin’ + A’BBin’ + ABBin



Bout=A’Bin + A’B + BBin

Logical expression for difference:

$D = A'B'B_{in} + AB'B_{in}' + A'BB_{in}' + ABB_{in}$

Some properties of exclusive 'or' ⊕ and exclusive 'nor' ⊙

$X \oplus Y = X'Y + XY' = Y \oplus X$ —— ①

$X \odot Y = XY + X'Y' = Y \odot X$ —— ②

$X \odot Y = X' \oplus Y = (X \oplus Y)'$ —— ③

$D = B_{in}'(AB' + A'B) + B_{in}(AB + A'B')$

$= B_{in}'(A \oplus B) + B_{in}(A \oplus B)'$

(using property 1; using property ② & ③)

$= (A \oplus B) \oplus B_{in}$ → using property ①

$= (A \odot B)' \oplus B_{in}$ → using property ③

$= ((A \odot B) \oplus B_{in})'$ → using property ③

$= ((A' \oplus B) \oplus B_{in})'$ → using property ③

Logical expression for borrow:

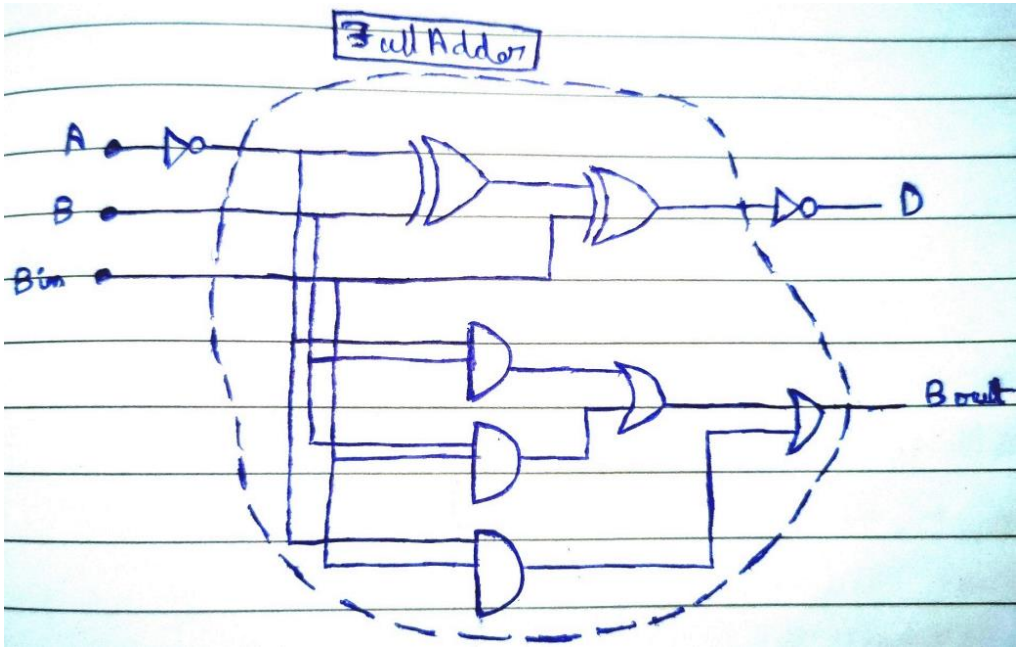
$B_{out} = A'B'B_{in} + A'BB_{in}' + A'BB_{in} + ABB_{in}$

$= A'B'B_{in} + A'BB_{in}' + A'BB_{in} + A'BB_{in} + A'BB_{in} + ABB_{in}$

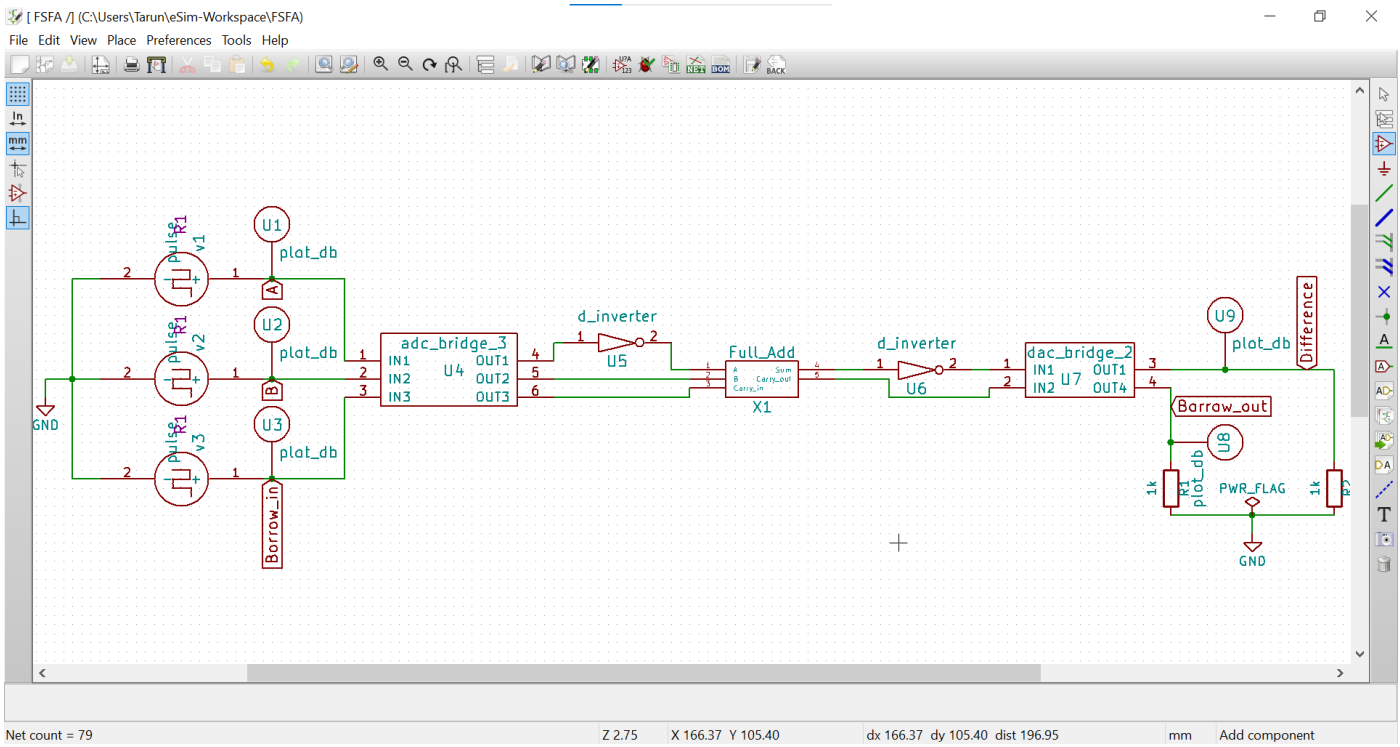
$= A'B_{in}(B + B') + A'B(B_{in} + B_{in}') + BB_{in}(A + A')$

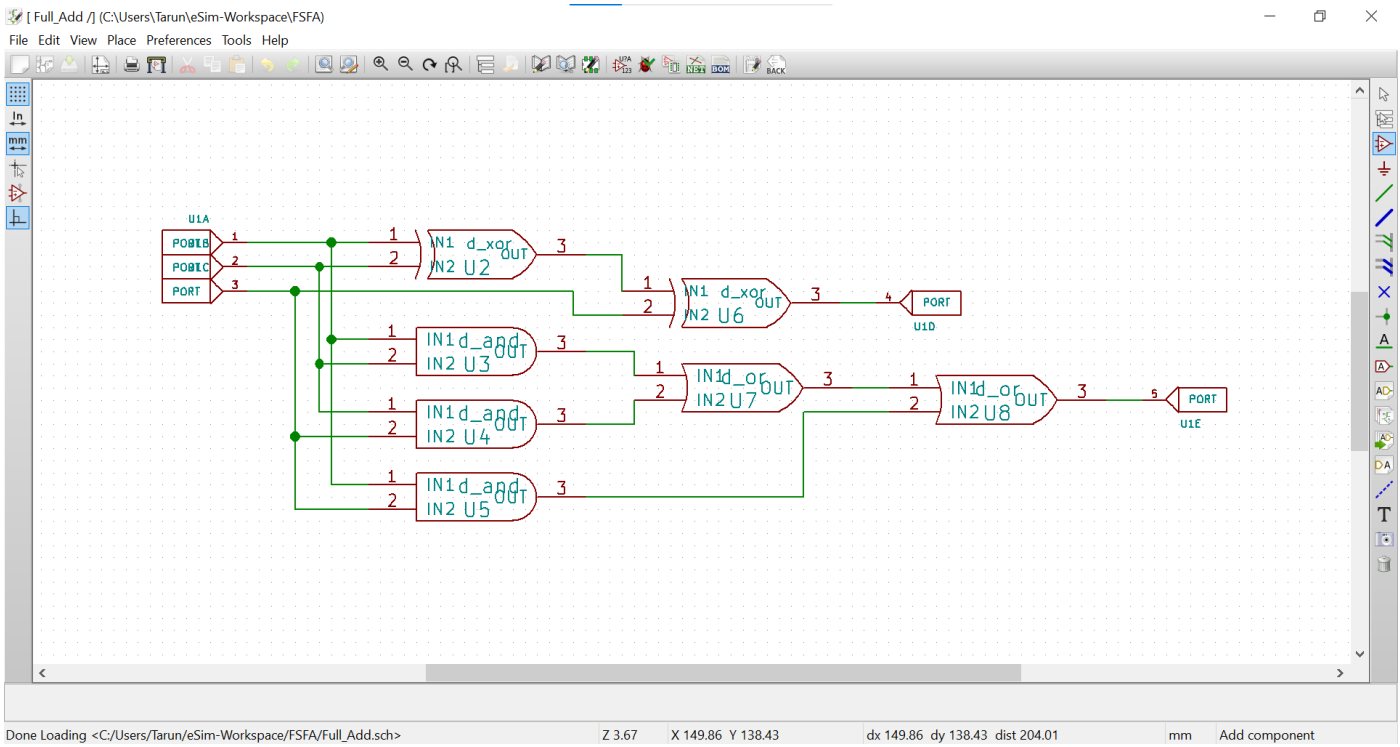
$= A'B_{in} + A'B + BB_{in}$

Model Circuit Diagram:



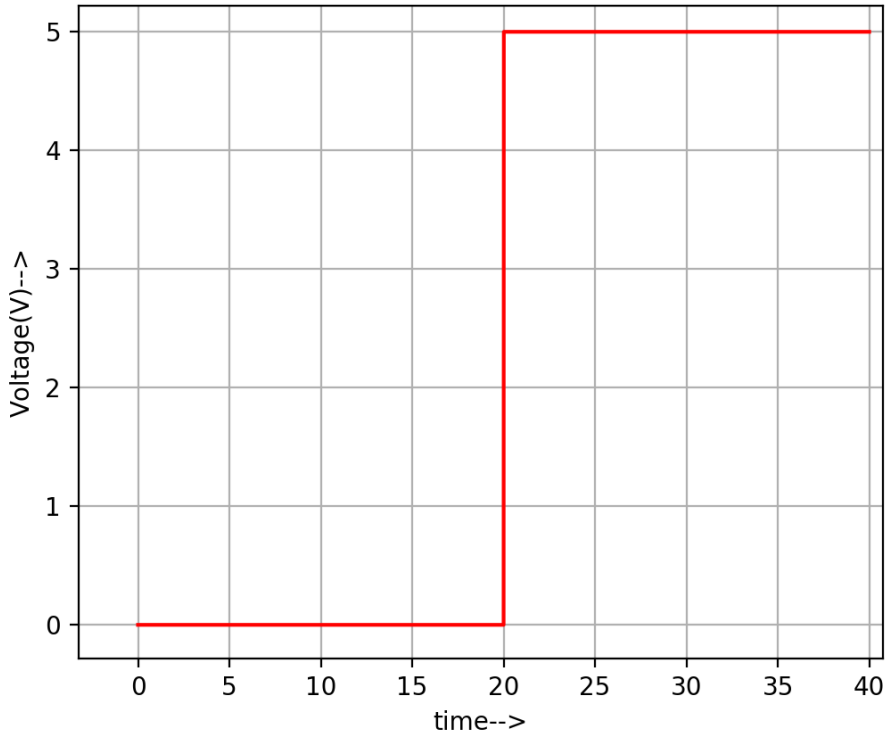
eSim Circuit Diagram:



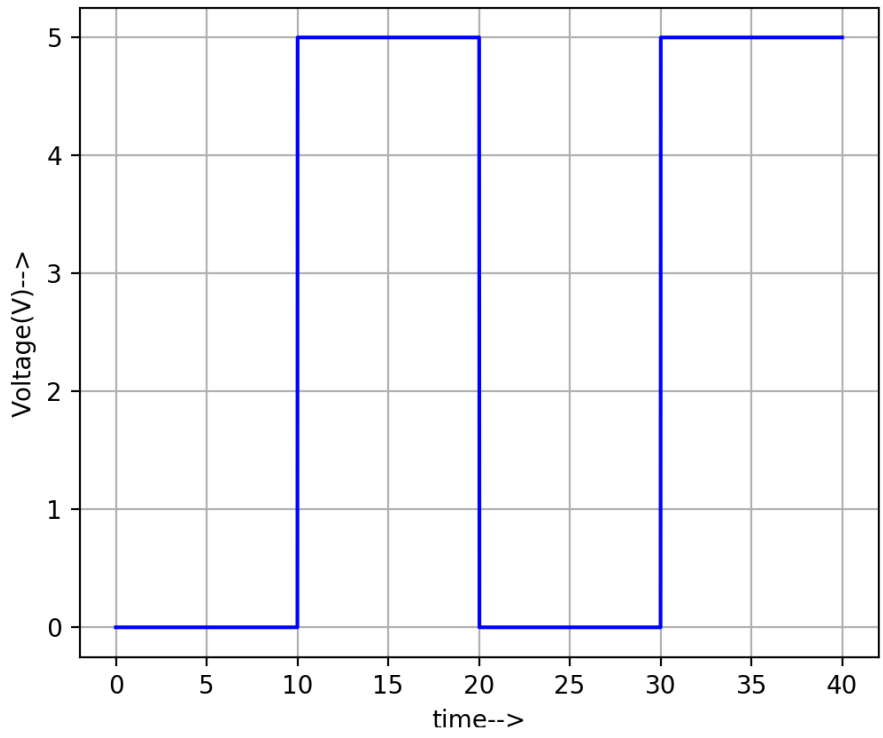


(Full Adder Subcircuit)

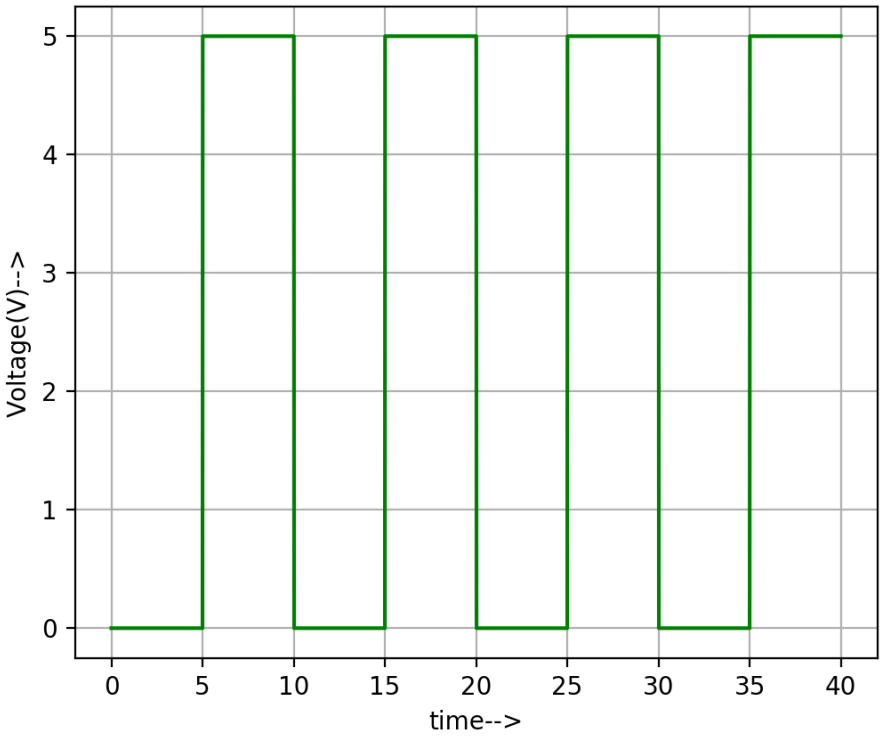
Waveforms (Input):



A

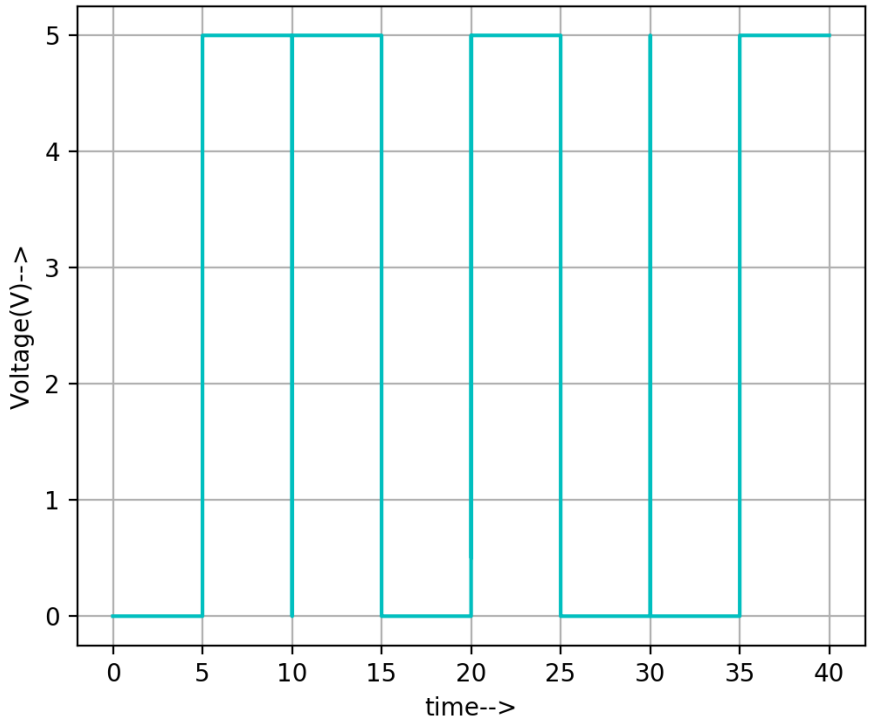


B

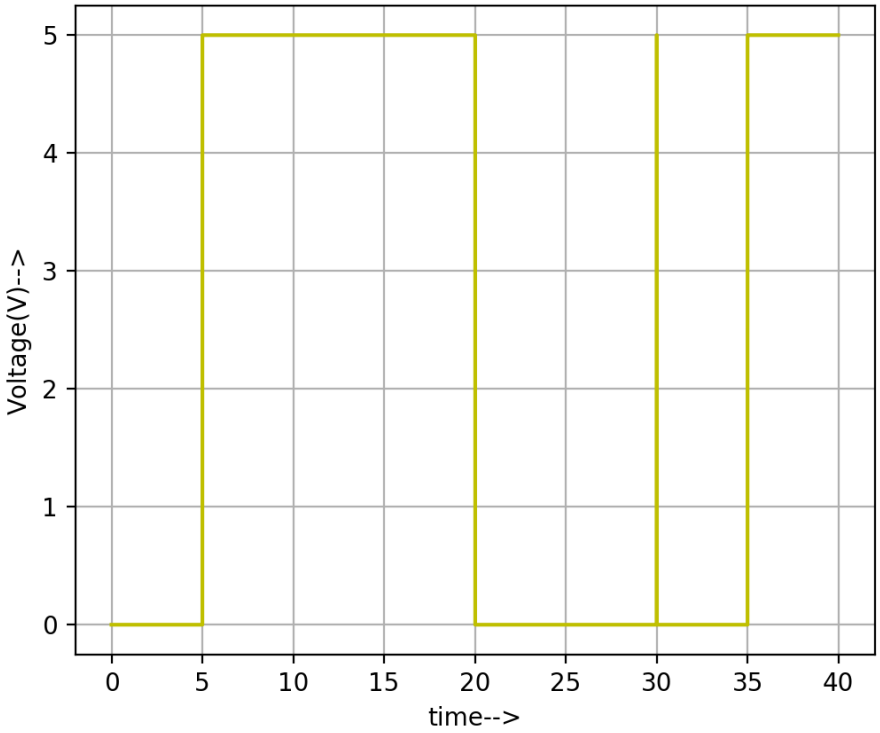


Borrow_in (Bin)

Waveforms (Output):



Difference (D)



Borrow_out (Bout)

Conclusion:

Hence, the analysis of Fall Subtractor using a Full Adder in eSim is studied and verified with the waveforms and truth table.

References:

https://en.wikipedia.org/wiki/Subtractor

https://www.geeksforgeeks.org/full-subtractor-in-digital-logic/