Project #4

SAT Solver and Implicit State Enumeration

ECE 582

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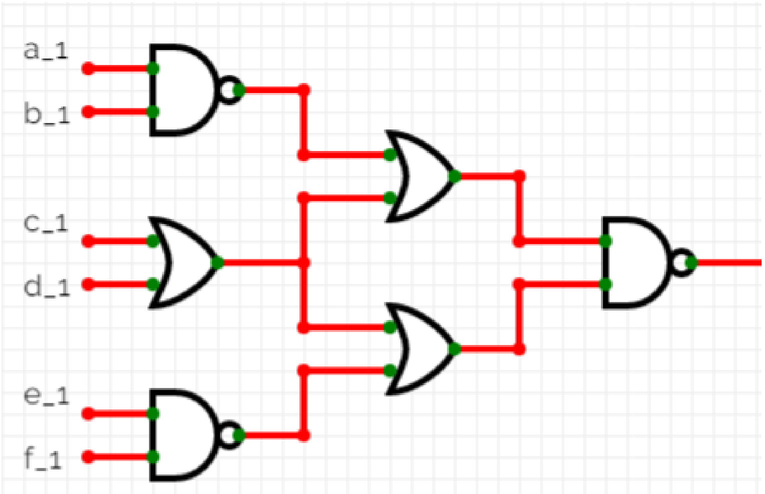
Task 1

Circuit C1

$a_1 b_1 \overline{c_1}\,\overline{d_1} + \overline{c_1}\,\overline{d_1} e_1 f_1$

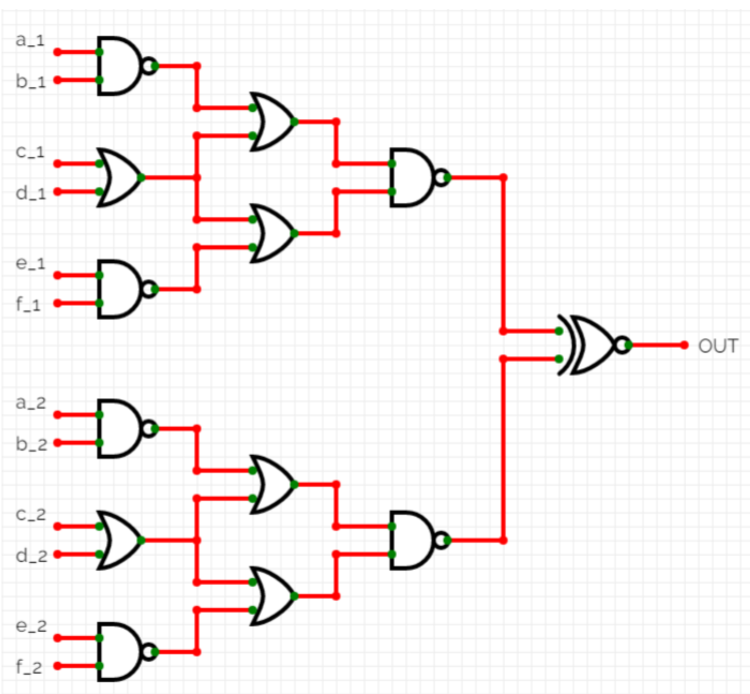


C1 and C2 Comparison

The equation for the equivalence digital circuit, C1 and C2 XORd using, (‘A+’B)(A+B)

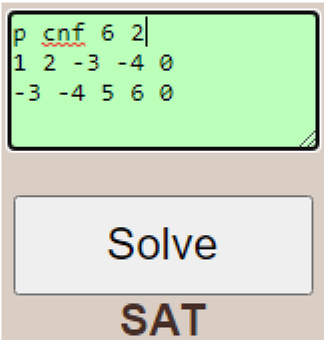
$(a_1 b_1 \overline{c_1}\,\overline{d_1} + \overline{c_1}\,\overline{d_1} e_1 f_1 + a_2 b_2 \overline{c_2}\,\overline{d_2} + \overline{c_2}\,\overline{d_2} e_2 f_2)$

$[(\overline{a_1} + \overline{b_1} + c_1 + d_1)(c_1 + d_1 + \overline{e_1} + \overline{f_1}) + (\overline{a_2} + \overline{b_2} + c_2 + d_2)(c_2 + d_2 + \overline{e_2} + \overline{f_2})]$

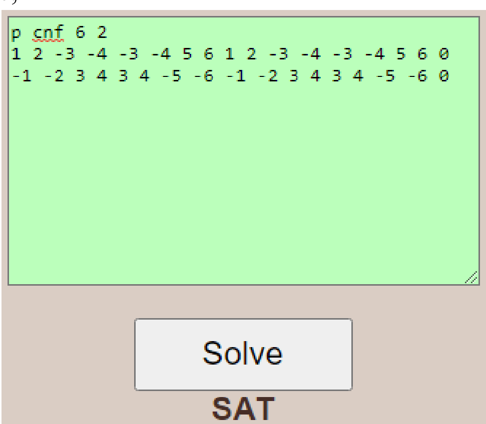


CNF

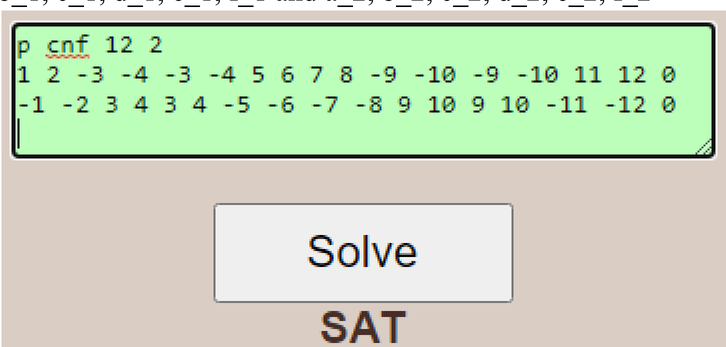
CNF for circuit C1



Comparing C1 and C2 where C1 = C2 for equivalence where the inputs are equal to each other. a, b, c, d, e, f



Comparing C1 and C2 where C1 = C2 for equivalence where the inputs are equivalent but unique: a_1, b_1, c_1, d_1, e_1, f_1 and a_2, b_2, c_2, d_2, e_2, f_2

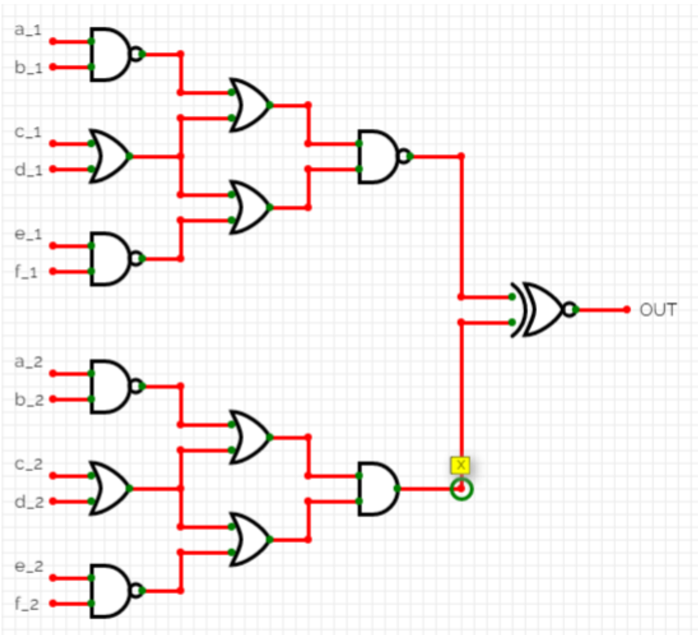


Task 2

Circuit C3

$$[(\overline{a_2}+\overline{b_2}+c_2+d_2)(c_2+d_2+\overline{e_2}+\overline{f_2})]$$

Comparing circuit C1 and C3



$$A+B=[(a_1b_1\overline{c_1}\overline{d_1}+\overline{c_1}\overline{d_1}e_1f_1)+(\overline{a_2}+\overline{b_2}+c_2+d_2)(c_2+d_2+\overline{e_2}+\overline{f_2})]$$

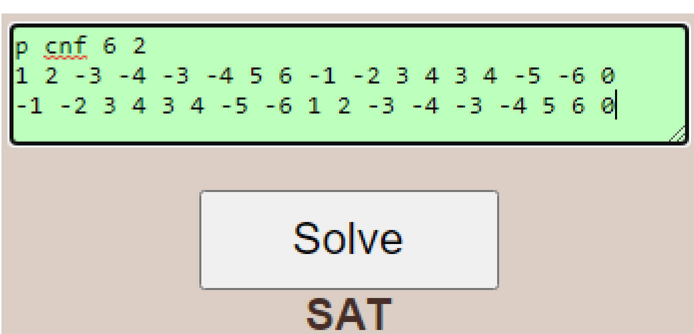
$$\overline{A}+\overline{B}=[(\overline{a_1}+\overline{b_1}+c_1+d_1)(c_1+d_1+\overline{e_1}+\overline{f_1})]+(a_2b_2\overline{c_2}\overline{d_2}+\overline{c_2}\overline{d_2}e_2f_2)$$

The equivalence is determined by:

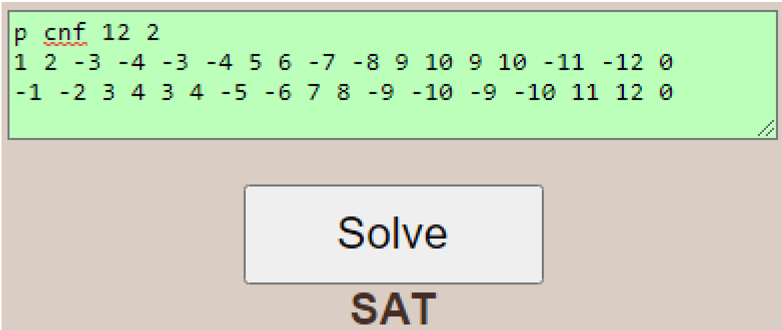
$$(A+B)(\overline{A}+\overline{B})$$

CNF

Using shared inputs for a, b, c, d, e, f for both C1 and C3 circuits is satisfiable.



Using 12 unique variables for C1 and C3 circuits is satisfiable.



Problem 2

From project #1, we have the following circuit to check for equivalence:

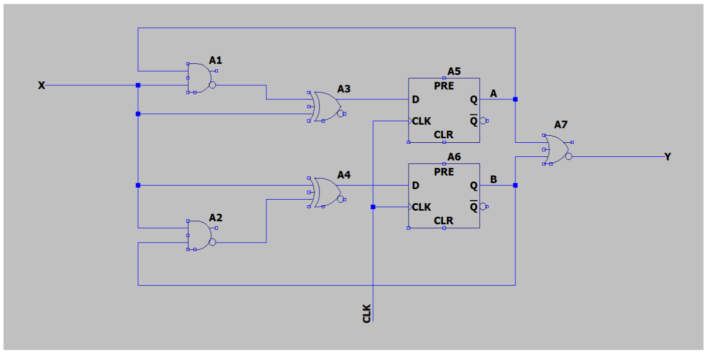


Figure 1: Sequential circuit S1

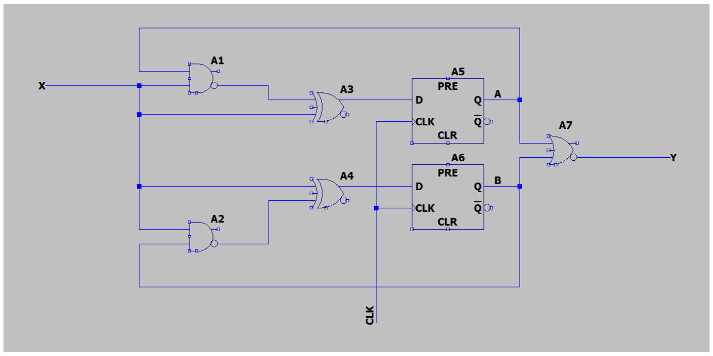


Figure 2: Sequential circuit S2

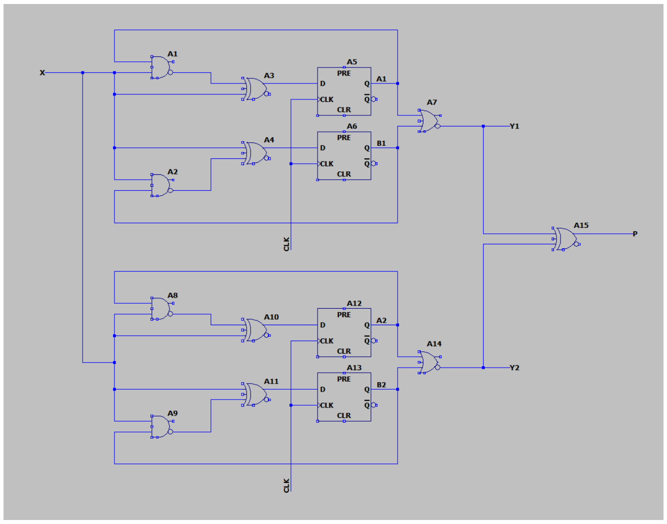


Figure 3: Product machine with the shared input

Implicit Equivalence Checking

a1, b1, a2, b2 – present state

a1’, b1’, a2’, b2’ – next state

S0 = !a1!b1!a2!b2

R1 = !x!a1!b1a1’b1’ + !x!a1b1a1’b1’ + !xa1!b1a1’b1’ + !xa1b1a1’b1’
+ x!a1!b1!a1’!b1’ + x!a1b1!a1’b1’ + xa1!b1a1’!b1’ + xa1b1a1’b1’

R2 = !x!a2!b2a2’b2’ + !x!a2b2a2’b2’ + !xa2!b2a2’b2’ + !xa2b2a2’b2’
+ x!a2!b2!a2’!b2’ + x!a2b2!a2’b2’ + xa2!b2a2’!b2’ + xa2b2a2’b2’

□x □a1 □b1 □a2 □b2 (S0 ^ R1 ^ R2)

= □x □a1 □b1 □a2 □b2 ((!a1!b1!a2!b2)
^ (!x!a1!b1a1’b1’ + !x!a1b1a1’b1’ + !xa1!b1a1’b1’ + !xa1b1a1’b1’
+ x!a1!b1!a1’!b1’ + x!a1b1!a1’b1’ + xa1!b1a1’!b1’ + xa1b1a1’b1’)
^ (!x!a2!b2a2’b2’ + !x!a2b2a2’b2’ + !xa2!b2a2’b2’ + !xa2b2a2’b2’
+ x!a2!b2!a2’!b2’ + x!a2b2!a2’b2’ + xa2!b2a2’!b2’ + xa2b2a2’b2’))

= !a1’!b1’!a2’!b2’ + a1’b1’a2’b2’

B = Rename (□x □a1 □b1 □a2 □b2 (S0 ^ R1 ^ R2)) = !a1!b1!a2!b2 + a1b1a2b2

Output: P = Y1 ⊕ Y2 = !(a1+b1) ⊕ !(a2+b2)

P ^ B = (!(a1+b1) ⊕ !(a2+b2))(!a1!b1!a2!b2 + a1b1a2b2) = 0 -> equivalence proved