

EE 709 : SAT Assignment

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1 Question 1(a)

- We can observe that the logic network represents the boolean function

$$K(A, B, C, D) = (A \cdot B \cdot C) \oplus (B \cdot C \cdot D) \quad (1)$$

We now apply few boolean theorems on this function to get K in the following (CNF) format

$$K = B \cdot C \cdot (A + D) \cdot (\bar{A} + \bar{D}) \quad (2)$$

We also express \bar{K} in its CNF by applying boolean theorems and obtain the following

$$\bar{K} = (\bar{A} + \bar{B} + \bar{C} + D) \cdot (A + \bar{B} + \bar{C} + \bar{D}) \quad (3)$$

2 Question 1(b)

- We need K to equal 0, so we apply SAT for \bar{K}
- Equation (3) was represented in `minisat` supported `.cnf` format as follows

```
c This is the expression for K = 0 for question 1 in the assignment
c Rohan Rajesh Kalbag, Roll: 20d170033
p cnf 4 2
-1 -2 -3 4 0
1 -2 -3 -4 0
```

- The following bash command was executed for it

```
minisat_static q1b.cnf q1b.result > q1b.txt
```

- The expression was **SAT** and the solution obtained was $(A, B, C, D) \equiv (F, F, F, F)$

3 Question 1(c)

- We need K to equal 1, so we apply SAT for K
- Equation (3) was represented in minisat supported .cnf format as follows

```
c This is the expression for K = 1 for question 1 in the assignment
c Rohan Rajesh Kalbag Roll: 20d170033
p cnf 4 4
2 0
3 0
1 4 0
-1 -4 0
```

- The following bash command was executed for it

```
minisat_static q1c.cnf q1c.result > q1c.txt
```

- The expression was **SAT** and the solution obtained was $(A, B, C, D) \equiv (F, T, T, T)$

4 Question 2

- The sequential circuit was unrolled four times as can be seen in the subsequent two pages.
- We denote each time-step as t and the corresponding of input given to X at $0 \leq t \leq 3$ as x_t starting with the initial condition that all the four D flip-flops have 1
- On seeing the $t = 3$ diagram in the following two pages, we need the inputs to all D flip-flops to be 0, for it to achieve the state $(0, 0, 0, 0)$ i.e

$$x_0 = 0 \quad (4)$$

$$x_1 \oplus \bar{x}_0 = 0 \quad (5)$$

$$x_2 \oplus (x_1 \iff \bar{x}_0) = 0 \quad (6)$$

$$x_3 \oplus (x_2 \iff (x_1 \iff \bar{x}_0)) = 0 \quad (7)$$

- Which can be captured by the following CNF by cascading all conditions with \cdot operations

$$\bar{x}_0 \cdot (x_1 \iff \bar{x}_0) \cdot (x_2 \iff (x_1 \iff \bar{x}_0)) \cdot (x_3 \iff (x_2 \iff (x_1 \iff \bar{x}_0))) \quad (8)$$

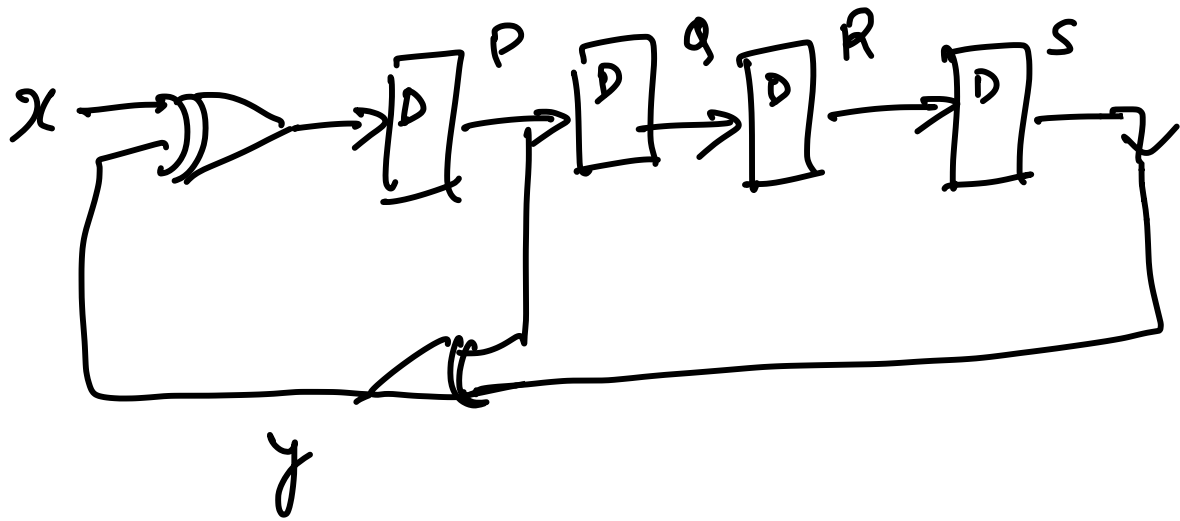
- Since we can notice that some of the terms are repeating inside this SAT expression, so we can simplify it as follows

$$\bar{x}_0 \cdot (x_1 \oplus x_1) \cdot (x_2 \iff 1) \cdot (x_3 \iff 1) \quad (9)$$

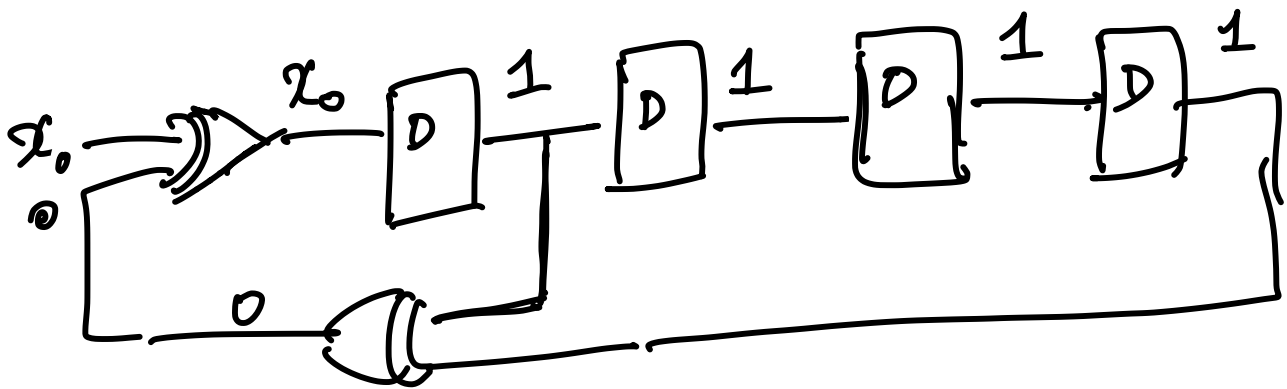
- The final CNF that we will use is

$$\bar{x}_0 \cdot (x_1 \cdot \bar{x}_0 + \bar{x}_1 \cdot x_0) \cdot x_2 \cdot x_3 \quad (10)$$

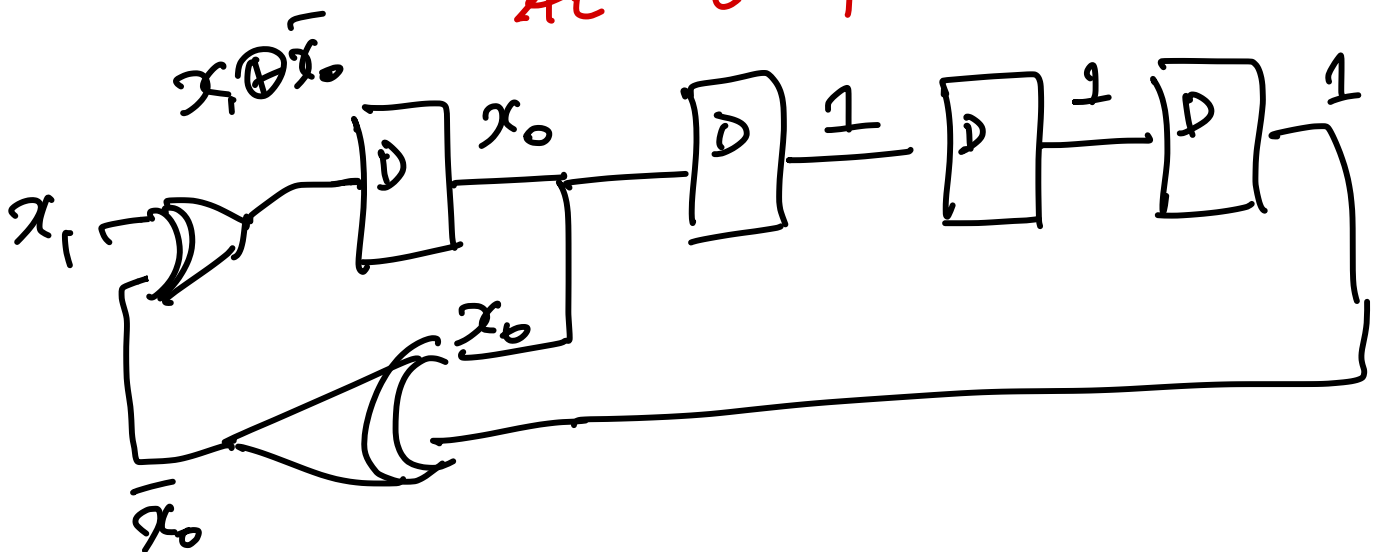
Original Sequential CKT



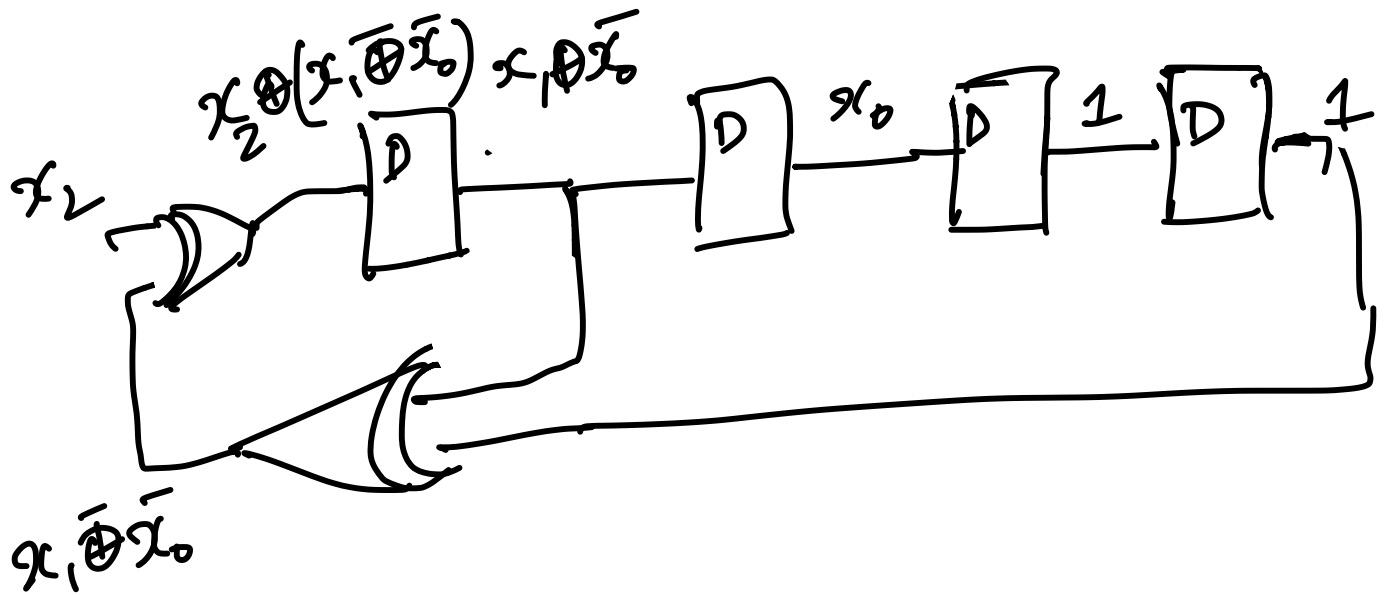
At $t=0$



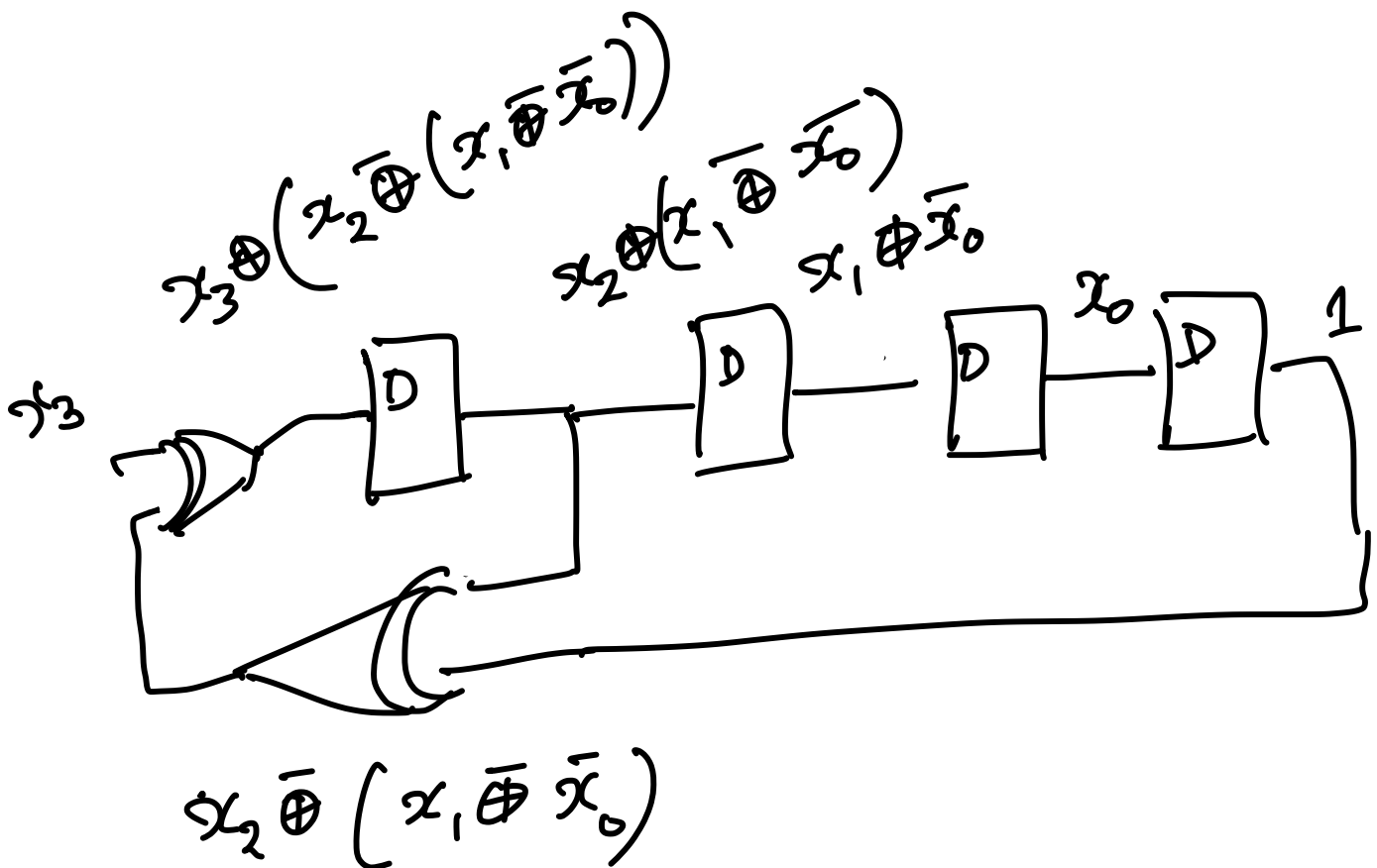
At $t=1$



At $t=2$



At $t=3$



- Equation (10) was represented in `minisat` supported `.cnf` format as follows

```
c This is the expression for question 2 in the assignment
c Rohan Rajesh Kalbag Roll: 20d170033
p cnf 4 5
-1 0
1 2 0
-1 -2 0
3 0
4 0
```

- The following bash command was executed for it

```
minisat_static q2.cnf q2.result > q2.txt
```

- The expression was **SAT** and the solution obtained was $(x_0, x_1, x_2, x_3) \equiv (F, T, T, T)$
- This the inputs to be given to X is the sequence (F, T, T, T) , inputted at each clock event.

5 Submission

The submission contains the following files in the `.zip` file. The `.pdf` report file, `commands.sh` with the bash commands run, `file.cnf` files used for `minisat`, `file.result` files with SAT outputs and the logs generated while execution `file.txt`, where `file` can take the values $\{q1a, q1b, q2\}$.