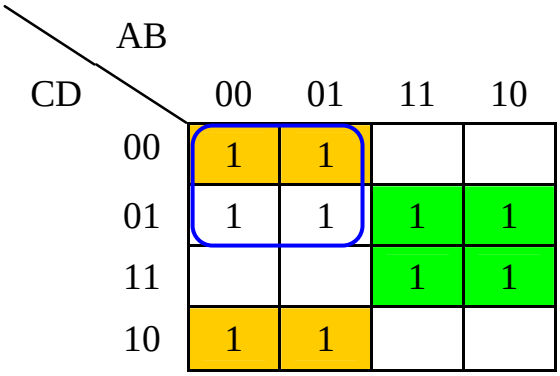
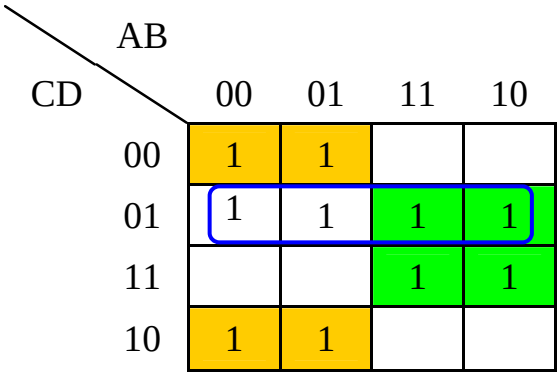
ECEn/CS 224
Chapter 18 Homework Solutions

18.1 Plot the following function on a KMap and identify a minimum POS solution for it. Then, solve it a second time using hazard-free minimization. Show your work.

F(A,B,C,D) = m0 + m1 + m2 + m4 + m5 + m6 + m9 + m11 + m13 + m15

The there are two minimum POS solutions to this minterm expansion. These two minimum solutions are shown in the K-maps below.

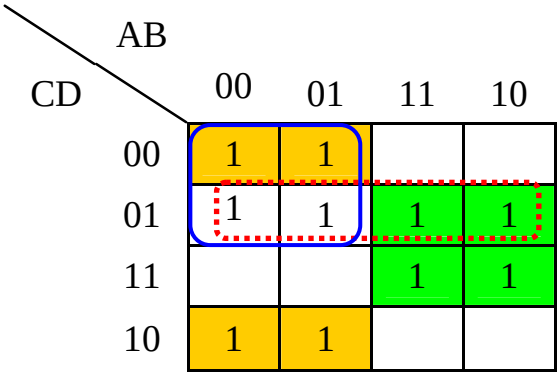


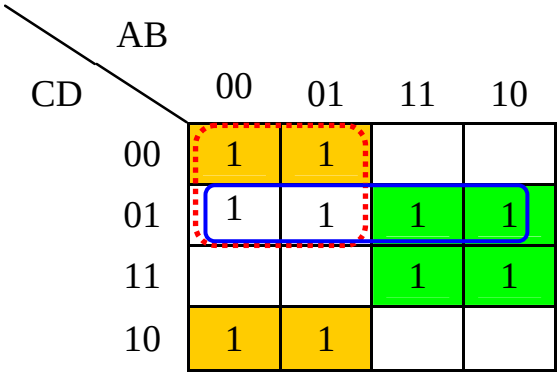


$F_1(A,B,C,D) = A'D' + AD + A'C'$

$F_2(A,B,C,D) = A'D' + AD + C'D$

To make either of these hazard free, we must add redundant prime implicants such that all adjacent 1s in the K-map are covered by an implicant. We will mark the redundant implicants we add with red, dashed boxes.





$F_1(A,B,C,D) = A'D' + AD + A'C' + C'D$

$F_2(A,B,C,D) = A'D' + AD + C'D + A'C'$

In this example, either minimum solution leads to the same hazard-free minimization:

F(A,B,C,D) = A'D' + AD + A'C' + C'D

18.2 Make a copy of the state graph of Figure 16.14. On it, list the asynchronous inputs. Circle the transitions dependent on those asynchronous inputs. Do any of these transitions depend on more than one asynchronous input? If so, redraw the state graph by adding additional states and transitions so that no transition is dependent on more than one asynchronous input.

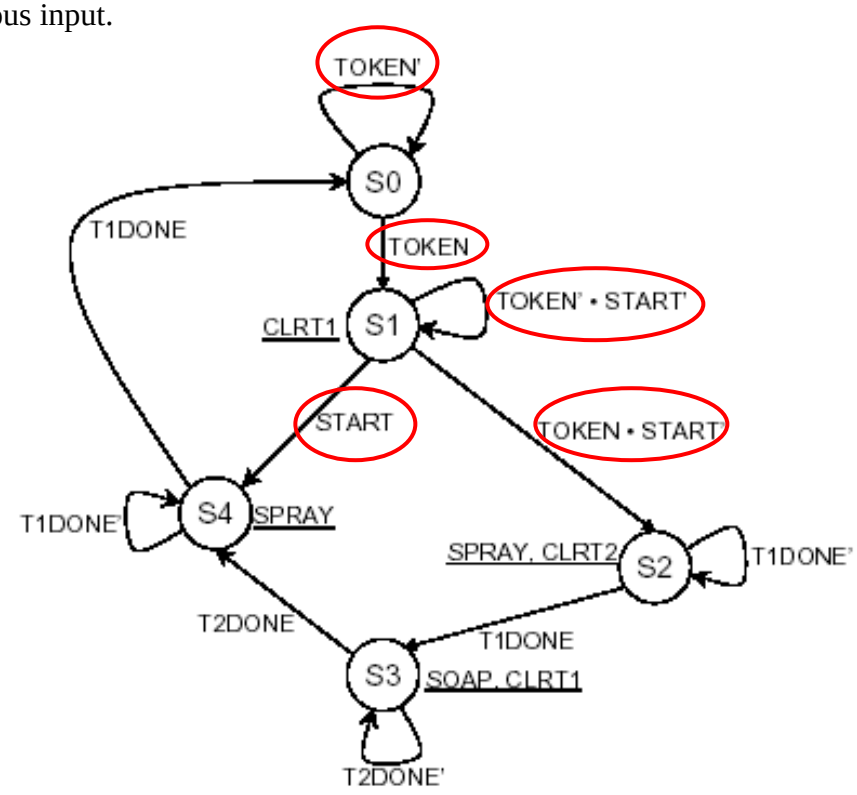
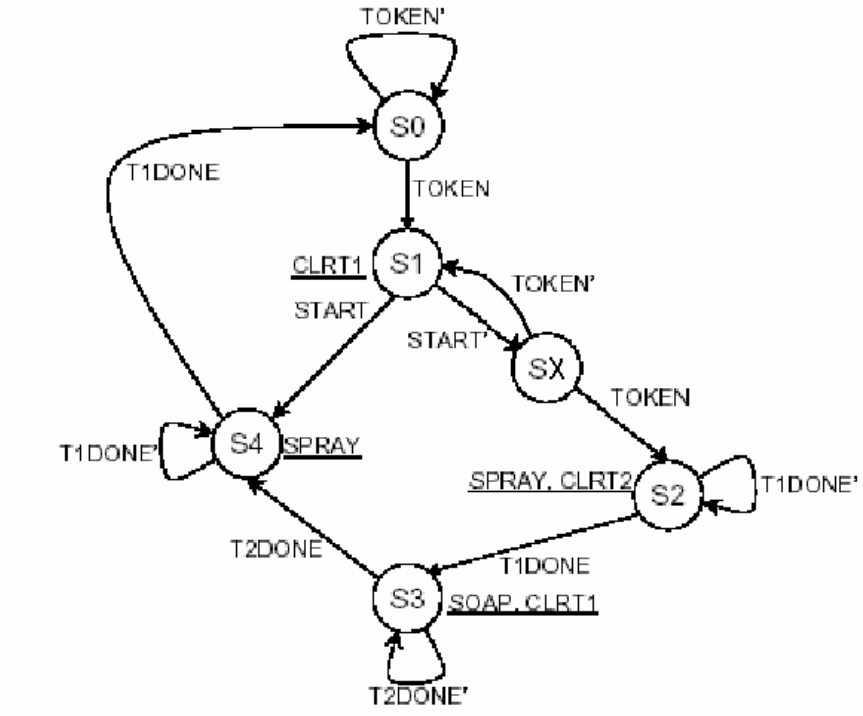
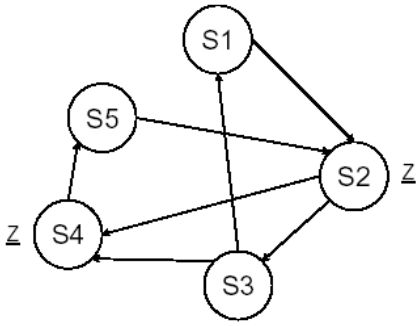


Figure 16.14: A Deluxe Car Wash Controller



18.4 Consider the FSM state graph shown below. No expressions have been shown for the transition conditions since they are not material to this problem. What is important is the set of state transitions and the Z output.



As can be seen, the Z output is asserted in both state **S2** and state **S4**. Further, it is desired that signal Z contain no false outputs on state transitions. Plot how you would assign state encodings using a KMap and explain the conditions required to avoid false outputs on signal Z. Then, list the state encoding chosen.

Below is a possible K-map for the Z output where we have labeled each position in the K-map with the state we have chosen for that value of $Q_2Q_1Q_0$.

Z Q_0 \ Q_2Q_1	00	01	11	10
0	S1 0	x	x	S2 1
1	S3 0	S5 0	x	S4 1

Note that the only states that have Q_2 being '1' are S2 and S4. Therefore, the Q_2 will only go high if we transition to S2 or S4. In either case, we want the Z output to go to "1". The Z output can therefore simply be:

$$Z = Q_2$$

Since no other states have Q_2 = '1', it will be impossible for Z to have a false transition. Even when moving between S2 and S4, there will not be a false transition because both minterms are covered by the same prime implicant. The final encoding is as follows:

S1 = 000
S2 = 100
S3 = 001
S4 = 101
S5 = 011