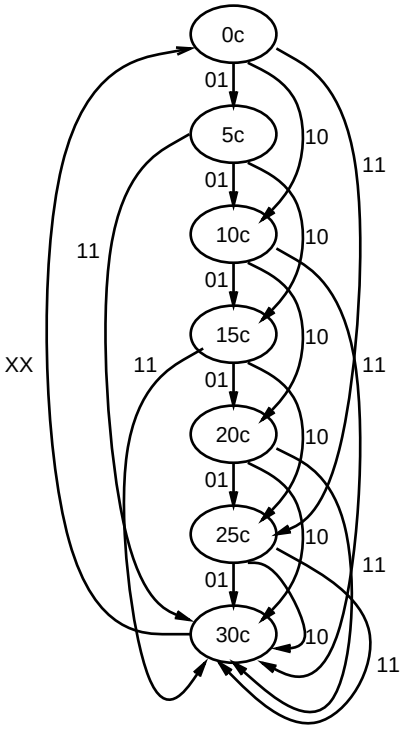
Solutions to Assignment 2

Question 1

The controller inputs are the coin detector outputs (labelled X and Y). The controller output is the candy release signal (labelled R). The seven states correspond to the possible sum of money deposited: 0, 5c, 10c, 15c, 20c, 25c, 30c which are encoded using three state variables (A, B, and C) as 000, 001, 010, 011, 100, 101, and 110. The state transition diagram is:



The tabular description of the state transitions is:

current state ABC	input conditions X	Y	next state $A'B'C'$
000	0	0	000
000	0	1	001
000	1	0	011
000	1	1	101
001	0	0	001
001	0	1	010
001	1	0	011
001	1	1	110
010	0	0	010
010	0	1	011
010	1	0	100
010	1	1	110
011	0	0	011
011	0	1	100
011	1	0	101
011	1	1	110
100	0	0	100
100	0	1	101
100	1	X	110
101	0	0	101
101	0	1	110
101	1	X	110
110	X	X	000

where X is a "don't care" condition.

The release is only turned on when the count of money reaches 30 cents. The tabular description of the outputs is:

state	R
0c	0
5c	0
10c	0
15c	0
20c	0
25c	0
30c	1

The next-state equations (not simplified) are:

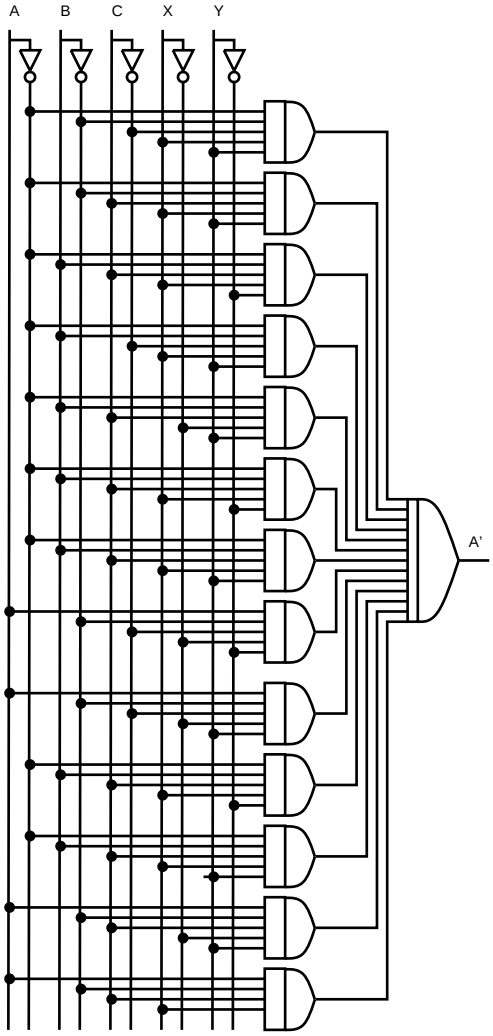
$A' = \overline{\mathrm{A}}\mathrm{BC}XY + \overline{\mathrm{A}}\mathrm{B}\overline{\mathrm{C}}XY + \overline{\mathrm{A}}B\overline{\mathrm{C}}X\overline{\mathrm{Y}} + \overline{\mathrm{A}}B\overline{\mathrm{C}}XY + \overline{\mathrm{A}}BC\overline{\mathrm{X}}Y + \overline{\mathrm{A}}BCX\overline{\mathrm{Y}} + \overline{\mathrm{A}}BCXY + A\overline{\mathrm{B}}\mathrm{C}\overline{\mathrm{X}}\overline{\mathrm{Y}} + A\overline{\mathrm{B}}\mathrm{C}\overline{\mathrm{X}}Y + A\overline{\mathrm{B}}\mathrm{C}X + A\overline{\mathrm{B}}C\overline{\mathrm{X}}\overline{\mathrm{Y}} + A\overline{\mathrm{B}}C\overline{\mathrm{X}}Y + A\overline{\mathrm{B}}CX$

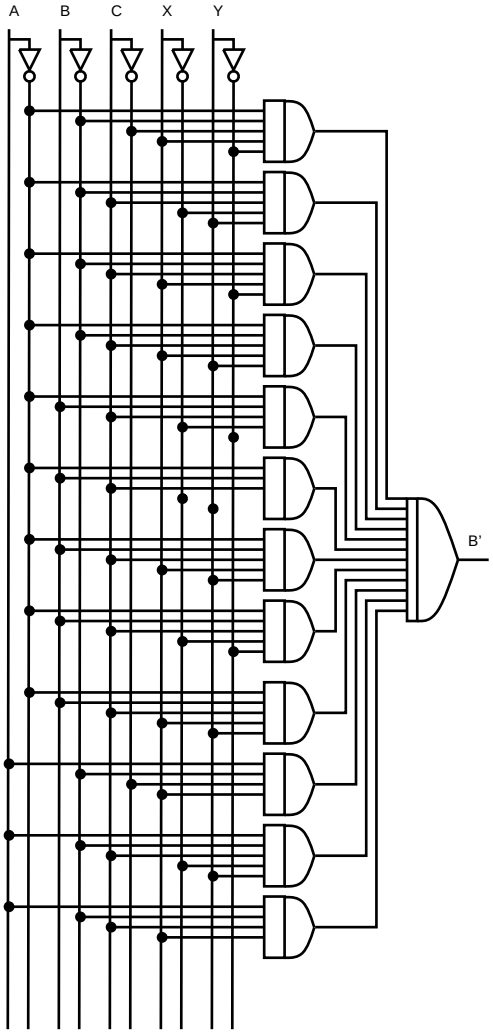
$$B' = \overline{\mathrm{A}}\overline{\mathrm{B}}\overline{\mathrm{C}}X\overline{\mathrm{Y}} + \overline{\mathrm{A}}\overline{\mathrm{B}}C\overline{\mathrm{X}}\overline{\mathrm{Y}} + \overline{\mathrm{A}}\overline{\mathrm{B}}CX\overline{\mathrm{Y}} + \overline{\mathrm{A}}\overline{\mathrm{B}}CXY + \overline{\mathrm{A}}B\overline{\mathrm{C}}\overline{\mathrm{X}}\overline{\mathrm{Y}} + \overline{\mathrm{A}}B\overline{\mathrm{C}}\overline{\mathrm{X}}Y + \overline{\mathrm{A}}B\overline{\mathrm{C}}XY + \overline{\mathrm{A}}BC\overline{\mathrm{X}}\overline{\mathrm{Y}} + \overline{\mathrm{A}}BCXY + A\overline{\mathrm{B}}\overline{\mathrm{C}}X + A\overline{\mathrm{B}}C\overline{\mathrm{X}}Y + A\overline{\mathrm{B}}CX$$

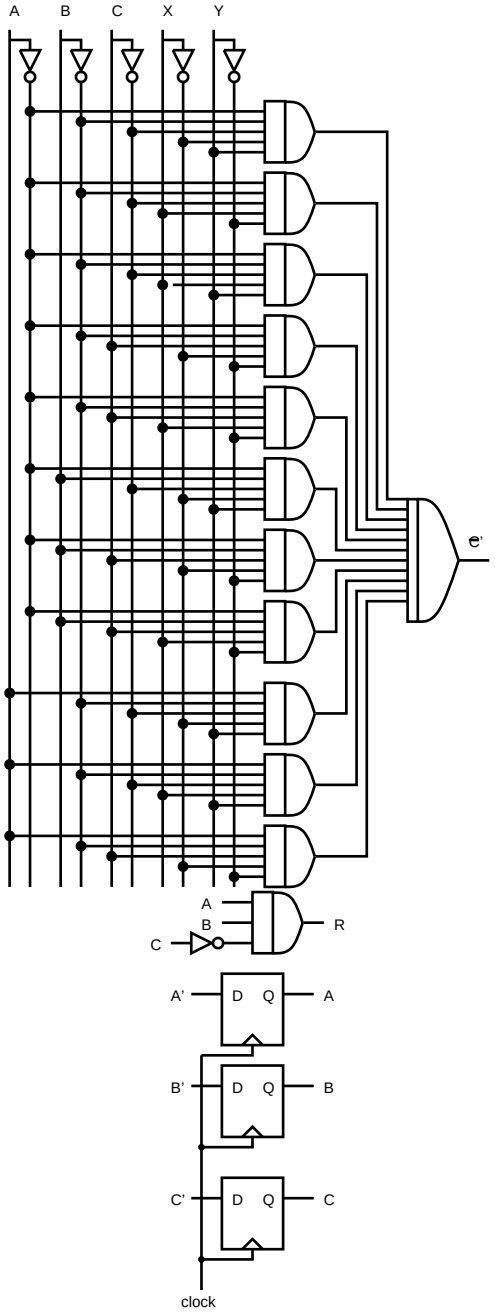
$$C' = \overline{\mathrm{A}}\overline{\mathrm{B}}\overline{\mathrm{C}}\overline{\mathrm{X}}Y + \overline{\mathrm{A}}\overline{\mathrm{B}}\overline{\mathrm{C}}X\overline{\mathrm{Y}} + \overline{\mathrm{A}}\overline{\mathrm{B}}\overline{\mathrm{C}}XY + \overline{\mathrm{A}}\overline{\mathrm{B}}C\overline{\mathrm{X}}\overline{\mathrm{Y}} + \overline{\mathrm{A}}\overline{\mathrm{B}}CX\overline{\mathrm{Y}} + \overline{\mathrm{A}}B\overline{\mathrm{C}}\overline{\mathrm{X}}Y + \overline{\mathrm{A}}BC\overline{\mathrm{X}}\overline{\mathrm{Y}} + \overline{\mathrm{A}}BCX\overline{\mathrm{Y}} + A\overline{\mathrm{B}}\overline{\mathrm{C}}\overline{\mathrm{X}}Y + A\overline{\mathrm{B}}C\overline{\mathrm{X}}\overline{\mathrm{Y}}$$

$$R = AB\overline{\mathrm{C}}$$

Schematic diagrams of the controller implemented directly from the sum-of-products expressions are given below:



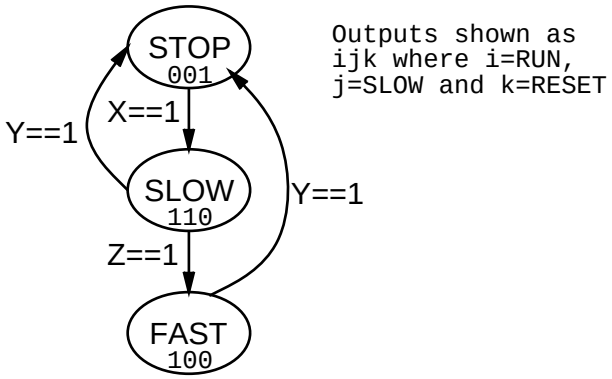




In this particular design the candy release signal will be high (equal to one) for one clock period (1 ms).

Question 2

1. The state transition diagram showing the possible states, the values of the outputs for each state and the transition conditions is shown below:



2. The outputs for each state are:

state	RUN	SLOW	RESET
STOP (00)	0	0	1
SLOW (11)	1	1	0
FAST (10)	1	0	0

where the values after each state name are the binary encodings of the state using two state variables, *A* and *B*.

3. A tabular description of the state transition diagram is as follows:

current state	input conditions			next state
	X	Y	Z	
STOP (00)	0	X	X	STOP (00)
STOP (00)	1	X	X	SLOW (11)
SLOW (11)	X	0	0	SLOW (11)
SLOW (11)	X	0	1	FAST (10)
SLOW (11)	X	1	X	STOP (00)
FAST (10)	X	1	X	STOP (00)

4. The sum-of-products boolean expressions for each output signal and for the signal giving the next state are:

$$RUN = A$$

$$SLOW = B$$

$$RESET = \overline{\mathrm{AB}}$$

$$A' = \overline{\mathrm{AB}}X + AB\overline{\mathrm{Y}}$$

$$B' = \overline{\mathrm{AB}}X + AB\overline{\mathrm{YZ}}$$

5. a schematic diagram for the controller is: