CSci 2021, Spring 2015
Homework Assignment V: Solutions

Problem 0: (1 point)

Should have been easy.

Problem 1:

$f_1 =$ `(b ^ (a & c)) & (a | c)`

a	b	c	`a & c`	`b ^ (a&c)`	`a | c`	f_1
0	0	0	0	0	0	0
0	0	1	0	0	1	0
0	1	0	0	1	0	0
0	1	1	0	1	1	1
1	0	0	0	0	1	0
1	0	1	1	1	1	1
1	1	0	0	1	1	1
1	1	1	1	0	1	0

$f_2 =$ `((a & b) ^ c) & (b | (a ^ b))`

a	b	c	`a & b`	`(a&b) ^ c`	`a ^ b`	`b | (a^b)`	f_2
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0
0	1	0	0	0	1	1	0
0	1	1	0	1	1	1	1
1	0	0	0	0	1	1	0
1	0	1	0	1	1	1	1
1	1	0	1	1	0	1	1
1	1	1	1	0	0	1	0

Problem 2:

x_1x_0	y_1y_0	$z_3z_2z_1z_0$
00 (0)	00 (0)	0000 (0)
00 (0)	01 (1)	0000 (0)
00 (0)	10 (-2)	0000 (0)
00 (0)	11 (-1)	0000 (0)
01 (1)	00 (0)	0000 (0)
01 (1)	01 (1)	0001 (1)
01 (1)	10 (-2)	1110 (-2)
01 (1)	11 (-1)	1111 (-1)
10 (-2)	00 (0)	0000 (0)
10 (-2)	01 (1)	1110 (-2)
10 (-2)	10 (-2)	0100 (4)
10 (-2)	11 (-1)	0010 (2)
11 (-1)	00 (0)	0000 (0)
11 (-1)	01 (1)	1111 (-1)
11 (-1)	10 (-2)	0010 (2)
11 (-1)	11 (-1)	0001 (1)

z_0

y_1y_0 \ x_1x_0	00	01	11	10
00	0	0	0	0
01	0	1	1	0
11	0	1	1	0
10	0	0	0	0

$z_0 = x_0 \& y_0$

z_1

y_1y_0 \ x_1x_0	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	0	1	0	1
10	0	1	1	0

$z_1 = (x_1\&!y_1\&y_0)|(y_1\&!x_1\&x_0)|(y_0\&x_1\&!x_0)|(x_0\&y_1\&!y_0)$

z_2

y_1y_0 \ x_1x_0	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	0	1	0	0
10	0	1	0	1

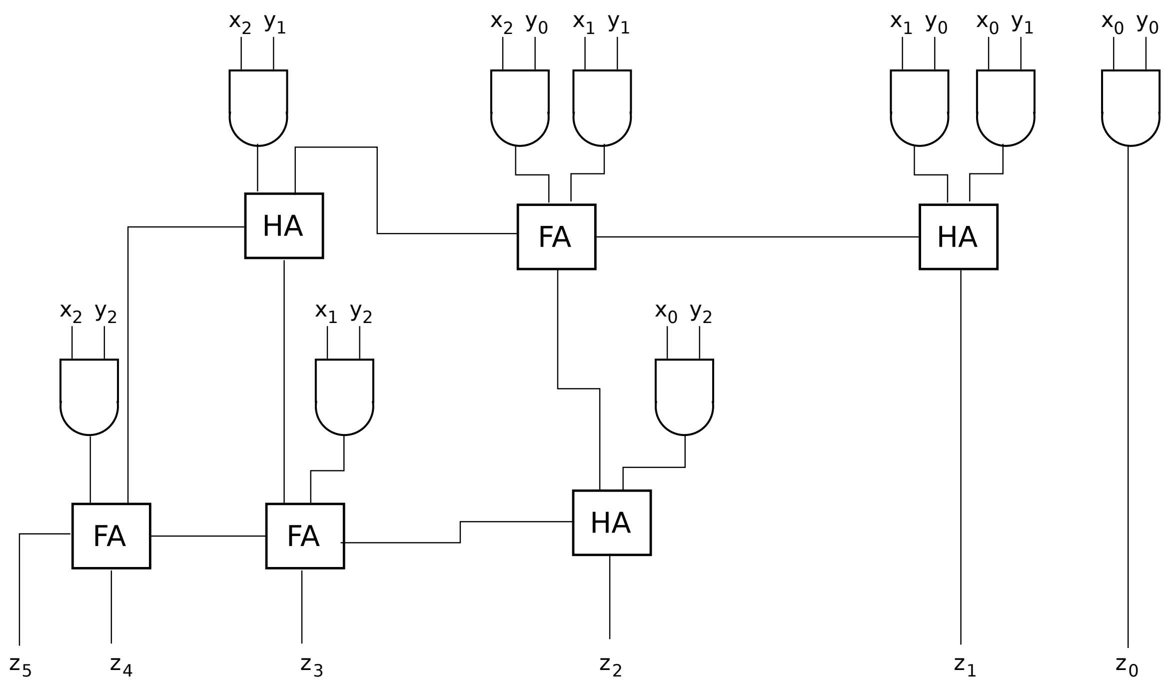
$z_2 = (x_1\&!y_1\&y_0)|(y_1\&!x_1\&x_0)|(x_1\&!x_0\&y_1\&!y_0)$

z_2

y_1y_0 \ x_1x_0	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	0	1	0	0
10	0	1	0	0

$z_3 = (x_1\&!y_1\&y_0)|(y_1\&!x_1\&x_0)$

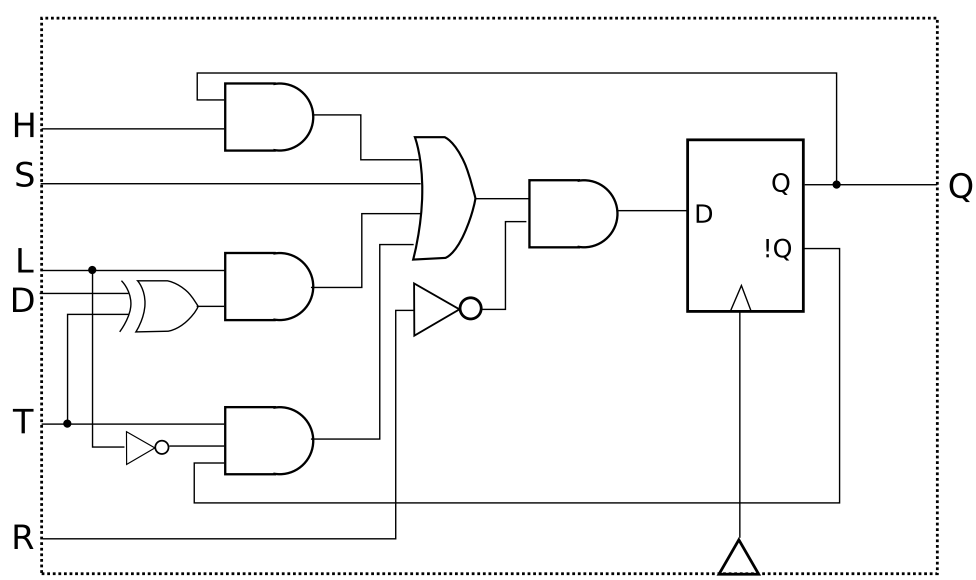
Problem 3:



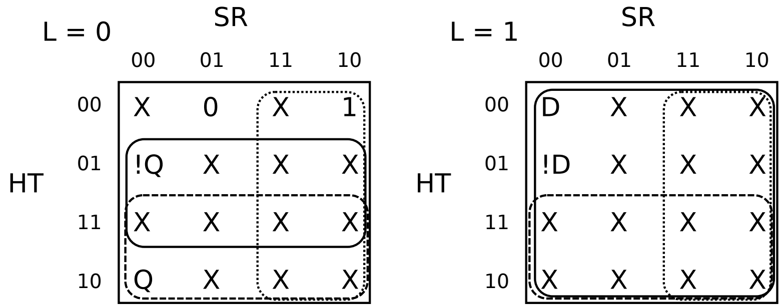
Problem 4:

a. One way of writing the update function for the HSRLTD flip-flop is:

$$Q^{+} = !R\&((H\&Q)|S|(L\&(D\hat{\ }T))|(T\&!L\&!Q))$$



This is not an ideal place to use a Karnaugh map, because if you include the 5 control signals plus D and Q, there are 7 inputs. But you could make a 5-input map based on just the control signals, by putting D and Q expressions in the map:

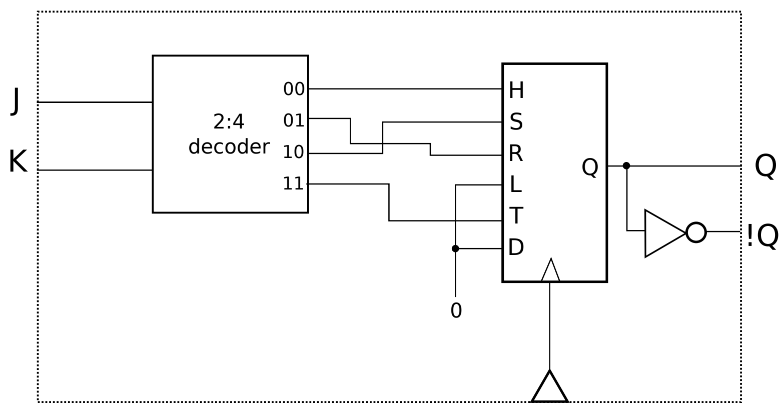


This gives the following alternative formula:

$$Q^{+} = (H\&Q)|S|(L\&(D\hat{\ }T))|(T\&!L\&!Q)$$

which shows that the R input is not actually needed.

b. The JK inputs 00, 01, 10, and 11 correspond to the HSRLTD signals H, R, S, and T respectively, so this a good job for a 2:4 decoder.



Problem 5:

a.

z_0

x_1x_0 \ x_3x_2	00	01	11	10
00	1	1	X	1
01	0	0	X	0
11	0	0	X	X
10	1	1	X	X

$z_0 = !x_0$

z_1

x_1x_0 \ x_3x_2	00	01	11	10
00	0	0	X	0
01	1	1	X	0
11	0	0	X	X
10	1	1	X	X

$z_1 = (!x_3\&!x_1\&x_0)|(x_1\&!x_0)$

z_2

x_1x_0 \ x_3x_2	00	01	11	10
00	0	1	X	0
01	0	1	X	0
11	1	0	X	X
10	0	1	X	X

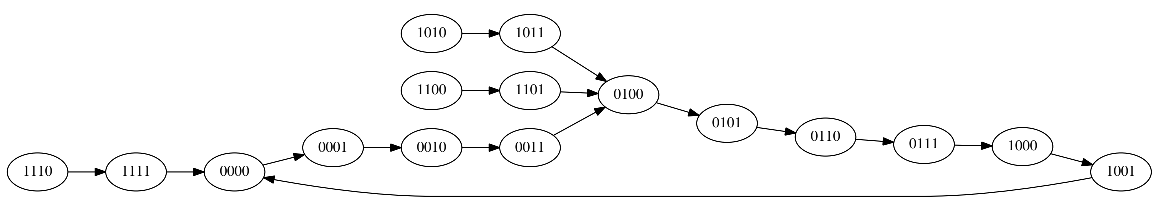
$z_2 = (x_2\&!x_1)|(!x_2\&x_1\&x_0)|(x_2\&x_1\&!x_0)$

z_3

x_1x_0 \ x_3x_2	00	01	11	10
00	0	0	X	1
01	0	0	X	0
11	0	1	X	X
10	0	0	X	X

$z_3 = (x_3\&!x_1)|(x_2\&x_1\&x_0)$

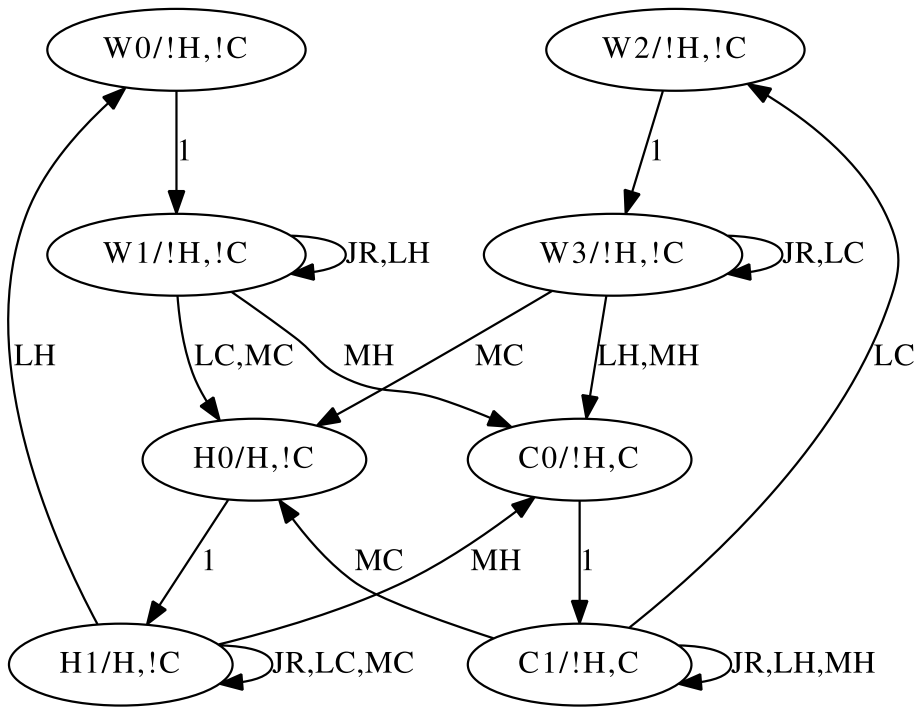
b.



Since every path leads to the main cycle, this design is self-starting.

Problem 6:

a.



b. State encoding and output:

State	Q_0	Q_1	Q_2	H	C
W_0	0	0	0	0	0
W_1	0	0	1	0	0
W_2	0	1	0	0	0
W_3	0	1	1	0	0
C_0	1	0	0	0	1
C_1	1	0	1	0	1
H_0	1	1	0	1	0
H_1	1	1	1	1	0

State transition function. Note that rows with a don't-care X in one of the T columns abbreviate a sequence of rows with the same output that differ only in those positions.

Label	Q_0	Q_1	Q_2	T_g	T_h	T_b	Q'_0	Q'_1	Q'_2
$W_0 \to W_1$	0	0	0	X	X	X	0	0	1
$W_1 \to H_0$	0	0	1	0	0	X	1	1	0
$W_1 \to W_1$	0	0	1	0	1	0	0	0	1
$W_1 \to C_0$	0	0	1	0	1	1	1	0	0
$W_1 \to W_1$	0	0	1	1	X	X	0	0	1
$W_2 \to W_3$	0	1	0	X	X	X	0	1	1
$W_3 \to W_3$	0	1	1	0	0	0	0	1	1
$W_3 \to H_0$	0	1	1	0	0	1	1	1	0
$W_3 \to C_0$	0	1	1	0	1	X	1	0	0
$W_3 \to W_3$	0	1	1	1	X	X	0	1	1
$C_0 \to C_1$	1	0	0	X	X	X	1	0	1
$C_1 \to W_2$	1	0	1	0	0	0	0	1	0
$C_1 \to H_0$	1	0	1	0	0	1	1	1	0
$C_1 \to C_1$	1	0	1	0	1	X	1	0	1
$C_1 \to C_1$	1	0	1	1	X	X	1	0	1
$H_0 \to H_1$	1	1	0	X	X	X	1	1	1
$H_1 \to H_1$	1	1	1	0	0	X	1	1	1
$H_1 \to W_0$	1	1	1	0	1	0	0	0	0
$H_1 \to C_0$	1	1	1	0	1	1	1	0	0
$H_1 \to H_1$	1	1	1	1	X	X	1	1	1