Unit 16

Sequential Circuit Design

Logic Circuits (Spring 2022)

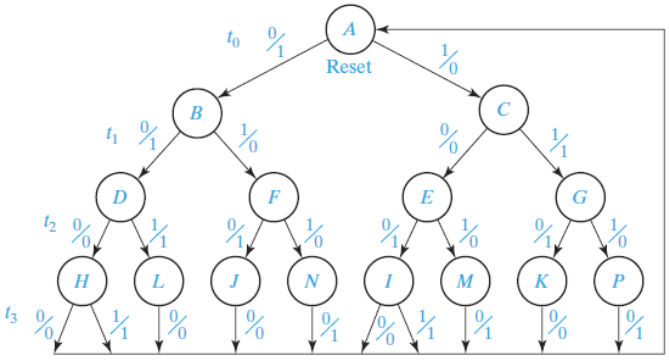
BCD to Excess-3 Code Converter

- Specification
  - Add three to a binary-coded-decimal digit in the range 0 to 9

X Input (BCD)				Z Output (excess-3)			
t_3	t_2	t_1	t_0	t_3	t_2	t_1	t_0
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0

BCD to Excess-3 Code Converter

- State diagram



BCD to Excess-3 Code Converter

- *State table*

Time	Input Sequence Received (Least Significant Bit First)	Present State	Next State $X=0$	Next State 1	Present Output (Z) $X=0$	Present Output (Z) 1
t_0	reset	*A*	*B*	*C*	1	0
t_1	0	*B*	*D*	*F*	1	0
	1	*C*	*E*	*G*	0	1
t_2	00	*D*	*H*	*L*	0	1
	01	*E*	*I*	*M*	1	0
	10	*F*	*J*	*N*	1	0
	11	*G*	*K*	*P*	1	0
t_3	000	*H*	*A*	*A*	0	1
	001	*I*	*A*	*A*	0	1
	010	*J*	*A*	–	0	–
	011	*K*	*A*	–	0	–
	100	*L*	*A*	–	0	–
	101	*M*	*A*	–	1	–
	110	*N*	*A*	–	1	–
	111	*P*	*A*	–	1	–

- *Reduced state table*

Time	Present State	Next State $X=0$	Next State 1	Present Output (Z) $X=0$	Present Output (Z) 1
t_0	*A*	*B*	*C*	1	0
t_1	*B*	*D*	*E*	1	0
	C	*E*	*E*	0	1
t_2	*D*	*H*	*H*	0	1
	E	*H*	*M*	1	0
t_3	*H*	*A*	*A*	0	1
	M	*A*	–	1	–

BCD to Excess-3 Code Converter

- Assignment map

Q_2Q_3 \ Q_1	0	1
00	A	B
01		C
11	H	D
10	M	E

- Transition table

		$Q_1^+Q_2^+Q_3^+$		Z	
	$Q_1Q_2Q_3$	$X=0$	$X=1$	$X=0$	$X=1$
A	0 0 0	1 0 0	1 0 1	1	0
B	1 0 0	1 1 1	1 1 0	1	0
C	1 0 1	1 1 0	1 1 0	0	1
D	1 1 1	0 1 1	0 1 1	0	1
E	1 1 0	0 1 1	0 1 0	1	0
H	0 1 1	0 0 0	0 0 0	0	1
M	0 1 0	0 0 0	x x x	1	x
–	0 0 1	x x x	x x x	x	x

BCD to Excess-3 Code Converter

- Next state and output maps

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	1	1
01	X	1	1	X
11	0	0	0	0
10	0	0	0	X

$D_1 = Q_1^+ = Q_2'$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	1	1	0
01	X	1	1	X
11	0	1	1	0
10	0	1	1	X

$D_2 = Q_2^+ = Q_1$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	1	0	1
01	X	0	0	X
11	0	1	1	0
10	0	1	0	X

$D_3 = Q_3^+ = Q_1Q_2Q_3 + X'Q_1Q_3' + XQ_1'Q_2'$

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	0	0
01	X	0	1	X
11	0	0	1	1
10	1	1	0	X

$Z = X'Q_3' + XQ_3$

BCD to Excess-3 Code Converter

- Logic diagram