COL215 Digital Logic and System Design   Quiz 3   08.11.2017

Q 1. Given below is the table showing timings in terms of pixel clocks for hsync and vsync synchronization signals for a 640-pixel by 480 row VGA display. Some entries are missing in the table. Derive the missing values from the rest of the data available in the question. Also find out what frequency of pixel clock will give a refresh rate of 60 Hz.

Symbol	Parameter	Vertical Sync		Horizontal Sync
		Clocks	Lines	Clocks
T_S	Sync pulse	A	B	C
T_{disp}	Display time	D	E	F
T_{pw}	Pulse width	1,600	2	96
T_{fp}	Front porch	8,000	10	16
T_{bp}	Back porch	23,200	29	48

Solution:

We need to fill values A, B, C, D, E and F in the table.

F = number of pixels per horizontal line = 640   ½ mark
E = number of horizontal lines per frame = 480

$T_S = T_{disp} + T_{pw} + T_{fp} + T_{bp}$

     Therefore, C = F + 96 + 16 + 48 = 800   ½ mark

     and   B = E + 2 + 10 + 29 = 521

D = E * clocks_per_line = E * C = 480 * 800 = 384,000   ½ mark
A = B * clocks_per_line = B * C = 521 * 800 = 416,800

For refresh rate of 60 Hz, pixel clock frequency = 60 * A = 60 * 416,800 = 25.008 MHz   ½ mark

Q 2. For a given completely specified FSM and two of its states P and Q, suppose the following two observations are known.
   (a) There is no input sequence of length 3 that produces different output with the FSM starting in state P or Q
   (b) There exists an input sequence of length 5 that produces different output with the FSM starting in state P or Q
What can you say about k-equivalence and k-distinguishability of P and Q for different values of k?

Solution:
   (a) P and Q are k-equivalent for all k less than or equal to 3.   ½ mark
   (b) P and Q are k-distinguishable for all k greater than or equal to 5.   ½ mark

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Q 3. Consider the Boolean function f = a b' + b'c' + b c + a'b . Using * operation of the Cubical technique, generate one more implicant that is not contained in any of the given implicants considered one at a time. Find out using # operation if inclusion of this new implicant makes any of the given implicants redundant.

Solution:

Cubical representation of the product terms -
Let W = a b' => 10x
　　X = b'c' => x00
　　Y = b c => x11
　　Z = a'b => 01x

W 10x	W 10x	W 10x	X x00	X x00	Y x11
X x00	Y x11	Z 01x	Y x11	Z 01x	Z 01x
* 100	* 1x1	* Φ	* Φ	* 0x0	* 011
contained in W,X	new, call it P			new, call it Q	contained in Y,Z

[1 mark: it is sufficient to find either P or Q]

We need to check if {P,X,Y,Z} covers W or {P,W,Y,Z} covers X or {P,W,X,Z} covers Y or {P,W,X,Y} covers Z.

Knowing from above that W and X do not intersect with Y and Z, we only need to check for redundancy within sets {P,W, X} and {P,Y,Z} .

W	10x	X	x00	Y	x11	Z	01x
P	1x1	P	1x1	P	1x1	P	1x1
W#P	100	X#P	x00	Y#P	011	Z#P	01x
X	x00	W	10x	Z	01x	Y	x11
(W#P)#X	Φ	(X#P)#W	000	(Y#P)#Z	Φ	(Z#P)#Y	010
	W is covered by{P,X}				Y is covered by{P,Z}		

This shows that inclusion of P makes W and Y redundant.

[1 mark: it is sufficient to find redundancy of either W or Y]

Alternative solution: we do similar analysis with Q

We only need to check for redundancy in sets {Q,W, X} and {Q,Y,Z} .

W	10x	X	x00	Y	x11	Z	01x
Q	0x0	Q	0x0	Q	0x0	Q	0x0
W#Q	10x	X#Q	100	Y#Q	x11	Z#Q	011
X	x00	W	10x	Z	01x	Y	x11
(W#Q)#X	101	(X#Q)#W	Φ	(Y#Q)#Z	111	(Z#Q)#Y	Φ
			X is covered by{Q,W}				Z is covered by{Q,Y}

This shows that inclusion of Q makes X and Z redundant.