



**Faculty of Engineering & Technology
Electrical & Computer Engineering Department**

**Advanced Digital Design ENCS3310
Asynchronous Circuits - Worksheet**

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Section: 2

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Work in groups (up to 3 students) to answer the following questions. Submission Deadline is Thursday 13/10/2022 till midnight (No late Submission is accepted). Expected time to finish the worksheet is 60 minutes. Only one student in the group to submit the solution (but should write all the names and IDs in the message body and in the attachment)

1) An OR-AND 2-level implementation circuit for $F(a,b,c) = (a+b) \cdot (a'+c')$

i) Determine if this circuit suffers from Hazard? and at which values?

ii) Draw the Hazard Free OR-AND 2-level implementation.

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i) $F(a,b,c) = (a+b) \cdot (a'+c')$

a \ bc	00	01	11	10
0	0	0	1	1
1	1	0	0	1

Labels below the table: $a+b$ (under 00, 01, 10), $b+c$ (under 01, 11), $a'+c'$ (under 01, 10). A red box highlights the 01 column, and a red arrow points from the 01 column to the $b+c$ label.

a	b	c
0	0	1
1	0	1

* Yes, this circuit suffer from Hazard at \neq Value:

$F = (a+b) \cdot (b+c) \cdot (a'+c')$

ii)

2) Show the primitive flow table of a positive edge T-FF (T Flip Flop).

State	T	CLK	Q	stable	comment (After)
a	0	0	0	✓	c, e
b	0	0	1	✓	d, f
c	0	1	0	✓	a, g
d	0	1	1	✓	b, h
e	1	0	0	✓	a, e a, g
f	1	0	1	✓	b, h
g	1	1	0	✓	d, f
h	1	1	1	✓	c, e

	00	01	11	10
a	(a), 0	e, -	- , -	e, -
b	(b), 1	d, -	- , -	- , -
c	a, -	(c), 0	h, -	- , -
d	b, -	(d), 1	g, -	- , -
e	a, -	- , -	h, -	(e), 0
f	b, -	- , -	g, -	(f), 1
g	- , -	c, -	(g), 0	e, -
h	- , -	d, -	(h), 1	- , -

3) Given the following notes about an asynchronous circuit. Go through Design Procedure process to implement the circuit using SR latch(es).

Stable State	Inputs		output	Notes
	x1	x2	Q	
a	1	1	1	After c
b	0	1	0	After e
c	0	1	1	After a, f
d	1	0	0	After a, e, f
e	1	1	0	After b, d
f	0	0	1	After b, c, d

3)

* primitive flow table

	00	01	11	10
a	f 2	c 3	a 2	d 3
b	f 3	b 2	e 3	- 3
c	f 3	c 1	a 3	- 3
d	f 3	- 3	e 3	d 0
e	- 3	b 3	c 0	d 3
f	f 1	c 3	- 3	d 3

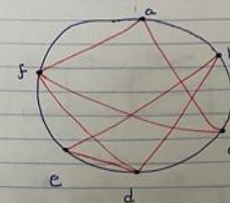
* Implication chart

b	X			
c	✓	X		
d	X	✓	X	
e	X	✓	X	✓
f	✓	b,c	✓	✓
a				X

* Compatible pairs

(a,c), (a,f), (b,e), (b,d), (c,f), (d,f), (d,e)

* Merger diagram



* Maximal compatibles:

(b,d,e), (a,c,f), (d,f)

* Minimum set:

(b,d,e), (a,c,f)

	x_1, x_2			
	00	01	11	10
b, d, e	$f_0 -$	$(b)_0$	$(e)_0$	$(d)_0$
a, c, f	$(f)_1$	$(c)_1$	$(a)_1$	$(d)_1$

$$b, d, e \equiv A$$

$$a, c, f \equiv B$$

	x_1, x_2			
	00	01	11	10
A	$B_2 -$	$A_2 0$	$A_2 0$	$A_2 0$
B	$B_2 1$	$B_2 1$	$B_2 1$	$A_2 -$

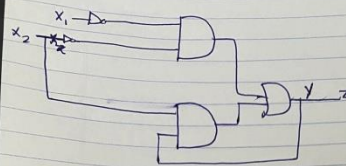
assign $A=0 \rightarrow B=1$

	x_1, x_2			
	00	01	11	10
y	1	0	0	0
1	1	1	1	0

$$Y = x_1 \bar{x}_2 + x_2 y$$

	x_1, x_2			
	00	01	11	10
y	1	0	0	0
1	1	1	1	0

$$Z = y$$



*using SR latch

	x_1, x_2			
	00	01	11	10
y	1	0	0	0
1	1	1	1	0

	x_1, x_2			
	00	01	11	10
y	0	0	X	X
1	0	0	0	1

$$S = x_1 \bar{x}_2$$

$$R = x_1 x_2$$

