# Lab 5:Design of Digital Stop Watch (counter0to5 and decoder0to5)

### Objective:

\* To design a Digital Stop Watch using concepts of digital system partitioning

### Digital design – 3-bit synchronous counter (counter0to5)

### <u>Step 1</u>

Draw a State diagram corresponding to the counter



State diagram

## Step 2

From the State diagram prepare the Transition table

Р	resent Sta	te	Next State						
Q2	Q1	Q0	Q2*	Q1*	Q0*				
0	0	0	0	0	1				
0	0	1	0	1	0				
0	1	0	0	1	1				
0	1	1	1	0	0				
1	0	0	1	0	1				
1	0	1	0	0	0				
1	1	0	X	Х	Х				
1	1	1	X	Х	Х				

Transition table

Step 3

Use K-maps to determine the excitation equations (D/Q\*)





Q1\* = D1 = Q1.Q0B + Q2B.Q1B.Q0



## Digital Stop Watch – *counter0to5*

## Reference Lab 3 to complete *counter0to5*



1. Draw the *counter0to5* circuit as shown in Figure 5.1.

Figure 5.1 counter0to5 circuit

Symbols used: and2, and3, or2, not, dff and vcc

Pins used: input and output

Input pin name: clk

Output pins names: q2, q1 and q0

Create symbol for the *counter0to5* circuit and complete the circuit as shown in Figure 5.2 and Click *File > Save*. Compile the circuit and ensure no error. Ignore warning/s.



Figure 5.2 *stopwatch.bdf* with *counter0to9*, *decoder0to9* and *counter0to5* symbols connected

3. Update/edit the stopwatch Vector Waveform File – *stopwatch.vwf* to test the *counter0to5* circuit as shown in Figure 5.3. (Refer to Lab 1 if you have forgotten how to create/edit Vector Waveform File).

pwatch	n.bdř				🕘 Co	mpilation Report	Flow Summary					15	stopwatch.	rwf*					
Mas	ter Time Bar:		0 ps	Pointer		338.71 ns	Interval		338.7	11 no	Sta	et:		0 ps		End		2.0 us	
	Name	Value at 0 ps	0 ps 100,0 ns 0 ps 1	200.0 ns 300.0 ns	400.0 ns	500.0 ns 600	1.0 ns 700.0 ns	800.0 ns	900.0 ns	1.0 us	1.1 us	1.2 us	1.3 us	1.4 us	1.5 us	1.6 us	1.7 us	1.8 us	1.9 us 2.0
100	0 clk	A 0																	
20	1 sece	AX	*****			******		******		****		******		****			*****	****	********
2	2 sect	AX	*****	*****	******	******	*****	******	*******	*****	********	*****	********	******	*******		*****	******	*********
0	3 seco	AX	***********	*******	*****	******	******	******	******	****	********	******	*******	******	*******	******	******	******	********
100	4 seco	AX		******	******	******		******	******	******	********	~~~~~	*******	******	*******	******	******	******	*********
0	5 sece	AX			*****	*******		******	~~~~~	~~~~~	*******	*****	******	*****	*******	******	*****	******	
0	6 secf	AX		*****	*******			******	******	******		******	*******	******	*******	******	******	******	
0	7 seco	AX		******	*******	**********	*************	******	*******	******	*******	******	*******	******	********	******	*******	*******	
0	8 q2	AX		*****	********	*********	************	*******	*******	*******	********	*****	*******	******	********	******	*******	*******	********
2	9 q1	AX		******	********	*********	*************	*******	*******	*******	*******	******	********	******	*******	******	*******	*******	
2	10 q0	AX		******	********		*****	******	********	******	*********	******	*******	*******	********	******	******	*******	********

Figure 5.3 stopwatch Vector Waveform File

4. Simulate the circuit to obtain results as shown in Figure 5.4.

Simu Sim	nulation Waveform: Immulation mode: Functional														
Mast	er Time Ba	st:	0 ps	♦ Pointer:	90.36 ns	Interval	90.36 ns	Start	0 ps	End:	2.0 us				
<b>A</b> <b>A</b>		Name	Value at 0 ps	0 ps 100.0 ns 200.0 ns 0 ps J	300.0 ns 400.0 ns	500.0 ns 600.0 ns	700.0 ns 800.0 ns 900.0 ns	1.0 us 1.1 us	1.2 us 1.3 us	s 1.4 us 1.5 us	1.6 us	1.7us 1.8us			
970 ©	<b>⊮</b> 0 ∞1	clk seca	A0 A0												
1	<b>@</b> ≱2	secb	A 0								TH				
桷	<ul> <li>2 3</li> <li>(2) 4</li> </ul>	secc	A0 A1								+++	++			
<b>n</b> ,	∞5	sece	A 0												
-	22 6 (™) 7	sect	A0 A1								——————————————————————————————————————	-+			
際	@ 8	q2	AO												
Z+	9	q1 q0	A 0												
	2 10	90	~												

Figure 5.4 stopwatch (counter0to5) waveform







$$a = Q2Q0 + Q1 + Q2BQ0$$















e = Q2BQ0B

## **Digital Stop Watch** – *decoder0to5*

## Reference Lab 3 to complete *decoder0to5*





Figure 5.5 *decoder0to5* circuit

Symbols used: and2, nand2, nor2, nor3 and not

Pins used: input and output

Input pin name: q2, q1 and q0

Output pins names: a, b, c, d, e, f and g

Create symbol for the *decoder0to5* circuit and complete the circuit as shown in Figure 5.6 and Click *File > Save*. Compile the circuit and ensure no error. Ignore warning/s.



Figure 5.6 *stopwatch.bdf* with *counter0to9*, *decoder0to9*, *counter0to5* and *decoder0to5* symbols connected

3. Update/edit the stopwatch Vector Waveform File – *stopwatch.vwf* to test the *decoder0to5* circuit as shown in Figure 5.7. (Refer to Lab 1 if you have forgotten how to create/edit Vector Waveform File).

🔝 stop	watch.bdf					Dompilation Report - Flow Summary								1	n stopwat	ch.vwf*						1
볞	Master Ti	ime Bar.	0	ps	< + Pointe	я: [	0 p	ps	Interv	ral:		0 ps		Start		0 ps		End		2.0 us		
<b>À</b> A ₩ ©		Name	Value at 0 ps	0 ps 100.0 0 ps	ns 200,0 ns	300,0 ns	400.0 ns	500.0 ns	600.0 ns 7	00.0 ns	800,0 ns	900.0 ns	1.0 us	1.1 <sub>,</sub> us	1.2 us	1.3 us	1.4 us	1.5 us	1.6 us	1.7 us	1.8 us	1.9 us
[]HE	<b>⊔≥</b> 0	clk	A0																			
44 0.5	21	seca	AX		********	*******	*******	******	*********	******	******	******	******	******	******	******	*****	*******	******	******	*******	******
Vo. ×	22	secb	AX		*********	******	*******	******	*********	******	******	******	******	******	******	******	******	*******	*******	******		*****
-0 1	123	secc	AX		********	******	*******	*******	********	******	******	******	*******	*******	*******	******	******	*******	*******	******	~~~~~	*****
	<b>1</b> 4	secd	AX		*********	~~~~~	*******	******	**********	******	*******	******	******	*******	*******	*******	******	********	~~~~~~	*******	~~~~~	*****
<u>~</u> ) <u>w</u>	100 5	sece	AX	P000000000	*********		*******			222222	*******	******				*****	******		******			
	126	sect	AX		*******	*******		22222222	********	******		******					2222222		******	********	22222222	
	21	secg	AX		*******	******		******	*******	******		*****				******	******	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	*******			******
	28	tenseca	AX		******	****	******	*******	~~~~~~~~~~~	******	*******	*****	******	******	******	******	******	*****	******	*****	~~~~~	*****
	29	tensecb	AX		~~~~~~~~~~~~	*****	*****	******	~~~~~~~~~~~~	~~~~~	******	~~~~~	*******	******	******	*******	******	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	******	*****	******	*****
	10	tensecc	AX		*********	~~~~~~	*******	******	**********	~~~~~	*******	******	*******	*******	******	*******	******	~~~~~	~~~~~~	******	~~~~~	******
88. 11	11	tensecd	AX		******	******	*******	******	*********	******	******	******	******	*******	*******	*******	******	*********	~~~~~~	*******	******	
1 ALCO	12	tensece	AX		*********		*******	******	**********	******	******	******	******	******	*******	*******	******	*******	******	******		*****
	13	tensecf	AX		********		******	******	*********	******	******	******	******	*******	*******	*******	*****	*******	*******	******		*****
	@14	tensecg	AX		******	*******	*******	******	*******	******	*******	******	******	*******	******	******	*****	*******		******	*******	*****

Figure 5.7 stopwatch Vector Waveform File

4. Simulate the circuit to obtain the results as shown in Figure 5.8. Verify the decoder0to5 outputs using Table 5.1

Simula	nulation Waveforms													
Sim	ulation mo	de: Functiona	J											^
														-
_														
Maste	r Time Bar:		0 ps		Pointer:	17.22 ns	Interval:	17.2	2 ns	Start	0 ps	End:	2.0 us	
R			Value at	0 ps	200.0 ns	400.0 ns	600.0 ns	800.0 ns	1.0 us	1.2 us	1.4 us	1.6 us	1.8 us	2.0 us
A		Name	0 ps	0 ps			10-							
¥				L .										
Æ		clk	A 0											
~		seca	A 0											
	🔊 2	secb	A 0											
44		secc	A 0											
*	• <b>⊡</b> ≥ 4	secd	A0											
-		sece	AO											
-	∞26	secf	A0											
80.		secg	A1											
		tenseca	AU											
24		tensecb	AU											
	10	tensecc	AU							_			_	
	11	tensecd	AU											
	OP 12	tensece	AU											
		tensect	AU					_						
	• <b>D</b> > 14	tensecg	A1											

Figure 5.8 *stopwatch* (*counter0to5*) waveform

Count	0	1	2	3	4	5
Time	Ons	100ns	200ns	300ns	400ns	500ns
tenseca	0	1	0	0	1	0
tensecb	0	0	0	0	0	1
tensecc	0	0	1	0	0	0
tensecd	0	1	0	0	1	0
tensece	0	1	0	1	1	1
tensecf	0	1	1	1	0	0
tensecg	1	1	0	0	0	0

Table 4.1 Expected *decoder0to5* outputs