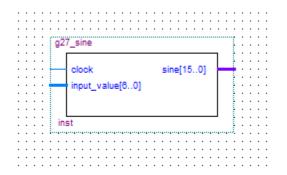
ECSE 323 Digital System Design

Lab #2 – g27_sine (sine function circuit)

Group 27

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Design of a sine circuit using a Lookup Table

Since sound is periodic pressure waves, we need a periodic function to represent sounds of different periods. Writing out all 128 values of sine for inputs in degrees is tedious, so we calculated the results in Excel and put the contents of the Excel table in a .mif file to be used by the Altera SRAM.

x (degree)	x (radian)	sin(x)	sin(x) * 2^16	int [sin(x) * 2^16]
0	0	0	0	0
1	0.017453	0.017452	1143.761	1143
2	0.034907	0.034899	2287.173	2287
3	0.05236	0.052336	3429.889	3429
4	0.069813	0.069756	4571.56	4571
5	0.087266	0.087156	5711.839	5711
6	0.10472	0.104528	6850.377	6850
7	0.122173	0.121869	7986.829	7986
8	0.139626	0.139173	9120.848	9120
9	0.15708	0.156434	10252.09	10252
10	0.174533	0.173648	11380.21	11380
11	0.191986	0.190809	12504.86	12504
12	0.20944	0.207912	13625.7	13625
13	0.226893	0.224951	14742.39	14742
14	0.244346	0.241922	15854.59	15854
15	0.261799	0.258819	16961.96	16961
16	0.279253	0.275637	18064.17	18064
17	0.296706	0.292372	19160.87	19160
18	0.314159	0.309017	20251.74	20251
19	0.331613	0.325568	21336.43	21336
20	0.349066	0.34202	22414.63	22414

	0.000=10	0.0=00.00	22122	20.406
21	0.366519	0.358368	23486	23486
22	0.383972	0.374607	24550.22	24550
23	0.401426	0.390731	25606.96	25606
24	0.418879	0.406737	26655.89	26655
25	0.436332	0.422618	27696.71	27696
26	0.453786	0.438371	28729.09	28729
27	0.471239	0.45399	29752.72	29752
28	0.488692	0.469472	30767.29	30767
29	0.506145	0.48481	31772.48	31772
30	0.523599	0.5	32768	32768
31	0.541052	0.515038	33753.54	33753
32	0.558505	0.529919	34728.79	34728
33	0.575959	0.544639	35693.46	35693
34	0.593412	0.559193	36647.27	36647
35	0.610865	0.573576	37589.91	37589
36	0.628319	0.587785	38521.09	38521
37	0.645772	0.601815	39440.55	39440
38	0.663225	0.615661	40347.99	40347
39	0.680678	0.62932	41243.14	41243
40	0.698132	0.642788	42125.73	42125
41	0.715585	0.656059	42995.48	42995
42	0.733038	0.669131	43852.14	43852
43	0.750492	0.681998	44695.44	44695
44	0.767945	0.694658	45525.13	45525
45	0.785398	0.707107	46340.95	46340
46	0.802851	0.71934	47142.65	47142
47	0.820305	0.731354	47930	47929
48	0.837758	0.743145	48702.74	48702
49	0.855211	0.75471	49460.65	49460
50	0.872665	0.766044	50203.49	50203
51	0.890118	0.777146	50931.04	50931
52	0.907571	0.788011	51643.07	51643
53	0.925025	0.798636	52339.38	52339
54	0.942478	0.809017	53019.74	53019
55	0.959931	0.819152	53683.95	53683
56	0.977384	0.829038	54331.81	54331
57	0.994838	0.838671	54963.11	54963
58	1.012291	0.848048	55577.68	55577
59	1.029744	0.857167	56175.32	56175
60	1.047198	0.866025	56755.84	56755
61	1.064651	0.87462	57319.08	57319

62	1.082104	0.882948	57864.85	57864
63	1.099557	0.891007	58393	58393
64	1.117011	0.898794	58903.37	58903
65	1.134464	0.906308	59395.79	59395
66	1.151917	0.913545	59870.12	59870
67	1.169371	0.920505	60326.21	60326
68	1.186824	0.927184	60763.92	60763
69	1.204277	0.93358	61183.13	61183
70	1.22173	0.939693	61583.7	61583
71	1.239184	0.945519	61965.51	61965
72	1.256637	0.951057	62328.44	62328
73	1.27409	0.956305	62672.39	62672
74	1.291544	0.961262	62997.25	62997
75	1.308997	0.965926	63302.91	63302
76	1.32645	0.970296	63589.3	63589
77	1.343904	0.97437	63856.32	63856
78	1.361357	0.978148	64103.88	64103
79	1.37881	0.981627	64331.92	64331
80	1.396263	0.984808	64540.36	64540
81	1.413717	0.987688	64729.14	64729
82	1.43117	0.990268	64898.21	64898
83	1.448623	0.992546	65047.5	65047
84	1.466077	0.994522	65176.99	65176
85	1.48353	0.996195	65286.62	65286
86	1.500983	0.997564	65376.36	65376
87	1.518436	0.99863	65446.19	65446
88	1.53589	0.999391	65496.08	65496
89	1.553343	0.999848	65526.02	65526
90	1.570796	1	65536	65536

Table1. Input and output values

When x = 90, $\sin(x)*2^16 = 2^16$ converted to binary 1000000000000000 which is a 17-bit number. We set the word size 16, it will show 0000000000000. (Write down 0 in decimal)

For inputs greater than 90 (from 91 to 127), the output should be all ones. (65535 in decimal)

Creating a Memory Initialization File:

g27_sine.mif*										
Addr	+0	+1	+2	+3	+4	+5	+6	+7		
0	0	1143	2287	3429	4571	5711	6850	7986		
8	9120	10252	11380	12504	13625	14742	15854	16961		
16	18064	19160	20251	21336	22414	23486	24550	25606		
24	26655	27696	28729	29752	30767	31772	32768	33753		
32	34728	35693	36647	37589	38521	39440	40347	41243		
40	42125	42995	43852	44695	45525	46340	47142	47929		
48	48702	49460	50203	50931	51643	52339	53019	53683		
56	54331	54963	55577	56175	56755	57319	57864	58393		
64	58903	59395	59870	60326	60763	61183	61583	61965		
72	62328	62672	62997	63302	63589	63856	64103	64331		
80	64540	64729	64898	65047	65176	65286	65376	65446		
88	65496	65526	0	65535	65535	65535	65535	65535		
96	65535	65535	65535	65535	65535	65535	65535	65535		
104	65535	65535	65535	65535	65535	65535	65535	65535		
112	65535	65535	65535	65535	65535	65535	65535	65535		
120	65535	65535	65535	65535	65535	65535	65535	65535		

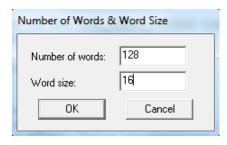


Figure 1. Memory Initialization File decimal)

Select Binary in Memory Radix (View list) (numbers in unsigned

Binary

9 g27	_sine.mif*							_
Addr	+0	+1	+2	+3	+4	+5	+6	+7
0	0000000000000000	0000010001110111	0000100011101111	0000110101100101	0001000111011011	0001011001001111	0001101011000010	0001111100110010
8	0010001110100000	0010100000001100	0010110001110100	0011000011011000	0011010100111001	0011100110010110	0011110111101110	0100001001000001
16	0100011010010000	0100101011011000	0100111100011011	0101001101011000	0101011110001110	0101101110111110	0101111111100110	0110010000000110
24	0110100000011111	0110110000110000	0111000000111001	0111010000111000	0111100000101111	0111110000011100	1000000000000000	1000001111011001
32	1000011110101000	1000101101101101	1000111100100111	1001001011010101	1001011001111001	1001101000010000	1001110110011011	1010000100011011
40	1010010010001101	1010011111110011	1010101101001100	1010111010010111	1011000111010101	1011010100000100	1011100000100110	1011101100111001
48	1011111000111110	1100000100110100	1100010000011011	1100011011110011	1100100110111011	1100110001110011	1100111100011011	1101000110110011
56	1101010000111011	1101011010110011	1101100100011001	1101101101101111	1101110110110011	1101111111100111	1110001000001000	1110010000011001
64	1110011000010111	1110100000000011	1110100111011110	1110101110100110	1110110101011011	1110111011111111	1111000010001111	1111001000001101
72	1111001101111000	1111010011010000	1111011000010101	1111011101000110	1111100001100101	1111100101110000	1111101001100111	1111101101001011
80	1111110000011100	1111110011011001	1111110110000010	1111111000010111	1111111010011000	1111111100000110	11111111101100000	1111111110100110
88	11111111111011000	11111111111110110	0000000000000000	1111111111111111	1111111111111111	1111111111111111	1111111111111111	111111111111111
96	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	111111111111111
104	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111
112	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	111111111111111
120	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	1111111111111111	111111111111111

Figure 1. Memory Initialization File (numbers in binary)

Input_value starts at 0000000, ends at 1111110, and is incremented by 1. Note_number is counted every 10 ns and the end time is **1270ns**, testing all 128 possible input patterns. The testing results are shown below.

Functional Simulation Results:

• t = 0 - 100ns

		0 ps 10	0.0 ns	20.0 ns	30.0 ns	40.0 ns	50.0 ns	60.0 ns	70.0 ns	80.0 ns	90.0 ns	100 _, 0 ns
	Name	0 ps J										
■ 0	clock	nnnnnnn	MMMMM.	mmmmm	wwwwww	wwwwww		nnnnnnn			wwwwww	MMM.
i 1	input_value	0000000	0000001	0000010	0000011	0000100	0000101	0000110	0000111	0001000	000100	
⊕ 9	 sine	(00000000000000000000000000000000000000	000001000111	0111,000010001110	1111,000011010110	0101/000100011101	1011 000101100100	01111 00011010110	00010\00011111001	10010 0010001110	100000 0010100000	001100,001

• t = 100 – 200ns

		100.0 ns 110) _i 0 ns 120	0 ns 130	0 ns 140	0 ns 150	0,0 ns 160	0,0 ns 170	0 ns 180	0 ns 190.	0 ns 200 _i 0 ns
	Name										
i 0	clock	mmmmm	wwwww	mmmm	nnnnnnn	mmmm		wwwww			
№ 1	input_value	0001010	0001011	0001100	0001101	0001110	0001111	0010000	0010001	0010010	0010011
₽ 9	± sine	001011000111010	QX0011000011011000	001101010011100	(001110011001011	00111110111110111	0010000100100000	1,0100011010010000	010010101101101	0100111100011011	X0101001101011000X01C

• t = 200 - 300ns

		200.0 ns 2	210 _, 0 ns	220,0 ns	230,0 ns	240,0 ns	250,0 ns	260 _, 0 ns	270 _, 0 ns	280,0 ns	290,0 ns	300,0 ns
	Name											
→ 0	clock	mmmm		nnnnnnn	nnnnnnnn	MMMMMM	MMMMM	mmmmm	wwwwww	wwwww	wwwww	nnnn.
₽ 1	■ input_value	0010100	0010101	0010110	0010111	0011000	0011001	0011010	0011011	0011100	0011101	
₽ 9	⊞ sine	00101011110001	110,01011011101	11110/010111111111	00110 01100100000	00110 01101000000	011111)(0110110000	110000,0111000000	111001)(0111010000	111000 0111100000	101111)(01111110000	011100 (100

• t = 300 - 400ns

		300.0 ns 310.	0 ns 320	0 ns 330	0 ns 340	0 ns 350	0 ns 360	0 ns 370	0 ns 380	0 ns 390	0 ns 400 _i 0	0 ns
	Name											
<u>■</u> 0	clock	mmmmm		nnnnnnn	nnnnnnn	mmmmm	MMMMMM	MMMMMM	mmmm	mmmmm	nnnnnnn	Л
<u> </u>	input_value	0011110	0011111	0100000	0100001	0100010	0100011	0100100	0100101	0100110	0100111	\subseteq
⊚ 9	 sine	()(100000000000000000000000000000000000	(1000001111011001	(1000011110101000	(1000101101101101	X100011110010011	X10010010110101010	(1001011001111001	X1001101000010000	(100111011001101	(1010000100011011)	X101

• t = 400 - 500ns

		400.0 ns 41	0,0 ns 420	0 ns 430,0	ns 440 _, 0	ns 450 _, 0	ns 460	0 ns 470 _i	0 ns 480 _i	0 ns 490 _i	0 ns 500 _i 0 ns
	Name										
→ 0	clock	mmmm	mmmmm	mmmm	nnnnnnn	mmmmm	wwwww	nnnnnnn	mmmmm	mmmmm	
i 1 1	<u>★ input_value</u>	0101000	0101001	0101010 X	0101011	0101100	0101101	0101110	0101111	0110000	0110001
₽ 9	 sine	()(101001001000110	71/10100111111111001	(1010101101001100)	(1010111010010111) <u>(</u> 1	011000111010101	1011010100000100	(101110000010010	(1011101100111001	X101111110001111110	X1100000100110100X11C

• t = 500 - 600ns

		500.0 ns 510	.0 ns 520	0 ns 530	0 ns 54	0,0 ns	550 _, 0 ns	560 _i 0 ns	570 _i 0 ns	580 _, 0 ns	590 _i 0 ns	600 _, 0 ns
	Name											
□ 0	clock	nnnnnnn	wwwww	wwwww	wwwww		wwwwww	mmmmm	nnnnnnnn	nnnnnnn	nnnnnnn.	
<u> </u>	input_value	0110010	0110011	0110100	0110101	0110110	0110111	0111000	0111001	0111010	0111011	
₽ 9	 sine	(110001000001101	(110001101111001	(110010011011101	1)(11001100011100	11\(1100111110001	1011 (110100011011	10011X11010100001	11011X11010110101	10011\(11011001000	11001\(11011011011	01111)(110

• t = 600 - 700ns

		600.0 ns	610 _, 0 ns	620,0 ns	630 _i 0 ns	640 _, 0 ns	650 _, 0 ns	660,0 ns	670 _, 0 ns	680 _i 0 ns	690 _i 0 ns	700 _i 0 ns
	Name											
 0	clock	mmmm	mmmm	mmmmm	nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn	nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn	mmmmm	mmmmm	mmmmm	wwwww	nnnnnnnn	MMM.
<u> 1</u>	<u>■ input_value</u>	0111100	0111101	0111110	X 0111111	1000000	1000001	1000010	1000011	1000100	1000101	
⊚ 9	⊞ sine	10/1101110110110	0011X110111111111	00111)(11100010000	01000\(\frac{11100100000}{}	11001) <u>/</u> 11100110000	1101111)(11101000000	000011)(11101001110	11110/1110101111010	0110 11101101010	11011 <u>X</u> 11101110111	11111)(111

• t = 700 - 800ns

	Name	700.0 ns 710	0,0 ns 720	0 ns 730	0 ns 740,0	ns 750 _i	0 ns 760	0 ns 770	0 ns 780,	0 ns 790	0 ns 800 _i 0 ns
■ 0	clock			וחחחחחחחחחח							
<u>→</u> 1	input_value	DX 1000110	1000111	1001000	1001001	1001010	1001011	(1001100)	1001101	1001110	1001111
₽ 9	 sine	01)(111100001000111	1×111100100000110	X11110011011111000	X1111010011010000X	1111011000010101	X11110111101000110	X1111100001100101	X1111100101110000	X1111101001100111	X1111101101001011X111

• t = 800 - 900ns

	Name	800.0 ns	810,0 ns	820 _, 0 ns	830 _, 0 ns	840 _i 0 ns	850 _i 0 ns	860 _, 0 ns	870 _i 0 ns	880 _, 0 ns	890 _, 0 ns	900 _i 0 ns
■ 0	clock		mmmmm	nnnnnnnn	mmimm		nnnnnnn	www.ww	wwwww	wwwww	wwwww	mmm
1	input_value input_sine ine input_value input_value						100 X 1010 10011000 X11111111					
	• t=0	900 – 1	000ns									
	Name	900.0 ns	910 _, 0 ns	920 _i 0 ns	930 _i 0 ns	940 _i 0 ns	950 _, 0 ns	960 _, 0 ns	970 _, 0 ns	980 _i 0 ns	990 _, 0 ns	1.0 us
₽ 0	clock input_value		0 X 10110				77777777777777777777777777777777777777				77777777777777777777777777777777777777	
⊕ 9	⊞ sine	0000000000						11111111				
	• t = 1	1000 –	1100ns									
		1.0 us	1.01 us	1.02.00	1.02.00	1.04.00	1.05.00	1.00.00	1.07.00	1.00.00	1.09.00	1100
	Name	1.0 us	1.01 us	1.02 us	1.03 us	1.04 us	1.05 us	1.06 us	1.07 us	1.08 us	1.09 us	1.1 us
→ 0	clock ★ input_value		MMMMM 11001		$\frac{1000}{1000}$	WWWWW	77777777777777777777777777777777777777	$\frac{1}{100}$	000 X 11010		MMMMM 100 X 1101	
⊕ 9	 sine						1	11111111111111111				
	• t = 1	1100 –	1200ns									
		1.1 us	1.11 us	1.12 us	1.13 us	1.14 us	1.15 us	1.16 us	1.17 us	1.18 us	1.19 us	1.2 us
	Name											
i ▶0 i ▶1	clock input_value	110111		11 X 11100)11 11101			77777777777777777777777777777777777777	
₽ 9	 sine				i			111111111111111111	İ			
	• t = 1	1200 –	1270ns									
1.2 u	s	1.21	US	1.22 us	1	.23 us	1.24 u	s	1.25 us	1.2	6 us	1.27 us
							<u> </u>					
ППГ		ппппг	<u> </u>				,,,,,,,,		100000		100000	וחחחר
	111100		1111001		1111010	1111		1111100		11101	11111	
	111	11111111	111111									

Timing Simulation Result:

Using an end time of 2usec and a clock signal with a period of 20nsec.

			0 ps	160,0 ns	320,0 ns	480,0 ns	640 _, 0 ns	800 _, 0 ns	960 _, 0 ns	1.12 us	1.28 us	1.44 us	1.6 us	1.76 us	1.92 us
		Name	0 ps												
	\rightarrow														
	• 0	clock	MMM.	mmm	ռոռուու	ոսուսու	mmmn	mmmm	nnnnnn	mmmm	mmmm	mnnnn	mmm	\mathbf{m}	mmmm.
	¥1	<u>★ input_value</u>		000	0000		11	11111			1010101			0101010	
	9	+ sine	\Box	0000000	000000000	X_	11111	11111111111	X	111	1111100000110	*	10	1010110100110	00

The output values are correct.

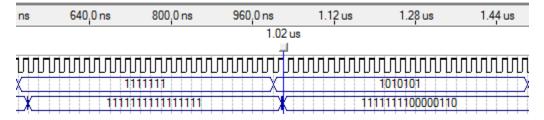
Setting time for different transition:

• Transition from 0000000 to 1111111

0 ps	160 _, 0 ns	320,0 ns	480,0 ns	640,0 ns	800 _, 0 ns	960 _, 0 ns
			520.0 ns			
			7			
MM	mmm	wwww	mmmm	mmm	mmmm	MMM
	000	0000		1	111111	
	0000000	000000000		1111	111111111111	

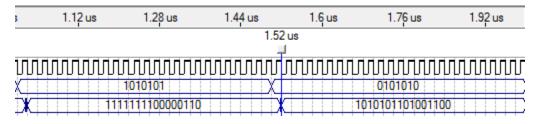
Settling time = 520 - 500ns = 20ns

• Transition from 1111111 to 1010101



Settling time = 1.02us - 1.0us = 0.02us

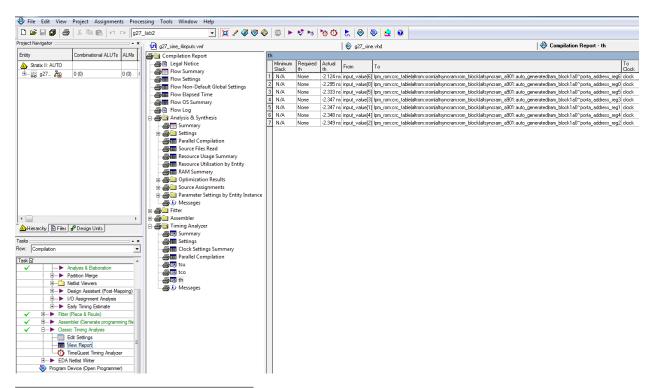
• Transition from 1010101 to 0101010



Settling time = 1.52us - 1.5us = 0.02us

The settling time is the same for every transition.

The compilation report gives us some interesting information about the efficiency of our hardware usage.



Ana	alysis & Synthesis Resource Usage Summary	
	Resource	Usage
1	Estimated ALUTs Used	0
2	Dedicated logic registers	0
3		
4	Estimated ALUTs Unavailable	0
5		
6	Total combinational functions	0
7	☐ Combinational ALUT usage by number of inputs	
8	7 input functions	0
9	6 input functions	0
10	5 input functions	0
11	4 input functions	0
12	<=3 input functions	0
13		
14	□ Combinational ALUTs by mode	
15	normal mode	0
16	extended LUT mode	0
17	arithmetic mode	0
18	shared arithmetic mode	0
19		
20	Estimated ALUT/register pairs used	0
21		
22	☐ Total registers	0
23	Dedicated logic registers	0
24	I/O registers	0
25		
26		
27	I/O pins	24
28	Total block memory bits	2048
29	Maximum fan-out node	clock
30	Maximum fan-out	16
31	Total fan-out	144
32	Average fan-out	3.60

tco				tco				Ī
	Slack	Required	Actual		Slack	Required	Actual	ľ
1	N/A	tco	tco	45		too	tco	ŀ
1	N/A N/A	None	8.628 ns	45	N/A	None	6.939 ns	ŀ
2		None	7.514 ns	46	N/A	None	6.934 ns	ŀ
-	N/A	None	7.292 ns	47	N/A	None	6.895 ns	ļ
4	N/A	None	7.236 ns	48	N/A	None	6.889 ns	
5	N/A	None	7.230 ns	49	N/A	None	8.628 ns	
6	N/A	None	7.219 ns	50	N/A	None	7.514 ns	Ī
7	N/A	None	7.175 ns	51	N/A	None	7.292 ns	ľ
8	N/A	None	6.989 ns	52	N/A	None	7.236 ns	Į
9	N/A	None	6.985 ns	53	N/A	None	7.230 ns	١L
10	N/A	None	6.952 ns	54	N/A	None	7.219 ns	١L
11	N/A	None	6.952 ns	55	N/A	None	7.175 ns	
12	N/A	None	6.950 ns	56	N/A	None	6.989 ns	L
13	N/A	None	6.939 ns	57	N/A	None	6.985 ns	L
14	N/A	None	6.934 ns	58	N/A	None	6.952 ns	L
15	N/A	None	6.895 ns	59	N/A	None	6.952 ns	
16	N/A	None	6.889 ns	60	N/A	None	6.950 ns	
17	N/A	None	8.628 ns	61	N/A	None	6.939 ns	
18	N/A	None	7.514 ns	62	N/A	None	6.934 ns	
19	N/A	None	7.292 ns	63	N/A	None	6.895 ns	
20	N/A	None	7.236 ns	64	N/A	None	6.889 ns	١.
21	N/A	None	7.230 ns	65	N/A	None	8.628 ns	
22	N/A	None	7.219 ns	66	N/A	None	7.514 ns	
23	N/A	None	7.175 ns	67	N/A	None	7.292 ns	
24	N/A	None	6.989 ns	68	N/A	None	7.236 ns	
25	N/A	None	6.985 ns	69	N/A	None	7.230 ns	
26	N/A	None	6.952 ns	70	N/A	None	7.219 ns	
27	N/A	None	6.952 ns	71	N/A	None	7.175 ns	
28	N/A	None	6.950 ns	72	N/A	None	6.989 ns	
29	N/A	None	6.939 ns	73	N/A	None	6.985 ns	
30	N/A	None	6.934 ns	74	N/A	None	6.952 ns	
31	N/A	None	6.895 ns	75	N/A	None	6.952 ns	
32	N/A	None	6.889 ns	76	N/A	None	6.950 ns	
33	N/A	None	8.628 ns	77	N/A	None	6.939 ns	
34	N/A	None	7.514 ns	78	N/A	None	6.934 ns	
35	N/A	None	7.292 ns	79	N/A	None	6.895 ns	
36	N/A	None	7.236 ns	80	N/A	None	6.889 ns	
37	N/A	None	7.230 ns	81	N/A	None	8.628 ns	
38	N/A	None	7.219 ns	82	N/A	None	7.514 ns	
39	N/A	None	7.175 ns	83	N/A	None	7.292 ns	
40	N/A	None	6.989 ns	84				
41	N/A N/A	None	6.985 ns		N/A N/A	None	7.236 ns	
42				85 oc	N/A N/A	None	7.230 ns	
_	N/A N/A	None	6.952 ns	86	N/A	None	7.219 ns	
43	N/A N/A	None	6.952 ns	87	N/A	None	7.175 ns	
44	N/A	None	6.950 ns	88	N/A	None	6.989 ns	

Ti	Timing Analyzer Summary							
	Туре	Slack	Required Time	Actual Time				
1	Worst-case tsu	N/A	None	2.574 ns				
2	Worst-case too	N/A	None	8.628 ns				
3	Worst-case th	N/A	None	-2.124 ns				

th								
	Minimum Slack	Required th	Actual th					
1	N/A	None	-2.124 ns					
2	N/A	None	-2.295 ns					
3	N/A	None	-2.333 ns					
4	N/A	None	-2.347 ns					
5	N/A	None	-2.347 ns					
6	N/A	None	-2.348 ns					
7	N/A	None	-2.349 ns					

tsı	tsu									
	Slack	Required tsu	Actual tsu							
1	N/A	None	2.574 ns							
2	N/A	None	2.573 ns							
3	N/A	None	2.572 ns							
4	N/A	None	2.572 ns							
5	N/A	None	2.558 ns							
6	N/A	None	2.520 ns							
7	N/A	None	2.349 ns							

89	N/A	None	6.985 ns
90	N/A	None	6.952 ns
91	N/A	None	6.952 ns
92	N/A	None	6.950 ns
93	N/A	None	6.939 ns
94	N/A	None	6.934 ns
95	N/A	None	6.895 ns
96	N/A	None	6.889 ns
97	N/A	None	8.628 ns
98	N/A	None	7.514 ns
99	N/A	None	7.292 ns
100	N/A	None	7.236 ns
101	N/A	None	7.230 ns
102	N/A	None	7.219 ns
103	N/A	None	7.175 ns
104	N/A	None	6.989 ns
105	N/A	None	6.985 ns
106	N/A	None	6.952 ns
107	N/A	None	6.952 ns
108	N/A	None	6.950 ns
109	N/A	None	6.939 ns
110	N/A	None	6.934 ns
111	N/A	None	6.895 ns
112	N/A	None	6.889 ns