INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

ASSIGNMENT-3

Computer Organization and Architecture Laboratory

Group-24

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1 Ripple Carry Adder

1.1 Half Adder

Truth Table:

Half-Adder							
a	b	sum	carryOut				
0	0	0	0				
0	1	1	0				
1	0	1	0				
1	1	0	1				

1.2 Full Adder

Truth Table:

Full-Adder								
a	b	carryIn	sum	carryOut				
0	0	0	0	0				
0	1	0	1	0				
1	0	0	1	0				
1	1	0	0	1				
0	0	1	1	0				
0	1	1	0	1				
1	0	1	0	1				
1	1	1	1	1				

1.3 Ripple Carry Adders

1.3.1 Half Adder

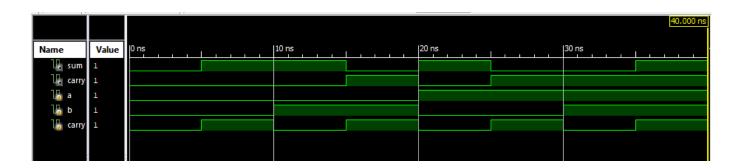


Figure 1: Half adder

Delay: 1.066 ns (0.125(logic) + 0.941(route))

1.3.2 Full Adder

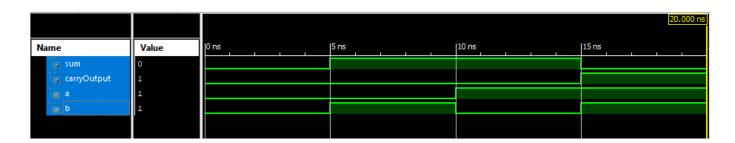


Figure 2: Full adder

Delay: 1.246 ns (0.125(logic) + 1.121(route))

1.3.3 8-bit Ripple Carry Adder

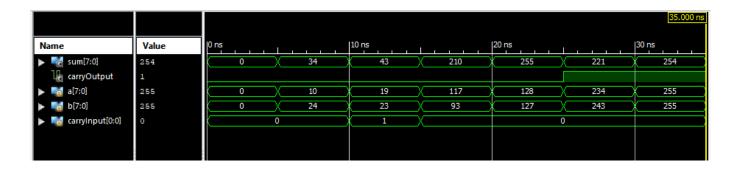


Figure 3: 8-bit Ripple Carry Adder

Delay: 3.471 ns (0.497(logic) + 2.974(route))

1.3.4 16-bit Ripple Carry Adder

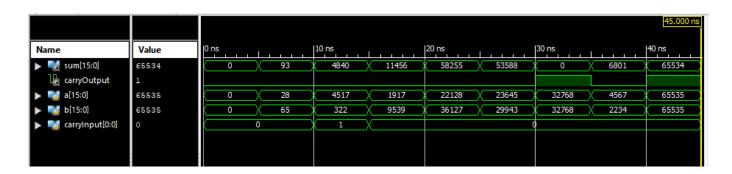


Figure 4: 16-bit Ripple Carry Adder

Delay: 6.167 ns (0.993(logic) + 5.174(route))

1.3.5 32-bit Ripple Carry Adder

										45.000 ns
Name	Value	0 ns		10 ns		20 ns		30 ns		40 ns
sum[31:0]	4294967294 1	0	5825195	53578898	4845520	11454276	65536	68024201	1310709845	4294967294
▶ ■ a[31:0]▶ ■ b[31:0]	4294967295 4294967295	0	2212768 3612427	23632145	4519087 326432	1915427 9538849	32768 32768	45633827 22390374	655355467 655354378	4294967295 4294967295
carryinput[0:0]	0		0	29940733	1	9550049	32/00	0	X 655354376	4294907293

Figure 5: 32-bit Ripple Carry Adder

Delay: 11.559 ns (1.985(logic) + 9.574(route))

1.3.6 64-bit Ripple Carry Adder



Figure 6: 64-bit Ripple Carry Adder

Delay: 22.343 ns ($3.969({\rm logic})$ + $18.374({\rm route})$)

1.4 How can you use the above circuit, to compute the difference between two n-bit numbers?

We can calculate sum of two numbers using the ripple carry adder.

```
• Inputs: a, b, carryInput = 0
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 \bullet output: a + b

Now we want to compute the difference between two n-bit numbers (a - b). To calculate the difference we can add 'a' with the 2's complement of 'b'. This can be achieved by adding 'a' with the bitwise complement of 'b' and setting the carryInput bit equal to 1.

```
\implies a - b = a + (2's \ complement \ of \ b)
\implies a - b = a + (bitwise \ complement \ of \ b) + 1
```

The above addition can be easily done using the ripple carry adder by giving the inputs: a, bitwise complement of b and carryInput = 1.