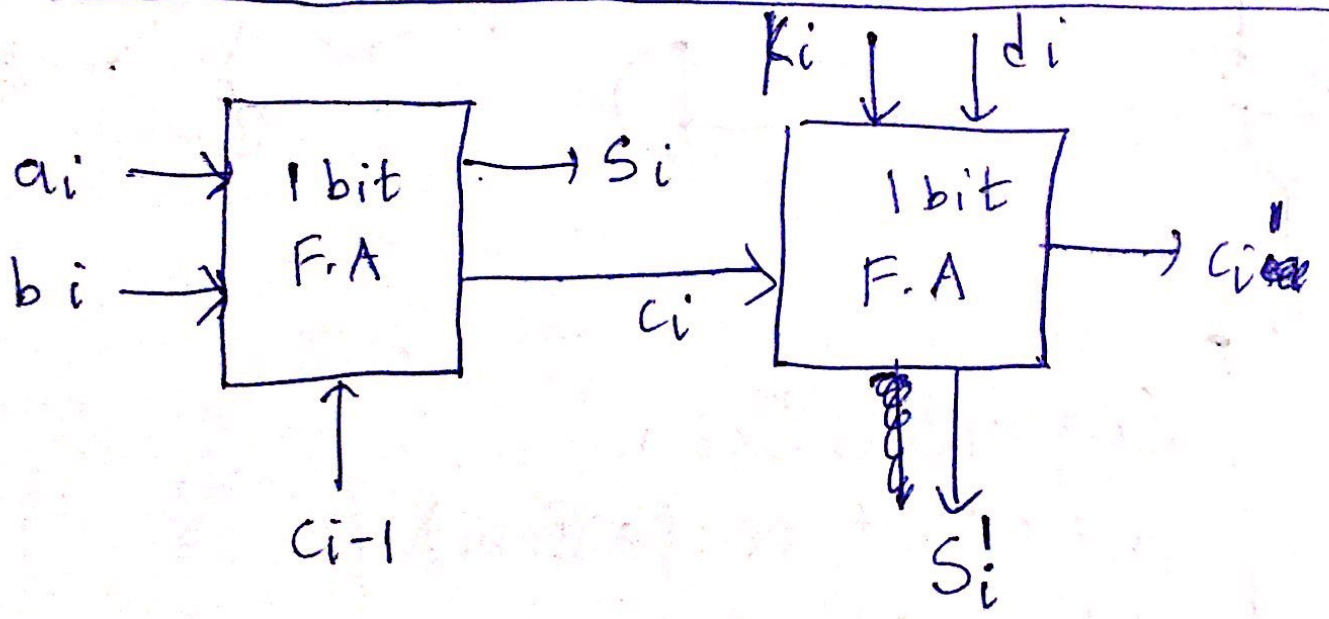
Let the 2 bit numbers be

$k_i a_i$ and $d_i b_i$

Carry input be c_{i-1}

We can cascade 2 one bit FA to make 2 bit FA



Carry output c_i'

Sum output $\boxed{s_i' s_i}$

1 bit Full Adder
Truth Table

c_{i-1}	a_i	b_i	S_i	c_i
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

---

a_ib_i \ c_{i-1}	0	1
00	0	1
01	1	0
10	1	0
11	0	1

For S_i

$$S_i = \bar{a}_i \bar{b}_i c_{i-1} + a_i b_i c_{i-1} + a_i \bar{b}_i \overline{c_{i-1}} + \bar{a}_i b_i \overline{c_{i-1}}$$

$$S_i = (a_i \oplus b_i)\overline{c_{i-1}} + \overline{(a_i \oplus b_i)}\, c_{i-1}$$

$$S_i = a_i \oplus b_i \oplus c_{i-1}$$

For c_i

$a_i b_i \rightarrow$

$c_{i-1} \downarrow$

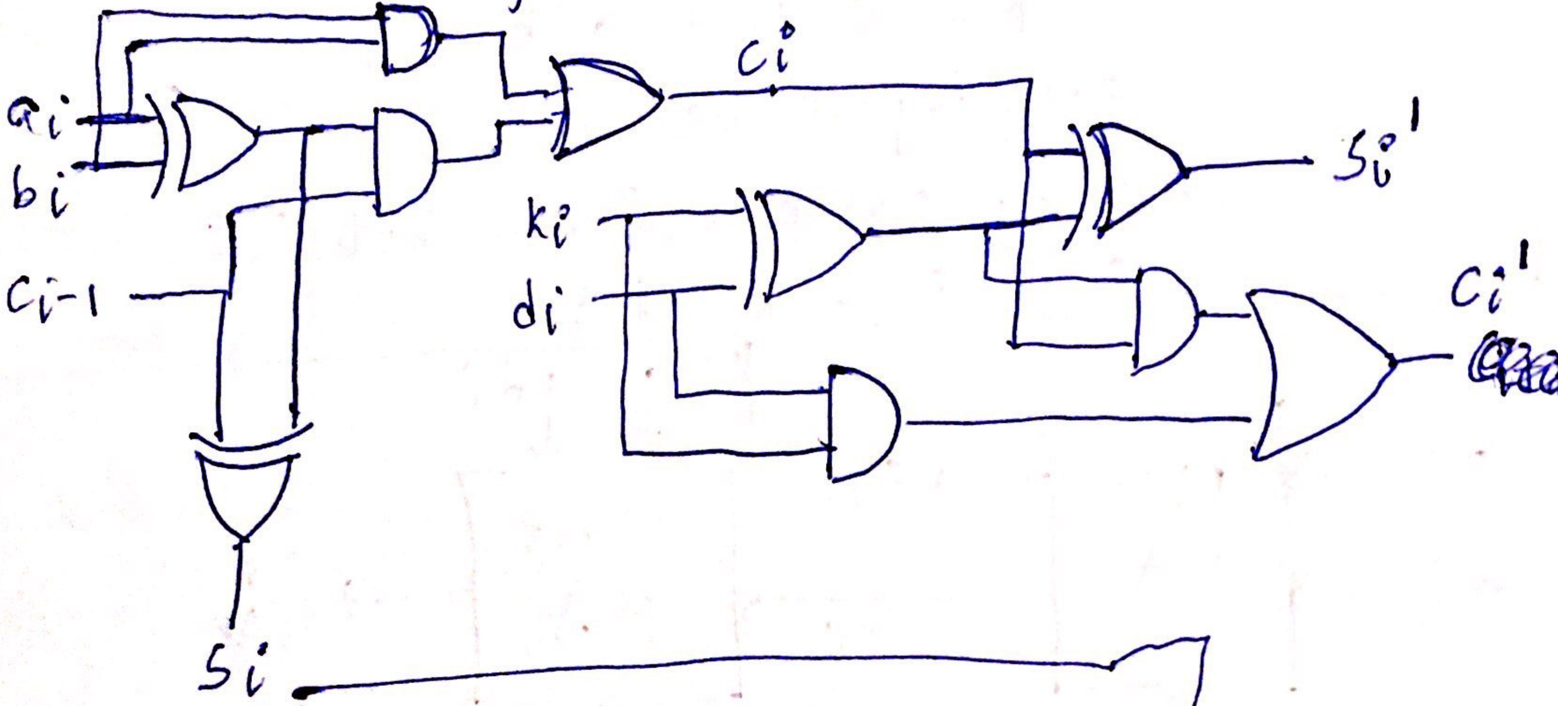
	00	01	10	11
0	0	0	0	1
1	0	1	1	1

$$c_i = a_i b_i c_{i-1} + a_i b_i \overline{c_{i-1}} + a_i \overline{b_i} c_{i-1} + \overline{a_i} b_i c_{i-1}$$

$$c_i = a_i b_i + c_{i-1}(a_i \oplus b_i)$$

We have made expressions for 1 bit FA

Now making final design



$$S_i = a_i \oplus b_i \oplus c_{i-1}$$

$$c_i = a_i b_i + c_{i-1}(a_i \oplus b_i)$$

$$S_i' = k_i \oplus d_i \oplus c_i$$

$$c_i' = k_i d_i + c_i(k_i \oplus d_i)$$