

Fall 2019
EE 4513 – Introduction to VLSI Design
Lab Assignment # 8

In this lab assignment,

1. You are required to design: (i) 64 x 64 Array Multiplier
(ii) 16-bit synchronous up/down (selectable) counter

Procedure:

In this lab assignment, I created the Verilog code for the array multiplier and the synchronous counter and ran simulations to ensure a proper output. After these steps, the process to create the Encounter schematics were straightforward as the instructions were the same as the tutorial.

(i) 64 x 64 Array Multiplier

1. The directory path (in Linux) where you worked on and created the multiplier and counter. Work on the two designs in separate directory.

Linux directory path for multiplier: /home/UTSARR/xzd304/Lab8mult64x64/

2. Simulation waveforms for your multiplier and counter

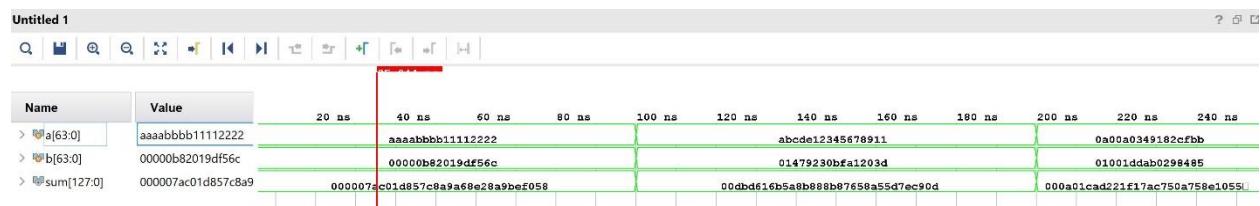


Figure 1: mult64x64 Simulation Waveform

3. Physical Layout snapshot of your design

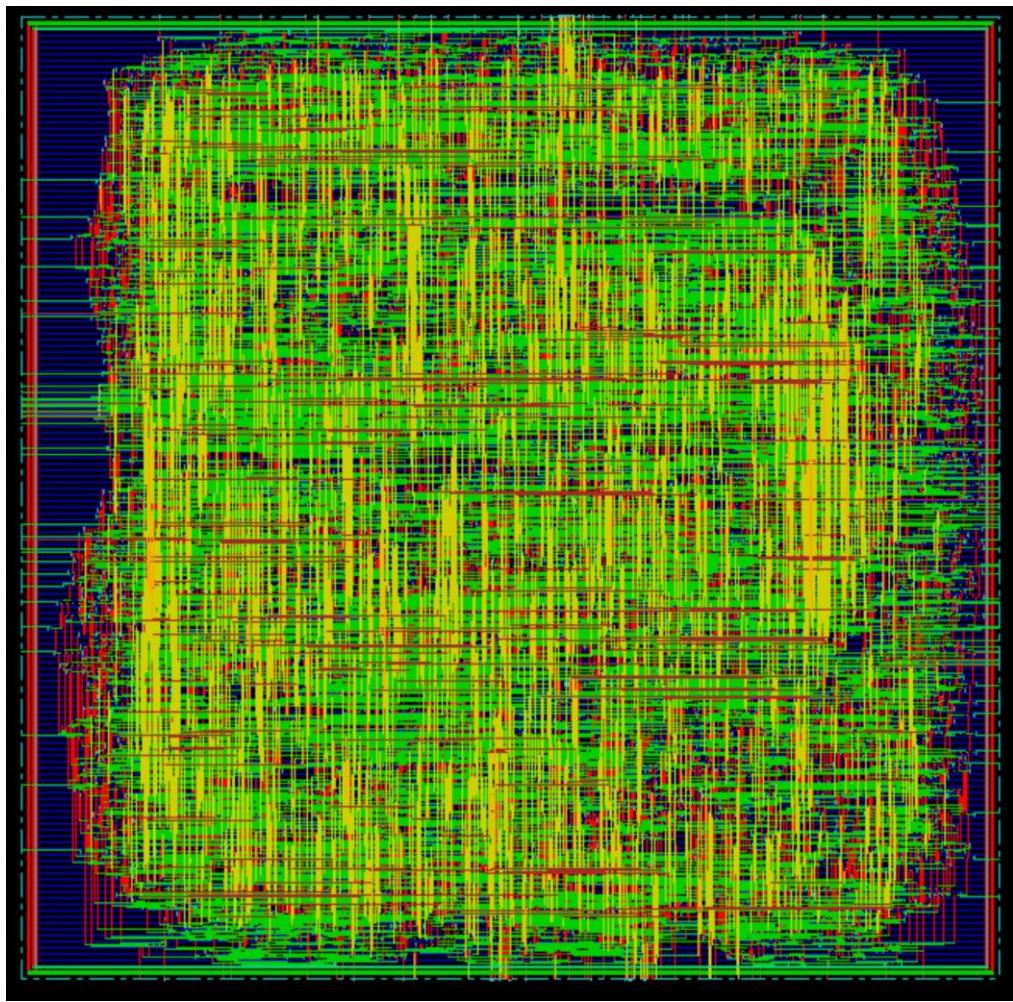


Figure 2: mult64x64 placement

4. Snapshots of portions of the connectivity and geometry verification reports, showing any violations, if present.

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Short      : 0
Overlap    : 0
End Summary

Verification Complete : 0 Viols. 0 Wrngs.

*****End: VERIFY GEOMETRY*****
*** verify geometry (CPU: 0:00:02.7 MEM: 233.9M)

encounter 1> VERIFY_CONNECTIVITY use new engine.

***** Start: VERIFY CONNECTIVITY *****
Start Time: Sun Oct 27 19:11:34 2019

Design Name: mult64x64
Database Units: 2000
Design Boundary: (0.0000, 0.0000) (792.6300, 781.1200)
Error Limit = 1000; Warning Limit = 50
Check all nets
**** 19:11:34 **** Processed 5000 nets.
**** 19:11:34 **** Processed 10000 nets.

Begin Summary
  Found no problems or warnings.
End Summary

End Time: Sun Oct 27 19:11:34 2019
Time Elapsed: 0:00:00.0

***** End: VERIFY CONNECTIVITY *****
  Verification Complete : 0 Viols. 0 Wrngs.
  (CPU Time: 0:00:00.4 MEM: 0.000M)

encounter 1>

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Figure 3: mult64x64 Connectivity

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VERIFY GEOMETRY ..... Starting Verification
VERIFY GEOMETRY ..... Initializing
VERIFY GEOMETRY ..... Deleting Existing Violations
VERIFY GEOMETRY ..... Creating Sub-Areas
..... bin size: 8320
VERIFY GEOMETRY ..... SubArea : 1 of 1
**WARN: (ENCVFG-47): Pin of Cell csa_tree_add_541_257_groupi/g205075 at (140.580, 14.7
20), (163.020, 15.520) on Layer Metall is not connected to any net. Because globalNetConn
ect or GUI Power->Connect Global Nets is not to specify global net connection rules prope
rly. Use globalNetConnect to connect the pins to nets, Type 'man globalNetConnect' for mo
re information.

VERIFY GEOMETRY ..... Cells          : 0 Viols.
VERIFY GEOMETRY ..... SameNet       : 0 Viols.
VERIFY GEOMETRY ..... Wiring        : 0 Viols.
VERIFY GEOMETRY ..... Antenna      : 0 Viols.
VERIFY GEOMETRY ..... Sub-Area : 1 complete 0 Viols. 0 Wrngs.
VG: elapsed time: 3.00
Begin Summary ...
  Cells      : 0
  SameNet    : 0
  Wiring     : 0
  Antenna   : 0
  Short      : 0
  Overlap    : 0
End Summary

Verification Complete : 0 Viols. 0 Wrngs.

*****End: VERIFY GEOMETRY*****
*** verify geometry (CPU: 0:00:02.7 MEM: 233.9M)

encounter 1>

```

Figure 4: mult64x64 Geometry

5. Schematic of your design (can be seen by clicking Tools -> Schematic Viewer)

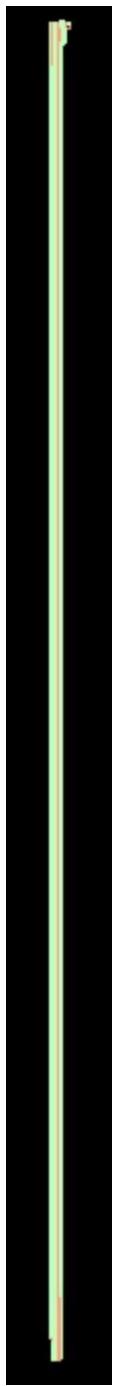


Figure 5: mult 64x64 Schematic Full View

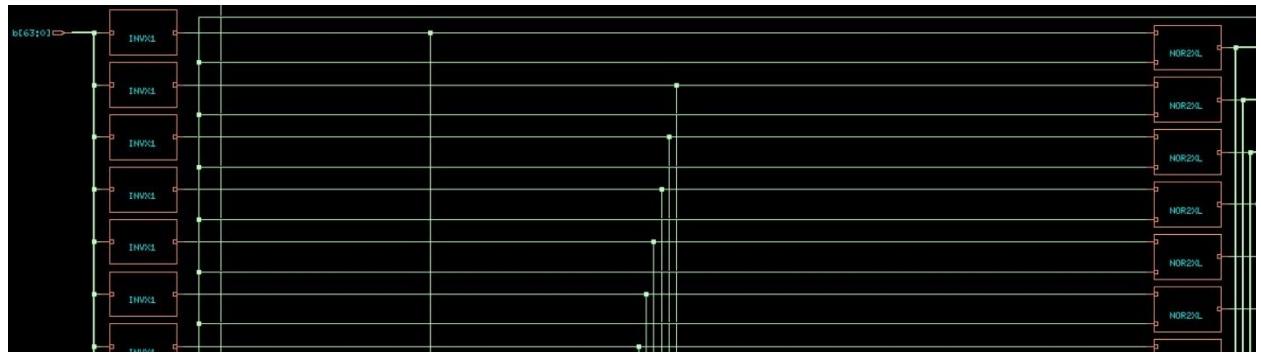


Figure 6: mult 64x64 Schematic Zoom

6. Report Your Timing Analysis (Slew, Delay, Arrival...etc) and Total Area from your RTL compiler for your design.

Mult64x64 Timing Analysis

```

1: =====
2: Generated by:          Encounter(R) RTL Compiler RC13.12 - v13.10-s021_1
3: Generated on:          Oct 27 2019 06:41:40 pm
4: Module:                mult64x64
5: Technology library:   tsmc18 1.0
6: Operating conditions: slow (balanced_tree)
7: Wireload mode:        enclosed
8: Area mode:            timing library
9: =====
10:
11:    Pin      Type     Fanout   Load Slew Delay Arrival
12:           (fF)   (ps)   (ps)   (ps)
13: -----
14: b[4]       in port    1  3.5   0  +0   0 F
15: g33080/A
16: g33080/Y     INVX1     64 204.8 2511 +1384  1384 R
17: g30035/A
18: g30035/Y     NOR2XL    1  6.8   406 +153  1537 F
19: csa_tree_add_541_257_groupi/in_59[4]
20: g203118/B
21: g203118/CO    ADDFX2    1  4.4   140 +595  2132 F
22: g204762/D
23: g204762/S    CMPR42X1   1  6.9   128 +786  2917 F
24: g3147/A
25: g3147/CO    ADDFX2    1  2.7   134 +483  3400 F
26: g205110/ICI
27: g205110/CO    CMPR42X1   1  2.7   100 +310  3710 F
28: g205109/ICI
29: g205109/CO    CMPR42X1   1  6.2   124 +325  4035 F
30: g3144/CI
31: g3144/CO    ADDFX2    1  2.7   134 +330  4365 F
32: g205108/ICI
33: g205108/CO    CMPR42X1   1  2.7   100 +310  4675 F
34: g205107/ICI
35: g205107/CO    CMPR42X1   1  6.2   124 +325  5000 F
36: g3141/CI
37: g3141/CO    ADDFX2    1  6.2   145 +343  5343 F
38: g3140/CI
39: g3140/CO    ADDFX2    1  2.7   134 +335  5678 F
40: g205106/ICI
41: g205106/CO    CMPR42X1   1  2.7   100 +310  5989 F
42: g205105/ICI
43: g205105/CO    CMPR42X1   1  2.7   100 +301  6290 F
44: g205104/ICI
45: g205104/CO    CMPR42X1   1  2.7   100 +301  6590 F
46: g205103/ICI
47: g205103/CO    CMPR42X1   1  2.7   100 +301  6891 F
48: g205102/ICI
49: g205102/CO    CMPR42X1   1  6.2   124 +325  7216 F
50: g3134/CI
51: g3134/CO    ADDFX2    1  2.7   134 +330  7546 F
52: g205101/ICI
53: g205101/CO    CMPR42X1   1  2.7   100 +310  7856 F
54: g205100/ICI
55: g205100/CO    CMPR42X1   1  2.7   100 +301  8157 F
56: g205099/ICI
57: g205099/CO    CMPR42X1   1  2.7   100 +301  8458 F

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58:	g205098/ICI					+0	8458
59:	g205098/CO	CMPR42X1	1	6.2	124	+325	8783 F
60:	g3129/CI					+0	8783
61:	g3129/CO	ADDFX2	1	2.7	134	+330	9113 F
62:	g205097/ICI					+0	9113
63:	g205097/CO	CMPR42X1	1	2.7	100	+310	9423 F
64:	g205096/ICI					+0	9423
65:	g205096/CO	CMPR42X1	1	2.7	100	+301	9724 F
66:	g205095/ICI					+0	9724
67:	g205095/CO	CMPR42X1	1	2.7	100	+301	10025 F
68:	g205094/ICI					+0	10025
69:	g205094/CO	CMPR42X1	1	2.7	100	+301	10326 F
70:	g205093/ICI					+0	10326
71:	g205093/CO	CMPR42X1	1	2.7	100	+301	10627 F
72:	g205092/ICI					+0	10627
73:	g205092/CO	CMPR42X1	1	2.7	100	+301	10928 F
74:	g205091/ICI					+0	10928
75:	g205091/CO	CMPR42X1	1	2.7	100	+301	11228 F
76:	g205090/ICI					+0	11228
77:	g205090/CO	CMPR42X1	1	2.7	100	+301	11529 F
78:	g205089/ICI					+0	11529
79:	g205089/CO	CMPR42X1	1	2.7	100	+301	11830 F
80:	g205088/ICI					+0	11830
81:	g205088/CO	CMPR42X1	1	2.7	100	+301	12131 F
82:	g205087/ICI					+0	12131
83:	g205087/CO	CMPR42X1	1	2.7	100	+301	12432 F
84:	g205086/ICI					+0	12432
85:	g205086/CO	CMPR42X1	1	6.2	124	+325	12757 F
86:	g3116/CI					+0	12757
87:	g3116/CO	ADDFX2	1	2.7	134	+330	13087 F
88:	g205085/ICI					+0	13087
89:	g205085/CO	CMPR42X1	1	2.7	100	+310	13397 F
90:	g205084/ICI					+0	13397
91:	g205084/CO	CMPR42X1	1	2.7	100	+301	13698 F
92:	g205083/ICI					+0	13698
93:	g205083/CO	CMPR42X1	1	2.7	100	+301	13999 F
94:	g205082/ICI					+0	13999
95:	g205082/CO	CMPR42X1	1	2.7	100	+301	14300 F
96:	g205081/ICI					+0	14300
97:	g205081/CO	CMPR42X1	1	2.7	100	+301	14601 F
98:	g205080/ICI					+0	14601
99:	g205080/CO	CMPR42X1	1	2.7	100	+301	14902 F
100:	g205079/ICI					+0	14902
101:	g205079/CO	CMPR42X1	1	2.7	100	+301	15202 F
102:	g205078/ICI					+0	15202
103:	g205078/CO	CMPR42X1	1	2.7	100	+301	15503 F
104:	g205077/ICI					+0	15503
105:	g205077/CO	CMPR42X1	1	2.7	100	+301	15804 F
106:	g205076/ICI					+0	15804
107:	g205076/CO	CMPR42X1	1	2.7	100	+301	16105 F
108:	g205075/ICI					+0	16105
109:	g205075/CO	CMPR42X1	1	2.7	100	+301	16406 F
110:	g205074/ICI					+0	16406
111:	g205074/CO	CMPR42X1	1	2.7	100	+301	16707 F
112:	g205073/ICI					+0	16707
113:	g205073/CO	CMPR42X1	1	2.7	100	+301	17008 F
114:	g205072/ICI					+0	17008

115:	g205072/CO	CMPR42X1	1	2.7	100	+301	17309	F
116:	g205071/ICI					+0	17309	
117:	g205071/CO	CMPR42X1	1	2.7	100	+301	17610	F
118:	g205070/ICI					+0	17610	
119:	g205070/CO	CMPR42X1	1	6.2	124	+325	17935	F
120:	g3099/CI					+0	17935	
121:	g3099/CO	ADDFX2	1	2.7	134	+330	18264	F
122:	g205069/ICI					+0	18264	
123:	g205069/CO	CMPR42X1	1	6.2	124	+334	18599	F
124:	g3097/CI					+0	18599	
125:	g3097/CO	ADDFX2	1	6.2	145	+343	18942	F
126:	g3096/CI					+0	18942	
127:	g3096/CO	ADDFX2	1	2.7	134	+335	19277	F
128:	g205068/ICI					+0	19277	
129:	g205068/CO	CMPR42X1	1	6.2	124	+334	19612	F
130:	g3094/CI					+0	19612	
131:	g3094/CO	ADDFX2	1	2.7	134	+330	19942	F
132:	g205067/ICI					+0	19942	
133:	g205067/CO	CMPR42X1	1	6.2	124	+334	20276	F
134:	g3092/CI					+0	20276	
135:	g3092/CO	ADDFX2	1	2.7	134	+330	20606	F
136:	g205066/ICI					+0	20606	
137:	g205066/CO	CMPR42X1	1	2.7	100	+310	20916	F
138:	g205065/ICI					+0	20916	
139:	g205065/CO	CMPR42X1	1	2.7	100	+301	21217	F
140:	g205064/ICI					+0	21217	
141:	g205064/CO	CMPR42X1	1	2.7	100	+301	21518	F
142:	g205063/ICI					+0	21518	
143:	g205063/CO	CMPR42X1	1	2.7	100	+301	21819	F
144:	g205062/ICI					+0	21819	
145:	g205062/CO	CMPR42X1	1	2.7	100	+301	22120	F
146:	g205061/ICI					+0	22120	
147:	g205061/CO	CMPR42X1	1	2.7	100	+301	22420	F
148:	g205060/ICI					+0	22420	
149:	g205060/CO	CMPR42X1	1	6.2	124	+325	22745	F
150:	g3084/CI					+0	22745	
151:	g3084/CO	ADDFX2	1	2.7	134	+330	23075	F
152:	g205059/ICI					+0	23075	
153:	g205059/CO	CMPR42X1	1	2.7	100	+310	23385	F
154:	g205058/ICI					+0	23385	
155:	g205058/CO	CMPR42X1	1	2.7	100	+301	23686	F
156:	g205057/ICI					+0	23686	
157:	g205057/CO	CMPR42X1	1	2.7	100	+301	23987	F
158:	g205056/ICI					+0	23987	
159:	g205056/CO	CMPR42X1	1	2.7	100	+301	24288	F
160:	g205055/ICI					+0	24288	
161:	g205055/CO	CMPR42X1	1	2.7	100	+301	24589	F
162:	g205054/ICI					+0	24589	
163:	g205054/CO	CMPR42X1	1	2.7	100	+301	24890	F
164:	g205053/ICI					+0	24890	
165:	g205053/CO	CMPR42X1	1	2.7	100	+301	25191	F
166:	g205052/ICI					+0	25191	
167:	g205052/CO	CMPR42X1	1	2.7	100	+301	25492	F
168:	g205051/ICI					+0	25492	
169:	g205051/CO	CMPR42X1	1	2.7	100	+301	25793	F
170:	g205050/ICI					+0	25793	
171:	g205050/CO	CMPR42X1	1	6.2	124	+325	26118	F

172:	g3073/CI				+0	26118	
173:	g3073/CO	ADDFX2	1	6.2	145	+343	26461 F
174:	g3072/CI				+0	26461	
175:	g3072/CO	ADDFX2	1	6.2	145	+349	26809 F
176:	g3071/CI				+0	26809	
177:	g3071/CO	ADDFX2	1	2.7	134	+335	27145 F
178:	g205049/ICI				+0	27145	
179:	g205049/CO	CMPR42X1	1	2.7	100	+310	27455 F
180:	g205048/ICI				+0	27455	
181:	g205048/CO	CMPR42X1	1	2.7	100	+301	27756 F
182:	g205047/ICI				+0	27756	
183:	g205047/CO	CMPR42X1	1	2.7	100	+301	28057 F
184:	g205046/ICI				+0	28057	
185:	g205046/CO	CMPR42X1	1	2.7	100	+301	28358 F
186:	g205045/ICI				+0	28358	
187:	g205045/CO	CMPR42X1	1	2.7	100	+301	28658 F
188:	g205044/ICI				+0	28658	
189:	g205044/CO	CMPR42X1	1	2.7	100	+301	28959 F
190:	g205043/ICI				+0	28959	
191:	g205043/CO	CMPR42X1	1	2.7	100	+301	29260 F
192:	g205042/ICI				+0	29260	
193:	g205042/CO	CMPR42X1	1	6.2	124	+325	29585 F
194:	g3062/CI				+0	29585	
195:	g3062/CO	ADDFX2	1	6.2	145	+343	29928 F
196:	g3061/CI				+0	29928	
197:	g3061/CO	ADDFX2	1	2.7	134	+335	30264 F
198:	g205041/ICI				+0	30264	
199:	g205041/CO	CMPR42X1	1	2.7	100	+310	30574 F
200:	g205040/ICI				+0	30574	
201:	g205040/CO	CMPR42X1	1	6.2	124	+325	30899 F
202:	g3058/CI				+0	30899	
203:	g3058/CO	ADDFX2	1	6.2	145	+343	31242 F
204:	g3057/CI				+0	31242	
205:	g3057/CO	ADDFX2	1	2.7	134	+335	31577 F
206:	g205039/ICI				+0	31577	
207:	g205039/CO	CMPR42X1	1	2.7	100	+310	31888 F
208:	g205038/ICI				+0	31888	
209:	g205038/CO	CMPR42X1	1	6.2	124	+325	32212 F
210:	g3054/CI				+0	32212	
211:	g3054/CO	ADDFX2	1	6.2	145	+343	32556 F
212:	g3053/CI				+0	32556	
213:	g3053/CO	ADDFX2	1	6.2	145	+349	32904 F
214:	g3052/CI				+0	32904	
215:	g3052/CO	ADDFX2	1	2.7	134	+335	33240 F
216:	g205037/ICI				+0	33240	
217:	g205037/CO	CMPR42X1	1	2.7	100	+310	33550 F
218:	g205036/ICI				+0	33550	
219:	g205036/CO	CMPR42X1	1	2.7	100	+301	33851 F
220:	g205035/ICI				+0	33851	
221:	g205035/CO	CMPR42X1	1	6.2	124	+325	34176 F
222:	g3048/CI				+0	34176	
223:	g3048/CO	ADDFX2	1	6.2	145	+343	34519 F
224:	g3047/CI				+0	34519	
225:	g3047/CO	ADDFX2	1	6.2	145	+349	34867 F
226:	g3046/CI				+0	34867	
227:	g3046/CO	ADDFX2	1	2.7	134	+335	35203 F
228:	g205034/ICI				+0	35203	

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229: g205034/CO    CMPR42X1      1   2.7  100  +310  35513 F
230: g205033/ICI
231: g205033/CO    CMPR42X1      1   6.2  124  +325  35838 F
232: g3043/CI
233: g3043/CO    ADDFX2       1   6.2  145  +343  36181 F
234: g3042/CI
235: g3042/CO    ADDFX2       1   2.7  134  +335  36516 F
236: g205032/ICI
237: g205032/CO    CMPR42X1      1   2.7  100  +310  36826 F
238: g205031/ICI
239: g205031/CO    CMPR42X1      1   2.7  100  +301  37127 F
240: g205030/ICI
241: g205030/CO    CMPR42X1      1   6.2  124  +325  37452 F
242: g3038/CI
243: g3038/CO    ADDFX2       1   6.2  145  +343  37795 F
244: g3037/CI
245: g3037/CO    ADDFX2       1   6.2  145  +349  38144 F
246: g3036/CI
247: g3036/CO    ADDFX2       1   6.2  145  +349  38493 F
248: g3035/CI
249: g3035/CO    ADDFX2       1   6.2  145  +349  38841 F
250: g3034/CI
251: g3034/CO    ADDFX2       1   6.2  145  +349  39190 F
252: g3033/CI
253: g3033/CO    ADDFX2       1   6.2  145  +349  39538 F
254: g3032/CI
255: g3032/CO    ADDFX2       1   6.2  145  +349  39887 F
256: g3031/CI
257: g3031/CO    ADDFX2       1   6.2  145  +349  40236 F
258: g3030/CI
259: g3030/CO    ADDFX2       1   6.2  145  +349  40584 F
260: g3029/CI
261: g3029/CO    ADDFX2       1   6.2  145  +349  40933 F
262: g3028/CI
263: g3028/CO    ADDFX2       1   6.2  145  +349  41281 F
264: g3027/CI
265: g3027/CO    ADDFX2       1   6.2  145  +349  41630 F
266: g3026/CI
267: g3026/S     ADDFXL        1   0.0   74   +292  41922 R
268: csa_tree_add_541_257_groupi/out_0[126]
269: sum[126]          out port           +0   41922 R
270: -----
271: Timing slack : UNCONSTRAINED
272: Start-point : b[4]
273: End-point   : sum[126]
274: =====
275: Generated by:      Encounter(R) RTL Compiler RC13.12 - v13.10-s021_1
276: Generated on:      Oct 27 2019 06:45:30 pm
277: Module:            mult64x64
278: Technology library: tsmc18 1.0
279: Operating conditions: slow (balanced_tree)
280: Wireload mode:      enclosed
281: Area mode:         timing library
282: =====
283:
284:     Pin          Type     Fanout  Load Slew Delay Arrival
285:                  (fF)   (ps)   (ps)   (ps)

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286: -----

287: b[4]	in port	1	3.5	0	+0	0	F
288: g33080/A					+0	0	
289: g33080/Y	INVX1	64	204.8	2511	+1384	1384	R
290: g30035/A					+0	1384	
291: g30035/Y	NOR2XL	1	6.8	406	+153	1537	F
292: csa_tree_add_541_257_groupi/in_59[4]							
293: g203118/B					+0	1537	
294: g203118/CO	ADDFX2	1	4.4	140	+595	2132	F
295: g204762/D					+0	2132	
296: g204762/S	CMPR42X1	1	6.9	128	+786	2917	F
297: g3147/A					+0	2917	
298: g3147/CO	ADDFX2	1	2.7	134	+483	3400	F
299: g205110/ICI					+0	3400	
300: g205110/CO	CMPR42X1	1	2.7	100	+310	3710	F
301: g205109/ICI					+0	3710	
302: g205109/CO	CMPR42X1	1	6.2	124	+325	4035	F
303: g3144/CI					+0	4035	
304: g3144/CO	ADDFX2	1	2.7	134	+330	4365	F
305: g205108/ICI					+0	4365	
306: g205108/CO	CMPR42X1	1	2.7	100	+310	4675	F
307: g205107/ICI					+0	4675	
308: g205107/CO	CMPR42X1	1	6.2	124	+325	5000	F
309: g3141/CI					+0	5000	
310: g3141/CO	ADDFX2	1	6.2	145	+343	5343	F
311: g3140/CI					+0	5343	
312: g3140/CO	ADDFX2	1	2.7	134	+335	5678	F
313: g205106/ICI					+0	5678	
314: g205106/CO	CMPR42X1	1	2.7	100	+310	5989	F
315: g205105/ICI					+0	5989	
316: g205105/CO	CMPR42X1	1	2.7	100	+301	6290	F
317: g205104/ICI					+0	6290	
318: g205104/CO	CMPR42X1	1	2.7	100	+301	6590	F
319: g205103/ICI					+0	6590	
320: g205103/CO	CMPR42X1	1	2.7	100	+301	6891	F
321: g205102/ICI					+0	6891	
322: g205102/CO	CMPR42X1	1	6.2	124	+325	7216	F
323: g3134/CI					+0	7216	
324: g3134/CO	ADDFX2	1	2.7	134	+330	7546	F
325: g205101/ICI					+0	7546	
326: g205101/CO	CMPR42X1	1	2.7	100	+310	7856	F
327: g205100/ICI					+0	7856	
328: g205100/CO	CMPR42X1	1	2.7	100	+301	8157	F
329: g205099/ICI					+0	8157	
330: g205099/CO	CMPR42X1	1	2.7	100	+301	8458	F
331: g205098/ICI					+0	8458	
332: g205098/CO	CMPR42X1	1	6.2	124	+325	8783	F
333: g3129/CI					+0	8783	
334: g3129/CO	ADDFX2	1	2.7	134	+330	9113	F
335: g205097/ICI					+0	9113	
336: g205097/CO	CMPR42X1	1	2.7	100	+310	9423	F
337: g205096/ICI					+0	9423	
338: g205096/CO	CMPR42X1	1	2.7	100	+301	9724	F
339: g205095/ICI					+0	9724	
340: g205095/CO	CMPR42X1	1	2.7	100	+301	10025	F
341: g205094/ICI					+0	10025	
342: g205094/CO	CMPR42X1	1	2.7	100	+301	10326	F

343:	g205093/ICI					+0	10326
344:	g205093/CO	CMPR42X1	1	2.7	100	+301	10627 F
345:	g205092/ICI					+0	10627
346:	g205092/CO	CMPR42X1	1	2.7	100	+301	10928 F
347:	g205091/ICI					+0	10928
348:	g205091/CO	CMPR42X1	1	2.7	100	+301	11228 F
349:	g205090/ICI					+0	11228
350:	g205090/CO	CMPR42X1	1	2.7	100	+301	11529 F
351:	g205089/ICI					+0	11529
352:	g205089/CO	CMPR42X1	1	2.7	100	+301	11830 F
353:	g205088/ICI					+0	11830
354:	g205088/CO	CMPR42X1	1	2.7	100	+301	12131 F
355:	g205087/ICI					+0	12131
356:	g205087/CO	CMPR42X1	1	2.7	100	+301	12432 F
357:	g205086/ICI					+0	12432
358:	g205086/CO	CMPR42X1	1	6.2	124	+325	12757 F
359:	g3116/CI					+0	12757
360:	g3116/CO	ADDFX2	1	2.7	134	+330	13087 F
361:	g205085/ICI					+0	13087
362:	g205085/CO	CMPR42X1	1	2.7	100	+310	13397 F
363:	g205084/ICI					+0	13397
364:	g205084/CO	CMPR42X1	1	2.7	100	+301	13698 F
365:	g205083/ICI					+0	13698
366:	g205083/CO	CMPR42X1	1	2.7	100	+301	13999 F
367:	g205082/ICI					+0	13999
368:	g205082/CO	CMPR42X1	1	2.7	100	+301	14300 F
369:	g205081/ICI					+0	14300
370:	g205081/CO	CMPR42X1	1	2.7	100	+301	14601 F
371:	g205080/ICI					+0	14601
372:	g205080/CO	CMPR42X1	1	2.7	100	+301	14902 F
373:	g205079/ICI					+0	14902
374:	g205079/CO	CMPR42X1	1	2.7	100	+301	15202 F
375:	g205078/ICI					+0	15202
376:	g205078/CO	CMPR42X1	1	2.7	100	+301	15503 F
377:	g205077/ICI					+0	15503
378:	g205077/CO	CMPR42X1	1	2.7	100	+301	15804 F
379:	g205076/ICI					+0	15804
380:	g205076/CO	CMPR42X1	1	2.7	100	+301	16105 F
381:	g205075/ICI					+0	16105
382:	g205075/CO	CMPR42X1	1	2.7	100	+301	16406 F
383:	g205074/ICI					+0	16406
384:	g205074/CO	CMPR42X1	1	2.7	100	+301	16707 F
385:	g205073/ICI					+0	16707
386:	g205073/CO	CMPR42X1	1	2.7	100	+301	17008 F
387:	g205072/ICI					+0	17008
388:	g205072/CO	CMPR42X1	1	2.7	100	+301	17309 F
389:	g205071/ICI					+0	17309
390:	g205071/CO	CMPR42X1	1	2.7	100	+301	17610 F
391:	g205070/ICI					+0	17610
392:	g205070/CO	CMPR42X1	1	6.2	124	+325	17935 F
393:	g3099/CI					+0	17935
394:	g3099/CO	ADDFX2	1	2.7	134	+330	18264 F
395:	g205069/ICI					+0	18264
396:	g205069/CO	CMPR42X1	1	6.2	124	+334	18599 F
397:	g3097/CI					+0	18599
398:	g3097/CO	ADDFX2	1	6.2	145	+343	18942 F
399:	g3096/CI					+0	18942

400:	g3096/CO	ADDFX2	1	2.7	134	+335	19277	F
401:	g205068/ICI					+0	19277	
402:	g205068/CO	CMPR42X1	1	6.2	124	+334	19612	F
403:	g3094/CI					+0	19612	
404:	g3094/CO	ADDFX2	1	2.7	134	+330	19942	F
405:	g205067/ICI					+0	19942	
406:	g205067/CO	CMPR42X1	1	6.2	124	+334	20276	F
407:	g3092/CI					+0	20276	
408:	g3092/CO	ADDFX2	1	2.7	134	+330	20606	F
409:	g205066/ICI					+0	20606	
410:	g205066/CO	CMPR42X1	1	2.7	100	+310	20916	F
411:	g205065/ICI					+0	20916	
412:	g205065/CO	CMPR42X1	1	2.7	100	+301	21217	F
413:	g205064/ICI					+0	21217	
414:	g205064/CO	CMPR42X1	1	2.7	100	+301	21518	F
415:	g205063/ICI					+0	21518	
416:	g205063/CO	CMPR42X1	1	2.7	100	+301	21819	F
417:	g205062/ICI					+0	21819	
418:	g205062/CO	CMPR42X1	1	2.7	100	+301	22120	F
419:	g205061/ICI					+0	22120	
420:	g205061/CO	CMPR42X1	1	2.7	100	+301	22420	F
421:	g205060/ICI					+0	22420	
422:	g205060/CO	CMPR42X1	1	6.2	124	+325	22745	F
423:	g3084/CI					+0	22745	
424:	g3084/CO	ADDFX2	1	2.7	134	+330	23075	F
425:	g205059/ICI					+0	23075	
426:	g205059/CO	CMPR42X1	1	2.7	100	+310	23385	F
427:	g205058/ICI					+0	23385	
428:	g205058/CO	CMPR42X1	1	2.7	100	+301	23686	F
429:	g205057/ICI					+0	23686	
430:	g205057/CO	CMPR42X1	1	2.7	100	+301	23987	F
431:	g205056/ICI					+0	23987	
432:	g205056/CO	CMPR42X1	1	2.7	100	+301	24288	F
433:	g205055/ICI					+0	24288	
434:	g205055/CO	CMPR42X1	1	2.7	100	+301	24589	F
435:	g205054/ICI					+0	24589	
436:	g205054/CO	CMPR42X1	1	2.7	100	+301	24890	F
437:	g205053/ICI					+0	24890	
438:	g205053/CO	CMPR42X1	1	2.7	100	+301	25191	F
439:	g205052/ICI					+0	25191	
440:	g205052/CO	CMPR42X1	1	2.7	100	+301	25492	F
441:	g205051/ICI					+0	25492	
442:	g205051/CO	CMPR42X1	1	2.7	100	+301	25793	F
443:	g205050/ICI					+0	25793	
444:	g205050/CO	CMPR42X1	1	6.2	124	+325	26118	F
445:	g3073/CI					+0	26118	
446:	g3073/CO	ADDFX2	1	6.2	145	+343	26461	F
447:	g3072/CI					+0	26461	
448:	g3072/CO	ADDFX2	1	6.2	145	+349	26809	F
449:	g3071/CI					+0	26809	
450:	g3071/CO	ADDFX2	1	2.7	134	+335	27145	F
451:	g205049/ICI					+0	27145	
452:	g205049/CO	CMPR42X1	1	2.7	100	+310	27455	F
453:	g205048/ICI					+0	27455	
454:	g205048/CO	CMPR42X1	1	2.7	100	+301	27756	F
455:	g205047/ICI					+0	27756	
456:	g205047/CO	CMPR42X1	1	2.7	100	+301	28057	F

457:	g205046/ICI					+0	28057
458:	g205046/CO	CMPR42X1	1	2.7	100	+301	28358 F
459:	g205045/ICI					+0	28358
460:	g205045/CO	CMPR42X1	1	2.7	100	+301	28658 F
461:	g205044/ICI					+0	28658
462:	g205044/CO	CMPR42X1	1	2.7	100	+301	28959 F
463:	g205043/ICI					+0	28959
464:	g205043/CO	CMPR42X1	1	2.7	100	+301	29260 F
465:	g205042/ICI					+0	29260
466:	g205042/CO	CMPR42X1	1	6.2	124	+325	29585 F
467:	g3062/CI					+0	29585
468:	g3062/CO	ADDFX2	1	6.2	145	+343	29928 F
469:	g3061/CI					+0	29928
470:	g3061/CO	ADDFX2	1	2.7	134	+335	30264 F
471:	g205041/ICI					+0	30264
472:	g205041/CO	CMPR42X1	1	2.7	100	+310	30574 F
473:	g205040/ICI					+0	30574
474:	g205040/CO	CMPR42X1	1	6.2	124	+325	30899 F
475:	g3058/CI					+0	30899
476:	g3058/CO	ADDFX2	1	6.2	145	+343	31242 F
477:	g3057/CI					+0	31242
478:	g3057/CO	ADDFX2	1	2.7	134	+335	31577 F
479:	g205039/ICI					+0	31577
480:	g205039/CO	CMPR42X1	1	2.7	100	+310	31888 F
481:	g205038/ICI					+0	31888
482:	g205038/CO	CMPR42X1	1	6.2	124	+325	32212 F
483:	g3054/CI					+0	32212
484:	g3054/CO	ADDFX2	1	6.2	145	+343	32556 F
485:	g3053/CI					+0	32556
486:	g3053/CO	ADDFX2	1	6.2	145	+349	32904 F
487:	g3052/CI					+0	32904
488:	g3052/CO	ADDFX2	1	2.7	134	+335	33240 F
489:	g205037/ICI					+0	33240
490:	g205037/CO	CMPR42X1	1	2.7	100	+310	33550 F
491:	g205036/ICI					+0	33550
492:	g205036/CO	CMPR42X1	1	2.7	100	+301	33851 F
493:	g205035/ICI					+0	33851
494:	g205035/CO	CMPR42X1	1	6.2	124	+325	34176 F
495:	g3048/CI					+0	34176
496:	g3048/CO	ADDFX2	1	6.2	145	+343	34519 F
497:	g3047/CI					+0	34519
498:	g3047/CO	ADDFX2	1	6.2	145	+349	34867 F
499:	g3046/CI					+0	34867
500:	g3046/CO	ADDFX2	1	2.7	134	+335	35203 F
501:	g205034/ICI					+0	35203
502:	g205034/CO	CMPR42X1	1	2.7	100	+310	35513 F
503:	g205033/ICI					+0	35513
504:	g205033/CO	CMPR42X1	1	6.2	124	+325	35838 F
505:	g3043/CI					+0	35838
506:	g3043/CO	ADDFX2	1	6.2	145	+343	36181 F
507:	g3042/CI					+0	36181
508:	g3042/CO	ADDFX2	1	2.7	134	+335	36516 F
509:	g205032/ICI					+0	36516
510:	g205032/CO	CMPR42X1	1	2.7	100	+310	36826 F
511:	g205031/ICI					+0	36826
512:	g205031/CO	CMPR42X1	1	2.7	100	+301	37127 F
513:	g205030/ICI					+0	37127

```

514: g205030/CO    CMPR42X1      1   6.2  124  +325  37452 F
515: g3038/CI
516: g3038/CO    ADDFX2       1   6.2  145  +343  37795 F
517: g3037/CI
518: g3037/CO    ADDFX2       1   6.2  145  +349  38144 F
519: g3036/CI
520: g3036/CO    ADDFX2       1   6.2  145  +349  38493 F
521: g3035/CI
522: g3035/CO    ADDFX2       1   6.2  145  +349  38841 F
523: g3034/CI
524: g3034/CO    ADDFX2       1   6.2  145  +349  39190 F
525: g3033/CI
526: g3033/CO    ADDFX2       1   6.2  145  +349  39538 F
527: g3032/CI
528: g3032/CO    ADDFX2       1   6.2  145  +349  39887 F
529: g3031/CI
530: g3031/CO    ADDFX2       1   6.2  145  +349  40236 F
531: g3030/CI
532: g3030/CO    ADDFX2       1   6.2  145  +349  40584 F
533: g3029/CI
534: g3029/CO    ADDFX2       1   6.2  145  +349  40933 F
535: g3028/CI
536: g3028/CO    ADDFX2       1   6.2  145  +349  41281 F
537: g3027/CI
538: g3027/CO    ADDFX2       1   6.2  145  +349  41630 F
539: g3026/CI
540: g3026/S     ADDFXL        1   0.0   74   +292  41922 R
541: csa_tree_add_541_257_group1/out_0[126]
542: sum[126]          out port      +0  41922 R
543: -----
544: Timing slack : UNCONSTRAINED
545: Start-point : b[4]
546: End-point   : sum[126]
547:

```

Figure 7: mult64x64 Timing Analysis

7. Snapshot of the message showing successful generation of GDS2 layout

```

Stream Out Information Processed for GDS version 3:
Units: 2000 DBU

Object           Count
-----
Instances        7224
Ports/Pins       0
Nets             0
    Via Instances 62373
Special Nets     0
    Via Instances 489
Metal Fills      0
    Via Instances 0
Metal FillOPCs   0
    Via Instances 0
Text             0
Blockages        0
Custom Text       0
Custom Box        0

**WARN: (ENCOGDS-1176): There are 7 empty cells. Check encounter.log# for the details.
It is probably because your mapping file does not contain corresponding rules.
Use default mapping file(without option -mapFile) to output all information of a cell.
#####Streamout is finished!
encounter l> SGN Version 10.10-p118 (18-Jul-2013) (64 bit executable)
Loading TOP (mult64x64)
*** End open schematic (cpu=0:00:00.2, mem=1012.5M (15.0M)) ***

```

Figure 8: mult64x64 GDS

(ii) 16-bit synchronous up/down (selectable) counter

1. The directory path (in Linux) where you worked on and created the multiplier and counter. Work on the two designs in separate directory.

The Linux directory path of the counter file is: /home/UTSARR/xzd304/Lab8counter/

2. Simulation waveforms for your multiplier and counter



Figure 9: counter Simulation Waveform

3. Physical Layout snapshot of your design

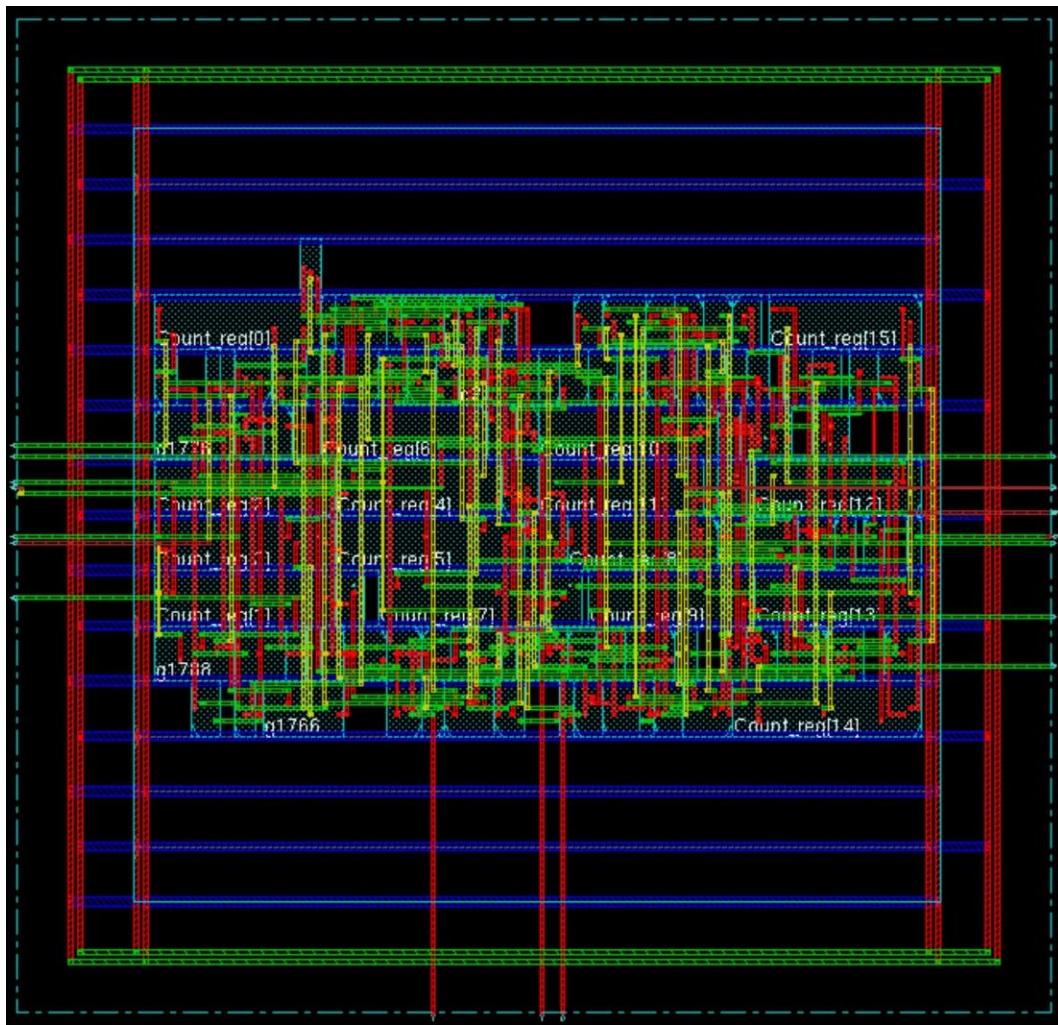


Figure 10: counter Placement

4. Snapshots of portions of the connectivity and geometry verification reports, showing any violations, if present.

```

Wiring      : 0
Antenna    : 0
Short      : 0
Overlap    : 0
End Summary

Verification Complete : 0 Viols.  0 Wrngs.

*****End: VERIFY GEOMETRY*****
*** verify geometry (CPU: 0:00:00.1  MEM: 1.0M)

encounter 1> VERIFY_CONNECTIVITY use new engine.

***** Start: VERIFY_CONNECTIVITY *****
Start Time: Sun Oct 27 20:24:19 2019

Design Name: counter
Database Units: 2000
Design Boundary: (0.0000, 0.0000) (94.2950, 90.6400)
Error Limit = 1000; Warning Limit = 50
Check all nets

Begin Summary
  Found no problems or warnings.
End Summary

End Time: Sun Oct 27 20:24:19 2019
Time Elapsed: 0:00:00.0

***** End: VERIFY_CONNECTIVITY *****
Verification Complete : 0 Viols.  0 Wrngs.
(CPU Time: 0:00:00.0  MEM: 0.00M)

encounter 1> █

```

Figure 11: counter Connectivity

```

encounter 1> *** Starting Verify Geometry (MEM: 867.7) ***
VERIFY GEOMETRY ..... Starting Verification
VERIFY GEOMETRY ..... Initializing
VERIFY GEOMETRY ..... Deleting Existing Violations
VERIFY GEOMETRY ..... Creating Sub-Areas
      ..... bin size: 8320
VERIFY GEOMETRY ..... SubArea : 1 of 1
**WARN: (ENCVFG-47): Pin of Cell g1782 at (15.840, 24.800), (18.480, 25.600) on Layer
Metall is not connected to any net. Because globalNetConnect or GUI Power->Connect Global
Nets is not to specify global net connection rules properly. Use globalNetConnect to con
nect the pins to nets, Type 'man globalNetConnect' for more information.

VERIFY GEOMETRY ..... Cells          : 0 Viols.
VERIFY GEOMETRY ..... SameNet       : 0 Viols.
VERIFY GEOMETRY ..... Wiring        : 0 Viols.
VERIFY GEOMETRY ..... Antenna       : 0 Viols.
VERIFY GEOMETRY ..... Sub-Area : 1 complete 0 Viols. 0 Wrngs.
VG: elapsed time: 0.00
Begin Summary ...
Cells      : 0
SameNet   : 0
Wiring     : 0
Antenna   : 0
Short     : 0
Overlap   : 0
End Summary

Verification Complete : 0 Viols.  0 Wrngs.

*****End: VERIFY GEOMETRY*****
*** verify geometry (CPU: 0:00:00.1  MEM: 1.0M)

encounter 1> █

```

Figure 12: counter Geometry

5. Schematic of your design (can be seen by clicking Tools -> Schematic Viewer)

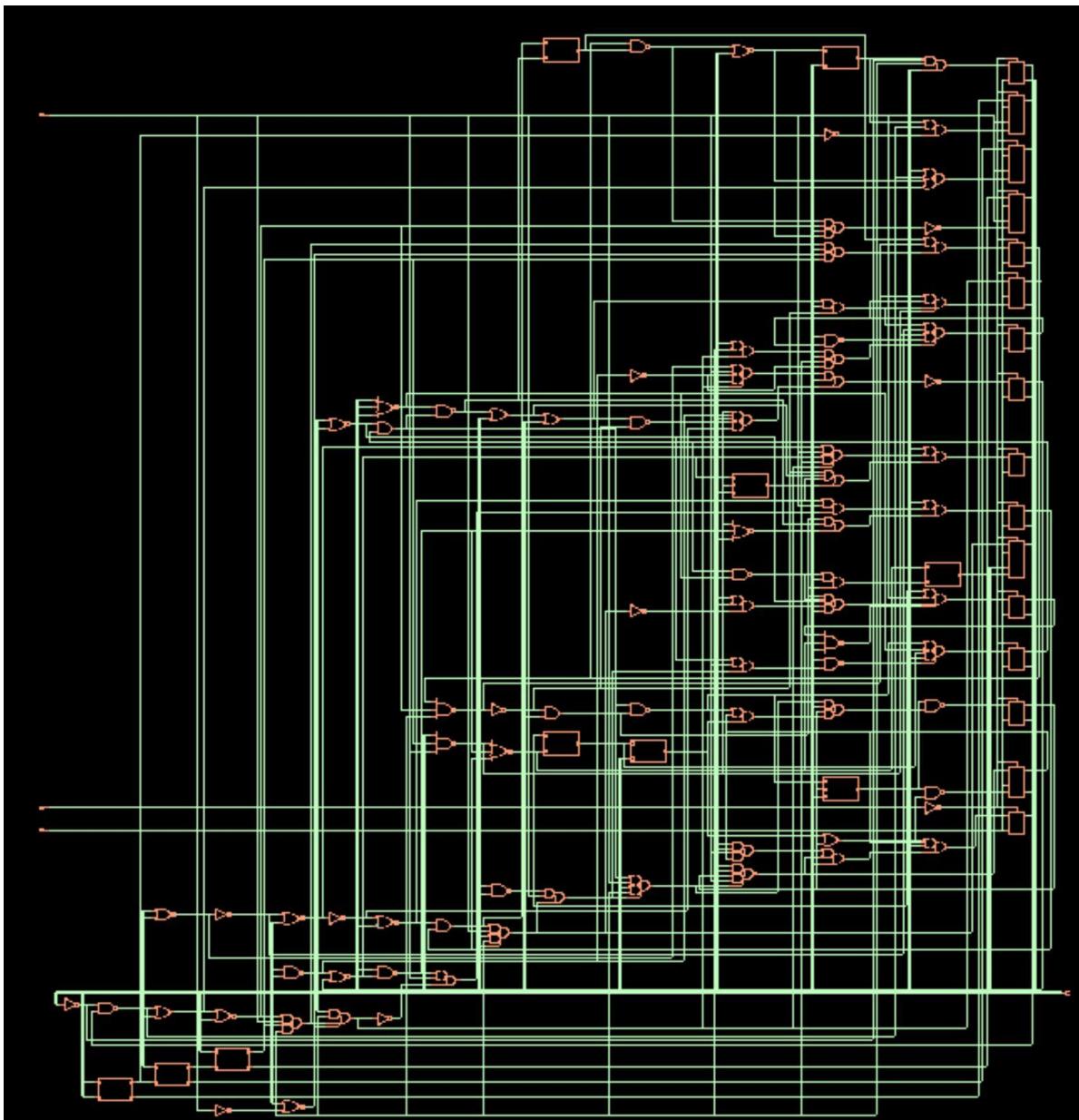


Figure 13: counter Schematic

6. Report Your Timing Analysis (Slew, Delay, Arrival...etc) and Total Area from your RTL compiler for your design.

```

1: =====
2: Generated by:          Encounter(R) RTL Compiler RC13.12 - v13.10-s021_1
3: Generated on:          Oct 27 2019 08:15:30 pm
4: Module:                counter
5: Technology library:   tsmc18 1.0
6: Operating conditions: slow (balanced_tree)
7: Wireload mode:        enclosed
8: Area mode:            timing library
9: =====
10:
11:      Pin           Type     Fanout Load Slew  Delay Arrival
12:                  (fF)    (ps)  (ps)  (ps)
13: -----
14: Count_reg[0]/CK          0          0 R
15: Count_reg[0]/Q    DFFRX1    3  7.8  145 +697  697 R
16: g1788/A                 +0          697
17: g1788/CO                2  8.5  195 +224  921 R
18: g1776/B                 +0          921
19: g1776/CO                1  5.9  155 +205  1126 R
20: g1766/B                 +0          1126
21: g1766/CO                3  9.6  213 +237  1363 R
22: g1760/B0                +0          1363
23: g1760/Y                 2  6.9  239 +157  1520 F
24: g1752/B0                +0          1520
25: g1752/Y                 5 14.7  686 +444  1964 R
26: g1751/A                 +0          1964
27: g1751/Y                 1  3.2  139 +83   2047 F
28: g1743/B0                +0          2047
29: g1743/Y                 2  6.3  284 +199  2246 R
30: g1733/C0                +0          2246
31: g1733/Y                 3  7.9  281 +205  2451 F
32: g1727/B0                +0          2451
33: g1727/Y                 2  6.3  292 +232  2684 R
34: g1716/C0                +0          2684
35: g1716/Y                 2  6.8  266 +196  2880 F
36: g1712/C0                +0          2880
37: g1712/Y                 2  4.1  400 +265  3144 R
38: g1704/A1N               +0          3144
39: g1704/Y                 1  3.0  130 +217  3361 R
40: g1700/B0                +0          3361
41: g1700/Y                 1  1.8  125 +97   3458 F
42: Count_reg[15]/D   DFFRHQX1
43: Count_reg[15]/CK   setup      0 +369  3828 R
44: -----
45: Timing slack : UNCONSTRAINED
46: Start-point : Count_reg[0]/CK
47: End-point   : Count_reg[15]/D
48:

```

Figure 14: counter Timing Analysis

7. Snapshot of the message showing successful generation of GDS2 layout

```
49                                         metal1
51                                         metal2
62                                         metal3

Stream Out Information Processed for GDS version 3:
Units: 2000 DBU

Object                      Count
-----
Instances                   0
Ports/Pins                  0
Nets                        0
    Via Instances            0
Special Nets                0
    Via Instances            0
Metal Fills                 0
    Via Instances            0
Metal FillOPCs              0
    Via Instances            0
Text                         0
Blockages                    0
Custom Text                  0
Custom Box                   0

**WARN: (ENCOGDS-1176): There are 1 empty cells. Check encounter.l
It is probably because your mapping file does not contain corres
Use default mapping file(without option -mapFile) to output all
#####Streamout is finished!
```

Figure 15: counter GDS