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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.

2. Simulation waveforms for your multiplier and counter

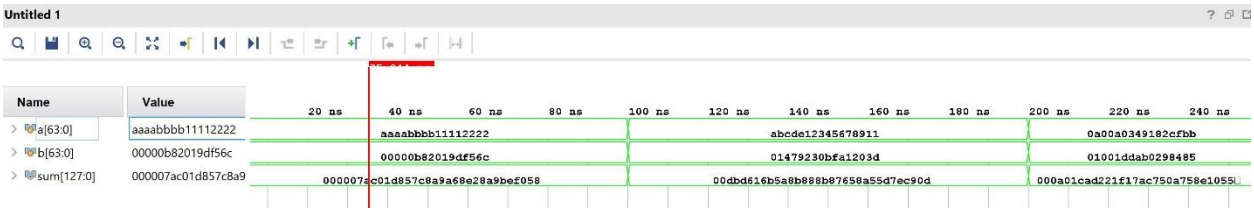

Figure 1: mult64x64 Simulation Waveform

3. Physical Layout snapshot of your design

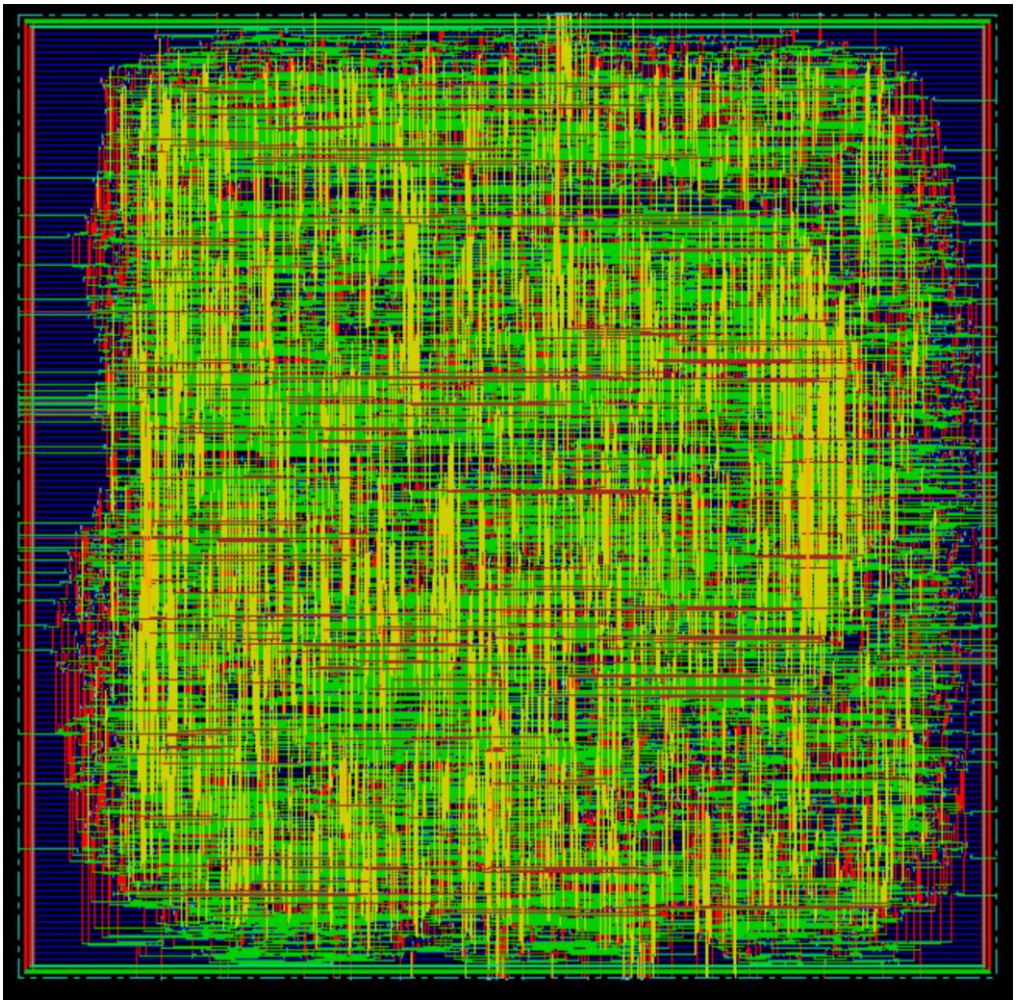

Figure 2: mult64x64 placement

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

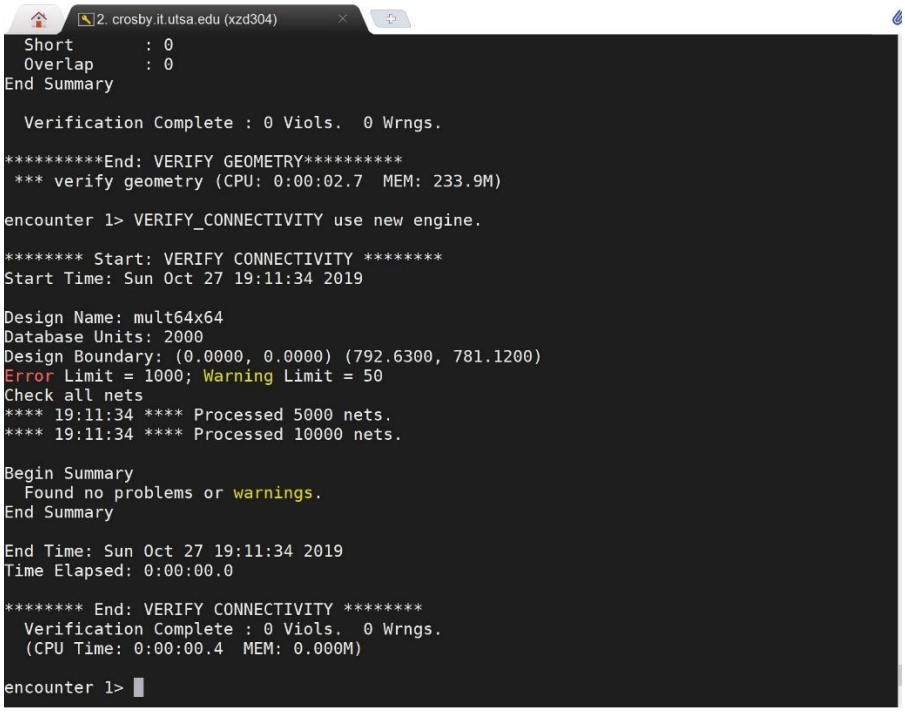

Figure 3: mult64x64 Connectivity

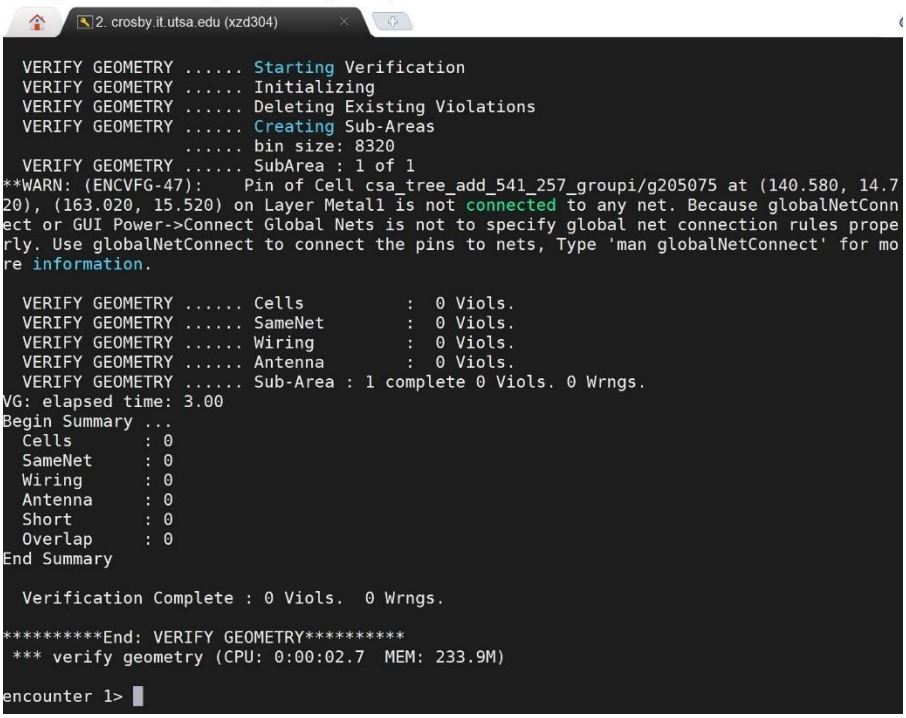

Figure 4: mult64x64 Geometry

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

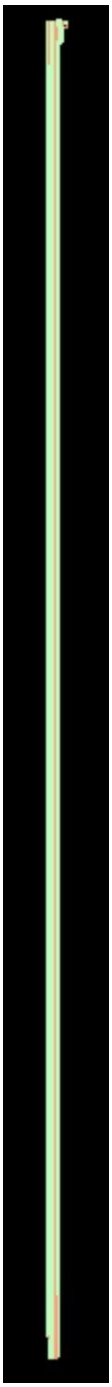

Figure 5: mult 64x64 Schematic Full View

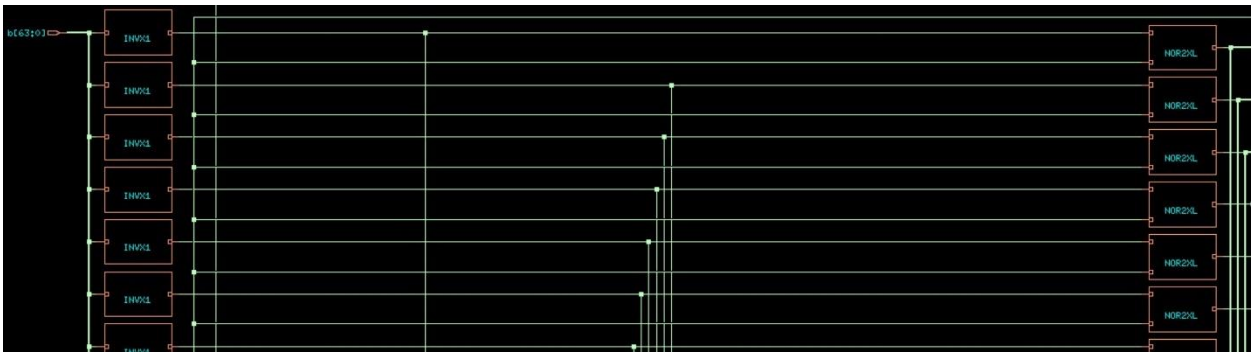

Figure 6: mult 64x64 Schematic Zoom

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                                          +0       0
16: g33080/Y         INVX1         64 204.8 2511 +1384    1384 R
17: g30035/A                                          +0    1384
18: g30035/Y         NOR2XL         1   6.8  406  +153    1537 F
19: csa_tree_add_541_257_groupi/in_59[4]
20:   g203118/B                                       +0    1537
21:   g203118/CO     ADDFX2         1   4.4  140  +595    2132 F
22:   g204762/D                                       +0    2132
23:   g204762/S     CMPR42X1       1   6.9  128  +786    2917 F
24:   g3147/A                                         +0    2917
25:   g3147/CO      ADDFX2         1   2.7  134  +483    3400 F
26:   g205110/ICI                                     +0    3400
27:   g205110/CO    CMPR42X1       1   2.7  100  +310    3710 F
28:   g205109/ICI                                     +0    3710
29:   g205109/CO    CMPR42X1       1   6.2  124  +325    4035 F
30:   g3144/CI                                        +0    4035
31:   g3144/CO      ADDFX2         1   2.7  134  +330    4365 F
32:   g205108/ICI                                     +0    4365
33:   g205108/CO    CMPR42X1       1   2.7  100  +310    4675 F
34:   g205107/ICI                                     +0    4675
35:   g205107/CO    CMPR42X1       1   6.2  124  +325    5000 F
36:   g3141/CI                                        +0    5000
37:   g3141/CO      ADDFX2         1   6.2  145  +343    5343 F
38:   g3140/CI                                        +0    5343
39:   g3140/CO      ADDFX2         1   2.7  134  +335    5678 F
40:   g205106/ICI                                     +0    5678
41:   g205106/CO    CMPR42X1       1   2.7  100  +310    5989 F
42:   g205105/ICI                                     +0    5989
43:   g205105/CO    CMPR42X1       1   2.7  100  +301    6290 F
44:   g205104/ICI                                     +0    6290
45:   g205104/CO    CMPR42X1       1   2.7  100  +301    6590 F
46:   g205103/ICI                                     +0    6590
47:   g205103/CO    CMPR42X1       1   2.7  100  +301    6891 F
48:   g205102/ICI                                     +0    6891
49:   g205102/CO    CMPR42X1       1   6.2  124  +325    7216 F
50:   g3134/CI                                        +0    7216
51:   g3134/CO      ADDFX2         1   2.7  134  +330    7546 F
52:   g205101/ICI                                     +0    7546
53:   g205101/CO    CMPR42X1       1   2.7  100  +310    7856 F
54:   g205100/ICI                                     +0    7856
55:   g205100/CO    CMPR42X1       1   2.7  100  +301    8157 F
56:   g205099/ICI                                     +0    8157
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
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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
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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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  g205034/CO    CMPR42X1       1   2.7  100  +310   35513 F
  g205033/ICI                                +0   35513
  g205033/CO    CMPR42X1       1   6.2  124  +325   35838 F
  g3043/CI                                   +0   35838
  g3043/CO      ADDFX2         1   6.2  145  +343   36181 F
  g3042/CI                                   +0   36181
  g3042/CO      ADDFX2         1   2.7  134  +335   36516 F
  g205032/ICI                                +0   36516
  g205032/CO    CMPR42X1       1   2.7  100  +310   36826 F
  g205031/ICI                                +0   36826
  g205031/CO    CMPR42X1       1   2.7  100  +301   37127 F
  g205030/ICI                                +0   37127
  g205030/CO    CMPR42X1       1   6.2  124  +325   37452 F
  g3038/CI                                   +0   37452
  g3038/CO      ADDFX2         1   6.2  145  +343   37795 F
  g3037/CI                                   +0   37795
  g3037/CO      ADDFX2         1   6.2  145  +349   38144 F
  g3036/CI                                   +0   38144
  g3036/CO      ADDFX2         1   6.2  145  +349   38493 F
  g3035/CI                                   +0   38493
  g3035/CO      ADDFX2         1   6.2  145  +349   38841 F
  g3034/CI                                   +0   38841
  g3034/CO      ADDFX2         1   6.2  145  +349   39190 F
  g3033/CI                                   +0   39190
  g3033/CO      ADDFX2         1   6.2  145  +349   39538 F
  g3032/CI                                   +0   39538
  g3032/CO      ADDFX2         1   6.2  145  +349   39887 F
  g3031/CI                                   +0   39887
  g3031/CO      ADDFX2         1   6.2  145  +349   40236 F
  g3030/CI                                   +0   40236
  g3030/CO      ADDFX2         1   6.2  145  +349   40584 F
  g3029/CI                                   +0   40584
  g3029/CO      ADDFX2         1   6.2  145  +349   40933 F
  g3028/CI                                   +0   40933
  g3028/CO      ADDFX2         1   6.2  145  +349   41281 F
  g3027/CI                                   +0   41281
  g3027/CO      ADDFX2         1   6.2  145  +349   41630 F
  g3026/CI                                   +0   41630
  g3026/S       ADDFXL         1   0.0   74  +292   41922 R
csa_tree_add_541_257_groupi/out_0[126]
sum[126]        out port                     +0   41922 R
-------------------------------------------------------------
Timing slack :  UNCONSTRAINED
Start-point  : b[4]
End-point    : sum[126]
=============================================================
  Generated by:           Encounter(R) RTL Compiler RC13.12 - v13.10-s021_1
  Generated on:           Oct 27 2019  06:45:30 pm
  Module:                 mult64x64
  Technology library:     tsmc18 1.0
  Operating conditions:   slow (balanced_tree)
  Wireload mode:          enclosed
  Area mode:              timing library
=============================================================

    Pin          Type     Fanout  Load Slew Delay Arrival
                                  (fF) (ps)  (ps)   (ps)
```

```
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
```

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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
```

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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
```

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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
```

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514:   g205030/CO     CMPR42X1        1   6.2  124  +325   37452 F
515:   g3038/CI                                    +0   37452
516:   g3038/CO       ADDFX2          1   6.2  145  +343   37795 F
517:   g3037/CI                                    +0   37795
518:   g3037/CO       ADDFX2          1   6.2  145  +349   38144 F
519:   g3036/CI                                    +0   38144
520:   g3036/CO       ADDFX2          1   6.2  145  +349   38493 F
521:   g3035/CI                                    +0   38493
522:   g3035/CO       ADDFX2          1   6.2  145  +349   38841 F
523:   g3034/CI                                    +0   38841
524:   g3034/CO       ADDFX2          1   6.2  145  +349   39190 F
525:   g3033/CI                                    +0   39190
526:   g3033/CO       ADDFX2          1   6.2  145  +349   39538 F
527:   g3032/CI                                    +0   39538
528:   g3032/CO       ADDFX2          1   6.2  145  +349   39887 F
529:   g3031/CI                                    +0   39887
530:   g3031/CO       ADDFX2          1   6.2  145  +349   40236 F
531:   g3030/CI                                    +0   40236
532:   g3030/CO       ADDFX2          1   6.2  145  +349   40584 F
533:   g3029/CI                                    +0   40584
534:   g3029/CO       ADDFX2          1   6.2  145  +349   40933 F
535:   g3028/CI                                    +0   40933
536:   g3028/CO       ADDFX2          1   6.2  145  +349   41281 F
537:   g3027/CI                                    +0   41281
538:   g3027/CO       ADDFX2          1   6.2  145  +349   41630 F
539:   g3026/CI                                    +0   41630
540:   g3026/S        ADDFXL          1   0.0   74  +292   41922 R
541: csa_tree_add_541_257_groupi/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

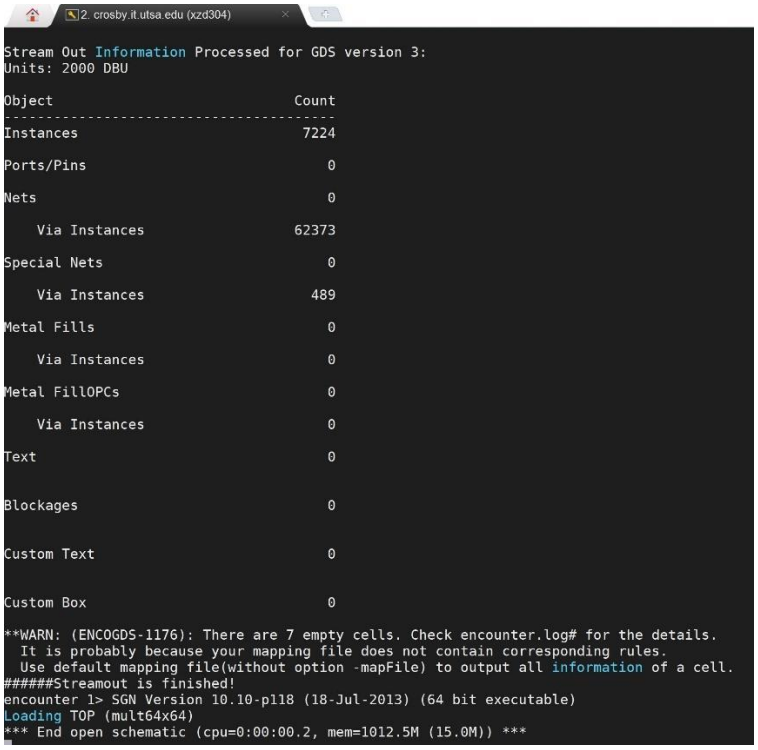

Figure 8: mult64x64 GDS

(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.

2. Simulation waveforms for your multiplier and counter

Figure 9: counter Simulation Waveform

3. Physical Layout snapshot of your design

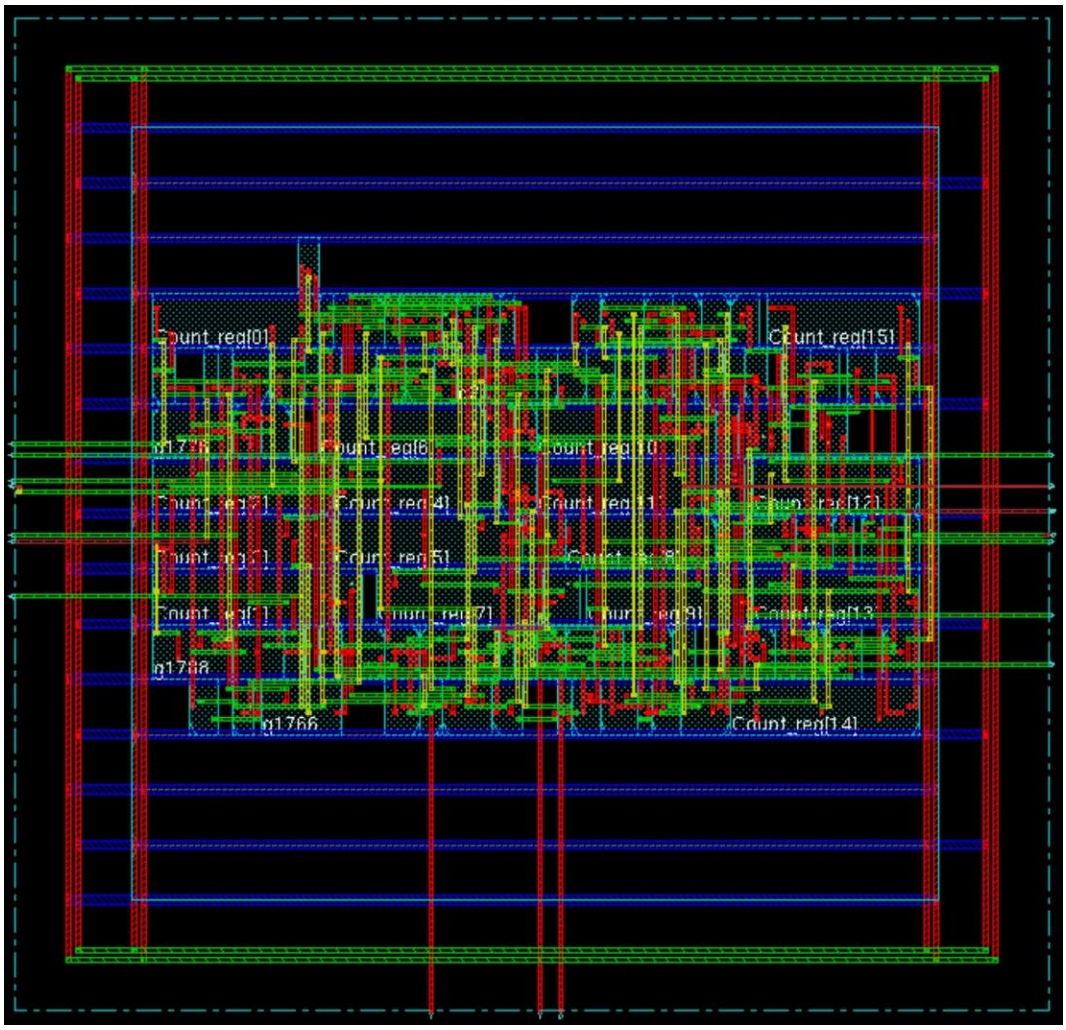

Figure 10: counter Placement

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

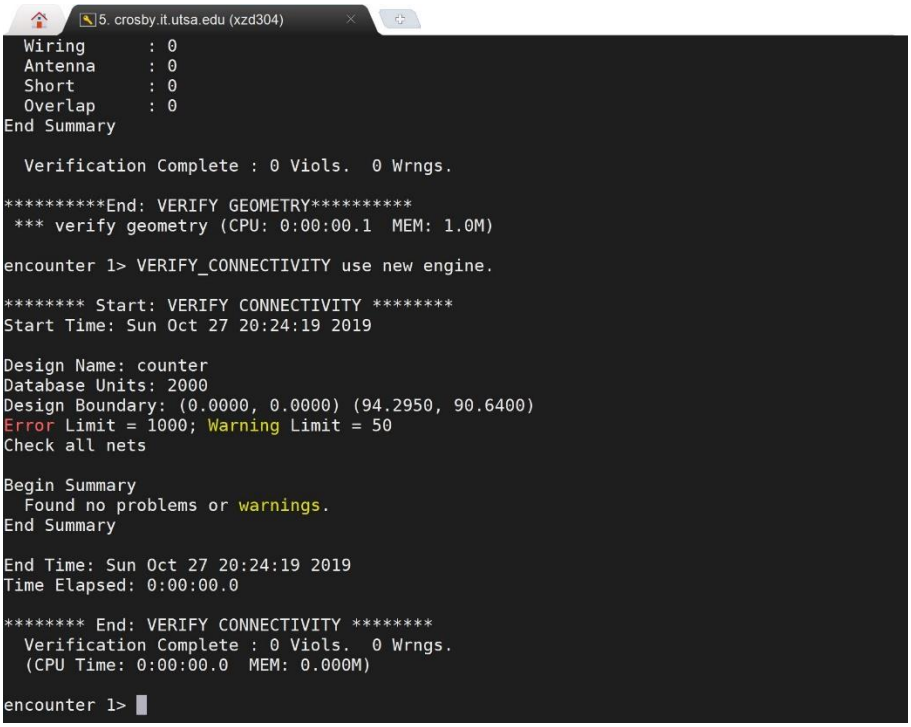

Figure 11: counter Connectivity

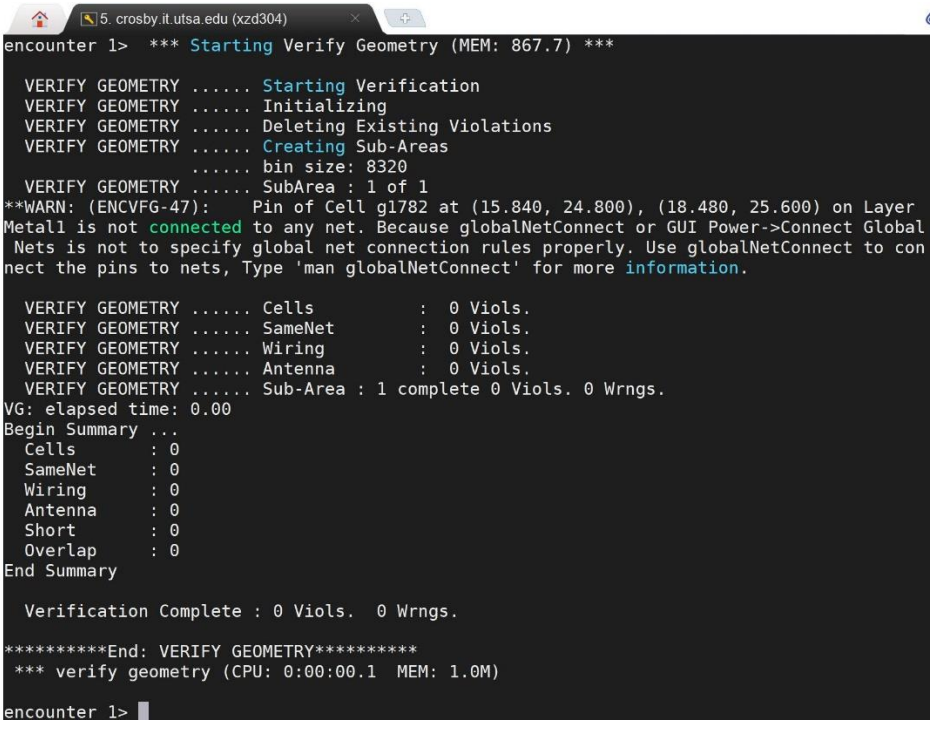

Figure 12: counter Geometry

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

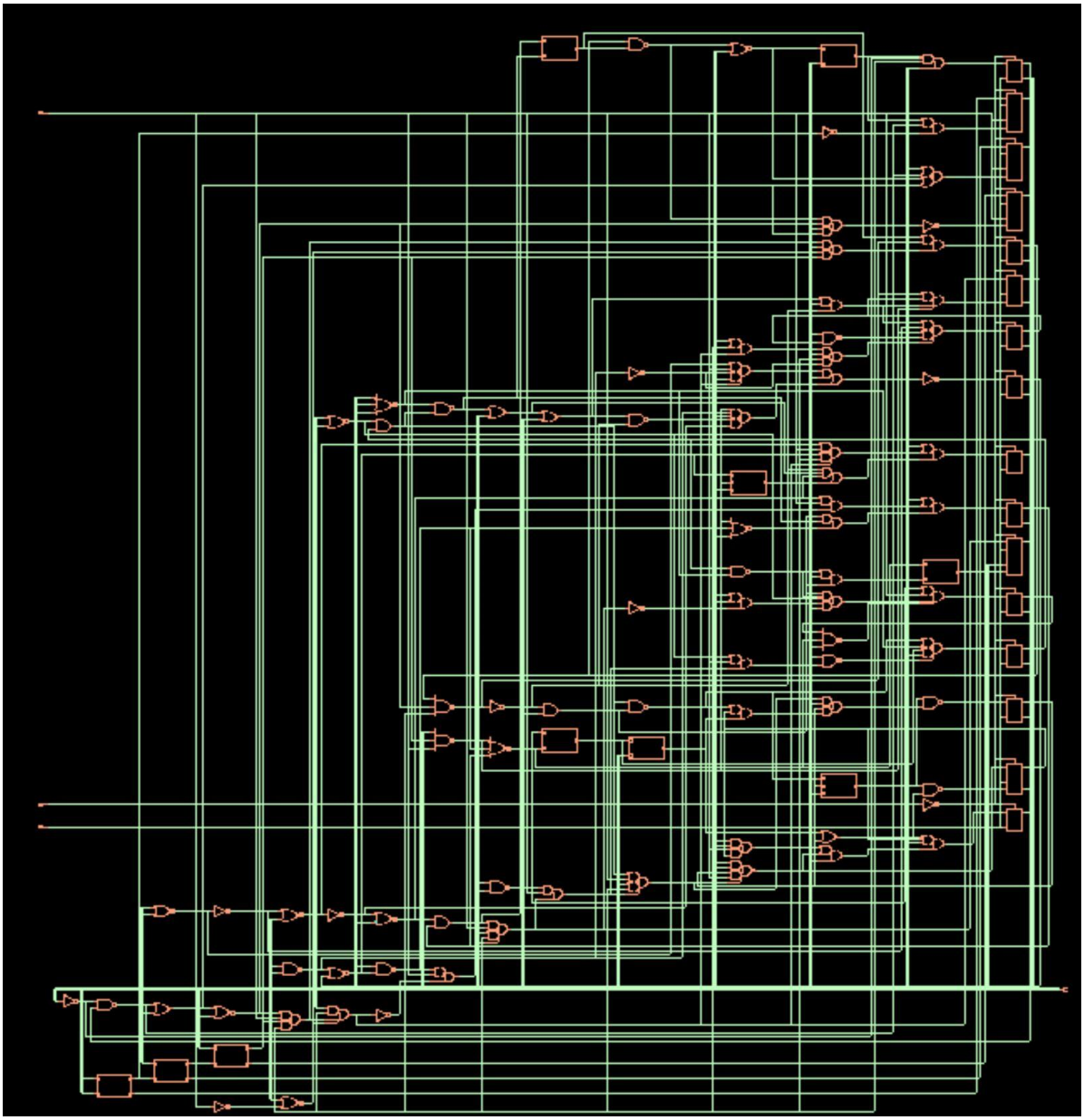

Figure 13: counter Schematic

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           ADDHXL           2  8.5  195  +224     921 R
18: g1776/B                                          +0     921
19: g1776/CO           ADDHXL           1  5.9  155  +205    1126 R
20: g1766/B                                          +0    1126
21: g1766/CO           ADDHXL           3  9.6  213  +237    1363 R
22: g1760/B0                                         +0    1363
23: g1760/Y            OAI22XL          2  6.9  239  +157    1520 F
24: g1752/B0                                         +0    1520
25: g1752/Y            AOI211XL         5 14.7  686  +444    1964 R
26: g1751/A                                          +0    1964
27: g1751/Y            INVXL            1  3.2  139   +83    2047 F
28: g1743/B0                                         +0    2047
29: g1743/Y            AOI21XL          2  6.3  284  +199    2246 R
30: g1733/C0                                         +0    2246
31: g1733/Y            OAI221XL         3  7.9  281  +205    2451 F
32: g1727/B0                                         +0    2451
33: g1727/Y            AOI21XL          2  6.3  292  +232    2684 R
34: g1716/C0                                         +0    2684
35: g1716/Y            OAI221XL         2  6.8  266  +196    2880 F
36: g1712/C0                                         +0    2880
37: g1712/Y            AOI221XL         2  4.1  400  +265    3144 R
38: g1704/A1N                                        +0    3144
39: g1704/Y            OAI2BB1XL        1  3.0  130  +217    3361 R
40: g1700/B0                                         +0    3361
41: g1700/Y            OAI31XL          1  1.8  125   +97    3458 F
42: Count_reg[15]/D    DFFRHQX1                      +0    3458
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

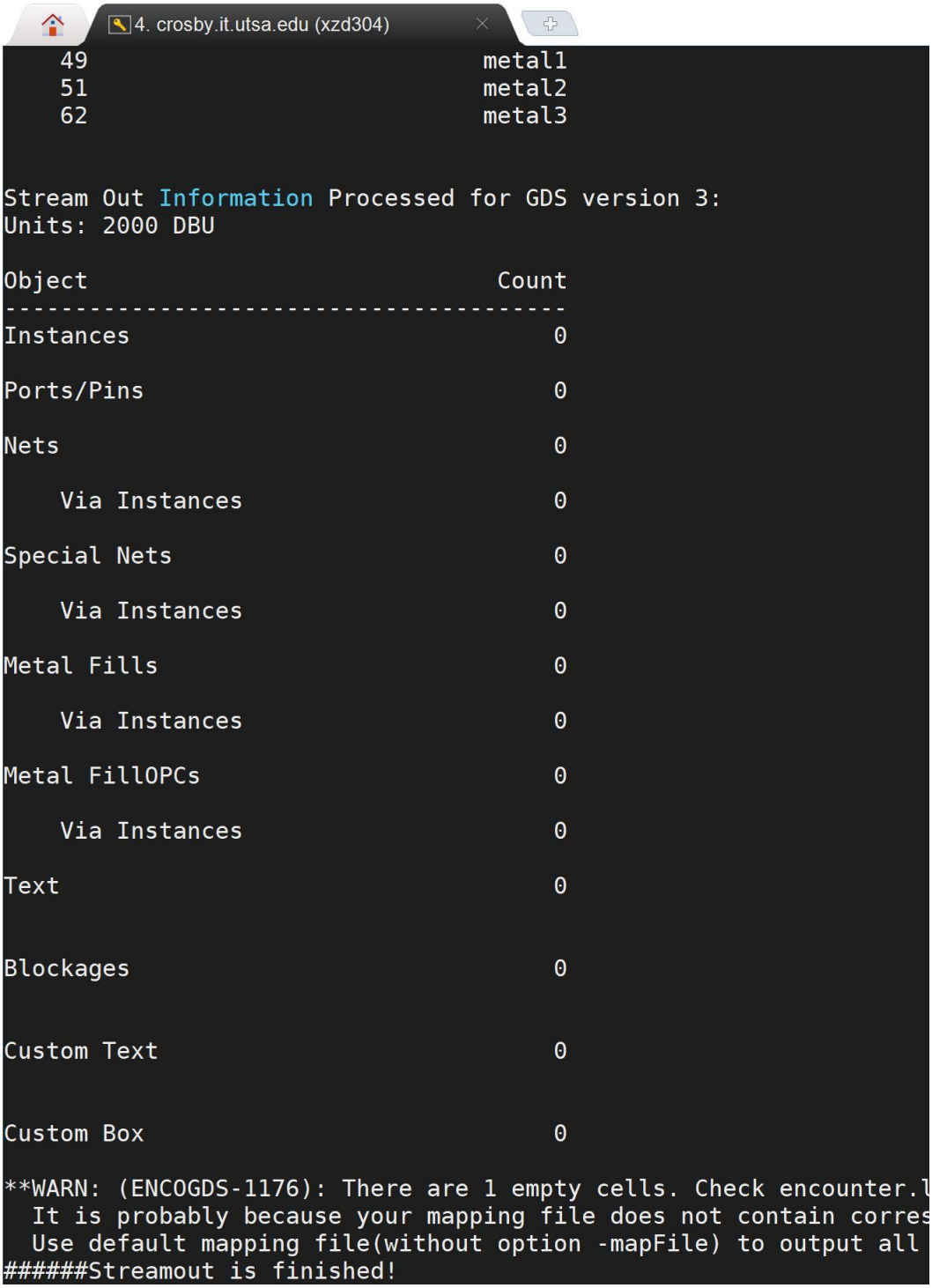

Figure 15: counter GDS