2022 Digital IC Design Homework 3

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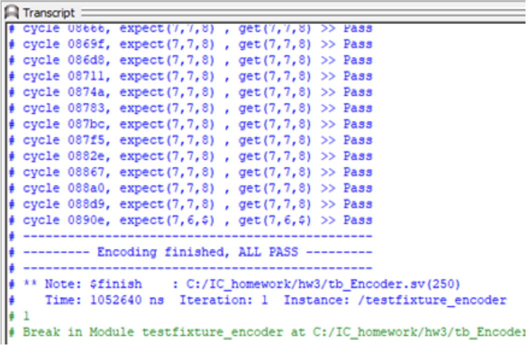
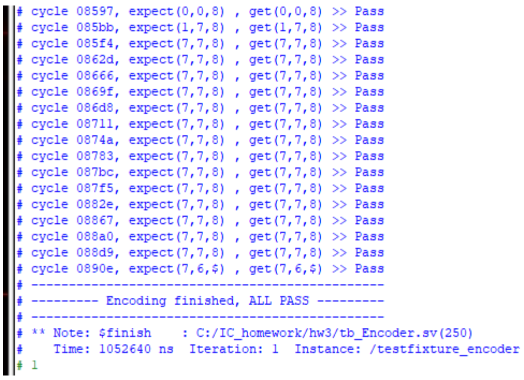
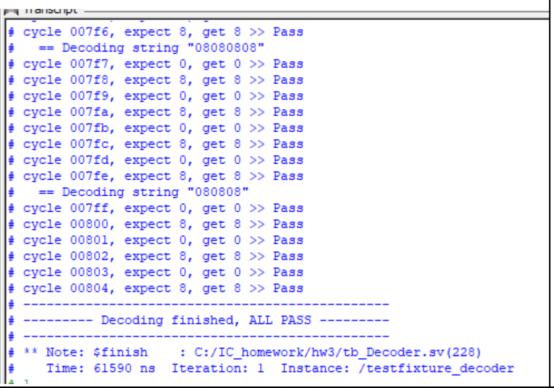
Simulation Result					
Functional simulation	Pass (encoder)	Pass (decoder)	Gate-level simulation	Pass (encoder)	Pass (decoder)



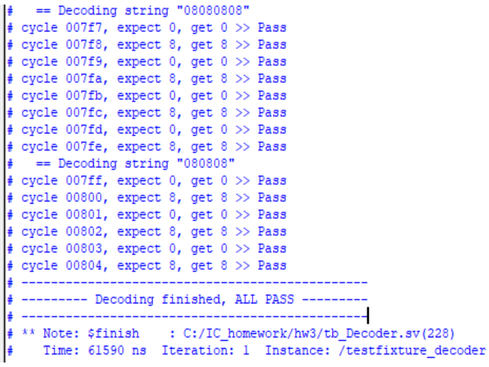
```
# cycle 08666, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0869f, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 086d8, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08711, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0874a, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08783, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 087bc, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 087f5, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0882e, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08867, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 088a0, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 088d9, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0890e, expect(7,6,$) , get(7,6,$) >> Pass
# ------------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 1052640 ns  Iteration: 1  Instance: /testfixture_encoder
# 1
# Break in Module testfixture_encoder at C:/IC_homework/hw3/tb_Encode
```



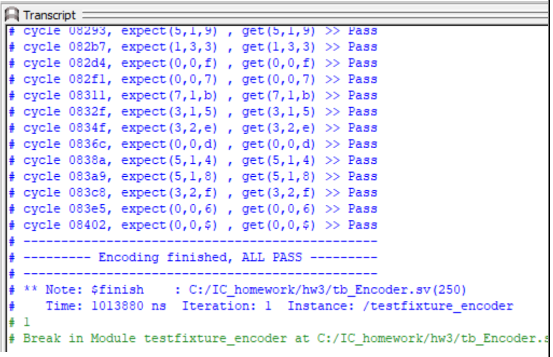
```
# cycle 08597, expect(0,0,8) , get(0,0,8) >> Pass
# cycle 085bb, expect(1,7,8) , get(1,7,8) >> Pass
# cycle 085f4, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0862d, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08666, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0869f, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 086d8, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08711, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0874a, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08783, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 087bc, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 087f5, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0882e, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 08867, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 088a0, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 088d9, expect(7,7,8) , get(7,7,8) >> Pass
# cycle 0890e, expect(7,6,$) , get(7,6,$) >> Pass
# ------------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 1052640 ns  Iteration: 1  Instance: /testfixture_encoder
# 1
```



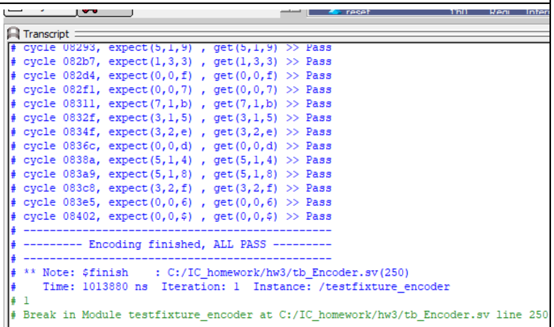
```
# cycle 007f6, expect 8, get 8 >> Pass
#    == Decoding string "08080808"
# cycle 007f7, expect 0, get 0 >> Pass
# cycle 007f8, expect 8, get 8 >> Pass
# cycle 007f9, expect 0, get 0 >> Pass
# cycle 007fa, expect 8, get 8 >> Pass
# cycle 007fb, expect 0, get 0 >> Pass
# cycle 007fc, expect 8, get 8 >> Pass
# cycle 007fd, expect 0, get 0 >> Pass
# cycle 007fe, expect 8, get 8 >> Pass
#    == Decoding string "080808"
# cycle 007ff, expect 0, get 0 >> Pass
# cycle 00800, expect 8, get 8 >> Pass
# cycle 00801, expect 0, get 0 >> Pass
# cycle 00802, expect 8, get 8 >> Pass
# cycle 00803, expect 0, get 0 >> Pass
# cycle 00804, expect 8, get 8 >> Pass
# ------------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61590 ns  Iteration: 1  Instance: /testfixture_decoder
```



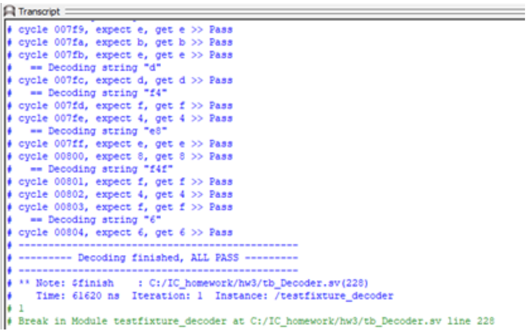
```
#    == Decoding string "08080808"
# cycle 007f7, expect 0, get 0 >> Pass
# cycle 007f8, expect 8, get 8 >> Pass
# cycle 007f9, expect 0, get 0 >> Pass
# cycle 007fa, expect 8, get 8 >> Pass
# cycle 007fb, expect 0, get 0 >> Pass
# cycle 007fc, expect 8, get 8 >> Pass
# cycle 007fd, expect 0, get 0 >> Pass
# cycle 007fe, expect 8, get 8 >> Pass
#    == Decoding string "080808"
# cycle 007ff, expect 0, get 0 >> Pass
# cycle 00800, expect 8, get 8 >> Pass
# cycle 00801, expect 0, get 0 >> Pass
# cycle 00802, expect 8, get 8 >> Pass
# cycle 00803, expect 0, get 0 >> Pass
# cycle 00804, expect 8, get 8 >> Pass
# ------------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61590 ns  Iteration: 1  Instance: /testfixture_decoder
```



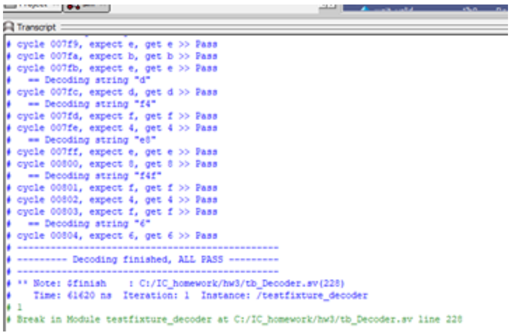
```
# cycle 08293, expect(5,1,9) , get(5,1,9) >> Pass
# cycle 082b7, expect(1,3,3) , get(1,3,3) >> Pass
# cycle 082d4, expect(0,0,f) , get(0,0,f) >> Pass
# cycle 082f1, expect(0,0,7) , get(0,0,7) >> Pass
# cycle 08311, expect(7,1,b) , get(7,1,b) >> Pass
# cycle 0832f, expect(3,1,5) , get(3,1,5) >> Pass
# cycle 0834f, expect(3,2,e) , get(3,2,e) >> Pass
# cycle 0836c, expect(0,0,d) , get(0,0,d) >> Pass
# cycle 0838a, expect(5,1,4) , get(5,1,4) >> Pass
# cycle 083a9, expect(5,1,8) , get(5,1,8) >> Pass
# cycle 083c8, expect(3,2,f) , get(3,2,f) >> Pass
# cycle 083e5, expect(0,0,6) , get(0,0,6) >> Pass
# cycle 08402, expect(0,0,$) , get(0,0,$) >> Pass
# ------------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 1013880 ns  Iteration: 1  Instance: /testfixture_encoder
# 1
# Break in Module testfixture_encoder at C:/IC_homework/hw3/tb_Encoder.s
```



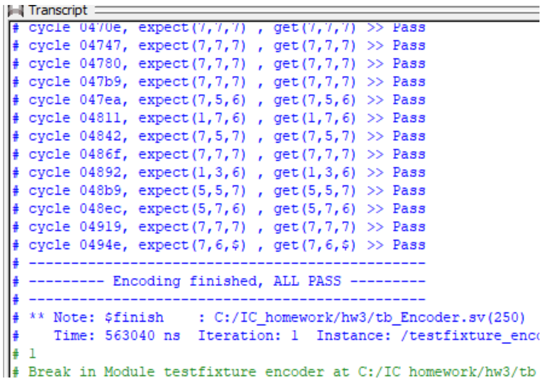
```
# cycle 08293, expect(5,1,9) , get(5,1,9) >> Pass
# cycle 082b7, expect(1,3,3) , get(1,3,3) >> Pass
# cycle 082d4, expect(0,0,f) , get(0,0,f) >> Pass
# cycle 082f1, expect(0,0,7) , get(0,0,7) >> Pass
# cycle 08311, expect(7,1,b) , get(7,1,b) >> Pass
# cycle 0832f, expect(3,1,5) , get(3,1,5) >> Pass
# cycle 0834f, expect(3,2,e) , get(3,2,e) >> Pass
# cycle 0836c, expect(0,0,d) , get(0,0,d) >> Pass
# cycle 0838a, expect(5,1,4) , get(5,1,4) >> Pass
# cycle 083a9, expect(5,1,8) , get(5,1,8) >> Pass
# cycle 083c8, expect(3,2,f) , get(3,2,f) >> Pass
# cycle 083e5, expect(0,0,6) , get(0,0,6) >> Pass
# cycle 08402, expect(0,0,$) , get(0,0,$) >> Pass
# ------------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 1013880 ns  Iteration: 1  Instance: /testfixture_encoder
# 1
# Break in Module testfixture_encoder at C:/IC_homework/hw3/tb_Encoder.sv line 250
```



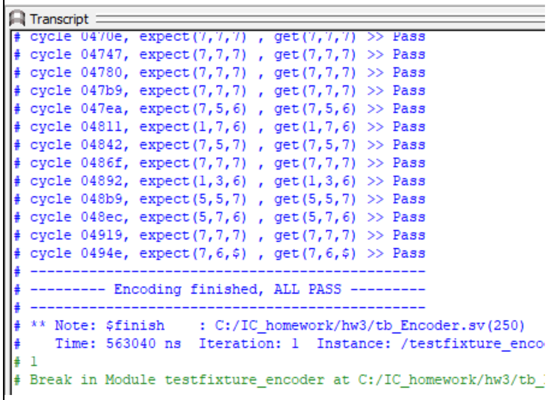
```
# cycle 007f9, expect e, get e >> Pass
# cycle 007fa, expect b, get b >> Pass
# cycle 007fb, expect e, get e >> Pass
#    == Decoding string "d"
# cycle 007fc, expect d, get d >> Pass
#    == Decoding string "f4"
# cycle 007fd, expect f, get f >> Pass
# cycle 007fe, expect 4, get 4 >> Pass
#    == Decoding string "e8"
# cycle 007ff, expect e, get e >> Pass
# cycle 00800, expect 8, get 8 >> Pass
#    == Decoding string "f4f"
# cycle 00801, expect f, get f >> Pass
# cycle 00802, expect 4, get 4 >> Pass
# cycle 00803, expect f, get f >> Pass
#    == Decoding string "6"
# cycle 00804, expect 6, get 6 >> Pass
# ------------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61620 ns  Iteration: 1  Instance: /testfixture_decoder
# 1
# Break in Module testfixture_decoder at C:/IC_homework/hw3/tb_Decoder.sv line 228
```



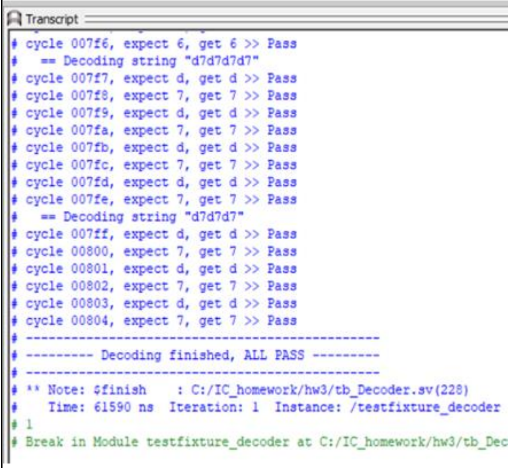
```
# cycle 007f9, expect e, get e >> Pass
# cycle 007fa, expect b, get b >> Pass
# cycle 007fb, expect e, get e >> Pass
#    == Decoding string "d"
# cycle 007fc, expect d, get d >> Pass
#    == Decoding string "f4"
# cycle 007fd, expect f, get f >> Pass
# cycle 007fe, expect 4, get 4 >> Pass
#    == Decoding string "e8"
# cycle 007ff, expect e, get e >> Pass
# cycle 00800, expect 8, get 8 >> Pass
#    == Decoding string "f4f"
# cycle 00801, expect f, get f >> Pass
# cycle 00802, expect 4, get 4 >> Pass
# cycle 00803, expect f, get f >> Pass
#    == Decoding string "6"
# cycle 00804, expect 6, get 6 >> Pass
# ------------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ------------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61620 ns  Iteration: 1  Instance: /testfixture_decoder
# 1
# Break in Module testfixture_decoder at C:/IC_homework/hw3/tb_Decoder.sv line 228
```



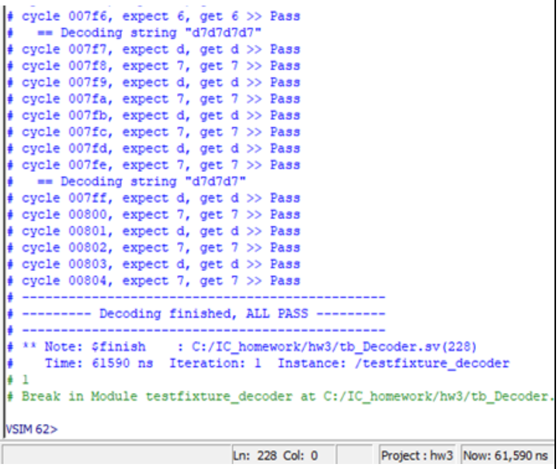
```
Transcript
# cycle 0470e, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04747, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04780, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 047b9, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 047ea, expect(7,5,6) , get(7,5,6) >> Pass
# cycle 04811, expect(1,7,6) , get(1,7,6) >> Pass
# cycle 04842, expect(7,5,7) , get(7,5,7) >> Pass
# cycle 0486f, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04892, expect(1,3,6) , get(1,3,6) >> Pass
# cycle 048b9, expect(5,5,7) , get(5,5,7) >> Pass
# cycle 048ec, expect(5,7,6) , get(5,7,6) >> Pass
# cycle 04919, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 0494e, expect(7,6,$) , get(7,6,$) >> Pass
# ---------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ---------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 563040 ns  Iteration: 1  Instance: /testfixture_enc
# 1
# Break in Module testfixture encoder at C:/IC homework/hw3/tb
```



```
Transcript
# cycle 0470e, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04747, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04780, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 047b9, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 047ea, expect(7,5,6) , get(7,5,6) >> Pass
# cycle 04811, expect(1,7,6) , get(1,7,6) >> Pass
# cycle 04842, expect(7,5,7) , get(7,5,7) >> Pass
# cycle 0486f, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 04892, expect(1,3,6) , get(1,3,6) >> Pass
# cycle 048b9, expect(5,5,7) , get(5,5,7) >> Pass
# cycle 048ec, expect(5,7,6) , get(5,7,6) >> Pass
# cycle 04919, expect(7,7,7) , get(7,7,7) >> Pass
# cycle 0494e, expect(7,6,$) , get(7,6,$) >> Pass
# ---------------------------------------------
# --------- Encoding finished, ALL PASS ---------
# ---------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Encoder.sv(250)
#    Time: 563040 ns  Iteration: 1  Instance: /testfixture_enco
# 1
# Break in Module testfixture_encoder at C:/IC_homework/hw3/tb_
```



```
Transcript
# cycle 007f6, expect 6, get 6 >> Pass
#   == Decoding string "d7d7d7d7"
# cycle 007f7, expect d, get d >> Pass
# cycle 007f8, expect 7, get 7 >> Pass
# cycle 007f9, expect d, get d >> Pass
# cycle 007fa, expect 7, get 7 >> Pass
# cycle 007fb, expect d, get d >> Pass
# cycle 007fc, expect 7, get 7 >> Pass
# cycle 007fd, expect d, get d >> Pass
# cycle 007fe, expect 7, get 7 >> Pass
#   == Decoding string "d7d7d7"
# cycle 007ff, expect d, get d >> Pass
# cycle 00800, expect 7, get 7 >> Pass
# cycle 00801, expect d, get d >> Pass
# cycle 00802, expect 7, get 7 >> Pass
# cycle 00803, expect d, get d >> Pass
# cycle 00804, expect 7, get 7 >> Pass
# ---------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ---------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61590 ns  Iteration: 1  Instance: /testfixture_decoder
# 1
# Break in Module testfixture_decoder at C:/IC_homework/hw3/tb_Dec
```

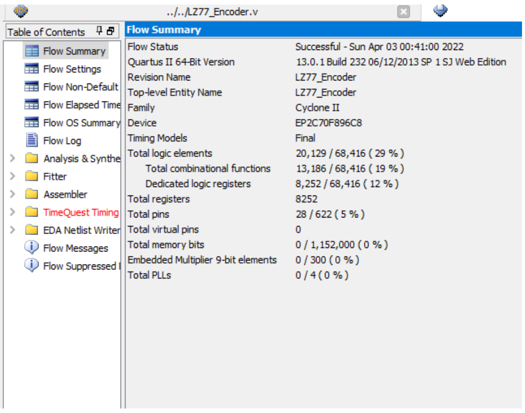


```
# cycle 007f6, expect 6, get 6 >> Pass
#   == Decoding string "d7d7d7d7"
# cycle 007f7, expect d, get d >> Pass
# cycle 007f8, expect 7, get 7 >> Pass
# cycle 007f9, expect d, get d >> Pass
# cycle 007fa, expect 7, get 7 >> Pass
# cycle 007fb, expect d, get d >> Pass
# cycle 007fc, expect 7, get 7 >> Pass
# cycle 007fd, expect d, get d >> Pass
# cycle 007fe, expect 7, get 7 >> Pass
#   == Decoding string "d7d7d7"
# cycle 007ff, expect d, get d >> Pass
# cycle 00800, expect 7, get 7 >> Pass
# cycle 00801, expect d, get d >> Pass
# cycle 00802, expect 7, get 7 >> Pass
# cycle 00803, expect d, get d >> Pass
# cycle 00804, expect 7, get 7 >> Pass
# ---------------------------------------------
# --------- Decoding finished, ALL PASS ---------
# ---------------------------------------------
# ** Note: $finish    : C:/IC_homework/hw3/tb_Decoder.sv(228)
#    Time: 61590 ns  Iteration: 1  Instance: /testfixture_decoder
# 1
# Break in Module testfixture_decoder at C:/IC_homework/hw3/tb_Decoder.

VSIM 62>
```

Ln: 228 Col: 0 | Project : hw3 | Now: 61,590 ns

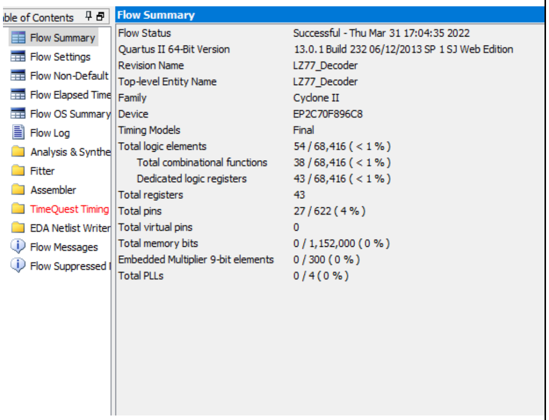
Synthesis Result	encoder	decoder
Total logic elements	20129	54
Total memory bit	0	0
Embedded multiplier 9-bit element	0	0
Simulation time img0	1052640 (ns)	61590 (ns)
Simulation time img1	1013880 (ns)	61620 (ns)
Simulation time img2	563040 (ns)	61590 (ns)



Flow Summary

Flow Status	Successful - Sun Apr 03 00:41:00 2022
Quartus II 64-Bit Version	13.0.1 Build 232 06/12/2013 SP 1 SJ Web Edition
Revision Name	LZ77_Encoder
Top-level Entity Name	LZ77_Encoder
Family	Cyclone II
Device	EP2C70F896C8
Timing Models	Final
Total logic elements	20,129 / 68,416 (29 %)
Total combinational functions	13,186 / 68,416 (19 %)
Dedicated logic registers	8,252 / 68,416 (12 %)
Total registers	8252
Total pins	28 / 622 (5 %)
Total virtual pins	0
Total memory bits	0 / 1,152,000 (0 %)
Embedded Multiplier 9-bit elements	0 / 300 (0 %)
Total PLLs	0 / 4 (0 %)

(



Flow Summary

Flow Status	Successful - Thu Mar 31 17:04:35 2022
Quartus II 64-Bit Version	13.0.1 Build 232 06/12/2013 SP 1 SJ Web Edition
Revision Name	LZ77_Decoder
Top-level Entity Name	LZ77_Decoder
Family	Cyclone II
Device	EP2C70F896C8
Timing Models	Final
Total logic elements	54 / 68,416 (< 1 %)
Total combinational functions	38 / 68,416 (< 1 %)
Dedicated logic registers	43 / 68,416 (< 1 %)
Total registers	43
Total pins	27 / 622 (4 %)
Total virtual pins	0
Total memory bits	0 / 1,152,000 (0 %)
Embedded Multiplier 9-bit elements	0 / 300 (0 %)
Total PLLs	0 / 4 (0 %)

Description of your design

1.Encoder :

我的作法類似於字串比較，首先我先比較 search_buffer[8]與ahead_buffer[7]，當相同時就繼續往下比對(search_buffer[7]與ahead_buffer[6])，但是如果不同就比較 search_buffer[7]與 ahead_buffer[7] (以此類推)，重複上述的動作直到比較到 searcher_buffer [0]為止。這時把剛剛比對的所有字串中長度最大的字串的開頭(offset)、長度(match_len)、字串後的第一個字元(char_nxt)拉到輸出即可，並更新 search_buffer 與 ahead_buffer 的內容。一直重複比對直到字串後的第一個字元(char_nxt)為 36 時，即終止程式運行(finish 拉為 high)。

2.Decoder :

這個部分比起 Encoder 算是相對簡單不少，我先用一個寬度為 4 bit 長度為 9 的陣列來儲存 search_buffer 的資料。

1.當輸入的 code_len 為 0 時就只要將輸入(chardata)直接拉到輸出(char_nxt)即可，最後把 search_buffer 全部往後平移一個位置並把 chardata 放入 search_buffer [0]。

2.當輸入的 code_len 不為 0 時就要先將 search_buffer[code_position] 拉到輸出(char_nxt)，再把 search_buffer 全部往後平移一個位置並把 search_buffer[code_position] 放入 search_buffer [0]。並重複此動作 code_len 次以後再執行一次 code_len 為 0 的情況即可。

*Scoring = (Total logic elements + total memory bit + 9*embedded multiplier 9-bit element)*