

Homework 3

Name: Yiqiao Jin

UID: 305107551

1. $G_0 = A_0 * B_0$.

Both A_0 and B_0 are available at 0T

Delay = $2T$, the delay of 1 AND gate

2. $P_0 = A_0 \oplus B_0$.

Delay = $2T$, the delay of 1 XOR gate

3. $G_\alpha = G_0 * P_1 * P_2 * P_3 + G_1 * P_2 * P_3 + G_2 * P_3 + G_3$

Delay = Delay of 4-input OR gate + maximum delay of the 4 inputs = $5T + \max(5T+2T, 3T+2T, 2T+2T, 2T) = 12T$

4. $P_\alpha = P_0 * P_1 * P_2 * P_3$

Delay = Delay of 4-input AND gate = $7T$

5. $C_{12} = G_\gamma + G_\beta * P_\gamma + G_\alpha * P_\beta * P_\gamma + C_0 * P_\alpha * P_\beta * P_\gamma$

The output OR gate has delay $5T$

Each Propagator P has delay $7T$

Each Generator G has delay $12T$

Delay = $5T + \max(12T, 2T + \max(12T, 7T), 3T + \max(12T, 7T, 7T), 5T + \max(0T, 7T, 7T, 7T)) = 5T + 15T = 20T$

6. $C_{15} = G_{14} + G_{13} * P_{14} + G_{12} * P_{13} * P_{14} + C_{12} * P_{12} * P_{13} * P_{14}$

Delay = $5T + \max(2T, 2T + \max(2T, 2T), 3T + \max(2T, 2T, 2T), 5T + \max(20T, 2T, 2T, 2T)) = 30T$

7. $C_{16} = G_\delta + G_\gamma * P_\delta + G_\beta * P_\gamma * P_\delta + G_\alpha * P_\beta * P_\gamma * P_\delta + C_0 * P_\alpha * P_\beta * P_\gamma * P_\delta$

Delay = $7T + \max(12T, 2T + \max(12T, 7T), 3T + \max(12T, 7T, 7T), 5T + \max(12T, 7T, 7T, 7T), 7T + \max(0T, 7T, 7T, 7T, 7T)) = 7T + \max(12T, 14T, 15T, 17T, 14T) = 24T$

8. $S_{15} = A_{15} \oplus B_{15} \oplus C_{15}$

Delay = $3T + 30T = 33T$

9.

$$C_{20} = G_{19} + G_{18} * P_{19} + G_{17} * P_{18} * P_{19} + G_{16} * P_{17} * P_{18} * P_{19} + C_{16} * P_{16} * P_{17} * P_{18} * P_{19}$$

For the CSA, C_{16} has delay $0T$. The output is generated by a 5-input OR gate.

Delay = $7T + \max(2T, 2T+2T, 3T+2T, 5T+2T, 7T+2T) = 7T + 9T = 16T$

10. $C_{19} = G_{18} + G_{17} * P_{18} + G_{16} * P_{17} * P_{18} + C_{16} * P_{16} * P_{17} * P_{18}$ For the CSA, C_{16} has delay $0T$. The output is generated by a 4-input OR gate.

Delay = $5T + \max(2T, 2T+2T, 3T+2T, 5T+2T) = 5T+7T = 12T$

$$S_{19} = A_{19} \oplus B_{19} \oplus C_{19}$$

Delay = $3T + \max(0T, 0T, 12T) = 15T$

11.

$$C_{24} = G_{23} + G_{22} * P_{23} + G_{21} * P_{22} * P_{23} + G_{20} * P_{21} * P_{22} * P_{23} + C_{20} * P_{20} * P_{21} * P_{22} * P_{23}$$

$$\text{Delay} = 7T + \max(2T, 2T+2T, 3T+2T, 5T+2T, 7T+16T) = 7T + 23T = 30T$$

$$12. C_{31} = G_{30} + G_{29} * P_{30} + G_{28} * P_{29} * P_{30} + C_{28} * P_{28} * P_{29} * P_{30}$$

$$C_{28} = G_{27} + G_{26} * P_{27} + G_{25} * P_{26} * P_{27} + G_{24} * P_{25} * P_{26} * P_{27} + C_{24} * P_{24} * P_{25} * P_{26} * P_{27}$$

$$\text{Delay of } C_{28} = 7T + \max(2T, 2T+2T, 3T+2T, 5T+2T, 7T+30T) = 44T$$

$$\text{Delay of } C_{31} = 5T + \max(2T, 2T+2T, 3T+2T, 5T+44T) = 54T$$

13. Before MUX:

$$C_{32} = G_{31} + G_{30} * P_{31} + G_{29} * P_{30} * P_{31} + G_{28} * P_{29} * P_{30} * P_{31} + C_{28} * P_{28} * P_{29} * P_{30} * P_{31}$$

$$\text{Delay} = 7T + \max(2T, 2T+2T, 3T+2T, 5T+2T, 7T+44T) = 58T$$

The selection bit C_{16} has delay 24T

$$\text{After MUX: } C_{32} = 4T + \max(58T, 58T, 24T) = 62T$$

14. Before MUX:

$$S_{31} = A_{31} \oplus B_{31} \oplus C_{31} = 3T + \max(0T, 0T, 54T) = 57T$$

After MUX:

$$S_{31} = 4T + \max(57T, 57T, 24T) = 61T$$

15. The maximal delay is the max latency of these 3 outputs:

$S_0 - S_{15}$ from the 16-bit HCLA. Max latency is 33T from S_{15}

$S_{16} - S_{31}$ from MUX of the 16-bit CSA. Max latency is 61T from S_{31}

C_{31} from MUX of the 16-bit CSA. Latency is 62T

So Maximal Delay = $\max(33T, 61T, 62T) = 62T$