Exercise 4.

\[
x(n_{1,n2})
\]

\[
\begin{array}{lll}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{array}
\]

\[
\begin{array}{lll}
D & D & D
\end{array}
\]

\[
\text{Line Delay}
\]

Exercise 6.

(a) Using broadcast architecture can save pipelining registers.

\[
x(n)
\]

\[
\begin{array}{lll}
c & b & a
\end{array}
\]

\[
\begin{array}{lll}
D & 2D & D
\end{array}
\]

(b) \( \therefore (G, j) \), could be achieved by \( (G, j) \), for clarity, retiming is applied first.

\[
x(n)
\]

\[
\begin{array}{lll}
c & b & a
\end{array}
\]

\[
\begin{array}{lll}
D & 2D & D
\end{array}
\]

Then the 3-parallel architecture is
Exercise 11.

Pipeline latch delay is negligible so $C_{\text{charge}}$ remains unchanged;

$$M(\beta V_o - V_i)^2 = \beta(V_o - V_i)^2$$

Solve $16M\beta^2 - (11.56 + 4.8M)\beta + 0.36M = 0$ for each $M$, then

$$\text{Power} = (C_{\text{total}} + C_{\text{latch}})(\beta V_o)^2 f$$

<table>
<thead>
<tr>
<th>$M$</th>
<th>$\beta$</th>
<th>$C_{\text{total}}$</th>
<th>$\text{Power}$</th>
<th>$V_{\text{dd}}$</th>
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<td>1</td>
<td>4.00</td>
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<td>3</td>
<td>0.4954</td>
<td>1.2</td>
<td>1.98</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.4281</td>
<td>1.3</td>
<td>1.71</td>
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<tr>
<td>5</td>
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<td>0.3575</td>
<td>1.5</td>
<td>1.43</td>
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<td>7</td>
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<td>1.35</td>
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<tr>
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<td>1.19</td>
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<tr>
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<tr>
<td>13</td>
<td>0.2732</td>
<td>2.2</td>
<td>1.09</td>
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</tr>
</tbody>
</table>

![Graph](image1.png)

![Graph](image2.png)
Chapter 4 Retiming

Exercise 1.

(a) \( T_w = \frac{T_M + 2T_A}{2} = 18 \)

(b) \( 6T_A + 2T_M = 88 \)

![Diagram 1](image1)

(c) Because \( T_M > T_w \), fine-grain pipelining is required and the multiplication units are divided into two sub-parts with 10-unit computation time each. The cutset for retiming is shown as following.

![Diagram 2](image2)

Exercise 8.

\[
[r_1 \ r_2 \ r_3 \ r_4 \ r_5]^T = [0 \ 0 \ -1 \ -2 \ 0]^T
\]

Exercise 17.