



CSARCH Lecture Series: Sequential Circuitry Binary Multiplier

Sensei RL Uy

College of Computer Studies

De La Salle University

Manila, Philippines



Copyright Notice

This lecture contains copyrighted materials and is use solely for instructional purposes only, and not for redistribution.

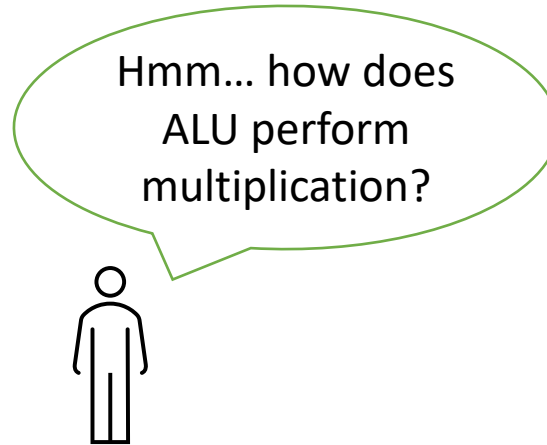
Do not edit, alter, transform, republish or distribute the contents without obtaining express written permission from the author.

Overview

Reflect on the following question:

- How does Arithmetic and Logic Unit (ALU) perform multiplication?

```
int main()
{
    int var, var1, var2;
    var = 5;
    var1 = 2;
    var2 = var * var1;
}
```



Overview

- This sub-module describes how Arithmetic Logic Unit (ALU) performs multiplication
- The objective is as follows:
 - ✓ Describe the process of performing sequential circuit binary multiplier

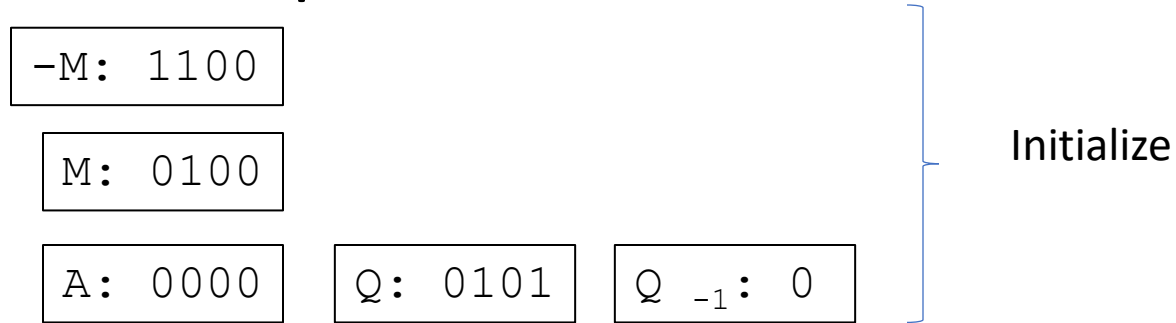
ALU Multiplication

- One of the method which Arithmetic and Logic Unit (ALU) uses to perform multiplication is called sequential circuit binary multiplier

Sequential Circuit Binary Multiplier

- Initialization
 - $A \leftarrow 0, Q_{-1} \leftarrow 0$
 - M gets multiplicand.
 - Q gets multiplier.
- Loop for each bit of multiplier
 - If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
 - else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
 - Arithmetic Shift right $A Q_0 Q_{-1}$.
- Result contained in register combination AQ .

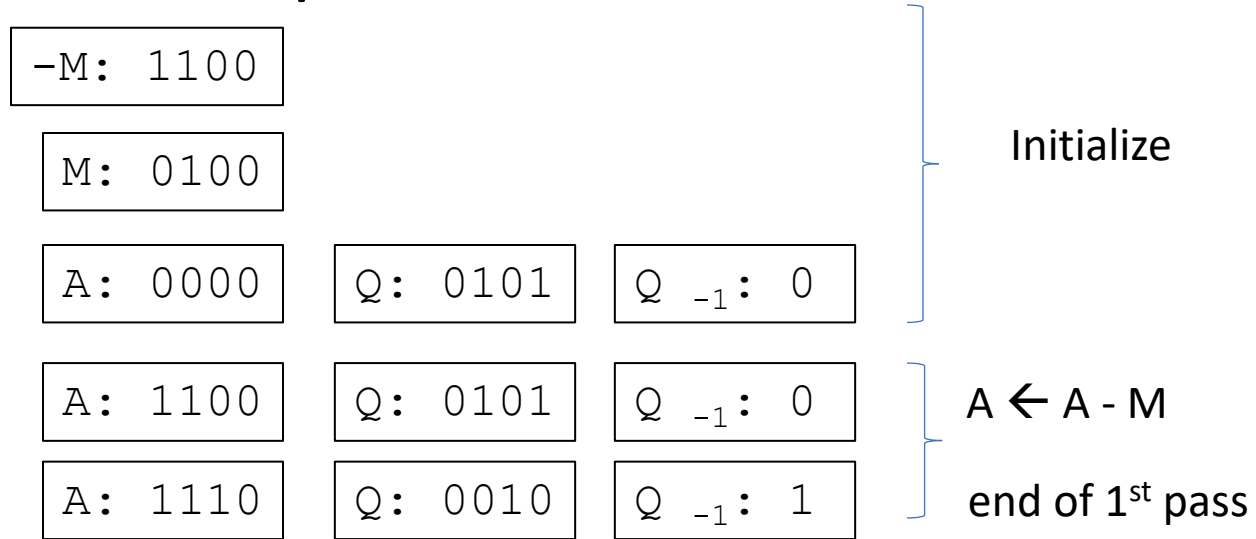
Sequential Circuit Binary Multiplier



0100 (M) * 0101 (Q)

- Initialization
 - $A \leftarrow 0, Q_{-1} \leftarrow 0$
 - M gets multiplicand.
 - Q gets multiplier.
- Loop for each bit of multiplier
 - If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
 - else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
 - Arithmetic Shift right $A Q_0 Q_{-1}$.
- Result contained in register combination AQ .

Sequential Circuit Binary Multiplier



0100 (M) * 0101 (Q)

- Initialization

- $A \leftarrow 0, Q_{-1} \leftarrow 0$
- M gets multiplicand.
- Q gets multiplier.
- Loop for each bit of multiplier
 - If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
 - else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
 - Arithmetic Shift right $A Q_0 Q_{-1}$.
- Result contained in register combination AQ .

Sequential Circuit Binary Multiplier

-M: 1100			Initialize
M: 0100			
A: 0000	Q: 0101	Q ₋₁ : 0	
A: 1100	Q: 0101	Q ₋₁ : 0	A ← A - M
A: 1110	Q: 0010	Q ₋₁ : 1	
A: 0010	Q: 0010	Q ₋₁ : 1	A ← A + M
A: 0001	Q: 0001	Q ₋₁ : 0	
			end of 2 nd pass

0100 (M) * 0101 (Q)

- Initialization

- $A \leftarrow 0, Q_{-1} \leftarrow 0$
- M gets multiplicand.
- Q gets multiplier.

- Loop for each bit of multiplier

- If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
- else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
- Arithmetic Shift right $A Q_0 Q_{-1}$.

- Result contained in register combination AQ .

Sequential Circuit Binary Multiplier

-M: 1100			Initialize
M: 0100			
A: 0000	Q: 0101	Q ₋₁ : 0	
A: 1100	Q: 0101	Q ₋₁ : 0	A ← A - M
A: 1110	Q: 0010	Q ₋₁ : 1	
A: 0010	Q: 0010	Q ₋₁ : 1	end of 1 st pass
A: 0001	Q: 0001	Q ₋₁ : 0	
A: 1101	Q: 0001	Q ₋₁ : 0	A ← A + M
A: 1110	Q: 1000	Q ₋₁ : 1	
			end of 2 nd pass
			A ← A - M
			end of 3 rd pass

0100 (M) * 0101 (Q)

- Initialization

- $A \leftarrow 0, Q_{-1} \leftarrow 0$
- M gets multiplicand.
- Q gets multiplier.

- Loop for each bit of multiplier

- If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
- else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
- Arithmetic Shift right $A Q_0 Q_{-1}$.

- Result contained in register combination AQ .

Sequential Circuit Binary Multiplier

-M: 1100			Initialize
M: 0100			
A: 0000	Q: 0101	Q ₋₁ : 0	
A: 1100	Q: 0101	Q ₋₁ : 0	A ← A - M
A: 1110	Q: 0010	Q ₋₁ : 1	
A: 0010	Q: 0010	Q ₋₁ : 1	end of 1 st pass
A: 0001	Q: 0001	Q ₋₁ : 0	
A: 1101	Q: 0001	Q ₋₁ : 0	A ← A + M
A: 1110	Q: 1000	Q ₋₁ : 1	
A: 0010	Q: 1000	Q ₋₁ : 1	end of 2 nd pass
A: 0001	Q: 0100	Q ₋₁ : 1	
A: 0001	Q: 0100	Q ₋₁ : 1	A ← A - M
A: 0010	Q: 0100	Q ₋₁ : 1	
A: 0010	Q: 0100	Q ₋₁ : 1	end of 3 rd pass
A: 0001	Q: 0100	Q ₋₁ : 1	
A: 0001	Q: 0100	Q ₋₁ : 1	A ← A + M
A: 0001	Q: 0100	Q ₋₁ : 1	
A: 0001	Q: 0100	Q ₋₁ : 1	end of 4 th pass

0100 (M) * 0101 (Q)

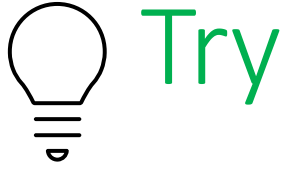
- Initialization

- $A \leftarrow 0, Q_{-1} \leftarrow 0$
- M gets multiplicand.
- Q gets multiplier.

- Loop for each bit of multiplier

- If $Q_0 Q_{-1} = 01$ then $A \leftarrow A + M$
- else if $Q_0 Q_{-1} = 10$ then $A \leftarrow A - M$
- Arithmetic Shift right $A Q_0 Q_{-1}$.

- Result contained in register combination AQ .



Try: $11101 * 11010$ (using sequential circuit binary multiplier)
Show the value of A and Q after the end of each pass

After this pass	A	Q
1 st		
2 nd		
3 rd		
4 th		
5 th		



Try: $11101 * 11010$ (using sequential circuit binary multiplier)
Show the value of A and Q after the end of each pass

After this pass	A	Q
1 st	00000	01101
2 nd	11001	10110
3 rd	00011	01011
4 th	11011	00101
5 th	11101	10011

To recall ...

- What have we learned:
 - ✓ Describe the process of performing sequential circuit binary multiplier