



## Lab Manual

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### Experiment No: 3

**Experiment Name:** Design a 4-bit Binary Multiplication Unit

**Introduction:** Combinational Multipliers do multiplication of two unsigned binary numbers. Each bit of the multiplier is multiplied against the multiplicand, the product is aligned according to the position of the bit within the multiplier, and the resulting products are then summed to form the final result. Main advantage of binary multiplication is that the generation of intermediate products are simple: if the multiplier bit is a 1, the product is an appropriately shifted copy of the multiplicand; if the multiplier bit is a 0, the product is simply 0.

### Theory:

The design of a combinational multiplier to multiply two 4-bit binary number is illustrated below:

			A <sub>3</sub> B <sub>3</sub>	A <sub>2</sub> B <sub>2</sub>	A <sub>1</sub> B <sub>1</sub>	A <sub>0</sub> B <sub>0</sub>
			A <sub>3</sub> . B <sub>0</sub>	A <sub>2</sub> . B <sub>0</sub>	A <sub>1</sub> . B <sub>0</sub>	A <sub>0</sub> . B <sub>0</sub>
		A <sub>3</sub> . B <sub>1</sub>	A <sub>2</sub> . B <sub>1</sub>	A <sub>1</sub> . B <sub>1</sub>	A <sub>0</sub> . B <sub>1</sub>	
	A <sub>3</sub> . B <sub>2</sub>	A <sub>2</sub> . B <sub>2</sub>	A <sub>1</sub> . B <sub>2</sub>	A <sub>0</sub> . B <sub>2</sub>		
A <sub>3</sub> . B <sub>3</sub>	A <sub>2</sub> . B <sub>3</sub>	A <sub>1</sub> . B <sub>3</sub>	A <sub>0</sub> . B <sub>3</sub>			
S <sub>6</sub>	S <sub>5</sub>	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>0</sub>

If two n-bit numbers are multiplied then the output will be less than or equals to 2n bits.

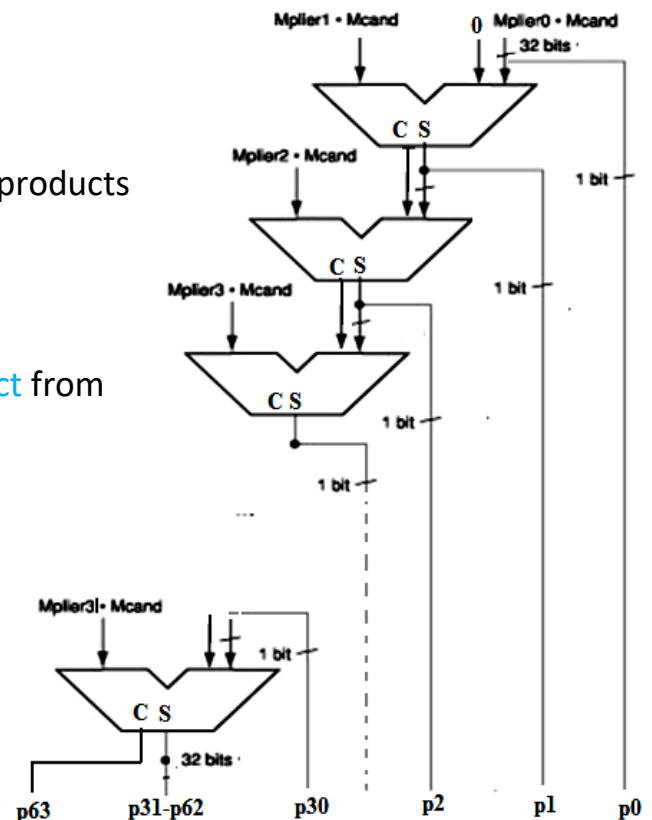
### Binary Multiplication Procedure:

- $m \times n$  bits =  $m + n$  bit product
- $m + n$  bits required to represent all possible products
- There are only two possibilities in every step
- If multiplier bit = 1
- copy multiplicand (1 x multiplicand)
- If multiplier bit = 0
- place 0 (0 x multiplicand)
- Need an adder unit to add

Multiplicand	1000
Multiplier	$\times$ 1001
	<u>1000</u>
	0000X
	0000XX
	<u>1000XXX</u>
Product	01001000

## ■ Multiplication Hardware 32-bit MIPS Example

- Use 31 32-bit adders to compute the partial products
- One input is the **multiplicand** ANDed with a **multiplier**, and the other is the **partial product** from previous step.



### Objectives:

- Understanding behavior of combinational multiplier from module designed by the student as part of the experiment
- Understanding the theory and implement the multiplication unit which is as follows (along with the logic diagram bellow)
- Check Multiplying bits and Show the sum outputs

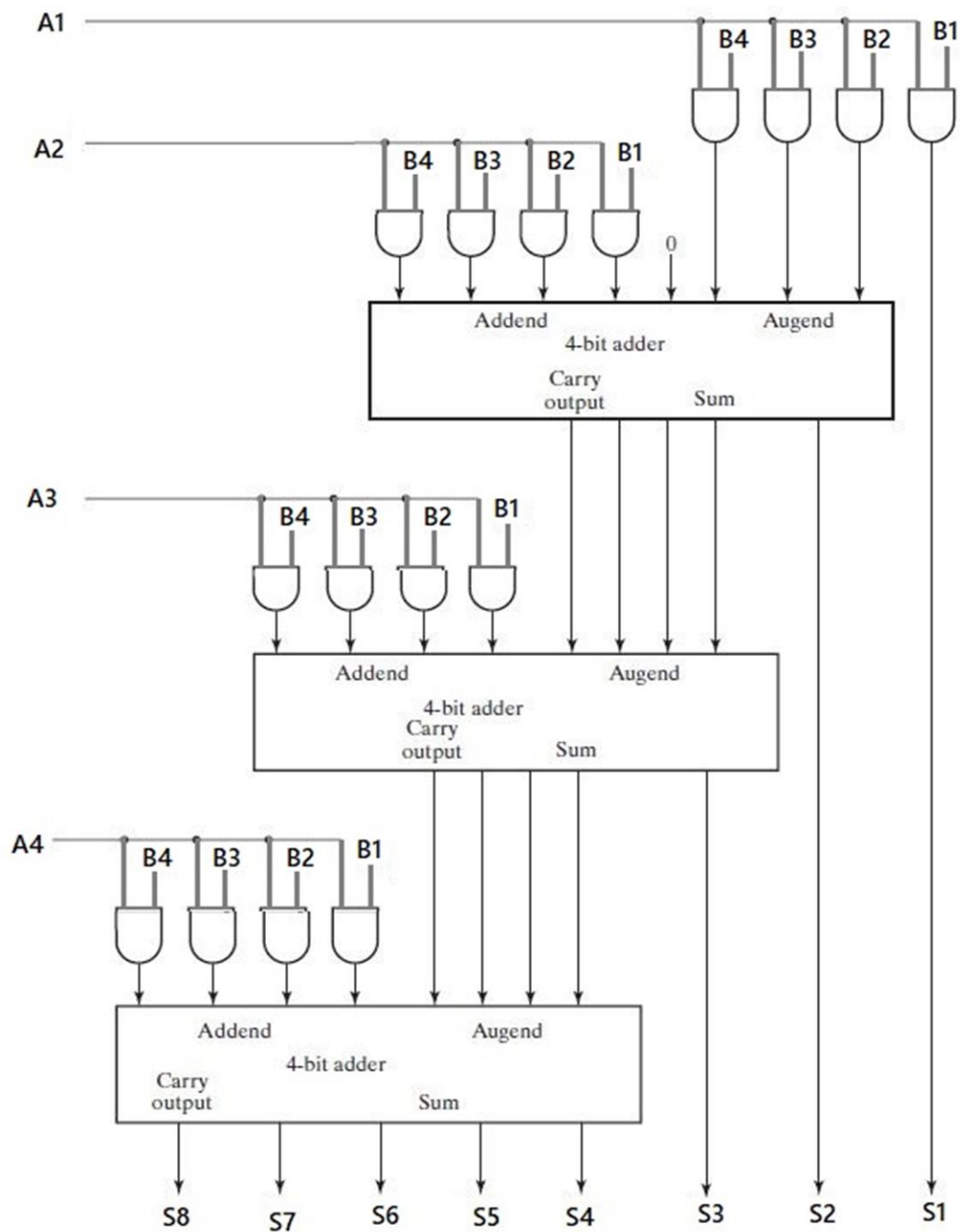
### Apparatus:

- 4 X 7408 AND IC
- 3 X 7483 or 74283 4-bit Adder IC
- Trainer Board
- Wires

### **D. Procedure:** Design a Combinational 4-bit multiplier.

1. Identify the inputs and outputs from the truth table and complete the system analysis.
2. Complete the Theoretical Truth Table in (**Table 1**) for the 4-bit multiplier.
3. Simulate the Entire circuit in Logisim showing the pin configurations and values properly (**Figure 1**).
4. Implement the circuit in the trainer board. Test one output one at a time.
  - Connect the 4 inputs of the **Multiplicand A1, A2, A3, A4**
  - Connect the 4 inputs of the **Multiplier B1, B2, B3, B4**
  - Connects the Total 8 Sums Output from the 3 Adders and Connect them to the LED and Observe Outputs
5. Now Complete the Experimental truth table (**Table 2**) for the 4-bit multiplier with the outputs from the hardware.

## LOGIC CIRCUIT DIAGRAM



A 4-Bit by 4-Bit Binary Multiplier

Fig:1

**Table:1 Theoretical**

<b>Multiplicand</b> A1 A2 A3 A4	<b>Multiplier</b> B1 B2 B3 B4	<b>Product</b> S8 S7 S6 S5 S4 S3 S2 S1	<b>Result in Decimal</b>
1 0 0 0	1 0 0 1	0 1 0 0 1 0 0 0	<b>8 × 9 = 72</b>
0 1 0 1	0 0 1 0		
0 1 1 1	0 0 1 1		
0 1 0 0	1 0 0 0		
0 1 0 1	0 1 1 0		
1 0 0 1	0 1 0 0		
1 1 1 1	1 0 1 1		

**Table:2 Experimental**

<b>Multiplicand</b> A1 A2 A3 A4	<b>Multiplier</b> B1 B2 B3 B4	<b>Product</b> S8 S7 S6 S5 S4 S3 S2 S1	<b>Result in Decimal</b>
1 0 0 0	1 0 0 1	0 1 0 0 1 0 0 0	<b>8 × 9 = 72</b>
0 0 0 1	0 0 1 0		
0 0 1 1	0 1 1 1		
0 1 0 0	1 0 0 0		
0 1 0 1	0 1 1 0		
1 0 0 1	0 1 0 0		
1 1 1 1	1 0 1 1		

**E. Report**

- Simulate the entire 4-bit Multiplication Unit in Logisim. Provide a screenshot of the Logisim circuit schematic and truth table with your report.
- Make a Sub-Circuit of the 4-bit Multiplier and also Provide the Screenshot along with the Truth Table in Logisim

## Pin Configuration of the ICs:

