Lab Manual
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Experiment No: 2
Experiment Name: Design a 4-bit by 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:

				B_4	B_3	B_2	B_1
				A_4	A_3	A_2	A_1
				$A_1 . B_4$	$A_1 . B_3$	$A_1 . B_2$	$A_1 . B_1$
			$A_2 . B_4$	$A_2 . B_3$	$A_2 . B_2$	$A_2 . B_1$	
		$A_3 . B_4$	$A_3 . B_3$	$A_3 . B_2$	$A_3 . B_1$		
	$A_4 . B_4$	$A_4 . B_3$	$A_4 . B_2$	$A_4 . B_1$			
S_7	S_6	S_5	S_4	S_3	S_2	S_1	S_0

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

Binary Multiplication Procedure:

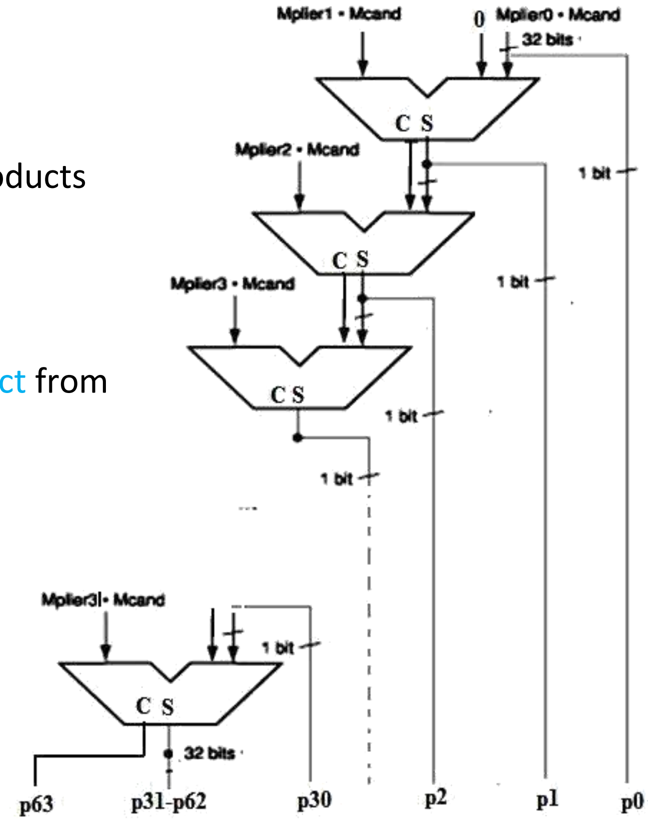
m x n bits = **m + n** bit product

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	x 1001
	1000
	0000X
	0000XX
	1000XXX
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

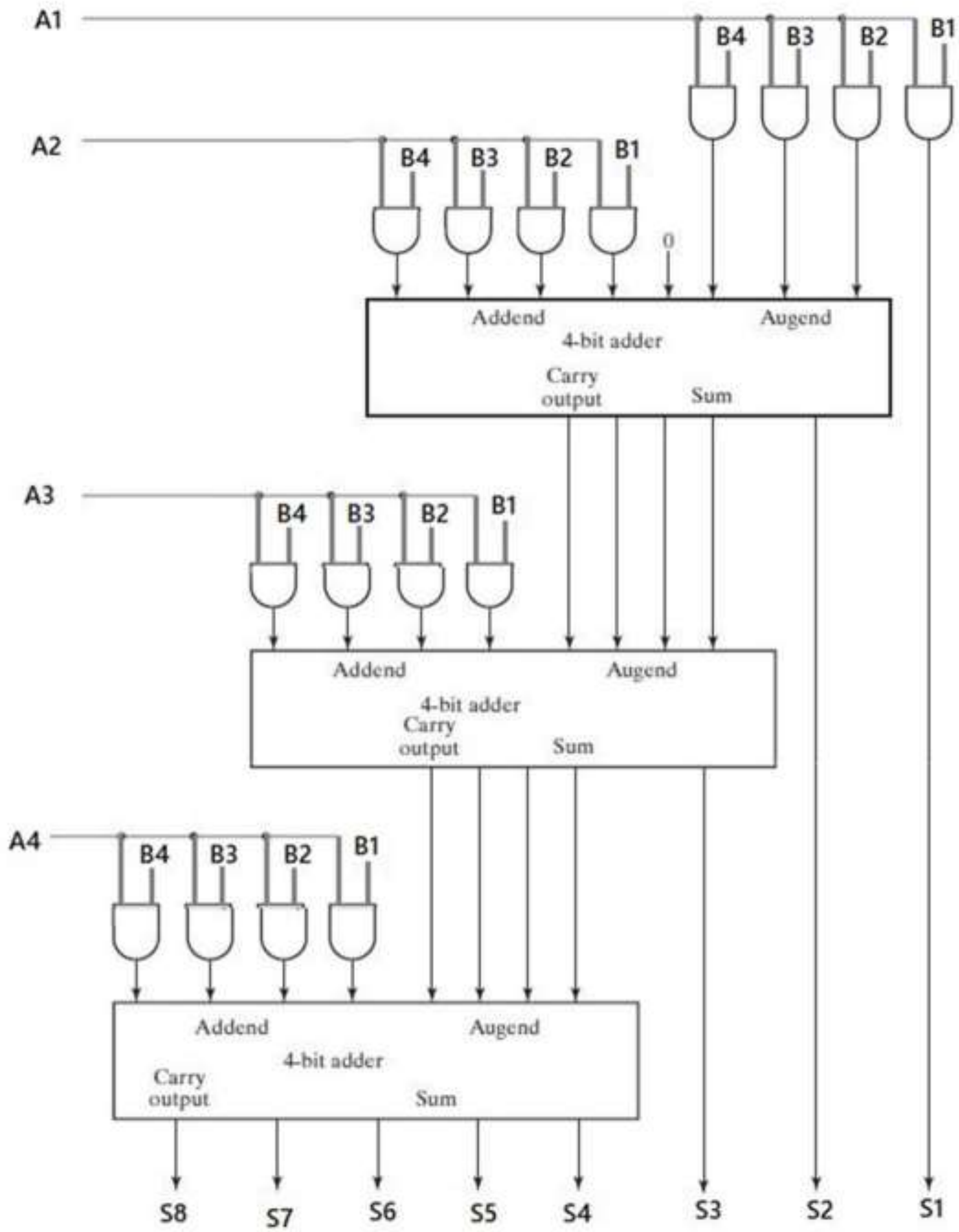
Apparatus:

- 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 **Multiplier A1, A2, A3, A4**
   - Connect the 4 inputs of the **Multiplicand 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

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

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

Assignment:

- **Implement the entire 4-bit Multiplication circuit in Logisim. Submit logisim (.circ) file within the given time by your lab instructor.**

- **Prepare and submit the lab report individually within the given time. In the report, you have to include the *Screenshot* of the circuit as a Circuit Diagram. The screenshot must contain your name and ID along with the circuit.**

****Plagiarism and late submission will not be acceptable.**

Pin Configuration of the ICs: