Lab Report

On

Multiplication of Two Unsigned Integer Binary Numbers

Computer Organization and Architecture

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1 Multiplication of Two Unsigned Integer Binary Numbers

1.1 Introduction

The multiplication of binary numbers is a fundamental operation in digital systems, forming the basis of arithmetic and logical operations in computer architecture. This report details the design and implementation of a hardware module to multiply two 4-bit unsigned binary numbers using the partial-product method in SystemVerilog, along with a testbench to verify its functionality.

1.2 Objective

To design an unsigned binary multiplier using the partial-product method in SystemVerilog and understand its workings.

1.3 Theory

The partial-product method for binary multiplication follows the following process:

1. Multiply each bit of the multiplier by the multiplicand to generate partial products.
2. Align the partial products according to their bit positions and sum all of them.

For 4-bit multiplication, the final product will be an 8-bit number.

1.4 Design

The `UnsignedMultiplier` module takes two 4-bit inputs, A and B, and produces an 8-bit product.

```
module UnsignedMultiplier(
  input [3:0] A, // 4-bit input A (multiplicand)
  input [3:0] B, // 4-bit input B (multiplier)
  output [7:0] Product // 8-bit output for the product
);

  // Internal signal for the product
  reg [7:0] partial_products [3:0]; // Array to store partial products
  integer i;

  // Generate partial products
  always @(*) begin
    for (i = 0; i < 4; i = i + 1) begin
      if (B[i])
        partial_products[i] = A << i; // Shift A left by i positions
      else
        partial_products[i] = 8'b00000000; // Zero if B[i] is 0
    end
  end

  // Sum the partial products
  assign Product = partial_products[0] +
                   partial_products[1] +
                   partial_products[2] +
                   partial_products[3] ;

endmodule
```

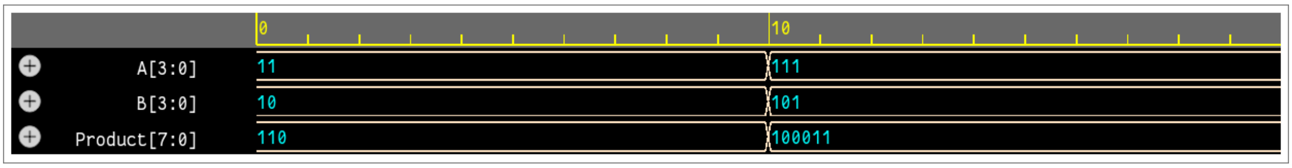
1.5 Testbench

The testbench module is used to apply various test cases to the `UnsignedMultiplier` module and verify the correctness of its outputs.

```
module testbench;
    // Inputs
    reg [3:0] A;
    reg [3:0] B;

    // Outputs
    wire [7:0] Product;

    UnsignedMultiplier dut (A, B, Product);

    initial begin
        $dumpfile("dump.vcd");
        $dumpvars(1);

        // Test case 1: A = 3, B = 2
        A = 4'b0011;
        B = 4'b0010;
        #10; // Wait for 10 time units
        // Display the output in the log
        $display(
            "1: A = %4b, B = %4b, Product = %8b", A, B, Product
        );

        // Test case 2: A = 7, B = 5
        A = 4'b0111;
        B = 4'b0101;
        #10; // Wait for 10 time units
        // Display the output in the log
        $display(
            "2: A = %4b, B = %4b, Product = %8b", A, B, Product
        );
    end
endmodule
```

1.6 Results

The simulation was conducted in EDA Playground. The results were as follows:



Output:

```
1: A = 0011, B = 0010, Product = 00000110
2: A = 0111, B = 0101, Product = 00101111
```

The results are the expected outputs.

1.7 Conclusion

The `UnsignedMultiplier` module correctly multiplies two unsigned 4-bit binary numbers using the partial-product method.