4 BIT MULTIPLIER

INTRODUCTION

A 4-bit multiplier is a digital circuit that multiplies two 4-bit binary numbers, producing an 8-bit output. It uses logic gates such as AND gates and adders to perform binary multiplication efficiently. Commonly used in microprocessors, arithmetic units, and embedded systems, the 4-bit multiplier is valued for its simplicity, speed, and low power consumption, making it a crucial building block in more complex digital systems.

OBJECTIVE

The objective of a 4-bit multiplier is to:

1. Multiply two 4-bit binary numbers.
2. Produce an 8-bit binary output.
3. Ensure accuracy using logic gates.
4. Optimize for speed and efficiency in digital circuits.
5. Serve as a building block for larger multipliers.

SCOPE

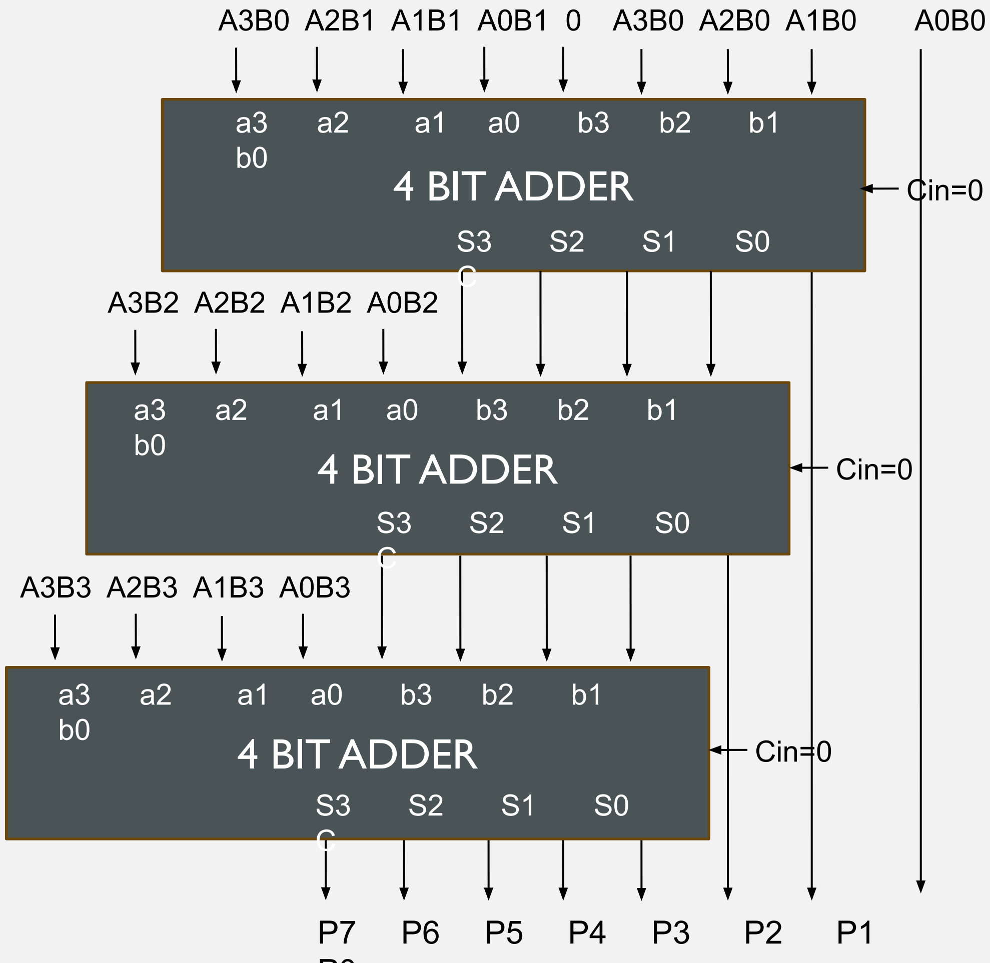
The scope of a 4-bit multiplier involves:

1. **Basic Arithmetic**: Used in microprocessors and ALUs for binary multiplication.
2. **Embedded Systems**: Applied in low-power, simple devices.
3. **Signal Processing**: Used in DSPs for filtering and encoding.
4. **Educational Tool**: Foundation for understanding larger multipliers.
5. **Scalability**: Expandable for higher-bit multipliers.
6. **Hardware Optimization**: Applied in efficient FPGA and ASIC designs.

It plays a vital role in digital circuits and low-complexity applications.

BLOCK DIAGRAM

4 BIT BY 4 BIT BINARY MULTIPLIER



DESIGN

A 4-bit multiplier multiplies two 4-bit binary numbers using logic gates and adders.

1. **Inputs**: Two 4-bit numbers: A (A3 A2 A1 A0) and B (B3 B2 B1 B0).
2. **Partial Products**: Generated by multiplying each bit of A with each bit of B using AND gates.
3. **Summation**: The partial products are summed using half adders and full adders.
4. **Output**: The final result is an 8-bit binary output: P7 P6 P5 P4 P3 P2 P1 P0.

This design efficiently performs binary multiplication and is commonly used in digital systems like microprocessors.

```verilog
module multiplier_4bit(
    input [3:0] a, // 4-bit input a
    input [3:0] b, // 4-bit input b
    output [7:0] product // 8-bit output product
);
    assign product = a * b; // Multiplication operation
endmodule
```

```
module testbench;
  reg [3:0] a, b;
  wire [7:0] product;

  // Instantiate the multiplier module
  multiplier_4bit uut (
    .a(a),
    .b(b),
    .product(product)
  );

  // Dump the variables into a .vcd file for GTKWave
  initial begin
    $dumpfile("multiplier_4bit.vcd"); // Create a VCD file
    $dumpvars(0, testbench); // Dump all signals in the testbench
  end

  initial begin
    // Test cases
    $monitor("a = %b, b = %b, product = %b", a, b, product);

```

```
      // First test
      a = 4'b0011; b = 4'b0101; // 3 * 5
      #10;

      // Second test
      a = 4'b1111; b = 4'b1111; // 15 * 15
      #10;

      // Third test
      a = 4'b1001; b = 4'b0110; // 9 * 6
      #10;

      $finish;
   end
endmodule
```

SOFTWARE REQUIREMENTS

1. **HDL Design Tools**: icarus Verilog or VHDL
2. **Simulation Tools**: Xilinx Vivado, ModelSim, or Quartus Prime
3. **Schematic Design Software**: Multisim or Proteus
4. **FPGA/ASIC Design Tools**: Xilinx ISE or Altera Quartus
5. **Circuit Design and Verification**: LTspice or Cadence

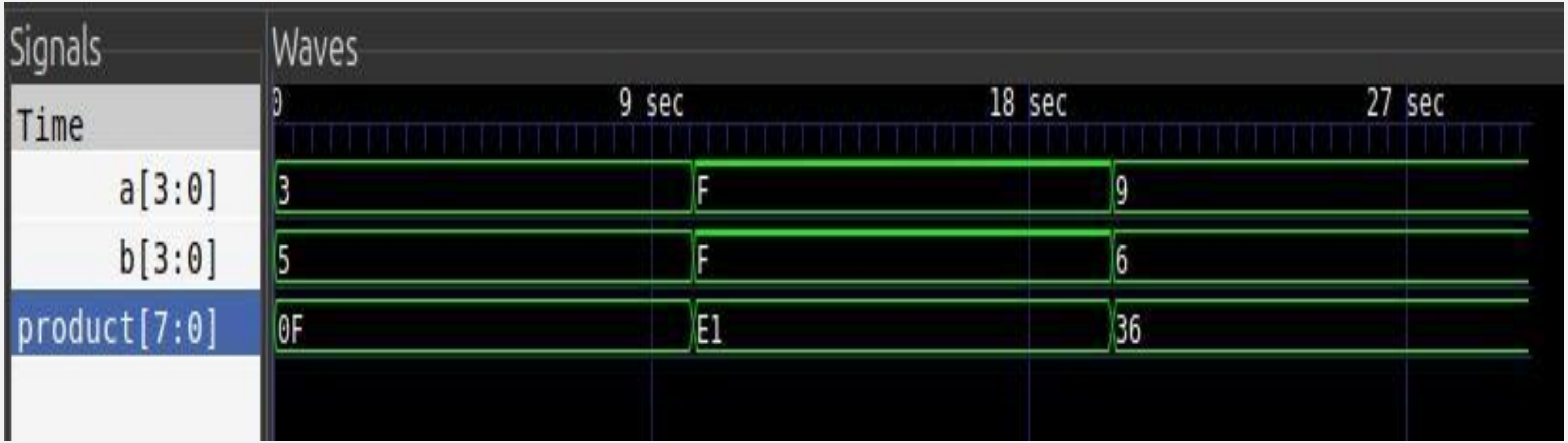
HARDWARE REQUIREMENTS

1. **4-Bit Adder IC (Binary Adder)**: IC 7483
2. **Logic Gates (if not using 4-bit adder IC)**: AND Gates (7408), OR Gates (7432), XOR Gates (7486), NOT Gates (7404)
3. **Flip-Flops or Registers (Optional)**: IC 7474 (D Flip-Flop)
4. **Power Supply**: Typically, 5V DC is required to power the ICs
5. **Breadboard or PCB (Printed Circuit Board)**
6. **Jumper Wires**
7. **Input Devices**: Toggle Switches or DIP Switches
8. **Output Devices**: LEDs, 7-Segment Display (optional)
9. **Oscilloscope or Logic Analyzer**
10. **Resistors**: **330Ω or 220Ω resistors** to limit current through the LEDs (if used for output display).
11. **FPGA Development Board** (if implementing in HDL): If you're designing the 4-bit adder digitally, a board like Xilinx or Altera FPGA will be required to synthesize and test the design in hardware.

BOM

1. **ICs**:
   - 1 x IC 7483
   - 1 x IC 7408
   - 1 x IC 7486
   - 1 x IC 7432
2. **Discrete Components**:
   - Resistors: 4 x 330Ω (LEDs), 4 x 1kΩ (pull-ups)
   - Capacitors: 2 x 0.1μF (decoupling)
3. **Input/Output**:
   - 4 x LEDs: Output display
   - 4 x Switches: Binary input
   - 1 x 7-Segment Displays (optional)
4. **Power Supply**:
   - 5V DC power source
5. **Prototyping Accessories**:
   - 1 x Breadboard
   - Jumper Wires
6. **Testing Equipment**:
   - 1 x Oscilloscope/Logic Analyzer

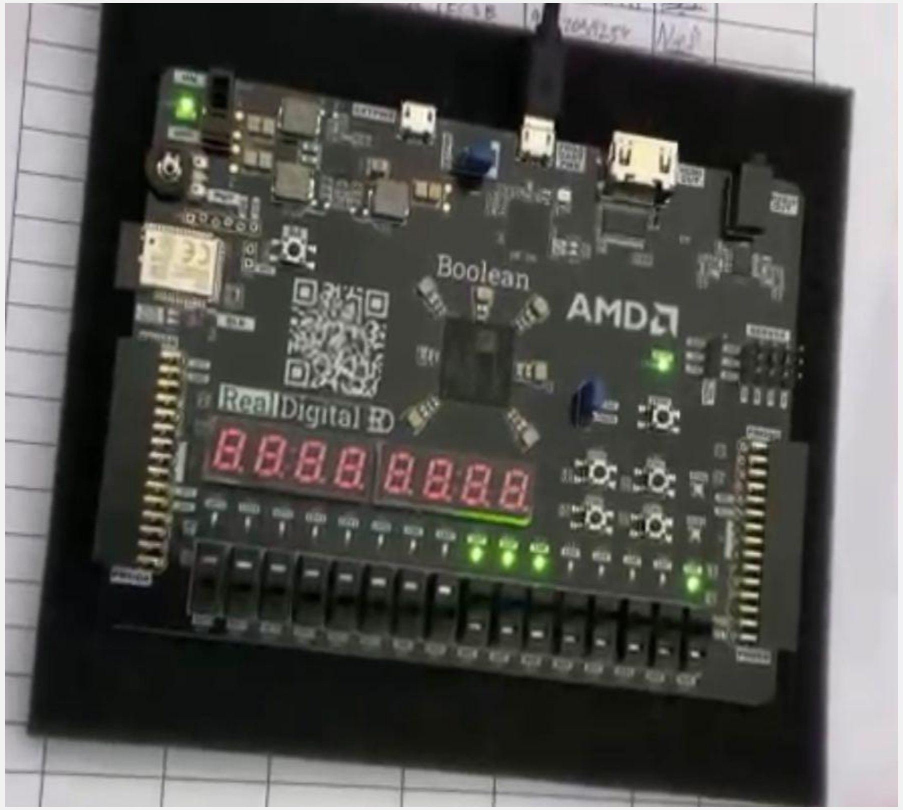
SIMULATION OUTPUT

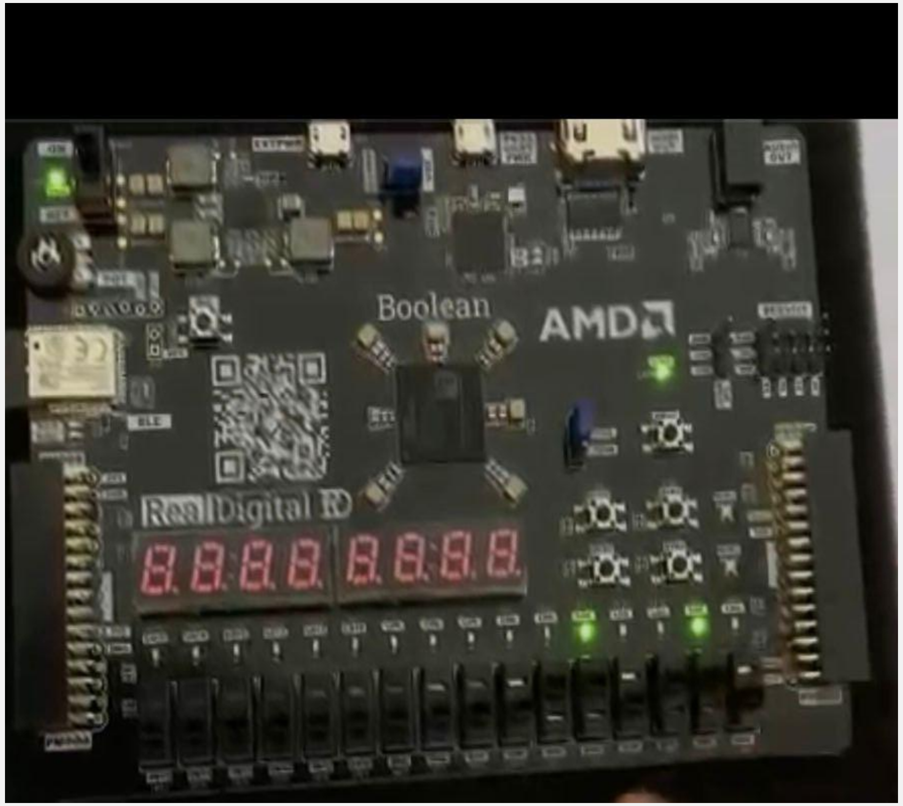


```
gedit multiplier_4bit.v
gedit testbench.v
iverilog -o multiplie_4bit1 testbench.v multiplier_4bit.v

vvp multiplie_4bit1
VCD info: dumpfile multiplier_4bit.vcd opened for output.
a = 0011, b = 0101, product = 00001111
a = 1111, b = 1111, product = 11100001
a = 1001, b = 0110, product = 00110110
testbench.v:34: $finish called at 30 (1s)
```

```
gtkwave multiplier_4bit.vcd

GTKWave Analyzer v3.3.116 (w)1999-2023 BSI

[0] start time.
[30] end time.
```

FPGA IMPLEMENTATION





15*15=225

3*6=18

CONCLUSION

- The 4-bit multiplier is crucial in digital computation, providing efficient and reliable multiplication of binary numbers. Its ability to produce accurate 8-bit results from two 4-bit inputs makes it ideal for integration into systems such as microprocessors and arithmetic units.
- Moreover, its scalability allows for expansion into larger multipliers, making it a versatile solution for more complex circuit designs.
- Overall, the 4-bit multiplier enhances digital systems by offering a balance of precision and efficiency in performing arithmetic operations.

REFERENCES

- [1] A. Kumar and B. Patel, "Design and Implementation of a 4-Bit Multiplier System," International Journal of Electronics and Communication Engineering.
- [2] M. Johnson, "Utilizing Multipliers in Digital Systems," Proceedings of the IEEE International Conference on Digital Systems

THANK YOU