Project 96: Automatic Door Controller

A Comprehensive Study of Advanced Digital Circuits

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1 Project Overview

To design and implement an automatic door controller system that uses sensors and actuators to open and close doors automatically, improving convenience, security, and energy efficiency. **Automatic Operation:**

- Opens and closes doors based on user detection using sensors.

Hands-Free Access:

- Facilitates access without physical contact, enhancing hygiene.

Customizable Settings:

- Adjustable opening/closing speeds and hold times.

Security Integration:

- Supports password, RFID, or biometric authentication for controlled access (optional).

Energy Efficiency:

- Reduces energy loss in climate-controlled environments by minimizing unnecessary door operation.

2 Automatic Door Controller

2.1 Key Components of Automatic Door Controller

Sensors:

- Infrared (IR), ultrasonic, or motion sensors for detecting users approaching the door.

Actuators:

- Electric motors or servo motors to operate the door mechanism.

Microcontroller:

- A microcontroller (e.g., Arduino, Raspberry Pi) to control the system logic.

Power Supply:

- Provides electricity to the entire system, possibly including backup batteries.

Authentication Module (Optional):

- Keypad, RFID reader, or fingerprint scanner for secured access.

Mechanical Setup:

- Sliding or hinged door with a motor-driven mechanism.

Additional Features:

- LED indicators, alarms for unauthorized access, or integration with IoT for remote monitoring.

2.2 Working of Automatic Door Controller

Detection:

- Sensors detect a person approaching the door.

Control:

- The microcontroller processes the signal and triggers the motor to open the door.

Hold Time:

- The door remains open for a pre-set duration or until the person passes through.

Closure:

- The motor closes the door automatically after the hold time or when the path is clear.

Security (Optional):

- Access is granted only if authentication is successful.

2.3 RTL Code

Listing 1: Automatic Door Controller

```
1
2  module automatic_door_controller (
3      input  logic clk, reset,
4      input  logic motion_detected,  // Motion sensor input (1 = motion
           detected, 0 = no motion)
5      input  logic manual_override,  // Manual override input (1 =
           override active, 0 = normal)
6      output logic door_open,        // Door open output (1 = open, 0 =
           closed)
7      output logic door_closed       // Door closed output (1 = closed,
           0 = open)
8  );
9
10     // Door states
11     typedef enum logic [1:0] {CLOSED = 2'b00, OPEN = 2'b01}
           door_state_t;
12     door_state_t current_state, next_state;
13
14     // State transition logic
15     always_ff @(posedge clk or posedge reset) begin
16         if (reset)
17             current_state <= CLOSED; // Start with door closed
18         else
19             current_state <= next_state;
20     end
21
22     // Next state and output logic
23     always_comb begin
24         case (current_state)
25             CLOSED: begin
26                 if (manual_override) begin
27                     next_state = OPEN;   // Manual override opens the
                           door
28                     door_open = 1;
```

```
29                      door_closed = 0;
30                  end else if (motion_detected) begin
31                      next_state = OPEN;   // Motion detected opens the
                            door
32                      door_open = 1;
33                      door_closed = 0;
34                  end else begin
35                      next_state = CLOSED; // No motion and no override,
                            door stays closed
36                      door_open = 0;
37                      door_closed = 1;
38                  end
39              end
40
41              OPEN: begin
42                  if (manual_override) begin
43                      next_state = OPEN;   // Manual override keeps the
                            door open
44                      door_open = 1;
45                      door_closed = 0;
46                  end else if (!motion_detected) begin
47                      next_state = CLOSED; // No motion, close the door
48                      door_open = 0;
49                      door_closed = 1;
50                  end else begin
51                      next_state = OPEN;   // Keep door open if motion
                            detected
52                      door_open = 1;
53                      door_closed = 0;
54                  end
55              end
56
57              default: begin
58                  next_state = CLOSED; // Default state should be closed
59                  door_open = 0;
60                  door_closed = 1;
61              end
62          endcase
63      end
64  endmodule
```

2.4 Testbench

Listing 2: Automatic Door Controller

```

module tb_automatic_door_controller();
    logic clk, reset;
    logic motion_detected, manual_override;
    logic door_open, door_closed;

    automatic_door_controller uut (
        .clk(clk),
        .reset(reset),
        .motion_detected(motion_detected),
        .manual_override(manual_override),
        .door_open(door_open),
        .door_closed(door_closed)
    );

    // Clock generation
    initial begin
        clk = 0;
        forever #5 clk = ~clk; // 10ns clock period
    end

    // Test scenario
    initial begin
        reset = 1; motion_detected = 0; manual_override = 0; // Start
            with reset
        #10 reset = 0;            // Deassert reset

        // Test 1: Door opens when motion is detected
        #10 motion_detected = 1;  // Door should open
        #10 motion_detected = 0;  // Door should close

        // Test 2: Door remains open with manual override
        #10 manual_override = 1;  // Manual override opens door
        #10 motion_detected = 0;  // No motion, door stays open due to
            override

        // Test 3: Door closes when no motion and no manual override
        #10 manual_override = 0;  // Turn off manual override
        #10 motion_detected = 0;  // Door should close

        #50 $stop; // Stop simulation
    end

    // Monitor outputs
    initial begin
        $monitor("Time: %0t | Motion Detected: %b | Manual Override:
            %b | Door Open: %b | Door Closed: %b",
                 $time, motion_detected, manual_override, door_open,
                    door_closed);
    end
endmodule
```

3 Results

3.1 Simulation

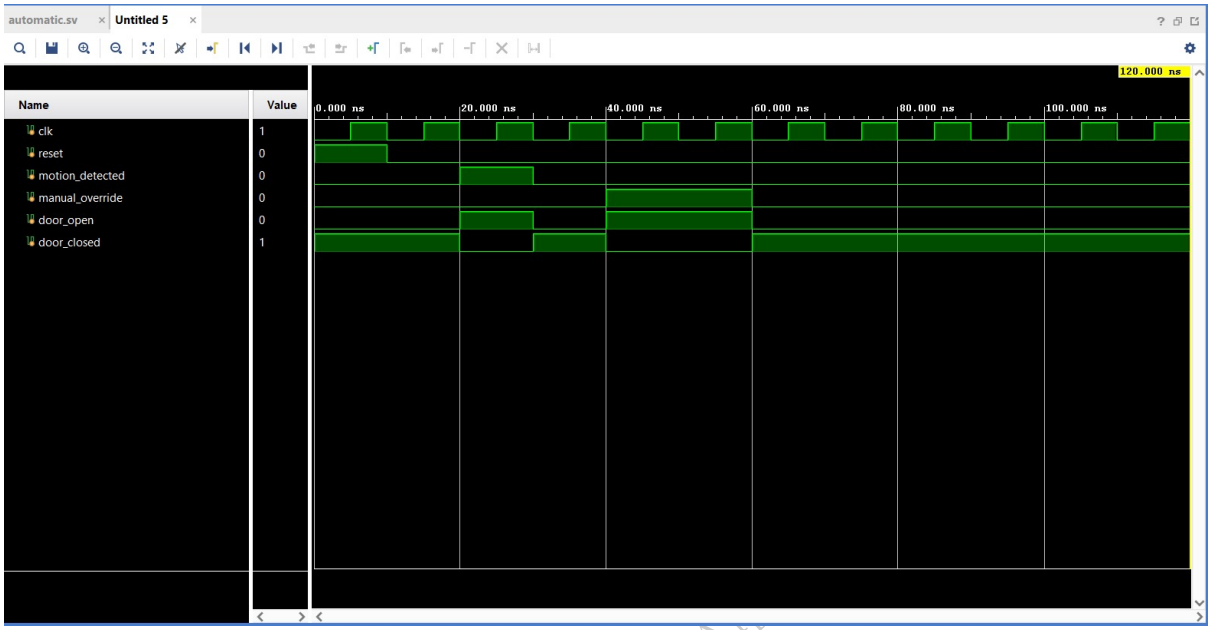

Figure 1: Simulation of Automatic Door Controller

3.2 Schematic

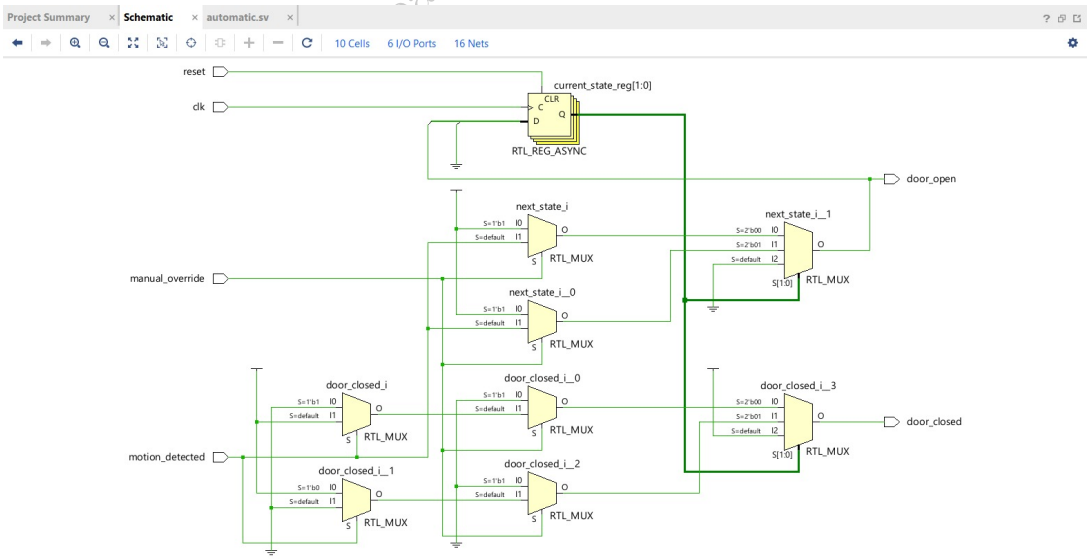

Figure 2: Schematic of Automatic Door Controller

3.3 Synthesis Design

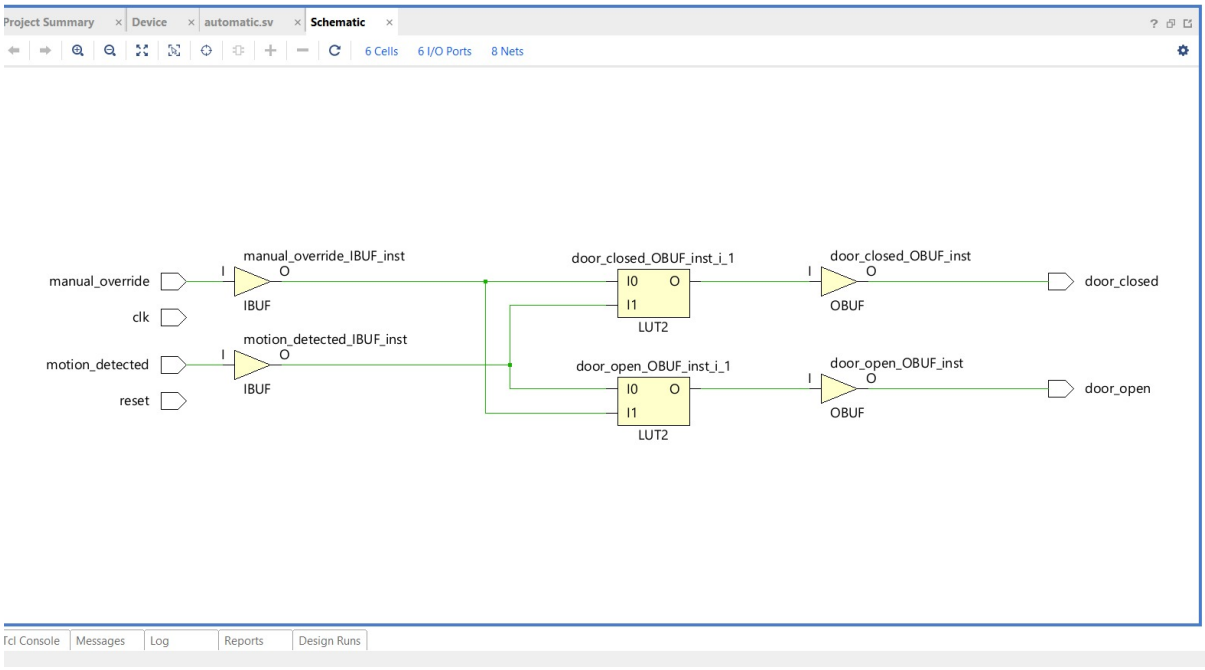

Figure 3: Synthesis Design of Automatic Door Controller

4 Advantages of Automatic Door Controller

- **Convenience:** Hands-free operation for easy access.
- **Improved Hygiene:** Reduces physical contact, minimizing germ spread.
- **Energy Efficiency:** Limits unnecessary door openings, conserving energy.
- **Enhanced Accessibility:** Assists people with disabilities or mobility challenges.
- **Increased Security:** Integrates with authentication systems for controlled access.
- **Smart Integration:** Connects with home automation systems.
- **Aesthetic Appeal:** Adds a modern, sleek look to buildings.
- **Low Maintenance:** Requires minimal upkeep once installed.

5 Disadvantages of Automatic Door Controller

- **High Initial Cost:** Installation and setup can be expensive.
- **Maintenance Requirements:** Sensors and motors may need regular servicing.
- **Sensor Sensitivity Issues:** Can be triggered by false movements or environmental factors.
- **Security Risks:** Vulnerable to unauthorized access if not properly secured.
- **Power Dependence:** Requires a constant power supply, with potential issues during power outages.
- **Complex Installation:** May require specialized knowledge for installation and integration.
- **Mechanical Wear:** Motors and moving parts can wear out over time.

6 Applications of Automatic Door Controller

- **Residential Buildings:** Enhances convenience and accessibility in smart homes.
- **Commercial Spaces:** Used in malls, offices, and airports for smooth entry and exit.
- **Healthcare Facilities:** Improves hygiene and accessibility in hospitals and clinics.
- **Industrial Settings:** Provides hands-free operation in cleanrooms and secure areas.
- **Hotels:** Offers easy access to rooms and facilities without physical contact.
- **Public Transport:** Used in buses, trains, and stations for efficient movement.

7 Conclusion

The Automatic Door Controller is a modern solution that enhances convenience, accessibility, and security across various settings. It provides a hands-free, energy-efficient way to manage door operations, reducing physical contact, improving hygiene, and making spaces more accessible for people with disabilities or those carrying items. Its integration with authentication systems further enhances security, making it ideal for both commercial and residential applications.

Despite its many advantages, challenges like high initial costs, maintenance, and sensor reliability need to be considered. However, with continuous advancements in technology, these issues can be mitigated, making automatic door controllers a valuable addition to smart buildings and modern infrastructure. Whether in high-traffic areas, healthcare facilities, or secure industrial environments, the system's benefits make it a worthwhile investment for improved functionality and safety.

8 FAQs

1. What is an Automatic Door Controller?

- An automatic door controller is a system that operates doors automatically based on sensors, allowing hands-free opening and closing for convenience, security, and energy efficiency.

2. How does the automatic door work?

- The system uses sensors (motion, infrared, or pressure) to detect a person's presence and trigger the door to open. Once the person has passed, the door closes automatically after a set time.

3. What types of sensors are used in automatic doors?

- Common sensors include infrared (IR) sensors, ultrasonic sensors, motion detectors, and pressure sensors to detect movement or proximity.

4. Is the automatic door system secure?

- Yes, the system can be integrated with security features such as RFID, biometric scanners, or keypads to restrict access and ensure that only authorized individuals can pass through.

5. Can automatic doors be used in all environments?

- Yes, but the environment should be considered, as sensors may be affected by weather conditions, dust, or extreme temperatures, especially in outdoor or industrial settings.

6. What are the benefits of using an automatic door controller?

- It provides convenience, enhances accessibility, improves hygiene by reducing physical contact, and can save energy by limiting unnecessary door openings.

7. What are the main disadvantages?

- The main disadvantages include high initial installation costs, maintenance requirements, sensor sensitivity issues, and the need for a constant power supply.

8. Can automatic doors be integrated with smart home systems?

- Yes, automatic doors can be integrated with smart home systems, allowing remote control and monitoring through smartphones or other connected devices.

9. Are automatic doors energy-efficient?

- Yes, by minimizing unnecessary openings and closing promptly, they help maintain indoor temperature control and reduce energy loss.

10. What happens if there is a power failure?

- Most automatic door systems come with battery backups or manual override options to ensure the door can still function during power outages.