

Project 96: Automatic Door Controller

A Comprehensive Study of Advanced Digital Circuits

By: Abhishek Sharma , Ayush Jain , Gati Goyal, Nikunj Agrawal

Documentation Specialist: Dhruv Patel & Nandini Maheshwari

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

```

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

```
1
2 module tb_automatic_door_controller();
3     logic clk, reset;
4     logic motion_detected, manual_override;
5     logic door_open, door_closed;
6
7     automatic_door_controller uut (
8         .clk(clk),
9         .reset(reset),
10        .motion_detected(motion_detected),
11        .manual_override(manual_override),
12        .door_open(door_open),
13        .door_closed(door_closed)
14    );
15
16    // Clock generation
17    initial begin
18        clk = 0;
19        forever #5 clk = ~clk; // 10ns clock period
20    end
21
22    // Test scenario
23    initial begin
24        reset = 1; motion_detected = 0; manual_override = 0; // Start
25        with reset
26        #10 reset = 0; // Deassert reset
27
28        // Test 1: Door opens when motion is detected
29        #10 motion_detected = 1; // Door should open
30        #10 motion_detected = 0; // Door should close
31
32        // Test 2: Door remains open with manual override
33        #10 manual_override = 1; // Manual override opens door
34        #10 motion_detected = 0; // No motion, door stays open due to
35        override
36
37        // Test 3: Door closes when no motion and no manual override
38        #10 manual_override = 0; // Turn off manual override
39        #10 motion_detected = 0; // Door should close
40
41        #50 $stop; // Stop simulation
42    end
43
44    // Monitor outputs
45    initial begin
46        $monitor("Time: %0t | Motion Detected: %b | Manual Override:
47        %b | Door Open: %b | Door Closed: %b",
48            $time, motion_detected, manual_override, door_open,
49            door_closed);
50    end
51 endmodule
```

3 Results

3.1 Simulation

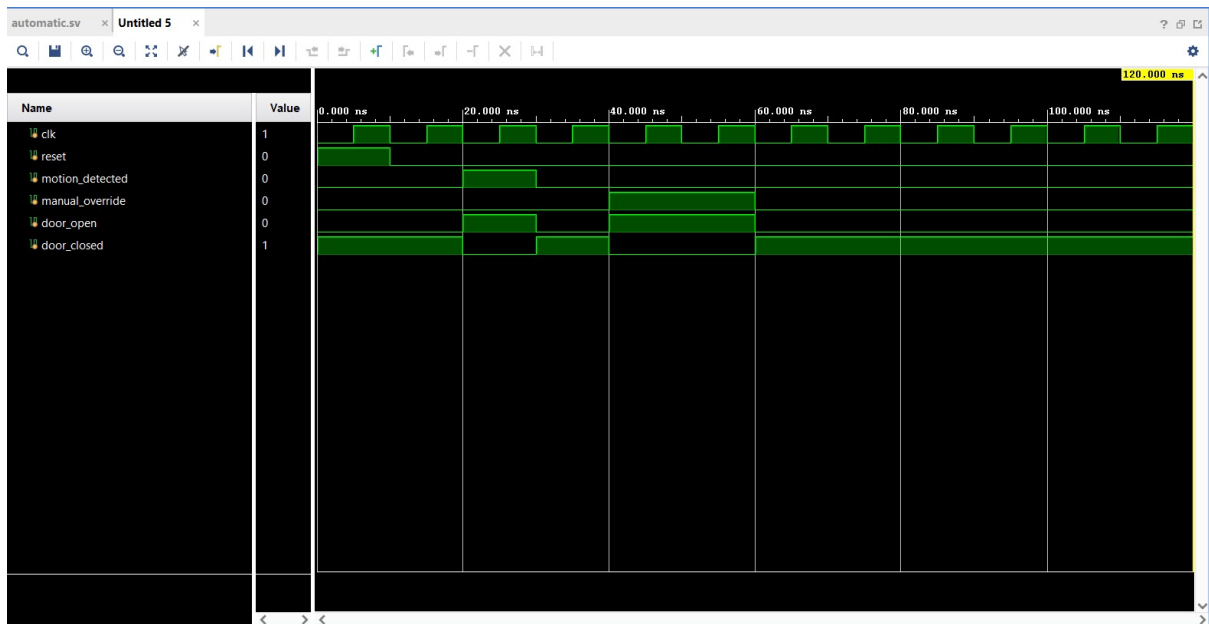


Figure 1: Simulation of Automatic Door Controller

3.2 Schematic

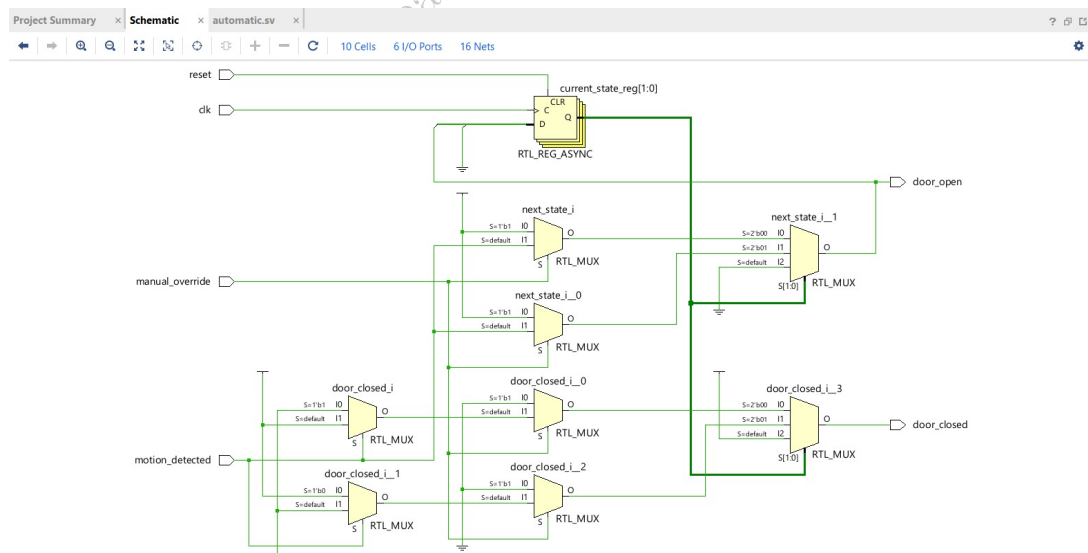


Figure 2: Schematic of Automatic Door Controller

3.3 Synthesis Design

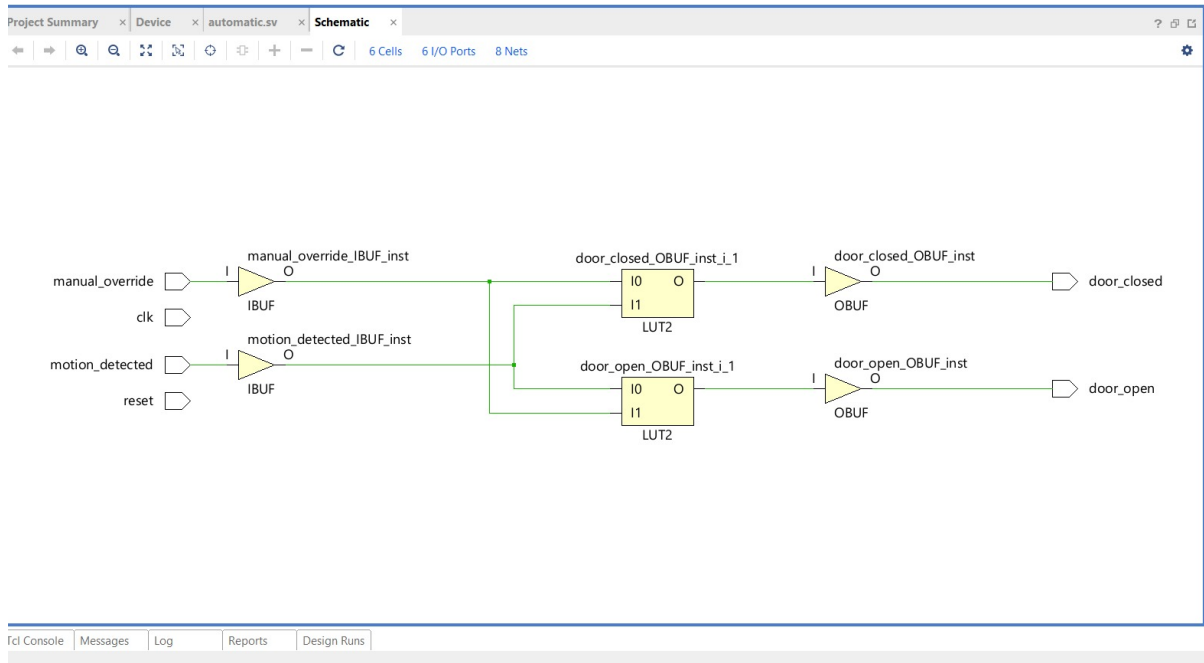


Figure 3: Synthesis Design of Automatic Door Controller

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.

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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.