



**Faculty of Computers & Artificial Intelligence**



**Benha University**

## **Elevator Control System**

**In  
Logic design**

**by**

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## 1. Abstract

This project documents the comprehensive design and engineering of an **8-level autonomous vertical transportation system "Elevator Control System"** (Ground + 7 floors), controlled entirely through **discrete digital logic components** without the intervention of microcontrollers like (Arduino or ESP-32) or software-based processing. Standing at a significant height of **100 cm**, the system operates on a **3-bit binary logic architecture**, utilizing a high-priority **74148 encoder** to streamline user requests and a **7485 magnitude comparator** as the central decision-making unit.

A critical feature of this design is the integration of **synchronous memory** using **7474 D-Flip-Flops**, which serves as a hardware-level 'command register' to store floor requests and current floor. This ensures system stability and prevents data loss during cabin transit. The mechanical challenges, including cabin stability and sensor-alignment jitter, were mitigated through a **dual-pillar structural design** and customized **signal-conditioning logic** (using NOT-gate inversion and RC-stabilization).

The system's operational logic is modeled as a **Finite State Machine (FSM)**, where the transition between states (Idle, Moving Up, and Moving Down) is dynamically triggered by the real-time comparison of the present and next states. By implementing this FSM through hardware-level components, the design ensures a deterministic response to user inputs, maintaining system integrity even during complex floor-to-floor transitions.

The final implementation achieves a seamless closed-loop control system where real-time feedback from **IR obstacle sensors** is compared against stored user data to drive a high-torque DC gear motor via an **L293D H-bridge**. This project not only demonstrates the practical application of **Boolean algebra** and **combinational-sequential logic integration** but also showcases innovative hardware troubleshooting in a complex, multi-stage engineering environment.

## **2. Introduction**

### **2.1 Overview**

Elevator control systems are among the most critical automation systems in modern infrastructure. They represent a complex interaction between user input, real-time sensing, and mechanical motion. While modern elevators utilize microcontrollers for flexibility, the core of elevator logic remains rooted in **Digital Logic Design**. This project explores the creation of an 8-floor elevator controller using discrete logic components to achieve a robust and reliable vertical transport system.

### **2.2 Problem Statement**

Designing a multi-floor elevator without a central processing unit (CPU) poses several challenges:

1. **Data Management:** How to store a user's request after the button is released.
2. **Decision Making:** How to determine the shortest path (Up or Down) to the target floor.
3. **Feedback Accuracy:** Ensuring the motor stops precisely at the floor level despite mechanical inertia.
4. **Signal Integrity:** Maintaining clean logic levels over a 100 cm vertical shaft where wire resistance and noise are factors.

### **2.3 Project Objectives**

The primary objectives of this project are:

- To implement a **3-bit Digital Control Loop** capable of managing 8 distinct floor levels.
- To utilize **Sequential Logic (Flip-Flops)** as a hardware memory solution for request latching.
- To design a stable mechanical tower (100 cm) with a reliable pulley
- To integrate audio-visual feedback (7-segment display, Buzzers, and Speaker) for an enhanced user experience.

### 3. Hardware Description & Components

Component	Quantity (IC)	Primary Role
Push Button	8	User interface to provide floor request signals.
Not Gate (7404)	4	Inverting logic signals for Active-High/Low compatibility and signal conditioning.
Priority Encoder (74148)	2	Converting 8 floor inputs into a 3-bit binary code (Target & Current floors).
OR Gate (7432)	2	Generating the Clock trigger signal for Flip-flops from multiple button inputs.
D-Flip-Flops (7474)	4	Acting as a 3-bit memory register to store the target floor state.
Decoder (7447)	2	Converting binary data into a format readable by the 7-segment display.
Seven Segment (common anode)	2	Visual output for the current floor and user-selected destination.
Comparator (7485)	1	The "Brain" of the system; compares target floor vs. current position.

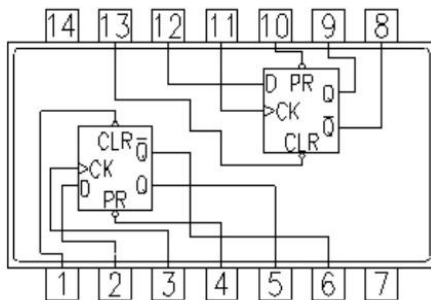
Timer 555	1	Configured in Monostable mode to control the duration of the arrival buzzer (2.5 seconds), simulating the door-opening period.
Arrow led	1	Indicating the motor direction (Upwards/Downwards).
Emergency stop switch	1	Safety cut-off to halt all operations instantly in case of failure.
Motor driver (L293D)	1	High-current H-bridge to drive the DC motor based on logic signals.
IR obstacle sensor	8	Real-time position feedback to identify the cabin's current floor.
Speaker (ISD1820)	1	Provides recorded voice announcements during elevator transit (Moving State).
DC motor	1	Mechanical actuator for lifting the cabin through the pulley system.
Bread board	4	Prototyping platform for connecting all integrated circuits and wires.
Resistors	-	Passive components for current limiting.
Capacitor	-	Passive components for voltage stabilization (Filtering).

Jumper wires	-	Establishing electrical connections between the modular logic units.
Buzzer	2	Provides an audible alert for 2.5 seconds upon arrival at the target floor and another one for Emergency Stop.
Pulley & String	1	The mechanical transmission system for lifting/lowering the cabin.
Steel Guide Rails (Inner Rods)	2	Thin metal rods passing through the cabin to prevent swaying and ensure precise vertical travel.
PVC Main Shaft (Outer Pipe)	1	The main outer structure (tower) housing the elevator cabin.

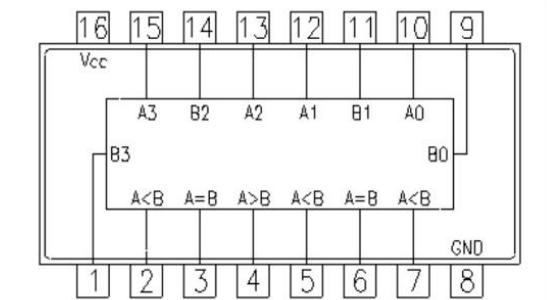
**Note:** The system is divided into two identical logic paths for data processing:

- the Request Path (Buttons → Encoder → Register).
- the Feedback Path (Sensors → Encoder → Register).

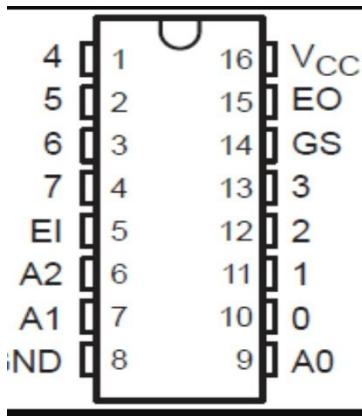
Both paths converge at the Magnitude Comparator for real-time decision making.



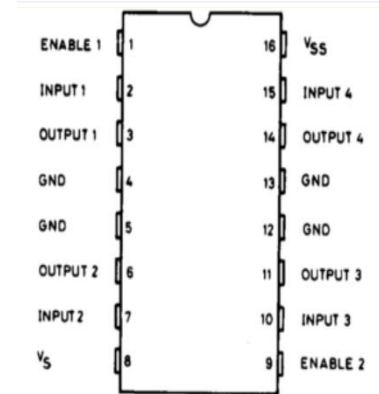
**7474**



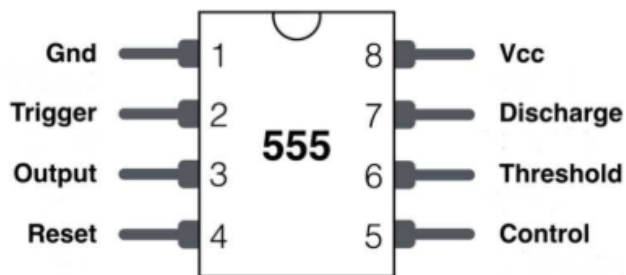
**7485**



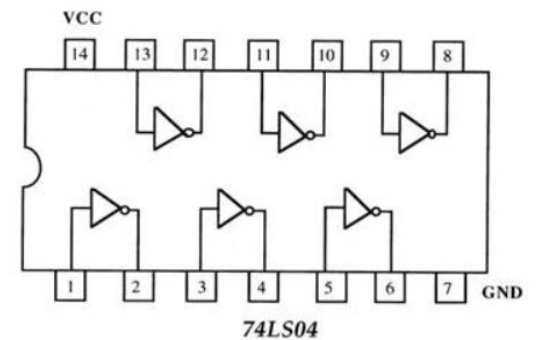
74148



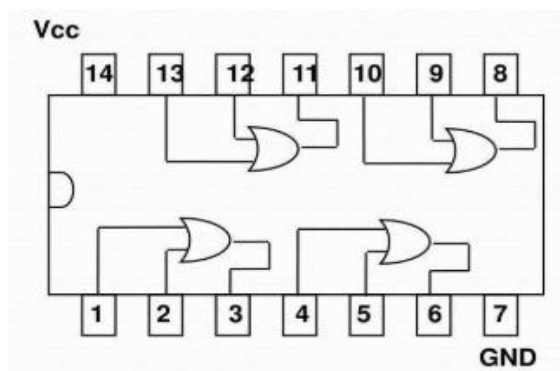
L293D



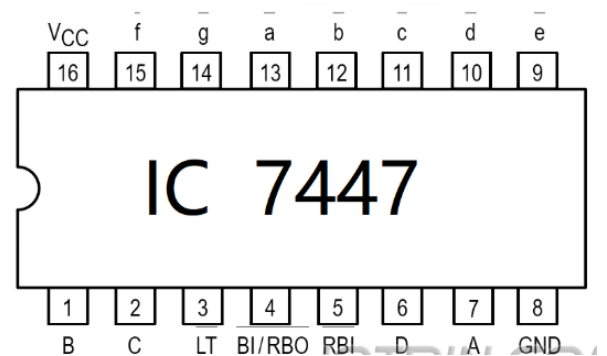
Timer 555



7404



7432



7447

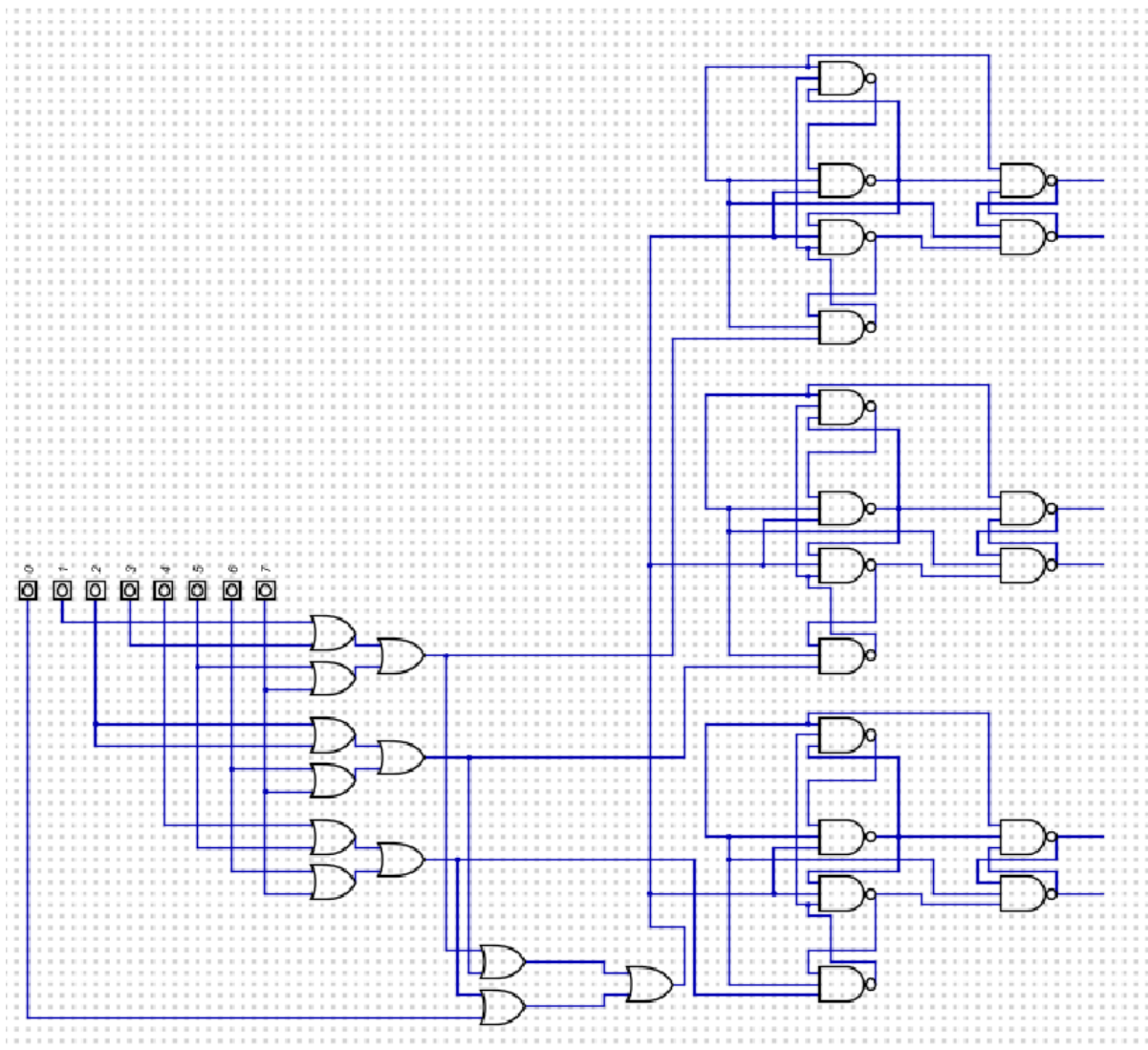
## **4. System Detailed Explanation & Logic Flow**

The operation of the elevator is divided into three functional stages that form a closed-loop control system.

### **4.1 Stage 1: Input Encoding and Data Latching (Memory)**

The system must "remember" the user's request even after the push-button is released. This is achieved through a combination of encoding and synchronous memory:

- **Binary Encoding (74148) :** Simultaneously, the pressed button's signal is converted into a 3-bit binary code by the 74148 Priority Encoder.
- **The Pulse Generator (OR Gates) :** All 8 push-buttons are connected to a network of 7432 OR gates (Through the encoder's output) . When any button is pressed, it generates a single "High" pulse used as a Clock signal.
- **The Command Register (7474 Flip-Flops) :** The 3-bit code is fed into the 7474 D-Flip-Flops. At the rising edge of the Clock pulse (from the OR gates), the Flip-Flops "Latch" (store) the floor number (Through the encoder's output) . This ensures the Target Floor (A) remains stable throughout the journey.



#### 4.2 Stage 2: Decision Making (The Magnitude Comparison)

The "Brain" of the elevator is the 7485 Magnitude Comparator, which constantly evaluates the relationship between two 3-bit values:

- **Value A** : The target floor stored in the Flip-Flops.
- **Value B** : The current location of the cabin provided by the IR Sensors.

The comparator logic dictates the system's behavior:

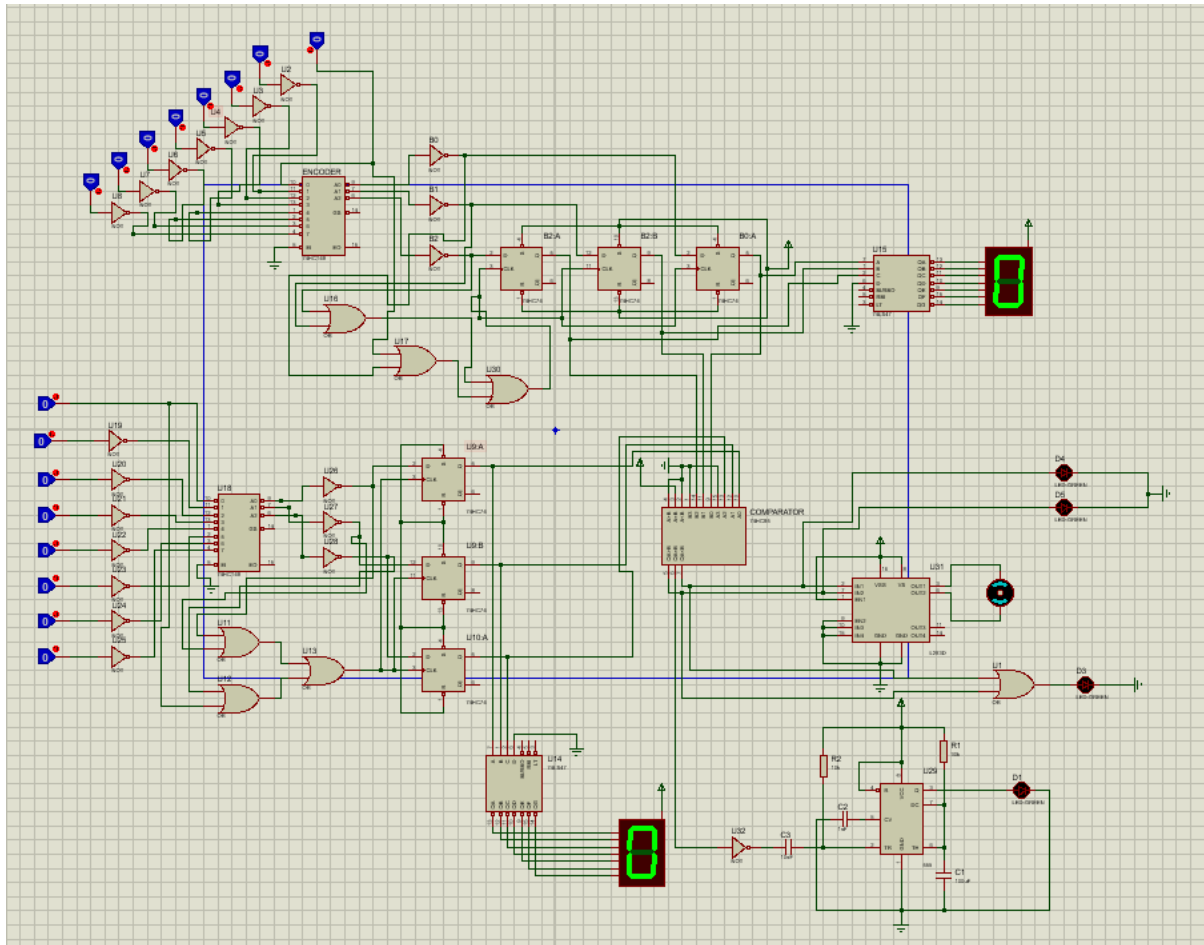
1. **If  $A > B$** : The target is higher than the current position. The comparator triggers the **UP signal**, making the motor rotate Clockwise.
2. **If  $A < B$**  : The target is lower than the current position. The comparator triggers the **DOWN signal**, making the motor rotate Counter-Clockwise.
3. **If  $A = B$**  : The target is reached. The comparator sends a signal to **disable the motor** driver and activate the Buzzer.

#### 4.3 Stage 3: Output Execution and Feedback

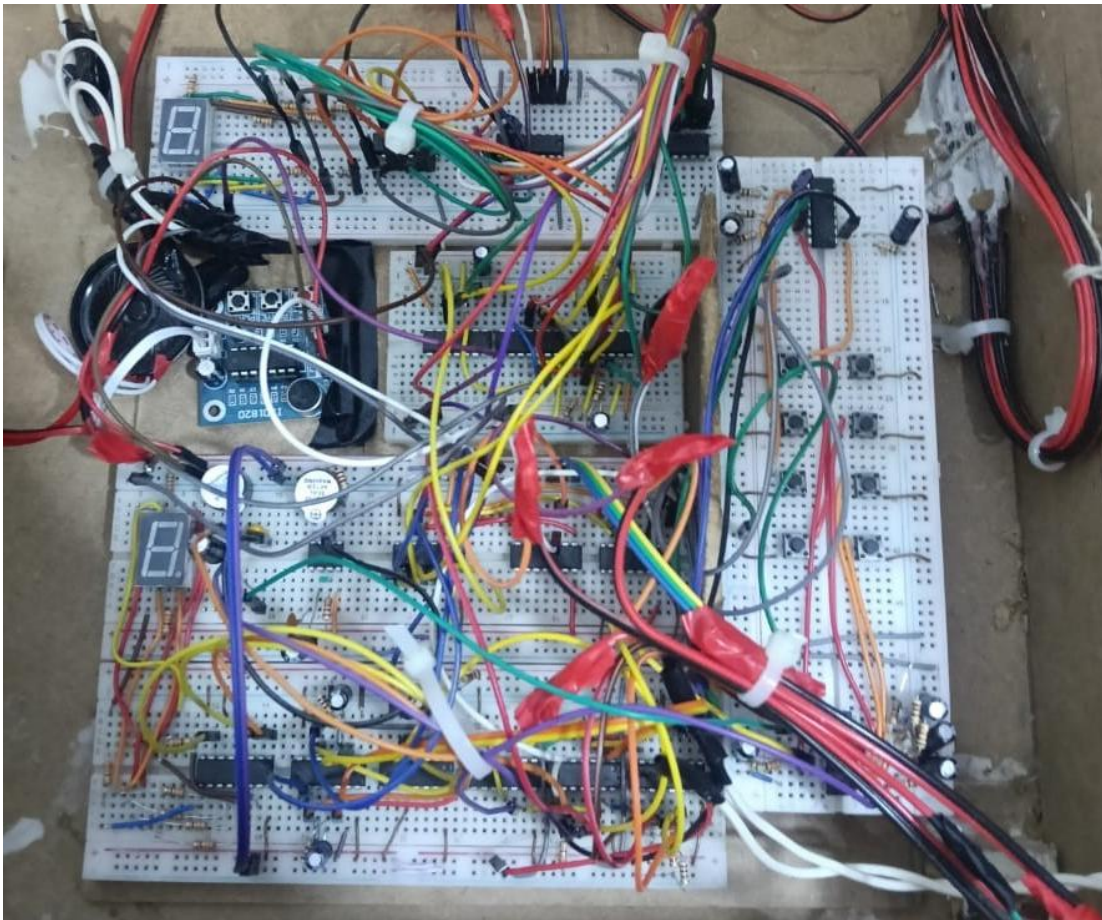
The final stage converts logic decisions into physical motion and multi-sensory user feedback:

- **Motor Control (L293D)** : The UP and DOWN signals from the comparator are fed into the L293D H-Bridge. This driver serves as the power interface, providing the necessary current to rotate the high-torque DC gear motor in the required direction.
- **Visual Feedback** : The 3-bit binary data for both the Target floor and Current position are processed by 7447 Decoders. These decoders drive two 7-Segment Displays, allowing the user to track the elevator's progress and confirm their selection in real-time.
- **Audio Announcement (ISD1820)** : To enhance the system's interactivity, an ISD1820 Voice Module is integrated. It is triggered whenever the elevator is in motion (either UP or DOWN). This ensures that a specific audio announcement or religious verse is played throughout the cabin's transit, providing an audible status update to the user.

- **Safety Protocol (Emergency Stop) :** An Emergency Stop switch is hardwired to the Enable pin of the L293D motor driver. Activating this switch immediately cuts power to the motor regardless of the logic comparator's state, ensuring a fail-safe mechanism for the system.
  
- **Directional Arrow LED :** a Directional Arrow LED are connected to the Comparator's  $A > B$  (Up) and  $A < B$  (Down) outputs, providing an intuitive visual cue of the elevator's current direction of travel.
  
- **Arrival Signaling & Timing Control:** When the condition  $A=B$  is met, the system initiates the arrival sequence:
  1. **Immediate Stop :** The motor's "Enable" pin is pulled LOW, halting the cabin precisely at the detected floor.
  2. **Timed Notification :** The  $A=B$  signal triggers a 555 Timer configured in Monostable Mode. This timer is calibrated to activate the Buzzer for exactly 2.5 second (  $T = 1.1 * R * C$  ).
  3. **Simulation :** This 2.5-second window acts as a "virtual door opening" period, providing a realistic transition before the system enters the IDLE state and becomes ready for the next request.



Proteus Design



Completed Circuit

## **5. Engineering Challenges & Troubleshooting**

During the implementation of this complex logic system, several critical issues were encountered. The following section details these challenges and the innovative hardware solutions applied:

### **1. Logic Polarity Conflict (Active-Low Encoder):**

- The Issue: The 74148 Encoder operates on Active-Low logic (triggers on 0V), whereas the push-buttons provided an Active-High signal (5V) when pressed.
- The Solution: Integrated 7404 NOT Gates between the buttons and the encoder to invert the signals, ensuring compatibility with the encoder's input requirements.

### **2. Unstable Memory Latching (Clock Timing):**

- The Issue: The D-Flip-Flops (7474) failed to store floor data consistently when buttons were pressed.
- The Solution: Investigation revealed the Clock signal (generated by the OR gates) was unstable. After refining the clock path and ensuring a clean rising edge, the memory synchronization was perfected.

### **3. Mechanical Load & Motor Torque:**

- The Issue: The DC gear motor struggled to lift the cabin's initial weight.
- The Solution: To avoid the complexity of changing the motor driver architecture under a tight budget and timeline, the cabin's weight was optimized and reduced, allowing the current motor to operate efficiently.

### **4. Cabin Stability (Mechanical Jitter):**

- The Issue: The cabin experienced significant shaking and leaning during vertical transit.
- The Solution: A Dual-Pillar structural design was implemented, providing stable guide rails that prevented lateral movement.

### **5. Data Loss Between Sensors:**

- The Issue: When the cabin moved between floors (leaving a sensor), the "Current Floor" value would reset to 0, causing the logic to fail.
- The Solution: We initially considered using a priority-extension method, but it caused "Floor +1" errors. The final robust solution was to use 3 additional Flip-Flops to store the "Last Known Floor" value, maintaining the current state until the next sensor is triggered.

### **6. Sensor Alignment & Precision:**

- The Issue: The elevator stopped at different heights depending on whether it was moving Up or Down because the sensors triggered at the room's edges.
- The Solution: We utilized the light-absorption properties of materials. By wrapping the cabin in Black Tape and leaving only a thin, precise transparent "window" in the middle, we forced the IR sensors to trigger at the exact same point regardless of the direction of travel.



## 6. Mechanical Design

**Structural Integrity & Stability:** The 100cm tower was engineered using a nested structural approach to ensure maximum stability:

- **The Shaft (PVC) :** A large PVC pipe acts as the primary housing for the elevator, protecting the internal components and providing a clean vertical path.
- **The Guide Rails (Steel Rods) :** To eliminate the "pendulum effect" or swaying during movement, two thin Steel Rods were integrated inside the shaft. These rods pass directly through the cabin structure, acting as precision guide rails that keep the cabin perfectly centered.
- **Wooden Support :** The entire structure is mounted on a Wooden Base, with wooden platforms marking each of the 8 floor levels for sensor mounting and visual alignment.



## **7. Final Prototype Design**



## **8. Conclusion**

The design and execution of this 8-floor elevator control system was a profound engineering challenge. As our first major project, it served as a transition from theoretical classroom concepts to a complex, real-world hardware application.

At the beginning, the path seemed nearly impossible, and the lack of a basic concept led us through phases of doubt. However, by persisting through every technical failure—from timing issues to mechanical instability—we gained more than just a functional prototype. This journey redefined our approach to problem-solving, replacing the word "impossible" with perseverance. The project not only taught us the intricacies of combinational and sequential logic but also highlighted the vital importance of teamwork and resilience in the face of continuous engineering conflicts. We have emerged from this project with a deep understanding of the true meaning of engineering: the ability to turn a desperate problem into a logical, working solution.



