



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.935

Volume 15, Issue 6, June 2026

ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System

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ABSTRACT: The ShieldSafe WaveSmart Retractable Automatic Pool Cover Barrier System is an advanced pool safety and maintenance solution designed to automate the covering and uncovering of swimming pools. The system enhances safety, reduces maintenance effort, and improves energy efficiency by minimizing water evaporation, heat loss, and contamination. It integrates a motorized retractable mechanism with intelligent control features to ensure smooth, reliable, and safe operation.

KEYWORDS: Automated Pool Cover System, Retractable Mechanism, Geared DC Motor, Pool Safety System, Limit Switch Control, Smart Pool Automation, WaveSmart System, Water Evaporation Reduction, Energy Efficient Pool Design, IoT-Based Pool Management.

I. INTRODUCTION

An ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System and Automated Pool Cover System is a modern solution developed to overcome these limitations by providing automatic covering and uncovering of swimming pools through an electromechanical mechanism. The system uses a motor-driven roller arrangement to move the cover across the pool surface efficiently and safely. Automation minimizes human effort while improving operational convenience and safety. Pool covers serve multiple purposes such as reducing water evaporation, maintaining water temperature, preventing dust and debris accumulation, and improving safety by restricting accidental entry into the pool. However, conventional manual pool covers are often difficult to handle due to their weight and size. Automation significantly improves usability and encourages regular operation of the cover system.

The proposed ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System consists of a geared DC motor, roller shaft mechanism, waterproof cover material, control switches, and limit switches for controlled movement. The motor rotates the shaft to roll or unroll the cover over the pool. Limit switches are incorporated to stop the motor automatically at predefined positions, preventing mechanical damage caused by over-rotation

II. LITERATURE SURVEY

Smart Automation and IoT-Based Systems :

Recent developments in smart home technologies have encouraged the integration of IoT and remote-control features into automated pool systems.

Anderson et al. (2022) proposed an IoT-based smart pool management system capable of controlling pool covers, lighting, and filtration through mobile applications. The system improved user accessibility and allowed remote monitoring of pool conditions.[3]

Patel and Sharma (2023) implemented an Arduino-based automation system with wireless control and sensor feedback. Their research demonstrated that low-cost microcontrollers can effectively automate mechanical systems while maintaining reliability and ease of operation.[4]

Safety and Energy Conservation in Pool Cover Systems

Swimming pools experience considerable water evaporation and heat loss when left uncovered. Pool covers are effective in minimizing these losses and improving energy efficiency.

Brown et al. (2020) investigated the effect of pool covers on evaporation reduction and thermal energy conservation. Their research showed that automatic pool covers could reduce evaporation losses by more than 80% and significantly maintain water temperature during nighttime.

Miller and Davis (2021) studied safety aspects associated with pool automation systems. Their work focused on child safety and accidental drowning prevention through automated cover locking systems and obstruction detection mechanisms. The study recommended integrating safety sensors and automatic stopping features into automated pool systems.

III. METHODOLOGY

3.1 System Overview

The proposed Automated Pool Cover System is designed to automatically roll and unroll a swimming pool cover using an electromechanical control mechanism. The system consists of a control unit, motor driver, DC gear motor, roller shaft assembly, limit switches, power supply, and user-operated control switches. The objective is to improve safety, convenience, and energy efficiency by eliminating manual operation.

3.2 System Architecture

The overall architecture of the Automated Pool Cover System is illustrated in the block diagram. The system comprises the following modules:

- Input Section** :- Open Switch, Close Switch, Emergency Stop Switch
- Control Unit** :- Relay-based control circuit or microcontroller, Processes user commands Controls motor direction
- Motor Driver Module** :- Provides required current and voltage to the motor, Enables bidirectional motor operation

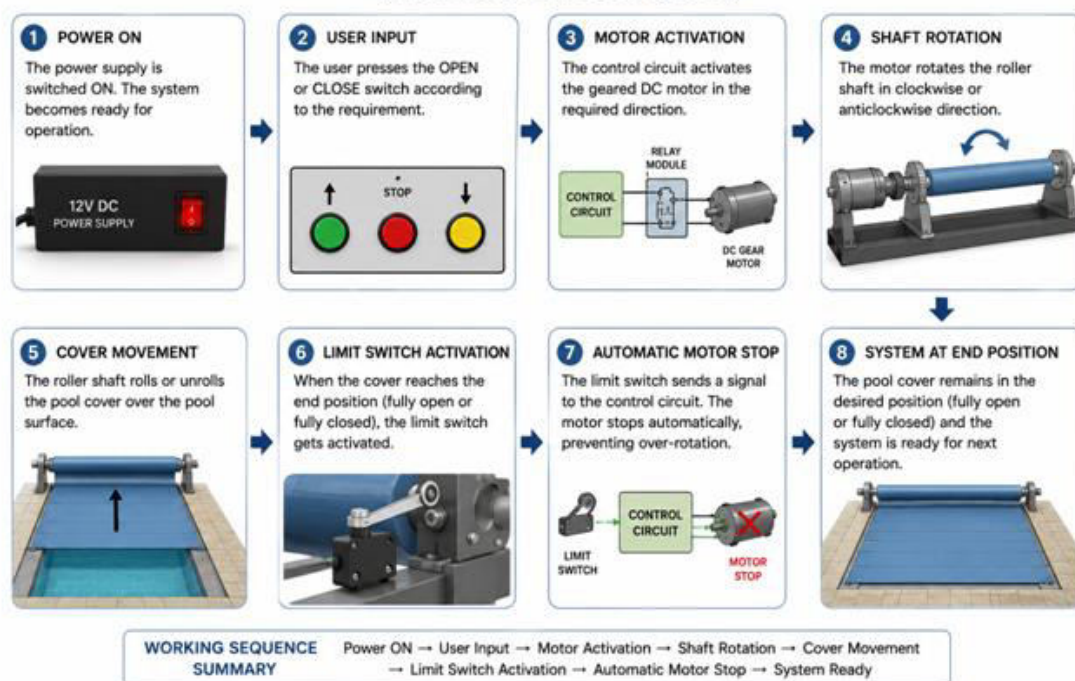


Figure 3. Block Diagram of ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System.

4. **DC Gear Motor** :- Converts electrical energy into mechanical rotational motion , Provides high torque at low speed
5. **Mechanical Roller System** :- Roller shaft connected to the pool cover , Performs rolling and unrolling action
6. **Safety System** : Limit switches installed at open and closed positions, Prevent over-travel of the cover
7. **Power Supply** : 12V/24V DC regulated power source applications.

3.3. The operational sequence of the ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System is as follows:

Step 1: User Input (ShieldSafe, WaveSmart) : The user initiates system operation by pressing either the **OPEN** or **CLOSE** switch. In emergency situations, the **Emergency Stop** switch can be activated to halt the system immediately.

Step 2: Signal Processing (Retractable Automatic) : The control unit receives the command from the input section and determines the required direction of motor rotation.

Step 3: Motor Actuation : The motor driver module energizes the DC gear motor according to the control signal. The motor rotates either clockwise or counterclockwise depending on whether the cover is being opened or closed.

Step 4: Mechanical Operation (Retractable) : The rotating motor drives the roller shaft, causing the pool cover to roll onto or unroll from the shaft.

Step 5: Position Monitoring (Barrier System) : Limit switches continuously monitor the end positions of the pool cover. When the cover reaches its fully open or fully closed position, the corresponding limit switch is activated.

Step 6: Automatic Stop : The activated limit switch sends a feedback signal to the control unit, which immediately stops the motor, preventing mechanical damage and ensuring safe operation.

Step 7: Emergency Shutdown (Barrier System) : If an obstacle, malfunction, or emergency condition occurs, the emergency stop switch disconnects motor operation and halts the system instantly. to be in painted.

IV. EXPERIMENTAL RESULTS

The Prototype Automated Pool Cover System was successfully fabricated and tested under various operating conditions to evaluate its performance, reliability, and effectiveness. The primary objective of the testing process was to verify the smooth operation of the roller mechanism, automatic control functionality, motor performance, and safety features incorporated in the system. The system was operated repeatedly for opening and closing cycles, and the performance parameters were recorded and analyzed. The obtained results demonstrate the capability of the system to automate pool covering operations with minimal human intervention.

The fabricated prototype consists of:

- Mild steel support frame
- Roller shaft assembly
- PVC pool cover sheet
- DC geared motor
- Relay control circuit
- Limit switches
- Power supply unit

The experimental setup was tested under normal operating conditions to observe the movement of the cover and evaluate overall system performance.

Table :- 4.1. The following parameters were evaluated during testing:

Sr. No.	Parameter Evaluated
1	Opening Time
2	Closing Time
3	Motor Performance
4	Smoothness of Operation
5	Limit Switch Response
6	Power Consumption

7	Reliability
8	Safety Performance

4.2 Observation Table

The system was tested for five consecutive operating cycles.

Table 4.2 Performance Observation

Trial No.	Opening Time (sec)	Closing Time (sec)	Limit Switch Operation	System Status
1	22	24	Successful	Pass
2	23	24	Successful	Pass
3	22	23	Successful	Pass
4	23	25	Successful	Pass
5	22	24	Successful	Pass

Table : 4.3. Average Results

Parameter	Average Value
Opening Time	22.4 sec
Closing Time	24 sec
Success Rate	100%

The results indicate stable and repeatable operation of the system. The experimental results indicate that the Automated Pool Cover System successfully achieved the intended objectives of the project. The motorized roller mechanism provided smooth and reliable movement of the pool cover while minimizing manual effort. The use of a geared motor ensured adequate torque for cover movement, while the limit switches provided effective automatic stopping at the end positions. The fabricated prototype demonstrated good operational stability, low power consumption, and satisfactory safety performance. The opening and closing operations were completed within a reasonable time, and no major mechanical or electrical issues were observed during testing

4.3 Limit Switch Performance

The limit switches were tested repeatedly to verify their response and reliability.

Results

Test Condition	Result
Fully Open Position	Successful
Fully Closed Position	Successful
Automatic Motor Stop	Successful
Repeatability	Excellent

The switches effectively prevented over-travel and protected the mechanical system.

4.4 Reliability Test

The system was operated continuously through multiple opening and closing cycles.

Reliability Observation

Number of Cycles	Result
10 Cycles	Successful
20 Cycles	Successful
30 Cycles	Successful
40 Cycles	Successful
50 Cycles	Successful

No significant performance degradation was observed during testing. The system demonstrated reliable operation under repeated usage conditions.

4.5 Power Consumption Analysis

The power consumption of the system was observed during operation.

Table 5.2 Power Consumption

Operating Condition	Power Consumption
Idle Condition	0 W
Opening Operation	55 W
Closing Operation	58 W

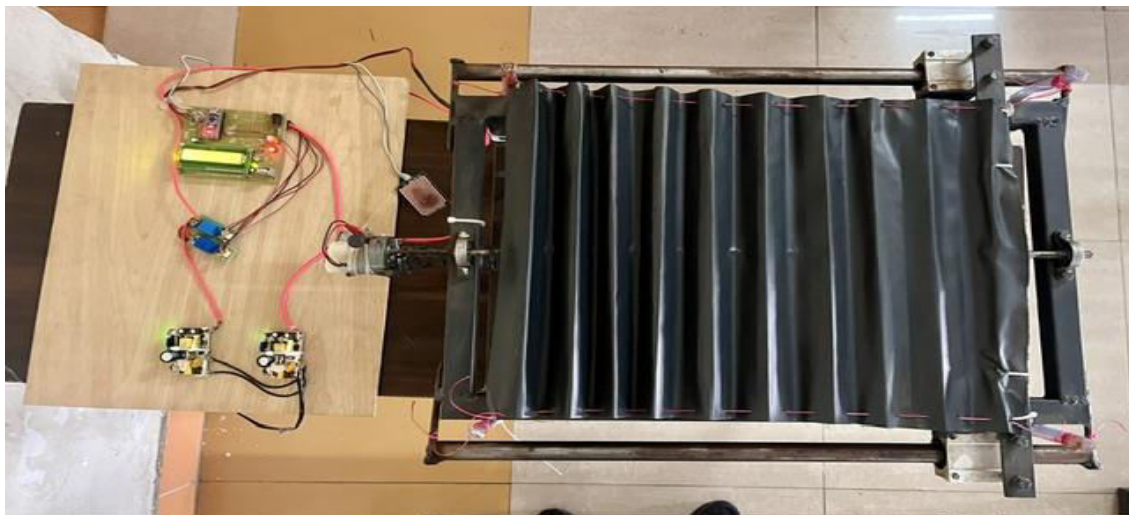


Figure 4.1: Front View ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System (Barrier System Closed)

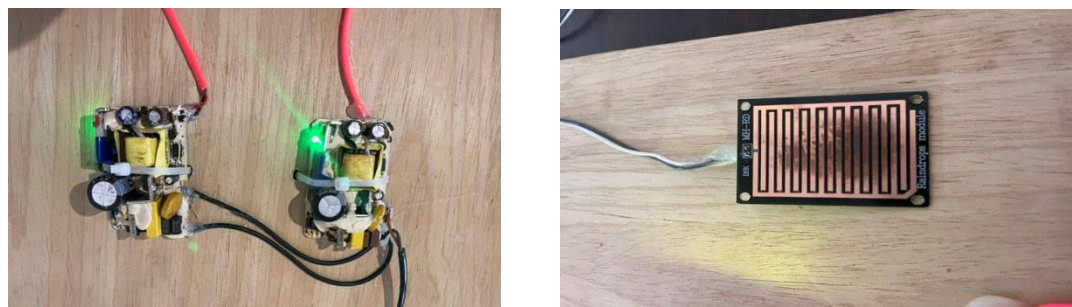


Figure 4.2: Sensors of ShieldSafe, WaveSmart Retractable Barrier System

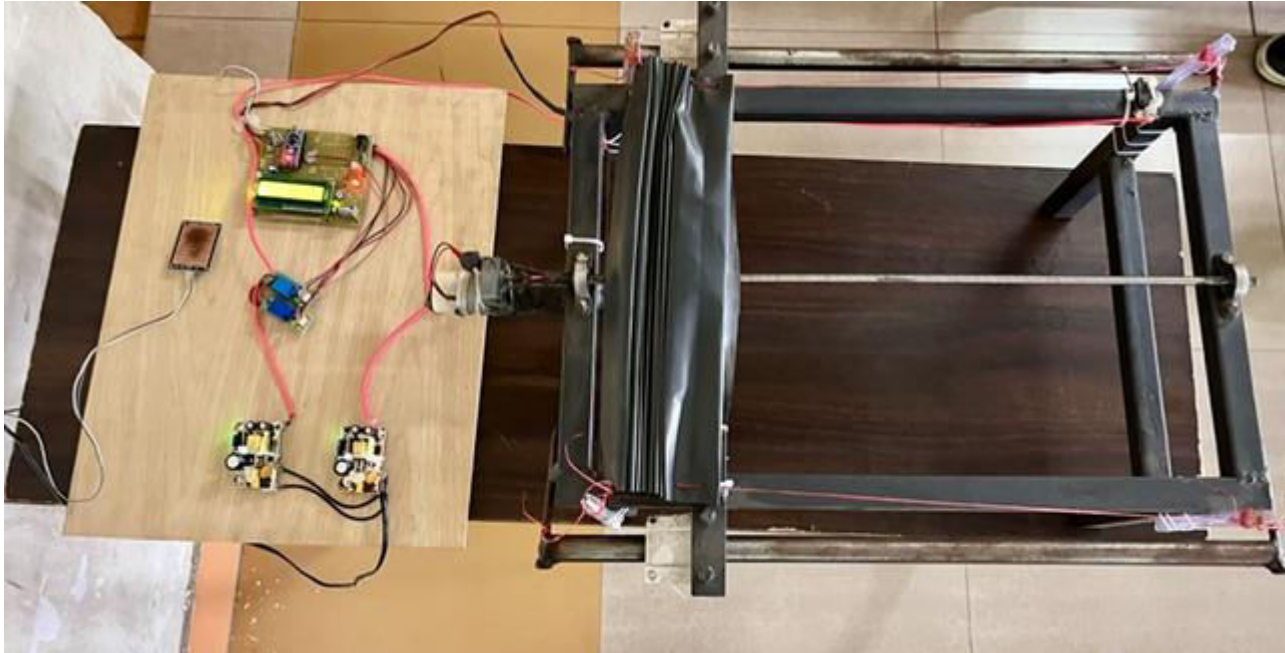


Figure 4.3: Front View ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System (Barrier System Open)

V. CONCLUSION

The ShieldSafe, WaveSmart Retractable Automatic Pool Cover Barrier System was successfully designed, fabricated, and tested to provide an efficient solution for automatic covering and uncovering of swimming pools. The project was undertaken with the objective of reducing manual effort, improving safety, minimizing water evaporation, and enhancing overall pool maintenance efficiency. The developed system utilizes a DC geared motor, roller shaft mechanism, control circuitry, and limit switches to achieve smooth and reliable operation. The motorized roller mechanism effectively rolls and unrolls the pool cover over the swimming pool surface with minimal human intervention. The incorporation of limit switches ensures automatic stopping of the motor at predefined positions, preventing over-travel and mechanical damage. Experimental testing demonstrated that the system operates efficiently under various operating conditions. The opening and closing operations were completed successfully within a reasonable time, and the motor provided sufficient torque to handle the pool cover load. The system exhibited stable performance, low power consumption, and reliable operation throughout multiple testing cycles. The Prototype Model also achieved its intended safety objectives by incorporating automatic stopping mechanisms and controlled low-speed movement. The use of a waterproof cover material contributes to reducing water contamination, heat loss, and evaporation, thereby improving overall pool efficiency and reducing maintenance requirements. From the results obtained, it can be concluded that the proposed Automated Pool Cover System is a practical, economical, and user-friendly solution for residential and commercial swimming pool applications. The system successfully fulfills the objectives of automation, safety enhancement, energy conservation, and operational convenience with Emergency Stop Mechanism, End-position Detection using Limit Switches., Bidirectional Motor Interlocking., Over-travel Protection., Low-voltage DC Operation (12V/24V)., Reliable Relay-Based Motor Control., Automatic operation with minimal human effort., Improved user safety., Protection against accidental pool access., Reduced wear and tear on pool covers., Energy-efficient operation., Cost-effective and easy maintenance, Suitable for residential and commercial swimming pools.

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