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IoT-Based Flood Pump Control System Using Smart Switch as Controller and Monitor

Bontor Panjaitan[1]; Ahmad Fatoni[2]

[1;2]Pamulang University

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Abstract: This paper presents the design of an IoT-based flood pump control system utilizing currently developed IoT devices and technologies. The system employs a smart switch (DIT AI-SM01) to control and monitor flood pumps. Experimental results confirm the effectiveness of the proposed system in automating flood pump operations. Equipment status can be monitored and controlled remotely via a smartphone or PC with the appropriate IoT application, simplifying the control system and significantly reducing response time within the flood pump control range.

Keywords: *Flood Pump, Internet of Things (IoT), Smart Switch, Water Level Control, Remote Monitoring.*

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I. INTRODUCTION

Flooding is one of the major recurring problems in Jakarta and its surrounding areas, including Bekasi, Depok, Tangerang, and Bogor. Jakarta's low-lying geography, high rainfall intensity, rapid population growth, shrinking water absorption areas, and poor drainage infrastructure are the primary contributing factors. Furthermore, global climate change has increased the frequency and intensity of extreme rainfall events, often overwhelming the capacity of urban drainage systems.

Flooding causes not only material losses but also severely disrupts economic activities, transportation, public health, and urban infrastructure. During major flood events, thousands of homes are submerged, road access is blocked, and daily activities grind to a halt for several days. Surrounding areas such as Bekasi and Tangerang also suffer similar impacts due to excessive upstream runoff and suboptimal flood control systems.

To mitigate flooding, the DKI Jakarta Provincial Government through the Department of Water Resources (Dinas Sumber Daya Air) has deployed flood pump stations at several flood-prone locations. As of 2025, Jakarta operates more than 602 stationary pumps and 573 mobile pumps to accelerate water discharge toward main channels and the sea. These pumps are especially critical in low-elevation areas where gravity-fed drainage is insufficient.

However, conventional flood pump operation systems still rely on manual control or simple On/Off switching based on a single sensor, resulting in slow adaptive response to rapid water level changes and reduced flood control efficiency. There is therefore a need to develop smarter, more automated systems integrated with modern technology.

The Internet of Things (IoT) presents a significant opportunity to enhance flood control effectiveness. IoT technology enables real-time connectivity of water level sensors, rainfall gauges, and pump status data through the internet, facilitating immediate monitoring and analysis. By leveraging the AI-SM01 smart switch module, the system can transmit flood condition information via digital dashboards, mobile applications, and automatic notifications. Beyond monitoring, IoT technology enables automatic pump control based on real-time field conditions. Integration of Artificial Intelligence methods such as Fuzzy Logic within IoT systems allows pumps to operate adaptively based on water level and flood risk conditions—yielding faster response times, improved energy efficiency, and reduced risk of delayed flood response compared to conventional methods.

II. THEORETICAL BACKGROUND

A. *Flood Pump*

A flood pump is a mechanical device specifically designed to transfer large volumes of water from inundated areas to drainage channels or safer storage locations. It plays a crucial role in urban flood control systems, especially in areas prone to waterlogging due to heavy rainfall, river overflow, or tidal flooding. In general, flood pumps operate on the principle of converting mechanical energy into fluid kinetic energy. A prime mover—typically an electric motor or diesel engine—drives a rotating impeller within a pump casing, creating a pressure differential that forces water from the inlet to the outlet.

Fig 1 Ilustration of Flood Pump.

➢ *Types of Flood Pumps*

- Centrifugal Pump: The most widely used pump type in drainage and flood control systems. It uses centrifugal force generated by a rotating impeller to increase fluid velocity and pressure. Its advantages include simple construction, low maintenance cost, and high flow capacity.

- Submersible Pump: Designed to operate while fully submerged in water. The motor and pump form a single waterproof unit that can be immersed directly in floodwater. This type is highly effective for basements, tunnels, and hard-to-reach areas.

- Axial Flow Pump: Moves fluid parallel to the rotation axis of the impeller. It offers very high flow capacity but relatively low head pressure, making it suitable for large-scale drainage with minimal elevation differences.

➢ *Key Performance Parameters*

Important performance parameters of flood pumps include: Flow Rate (Q) in L/s or m^3/h; Total Head (H) as the sum of static head, velocity head, and friction losses; Pump Power (P) in watts or kilowatts; Pump Efficiency (η) as the ratio of hydraulic power output to power consumed; and Operating Point, the intersection of pump and system characteristic curves.

➢ *Flood Pump Control System*

Modern flood pump control systems have evolved significantly from manual to fully automated sensor- and microcontroller-based systems. Automated control enables pumps to operate independently based on predefined parameters such as water level setpoints. When the water level reaches the upper threshold, the system activates the pump; when it falls below the lower threshold, the pump is deactivated.

B. Internet of Things (IoT)

The Internet of Things (IoT) is a technological paradigm that connects physical devices to the internet, enabling them to communicate, exchange data, and be controlled remotely in real time. The term was first introduced by Kevin Ashton in 1999 in the context of supply chain management using Radio Frequency Identification (RFID) technology.

According to the International Telecommunication Union (ITU), IoT is defined as a global infrastructure for the information society that enables advanced services by interconnecting physical and virtual objects based on existing and evolving information and communication technologies.

➢ *IoT System Architecture*

IoT systems generally consist of four main layers: (a) Perception Layer — comprising sensors and actuators interacting directly with the physical environment; (b) Network Layer — responsible for transmitting sensor data using protocols such as Wi-Fi (IEEE 802.11), Bluetooth Low Energy (BLE), Zigbee, LoRaWAN, NB-IoT, and 4G/5G cellular networks; (c) Processing Layer — encompassing cloud platforms, servers, and middleware including AWS IoT, Google Cloud IoT, Microsoft Azure IoT Hub, and open-source platforms such as ThingsBoard and Node-RED; (d) Application Layer — the user-facing interface that presents processed data through dashboards, mobile applications, or web interfaces.

➢ *IoT Communication Protocols*

Common protocols include: MQTT (Message Queuing Telemetry Transport) — a lightweight publish-subscribe

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protocol for resource-constrained devices; HTTP/HTTPS — a standard web protocol compatible with existing web infrastructure; CoAP (Constrained Application Protocol) — designed for resource-limited devices, operating over UDP; and WebSocket — enabling full-duplex real-time communication over a persistent TCP connection.

➢ *IoT Application in Flood Control*

IoT technology has significantly improved the effectiveness and efficiency of flood management. Real-time hydrological monitoring across multiple distributed points, automatic data transmission to control centers, and faster, more accurate decision-making are among its key advantages. Specific benefits include continuous monitoring of river and drainage water levels, automatic pump activation based on predefined thresholds, early warning notifications to residents and authorities, and historical data logging for future flood mitigation planning.

C. Smart Switch

A smart switch is an electronic device capable of connecting and disconnecting electrical power to a load automatically or under remote control via a communication network. Unlike conventional switches that can only be operated manually, smart switches incorporate wireless communication modules that enable integration with IoT systems, supporting control through mobile applications, web interfaces, or automated sensor-based inputs.

In automation contexts, smart switches serve as actuators that receive command signals from a control unit (microcontroller or microprocessor) and execute switching commands to activate or deactivate connected devices. Common components used as smart switches in IoT applications include electromechanical relays, solid-state relays (SSR), and transistor-based relay modules.

➢ *Smart Switch in Pump Automation*

In an IoT-based flood pump automation system, the smart switch serves as the interface between the microcontroller-based control system and the high-power pump motor. The operational sequence is as follows: (1) The water level sensor detects the water level and transmits data to the microcontroller; (2) the microcontroller compares sensor data against predefined setpoints; (3) if water level exceeds the upper setpoint, a logic HIGH signal is sent to the relay control pin; (4) the relay closes, connecting the power supply to the pump motor; (5) when the water level drops below the lower setpoint, a logic LOW signal is sent and the relay opens, stopping the pump; (6) pump status and water level data are transmitted to the cloud platform via Wi-Fi for remote monitoring and historical data recording.

D. Supporting System Components

➢ *ACOME Smart Switch Module (Mini) AI-SM01*

The ACOME Smart Switch Module Mini AI-SM01 is an IoT-based electronic device designed to control electrical systems automatically and remotely via the internet. It functions as an interface between the power source and electrical loads—such as lamps, water pumps, fans, and other electronic devices—enabling control through smartphone applications or voice assistant systems.

The device operates using Wi-Fi 2.4 GHz and Bluetooth wireless communication technology, allowing integration with smart home systems. In implementation, the AI-SM01 can be installed in place of a conventional switch without requiring major modifications to the existing electrical installation. Its compact form factor (mini module) allows placement inside a standard switch box for practical and efficient deployment.

The operating principle of the ACOME AI-SM01 is based on an electronic relay control system connected to the internet. When the user issues a command through the smartphone application, a data signal is transmitted via Wi-Fi to the AI-SM01 module. The internal relay then activates or deactivates the electrical load accordingly.

In addition to manual control through the application, the device supports timer-based automation and integration with voice assistants such as Google Assistant and Amazon Alexa. This enables automatic, scheduled, or voice-controlled operation of electrical devices.

Table 1 Technical Specifications of ACOME AI-SM01 Smart Switch

Parameter	Specification
Model	AI-SM01
Operating Voltage	AC 100–240 V
Frequency	50/60 Hz
Maximum Current	16 A
Maximum Power	±3500 W
Communication	Wi-Fi 2.4 GHz & Bluetooth
Control System	Smartphone Application
Material	Fire Retardant ABS
Additional Features	Timer, Remote Access, Voice Control

In the IoT context, the AI-SM01 functions as a smart actuator capable of receiving, processing, and executing internet-based instructions. Its key applications include smart home systems, automatic lighting control, automated water pump systems, energy consumption monitoring, flood control systems, smart building systems, and small-scale industrial automation.

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In flood control systems, the AI-SM01 module can be integrated with water level sensors and microcontrollers so that the water pump operates automatically when the water level reaches a specified threshold, improving operational efficiency and accelerating flood response.

➢ *WBR2 Microcontroller in DIT AI-SM01 Smart Switch*

The WBR2 is a wireless embedded system microcontroller module designed to support smart home applications, monitoring systems, simple industrial automation, and various other IoT-based devices. It enables real-time data exchange via the internet, allowing both remote and automated control based on specified conditions.

The WBR2 microcontroller integrates a data processing unit (processor), memory, input/output systems, and a wireless communication module within a single device. It serves as the central controller that receives input data from sensors, processes it according to a programmed algorithm, and generates control output signals to actuators or other connected devices.

The WBR2 architecture consists of: (1) CPU — the core processing unit for all decision-making, sensor data processing, and device control; (2) Memory — including Flash memory (for firmware), RAM (for temporary data), and in some variants EEPROM; (3) GPIO (General Purpose Input Output) — the communication interface between the microcontroller and external devices such as sensors, relays, LEDs, and actuators; (4) Wireless Communication Module — featuring Wi-Fi 2.4 GHz and Bluetooth for real-time data exchange with applications and cloud servers; (5) Power Management System — regulating power consumption for stable and efficient operation.

The operational sequence of the WBR2 in a flood pump system is: water level sensor detects rising water level → data transmitted to WBR2 → WBR2 processes condition based on programmed logic → pump relay activated → water pump operates automatically → pump status information transmitted to the user application in real time.

Table 2 Technical Characteristics and Specifications of WBR2 Microcontroller

Parameter	Specification
System Type	Wireless IoT Module
Operating Voltage	3.3 V
Communication	Wi-Fi & Bluetooth
Wi-Fi Frequency	2.4 GHz
Input/Output	Digital GPIO
Power Consumption	Low
Primary Function	IoT Monitoring and Control
Application	Smart Home & Automation

**Specifications May Vary Depending on the Device Variant and Firmware Version.*

III. METHODOLOGY

➢ *Research Approach*

This study employs a quantitative experimental approach using the Research and Development (R&D) method. This approach was selected because the research aims to design, build, and test an IoT-based flood pump control system using a smart switch as both controller and operational status reader. Experimental testing was conducted on a developed prototype system to obtain measurable performance data for statistical analysis.

The research stages follow a prototype-based system development model (prototyping model), where the system is developed iteratively from requirements identification, design, implementation, testing, to evaluation and refinement until system specifications are met.

➢ *Research Schedule and Location*

The study was conducted over approximately six months, covering planning, system design, hardware and software implementation, testing, and result analysis. Research activities were divided between two primary locations: (1) the Electrical/Electronics Engineering Laboratory for circuit schematic design, component assembly, and hardware functionality testing; (2) a Field Simulation Site for end-to-end system testing under conditions approximating real flood scenarios, including sensor response testing and remote pump control via the IoT network.

Table 3 Research Activity Schedule

No.	Activity	M1	M2	M3	M4	M5
1	Literature Study & Requirement Identification	✓				
2	System Design (HW & SW)		✓			
3	Component Procurement & Assembly		✓	✓		
4	Program Implementation & IoT Configuration			✓		
5	Testing & Measurement				✓	
6	Data Analysis & Report Writing				✓	✓

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➢ *Research Tools and Materials*

The hardware components used in this research are listed in Table 4 below.

Table 4 List of Research Equipment

No.	Component	Specification	Qty.
1	SMART SWITCH DIT AI-SM01	Wireless IoT Module, GPIO Digital, 3.3V, 2.4 GHz	1
2	Smartphone	Compatible device	1
3	Water Level Sensor (Hanyoung Nux FS-3)	110/220V AC, 50/60Hz, Max 80ms (ON), Relay output 250VAC 5A	1
4	Magnetic Contactor NCH8-20/20	1-phase Chint 20A 2NO 220V	1
5	Submersible Water Pump	12V DC, 200–300 L/h capacity	1
6	Power Supply	Input 220V AC, Output 5V & 12V DC	1
7	Jumper Cables & PCB	Various sizes, stripboard PCB	As needed
8	Flood Simulation Tank	Plastic container	1

➢ *System Design*

• *System Architecture*

The IoT-based flood pump control system designed in this study consists of three interconnected components:

✓ Internet Network Infrastructure: A network facility (router or switch hub from providers such as Telkom, FirstMedia, CBN, Biznet, etc.) connects and enables interaction between all flood pump control equipment—including monitoring devices (smartphone) and the AI-SM01 smart switch—enabling comprehensive pump condition control and monitoring.

✓ Command Equipment: This layer provides operational instructions to the main control equipment, comprising the FS-3 water level control sensor, the DIT AI-SM01 smart switch, and an overload sensor. These devices read environmental water conditions and issue instructions to the main control equipment to activate or deactivate the pump.

✓ Main Control Equipment: This layer connects the power source to the electrical load and consists of a Circuit Breaker (MCB) and a Magnetic Contactor.

• *Control Schematic*

The control schematic describes the power diagram of the flood pump system design. It illustrates the connections between the power source and the circuit breaker, the Normally Open (N.O.) contact of the magnetic contactor, the N.O. contact of the smart switch (providing supply input to the contactor coil), and the N.O. contact of the water level control—which acts as a trigger signal to the status terminal of the smart switch when water is detected by the sensing electrodes placed in the rainwater collection tank.

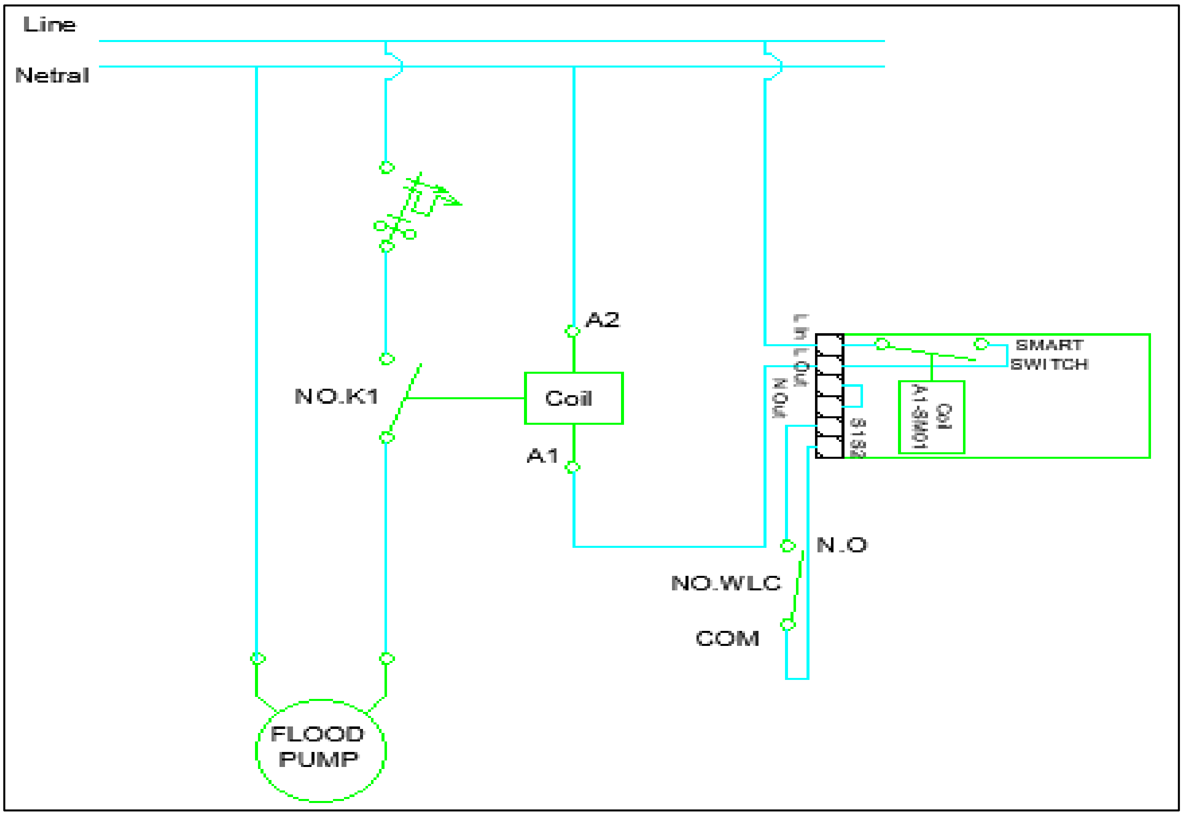

Fig 2 Power Control Schematic of the IoT-Based Flood Pump System.

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- *Smart Switch Operating Principle as Controller and Status Reader*

The smart switch in this study incorporates an embedded WBR2 microcontroller. This microcontroller contains digital pins that both issue relay switching commands within the smart switch and receive input signals reflecting the environmental water condition during flooding. The operating principle is described as follows:

✓ Condition 0 (Low Water Level): The FS-3 Water Level Control (WLC) sensor detects that water has not yet reached the upper sensing point—i.e., the two terminal points on the sensor are not bridged by water. Consequently, the WLC FS-3 relay remains open, providing no voltage signal to the digital input pin of the AI-SM01 smart switch. The smart switch relay remains open, no voltage is applied to the contactor coil, and the main contactor contacts remain open—disconnecting the power supply from the flood pump. The flood pump does not operate.

✓ Condition 1 (High Water Level): The FS-3 WLC sensor detects that water has reached the upper sensing point—the two terminal points are bridged. The WLC FS-3 relay closes, providing a voltage signal to the digital input pin of the AI-SM01 smart switch. The smart switch relay closes, voltage is applied to the contactor coil, and the main contactor contacts close—connecting the power supply to the flood pump. The flood pump operates.

- *System Control Logic*

The system employs threshold-based control logic with three defined water level conditions, as shown in Table 5 below. The threshold values can be calibrated and adjusted dynamically through the IoT dashboard interface without modifying the program code.

Table 5 Water Level Conditions and System Actions

Condition	**Water Level Range**	**System Action**
Normal	0 – 15 cm	Pump OFF, Green LED ON, 'Safe' notification
Running	15 – 25 cm	Pump ON, Yellow LED ON

➢ *System Flowchart*

The overall system workflow begins with hardware initialization and connection to the Wi-Fi network and IoT platform. After successful initialization, the system enters a continuous main loop.

In the operational cycle following AI-SM01 smart switch initialization, the simulation begins with the FS-3 Water Level Control providing a voltage input to the smart switch digital input pin, signaling Condition 0 or Condition 1. At Condition 0, the AI-SM01 relay opens and the contactor coil receives no voltage—the load contacts remain open and the pump is OFF. At Condition 1, the AI-SM01 relay closes and the contactor coil receives voltage—the load contacts close and the pump is ON.

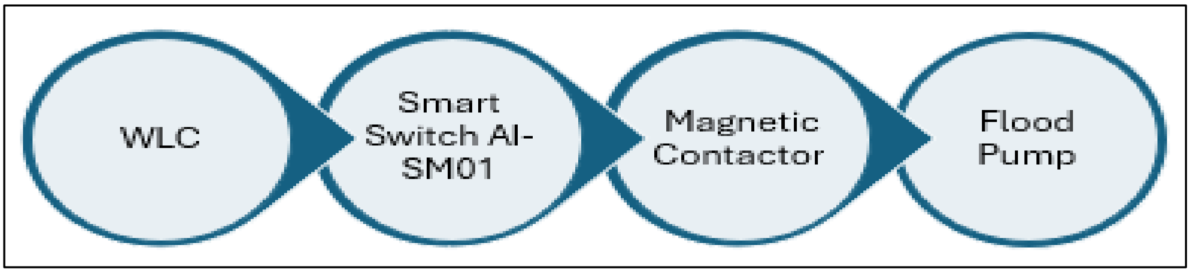

Fig 3 Cycle of Instruction Diagram.

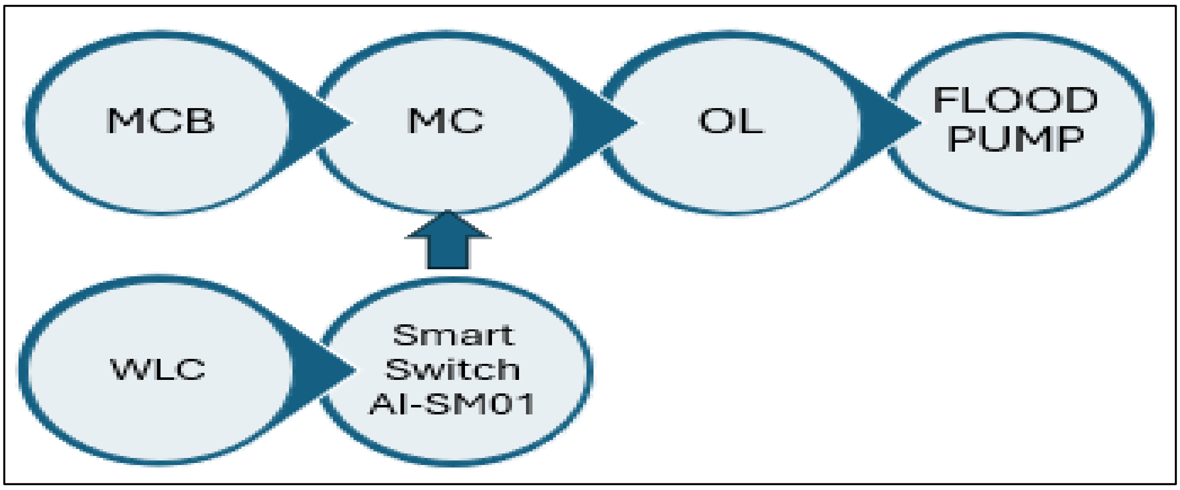

Fig 4 Main Control Flowchart of the Flood Pump System.

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➢ *System Implementation*

System implementation in this study was carried out in three stages: (1) Hardware Implementation — assembling the main control equipment, IoT-based devices, and supporting components; (2) Software Implementation — installing and configuring the IoT device operating software and application; (3) Platform Configuration — configuring the IoT platform to receive data from the DIT AI-SM01 smart switch via the installed router and network provider. The transmitted data consists of the device ID of the AI-SM01, enabling the equipment to be controlled and programmed according to the planned system through the software or application installed on the smartphone or compatible control device.

➢ *System Testing Method*

System testing was conducted in a structured, phased manner to validate the performance of each component and the overall integrated system. Testing methods included functional testing and performance testing, covering: (1) Accuracy testing of the FS-3 Water Level Control sensor; (2) Smart switch response testing; (3) IoT connectivity and latency testing; (4) Integrated system testing.

➢ *Data Analysis Technique*

Data obtained from the test series were analyzed using descriptive statistical methods, including: (1) Calculation of mean, minimum, maximum, and standard deviation for each measured control parameter from sensors and control devices; (2) Analysis of the functional test success rate for the overall system based on the alignment of system responses with planned test scenarios; (3) Data presentation in tabular and graphical forms to facilitate interpretation and conclusion drawing.

The system is considered successful if it meets the following predefined criteria: sensor accuracy ≥ 95%, relay response time ≤ 50 ms, IoT latency ≤ 2 seconds, and integrated system test success rate ≥ 90%.

➢ *Validation and Calibration*

System validation was performed using two approaches. First, internal validation was conducted by comparing the response results of the IoT-based smart switch equipment against conventional systems in general use. Second, external validation was conducted by soliciting expert evaluation from specialists in the field of control systems and IoT regarding the conformity of the system design with applicable standards.

IV. RESULTS AND DISCUSSION

➢ *Equipment Test*

Testing was conducted under the planned conditions described in Section III, corresponding to the criteria listed in Table VI. Two primary test conditions were evaluated: Normal and Running.

- NORMAL Condition: When the water level is below 15 cm, the Water Level Control does not trigger the relay contact—the WLC N.O. contact remains open. Consequently, the digital/status contact of the DIT AI-SM01 smart switch remains at Condition 0 (zero), the N.O. contact of the smart switch remains open, and the N.O. contact of contactor K1 remains open. The flood pump is therefore disconnected from the power supply and does not operate.

- RUNNING Condition: When the water level exceeds 15 cm, the Water Level Control triggers the relay contact and changes the WLC N.O. contact to N.C. Consequently, the digital/status contact of the DIT AI-SM01 smart switch changes to Condition 1 (one), the N.O. contact of the smart switch changes to N.C., and the N.O. contact of K1 changes to N.C. The flood pump is thereby connected to the power supply and operates.

Based on the above description, all test criteria conditions for the IoT-based flood pump system have been satisfied.

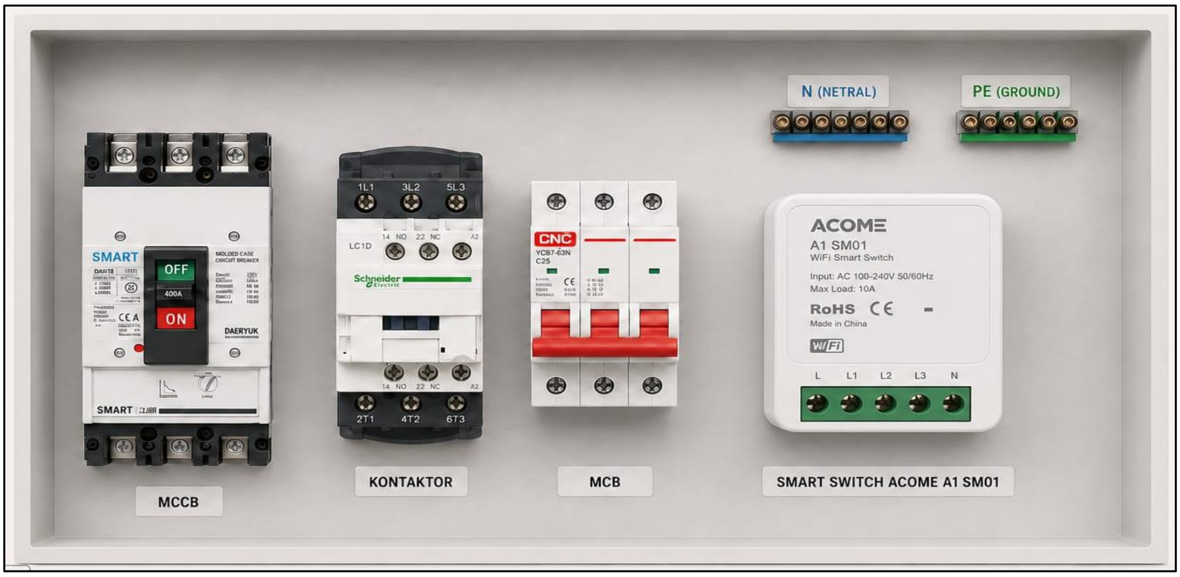

Fig 5 Actual Lay Out of IoT-Based Flood Pump Control System

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➢ *Test Results*

The test results for both conditions are summarized in Table 6 below.

Table 6 IoT-Based Flood Pump System Test Results

Condition	Water Level	System Action	Result	Remarks
Normal	0 – 15 cm	Pump OFF, Green LED ON, 'Safe' notification	✓	Output matches expected system action
Running	15 – 25 cm	Pump ON, Yellow LED ON	✓	Output matches expected system action

The results demonstrate that the IoT-based flood pump control system using the ACOME DIT AI-SM01 smart switch successfully responded to both water level conditions in accordance with the predefined system actions. The integration of the smart switch with the FS-3 water level sensor and magnetic contactor enabled reliable automatic pump control with real-time remote monitoring capability via smartphone.

V. CONCLUSION

This paper presented the design and implementation of an IoT-Based Flood Pump Control System using a Smart Switch as Controller and Monitor. The findings demonstrate that this control system is highly effective and practically applicable for real-world flood control, particularly in Indonesia and specifically in Jakarta. The flood pump can be monitored and controlled remotely as well as locally, and can be managed by multiple users simultaneously. This capability significantly reduces the risk of human error that commonly occurs in conventional pump control operations, while enabling faster and more reliable flood response through real-time IoT-based automation.

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