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Research Article

Optimizing Agricultural Water Management: IC 555 Controlled DC Motor With Soil Moisture Sensor For Sustainable Irrigation

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ABSTRACT

This paper discusses an Automatic Irrigation System employing a 555 IC M08A (IPC-7351) and the Soil Moisture Sensor aim to revolutionize water management in agriculture and household applications, respectively. Utilizing the 555 timer IC as a timing mechanism, the irrigation system regulates watering intervals based on soil moisture levels, activating the water pump via a relay controlled by the 555 IC when the moisture falls below a set threshold. Operating in astable mode, the 555 IC generates a square wave, which controls the relay to initiate irrigation, optimizing water usage and promoting sustainable irrigation practices to address escalating water scarcity issues. On the other hand, the Water Level Controller addresses excessive water wastage in households due to overflow from overhead tanks by employing sensing probes and electronic circuits that detect water level fluctuations. This system automates the water pumping process to overhead storage tanks, allowing users to select desired water levels for pumping rather than relying on conventional filling methods. Together, these systems offer efficient water management solutions without the need for complex microcontrollers, conserving water and fostering environmentally friendly practices for a sustainable future.

Keywords: Irrigation System, Automatic, 555 Timer Circuit, Water Level Controller, Water Management, Sustainable Practices, 555 Timer IC, Transistor, Diode, Soil Moisture Sensor, Power Supply

1. Introduction

Water is a resource that is necessary for many different kinds of activity, which highlights how important it is to conserve it. Water management and storage must be done effectively for industrial, residential, and agricultural uses. In order to ensure efficient use and conservation of water, automatic water level controllers have become an indispensable instrument for managing tank levels.

To control water levels, many of the systems in use today use PIC ICs or Microcontrollers [1]. But rather of using Microcontrollers, this study takes a more straightforward approach, relying instead on relays, transistors and the flexible Timer IC555. Without the need for human involvement, this automatic water level controller circuit effectively controls the water levels in above and subterranean tanks. By means of a relay, the system regulates a single-phase AC pump motor to fill the overhead tank to the required level or capacity.

The M08A (IPC-7351) IC, the central part of this controller circuit, enables automatic management of the water level by the use of sensing probes or circuits inside the tank [2]. In addition to keeping an eye on the water level, this system triggers the motor when the overhead tank is empty, making sure it shuts off as soon as the target water level is reached—as indicated by LED notifications or cutoff the supply to the DC motor. Crucially, when the subsurface water level drops below the predetermined threshold, the pump motor stays dormant, avoiding needless pump operation and water waste [3]. This simple design minimises overflow and encourages water conservation by providing an effective way to control water levels.

Water shortage is becoming a bigger problem, which emphasises how urgently effective water management techniques are needed, particularly in agriculture. This study presents a novel automatic irrigation system that maximises watering techniques by utilising the adaptability of the 555 IC - M08A (IPC-7351) timer. When irrigation is necessary, the system's integrated soil moisture sensor senses the soil's moisture content and dynamically activates the water pump. This system's objectives are to preserve water resources, guarantee ideal plant growth, and advance sustainable agriculture methods by automating watering intervals. This study M08A (IPC-7351) 555 IC Automatic Irrigation System is to create an automated, resource-efficient agricultural irrigation system, other objectives include: a) Water Conservation: Reduce water use by using dynamic irrigation that adjusts to the moisture content of the soil.
b) Automation: Reduce manual involvement by automating watering intervals with the M08A (IPC-7351) 555 IC timer. c) Energy Efficiency: Reduce electricity consumption by only turning on the water pump when absolutely required. d) Crop Health: Sustaining ideal soil moisture levels will improve crop health. e) User-Friendly Operation: Provide an easy-to-use interface that makes scheduling irrigation programmes simple.

2. Experimental

Figure 1 shows the suggested model's block diagram, and Figure 2 shows its electrical circuit diagram. A pump, an overhead tank, an underground tank, and a control circuit with level probes are all included in the versatile water level controller. The level probes must be installed correctly, with the control unit placed inside the home/ agricultural land and the probes placed in the overhead tank.

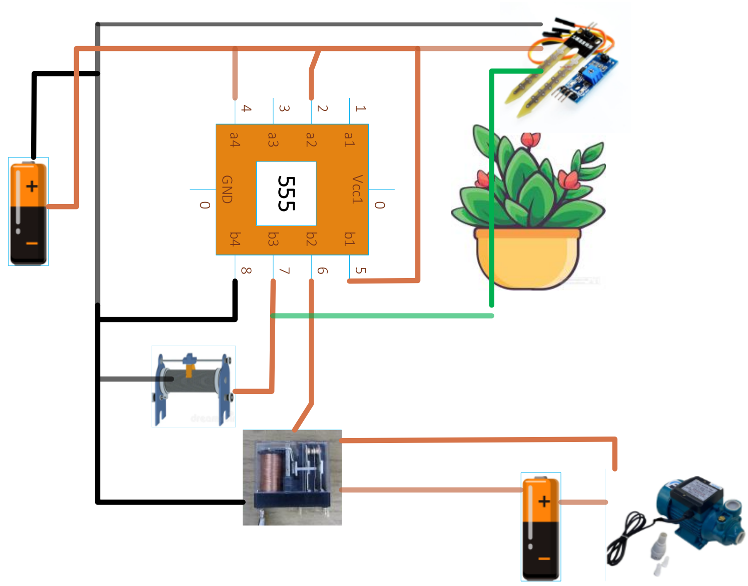

Figure 1Block Diagram Illustration of M08A (IPC-7351) IC 555 Controlled Water Management

The operation of the water level controller becomes clear when considering the following scenario. In Figure 1, the left side represents a relay as controlled unit simulated by a DC motor attached with water container. If the moisture level falls below the threshold, the relay circuit activates the pump motor otherwise, it remains off. Assuming a threshold level of Th_{min} is chosen by using moisture sensor, the pump remains on until the water level reaches the respective sensing probe in the overhead tank, at which point it switches off. The pump operates cyclically according to the situation and request. To prevent overflow and avoid unnecessary billing from the water supply board.

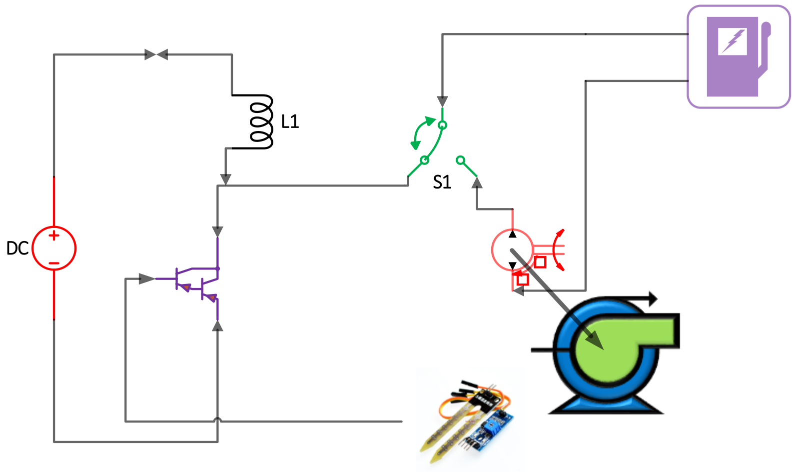

Figure 2 Electrical Circuit Diagram Illustration of M08A (IPC-7351) IC 555 Controlled Water Management

Unlike conventional controllers, this proposed system offers flexible level control. It includes an optional feature allowing the pumping of a specific volume of water preset by the sensors. Users can use the sensor switch to determine the desired level water/ moisture for pumping. The circuit automatically stops the pump motor once the designated level is reached beyond $(Th)_{Min}$.
The values of R1, R2, and C1 determine the frequency at which the M08A (IPC-7351) 555 timer produces a continuous square wave output at pin 3 while it is operating in astable mode. The soil moisture sensor's values control the NPN transistor's switch function. The relay is able to power the water pump when the transistor activates due to low soil moisture, which indicates dry circumstances. To get the ideal watering frequency, adjust the values of R1, R2, and C1.
The soil moisture sensor modules employed in this setup feature both digital and analog output pins. The moisture probe's output triggers aa set reference value to the IC 555 Timer. Adjustment of this reference value is facilitated by a potentiometer on the module. When the soil is wet, the digital pin provides an active low output.

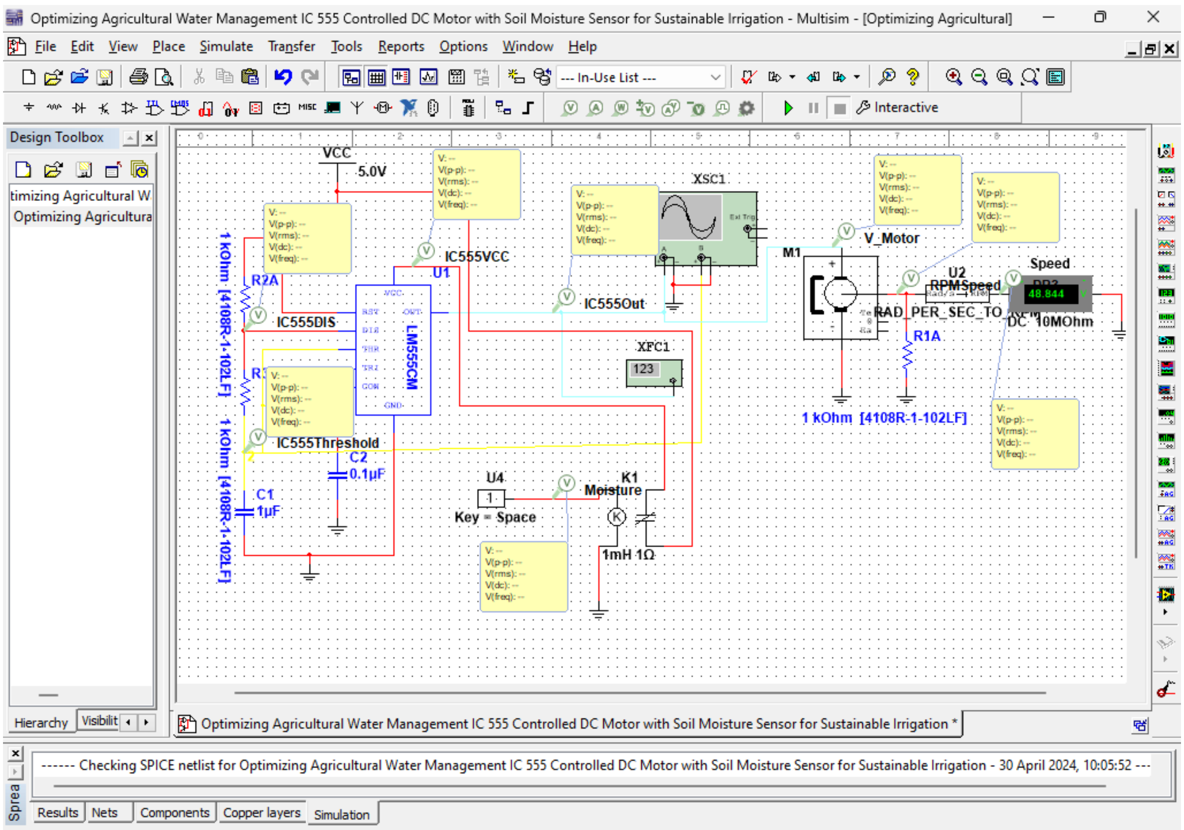

Figure 3 M08A (IPC-7351) IC 555 Controlled Water Management Circuit Analysis and Simulation in NI MultiSIm

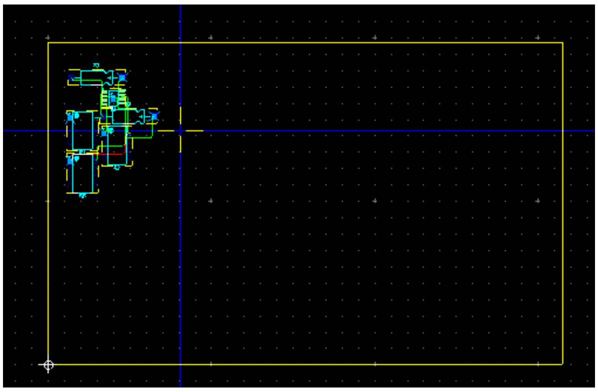

Figure 4 2-D PCB Layout for M08A (IPC-7351) IC 555 Controlled Water Management Circuit

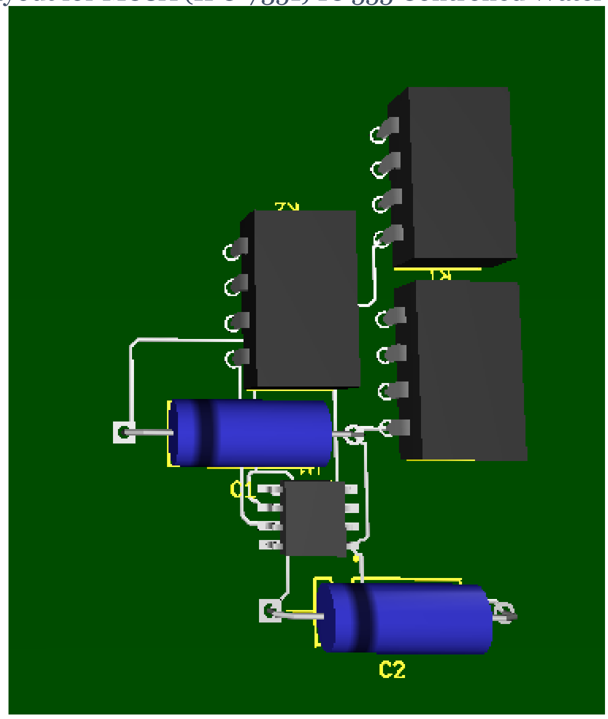

Figure 5 3-D PCB Layout for M08A (IPC-7351) IC 555 Controlled Water Management Circuit

In the circuit layout depicted, a float switch is linked to an analog pin of the M08A (IPC-7351) IC 555, with a 1K Ohm resistor utilized to pull up the line. Arduino's analog pins can serve as digital inputs as well. To sense the water level in the field or tank, Moisture sensor reads the voltage drop across the pull-up resistor. This information is then relayed to the base of a M08A (IPC-7351) 555 IC transistor, which subsequently powers the 5V DC motor.

3. Result and Discussion

Field testing of the system demonstrated its suitability for medium-sized agricultural fields. The Soil Moisture sensor's reference voltage can be adjusted based on the crop type and moisture required using register attached with the moisture sensor. The Voltage level across the pin no 3 of M08A (IPC-7351) IC 555 in active high and having level of DC voltage attached to pin no 8 of M08A (IPC-7351) IC555, In this study the voltage level is 5 V DC. The Figure no 6 Clearly shows that the voltage level at channel A as per Figure no 3 is Output of M08A (IPC-7351) IC555 which is high when output of Moisture sensor is at high or logic 1, and reduced to 0 when output of Moisture sensor is low. The transition time of switching is in millisecond.

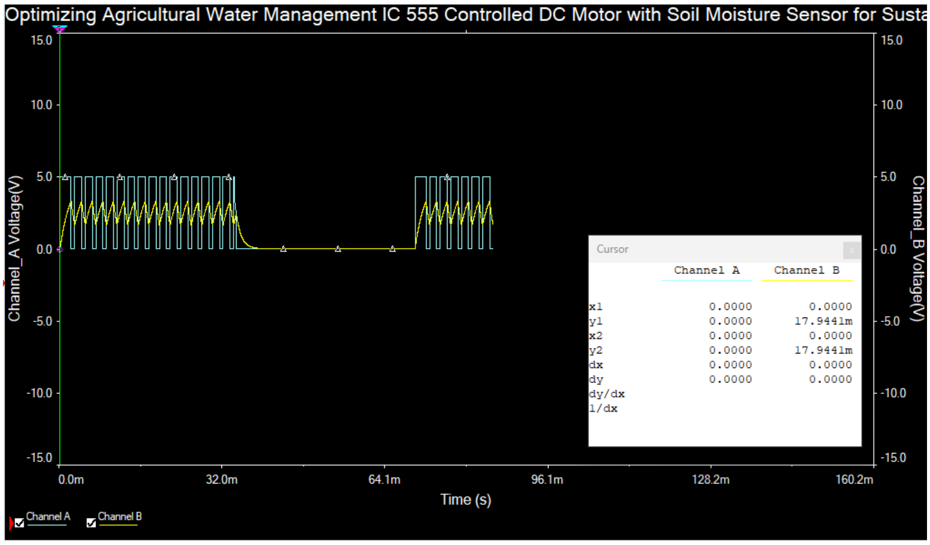

Figure 6 The Fluctuation in M08A (IPC-7351) IC 555 Output Pin in respect to Soil Moisture Sensor

The transition parameters observes that when Moisture sensor provides the 5.0V DC Hight output when the field/ tank is dry and not suitable for crop growth then it triggers the relay circuit (Which is initially at NO position which triggers the DC Motor for water Supply.) so the Vcc of IC 555 is connected to 50 V Dc supply and started charging Capacitor C1 (1μF) throght two egister R1 1 kΩ[4108R-1-102LF]and R2 kΩ [4108R-1-102LF]. When C1 charges 2/3 of Vcc then it generate a square wave in 9 ms as shown in Figure No 6. Initially, the capacitor (C) is discharged, and the output is in the low state.

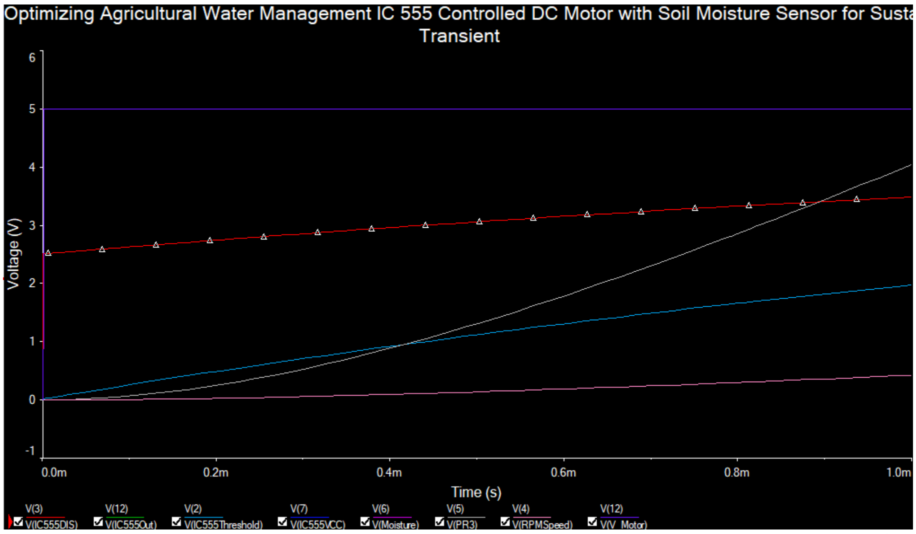

Figure 7 The Transient responses in M08A (IPC-7351) IC 555 Output Pin in respect to Soil Moisture Sensor

When a trigger signal is applied to pin 2, the voltage at this pin drops below 1/3 of VCC (50.00V), triggering the timer. The output of the timer goes high, and the capacitor (C) starts charging through resistor (R11 kΩ[4108R-1-102LF] and R21 kΩ[4108R-1-102LF) towards VCC. When the voltage across the capacitor (C) reaches 2/3 of VCC, the timer switches its output state to low. The capacitor (C) then discharges through the discharge pin (pin 7) until it reaches 1/3 of VCC. An oscillating square wave is generated and send to the output which starts the DC motor that waters the field. When field is dry and having moisture with sufficient threshold level the output of the Soil Moisture sensor goes low, which cutoff the relay and Vcc Supply is being triggered off so the IC 555 circuit output goes low. Dc motor stops the operation and watering stops in field.
The Figure 7 illustrated the transient analysis of the circuit where 1.0 ms time required by the circuit to generate the triggering voltage to level 50 Dc Voltage.

4. Conclusion

The "Automated Irrigation System based on Soil Moisture" has been successfully designed and tested, integrating various components. Each module has been strategically placed to ensure optimal performance. The moisture sensors gauge the water content of different plants. If the moisture level falls below the set threshold, the sensor sends a signal to the IC 555, activating the water pump to irrigate the respective plant via the rotating DC Motor. Once the desired moisture level is attained, the system autonomously ceases operation, turning off the water pump. Through thorough testing, the entire system has demonstrated reliable functionality and is deemed successful.

Potential enhancements include IoT integration for remote monitoring, machine learning algorithms for optimized irrigation schedules, weather forecast integration for dynamic adjustments, and solar power integration for sustainability, among others.

This system innovatively combines the 555 IC timer and soil moisture sensing to optimize irrigation, reducing water wastage and promoting sustainable agriculture. The automation simplifies irrigation processes, enhancing efficiency and user convenience.

In conclusion, the 555 IC-powered autonomous irrigation system provides a creative answer to the problems associated with conventional agricultural irrigation techniques. The system offers several advantages by utilising the adaptable 555 IC as a timer and integrating soil moisture sensor technologies. Water conservation is greatly aided by the system's accurate management of watering intervals, which is made possible by the 555 IC. This helps to address the urgent problem of water scarcity in agriculture.

Farmers can manage their irrigation more easily because to the system's automation, which reduces human error and streamlines the procedure. Its applicability across multiple agricultural contexts is highlighted by its features for real-time monitoring, customisable settings, and flexibility to fit a range of crop needs. Moreover, the system's emphasis on cost-effectiveness, scalability, and energy efficiency makes it more appealing to farmers operating at various scales.

Through its advocacy of ecologically responsible farming practices, integration of state-of-the-art technology, and support of sustainable water management, the automatic irrigation system with a 555 IC proves to be a useful tool in the advancement of environmentally responsible and productive farming. Innovative solutions like this are essential to fulfilling the demands of a growing global population while maintaining the prudent use of resources as the agricultural landscape continues to change.

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