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AN EFFICIENT URINAL WATER SPRINKLER WITH DISINFECTANT DISPENSER

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Abstract

This study introduces an innovative urinal system design incorporating urine detection sensors to optimize water conservation and hygiene. This approach addresses the inefficiencies of conventional automatic urinals that indiscriminately activate flush mechanisms, leading to significant water wastage. By ensuring that flushing only occurs upon actual urinal use, the proposed design significantly reduces water consumption, aligning with sustainability goals and enhancing restroom hygiene in high-traffic areas.

Index Terms— Automatic urinal system, urine detection sensor, water conservation, hygiene improvement, solenoid valves, IoT-based flushing system, false flushing prevention, energy efficiency, restroom automation, sustainable sanitation solutions.

I. INTRODUCTION

The development and adoption of automatic urinal flushing systems have become critical for modern restroom management, especially in high-traffic public facilities[1]. These systems have evolved since the 1990s, with numerous innovations aimed at enhancing their technical and functional capabilities [2]. However, challenges such as false flushing, water wastage, and inefficient energy use persist. One of the most significant concerns in current systems is the issue of false flushing, which is commonly triggered by infrared and ultrasonic sensors detecting a presence, regardless of whether the urinal is actuallyused [3]. This leads to unnecessary water consumption, withestimating that each urinal flush wastes up to 40 litres of water and 14 litres of urine daily, a resource loss that is unsustainable in today's environmental landscape[4].

Various attempts have been made to address these inefficiencies.[5] introduced a system using an ultrasonic distance sensor to detect the presence of a person within a defined proximity to the urinal. While effective in reducing unnecessary flushes, this system remains vulnerable to unintended flushing triggered by cleaning personnel or passersby. Similarly,[6] designed a misting jet that conserves water by using minimal amounts of mist to clean the urinal, yet his system, too, failed to resolve the issue of false flushing and did not improve hygiene standards by targeting urine contact within the bowl.

More recent studies have focused on integrating smart technologies, such as IoT-based automation systems, to optimize water and energy usage in urinals[7]. The introduction of Passive Infrared (PIR) sensors with delayed-action flushing, as examined by [8], demonstrates how grouping flushing events and introducing timed delays can significantly reduce water consumption in

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university settings, achieving up to 64% reduction in water use during peak times. Although promising, these technologies still face limitations, particularly in avoiding hygiene risks posed by urine splashes, which may harbour harmful microorganisms [9].

This paper presents an innovative approach to automatic urinal systems that addresses both the issues of water wastage and hygiene. By incorporating a urine detection sensor, the proposed system ensures that flushing only occurs upon actual use, significantly enhancing water conservation and improving restroom hygiene.

II. THE URINAL DISPENSER DESIGN

The developed urinal system consists of three units: the urine sensor, the valve control unit and solenoid valves connected to the water sprinkler and the disinfectant dispenser. The system can be represented by the block diagram of Figure 1.

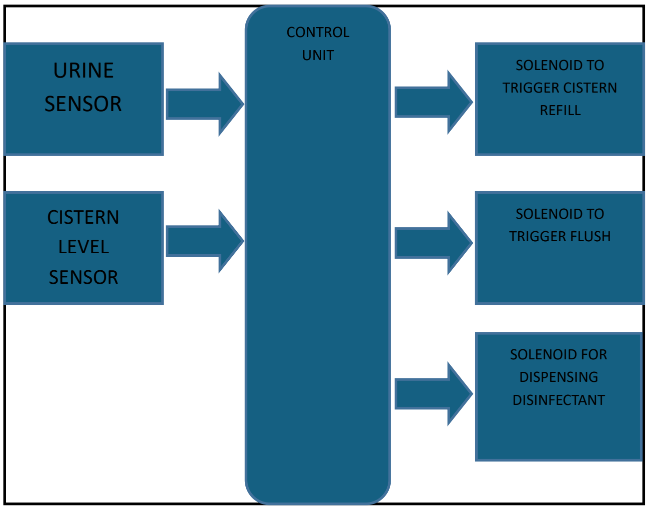

Figure 1: Block diagram of the urinal water sprinkler system

A. Urine Sensor

The urine sensor, illustrated in Figure 2, comprises two metallic probes and a transistor-based circuit, powered by a 5V DC supply. The sensor operates by measuring the electrical resistance of the fluid in contact with the probes. To establish a threshold that distinguishes urine from water, samples of urine were obtained from voluntary donors. The emitter voltage drop was observed and recorded for both water and various urine samples during testing. This data enabled the identification of a reliable threshold for differentiating between the two fluids based on their electrical properties.

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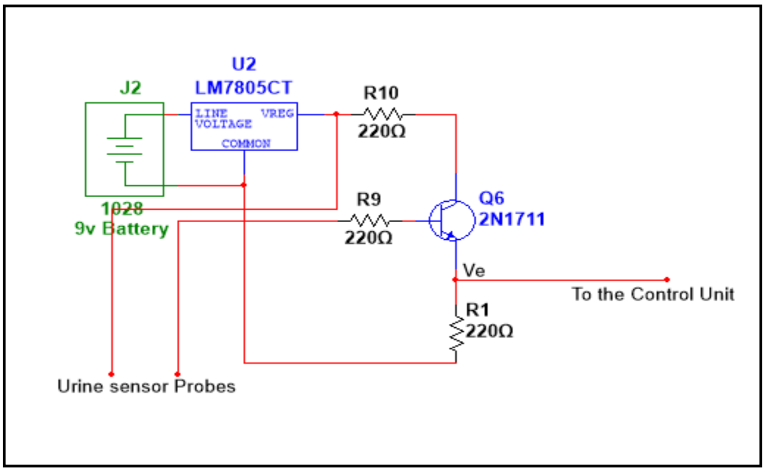

Figure 2: Urine sensor circuit

B. The solenoid valves

The solenoid valves facilitate the flow of water when activated by the control unit. Due to the insufficient current output from the control unit to directly drive the valves, power transistors (TIP41C), as illustrated in Figure 3, are employed for switching the valves. The TIP41C transistors are controlled by signals from the control unit, which bias the transistor and enable current flow from an external battery source to the solenoid valves. Additionally, a diode is connected across the terminals of the valve to prevent damage from back electromotive force (EMF) generated during operation.

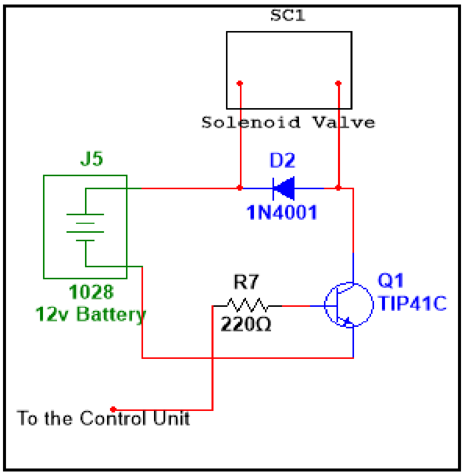

Figure 3: The solenoid valve drive circuit

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C. The Control Unit

The control unit is comprised of an Arduino Uno board, which processes input signals from the sensor, evaluates them against a pre-determined threshold, and activates the solenoid valves accordingly. The solenoid valve, which remains in a normally closed state, opens upon activation and permits water flow into the urinal for approximately six seconds. This cycle continues until the water level in the cistern, monitored by a water level sensor, falls below the specified threshold. At this point, the control unit transmits a signal to energize the solenoid valve connected to the main water supply, enabling water to refill the cistern. This automatic refill cycle repeats whenever the cistern's water level reaches the defined minimum. Additionally, at designated intervals, the control unit dispenses disinfectant into the cistern in preparation for the subsequent urinal flush, ensuring hygienic operation.

III. TESTS AND RESULTS

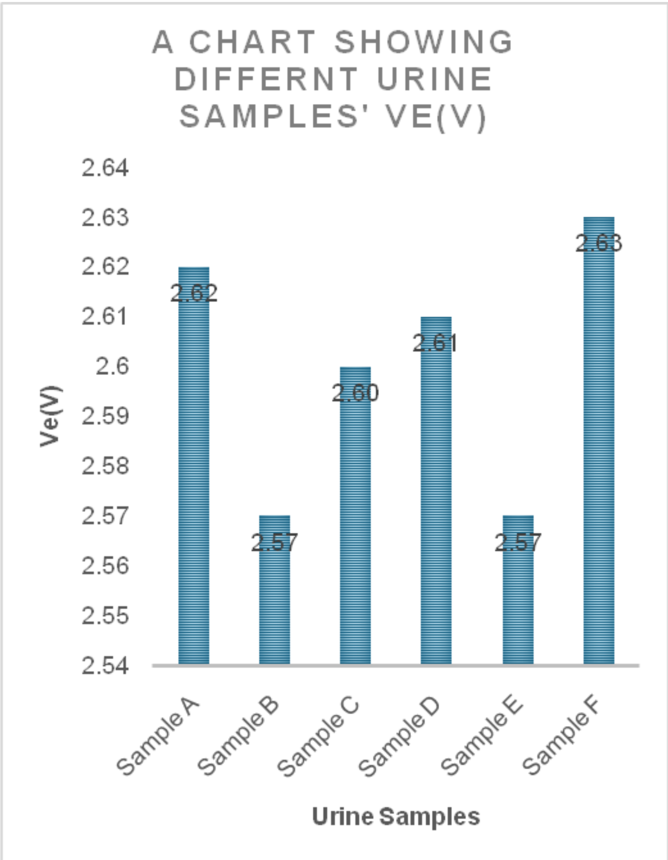

Figure 4: Graph showing voltage drops for different samples of fluids.

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As illustrated in Figure 4, the minimum emitter voltage for urine was measured at 2.57V. Consequently, this threshold was employed to program the control unit, enabling it to effectively distinguish between urine and water. Further analysis was conducted by testing the sensor across various fluids, revealing distinct sensor outputs and resistance values, as presented in Table 1. These findings suggest the sensor's potential for broader applications within engineering and industrial sectors, such as beverage production, and oil and gas industries, where the differentiation of fluids based on their electrical resistances is critical.

Table 1: Resistance and Voltages for different fluids.

Sample	Concentration	Concentration of solute = 125g/dm3	higher concentration of solute
		Ve(V)	Ve(V)
Water	nil	2.53	2.53
Milk solution	125g/dm3	2.55	2.57
Salt solution	125g/dm3	2.62	2.66
Soap Solution	125g/dm3	2.59	2.64
Urine	nil	2.63	2.63
Kerosene	nil	0.07	0.07

IV. CHALLENGES ENCOUNTERD

During this research, several challenges emerged, primarily related to sensor calibration and accuracy. Establishing a reliable threshold to differentiate between urine and water required extensive testing and data collection from different samples. The sensors occasionally faced issues with false detections due to environmental factors such as water splashes, necessitating additional adjustments. The power requirements for operating solenoid valves were also a challenge, as the control unit's current output was insufficient, requiring power transistors for proper functioning. Moreover, integrating all components to ensure seamless operation of the control unit and maintaining consistent performance in varied conditions was complex.

V. FUTURE RESEARCH

Future research could explore improving sensor accuracy using machine learning algorithms for better fluid differentiation. Additionally, integrating the system with advanced IoT networks could facilitate remote monitoring and management of the urinals, optimizing maintenance schedules and minimizing water use. Research could also consider expanding the application of this detection technology to other industrial contexts, such as differentiating fluids in manufacturing processes. Enhancing energy efficiency by investigating alternative power sources, such as solar energy for autonomous operation, and incorporating predictive maintenance based on usage data could further elevate the effectiveness of the proposed system.

VI. CONCLUSION

From the research, we can conclude the following:

1. A sensor circuit was successfully developed to detect urine and distinguish between urine and water by measuring the electrical resistance of fluids in contact with the sensor probes.
2. Findings indicated that urine has a lower electrical resistance compared to water.
3. The designed sensor can be applied in other industries, such as food and beverage production, to differentiate products based on electrical resistance.
4. A disinfectant dispenser was integrated to facilitate a regular medic flush to ensure a high standard of hygiene during urinal use and provide a flush duration of approximately six seconds, which is faster compared to conventional urinals.
5. The average emitter voltage (Ve) for different fluids was determined to be 2.57V for Urine and 2.48V for Water. The control unit was programmed with a threshold of 2.57V to effectively distinguish between the two fluids.
6. The approach provides several benefits including the resolving of false flushing, optimizing energy efficiency and maintaining hygiene by regularly disinfecting the urinal.

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