# Novel Low-Cost Device for Detecting Urine Bag Filling Using the Remote Control

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**Abstract** – The present study aims to facilitate the work of nurses and medical staff in patient care. Nurses have always faced the challenge of being aware of the filling status of urine bags (urinary catheters). Failure to empty the urine bag in a timely manner for patients with disabilities, paralysis, or impaired consciousness can lead to urinary difficulties such as retention and urine reflux. Repeated occurrences of this issue may result in more serious complications like renal problems and urinary tract infections, jeopardizing patient health and prolonging hospital stays significantly. Given the advancement of technology and the widespread use of wireless communication, this project utilizes code-learn remote control technology. By attaching a special clamp to the urine bag, an alarm is triggered in the nurses' station or a designated area when the bag is full, enabling prompt intervention and ensuring better patient management, comfort, and safety around the clock, therefore improving overall healthcare quality. Unlike previous works that rely on complex sensors or continuous monitoring via computers, the proposed design offers a simple, modular, and wireless alarm system that can be used in any hospital setting without structural modifications to urine bags. This novelty lies in its affordability, ease of integration, and non-hackable communication protocol, which together represent a distinct contribution to patient care and hospital resource optimization.
**Keywords**: remote control, remote alarm, urine bag

## 1. Introduction

The urine bag consists of a bag with a tube and is usually used for people who are unable to urinate normally due to illness or surgery. Urine enters the urine bag, through a catheter that is attached to the patient's bladder and if necessary is drained throughout by a small socket at the end of the bladder tube. There are a number of reasons that can prevent a nominal urinate. So doctors must use catheters and urine bag. some usage of urine bags are: obstruction of the urinary tract, prostate problems in the, kidney stone, bladder damage, cysts or tumors of the urinary tract, people with urinary incontinence, emptying the bladder before and after surgery, emptying the bladder during childbirth, measuring the exact amount of urine or urine test, measuring the volume of urine, Remaining after urination, urinary incontinence for patients with mobility impairment, a person may also require a catheter for medical reasons.

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### 1.1. Motivation and background

Urine bags play an important role in showing the amount of urine output, which helps diagnose some infectious, urinary, and kidney diseases [1]. Acute Kidney Injury (AKI), for example, is defined by a sudden decrease in kidney function and is currently assessed by changes in serum creatinine and urinary output (UO) [2] or in the purple urine bag syndrome occurs when a combination of intra-urinary material with plastic material of the bladder [3-4], and this may not have been known without these bags [5]. Therefore, many studies have been done on different types of urine bags, and attempts have been made to add to their capabilities. Regarding this issue, reference [6] has stated multifunctional urine bags with the ability to measure urine PH and urine volume control per unit time simultaneously. Reference [7] introduces a new urine collection kit for babies. Reference [8] presents a tool that is capable of automatic monitoring of urine output with the possibility of minute-by-minute monitoring. The purpose of reference [9] was to design a Urine Analysis Device (UAD) to measure the urine output of the patient automatically. The evaluation results revealed that this device has a 40% higher efficiency than manual calculation.

A fully automated IoT-based measurement system (IoT) was presented in [10], they used the Photo Interrupter to measure urine drop by drop. unlike many of the previous articles. this system uses the modern Arduino microcontroller and uses wireless media to send data to a remote server where it is analyzed for physicians' understanding. In reference [11], twelve different methods of measuring the amount of urine output have been collected, and the advantages and disadvantages of each are given in a table. Reference [12] provides methods through which the amount of output is calculated online at any time, and the output is sent to the computer and monitored by wireless communication.

In [13], an optical sensor was placed in a medical dropper to record the number of drops counted. Several sensors, including a cut-off sensor, an infrared proximity sensor, and an ultrasonic sensor, were also used to detect dripping and urine flow, and the complete system was launched using an Arduino circuit based on drop count to detect urine volume. The integrated system for measuring and analyzing urine output, consist of three different sections called a recording unit, an analysis unit and a transfer unit. The recording unit includes sensors (acoustic and camera) connected to the input urinary catheter while the analysis unit includes hardware and software that help analyze the recorded data on various parameters. Finally, the transmission unit that may consist of a wireless or wired connection, transfer the recorded data to processor. Note that the use of an audio sensor and an optical device may affect the recorded data under certain noise conditions. References [14-16] also offer various methods for wireless communication using the remote control, the complexity of the design is the only drawback of this system and may prevent it from being built on a commercial scale. Table 1 shows a comparison between existing methods and the proposed device.

In addition to medical centers and hospitals, the plan presented in this article can be used for patients with mobility impairments such as heart attacks and strokes, people with disabilities who perform medical procedures at home and may not be cared for by a nurse, people whose muscles are paralyzed, etc. As mentioned, the primary purpose of this project is to build a cheap and easy-to-use device to inform the filling of the bladder at the right time to empty it in time. Since the use of this device is not to measure urine output accurately, it does not need to be monitored, and the fact that this device is not dependent on a computer makes it possible for anyone to use it.

The advantages of this project include the following:

- Ability to be used in all hospitals to facilitate the work of nursing staff without restrictions
- Extremely easy to use and without complexity
- Better care for patients who have to use catheters.
- Easy supply at a low cost
- Design of parts in a modular and detachable way
- Non-hackable design and prevention of communication disruption
- Being able to be used for 100 catheter bags simultaneously without the possibility of interaction
- Ability to be utilized for all types of catheter bags with different designs without changing their structure
- Sufficient to provide the required equipment only once for permanent use

### 1.2. Main Contribution

The main contribution of this work is the development of a practical and inexpensive system that can simultaneously support up to 100 urine bags without interference, does not require modification of existing medical equipment, and ensures secure wireless communication. This approach fills the gap in previous studies that have mainly focused on expensive, sensor-based, or computer-dependent designs. Its modular structure also facilitates maintenance and repair measures.

### 1.3. Organization

First, a basic description of the remote controls and how they work, followed by an introduction to the project components and how to make a special clamp for attaching to the urine bag, are offered. Next, how to connect and assemble the system is described. Then, the instructions for using this project are put forward, and the various possible modes for utilization will be fully explained. Finally, results obtained from this project are presented.

**Table 1**. Comparing proposed device with related works

| ref | Cost | Accuracy | Complexity | Computer Dependency | Multi-bag Support | Key Limitation |
|---|---|---|---|---|---|---|
| Ref [5] | High | High | High | Required | Single patient | Expensive, niche use |
| Ref [6] | High | High | High | Required | Single bag | Expensive, limited usability |
| Ref [7] | Moderate | Moderate | Moderate | Not required | Single bag | Limited to neonates |
| Ref [8] | High | High | High | Required | Single bag | Costly, sensor calibration needed |
| Ref [9] | High | High | High | Required | Single bag | Expensive, limited usability |

| | | | | | | |
|---|---|---|---|---|---|---|
| Ref [10] | High | High | High | Required | Limited | Needed continuous internet/server |
| Ref [13] | Moderate | Moderate | High | Required | Limited | Noise sensitive, complex |
| **Proposed device** | Low | Moderate | Low | Not required | Up to 100 bags | Only alarm based, no precise urine measurement |

## 2. Remote Control

Modulation is a process to facilitate the transfer of information through an interface. Human voice alone cannot travel long distances, hence modulation is required for signal transmission. To increase the range of sound, we need to transmit it through another interface other than air, such as telephone lines or radio. The process of converting information (for example, the human voice) to successfully transmit it through an interface (wire or radio waves) is called modulation. Modulation is like sending an information signal over another signal called a carrier. This carrier usually has a much larger and more constant frequency. The modulated carrier contains the primary signal information, which can be transferred from one place to another and retrieve the original information at the destination. We deal with two logics in digital circuits, zero and one, converted to frequencies F0 and F1 for transmission. Frequency F0 means logic 0, and frequency F1 means logic 1. In this method, the receiver is straightforward and must detect and tell the difference between frequencies F0 and F1. This type of modulation or similar ones are used in radio remote controls to send data.

Code learn remotes use ASK modulation to send data. ASK modulation is a simplified subset of digital modulation; Frequency F0 has been removed, and only frequency F1 is used. When logic is 1, the frequency F1 is generated, and when logic is zero, the transmitter is turned off, and no signal is generated.

### 2.1 Reason for Using Code Learn Remote

Because in code learn remotes, a 24-bit code is assigned to each input, the probability of the similar output of two different inputs equals $1/2^{24}$. That is about one-millionth, which can be considered zero. This is the case in fixed code remotes where the inputs are distinguished by only 8 bits, and the probability of the same output of two different inputs equals $1/2^{8}$ which is much higher than code learn remotes. When the remote control of the fixed code is lost, the deep switch of the receiver must be replaced, which is a difficult task; that is why the security of this remote is low, and it is easy to copy.

Although the frequency adjustment is done as software in the code learn remote, and there is no need to use solder to define the remote on the receiver, using this remote model is easier for the user. Because these two types of remotes differ only in the software part and have very little difference in terms of costs, in this project, the code learn remotes have been used due to the higher communication security. Given what was stated above and the problem we face in this design, the possibility of filling two different catheter/ urine bags activating a common outlet in the nurses' room or designated location is zero in this type of remote. In other words, it is no longer possible. This shows the security of communication of this plan.

## 3. Receiver Circuit

There are several ways to design this circuit that can be customized or changed based on the needs. The most common type of this circuit is the alarms used in cars, or even ready-made circuits in the market can be used, which are too many in types. Depending on the type of remote used, the frequency of the remotes is usually either 433 or 315. The only thing that matters is the encoder inside the remote, which should be from the 527 family, such as EV1527 or HS527, etc. The way to encode these chips is in such a way that first, a fixed 20-bit code is sent to each remote and then 4-bit corresponding data is sent through the keys that are pressed on the remote.

In order to introduce each remote to the receiver, called learning, a controller in the receiver circuit that can decode the received information must be used. Using a microcontroller is the best option to do so. The microcontroller's task is to receive its information from the radio receiver module and capture the correct information of its transmitter from the ambient noise and various waves in the environment. Moreover, it decodes them so that, first, it can detect that the transmitted information is allowed, which means that the sender should be introduced to the recipient. Second, what key or keys are pressed and issue the relevant command at the end.

A simple circuit using atmega8 was utilized to store up to 100 remote addresses. The written program continuously measures the width of the pulses received from the radio receiver module and enters the stage of decoding the remote address if the pulse width is within the defined range. When the allowed remote address is detected, the receiver checks the code information of the pressed keys and issues the output command accordingly. The microcontroller of this device is programmed so that to learn the remote, you should press the Learn button. Thus, the learn LED turns on and stays on. Then we press one of the remote keys (key A has been used here). If the remote is learned, the Learn LED turns off. We have to do the same to learn other remotes. To delete the learned remotes, the learn button must be pressed for a few seconds and not be released until a continuous beep is heard, in which case the data written to the memory will be erased. The important thing about learning is that if you do not decide to move the remotes, it is enough to learn them once and for all.

**Fig. 1.** Applying changes to the remote code learn transmitter circuit and adding a wire to the desired key to apply the command to the transmitter without pressing any key.

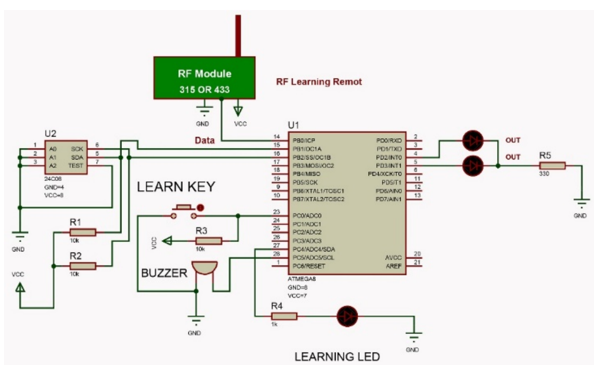


**Fig. 2.** Code learn remote control receiver circuit schematic.

## 4. Clamp Attachment

For the clamp to have the desired capabilities, it must be modified. Due to molding and clamp production limitations, we had to form a structure to meet expectations. In order for the clamp to return well with increasing bag volume and spacing of the walls, there must be minimal resistance, allowing the clamp spring to separate easily as the bag volume increases. Also, the longer the branches at the beginning of the clamp, the closer it should be to the center of the catheter, and when the fluid enters the catheter, with the slightest error, it shows this increase in volume as the branches move away.

Now, this mechanical clamp should communicate with the electric code learn transmitter. To achieve this goal, aluminum foil is used at the bottom of the clamp, and the male wires of the board are also connected to it. The bottom of the clamp is covered with foil, and the board wires are attached to it. Two plastic plates are used to make the branches taller, and the bottom part is connected by opening the beginning part of the clamp. After connecting the two ends of the clamp, the remote control key is activated, and sounds the alarm.

## 5. Method

First, there is a need to ensure that the transmitter and receiver circuits are working correctly. In order to make the design modular, minor changes are made in the transmitter circuit (Fig 1). This figure illustrates the additional wiring required to connect the clamp mechanism to the transmitter, enabling automatic activation of the alarm without manual key pressing. Fig 2 shows the schematic of microcontroller and radio module configuration for decoding transmitted signals and triggering the alarm output. After constructing the receiver circuit according to its schematic shown in Fig 2, the power supply is connected to the circuit (the voltage required to start the circuit is 5 volts, which is supplied by a 5-volt adapter and is connected to the circuit). We will learn the remote control, which is fully explained in accordance with the instructions in the receiver circuit section.

Then, there is a need to connect the catheter bag to the remote control. For this purpose, it was initially decided to use a floating hub to determine the level or sensors to detect fluid levels, however given that these methods require a change in the structure of the catheter bags, they may not be a good option in terms of production costs. Therefore, there is no need to change the design of catheter bags in the final method, and they can be used in the same way that they are available in pharmacies. In this design, the fluid mechanics' capability of the catheter bag is used, and it is connected to all types of catheters, as can be seen in Fig 3. This figure shows, as the bladder fills, the conductor points of the clamp converge, which activates the transmitter and sends the filling alert to the receiver circuit. Moreover, it can be separated modularly, and it can also be easily installed on the catheter bag.

The bag's volume increases when the catheter is filled; this increase in volume causes the catheter bag to come out of the flat position and its walls to be separated from each other. The distance between the sac walls is directly related to the increase in catheter volume. This means that the greater the volume of liquid in the bag, the greater the distance between the walls. This system has used this subject. When the beginning of the clamp is attached to the empty catheter body, the bottom side of the clamp is farthest from each other. On the contrary, as the catheter fills, the distance between the beginning parts of the clamp increases (due to the distance between the bag walls), and the bottom parts get closer to each other in the same proportion. As the bottom plug of the clamp gets closer and connected, the remote is activated and sends the message of filling the bag to the receiver. At this stage, depending on how the output is defined, the nursing staffs are informed about this issue, and future actions are taken immediately. Fig 4 shows the primary and complete map of the device including.

For a more convenient and more durable connection to the catheter, two wires have been led to the outside of the body of the transmitter's switch 1. (If you use the switch keys for other purposes such as sirens, the same can be repeated for the switch keys). To let the wire out, there is a need to drill a hole near the transmitter board housing to create an opening for the soldered wires to pass through the case. These wires are female to be easily attached to the male wires at the end of the clamp.

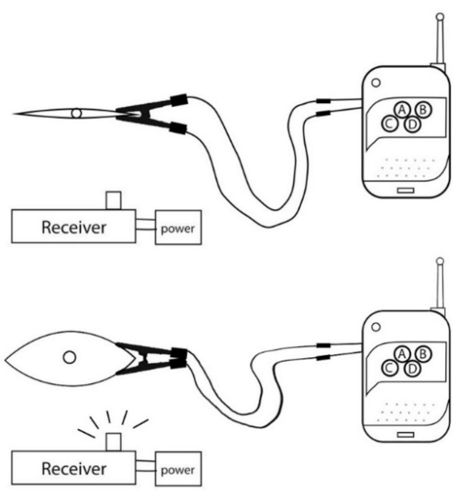


**Fig. 3.** A view from the top of the catheter bag when the bladder fills and the conductor points of the clamp stick together, thus activating the alarm in the receiver circuit.

Up to this design stage, we are well acquainted with the four main parts of the system (transmitter, receiver circuit, catheter bag & clamp). The following will discuss how to use and connect these parts. In this design, two outputs are used, i.e., they can be utilized for two separate catheters. As mentioned earlier, up to 100 catches can be added simultaneously without interference. The receiver part is the one that should be installed in the nursing room or where we want the alarm to sound. The clamp must also be attached to the catheter bag. According to the tests performed, installing the clamp in the middle and slightly higher is recommended. The clamp is attached to the catheter bag with a double-sided adhesive mounted on it. The only and most crucial remaining part is the transmitter remote, which is easily connected to the end of the clamp using the male and female parts of the board wire. Now, the system is complete, and when the bag is full, and its volume is increased, the remote control is activated, and the alarm defined in the relevant place is turned on. The component of this device was shown in Fig 4. It is important to note that this system can be used for as long as desired and at no additional cost, with only one transmitter, receiver, and clamp supply.

Using this system can be on a larger scale, with an LCD to accurately display the desired location address, which is relatively easy to Add to this system. It is even possible to prepare a board with the appropriate information in the receiver section based on the required number of outputs, including information, address, and output rooms so that there is no need for a character LCD and when each output is turned on in front of each information, there is no ambiguity for nursing staff. The product can be designed and implemented according to the environmental conditions when customizing. Also, if filling the catheter is the only concern, single-channel transmitters can be used or other buttons for other purposes. It is necessary to do wiring from the relevant switch to the required equipment for each consumption.

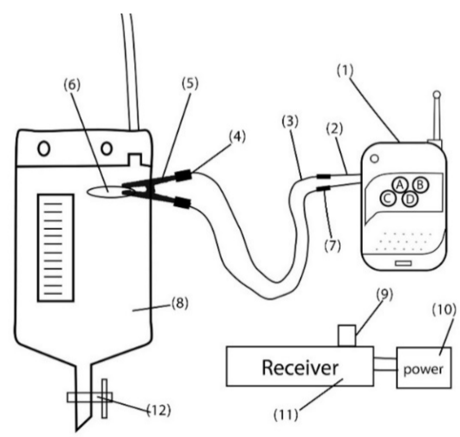


**Fig. 4.** shows the primary and complete map of the device including 1) code learn transmitter 2) wire added to code learn transmitter's switch A 3) connection wire to the end of the clamp connected to the foley catheter 4) conductor end part of the clamp 5) urine bag connection clamp 6) plastic plate added to the clamp to make it longer 7) clamp connection to remote control 8) foley catheter bag 9) receiver circuit alarm which can be in the form of a siren or light 10) power supply 11) the learn code receiver circuit 12) urinary bladder drain valve.

Also, In Fig 5, which shows the manufactured device, it can be seen that the alarm is activated after the urine bag is filled.

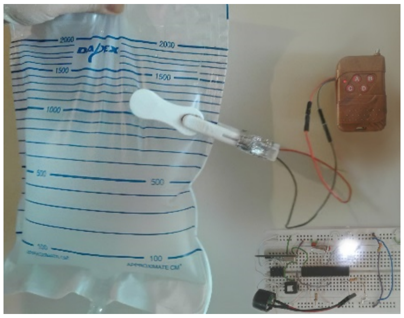

**Fig. 5.** manufactured device

This figure shows the physical implementation, where the alarm activates after the urine bag is filled, confirming the practical feasibility of the design.

## 6. Conclusion

Regarding the explanations made, it was observed that a system could be designed to facilitate the work of nursing staff with a low cost and equipment that is easy to obtain and provide. The quality of patient care is also improved. The convenience of working with this system allows those with low medical literacy to use it easily. Non-interference in this connection allows up to 100 catheter bags to be used simultaneously on a large scale and in crowded hospitals. The technology of this system is wireless, no wires are used between the transmitter and the receiver, and there is no need for cabling and ducting in medical centers. This design can be customized with different designs and additional features that can be easily added to the system. This communication between transmitter and receiver is wireless and responsive up to a distance of 100 meters and is designed modularly, which means that once the transmitter and receiver elements are provided, they can be used forever.

Despite its advantages, the current design has certain limitations, such as sensitivity and the absence of precise urine output measurement. Future research should focus on integrating digital sensors for enhanced accuracy, developing mobile-app-based monitoring for remote caregivers, and testing the device across diverse patient populations in clinical trials. Such directions will further strengthen the applicability and reliability of the proposed system.

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