

FLUID MONITORING AND ALERT SYSTEM WITH CONDUCTION TECHNOLOGY

FIELD OF INVENTION

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[001] The present invention relates to the field of biomedical engineering and biomaterial engineering more specifically to the field of medical device and IV fluid administration and monitoring systems.

10 BACKGROUND

[002] Intravenous (IV) therapy is a cornerstone of modern medical care, providing patients with essential fluids, medications, and nutrients. It is particularly critical in emergency care, critical care units, and surgeries, where
15 precise control over fluid administration is vital to ensure patient safety and effective treatment. Despite its widespread use, the systems and methods currently available for monitoring IV fluid administration are far from perfect, often relying heavily on manual oversight by nurses and healthcare staff. This dependence on manual human intervention introduces significant risks,
20 especially in high-pressure environments such as intensive care units (ICUs) where staff manage multiple patients and respond to time-sensitive situations.

[003] The existing solutions for monitoring IV therapy are predominantly manual or semi-automated, requiring healthcare workers to frequently check

drip rates and fluid levels by physically observing the IV lines. In these systems, medical staff must adjust the flow rates based on visual estimations, record data manually, and attend to alarms that may be delayed or difficult to interpret. In many cases, this manual oversight leads to variability in fluid delivery, as the

5 exact drip rate can fluctuate due to factors such as changes in patient positioning, line blockages, or kinks in the tubing. Over time, these inconsistencies can have serious consequences, including under- or over-administration of fluids, electrolyte imbalances, and delayed treatment responses. In critical care settings, where patients often require exact dosages of

10 medications or fluids, even minor discrepancies can exacerbate patient conditions, leading to further complications or prolonged hospital stays. One of the significant issues with the current approach is the increased burden on nursing staff, who are tasked with managing multiple patients and are often spread thin across various responsibilities. In an ICU or emergency department,

15 nurses must constantly juggle multiple priorities, including patient monitoring, administering medications, responding to alarms, and performing critical interventions. The need for frequent IV line checks only adds to this burden, increasing the likelihood of human error. Furthermore, healthcare staff are prone to fatigue, especially during long shifts or in high-pressure situations, making it

20 easier for critical mistakes to slip through the cracks. Errors such as a missed change in drip rate or a blocked line may go unnoticed for extended periods, leading to severe complications like dehydration, fluid overload, or delayed medication delivery.

[004] The nurses must manually enter data from IV therapy sessions into the patient's medical record, which is time-consuming and further prone to errors. The lack of real-time, automated data collection and reporting in current systems leads to discrepancies in patient records, making it difficult for clinicians to get an accurate and up-to-date picture of the patient's fluid balance and medication administration. As a result, important clinical decisions may be delayed or based on incomplete information, particularly in fast-paced environments where time is of the essence. Moreover, existing systems often rely on outdated technology that is not well-suited to the evolving demands of modern healthcare wherein medical technology is rapidly advancing, the lack of reliable, automated solutions for IV monitoring represents a significant gap in care. Many existing systems are expensive, complex, and difficult to scale, making them inaccessible to smaller clinics or underfunded hospitals. Even where these systems are available, their installation can be disruptive and costly, requiring extensive wiring and hardware setup, which limits their flexibility and adaptability to different hospital environments. The critical care landscape, with its evolving demands and the increasing complexity of patient needs, requires solutions that can keep pace with advancements in medical technology. The growing trend toward digital integration in hospitals and the need for real-time data to inform clinical decisions underscore the necessity for a more efficient, accurate, and scalable system for IV fluid monitoring. As healthcare systems strive to improve patient outcomes while managing resource constraints, it is clear that the existing solutions for IV therapy monitoring are no longer sufficient.

[005] US20140278156 discloses a bag sensing element carried by an IV fluid bag that includes first and second sensing elements positioned on opposite sides of the IV fluid bag and configured to interact with the bag sensing element. The first and second sensing elements are physically separate from the IV fluid bag.

5 The bag sensing element and the first and second elements are positioned such that a line of sight between at least the first sensing element and the bag sensing element extends through the IV fluid within the IV fluid bag while the IV fluid bag is in a filled state

[006] US20180099083 discloses a sensing element, a user locator device, a
10 location server, and an analytics server. The sensing element senses the weight of an IV bag and transmits weight data and a first ID signal corresponding to the IV bag. The user locator device transmits a second ID signal corresponding to a user. The location server stores and periodically updates sets of ID data and locations of a set of users and a plurality of IV bags. The analytics server stores
15 and periodically updates a set of weight data of the plurality of IV bags.

[007] KR1020210142224 describes a server that analyzes the IV fluid drip information transmitted from an infusion sensor, and sends notifications and commands through a network; an infusion sensor that detects the infrared rays emitted from the IV fluid and detects the IV fluid drip and a terminal that
20 receives the IV fluid drip information analyzed by the server through the network and displays the same

[008] The present invention addresses these shortcomings by offering an automated, real-time monitoring solution integrating wireless technology and

advanced data management thus reducing the need for manual checks, minimizing human error, and ensuring more precise control over IV fluid administration. By continuously monitoring the drip rate and providing instant alerts in case of any irregularities, the system empowers healthcare providers to respond quickly to potential problems before they escalate into critical issues.

SUMMARY OF THE INVENTION

[009] The present invention describes intravenous (IV) fluid monitoring system that helps generating automatic alert in the process of administering and managing IV fluids for patients. The invention comprises a drip sensor that tracks the flow rate of fluids in real time, a microcontroller for data processing, and a battery management system (BMS) to ensure long-term power efficiency. The system employs Bluetooth gateway technology for wireless data transmission to a central server or monitoring platform, allowing healthcare providers to oversee multiple patients simultaneously. The system generates real-time alerts when irregularities, such as blockages or deviations in drip rate, are detected, improving patient safety. It is scalable, allowing for integration in both small clinics and large hospitals.

[010] In one embodiment, the present invention describes a system utilizing capacitive sensing electrode to monitor the fluid level inside an IV bottle. The capacitive sensor is connected via male and female earphone jacks to the monitoring device, ensuring a stable and easy-to-maintain connection allowing

for precise and real-time detection of fluid levels, enabling immediate feedback to healthcare professionals.

[011] In one embodiment, the system features a proactive alert system that sends notifications to nursing staff 3-5 minutes before the IV bottle runs out.

5 The feature is particularly useful in busy hospital environments, providing nurses ample time to replace the bottle without interrupting the patient's treatment.

[012] In one embodiment, wireless connectivity is realized through both WiFi and Bluetooth modules. The WiFi module enables data to be sent to a central
10 server, while the Bluetooth feature allows for easy configuration, setup, and smoothly receives data advertised by the Bluetooth of each drip monitor and sends it to the central server via WiFi, ensuring integration into the hospital's existing infrastructure.

[013] In one embodiment, the system includes an optimized PCB design,
15 which enhances energy efficiency and overall performance. The PCB layout minimizes power consumption by using shorter signal paths better thermal management, and adaptive deep sleep technology ensuring the system operates reliably in high-demand environments.

[014] In one embodiment, the Battery Management System (BMS) is
20 integrated with the microcontroller to manage power distribution efficiently. The BMS works with the deep sleep algorithm to conserve energy during idle periods, significantly extending the device's operational life.

[015] In another embodiment, the system incorporates a deep sleep algorithm, which reduces power usage by putting non-essential components into low-power states when the IV fluid level is stable, activating only when a significant change is detected.

5 [016] In one embodiment, the remote monitoring application allows healthcare staff to track IV fluid levels and device status from their smartphones, computers, and other devices. This application sends real-time alerts, providing nurses with essential information about patient IV levels without requiring constant manual checks.

10 [017] In another embodiment, the clip mechanism allows for easy attachment to IV bottles, making the device adaptable to a variety of IV setups and hospital environments. This design ensures reliable monitoring regardless of the type of IV system in use.

[018] In one embodiment, the invention is designed to work with various IV
15 setups and beds, offering versatile compatibility across different healthcare settings, from general wards to intensive care units, ensuring consistent and reliable monitoring.

[019] In another embodiment, the invention integrate with smart devices empowers healthcare professionals with detailed, real-time insights into the IV
20 infusion process, reducing the risk of therapy interruptions and improving patient outcomes through proactive care management.

OBJECTIVES

[020] It is an objective of the invention to provide a real-time IV fluid monitoring system using capacitive sensing electrode for precise detection of fluid levels.

[021] It is another objective of the invention to offer proactive alerts 3-5 minutes before the IV bottle is depleted, ensuring timely intervention.

[022] It is another objective of the invention to integrate wireless communication technologies, including WiFi and Bluetooth, for seamless data transmission and remote monitoring.

[023] It is yet another objective of the invention to provide a compact, durable, and easy-to-attach device compatible with various IV setups and hospital environments.

[024] It is yet another objective of the invention to incorporate a deep sleep algorithm and Battery Management System (BMS) for energy optimization and extended battery life.

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DRAWINGS

[025] Other characteristics, details and advantages of the invention can be inferred from the description of the invention hereunder. A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein:

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[026] FIG. 1 illustrates the fabrication of an intelligent drip sensor.

[027] FIG. 2 illustrates the system architecture for the drip sensor ecosystem

DETAILED DESCRIPTION

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[028] It must be noted that the figures disclose the invention in a detailed enough way to be implemented, said figures helping to better define the invention if needs be. The invention should however not be limited to the embodiment disclosed in the description.

10 [029] Throughout the specification and claims, the following terms take the meanings explicitly associated herein unless the context clearly dictates otherwise. The meaning of "a", "an", and "the" include plural references. The meaning of "in" includes "in" and "on." Additionally, a reference to the singular includes a reference to the plural unless otherwise stated or inconsistent with the
15 disclosure herein. The term IV means intravenous throughout the description unless stated otherwise.

[030] The present invention discloses a system for monitoring and managing the flow of intravenous (IV) fluids using a combination of hardware components and wireless communication technologies. The system addresses the limitations
20 of current IV monitoring techniques, offering automated, real-time, and precise control of fluid administration wherein each component plays a distinct role in ensuring the accurate and efficient delivery of IV fluids, and the components

work in synergy to achieve the overall functionality and objectives of the invention.

[031] In one embodiment, the present invention describes an intravenous (IV) fluid Monitoring and Alert System wherein an Intellidrip sensor mechanism

5 (100) comprising a capacitive sensor (101), microcontroller (102), Battery Management System (105), Bluetooth module (103), and Type-C charging port and drip sensor ecosystem comprising sensor-1 (201), sensor-2 (202), Bluetooth to WiFi Gateway (203), Local Area Network (204), PC with Server (205), and application (206). The capacitive sensor (101) monitors the fluid level in an IV

10 bottle by detecting capacitance variations corresponding to changes in fluid levels. The sensor data is processed by the microcontroller (102), which then transmits this information wirelessly via Bluetooth to the Bluetooth WiFi gateway to reach the central server. The system utilizes male and female earphone jacks to connect the sensor node to the monitoring device, enabling

15 precise and easy attachment to the IV bottle. A conductive clip ensures the system's stability and effectiveness in monitoring fluid levels. The microcontroller (102) works in tandem with the BMS (105) to manage power consumption effectively, ensuring long battery life. The Type-C charging port allows for fast and convenient recharging of the system's battery (104). A key

20 feature is the deep sleep algorithm, which minimizes power usage by activating the Bluetooth module (103) only when the IV fluid is nearing depletion. When the fluid reaches a critical level, the microcontroller (102) activates the Bluetooth module (103) and transmits the data to a designated nursing station

server. This transmission is acknowledged by a handshake signal by the healthcare professional and nursing staff, after which the system re-enters deep sleep mode. The system also supports an application (206) that allows healthcare professionals to monitor IV fluid levels in real time, ensuring timely intervention. The healthcare professionals can set the desired time for the alerts to be generated before the IV bag becomes empty to give them the time for the duration to change the IV bag. Each device is assigned a unique address, allowing easy identification of the IV bottle that needs attention, thereby streamlining workflow in hospital settings. The sensor 1 (201) and sensor 2 (202), monitor IV fluid levels and transmit data via a Bluetooth to WiFi Gateway (203) to a local area network (204). This data is then passed to a PC with a server (205) that stores and provides the information to a dedicated application (206) accessible on smartphones and computers. The system issues alerts 3-5 minutes before an IV bottle is depleted, ensuring timely replacement. The application also tracks the status and replacement timeline of each IV bag, streamlining hospital IV fluid management and improving patient care.

[032] In one embodiment, the present invention describes the Capacitive Drip Sensor (101) detecting the fluid levels within an IV bottle. The sensor operates by measuring changes in capacitance, a process influenced by the fluid's dielectric properties compared to air. As fluid levels decrease, the dielectric constant changes, altering the capacitance between two conductive plates embedded in the sensor. These changes in capacitance are detected by the sensor and transmitted to the microcontroller (102) for processing. Structurally, the

capacitive sensor consists of two conductive plates or electrodes, separated by a dielectric material, and is connected to the system via a male and female jack configuration. The female jack plugs into the microcontroller, while the male jack connects to the capacitive sensing electrode. The sensor is fabricated from
5 conductive materials such as copper or aluminum, with a dielectric layer typically made from non-conductive materials like plastic. In operation, the sensor continuously monitors the fluid levels in the IV bottle, sending real-time data to the microcontroller. The manufacturing of these sensors involves precise techniques such as metal etching to ensure sensitivity and reliability in detecting
10 capacitance changes. The materials used ensure durability and accurate measurement, offering a non-invasive method for monitoring IV fluid levels.

[033] In one embodiment, the present invention comprises Microcontroller (102) as the central processing unit of the IV monitoring system, responsible for interpreting the data received from the capacitive sensor (101) and managing
15 other key components. The microcontroller processes the capacitance data and activates the necessary communication modules, like the Bluetooth unit (103), to transmit information wirelessly to the local area network (LAN). Structurally, the microcontroller is mounted on a Printed Circuit Board (PCB) and consists of a central processing unit (CPU), memory, and input/output interfaces. It is pre-
20 programmed with firmware to control various functions, including managing power through the deep sleep algorithm, which conserves battery life. The microcontroller is manufactured from silicon using semiconductor etching techniques and is integral to the system's operation. When fluid levels approach

depletion, the microcontroller activates the Bluetooth module to transmit alerts. It also manages the power usage by switching components on or off based on system requirements, ensuring optimal battery performance.

[034] In one embodiment the present invention comprises the Bluetooth Unit
5 (103) enabling wireless communication between the IV monitoring device and the local network and transmits fluid level data and other system statuses to the hospital server through Bluetooth to WiFi Gateway (203) and local area network (204). The Bluetooth unit (103) further comprises a radio transceiver, antenna, and processing components, all housed in a small form factor on the PCB. The
10 Bluetooth unit is made from semiconductor materials and assembled using surface-mount technology (SMT), allowing for a compact and reliable wireless communication module. In operation, when the microcontroller (102) determines that the IV fluid is nearing depletion, it activates the Bluetooth unit to send data wirelessly. The unit also plays a role in the initial configuration of
15 the device, allowing users to connect it to the hospital's local area network (204) through the application.

[035] In one embodiment, the present invention comprises Battery (104) as the power source for the entire IV monitoring system. It ensures that all the components, including the capacitive sensor, microcontroller, and Bluetooth
20 module, have the necessary energy to operate continuously. The battery is typically a rechargeable lithium-ion or lithium-polymer cell, chosen for its high energy density and long life. Structurally, the battery is connected to the system via the PCB, allowing it to supply power as needed. The battery is manufactured

using layers of anode, cathode, separator, and electrolyte materials, assembled into a compact form to fit within the device. The battery powers the system during normal operation and switches to a low-power mode when the system is idle, thanks to the deep sleep algorithm controlled by the microcontroller (102).

- 5 This conserves energy, extending the battery life significantly. The battery can be recharged through a Type-C universal charger, allowing for fast and convenient recharging, ensuring the system remains operational with minimal downtime.

[036] In one embodiment the present invention comprises the Battery
10 Management System (105), responsible for optimizing the battery usage and charging process. It regulates the power consumption of the device, ensures that the system operates efficiently and that the battery's lifespan is extended. The BMS is a circuit board integrated with sensors and microcontrollers that monitor the battery's health, charge level, and power distribution. It is mounted on the
15 PCB and communicates with the main microcontroller (102). The BMS is manufactured using semiconductors and electronic components, assembled with surface-mount technology. Its role in the system includes managing the deep sleep algorithm, which conserves power by turning off unnecessary components when the system is not actively monitoring fluid levels. The BMS also prevents
20 overcharging and ensures that the battery (104) is used efficiently, especially during critical monitoring periods and prolongs the operational life of the battery while maintaining the device's reliability.

[037] In one embodiment the present invention comprises Capacitive Sensors 1 (201) and 2 (202) function similarly to the main capacitive sensor (101), but they are placed in different IV units to monitor fluid levels at multiple locations within the hospital. These sensors detect the fluid levels in their respective IV bottles and send data to the Bluetooth to WiFi Gateway (203) for further processing. Structurally, each capacitive sensor is made of conductive plates and dielectric materials, similar to sensor (101), and is attached to the IV bottles they monitor. These sensors are manufactured using the same materials and techniques as the main capacitive sensor, ensuring consistent accuracy and reliability across the monitoring system. In operation, when fluid levels change, the sensors send their data to the Bluetooth gateway, which aggregates the information for the server and application.

[038] In one embodiment the present invention comprises the Bluetooth to WiFi Gateway (203) collects data from multiple capacitive sensors (201, 202) and transmits it to the local area network (204) for processing. The gateway includes an antenna, processor, and communication interface to receive and transmit data wirelessly. It is made from semiconductor materials and integrated with wireless communication technology, allowing it to manage multiple data streams from various sensors. The gateway's role is to ensure that all fluid level data is efficiently transmitted to the server, where it is processed and alerts are generated. Manufactured using SMT and RF technology, the gateway is designed to handle high volumes of data in a hospital setting.

[039] In one embodiment, the present invention comprises the Local Area Network (204) providing the communication infrastructure that connects the Bluetooth to WiFi Gateway (203) and the server (205), allowing fluid level data to be transmitted securely and efficiently. The local area network consists of
5 routers, switches, and cables, ensuring stable communication between the devices and the hospital's central system. The LAN is made using standard networking materials like fiber optics, copper cables, and wireless routers, ensuring fast and reliable data transmission. In operation, the LAN facilitates seamless communication between the Bluetooth gateway and the server,
10 ensuring that data is transmitted and processed without delay.

[040] In one embodiment the present invention comprises the PC with Server (205), responsible for storing the fluid level data transmitted from the IV monitoring system and processing it for alert generation. The server is a powerful computer system with high-capacity processors, memory, and storage
15 to handle large amounts of data. Structurally, the server is made from standard computer hardware components, including CPUs, RAM, and storage drives. The server processes the data received from the local area network (204) and sends real-time alerts to the healthcare application (206). Its role in the system is to act as the central repository for all monitoring data, ensuring that healthcare
20 professionals receive timely and accurate notifications.

[041] In one embodiment, the present invention comprises the Device Application (206) serving as the user interface through which healthcare professionals can access real-time IV fluid level data. The application is

available on smartphones and computers, providing alerts and status updates for each IV bottle connected to the monitoring system. The application is designed to be user-friendly, allowing nurses and doctors to monitor IV levels remotely and receive notifications when fluid levels are low. The application's
5 functionality ensures that timely intervention can occur, reducing the risk of IV bottle depletion without immediate replacement.

[042] The present invention monitors the fluid levels with the capacitive sensor which detects the amount of fluid in an IV fluid bag by utilizing the changes in capacitance that occur due to variations in the dielectric properties of the
10 materials inside and outside the IV bag. The fundamental principle of capacitive sensing involves two conductive plates or electrodes that form an electric field between them. When a material with a different dielectric constant, such as a liquid, is introduced between these electrodes, the capacitance of the system changes. This change in capacitance is directly proportional to the dielectric
15 constant of the material present between the sensor's electrodes. In the case of an IV fluid bag, the liquid inside, such as saline solution, possesses a different dielectric constant compared to air or the plastic material of the IV bag itself. As the fluid level in the bag changes, the amount of liquid between the sensor's electrodes also changes, resulting in a variation in capacitance. When the IV bag
20 is full, the capacitance is higher because the liquid with a higher dielectric constant occupies the space between the electrodes. As the fluid level decreases and more air or empty space replaces the liquid, the capacitance reduces. Capacitive sensors are often positioned near or around the IV fluid bag, allowing

them to measure these variations in capacitance as the fluid level fluctuates. The system is typically calibrated to correlate specific capacitance values with corresponding fluid levels in the bag. Through this calibration, the sensor can precisely determine the amount of fluid remaining in the bag by measuring the
5 changing capacitance in real-time. As the capacitance changes based on the fluid level, the sensor continuously monitors these fluctuations and provides real-time data to healthcare providers. This data can be used to trigger alerts when the fluid level drops below a critical threshold, ensuring timely intervention from medical staff. The capacitive sensors offer an efficient and accurate means of
10 tracking fluid levels in IV bags, helping to reduce manual monitoring and the associated risks of under- or over-administration of IV fluids.

[043] In alternate embodiments, the present invention incorporates the Optimization of PCB Files to improve the overall efficiency and performance of the Wireless IV Monitoring and Alert System. The Printed Circuit Board (PCB)
15 serves as the central hub for all the system's components, such as the microcontroller, capacitive sensor, Bluetooth unit, and Battery Management System (BMS). By optimizing the design and layout of the PCB, the system ensures faster signal processing, lower energy consumption, and more reliable performance under continuous operation. The optimization process begins with
20 careful planning of the PCB layout, where the paths of electrical signals are streamlined to reduce resistance and interference between components. By minimizing the length of critical connections, such as those between the capacitive sensor and the microcontroller, signal integrity is preserved, and the

risk of data loss or miscommunication is reduced. This is particularly important in a system where real-time monitoring and timely alerts are crucial to patient care. In terms of manufacturing, advanced software tools are employed to design and simulate the PCB files before production. This simulation process allows

5 the engineers to test the electrical performance of the board virtually, identifying potential bottlenecks, such as areas of excessive heat generation or electrical noise. Once the design is optimized, the PCB is fabricated using precise techniques like photolithography, where a pattern of the circuit is transferred onto a copper-clad substrate. The unnecessary copper is etched away, leaving

10 behind the desired circuitry that connects the components. In the IV Monitoring and Alert System, optimized PCB design also contributes to the system's compactness and durability. The components are strategically placed to minimize the device's footprint, allowing it to be easily attached to an IV bottle without adding significant weight or bulk. Additionally, reducing the complexity

15 of the PCB design helps lower power consumption, which is critical for extending the life of the device's battery. The technique of optimizing PCB files also improves the thermal management of the system. By distributing heat-generating components, such as the microcontroller and Bluetooth unit, across the board, heat is dissipated more effectively, ensuring that the system operates

20 at a stable temperature even during prolonged use. This enhances the reliability of the device, particularly in high-demand environments such as emergency rooms and intensive care units, where continuous operation is essential. Moreover, the optimized PCB files help streamline the assembly process,

reducing the potential for manufacturing errors. The precise alignment of components and the simplified circuit paths make the board easier to assemble, lowering production costs and improving the consistency of the final product also crucial in supporting the deep sleep algorithm used in the device, as
5 efficient power routing on the PCB ensures that only the necessary components, such as the capacitive sensor, are powered during sleep mode, while the rest of the system conserves energy.

[044] In alternate embodiments, the present invention incorporates enhancement of the Sensor Node by implementing advanced sensor
10 technologies to improve the accuracy, sensitivity, and reliability of the IV fluid level monitoring system. The sensor node, particularly the capacitive sensor responsible for detecting changes in fluid levels within the IV bottle, is critical to the performance of the Wireless IV Monitoring and Alert System. By advancing the design and materials used in the sensor, the system's overall
15 effectiveness in real-time monitoring can be significantly improved. The enhancement of the sensor node begins with a deep understanding of the physical principles that govern capacitive sensing. In this context, the sensor works by detecting changes in capacitance caused by variations in the dielectric properties of the fluid inside the IV bottle. As fluid levels decrease, the dielectric
20 constant between the sensor's electrodes changes, which is then translated into an electrical signal. To improve the precision of this detection, newer sensor materials with higher sensitivity to dielectric variations are explored. Advanced materials such as conductive polymers or nanomaterial can be incorporated into

the sensor electrodes, allowing for more accurate and immediate detection of even minor fluid level changes. Moreover, the structure of the sensor node is also refined to optimize its performance. Instead of using a basic electrode configuration, the sensor node might adopt a more sophisticated design, such as

5 a multi-layer or spiral electrode arrangement, which increases the surface area exposed to the fluid and thereby enhances the sensor's sensitivity to capacitance changes. This structural enhancement allows the sensor to detect smaller variations in fluid levels with greater accuracy, reducing false alerts and ensuring that healthcare professionals are notified only when the IV fluid is

10 genuinely nearing depletion. The process of making the enhanced sensor node involves precision fabrication techniques, such as micro-electromechanical systems (MEMS) technology. MEMS allows for the creation of highly sensitive, miniaturized sensors that can be integrated into the compact design of the IV monitoring system without increasing its size or power consumption. By

15 employing MEMS fabrication techniques, the sensor node can achieve a higher level of performance while maintaining the device's overall practicality in a hospital setting. This is particularly beneficial in environments like emergency rooms and intensive care units, where device reliability and responsiveness are paramount. In terms of working, the enhanced sensor node improves the

20 system's ability to detect fluid levels in real-time, with a higher degree of precision. As the fluid level in the IV bottle decreases, the sensor sends updated capacitance data to the microcontroller with improved accuracy, ensuring that the system can reliably predict when the IV bottle is about to be emptied. This

refined sensitivity also allows for better calibration of the sensor node, as it can be tuned to detect specific fluid levels with more granularity, thus allowing for more accurate fluid tracking and timely notifications. Another important aspect of enhancing the sensor node is improving its long-term stability and reliability.

5 In typical hospital settings, IV monitoring devices are used continuously, and sensor nodes must maintain their accuracy over extended periods of operation without degradation. By using durable and wear-resistant materials in the construction of the sensor node, the device's lifespan is extended, and it continues to provide reliable monitoring even after repeated use. Advanced
10 coatings, such as protective films, can be applied to the sensor electrodes to shield them from environmental factors like moisture, which could otherwise interfere with the sensor's readings. The enhanced sensor node also incorporates smarter algorithms for data processing. By combining the physical improvements with advanced software, the system can filter out noise or
15 irrelevant signals, ensuring that only accurate and actionable data is transmitted to the microcontroller and ultimately to the healthcare provider. This combination of hardware and software improvements leads to a significant increase in the overall reliability of the IV monitoring system, reducing the risk of false alarms or missed alerts.

20 [045] In alternate embodiments, the present invention incorporates Advanced Sensing Technology that revolutionizes the way intravenous (IV) fluid levels are monitored. This invention utilizes capacitive sensing to offer precise, real-time tracking of IV fluid levels, providing significantly increased accuracy compared

to traditional manual or less sophisticated electronic methods. Capacitive sensors work by detecting changes in capacitance as the IV fluid level changes, with these variations directly corresponding to the amount of liquid remaining in the bottle. This real-time monitoring allows healthcare professionals to respond promptly to changes, reducing the risk of IV bottle depletion going unnoticed.

[046] In one embodiment the present invention employs a combination of female and male earphone jacks to enhance sensor connectivity and ease of use. The female earphone jack connects to the microcontroller, while the male earphone jack connects with the capacitive sensing electrode, creating a robust and reliable connection that simplifies setup and maintenance ensuring secure sensor attachment but also adds versatility to the device, making it compatible with various IV setups. The use of standard earphone jack connectors makes the system user-friendly, reducing the need for specialized training or equipment to maintain the connection between the sensor and the monitoring device. The system also features a Proactive Alert System, distinguishing it from traditional IV monitoring systems that typically offer only basic alarms when the IV bottle is nearly empty. In contrast, this invention sends proactive alerts to nursing staff 3 to 5 minutes before the IV bottle reaches depletion. This proactive approach allows nurses to prepare for IV bottle changes ahead of time, minimizing the chance of therapy interruptions. Such timely alerts ensure that medical staff are not caught off guard by an empty IV bottle, improving both workflow efficiency and patient care. Moreover, the system integrates Wireless Connectivity and Remote Monitoring capabilities, leveraging a Bluetooth module for the seamless

transmission of real-time fluid-level data to a dedicated smartphone or computer application. This enables remote monitoring, allowing healthcare providers to check the status of IV infusions without needing to be physically present at the patient's bedside. In addition to Local area connectivity, the device includes

5 Bluetooth capability, which enhances the ease of setup and configuration, allowing the device to connect easily to available networks or be customized according to hospital requirements. Bluetooth connectivity also makes the system easier to integrate with existing hospital infrastructure, offering greater flexibility in different care environments.

10 [047] In one embodiment the present invention offers Real-Time Monitoring, which provides healthcare staff with accurate and immediate updates on IV fluid levels. This proactive monitoring enables more effective management of infusion procedures, reducing the need for manual checks and ensuring that IV bottles are replaced before they run empty. The system's Efficiency enhances

15 the workflow in busy hospital settings by automating IV monitoring, saving valuable time for nursing staff who would otherwise have to perform frequent manual checks. This time savings translates into more time spent on direct patient care, ultimately improving the overall quality of care. Additionally, the system contributes to Enhanced Patient Care by enabling timely interventions

20 that reduce the risk of interruptions in IV therapy. By ensuring that fluid levels are continuously monitored and that alerts are sent well before the IV bottle is empty, the system helps prevent situations where patients may experience delays in receiving necessary fluids or medications. This enhances both patient

outcomes and satisfaction, as continuous therapy is critical in many clinical situations. The device's Versatility makes it suitable for use in a wide variety of hospital environments, from general wards to intensive care units. Its compatibility with different IV setups and beds ensures that it provides

5 consistent and reliable monitoring across all hospital settings. Remote Monitoring capabilities further extend the system's usefulness, allowing nursing staff to keep track of IV infusion levels and device status from anywhere within the hospital using a smartphone or computer application. This added flexibility enhances the convenience for healthcare providers, especially in large or busy

10 hospitals. The invention is integrated with Smart Devices and empowers nursing staff by providing detailed insights and real-time notifications through a user-friendly application. This app allows healthcare professionals to monitor multiple patients simultaneously, streamlining care management and enabling faster responses to critical situations. The system's seamless integration with

15 modern smart devices ensures that healthcare staff have all the necessary information at their fingertips, making IV management more efficient and less prone to human error.

[048] In alternate embodiments, the present invention integrates with Electronic Health Records (EHR) systems, automatically updating patient

20 records with real-time data on IV fluid levels. The IV Monitoring and Alert System continuously tracks the fluid administered to a patient via capacitive sensing, and this data is wirelessly transmitted to a central server, where it can be stored in the patient's EHR. As the system monitors fluid intake and depletion

in real-time, the data is time-stamped and associated with the patient's unique medical ID, allowing healthcare professionals to access precise information on the volume of fluids delivered, the timing of bottle replacements, and any alerts or interventions. This automation ensures that patient records are always up-to-date, reducing the need for manual input from healthcare staff and minimizing the risk of errors. The system's ability to sync with existing hospital EHR infrastructures allows seamless integration, providing comprehensive records for each patient's treatment, which are crucial for continuous monitoring and long-term care planning.

10 [049] Example 1: Emergency Section of a Major Hospital

A patient is receiving intravenous (IV) fluids after being admitted for severe dehydration. The IV bottle connected to the patient is fitted with the Capacitive Drip Sensor (101), which continuously monitors the fluid level in real-time. The sensor is connected to the microcontroller (102), which processes the capacitance data to assess the amount of fluid remaining in the bottle.

As the patient receives fluids, the capacitive sensor detects the gradual depletion of the IV bottle's contents. When the fluid level reaches a critical low—approximately 3-5 minutes before the bottle is empty—the microcontroller (102) activates the Bluetooth Unit (103), which transmits the fluid level data to the hospital's Local Area Network (204) via the Bluetooth to WiFi Gateway (203). This data is processed by the hospital's Server (205) and immediately relayed to the healthcare professionals through the Device Application (206).

An alert notification is sent to the smartphones and computer terminals of the attending nurses and doctors, indicating that the IV bottle for the patient in bed 5 is about to be depleted. The alert provides a 3-5 minute window for the healthcare team to respond and replace the IV bottle. Simultaneously, an alarm
5 sounds on the application to ensure that the notification is not missed.

As the healthcare professional receives the notification on their device, they can acknowledge it and turn off the alarm by shaking their smartphone or tablet. This feature allows for quick and convenient interaction without the need to manually unlock the device or navigate through the application. After the alert is
10 dismissed, a nurse promptly replaces the IV bottle, ensuring continuous treatment without interruption, and the monitoring system automatically resets to track the new IV bottle's fluid level.

[050] Example 2: Intensive Critical Care Unit (ICU)

A patient in the ICU is receiving medication and fluids through an IV, which is
15 critical for maintaining stability in their condition. The IV setup includes the Capacitive Sensor (101), which continuously monitors the level of fluids in the IV bottle.

As the fluid level in the IV bottle approaches depletion, the Microcontroller (102) processes the data and, when the level is approximately 3-5 minutes from
20 being empty, sends a command to the Bluetooth Unit (103). The Bluetooth unit transmits the data to the Local Area Network (204) via the Bluetooth to WiFi Gateway (203). This information is sent to the Server (205), which updates the Device Application (206) used by healthcare professionals in the ICU.

An alert is sent out to the ICU nurses and doctors on their smartphones or workstations, indicating that the IV bottle for the patient in bed 12 is nearing depletion. The alert is accompanied by an alarm on the devices to ensure immediate action.

5 [051] As discussed in more detail above, using the above embodiments, with little or no modification and/or input, there is considerable flexibility, adaptability, and opportunity for customization to meet the specific needs of various parties under numerous circumstances.

[052] The present invention has been described in particular detail with respect
10 to specific possible embodiments. Those of skill in the art will appreciate that the invention may be practiced in other embodiments. For example, the nomenclature used for components, capitalization of component designations and terms, the attributes, is not significant, mandatory, or limiting, and the mechanisms that implement the invention or its features can have various
15 different names, formats, or protocols. Also, particular divisions of functionality between the various components described herein are merely exemplary, and not mandatory or significant. Consequently, functions performed by a single component may, in other embodiments, be performed by multiple components, and functions performed by multiple components may, in other embodiments,
20 be performed by a single component.

[053] It should also be noted that the language used in the specification has been principally selected for readability, clarity, and instructional purposes, and may not have been selected to delineate or circumscribe the inventive subject

matter. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the claims below.

[054] In addition, the parts shown in the figures, or as discussed herein, are
5 identified using a particular nomenclature for ease of description and understanding, but other nomenclature is often used in the art to identify equivalent operations.

[055] Therefore, numerous variations, whether explicitly provided for by the specification or implied by the specification or not, may be implemented by one
10 of skill in the art in view of this disclosure.

CLAIMS

1. A system for monitoring intravenous (IV) fluid administration, comprising:
 - 5 – a drip sensor (101) configured to detect and measure the fluid level of the IV fluids bag in real-time;
 - a microcontroller (102) is connected to the drip sensor (101);
 - a Bluetooth module (103) is connected to Bluetooth to WiFi Gateway (203);
 - 10 – a battery (104) connected to the microcontroller (102) through a battery management system (103);
 - a Bluetooth network gateway is connected to the local area network (204) that connects to the Server (205) and receives the signal from the Bluetooth module (103); and
 - 15 – a server (205) connected to a monitoring application (206).
2. The system of claim 1, wherein the drip sensor (101) is a capacitive sensor.
3. The system of claim 1, wherein the microcontroller (102) is connected to the drip sensor by a female and male jack for processing the flow level data of
20 the IV bag, comparing it to a predetermined threshold, and detecting deviations;

4. The system of claim 1, wherein the Bluetooth module (103) transmits real-time data from the drip sensor to the server (205) via Bluetooth network gateway (206).
5. The system of claim 1, wherein the battery management system (BMS)
5 optimizes the power consumption of the drip sensor and provides real-time battery status monitoring.
6. The system of claim 1, wherein server (205) receives and stores data from multiple drip sensors (101);
7. The system of claim 1, wherein the monitoring application (206)
10 collects, stores, and analyzes the data transmitted from the drip sensor, and generate real-time alerts for healthcare personnel before the IV fluid bag empties.
8. The system of claim 7, wherein the real-time alerts generation time can be optimized to the desired duration before the IV fluid bag empties.
- 15 9. A method for monitoring intravenous (IV) fluid administration, comprising:
 - detecting and measuring the fluid levels of IV fluids in real-time;
 - transmitting the detected IV fluid level followed by processing and comparing against predetermined thresholds;
 - 20 – wirelessly transmitting the fluid level data of the IV bags using Bluetooth technology;

– generating alerts based on detected deviations in the fluid level and transmitting those alerts.

10. The method of claim 1, further comprising switching the drip sensor to a low-power mode by using deep sleep algorithm.

5 11. The method of claim 1, wherein the flow rate data and alerts are customized based on patient-specific fluid requirements and thresholds timings set by medical staff.

12. The method of claim 1, wherein storing and analyzing historical data of IV fluid administration data on a central server for reporting, auditing, and
10 integration with electronic health record (EHR) systems.