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Embedded based - urinary tract infection monitoring system using IOT

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ABSTRACT

Urinary tract infection (UTI) is one of the most common infections in humans. UTI is easily treatable using antibiotics if identified in early stage. However, without early identification and treatment, UTI can be a major source of serious complications in geriatric patients, in particular, those suffering from neurodegenerative diseases. Also, for infants who have difficulty in describing their symptoms, UTI may lead to serious development of the disease making early identification of UTI crucial. In this project, we present a diaper-embedded, wireless, self-powered, and autonomous UTI monitoring sensor module that allows an early detection of UTI with minimal effort. The sensor module consists of a paper-based colorimetric nitrite sensor, urine-activated batteries, a boost dc–dc converter, a low-power sensor interface utilizing pulse width modulation, and a Wi-Fi low energy module for wireless transmission .The proposed sensor module achieves a sensitivity of 1.35 ms/(mg/L)and a detection limit of 4 mg/L for nitrite.

INTRODUCTION

URINARY TRACT INFECTION (UTI) is the second most common infection caused by bacterial pathogens, accounting for about 8.1 million hospital visits to health care providers in the US annually. In general, UTI is considered to be easily treatable using antibiotics. However, if not found and treated early, UTI can be a major source of serious complications such as ascending infections, loss of kidney function, bacteremia, and sepsis in infants and geriatric patients suffering from neurodegenerative diseases such as dementia. Both groups who use diapers have difficulties in communicating about urinary discomfort and UTI-associated symptoms to their care givers. These difficulties and the fact that UTI is often asymptomatic make early stage identification quite challenging. Traditionally, an accurate diagnosis of UTI is made with the urine culture test in a laboratory. This test allows quantification of the bacterial growth, but takes 2–3 days between specimen collection and final diagnosis because of the time period for cell cultivation. Furthermore, the urine culture test is not the best method for early detection of UTI. First, the relatively high cost for hospital visit and the urine culture test prohibits frequent urine culture tests. Second, hospital visit for the urine culture test implies that the caregiver or patient already recognized the symptoms of UTI, which often happens after serious complications, particularly for asymptomatic patients. Urine dipsticks have been widely used in detecting UTI in early stages. It features quick detection and low-cost, but shows less accuracy with a relatively high false alarm rate. Moreover, collecting urine specimen from infants and disabled elderly for the dipstick test is often painful, time-consuming, and privacy-sensitive. It becomes particularly challenging when multiple tests are required to filter out false alarms. For this reason, an alternative method for early-stage identification of UTI has been sought-after, and a better screening method that can alert caregivers about UTI with minimal effort is imperative.

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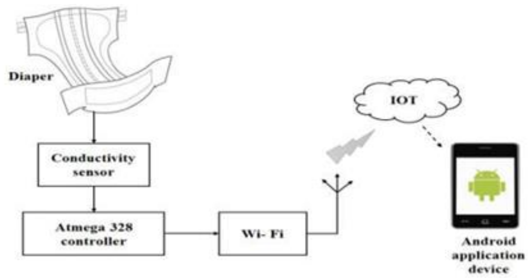
BLOCK DIAGRAM



Block description

Conductivity sensor is used to measure the volumetric water content in diaper. Sensor sends the signal to controller. Controller we use Atmega328. It consists of 28 pins. It has inbuilt ADC. The inputs can be controlled by transmitting and receiving the inputs to the external device. Controller receive the sensor data and to send the information through IOT via Wi-Fi. The Wi-Fi module connected to the IOT server and upload the data and remote side user easily access the status of the diaper using smart phone.

Existing system

UTI dipstick is printed on a commercial diaper with a hand-held printer which is designed to guarantee that a specific chemical factor will be printed in a specific square area. Reaction between the chemicals and urine occurs, a camera of a smart phone records the change in colors, processes. The images with a mobile application software which is designed for smart phone using technology of imaging analysis, and takes further action concerning UTI.It requires an additional process to record the change in colors and process a images, prohibiting an autonomous operation. It also suffers from color fading issues because the time gap between urination and photo events is often unpredictable and the color of the sensing part fades over time when

Propossed system

This module simplifies the design by eliminating the need for periodic wakeup for checking the event of urination.Urine samples were dropped onto the sensors and the urine - activated plate. The voltage variation of the urine-activated plate and the voltage amplify by converter. The batteries are activated in 10s after initial urine exposure and the converter starts the operation. The WI-FI module connected to the IOT server and upload the data and remote side user easily access the status of the diaper using smart phones. used for both input and output process. These digital pins can access only the digital inputs.

Digital input

Digital inputs can be defined as the non continuous time signal with discrete input pulses. It can be represented as 0's and 1's. These digital inputs can be either on state or in off state. Arduino atmega328 microcontroller also consists of 12 digital input pins. It can be stated as D0 to D11. Nearly 12 inputs can be used for digital input/output applications. The working of the digital input ports is where the discrete input pulses the form of discredited form. Both analog and digital input ports can be used for various

Atmega 328

ATMEGA 328 microcontroller, which acts as a processor for the arduino board. Nearly it consists of 28 pins. From these 28 pins, the inputs can be controlled by transmitting and receiving the inputs to the external device. It also consists of pulse width modulation (PWM). These PWM are used to transmit the entire signal in a pulse modulation. Input power supply such as Vcc and Gnd are used. These IC mainly consists of analog and digital inputs. These analog and digital inputs are used for the process of certain applications.

Description of input

Analog input

Arduino atmega-328 microcontroller board consist of 6 analog inputs pins. These analog inputs can be named from A0 to A5. From these 6 analog inputs pins, we can do the process by using analog inputs. Analog inputs can be used in the operating range of 0 to 5V. Analog signal is considered as the continuous time signal, from which these analog signal can be used for certain applications. These are also called as non discrete time signal. Inputs such as voltage, current etc.., are considered to be either analog signal or digital signal only by analysing the time signal properties. Various applications of arduino microcontroller can use only an analog input instead of digital inputs. For these applications, analog input ports or pins can be used input/output applications. The working of the digital input ports is where the discrete input pulses the form of discredited form. Both analog and digital input ports can be used for various applications for the input power supply, VCC and GND pins are used. Pins PB6 and PB7, which acts as a crystal to generate a clock signal. By using these crystals, we can generate the clock signals and by these clock signals, we can use this clock signals for input sources. PC6 pin are the one where it can be used for the reset option. Resetting the program can be done by using this PC6 pin can be triggered and supplied to the ports. These ports receive the input and therefore the port can be used for both input and output process. These digital pins can access only the digital inputs.

This ATMEGA-328 integrated chip consists of 28 pins. It consists of 6 analog inputs that are shown in the pin diagram. Analog inputs can be represented as PC0 to PC5. These analog input pins possess the continuous time signal which acts as an analog input for the system. Further it also consists of 12 digital inputs. It can be represented as PD1 to PD11 which act as a digital input ports based on pulse width modulation (PWM). These PWM, which transmits the signal in the form of discredited form. Both analog and digital input ports can be used for various applications for the input power supply, VCC and GND pins are used. Pins PB6 and PB7, which acts as a crystal to generate a clock signal. By using these crystals, we can generate the clock signals and by these clock signals, we can use this clock signals for input sources. PC6 pin are the one where it can be used for the reset option. Resetting the program can be done by using this PC6 pin.

Conductivity sensor

Conductivity Sensor measures the conductivity of aqueous solutions in industrial and municipal process applications. It is designed to perform in the harshest of environments. The Conductivity

Sensors are based on an inductive principle. This provides for stable measurement without electrodes that are easily fouled and may wear out in the field.

Wi-fi module (esp8266)

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

The table below gives a description for each of the pins, along with their function.

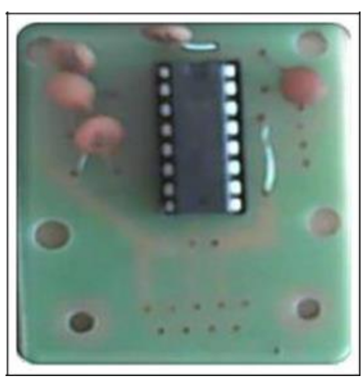
Pin Number	Description	Function
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	Vcc	Positive Voltage (Power)
8	GND	Ground
9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

Allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts. The **ESP8266** is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Expressive Systems.

The chip first came to the attention of western makers in August 2014 with the **ESP-**1 module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation. The **ESP8285** is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.

Wi-Fi Protocols

- 802.11 b/g/n support
- 2 x Wi-Fi interface, supports infrastructure BSS Station mode / P2P mode / SoftAP mode support
- Hardware accelerators for CCMP (CBC-MAC, counter mode), TKIP (MIC, RC4), WAPI (SMS4), WEP (RC4), CRC
- 802.11n support (2.4 GHz)
- Supports MIMO 1×1 and 2×1, STBC, and 0.4 µs guard interval



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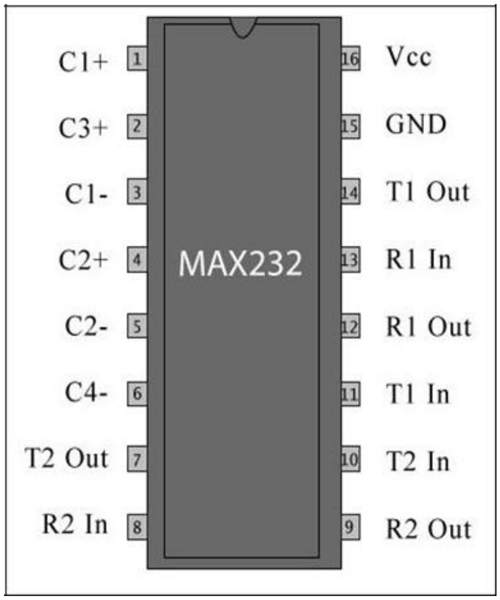
MAX 232

- It used for interfacing with PC
- It is serial port
- It is used to convert TTL signal to RS232 level
- Typical voltage 1.5V,hysteresis voltage 0.5V

Pin Diagram – MAX 232



The MAX232 IC is used to convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontrollers with PC. The controller operates at TTL logic level (0-5V) whereas the serial communication in PC works on RS232 standards (-25 V to + 25V). This makes it difficult to establish a direct link between them to communicate with each other. The intermediate link is provided through MAX232. It is a dual driver/receiver that includes a capacitive voltage generator to supply RS232 voltage levels from a single 5V supply. Each receiver converts RS232 inputs to 5V TTL/CMOS levels. These receivers (R1 & R2) can accept ±30V inputs.

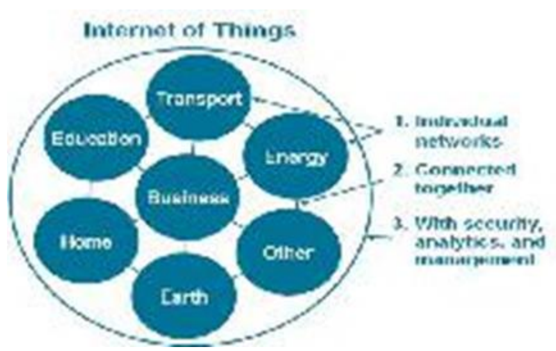
Microcontroller	MAX232		RS232
Tx	T1/2 In	T1/2 Out	Rx
Rx	R1/2 Out	R1/2 In	Tx

Pin No	Function	Name
1		Capacitor 1 +
2		Capacitor 3 +
3		Capacitor 1 -
4	Capacitor connection pins	Capacitor

		2 + Capacitor
5		
		2 - Capacitor
6		
		4 -
7	Output pin; outputs the serially transmitted data at RS232 logic level; connected to receiver pin of PC serial port	T2 Out
8	Input pin; receives serially transmitted data at RS 232 logic level; connected to transmitter pin of PC serial port	R2 In
9	Output pin; outputs the serially transmitted data at TTL logic level; connected to receiver pin of controller.	R2 Out
10	Input pins; receive the serial data at TTL logic level; connected to	T2 In
11	serial transmitter pin of controller.	T1 In
12	Output pin; outputs the serially transmitted data at TTL logic level; connected to receiver pin of controller.	R1 Out
13	Input pin; receives serially transmitted data at RS 232 logic level; connected to transmitter pin of PC serial port	R1 In
14	Output pin; outputs the serially transmitted data at RS232 logic	T1 Out

	level; connected to receiver pin of PC serial port	
15	Ground (0V)	Ground
16	Supply voltage; 5V (4.5V – 5.5V)	Vcc

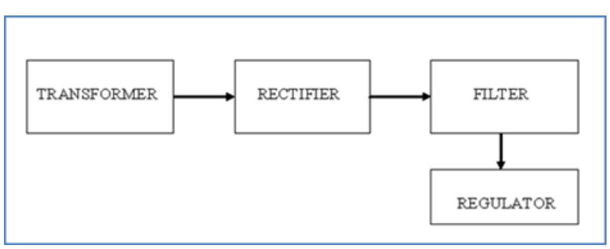
IOT as a Network of Networks: These networks connected with added security, analytics, and management capabilities. This will allow IOT to become even more powerful in what it can help people achieveinter-connectivity of everything from urban transport to medical devices to household appliances Integration with the Internet implies that devices will use an IP address as a unique identifier. However, due to the limited address space of IPv4 (which allows for 4.3 billion unique addresses), objects in the IOT will have to use IPv6 to accommodate the extremely large address spaced.



Objects in the IOT will not only be devices with sensory capabilities, but also provide actuation capabilities (e.g., bulbs or locks controlled over the Internet).On the other hand, IOT systems could also be responsible for performing actions, not just sensing things. Intelligent shopping systems, for example, could monitor specific users' purchasing habits in a store by tracking their specific mobile phones. These users could then be provided with special offers on their favourite products, or even location of items that they need, which their fridge has automatically conveyed to the phone.

Additional examples of sensing and actuating are reflected in applications that deal with heat, electricity and energy management, as well as cruise-assisting transportation systems. Other applications that the Internet of Things can provide is enabling extended home security features and home automation.

Block diagram for power supply

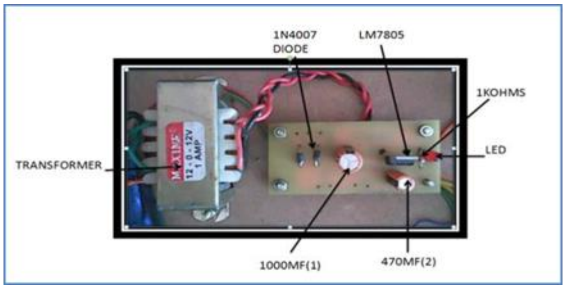


Block diagram of AC to DC power Supply consists,

1. Transformer: Steps the household line voltage up or down as required.
2. Rectifier: Converts ac voltage into dc voltage.
3. Filter: Smooth the pulsating DC voltage to a varying DC voltage.
4. Regulator: Fix the output voltage to constant value.

Brief Introduction to an Electrical Transformer

A Transformer is an electrical device that takes electricity of one voltage and changes it into another voltage. In AC circuits, AC voltage, current and waveform can be transformed with the help of Transformers. Transformer plays an important role in electronic equipment. AC and DC voltage in Power supply equipment are almost achieved by transformer's transformation and commutation. Figure 1 shows the Transformer.



Basically, a Transformer changes electricity from high to low voltage or low to high voltage using two properties of electricity. In an electric circuit, there is magnetism around it. Second, whenever a magnetic field changes (by moving or by changing strength) a voltage is made.

A Transformer takes in electricity at a higher voltage and lets it run through lots of coils wound around an iron core. ". A single-phase Transformer can operate to either increase or decrease the voltage applied to the primary winding. Because the current is alternating, the magnetism in the core is also alternating. Also around the core is an output wire with fewer coils. The magnetism changing back and forth makes a current in the wire. Having fewer coils means less voltage. When it is used to "decrease" the voltage on the secondary winding with respect to the primary it is called a **Step-down Transformer**. When a Transformer is used to "increase" the voltage on its secondary winding with respect to the primary, it is called a **Step-up Transformer**.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to input. This type of Transformer is called an **"Impedance Transformer"** and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

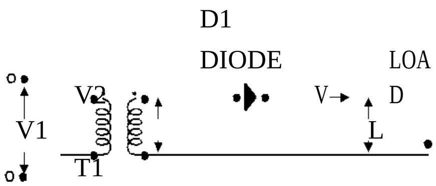
Rectifiers

A rectifier circuit converts an AC voltage into a pulsating DC voltage. This is accomplished by using one or more diodes because diodes conduct current in only one direction.

Types of Rectifiers

- Half-wave Rectifier
- Full-wave Rectifier
- Full-wave bridge rectifier

Half-Wave Rectifier



The transformer (T1) isolates the household voltage and also steps down the household voltage to a more useful voltage level. The diode lets current flow into the load in only one direction. The load current is unidirectional; therefore, it has a significant dc component (or average value).When V2 is positive, diode D1 conducts and VL=V2. When V2 is negative, diode D1 blocks the current flow and VL=0volts. The load voltage consists of dc voltage along with ripple voltage. In a half-wave rectifier circuit, the ripple component is larger than the DC component, which is undesirable.

Useful formulas

VAVG (DC) = 0.637V2
VL (DC) = 0.318V2

VL (AC) = 0.386V2
%RIPPLE = VL (AC)/VL (DC) = 121%
RIPPLE FREQUENCY = SUPPLY FREQUENCY

Filters

The 121% ripple in the output of the half-wave rectifier and 48% in the full-wave rectifier is more than can be normally tolerated. In the full wave filtering, wherein the frequency of the ripple is 100Hz for a 50Hz ac line voltage. This is an advantage where either an inductor is used to prevent the passage of the ripple current(due to its high inductive reactance to ac but quite low resistance to dc), or a capacitor is used to 'short' the ripple to ground but leave the dc to appear at the output. Various combinations of L and C are also used.

Regulators

The simplest regulator is a large capacitor in parallel with the load. The capacitor stores DC voltage while the load voltage increases to its peak value. The capacitor converts the pulsating DC voltage of a rectifier into a smooth Dc load voltage.

Two important parameters of a capacitor regulator are its working voltage and its capacitance. The working voltage must be at least equal to no-load output voltage of power supply. The capacitance determines the amount of ripple that appears on the Dc output when current is drawn from the circuit. The amount of ripple decreases with increase in capacitance.

CONCLUSION

This work reports a diaper-embedded UTI monitoring sensor module self-powered by urine-activated batteries. The sensor module can detect UTIs autonomously and transmit the data to a caregiver's mobile device that is presumably connected to a healthcare network, allowing a reliable early detection and screening of UTI with minimal efforts. The sensor module consists of a paper-based colorimetric nitrite sensor, urine activated batteries, a boost dc–dc converter, a low-power PWM sensor interface, and a Wi-Fi module. The urination-event-driven wakeup method allows the proposed sensor module to be compact, power efficient, and reliable. The sensor module achievesa sensitivity of 1.35 ms/(mg/L) and a detection limit of 4 mg/Lfor nitrite. The future work includes the miniaturization of the whole system on a flexible substrate.

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