A Design of Smart Diaper Wet Detector Using Wireless and Computer

Mohamed Y. E. Simik, Feng Chi, Randa S. I .Saleh, and Abdeldime M.S. Abdelgader

Abstract— **This paper presents a design of smart diaper wet detector using wireless and computer, which consists of wet sensor, wet detector unit, RF transceiver, GSM alarm system and computer. A wet diaper detector comprises an elongated pair of spaced fine conductors which form the wet sensor. The sensor is positioned between the layers of a diaper in a region subject to wetness. When the diaper is wet, the resistance between the spaced fine conductors falls below a pre established value, the wet detector being operative. Consequently, RF transceiver sends a wireless signal to the GSM alarm system, then GSM system sends signal to the computer (Healthcare applications) to switch on a warning informing intended persons that such moisture is occurring**

Index Terms— **wet detector; RF transceiver; GSM door sensor; mobile call GSM alarm system; SMS; Computer.**

I. INTRODUCTION

Diapers (Nappies) were wonderful invention, controlling infants waste in a relatively, clean, and healthy way. The diaper has several types such as, disposable diapers and cloth, also diaper has different usage, child's diapers, adult diapers and animal's diapers [1],[2],[3]. Since most of people now live in apartments, the use of diapers is inevitable. The purpose of a diaper is to absorb moisture and contain mess, so that the wearer can remain dry and comfortable after wetting or soiling themselves. Diapers are used now not only for babies, but also for individuals who are incapable of controlling their bladder or bowel movements or unwilling to use the toilet. These include people with medical conditions such like people who are bedridden, or in a wheel chair. For the same reasons, diapers are now used for home pets [3]. We conducted a simple survey for 20 mothers, as a result of this survey, It is estimated that babies will spend about 7000 hours/year in diapers and need about 1500 diaper changes during the first years of life, for sure the other individuals may consume more and more [4]. However, diapers have one major drawback, they cause skin rash [5]. Skin rash develops when the skin is exposed to prolonged wetness. Diapers cause skin rash which develops when the skin is exposed to prolonged wetness, increased skin pH caused by urine and feces, and resulting breakdown of the stratum corneum, or outermost layer of the skin. Skin wetness for prolonged periods is therefore the common denominator underlying the various causes of diaper rash [6], [7], [8], [9].

In an effort to reduce the time during which wet diapers are in contact with a wearer's skin, for example, mother's often adhere to a specific change of diaper schedule wherein a baby's diapers are changed periodically according to a pre-established timetable, same scenario is repeated with other wearers from in charge person. Although such diaper-changing schedules are helpful, a real reduction of time during which urine contacts the skin is not often realized because no prescribed time table can anticipate an individual wearer's changeable physical constitution. For example, an infant might wet its diaper immediately after a scheduled change of the diaper and thus, unknown to the mother, be left in a soiled diaper until the next scheduled change of the diaper.

Majority of efforts that used to eliminate the skin rash, such as adding absorbent gel failed to solve the problem [1], [7],[9]. On the contrary, some of these gels create other problems such as irritations, allergy, toxic shock…..Etc. Moreover, the Agency Ogilvy Brazil designed the Huggies TweetPee. It is a small, connected device that attaches to the front of a baby's diaper and alerts the attendance when the baby urinates in the diaper and needs a change. They are utilizing a humidity sensor with the device. The TweetPee constantly monitors humidity levels and fires off a tweet notification. However the size of the Tweetpee needs to be reduced so it can be comfortable for a baby sleeping in different positions, and is specially designed for Diaper wets. Also Potty Patrol is a Potty Training Alarm Diapers are designed to notify the attendance when wetting occurs, so that they can place the child on the toilet immediately [4], [10]. Potty Patrol's Potty Training Alarm Diapers had been already in use in many places. They carried out the idea of positioning the fine conductors (the sensor) between the layers of a diaper in a region subject to wetness [11]. This confirms that the idea is safe, healthy, feasible and not harmful to diaper wearer. In terms of cost the potty alarm training kit includes an alarm (with batteries built in), 24 sensor diapers, and a training guide cost is around 35 USD, note that wet detector unit is decoupled from the pressing studs for reuse.

We believe, skin rash can be eliminated if diapers are changed immediately when they become wet. This paper discusses the design of an automated alarm system for

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diaper wet using mobile call, audio alarm or SMS to alert the in charge person or an attendant immediately when the diaper is wet. The design will be fabricated into a real diaper integrated with RF Transceivers and mobile call GSM alarm system. The difference between previous ideas and ours is the usage of the RF transceiver to transfer the signal from the diaper to the advance GSM system to alert the in charge person anywhere by giving an automatic phone call or sending SMS. On the other hand, the proposed idea can be used for people with medical conditions, people who are bedridden, and in hospitals in case of surgical procedures to monitor the sudden bleeding. Design wise, the proposed system utilized existing systems (GSM alarm & RF TX/RX) that are already tested. These systems can also be used for other purposes in the apartment at the same time. This paper also designs a very simple wet detector, which can be used for many applications related to water, blood and other conductive liquids. The detector can be used in case of detecting any type of wetness and can be used to support some existing systems.

This paper is organized into five sections. After a brief introduction in section I, a general definition about the RF transceiver, GSM alarm system and wet detectors are presented in section II. The proposed alarm system is described in section III. The results and conclusions are presented in section IV, V respectively.

II. RF TRANSCEIVER AND GSM SYSTEMS

A. Based Wireless Remote using TX- RX Modules

The RF transceiver is composed of a simple wireless transmitter and receiver used to carry signals between two parties[12]. This radio frequency (RF) transmission system employs Amplitude Shift Keying (ASK) with transmitter/receiver (TX/RX) pair operating at 434 MHz. The transmitter module takes serial input and transmits these signals through RF. The transmitted signals are received by the receiver module placed away from the source of transmission. The basic operation of the RF system is depicted in Fig. 1. The RF module is characterized by scalability, simplicity, light weight, low cost and small size. In this paper, we will utilize four-channel system to transfer the signal from the diaper to the GSM alarm system through the GSM door sensor[13],[14].
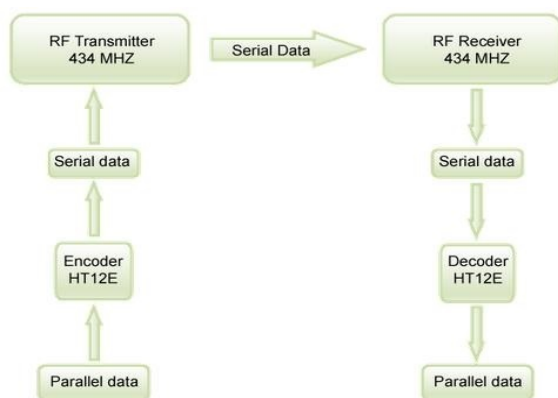

Fig 1.   RF Based Wireless Remote using RX-TX Modules

B. Mobile Call GSM Alarm System

The mobile call GSM alarm is an integrated system of digital speech, mobile messaging and multiple modes of wireless coding for long-distance home appliance control, SMS messaging, and other technologies [15],[16],[17]. When the alarm is triggered, it will automatically notify users via mobile network about a possible break-in using either voice calling or SMS. The mobile-call GSM alarm system can store six phone numbers for voice calls and three SMS numbers. The device also has remote-control arm, disarm, monitor, and intercom features, which can be used for many other purposes and applications. It is stable, reliable and safe. In this paper, we use the GSM system to transmit the wireless signal to the Computer network through gateway such as (API) Application Programming Interface to make integration between GSM alarm system and Computer to connect the Healthcare Application, in addition to that the GSM alarm produces alarm calls and messages to the intended person when moisture is detected, as shown in Fig.2, [11],[12],[13].

Fig 2.   The use of GSM Door Sensor & GSM Alarm System in the proposed system

C. Wet Detector

Electronic wetness detectors are well known and are used in many applications such as water level detection, rainfall detection, soil-moisture detection and flood-warning alarms[18],[19]. Many different available circuits can function as a moisture detector. The purpose of the bleeding detector is to give a positive response in the presence of moisture[1],[20].

III. THE PROPOSED ALARM SYSTEM

The proposed system consists of four main parts. The first part includes fine conductors, the wet detector, an analogue switch, and an RF transmitter. This part will be coupled to the diaper through the pressing studs, except that the fine conductors are integrated into diaper and discarded with the soiled diaper. The fine wires are coupled to the detector circuit using simple pressing stud as shown in Figs 5. The second part consists of an RF transceiver, an analogue switch, and a GSM door sensor. The third part consists of a mobile-call GSM alarm system as shown in Figs 2. The fourth part consisting of a gateway technology in Computer

network such as (API) Application Programming Interface to make integration between GSM alarm system and Computer network. The overall block diagram of the system is shown in Fig. 2, and summarized in Fig. 3.
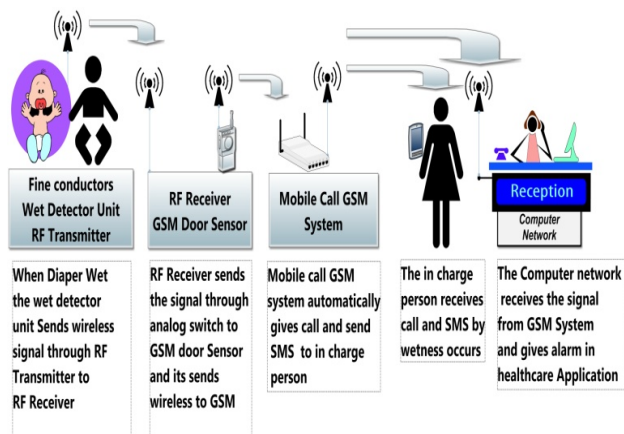

Fig 3.   System Block Diagram

A.   Circuit Description of Wet Detector part

The detector unit is composed of two parts, which are pairs of spaced fine wires embedded inside the Diaper and simple electronic circuit illustrated in Fig.4. The fine wires are coupled to the detector circuit using simple pressing stud as shown in Fig. 5. In operation, the electrical resistance between conductors L2 falls when the wires are contacted with urine or other wetness in the diaper. In turn, current is conducted through resistor R1 and R2. The resulting voltage drop across resistor R2 forward bias transistor TR1 and force it to conduct. With transistor TRI conducting, power is supplied to the analogue switch and turn it on. The spaced fine conductors that are inserted between the diaper layers are shown in Fig.5. They are positioned in the region of the diaper that subject to wetness. The other end of the pair of conductors is extended along the diaper and terminates at pressing studs at the front upper end of the diaper as shown in Fig.5. A square flexible thin plastic box, used carry the electronic detector, analogue switch and RF Transmitter circuitry is fixed on the exterior upper-front portion of the diaper as demonstrated in Fig.5 and 9. The detector unit also comprises a power source in the form of a small thin watch battery that powers the detector unit circuits.
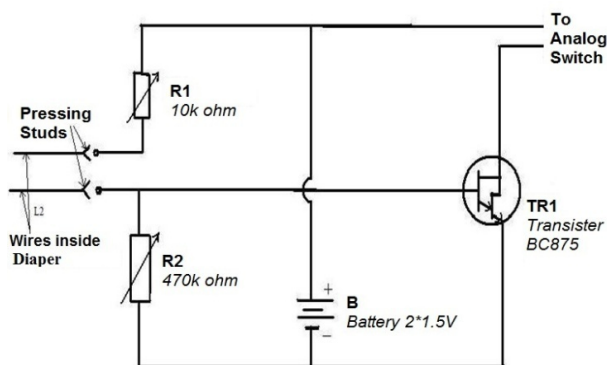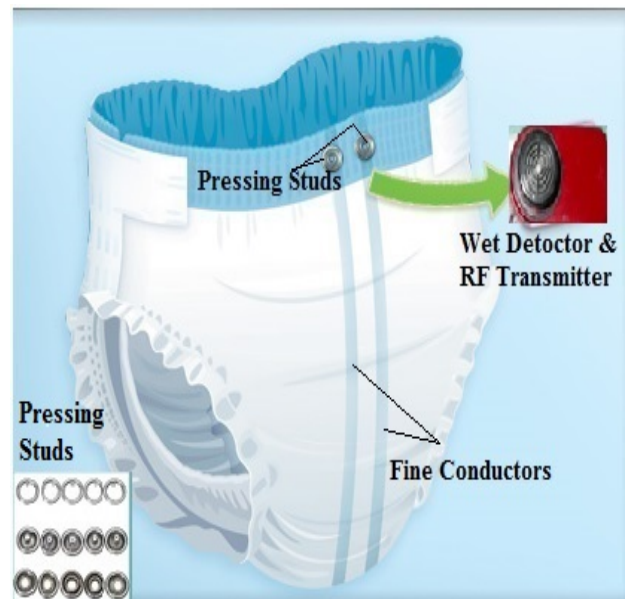

Fig 4.   Wetness Detector Circuit

Fig 5.   Pressing studs and fine wires fixed on diaper

B.   Circuit Description of the Wetness detector and Transmitter

The wet detector consists of the wetness detector, analogue switch DG418DJ, encoder HT12E, and the RF transmitter (Fig. 6). The wetness detector implemented by the authors for testing purposes. As described in the previous subsection, any wetness in the diaper leads to a signal at pins3 and 6 of the analogue switch, IC1 (DG418DJ).The output of DG418DJ, pins1 and 8, is connected across pins 9 and 14 of the encoder, IC2 (HT12E), which becomes active when pin 14 is grounded (active low) and the signal is transmitted by IC3 to the receiver side[1].

C.   Circuit Description of Receiver and GSM

Fig. 7, illustrates RF receiver, Decoder HT12D, analogue switch DG418DJ, GSM door sensor and mobile call GSM alarm system. The RF signal that is transmitted by IC3 will be received by the IC4 RF receiver, which activates the decoder IC5 HT12D. The output of the decoder pin 10 is programmed to be high when HT12D is active. This output is connected to the input of IC6 DG418DJ. The output switch of IC6 DG418DJ activates the GSM door sensor. Consequently, the GSM door sensor starts transmitting a signal to the base unit of the mobile call GSM alarm system. The GSM alarm system upon receiving a signal from its door sensor, directly starts sending a message to the programmed mobile number who is in charge of taking care of changing the wet diaper. It is worth mentioned here, up to six mobile numbers can be addressed at the same time.
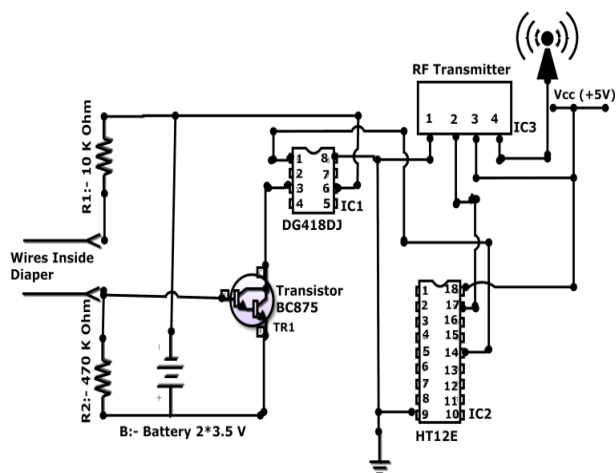
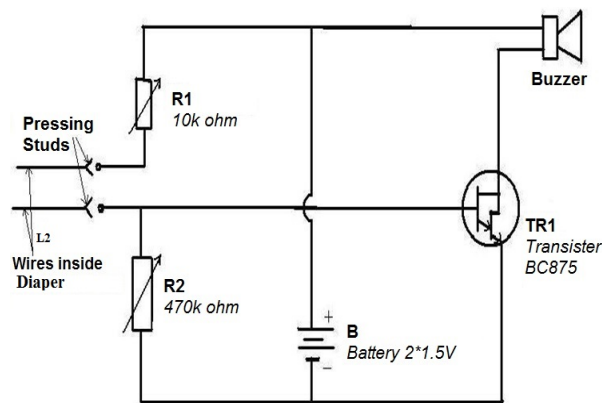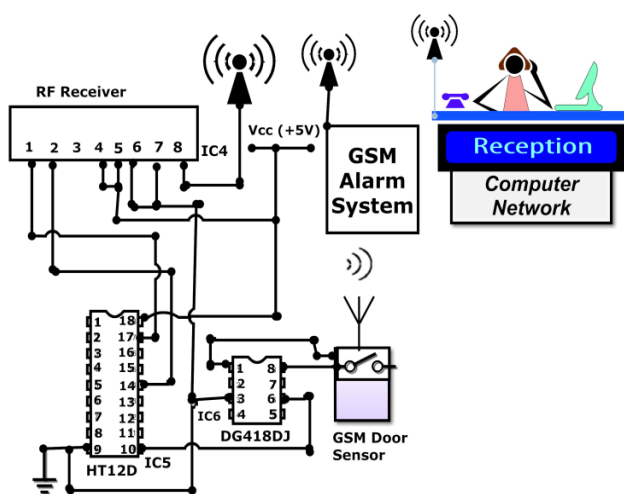Fig 6.   Wetness Detector and RF Transmitter Electronic Circuit Diagram

Fig 7.   RF Receiver, GSM Alarm and Computer Circuit Diagram

IV.   RESULTS AND DISCUSSIONS

In order to evaluate the performance of the proposed system, we conducted an experimental test for the wet detector. We connected the wet detector with speaker (buzzer) to adjust the sensitivity and test the operation of the wet detector, as shown in Fig.8. To adjust the sensitivity and test the operation of the wet detector, the dough was needed by adding water (40 %) to wheat flour. This floor dough is used in place of feces. Five diapers with the sensor fixed on them are prepared. 10 grams of the dough are placed on the inner surface of the diaper. The variable resistance R2 that illustrated in Fig.8 is varied from max resistance to low until a sound is heard from the buzzer. The value of R2 is measured and replaced by a fixed resistor when testing the other four diapers. Different volumes 1ml, 2 ml, 3ml, 4 ml and 5ml of tap water are prepared to be used instead of urine. The five volumes are added to five different diapers. After performing the tests, the wet detector gave a good response.

Fig 8.   Wet Detector Circuit Design with Buzzer

The conducted tests show that the wet detector can be adjusted to detect any level of wetness required. This is a very helpful feature that can be used to adjust the Diaper to specific levels of wetness according to its usage, such as in case of severe diaper rash infection and according to the requirements of the detection situation. The detector unit which also comprises the batteries and buzzer, is fixed on the upper front portion of the diaper by using pressing studs as depicted in Fig. 9. The unit will be removed when the diaper gives an alarm sound or SMS. The detector unit can be reused until the audible sound becomes weak. The only part need to be changed in the detector unit is the flat battery. The detector unit can be reused more than 100 times before the need to change the battery. Battery lifetime can be improved in the future. The wet detector circuit and RF transmitter form the part which is attached to the Diaper. As this part consists of very small component as in Fig.6, it can be fabricated into smaller chip, to ensure diaper wearers comfortable and safety.

Fig 9.   Pressing studs fixed on detector unit & the wet detector unit fixed
on the upper front portion of the diaper

V. CONCLUSION

Diaper rash is a nightmare for diaper wearer and the people who is in charge for those wearers. In this paper, the designed wet detector has been tested in real diaper with speaker. A clear sound is heard from the buzzer. The analogue switch, encoder, RF transceiver, decoder, GSM door sensor and mobile call GSM alarm system components are already tested and working with many applications and circuits. Cost wise the designed system is not costly, the two fine conductors plus the pressing studs may cost maximum from 0.1 to 0.2 USD. In addition the wet detector unit is decoupled from pressing studs for reuse. The costly part of the parents in this system are the mobile call GSM system, but the other parts are very cheap. However, nowadays the GSM alarm system became very necessary for houses because it is used for safety security purpose against fire and theft. Therefore, the GSM alarm system can be used at home for many purposes beside its usage in this system. Although this system may look a little bit expensive for the parents, but the diaper's wearer health are the most important. On the other hand, considering other applications, such as patients in incentive care, bedridden, disabled, people who are unable to move, nurseries in hospitals how they are suffering from the diaper rash and suddenly bleeding, in these situations the cost is not the main factor. In order to guarantee babies comfort, the detector unit can be fabricated in a very small reusable board with minimum cost, owing to the design simplicity of both the wet detector and the RF transmitter. The alarm system can be developed to support an Android application

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