Wetness Warrior: Capacitor-Based Diaper System for Real-time Wetness Detection

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Executive Summary

The Wetness Warrior aims to mitigate the occurrence of Diaper Dermatitis in infants and adults. Statistics have shown that large number of all diaper-wearing infants will be diagnosed with the condition. Additionally, up to 50% of adults living in assisted care homes are incontinent and require the use of a diaper. Both groups of patients are more prone to rash and infection because their skin is exposed to a moist environment for long periods of time. Our design alleviates this problem by providing real-time notifications to a caregiver when a diaper is wet through an embedded wireless moisture sensing system.

Description of Problem

- Prolonged exposure to urine and stool in a diaper weakens skin and causes diaper dermatitis
- Overzealous parents often check to see if the diaper is soiled too often, causing them to throw away diapers unnecessarily

Figure 1. Image of a severe case of diaper dermatitis.

Description of Market

Infant Market

•7-35% of infants in the United States will report a case of diaper dermatitis

Adult Market

•Over 50% of individuals residing in assisted living homes suffer from incontinence and require adult diapers

Combined Market

•Total diaper market in the United States alone accounts for $1.8 billion per year in revenue

Novel Solution

Innovative Diaper Changing Alert System

Diaper Insert

•Capacitor-Based Circuit completed when diaper is wet

•FM radio signal is powered and broadcasts a signal using a built-in antenna

Remote Sensing Device

- FM Shield receives FM signal from diaper
- Arduino monitors signal strength to noise ratio and sends alert upon the eclipse of a threshold ratio

Description of Design

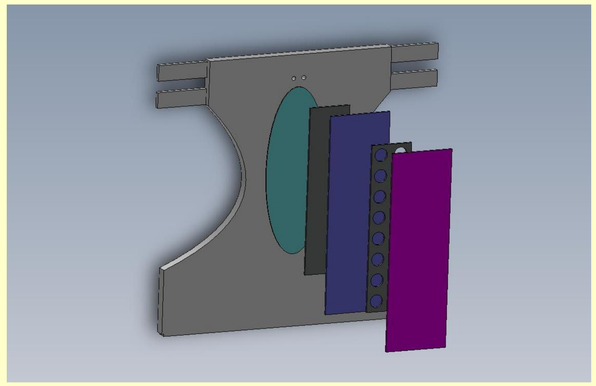

Figure 2. Exploded SolidWorks depiction of the various layers that compose the prototype.

Diaper Insert

1) Solid Foil Strip
   - Extends sensing area of circuit
2) Paper Absorbing Layer
   - Inhibits contact between foil layers
   - Absorbs urine to permit circuit completion
3) Permeable Foil Strip
   - Allows urine to reach absorbing layer
   - Extends sensing area of circuit
4) Paper Covering Area
   - Provides layer of comfort between the user and outer foil layer

Embedded Transmitter Circuit

1) FM Jamming Circuit
   - Can be tuned by controlling inductance
2) Charged 1mF capacitor powers circuit
   - Initially charged to 12V
   - Fully discharges when moisture sensor completes circuit

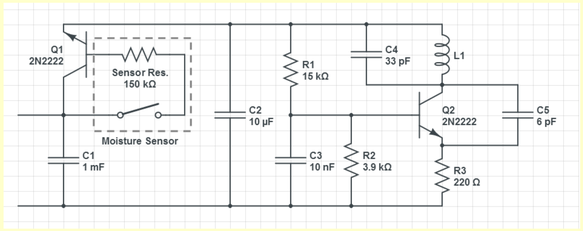

Figure 3. Schematic depicting the layout implemented in the sensor circuit.

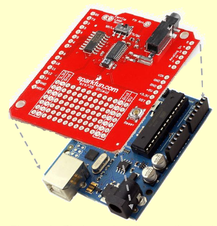

Figure 4. Photograph of the monitoring device.

Monitoring Device

1) AM/FM Shield
   - Receives signal sent from transmitter
2) Arduino Uno
   - Measures SNR
   - If high SNR is detected, Arduino output notification to user

Design Metrics

- **Operational Lifetime**
  - Minimum of six hours of use per charge
  - Timeframe a user would remain unattended over course of an evening
- **Reading Distance**
  - Minimum of ten feet
  - Distance a strategically placed monitor can cover entire floor space of an average room
- **User Comfort**
  - Does not induce pooling of urine
  - Does not significantly increase diaper rigidity

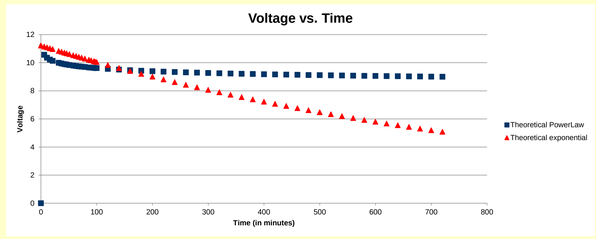

Figure 5. Plot displaying capacitor voltage versus time.

Orientation About Antenna (°)	Max Distance (ft)	Orientation About Antenna (°)	Max Distance (ft)
0	32	180	28.91
30	32	210	23.83
60	32	240	20.33
90	30.33	270	25.17
120	26.33	300	22.75
150	21.26	330	32

Table 1. Max reading distances based on monitor orientation to sensor antenna.

Estimation of Product Costs

Diaper Embedded System

Circuit Component Material Cost			
Part Name	**Part Cost**	**Num. Components/Unit**	**Total Cost/Unit**
Resistors -	$0.00256	3	$0.0768
Capacitor -	$0.00500	4	$0.02000
Capacitor - 100µF	$0.03700	1	$0.03700
Transistor - 2N2222	$0.05200	2	$0.10400
PCB	$0.1700	1	$0.1700
Moisture Sensor Material Cost			
Aluminum Foil - 3"x12"	$0.1133	2	$0.2266
Absorbent material	$0.001718	1	$0.001718
Assembly Costs			
PCB Assembly - per pad	$0.0033	22	$0.0732
Total Cost of Embedded Components			**$0.6401**

Reading Station System

Part Name	**Part Cost**	**Num. Components/Unit**	**Total Cost/Unit**
Arduino Board	$29.95	1	$29.95
FM Shield	$34.95	1	$34.95
Total Cost of Prototype Components			$69.90
Total Cost of Production Components			**$16.225**

Regulatory Pathway

FDA Product Classification

- Class II device similar to other Enuresis alarms and other monitoring technologies

Exempt from Premarket Notification Procedure

- Specified in Part 876, Subpart C of the FDA's Code of Federal Regulations

Exempt from 510(k) Clearance

- Can be marketed without FDA review as long as product fulfills certain requirements
  - suitability of use
  - proper packaging and labeling
  - registration with FDA

Acknowledgements

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References

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4) "CFR - Code of Federal Regulations Title 21." *Food and Drug Administration*. U.S. Department of Health & Human Services, 1 Apr. 2012. Web. 7 May 2013. <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=876.2040>.

For Further Information

Please visit http://www.bme.cmu.edu/ for more information on this project.