Skin Color Monitoring Device

Jack Ho, Joseph Yuen, Patrick Kurkiewicz, Brian Ginter

Advisor: William L. Murphy Ph. D., *Client:* John G. Webster, Ph. D.

Abstract

Many menopausal women suffer from hot flashes, the symptoms include momentary sensation of heat, sweating, flushed face, and increased heart rates. Our goal was to develop a device that will accurately monitor hot flashes by detecting the change in skin color during a hot flash and also be small, comfortable, cheap, and effective. A prototype was created consisting of an LED light source to shine light onto the skin, which would be reflected by the skin and picked up by a phototransistor. Changes in the skin color would alter the amount of light picked up by the phototransistor and change the output voltage of the circuit. Testing was done to see if the prototype would be able to detect the reddening of skin color induced by hot flashes. In fact, it was determined that an evident change in the range of 12 mV could be detected by our device.

Problem Definition

Statement
- Develop a miniature electronic device that records change in skin color during hot flashes.

Motivation
- In drug and other treatment development, developers use devices to record the accounts of hot flashes in women.
- Devices that accurately study hot flashes in women are especially useful in developing new drugs to help relieve the symptoms of hot flashes.
- Currently, the devices used to monitor hot flashes are big, bulky, and simply inconvenient to wearers.

Current Devices
- Journals
  - ambiguous and subjective
- Webster
  - detects skins electrical resistance
- BIOLOG device
  - heavy (200 g)
  - bulky (3.3 x 7 x 13 cm)

Design Criteria

- Miniature size and weight (maximum size of 6 cm x 6 cm x 1 cm including all possible attachments)
- Must be lighter than 50 g.
- Must output varying voltage levels corresponding to amount of light reflected from skin at an interval of 10 s.
- Must last for the minimum duration of an overnight recording and retrieval of data (12 hrs).
- Comfortable for wearer
- FDA approval for use on humans
- Low cost, Target Product Cost <$7 USD

Cost of Materials

Plastic case materials	**$1.00**
Resistors (x2)	**$0.20**
LED	**$1.62**
Phototransistor	**$0.30**
Total Cost	**$2.92**

Final Design

Polycarbonate case

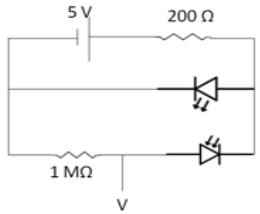
- *Height*
  1.4 cm
- *Diameter*
  3.8 cm
- *Acrylic shield*
  4.7 cm x 5.0 cm
- *Weight*
  13.4 g
- Blue LED and phototransistor both oriented 15˚ from vertical
  -cave structures for both elements to prevent direct light from one to another

A rigid plastic body prevents deformation of device and reorientation of electronic parts during testing. A clear plastic shield was added to prevent the movement of skin during testing.

From left to right: Interior view of device, Size comparison between quarter and a computer mouse, Top view.

Circuitry

LED shines light to be reflected off of wearer's skin, which is picked up by the phototransistor (PT). Current leakage through PT is proportional to the intensity of light detected. Output voltage is measured at 1 MΩ resistor

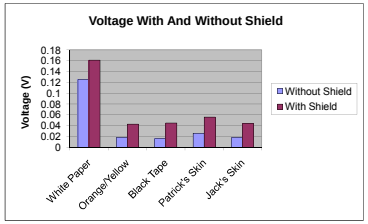


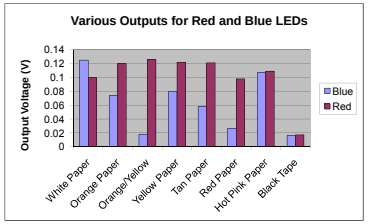
Acrylic case (alternate casing)

- *Height*
  1.3 cm
- *Base*
  2.54 cm x 2.54 cm
- *Weight*
  9.4 g

Bottom View of device with acrylic case

Testing: Protocol and Results





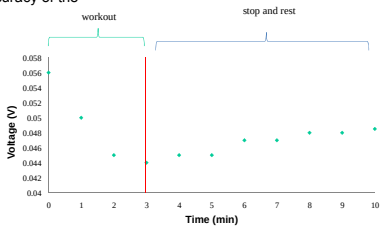
Surface	Blue Led, no screen, Polycarbonate*	w/Clear Shield*	Red Led, no screen, Acrylic Cube*
White Paper	0.125	0.161	0.1
Teal Paper	0.066		0.025
Blue Paper	0.103		
Lt. Blue Paper	0.101		
Green Paper	0.034		
Lt. Green Paper	0.071		
Orange Paper	0.074		0.12
Orange/Yellow	0.018	0.043	0.126
Yellow Paper	0.08		0.122
Tan Paper	0.058		0.121
Red Paper	0.026		0.098
Hot Pink Paper	0.107		0.109
Lt. Pink Paper	0.095		
Grey Counter	0.06		0.042
Black Tape	0.016	0.045	0.017
Patrick's Skin	0.026	0.056	
Jack's Skin	0.018	0.044	

*Fluctuation < ~2 mV

Devices were tested by recording the output voltages for differently colored surfaces.
- We saw that the correlation between color change and output change was the greatest using blue, rather than red light.
- We also observed that the spectral reflection from the plastic shield was relatively constant, which means it does not greatly affect the accuracy of the device.

Exercise test was performed to simulate a hot flash.
- Device was able to detect the reddening of skin due to exercise and the slower dissipation from recovery.
- Larger fluctuation (~5 mV) was noticed during workout than during rest (< 2 mV), however averaged results show trend.

Voltage vs. Time During Workout



Conclusions

- Earlier tests (not shown on poster) showed the device needed to be rigid and the LED and phototransistor must be held securely in place so that the orientation does not change during testing, preventing large fluctuations in output voltage.
- Experimental data shows correlation between color and output voltage, suggesting that the change in skin color can be reliably detected by our device, thus hot flashes should be detected.
- While other light, such as red, reflected more, changes in color were more evident when testing with blue light.
- While the use of a plastic shield altered reflection readings, the use of it to keep skin flat and at a constant distance from device is a major benefit.

Future Work

- Method of device attachment
- More quantitative testing
  - Generate output averages and standard deviations
  - LabView
  - Under different conditions
    - Different ethnic skin colors
    - Different age groups
- Continued R & D for optimization
  - Testing of more accurate phototransistors
  - Better circuit configuration
- Chipset & Battery
  - Recording device
  - Mobile voltage source (battery)
  - On/Off switch
- Further miniaturization
- Reduce Spectral Reflection
  - Place LED and Phototransistor on same side

References

•Angelopoulou, Elli. The Reflectance Spectrum of Human Skin. GRASP Laboratory. Department of Computer and Information Science, University of Pennsylvania. Dec. 20, 1999.
•Digi-Key Corporation. [Online] www.digikey.com. [2007].
•UFI. Hot Flash Electrodes [Online]. http://www.ufiservingscience.com/HFMon1.html [Oct. 9, 2007].
•WebMD. Hot flashes [Online]. http://www.webmd.com/menopause/guide/hot-flashes [2007].
•Webster, J. G., Bahr, D. E., Schults, M. C., Grady, D. G., Macer, J. A miniature sternal skin-attached hot flash recorder. IFMBE Proc. http://www.engr.wisc.edu/bme/faculty/webster_john/2542hotflash.pdf. 2006.

Acknowledgements

The authors would like to thank advisor William L. Murphy, client John G. Webster, and Amit Nimunkar for their continual help throughout the semester.