SKIN COLOR MONITOR

FOR DETECTING AND RECORDING HOT FLASH OCCURRENCE

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Client
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Abstract

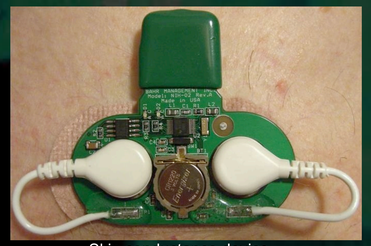
Our objective is to develop a device that detects hot flashes by measuring changes in skin redness. Our prototype uses a 525 nm LED to illuminate the skin and a photodiode in photovoltaic mode to detect the reflected light. The output signal from the photodiode is amplified through an inverting amplifier with a low pass filter. Using this setup, we observed decreasing skin reflectance with increasing skin flushness as expected. The device consistently output a decrease of 5-10 mV between flushed and normal skin. Much effort was also given this semester to minimizing the size and weight of the device through a complete re-fabrication of the LED/ photodiode housing as well as a semi-permanent soldered circuit.

Why Do We Need This?

Middle-aged women commonly experience hot flashes as a symptom of menopause. Hot flashes are characterized by sudden sensations of heat, sweating, flushness of the skin, and increased heart rate. A device to help monitor hot flash occurrence would help in diagnosing hot flashes as well as quantifying the effectiveness of any drug treatments. Current methods of logging hot flash occurrence mostly consist of personal journals which are qualitative, unreliable, and prone to human error. Our device aims to provide a reliable quantitative solution to this problem.

What Currently Exists

Many devices that record the occurrence of hot flashes already exist, but problems are associated with these devices that counter the client's needs. One device, the BIOLOG by UFI, is multi-purpose and can be programmed to monitor different biological characteristics. The problems associated with this device are that it is bulky and too heavy and costs thousands of dollars. A device that is currently utilized by Professor John Webster monitors skin conductance by using electrodes. Webster wants to shy away from this method and analyze skin color as opposed to skin conductance.



Skin conductance device

BIOLOG

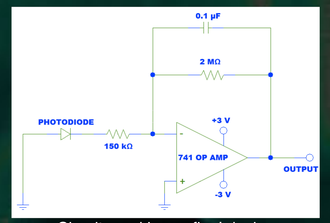
Design Criteria

- Compact size (maximum of 6 cm x 6 cm x 1 cm)
- Weighs less than 50g
- Smooth surfaces with no sharp points
- Fabricated from materials that will cause no irritation of the skin
- Device must remain attached to the skin and must be in contact with the skin at all times
- Must be powered by 3V battery
- Voltage output readings should be recorded every 10s
- Low cost (Target cost < $200 USD)

Final Design

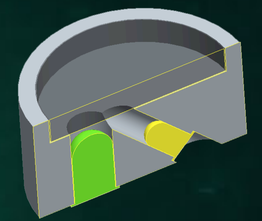
Housing:
Weight: 7.97 g (empty housing)
16.44 g (with photodiodes and wires)
Dimensions: 1.0" x 1.0" x 0.55"
(2.5 cm x 2.6 cm x 1.4 cm)

Circuit:
Gain: 13.33
Cutoff Frequency: 0.80 Hz
Output Range: 0 V - 1.5 V

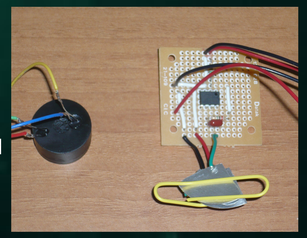


Circuit used in our final device

Cost Analysis:
- Green LED - $0.49
- Photodiode - $1.02
- 3 Volt Battery (2) - $8.98
- Resistors – donated
- Capacitor – donated
- Circuit Board – donated
- Wires – donated
- Plastic Casing – donated
- Plexiglass – donated
- Black Paint - $3.99



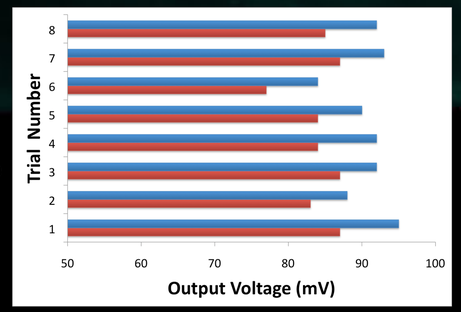
3D model of device (cross section)



Photograph of prototype

Testing

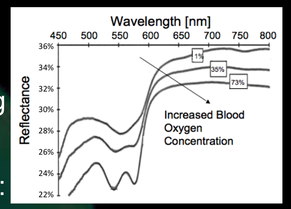
Voltage readings were taken on two areas of the underside of the forearm. Then, redness was induced to a noticeable visual degree in one of the two areas. Subsequent measurements were taken for each area. The photodiode was able to provide reliable, repeatable measurements that distinguished pale and visibly flushed skin.

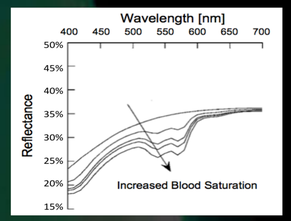


Device output on normal and flushed skin over 8 trials

Research

- Factors determine skin color: Melanin concentration, blood oxygen saturation, skin blood saturation
- Only skin blood saturation changes during hot flashes (most sensitive to green wavelengths, 500 nm to 600 nm)
- Potential problems monitoring hot flashes: inconsistent frequency of intensity, duration, location, and effects of hot flashes.
- Design to minimize measurement other than skin reflectance: no direct spectral reflection, no direct transmittance
- Some diffuse internal reflection from acrylic, but constant, unaffected by skin





Future Work

- Method of device attachment that prevents the movement of the device away from the skin
- Data recording device which records readings every 10s
- Further miniaturization by using a smaller LED
- Possible use of light to frequency converter
- Optimize for different skin colors

Acknowledgements

- John G. Webster – Client
- Wally Block – Advisor
- Amit Nimunkar – Circuit and Lab help
- Kevin Eliceiri – circuitry, LEDs
- Matt Erickson - photodiodes

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