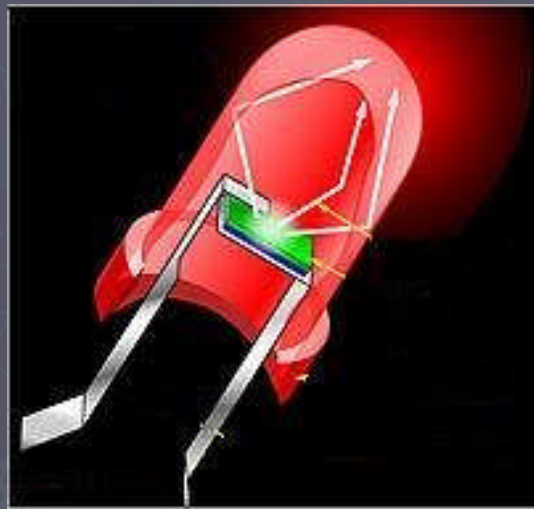


Handheld Device for Remotely Measuring Brain Function

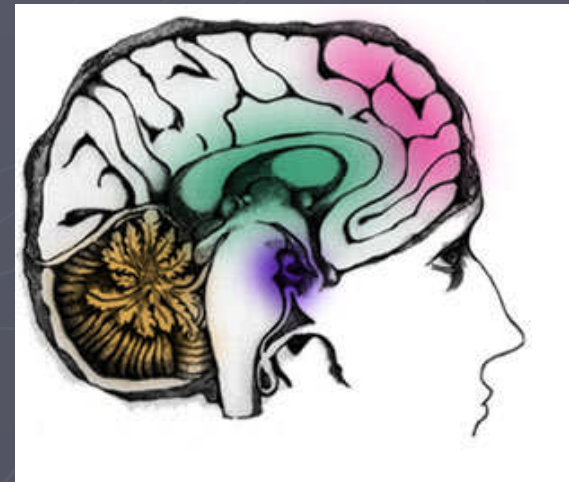


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July 29, 2005

Advisor: Dr. Britton Chance



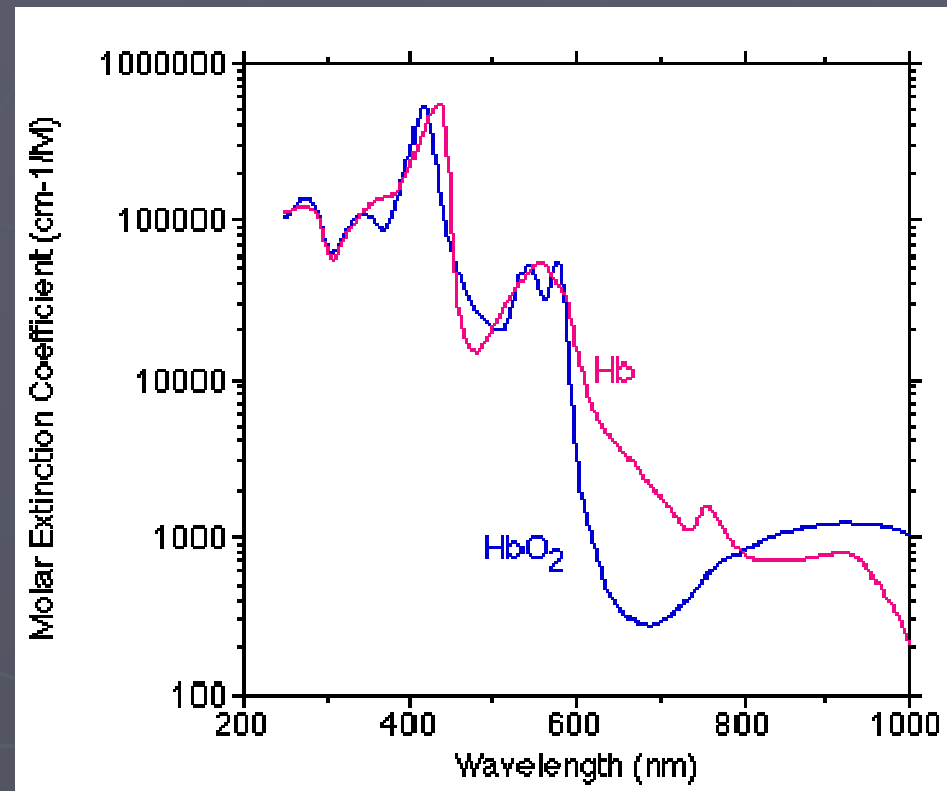
Motivation

- ▶ Need non-invasive technique to measure brain oxygen level, especially babies
- ▶ Remotely measure brain activity as an indicator of brain function
- ▶ Need portability, ease of use



How Near Infrared Works

- ▶ Brain oxygen level a good measure of brain function
- ▶ Oxygen levels determined from amount of oxygenated and deoxygenated hemoglobin
- ▶ Near infrared good choice – isosbestic point, little absorption by other tissue



A Continuous-Wave System

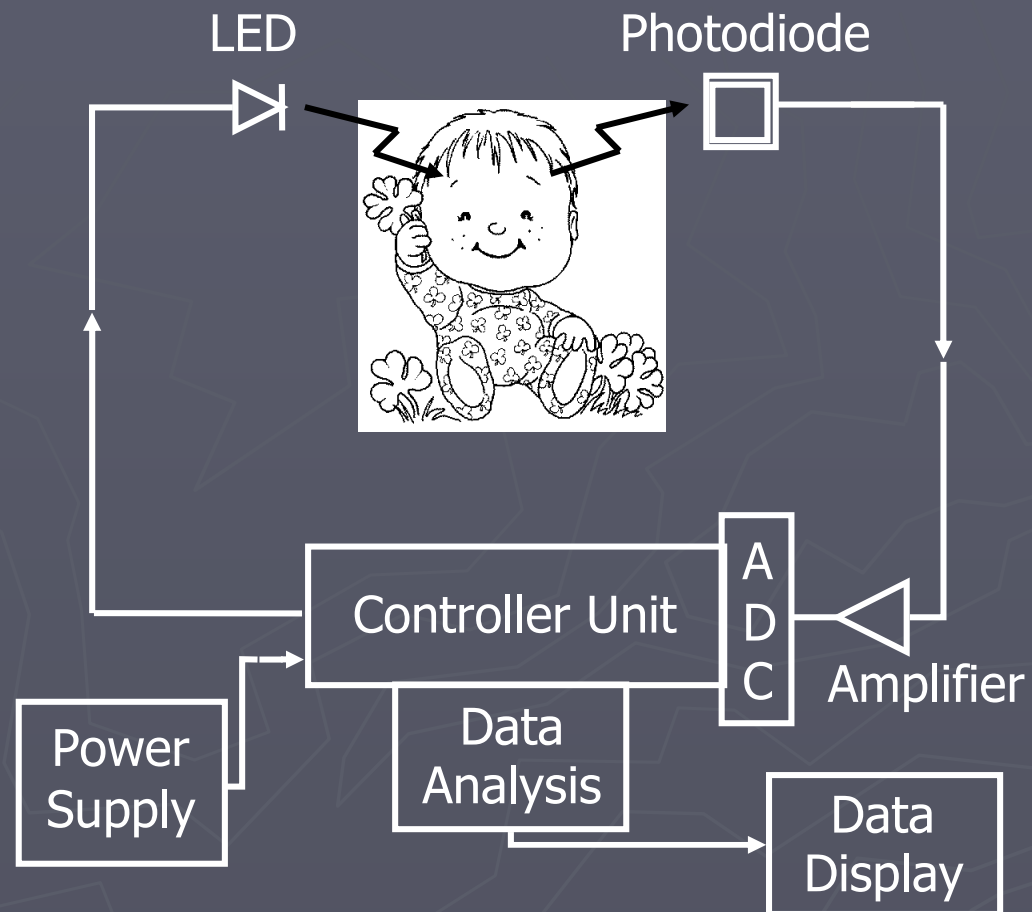
- ▶ Relies on measuring backscattered light from subject
- ▶ Determines changes in blood volume and oxygen levels
- ▶ Cannot determine absolute value of blood volume and oxygen levels
- ▶ Requires two wavelengths

Goals of Project

- ▶ Study NIR method and current devices
- ▶ Test effectiveness of remote sensing with LEDs and photodiodes
- ▶ Suggest a design for a handheld remote sensing device

Approach

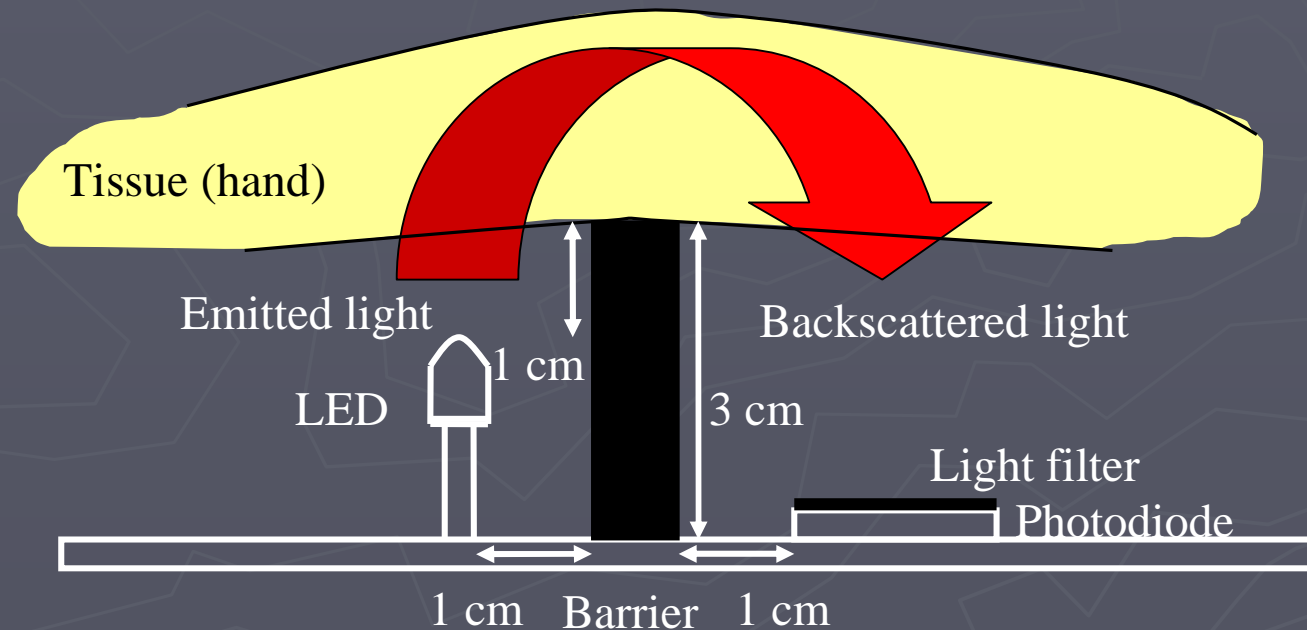
- ▶ LED emits light
- ▶ Photodiode measures backscattered light from subject
- ▶ Circuit extracts and amplifies signal
- ▶ Sampled data analyzed



Experimental Results

- ▶ Arterial Pulse
- ▶ Ink Tests

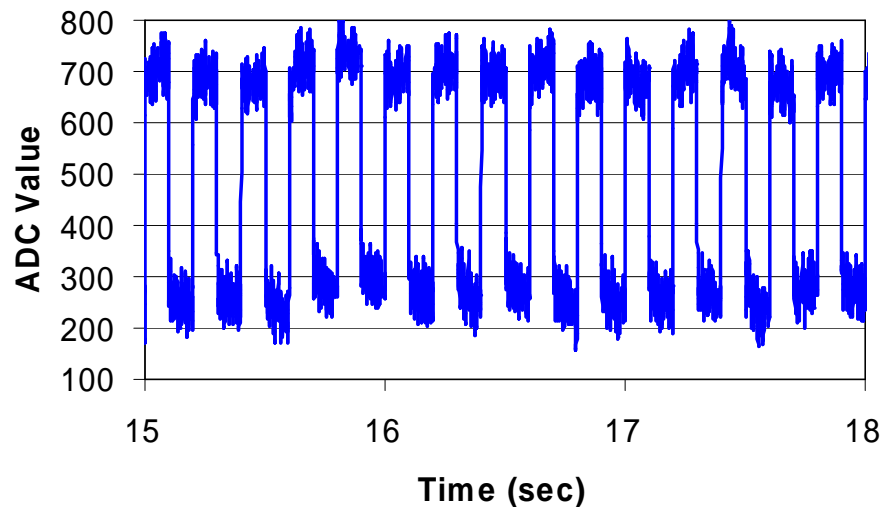
Small-Scale Remote Sensing



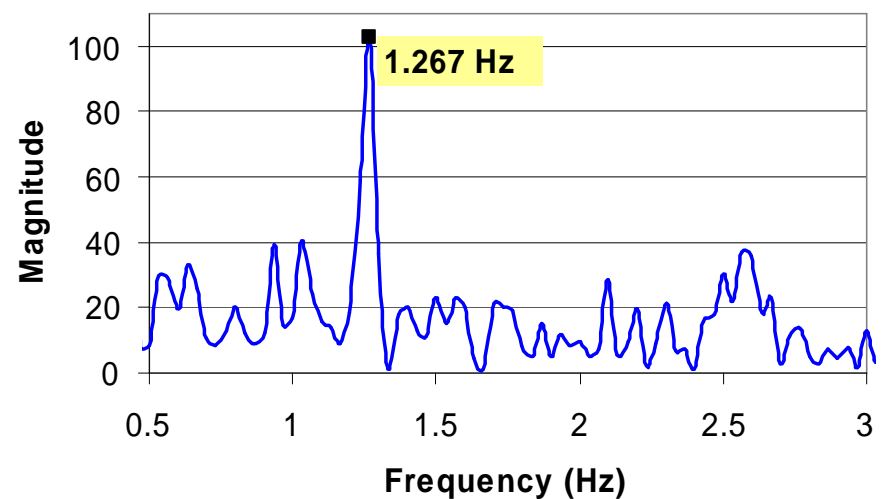
Arterial Pulse

- ▶ Two LEDs necessary
- ▶ Arterial pulse still modulates both wavelengths

Dual LED Measurement

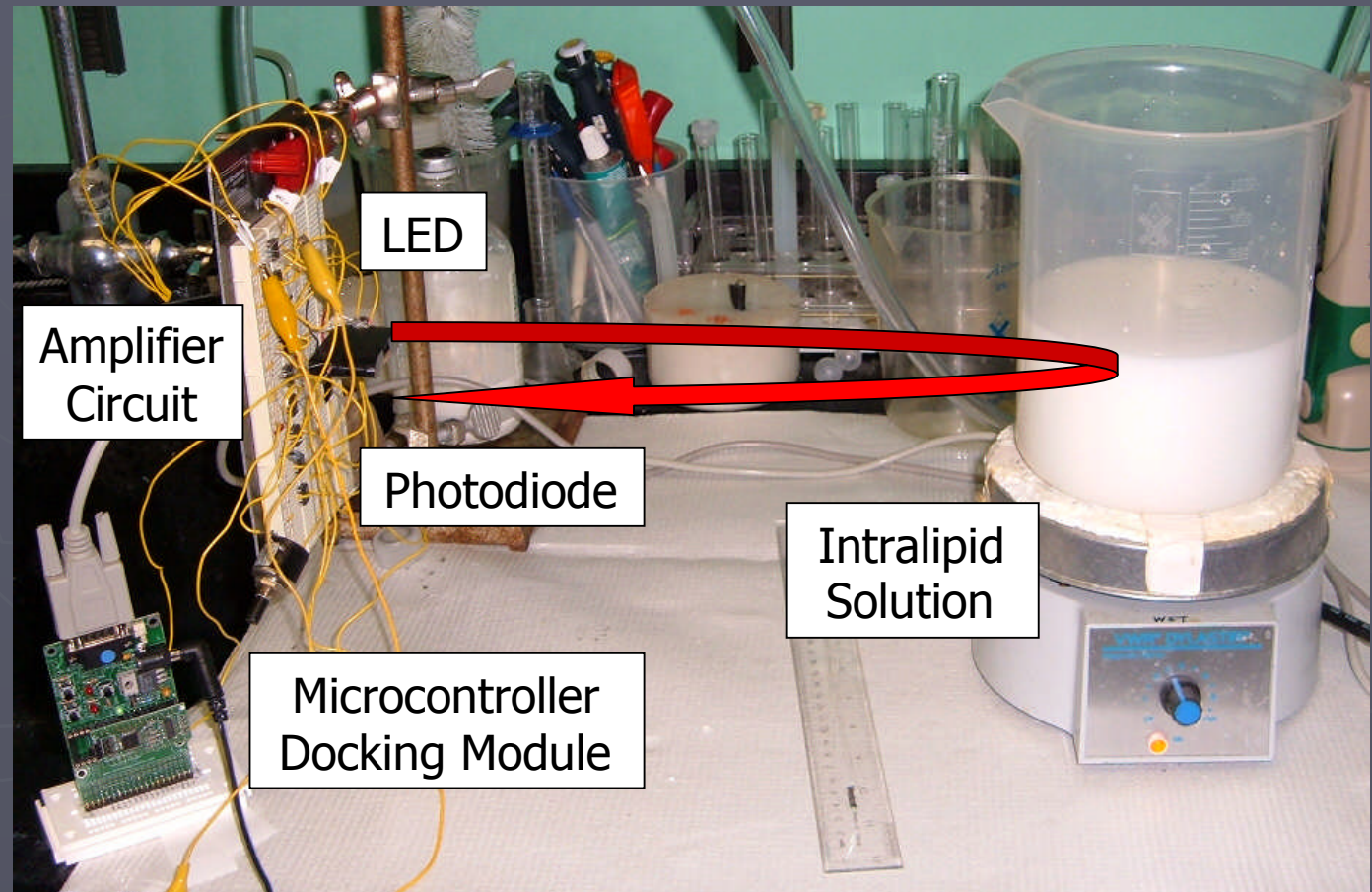


DFT of Dual LED Measurement



Ink Tests

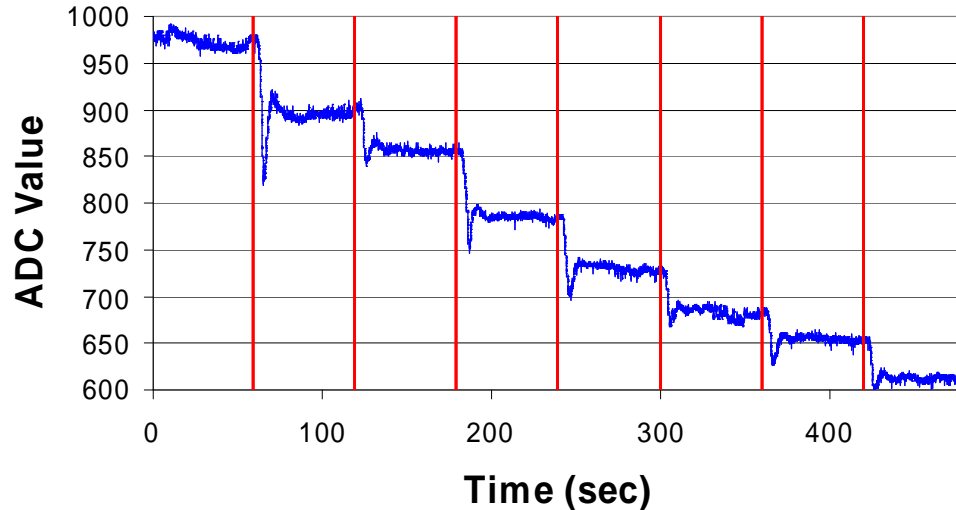
- ▶ Add ink to increase light absorption
- ▶ Look for decrease in backscattered light
- ▶ Simulates change in Hb or HbO₂ concentrations



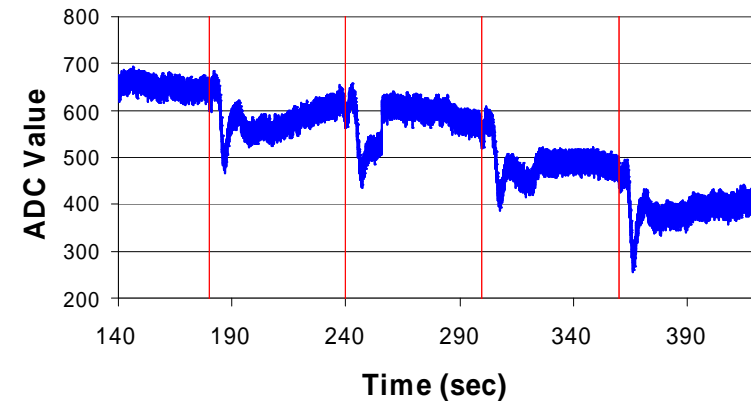
Ink Tests

- ▶ Distance and room light weaken signal

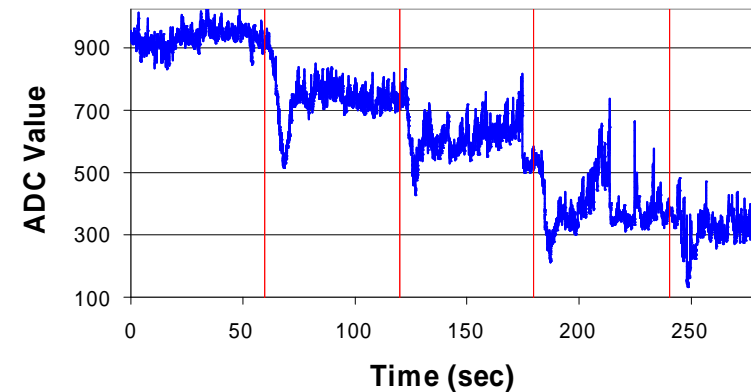
Ink Test (760 nm LED, 10 cm Distance, No Room Light)



Ink Test (760 nm LED, 10 cm Distance, Room Light)

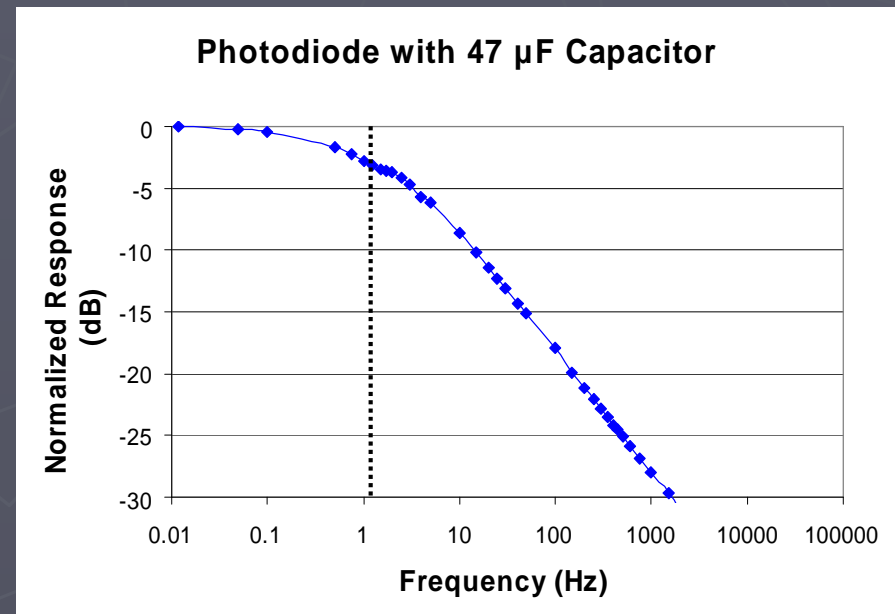
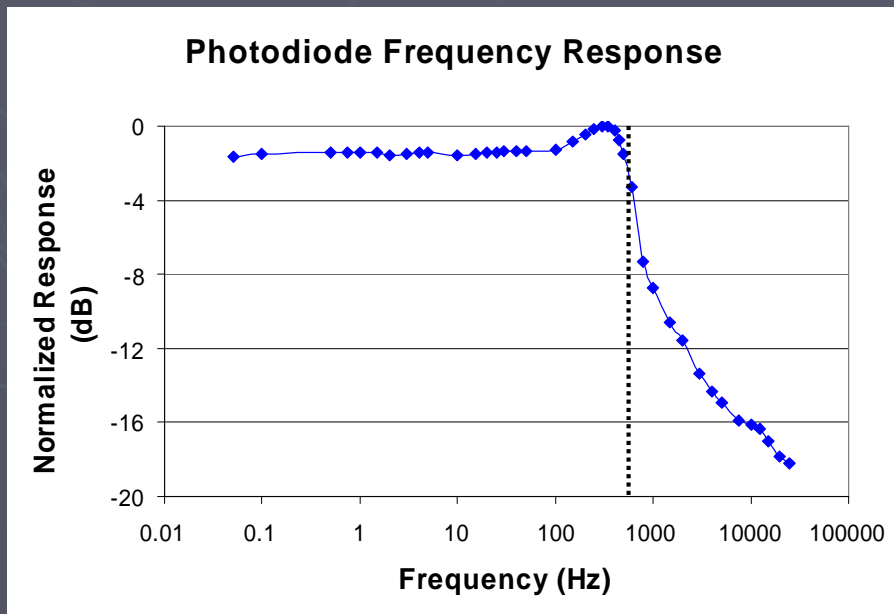


Ink Test (760 nm LED, 30 cm Distance, No Room Light)



Bandwidth Issue

- ▶ Shot noise proportional to the square root of bandwidth
- ▶ Reduction of bandwidth from 600 Hz to 1 Hz could reduce shot noise by almost a factor of 25



Further Work

- ▶ Interference filter
- ▶ Increase effective illumination intensity or effective collecting area
- ▶ Automatic gain control
- ▶ Limit movement, room light, and changes in the environment
- ▶ Integrate features such as external LCD reading, user inputs, warning system with microcontroller

Conclusion

- ▶ Study has shown the feasibility, challenges, and limitations of remote sensing with an LED, photodiode, and microcontroller
- ▶ Remote sensing with handheld device components successful on a small-scale
- ▶ Further work could very possibly bring remote sensing in the real world to reality

Acknowledgments

- ▶ Dr. Britton Chance and his lab
- ▶ SUNFEST