

## **Artifact-Resistant, Power-Efficient, High-Speed Modulation Design for Photo Plethysmographic Ring Sensors**

P Shaltis\*, S Rhee, H Asada, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

### **Abstract**

A novel high-speed modulation design for wearable photo plethysmographic (PPG) sensors is presented. This design involves implementing a transmittance sensor configuration to reduce the effects of motion artifacts associated with reflectance sensor configurations. Simultaneously, a high-speed modulation LED design is employed to minimize power consumption since the new sensor configuration requires a higher instantaneous power for signal acquisition.

In this paper, the causes of motion artifacts associated with both reflectance and transmittance sensor configurations are described, explained, and verified through experimental evidence. It is shown that improvements in signal stability over previous ring sensor designs<sup>1</sup> can be achieved by implementing a transmittance sensor arrangement. It is next demonstrated that in this configuration, high-speed optical devices can be used to significantly reduce power consumption through high-speed modulation. Experimental results confirm that designs with an LED modulation frequency of 1 kHz and 0.1% duty ratio lead to approximately 1000 times less power consumption than designs without modulation. Finally, the new design is benchmarked with previous wearable sensor designs to demonstrate the improvements in both signal stability and power consumption.

<sup>1</sup> Yang B-H. and Rhee, S., "[Development of the Ring Sensor for Healthcare Automation](#)," Robotics and Autonomous Systems, 30 (3) (2000) pp. 273-281.