Feasibility of an Incandescent Pulse Oximeter

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Introduction: A pulse oximeter works by transmitting light at different wavelengths through blood filled tissue. Conventional oximeter sensors use two light emitting diodes (LEDs) with carefully chosen accurate and narrow spectral bandwidths. The tight component requirements make the LED pair the most expensive part of the entire sensor. We consider the feasibility of replacing the LEDs with a single wide-bandwidth emitter in the form of a low-voltage incandescent micro-bulb, currently in common use as cheap indicators in instruments and toys.

Method: The micro-bulb emits a continuous black body spectrum defined by the tungsten filament temperature, which can be 1400K-2300K depending on the driving voltage [1]. We model the sensor signal by integrating the product of signal spectral intensity, photodiode sensitivity, and hemoglobin absorption over the entire spectrum. An oximeter can now be realized by driving the incandescent bulb at two different voltages corresponding to filament temperatures T_1 and T_2 (Fig. 1 (a)) and forming the conventional oximeter ratio from the two resulting signal intensities.

Results: The modeled incandescent oximeter ratio is found to have an approximate linear response to the oxygen saturation for a range of filament temperatures (Fig. 1 (b)). This means that an incandescent sensor can potentially be calibrated to provide direct oxygen saturation readings. The incandescent ratio changes about 5% over the clinical range of oxygen saturation (70-100%). This sensitivity is much lower than in a conventional oximeter where the equivalent change in ratio is approximately 200%.

Conclusion: We find that an incandescent pulse oximeter does exhibit a relationship between the raw oximeter ratio and oxygen saturation that is suitable for calibration. The sensitivity is however prohibitively small, due to the signal integration performed over the entire hemoglobin absorption spectrum. Use of a wide-bandwidth emitter will therefore require additional modification of the sensor, for example the introduction of passive filters, to be practical.

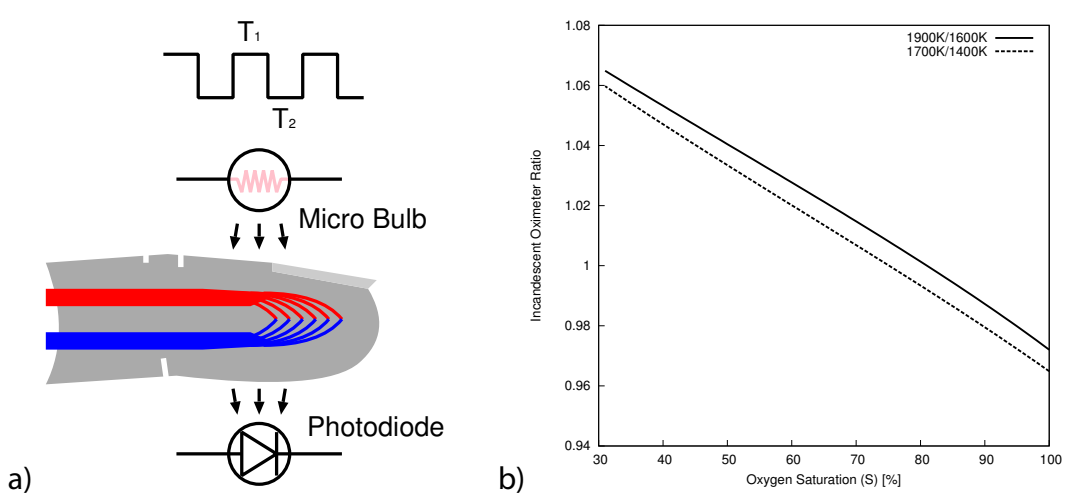

Figure 1: (a) Incandescent Pulse Oximeter and (b) Oximeter ratio as function of saturation

[1] Ahmad I, Khalid S, Khawaja EE, Filament temperature of low power incandescent lamps: Stefan-Boltzmann law Lat. Am. J. Phys. Educ. Vol. 4, 2010