BY BONNIE BAKER

Do you question your sanity?

Have you ever been in need of a second opinion when your sanity is at stake? The pulse oximeter may be able to provide that second opinion if your brain is oxygen-deprived. This condition could affect you if you are a pilot, hiking in the high altitude of a mountain range, or even undergoing surgery. The pulse oximeter is a noninvasive instrument that monitors SpO_2 (saturation of hemoglobin with oxygen) in your blood.

You measure the oxygen in the blood by alternating the on-times of a red LED with a 650-mm wavelength and an NIR (near-infrared) LED with a 940-mm wavelength, taking the ratio between the intensities from a photodiode, and comparing that ratio with an SpO_2 look-up table in the microcontroller (**Reference 1**).

The transimpedance amplifier appears in medical and laboratory instrumentation, position and proximity sensors, photographic analyzers, bar-code scanners, and even smoke detectors. In the medical field, you will primarily find transimpedance amplifiers in the CT (computed-tomography)-scanner front end and the pulse oximeter. **Figure 1** shows a simplified block diagram of a pulse oximeter (**Reference 2**).

In the circuit in **Figure 1**, the red LED is on for 50 μsec, both LEDs are off for 450 μsec, the NIR LED is on for 50 μsec, and then both LEDs are off for 450 μsec. The system repeats this cycle continuously. The transimpedance amplifier, A_1, converts the photodiode current generated by the LEDs to a voltage at the output. The signal then travels through a bandpass filter and gain stage to the 12-bit ADC. The signal also travels through a lowpass filter to regulate the driver power to the LEDs. The microcontroller acquires the signals from the 12-bit ADC, computes the ratio of the red- and NIR-LED signals, and compares the results with a look-up table. The LCD shows a percentage of oxygenated hemoglobin versus nonoxygenated hemoglobin and your heart rate.

When you choose your device for the pulse-oximeter transimpedance-amplifier circuit, you need to make sure that the amplifier's input-bias current is very low or in a picoamp region at 25°C. The amplifier's input-bias current creates an output-voltage error by conducting through the high-impedance resistor, R_F, in the amplifier's feedback loop. FET- or CMOS-amplifier input devices usually meet this requirement. A second consideration is that the low-frequency voltage noise of your amplifier must be very low. When you consider the input-voltage noise of the amplifier, scrutinize the impact of the flicker noise. After the transimpedance amplifier, a bandpass filter eliminates the noise above 5 Hz. Finally, the amplifier's initial offset error and overtemperature should be in the microvolt region if you want to minimize linearity errors. It may be worthwhile to use an autozero amplifier.

A normal output for the pulse oximeter is approximately 97%±2%, ranging from 95 to 100%. The alarms on the pulse oximeter usually sound when the SpO_2 level drops below 90%. If there is a shortage of oxygen in your system, you may experience poor judgment or loss of motor function. If a pulse oximeter indicates that your oxygen levels are stable, you may want to explore other diagnostic avenues, or perhaps you just dance to the beat of a different drummer. Good luck! EDN

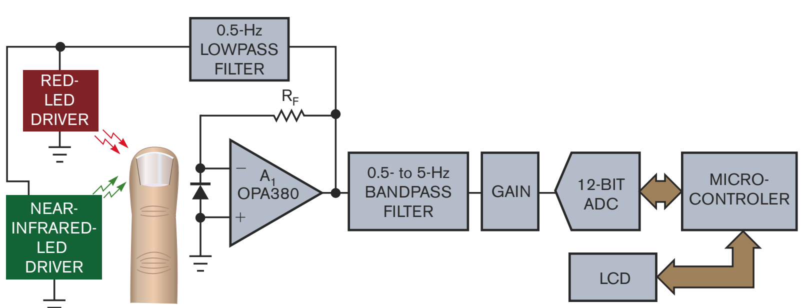

Figure 1 This pulse-oximeter circuit alternates the on-time of a red LED and a near-infrared LED to monitor oxygen saturation in the blood.

REFERENCES

1 *Medical Applications Guide*, pg 27, Texas Instruments, second quarter 2007, http://focus.ti.com/lit/ml/slyb108b/slyb108b.pdf.

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