Simple circuits sort out the highest voltage

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In a water-cooled power converter, analog-output sensors measure the cooling water temperature at three locations. If any of the three temperatures rises above a preset threshold, an alarm sounds and attracts the attention of the system's operator. When the alarm activates, knowing which measurement site has reached the highest temperature saves troubleshooting time and prevents system damage. The circuit in **Figure 1** delivers an analog-output voltage equal to the highest of three input voltages that drives a display for continuous temperature monitoring. LED indicators identify which of three sensors shows the highest temperature. An external adjustable-threshold comparator (not shown) monitors the analog-voltage output and activates an audible alarm.

Each of three analog input signals spans a range of 0 to 10V. Driven by the highest-voltage input, which you apply at IN_1 in this example, operational amplifier IC_{1A} functions as a voltage follower with diode D_1 in its feedback path. The op amp's open-loop gain divides the diode's forward-voltage drop to a fraction of its nominal value, producing an "ideal diode" with a voltage drop of millivolts.

THE CIRCUIT DELIVERS AN ANALOG-OUTPUT VOLTAGE EQUAL TO THE HIGHEST OF THREE INPUT VOLTAGES THAT DRIVES A DISPLAY FOR CONTINUOUS TEMPERATURE MONITORING.

Op amps IC_{1B} and IC_{1C} function as high-input-impedance inverting comparators. Each "sees" the highest input voltage on its inverting input and one of two lower input voltages, IN_2 and IN_3, on its noninverting input and delivers an output voltage near that of the negative-supply-voltage rail. Thus, only IC_{1A} delivers a positive-voltage output to MOSFET Q_1's gate, and IC_{1B} and IC_{1C} deliver negative outputs to the gates of Q_2 and Q_3. Q_1 turns on, lighting LED D_4 and drawing approximately 5 mA to develop 11V across R_3, which guarantees that Q_2 and Q_3 and their corresponding LEDs remain off. The voltage that develops across R_1 represents the largest voltage of the three inputs, and resistor R_4 and capacitor C_1 form a lowpass filter that reduces high-frequency noise that the sensor cables pick up. Voltage follower IC_{1D} buffers the filter's output voltage. **Figure 2** (pg 136) shows the results of an LTSpice simulation featuring three sinusoidal inputs and the resultant analog output summed with a small dc-offset voltage for clarity.

The breadboarded circuit works as designed. Given its electrically noisy location near a 300-kHz, 30-kW switched-mode power converter, it uses slow-switching 1N4004 diodes to avoid malfunctions, which the rectification of stray high-frequency interference introduces. In less noisy environments, use any small-signal diode whose peak-inverse voltage exceeds at least 30V. Most varieties of operational amplifiers work well in the circuit, but for greater high-frequency immunity, use a JFET-input quad op amp, such as Texas Instruments' (www.ti.com) TL084.

Although the circuit's prototype uses red-LED indicators, LEDs of other colors work well. To change the LEDs' current to another value, change the values of R_2 and R_3, keeping approximately the same 3-to-2 ratio. For example, values of 1.8 kΩ for R_2 and 1.2 kΩ for R_3 drive the "on" LED with approximately 10 mA. If you increase the LED current, note that the resistors continuously dissipate power. For greatest reliability, choose resistors rated for twice the calculated power dissipation. EDN

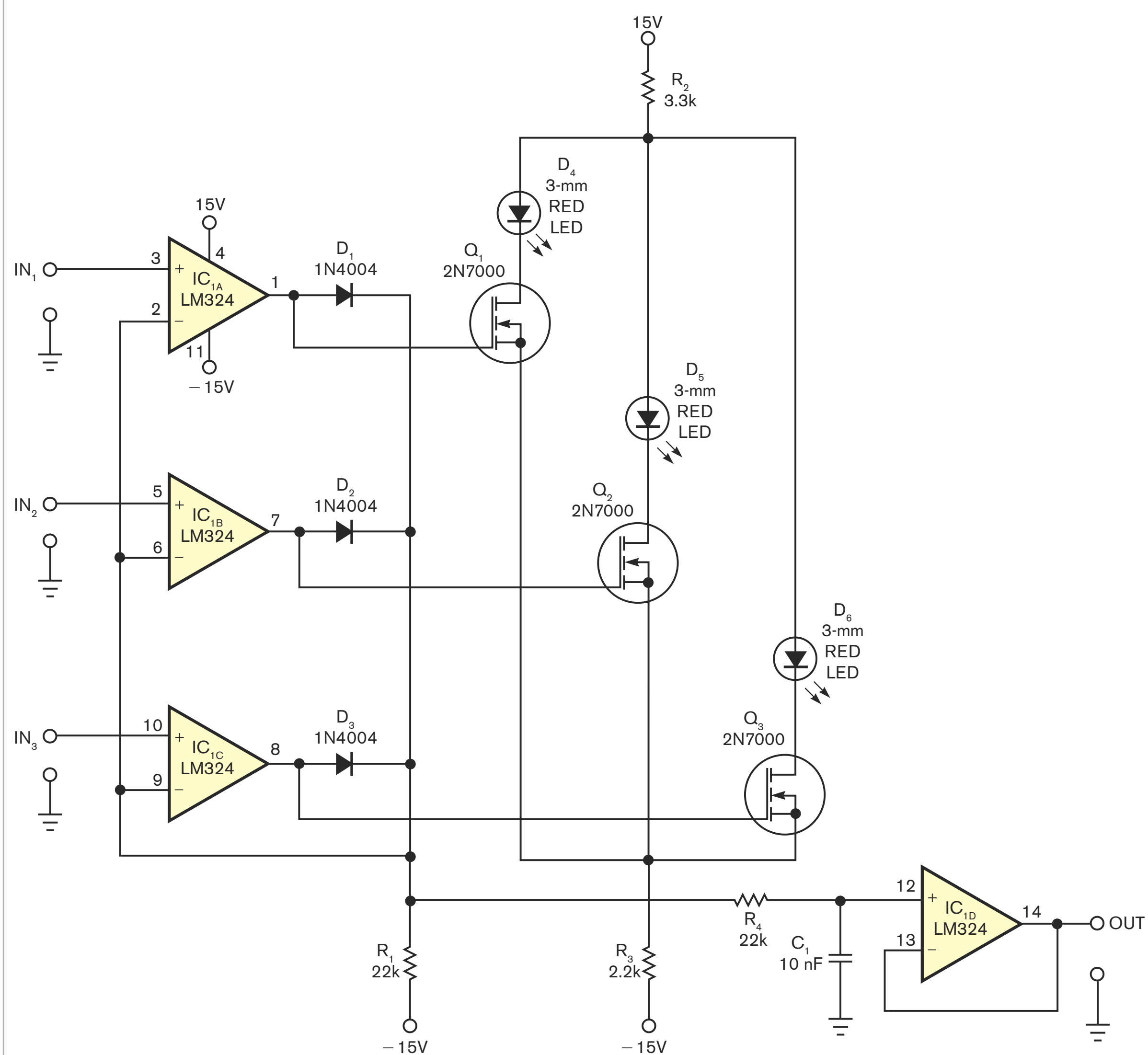

Figure 1 This circuit's output voltage tracks and indicates the highest of three input voltages and can drive an external strip-chart recorder or alarm comparator.

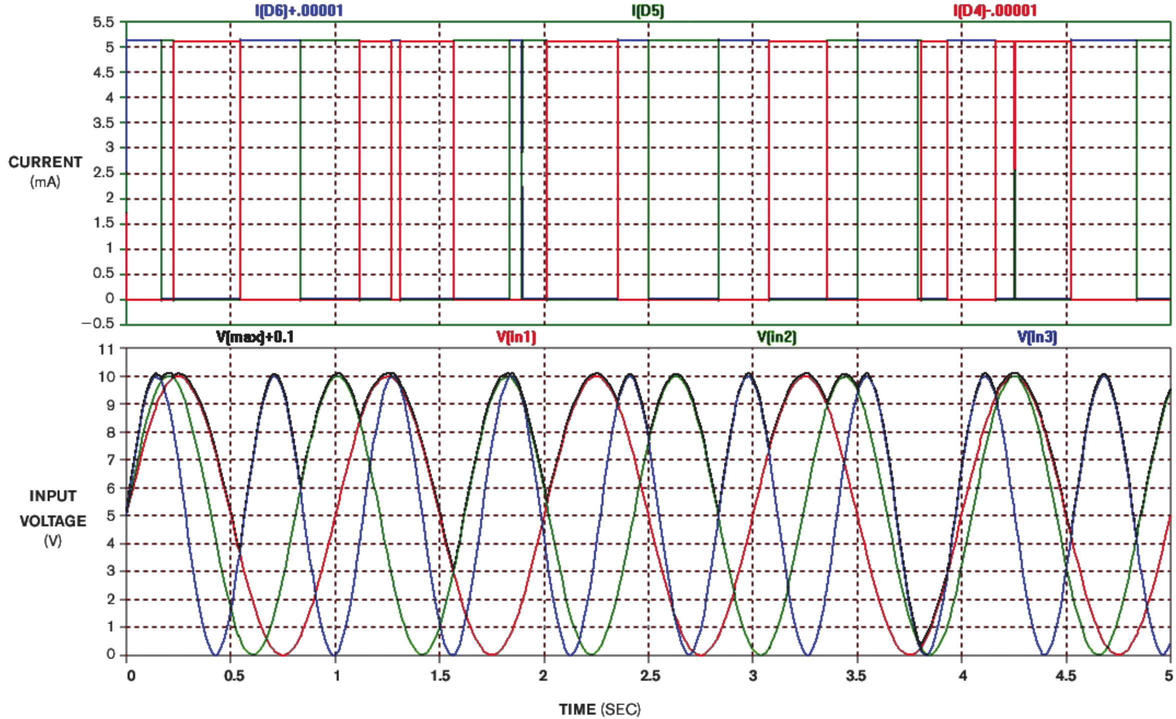

Figure 2 Three sine waves of different frequencies provide input voltages (lower traces) that evoke the greatest-of-three response in the current through R_2 (top trace, in which colored horizontal segments match the largest inputs).