

Noncascaded Arrangement Optimizes Bridged Amplifiers

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Low-voltage systems that drive loudspeakers often employ a bridged-amplifier configuration

that effectively doubles the voltage swing at the transducer (speaker). In a typical bridge-amplifier cir-

cuit, an ac-coupled inverting stage with gain is used to drive one side of the speaker (Fig. 1). This stage also drives a second unity-gain inverting amplifier. This amplifier, in turn, is used to drive the other side of the speaker.

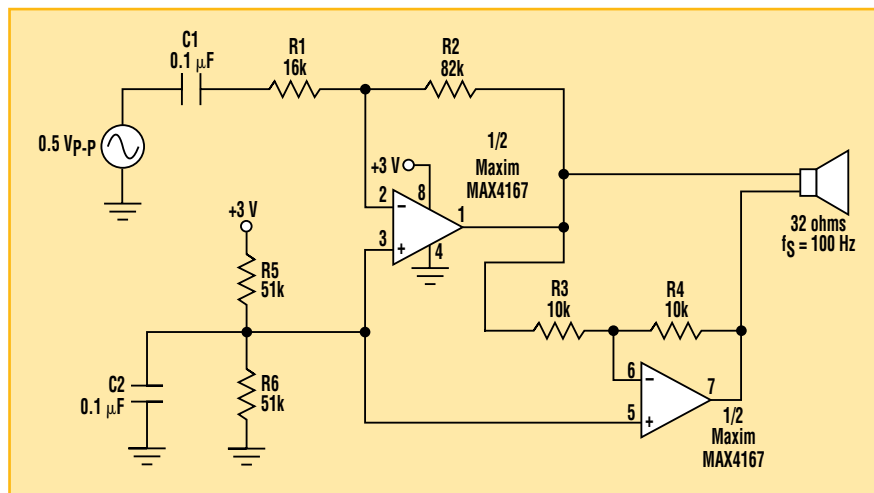
Usually, bridged amplifiers incorporate a matched pair of amplifiers. Yet in this configuration, the first amplifier dominates the overall performance since its output noise and distortion are replicated in the second amplifier.

This drawback can be eliminated by placing the two amplifiers in a noncascaded configuration. While one is inverting, the other is noninverting (Fig. 2). Since both amplify the same input signal, neither amplifier reproduces the noise, distortion, or clipping introduced by the other amplifier.

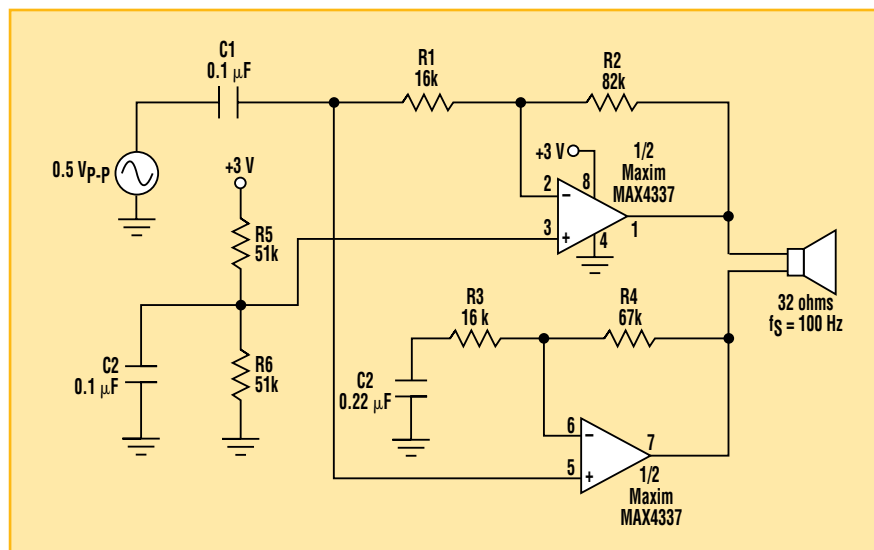
An additional improvement to the design in Figure 1 is the bias arrangement in the Figure 2 circuit. In this circuit, the dc bias for the noninverting circuit is derived from the inverting amplifier's source resistor (bias is required because the input is ac-coupled). Using the inverting amplifier's source resistor as a bias source lowers the component count and eliminates signal injection into the high-impedance bias source ($V_{CC}/2$ applied to the top amplifier's noninverting input).

Another advantage of the circuit in Figure 2 is the elimination of dc gain in the noninverting amplifier. For the circuit shown, C2 sets the -3dB point at half the input cutoff frequency. R1/C1 sets the input high-pass cutoff frequency at 100 Hz.

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1. This conventional bridged amplifier features two matched amplifiers in tandem.



2. This circuit optimizes the configuration in Fig. 1 by distributing gain between the two amplifiers. The elimination of dc gain in the noninverting amplifier also improves the design.

Thermostat For High-Altitude Atmospheric Sampler Is Fault-Tolerant

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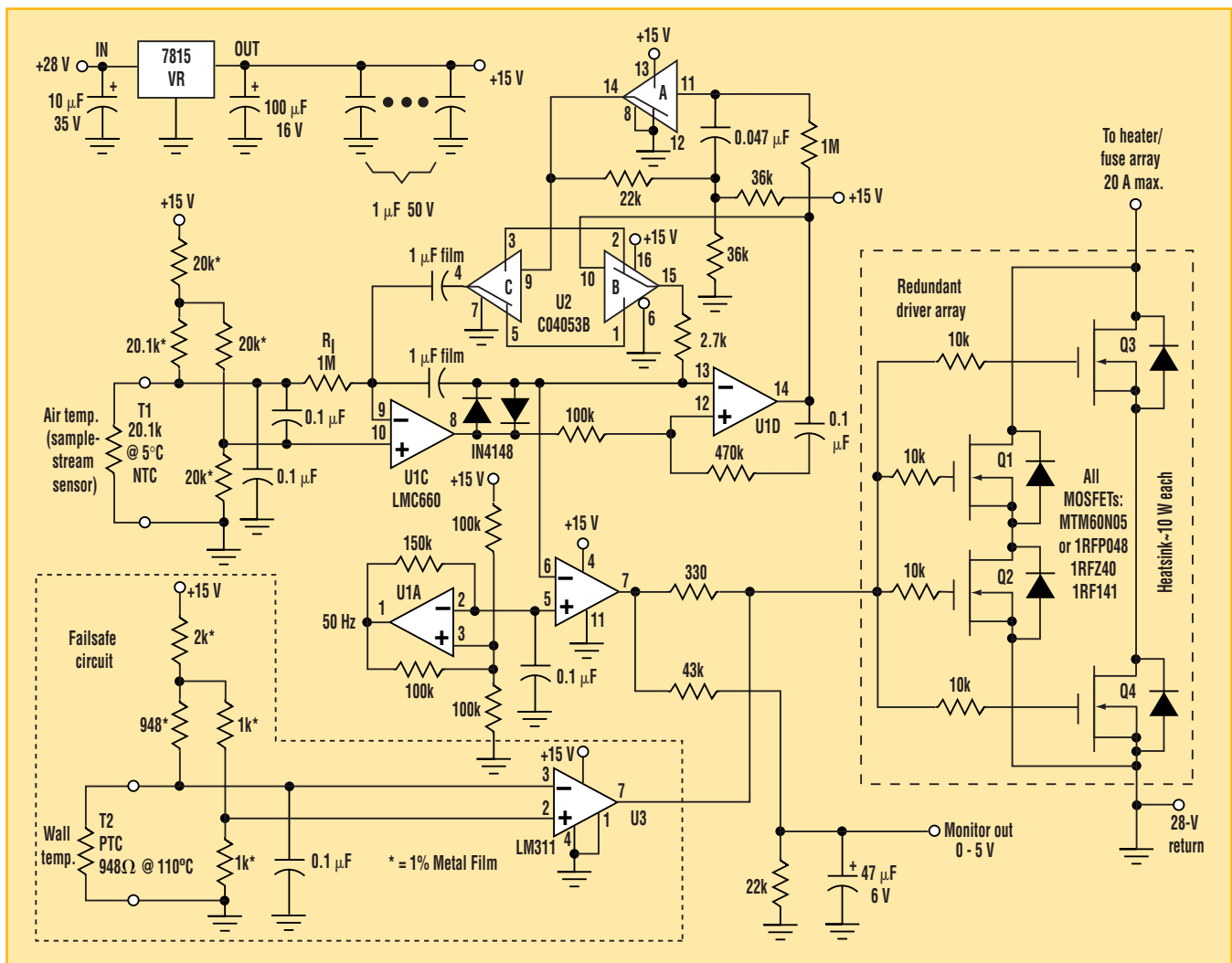
Among the many measures of good circuit design (e.g., cost, performance, and efficiency), none is more important than reliability. Usually, adequate expected reliability can be achieved by simply sticking to conservative design rules and good engineering practices. Yet in some critical applications, “any” unnecessary risk of failure may be unacceptable. At the same time, the trouble and cost of exhaustive environmental and life-cycle testing may be difficult to justify for one-of-a-kind research instruments. In

these cases (like the one shown here), special design-in-depth tactics may be the most cost-effective route to adequately bulletproof system designs.

In this example, an atmospheric analysis apparatus carried aboard a NASA ER-2 high-altitude aircraft is used in ozone-layer depletion research. This device incorporates an electrically heated, constant-temperature air-sampling probe. The probe warms the incoming air stream from the stratosphere (ambient temperatures from -70°C to 5°C , $\pm 1^{\circ}\text{C}$) for input to a laser spectrometer.

The large delta-T (about 75°C) and high flow rate (tens of liters per second) involved in this application dictate large heater power inputs—around 400 W. Consequently, any failure of the heater control circuits would risk severe thermal probe damage. Even if permanent probe damage doesn’t occur, in-flight thermostat failure would cause the loss of valuable scientific data and waste very expensive aircraft flight time.

To prevent these calamities, this design incorporates several backup provisions in the heater-control circuit-



This heater-control design incorporates several backup provisions for improved reliability, including parallel MOSFET outputs and a probe-wall overtemperature monitor.

ry. The central principle of operation of the thermostat is an analog implementation of the "Take-Back-Half" (TBH) algorithm (see "Take-Back-Half: A Novel Integrating Temperature-Control Algorithm," *ELECTRONIC DESIGN*, December 4, 2000; "Circuit Enables Precision Control In Radiant Heating Systems," January 8, 2001; and "Linear-RMS Phase Control Improves Thyristor-Based Thermostat," March 5, 2001).

The temperature of the sampled air stream is sensed by T1, an NTC thermistor. The resistance of T1 will equal 20.1 k Ω when the sample-stream temperature equals the 5°C setpoint, resulting in bridge balance. At any other sample-stream temperature, the voltage at the common node of T1 and the 20.1-k Ω reference resistor will not equal the voltage at pin 10 of U1C. This imbalance will cause an error current to flow

through R_T to the TBH integrator formed by U1C and the 1- μ F feedback capacitor. The resulting charge accumulation will cause pin 6 of U1B to ramp down for stream temperatures below the setpoint, and up for temperatures above the setpoint.

U1B compares the integrated error voltage to the 5-V p-p, 50-Hz triangle waveform produced by U1A. This comparison produces a square wave at U1B-pin 7, with a duty cycle that increases as the integrated error signal decreases. U1B's output is applied to the MOSFET array, resulting in an average heater power that can proportionate from 0 to 400 W in response to the integrator. Thus, the average heater power will gradually increase when the stream temperature is below the setpoint, and decrease when the temperature is too high. The net result is to drive tempera-

ture deviations toward the setpoint, as any good thermostat should. Meanwhile, the TBH principle forces steady-state convergence.

To enhance reliability, four MOSFETs are used for heater power switching where one would theoretically suffice. This lets the MOSFETs be arranged in a redundant series-parallel topology that permits uninterrupted operation even with any single MOSFET open and/or any single MOSFET shorted. As further safety backup to prevent overheating damage to the probe in the event of thermostat runaway, thermal override comparator U3 monitors the probe's wall temperature. The U3 override function will take over the degraded (but still useful) control of the heater drive if a primary U1 control-loop failure should ever allow the probe wall to heat beyond 110°C. \curvearrowright

"Manually Operated Digital Pot" Is Revisited

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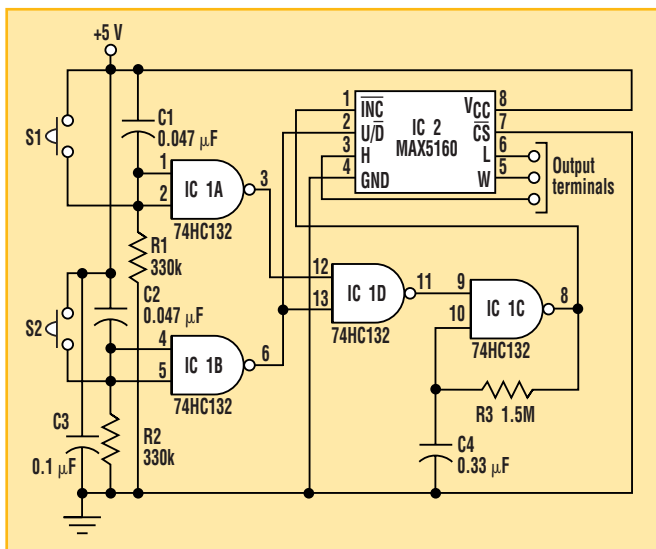
An idea for design published in the April 2, 2001 issue, "Manually Operated Digital Pot Doesn't Need A Microprocessor," uses two proprietary ICs to manually control a digital potentiometer. After reviewing this design, a simpler solution came to mind. This solution employs a commonly used

IC with fewer components, resulting in a much lower cost (see the figure).

IC1 is a quad, two-input NAND Schmitt trigger. IC1A, R1, and C1 form a debouncer for S1. Switch S2 is debounced by IC1B, R2, and C2. IC1C, R3, and C4 form an oscillator that's used as the clock signal for the digital pot. The oscillator is controlled by the status of S1 and S2 through IC1D. If no switches are pressed, both inputs of IC1D remain at logic high. This causes IC1D to output a logic low, which inhibits oscillation. The output of IC1C remains at logic high. When S1 or S2 is pressed, IC1D's output becomes high. This change generates a high-to-low transition on IC1C's output. This transition

forces IC2 to increase or decrease the wiper position of the pot by one step.

Holding down either S1 or S2 will allow the oscillator to continue running, stepping the pot's wiper position continuously. The oscillation frequency is around 3 Hz. Since the increase or decrease of the wiper position is controlled by the output of IC1B, pressing or releasing S2 determines the pot's direction. \curvearrowright



This simpler manual-control design for a digital pot uses less expensive, second-sourced components.

ifd winners

Elliott Simons, Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086. The idea: "Negative-Resistance Load Canceller Helps Drive Heavy Loads," March 19, 2001.

Ken Yang, Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086. The idea: "Manually Operated Digital Pot Doesn't Need A Microprocessor," April 2, 2001.

Victor Koren, Tioga Technologies, 32 Nachalat Yitzhak St., Tel Aviv 67448 Israel. The idea: "Programmable-Gain Amp Uses Arbitrary-Attenuation Step Ladder," April 16, 2001.

Iikka Marttila, VTT Information Technology, Otakaari 78, P.O. Box 1201, FIN-02044 Espoo, Finland. The idea: "Second-Order Audio Filter Performs Multiple Functions," April 30, 2001.