STATE OF SOLID STATE

Precision op-amps

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PRECISION OPERATIONAL AMPLIFIERS are the mainstay of medical and industrial instrumentation. Linear Technology Corporation recently introduced the LT1014 precision op-amp, which is the first improved replacement for such industry-standard, 14-pin quad op-amps as the LM324, LM348, OP-11 and 4156. The LT1014's 50–μV offset voltage, 0.3–μV/°C drift, 0.15–nA offset current, open-loop gain of 8 million, 117–dB common-mode rejection ratio and 120–dB power-supply rejection ratio definitely place it in the precision class.

The offset voltage of the LT1014 is so low that no offset adjustment terminals are provided on the IC. A new and improved output stage draws only 350 μA, can source or sink more than 20 mA, and still retains high voltage gain.

Another member of the family, the LT1013, is the first improved direct replacement for industry-standard, 8-pin dual packages such as the MC1458/1558, LM148 and OP-221. The LT1013's specifications are similar to, but slightly better than, the LT1014's.

Both the LT1013 and the LT1014 can be operated from a single 5-volt supply. The common-mode input range includes ground, and the output can swing to within a few millivolts of ground. Crossover distortion, a characteristic of early single-supply designs, has been eliminated. Linear Technology gives complete specifications for both single-ended 5-volt and ±15-volt operation.

Absolute maximum ratings are: supply voltage: ±22 volts, differential input voltage: ±30 volts, input voltage: equal to the positive supply voltage. Operating temperature range is −55°C to +125°C for devices with the AM and M suffixes, and 0°C to +70°C for devices with the AC, C and D suffixes.

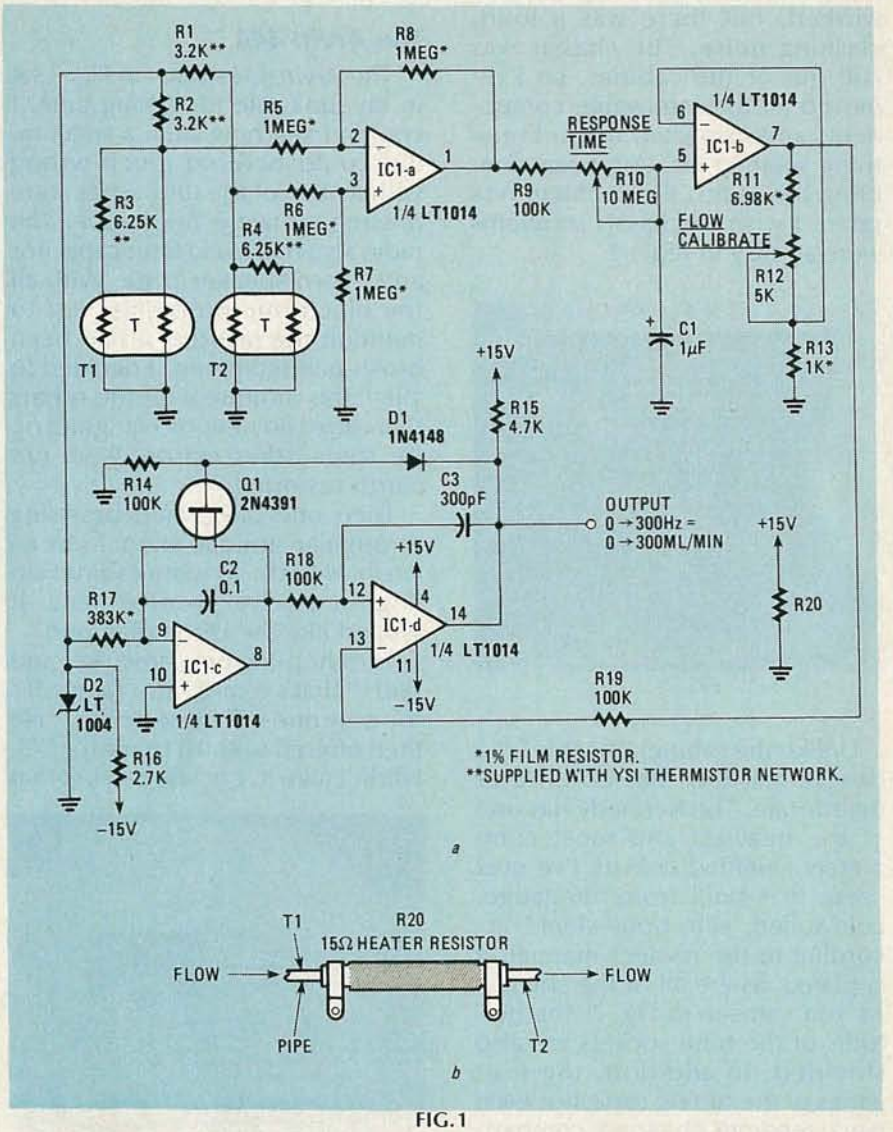

FIG. 1

Using the LT1013 and LT1014

In earlier single-supply designs using such devices as the LM124, LM158, OP-20, and OP-221, if the input goes more than a few millivolts below ground, two kinds of problems may occur, both of

which the Linear Technology devices provide protection against.

- If the input falls more than 400 mV below ground, transistors in the input stage saturate and phase reversal could cause lock-up in servo systems. The LT1013/1014 devices include unique phase-reversal protection circuitry that prevents the output from reversing phase, even when the inputs are as low as −1.5 volts.
- If the input falls more than a diode-drop below ground, the device could be destroyed because essentially unlimited current could flow from the substrate ($-V_{SS}$) to the input terminal. The LT1013/1014 devices are protected against that type of failure by a 4000-ohm resistor in series with each op-amp input.

There is one circumstance in which the phase-reversal protection circuity will not work: when the output of another op-amp in the same package is driven hard into negative saturation. In the LT1013, either op-amp can disable the other's protection circuitry. In the LT1014, amplifiers A and D can affect each other, but amplifiers B and C are completely independent of the former. Similarly, amplifiers B and C can affect each other, but amplifiers A and D are completely independent of them.

An application

Figure 1 shows a liquid-flow meter designed around an LT1014 (or two LT1013's). The rate of flow through the pipe is determined from the temperature differential that occurs as liquid flows through a heated section of pipe. The ambient temperature of the liquid is measured by thermistor T1 at the input end of the pipe. Thermistor T2 measures the temperature at the output end of the pipe. The temperature difference varies inversely with the rate of flow.

Op-amps IC1-*a* and IC1-*b* amplify the differential voltage developed by the thermistors, and op-amps IC1-*c* and IC1-*d* form a linear voltage-to-frequency converter. The output frequency ranges from zero (for a flow rate of zero) to 300 Hz (for a flow rate of 300 milliliters per minute). The rate of flow can be read directly on any audio-frequency meter.

The 15-ohm heater is a Dale Electronics 25-watt wirewound resistor, type HL-25. Thermistors T1 and T2 are YSI type 44201 thermistor networks available from Yellow Springs Instrument Co., Box 465, Yellow Springs, OH 45387. For additional information on the LT1013/1014 precision op-amps write to Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035. **R-E**

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broad categories, rigid and flexible. Here we will look at flexible endoscopes. Those use fiber optics to allow the viewing of regions deep inside the body.

Actually, modern technology allows physicians to do more than just look into those areas. It is possible to take tissue samples and even do surgery from a distance through a slender endoscope passed into the area of interest. That is possible because the structure of an endoscope contains several channels that run the full length of the instrument. Several of those channels carry the fiber optics. One fiber-optic channel is usually used for illumination (light sources used for endoscopes include tungsten projection lamps, lasers, and xenon and mercury arc lamps). A second channel can be used for viewing, taking photographs, and, if desired, making videotapes of procedures. Fiber-optic channels can also be used to transmit laser light for surgical cutting or for providing heat to close bleeding blood vessels. Other channels of the endoscope carry fluids for cleansing the area being viewed, suction for clearing away fluids and blood, and mechanical devices for cutting and taking biopsies (collecting samples of tissue).

Endoscopes of different diameters are used for different applications. Needle endoscopes, 1.7 millimeters in diameter, or instance, are used to examine the insides of knees and other joints. Similar instruments are useful in examining fetuses. Larger endoscopes are used in the gastrointestinal tract and other areas to find and treat tumors and bleeding blood vessels. Using such a device, foreign bodies can be found and removed, and other conditions can be diagnosed.

As we've seen, the field of medical optics has taken on new importance. Now, thanks to advances in such areas as fiber optics and lasers, it has become possible to visually examine and operate on many internal areas without resorting to conventional surgical techniques. And future advances are sure to make this area of medical electronics even more important and valuable in the coming years. **R-E**