DESIGN NOTES

1µA Op Amp Permits Precision Portable Circuitry – Design Note 163

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A new dual op amp with only 1µA power consumption and precision DC specifications permits high performance portable applications. The LT®1495 has 375µV offset, 2µV/°C drift, 1nA bias current and 100dB of open-loop gain. These attributes, combined with careful design, make portable, high performance circuitry possible.

5.5µA, 0.05µV/°C Chopped Amplifier

Figure 1 shows a chopped amplifier requiring only 5.5µA supply current. Offset voltage is 5µV, with 0.05µV/°C drift. Gain exceeding 10^8 affords high accuracy, even at large closed-loop gains.

Micropower comparators C1A and C1B form a biphase 5Hz clock. The clock drives the input-related switches, causing an amplitude modulated version of the DC input to appear at A1A's input. AC-coupled A1A takes a gain of 1000, presenting its output to a switched demodulator similar to the aforementioned modulator.

The demodulator output, a reconstructed, DC amplified version of the circuit's input, feeds DC gain stage A1B. A1B's output is fed back, via gain setting resistors, to the input modulator, closing a feedback loop around the entire amplifier. Amplifier gain is set by the feedback resistor's ratio, in this case 1000.

The circuit's internal AC coupling prevents A1's DC characteristics from influencing overall DC performance, accounting for the extremely low offset errors noted.

The desired micropower operation and A1's bandwidth dictate the 5Hz clock rate. As such, resultant overall bandwidth is low. Full power bandwidth is 0.05Hz with a slew rate of about 1V/s. Clock related noise, about 5µV, can be reduced by increasing C_{COMP}, with commensurate bandwidth reduction.

0.03% Linear V/F Converter with 13µA Power Drain

Figure 2's voltage-to-frequency converter takes full advantage of the LT1495's low power consumption. A 0V to 2.5V input produces a 0Hz to 10kHz output, with 0.03% linearity, 250ppm/°C drift and 10ppm/V supply rejection. Maximum current consumption is only 13µA, 200 times lower than currently available ICs. Comparator C1 switches a charge pump comprising D1, D2 and the 100pF capacitor to maintain its negative input at 0V. A1 and associated components form a temperature compensating reference for the charge pump. The 100pF capacitor charges to a fixed voltage;

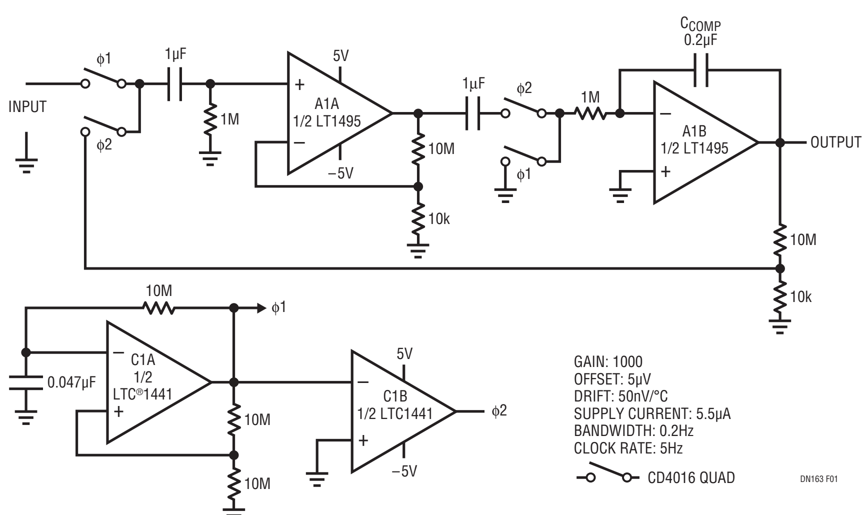

Figure 1. 0.05µV/°C Chopped Amplifier Consumes 5.5µA Supply Current

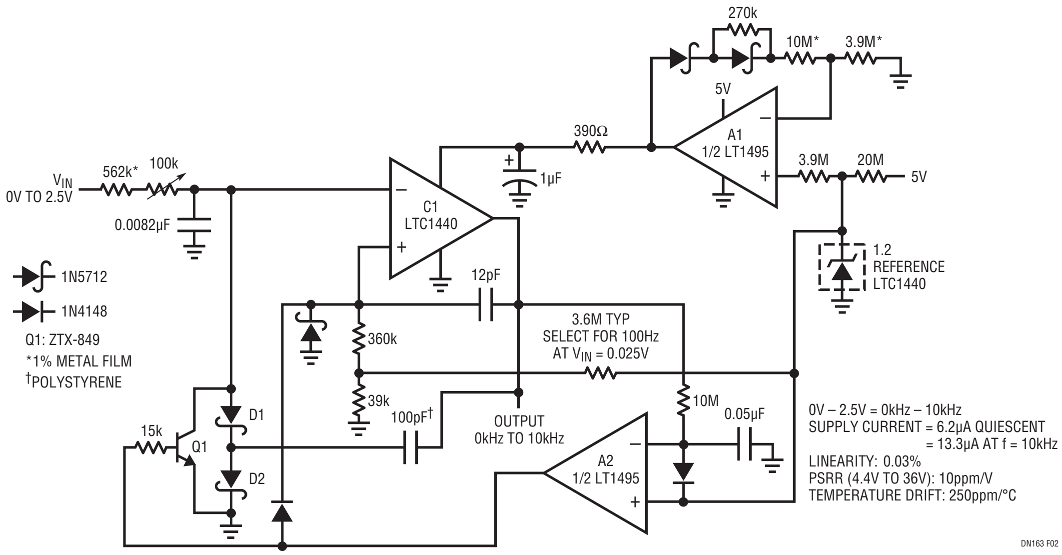

Figure 2. 0kHz to 10kHz Voltage to Frequency Converter Consumes Only 13µA

hence, the switching repetition rate is the circuit's only degree of freedom to maintain feedback. Comparator C1 pumps uniform packets of charge to its negative input at a repetition rate precisely proportional to the input voltage derived current. This action ensures that circuit output frequency is strictly and solely determined by the input voltage.

Start-up or input overdrive can cause the circuit's AC-coupled feedback to latch. If this occurs, C1's output goes low; A2, detecting this via the 10M/0.05µF lag, goes high. This lifts C1's positive input and grounds the negative input with Q1, initiating normal circuit action.

Portable Reference

A final circuit is Figure 3's unique portable reference, which draws only 16µA from a pair of AAA alkaline cells. Battery life is five years—equivalent to shelf life.

Two outputs are provided: a buffered, 1.5V voltage output and a regulated 1.5µA current source. The current source compliance ranges from approximately 1V to –43V.

The LT1634A reference is self-biased, completely eliminating line regulation as a concern. Start-up is guaranteed by the LT1495 op amp, whose output initially saturates at 11mV from the negative rail. The 1µA current output is derived from a fraction of the reference voltage impressed across R3.

Note that the portable reference's current output can be pulled well below common, limited only by Q1's 45V breakdown. The 1.5V output can source or sink up to 700µA and is current limited to protect batteries in case of a short circuit.

Once it is powered, there is no reason to turn the circuit off. One AAA alkaline contains 1200mAH capacity, enough to power the circuit through the five year shelf life of the battery.

The voltage output accuracy is about 0.17% and the current output accuracy is about 1.2%. Trim R1 to calibrate voltage (0.1%/kΩ) and R3 to calibrate the output current (0.4%/kΩ).

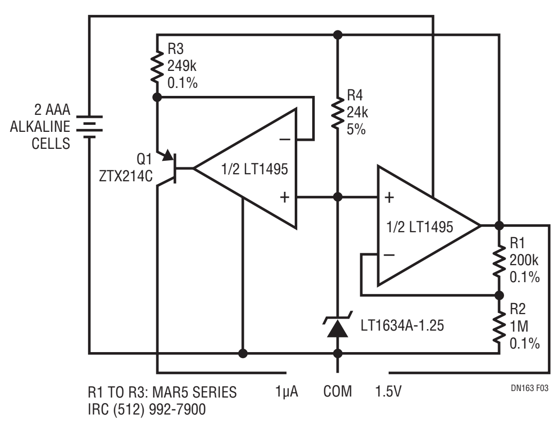

Figure 3. Portable reference Operates Five Years on One Pair of AAA Cells

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