Lowpass filter has improved step response

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A COMMON PROBLEM that arises when you design lowpass filters for signal conditioning is the filters' effect on the system's time-domain response. Because pushing the cutoff frequency lower slows the step response, the system may fail to recognize significant changes within a reasonable amount of time. The circuit in **Figure 1** accommodates lower cutoff frequencies without sacrificing the step-response time. A window comparator monitors the delta (difference) between the filter's input and output. When the delta exceeds ±50 mV, the filter increases its slew rate by increasing the cutoff frequency by an order of magnitude. The switched-capacitor filter, IC_1, normally operates as a self-clocked device. Capacitors C_1 and C_2 set the cutoff frequency at 0.1 Hz, and other circuitry forms a dynamic window comparator. Transistor pairs Q_1-Q_2 and Q_3-Q_4 form a complementary current mirror whose output flows through R_2 and R_3, creating a delta of ±50 mV. Connecting the output voltage to the center tap of the two resistors centers the delta on the output voltage. You therefore set the window comparator's upper threshold at V_{OUT}+50 mV and the lower threshold at V_{OUT}−50 mV.

R_4 and C_3 provide lowpass-filtering to the original input signal, producing a 312-Hz cutoff frequency that reduces sensitivity to momentary glitches. The filtered input drives the window comparator's input. If that input is outside the

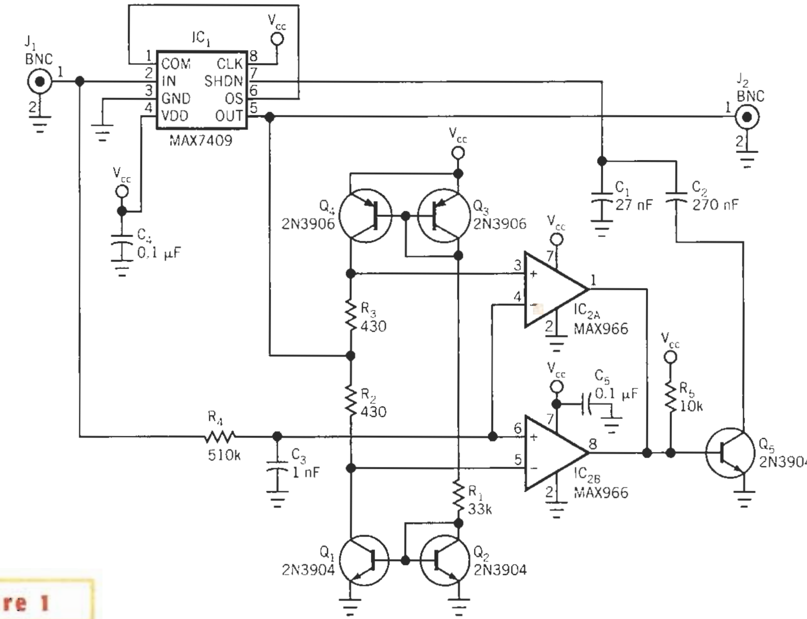
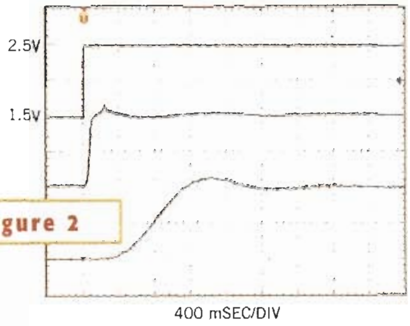


Figure 1

This lowpass filter maintains a fast step response by dynamically adjusting its cutoff frequency.

±50-mV window, comparator IC_{2A} or IC_{2B} asserts its output low. The low output drives Q_5 into cutoff, causing its collector to assume a high impedance. Because Q_5's collector no longer grounds capacitor C_2, the filter's cutoff frequency increases by a factor of 10. When the system's output changes to within 50 mV of the input, the cutoff frequency throttles back to its quiescent state. **Figure 2**'s oscilloscope photo shows the effect. The top trace is a step from 1.5 to 2.5V, the middle trace is the output with optimization circuitry enabled, and the bottom trace shows the filter's unmodified response. The optimized response includes a slight perturbation during the cutoff-frequency transition, but is five times faster than that of the unmodified circuit. The circuit in **Figure 1** is configured for low cutoff frequencies, but you can rescale it for higher frequencies by changing C_1 and C_2. You can also modify R_2 and R_3 for different window values, for which the delta equals the resistance multiplied by 115 μA. The comparator must be an open-drain type.□

Figure 2



These traces show the time-domain response for the circuit in Figure 1 with optimization circuitry (middle trace) and without it (bottom trace).