Saving Power in an AC-Coupled Amplifier Circuit

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AC-coupled circuits are often used for single supply operation to bring the input voltage into the input range of the amplifier. This circuit topology can be used in AC smoke detectors or in AC proximity sensors. Figure 1 shows an AC-coupled inverting-amplifier circuit.

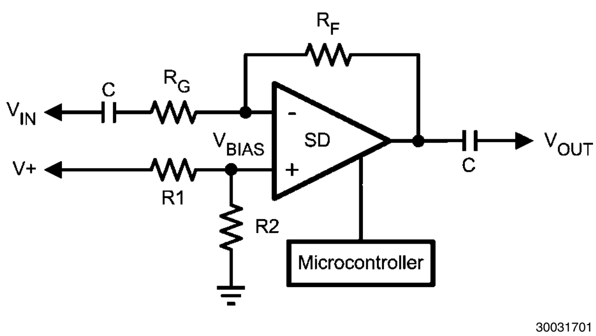

FIGURE 1. AC-Coupled Inverting Amplifier with Shutdown Pin

In the previous circuit, the non-DC input voltage is multiplied by the desired negative gain as follows:

$$V_{OUT} = -\frac{R_F}{R_G} \times V_{IN} + V_{BIAS}$$

The biasing voltage (V_{BIAS}) is half of the supply voltage (V+) and is added to the non-inverting input to bring the input voltage within the normal operating range of the amplifier. It also provides an off set for the output so that it is within its operating range.

In battery-operated circuits such as a smoke detector, an effective way to save power is to power down the circuit for a few seconds, and only sense smoke for a few microseconds. Usually when power saving is necessary, the conventional implementation is to power off the circuit by using an amplifier with a shutdown pin. This method has the disadvantage of allowing the coupling capacitors to discharge during the shutdown state. When the amplifier is turned on again, the circuit needs to reestablish the quiescent DC voltages. During this time, the amplifier's output is not usable because the output signal is a mixture of the amplified input signal and the charging voltage on the coupling capacitors. And the settling time can range from several microseconds to several milliseconds, depending on the resistor and capacitor values.

LPV531 Programmable Amplifier

The LPV531 programmable operational amplifier is ideal for AC-coupled circuits; its programmable-power mode allows the circuit to be kept active to maintain, in low-power mode, a quiescent charge on the coupling capacitor. The advantage of this method is the reduction of time needed to reestablish a quiescent operating point when the amplifier is switched to full-power mode.

The LPV531 op amp offers the capability to adjust the supply current, which is made possible by the ISEL control pin. The supply current is 40 times higher than the ISEL current. The maximum current that can fl ow from the ISEL pin is determined by an internal 110 mV reference voltage, and an 11 kΩ internal resistor. The supply current can be reduced by connecting an external resistance to the ISEL pin.

$$I_S = I\ \mu A + 40 \times \frac{110\ mV - V_{CONTROL}}{R_{EXT} + 11\ k\Omega}$$

Figure 2 shows an example of how to control the supply current.

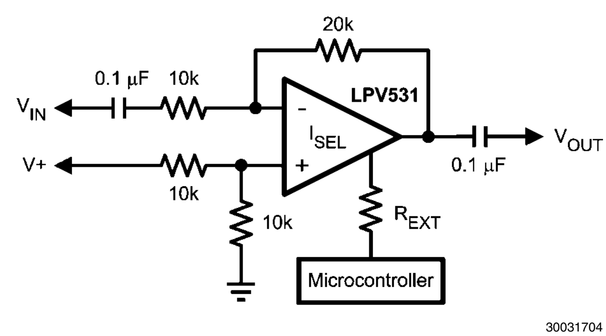

FIGURE 2. AC-Coupled Inverting Amplifier with the LPV531 Amplifier

The power mode of the amplifier can be controlled by the microcontroller. By increasing the control voltage up to 110 mV, the supply current of the amplifier will decrease. Therefore it is possible to choose between a full-power mode and a low-power mode, while maintaining an active circuit. Figure 3 illustrates the relationship between the control voltage and the supply current of the amplifier.

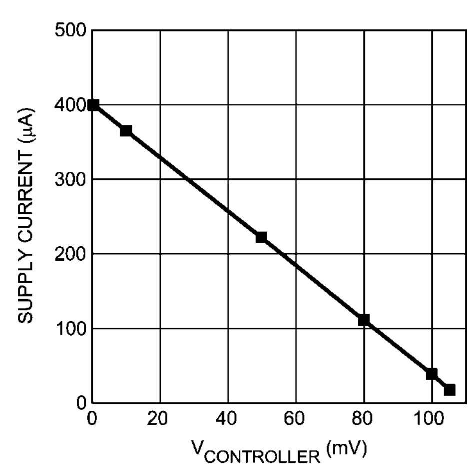

FIGURE 3. Power-Mode Control (R_{EXT} = 20Ω).

Faster Settling Time With The LPV531 Amplifier

Comparing the results obtained with the LPV531 op amp and an amplifier with shutdown mode such as the LMV981 will further illustrate the much shorter settling time. Figure 4 shows the measurement obtained with the LPV531 amplifier.

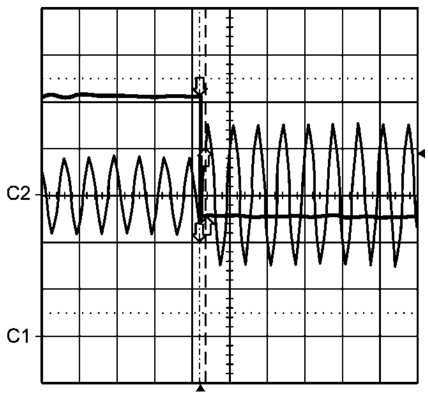

FIGURE 4. Output Signal with the LPV531 Op Amp

The yellow line is the control voltage. When the control voltage passes from high level to low, the amplifier switches to full-power mode. As Figures 3 and 4 indicate, we can estimate that for a control voltage of 105 mV (low-power mode), the supply current is 20 µA. For a control voltage of 55 mV (high-power mode), it is 200 µA. The yellow signal is the output signal, where we can estimate that the settling time to obtain a stable signal is around 634 ns.

Figure 5 shows the results obtained with the LMV981 amplifier featuring a shutdown pin. The voltage applied on the shutdown pin is the yellow signal. To shut down the LMV981 amplifier, the turn-off voltage is 0.55V. The turn-on voltage to enable the device is 1V.

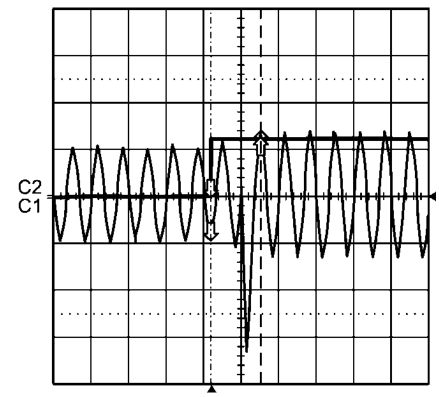

FIGURE 5. Output Signal with an Amplifier with Shutdown

The measurement illustrates the fact that the set-up time is really longer with this kind of circuit. The circuit needs approximately 6.7 µs to be stable, which is ten times more than the circuit using the LPV531 op amp. During this settling time, the output signal is not usable.

Conclusion

This article has shown that the LPV531 amplifier is ideal for use in AC-coupled applications to reduce the settling time of the output signal by maintaining a quiescent charge on the capacitors. For battery-operated applications which are non-AC coupled, the LMV981 amplifier is a very good choice. This amplifier can be supplied from 1.8V to 5V, has a supply current of only 100 µA, and has rail-to-rail input and output.

Notes

Notes

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