Ask The Applications Engineer—1

by James Bryant

MULTI TROUBLES

Q. *My multiplexed ADC system is misbehaving . . .*

A. Before you go any further, have you grounded all unused multiplexer channels?

Q. *No. But how did you know?*

A. Because the floating terminal is one of the commonest causes of problems in systems containing CMOS multiplexers. Unused MUX inputs and outputs (whether integrated into a multiplexed ADC or part of a self-contained MUX chip) can pick up signals from stray fields and inject them into the device's substrate, turning on spurious substrate devices. Then, even when the unused channel is turned off, the performance of the *on-channel may be* badly degraded (at *the* unlikely extreme, *the* injection may turn on a spurious four-layer device and destroy some chips).

Whenever a MUX is used, all its inputs and outputs must be connected to a potential between its supply rails. The best way to deal with unused channels is to ground them, but they may be connected to a more-convenient potential within the rails. ▶

TROUBLE FROM THE START

Q. *To save power, my ADC is powered up only to make a measurement. The system is very accurate in continuous operation, but unpredictable when power is strobed. Why?*

A. When an ADC's power is switched on only to perform a conversion, it may misbehave for three reasons: slow reference turn-on, random initial logic states, and system latch-up.

For various reasons—thermal stabilization, capacitance charging, slow starting of regenerative current mirrors using PNP transistors in band-gap references— it is not uncommon for some voltage references to have relatively large errors for many milliseconds after power-up. Such errors in an ADC's external or internal reference during conversion lead to inaccurate results.

At turn-on, a typical ADC's logic will be in a random state; for a conversion triggered at that time, the ADC may not be able to perform correctly. With one conversion triggered, the logic should return to its correct pre-conversion state—but cases exist where two conversion cycles are necessary before the ADC is certain to perform a valid conversion. Hence, a good general rule is to perform two "dummy" conversions after powerup before relying on the results. (It is also well to recall that some ADCs react badly to having a conversion triggered before the previous conversion is complete; when this happens, one or two "dummy" conversions may be needed to return the logic to a known state.)

If an ADC's external logic is arranged so that the end of the ADC "Busy" signal starts a delay which ends with the start of the next conversion, it is important to realize that if the converter powers up in the Busy state, the Busy signal may remain latched up until a conversion Start pulse has been received. In this case, such a system cannot self-start. If the Busy signal is always present on power-up the problem is almost certain to be recognized—and addressed—during the design of the system; but if the Busy signal is only occasionally present on power-up the system may latch unpredictably. As a rule, control signals to an ADC during start-up should not depend on the logical state of Busy. ▶

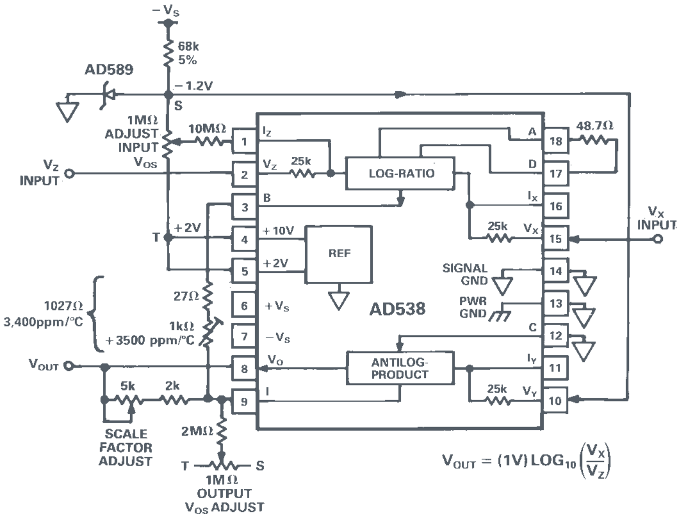
ABOUT LOG COMPENSATION RESISTORS

Q. *Designs of logarithmic circuits*, including those using the AD538 $Y[Z/X]^m$ unit: (for example, Figure 6 from the AD538 Multifunction Unit data sheet†) call for "kT/q compensation resistors". What are they and where do I get them?*

A. The V_{BE} difference across two opposed silicon junctions, one carrying a current, I, and the other a current, I_{REF}, is $(kT/q)\ln(I/I_{REF})$. Here, k/q is the ratio of Boltzmann's constant to the charge on an electron (about 1/11,605 K/V), and T is the absolute temperature in kelvins.

Although employing similar junctions in isothermal pairs eliminates the effects of temperature-sensitivity of reverse saturation current, the kT/q term is still temperature-dependent. To eliminate this dependency in the application, the logarithmic voltage must be used in a circuit whose gain is inversely proportional to the absolute temperature of the junctions. Over a reasonable range of temperatures near 20°C, this may be arranged by the use of a gain-setting 1-kΩ resistor having a positive temperature coefficient of approximately 3,400ppm/°C—and keeping it at the same temperature as the junctions.

A 3,500 ppm/°C resistor is available from Tel Laboratories, 154G Harvey Road, Londonderry, New Hampshire 03053 (603)-625-8994, Telex: (710)-220-1844, designated Q-81, and from the Precision Resistor Co. Inc., 10601, 75th. St., Largo, Florida 33543 [(813)-541-5771 Telex: 821788], as the PT146. Analog Devices offices in most European countries are aware of local suppliers of these resistors. ▶



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*Much useful information about logarithmic and other analog function circuits can be found in the Nonlinear Circuits Handbook, published by Analog Devices ($5.95), P.O. Box 9902, Norwood MA 02062.

†See The Best of *Analog Dialogue* 1967–1991, pp. 164-167.