Multiple ADC Grounding

by Dr. Howard Johnson. First publ. in EDN magazine, February 2001

Several of you wrote about ADC Grounding (*EDN*, Dec 7, 2000, pg 36) to ask if the lessons from that article apply if you have more than one ADC .

The main thrust of the previous article is that each ADC needs a solid connection between its analog and its digital grounds. As I pointed out in the article, "Any voltage differences between the points at which you connect these pins may interfere with the [ADC] chip's ability to communicate across its own internal analog-to-digital boundary."

If you have a lot of ADCs on the same board all leading to the same digital processor, then the various ADC grounds must *at some point* be tied together.

In a low-resolution, 8-bit system, which needs only about 60 dB of noise rejection, you can use one big, solid ground plane for all the analog channels and the digital logic. A good layout physically separates the analog circuits from the digital circuits to control crosstalk. This architecture satisfies the requirement of tying together AGND and DGND and often works for multiple A/D converters.

In higher resolution systems requiring more noise isolation, you might worry about stray digital currents flowing across the analog-ground region of your pc board. These currents can interfere with some extremely sensitive analog circuitry.

In general, when you encounter undesirable currents flowing in a particular pathway, you can address the problem through one of three approaches:

1. Reduce the level of the aggressive signal.
2. Disrupt the stray current by putting a high impedance in series with it.
3. Introduce a low-impedance element to shunt the stray current somewhere else.

The first approach reminds you to always select the lowest speed logic possible commensurate with the operational requirements of your system design. Physically moving the digital layout far enough back from the analog circuitry also helps.

The second item suggests that you use a differential, transformer-coupled, or optically coupled floating analog inputs. Such inputs do not require a direct ground-to-ground connection, and thus do not encourage the flow of stray common-mode currents in your analog ground region. If you have such inputs, you can use a variation of the Mickey Mouse approach described in "ADC Grounding", and shown here in Figure 1. Chop your pc ground into N+1 regions—one analog region for each ADC and one common digital region for everything else. Tie each analog-ground region to the digital ground at one place, directly under its respective ADC. The slots between regions disrupt the flow of currents in the ground plane. Wire each analog region accepts so it accepts its analog signals through floating connections, directly into the analog region (if you have floating inputs don't connect them to the common ground area as shown at the bottom of Figure 1, just route your cabling straight into each section as needed). Because each analog-ground region connects in only one place to the rest of the system, each analog-ground region acts like a dead end for stray digital currents, preventing them from going in. Once you've cut up the ground plane, never route pc traces across the slots.

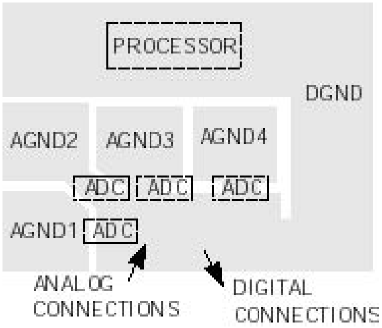

Figure 1—This layout incorporates five isolated ground regions, one for each ADC plus one more for the processor, all connected to the central region at the bottom, which ties to the product chassis.

Chassis-referenced inputs introduce complications, because each analog-ground region must touch *two* grounded objects: (1) the ADC ground, and (2) the chassis-ground reference for its input signal. Unfortunately, any analog-ground region touching two other grounds attracts stray currents, which defeats the purpose of isolation. The ground topology in Figure 1 avoids that complication, routing all its analog inputs from one common area, fanning them out to the various analog regions as needed, and keeping them isolated from the noisy digital processor located on the "flag lot" at the back of the card. This approach assumes you can obtain adequate isolation between the analog and digital inputs and outputs as they route through the common zone. This approach works well in systems that have fast processors (very noisy) but send out relatively slow-speed signals (like T1 or T3 telephone interfaces, which by today's standards are quite slow).

Hint

For best isoation in the central region, route the analog signals on the top layers of the board and the digital ones on the back.

If you absolutely insist on chassis-referenced analog signals, and also chassis referenced digital I/O, and you can't truly isolate the connection between the analog and digital regions, then your only hope may be the third approach. To make a shunt, provide a solid- metal sheet underneath the pc board that connects to the edges of all the various pc-ground regions (Figure 2). The solid-metal sheet, which should contain no holes, acts as a low-impedance shunt around each analog-ground region, somewhat reducing the impact of stray digital currents on that analog region. Shunting also across the digital region provides a reciprocal benefit, adding a few more dB's of isolation. If you try this technique, fabricate boards with and without the ground connections, so you can quantitatively measure the difference in performance. It may take a few passes to learn what works for your geometry.

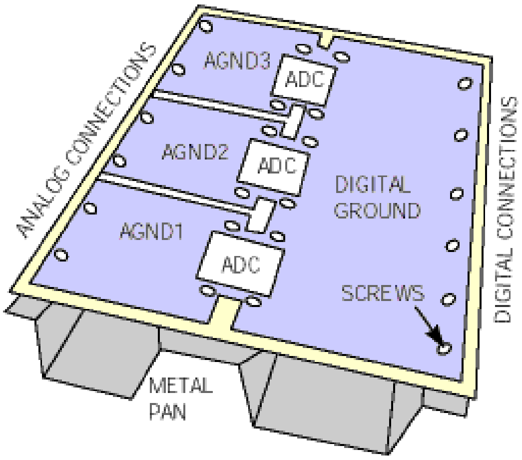

Figure 2—Chassis-referenced inputs sometimes benefit from a solid-metal pan underneath the pc board, which shunts across each ground region.
