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Other Parts Discussed in Post: ADS1278, ADS1220, ADS1247, TIPD120

OK so power supplies are important – what more can I do?

My previous post explained the impact that power supply variation and noise can have on analog-to-digital converter (ADC) performance. Thankfully, your data acquisition systems are not doomed. Here are four steps that you can take to ensure that your ADC is less susceptible to variation and noise in your power supplies.

1. Choose an ADC with a good power-supply rejection ratio (PSRR). Of course, the best way to protect your system performance from its power supply is to choose an ADC with sufficient PSRR to begin with. If the ADC you've chosen does not quite meet your PSRR needs, you can increase system PSRR by adding a high-PSRR low-dropout regulator (LDO) after your original switching supply source. This will help clean up any remaining ripple and directly add to the total system PSRR. Take a look at high-PSSR LDOs like the 3-V to 36-V, 150-mA, ultra-low noise TPS7A4901.

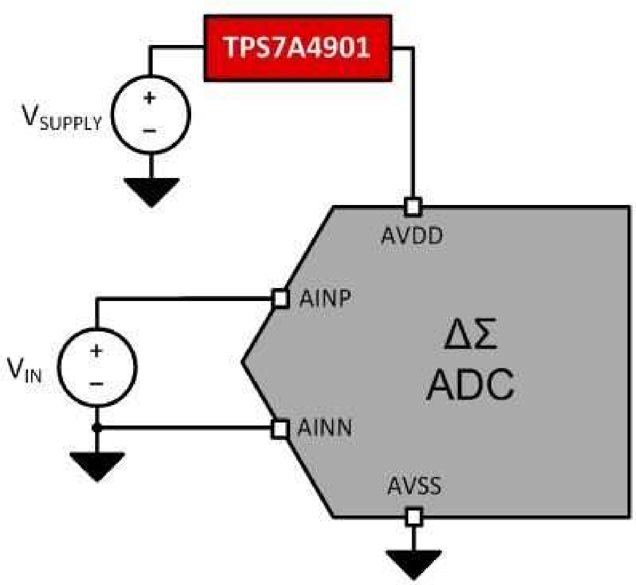

Figure 1: TPS7A4901 added to improve power supply rejection

- **2. Proper decoupling and filtering.** Power supply decoupling generally takes place at two points in the system: at the supply source and at the device supply pins. Larger "bulk" decoupling capacitors (typically 1μF and above) are often placed directly at the supply output and connected to ground. This helps stabilize the supply and immediately filter as much of the supply noise as possible. Sometimes, you can place extra bulk capacitors closer to the ADC pins if you expect the current draw to be large.

  Place additional smaller or "local" decoupling capacitors (typically 1μF and below) closest to the ADC supply pins to help filter away any noise picked up along the way. Using two local decoupling capacitors (i.e. 1μF and 100nF) in parallel will provide low impedance over a wider frequency range.

3. Pay attention to layout. Treat the routing of your power supplies like all other important analog signals. You want to provide the most direct and least inductive path from the supply source to the ADC supply pins. If you cannot use power planes, keep the traces short and direct, yet wide enough to handle the expected current flow. Route supply traces directly over a ground plane to allow the return current to get back to the source as easily as possible.

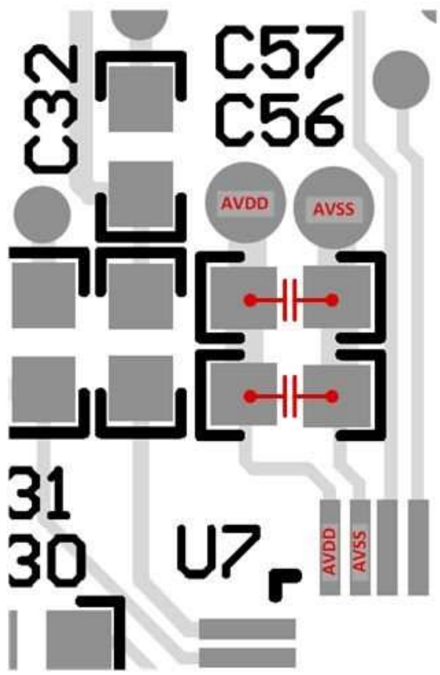

Figure 2: Layout example of local decoupling capacitors

Low inductance is especially important when dealing with transients. High inductance could "choke" the supply when the ADC demands a sudden increase in supply current, such as during power-up. If there is any inductance between analog and digital grounds, a transient may produce a voltage difference between them that exceeds the absolute maximum ratings, causing permanent damage to the ADC.

- Figure 3 shows that some devices, like the ADS1278, have a very tight restriction on the allowable voltage difference between AGND and DGND.

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range unless otherwise noted[(1)]

	ADS1274, ADS1278	UNIT
AVDD to AGND	–0.3 to +6.0	V
DVDD, IOVDD to DGND	–0.3 to +3.6	V
AGND to DGND	–0.3 to +0.3	V

Figure 3: Absolute maximum rating for ADS1278 AGND and DGND

4. Be aware of certain power supply frequencies. If power supply noise does find a way past the filtering and decoupling, delta-sigma ADCs have one last line of defense: the digital filter. One of the most important functions of the digital filter is to attenuate out-of-band signals; however, the filter response repeats itself and returns to 0dB at multiples of the modulator sampling frequency (f_{MOD}). Power supply noise near these frequencies can alias back into the signal bandwidth of interest.

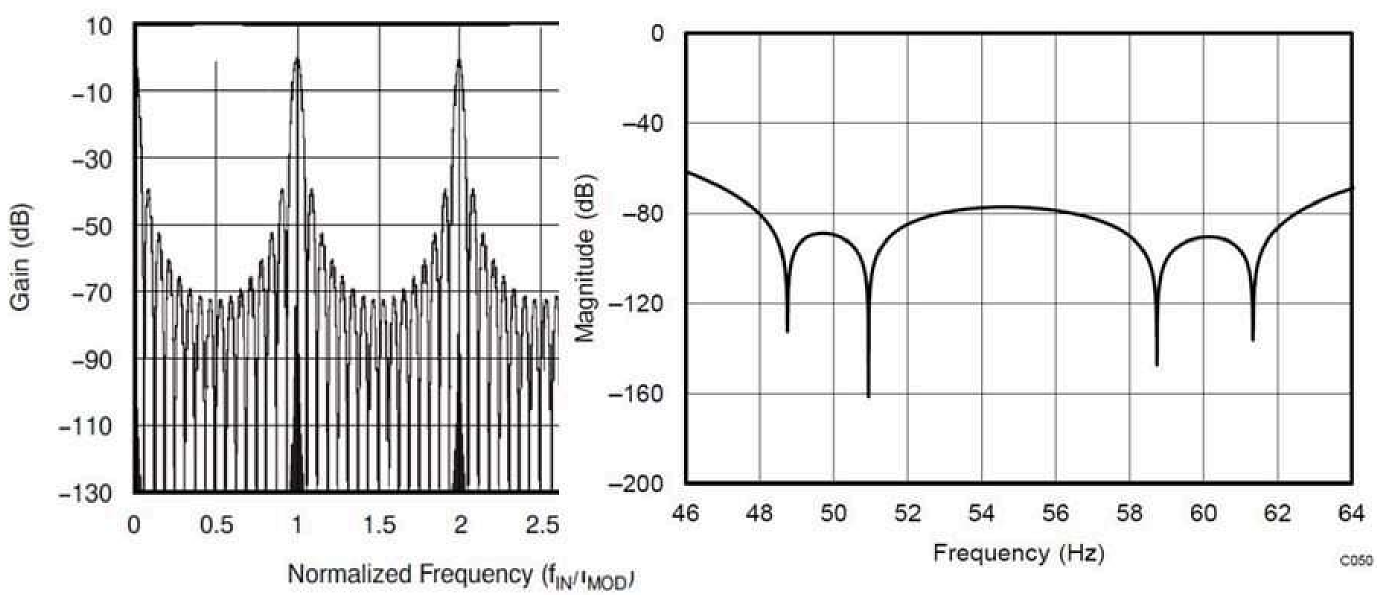

Figure 4: Sinc-3 filter response out to 4 x f_{MOD} in the ADS1298 (a) and simultaneous 50Hz and 60Hz rejection in the ADS1220 (b)

If you must use a switching power supply, synchronize it to an exact multiple of the output data rate. Depending on the filter response, the tone at the switching frequency will either fold back to DC or will be attenuated by the filter notches. Some precision ADCs, like the 24-bit ADS1220 and ADS1248, include additional filter notches at 50Hz/60Hz for select output data rates.

I hope that parts 1 and 2 of this blog series gave you a high-level understanding of how power supplies can affect ADC performance and how to mitigate their impact in your system. Remember to pay more attention to the design of your power supplies next time!

Additional resources

- Check out the TIPD120 reference design to see the ADS1247 delta-sigma ADC and the TPS7A4901 in action in the TI Designs library.
- Take a look at how to deal with rejection when designing with instrumentation amplifiers by fellow TI applications engineer John Caldwell.
- Search TI's precision ADC portfolio, including ADCs like the ADS1220 and ADS1262, for temperature measurement and programmable logic controller (PLC) applications.
- Download the new e-book, "Best of Baker's Best: Delta-Sigma ADCs," which compiles the best of short articles about delta-sigma ADCs by popular EDN columnist and TI analog applications engineer Bonnie Baker (myTI login required).
- Don't forget to check out other posts by my colleagues with design tips and delta-sigma ADC basics.