CircuitClarity RESOURCE

Understanding ADC and DAC performance metrics

https://circuitclarity.com/resources/data-converter-performance-metrics/

The decision this guide supports

Resolution, LSB size, ENOB, SNR, SINAD, THD, offset, gain error, INL, DNL, settling, and sample conditions describe different limits.

A useful calculation is not the finish line. It becomes useful when its method, units, source conditions, and omitted effects fit the actual design question. Use this reference to identify that boundary before treating a nominal result as an implementation decision.

DECISION MAP

From first estimate to defensible next step

1. **Identify which specific metric the design decision actually depends on.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Confirm the test conditions (input frequency, amplitude, sample rate) behind that metric.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Distinguish resolution-based limits (LSB, quantization) from measured dynamic limits (SNR, SINAD, THD).**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Compare only metrics measured under matching conditions.**
   Treat this as the handoff point. Compare the result with selected-part evidence, the real layout or assembly, and a measurement method that can reveal the remaining uncertainty.

Worked design review

Consider a designer using this method to make a first selection. The initial estimate establishes the nominal target, but it should not silently absorb a rating, curve, parasitic, temperature condition, or measurement setup from a different scenario. The correct outcome is often not a single chosen value: it is a short list of conditions that must be satisfied together.

Begin with the first two steps above, then ask whether the value still fits when the most consequential real-world condition changes. If it does, the estimate has earned a more detailed check. If it does not, the discrepancy identifies the design variable that deserves attention before a board, part, or test plan is committed.

> **Practical interpretation**
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> A converter metric is only meaningful under the specific test conditions it was measured at; comparing metrics from mismatched conditions is comparing different quantities. That is not a weakness in the method. It is the cue to use the correct next source of evidence.

Questions to take into a design review

- Is the specific metric being used (resolution, ENOB, SNR, SINAD, INL, DNL) actually the one this design decision depends on?
- Were the metrics being compared measured under matching input frequency, amplitude, and sample-rate conditions?
- Has the difference between calibratable errors (offset, gain) and non-calibratable errors (INL, DNL) been accounted for in the accuracy budget?

These questions prevent a common failure mode: moving a correct equation into a context where its assumptions no longer hold. They also make it easier for another engineer to reproduce the reasoning and identify which condition needs more evidence.

Common ways this reasoning goes wrong

Comparing SNR or SINAD figures measured at different input frequencies or amplitudes

Converter dynamic-performance metrics are measured under specific test conditions; a figure quoted at one input frequency is not directly comparable to one measured at a different frequency or amplitude.

Assuming a high resolution number guarantees a correspondingly low noise floor

Resolution describes the number of quantization levels the converter is designed for; the actual achievable ENOB depends on the converter's real analog noise and distortion, which can be substantially worse than the ideal quantization-noise floor implied by resolution alone.

Treating INL and DNL errors as something offset and gain calibration can remove

Offset and gain calibration corrects a linear shift and slope error in the transfer function; INL and DNL describe nonlinear, code-dependent deviations that a simple two-point calibration cannot correct.

Where this guide stops

A converter metric is only meaningful under the specific test conditions it was measured at; comparing metrics from mismatched conditions is comparing different quantities.

For a consequential design, preserve the inputs and conditions used here, then compare them with the selected component or system evidence. That makes the follow-up review faster and keeps a useful first estimate from becoming an unsupported claim.

Frequently asked questions

▶ **What is the difference between resolution and ENOB?**

▶ **Why does SINAD differ from SNR?**

▶ **Are INL and DNL the same kind of error as offset and gain error?**

Related engines

- **ADC quantization-noise estimator**
- **Clock-jitter SNR limit**
- **DAC settling and update-rate planner**

Method authorities and source conditions

Use this guide alongside the engine-specific method and selected component or system data. The underlying reference families are Analog Devices toolbox references, Analog Devices tools references. Those sources establish condition-specific behavior; CircuitClarity uses them to frame the decision and its limits.