CircuitClarity RESOURCE

Electronics noise fundamentals

https://circuitclarity.com/resources/electronics-noise-fundamentals/

The decision this guide supports

Noise numbers only become comparable when reference impedance, temperature, bandwidth, weighting, density units, and integration method are explicit. A small density can still produce material total noise over a broad band.

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. **State source, temperature, impedance, and frequency range.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Use the appropriate density or spectral model.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Integrate through the actual equivalent noise bandwidth.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Include amplifier, source, aliasing, and measurement terms.**
   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**
>
> Ideal Johnson noise does not include amplifier noise, interference, nonlinearity, or sampling artifacts. 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

Was the equivalent noise bandwidth used for RMS integration, not just the filter's 3 dB bandwidth?

Are the reference impedance, temperature, and bandwidth stated explicitly whenever a noise figure is compared or combined with another?

Does the total noise estimate include amplifier, aliasing, and interference terms, not just the ideal Johnson-noise floor?

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

Integrating a noise density over the filter's 3 dB bandwidth instead of its equivalent noise bandwidth

The equivalent noise bandwidth of a real rolloff is wider than the 3 dB bandwidth; using the 3 dB figure directly in an RMS-noise integration understates the actual total noise.

Comparing two noise specifications quoted at different reference impedances or temperatures

A noise density or voltage figure is only comparable to another one measured or specified under the same reference impedance, temperature, and bandwidth conditions; comparing mismatched conditions is comparing different quantities.

Treating the ideal Johnson-noise floor as the entire system noise budget

Amplifier input-referred noise, source resistance noise, aliasing from sampling, and interference pickup all add to the thermal floor; a system noise estimate that stops at the ideal resistor-noise calculation is incomplete.

Where this guide stops

Ideal Johnson noise does not include amplifier noise, interference, nonlinearity, or sampling artifacts.

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

▶ **How can a tiny noise density number (like 5 nV/√Hz) add up to a noticeable voltage?**

▶ **Is the noise bandwidth the same as the 3 dB bandwidth of a filter?**

▶ **Does a resistor's Johnson noise depend on the current flowing through it?**

Related engines

Johnson noise calculator

Shot-noise calculator

Integrated noise calculator

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 precision references. Those sources establish condition-specific behavior; CircuitClarity uses them to frame the decision and its limits.