CircuitClarity RESOURCE

Building an analog error budget

https://circuitclarity.com/resources/analog-error-budgets/

The decision this guide supports

An error budget becomes useful only when every term is placed at a common reference node and its statistical or bounded nature is declared. A single device specification never tells the complete system error story.

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. **Choose an input- or output-referred reference node.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **List offset, bias, resistor, CMRR, PSRR, temperature, and noise terms.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Separate bounded worst-case terms from independent random-like terms.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Identify the dominant contributor before changing a part.**
   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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> The budget must use data-sheet conditions that match the real circuit and does not replace dynamic or stability validation. 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

Are every term's reference node (input-referred or output-referred) and units consistent before they are combined?

Has each term been classified correctly as a bounded worst-case contributor or an independent random one before choosing how to combine it?

Do the data-sheet conditions used for each term (temperature, supply, common-mode range) match the real circuit's operating envelope?

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

Combining a bounded worst-case term with an independent random term the same way

A fixed offset voltage and a random noise term answer different statistical questions. Summing them with the same method (all worst-case, or all RSS) either overstates or understates the real combined error.

Using a typical data-sheet value where the design needs a guaranteed maximum

Typical values describe the center of a manufacturing distribution, not a worst-case bound. A budget built on typical numbers will not hold up in production without adding margin.

Forgetting temperature drift because room-temperature numbers looked acceptable

Offset, gain, and bias-current specs each carry their own temperature coefficient. A budget that passes at 25°C can fail entirely once the full operating temperature range is included.

Where this guide stops

The budget must use data-sheet conditions that match the real circuit and does not replace dynamic or stability validation.

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

▶ **Should every error term be referred to the input or the output?**

▶ **Why not just add every error term directly for a guaranteed worst case?**

▶ **Does CMRR or PSRR ever dominate an error budget that looks fine on paper?**

Related engines

- Complete op-amp error budget
- Wheatstone bridge output
- Current-sense shunt designer
- Summing amplifier designer
- Difference amplifier designer
- Charge amplifier designer
- Precision rectifier designer
- Peak detector and hold-time designer
- Constant-current op-amp source
- Relaxation oscillator designer

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.