CircuitClarity RESOURCE

Op-amp stability and capacitive loads

https://circuitclarity.com/resources/op-amp-stability-and-capacitive-loads/

The decision this guide supports

Stability is a loop-gain and layout problem; simple isolation estimates identify experiments but do not replace device guidance, simulation, or bench verification.

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 the capacitive load driving the op-amp output.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Estimate an isolation resistor and corner frequency as a starting point.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Compare against the selected device's own capacitive-load stability guidance.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Confirm with simulation or a bench step-response measurement.**
   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**
>
> A first-order isolation estimate is a starting point for experimentation, not a stability verdict; only the device's own guidance and measurement confirm real-world stability. 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

- Has the capacitive load's effect on loop phase margin been checked, not just the open-loop gain and bandwidth specs?
- Was the isolation-resistor value checked against the specific selected device's own capacitive-load guidance, not a generic rule of thumb?
- Has the design been confirmed with simulation or a bench step-response measurement, not left as a calculation alone?

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

Trusting open-loop gain and bandwidth specs alone to predict stability with a capacitive load

Those specs do not include the load-dependent pole a capacitive load adds inside the feedback loop; a device that looks stable on paper by those specs alone can still oscillate with a real capacitive load.

Choosing an isolation-resistor value from a generic rule of thumb without checking it against the specific device

The correct isolation resistor value depends on the specific op-amp's output impedance and the actual load capacitance; a value that worked for one device and load combination will not necessarily work for another.

Treating a passing simulation as equivalent to a passing bench measurement

A simulation is only as accurate as its device model and parasitic extraction; the real board's layout parasitics and the actual device's manufacturing variation are confirmed only by measurement.

Where this guide stops

A first-order isolation estimate is a starting point for experimentation, not a stability verdict; only the device's own guidance and measurement confirm real-world stability.

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

▶ **Why does my op-amp oscillate when driving a capacitive load, even though the datasheet gain and bandwidth look fine?**

▶ **Does adding an isolation resistor always fix capacitive-load instability?**

▶ **Is a stability problem something a simple calculation can rule out?**

Related engines

- **Op-amp differentiator designer**
- **Transimpedance amplifier designer**
- **Op-amp stability and capacitive-load screening**

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