CircuitClarity RESOURCE

Sampling, aliasing, windows, and FFT records

https://circuitclarity.com/resources/sampling-and-fft-planning/

The decision this guide supports

Nyquist is a boundary, not a complete acquisition plan; anti-alias filtering, coherent sampling, window choice, record duration, and frequency resolution interact.

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. **Confirm the anti-alias filter adequately attenuates content above Nyquist.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Choose a sample rate and record length that give the needed frequency resolution.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Check whether the test tone can be made coherent with the record length.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Select a window function appropriate for non-coherent sampling, if used.**
   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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> Satisfying the Nyquist criterion alone does not guarantee a clean spectral measurement; filtering, coherence, and windowing each address a separate source of spectral error. 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 anti-alias filter been checked against all content above Nyquist, not just the frequency of the signal being measured?
- For a swept or single-tone test, has coherent sampling been used, or has an appropriate window function been applied if it has not?
- Was record length chosen with the signal's actual stationarity in mind, not just to maximize frequency resolution?

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

Satisfying the Nyquist criterion for the signal of interest while leaving other content unfiltered

Aliasing does not care whether the folded-down content was your intended signal; any unfiltered content above half the sample rate can fold into your measurement band regardless of whether your own signal is comfortably below Nyquist.

Using a non-coherent sample rate and skipping a window function

Non-coherent sampling without a window function produces significant spectral leakage that can obscure nearby low-level tones or misrepresent the true noise floor.

Increasing record length to improve frequency resolution without checking whether the signal is stationary over that window

A longer record trades time resolution for frequency resolution; for a signal that changes behavior within the acquisition window, this can average away or misrepresent the actual time-varying behavior.

Where this guide stops

Satisfying the Nyquist criterion alone does not guarantee a clean spectral measurement; filtering, coherence, and windowing each address a separate source of spectral error.

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

▶ **If my sample rate is more than twice my signal frequency, am I safe from aliasing?**

▶ **Why go through the effort of coherent sampling instead of just using a window function?**

▶ **Does a longer FFT record always give a better measurement?**

Related engines

- **Butterworth filter order estimator**
- **FFT bin and record-length planner**
- **Sampling and aliasing explorer**
- **Coherent sampling planner**
- **PWM reconstruction filter 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, Tektronix scope references. Those sources establish condition-specific behavior; CircuitClarity uses them to frame the decision and its limits.