

Load Termination Requirements

How Important Is a 50-Ohm Termination?

A true 50-ohm termination is critical to the health of a small-signal RF amplifier because it ensures free-flowing signal propagation, maximum power transfer, and prevents damage from output reflections. If a 50-ohm amplifier is placed in an RF chain facing a mismatched impedance, issues, including amplifier failure, may occur. The importance of impedance-matching a 50-ohm small-signal amplifier with surrounding components cannot be overstated; moreover, it is considered an industry standard.

Maximum Power Output

When the input signal and load impedances are matched to 50 ohms, nearly all of the amplifier's output power is delivered to the next cascaded chain component. In an unmatched or poorly matched system, some of that power is reflected, either back to the amplifier (when the amplifier sees a mismatch) or back to the source (when the mismatch is at the amplifier's input).

Preventing Signal Reflections

Impedance mismatches cause signal reflections, this is well known. The reflected signal then travels back along the signal path and interferes with the output signal, creating standing (stationary) waves.

Signal Integrity

Standing waves can appear as current or voltage fluctuations along the signal path. This can manifest as distortion, a deterioration in the signal-to-noise ratio (SNR), and can seriously affect or degrade the amplifier's output.

What Are the Consequences of a Mismatch?

When a small-signal RF amplifier operates in a chain with a mismatched impedance, the result can range from a slight reduction in performance to reflections that cause serious or even permanent damage to the amplifier.

Reduced Performance

- **Output Power Loss:** In a small-signal RF amplifier, any output power reflected from the load is lost energy. This reduces the total power output intended for the downstream component. As the load mismatch worsens, the intended output power loss increases dramatically.
- **Distortion:** When standing waves are present due to load mismatch, their interference produces distortion, degrading signal fidelity.
- **Gain Loss:** The gain of an amplifier in an RF chain can be lowered by load-mismatch losses at each gain block stage.

Can Impedance Mismatches Damage an Amplifier?

Transistor Damage

In cases of an open (infinite impedance) or short (zero impedance), all forward-directed output power is reflected back into the amplifier's output pin or connector. This can cause a sudden and dramatic increase in voltage or current directed at the transistors. Designers sometimes employ diodes to absorb that reflection or large capacitors to ground to drain it away, but such measures are not always 100% effective.

MTBF

Reflected power must eventually dissipate as heat if the mismatch is severe enough. This additional heat can reduce the mean time between failures (MTBF), shortening the amplifier's lifespan.

Can I Prevent Damage to an Amplifier with a Poor Mismatch?

Share Your Incident Impedance Measurements with the RF Amplifier Supplier

Knowing potential mismatch issues before amplifier selection can help mitigate problems later. Spectrum Control can often include elements such as diodes or pads on the output to help absorb, reflect, or condition harmful mismatch reflections.

Add a Pad

For reflection-sensitive amplifiers, a small pad, perhaps $\frac{1}{4}$ dB to $\frac{1}{2}$ dB (if there's sufficient output power margin), can be strategically placed at the amplifier output or at the next component's input to reduce reflected power.

Use a Proper Load During the Test Phase

Always terminate an amplifier with a 50-ohm load. During test sessions, this means using a 50-ohm dummy load. In a system-level evaluation, this requirement extends to the entire RF chain, including connectors, cables, and all other components.