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POPULAR SCIENCE SUMMARY

The Hidden Waves That Make Electronics Misbehave

That buzz from your car radio? It's a tiny hint of a huge problem: electromagnetic interference (EMI). This invisible noise can make its way to the electrical grid and cause costly malfunctions or even blackouts. Our thesis progresses towards the fix this by predicting the noise on a computer, long before any physical machine is built which saves time, money, and headaches

Predicting the Unpredictable

Fixing this kind of noise normally is a very expensive and time-consuming game of trial and error. Engineers build a prototype, test it in a specialized lab to see if it behaves as it should, and if it doesn't, they have to go back, redesign parts, and test again. Our work aims to replace this reactive approach with a proactive one. We built a detailed simulation model of a high-power electrical converter, the kind used to control motors and manage energy, to see these hidden waves before they caused trouble.

The core of our investigation was to understand the secret pathways this noise travels on. We discovered that the biggest factor influencing the noise is whether the metal cooling frame, or heatsink, of the device is grounded. Think of it like an ocean: all rivers, big or small, eventually flow into it. Similarly, all electromagnetic disturbances ultimately drain into this stable reference point, neutralising their effect. Grounding the heatsink forces the noise into a well-defined, predictable path, creating a strong low-frequency signal that our simulation could predict with great accuracy. However, when we left the heatsink ungrounded, the noise escaped on a completely different, ghost-like path, jumping to a much higher frequency that our initial model completely missed. This was our "wow" moment, a A clear sign that these invisible paths through the air and structure were far more important than we first thought.

We also mapped out exactly which physical components were to blame for the noise at different frequencies, those being the lower frequency noise in the range of 600 kHz to 1.8 MHz while the higher frequencies were in the tens of MHz. For the lower-frequency noise, the main culprits were the chunky copper filtering coils and tiny parasitic capacitors which are unwanted energy storage pockets that naturally form between the electronics and the metal frame. For a second, much higher-frequency noise we found in the tens of megahertz, the problem wasn't the large components, but the microscopic wiring *inside* the silicon power switches themselves.These nanoscopic wires act like tiny, unintended coils, where circulating currents generate magnetic fields that can couple into nearby circuits. Our biggest success came when we doubled the tiny inductance in our simulation to account for these unmodeled internal connections; suddenly, our predicted high-frequency noise dropped dramatically and lined up almost perfectly with our real-world measurements.

The most practical part of this work was proving that a simple "double-pulse" test could replace hours of complex simulation. Instead of simulating the whole machine running for over an hour, our method excited the same noise with just two quick electrical pulses, giving us the answers we needed in just three minutes, saving engineers an hour of sitting around and waiting! This turns a slow, expensive check into a fast, agile design tool. This thesis provides a clear guide for engineers to build better, quieter electronics from the very first sketch on a napkin, making our future devices more reliable and less prone to those mysterious electronic tantrums.