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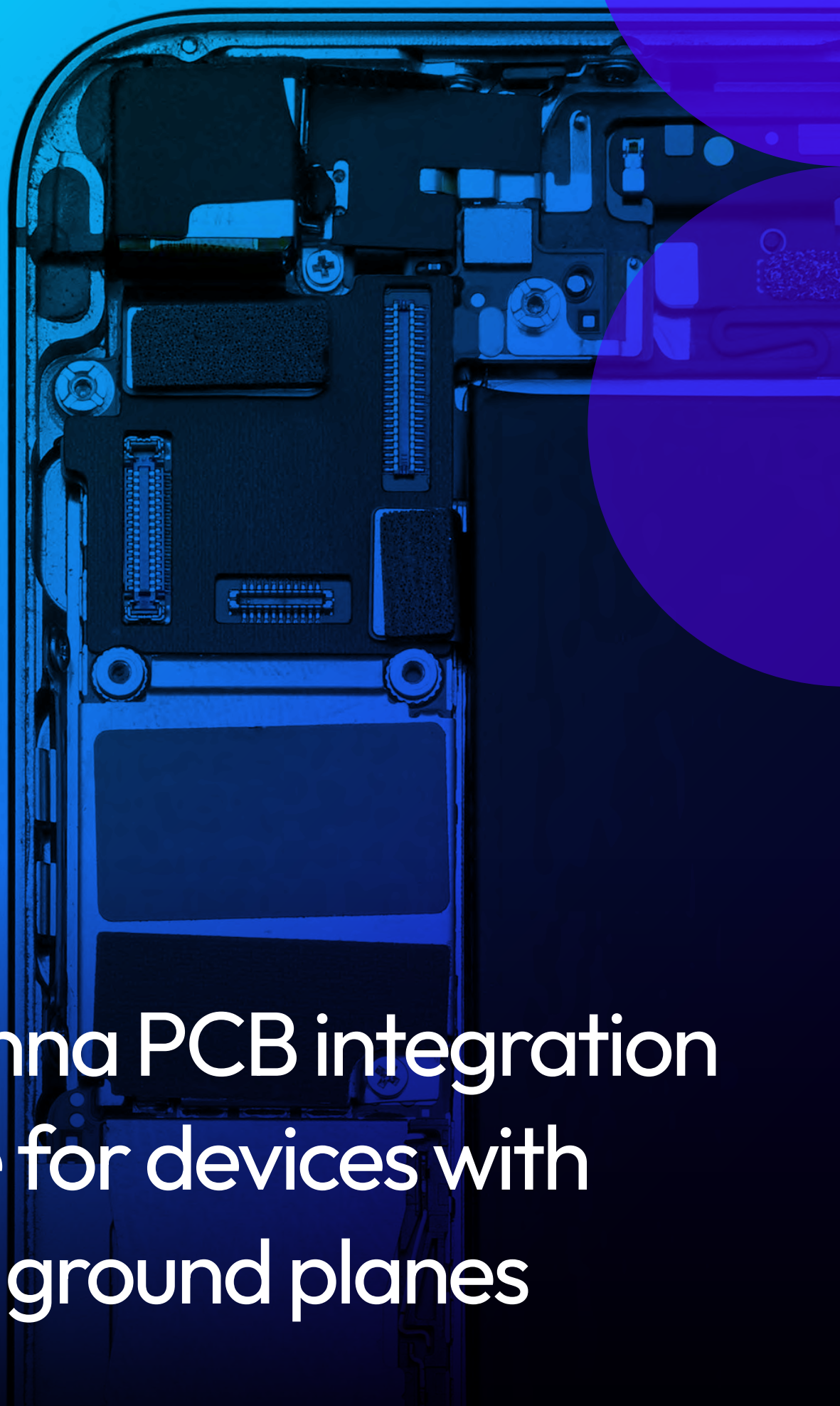

GUIDE

Antenna PCB integration guide for devices with small ground planes

Introduction

The seemingly relentless drive toward miniaturisation in connected devices has reshaped the way engineers approach antenna design. IoT sensors, wearables, medical implantables and consumer electronics all demand smaller form factors without compromising wireless performance. Achieving this balance requires careful antenna integration, particularly when working with small ground planes.

This guide explores the core principles of antenna integration for space-constrained designs, the challenges of maintaining efficiency and best practices to ensure your compact device performs reliably in the real world.

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Wireless for the next generation

Antenova designs high-performance antennas and RF modules that power the connected world. From IoT to wearables, our technology delivers seamless, reliable wireless performance.

Find out more

What is an antenna ground plane and why is it important?

An antenna relies on the device's or PCB's ground plane to form part of its radiating structure. In compact designs, the PCB often doubles as the primary ground plane. This leaves designers needing to find creative ways to maximise the effective ground without increasing overall device size. The size, shape and continuity of this ground plane have a direct effect on key areas surrounding overall wireless performance.

- **Efficiency:** Smaller ground planes reduce the effective radiation area, causing energy loss.
- **Bandwidth:** Limited ground size can narrow the operating bandwidth, making antennas more prone to detuning.
- **Radiation pattern stability:** Constrained grounds can distort or skew radiation patterns, reducing range and reliability.

Key challenges when it comes to smaller PCB sizes

Designing wireless devices with small ground planes is as much art as engineering challenge. As product sizes shrink, physical constraints of the PCB directly impact RF performance. Every millimetre becomes invaluable and the once straightforward task of antenna integration now involves carefully balancing efficiency and bandwidth with mechanical design.

Detuning from nearby components

Antennas are highly sensitive to their surroundings. Placing them near metallic components, batteries or shielding can cause reduced efficiency and unpredictable performance. Detuning is especially prevalent in small devices where antennas cannot be properly isolated from other electronics.

Limited ground plane space

As devices shrink, the ground plane available to the antenna shrinks with it. As we mentioned earlier, this leads to weaker radiation and lower gain. Without careful design, your device may fail OTA testing or struggle to maintain a stable connection.

PCB material, layout and mechanical constraints/compromises

High-density layouts and low-cost substrates can introduce dielectric losses. Every trace and bend in the RF path matters more in miniaturised designs. Adding antennas to already-crowded PCBs can also conflict with heat dissipation needs or potentially compromise the overall mechanical stability.

Design best practices for antenna integration on small ground planes

Optimising wireless performance in compact devices requires a combination of smart PCB design, component placement and antenna selection.

Strategic component placement

Taking the antenna and surrounding component placement into consideration during design can make a world of difference for small devices.

- **Isolate the antenna where possible:** Keep the antenna away from metallic components, batteries and high-speed digital traces that may generate interference.
- **Respect antenna keep-out zones:** Follow manufacturer guidelines for clearance around the antenna. Even small intrusions into this area can reduce efficiency dramatically.
- **Avoid corners crowded with shielding or metal frames:** Corners can be beneficial for radiation, but nearby metal can detune the antenna if not managed carefully.

Managing detuning and interference

Detuning is one of the most common performance killers in miniaturised devices due to the density of components that are packed together. To avoid this, engineers can utilise a range of strategies:

- **Simulation before prototyping:** Electromagnetic simulation can identify high-risk interference zones and optimise antenna placement.
- **Incorporating tuning components:** Matching networks and tuning capacitors can help restore efficiency if nearby components shift resonance frequencies.
- **Avoiding last-minute PCB changes:** Minor layout adjustments can unintentionally impact the antenna's environment, especially in dense designs.

Early prototype and OTA testing

Testing should not wait until final production. Miniaturised devices leave little margin for late-stage fixes, so there are a few steps you should take early on.

- **Prototype multiple antenna positions:** Test different orientations and placements to find the optimal configuration.
- **Conduct OTA (Over-The-Air) measurements:** Evaluate Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) to ensure compliance with regulatory and performance requirements.
- **Verify performance under real-world conditions:** Test the device in its intended enclosure and operating environment, as plastics, adhesives, and other packaging materials can further affect RF performance.

Select the right antenna for miniaturised designs

All of the above steps can definitely help to improve antenna performance when you've got limited space to work with. That said, there is no better solution than simply choosing the best fit of antenna for your specific needs. Selecting one that is optimised for small form factors and your wireless requirements is essential to get the most out of a small package.

- High-efficiency embedded antennas (SMD or FPC) are specifically designed for constrained spaces.
- Multi-band or wideband options are available if the device must operate across multiple protocols without increasing footprint.
- Pre-tuned solutions from reputable suppliers (like Antenova) can minimise the need for complex custom matching on small boards..

Optimising wireless in the smallest of devices

Designing wireless devices with small ground planes is a balancing act between size, efficiency and reliability. By prioritising antenna integration early or playing around with different placements, engineers can achieve excellent wireless performance without increasing device footprint. But the best solution will always be careful planning and choosing the right antenna solution to deliver high-efficiency and reliable connectivity.

For engineers tackling the challenges of shrinking PCBs and demanding wireless requirements, Antenova offers high-performance, integration-friendly antennas designed specifically for compact and space-constrained devices. Our antennas are engineered to maintain efficiency and reliability even in the smallest enclosures, helping you overcome issues like detuning, limited ground planes and tight component layouts.

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