

Embedded Antenna Design Guide



Introduction

It’s a competitive world and developing a successful wireless product that meets the requirements of today’s tech savvy customers requires a highly diverse team of engineers and designers. Creating a reliable and efficient wireless subsystem requires a unique skill set and employing a full-time specialist Antenna Designer to develop a custom solution for your product maybe beyond the budget of many SME’s. Employing the services of an antenna design consultant is therefore often the most cost effective route to achieving the optimum solution.

A custom antenna allows the designer to make best use of the space inside of the product, which can significantly improve the efficiency of the antenna when compared to generic off-the-shelf solutions. An efficient custom antenna will maximize wireless range and potentially reduce power consumption of your product. A bespoke antenna can also significantly reduce the overall BOM cost.  Of-the-shelf antenna solutions can be prohibitively expensive, whilst in many cases, a custom design could cost just a couple of cents per unit.

Planning for the antenna at the start of the project is essential to maximize product performance and reduce delays and redesigns in later stages of the project. This non-technical guide is aimed at program managers and engineers that do not have antenna design experience. It's intended to help with the preparation and planning of the embedded antenna design.

1. ​The Suggestions of Physics!

I’ve often been asked to squeeze an antenna into a smaller physical space than is parametrically desirable. Sometimes the requirement for an electrically small antenna is essential to meet the form factor requirements of the product, however, occasionally, it’s just simply due to lack of planning. An ex colleague once quipped that the optimum size for an antenna is defined “By the laws, not the suggestions of physics,” and although there are several techniques available which enable the designer to reduce the overall size of the antenna system, these all result in compromise. The smaller the antenna for a given operational frequency/bandwidth the less efficient it will be.

To ensure your wireless product will have good range performance, an efficient antenna will be required and you will need to allow sufficient space for the antenna system. It’s therefore essential that the antenna designer is involved at the early stages of the product development cycle, so that the design options and potential compromises can be discussed and understood at the beginning of the project.

1. Product location

It’s very likely that the antenna will be located at the extremities of the product. It will therefore be sensitive to its location in relation the external environment. Think about how the product is going to be used and where it’s likely to be located. For example, if it’s a hand-held device, you’ll want to ensure that the antenna isn’t covered by the user’s hand when held in the most natural position. If it’s wall mounted, is it likely to be mounted on a metallic surface? This could significantly impact performance if not planned for.

​3. Antenna Type and Position

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There are a myriad of antenna configurations available to the designer. Probably the simplest and most cost effective is to etch the antenna structure onto the PCB of your product, however, due to size or location constraints this isn’t always possible.  Some other popular options include metal formed antennas and LDS (Laser Direct Structured) systems.  Ceramic antennas are also an obvious option, though despite what the ceramic antenna manufactures suggest, these are rarely as efficient as a bespoke embedded solution.  Your antenna designer/consultant will guide you through the appropriate options for your specific product.

​4. Materials

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Whether the antenna structure is etched onto the PCB, metalized onto the plastics or formed by stamped metal, it’s important that any materials in contact with, or adjacent to the antenna have known and stable dialectic properties.

The dielectric of low cost FR4 PCB material can vary significantly from vender to vender and even from batch to batch, it is therefore essential that the PCB material characteristics are clearly specified from the start.  If possible, using the same PCB vendor throughout the project will minimize performance variation as the product moves from prototype to full production.

Similarly, any other materials in contact with the antenna should be well defined. For example, for LDS structures, where the antenna is metalized onto a plastic substrate, the RF characteristics of the plastics need to be fully quantified.  Again, it is beneficial to use the same material for prototypes and production.

5. Casings and coatings

It would seem obvious that to ensure best antenna performance, that you wouldn’t encase the antenna in a metallic box, or coat the product exterior with metalized covering. It’s surprising however how often this fundamental rule is overlooked. It is very important to work closely with the mechanical and ID departments within your organisation to ensure that the area around the antenna is void of potentially disruptive materials.

6. Internal Structures

The position of internal metallic structures relative to the antenna can also impact performance. For example, in handheld or wearable devices, the product’s battery is likely to be a major component part of the overall assemble and as such, it’s position and role within the antenna system must be defined. In some circumstances, the battery will be grounded, either directly or capacitively by virtue of its position relative to the main PCBA, however, it could also be isolated or even designed to be part of the main antenna structure. Either way, it’s position and potential impact on antenna performance must be carefully considered.

​7. Antenna Counterpoise

​​When people talk about the antenna within a system, they are usually referring to the obvious physical structure; for example, the specifically etched section of the PCB or the metalized area of the case plastics, however, in most cases, this is just one half of the antenna system.

The other part of the antenna, the counterpoise, is usually formed by the by the primary ground in your system. This would normally be the main PCB ground or product chassis. Care must be taken to ensure that there is a sufficient counterpoise to allow the antenna to resonate at the desired frequency and ensure that the antennas radiation pattern isn’t distorted.

​8. Circuit Sensitivities EMI/RFI

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Every wireless communication system will consist of at least one transmitter and one receiver. The transmitter has the potential to generate interference to nearby circuity and the receiver will be susceptible to interference from the same local circuits.  Positioning of the antenna relative to sensitive or electrically noisy circuity is therefore crucial to maintaining good wireless system performance.  EMI (Electromagnet Interference) and RFI (Radio Frequency Interference) are both huge topics and I won’t attempt to cover them here, however it’s important to understand that some pre-emptive planning to mitigate interference can save a considerable amount of time later in the project. Working with the design engineers to identify potential interference sources and susceptible circuitry at the early stages of the project is therefore crucial.



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