Build a Smarter World

Whitepaper

IoT ANTENNAS

Accelerate IoT device time-to-market by combining antennas and modules

Contents

Introduction

As IoT continues its move into the mainstream with billions of devices entering deployment, organizations are moving from limited, pilot projects to hyperscale roll-outs which the digital future of the business depends upon. The earlier stages of IoT, in which getting design and configuration wrong was acceptable, are over because fixing hundreds of thousands of devices out in the field is too costly for many IoT business cases to sustain. In order to avoid this, huge development attention has been devoted to the communications module, ensuring the right network is selected for the application, as well as to the power usage of the IoT device. This is because some use cases require device lifecycles of more than a decade, making power consumption a priority.

Alongside connectivity and power, a third area – the antenna – needs to be given equal attention because of the fundamental impact it has on device performance. The antenna is the means by which an IoT device receives and sends signals to the outside world and therefore is a fundamental element of an IoT device. However, antenna decisions are often neglected until the end of the development process, resulting in unnecessary compromises and sub-optimal siting of antennas that could have been avoided with better planning and design.

Without an antenna, it can't be wireless!

Embedded vs external

"In the US, where a product must pass PTCRB and network approval, an integrated, embedded product from a single vendor would make passing pre-compliance testing simpler.."

Embedded antennas, which are integrated within IoT devices, are more complex to design for than external antennas, which are mounted to the outside of devices and are easier to add retrospectively with fewer integration issues.

External antennas are typically a dipole design and are independent of the wireless product they are connected to and therefore much easier to use. In addition, because they are external to the product's electronics, there is less risk of interference, electro-magnetic compatibility (EMC) issues and fewer size constraints with external antennas. They also need less design-in support except in situations, such as in the US, where a product must pass PTCRB and network approval. In this scenario an integrated, embedded product from a single vendor would make passing pre-compliance testing simpler because it would involve a single company.

" ....the need to consider antennas at the design stage rather than as a retrofitted addition"

In spite of these benefits, there are downsides to external antennas and the IoT marketplace tends to favour embedded antennas because of the small size of the products and aesthetic requirements. Embedded antennas are typically a monopole structure which requires a physical ground plane to work, normally the customers host printed circuit board (PCB), hence the importance of layout and position. The form factor, cost and installation requirements of IoT applications are seeing increased adoption of embedded antennas, highlighting the need to consider antennas at the design stage rather than as a retrofitted addition.

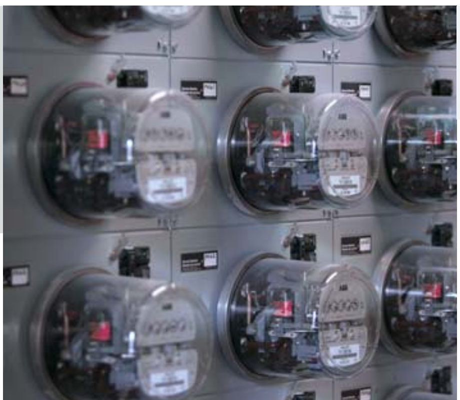
Common Mistakes

Antenna location

Embedded antennas are sensitive components that operate under strict constraints in terms of how and where they are placed within devices. This means careful – and early – consideration needs to be given to the location where each device needs to accommodate an antenna. Sufficient room must be apportioned to the antenna so selecting a suitably sized product must be prioritized.

Sub-1Ghz antennas, for example require a host PCB that is at least 100mm long to operate efficiently without the use of complex switching RF impedance networks. Many devices by their nature are space-constrained so complex work must be done to ensure limited area in applications such as micro-scooters is maximized for the IoT module, the battery and the antenna in addition to the MCU and other device functions.

Other factors that influence antenna location include the material type of the product housing which can also impact antenna performance. Thick plastics or metals can impede signal propagation and reception and designers also need to consider how the antenna will react to other components in the device. Metal, for example, heavily detunes antennas so the location of a battery, LCD, connectors and other metallic items in relation to the antenna is a key consideration.

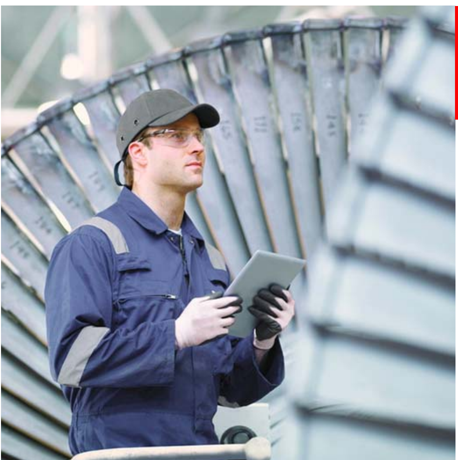


Deployment criteria

How and where the product will be used is also a critical consideration that is often ignored. If a product is to be handheld, for example, the design needs to take account of the human hand being positioned around the central area of the device. The hand obscures the antenna so, in this scenario, the antenna should be mounted either at the top or bottom of the device. In addition to this, if it is a body-mounted product with a cellular antenna, then consideration of specific absorption rate (SAR) and the location of the antenna position is important. Similarly, with products such as microscooters, the rider's body can obscure the antenna so careful siting criteria need to be taken into account.

Installation of the device or external antenna also needs to be considered such as if the device will be mounted on a metal surface or upside down. These influence the optimum position for the antenna and are best solved at the design stage. In addition, issues such as weather conditions and temperature, which can affect performance, need to be taken into account.

It's also important to consider where the product will be used at the design stage. Different regions have different regulations relating to antennas and various certifications and approvals are required. In the US, for example, certain types of LTE products require a main and diversity antenna to be installed in order to achieve compliance.



Performance requirements

Although IoT device designers prioritize functions such as power usage, the antenna also needs to be considered with the same emphasis because an inefficient antenna layout will drain the battery far more quickly than an optimized location. For finely balanced applications such as smart meters in which batteries are expected to work for up to 20 years, poor antenna location can ruin battery life and require batteries to be replaced more often during the device lifecycle, adding unforeseen cost and damaging the business case.

Wireless range is another baseline consideration and fundamental to IoT device performance. Having a sufficiently powerful antenna is a prerequisite to connect effectively so this must be included at the design stage, along with considerations such as reliability and robustness.

Ease of installation

"an inefficient antenna layout will drain the battery far more quickly"

With IoT device volumes moving into the billions, any complexity in the production phase has a greater impact than it did in the lower volume era. Therefore, IoT organizations are faced with a choice between surface-mount design (SMD) or flexible printed circuit board (FPC) antennas. FPC antennas take longer to integrate on the assembly line and their cable routing needs to be carefully considered because the cable, as well as the antenna, radiates the signal. This cable routing needs to be followed exactly to ensure repeatable performance.

In contrast, an SMD antenna allows for simpler assembly, making it more suited to high volume production because the antenna can be simply mounted onto the PCB.

Overcome The Challenges

The common mistakes organizations make in specification and design of devices can readily be overcome provided sufficient attention is devoted early enough to influence design of the overall device and ensure smooth integration. An obvious first step for designers is to follow the guidelines in antenna products' data sheets. Don't forget there is no way to fix a bad antenna integration so preparation is vital.

Next, check carefully to review the architecture and design. Quectel, for example, offers this review as a service from its experienced engineers and strongly recommends 3D file and Gerber file review because it is far less time consuming to identify and rectify any issues at this early stage than later in the field.

In addition to the architecture review, a productive step is to check the application notes to ensure the device's mode of operation is appropriate for the antenna selected before moving on to a full system check by software and test instruments.

This strong evaluation process can highlight and address issues before they have a live impact on deployed devices. There is no substitute for experience here, so seek suppliers that have strong R&D capability and the field application engineer (FAE) base to support your deployment.

Tips for embedded antenna design success

- Understand where the antenna will be positioned and located
- Design for the type and style of antenna you select
- Take into account the distance between each antenna if you are using multiple antennas to ensure sufficient isolation
- Locate an SMD antenna close to the wireless module to reduce the connecting track/trace length and minimize pick-up noise
- Use a coplanar waveguide with sufficient ground vias along the transmission line length
- If using FPC with a cable, remember the cable routing is important because it acts as part of the antenna
- Accommodate 50ohms impedance
- Match the SMD antenna after design com

Simplify with a single supplier

" choose a vendor that can provide the RF front end, the antenna, the wireless module and the interconnection.."

Traditional device development is oriented around sourcing components from multiple suppliers and bringing them together into an integrated device. However, this adds complexity and time because it brings a series of stakeholders into the process. By choosing a vendor that can provide the RF front end, the antenna, the wireless module and the interconnection, organizations can streamline the process.

This is particularly important with regards to the relationship between the antenna and the wireless module because these components work in close association and connect to each other. By specifying these from the same supplier technical support is easier because the company knows both technologies and the situation in which one supplier blames the other is avoided.

Further advantages of this one-stop solution are that the vendor should have tested and proven reference designs for using both components. In addition to this, the one-stop vendor will have streamlined and integrated FAE and design engineering support and be able to share knowledge and design roadmaps across these resources.

Additional operational benefits can also accrue. For example, having one supplier for both purchase orders reduces administrative costs, strengthens the customer supplier relationship and puts the customer at the forefront of combined technological developments.

How Quectel Helps Handle the Complexities

As outlined above, Quectel has the knowledge and experience of how both modules and antennas work in addition to complete understanding of RF layout. This is augmented by the company's vast knowledge based and the sharing of different component designs between teams. Quectel sees the combination of modules and antennas as a vital service for IoT organizations and has regionally-based antenna and module FAEs that work together to address customers' deployment needs. Quectel's scale means it has dedicated antenna engineering, design and support teams in the same locations as module engineers and these are backed by state of the art test equipment and both passive and active anechoic chambers. This means Quectel has a comprehensive portfolio of engineering support services from architecture design to review to antenna matching and onwards to pre-compliance active testing capabilities.

With time to market a key determining factor for the success or failure of many IoT initiatives, this combined approach to integrating modules and antennas is attractive in the market. Time to market ranks alongside overall wireless performance of a product in terms of priority for many IoT organizations so having support for the entire RF front end from a single company is increasingly seen as a critical enabler.

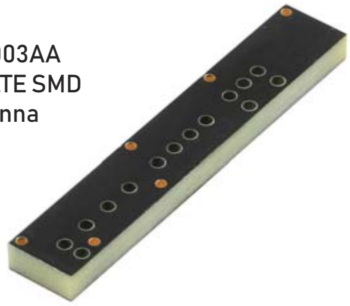
The ability to have combination modules that support cellular, GNSS and WLAN in one offering plus GNSS and WLAN modules that combine the antenna with the module is a key step towards maturity in device design. The module cannot work without the antenna and vice-versa so it is an obvious step to simplify the design process and accelerate time to market by buying both from one supplier. With its antennas portfolio, its regionally-located engineers and developers, plus its leadership in IoT modules, Quectel is uniquely positioned to streamline integration of antennas and modules into IoT devices that are helping build a smarter world.

To learn more about how Quectel can reduce device design complexity and accelerate time to market with our combined antenna and module offerings, visit:
https://bit.ly/3rElmDJ

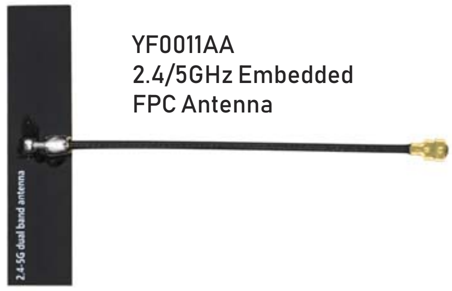
A Selection of Quectel Antennas

YB0006AA
7 in 1 Combo Antenna. 4x4 MIMO 5G, 2x2 MIMO Wi-Fi and GNSS

YG0028AA
L1/L5 GNSS External Magnetic Mount Antenna

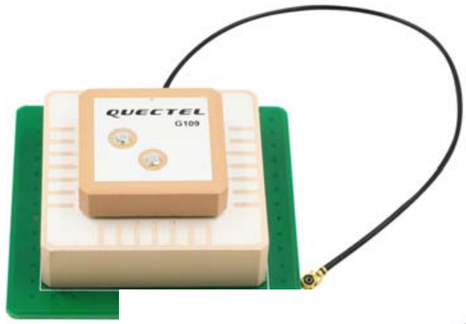


YC0003AA
4G/LTE SMD Antenna



YF0011AA
2.4/5GHz Embedded FPC Antenna

Stamp Metal Custom Antenna Solution



YCGO002AA
Embedded Ceramic Patch L1/L5 GNSS

YC0008AA
LDS Custom Antenna Solution

YE0032AA
2.4/5GHz Wi-Fi/BT Antenna

YE0007AA
5G LTE External Terminal Mount

YG0021AA
Embedded L1 GNSS Antenna