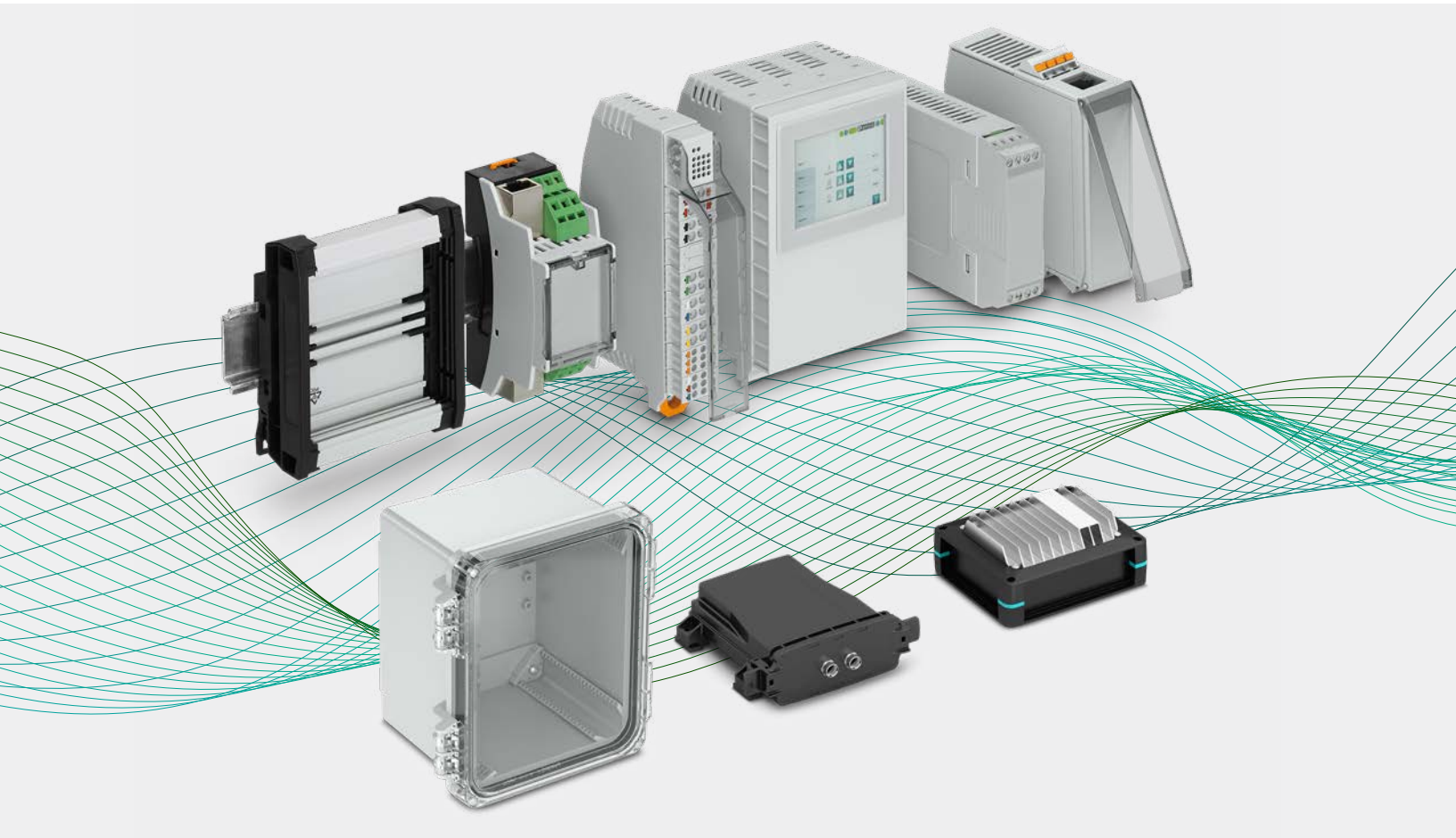




Understanding electronic device enclosure development for industrial applications

By Michael Wayde, Product Marketing Manager, Phoenix Contact USA

Key takeaways:

- Electronic enclosure development involves multiple stages, each introducing unique engineering, manufacturing, and production challenges
- Early design decisions can influence manufacturability, tooling costs, production scalability, and overall time to market
- Existing enclosure platforms and engineering support services can help reduce risk, simplify development, and accelerate the path from concept to production

Introduction

The development of electronic devices has become increasingly complex as performance demands, miniaturization, and reliability expectations continue to rise. While internal electronics often receive the most attention, the design and development of the product enclosure play a critical role in overall functionality, durability, and manufacturability.

Developing an enclosure is not a simple, single-step process. It involves multiple stages, including concept development, prototyping, testing, and large-scale production. Each stage introduces unique challenges, particularly when transitioning from early design concepts to full manufacturing.

This paper outlines the key steps involved in electronic device enclosure development and highlights important considerations at each stage. It also explores the decision between developing a custom enclosure and leveraging existing solutions. ■

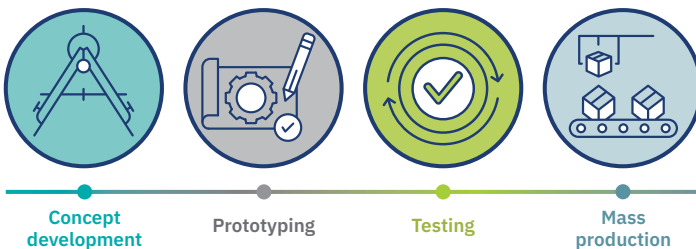


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Electronic device development process

The development of an electronic device enclosure typically follows a structured process that begins with concept development and continues through prototyping, testing, and mass production. Each phase builds on the previous one. Early design choices can have a major impact on later manufacturing costs and complexity.



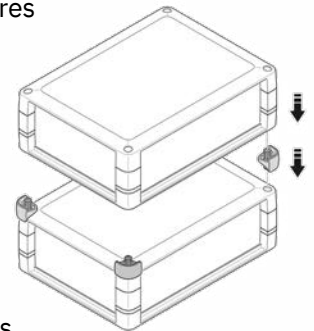
A key decision throughout this process is whether to build a fully custom enclosure or buy an existing enclosure platform. This make-versus-buy decision can influence speed-to-market, engineering workload, tooling investment, supply chain complexity, and long-term production costs. Understanding these trade-offs early can help guide more efficient development and reduce risk as the product moves towards manufacturing.

Concept development



The concept development stage establishes the foundation for the enclosure design. At this point, key decisions are made regarding the enclosure's size, shape, material, and overall functionality. These decisions ultimately influence both the product's performance and its ability to be manufactured at scale.

Developing a custom enclosure requires specialized engineering resources, particularly mechanical engineers with experience in 3D design and manufacturing methods such as injection molding. In applications where appearance and user interaction are important, industrial designers may also be involved to ensure the enclosure meets both functional and aesthetic requirements.



The design process typically begins with the creation of a 3D computer model using CAD software such as SolidWorks, PTC Creo, or Fusion 360. Once the model is developed, it can be used to produce physical prototypes for evaluation and refinement.

One of the key challenges during this stage is ensuring that the design is suitable not only for prototyping but also for

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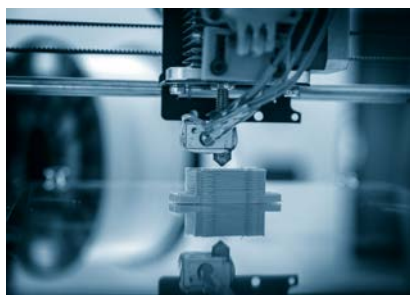
large-scale manufacturing. Designs that work well in early development may require modification to meet the constraints of production processes such as injection molding.

Prototype development



Following concept development, physical prototypes are created to evaluate the enclosure design in a real-world form. Prototyping allows engineers to assess fit, functionality, and overall performance before committing to production tooling.

Prototypes are typically produced using either additive or subtractive manufacturing processes. Additive methods, such as 3D printing, build components layer by layer.



They are widely used due to their speed and flexibility in creating complex geometries. Subtractive methods, such as CNC machining, remove material from a solid block. This allows prototypes to match the properties of final production materials more closely.



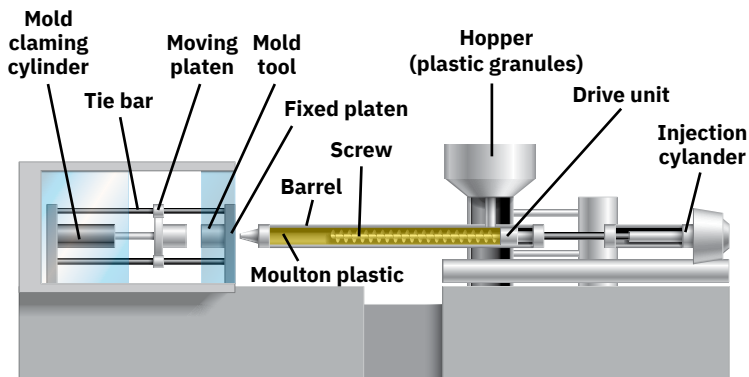
While additive prototyping is more common in early development, it often uses materials that differ from those used in mass production.

As a result, designers must consider how prototype performance will translate to final manufacturing. Maintaining awareness of production constraints during this stage helps reduce the risk of costly redesigns later in the process.

Prototype evaluation and iteration

Once prototypes are produced, they must be evaluated and refined through multiple design iterations. While 3D models provide a strong visual representation, physical prototypes allow engineers to identify functional and cosmetic improvements that may not be evident during the design phase.

It is common to develop several prototype versions before finalizing the enclosure design. This iterative process helps ensure the product meets performance, fit, and usability expectations before transitioning to production.



Transition to injection molding

Following prototype evaluation and refinement, the enclosure design must transition into full-scale production. This stage is often one of the most complex and costly parts of the development process, as it introduces new requirements related to manufacturing, tooling, and production efficiency.

Most plastic enclosures are manufactured using injection molding. Two halves of precision-machined steel clamp together under high pressure to form the mold. The mold contains a cavity shaped like the final enclosure.

Molten plastic is injected into the mold cavity, filling the shape of the part. Once the material cools and solidifies, the enclosure is removed using ejector pins. This process enables the production of large volumes of identical parts with consistent quality.

While injection molding offers significant cost advantages at high volumes, it requires substantial upfront investment. The molds used in the process must be precisely machined to match the enclosure design. Depending on the part's complexity and the expected production volume, tooling costs can range from a few thousand dollars to tens of thousands or more.

Because of these costs, it is critical to fully validate the enclosure before committing to production tooling. Changes made after this stage can result in delays, added costs, and the need to rework or recreate molds. Careful planning during earlier design and prototyping stages ensures a smoother transition to manufacturing.

Verification and testing stages



After the transition to manufacturing, products must undergo a series of verification stages to ensure performance, reliability, and manufacturability. These stages help identify any remaining design issues before full-scale production begins.

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The Engineering Verification Test (EVT) stage represents the first integrated version of the product. This step brings together both functional and physical design elements. Testing focuses on system performance, assembly, and initial reliability.

The Design Verification Test (DVT) stage ensures that the product meets all design and environmental requirements. This phase helps prepare manufacturing partners for production by refining processes and validating component selection.

In addition to internal validation, products must often undergo regulatory testing to meet certifications such as CE, RoHS, FCC, or UL. These tests confirm that the product complies with safety and performance standards in its target market.



The Production Verification Test (PVT), the final stage, focuses on validating the manufacturing process itself. A pilot production run is used to ensure consistent quality, optimize production efficiency, and identify any issues before scaling to full mass production.

Mass production



Once successfully tested and verified, the product moves into full-scale mass production. At this stage, manufacturing operations are scaled to meet required volumes while maintaining consistent quality and performance.

Production typically begins with a gradual ramp-up phase, allowing teams to monitor output, identify potential issues, and optimize manufacturing processes. As production scales, efficiency improvements can help reduce unit costs while ensuring consistent product quality.

Even after full-scale production begins, ongoing testing and quality control remain critical to ensuring long-term product reliability and performance.

Enclosure development considerations

After understanding the full enclosure development process, it becomes clear that each stage introduces complexity, cost, and risk. Decisions made early in the process can have significant downstream impacts.

Organizations must consider factors such as time-to-market, available engineering resources, production volume, supply chain complexity, and overall cost when determining the best approach to enclosure development. In some cases, developing a fully custom enclosure may be necessary to meet specific design requirements. In others, existing enclosure platforms offer a more efficient and cost-effective solution. ■

Phoenix Contact enclosure solutions

Phoenix Contact offers enclosure solutions that simplify the product development process while reducing risk, costs, and time-to-market. Rather than starting from a blank sheet of paper, manufacturers can rely on existing enclosure platforms that have already been developed, tested, and validated.

Pre-designed enclosure systems can help organizations avoid many of the challenges associated with custom enclosure development. Existing housing platforms also provide a proven foundation for PCB integration and mechanical design.

In addition to enclosure products, Phoenix Contact offers a range of engineering and support services to assist throughout the development process. These capabilities can help accelerate product development while allowing engineering teams to focus on their core application requirements.

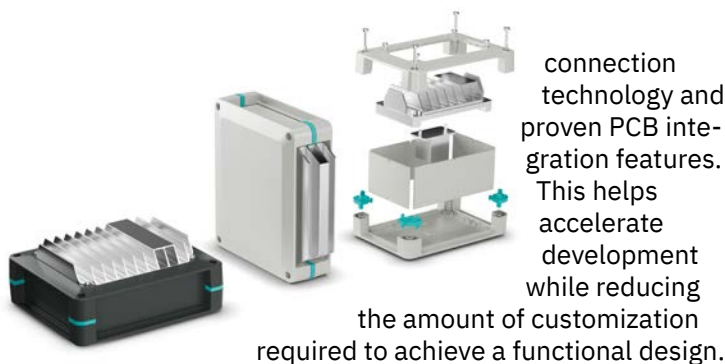
Existing technology and proven designs

Existing enclosure platforms offer several advantages over fully custom development. Components are already designed, tested, and optimized for industrial applications, reducing development effort and minimizing risk.

Many Phoenix Contact enclosure systems include integrated

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Reduced cost and faster development

One of the primary benefits of selecting an existing enclosure platform is avoiding tooling costs associated with custom mold creation. Injection molding tools can require significant upfront investment, particularly for higher production volumes.

Because Phoenix Contact enclosure components are already available and production-ready, organizations can reduce development timelines, simplify sourcing, and accelerate prototype creation. Access to stocked components and available samples supports faster evaluation and design validation.

Engineering and application support

Beyond enclosure hardware, Phoenix Contact supports customers throughout the product development lifecycle with services including thermal analysis,

PCB layout support, component sourcing, kitting, and assistance with testing and certification requirements.

By combining enclosure platforms with engineering support, manufacturers can reduce development complexity and improve overall project efficiency. ■

Conclusion

Developing an electronic device enclosure requires careful planning throughout each stage of the product lifecycle. From concept development and prototyping to verification testing and mass production, every decision can affect performance, manufacturability, cost, and time-to-market.

Understanding these challenges early allows organizations to make more informed enclosure development decisions. Whether pursuing a fully custom design or leveraging an existing enclosure platform, selecting the appropriate approach can help reduce risk, improve efficiency, and accelerate product development.

Phoenix Contact enclosure solutions provide a proven path to simplify development, reduce complexity, and bring products to market faster. For more information on the wide variety of DIN rail and field-installed enclosures, visit us at www.phoenixcontact.com/enclosures. ■

About Phoenix Contact

Since 1923, Phoenix Contact has created products to connect, distribute, and control power and data flows. Our products are found in nearly all industrial markets. Sustainability and responsibility guide every action we take, and we are proud to collaborate with our customers to empower a smarter and better world for future generations. Together, we are creating a sustainable world based on our passion for technology and innovation.

For more information about Phoenix Contact or its products, visit www.phoenixcontact.com, call technical service at **800-322-3225**, or email us-info@phoenixcontact.com.



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