



# Applications & Advantages of Rigid Flex PCB

A rigid flex PCB (printed circuit board), also called a rigid flex circuit board, is a hybrid circuit used in high-reliability, high-density applications. They offer several advantages over traditional hardboards and flex boards, but their higher cost often raises questions about when and where they should be used. In this blog, we'll provide an overview of rigid flex circuit boards, their applications, and the advantages of rigid flex PCB use.

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# Understanding Rigid Flex Circuit Boards

First things first: What is a rigid flex PCB, exactly? As we briefly touched on above, a rigid flex circuit board is a hybrid construction that combines elements of both rigid and flexible circuits into a single board. It is constructed of flexible circuit sections interconnected with rigid sections, providing an advantageous combination of flexibility and structural integrity. Rigid flex boards are used in applications that require the circuitry to bend or conform to fit into a specific form factor while maintaining the necessary stability and reliability.

Rigid flex PCBs are different from flexible circuit boards with stiffeners, and the main differences lie in their construction and performance characteristics. In terms of construction, rigid flex PCBs integrate both rigid and flexible components on a single board, while flex boards with stiffeners are essentially flexible circuits reinforced with additional stiffeners to provide rigidity in specific areas. Because of these differences, rigid flex PCBs provide the electronics designer with much higher circuit routing density in a package that is more durable, more reliable and yet still flexible. A downside to rigid flex PCBs is their higher manufacturing cost — flex boards with stiffeners, being a simpler construction, tend to be more cost-effective.

Other significant construction characteristics of rigid flex PCBs are the plated through holes (PTH) and mounting components included in their design. PTH provide electrical interconnections between the flexible and rigid sections of the board, allowing for seamless integration of circuitry and components throughout the entire assembly. Then, by leveraging a combination of vias, proper component placement, and design considerations for the flexible sections, rigid flex PCBs can incorporate mounting components on both sides of the board. This allows for increased component density, improved functionality, and optimized use of space in a compact and flexible electronic assembly.

## Rigid Flex PCB Applications

Generally, rigid flex PCBs are used across various industries in applications for which a combination of flexibility, space efficiency, and high reliability is required. Rigid flex PCBs are often seen in aerospace and defense applications, like aircraft instrumentation and military equipment, as well as in the medical industry, where they are utilized in devices like implants and diagnostic equipment. Automotive electronics, industrial machinery and many other applications that demand an adaptable circuitry solution will also use rigid flex PCBs to great effect.

On a more granular level, rigid flex circuit boards are ideal for applications that present challenges to the circuitry during installation or operation. Flex-to-install applications, in which the circuit is designed to be flexed or bent during the installation process, call for rigid flex PCBs due to the application's space constraints and/or the need for conformability to irregular shapes. In dynamic flex applications, the circuit will be continuously flexed during operation, so they are specifically designed to withstand and accommodate the ongoing mechanical stress without compromising their electrical performance or reliability. Rigid flex PCBs that follow the manufacturer's recommended minimum bend radius offer hundreds of thousands of flex cycles without failure.

Applications in high-vibration environments present their own challenges that rigid flex PCBs overcome. Vibration generates mechanical stress that can impact circuits, causing them to flex and bend repeatedly during operation. This dynamic flexing can raise various concerns, including material fatigue, interconnect reliability issues, and component integrity failures.

To mitigate these risks, rigid flex PCBs designed for high-vibration environments are subjected to specific design and manufacturing considerations, like reinforcement to enhance their rigidity and mechanical stability or selecting a material with high flexural strength for their construction.

## Rigid Flex PCB Applications Cont.

Finally, rigid flex PCBs are also commonly used in applications that handle high currents and generate heat, like high-speed data communication, industrial equipment or power electronics. Rigid flex PCBs generally have a higher current carrying capacity than rigid boards with flex circuit connections, which makes them a compelling choice for these applications — but that higher capacity comes at a cost.

In a phenomenon known as thermal expansion, the heat generated by a high current passing through a conductive trace or copper plane on a PCB causes the circuit material to expand and contract repeatedly. The flexible sections may undergo stretching or elongation, while the rigid sections experience minimal expansion; when the current stops or decreases, the PCB cools down and contracts. This presents several potential problems for the integrity of the circuit board, including the risks of mechanical stress and fatigue, as well as the risk of electrical performance issues.

But as with rigid flex PCBs designed for high-vibration applications, flex circuit board manufacturers can implement certain design and manufacturing considerations to help mitigate these risks. Choosing materials with good thermal stability and low coefficient of thermal expansion (CTE), implementing thermal management techniques like heat sinks and thermal vias, and optimizing the trace widths, thickness, and copper plane configurations can all help ensure the reliability and long-term performance of rigid flex PCBs in high-heat environments.

# Advantages of Rigid Flex Circuit Boards

Rigid flex circuit boards offer a wide range of advantages to their use, particularly in applications that require reliable, durable circuitry that can be bent to conform to a complex shape or environment. Some of the most compelling advantages of rigid flex PCBs include:

## **Space Efficiency.**

Thanks to their hybrid design, rigid flex PCBs allow for compact and space-efficient designs. They can be bent or folded to fit into tight or irregularly shaped spaces, saving valuable space in electronic assemblies.

## **Reliability.**

Again, the hybrid design of rigid flex PCBs creates an enhanced mechanical stability, reducing the risk of fatigue, cracking, or failure in high-shock and high-vibration environments and improving the overall reliability and durability of the circuit.

## **Higher Component Density.**

Rigid flex PCBs support the mounting of components on both sides of the board, increasing the component density for more compact and sophisticated designs. This is especially advantageous in miniaturized electronic devices where real estate is at a premium, and there is no longer room for connectors.

## **Design Versatility.**

Rigid flex PCBs offer greater design versatility than traditional rigid PCBs and fully flexible PCBs alike. The ability of rigid flex PCBs to flex, bend and fold into various shapes without losing its rigidity in certain areas allows for more creativity (and, yes, flexibility) in the design process, resulting in unique and innovative designs.

## **Simplified Assembly.**

Rigid flex PCBs streamline assembly by reducing the need for complex interconnects, connectors, and cables. This simplifies the overall assembly, reduces the number of interconnection points, and improves the overall reliability of the system. On designs requiring four or more interconnected rigid boards, a rigid flex design can actually provide you with an overall lower cost.

## **Budget-Friendly.**

Although rigid flex PCBs may have higher upfront manufacturing costs compared to traditional rigid PCBs, they can actually deliver cost savings in the long run. Their compact design, reduced interconnects, and improved reliability can result in lower maintenance costs, reduced system failures, and increased product longevity. Rigid flex PCBs are also an ideal lower-cost option for complex assemblies with four or more rigid boards connected with flex cables.

# When to Choose Rigid Flex Circuit Boards

While rigid flex circuit boards have many significant advantages, the suitability of a rigid flex PCB for your specific application depends largely on the application itself and the construction and performance requirements therein.

As covered previously, you can confidently choose rigid flex circuit boards if your application calls for a high degree of reliability, durability and flexibility, especially when space constraints or complexities are in play. Medical imaging equipment, military missile guidance systems, cameras and video cameras, along with wearable electronics, vehicle infotainment systems, and industrial robotics would all be appropriate applications for rigid flex PCBs.

However, there are situations in which rigid flex PCBs may not be the best choice.

## **Cost Constraints:**

Rigid flex PCBs often have higher manufacturing costs compared to traditional rigid PCBs or fully flexible circuits. If cost is a primary consideration for your project and the design does not require the specific benefits of a rigid flex PCB, alternative options may be more cost-effective.

## **Simple Designs:**

If the design does not require complex interconnections, bending or folding capabilities, or high-density component mounting, a traditional rigid PCB or a fully flexible circuit may suffice. Rigid flex PCBs are more suitable for designs that demand flexibility, space optimization, or unique form factors.

## **Low-Volume Production:**

Rigid flex PCBs often require specialized fabrication techniques and expertise, making them better suited for medium- to high-volume production runs. For low-volume production or prototyping, it may be hard to justify the cost and time associated with rigid flex PCB fabrication. Ultimately, it's best to weigh the advantages and disadvantages of rigid flex circuit board use for your specific application and make your decision accordingly.

## **The Bottom Line**

Whatever type of flex circuit you choose, All Flex is here to help make the process simple and the board top-quality. We're here for all your specialty flex and rigid flex printed circuit, flexible heater, and value-added assembly needs. Contact us today to learn more about All Flex's quality rigid flex circuit board solutions!