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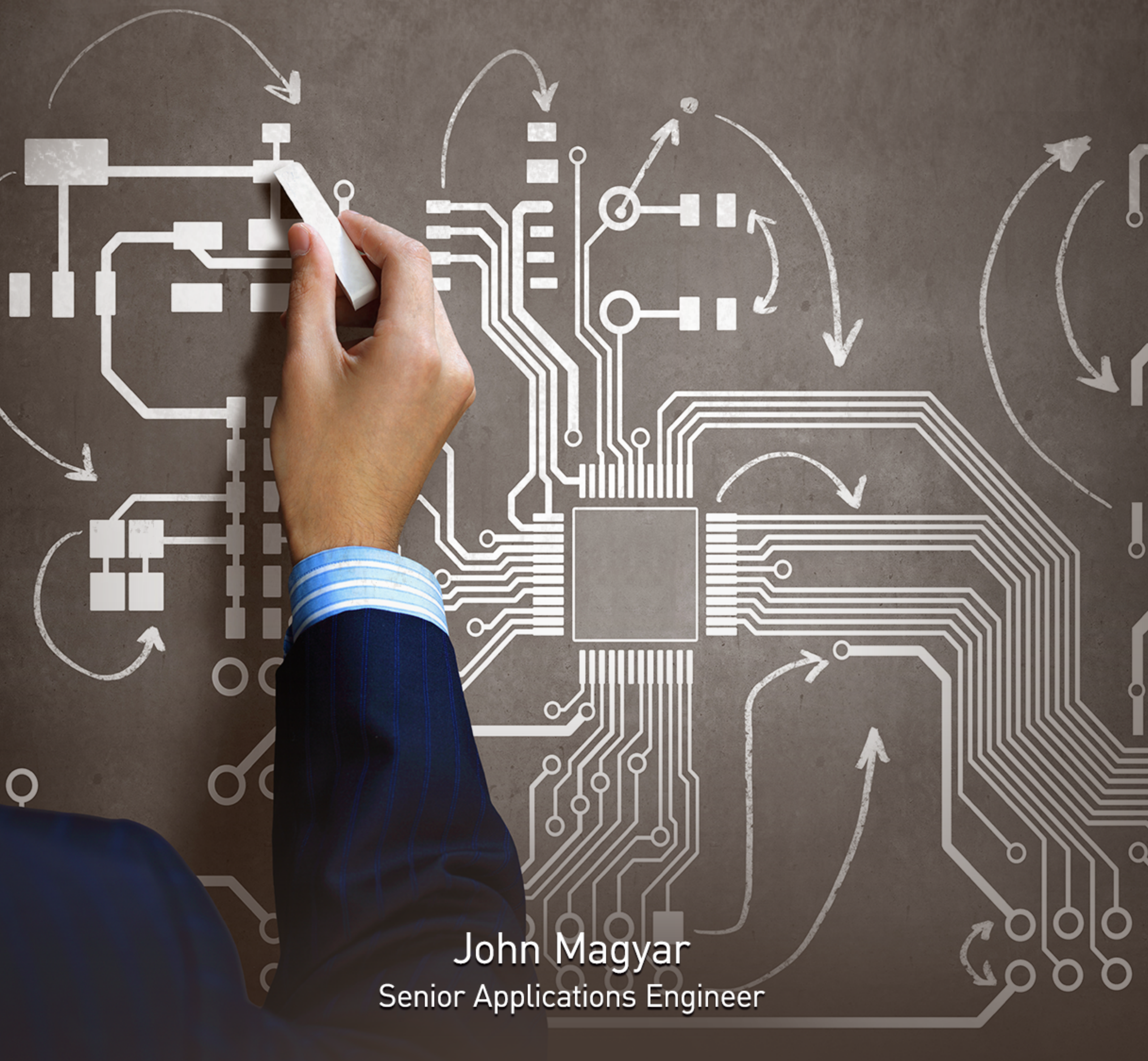
Challenges with Rigid-Flex Design



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CHALLENGES WITH RIGID-FLEX DESIGN

Rigid-flex PCB technology offers tremendous benefits in terms of reduced weight, space, durability, and reliability. Today's small lightweight consumer electronics products are best implemented with rigid-flex technology, however, there can be many challenges in achieving successful rigid-flex PCB designs. This paper highlights several key considerations for rigid-flex design.

INTRODUCTION

Rigid-flex PCB is a time-proven, well-understood technology initially used within the military/aerospace industry decades ago. Today it is recognized as the ideal solution for contemporary small form factor, highly durable, and lightweight electronic products such as wearables, medical devices, and mobile wireless products. However, as many PCB designers contemplate designing rigid-flex PCBs for the first time, several challenges come to mind:

- How much will rigid-flex cost to fabricate and assemble?
- How are the dissimilar rigid and flex sections described as one PCB assembly?
- How are the different rigid and flex materials and layer specifics managed and communicated to a fabricator?
- How can the range of motion and critical folded states be modeled and verified?
- How is placement and routing within flex regions different from that of traditional rigid PCB?

These and many other questions reflect the challenges of rigid-flex PCB design.

COST

As compared with traditional rigid PCB fabrication, rigid-flex requires additional materials and more complicated process steps, so it inherently costs more to fabricate. Such extra fabrication costs can be offset by potentially lower BOM costs (fewer connector and cable components), lower assembly costs (less manual wiring or assembly), and increased product reliability.

Rigid-flex cost can be optimized by carefully managing the design implementation relative to the end application's requirements. Certain factors such as material choices, hole size/count, and layer stack configuration can drive rigid-flex cost up significantly. Using high-end materials, asymmetrical layering, or a large number of excessively small hole sizes in the flex regions for non-critical end applications will result in an unnecessarily costly rigid-flex fabrication.

To properly manage rigid-flex fabrication costs, speak with several fabricators regarding your product requirements and the cost drivers of their specific fabrication processes. Choose a fabricator who can provide guidelines on how to manage costs and achieve an optimal design.

CHALLENGES WITH RIGID-FLEX DESIGN

BOARD SHAPE

A rigid-flex PCB, including several rigid and flex sections, is designed as one composite board outline. Within the outline, individual regions are defined as being either rigid or flex. Rigid or flex specific stackup information is then assigned to each individual section. One of the most important aspects of the board shape is if it can achieve the range of movement required for the end application. The range of movement will depend on the bending radius of the flex section. The minimum allowed bending radius is dependent on the thickness of the flex section. Generally, the minimum bending radius is ten times the flex region's total thickness.

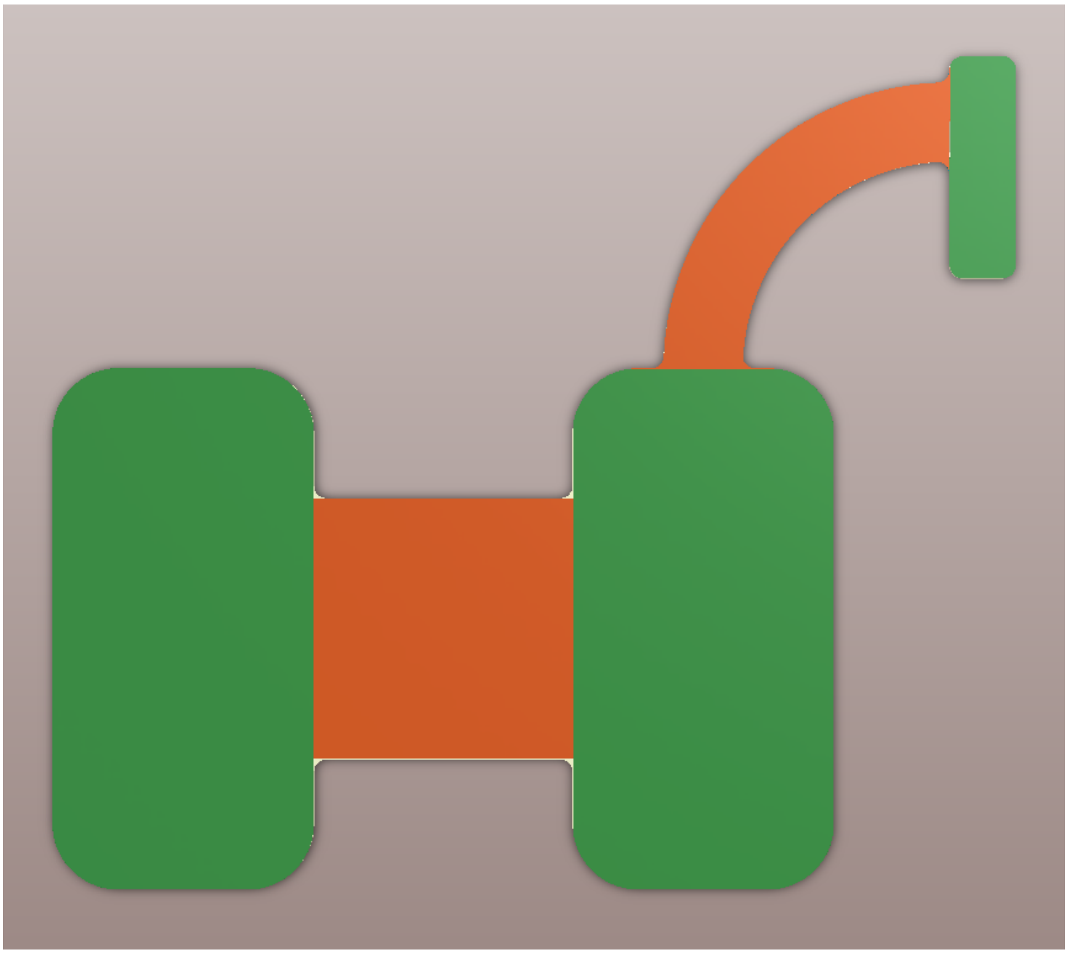
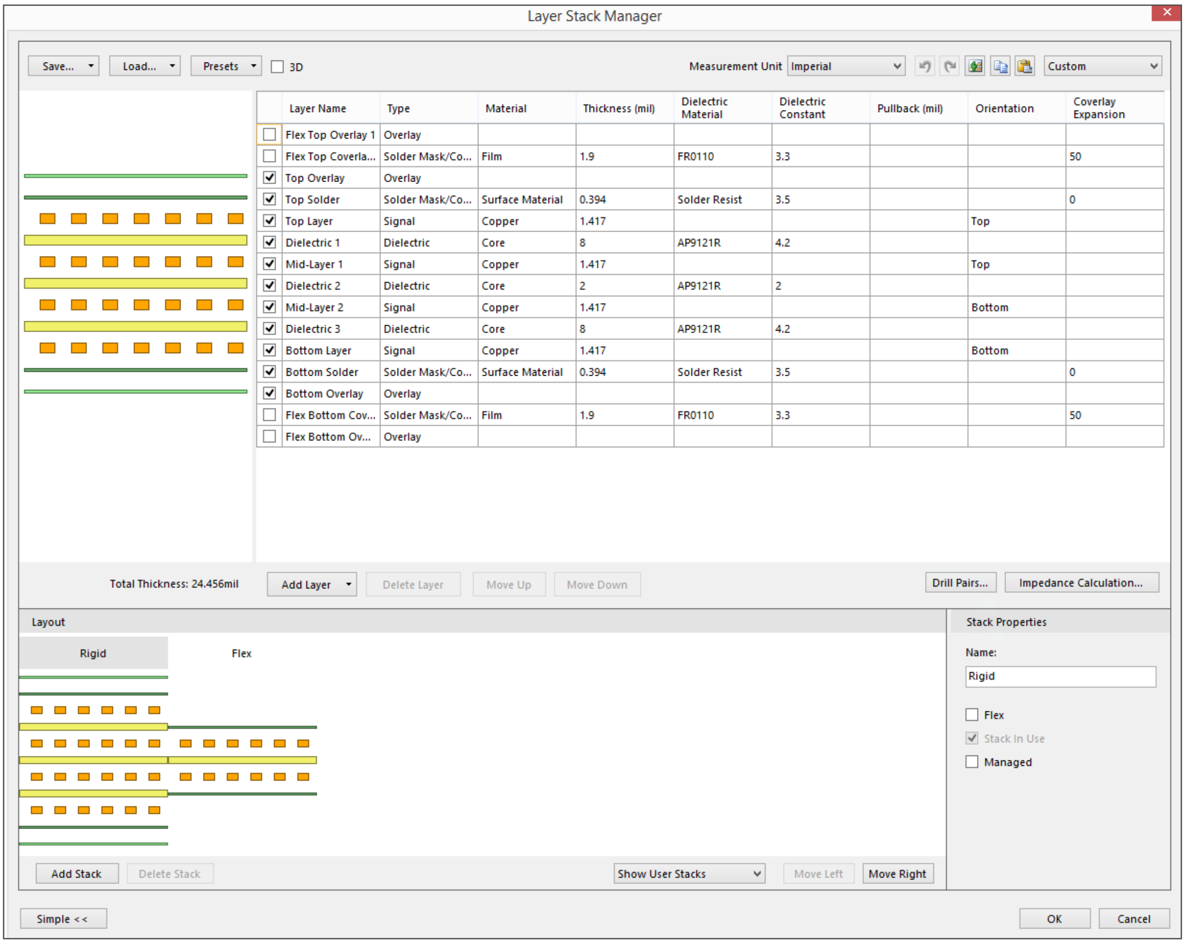


Figure 1. Typical rigid-flex board shape (green: rigid sections, amber: flex sections)

While fabricators recommend using paper or mylar cutout of the board shape to verify range of motion, bending radius, and folded states, you may want to explore PCB design tool capabilities which enable the animation of flex region movement and point to point measurement within a 3D context. Such 3D capabilities not only provide visualization of the rigid-flex board as a solid model, but also enable real-time component clearance checking and precise definition of flexible region bending locations and radii.

LAYER STACKUP

Rigid-flex stackup configurations can vary greatly from simple single copper conductive layer on a flexible polyimide dielectric to complex multiple layer copper and dielectric flexible sections including adhesive and coverlay layers. Accurate layer representation including layer order, type, material, thickness, and dielectric constant must be definable and propagate accurately out to fabrication outputs such as Gerber, ODB++, or IPC-2581.



☐ 3D

Measurement Unit: Imperial

Custom

	Layer Name	Type	Material	Thickness (mil)	Dielectric Material	Dielectric Constant	Pullback (mil)	Orientation	Coverlay Expansion
☐	Flex Top Overlay 1	Overlay							
☐	Flex Top Coverla...	Solder Mask/Co...	Film	1.9	FR0110	3.3			50
☑	Top Overlay	Overlay							
☑	Top Solder	Solder Mask/Co...	Surface Material	0.394	Solder Resist	3.5			0
☑	Top Layer	Signal	Copper	1.417				Top	
☑	Dielectric 1	Dielectric	Core	8	AP9121R	4.2			
☑	Mid-Layer 1	Signal	Copper	1.417				Top	
☑	Dielectric 2	Dielectric	Core	2	AP9121R	2			
☑	Mid-Layer 2	Signal	Copper	1.417				Bottom	
☑	Dielectric 3	Dielectric	Core	8	AP9121R	4.2			
☑	Bottom Layer	Signal	Copper	1.417				Bottom	
☑	Bottom Solder	Solder Mask/Co...	Surface Material	0.394	Solder Resist	3.5			0
☑	Bottom Overlay	Overlay							
☐	Flex Bottom Cov...	Solder Mask/Co...	Film	1.9	FR0110	3.3			50
☐	Flex Bottom Ov...	Overlay							

Total Thickness: 24.456mil

Stack Properties

Name: Rigid

☐ Flex

☑ Stack In Use

☐ Managed

Figure 2. Example 4-layer rigid with 2-layer flex stackup definitions

As rigid and flex stackups differ but share certain layers in common, it is essential that the PCB design tool enables the ability to define and manage multiple layer stackup within the context of one PCB board shape. Also important is the ability to convey a layer stackup legend within the fabrication notes detailing the layers specifics such as material, type, thickness, and dielectric constant. It is essential that the fabricator can easily understand the layer stackup of each rigid and flex section.

BEST DESIGN PRACTICES

Placing and routing traces, vias, and components on flexible regions is very different than compared with that of rigid regions. Flexible regions have very different physical properties and characteristics than rigid regions. Therefore different design guidelines apply to flexible sections. For example, drilling of via holes in flexible regions is less precise than that of rigid regions. Therefore, annular rings within flexible regions must be larger than those within rigid regions. Minimum hole sizes within flex regions must be greater relative to rigid regions. It is important to have configurable DRC rules which allow specification of design constraints targeted to specific regions of the board.

When copper traces traverse flexible sections, they must do so perpendicular to the bend. Trace routes must not use 90 or 45 degree angles within flex regions, instead arcs must be used. Vias placed within flexible regions should include teardrops to strengthen the transition point between the track and annular ring—making it less susceptible to fatigue and cracking due to repeated flexing. Solid polygons cannot be used with flex regions but instead must be implemented as hatched polygons to permit flexing. It is important the PCB design tool can easily implement flex region specific constraints and routing requirements, while being able to easily switch back to that of the rigid regions.

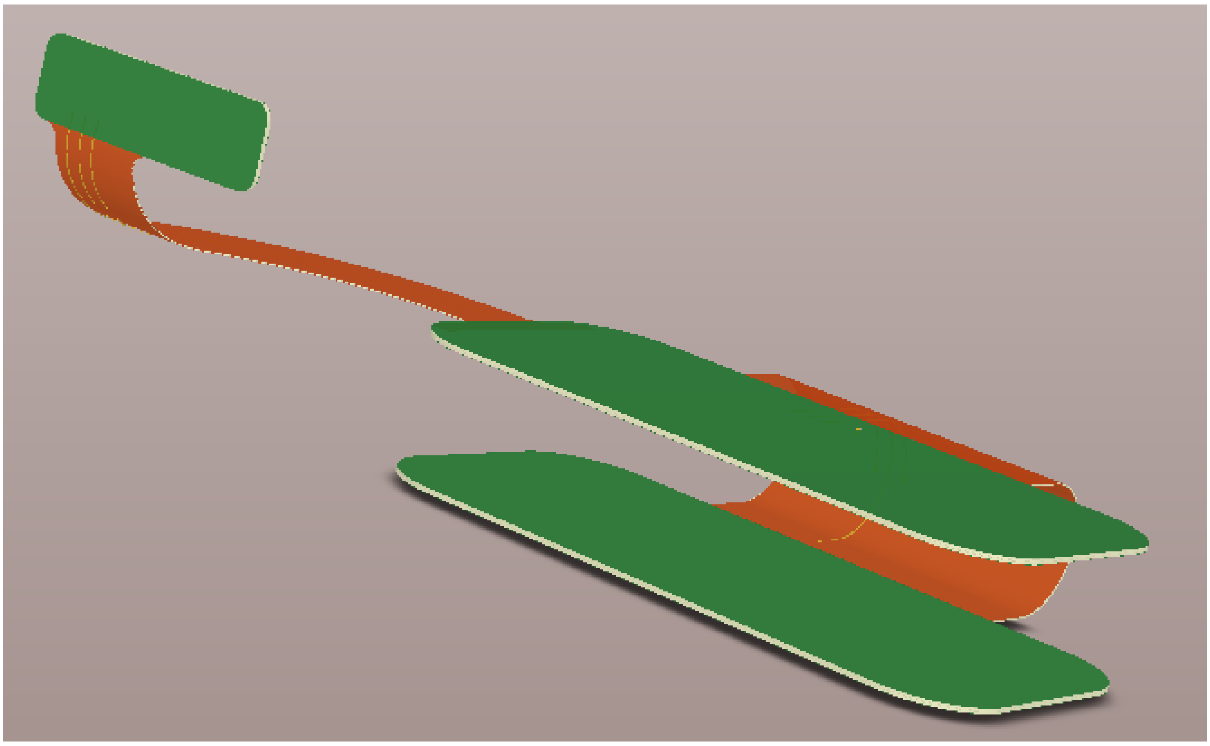


Figure 3. Flex region folded state animation

CONCLUSION

Rigid-flex PCBs are becoming more common in contemporary electronic products. They are an excellent solution to meet the requirements for lightweight, mechanically constrained, high durability, and high reliability PCB assemblies. While rigid-flex provides many benefits, it also presents many design challenges, especially when attempting rigid-flex design for the first time. Successful rigid-flex design implementations can be achieved by discussing the end application requirements with an experienced rigid-flex fabricator. Also critical to successful rigid-flex design is the use of a PCB design tool which includes the necessary capabilities to manage rigid-flex specific board shape definitions, layer stackup information, range of motion animation, folded state verification, and flex region routing constraints.