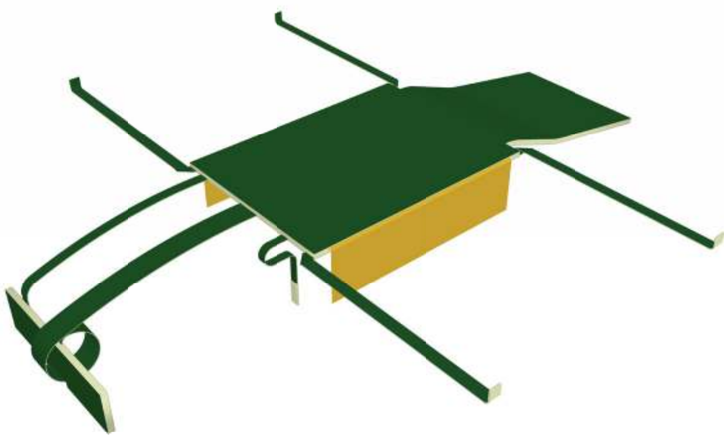
syncroness
complex problems inspired solutions

Flexible and Rigid-Flex Circuits



Objectives

- Provide a solution when rigid PCBs do not satisfy all of a customer's product requirements
- Reduce weight and size
- Improve manufacturability
- Increase reliability

Approach

- Clearly understand and define requirements
- Use Syncroness' product design process for consistent and efficient implementation
- Interface with manufacturers

Results

- Successful robust design and integration of flexible and rigid-flex circuits into medical, aerospace, and industrial products
- Reduced weight and space claim
- Reduced component count and assembly time

Syncroness application examples

- Heart monitor patch that attaches to patient's skin (medical wearable)
- Flexible and comfortable monitoring bracelet
- Vertical Take Off and Landing (VTOL) UAV
- Electronic ballast for avionics

A COMPLETE PRODUCT DEVELOPMENT PARTNER

- Brainstorming and Concept Generation
- Feasibility Studies and System Architecture
- Detailed Product Design
- Prototyping
- Design for Manufacturing (DFM)
- Verification Testing
- Manufacturing Assembly and Test Equipment
- Sustaining Engineering

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Complex Problem

New products need circuits that are smaller and lighter than previous designs. Often that means a fully rigid PCB will not meet the space constraints. When appropriate, Syncroness implements flexible and rigid-flex circuits to solve demanding aerospace and medical product requirements such as:

1. The product shall fit within a specific form factor.
2. The product shall conform to a user's body.
3. The product shall flex dynamically during its lifetime, not just one time during installation.
4. The product shall weigh less than a given value.
5. The connections shall be robust enough to survive the product's operating conditions.
6. The assembly time shall not exceed a certain limit.

What exactly is a flexible or rigid-flex circuit?

Per IPC-6013 Qualification and Performance Specification for Flexible Printed Boards, "The flexible printed board may be single-sided, double-sided, multilayer, or rigid-flex multilayer. All of these constructions may or may not include stiffeners, plated-through holes, and blind or buried vias (electrical connections between layers in a physical circuit). The flexible or rigid-flex printed board may contain build up High Density Interconnect (HDI) layers. The printed board may contain embedded active or passive circuitry with distributive capacitive planes, capacitive or resistive components conforming to IPC-6017. The rigid section of the printed board may contain a metal core or external metal heat frame, which may be active or non-active."

Electrical Engineering Principles for Flex

Evaluating electronic concepts and architectures from a design for manufacturing and assembly perspective may lead to selecting a rigid-flex design path. By creating a functional block diagram that shows connectivity, a flex circuit design is quickly visualized. Typically, major considerations for choosing a flexible or rigid-flex design are size weight and power (SWaP), manufacturing and assembly time, and dynamic flexibility requirements.

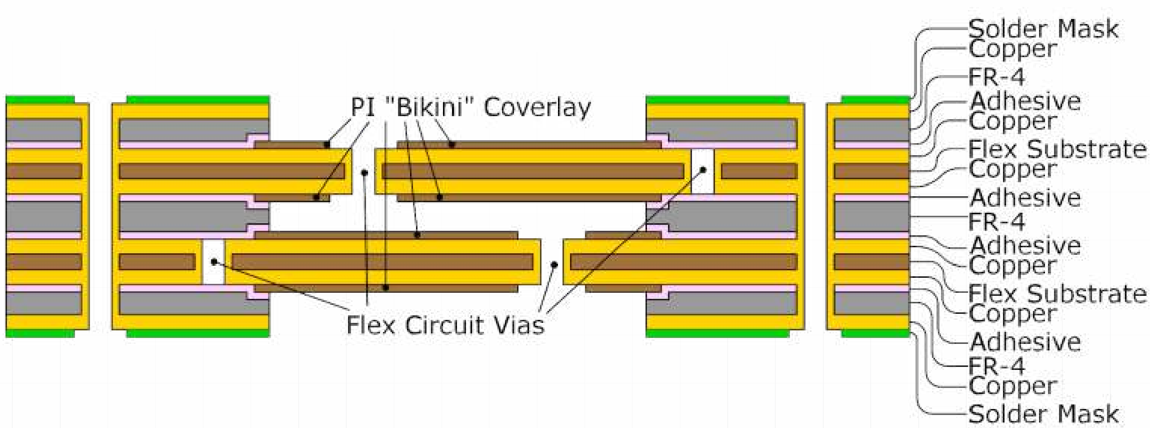

Figure 1: Rigid-flex stack-up

Cost is often a major consideration when deciding to design flexible or rigid-flex printed circuits. Some of the significant factors impacting the cost are the number of layers, trace and space specifications, usage of stiffeners, plating on flex areas, board thickness, and the use of special core and prepreg materials. To mitigate some of the additional cost of flexible or rigid-flex printed circuits, Syncroness works closely with flexible printed circuit fabricators to define standard material stack-ups and use standard process capabilities.

To improve reliability and reduce flex breakage, Syncroness considers fabrication processes and material differences during the design of the rigid-flex stack-up and layout. Using prepreg within the rigid stack-up instead of coverlay improves the strength of the interface between the flex and rigid areas due to significant differences in the coefficient of thermal expansion between rigid and flex materials. This is typically referred to as a bikini coverlay where a small portion of the coverlay extends into the rigid portion to hold the coverlay in place. See Figure 1.

In addition, careful coordination with the fabricator and mechanical designers allow the rigid-flex circuits to be folded from a flat pattern into the desired shape to fit in the product.

Example: Heart monitor

Syncroness revised a prototype design to improve flex reliability and manufacturability. The non-volatile memory in a ball grid array (BGA) package required a stiffener to support the larger package and BGA pads. The stiffener was added to the board as part of the PCB fabrication layup process. Additionally, we integrated battery contacts into the flexible circuit by folding the flexible circuit around the battery. Syncroness designed an injection molded clip (~200k clips/year volume) to secure the batteries. Instead of adding a physical tactile switch, we created a switch using folded flex with contact pads. Furthermore, we added USB connectivity for robust data access. See Figure 2.

Example: Ankle bracelet tracking device

Syncroness designed a flexible backbone for a wearable device that included multiple rigid boards connected using flexible circuits. The ankle bracelet tracking device needed to be compact, flexible and light-weight. The design included a GPS receiver, cellular modem, Wi-Fi and both permanent and removable batteries.

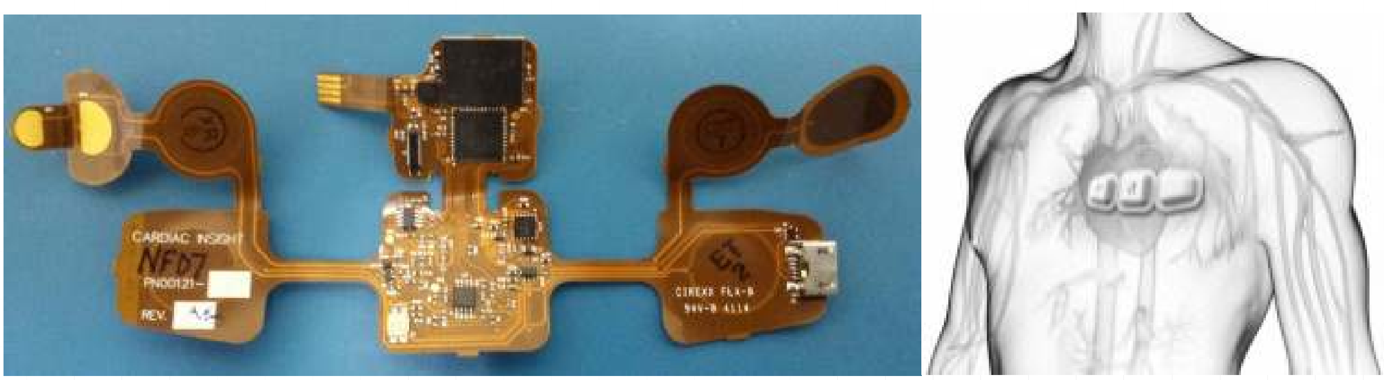

Figure 2: Wearable ECG monitor

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Example: Single rigid-flex board with heat dissipation and shielding for UAV application

Syncroness combined multiple boards into a single rigid-flex design to reduce assembly time, mass, and space claim. The Syncroness hardware architecture allowed for a simplified layout and routing due to fewer components and less inter-component connections. The processor used a Single Chip Module package that significantly reduced the number of routed connections between the processor and memory chips, thereby reducing the number of layers required. In addition, since all subsystems were unified into one rigid-flex circuit, there was no need for connectors. Eliminating connectors reduced mass, volume, and potential failure points.

The cost of a rigid-flex board is highly dependent on the effective use of the PCB panel, which can be greatly improved using flex design techniques. This layout maximizes the panel usage by designing the flexible arms to be parallel with the main board for fabrication and then folded perpendicular for assembly. This technique improves reliability because the grain direction of the copper is maintained in the same direction as the traces.

The rigid-flex circuit design included heat sinks and shielding. This reduced assembly time, mass, and cost. The mass of a 10 cm2 flex heat sink of 1 oz. copper is 0.4g. See example stack-up in Table 1.

Table 1: Example flex stack-up

Layer	Thickness	Material Name
Polyimide Film	1 mil	Pyralux LF 0110
Pyralux LF Adhesive	1 mil	
Copper	1 oz	Pyralux AP9111R, bottom copper etched
Polyimide Film	1 mil	

Shielding was incorporated into the rigid-flex circuit design to protect sensitive circuitry from harmful noise and to maintain a continuous ground. See Figure 3.

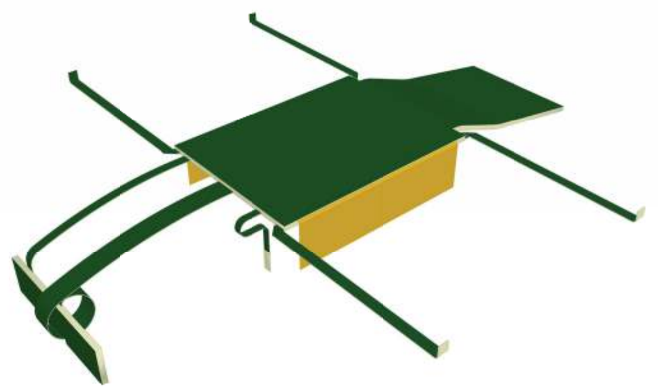

Figure 3: Single rigid-flex concept

Example: Electronic ballast for aircraft lighting

Syncroness designed a florescent lighting ballast for a commercial aircraft. This design reduced the power consumption and enhanced features of an existing product that had been experiencing failures due to overheating. The design had to handle the high voltage requirements of florescent lamps and the power requirements to support up to four florescent tubes per ballast. The flex circuit connection between the two PCBs carries the 933 Volt peak voltage and other high current signals between the rigid sections with solid copper shielding on the outer layers of the flexible portion.

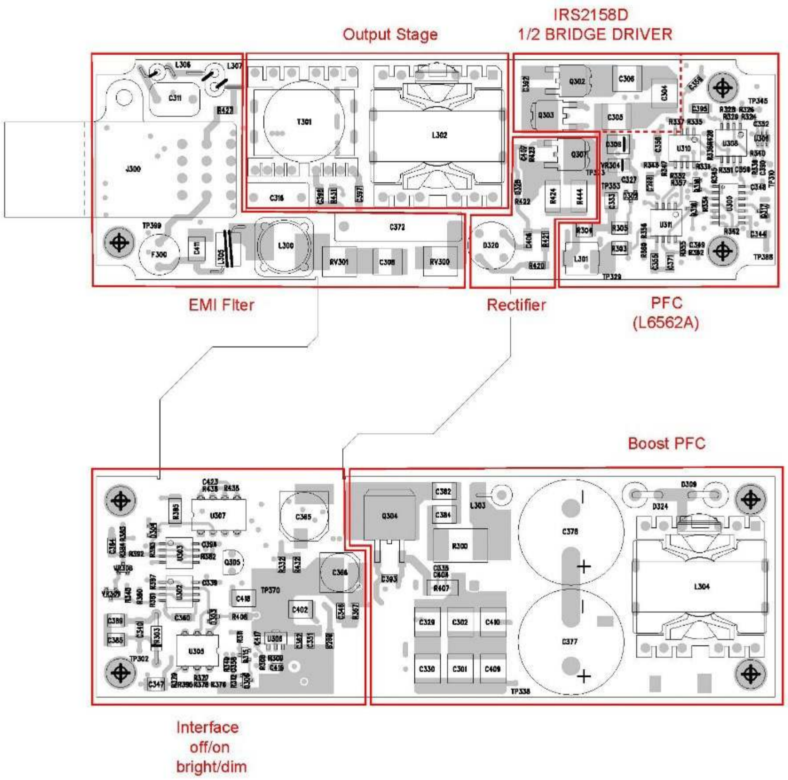

Figure 4: Layout placement overview

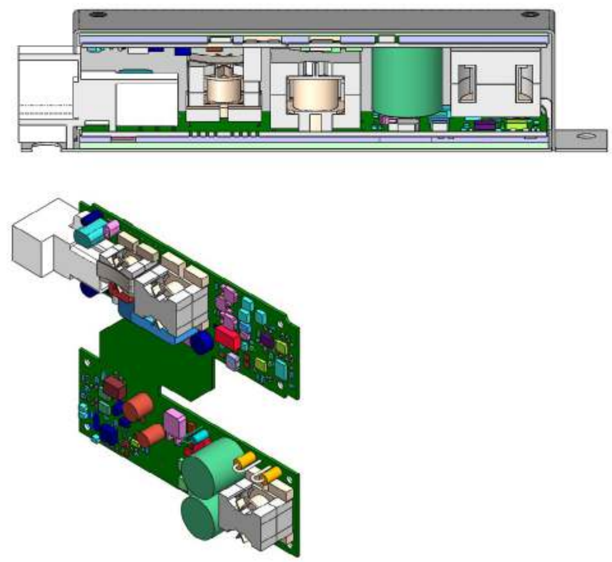

Figure 5: Mechanical interface of rigid-flex circuit

The physical space was limited, prohibiting the use of connectors between the two PCBs. As a result, Syncroness integrated the rigid-flex circuit shown in Figure 4 into the enclosure's constrained space shown in Figure 5. Mechanical and electrical engineers worked closely to plan how the rigid-flex board would fold. Our design maintained the minimum bend radius, and the installation did not overstress the flexible portions. We ran highly accelerated life tests (HALT) shown in Figure 6 to expose and subsequently correct any weak points in the system.

Syncroness' Solution

Syncroness has a wide range of experience working with flex and rigid-flex systems. Each design challenge takes all of the design factors into account and establishes priority order of the design requirements that need to be used in the flexible or rigid-flex circuit design. Syncroness works closely with customers to ensure a complete understanding of the design requirements and what is necessary to make the design successful.

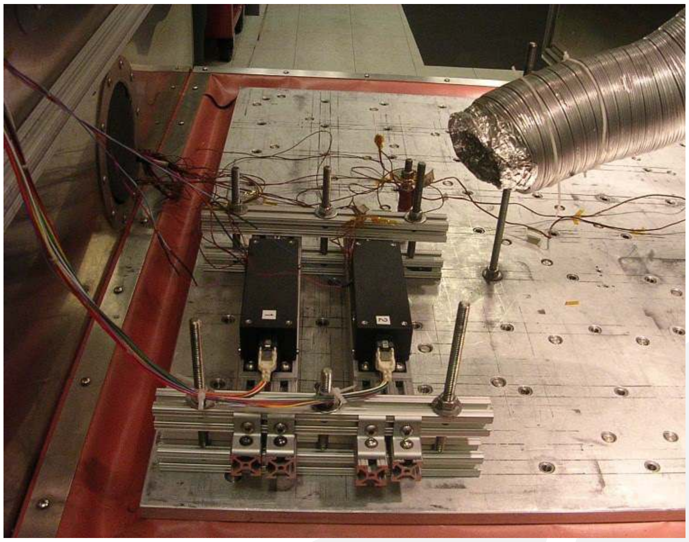

Figure 6: HALT of electronic ballasts containing rigid-flex circuits