Mechanics/Machinery

Robust Tensioned Kevlar Suspension Design

A suite of compact design elements improves the reliability of Kevlar suspension systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

One common but challenging problem in cryogenic engineering is to produce a mount that has excellent thermal isolation but is also rigid. Such mounts can be achieved by suspending the load from a network of fibers or strings held in tension. Kevlar fibers are often used for this purpose owing to their high strength and low thermal conductivity. However, Kevlar presents challenges since it expands on cooling and tends to creep after initial tensioning, causing reductions in the resonant frequencies and a shift in the position of the suspended element, which can lead to misalignment and thermal short circuits. With existing designs, such as the Kevlar suspension used on the Herschel SPIRE instrument, it is difficult to re-tension the Kevlar or measure the tension because parts of the Kevlar string are staked with epoxy. Non-cryogenic designs used on a larger scale, such as tensioning reels on sailboats, use turnbuckles and fixed eyebolts that cannot be scaled down to a small-scale structure without a significant addition of mass.

A suite of compact design elements has been developed to improve the reliability of suspension systems made of Kevlar. The Kevlar is anchored to the load via a pair of tensioning stars whose arm stiffness is optimized to ensure that the Kevlar spans remain sufficiently taut during and after thermal cycling. All other anchor points for the Kevlar are designed to have much higher stiffness to maintain the optimal geometry when under load. Pulleys are used at each anchor point allowing the tension to equalize between all spans. The resulting symmetry allows the load to remain fixed in space even as the suspension elements undergo thermal strain, and the tension buffering provided by the tensioning stars reduces the concomitant changes in the structure's resonant frequencies.

The tension is adjusted by means of a capstan made of an array of stainless steel dowel pins to which the Kevlar string is belayed. Each pin has a large diameter compared to the Kevlar string so there are no machined corners that might initiate fraying of the Kevlar. The capstan is locked with an integrated mechanical clamp, so no epoxy is needed to secure the Kevlar or the capstan in place. Thus, the tension of the Kevlar can be adjusted after the initial creep or easily reworked if needed. The tension can be measured in situ by measuring the flexure of a single arm of the tensioning star.

This work was done by Joseph B. Young, Bret J. Naylor, and Warren A. Holmes of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47940

Focal Plane Alignment Utilizing Optical CMM

This approach will eliminate all requirements on positional tolerances.

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In many applications, an optical detector has to be located relative to mechanical reference points. One solution is to specify stringent requirements on (1) mounting the optical detector relative to the chip carrier, (2) soldering the chip carrier onto the printed circuit board (PCB), and (3) installing the PCB to the mechanical structure of the subsystem. Figure 1 shows a sketch of an optical detector mounted relative to mechanical reference with high positional accuracy. The optical detector is typically a fragile wafer that cannot be physically touched by any measurement tool.

An optical coordinate measuring machine (CMM) can be used to position optical detectors relative to mechanical reference points. This approach will eliminate all requirements on positional tolerances. The only requirement is that the PCB is manufactured with oversized holes. An exaggerated sketch of this situation is shown in Figure 2. The sketch shows very loose tolerances on mounting the optical detector in the chip car-

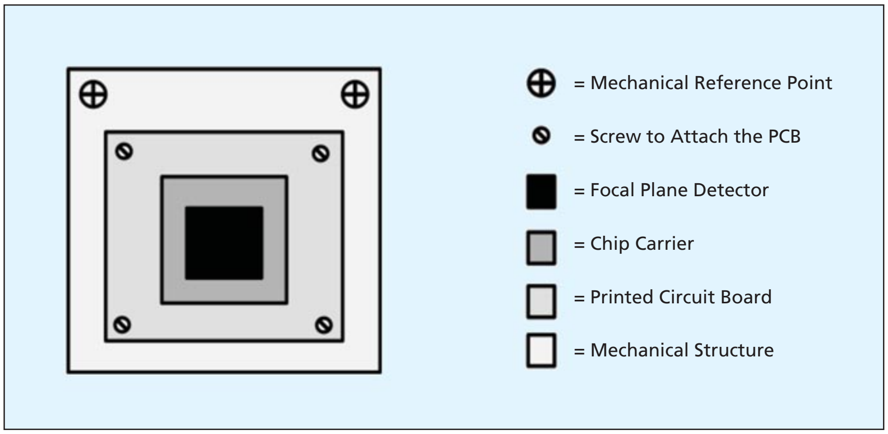

Figure 1. **Sketch of an Optical Detector.**

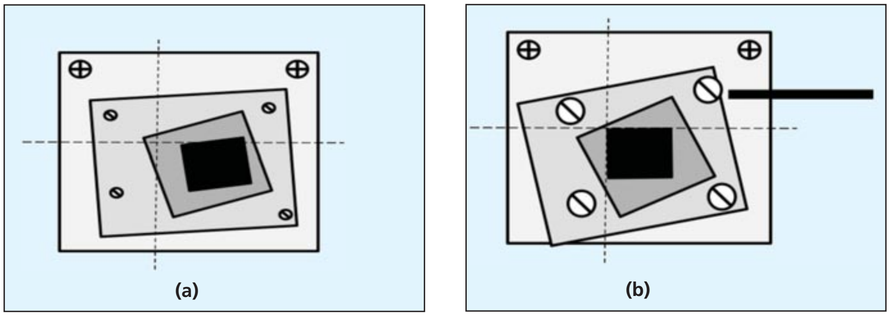

Figure 2. The **Optical CMM Measures the Mechanical Reference Points**. (a) Cross hairs indicate where the detector is supposed to be. (b) The PCB is tapped around until the corner of the optical detector is at the crosshairs of the CMM.

rier, loose tolerance on soldering the chip carrier to the PCB, and finally large tolerance on where the mounting screws are located. The PCB is held with large screws and oversized holes.

The PCB is mounted loosely so it can move freely around. The optical CMM measures the mechanical reference points. Based on these measurements, the required positions of the optical detector corners can be calculated. The optical CMM is commanded to go to the position where one detector corner is supposed to be. This is indicated with the crosshairs in Figure 2(a). This figure is representative of the image of the optical CMM monitor. Using a suitable tapping tool, the PCB is manually tapped around until the corner of the optical detector is at the crosshairs of the optical CMM. The CMM is commanded to another corner, and the process is repeated a number of times until all corners of the optical detector are within a distance of 10 to 30 microns of the required position. The situation is sketched in Figure 2(b) (the figure also shows the tapping tool and where to tap). At this point the fasteners for the PCB are torqued slightly so the PCB can still move. The PCB location is adjusted again with the tapping tool. This process is repeated 3 to 4 times until the final torque is achieved. The oversized mounting holes are then filled with a liquid bonding agent to secure the board in position (not shown in the sketch). A 10- to 30-micron mounting accuracy has been achieved utilizing this method.

This work was done by Carl Christian Liebe, Patrick L. Meras, Gerald J. Clark, Jack J. Sedaka, Joel V. Kaluzny, and Brian Hirsch of Caltech; Todd A. Decker of Calwest Engineering; and Christopher R. Scholz of the University of California Berkeley for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47846