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[PROJECT SCOPE & NEEDS ASSESSMENT]

EML4551C – Senior Design – Fall 2012 Deliverable 1

Needs Assessment

The purpose of this project is to build a prototype to demonstrate the versatile application of shape memory alloys/polymers for active surface shaping for reflectors. The concept behind this design is to use shape memory alloy (SMA) elements to either make final adjustments once a reflector is deployed, or to change the shape of a reflector surface to modify its optical properties. The shape change will be an active system that will be controlled by a computer using a breadboard.

Project Scope

Problem Statement

Current fixed-mesh reflector (FMR) designs used today are used to significantly lower the antenna's mass for a given aperture size compared to traditional solid reflectors. With the addition of SMAs applied to various reflector products such as FMRs and deployable mesh reflectors, the overall structure and mass of a satellite system can be reduced to greatly increase potential mission performance.

Justification/Background

The project focuses on the research for possible adaptation of SMAs to be applied to current reflector products that are used in the commercial field of satellite communications. These products are generally used in space where the temperatures are range from 250F to -436F depending on position of the satellite relative to the sun. SMAs are metallic alloys that can be deformed into multiple shapes and return to their parent shape when they are heated above a certain temperature. However, since there is such a wide variation of temperature in space for an orbiting satellite, a different technique using an applied current must be used to alter the shape of the SMA.

The idea consists of applying a current through the shape memory element (SMA, FSMA, SMP) to modify its crystalline structure and thus its shape. For final adjustments, one-way SMA's can be used while for active adjustments two-way materials can be used. The change in shape of these elements can be used to change the length of rear cords or ties to change the shape of the surface of deployable mesh reflectors. For FMRs, the SMA elements can be used on the surface splines or other structural members to alter the shape of the surface.

Objective

The main objective of this project is to design and build a prototype a base structure that will support a SMA material that can change its geometry based off the applied voltage. The design will be used in further research to ultimately apply SMAs to commercial satellites. This requires the system to be highly versatile with a friendly user interface that can be easily adapted. The shape of the SMA will be induced via the various points along the frame that are connected to a breadboard and controlled by a computer. The base dimensions of the frame should allow the structure to easily fit on top of a table.

Methodology

To begin to decide which direction we are going to go with this project, initial research must be done to gain a broad understanding of how SMAs work. Once we find a how they are used in the field, we can then narrow down our selection of materials to use for this experiment. It is important that the concept behind SMAs are well understood by each of the teammates to reduce confusion.

Before the purchase of SMA materials are to be purchased, the frame to support the SMA sheet will have to be designed in ProE and built, with potential geometries of a circle, elliptical, square, rectangle, etc. With the frame built, various configurations for the SMA wire set up will have to be test out, such as crisscross, circular, set up like a spider web, etc.

With the frame and SMA spring sheet setup, then various points along the frame can be attached that will be connected to the breadboard. Depending on SMA wire configuration, the breadboard may have alternate setups as well. Then spacing between the attachment points can be determined through trial and error of which areas of the SMA are or are not affected. With this basic platform we can then program an algorithm that can control the current/voltage applied to each individual connection. The final configuration of the SMA spring sheet will be a trial and error process to determine which is the most efficient model based on the response time and power consumption.

Once the final configuration is decided, an elastic material such as pantyhose or muscle wire will be woven in to the SMA spring sheet to give it a smooth surface. The algorithm programed will be controlled by the program CodeWarrior in the language of C on a user's computer.

Deliverables

1. Development plan (schedule and technical) with key milestones
2. Weekly status – Email format, bulletized recent accomplishments, plans and issues
3. Preliminary design presentation package – Fall, preliminary trades and design rationale (if providing for University class, this will be adequate)
4. Critical design presentation package – spring, inclusive of all design development trades, analyses and control algorithms (This should be the University final review presentation)
5. Demonstration (University demo adequate)
6. Final summary report
7. Final breadboard, supporting hardware & software (control algorithms)

Expected Results

At the end of the project, the need of the sponsor from Harris Corp should be satisfied, with the most efficient design that is within our budget. There should be a representative breadboard that can facilitate a demonstration of an active surface shaping to a rigid surface. The surface will be changed into a smooth parabolic shape with the use of SMAs that will be controlled by a user via computer. The testing apparatus should be able to do continuous cycles without malfunctioning.

Constraints

Several constraints must be considered for this project. The most important is that is done by the end of spring 2013 within the budget of $2,500. Physical limitations of the system should be able to fit on top of a table. The final shape of the SMA spring sheet should be in a smooth, parabolic configuration. The interface of the system should be controlled by a computer via breadboard.

Resources

"Harris Corporation Introduces New Ultra-Light, High-Frequency Spaceborne Antenna Reflector." *Harris Press Release*. Harris, 12 Mar. 2012. Web. 26 Sept. 2012. <harris.com/view_pressrelease.asp?act=lookup&pr_id=3416>.