Deployable Parabolic Antenna (DPA)

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Abstract

CubeSats provide a miniature, low-cost platform within the satellite industry. Recent advancements in attitude control have allowed for stable flight, however the current use of a dipole antenna has placed a restriction on CubeSat functionality. The use of a parabolic antenna would allow for a more directed signal, as well as a higher data transfer rate, therefore increasing their overall capability. Our team was given the task of constructing a full-scale proof-of-concept prototype of a deployable parabolic antenna to replace CubeSats’ current dipole antenna.

Figure 1. CubeSat with Current Dipole Antenna

Design Considerations

The primary design considerations encountered during concept generation were due to the miniature scale of CubeSats. This resulted in various design constraints, based on geometry, power supply, and load capacity, summarized in Table 1 below.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Verification Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stowed Volume</td>
<td>≤ 340 cm³</td>
<td>Testing</td>
</tr>
<tr>
<td>Stowed Length</td>
<td>≤ 10 cm</td>
<td>Testing</td>
</tr>
<tr>
<td>Deployed Diameter</td>
<td>≥ 60 cm</td>
<td>Testing</td>
</tr>
<tr>
<td>Weight</td>
<td>&lt; 330 g</td>
<td>Testing &amp; Analysis</td>
</tr>
<tr>
<td>Power for Deployment</td>
<td>1 W</td>
<td>Testing</td>
</tr>
<tr>
<td>Deployment Orientation</td>
<td>90° from housing</td>
<td>Testing</td>
</tr>
</tbody>
</table>

Table 1. Essential Performance Requirements

Design Features

Nylon Backing Material
- Absorbs deployment energy
- Fabricated to desired parabolic shape

Eight Fiberglass Spars
- Elastic energy provides power for deployment
- Creates tension in backing material while deployed, maintaining desired shape

Central Hub
- Provides centralized joint for fiberglass spars
- Ensures DPA deploys 90° relative to housing

Testing and Analysis

In order to stow our DPA within the allowed volume, we analyzed various materials and cross sections of spars. Through testing we validated our analysis by confirming that the 1/25" fiberglass spars with a circular cross section would provide the optimal combination of flexibility and strength. After assembling our final prototype, three deployment test trials were performed to ensure all performance requirements were met.

Figure 2. Model of Deployed Antenna

Figure 4. Bend Radius Testing (left), Stowage Testing (right)

Conclusion

Final testing of the DPA system proved that we had successfully met all of our performance requirements. Our final design concept yielded the following characteristics:
- Capable of stowing within 1/3 of a CubeSat unit
- Total weight of 67.1 g
- Average deployed diameter of 63.6 cm
- 90° deployment orientation angle, relative to housing unit

The prototype demonstrates a simple, viable design concept to replace the current dipole antenna in order to increase CubeSat functionality.

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