P16105:
CubeSat Attitude Determination Control System (ADCS) Testing Apparatus
Presents

Safety, Build Up, Disassembly, and Storage: The Essentials

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Foreword

Before taking you through the construction and deconstruction process, P16105 would like to share a few thoughts with the reader(s):

First, we request the user(s) to treat the device as intended and to not use it in any unauthorized fashion. Not to overlook the potential damages to the apparatus, we are primarily concerned with the users and those in the area of the device.

Second, we request the user(s) to be both adequately trained and capable before handling any of the parts. Along with the physical ability to carry and pick up the pieces, a fundamental understanding of electricity, magnetism, and circuitry is essential. This will prevent problems relating to safety and operation.

Last, we ask anyone who will be involved with any ADCS testing review all literature and media provided by P16105. Should any questions arise, we are happy to field any and all inquiries.

We would like to thank you for your interest in utilizing our creation, and your time for reviewing the associated documentation. P16105 spent a great deal of time and effort to make this concept into a reality, with full intentions supporting future aerospace researchers as they conduct experiments. As fellow aerospace enthusiasts, we hope the device is beneficial to to any and all future work. Most importantly, we hope all users remember the impact of their research and have fun!

“Live long and prosper” - Mr. Spock
Safety Precautions

As you are about to learn of, and potentially complete, the process of assembly, there are several safety precautions that must be considered before setting up.

1. To reiterate, ensure informed, adequately trained, capable individuals execute the procedure. As there is a particular degree of lifting and flexibility required, we ask only those able to execute these processes do so.

2. Treat the device with care. Design measures were made to make this robust, however no design is infallible.

3. Be aware of the environment, check to ensure the apparatus is not near any great electromagnetic sources (phone, computer, etc.) Additionally, ensure the test environment is not near a lot of metal (in the structure, objects in the area, etc). Additionally, please be sure there is a 2m x 2m x 2m space before beginning the assembly process.

4. Please be sure to not have any individuals with magnetic/electromagnetic devices near the apparatus amidst testing. Although emulating Earth's magnetic field, medical devices (cochlear implants, pacemaker, etc) can be altered potentially yielding an unfavorable scenario.

5. Be aware of wire location. Avoid stepping on the wires at all times, and be sure to move the out of the way during construction, break down, and storing.
Inventory

Below are labeled pictures, accompanied by a table, of the items you will need.

<table>
<thead>
<tr>
<th>Letter From Picture</th>
<th>Item Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Velcro Ties</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>Overhead Cross-Bar</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Feet Supports</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>AB Bar</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>CD Bar</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>WX Bar</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>YZ Bar</td>
<td>1</td>
</tr>
<tr>
<td>H</td>
<td>Coil 1</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>Coil 2</td>
<td>1</td>
</tr>
<tr>
<td>J</td>
<td>Coil 3</td>
<td>1</td>
</tr>
<tr>
<td>K</td>
<td>Coil 4</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>Coil 5</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>Coil 6</td>
<td>1</td>
</tr>
</tbody>
</table>
Assembly

The following is a 19 step process in order to achieve proper construction. The directions begin with the assumption all of the pieces are unpacked and untethered. Additionally, the 8 velcro ties are split into pairs and the pieces are nearby for ease of access.

Please read all of the instructions before beginning, and follow the steps as closely as possible. For further reference please find our instructional video online!

1. (1) Grab a pair of velcro ties as shown below. (2) Grab Coil 4 and orient it as shown below.

2. Grab the AB bar and insert the ’A’ end as shown below.

3. Peel off one of the velcro ties and align it as shown in the image below.

4. (1) Wrap the velcro tie around the AB bar and the coil and feed it through the hole in the tie, shown below. (2) Proceed to tighten and reconnect the passing through velcro.
5. Grab Coil 5. Insert the ‘B’ end into the fitting. Proceed to fasten with a velcro as shown.

Below is the current state of the apparatus, please reassure your progress against this picture.

6. Further down the coils, from the AB Bar, input the CD Bar into the ‘C’ and ‘D’ slots as shown below.

7. Connect the velcro ties as done in steps 3, 4, and 5.

8. Flip the assembly over and repeat steps 3, 4, 5, 6 and 7 with the WX Bar and YZ Bar. Upon completion of this step, the state of construction should match the images shown below.

9. Grab coil 5. You will have to wiggle the coil to fit it into the apparatus. The figures below show some guidance as to how to orient the coil to ensure the fit.

   **Note:** This is a horizontal approach to inserting the coil. If this is found difficult, our video shows a vertical approach
10. Once inside, rotate the coil so the protruding attachment pieces align within the marked lines. This is shown in the pictures below.

11. This step may be a tricky, initially, please be patient. Grab Coil 6. Through various turns and pivots the coil will fit into the structure. Once in rotate the coil to be oriented exactly that to of Coil 5, which is already in there. The images below should help you along the way.

**Note:** This is a horizontal approach to inserting the coil. If this is found difficult, our video shows a vertical approach.

12. Reorient Coil 6 to match the images below.
13. Rotate the lower end of Coil 6 so the silver piece becomes aligned with the blue piece. Lift up the coil so it fits through the carved out section of the WX Bar, as shown below.

14. Once Coil 6 is on the upper level of horizontal bars, be sure to rotate it so both of the silver pieces are within the marked off areas.

15. (1) Grab the Overhead Cross-Bar. (2) Begin to slide it onto the red and yellow top connectors on the tops of Coils 3 and 4. (3) While still sliding the piece through, ensure the other end is properly aligned so it can slide through.

16. Grab Coils 1 and 2. Orient them as shown in the pictures below. Be sure to have the wires leading to the outside of the apparatus as well as in the same direction as Coils 5 and 6.
17. This step requires two people. One volunteer must be able to lift the structure (<10 lb) with one hand. While one volunteer lifts the device with one hand, they will use their other hand to align Coil 1. The other volunteer will be responsible for aligning Coil 2. After the apparatus is supported by the largest coils, one volunteer should maintain contact in order to prevent the structure from falling. **Note:** This step is tricky, please be sure to reference the video before attempting this step.

18. With the test rig standing, slide in the feet supports on both sides. The feet align as depicted below, with the longer portion on the floor, as depicted. The feet are then slid into place, providing stabilization.

19. Congratulations! You have successfully completed the assembly of this device. To ensure proper setup, please refer to the picture below. Please put the extra velcro tie to the side.
Wiring

Included should be an electrical box with many banana plug terminals. Each of the ends of the wires are labeled. Five of the terminals go to the power supply, and the rest get connected to the coils. The five that connect to the power supply are +6V, -6V, +25V, COM, and -25V. They get connected to the equivalent outputs of the power supply as shown in the image below.

The remaining wires get connected to the coils. The coils have reciprocating female banana plug terminals for the connection. Both the electrical box wires and the coil wires are labeled as well. The wires should be connected to matching labels. For example, the wire SMALL 1B should be connected to the wire SMALL 1B as seen in the image below. Each of the male banana plugs should match with a female banana plug of the same color.

The full list of electrical box to coil wires:

- SMALL 1A <= SMALL 1A
- SMALL 1B <= SMALL 1B
- SMALL 2A <= SMALL 2A
- SMALL 2B <= SMALL 2B
- MEDIUM 1A <= MEDIUM 1A
- MEDIUM 1B <= MEDIUM 1B
- MEDIUM 2A <= MEDIUM 2A
- MEDIUM 2B <= MEDIUM 2B
- LARGE 1A <= LARGE 1A
- LARGE 1B <= LARGE 1B
- LARGE 2A <= LARGE 2A
- LARGE 2B <= LARGE 2B
Disassembly

For the disassembly sequence, please follow the reverse order of the assembly instructions. The disassembly is performed in the video online.

Packing/Storage

The following are a few details to keep in mind when putting the device away.

- Place in a dry, temperate, closed off area.
- Please do not put heavy objects on top any of the pieces as this could cause damage and/or reduce structural integrity.
- Put eight of the velcro ties in the alignment shown in the inventory.
- Use one velcro tie around the AB Bar, CD Bar, WX Bar, and WZ Bar
- Tuck all wires away once on the final storage orientation
- As the apparatus was designed to be fully collapsible, the pieces should be able to fit into a tight orientation as shown below.

**Note:** This is a vertical orientation, please note that if needed to be stored horizontally, The same precautions apply.