



# PreciseFlex™ 400 Robot

## Service Manual

### Robot Revision D

Part Number 670845, Revision A



# Brooks Automation

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## Revision History

This service manual applies only to Rev D of the PreciseFlex 400 robot. Refer also to the *PreciseFlex Rev D User Manual* and the previous *PreciseFlex 400 Rev C Service Manual*. Both are online at <https://www.brooks.com/support/brooks-preciseflex-support/robots/>.

Revision	ECO	Date	Action	Author
A	EC169162	5/1/2026	New Release for PreciseFlex 400 Rev D	S. McLellan

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# 1. Safety

## Safety Setup

Brooks uses caution, warning, and danger labels to convey critical information required for the safe and proper operation of the hardware and software. Read and comply with all labels to prevent personal injury and damage to the equipment.

 <b>DANGER</b> <b>Read the Safety Chapter</b>	
<p>Failure to review the <i>Safety</i> chapter and follow the safety warnings can result in serious injury or death.</p> <ul style="list-style-type: none"><li>• All personnel involved with the operation or maintenance of this product must read and understand the information in this safety chapter.</li><li>• Follow all applicable safety codes of the facility as well as national and international safety codes.</li><li>• Know the facility safety procedures, safety equipment, and contact information.</li><li>• Read and understand each procedure before performing it.</li></ul>	

## Explanation of Hazards and Alerts

This manual and this product use industry standard hazard alerts to notify the user of personal or equipment safety hazards. Hazard alerts contain safety text, icons, signal words, and colors.




### Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard
- State the consequences if the hazard is not avoided
- State how to avoid the hazard.

### Safety Icons

- Hazard alerts contain safety icons that graphically identify the hazard.
- The safety icons in this manual conform to [ISO 3864-1:2011](#) *Graphical symbols — Safety colours and safety signs* and [ANSI Z535](#) standards.

Safety Icon Examples	
	Warning
	Two-Person Lift
	Electric Shock

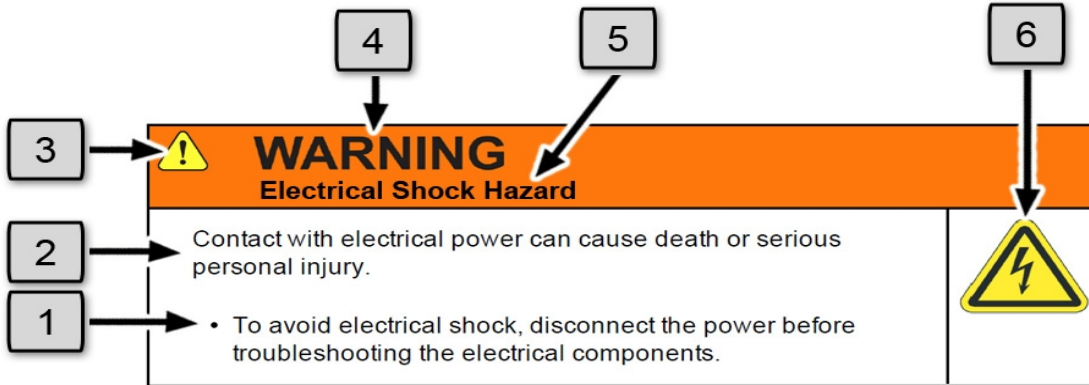
## Signal Words and Colors

Signal words and colors inform of the level of hazard.

	<p>Danger indicates a hazardous situation which, if not avoided, <b>will result in serious injury or death.</b></p> <p>The Danger signal word is white on a red background with an exclamation point inside a yellow triangle with black border.</p>
	<p>Warning indicates a hazardous situation which, if not avoided, <b>could result in serious injury or death.</b></p> <p>The Warning signal word is black on an orange background with an exclamation point inside a yellow triangle with black border.</p>
	<p>Caution indicates a hazardous situation or unsafe practice which, if not avoided, <b>may result in minor or moderate personal injury.</b></p> <p>The Caution signal word is black on a yellow background with an exclamation point inside a yellow triangle with black border.</p>
	<p>Notice indicates a situation or unsafe practice which, if not avoided, <b>may result in equipment damage.</b></p> <p>The Notice signal word is white on blue background with no icon.</p>



## Alert Example



The following is an example of a Warning hazard alert.







Number	Description
1.	How to Avoid the Hazard
2.	Source of Hazard and Severity
3.	General Alert Icon
4.	Signal Word
5.	Type of Hazard
6.	Hazard Symbol(s)



## General Safety Considerations



 <b>WARNING</b> <b>Robot Mounting</b>	
<p>Before applying power, the robot must be mounted on a rigid test stand, secure surface, or system application. Improperly mounted robots can cause excessive vibration and uncontrolled movement that may cause equipment damage or personal injury.</p> <ul style="list-style-type: none"> <li>• Always mount the robot on a secure test stand, surface, or system before applying power.</li> </ul>	



 <b>WARNING</b> <b>Do Not Use Unauthorized Parts</b>	
<p>Using parts with different inertial properties with the same robot application can cause the robot's performance to decrease and potentially cause unplanned robot motion that could result in serious personal injury.</p> <ul style="list-style-type: none"> <li>• Do not use unauthorized parts.</li> <li>• Confirm that the correct robot application is being used.</li> </ul>	

 <b>WARNING</b> <b>Magnetic Field Hazard</b>	
<p>This product contains magnetic motors that can be hazardous to implanted medical devices, such as pacemakers, and cause personal harm, severe injury, or death.</p> <ul style="list-style-type: none"> <li>• Maintain a safe working distance of 30 cm from the motor when with an energized robot if you use a cardiac rhythm management device.</li> </ul>	

 <b>CAUTION</b> <b>Unauthorized Service</b>	
<p>Personal injury or damage to equipment may result if this product is operated or serviced by untrained or unauthorized personnel.</p> <ul style="list-style-type: none"><li>• Only qualified personnel who have received certified training and have the proper job qualifications are allowed to transport, assemble, operate, or maintain the product.</li></ul>	



 <b>CAUTION</b> <b>Damaged Components</b>	
<p>The use of this product when components or cables appear to be damaged may cause equipment malfunction or personal injury.</p> <ul style="list-style-type: none"><li>• Do not use this product if components or cables appear to be damaged.</li><li>• Place the product in a location where it will not get damaged.</li><li>• Route cables and tubing so that they do not become damaged and do not present a personal safety hazard.</li></ul>	



 <b>CAUTION</b> <b>Inappropriate Use</b>	
<p>Use of this product in a manner or for purposes other than for what it is intended may cause equipment damage or personal injury.</p> <ul style="list-style-type: none"><li>• Only use the product for its intended application.</li><li>• Do not modify this product beyond its original design.</li><li>• Always operate this product with the covers in place.</li></ul>	

 <b>CAUTION</b> <b>Seismic Restraint</b>	
<p>The use of this product in an earthquake-prone environment may cause equipment damage or personal injury.</p> <ul style="list-style-type: none"> <li>The user is responsible for determining whether the product is used in an earthquake prone environment and installing the appropriate seismic restraints in accordance with local regulations.</li> </ul>	

## Electrical Hazards

Refer to the specifications of the *Guidance Controller Quick Start Guide* for the electrical power.

 <b>DANGER</b> <b>Electrical Shock Hazard</b>	
<p>Contact with electrical power can cause personal harm and serious injury.</p> <ul style="list-style-type: none"> <li>To avoid electrical shock, disconnect the power before troubleshooting the electrical components.</li> <li>Check the unit's specifications for the actual system power requirements and use appropriate precautions.</li> <li>Never operate this product without its protection covers on.</li> </ul>	

 <b>WARNING</b> <b>Electrical Burn</b>	
<p>Improper electrical connection or connection to an improper electrical supply can result in electrical burns resulting in equipment damage, serious injury, or death.</p> <ul style="list-style-type: none"> <li>Always provide the robot with the proper power supply connectors and ground that are compliant with appropriate electrical codes.</li> </ul>	



## WARNING

### Electrical Fire Hazard

All energized electrical equipment poses the risk of fire, which may result in severe injury or death. Fires in wiring, fuse boxes, energized electrical equipment, computers, and other electrical sources require a Class C extinguisher.

- Use a fire extinguisher designed for electrical fires (Class C in the US and Class E in Asia).
- It is the facility's responsibility to determine if any other fire extinguishers are needed for the system that the robot is in.







## NOTICE



Improper handling of the power source or connecting devices may cause component damage or equipment fire.

- Connect the system to an appropriate electrical supply.
- Turn off the power before servicing the unit.
- Turn off the power before disconnecting the cables.

## Ergonomic Hazards



 <b>CAUTION</b> <b>Heavy Lift Hazard</b>	
<p>Failure to take the proper precautions before moving the robot could result in back injury and muscle strain.</p> <ul style="list-style-type: none"><li>• Use a lifting device and cart rated for the weight of the drive or arm.</li><li>• Only persons certified in operating the lifting device should be moving the product.</li></ul>	

 <b>CAUTION</b> <b>Tipover Hazard</b>	
<p>This product has a high center of gravity which may cause the product to tip over and cause serious injury.</p> <ul style="list-style-type: none"><li>• Always properly restrain the product when moving it.</li><li>• Never operate the robot unless it is rigidly mounted.</li></ul>	

 <b>CAUTION</b> <b>Trip Hazard</b>	
<p>Cables for power and communication and facilities create trip hazards which may cause serious injury.</p> <ul style="list-style-type: none"><li>• Always route the cables where they are not in the way of traffic.</li></ul>	

## Emergency Stop Circuit (E-Stop)

The integrator of the robot must provide an external emergency stop switch.

 <b>WARNING</b> <b>Emergency Stop Circuit</b>	
<p>Using this product without an emergency stop circuit may cause personal injury.</p> <ul style="list-style-type: none"><li>• Customer is responsible for integrating an emergency stop circuit into their system.</li><li>• Do not override or bypass the emergency stop circuit.</li></ul>	

## Recycling and Hazardous Materials

Brooks Automation complies with the EU Directive 2002/96/EU Waste Electrical and Electronic Equipment (WEEE).

The end user must responsibly dispose of the product and its components when disposal is required. The initial cost of the equipment does not include cost for disposal. For further information and assistance in disposal, email Brooks Automation Technical Support at [support@preciseflex@brooks.com](mailto:support@preciseflex@brooks.com).

## 2. Service Procedures

### Recommended Tools

The following tools are recommended for these service procedures:

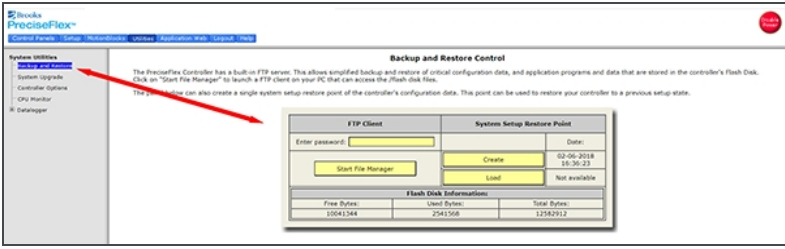
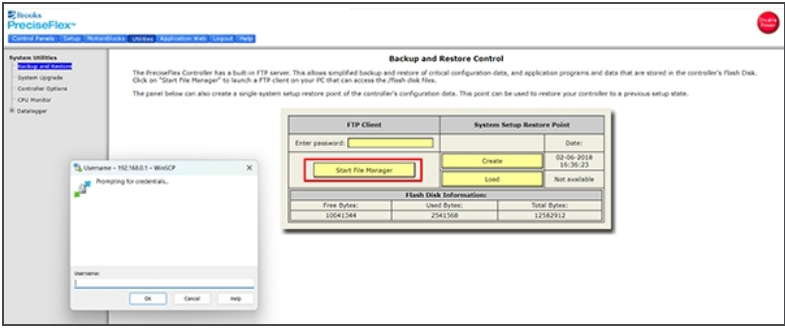
- Gates Sonic Belt Tension Meter, Model 507C for checking timing belt tension
- A set of metric “stubby” hex L-keys, for example McMaster Carr PN 6112A21 with 1.5, 2.0, 2.5, 3.0, 4, 5, and 6 mm L Keys
- A set of metric hex drivers including 1.27, 1.5, 2.0, 2.5 and 3.0 mm driver, for example McMaster Carr PN 52975A21
- A pair of tweezers or needle nose pliers
- A pair of side angle cutters
- Small flat bladed screwdriver, with 1.5 mm wide blade typical
- M5 socket driver or M5 open end wrench or pliers.

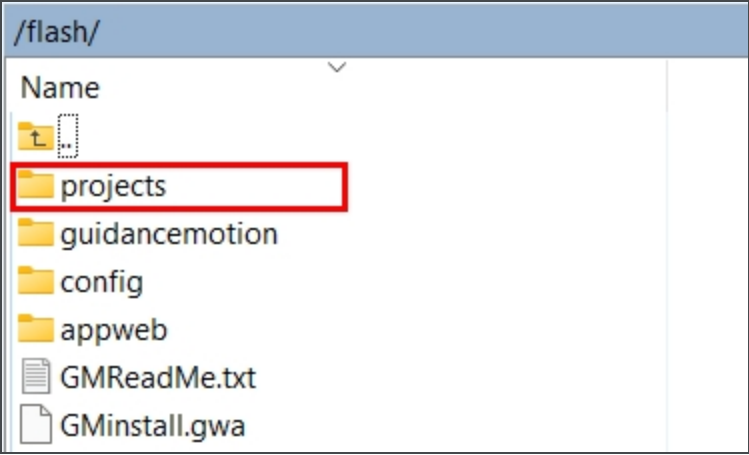
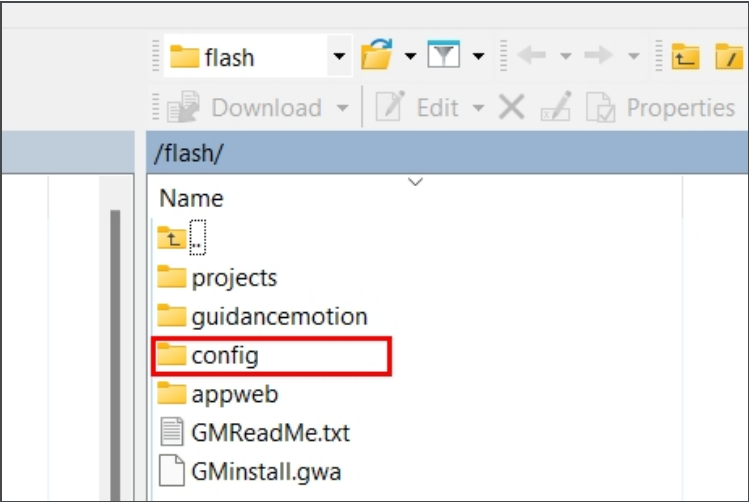
### Replacing Belts and Motors

The timing belts and motors are designed to last the life of the robot. It is not expected that they will need to be replaced in the field. In most cases, if a belt or a motor needs to be replaced, the robot should be returned to the factory. While there are procedures at the end of this manual for replacing the Z-axis drive belts and motor, only training service technicians should attempt these procedures.

## Loading a Project (Program) or PAC Files

If CAL\_PP or a different GPL project Manager needs to be loaded into the controller flash from an external computer, this may be done using the browser-based controller interface. Perform the following procedure.

Step	Action						
1.	<p>In the controller interface, select <b>Utilities &gt; System Utilities &gt; Backup and Restore</b>.</p>  <p>The screenshot shows the 'Backup and Restore Control' page. The 'FTP Client' section has an 'Enter password' field, a 'Start File Manager' button, and a 'Date' field. The 'System Setup Restore Point' section has 'Create' and 'Load' buttons. Below is a 'Flash Disk Information' table:</p> <table border="1"> <thead> <tr> <th>Free Bytes</th> <th>Used Bytes</th> <th>Total Bytes</th> </tr> </thead> <tbody> <tr> <td>10041344</td> <td>2541568</td> <td>12582912</td> </tr> </tbody> </table>	Free Bytes	Used Bytes	Total Bytes	10041344	2541568	12582912
Free Bytes	Used Bytes	Total Bytes					
10041344	2541568	12582912					
2.	<p>Click <b>Start File Manager</b> to connect to an FTP utility.</p>  <p>The screenshot shows the same interface as step 1, but with a 'Prompting for credentials' dialog box open in the foreground. The 'Start File Manager' button in the 'FTP Client' section is highlighted with a red box.</p>						

Step	Action
<p>3.</p>	<p>To load a GPL project, open the <i>projects</i> folder and paste the GPL project folder into this area. There may be several other projects (programs) loaded into this folder, which is stored in flash ram in the controller. A <i>project</i> folder is a software folder that may have several files inside it. Load the entire folder, not just the files inside.</p>  <p>The screenshot shows a file explorer window titled '/flash/'. The 'Name' column lists several folders and files: a folder with a 't' icon, 'projects', 'guidancemotion', 'config', 'appweb', 'GMReadMe.txt', and 'GMinstall.gwa'. The 'projects' folder is highlighted with a red rectangular box.</p>
<p>4.</p>	<p>To load PAC files, open the <i>config</i> folder and paste a backup copy of the PAC files into the <i>config</i> folder. These files will all have a .pac extension. The robot must be re-booted after new PAC files are installed for them to take effect.</p> <p>See also "<a href="#">Updating Robot PAC Files</a>".</p> <p><b>NOTE:</b> Please wait at least 10-15 seconds before re-booting the robot to give flash enough time to update. Failing to do so can result in corrupted PAC files.</p>  <p>The screenshot shows a file explorer window titled '/flash/'. The 'Name' column lists several folders and files: a folder with a 't' icon, 'projects', 'guidancemotion', 'config', 'appweb', 'GMReadMe.txt', and 'GMinstall.gwa'. The 'config' folder is highlighted with a red rectangular box.</p>
<p>5.</p>	<p>Once the appropriate GPL project (for example CAL_PP) has been loaded into flash memory, load it into dynamic memory in order to execute.</p> <p>Calibrate the robot. See "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>".</p>

## Updating Robot PAC Files

Sometimes a robot needs to be re-configured to add an additional axis such as a linear rail, sometimes a gripper model needs to be changed after hardware changes, other times files get corrupted and need to be re-installed. This is the procedure for installing different or fresh configuration files.

The following data is overwritten and lost when overwriting with new PAC files:

- Robot Encoder Offset (Data ID 16120)
- Rail Orientation Configuration (Data ID 16050)
- Commutation Offset (Data ID 10775)

Always perform a complete controller backup before modifying anything on the flash memory.

When in doubt, email [support\\_preciseflex@brooks.com](mailto:support_preciseflex@brooks.com).

### Procedure Overview

The general procedure is as follows:

- a. Install correct PAC files
- b. Configure rail orientation
- c. Run robot calibration (set's rail length)

### Installing the Correct PAC Files

The PAC file names describe their configurations. They usually follow one of two naming conventions.

Older naming convention:

L	Linear Rail
X	Extended Reach Robot
S	Spring Gripper

D	Dual Gripper
---	--------------

Newer naming convention:

Rail	Linear Rail
23 N Spring Gripper	IntelliGuide s23 or v23 Gripper
60N Spring Gripper	IntelliGuide s60 or v60 Gripper
23N Dual Spring Gripper	IntelliGuide s23D

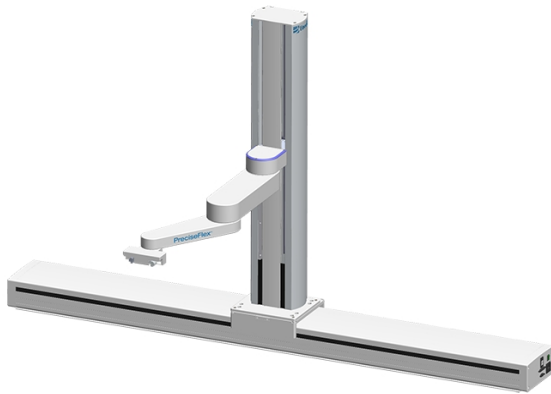
The version of the files is a number-letter combination. It can be found in the file name and can also be found on the robot browser-interface page at the end of the System Name.



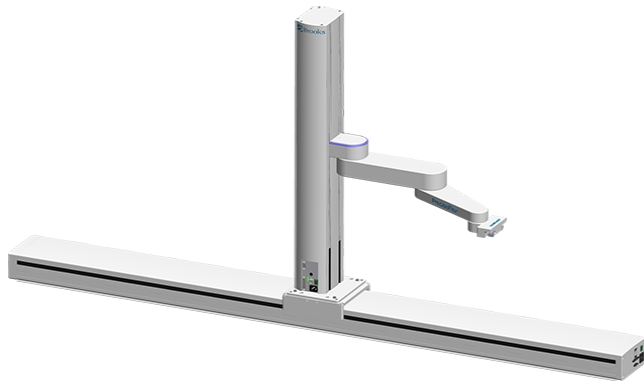
If you don't know the correct version number, email [support\\_preciseflex@brooks.com](mailto:support_preciseflex@brooks.com).

## Configuring the Linear Rail Orientation

PreciseFlex 400 robots can be mounted in one of two configurations. The default configuration is with the robot Y-axis moving in the direction of the PreciseFlex linear rail travel. PreciseFlex robots can also be rotated counterclockwise 90° so that the PreciseFlex robot X-axis moves along the PreciseFlex linear rail travel.



**Figure 2-1: PreciseFlex 400 Robot on a linear rail (shown in the default mounting configuration with optional IntelliGuide servo gripper)**



**Figure 2-2: PreciseFlex 400 Robot on a linear rail (shown in the 90° mounting configuration with optional IntelliGuide servo gripper)**

After mounting the robot (see the Installation chapter of the *PreciseFlex Linear Rail User Manual 663245*), verify the configuration in the PAC file.


Step	Action
1.	In the browser interface, go to <b>Admin &gt; Setup &gt; Parameter Database &gt; Robot &gt; Calibration Parameters &gt; Msc.</b>

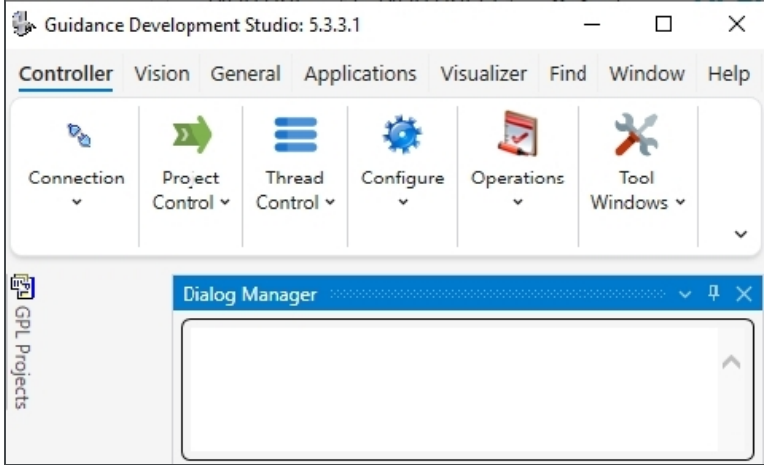
Step	Action																					
2.	<p>Under Data ID 16050, the 5th parameter, if you're in the 00 position, use 0 value, and if you're in the -90 degree orientation, enter -90.</p> <table border="1"> <thead> <tr> <th>ID</th> <th>Parameter name Green = restart required Red = high power must be off</th> <th>Robot: 1 , PreciseFlex 3400SXL Parameter value</th> </tr> </thead> <tbody> <tr> <td>16000</td> <td>Robot serial number</td> <td>PF34-20000</td> </tr> <tr> <td>16050</td> <td>Kinematic dimensional constants</td> <td>0, 302, 289, 0, <b>-90</b>, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0</td> </tr> <tr> <td>16051</td> <td>Tool set at restart</td> <td>0, 0, 162, 0, 0, 0</td> </tr> <tr> <td>16052</td> <td>Base set at restart</td> <td>0, 0, 0, 0, 0, 0</td> </tr> <tr> <td>16060</td> <td>Conveyor robot nominal transform</td> <td>0, 0, 0, 0, 0, 0</td> </tr> <tr> <td>16061</td> <td>Conveyor robot limit1 transform</td> <td>0, 0, 0, 0, 0, 0</td> </tr> </tbody> </table>	ID	Parameter name Green = restart required Red = high power must be off	Robot: 1 , PreciseFlex 3400SXL Parameter value	16000	Robot serial number	PF34-20000	16050	Kinematic dimensional constants	0, 302, 289, 0, <b>-90</b> , 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	16051	Tool set at restart	0, 0, 162, 0, 0, 0	16052	Base set at restart	0, 0, 0, 0, 0, 0	16060	Conveyor robot nominal transform	0, 0, 0, 0, 0, 0	16061	Conveyor robot limit1 transform	0, 0, 0, 0, 0, 0
ID	Parameter name Green = restart required Red = high power must be off	Robot: 1 , PreciseFlex 3400SXL Parameter value																				
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16052	Base set at restart	0, 0, 0, 0, 0, 0																				
16060	Conveyor robot nominal transform	0, 0, 0, 0, 0, 0																				
16061	Conveyor robot limit1 transform	0, 0, 0, 0, 0, 0																				

## Calibrate the Robot

Robot calibration is specific to each robot. [See "Calibrating the Robot: Setting the Encoder Zero Positions"](#) for more information. Find their instructions under the associated service manual.

The general procedure is:

Step	Action
1.	Load and run the Cal_pp_rev... GPL program via the browser interface or GDS
2.	<p>Open the <i>Dialog Manager</i>, and follow the prompts from the browser interface at <b>Admin &gt; Control Panels &gt; Web Dialog</b>.</p> 



Step	Action
	<p>Follow the prompts from the browser interface to <b>GDS &gt; Controller &gt; Controller Tool Windows &gt; Dialog Manager</b>.</p> 

When removing the robot from a rail setup, you can save time by copying over the previous calibration from Data ID (16120) and removing the last value which represents the linear rail.

ID	Parameter name <span style="color: green;">Green = restart required</span> <span style="color: red;">Red = high power must be off</span>	Robot: 1 , Parameter value
16120	Calibration home offset, mcnt	0, 0, 0, 0
16653	Commutation position at zero index, mcnt	-1, -1, -1, -1

Conversely when adding a linear rail you can A) perform a single axis calibration or B) calibrate all axes and overwrite the non-rail axis values with the values from your backup.

## Calibrating the Robot: Setting the Encoder Zero Positions

 <b>DANGER</b> <b>Electrical Shock</b>	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before tensioning the timing belts.	

Cal\_PP is a service program that must be run to set the zero positions of the absolute encoders on each motor. The zero positions must be re-established if any of the motors are replaced, their cables disconnected for a long duration, or the encoder backup battery has been disconnected.

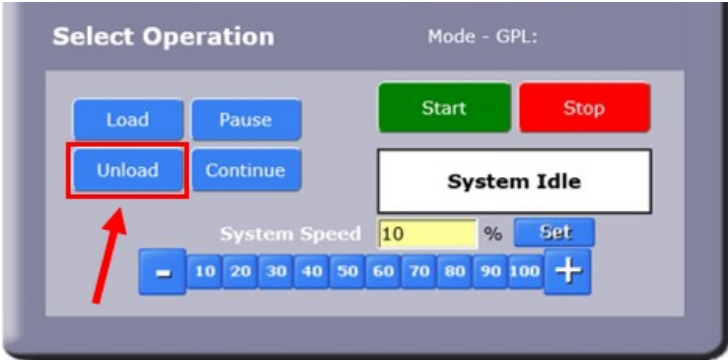
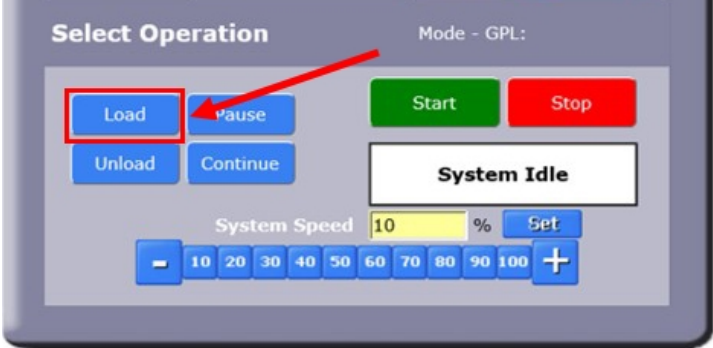
Cal\_PP is supplied on the flash drive of the robot and is available in the Support area of the Brooks website at <https://www.brooks.com/support/brooks-preciseflex-support/software-updates/>.

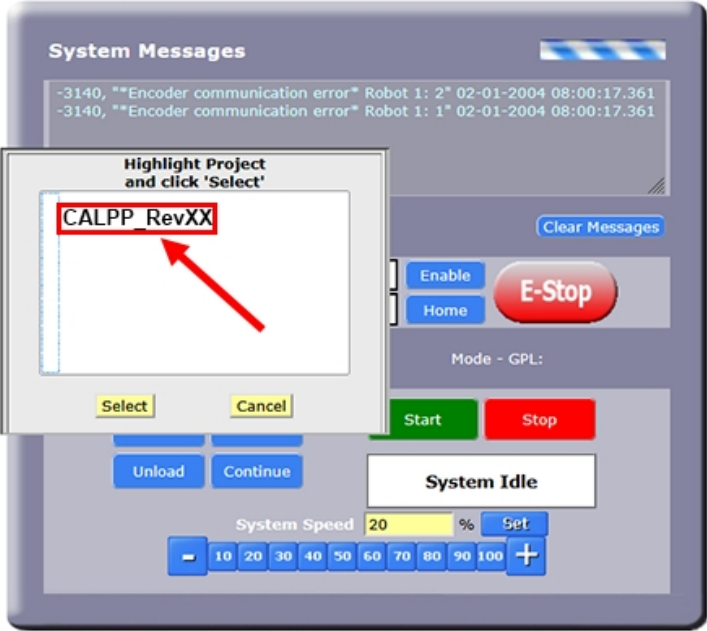
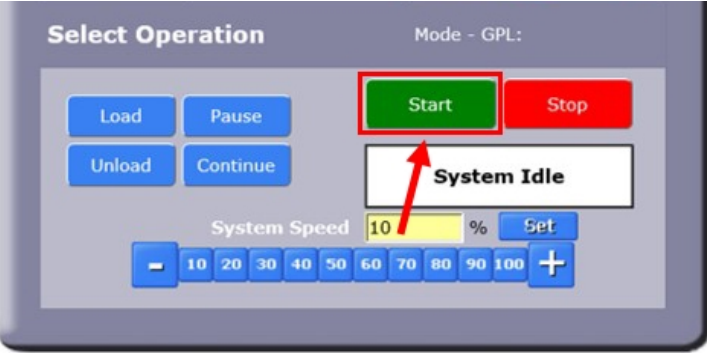
To run Cal\_PP, the controller must be configured to run GPL programs, and Cal\_PP must be loaded into the controller's memory.

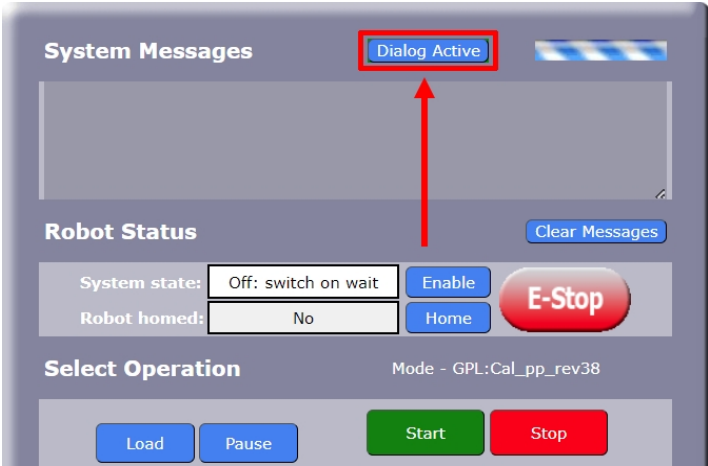
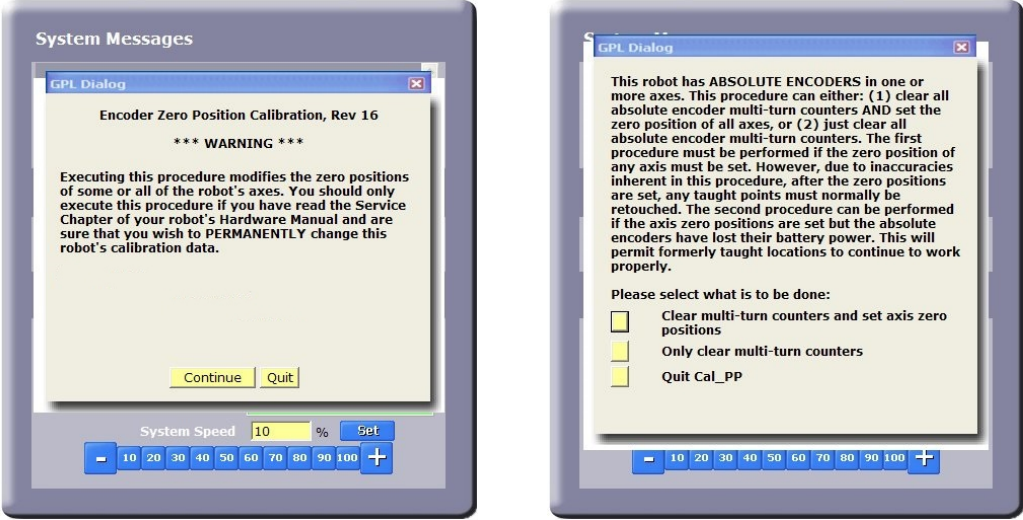
### Tools Required

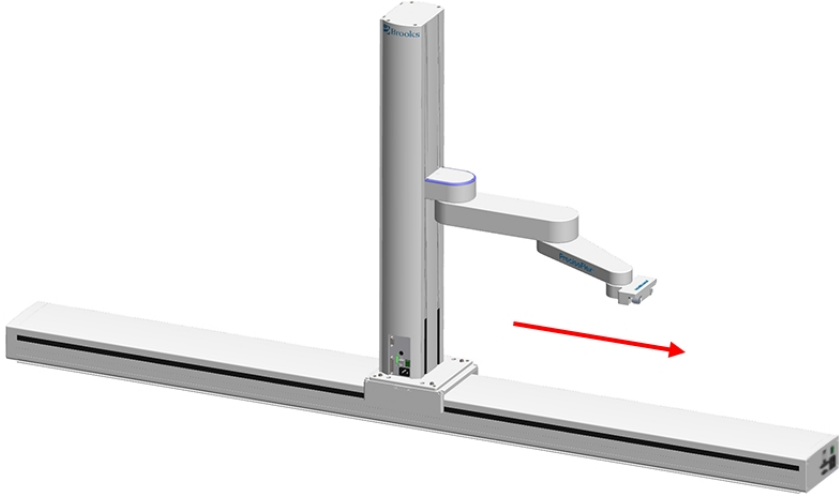
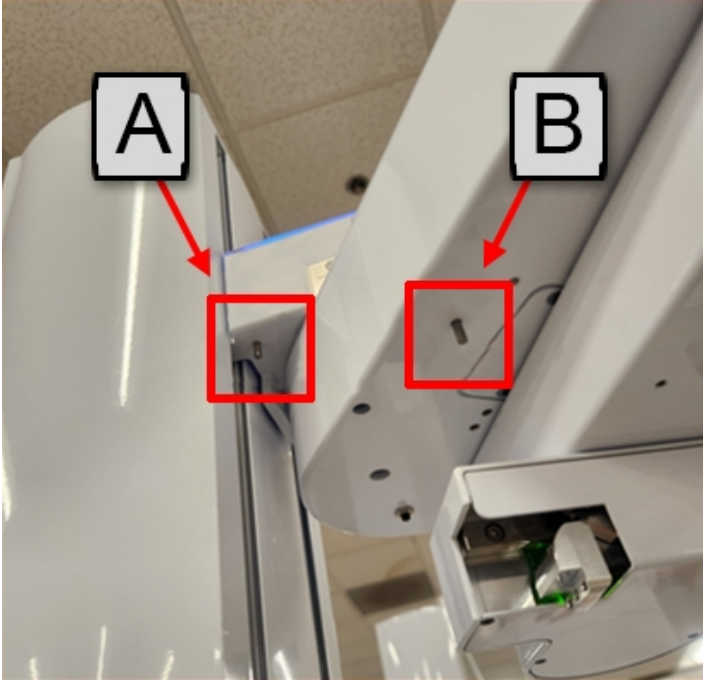
- Calibration Kit (located in the slot at the bottom of the removeable front cover)

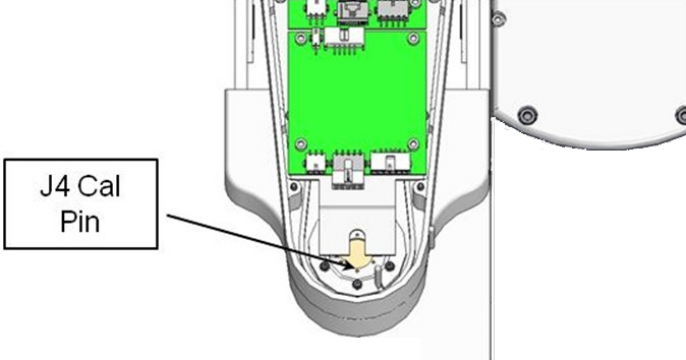
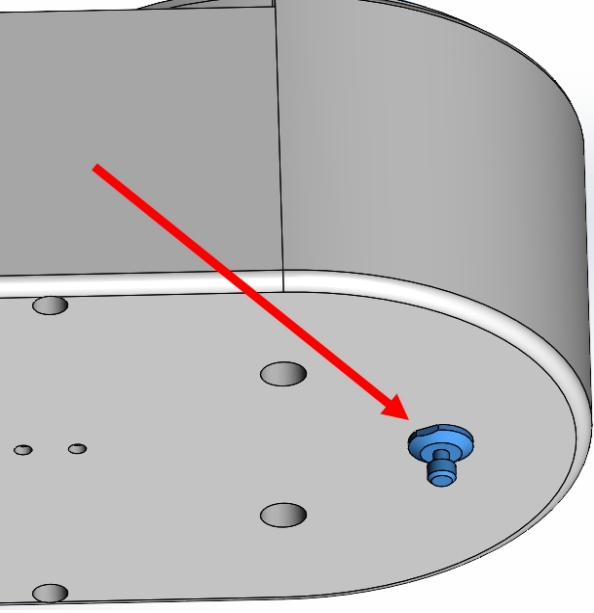
To define the zero positions of the PreciseFlex 400 robot axes using Cal\_PP, perform the following procedure:


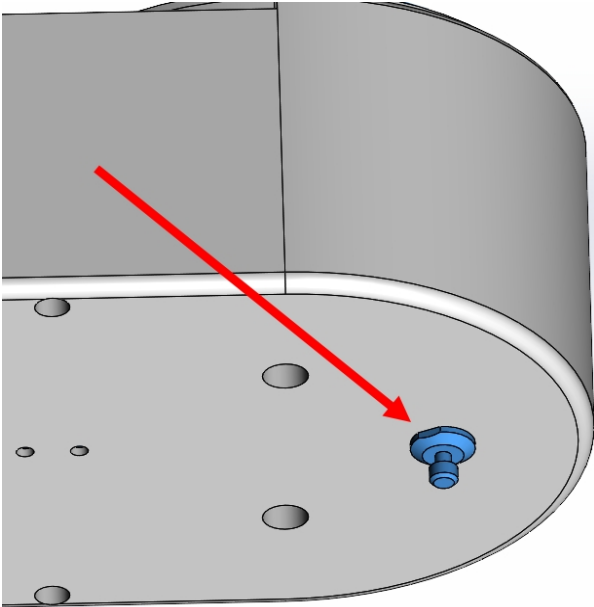
Step	Action
1.	<p>Power on the robot and allow it to complete its boot sequence. Robot motor power does not need to be enabled for this step.</p> <p><b>NOTE:</b> Perform this procedure with the motor power off so the robot does not move.</p>
2.	<p>The CALPP program is typically installed at the factory and should be loaded into flash memory. In the controller's browser interface, go to <b>Admin &gt; Control Panels &gt; Operator Control Panel</b>, and click <b>UnLoad</b> to unload any currently loaded programs.</p>  <p>The screenshot shows the 'Select Operation' interface. At the top right, it says 'Mode - GPL:'. Below this are four buttons: 'Load', 'Pause', 'Start', and 'Stop'. 'Start' is green and 'Stop' is red. Below these are 'Unload' and 'Continue' buttons. The 'Unload' button is highlighted with a red box, and a red arrow points to it from the bottom left. In the center, there is a box labeled 'System Idle'. Below that is a 'System Speed' section with a yellow input field containing '10' and a '%' sign, followed by a 'Set' button. At the bottom, there is a row of buttons for speed selection: '-', '10', '20', '30', '40', '50', '60', '70', '80', '90', '100', and '+'. The '10' button is highlighted in yellow.</p>
3.	<p>Click <b>Load</b>.</p>  <p>The screenshot shows the same 'Select Operation' interface. The 'Load' button is now highlighted with a red box, and a red arrow points to it from the top right. The 'Unload' button is no longer highlighted. The 'System Idle' box and 'System Speed' section remain the same.</p>

Step	Action
4.	<p>This displays a list of projects that are in the flash disk and available for execution. Click <b>CALPP_RevXX</b></p> 
5.	<p>When ready to execute the project, click <b>Start</b>.</p> 

Step	Action
6.	<p>After clicking <b>Start</b>, the <b>Dialog Active</b> button will display at the top. Click the <b>Dialog Active</b> button to begin the calibration steps</p> 
7.	<p>An application should start and prompt the user to confirm the correct robot position for calibration, the height of the robot, and the length of the linear rail (if installed).</p> 

Step	Action
8.	<p data-bbox="293 268 1386 327">If the PreciseFlex 400 is on a linear rail, move it to the hard stop at the end of the linear rail by the facilities panel. The robot can be in either 0° or -90° orientation.</p> 
9.	<p data-bbox="293 892 1373 982">Insert a tapered 0.5 in Calibration Dowel Pin into the hole in the bottom of the J2 shoulder (A). Insert a tapered 0.5 in calibration dowel pin into the hole on the J3 inner link (B). Rotate the inner link until it rests against the pin.</p> 

Step	Action
10.	<p>Insert an M3 X 30 mm Calibration Dowel Pin into the J4 wrist pulley with the gripper positioned under the outer link and rotate the gripper back and forth until the pin drops into a slot in the outer link, centering the gripper under the outer link.</p>  <p>The diagram shows a top-down view of the robot's wrist assembly. A green rectangular component, labeled 'J4 Cal Pin', is being inserted into a slot in the pulley mechanism. A callout box with a line pointing to the pin contains the text 'J4 Cal Pin'.</p>
11.	<p>Rotate the outer link until it rests against the dowel pin.</p>
12.	<p>Push the brake release button under the inner link to release the Z-axis brake. Support the robot arm with your hand, and lower the robot arm gently until it rests on the lower hard stop.</p>  <p>The diagram shows a perspective view of the robot's lower arm section. A red arrow points to a blue cylindrical component labeled 'Brake-Release Button' located on the inner surface of the arm.</p> <p><b>Brake-Release Button</b></p>

Step	Action
13.	<p>Ensure that the joints are rotated against the calibration pins.</p> 
14.	<p>After the robot is correctly positioned, click <b>Execute</b> to execute CALPP. The CALPP application takes about one minute to run.</p>
15.	<p>After calibration is complete, move all the axes a few millimeters away from the hard stops, including the linear rail, if applicable. For the Z-axis, press the brake-release button to lift the arm off the hard stop. Failing to do this will produce a PID error because the robot is outside of the soft-stop limits.</p>  <p><b>Brake-Release Button</b></p>

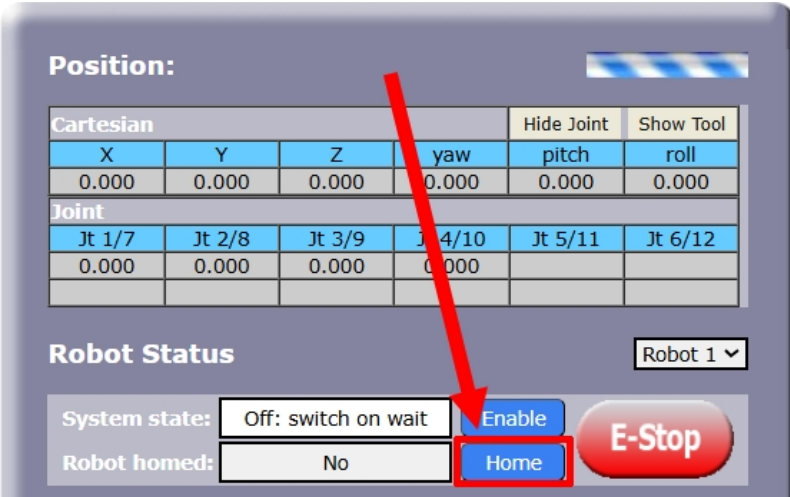
Step	Action
16.	<p>Remove the calibration pins that were installed previously. Enable power and home the robot. Calibration does not take effect until the robot is homed.</p> <p>Power cycle is not necessary; it is only needed if a PAC file change has been made. For PAC file changes, refer to "<a href="#">Updating Robot PAC Files</a>".</p> <p><b>NOTE:</b> <i>The robot must be homed to complete the calibration process. Robot does not need to be power cycled after calibration.</i></p>

## Manual Calibration of PreciseFlex Robots



The standard calibration procedure for the PreciseFlex 400 is listed in "[Calibrating the Robot: Setting the Encoder Zero Positions](#)". However, there may be situations where the robot cannot be placed in the standard calibration position, for example when mounted in a work cell where equipment may be in the way. In this case, the calibration can be performed manually according to the following steps.

Step	Action
1.	<p><b>Recommended, but optional:</b> If possible, move the robot to the top of the Z-rail travel where it is clear of equipment, and place J2, J3, and J4 in the standard calibration position. Once positioned, Cal_PP can be fully executed.</p> <p>This process correctly calibrates J2, J3, and J4, leaving only J1 requiring adjustment. The Z-rail calibration will be set to -2 mm at the top of travel, resulting in an offset of 400 mm, 750 mm, or 1160 mm depending on the robot's Z-rail stroke. If this step is performed, the offset change value in Step 2 will be 400, 750, or 1160 accordingly.</p>



Step	Action																																				
5.	<p>Identify the value of parameter 16120 (Calibration home offset, mcnt). This contains the Z rail offset in encoder counts set by Cal_PP, which will need to be corrected for the new calibration. These values are in the order of the axes, Z, J2, J3, J4, Gripper. Take the value in position 1 and subtract the correction value computed step 2.</p> <p><b>NOTE:</b> Note it is OK if the resulting value is negative. Then, enter this new value into position 1 and press “Set new values,” followed by “Save all to Flash.”</p>																																				
6.	<p>After setting the new offset, go to <b>Admin &gt; Control Panels &gt; Virtual Pendant</b> and click the <b>Home</b> button. Check the Z value for J1. It should now read the correct Z height.</p>  <p>The screenshot shows the Virtual Pendant interface with the following data:</p> <table border="1" data-bbox="443 758 1133 953"> <thead> <tr> <th colspan="4">Cartesian</th> <th>Hide Joint</th> <th>Show Tool</th> </tr> <tr> <th>X</th> <th>Y</th> <th>Z</th> <th>yaw</th> <th>pitch</th> <th>roll</th> </tr> </thead> <tbody> <tr> <td>0.000</td> <td>0.000</td> <td>0.000</td> <td>0.000</td> <td>0.000</td> <td>0.000</td> </tr> </tbody> </table> <table border="1" data-bbox="443 852 1133 953"> <thead> <tr> <th colspan="6">Joint</th> </tr> <tr> <th>Jt 1/7</th> <th>Jt 2/8</th> <th>Jt 3/9</th> <th>Jt 4/10</th> <th>Jt 5/11</th> <th>Jt 6/12</th> </tr> </thead> <tbody> <tr> <td>0.000</td> <td>0.000</td> <td>0.000</td> <td>0.000</td> <td></td> <td></td> </tr> </tbody> </table> <p>Robot Status: Robot 1 ▼</p> <p>System state: Off: switch on wait [Enable]</p> <p>Robot homed: No [Home] [E-Stop]</p>	Cartesian				Hide Joint	Show Tool	X	Y	Z	yaw	pitch	roll	0.000	0.000	0.000	0.000	0.000	0.000	Joint						Jt 1/7	Jt 2/8	Jt 3/9	Jt 4/10	Jt 5/11	Jt 6/12	0.000	0.000	0.000	0.000		
Cartesian				Hide Joint	Show Tool																																
X	Y	Z	yaw	pitch	roll																																
0.000	0.000	0.000	0.000	0.000	0.000																																
Joint																																					
Jt 1/7	Jt 2/8	Jt 3/9	Jt 4/10	Jt 5/11	Jt 6/12																																
0.000	0.000	0.000	0.000																																		
7.	<p>If Step 1 is not feasible, repeat Steps 2–4 for axes 2–4, replacing the ID 2300 value from Step 2 and the ID 16120 value from Step 3 with the appropriate rail value.</p>																																				

## Replacing the Power Supplies

 <b>DANGER</b> <b>Electrical Shock</b>	
Disconnect the AC power before replacing the power supplies or belt.	

### Tools Required:

- 2.0, 2.5, and 3.0 mm ball-end hex driver or hex L wrench
- 2.0, 2.5, and 3.0 mm straight hex drivers

### Spare Parts Required:

New Power Supply (one of the following):

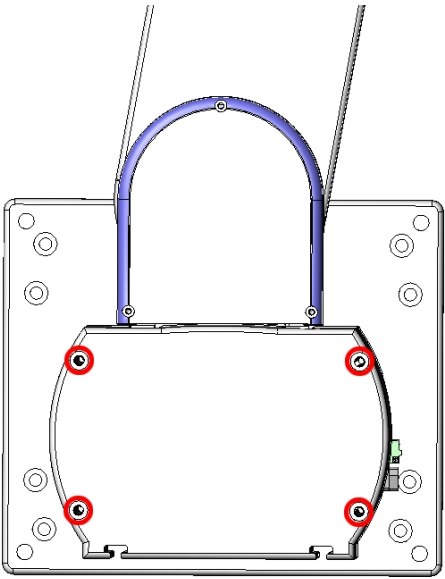
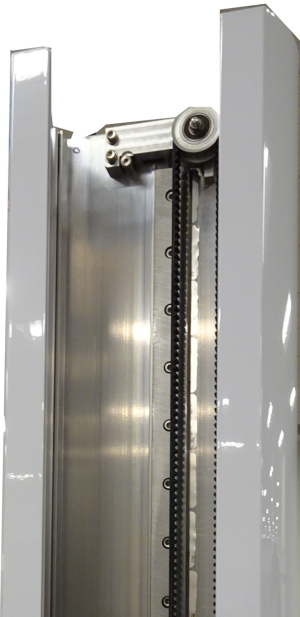
- 24 VDC Power Supply, 150W (PS10-EP-24150)
- 48 VDC Power Supply, 500W (605889)


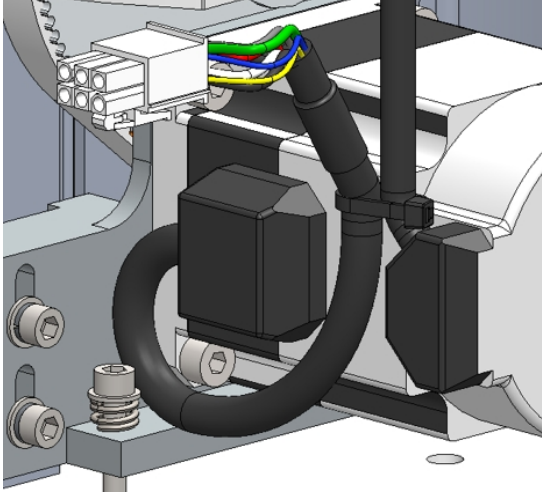
J1 Stage 2 Belt (one of the following):

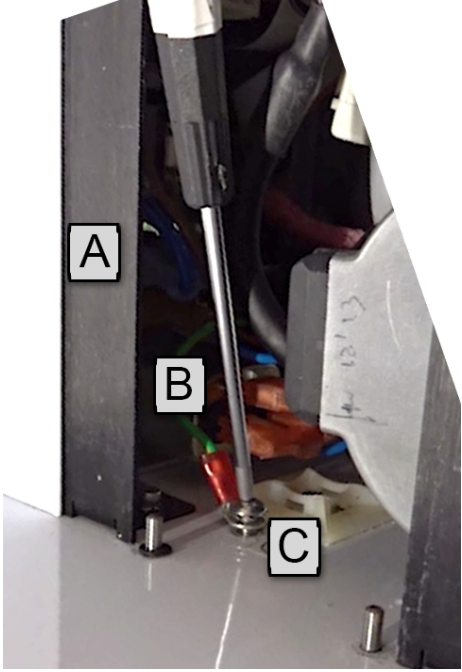
- 400mm, PreciseFlex 400 (PF00-MC-X0023-1)
- 750mm, PreciseFlex 400 (PF00-MC-X0023-2)
- 1160mm, PreciseFlex 400( PF00-MC-X0023-3)

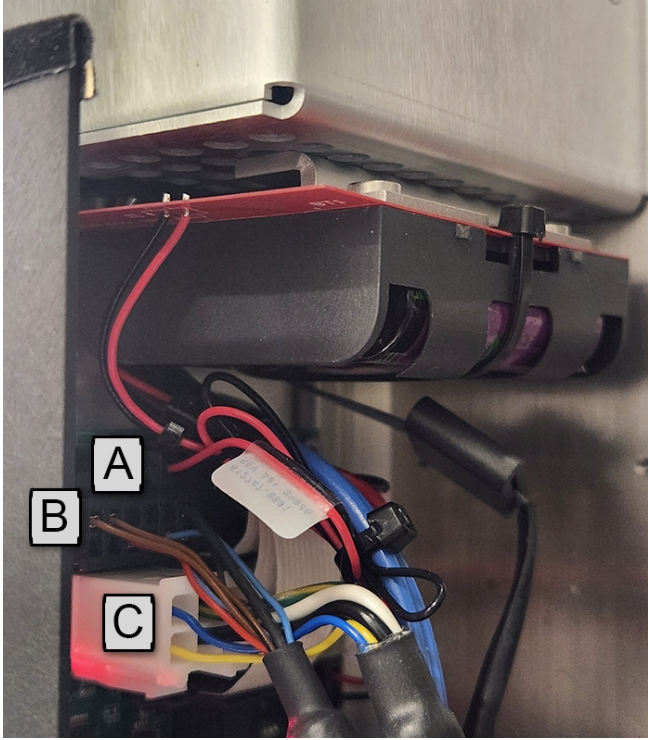
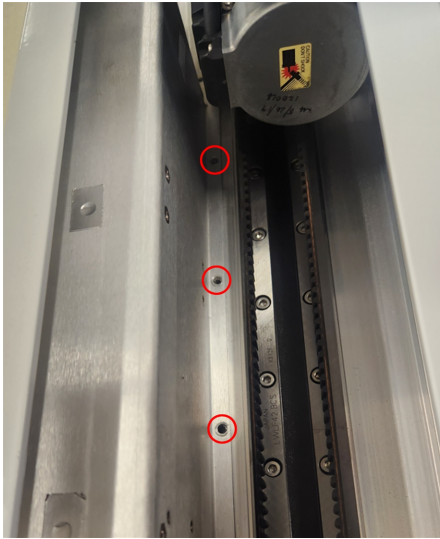
To replace the power supplies, perform the following procedure:

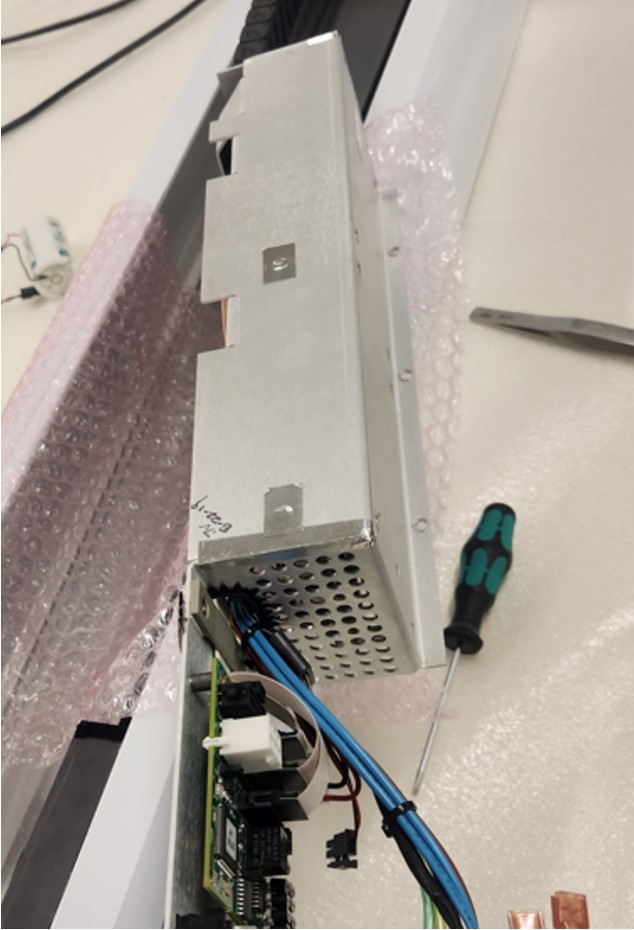
Step	Action
1.	Move the robot arm to the top of the Z column travel.
2.	Turn off the robot power and unplug the AC power cord.

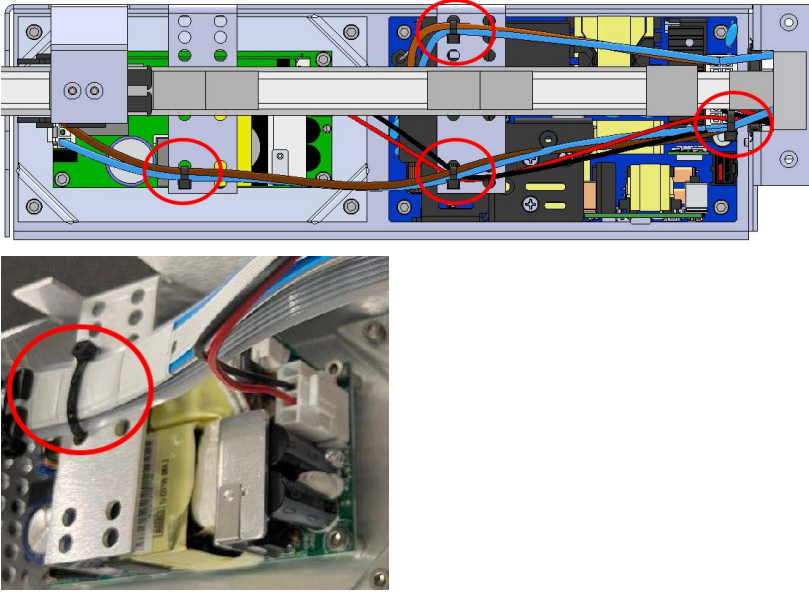
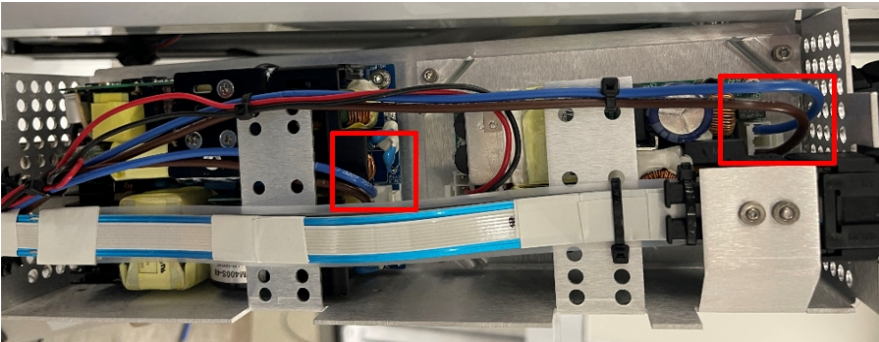
Step	Action
3.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot (shown below in red) that attach the top plate to the Z column. Lift up the top plate.</p> 
4.	<p>Remove the front cover by lifting it out vertically.</p> 

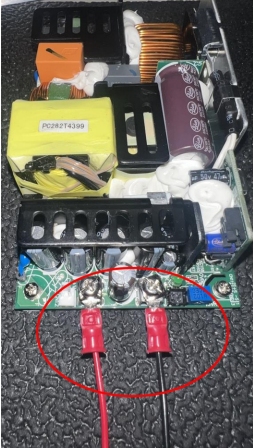

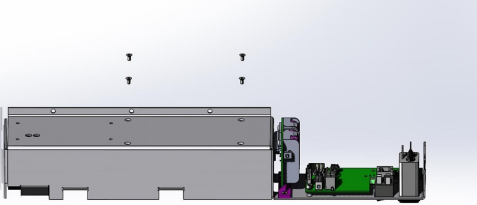
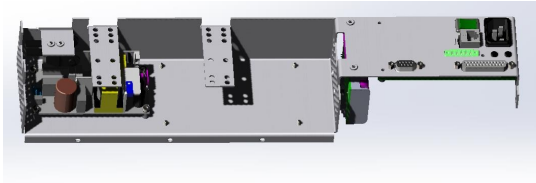
Step	Action
5.	<p>Remove the screws that hold the E-chassis to the Z extrusion (A) and the screws that attach the electronic chassis and ground wire to the base plate (B).</p> 
6.	<p>Remove the J1 motor and encoder connectors that plug into the J1 motor interface board.</p> 
7.	<p>Remove the battery connector that plugs into the J1 motor interface board.</p>

Step	Action
8.	<p>Remove:</p> <ul style="list-style-type: none"><li>A. the left splash guard screw , and remove the left splash guard.</li><li>B. one screw from the E-chassis (which contains the power supplies)</li><li>C. the E-chassis ground screw.</li></ul> 



Step	Action
9.	<p>Disconnect the:</p> <ul style="list-style-type: none"><li>A. encoder battery cable (two-pin connector)</li><li>B. encoder connector from the J1 motor</li><li>C. motor power cables.</li></ul> 
10.	<p>Remove the three screws from the E-chasis panel.</p> 

Step	Action
11.	<p data-bbox="282 262 1055 294">Gently lift the E-chassis above the guide pins and wiggle it out of the robot.</p> 

Step	Action
12.	<p>Cut the Zip ties holding the AC (brown and blue) and DC (red and black) wires.</p>  <p>The diagram shows a top-down view of the robot's internal wiring. Red circles highlight four zip ties: two on the left side securing brown and blue AC wires, and two on the right side securing red and black DC wires. The photograph below shows a close-up of the physical wiring, with a red circle highlighting a zip tie on a white metal rail.</p>
13.	<p>Disconnect the AC connectors from -24 V and -48 V power supplies. Remove the AC wire harness</p> <p><b>NOTE:</b> The 24 V connector has a latch.</p>  <p>The photograph shows the internal wiring from a different angle. Two red boxes highlight the AC connectors being disconnected from the power supplies. One box is on the left, near a -24V supply, and the other is on the right, near a -48V supply. The AC wire harness is a bundle of blue and brown wires.</p>

Step	Action
14.	<p>Disconnect the DC power harness from the 24 V and 48 V power supplies, and remove the DC power harness from the E-chassis</p> <p><i>NOTE: Both have a latch.</i></p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="302 466 553 911">  <p data-bbox="302 919 553 976"><b>48 V DC power harness connector</b></p> </div> <div data-bbox="675 525 1313 882">  <p data-bbox="675 890 889 919"><b>24 V DC connector</b></p> </div> </div>
15.	<p>Remove the (4) 2.5 mm screws holding the MeanWell power supply. There is one screw in each corner. After removing the screws, remove the MeanWell 48 V power supply.</p> <p><i>NOTE: Once the screws have been removed, the 48 V power supply can be lifted out..</i></p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="315 1178 789 1381">  <p data-bbox="302 1423 630 1453"><b>48 V DC power power supply</b></p> </div> <div data-bbox="821 1192 1354 1373">  <p data-bbox="821 1409 1073 1438"><b>24 V DC power supply</b></p> </div> </div>
16.	<p>To reinstall the power supplies, perform the previous replacement steps in reverse order, reconnect all components, and reinstall the robot's front and top covers."</p>
17.	<p>After replacing the power supply, calibrate the robot.</p>

## Replacing the Robot Controller

 <b>DANGER</b> Electrical Shock	
Disconnect AC power before replacing the robot controller.	

### Tools Required:

- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex driver or hex L wrench
- Small flat bladed screwdriver, with 1.5 mm wide blade type
- M5 socket driver or M5 open end wrench or pliers

### Spare Parts Required:

- Guidance Controller, 5400B, PreciseFlex 400 Rev D (G5X0-EA-B5400)

[See "5400 Controller Board Connectors"](#) for more information.

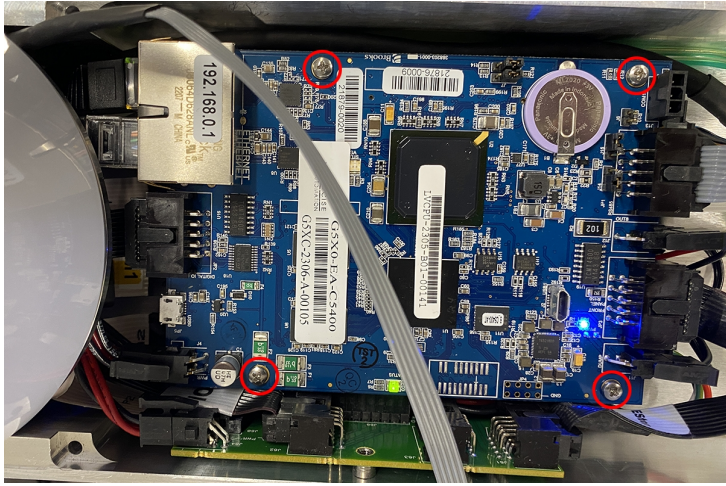
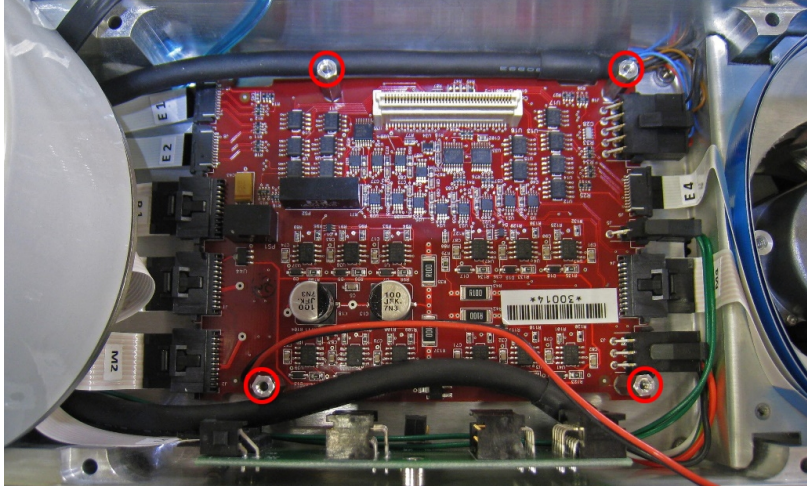
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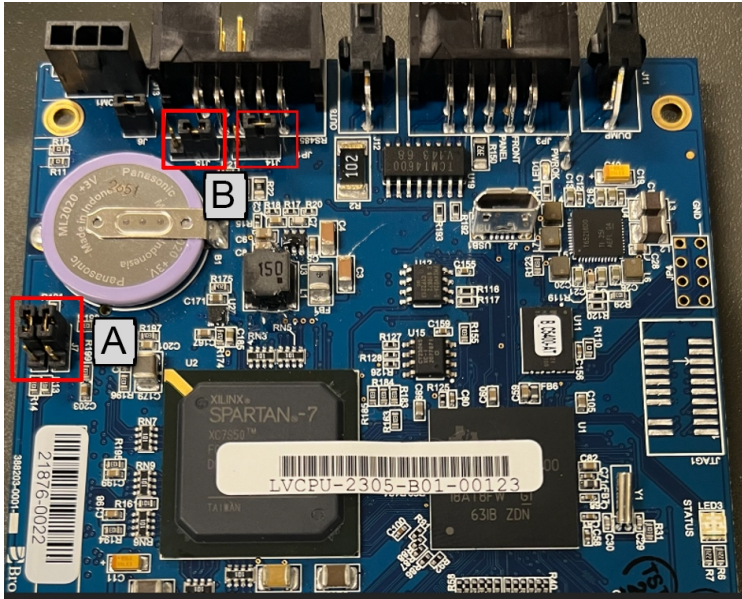
**NOTE:** Prior to replacing the controller, make copies of the robot PAC files and any project files to a PC, using a procedure similar to that described in "[Loading a Project \(Program\) or PAC Files](#)".

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To replace the robot controller, perform the following procedure:

Step	Action
1.	Turn off the robot power and remove the AC power cord.
2.	Remove the inner link cover by removing the (4) M3 X 20 mm SHCS that attach the cover.

Step	Action
3.	Unplug the cables from upper circuit board.
4.	<p>Remove the upper circuit board by removing the (4) M2.5 X 6 mm screws (shown below circled in red).</p>  A photograph showing the upper circuit board (blue) installed in a robot controller. Four screws are circled in red, indicating they need to be removed. The board has various components, including a coin cell battery, a barcode label with the part number G5XO-EA-C-5400, and several connectors. A white cable is plugged into the board.
5.	<p>Remove the lower circuit board by removing the (4) M2.5 X 16 mm standoffs with an M5 socket driver.</p>  A photograph showing the lower circuit board (red) installed in a robot controller. Four standoffs are circled in red, indicating they need to be removed. The board has various components, including a barcode label with the part number 30014, and several connectors. A black cable is plugged into the board.
6.	Unplug the cables from the lower circuit board.
7.	Gently pry open the 3 zero-insertion-force (ZIF) flat flexible cable (FFC) connector compression lids with a small flat bladed screwdriver.

Step	Action
<p>8.</p>	<p>Check the jumpers on the replacement CPU board (top board).</p> <ul style="list-style-type: none"> <li>• A - J7 and J8, pin 2 and 3</li> <li>• B - J14 and J15, pin 2 and 2</li> </ul> 
<p>9.</p>	<p>Re-attach the harness and replace the circuit boards. Refer to the "<a href="#">Power Supplies</a>" in the appendix for connector labeling on the circuit boards.</p> <p>Be careful that:</p> <ul style="list-style-type: none"> <li>• the 2-pin plug from the brake release switch plugs into the <b>lower</b> board</li> <li>• the 2-pin plug on the pigtail from the lower board plugs into the <b>upper</b> board.</li> </ul> <p>Be careful to gently press in the compression latch on the FFC encoder connectors with your finger and not a sharp object.</p>
<p>10.</p>	<p>Make sure the Ethernet cable folds back along the under the upper circuit board but does not obstruct the board to board connector.</p>
<p>11.</p>	<p>Make sure no cables will be pinched by the inner link cover and replace the cover.</p>
<p>12.</p>	<p>After replacing the robot controller:</p> <ul style="list-style-type: none"> <li>• install the BenchBot PAC files and BenchBot application program</li> <li>• recalibrate the robot. See "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>".</li> </ul>

## Replacing the Z-Axis Motor Assembly

 <b>DANGER</b> <b>Electrical Shock</b>	
Disconnect the AC power before replacing the Z-axis motor.	

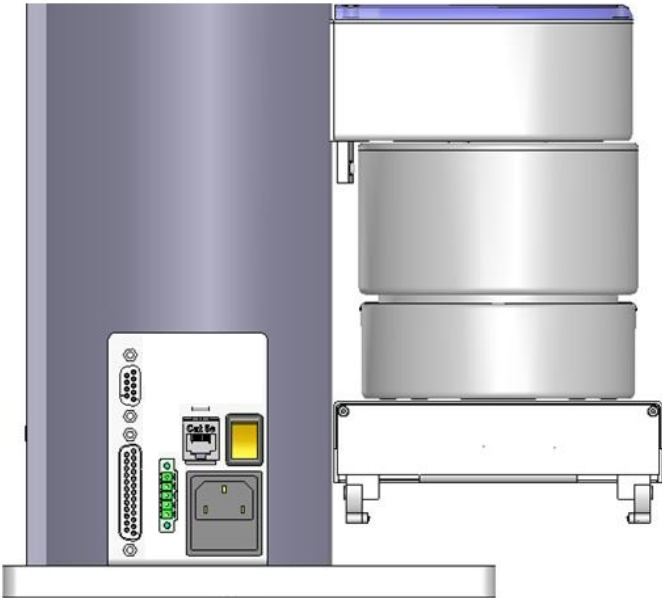
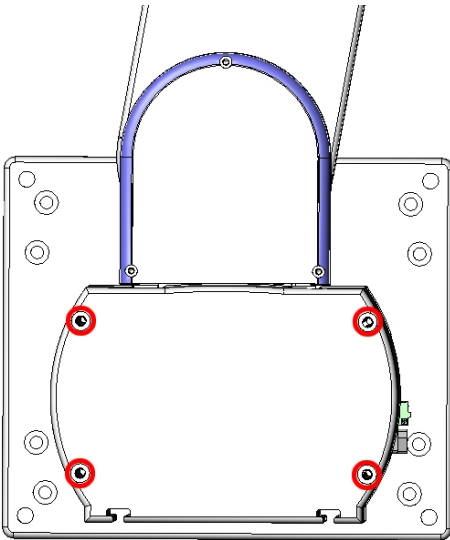
### Tools Required:

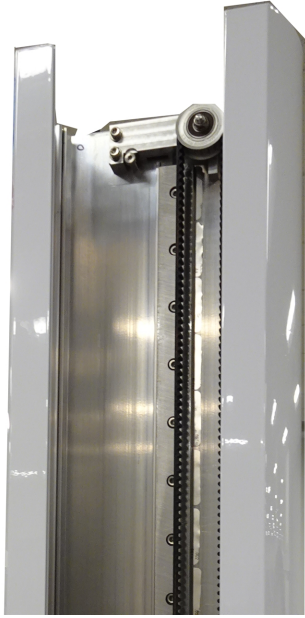
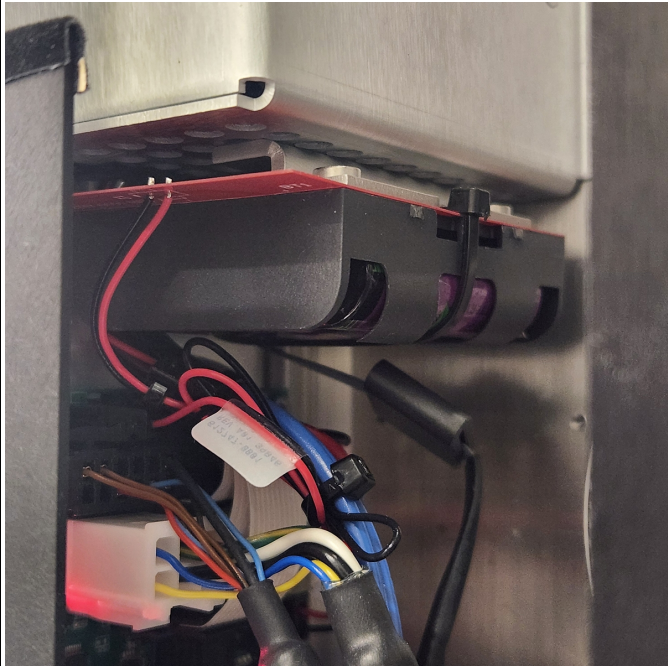
- 5.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench
- Loctite 243

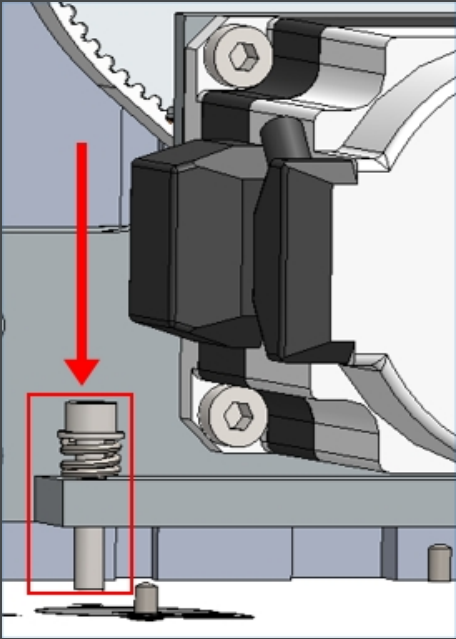
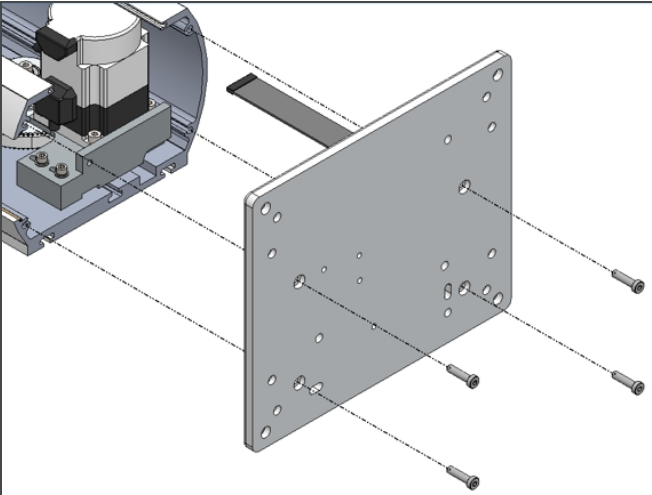
### Spare Parts Required:

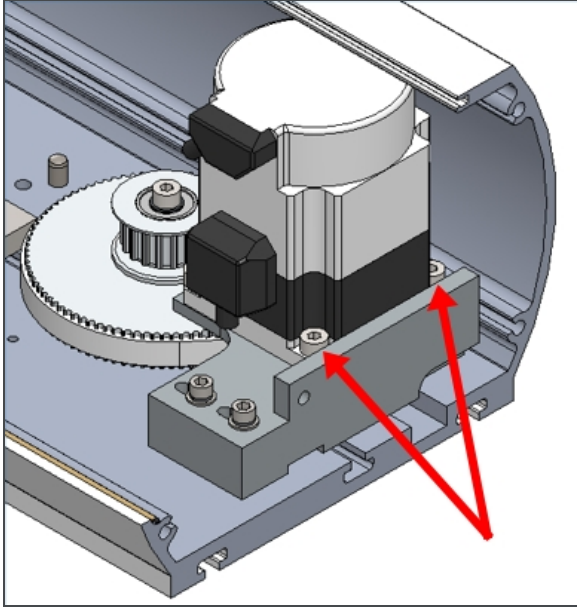
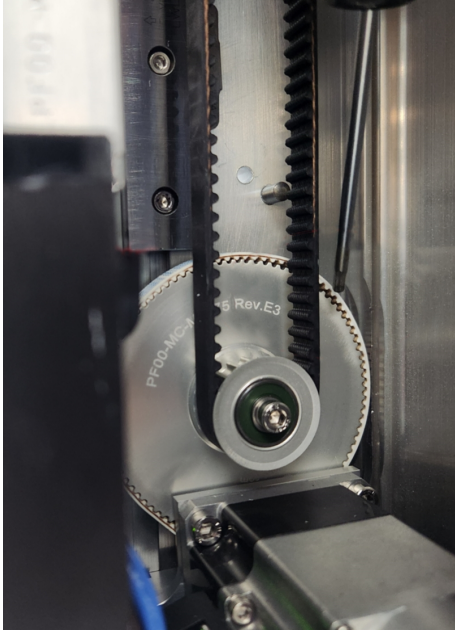
- J1 Motor Assembly (PF00-MA-00028)

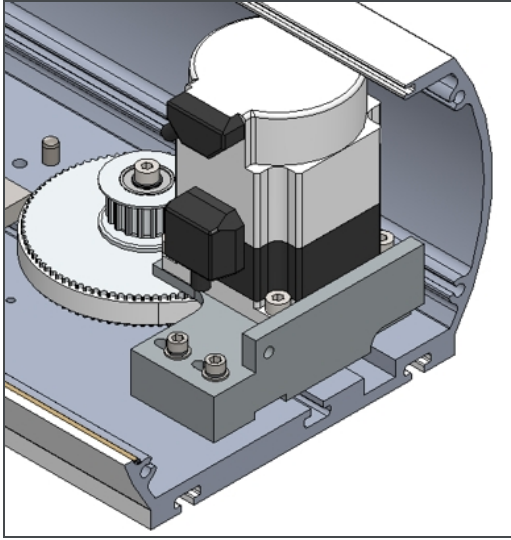
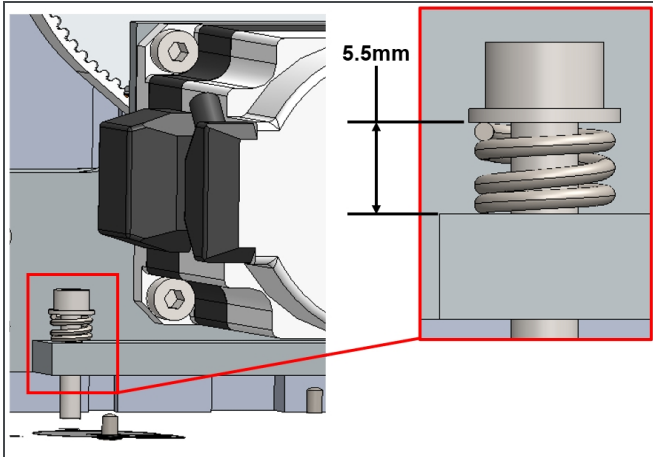
The J1 Motor Assembly is composed of the J1 motor, connectors, and a timing belt pulley. To replace the Z-axis motor assembly, perform the following procedure:

Step	Action
1.	<p data-bbox="341 268 1052 298">Disconnect the AC power and connectors from the base of the robot.</p>  <p>The diagram shows the rear view of the robot's base. On the left is a vertical panel with several ports: a multi-pin connector, a network port, a yellow indicator light, and a power input. To the right of this panel is the Z-axis motor assembly, which consists of three stacked cylindrical components and a base plate with four mounting feet.</p>
2.	<p data-bbox="341 974 1127 1003">Unfasten the robot from its mounting surface by removing the (4) M6 SHCS.</p>
3.	<p data-bbox="341 1050 1045 1079">Remove the top cover by removing the (4) M5 low head cap screws.</p>  <p>The diagram shows the top view of the robot's base. A blue handle is attached to the top edge. Four red circles with arrows pointing outwards are located at the corners of the base, indicating the positions of the M5 low head cap screws that hold the top cover in place.</p>

Step	Action
4.	<p>Remove the front cover by sliding it out.</p> 
5.	<p>Remove the left splash guard by removing the M3 X 8 mm SHCS and M3 star washer.</p>
6.	<p>Remove the screws attaching the electronics chassis and ground lug to the bottom mounting plate.</p>
7.	<p>Unplug the battery from the J1 motor interface Board.</p> 



Step	Action
8.	<p data-bbox="342 268 1084 300">Remove the screw compressing the J1 motor tension spring and spring.</p> 
9.	<p data-bbox="342 1003 1395 1062">Remove the base mounting plate by removing the (4) M5 SHCS. The right splash guard is attached to the base mounting plate.</p> 

Step	Action
10.	<p>Remove the M4 locking screws that attach the J1 motor mount bracket to the Z column.</p> 
11.	<p>Slide the J1 Stage 1 timing belt off the large idler pulley.</p> 

Step	Action
12.	<p>Slide the J1 motor and motor mount bracket assembly out the bottom of the Z column.</p> 
13.	<p>Remove the J1 motor assembly from the J1 motor mount bracket, and replace with the new motor, using Loctite 243.</p>
14.	<p>Replace the components in reverse order. Use Loctite 222 or 243 on the base plate and top plate screws.</p>
15.	<p>Compress the tension spring to 5.5 mm under the washer with the M4 motor bracket locking screws slightly loose, then tighten the screws.</p> 
16.	<p>Before replacing the front cover and top plate, remove the calibration pins from inside the front cover.</p>
17.	<p>Recalibrate the robot following the calibration procedure in "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>".</p>

## Tensioning the J1 (Z Column) Belts

### Tensioning the 1<sup>st</sup> Stage Belt

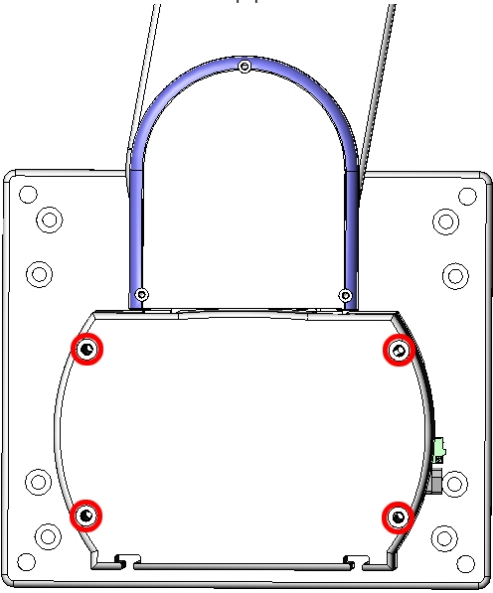
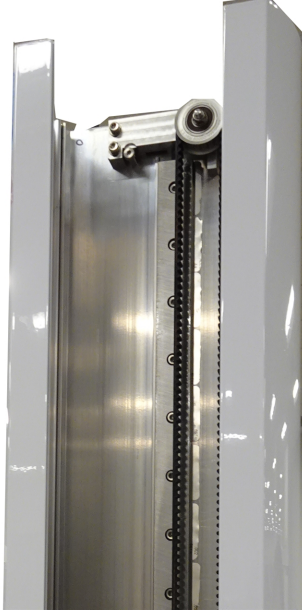
 <b>DANGER</b> <b>Electrical Shock</b>	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before tensioning the timing belts.	

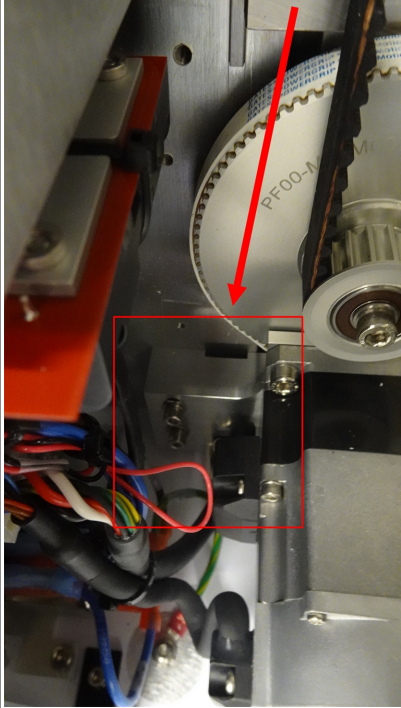
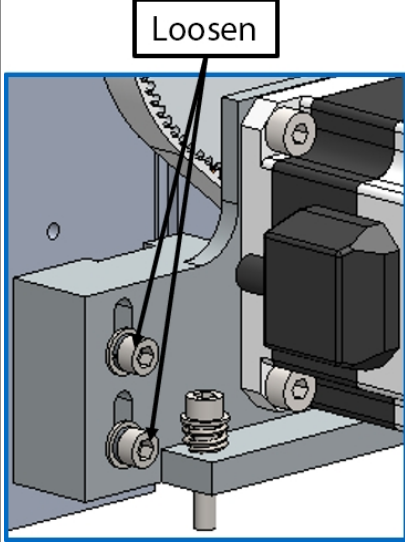
#### Tools Required

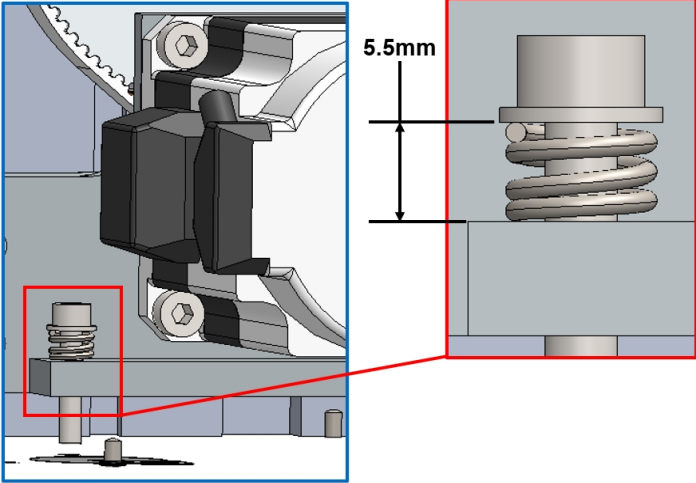
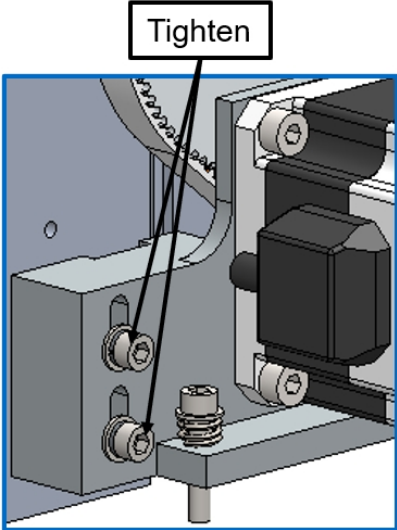
- 3.0 mm hex driver or hex L wrench

To tension the first stage belt, perform the following procedure:



Step	Action
1.	Move the robot arm to the top of the Z Column travel.
2.	Turn off robot power and unplug the AC power cord.

Step	Action
3.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the top plate.</p> 
4.	<p>Remove the front cover by lifting it out vertically.</p> 

Step	Action
5.	<p data-bbox="293 264 1256 296">At the base of the Z column, locate the (2) M4 locking screws on the J1 motor mount bracket.</p>  <p>The photograph shows the base of the Z column where the J1 motor mount bracket is located. A red arrow points to two M4 locking screws on the bracket. A red box highlights the area around the screws. The motor and its pulley are visible in the background.</p>
6.	<p data-bbox="293 1066 1360 1125">Loosen the (2) M4 locking screws on the J1 motor mount bracket to allow the mount bracket to slide up and down.</p>  <p>The diagram shows a 3D perspective view of the J1 motor mount bracket. A callout box labeled 'Loosen' points to the two M4 locking screws on the bracket. The motor and its pulley are also shown in the diagram.</p>

Step	Action
7.	<p>Adjust the M4 tension screw compressing the spring assembly. The tension spring should be compressed until the spring length is 5.5 mm under the washer.</p> 
8.	<p>After adjusting the tension screw, tighten the M4 locking screws to lock the assembly in place, and replace the front cover and top plate.</p> 

## Tensioning the 2<sup>nd</sup> Stage Belt

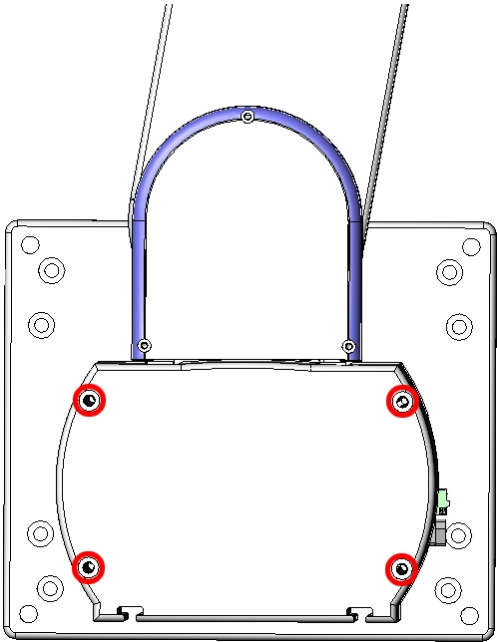
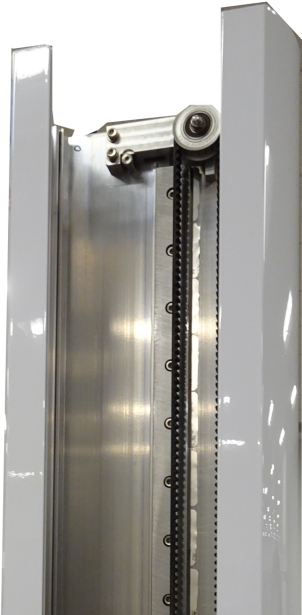
 <b>DANGER</b> <b>Electrical Shock</b>	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before tensioning the timing belts.	

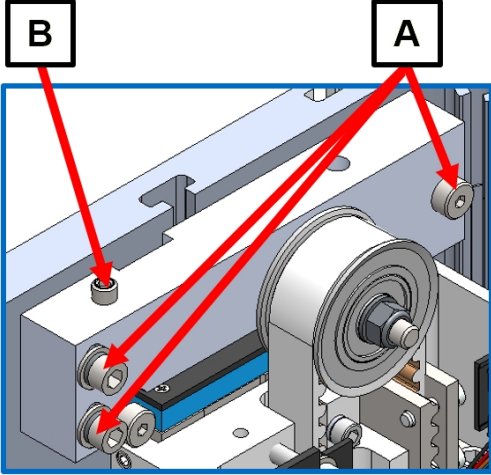
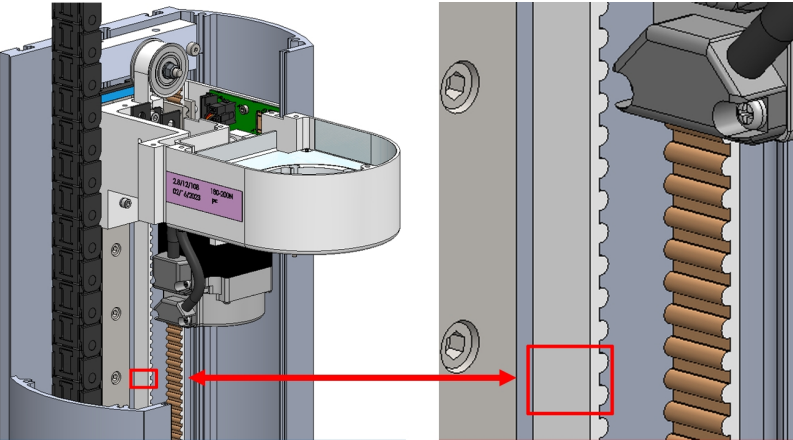
### Tools Required

- Gates Sonic Belt Tension Meter, Model 507C
- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench

To tension the second stage belt, perform the following procedure:



Step	Action
1.	Move the robot arm to the top of the Z Column travel.
2.	Turn off the robot power and remove the AC power cord.

Step	Action
3.	<p data-bbox="295 268 1354 327">Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the top plate.</p> 
4.	<p data-bbox="295 1031 792 1060">Remove the front cover by lifting it out vertically.</p> 

Step	Action
5.	<ul style="list-style-type: none"> <li>At the top of the Z column, loosen the two M4 locking screws and the M5 shoulder screw (A) on the Z-rail idler plate.</li> <li>Turn the tension adjust screw (B) to change the tension.</li> </ul> 
6.	<p>Pluck the belt at the spot indicated below, and keep turning the tension adjust screw to change the tension. Set the tension to the value in "<a href="#">Belt Tensions, Gates Tension Meter</a>".</p> 
7.	<p><b>Alternate Method</b></p> <p>For robots with 750 mm and 1160 mm Z-axis travel, obtaining an accurate tension reading can be challenging because the belt spans are long (880 mm and 1290 mm respectively). These lengths result in low vibration frequencies.</p> <p>In this case, it may be easier to position the Z-carriage so that the span from the top idler pulley to the Z-carriage is 530 mm, which matches the span used for the 400 mm Z-stroke when measured on the left side of the belt. With the carriage positioned to create a 530 mm span, the tension for the longer Z-stroke robots can be measured on the right side of the belt, using the tension and frequency values specified for the 400 mm Z-stroke.</p>

Step	Action
8.	When finished, tighten the three screws on the Z-rail idler plate, and replace the front cover and top plate.

## Replacing the J1 Stage Two (Output) Timing Belt

 <b>DANGER</b> <b>Electrical Shock</b>	
<p>Disconnect the AC power before replacing the power supplies or belt.</p>	

### Tools Required:

- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench

### Spare Parts Required:

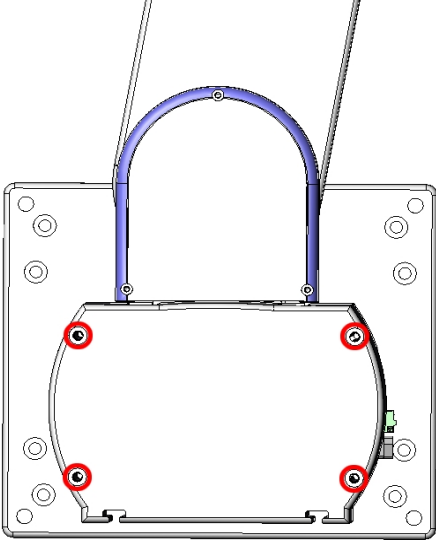
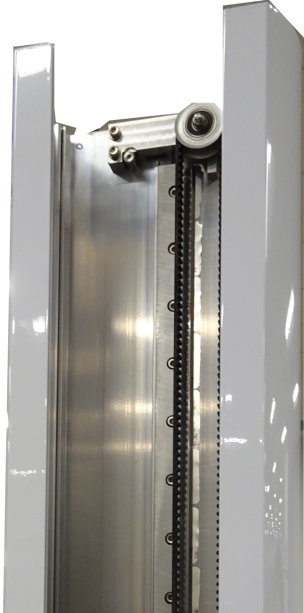
New Power Supply (one of the following):

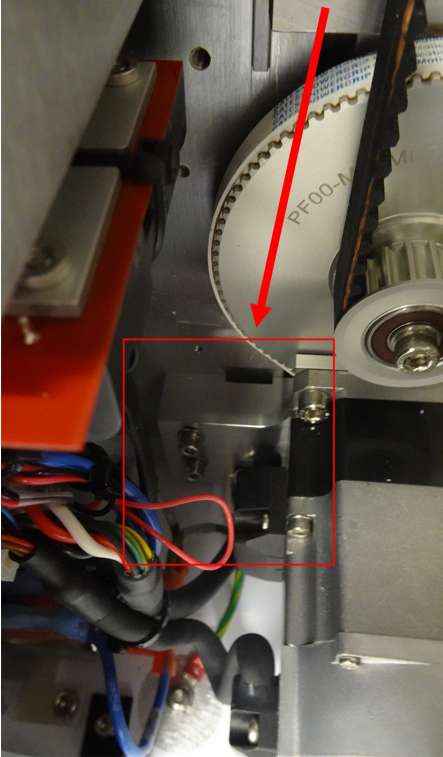
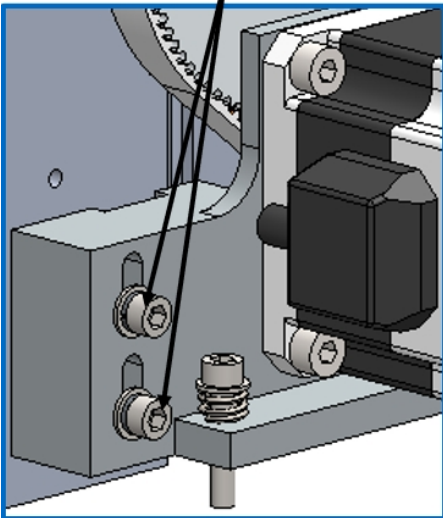
- 24 VDC Power Supply, 150W (PS10-EP-24150)
- 48 VDC Power Supply, 500W (605889)

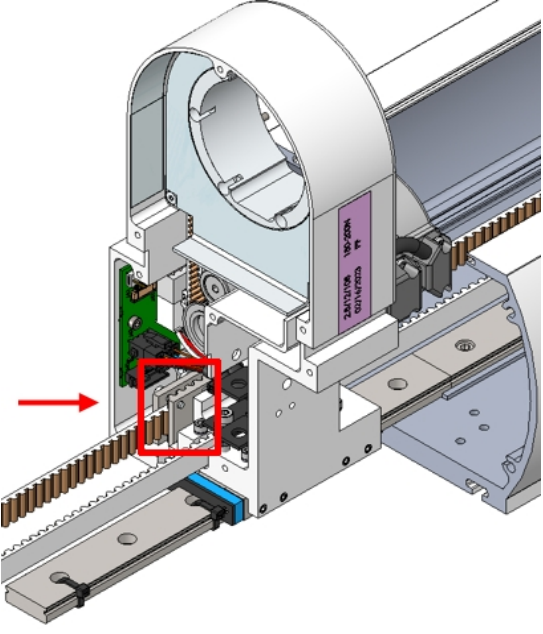
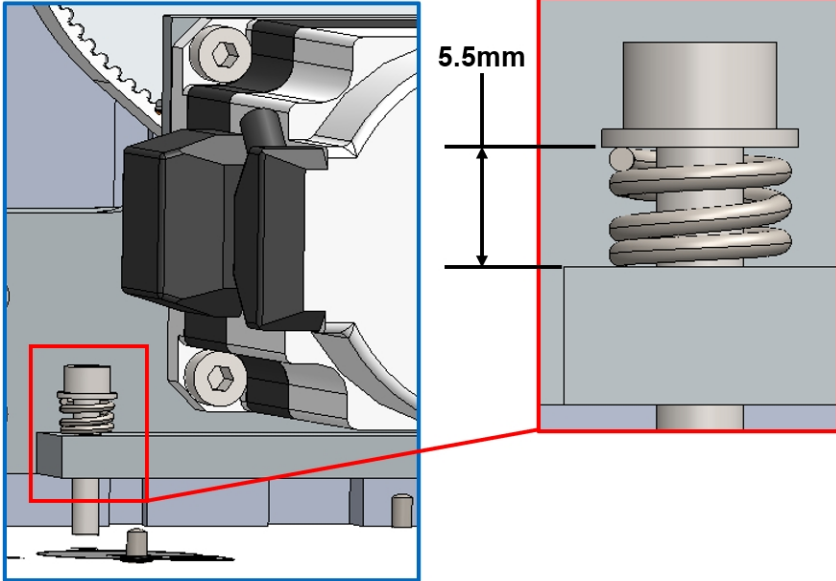
J1 Stage 2 Belt (one of the following):

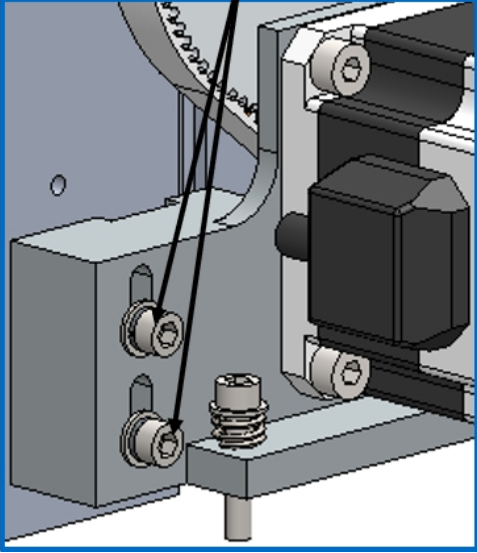
- 400mm, PreciseFlex 400 (PF00-MC-X0023-1)
- 750mm, PreciseFlex 400 (PF00-MC-X0023-2)
- 1160mm, PreciseFlex 400( PF00-MC-X0023-3)

To replace the J1 stage two (output) timing belt, perform the following procedure:



Step	Action
1.	Move the robot arm to the top of the Z column travel.
2.	Turn off the robot power and remove the AC power cord.
3.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot (shown below in red) that attach the top plate to the Z column. Lift up the top plate.</p> 
4.	<p>Remove the front cover by lifting it out vertically.</p> 

Step	Action
5.	<p data-bbox="354 268 1317 300">At the base of the Z column, locate the (2) M4 locking screws on the J1 motor mount bracket.</p> 
6.	<p data-bbox="354 1094 1386 1150">Loosen the (2) M4 locking screws on the J1 motor mount bracket to allow the mount bracket to slide up and down.</p> <p data-bbox="500 1157 654 1220">Loosen</p> 

Step	Action
7.	<p>Disengage the Z carriage timing belt from the lower drive pulley. If it is necessary to replace the Z carriage 2nd state timing belt, remove the Z carriage inner cover and then the timing belt clamp (shown below in red) from the Z carriage by removing the (2) M4 X 12 mm SHCS and lock washers, and replace the belt.</p> 
8.	<p>Replace the belt and clamps.</p>
9.	<p>Adjust the M4 tension screw compressing the spring assembly. The tension spring should be compressed until the spring length is 5.5 mm under the washer.</p> 

Step	Action
10.	<p data-bbox="354 268 1372 331">After adjusting the tension screw, tighten the M4 locking screws to lock the assembly in place, and replace the front cover and top plate.</p> <div data-bbox="354 359 831 1003"><p data-bbox="509 365 678 428">Tighten</p></div>

## Replacing the J2 (Shoulder) Motor or Timing Belt

 <b>DANGER</b> <b>Electrical Shock</b>	
Disconnect AC power before replacing the J2 motor or timing belt.	

### Tools Required:

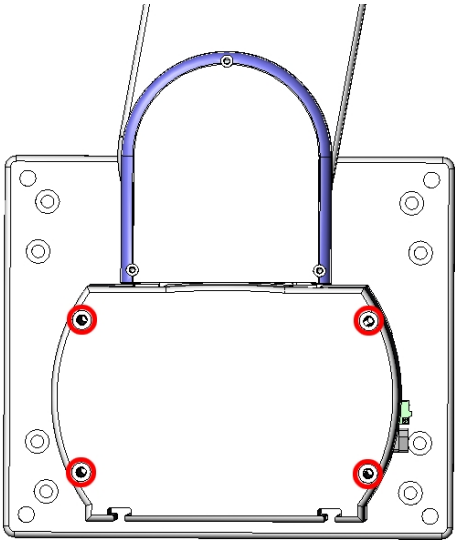
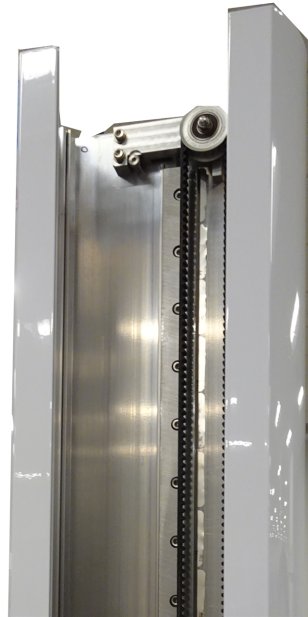
- 5.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex driver or hex L wrench
- Fine point tweezers
- 0.06 in flat blade screwdriver

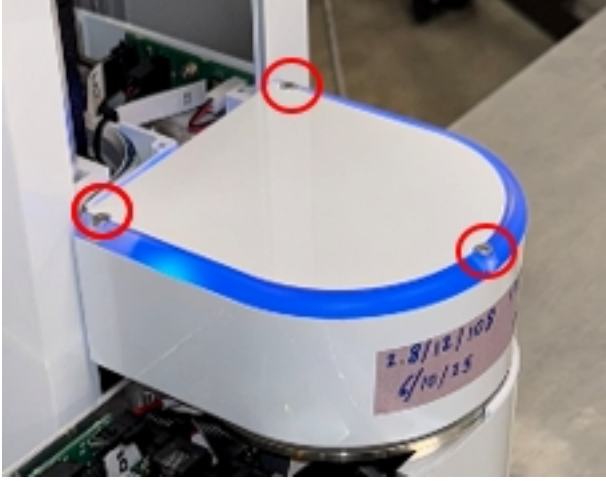
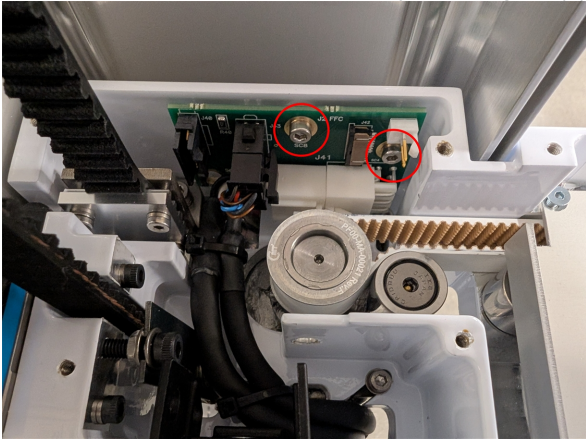
### Spare Parts Required:

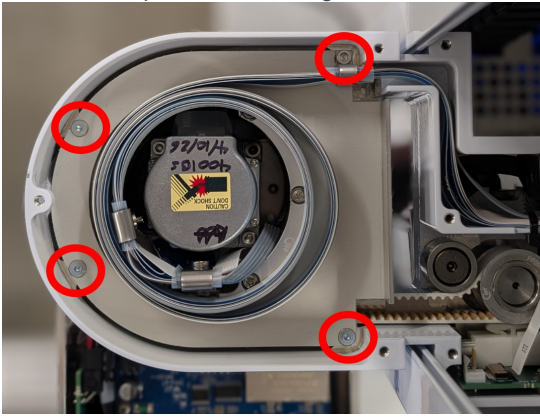
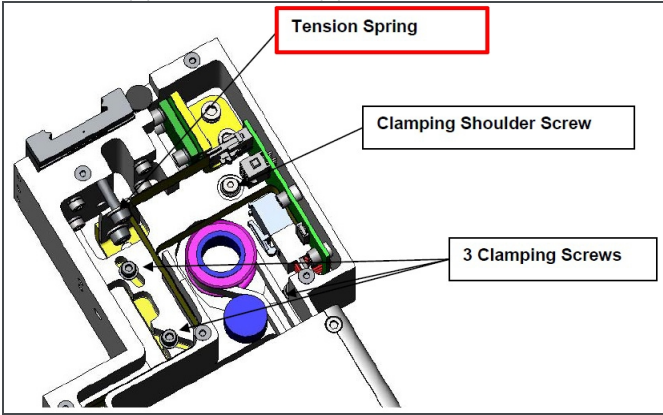
- J2 Motor, PreciseFlex (400 PF00-MA-00029) **OR** J2 Belt, PreciseFlex 400 (PF00-MC-X0081)
- 2 1/8<sup>th</sup> by 8 in tie wraps
- Loctite 243

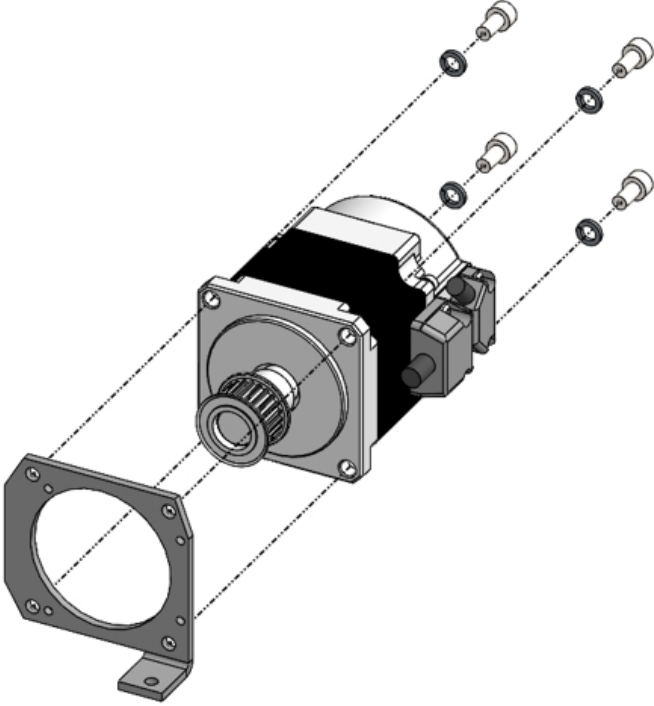
The J2 motor assembly is composed of the J2 motor, connectors, and a timing belt pulley. To replace the J2 (shoulder) motor or timing belt, perform the following procedure:

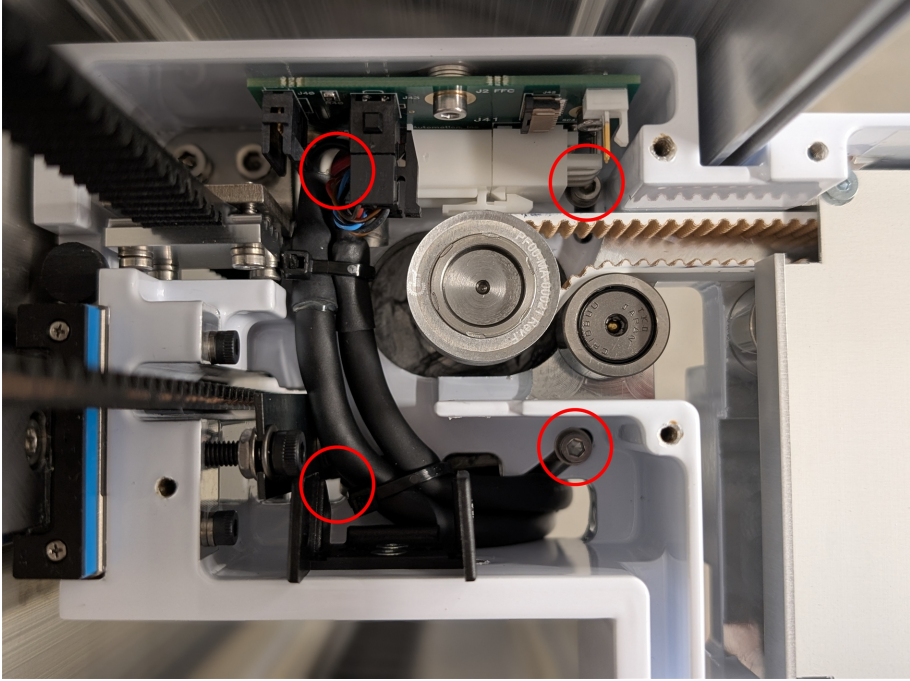
Step	Action
1.	Turn off the robot power and remove the AC power cord.
2.	Unbolt the robot from its mounting surface and set it vertically on the floor or a low surface.
3.	Move the robot arm to about 2" below the top of the Z column travel.

Step	Action
4.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot that attach the top plate to the Z column.</p> 
5.	<p>Remove the front cover by lifting it out horizontally.</p> 
6.	<p>Remove the Z carriage inner cover by removing the (5) M3 X 10 mm FHCS.</p>



Step	Action
7.	<p>Remove the light bar by removing the (3) M3 X 8 mm SHCS and unplugging the connector from the J2 motor interface PCA.</p> 
8.	Remove the tie wrap securing the harness loop to the Z carriage.
9.	Remove the M2 and E2 flat ribbon cables from the J2 motor interface board.
10.	<p>Remove the J2 motor interface PCA by removing the (2) M3 X 8 mm SHCS.</p> 
11.	Cut the tie wrap securing the J2 motor cables to the Z carriage.
12.	Unplug the J2 motor and encoder cable from the J2 motor interface PCA.
13.	Disconnect the harness retaining clip from the Z carriage, but do not remove the clips that attach the harness to the J2 pulley.
14.	Uncoil the harness. One end will remain connected to the E-chain and the other end will be connected to the J2 pulley.

Step	Action
15.	<p>Remove the J2 belt cover by removing the (4) M3 X 10 mm FHCS, and pull it partially up the uncoiled harness to expose the J2 timing belt.</p> 
16.	<p>Unsnap (3 or 4) the E-chain harness retaining segments, working up from the carriage, and fold the E-chain and harness back over the power supply side of the robot to get it out of the way.</p>
17.	<p>Loosen the (3) M3 SHCS and (1) M4 shoulder screws that attach the J2 motor bracket.</p> 
18.	<p>Measure and record the distance from the back of the tension spring to the carriage, then remove the M4 X 20 mm SHCD and washer that compress the tension spring.</p>
19.	<p>Pull the timing belt up over the idler cam follower closest to the large J2 pulley to release belt tension and provide enough slack to remove the motor.</p>
20.	<p>If it is necessary to replace the J2 timing belt, replace the belt and reassemble the robot. Otherwise, skip this step.</p>

Step	Action
21.	<p>Loosen the (4) screws and washers that attach the motor mount plate to the Z carriage while supporting the motor.</p> <p><b>NOTE:</b> <i>It may be easiest to leave these screws in the carriage during this process.</i></p> 
22.	<p>Drop the motor assembly downwards while threading the motor cables through the access hole in the bottom of the Z carriage, and pulling the timing belt up over the pulley flange.</p>

Step	Action
23.	<p>Remove the motor from the motor mount bracket by removing the (4) M5 X 12 mm SHCS. Attach the new motor to the motor mount bracket using Loctite 243.</p> <p><b>NOTE:</b> The motor wires can obscure the screws and might need to be lifted to access them.</p> 
24.	<p>Re-install motor, threading cables through the Z carriage first, and pulling timing belt over pulley flange. Attach motor with (4) clamping screws. Do not tighten clamping screws all the way.</p>
25.	<p>Re-install the M4 X 20 mm tension bolt and compress the tension spring to the previous value.</p> <p>Tighten the M4 jam nut to lock the bolt and tension spring. This will cause motor assembly to pivot on the shoulder screw and will apply tension to the timing belt.</p> <p>Before tightening the clamping screws, rotate the J2 output pulley back and forth to ensure that the timing belt is running true on the output pulley.</p>
26.	<p>Tighten the clamping screws. If a tension meter is available check the belt tension for a minimum tension of 150 N. (See "<a href="#">Belt Tensions, Gates Tension Meter</a>").</p>
27.	<p>Re-assemble the robot except for the front cover and top cover.</p>
28.	<p>Remove the calibration pins from the inside of the front cover extrusion and re-calibrate the robot following the calibration procedure in "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>".</p>

## Tensioning the J2 Belt

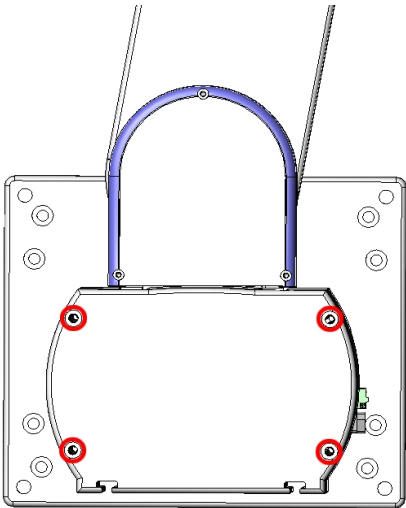

 <b>DANGER</b> <b>Electrical Shock</b>	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before tensioning the timing belts.	

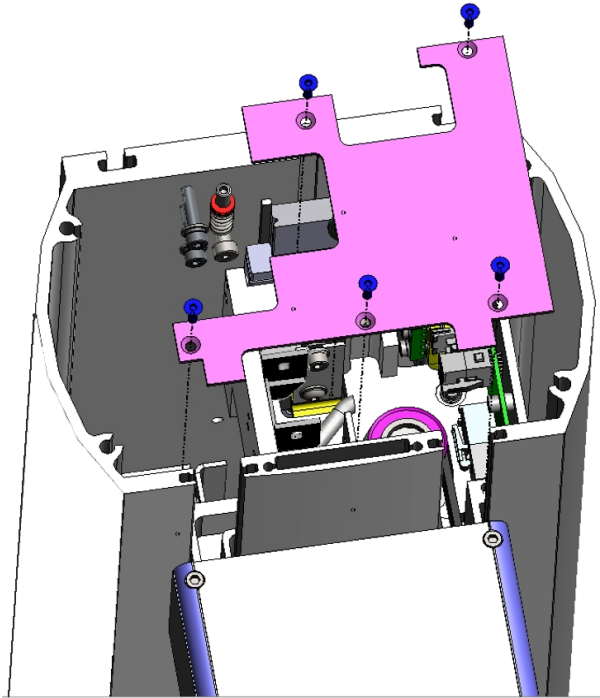
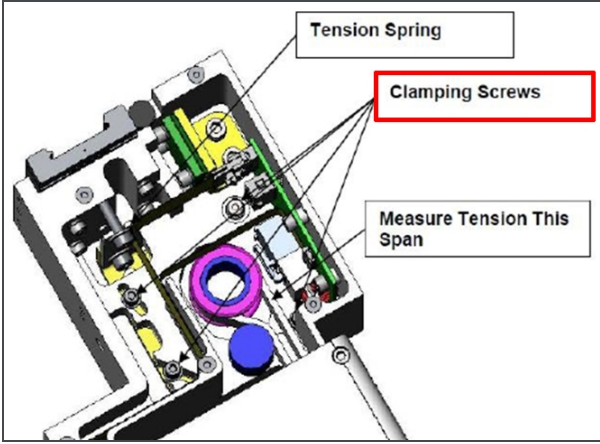
### Tools Required:

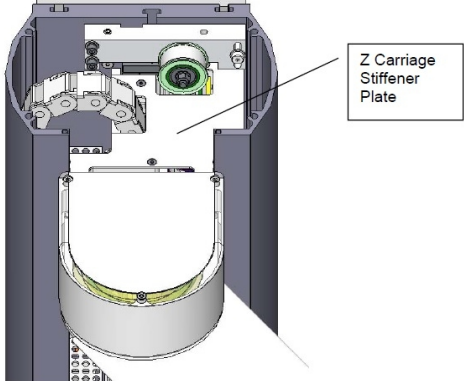
- Gates Sonic Belt Tension Meter, Model 507C
- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex ball driver or hex L wrench

In order to re-tension the J2 (shoulder) Timing Belt, perform the following steps:



Step	Action
1.	Move the robot arm to the top of the Z Column travel.
2.	Turn off the robot power and remove the AC power cord.

Step	Action
3.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the top plate.</p> 
4.	<p>Remove the front cover by lifting it out vertically.</p> 

Step	Action
5.	<p>Remove the Z carriage stiffener plate by removing the (5) M3 X 6 FHCS attaching it to the Z carriage (shoulder).</p>  <p>The diagram shows a cutaway view of the Z carriage assembly. A pink rectangular stiffener plate is mounted on top of the carriage. Five blue screws are shown being removed from the plate. The carriage itself is grey and contains various mechanical components like rollers and a belt.</p>
6.	<p>Loosen the (3) M3 SHCS and (1) M4 shoulder screws clamping the J2 motor mount plate to the Z carriage.</p> <p><i>NOTE: It may be necessary to remove the tie wrap securing the J2 motor cables to the Z carriage in order to access the clamping screw under these cables.</i></p>  <p>The diagram shows a close-up of the J2 motor mount plate. A yellow tension spring is attached to the plate. Three green screws are labeled 'Clamping Screws' and are highlighted with a red box. A blue screw is labeled 'Measure Tension This Span'. The plate is mounted on a grey carriage.</p>

Step	Action
7.	<p>Measure the belt tension with a tension meter as described in "<a href="#">Belt Tensions, Gates Tension Meter</a>". If a belt tension meter is not available, the tension leaf spring will automatically reset the belt tension.</p> <p>It is helpful to jiggle the motor a little bit to be sure any friction is overcome. The motor can be easily grasped by reaching under the Z carriage (shoulder). Then re-tighten the clamping screws. Replace the tie wrap if it was removed.</p>
8.	<p>Replace the Z carriage stiffener plate.</p> 
9.	Replace the front cover.
10.	Replace the top plate.

## Replacing the J3 (Elbow) Motor or Timing Belt

 <b>DANGER</b> Electrical Shock	
Disconnect the AC power before replacing the motor.	

### Tools Required:

- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex driver or hex L wrench
- Fine point tweezers
- 0.06" flat blade screwdriver

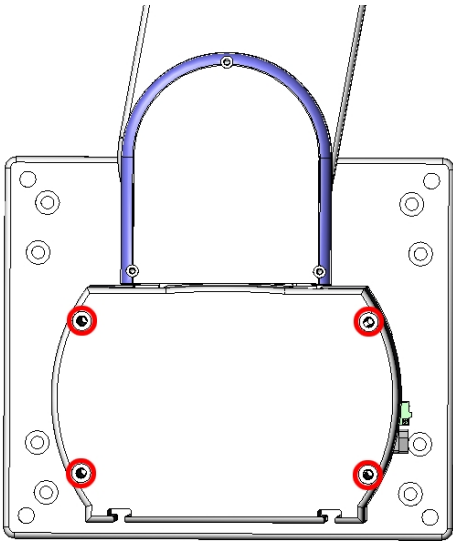
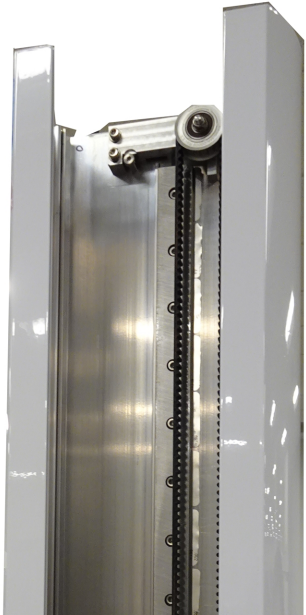
### Spare Parts Required:

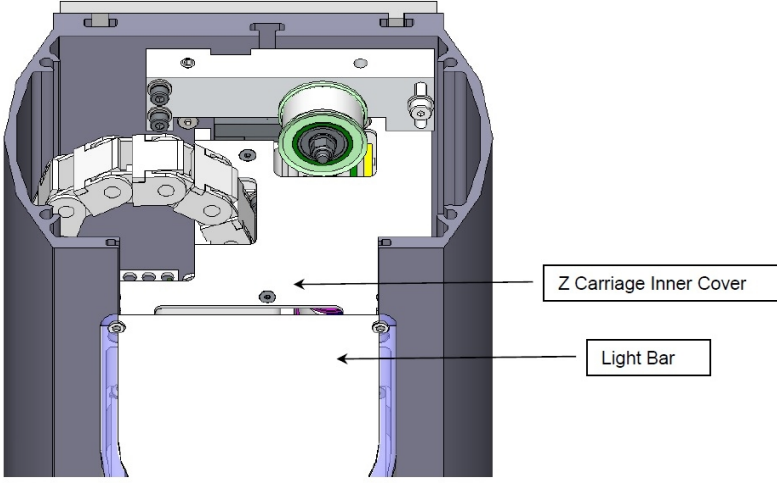
- J3 Motor, PreciseFlex 400/ 3400 (PF00-MA-00030) **OR** J3 Belt, PreciseFlex 400 Standard Reach (PF00-MC-X0035)
- 2 1/8<sup>th</sup>" by 8" tie wraps
- Loctite 222 and 243

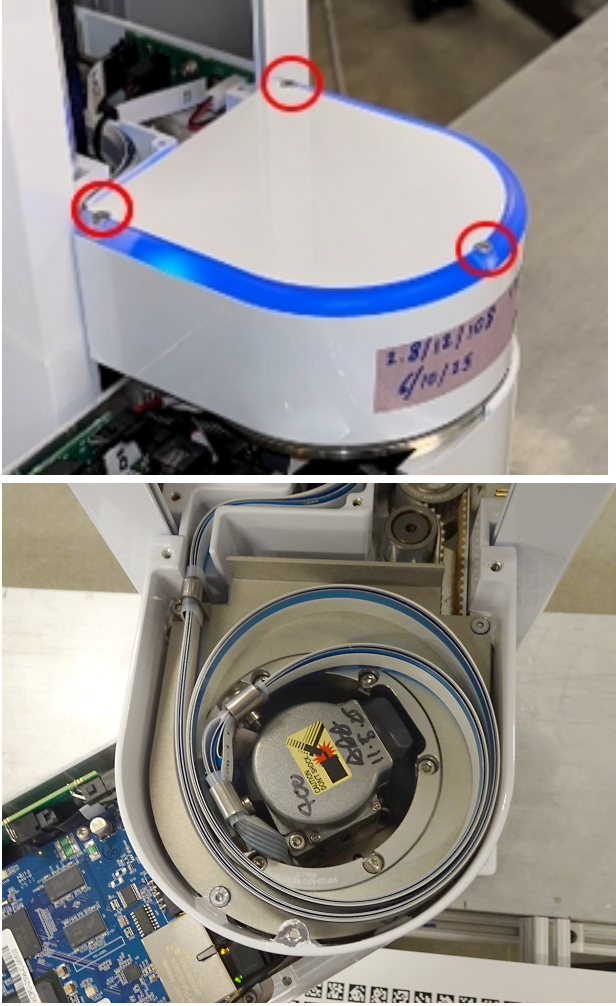
The J3 motor assembly is composed of the J3 motor, connectors, and a timing belt pulley.

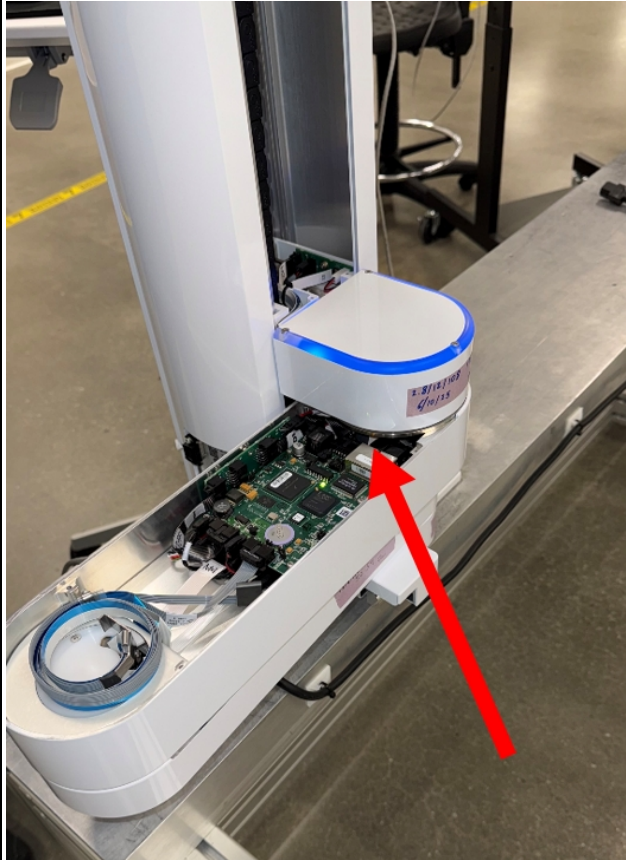
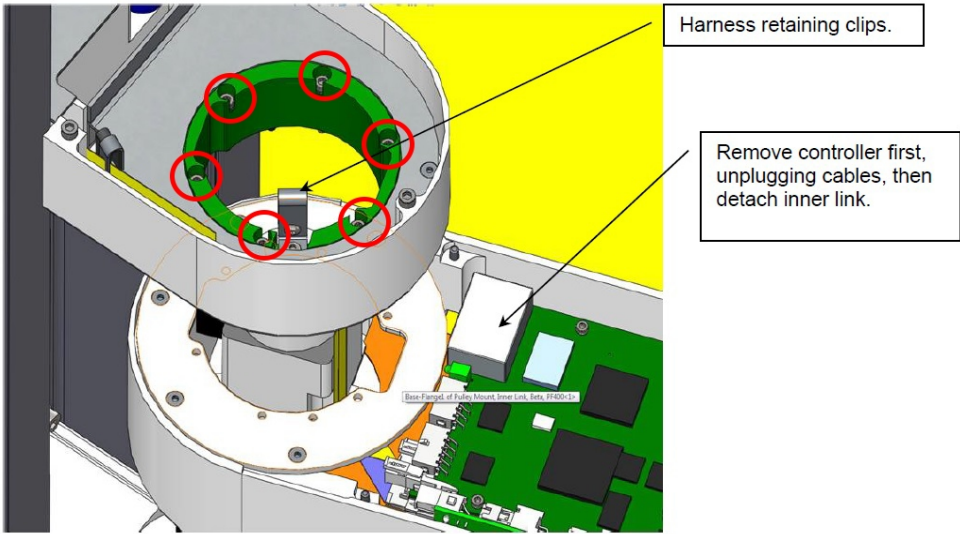
To replace the J3 (elbow) motor or timing belt, perform the following procedure:

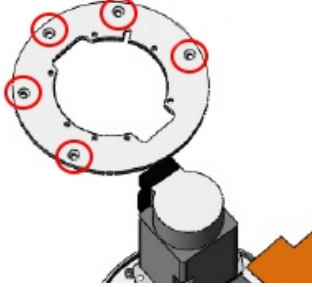
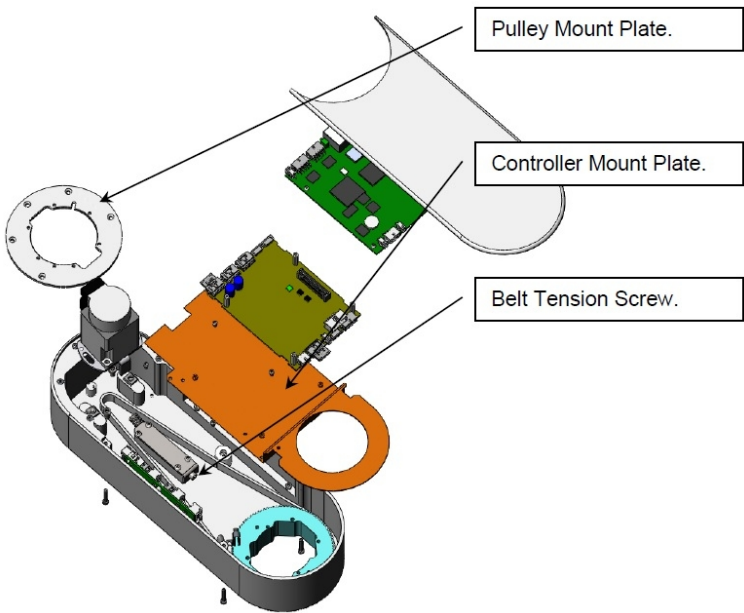
Step	Action
1.	Unbolt the robot from its mounting surface and set it vertically on the floor or a low surface.
2.	Move the robot arm to about 2 inches below the top of the Z column travel.
3.	Turn off the robot power and unplug the AC power cord.

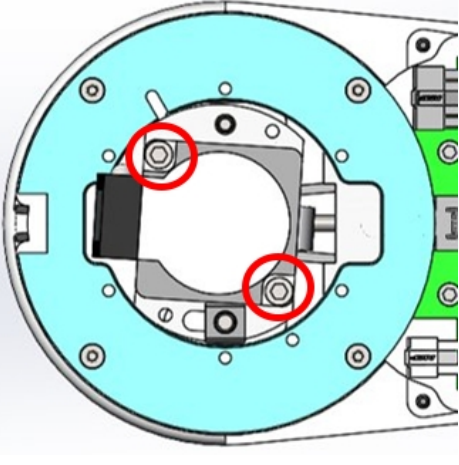
Step	Action
4.	<p>Remove the top plate of the robot by removing the (4) M5 socket head screws from the top plate of the robot that attach the top plate to the Z column.</p> 
5.	<p>Remove the front cover by lifting it out horizontally.</p> 

Step	Action
6.	<p>Remove the Z carriage inner cover by removing the (5) M3 X 10 mm FHCS.</p> 



Step	Action
7.	<p>Remove the light bar by removing the (3) M3 X 8 mm SHCS and unplugging the connector from the J2 motor interface PCA.</p> 

Step	Action
8.	<p>Unplug the controller from the inner link.</p> <p><b>NOTE:</b> This image depicts the light bar that was removed in the previous step.</p> 
9.	<p>Detach the inner link from the Z carriage by removing the (6) M3 X 35 mm SHCS and lock washers.</p> 

Step	Action
10.	<p>Remove round pulley mount plate from the inner link by removing the (5) M3 FHCS.</p> 
11.	<p>Remove the J3 controller mount plate from the inner link by removing the (4) M3 X 5 mm SHCS.</p> 

Step	Action
12.	<p>Remove the J3 motor by removing the (2) M4 screws that attach the motor to the motor mount plate, and rotate the motor up and out of the motor mount plate. This procedure will preserve the belt tension and avoid having to use a tension meter to reset the belt tension, as it preserves the position of the motor mount plate.</p>  <p>The diagram shows a top-down view of the J3 motor assembly. A light blue circular motor mount plate is highlighted. Two M4 screws are circled in red, indicating they are to be removed. The motor is mounted on the plate, and the diagram shows it being rotated upwards and outwards.</p>
13.	<p>Replace the J3 motor, using Loctite 243, or optionally, replace the J3 timing belt if necessary. Since the motor mount plate has not been removed, the belt tension should not need to be adjusted.</p>
14.	<p>If a belt tension meter is available, check the belt tension per "<a href="#">Belt Tensions, Gates Tension Meter</a>". Check the belt tension every 10 degrees of rotation of the J3 output pulley and set the belt tension at its lowest point to the minimum value in "<a href="#">Belt Tensions, Gates Tension Meter</a>".</p>
15.	<p>Replace the pulley mount plate using Loctite 222 and re-assemble the robot.</p>
16.	<p>Re-calibrate the robot. See "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>".</p>

## Replacing the J4 (Wrist) Motor or Timing Belt

 <b>DANGER</b> <b>Electrical Shock</b>	
<p>Remove the AC power before replacing the motor.</p>	

### Tools Required:

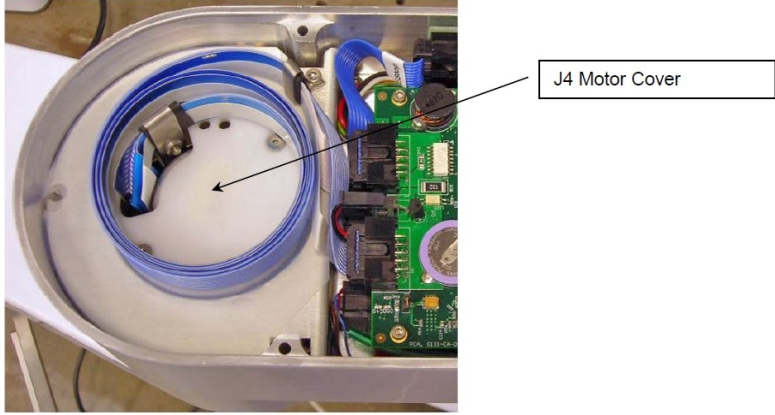
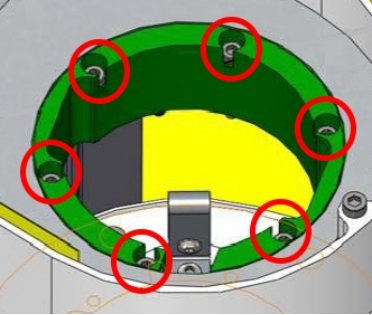
- 3.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex driver or hex L wrench
- Fine point tweezers
- 0.06 in flat blade screwdriver

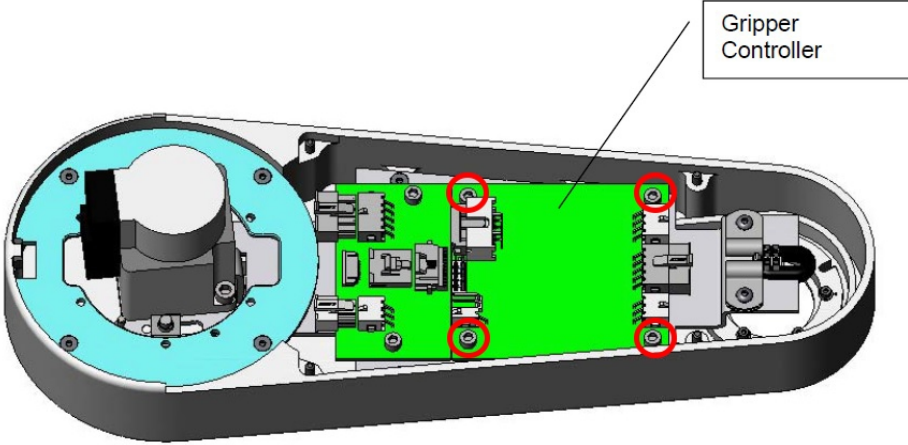
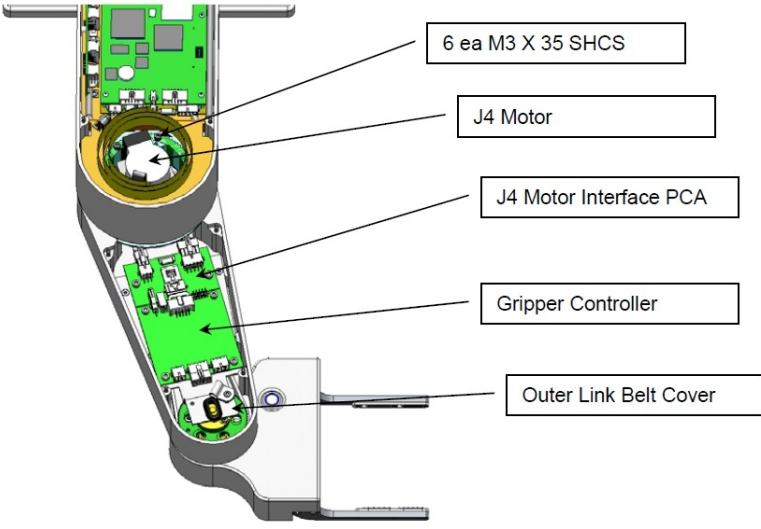
### Spare Parts Required:

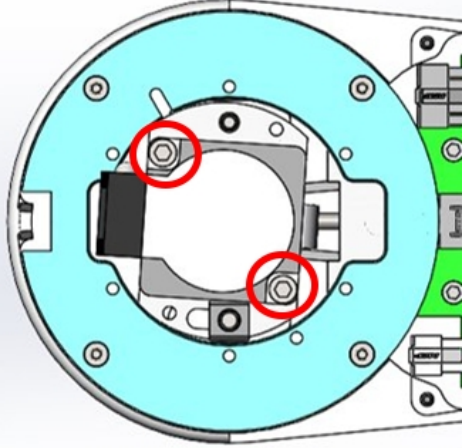
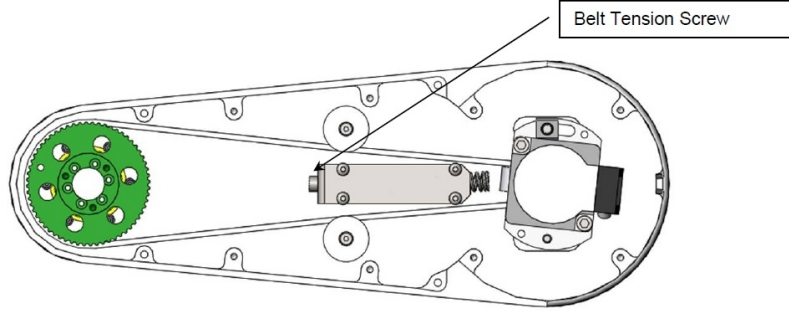
- J4 Motor, PreciseFlex 400(PF00-MA-00031) **OR** J4 Belt, PreciseFlex 400 Standard Reach (PF00-MC-X0004)
- Loctite 222 and 243

The J4 motor assembly is composed of the J4 motor, connectors, and a timing belt pulley. To replace the J4 (wrist) motor or timing belt, perform the following procedure:

Step	Action
1.	Move the robot arm to a convenient height on the Z column for removing the outer link.
2.	Turn off the robot power and remove the AC power cord.
3.	Remove the inner link cover by removing the (4) M3 X 20 mm SHCS and lock washers.
4.	Remove the outer link cover by removing (4) M3 X 20 mm SHCS and lock washers.

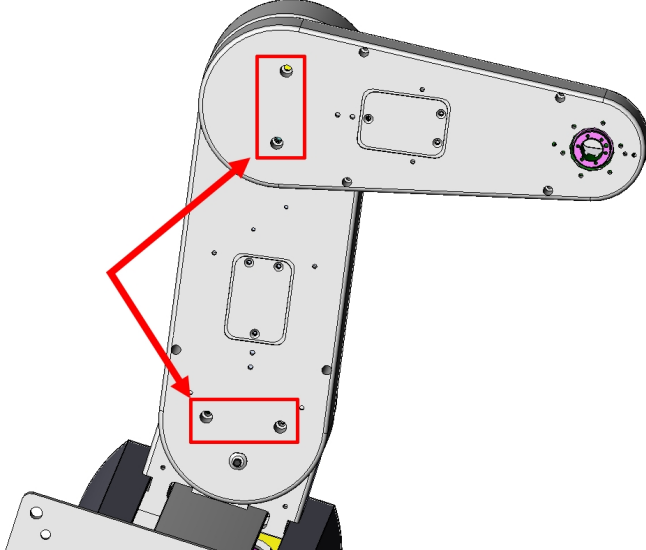
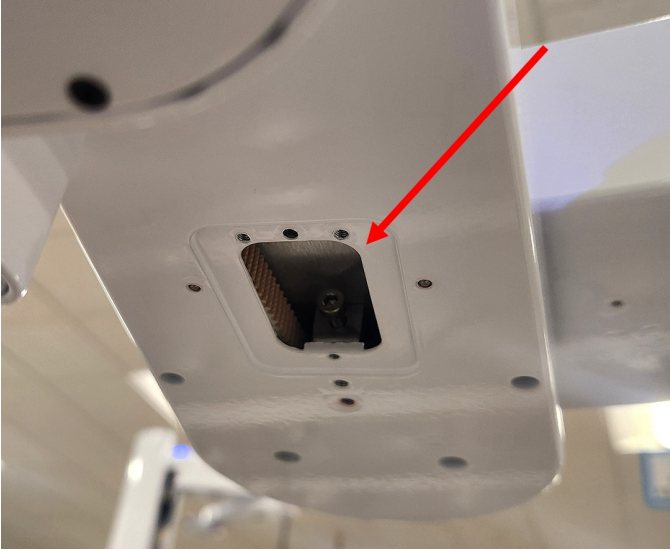
Step	Action
5.	<p>Remove the J4 motor cover in the elbow by removing the (2) M3 X 10 mm FHCS.</p> 
6.	<p>Rotate the outer link clockwise (viewing from above) until it hits the hard stop. This will expand the harness coil and the link will be position as shown below, about 10 degrees from straight out.</p>
7.	<p>Remove the J4 motor interface board in the outer link and unplug the cables.</p>
8.	<p>Remove the outer link by removing the (6) M3 X 35 mm SHCS screws in the J3 output pulley that attach the outer link.</p> 


Step	Action
9.	<p>Remove the gripper controller by unplugging the gripper harness and removing the (4) M3 X 8 mm SHCS.</p>  <p>The diagram shows a top-down view of the gripper controller assembly. A green PCB is mounted on a grey metal housing. Four screws are circled in red, indicating they need to be removed. A callout box labeled 'Gripper Controller' points to the assembly.</p>
10.	<p>Remove the outer link belt cover by removing the (4) M3 X 10 mm SHCS.</p>  <p>The diagram shows a side view of the outer link belt cover assembly. Various components are labeled with callout boxes: '6 ea M3 X 35 SHCS' (pointing to the top cover), 'J4 Motor' (pointing to the motor), 'J4 Motor Interface PCA' (pointing to the interface board), 'Gripper Controller' (pointing to the PCB), and 'Outer Link Belt Cover' (pointing to the bottom cover).</p>

Step	Action
11.	<p>Remove the J4 motor by removing the (2) M4 screws attaching the motor to the motor mount plate, and rotate the motor up and out of the motor mount plate. This procedure will preserve the belt tension and avoid having to use a tension meter to reset the belt tension, as it preserves the position of the motor mount plate.</p> 
12.	<p>Replace the J4 motor, using Loctite 243, or optionally, replace the J4 timing belt if necessary. Since the motor mount plate has not been removed, the belt tension should not need to be adjusted.</p>
13.	<p>If a belt tension meter is available, check the belt tension per <a href="#">"Belt Tensions, Gates Tension Meter"</a>. Check the belt tension every 10 degrees of rotation of the J4 output pulley and set the belt tension at its lowest point to the minimum value in <a href="#">"Belt Tensions, Gates Tension Meter"</a>.</p> 
14.	<p>Replace the pulley mount plate using Loctite 222 and re-assemble the robot, with the outer link positioned as shown in Step 10 so that the link is correctly oriented with respect to the hard stop.</p>
15.	<p>Re-calibrate the robot. See <a href="#">"Calibrating the Robot: Setting the Encoder Zero Positions"</a>.</p>

## Tensioning the J3 and J4 Belts

To tension the J3 and J4 belts, perform the following procedure:

Step	Action
1.	<p>Loosen the appropriate motor locking screws <b>one turn</b> to unclamp the motor. Do not loosen these screws more than one or two turns or the retaining nuts can fall off inside the link.</p>  <p>The diagram shows a perspective view of a robot arm. Two red rectangular boxes highlight the motor locking screws on the inner and outer links. Red arrows point from these boxes to the specific screws.</p>
2.	<p>Unscrew and remove the access hatch covers on the inner and outer links.</p>  <p>The photograph shows a close-up of the robot arm link. A red arrow points to the access hatch cover on the inner link, which is a rectangular opening in the metal plate.</p>

Step	Action
3.	<p>Insert the microphone from the belt tension meter near the belt to measure belt tension and adjust the M4 SHCS to adjust belt tension. Be sure to measure the belt tension eight times, at 45 increments of the pulley in the rail rotation, and set the tension at the position that has the lowest tension.</p> <p>See <a href="#">"Belt Tensions, Gates Tension Meter"</a>.</p> 

## Replacing the Outer Link Harness

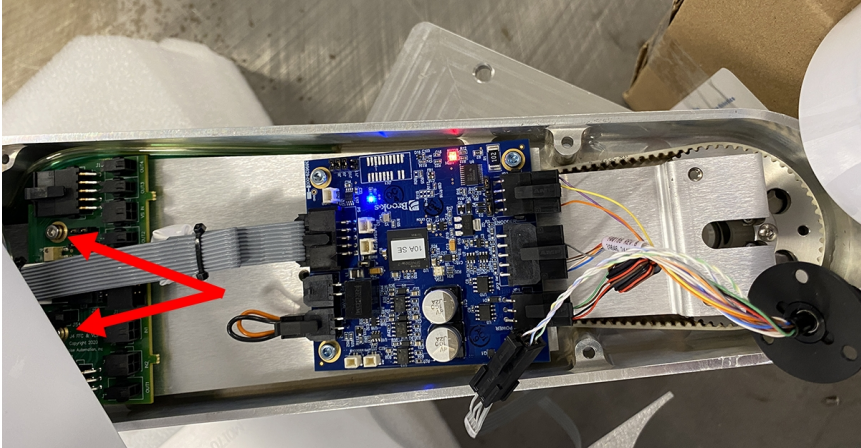
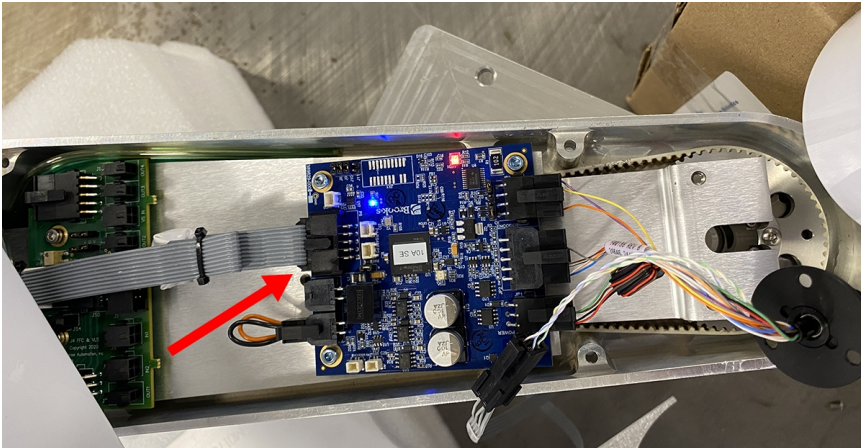
The outer link harness is composed of three cables:

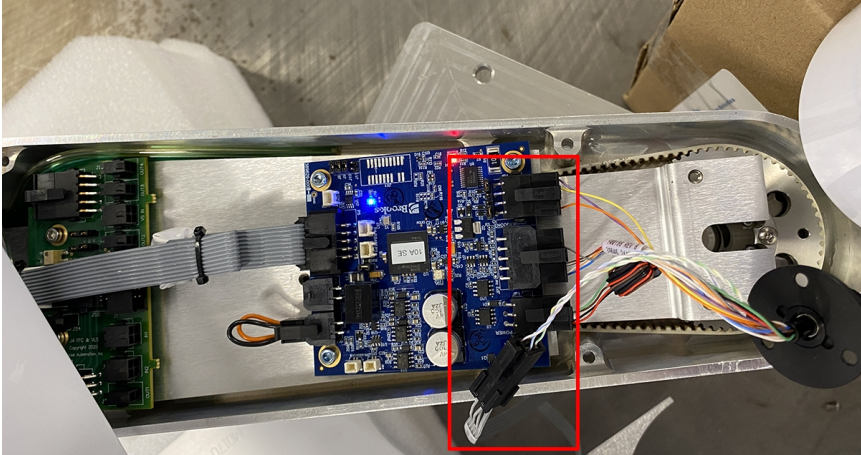
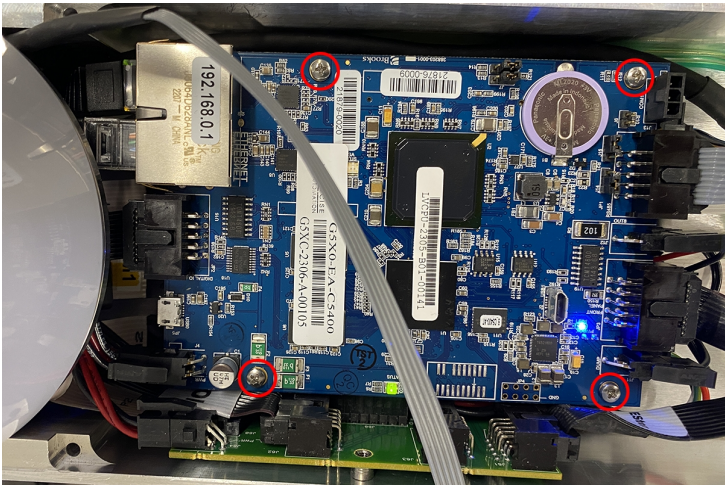
- Harness, FFC, J4 Motor
- Harness, FFC, J4 Encoder
- Harness, Gripper Controller

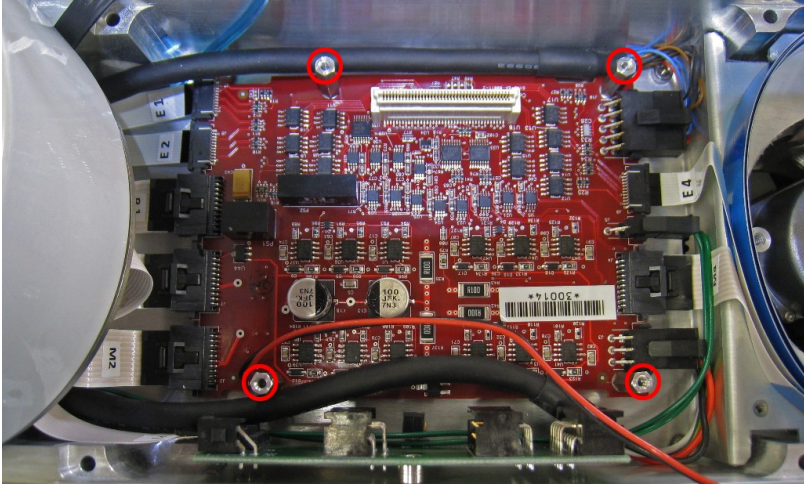
See ["5400 Controller Board Connectors"](#) for more information.

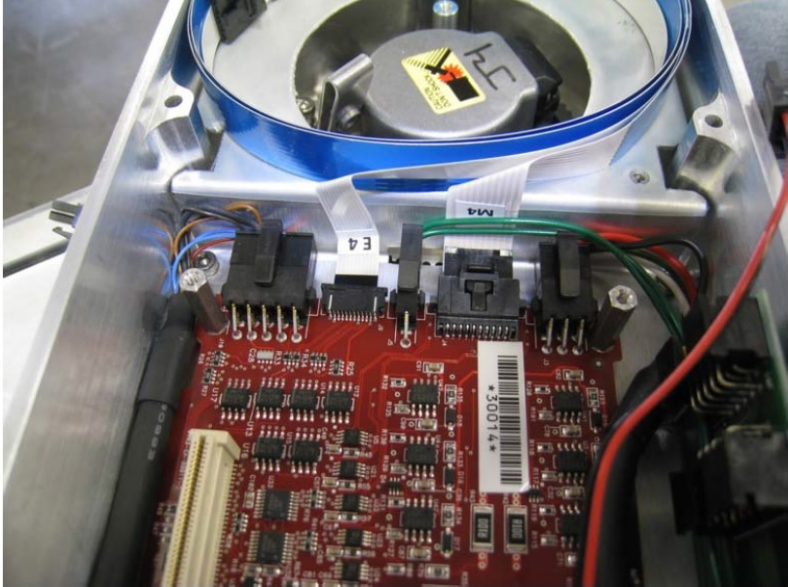
Replacing the outer link harness does not require unmounting the robot from its surface. To replace the outer link harness, perform the following procedure:


Step	Action
1.	Remove the inner link cover and the outer link cover.
2.	Turn the outer link counterclockwise, looking down from above the J3 rail, until it reaches the hard stop.

Step	Action
3.	<p>Release the J4 motor interface circuit board by removing the (2) M3 X 10 mm SHCS.</p> 
4.	<p>Disconnect the outer link harness from the J4 motor interface PCA.</p> 

Step	Action
5.	<p>Disconnect the GSB in the outer link.</p> 
6.	<p>Remove the upper circuit board in the robot controller by removing the (4) M2.5 X 6 mm screws (shown below in red), and disconnect the harness.</p> 
7.	<p>Remove the harness retaining clip from the robot controller mount plate to release the controller end of the harness.</p>

Step	Action
8.	<p>Remove the (4) M2.5 X 16 mm standoffs attaching the lower circuit board in the robot controller (shown below in red). Gently tip the lower circuit board upwards and disconnect the motor and encoder cables from the lower circuit board.</p> 
9.	<p>Release the harness retaining clip from the J3 output pulley by loosening the M3 X 25 mm SHCS attaching the clip to the pulley.</p>
10.	<p>Pull the clip upwards and remove the M3 X 4 mm BHCS that clamps the harness to release the harness from the clip.</p>
11.	<p>Replicate the folds on the controller end of the replacement harness.</p>

Step	Action
12.	<p>Insert the replacement harness into the robot controller circuit boards, and reattach the robot controller circuit boards.</p> 
13.	Attach the harness retaining clip near the robot controller to retain the robot controller end of the harness.
14.	Coil the replacement harness into (3) loops.
15.	Fold the ends of the harness down at a right angle to replicate the replaced harness.
16.	Insert the connectors down through the elbow into the outer link.

Step	Action
17.	<p>Attach the J3 harness retaining clip with the M3 X 4 mm BHCS and the 1/32" thick Neoprene rubber strain relief pad around the harness to protect it along with the bent stainless steel retaining clip that protects the harness fold.</p> 
18.	Attach the J3 harness retaining clip to the J3 output pulley.
19.	Attach the connectors to the circuit boards in the outer link.
20.	Attach the J4 motor interface circuit board.
21.	Replace the covers.
22.	After replacing the harness the robot must be re-calibrated. See <a href="#">"Calibrating the Robot: Setting the Encoder Zero Positions"</a> .

## Checking the Encoder Batteries Voltage

PreciseFlex400 robots are equipped with multi-turn absolute encoders that keep track of the robot position even when AC power is disconnected from the robot. To maintain encoder position, the encoders are backed up with batteries. The encoder batteries are designed to last for several years with robot power off. With robot power on, there is no drain on the battery.

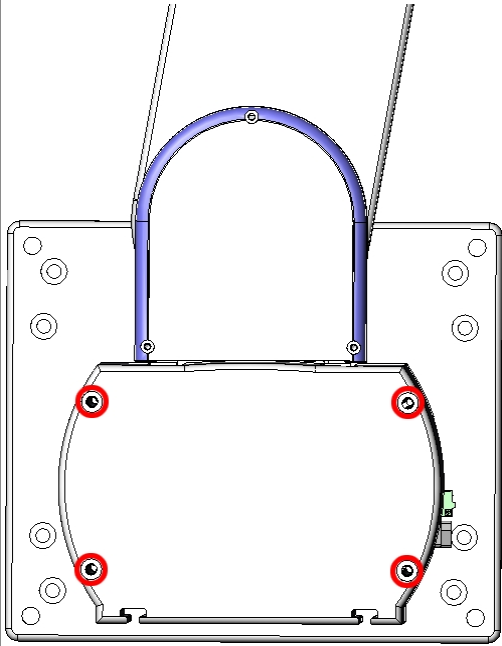
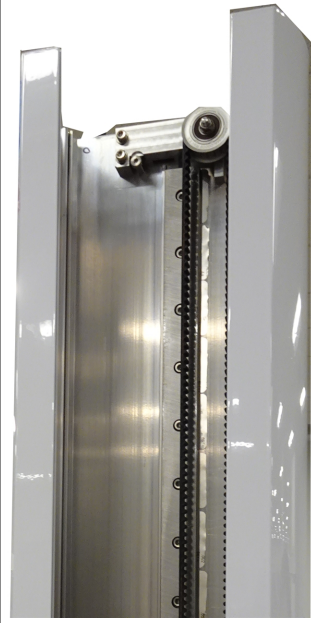
The system monitors the battery voltage. The nominal battery voltage is 3.6 V. When the battery voltage drops to 3.3 V, an error message “Encoder Battery Low” is displayed. At this level, the absolute encoder backup function will still work. However, the battery should be replaced. If the voltage drops to 2.5 V, an error message “Absolute Encoder Down” is displayed. At this point, the absolute encoder backup function will not work.



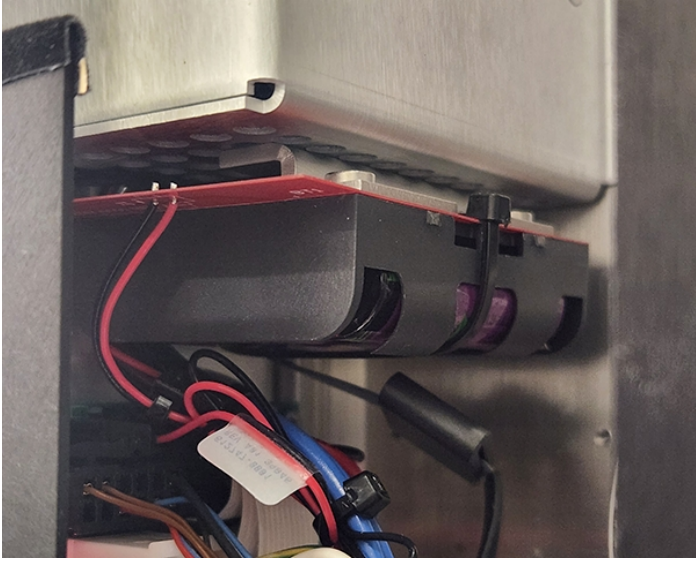
### Tools Required

- 3.0 mm hex driver or hex L wrench
- Voltmeter



To check the voltage of the encoder batteries, perform the following procedure:

Step	Action
1.	Turn off power to the robot and unplug the AC power plug.

Step	Action
2.	<p data-bbox="293 268 1360 331">Remove the top plate of the robot by removing the (4) M5 low socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the top plate.</p> 
3.	<p data-bbox="293 1035 792 1066">Remove the front cover by lifting it out vertically.</p> 

Step	Action
	<p>Locate the encoder batteries in the base of the robot behind the Z column front cover.</p> <div data-bbox="295 319 1365 457" style="background-color: #ff8c00; padding: 5px;">  <b>WARNING</b> Possible Electrical Damage         </div> <div data-bbox="295 457 1081 659" style="border: 1px solid black; padding: 5px;"> <p>If you put the batteries in the incorrect pole orientation, the system will overheat and possibly melt the board and connectors. Put the replacement batteries in the original +/- pole orientation.</p> </div> <div data-bbox="1081 457 1365 659" style="border: 1px solid black; text-align: center; padding: 10px;">  </div>
4.	
5.	<p>Without removing the battery, place the voltmeter leads into the battery holder to contact the ends of the battery directly. This should allow for a clear reading to be procured.</p> <p>Alternatively, the exposed metal contacts at the ends of the holder can also serve as measurement points.</p> <p><b>NOTE:</b> <i>If the battery is removed, calibration will be required.</i></p>
6.	<p>Replace the front cover and top plate.</p>
7.	<p>If the error message "Encoder Battery Down" displays, the robot must be re-calibrated after this procedure. Otherwise it is not necessary to re-calibrate the robot. See <a href="#">"Calibrating the Robot: Setting the Encoder Zero Positions"</a>.</p>

## Replacing the Encoder Battery

 <b>DANGER</b>	
<b>Electrical Shock</b>	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before replacing the encoder battery.	

The encoder battery is designed to last for several years with robot power turned off. With robot power turned on, there is no drain on the battery. The battery voltage is monitored by the system. The nominal battery voltage is 3.6 V. If the battery voltage drops to 3.3 V, an error message “Encoder Battery Low” will display. At this level, the absolute encoder backup function will still work, but the battery should be replaced. If the voltage drops to 2.5 V, an error message “Absolute Encoder Down” will display. At this point, the absolute encoder backup function will not work.

If any motor/encoder is disconnected from the encoder battery by disconnecting the encoder cable, the “Encoder Battery Low” or Encoder Battery Down” message will display. However, in this case, the encoder battery does not need to be replaced. It is only necessary to recalibrate the robot.

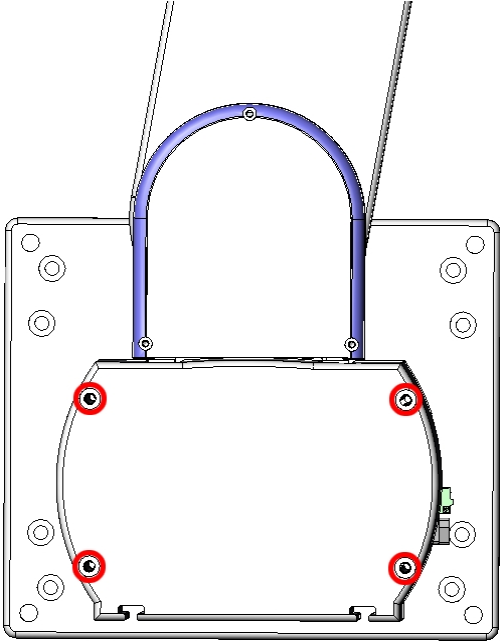
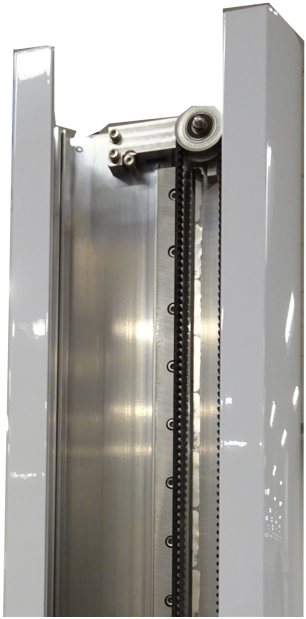
### Tools Required



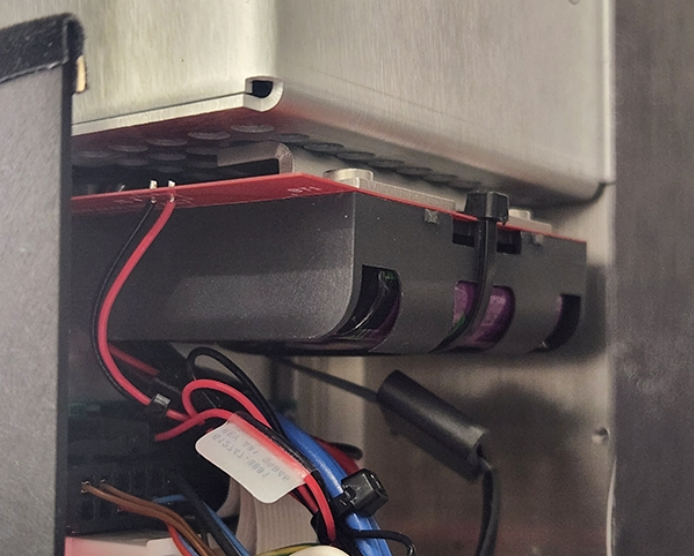
- 3.0 mm hex driver or hex L wrench

### Parts Required

- New encoder battery
- 6" X 1.25" tie wrap

To replace the encoder battery, perform the following procedure:

Step	Action
1.	Turn off power to the robot and unplug the AC power plug.
2.	<p>Remove the top plate of the robot by removing the (4) M5 low socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the top plate.</p> 
3.	<p>Remove the front cover by lifting it out vertically.</p> 

Step	Action
4.	<p>The encoder batteries are located in the base of the robot behind the Z column front cover. Cut the tie wrap holding the batteries, and remove the batteries.</p> <p><b>NOTE:</b> Observe the battery's +/- pole orientation. Put the replacement batteries in the same pole orientation.</p> <div data-bbox="297 506 1365 846" style="border: 1px solid black; padding: 5px;"> <div style="background-color: #ff9900; padding: 5px; display: flex; align-items: center;">  <div> <p><b>WARNING</b></p> <p><b>Possible Electrical Damage</b></p> </div> </div> <div style="display: flex; justify-content: space-between; padding: 5px;"> <div style="width: 60%;"> <p>If you put the batteries in the incorrect pole orientation, the system will overheat and possibly melt the board and connectors. Put the replacement batteries in the original +/- pole orientation.</p> </div> <div style="width: 35%; text-align: center;">  </div> </div> </div> 
5.	Secure the new encoder batteries in place with a tie wrap.
6.	Replace the front cover and top plate.
7.	If the error message "Encoder Battery Down" displays, the robot must be re-calibrated after this procedure. Otherwise it is not necessary to re-calibrate the robot. See <a href="#">"Calibrating the Robot: Setting the Encoder Zero Positions"</a> .

## Replacing the Ethernet Cable

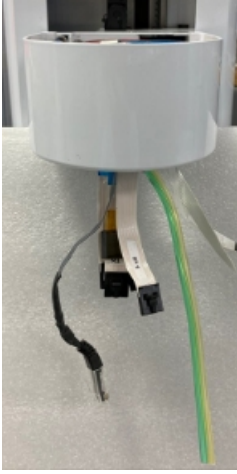
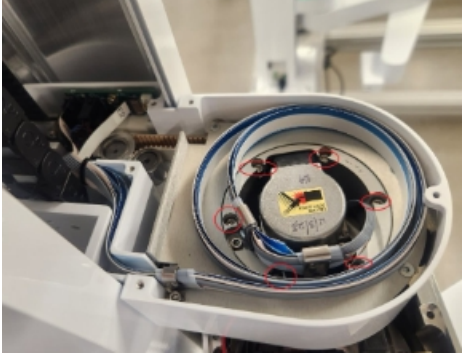
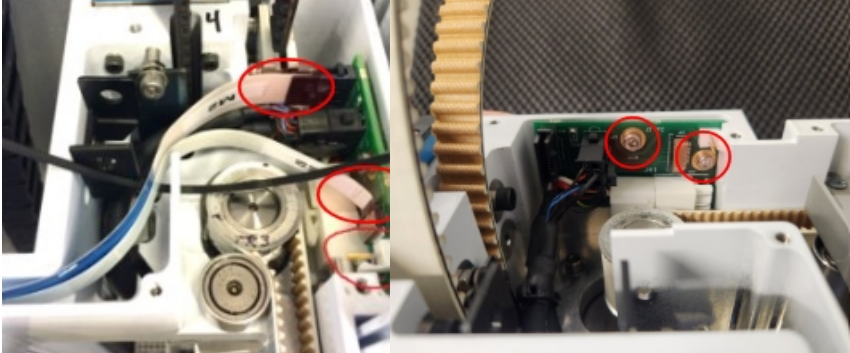
This procedure describes how to replace the Ethernet cable in a PreciseFlex PF400/PF3400 robot. Ethernet cable replacement is required when poor communication is observed.

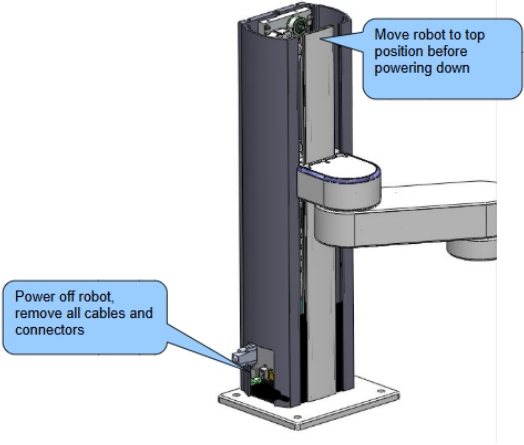
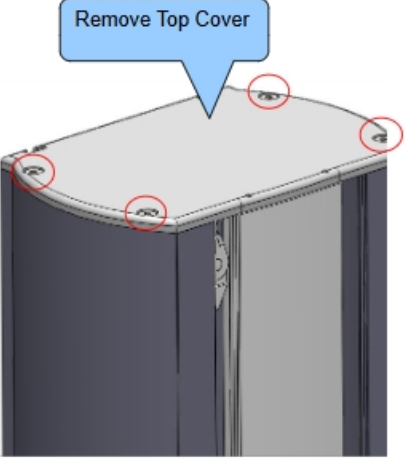
### Tools Required:

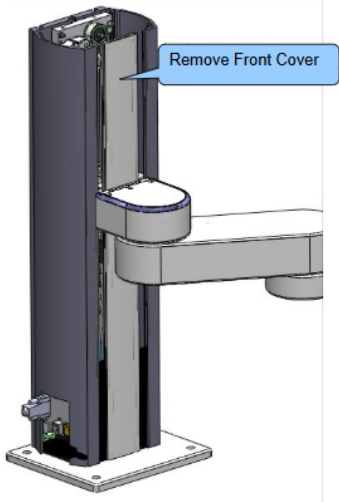

- 3• M2, M2.5, and M3 ball end hex drivers
- M2, M2.5, and M3 straight hex drivers
- M1.3 hex driver
- Tweezers
- Towels or blue tape (for paint protection)


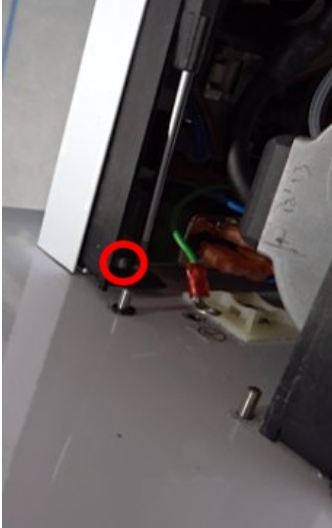
To tension the Ethernet cable, perform the following procedure:

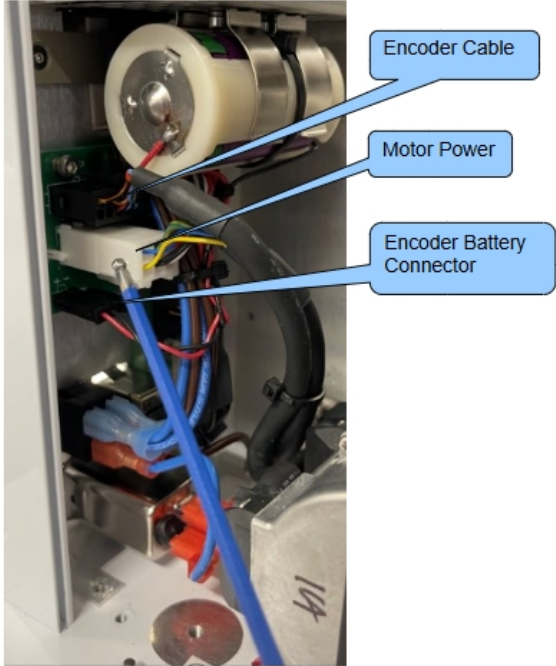
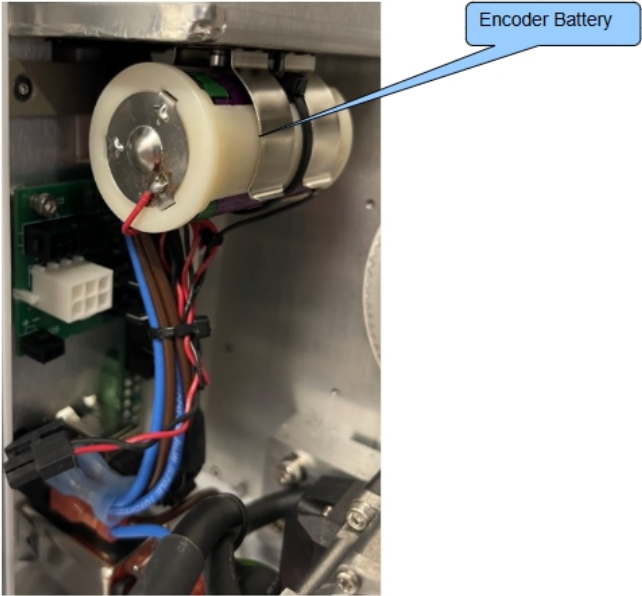
Step	Action
1.	Before beginning disassembly, power off the robot and disconnect all cables. Ensure correct cable routing during reassembly by taking photos at each stage of disassembly . <i><b>NOTE:</b> Exercise care to avoid pinching cables during reassembly, especially near pulleys and mounting plates.</i>
2.	Move the Z stage away from the base of the robot to allow access to the E chassis.
3.	Disassemble the Inner Link Assembly by removing the inner link, outer link, and servo gripper. <i><b>NOTE:</b> Only the inner link is detached from the Z extrusion. The outer link and gripper remain connected.</i>
4.	Remove the (4) M3 screws from the outer link cover using an M2.5 hex driver. Remove the outer link cover.
5.	Remove the (3) M3 6 SHCS screws from Z carriage cover (J2 Cover Assembly). Remove the cover.

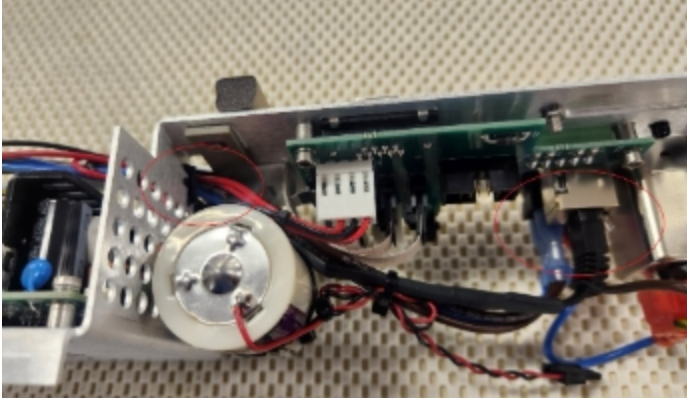
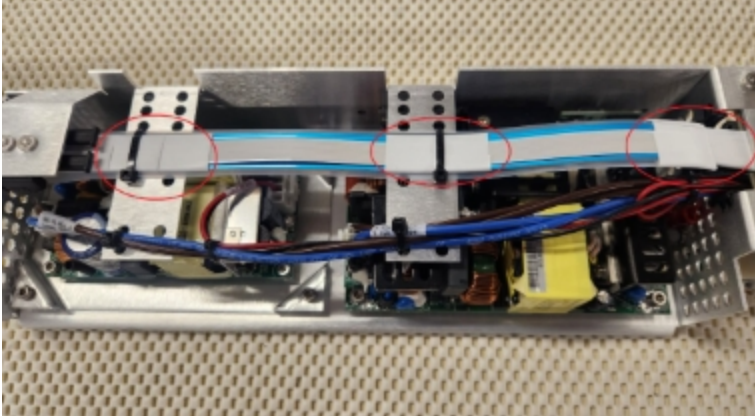
Step	Action
6.	<p>Disconnect all connections to the G1400 controller.</p> 
7.	<p>Loosen the (6) M3×35 SHCS screws from the inner link. It will release from the assembly.</p> 
8.	<p>Take reference photos and note the cable routing for reassembly.</p>
9.	<p>Detach the M2 and E2 connectors. Take photos before proceeding. The 2 pin LED connector may also need to be removed.</p> <p><b>NOTE:</b> The 2 pin LED connector may also need to be removed. If necessary, remove the J2 FFC board to assist with reconnecting the M2 and E2 harnesses during reassembly.</p> 

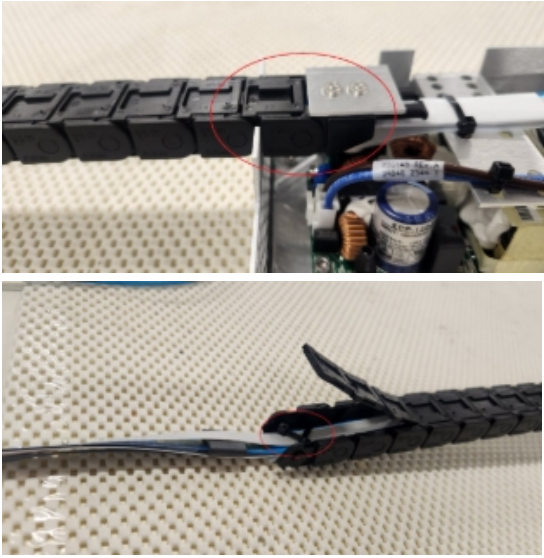
Step	Action
10.	<p>Move the Z axis to the top position. Ensure the power is off to the robot and all external cables are disconnected.</p>  <p>The diagram shows a vertical robot column with a horizontal arm. A callout bubble at the top of the column says "Move robot to top position before powering down". Another callout bubble at the base of the column says "Power off robot, remove all cables and connectors".</p>
11.	<p>Remove the (4) M5 screws using an M3 straight hex driver. Remove the top cover and set it aside.</p>  <p>The diagram shows the top of the robot column. Four screws are circled in red. A callout bubble points to them and says "Remove Top Cover".</p>

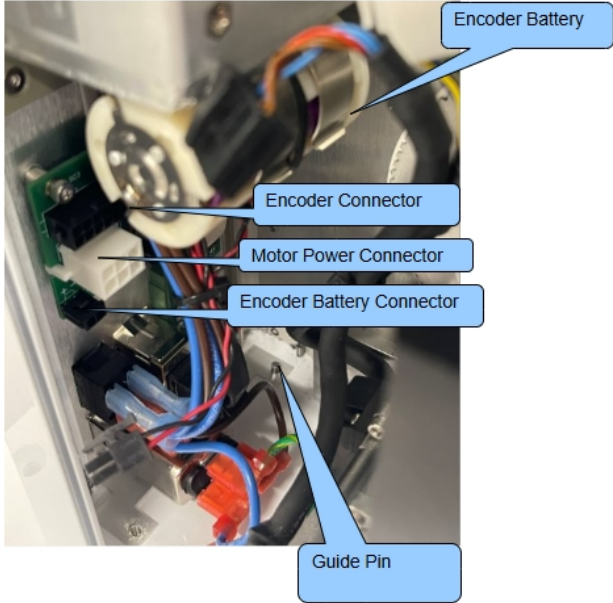
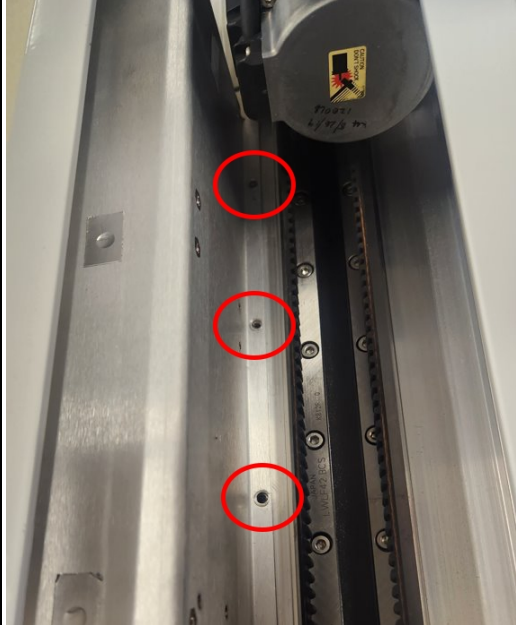
Step	Action
12.	<p>Remove the front cover by sliding the front cover out of its slot.</p>  <p>The diagram shows a vertical robot arm assembly. A blue callout box with the text 'Remove Front Cover' has a line pointing to the front cover of the upper section of the arm.</p>
13.	<p>Using tweezers and an M2 hex driver, remove the (5) FHCS screws from the stiffener plate. Remove the stiffener plate.</p>
14.	<p>Remove the chassis ground screw using an M2 ball end hex driver and tweezers.</p>  <p>The photograph shows a close-up of the robot's chassis. A red circle highlights a screw being turned by a hex driver. The driver is being used to remove the chassis ground screw.</p>

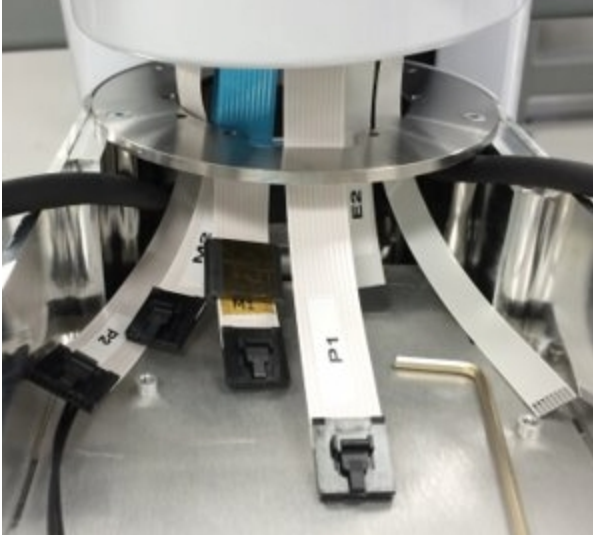
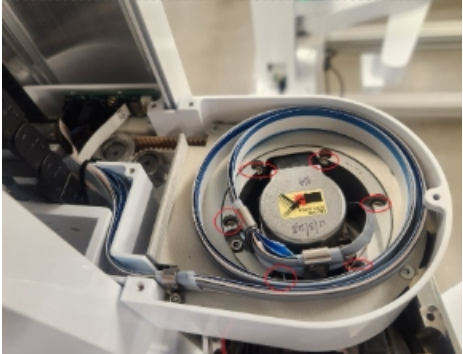
Step	Action
15.	<p>Remove the left splash guard using an M2.5 ball end hex driver.</p> 
16.	<p>Remove the screw securing the E chassis.</p> 

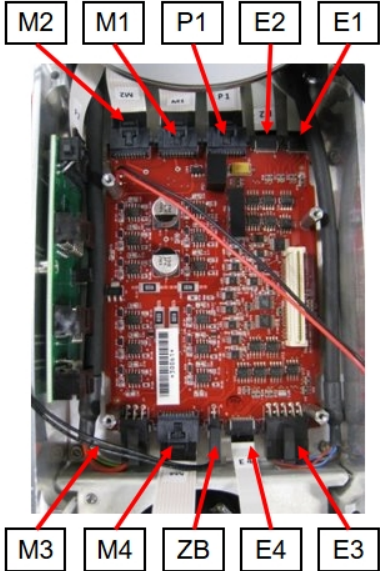
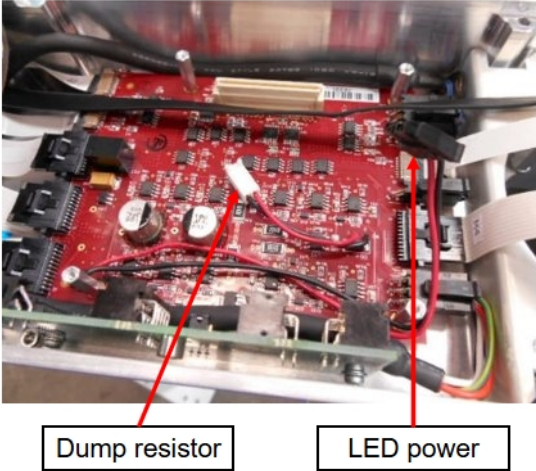
Step	Action
17.	<p>Disconnect the following from the E chassis:</p> <ul style="list-style-type: none"> <li>• Motor power connector</li> <li>• Encoder cable</li> <li>• Encoder battery connector</li> </ul>  <p>Remove the encoder battery from its holder.</p> 

Step	Action
18.	Remove the (3) screws securing the E chassis. Lift the E chassis above the guide pins and carefully wiggle it out of the Z extrusion.
19.	<p>Locate the Ethernet cable routing:</p> <ul style="list-style-type: none"><li>• The cable connects to the back of the facilities panel and passes through the Panel PCA.</li><li>• The cable is bundled with other harnesses.</li></ul> 
20.	<p>Remove zip ties and white holding tape securing the Ethernet cable.</p> 

Step	Action
21.	<p>Remove the female connector bracket. Cut zip ties inside the E chain.</p> <p><b>NOTE:</b> <i>These must be replaced later.</i></p> 
22.	Remove the Ethernet cable from the harness bundle.
23.	Install the replacement Ethernet cable following the same routing path.
24.	Re apply zip ties and white holding tape in the same locations as before.
25.	Reassemble the E chain.
26.	Attach the entire harness to the last E chain link using two crossed cable ties (8 in × 0.1 in, Hellermann Tyton T18L0M4).
27.	<p>Reinstall the E chassis by placing the encoder battery back into its mount. Then insert the E chassis back into the robot behind the rail.</p> <p><b>NOTE:</b> <i>Ensure the guide pin passes through the E chassis mount.</i></p>

Step	Action
28.	<p>Reconnect the encoder connector, motor power connector, and encoder battery connector .</p>  <p>The image shows a close-up of the robot's internal wiring. A yellow connector is labeled 'Encoder Battery'. A white connector is labeled 'Encoder Connector'. A black connector is labeled 'Motor Power Connector'. A green connector is labeled 'Encoder Battery Connector'. A blue pin is labeled 'Guide Pin'.</p>
29.	<p>Install the (3) screws securing the E chassis to the robot. Reinstall the base hardware including the chassis ground screw, the left splash guard, and the remaining E chassis screw.</p>  <p>The image shows the robot's chassis with three screws circled in red, indicating the locations for installation.</p>
30.	<p>Restore all harness routing to match pre disassembly photos.</p>

Step	Action
31.	<p>Slide harness cables between the motor and mounting plate.</p> 
32.	<p>Slowly move the inner link into position. by aligning the hole and slot in the pulley mounting plate to the dowel pins in the J2 pulley.</p> <p><b>NOTE:</b> Ensure no cables are pinched in the process.</p>
33.	<p>Secure the inner link to the Z carriage by tightening the (6) M3×35 SHCS screws.</p> 

Step	Action
34.	<p>Connect all motor and encoder cables to the red amplifier board.</p> <p><b>NOTE:</b> One motor and one encoder per axis.</p> 
35.	Connect Z brake release (ZB) wires.
36.	Ensure cables are correctly oriented before routing through the J2 pulley.
37.	Connect the dump resistor to the two pins beneath the MIDS4 board.
38.	<p>Connect LED power wires to the middle connector on the front of the MIDS4 board.</p> 

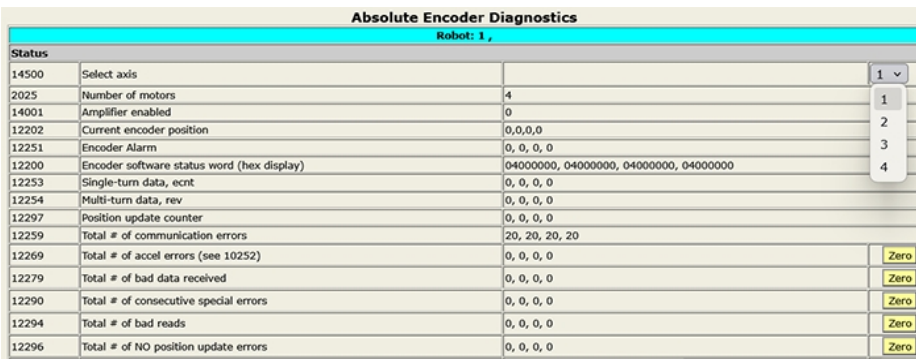
Step	Action
39.	Reinstall the stiffener plate and LED cover.
40.	Install the front panel cover.
41.	Install the top cover and secure with four (4) M5 screws.
42.	Power on the robot and calibrate the robot as required.
43.	Run the exercise routine for approximately 10 minutes. Verify that no errors are present and that Ethernet communication is restored.

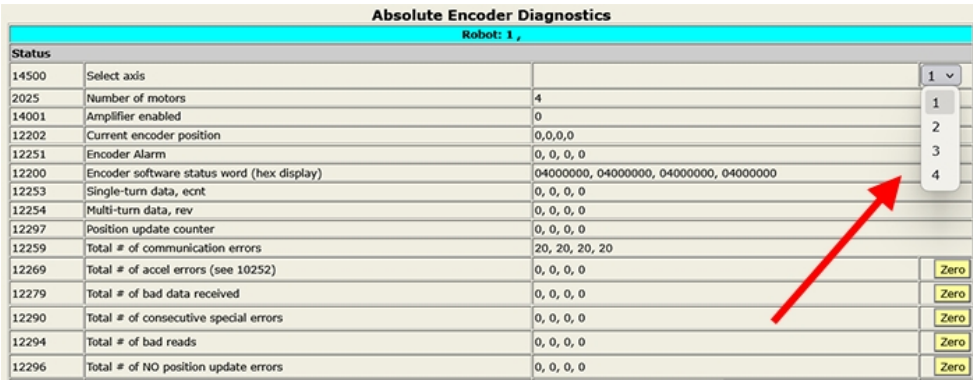
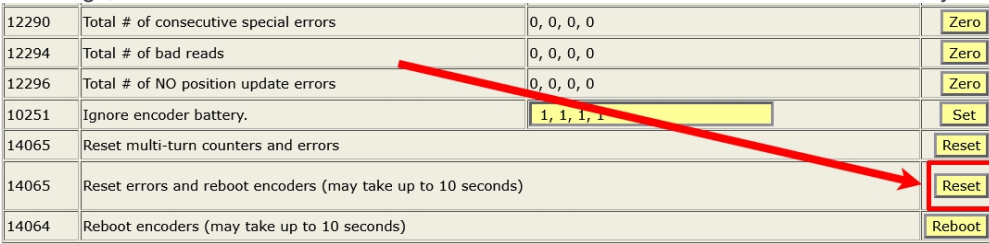
## Encoder Operation Error

The PreciseFlex 400 robot is equipped with absolute encoders that keep track of the robot position even when AC power to the robot is disconnected. There is a battery in the base of the robot that provides standby power to the encoders. In standby mode, there is a limit on how quickly the motor can turn and still have the standby counter operate properly. The limits are 6,000 rpm and 4000 rad/s<sup>2</sup>. Even at 100% speeds the robot joints normally do not move faster than about 2,000 rpm and 1300 rad/s<sup>2</sup>. However, if the robot is shocked during shipping, it is possible the standby operation acceleration error limit may be exceeded. This can generate an encoder operation error that will prevent the robot from homing after power up.

This error will display in the *Operator* window of the browser interface as “Encoder Operation Error” Robot 1: <axis number>.

Assuming the robot has not been damaged by the shipping process, this error can be reset by the following procedure:

Step	Action																																																																								
1.	<p>In the browser interface, go to <b>Admin &gt; Setup &gt; System Setup &gt; Hardware Tuning and Diagnostics &gt; Absolute Encoder</b>.</p>  <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4" style="text-align: center; background-color: #e0e0e0;">Absolute Encoder Diagnostics</th> </tr> <tr> <th colspan="4" style="text-align: center; background-color: #e0e0e0;">Robot: 1</th> </tr> <tr> <th colspan="4" style="text-align: left; background-color: #e0e0e0;">Status</th> </tr> </thead> <tbody> <tr> <td>14500</td> <td>Select axis</td> <td></td> <td style="text-align: right;">1 ▾</td> </tr> <tr> <td>2025</td> <td>Number of motors</td> <td>4</td> <td style="text-align: right;">1</td> </tr> <tr> <td>14001</td> <td>Amplifier enabled</td> <td>0</td> <td style="text-align: right;">2</td> </tr> <tr> <td>12202</td> <td>Current encoder position</td> <td>0,0,0,0</td> <td style="text-align: right;">3</td> </tr> <tr> <td>12251</td> <td>Encoder Alarm</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">4</td> </tr> <tr> <td>12200</td> <td>Encoder software status word (hex display)</td> <td>04000000, 04000000, 04000000, 04000000</td> <td></td> </tr> <tr> <td>12253</td> <td>Single-turn data, ecnt</td> <td>0, 0, 0, 0</td> <td></td> </tr> <tr> <td>12254</td> <td>Multi-turn data, rev</td> <td>0, 0, 0, 0</td> <td></td> </tr> <tr> <td>12297</td> <td>Position update counter</td> <td>0, 0, 0, 0</td> <td></td> </tr> <tr> <td>12259</td> <td>Total # of communication errors</td> <td>20, 20, 20, 20</td> <td></td> </tr> <tr> <td>12269</td> <td>Total # of accel errors (see 10252)</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">Zero</td> </tr> <tr> <td>12279</td> <td>Total # of bad data received</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">Zero</td> </tr> <tr> <td>12290</td> <td>Total # of consecutive special errors</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">Zero</td> </tr> <tr> <td>12294</td> <td>Total # of bad reads</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">Zero</td> </tr> <tr> <td>12296</td> <td>Total # of NO position update errors</td> <td>0, 0, 0, 0</td> <td style="text-align: right;">Zero</td> </tr> </tbody> </table>	Absolute Encoder Diagnostics				Robot: 1				Status				14500	Select axis		1 ▾	2025	Number of motors	4	1	14001	Amplifier enabled	0	2	12202	Current encoder position	0,0,0,0	3	12251	Encoder Alarm	0, 0, 0, 0	4	12200	Encoder software status word (hex display)	04000000, 04000000, 04000000, 04000000		12253	Single-turn data, ecnt	0, 0, 0, 0		12254	Multi-turn data, rev	0, 0, 0, 0		12297	Position update counter	0, 0, 0, 0		12259	Total # of communication errors	20, 20, 20, 20		12269	Total # of accel errors (see 10252)	0, 0, 0, 0	Zero	12279	Total # of bad data received	0, 0, 0, 0	Zero	12290	Total # of consecutive special errors	0, 0, 0, 0	Zero	12294	Total # of bad reads	0, 0, 0, 0	Zero	12296	Total # of NO position update errors	0, 0, 0, 0	Zero
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Step	Action
2.	<p>In the drop-down menu at the top right of the screen, select the robot axis that was associated with the error and check to see if the <i>Overspeed</i> panel is yellow.</p>  <p>This indicates an overspeed error during encoder standby mode due to shock or vibration. This error can be reset by selecting the reset button next to <b>Reset and initialize encoder</b>. This button resets error flags, but does not reset the encoder counters. The robot can then be homed normally.</p> 
3.	<p>For cases where the encoder operation error was triggered by shipping vibration, in most cases the encoder will not have lost any position data. However, after homing the robot, it is recommended to move the robot to the calibration position, using the calibration pins if desired. See "<a href="#">Calibrating the Robot: Setting the Encoder Zero Positions</a>", or another known position, and check the joint angles in the <i>Virtual Pendant</i> in the browser interface.</p> <p>The joint angles in the calibration position are:</p> <ul style="list-style-type: none"> <li>• Z-axis: -1 mm (-2 mm for Beta robots)</li> <li>• J2 or Shoulder: -90</li> <li>• J3 or Elbow: 179.99</li> <li>• J4 or Wrist: -180</li> </ul>

If the robot joints after this procedure followed by homing are different from the above, then the robot needs to be re-calibrated. See "[Calibrating the Robot: Setting the Encoder Zero Positions](#)".

## Replacing the Main Harness

Replacement of the Main Robot Harness is typically only performed at the factory. The Main Robot Harness is intended to last for the life of the robot.

## Troubleshooting

PreciseFlex robots and controllers have an extensive list of error messages. Search PreciseFlex Online Help at <https://www.brooks.com/support/brooks-preciseflex-support/online-help/> for specific error messages and causes. Listed in the table below are a few errors that may be generated by hardware failures.

Symptom	Recommended Action
<b>System error message generated</b>	
"E-Stop not Enabled"	Check both Phoenix plug and 9 pin D-sub for E-Stop jumpers.
"Encoder Battery Low"	Replace absolute encoder battery in base of robot
"Encoder Battery Down"	If encoder cable has been disconnected, recalibrate robot. If battery voltage has dropped below 2.5V replace encoder battery and recalibrate robot.
"Encoder Operation Error"	Joint rotated too quickly with power off. See Procedure below.
"Encoder Data, Accel/decel Limit Error"	Check that the FPGA code is dated Jan 25, 2012 or later. Upgrade FPGA if necessary. Encoder cable may be damaged and encoder is getting intermittent communication, causing apparent jumps in position. Check encoder connectors on flat ribbon cable. Replace cable. Replace motor.
"Encoder Communication Error"	Check that the FPGA code is dated Jan 25, 2012 or later. Check encoder connectors on flat ribbon cable. Replace encoder cable or motor/encoder.
"Encoder quadrature error"	Replace slip ring. Replace motor/encoder (only Gripper motor).
"Missing zero index"	See "Encoder quadrature error"
"Motor duty cycle exceeded"	Reduce speed or acceleration of robot. Check for instability.
"Amplifier under voltage"	Motor power supply has reached current limit and shutdown. Slow down robot. Check Energy Dump PCA. Replace 48V supply.

Symptom	Recommended Action
“Amplifier Fault”	Check harness and motor for shorts.
“Amplifier Over Voltage”	Replace energy dump board. Check harness for shorts.
“Soft Envelope Error”	Make sure robot not pressing against surface. If this occurs on the gripper repeatedly, replace slip ring.
“Hard Envelope Error”	Typically means robot has crashed into something.
Pneumatic Gripper Sensor not working	Check continuity of cable through wrist. Check green lights on sensor to see if sensor is triggering.
“Time Out Nulling Error”	Check that joint is free to move with brake off. Check that joint is not vibrating or unstable. If unstable check belt tension. If Gripper, replace slip ring after checking that brake releases.
“Joint Out of Range”	The joint actual or commanded position may be beyond the software limit stop. Move joint back into range while monitoring virtual pendant or check program for commanded position.
“PAC Files Corrupted”	See recovering from corrupted PAC Files
<b>Physical or audible problem</b>	
Brown streaks on linear bearing	Clean with alcohol and add grease to bearing blocks. This should not be required sooner than 20,000 hours of run time. Grease is Alvania Grease EP2 from Shell.
Mechanical noise from any joint	Check joint bearings for failure. Re-tension belt.
Loud buzzing or vibration from any joint	Re-tension timing belts. If timing belt will not hold tension, replace.
Squeaking from Z belt	Apply thick grease to front and rear edges of belt, (Mobile 222 XP). Belt can get stiff over time and squeak against pulley flanges.

# Appendices

## Appendix A: PreciseFlex 400 (Robot Revision D) Robot Specifications

### General Specifications

General Specification	Range
<b>PERFORMANCE</b>	
Payload	<ul style="list-style-type: none"> <li>• 0.5 kg with IntelliGuide s23 or v23 gripper</li> <li>• 1.0 kg without IntelliGuide s23 or v23 gripper</li> </ul>
Max speed at TCP	Horizontal: 500 mm/sec Vertical: 500 mm/sec
Max Joint Speed	J1 - 500 mm/sec J2 - 360°/sec J3 - 720°/sec J1 - 500 mm/sec
Max Acceleration	2500 mm/sec <sup>2</sup>
Repeatability	±0.090 mm
<b>RANGE OF MOTION</b>	
Joint 1 (Z-axis)	400, 750, 1160 mm
Joint 2 (Base)	±93°
Joint 3 (Elbow)	12° to 348°
Joint 4	±960° with IntelliGuide s23 or v23 gripper
Horizontal Reach (from center of Joint 2 to gripper finger mount)	500.8 mm, standard reach 656.54 mm, extended reach
<b>COMMUNICATIONS</b>	

General Specification	Range
General	100 Mb Ethernet, TCP/IP EtherNet/IP ModbusTCP, RS232 at base and end of arm
Operator Interface	Browser-based operator interface
Digital I/O	8 inputs at 24 VDC 8 outputs at 24 VDC (100 mA)
<b>FACILITIES</b>	
Power	100 to 240 VAC, auto selecting 50-60 Hz 100-175 watts typical operation
Pneumatics	None
External E-stop	Dual channel
Controller Type	Embedded into robot base
Weight	<ul style="list-style-type: none"> <li>• Standard Reach                             <ul style="list-style-type: none"> <li>◦ 400 mm Z-axis: 20 kg</li> <li>◦ 750 mm Z-axis: 25 kg</li> <li>◦ 1160 mm Z-axis: 30 kg</li> </ul> </li> <li>• Standard Reach/Extended Reach                             <ul style="list-style-type: none"> <li>◦ 400 mm Z-axis: 25 kg</li> <li>◦ 750 mm Z-axis: 30 kg</li> <li>◦ 1160 mm Z-axis: 35 kg</li> </ul> </li> </ul>
Noise Level	<40db LAF50
<b>SOFTWARE</b>	
Programming	<ul style="list-style-type: none"> <li>• TCS API for controlling robot from workflow, scheduling software</li> <li>• GPL (Guidance Programming Language): full-featured object-oriented programming language</li> <li>• GP Flow for no-code, point-and-click application builder</li> <li>• Programming via Guidance Development Studio (GDS)</li> </ul>
Enhanced Functions	Hand guiding (standard) Horizontal compensation (X/Y compliance) Z-height detection
<b>PERIPHERALS AND ACCESSORIES</b>	
General	IntelliGuide s23 servo gripper Gripper fingers for SBS-format microplates
Vision	IntelliGuide v23 gripper
Linear Rail	Horizontal travel 1.0, 1.5, and 2.0 meters Speed up to 750 mm/sec Repeatability: ±0.05 mm

## Environmental Specifications

**NOTE:** Our PreciseFlex robots are powered by 24 VDC and 48 VDC low-voltage DC power supplies with built-in overcurrent protection. For this reason, the PreciseFlex robots do not have an SCCR.

The PreciseFlex Robots must be installed in a clean, non-condensing environment with the following specifications:

General Specification	Range & Features
Indoor use only	Yes
Ambient temperature	0°C to 40°C (indoor use only)
Storage and shipment temperature	-25 °C to +55 °C
Relative Humidity	10 - 75%, non-condensing, non-corrosive
Altitude	Up to 3000 m
Voltage	100-240 VAC +/- 10%, 50/60 Hz
Mains cord rating, min	18 AWG, 3 conductor, 5 amps min
Pollution Degree	2
Approved cleaning agents	IPA, 70% Ethanol/30% water, H <sub>2</sub> O <sub>2</sub> vapor up to 1000 ppm
IP rating	11
IK impact rating	IK08: 5 joule

## Appendix B: Spare Parts List

**NOTE:** Email [support\\_preciseflex@brooks.com](mailto:support_preciseflex@brooks.com) for help replacing spare parts.

The robot serial number format is:

- F0v-w1www-xy-zzzzz
- v - Major version - "X" for rev A; "B" for rev B; "C" for rev C, and "D" for rev D
- www - Ship date,yyymm, so 1207 means July 2012
- x is the controller rev
- y is the robot rev
- zzzzz - is a unique robot number.

Part Number	Description
PF00-MA-00042	Cover, Inner Link, PreciseFlex 400 Ext/3400
PF00-MA-00041-1	Cover, Inner Link, PreciseFlex 400 Standard Reach
PF00-MA-00044	Cover, Outer Link, PreciseFlex 400 Ext/3400
PF00-MA-00043-1	Cover, Outer Link, PreciseFlex 400 Standard Reach
PF00-MA-00040-1	Cover, Z-Carriage, PreciseFlex 400/3400
G5X0-EA-B5400	Guidance Controller, 5400B, PreciseFlex 400 Rev D
PS10-EP-24150	Power supply, 24 VDC, 150 W
605889	Power Supply, 48 VDC, 500W
612747-0001	Encoder Battery Holder
PF0H-MA-00002-2	Cable, J4 Motor, PreciseFlex 400/3400
PF0H-MA-00020-2	Cable, J4 Encoder, PreciseFlex 400/3400
389629-0005	GSB4, 10A, PreciseFlex 400, 3400 Rev D, PreciseFlex c5, c10

Part Number	Description
602414-0031	IO and Power Distribution Board, PreciseFlex 400/3400 Rev D
602414-0011	J1 SFT Board, PreciseFlex 400/3400 Rev D
602414-0021	J2 FFC Board, PreciseFlex 400/3400 Rev D
602414-0041	J4 SFT Board, PreciseFlex 400/3400 Rev D
PF00-MA-00028	Motor, J1, PreciseFlex 400
PF00-MA-00029	Motor, J2, PreciseFlex 400
PF00-MA-00030	Motor, J3, PreciseFlex 400/3400
PF00-MA-00031	Motor, J4, PreciseFlex 400
PF00-MC-X0021	Belt, J1 Stage 1, PreciseFlex 400
PF00-MC-X0023-1	Belt, J1 Stage 2, 400mm, PreciseFlex 400
PF00-MC-X0023-2	Belt, J1 Stage 2, 750mm, PreciseFlex 400
PF00-MC-X0023-3	Belt, J1 Stage 2, 1160mm, PreciseFlex 400
PF00-MC-X0081	Belt, J2, PreciseFlex 400
PF00-MC-X0035	Belt, J3, PreciseFlex 400 Standard Reach
PF00-MC-X0066	Belt, J3, PreciseFlex 400 Ext/3400
PF00-MC-X0004	Belt, J4, PreciseFlex 400 Standard Reach
PF00-MC-X0065	Belt, J4, PreciseFlex 400 Ext/3400
PF00-MC-B0017	Cam Follower, PreciseFlex 400/3400
90681A099 (McMaster Carr)	Calibration Pin, Tapered 0.125" dia large end, 1/2" length, Stainless Steel 18 8
91585A423 (McMaster Carr)	Calibration Pin, M3 x 32 mm, Stainless Steel 18 8

## Appendix C: Preventative Maintenance

For support with preventative maintenance, addressing error codes, or service related issues contact [support\\_preciseflex@brooks.com](mailto:support_preciseflex@brooks.com).

The following preventative maintenance procedures should be performed at an interval of one to two years. For robots operating continuously 24 hours per day, 7 days a week at moderate to high speeds, a one-year interval is recommended. For robots with low duty cycles and low to moderate speeds, these procedures should be performed at least once every two years.

### Preventative Maintenance, Checklist, and Procedures

Check List	Procedure If Problem Detected
Check all belt tensions	Re-tension if necessary
Check air harness tubing in elbow if present, and theta axis for any wear	Replace if necessary
Replace timing belt in optional linear axis	Typically, every 6,000 hours of continuous operation
Check all joints in "free mode" for low bearing friction and any sticking.	If a bearing gets stiff, return it to the factory for bearing replacement.
Check second stage (long) Z belt for any squeaking	If noisy, add thick grease to the front and rear edge of the belt if necessary. (Shell 222 XP or similar). Z timing belt can get stiffer over time (2-3 years) and occasionally start squeaking against pulley flanges.
Check if front cover is rattling	If so, check .125 in ID by .062 in thick O rings on dowel pins in base plate under front cover for any deterioration and replace if necessary.
Check Cam Followers on J2 timing belt for grease leaking or discoloration.	Replace if necessary. Note that units have a 12 mm wide timing and the Cam Followers are different. See the " <a href="#">Spare Parts List</a> ".
Replace slip ring	Replace the slip ring every third inspection test.

### Preventative Maintenance Schedule

Component	Expected Life	Action
Slip ring	3-5 years	Replace component
J2 timing belt	5 years	Replace component

## Appendix D: Belt Tensions, Gates Tension Meter

In some cases, it may be desirable to confirm the belt tension of one of the axes in the robot. This is not normally required, as the robot has been designed with spring tensioners that only require loosening and then re-tightening some clamping screws to reset the belt tensions. However, in the case of the long Z column belts, it is possible that after several years of operation, the belt may stretch enough that the tension spring pre-load screw may need to be adjusted. If it appears a belt tension is not being adjusted properly by the pre-load spring, the tension can be checked with a Gates Sonic Tension Meter, Model 507C, 508C, or 550C.



**Gates Sonic Tension Meter**

To use the tension meter

- a. Turn on the power.
- b. Click the **Mass** button and enter the belt mass from the table below.
- c. Click the **Width** button and enter the belt width from the table below.
- d. Click the **Span** button and enter the belt free span from the table below.
- e. Click **Select** to record the data.
- f. Click **Measure** to take a tension reading.
- g. Place the microphone near the belt, typically within 3 mm or so. Gently pluck the belt so that it vibrates. The tension meter will calculate the belt tension from the acoustic vibrations and display the tension in Newtons. Compare the tension to the table below. Adjust the belt tension preload screws if necessary.

**NOTE:** SDT denotes standard reach, and EXT denotes extended reach robots.

Belt Tension

Belt	Mass (g)	Width (mm)	Span (mm)	Tension (N)
J1 S2 - 400	4.1	12	530	100-130
J1 S2 - 750	4.1	12	880	100-130
J1 S2 - 1160	4.1	12	1290	100-130
J2 - 12 mm	2.8	12	108	160-200
J3 - STD/ EXT	2.8	12	113	90-120
J4 - STD	2.8	9	95	45-70
J4 - EXT	2.8	9	146	65-80

Linear Rail Belt Tension Values

Mass (g)	Width (mm)	Span (mm)	Tension (N)
4.1	20	500	135-160

## Appendix E: Example Performance Level Evaluation

### Example Workcell Description

A PreciseFlex 400 plate handler moves 80-gram plastic trays from storage racks to an instrument and back to the storage racks. The gripper is an electric parallel jaw gripper with maximum 23 N of gripping force for plastic trays and is spring loaded so it will not drop trays if the power fails. Robot motion is programmed with approach point 50 mm above the instrument tray and final motion into instrument is made at 50 mm/sec. The lowest storage rack position is 50 mm above the table surface.



Example PreciseFlex 400 Workcell, Courtesy of Biosero

### Normal Operator Interaction with Robot

Teaching locations in workcell by hand guiding or teach pendant. Maximum robot forces under manual control from PreciseFlex 400 Table 1 are 60 N. Pausing robot and removing racks from workcell with no safety interlocks in workspace. Robot is stopped.

### Possible Low Frequency (rare) Interaction with Robot

Untrained operator reaches into workcell while robot is moving and robot collides with operator. Maximum free space collision force from PreciseFlex 400 Table 1 is 80 N. Untrained operator reaches into workcell while robot is moving into instrument tray and hand is trapped between robot and instrument tray. From PreciseFlex 400 Table 1 max trapping force in downwards Z

direction at 50 mm/sec (10% of max speed of 500 mm/sec) is 80 N. Performance Level: From the above, based on ISO 13849-1:2006:

- S is S1, as possible operator collision forces will not injure operators
- F is F1 as normal operation does not involve collisions with robot
- P is P1 as the robot does not make unexpected motions.

So PL is “a” and even a Category B controller is sufficient, given the low speeds and small possible collisions forces involved which cannot injure an operator. (See 5.2.3 under EN/ISO 10218-1:2011).

## Appendix F: Power Supplies

The robot has a 24 VDC and 48 VDC power supply located in the Z column. For revisions A and B, the AC input to these power supplies is fused with two fuses in a pull-out fuse drawer in the IEC type power entry module. For revision C and later, these fuses have been removed. The power supplies have both over-current and over-voltage protection and are CSA, UL, and CE certified.

The robot controller and electric gripper are powered by the 24 VDC supply. The four main robot motors are powered by the 48 VDC supply. The 48 VDC supply is protected against over-voltage bus pump up by an energy dump circuit, which connects a 25-Watt dump resistor across the 48 VDC supply output when the voltage reaches 56 Volts and disconnects the dump resistor when the voltage drops to 52 Volts. This protects the power supply during high speed motor deceleration when the motor generates Back EMF voltage that adds to the power supply voltage.

DC power is routed from the power supplies to an interconnect board in the base of the Z column (Z base motor interface board). From this interconnect board, the power is routed in P1 and P2 flat ribbon cables. The P2 cable contains the 48 VDC motor power and is connected to the power amplifier board in the controller. The P1 cable contains the 24 VDC controller power and is routed to a second interconnect board (the MIDS power interface board), which is mounted on the side wall inside the inner link of the robot. From this board, 24 VDC power is connected to the main robot controller.

Four digital input and four digital output signals from the main robot controller are also connected to the MIDS Power Interface Board through a ten-conductor ribbon cable. One digital input signal, DI3, is routed down to the base of the robot thru the P1 ribbon cable where it is connected to the green Phoenix E-stop connector. This provides a digital input for safety interlock purposes. There is a jumper on the MIDS Power Board which jumps this signal to the P1 cable. This jumper must be installed for this connection to work.

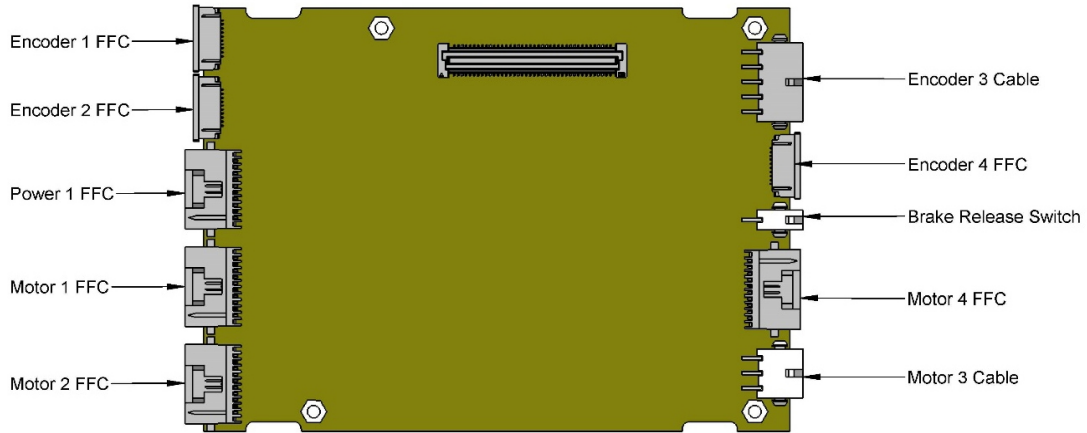
The rest of the digital inputs and outputs are daisy chained to a second connector on the MIDS board for use if needed. Some of these signals are used when the pneumatic gripper option is installed.

The E-stop circuit is also connected from the controller to MIDS Power Interface Board and down through the P1 cable to two E-stop connectors: the green Phoenix connector (J24) and the 9 pin D-sub connector (J30). The E-stop pins on these connectors are wired in series so that both connectors must have either a jumper or E-stop switch installed that completes the E-stop circuit.

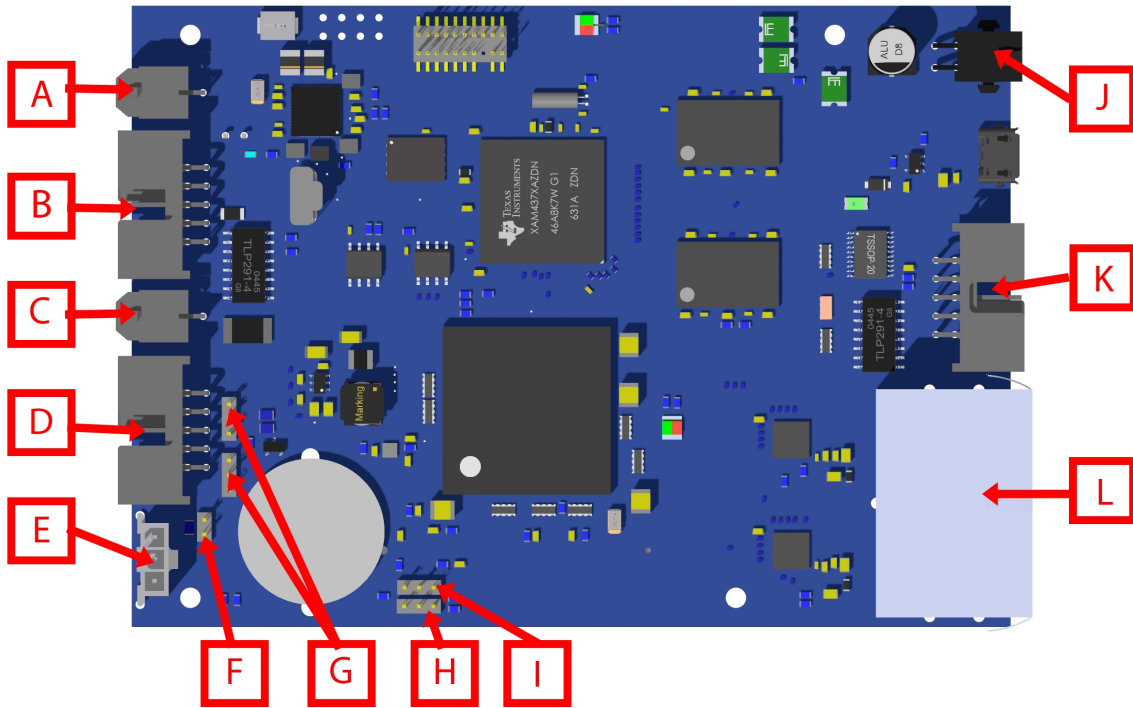
The gripper controller is connected to the main controller through an RS-485 cable routed through the elbow along with the power and encoder cables for the J4 motor. The RS-485 cable also supplies power for the gripper controller.

The motors for the Z column, the shoulder, and the wrist all plug into an interconnect board that converts the signals from the motor cables to the flat ribbon cables. The motor for the elbow plugs directly into the controller amplifier board in the inner link.

The cable from the brake release button under the shoulder plugs into the amplifier board in the inner link. This button provides a ground return from the Z column brake to ground bypassing the transistor that performs this function under computer power so that the brake can be released manually without motor power being enabled.

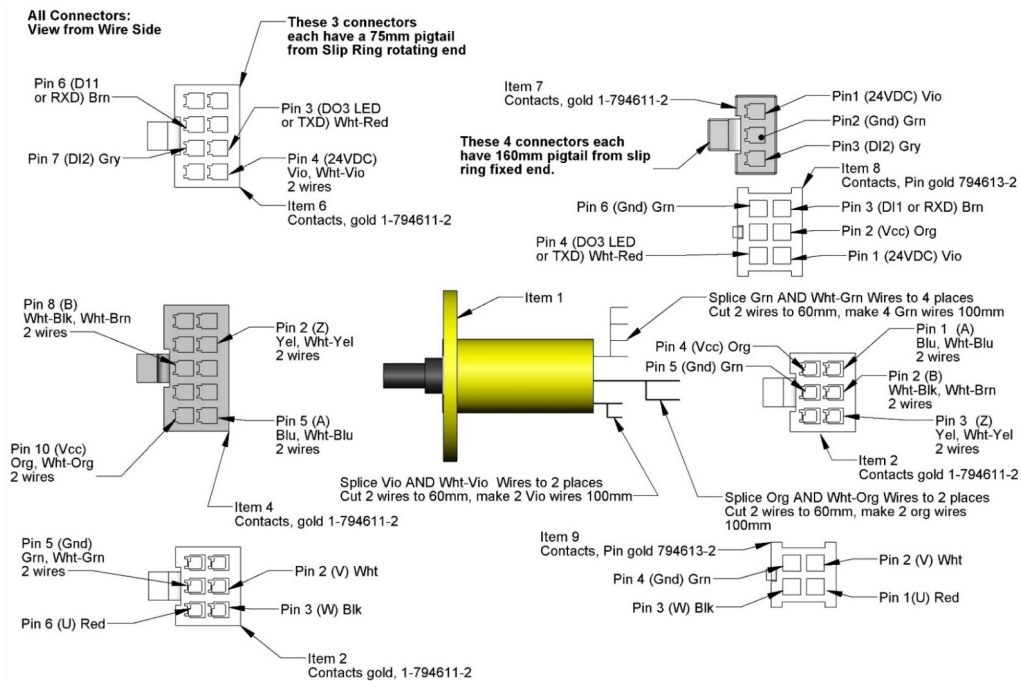


### Controller Power Amplifier Connectors

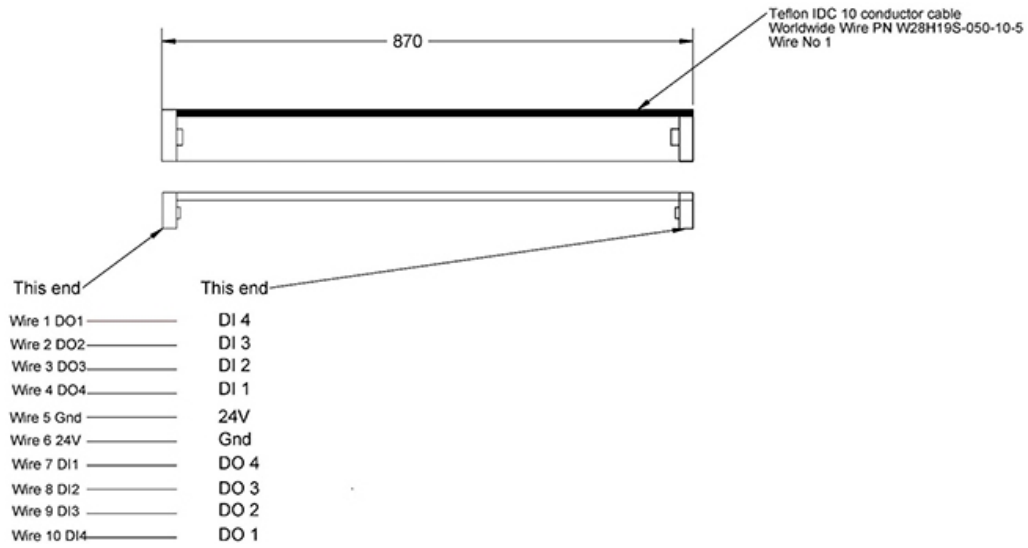


### 5400 Controller Board Connectors

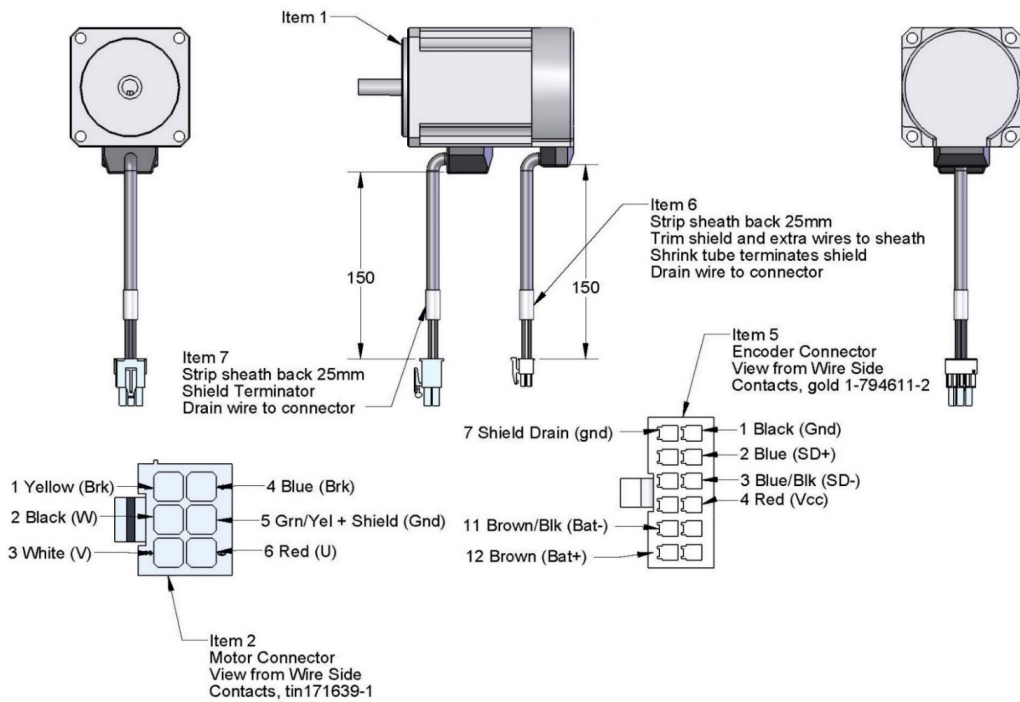
Letter	Description
A	Dump Resistor Connector
B	Facilities Panel/Safety Board Connector
C	LED Connector
D	RS485 Connector
E	RS232 Connector
F	RS485 Termination
G	RS232 Passthrough
H	Reset Jumper
I	Slave Jumper
J	24 volt/High Power Enable Connector
K	Digital I/O
L	Ethernet



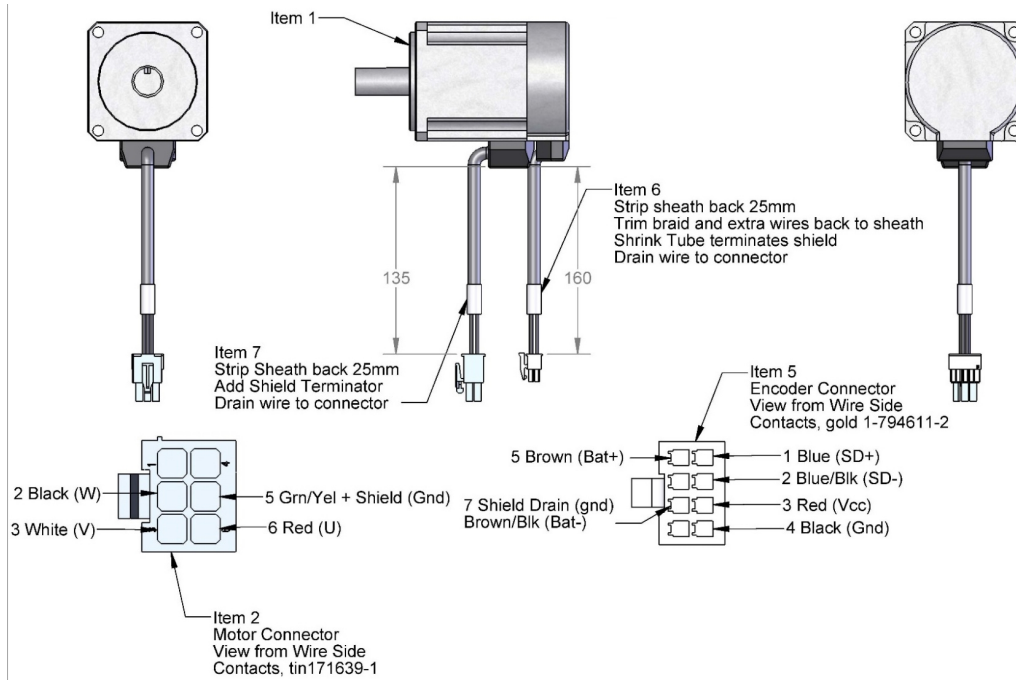
**Slip Ring Harness Assembly (397515)**



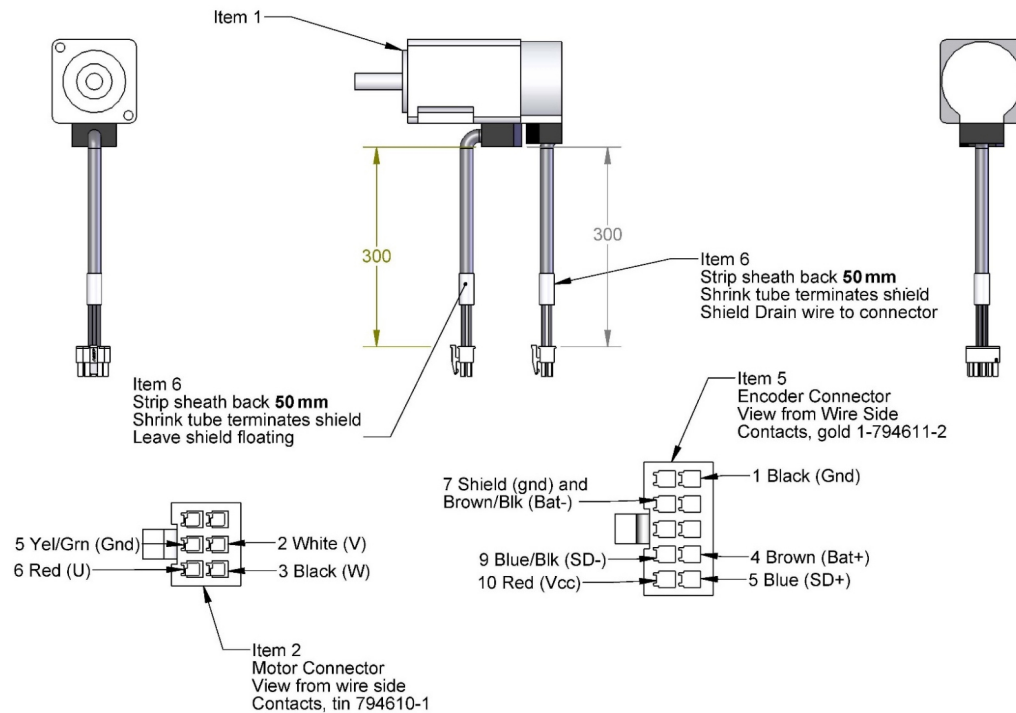
### Harness PreciseFlex 400 Vacuum Gripper



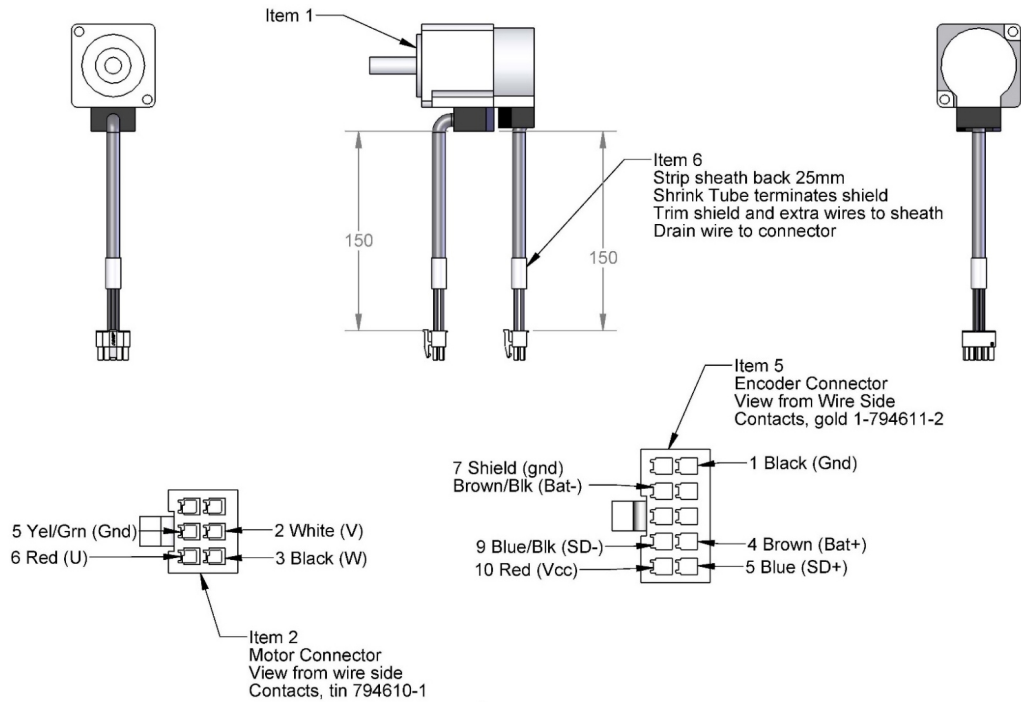
### J1 Motor, PreciseFlex 400 (PF00-MA-00028)



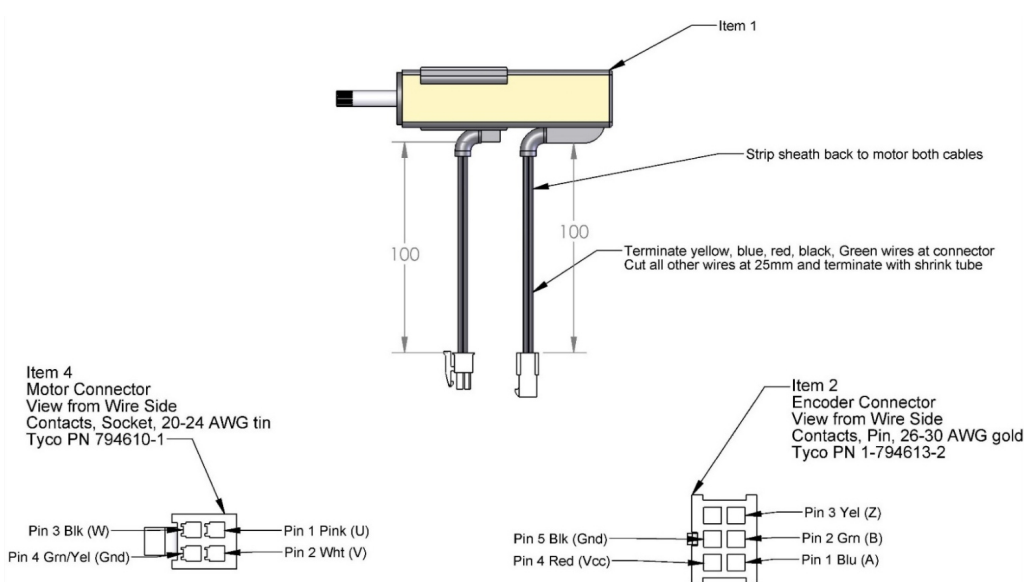
**J2 Motor, PreciseFlex 400 (PF00-MA-00029)**



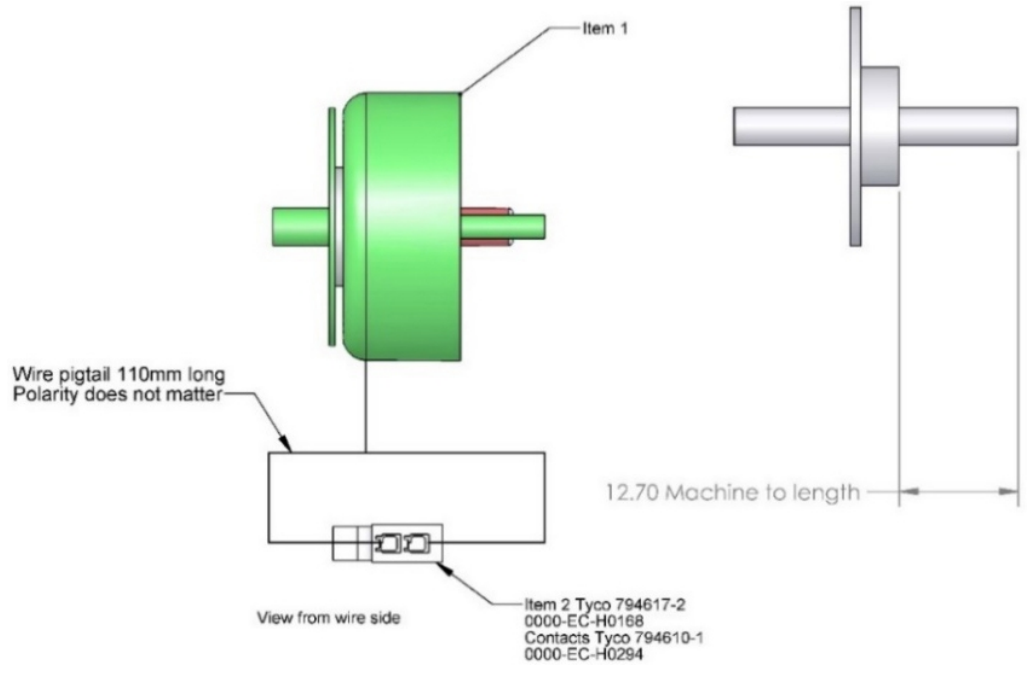
**J3 Motor, PreciseFlex 400/ 3400 (PF00-MA-00030)**



### J4 Motor, PreciseFlex 400 (PF00-MA-00031)



### Gripper Motor with Pigtail



### Brake Solenoid Harness

## Appendix G: Torque Values for Screws

Use these torque values for all screws and fasteners unless otherwise stated.

Torque Values in Newton-Meters

Screw Size M	Zinc	SS	Zinc	SS	Zinc	SS
	SHCS	SHCS	BHCS	BHCS	FHCS	FHCS
1.6	0.18	0.15	0.00	0.00	0.00	0.00
2	0.37	0.31	0.00	0.00	0.00	0.00
2.5	0.77	0.64	0.00	0.00	0.00	0.00
3	1.34	1.12	0.56	0.51	0.83	0.75
4	3.16	2.63	1.31	1.17	1.53	1.38
5	6.48	5.40	2.66	2.39	3.11	2.79
6	10.96	9.14	4.50	4.05	5.40	4.86

## Appendix H: Conditions of Acceptability

For use only in (or with) complete systems, the following items should be evaluated to determine the acceptability for use in the end user application:

- These devices shall be installed in compliance with the requirements for enclosure, mounting, electrical spacing, and segregation of the end-use equipment.
- The power supply and drives in this report have been evaluated as a system and they shall be installed accordingly. The suitability of any other installation manner shall be determined in the end product application.
- The front face has not been evaluated as an ultimate or part of the overall enclosure.
- Wait 7 minutes after removal of power before servicing equipment for the system capacitance to discharge below a 50 VDC level.
- The input and output connectors are suitable for factory wiring only.
- The spacings have been evaluated to Pollution Degree 2.
- These devices are intended for installation in a Pollution Degree 2 environment.
- These models are suitable for operation in a surrounding air temperature of 40°C.
- This system, power supply and motor drives, are suitable for use on a circuit capable of delivering not more than 1,500 rms symmetrical amperes, 250 VAC maximum.
- The Motor Drive Series 6000 shall be provided with complete instructions as to how to replace the battery cell ending with the statement: "Dispose of used cell promptly. Keep away from children. Do not disassemble and do not dispose of in fire."
- Peak currents indicated in the nomenclature are temporary over-currents only, not intended for use as continuous ratings.