400 mm Z Axis | 750 mm Z Axis | 1160 mm Z Axis

PreciseFlex™ c5 Robot

Service Manual

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Brooks Automation

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Brooks Automation
15 Elizabeth Drive
Chelmsford, MA
01824-2400
Tel: +1 978-262-2400
Fax: +1 978-262-2500

Brooks Automation, PreciseFlex Collaborative Robots
201 Lindbergh Avenue
Livermore, CA
94551
Tel: +1-408-224-2838

Worldwide Headquarters
15 Elizabeth Drive
Chelmsford, MA 01824 U.S.A.

Brooks Automation,
PreciseFlex Collaborative Robots
201 Lindbergh Avenue
Livermore, CA 94551 U.S.A

Technical Support

Location	Contact	Website
North America	+1-800-447-5007 (Toll-Free) +1-978-262-2900 (Local) +1-408-224-2838 (PreciseFlex)	http://www.brooks.com/
Europe	support_preciseflex@brooks.com	
Japan	+81 120-255-390 (Toll Free) +81 45-330-9005 (Local)	
China	+86 21-5131-7066	
Taiwan	+886 080-003-5556 (Toll Free) +886 3-5525258 (Local)	
Korea	1800-5116 (Toll Free)	
Singapore	+65 1-800-4-276657 (Toll Free) +65 6309 0701 (Local)	

General Emails

Division	Email Address
Sales	sales_preciseflex@brooksautomation.com
Technical Support	support_preciseflex@brooks.com
Technical Publications	Technical.Publications@brooksautomation.com

Brooks Automation
15 Elizabeth Drive
Chelmsford, MA
01824-2400
Tel: +1 978-262-2400
Fax: +1 978-262-2500
www.brooks.com

Brooks Locations Worldwide:

Brooks Automation
46702 Bayside Parkway
Fremont,CA 94538
Tel: +1-510-661-5000
Fax: +1-510-661-5166

Brooks Automation
AIM Servicios Administrativos
S de RL de CV
Carretera Huinalá km 2.8
Parque Industrial Las Américas
66640 Apodaca, NL Mexico
Tel: +52 81 8863-6363

Brooks Automation (Germany) GmbH
Ernst-Ruska-Ring 11
07745 Jena, Germany
Tel: +49 3641 4821 100
Fax: +49 3641 4821 4100

Brooks Automation (Germany) GmbH
Daimler-Straße 7
78256 Steißlingen, Germany
Tel: +49-7732-9409-0
Fax: +49-7732-9409-200

Brooks Automation
9601 Dessau Road, Suite 301
Austin, TX 78754
Tel: +1 512-912-2840
Toll-Free: +1 800-367-4887

Brooks Automation (Israel) Ltd.
Mevo Yerach 5
Kiryat-Gat 82000
Israel
Tel: +972 8672 2988
Fax: +972 8672 2966

Brooks Technology (Shanghai) Limited
2nd Floor, No. 72,
887 Zuchongzhi Road
Zhangjiang Hi-Tech
Park Pudong, Shanghai
China 201203
Tel: +86-21-5131-7070
Fax: +86-21-5131-7068

Brooks Japan K.K.
HEADQUARTERS
Nisso Bldg. No 16, 9F
3-8-8 ShinYokohama, Kohoku-ku
Yokohama, Kanagawa 222-0033
Tel: +81-45-477-5570
Fax: +81-45-477-5571

Brooks Japan K.K.
YOKOHAMA TECHNICAL CENTER
852-1 Kawamuko-cho, Tsuzuki-ku
Yokohama, Kanagawa 224-0044
Tel: +81-45-477-5250
Fax: +81-45-470-6800

Brooks Japan K.K.
KUMAMOTO SERVICE OFFICE
202 Mirai Office II
312-1 Tatsudamachi Yuge
Tatsuda, Kumamoto 861-8002
Tel: +81-96-327-9720
Fax: +81-96-327-9721

Brooks CCS Japan K.K.
CONTAMINATION CONTROL SOLUTIONS
Nisso Bldg. No 16, 9F
3-8-8 ShinYokohama, Kohoku-ku
Yokohama, Kanagawa 222-0033
Tel: +81-45-477-5570
Fax: +81-45-477-5571

Brooks Automation Ltd.
TAIWANHEADQUARTERS
5F-5, No.32, Tai-Yuen Street
Chu-Pei City
Hsinchu County 302, Taiwan, R.O.C.
Tel: +886-3-552 5258
Fax (G&A): +886-3-552 5255
Fax (Sales): +886-3-552 5200

Brooks Automation Korea, Inc.
#35 Giheungdanji-Ro 121Beon-Gil
Giheung-Gu, Yongin-Si
Gyeonggi-Do, 17086
Korea
Tel : +82-31-288-2500
Fax: +82-31-287-2111

Brooks Automation CCS RS AG
Lohstampfestrasse 11
CH-8274 Tagerwilen, Switzerland
Tel: + 41 71-666-72-10
Fax: + 41 71-666-72-11

Brooks Automation Korea
#35 Giheungdanji-Ro 121Beon-Gil
Giheung-Gu, Yongin-Si
Gyeonggi-Do, 17086
Korea
Tel : +82-31-288-2500
Fax: +82-31-287-2111

Brooks Automation (S) Pte Ltd
51-18-C1 Menara BHL,
57 Jalan Ahmad Shah,
10050, Penang,
Malaysia
Tel: +60 4 3701012
Fax: +60 4 3701015

Brooks Automation (Singapore) Pte Ltd
Blk 5008 Ang Mo Kio Avenue 5
#05-08, Techplace II
Singapore 569874
Tel: +65-6836-3168
Fax: +65-6836-3177

Brooks Automation Ltd.
TAINAN OFFICE
3F., No.11, Nanke 3rd Rd., Xinshi Dist.
Tainan Science Park
Tainan City 74147, Taiwan (R.O.C.)
TEL: +886-6-505-0268
FAX: +886-6-505-5228

Brooks Automation Precise Collaborative Robotics
201 Lindbergh Drive
Livermore, CA 94551
Tel: +1-978-262-2400

Revision History

Revision	ECO	Date	Action	Author
A	EC169344	5/26/2026	Released manual at Rev. A to follow standard Brooks technical publication styles.	S. McLellan

Table of Contents

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.

DANGER

Read the Safety Chapter

Failure to review the *Safety* chapter and follow the safety warnings can result in serious injury or death.

- All personnel involved with the operation or maintenance of this product must read and understand the information in this safety chapter.
- Follow all applicable safety codes of the facility as well as national and international safety codes.
- Know the facility safety procedures, safety equipment, and contact information.
- Read and understand each procedure before performing it.

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

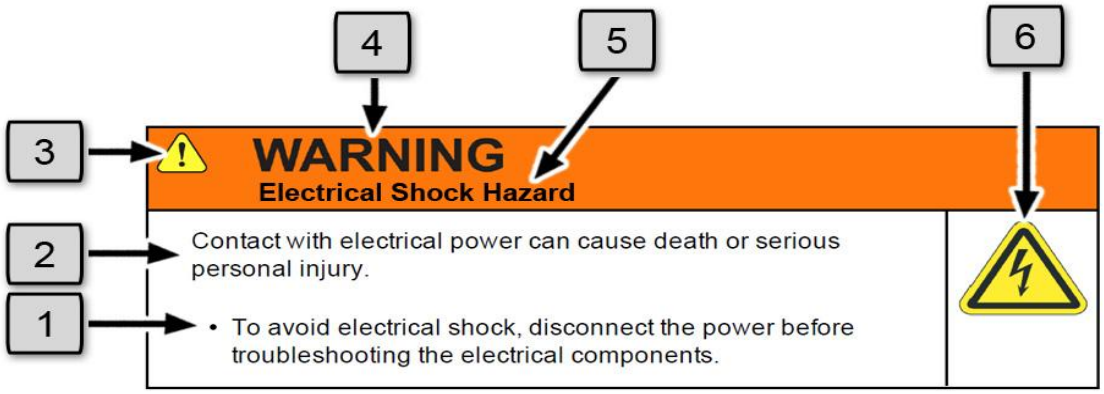
Signal Words and Colors

Signal words and colors label the threat level for potential harm or trouble.

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

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

WARNING

Robot Mounting

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.

- Always mount the robot on a secure test stand, surface, or system before applying power.

WARNING

Do Not Use Unauthorized Parts

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.

- Do not use unauthorized parts.
- Confirm that the correct robot application is being used.

WARNING

Magnetic Field Hazard

This product contains magnetic motors that can be hazardous to implanted medical devices, such as pacemakers, and cause personal harm or severe injury.

- Maintain a safe working distance of 30 cm from the motor when with an energized robot if you use a cardiac rhythm management device.

CAUTION

Unauthorized Service

Personal injury or damage to equipment may result if this product is operated or serviced by untrained or unauthorized personnel.

- Only qualified personnel who have received certified training and have the proper job qualifications are allowed to transport, assemble, operate, or maintain the product.

CAUTION

Damaged Components

The use of this product when components or cables appear to be damaged may cause equipment malfunction or personal injury.

- Do not use this product if components or cables appear to be damaged.
- Place the product in a location where it will not get damaged.
- Route cables and tubing so that they do not become damaged and do not present a personal safety hazard.

CAUTION

Inappropriate Use

Use of this product in a manner or for purposes other than for what it is intended may cause equipment damage or personal injury.

- Only use the product for its intended application.
- Do not modify this product beyond its original design.
- Always operate this product with the covers in place.

CAUTION

Seismic Restraint

The use of this product in an earthquake-prone environment may cause equipment damage or personal injury.

- 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.

Electrical Hazards

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

DANGER

Electrical Shock Hazard

Contact with electrical power can cause personal harm and serious injury.

- To avoid electrical shock, disconnect the power before troubleshooting the electrical components.
- Check the unit's specifications for the actual system power requirements and use appropriate precautions.
- Never operate this product without its protection covers on.

WARNING

Electrical Burn

Improper electrical connection or connection to an improper electrical supply can result in electrical burns resulting in equipment damage, serious injury, or death.

- Always provide the robot with the proper power supply connectors and ground that are compliant with appropriate electrical codes.

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

CAUTION

Heavy Lift Hazard

Failure to take the proper precautions before moving the robot could result in back injury and muscle strain.

- Use a lifting device and cart rated for the weight of the drive or arm.
- Only persons certified in operating the lifting device should be moving the product.

CAUTION

Tipover Hazard

This product has a high center of gravity which may cause the product to tip over and cause serious injury.

- Always properly restrain the product when moving it.
- Never operate the robot unless it is rigidly mounted.

CAUTION

Trip Hazard

Cables for power and communication and facilities create trip hazards which may cause serious injury.

- Always route the cables where they are not in the way of traffic.

Emergency Stop Circuit (E-Stop)

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

WARNING

Emergency Stop Circuit

Using this product without an emergency stop circuit may cause personal injury.

- Customer is responsible for integrating an emergency stop circuit into their system.
- Do not override or bypass the emergency stop circuit.

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 the cost of disposal. For further information and assistance in disposal, email Brooks Automation Technical Support at support_preciseflex@brooks.com.

2. Service Procedures

Introduction

Robot servicing should be performed with care and a clear understanding of the procedures. Training is recommended and is available through Brooks training programs in Livermore, California, and Steißlingen, Germany. Follow all instructions closely, and do not adjust PAC file settings unless directed by trained personnel.

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
- Metric ball end hex drivers, 4.0 mm and 5.0 mm for M5 and M6 SHCS
- 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

General Belt Tensioning

The PreciseFlex c5 has been designed to make belt tensioning simple. See Belt Tensions and the Gates Tension Meter for belt tension specifications

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. Should a motor need 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 trained service personnel or engineers should attempt these procedures.

Updating Robot PAC Files

PAC files contain important robot data such as GSB node addresses, link lengths, joint limit stops, nominal speeds, servo tuning, joint zero-positions and calibration information. They exist in the flash memory of the controller and are needed for the robot to work properly. Different sets of PAC files exist for different configurations of PreciseFlex robots; a robot on a linear rail with an IntelliGuide gripper will have different PAC files than a robot without a linear rail and with a pneumatic gripper. This is the procedure for installing new PAC 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)

The following data is related and should not be deleted when installing new PAC files:

- Cogging compensation tables (Controller: Flash/Sys/Comp)

Always perform a complete controller backup before modifying anything on the flash memory. When in doubt, email support_preciseflex@brooks.com.

Procedure Overview

The general procedure is as follows:

1. Install correct PAC files
2. Configure linear rail orientation (if applicable)
3. Run robot calibration

Robots from the c-Series will need to perform the following procedures:

4. Update the commutation offsets
5. Update the cogging compensation (as needed)

Accessing the Correct PAC Files

New PAC files to be used for updating the original robot PAC files can be found in the robot flash memory under flash/config_other. The folder or zip file names describe their configurations. They follow one of two naming conventions.

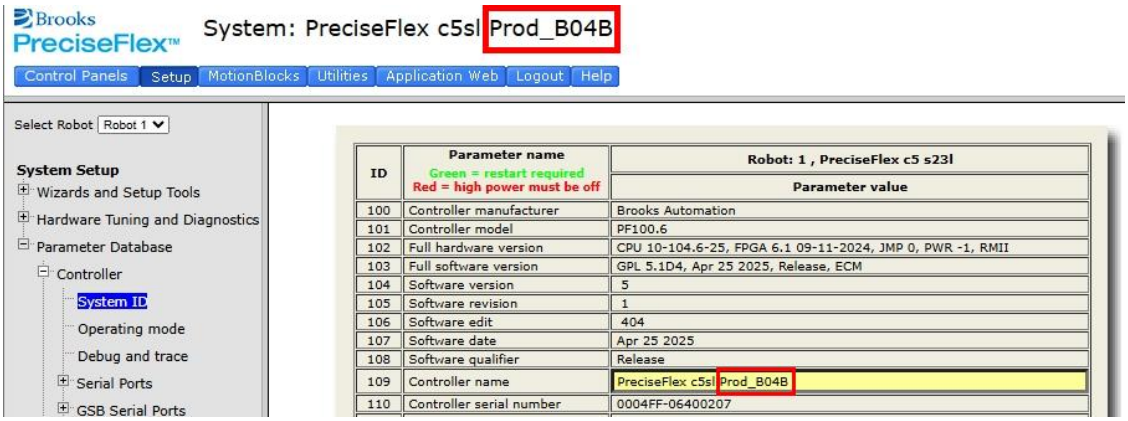
Older naming convention:

- Robot Name
- "L" = Linear Rail
- "X" = Extended Reach Robot
- "S" = Spring Gripper
- "D" = Dual Gripper

Newer naming convention:

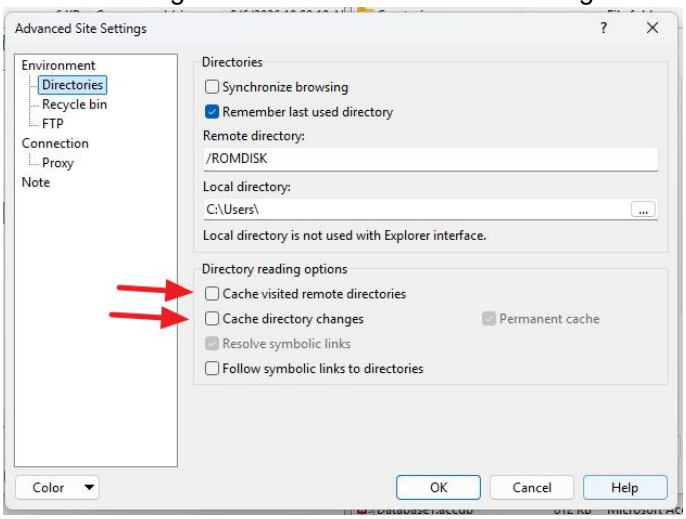
- Robot Name
- "Rail" = Linear Rail
- "23N Spring Gripper" = IntelliGuide s23 or v23 Gripper
- "60N Spring Gripper" = IntelliGuide s60 or v60 Gripper
- "23N Dual Spring Gripper" = IntelliGuide s23D Gripper

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. It is important to install new PAC files that match the version of PAC files originally installed on the robot.



If the correct version number is not known, contact support_preciseflex@brooks.com.

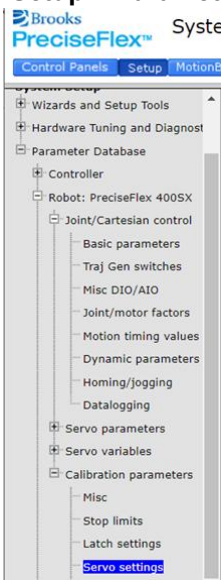
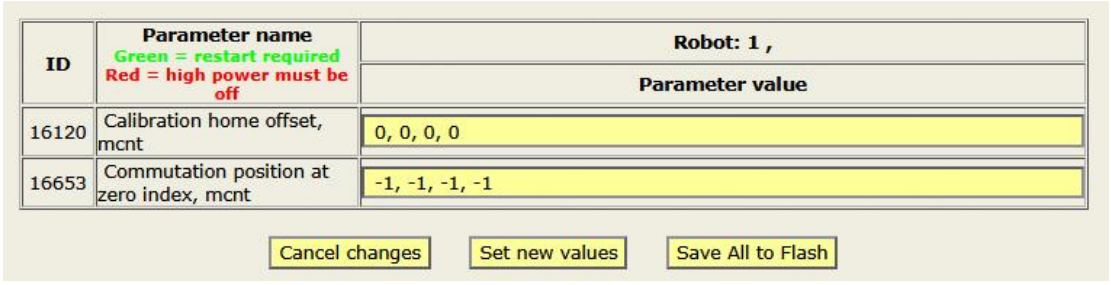
Installing New PAC Files Procedure

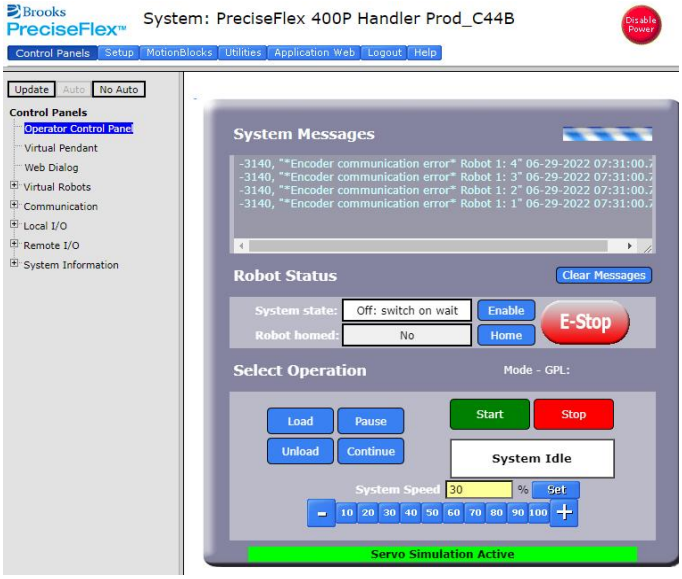
Step	Action
1.	Establish a connection to the robot via the controller's web server interface.
2.	Navigate to **Admin > Setup > Parameter Database > Servo Parameters > Commutation Process** and locate *DataID 10775 Commutation Offset*. Copy the values displayed in the text field.
3.	Paste the copied values into a separate document for temporary reference.
4.	Connect to the robot using an FTP client such as WinSCP or FileZilla.
5.	Ensure caching is disabled in the FTP client settings. 
6.	Copy the contents of *flash/config* from the robot to a local computer as a backup.
7.	In the FTP client, navigate to the directory *flash/other_config*.
8.	Select the appropriate PAC files based on the desired configuration of your robot. **X**: Extended Reach **L**: Linear Rail **S**: IntelliGuide v23, s23, v60 or s60 Gripper **D**: IntelliGuide s23D Gripper These are combined to form the configuration of the robot. For instance, "SL" = PreciseFlex robot with IntelliGuide gripper and linear rail. ***NOTE:*** *The "Prod" designation indicates the type of IntelliGuide Gripper (v23/s23 vs v60/s60).*

Step	Action
9.	Copy the files from the selected subfolder and overwrite the existing files in *flash/config*. ***NOTE:*** *Wait at least 15 seconds for the controller to finish writing to flash memory. Interrupting this process too early can result in flash-memory corruption.*
10.	Power cycle the robot.
11.	Verify installation by accessing the robot homepage. If no fatal errors are present, installation is complete.
12.	Re-enter the saved values from step three into *DataID 10775 Commutation Offset*.
13.	Select **Save All to Flash**. ***NOTE:*** *Wait at least 15 seconds for the controller to finish writing to flash memory. Interrupting this process too early can result in flash-memory corruption.*
14.	Calibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions for more information on performing the calibration procedure.

Changing PAC Files Without Recalibration

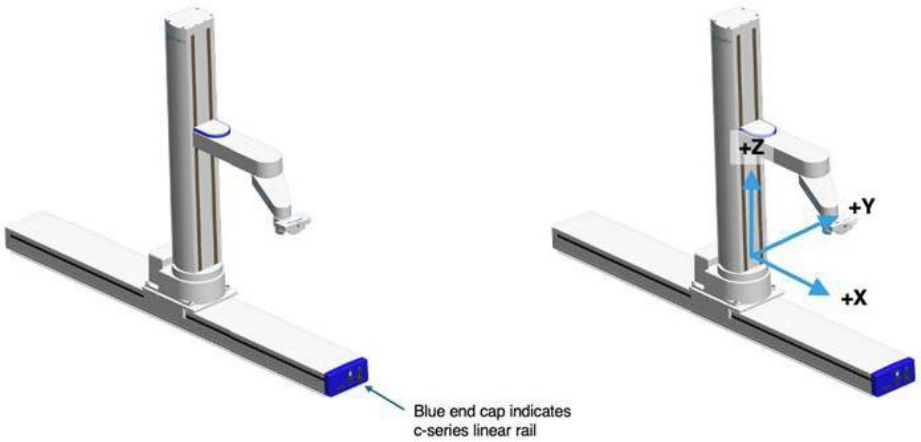
This procedure is intended only for situations where original PAC files have become corrupted and require replacement. It is not intended for configuration changes such as adding or removing a linear rail or IntelliGuide gripper.

Step	Action
1.	Establish a connection to the robot via the controller's web server interface.
2.	From the homepage, select **Admin**, then navigate to: **Setup > Parameter Database > Robot > Calibration Parameters > Servo Settings** 
3.	Locate *DataID 16120 Calibration home offset, mcnt* and copy the values displayed in the text field. ***NOTE:*** *The image below is for reference only. The values must come from the original PAC files installed on the robot. The values shown in this procedure may differ from those on the actual system.* 
4.	Paste the copied values into a document for temporary reference.
5.	Navigate to **Admin > Setup > Parameter Database > Servo Parameters > Commutation Process** and perform steps three and four above for *DataID 10775 Commutation Offset*.

Step	Action
6.	Perform steps four through eight from "Installing New PAC Files Procedure" on page 15.
7.	After PAC file replacement, return to: **Admin > Setup > Parameter Database > Robot > Calibration Parameters > Servo Settings**
8.	Re-enter the saved values from step four into *DataID 16120 Calibration home offset, mcnt* and *DataID 10775 Commutation Offset*.
9.	Navigate to the *Operator Control Panel* and select **Enable.** Wait for the audible click. 
10.	Select **Home** to apply the previous calibration.

Configuring the Linear Rail Orientation

When installed on the linear rail, the PreciseFlex c5 Robot is limited to one orientation, positioned facing the blue linear-rail end cap.



Rail Orientation for PreciseFlex c5

After mounting the robot and installing the correct PAC files, verify the configuration in the PAC files.

Step	Action
1.	In the browser interface, go to **Admin > Setup > Parameter Database > Robot > Calibration Parameters > Misc**.
2.	Under Data ID 16050, the 5th parameter should already be set to -90.

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, -90, 0, 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

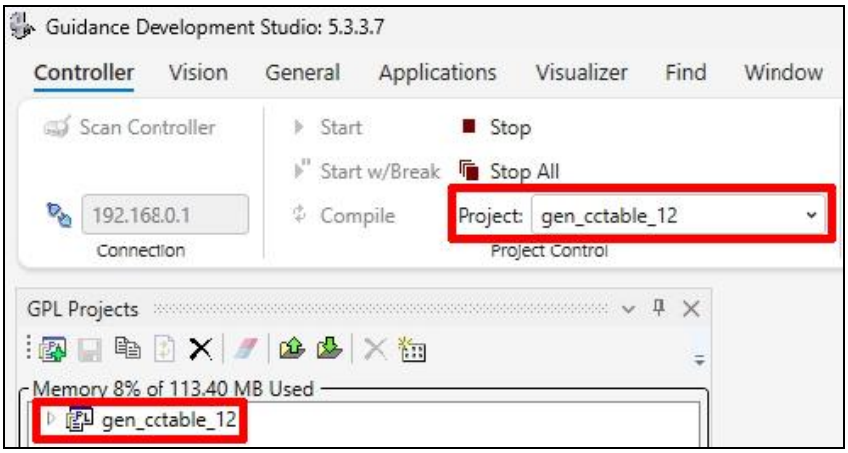
Running Cogging Compensation

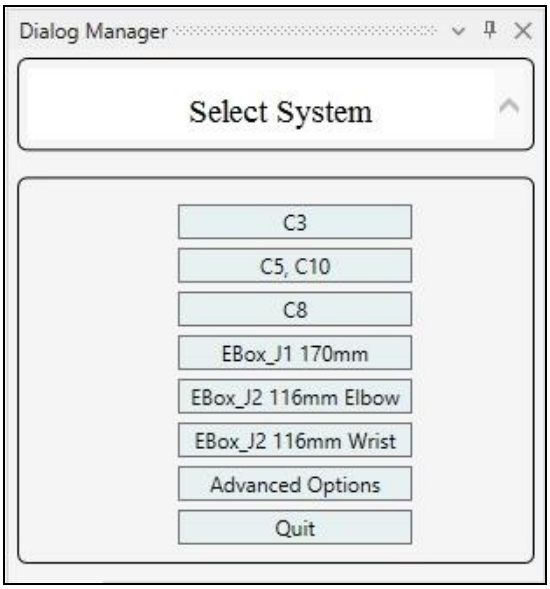
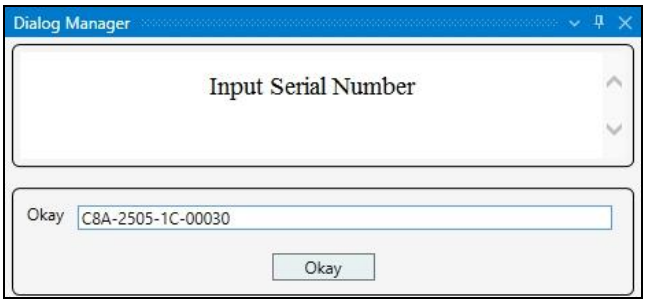
In events where the flash memory becomes corrupted, cogging compensation must be executed on PreciseFlex c-Series robots. Cogging compensation is performed at the factory and should otherwise not be performed by users. Cogging compensation can only be executed if the robot's working envelope is clear of obstacles as it will move its joints through their full range of motion.

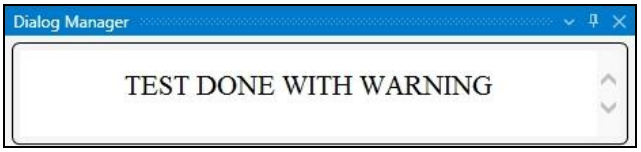
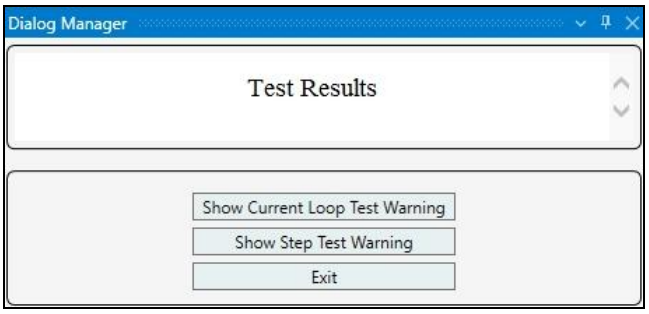
NOTE: Linear rails will not move.

From the browser interface or GDS, load and run the GPL program "gen_cctable." The *Dialog Manager* can be used to follow the process.

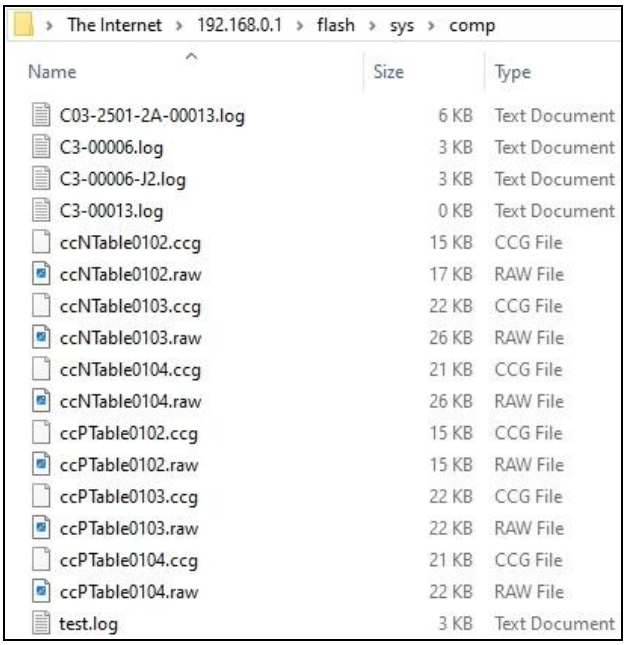
The general procedure is:

Step	Action
1.	Backup the entire controller flash memory.
2.	Load and Run the "**gen_cctable_XX**" GPL program via the browser interface or GDS. 
3.	Open the *Dialog Manager* to follow the prompts.

Step	Action
4.	Select the robot model. 
5.	Enter the robot's serial number, found at the base of the robot (this example is from a PreciseFlex c8A). ***NOTE:*** *Robot will start moving.* 
6.	The display will list the motor currently being tested. 

Step	Action
7.	The dialog manager will display either “Test Done With Warning” or “Test Done without Warning.” 
8.	If errors occur, the support team should be emailed with a copy of the *Console Output Window* text along with each reported error including the code and message. If no warnings or errors occur, select **Exit** to exit the cogging compensation procedure. 
9.	Repeat step one to backup the flash memory.

The following files are generated by the GPL Program:

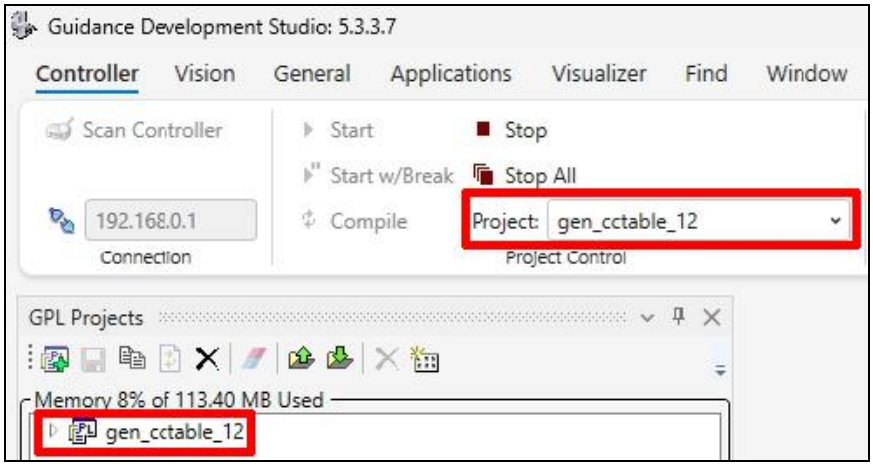


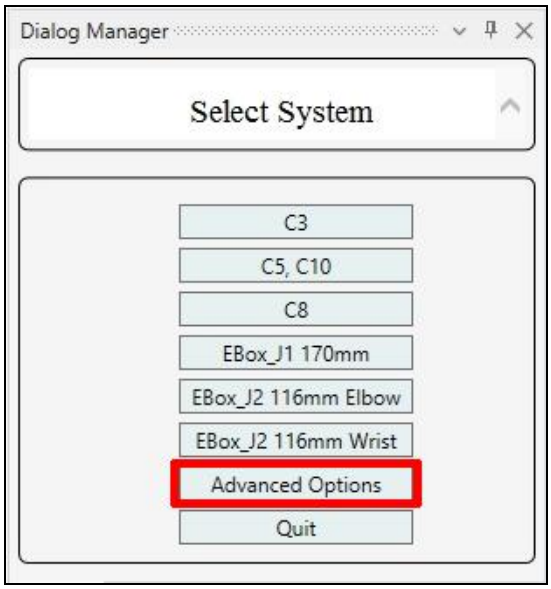
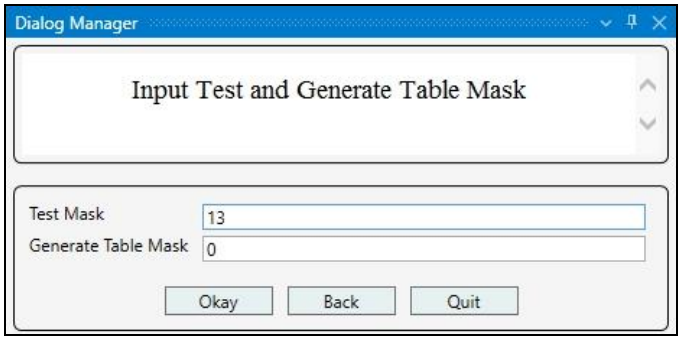
Generating the Commutation Offset

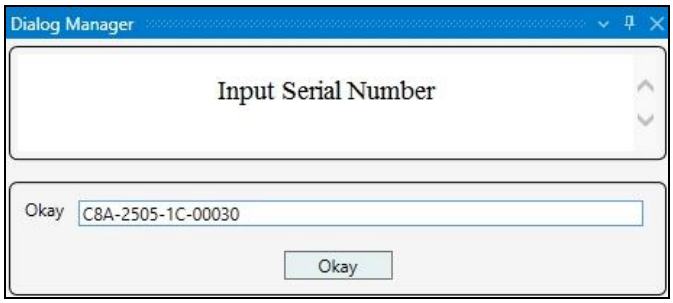
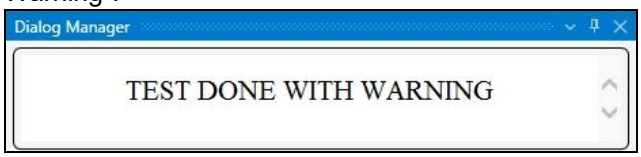
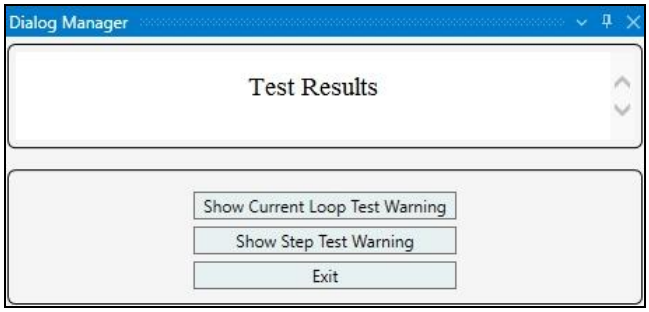
In cases where DataID 10775 Commutation Offset cannot be recovered or carried over to new PAC file installation, users can generate the commutation offset without running the full cogging compensation routine. While the cogging compensation routine requires full range of motion of the robot, the commutation offset can be generated with limited space (~30 degrees per joint in whatever starting position is available).

> ***NOTE:*** The same approach can be used for cogging compensation when performing the process one axis at a time.

The general procedure is:

Step	
1.	Backup the entire controller flash memory.
2.	Load and Run the "**gen_cctable_XX**" GPL program via the browser interface or GDS. 
3.	Open the *Dialog Manager* to follow the prompts.

Step	
4.	Select **Advanced Options**. 
5.	Enter "0" in the *Generate Table Mask* field. Within the *Test Mask* field, enter the following values below based on the c-Series robot: • PreciseFlex c5 = "13" for joints 1, 3, and 4 • PreciseFlex c10 = "13" for joints 1, 3, and 4 • PreciseFlex c8A = "5" for joints 1 and 3 

Step	
6.	Enter the robot's serial number that can be found at the base of the robot (this example is from a PreciseFlex c8A). ***NOTE:*** *Robot will start moving.* 
7.	The display will list the current motor currently being tested. 
8.	The dialog manager will display either "Test Done With Warning" or "Test Done without Warning". 
9.	If errors occur, the support team should be emailed with a copy of the *Console Output Window* text along with each reported error including the code and message. If no warnings or errors occur, select **Exit** to exit the cogging compensation procedure. 

Calibrating the Robot: Setting the Encoder Zero Positions

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.

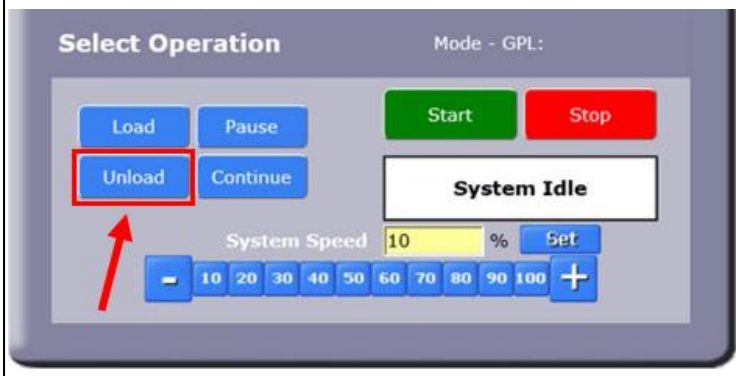
Cal_PP is supplied on the flash drive of the robot and is available in the Support area of the Brooks website at https://www.brooks.com/support/brooks-preciseflex-support/software-updates/.

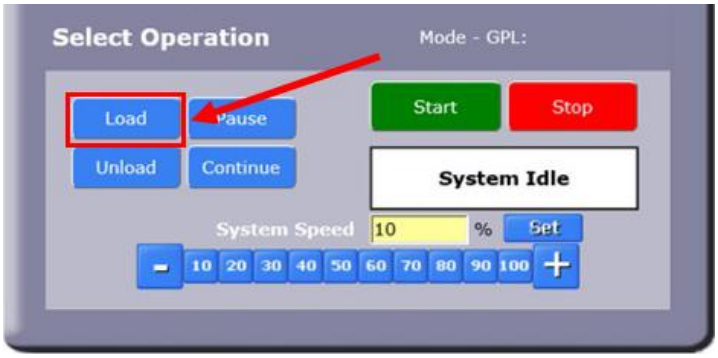
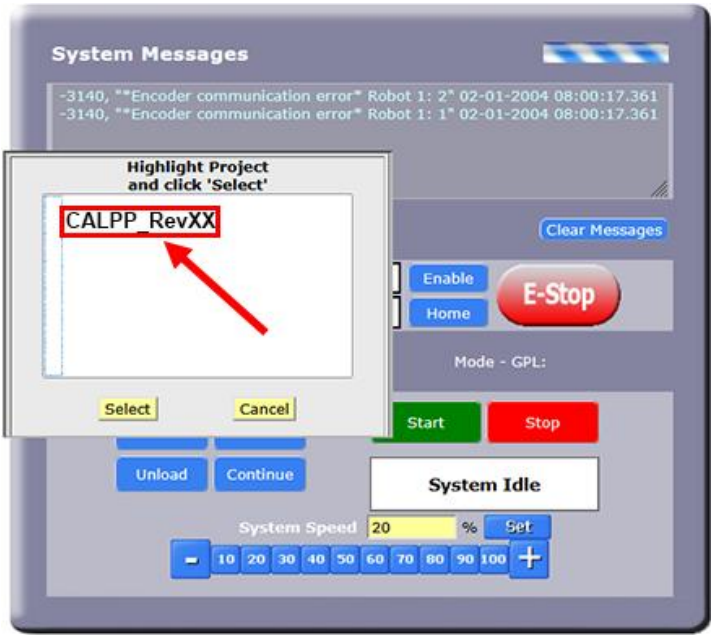
To run Cal_PP, the controller must be configured to run GPL programs, and Cal_PP must be loaded into the controller's memory.

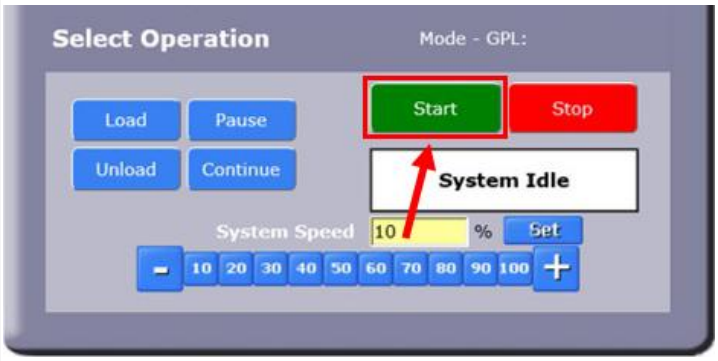
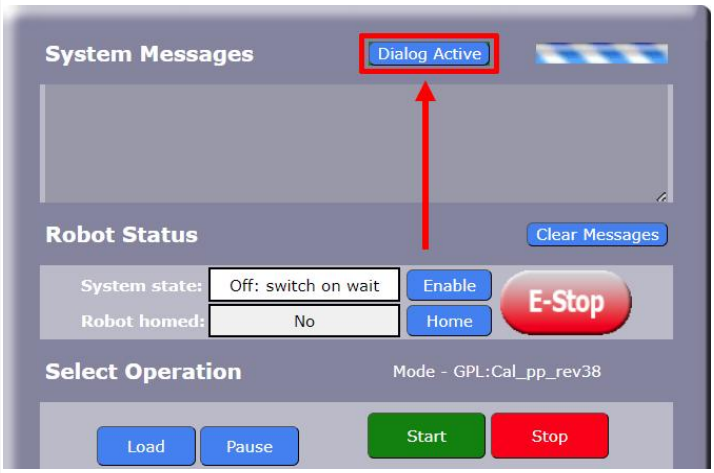
Tools Required

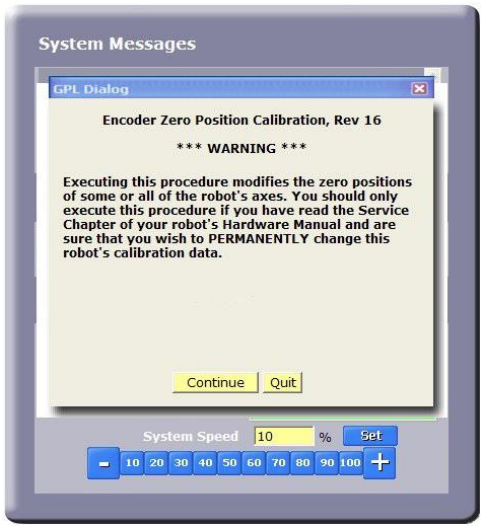
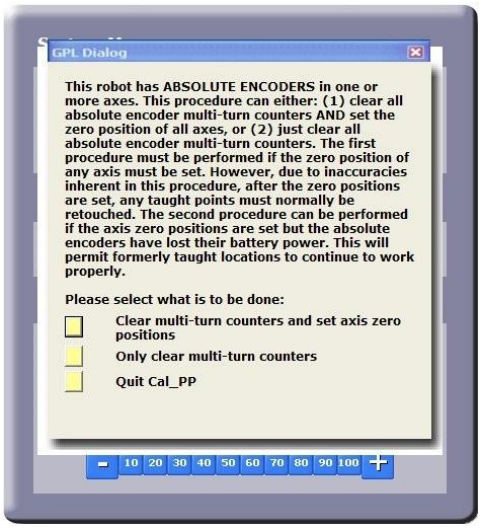
- Calibration Kit with M6 X 70 and M3 x 32 mm dowel

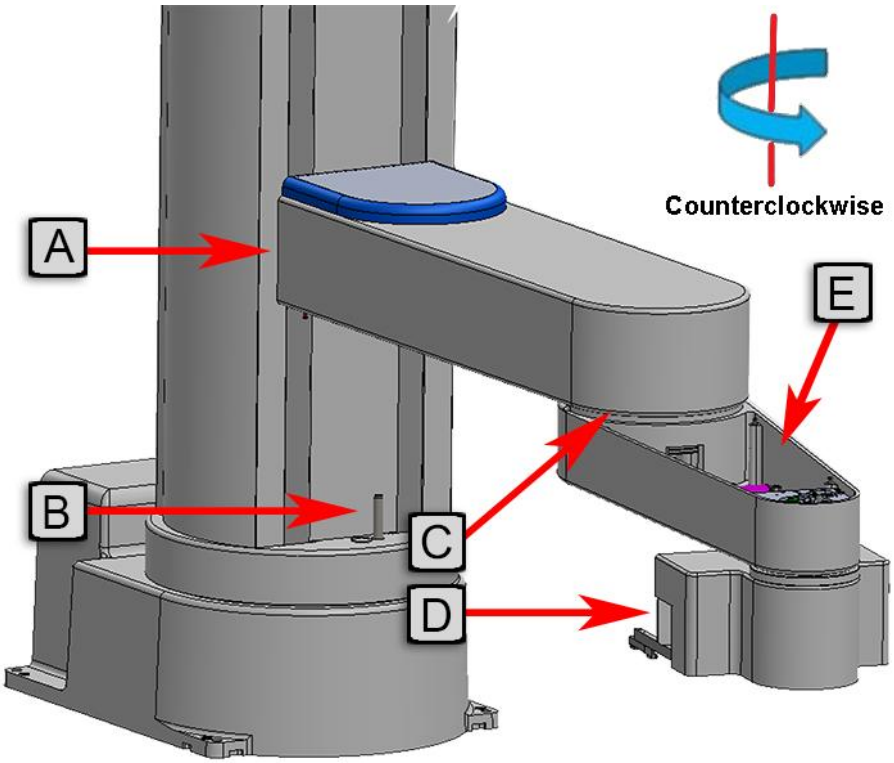
To define the zero positions of the PreciseFlex c5 robot axes using Cal_PP, perform the following procedure.

Step	Action
1.	Switch on the robot and wait for boot up to complete. There is no need to enable robot motor power. ***NOTE:*** *Perform this procedure with the motor power off so the robot does not move.*
2.	The CALPP program is typically installed at the factory and should be loaded into flash memory. In the controller's browser interface, go to **Admin > Control Panels > Operator Control Panel**, and click **Unload** to unload any currently loaded programs. 

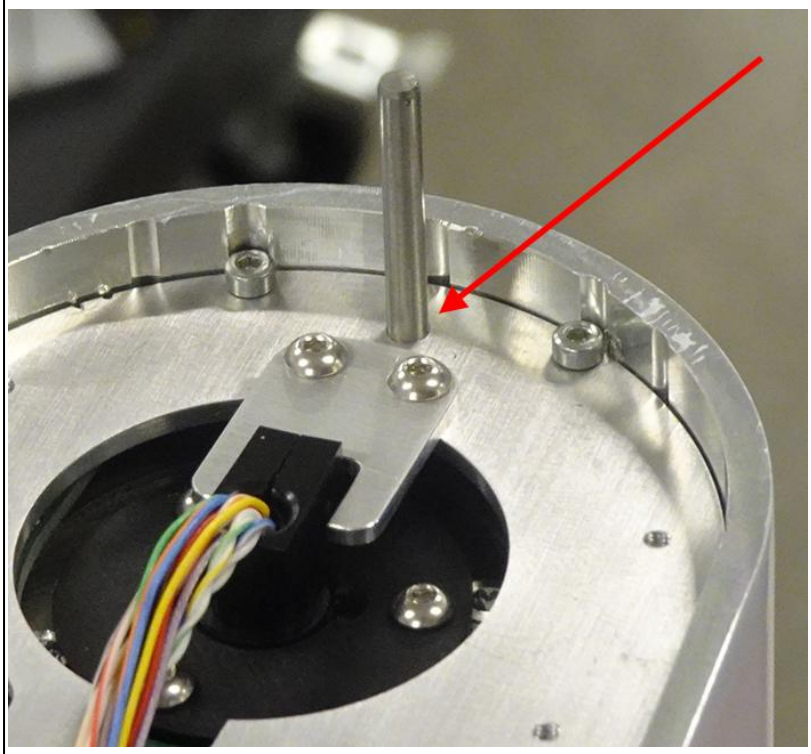
Step	Action
3.	Click **Load**. 
4.	This displays a list of projects that are in the flash disk and available for execution. Click **CALPP_RevXX** 

Step	Action
5.	When ready to execute the project, click **Start**. 
6.	After clicking **Start**, the **Dialog Active** button will display at the top. Click the **Dialog Active** button to begin the calibration steps 

Step	Action
7.	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).  

Step	Action
8.	Manually move the robot into the configuration shown below. 

Step	Action
A	Lower Z to hard stop (-2mm)
B	Insert the M6 X 70 mm long pin here to center J1 (0 degrees).
C	Rotate J3 counter-clockwise to a hard stop (350 degrees).
D	Rotate the gripper counter-clockwise, as viewed from above, until it is positioned beneath the outer link (-180 degrees, as shown).
E	Remove the outer link cover held in place by (4) M3 x 20 mm SHCS with lock washers.

Step	Action
9.	At the end of J4, insert M3 x 32 dowel pin calibration pin. 
10.	After the robot is correctly positioned, click **Execute** to execute CALPP. The CALPP application takes about one minute to run.
11.	Ensure that the pin is removed from the base rotation plate and the calibration pin from the outer link of the c5.
12.	After calibration is complete, move all the axes a few millimeters away from the hard stop. Failing to do this will produce a PID error on J2 because the lower hard-stop is exerting an upward force on the arm.
13.	Remove the calibration pins before enabling power and homing the robot. Calibration does not take effect until the robot is homed. Power cycle is not necessary; it is only needed if a PAC file change has been made. For PAC file changes, refer to Updating Robot PAC Files. ***NOTE:*** *Robot does not need to be power cycled after calibration.*

Replacing the Power Supplies

DANGER Electrical Shock	
Turn off the AC power before replacing the power supplies.	

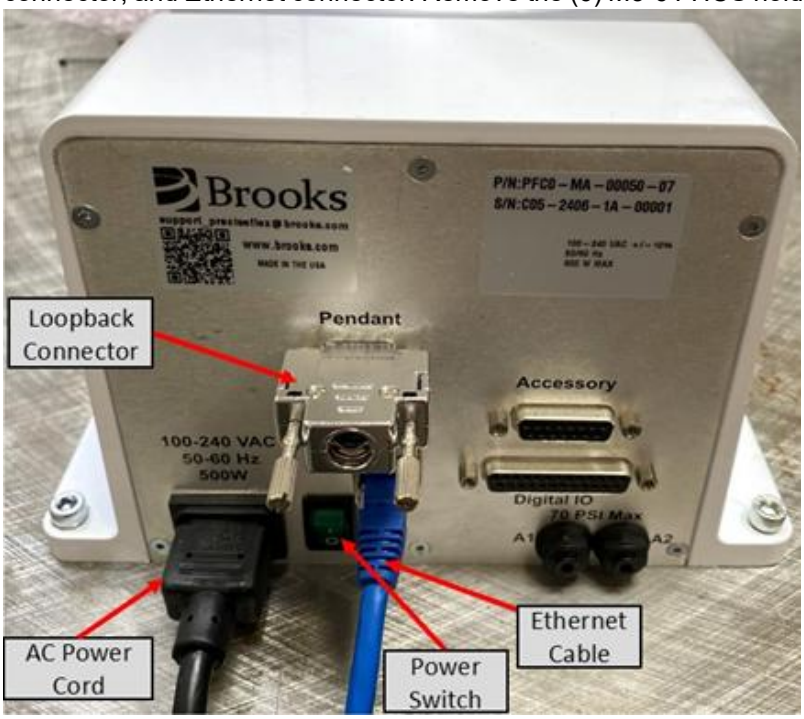
Tools Required

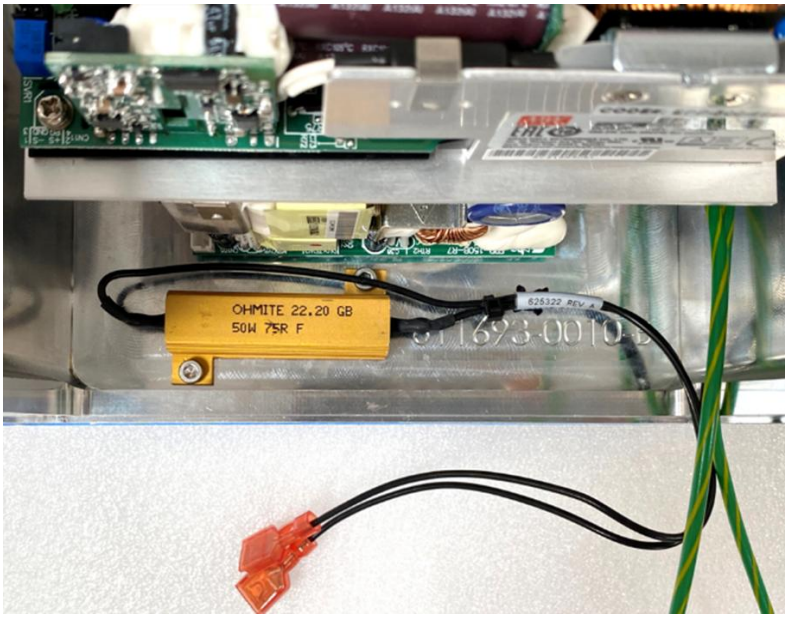
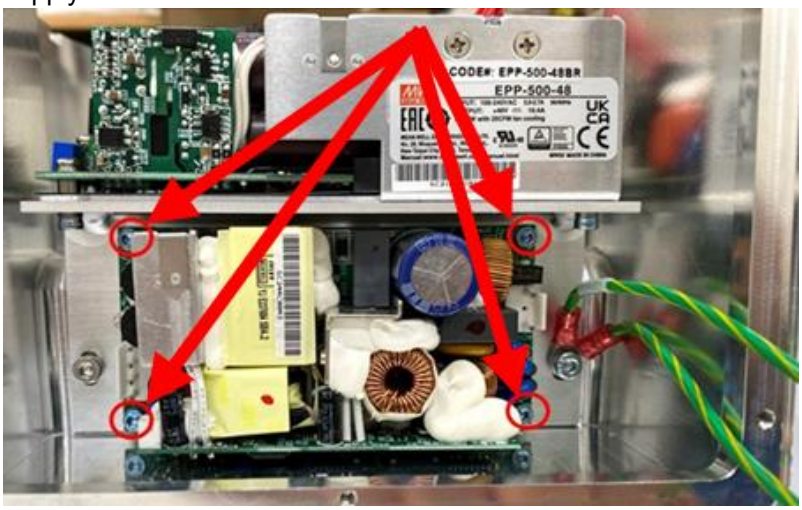
- 2.0 mm hex driver or hex L wrench
- 2.5 mm hex driver or hex L wrench

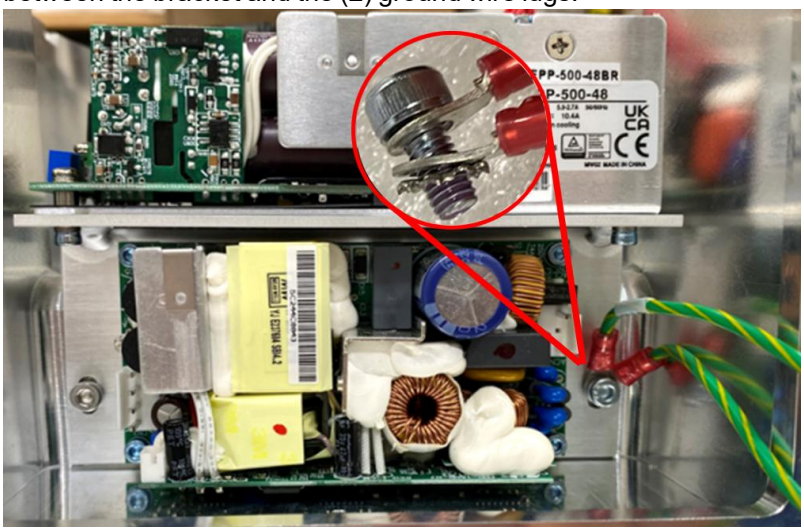
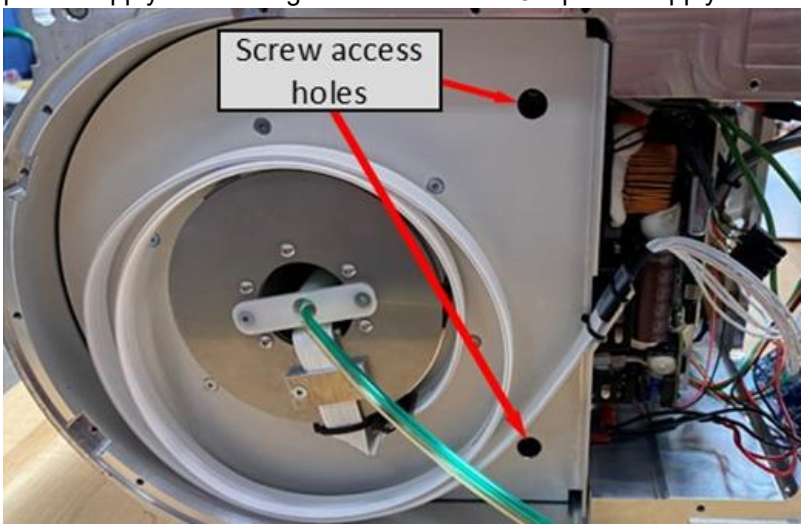
Spare Parts Required

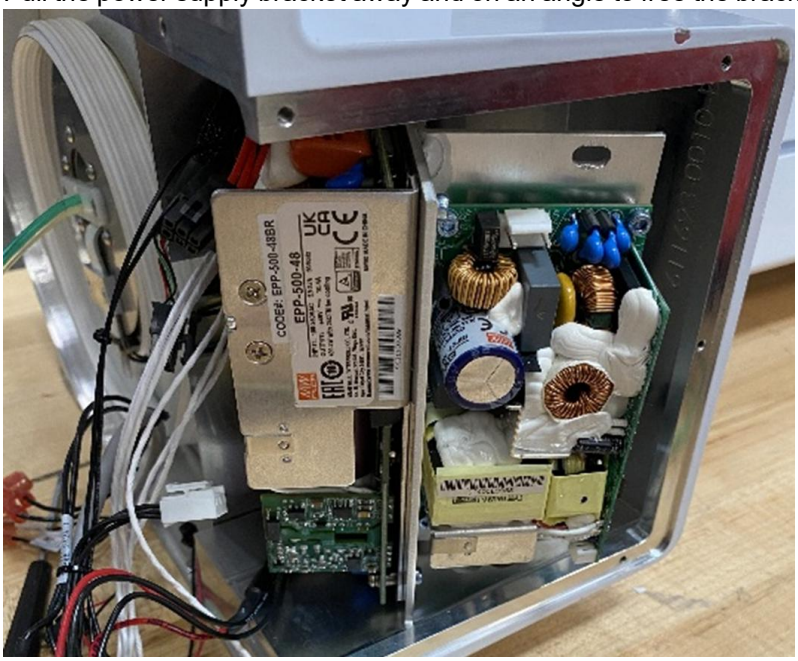
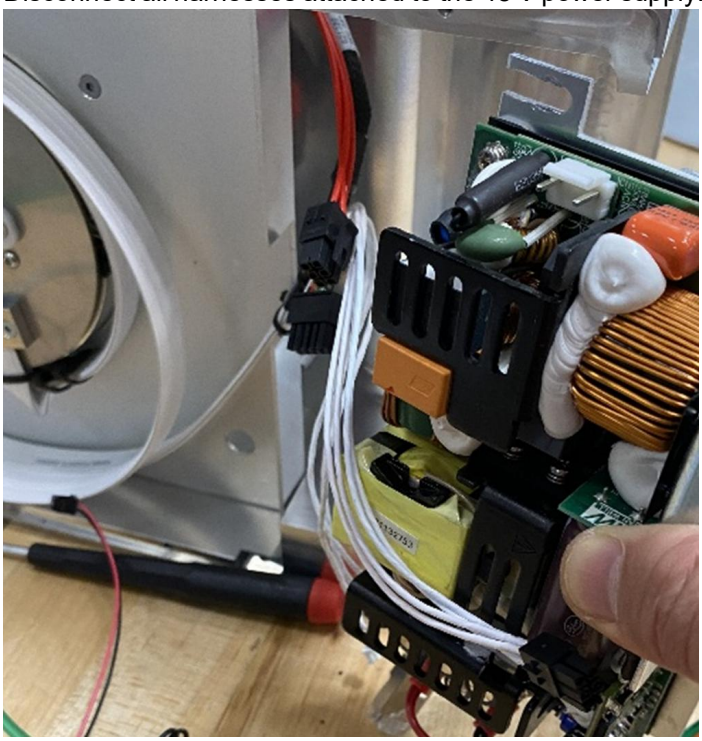
- New Power Supply (one of the following):
  - 24 VDC Power Supply, 150W (PS10-EP-24150)
  - 48 VDC Power Supply, 500W (605889)

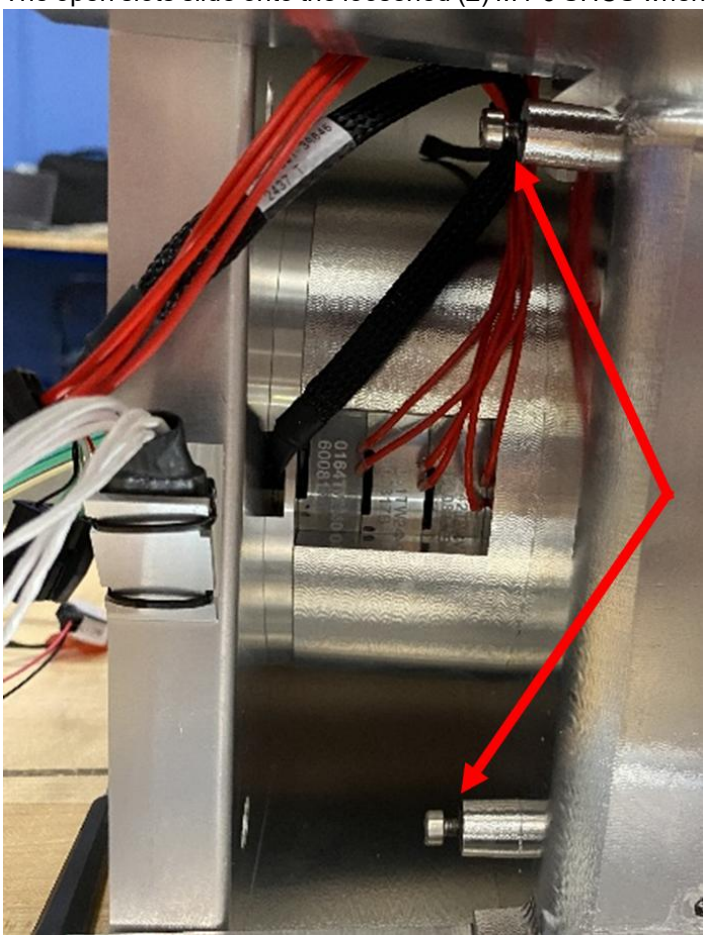
To replace the power supplies, follow this procedure.

Step	Action
1.	On the facilities panel, turn off the robot power and unplug the AC power cord, loopback connector, and Ethernet connector. Remove the (6) M3-6 FHCS holding the panel to the base. 
2.	Lay the robot on its side with the arm well supported. Remove the (7) M3-6 FHCS holding the bottom cover to the base housing. 

Step	Action
3.	Pull the back plate away from the base housing so the cable connectors on the controller are accessible. Disconnect the harness connectors from the controller.
4.	Remove the dump resistor by removing the (2) M3-5 SHCS. When re-installing the dump resistor, use Loctite 222 on the screws. 
5.	If only the 24 V power supply is being replaced, the harnesses connected to the 24 V unit are removed, followed by removal of the (4) M3-8 SHCS and the power supply. The new power supply is then installed and the harnesses reconnected. 

Step	Action
6.	If only the 48 V power supply is being replaced, remove the M4-6 SHCS and M4-8 SHCS holding the power supply bracket to the base housing. The M4-8 SHCS has a star washer between the bracket and the (2) ground wire lugs. 
7.	There are (2) M4-6 SHCS holding the power supply bracket to the base housing under the harness plate with screw access holes. Loosen the (2) M4-6 SHCS just enough to slide out the power supply bracket to gain access to the 48 V power supply. 

Step	Action
8.	Pull the power supply bracket away and on an angle to free the bracket from the base housing. 
9.	Disconnect all harnesses attached to the 48 V power supply. 

Step	Action
10.	The open slots slide onto the loosened (2) M4-6 SHCS when re-installing. 
11.	Remove the (4) M3-6 SHCS to remove the 48 V power supply from the bracket.  
12.	Re-install all the components in reverse order.

Replacing the Robot Main Controller

DANGER Electrical Shock	
Turn off the AC power before replacing the robot controller.	

Tools Required

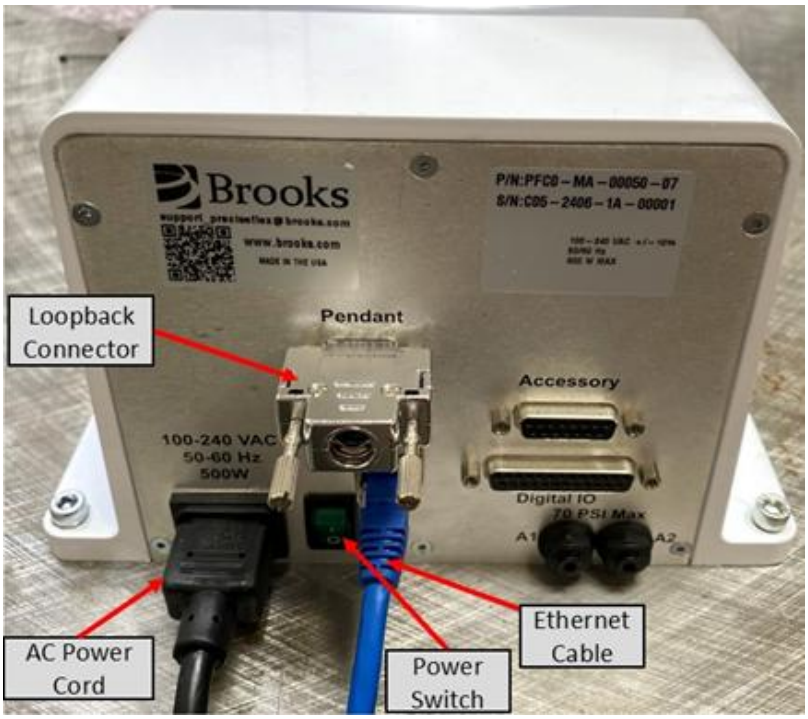
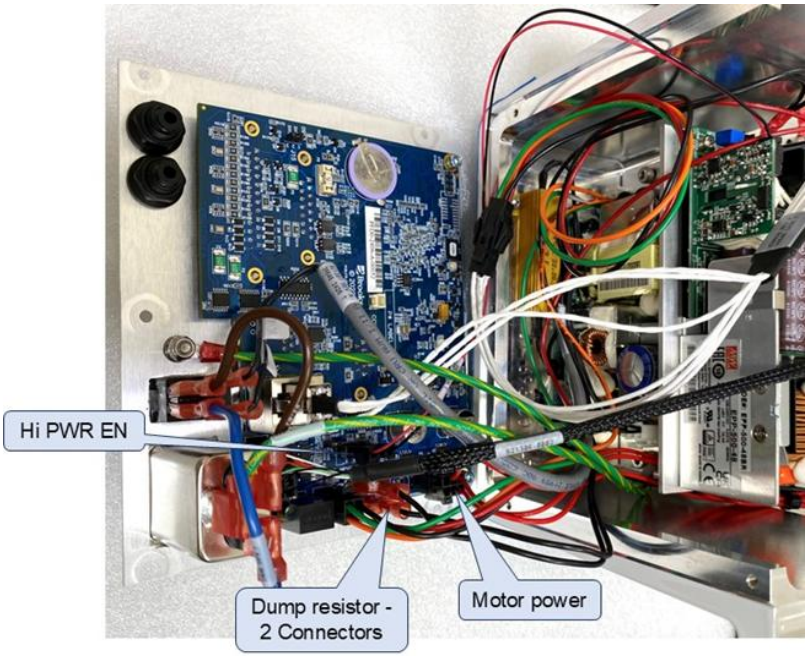
- 2.5 mm hex driver or hex L wrench
- 2.0 mm hex driver or hex L wrench
- 5.0 mm socket driver

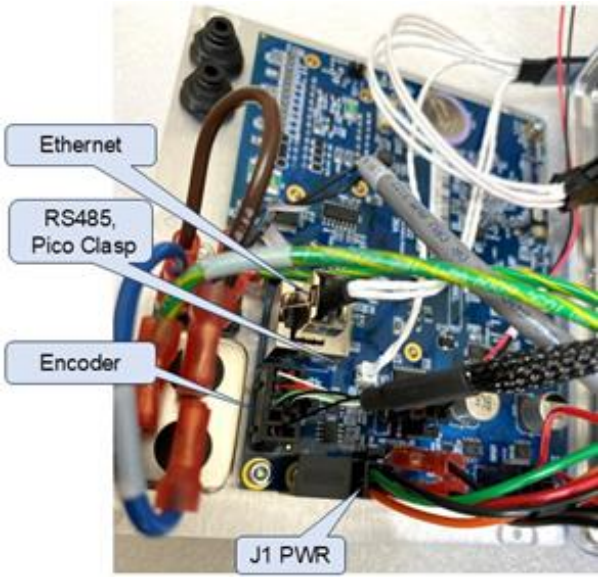
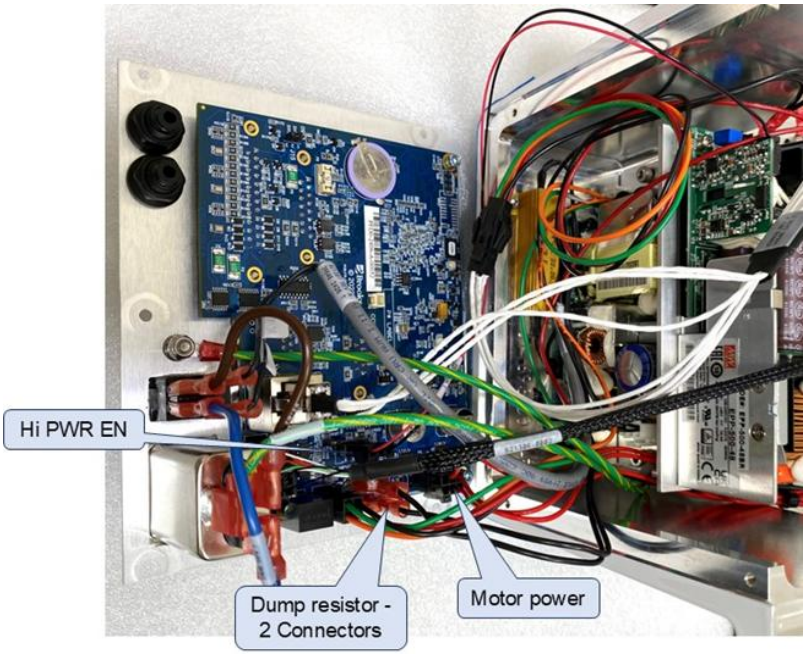
Spare Parts Required

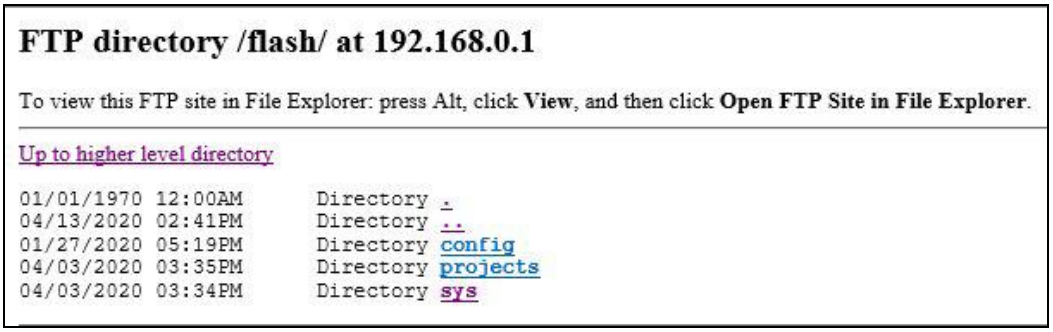
- Guidance Controller, PFD0X3 (890242-0001)

Prior to replacing the controller, if the controller will boot up, make copies of the robot PAC files (config directory), any project files (projects directory), and the “Sys” files (sys directory). These files can be copied using ftp://192.168.0.1/flash or the IP address of the controller.

To replace the robot main controller, follow this procedure.

Step	Action
1.	On the facilities panel, turn off the robot power and unplug the AC power cord, loopback connector, and Ethernet connector. Remove the (6) M3-6 FHCS holding the panel to the base. 
2.	Pull the back plate away from the base housing so the cable connectors are accessible on the controller. Disconnect the harness connectors from the controller. 

Step	Action
3.	Disconnect connectors 
4.	Prior to replacing the controller, check the RS-485 termination jumpers. See "RS-485 Network Termination with Linear Rails" on page 42 for more information.
5.	Remove the PFD03X controller by removing the (3) M3-8 mm SHCS and the D-sub standoffs from the connector side of the panel. 
6.	Replace the controller and connect the cables as shown above.

Step	Action
7.	Replace the connector panel. Place all harness cables and wires neatly into the base, and be careful to not pinch any wires while installing the connector panel to the base with the (6) M3-6 FHCS.
8.	Reload the robot PAC files (config directory), any project files (projects directory), and the "Sys" files (sys directory), from a PC. These files can be copied using ftp://192.168.0.1/flash or the IP address of the controller.  **FTP directory /flash/ at 192.168.0.1** To view this FTP site in File Explorer: press Alt, click **View**, and then click **Open FTP Site in File Explorer**. Up to higher level directory 01/01/1970 12:00AM Directory . 04/13/2020 02:41PM Directory .. 01/27/2020 05:19PM Directory config 04/03/2020 03:35PM Directory projects 04/03/2020 03:34PM Directory sys
9.	Recalibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions.

RS-485 Network Termination with Linear Rails

The PreciseFlex c5 robot uses an internal RS-485 network to communicate between the main robot controller (located in the base) and the GSB servo boards. To maintain signal integrity and improve noise immunity, termination resistors are installed at the ends of the RS-485 network. This termination is enabled by a jumper installed on J6 of the main robot controller.

When the PreciseFlex c5 robot is installed on a linear rail, the RS-485 network is extended to the GSB inside the linear rail. It is then necessary to remove the J6 jumper deactivating the termination resistors on the main controller. C-series linear rails are pre-configured with the necessary termination resistors in place.

To remove the J6 jumper on the PreciseFlex c5 robot, follow the procedure below.

DANGER

Electrical Shock

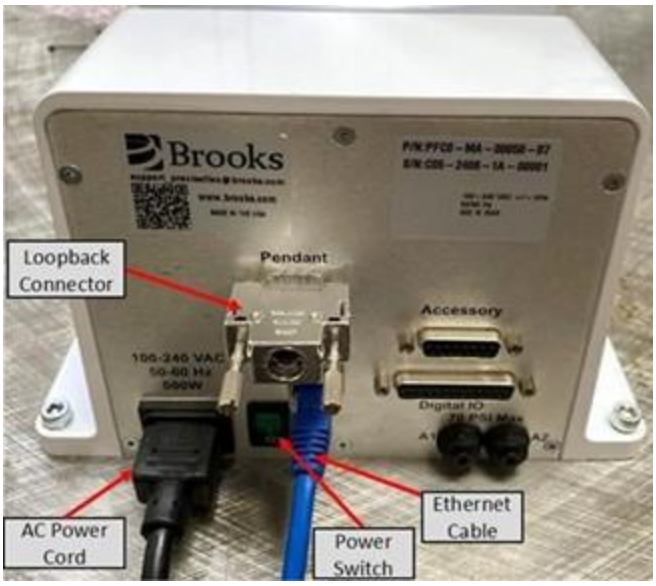
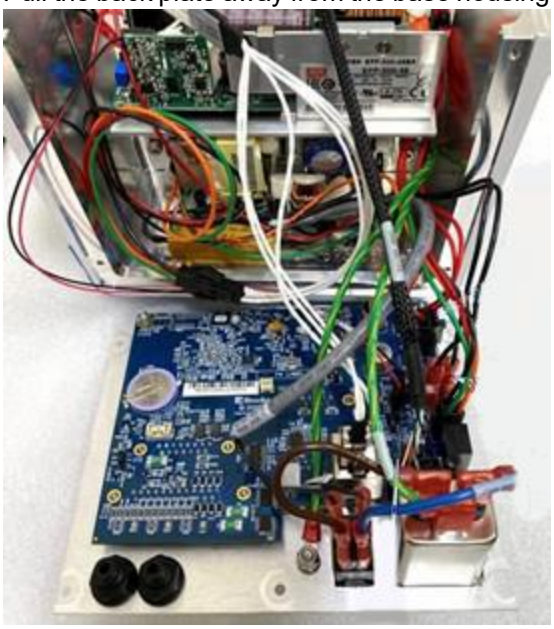
Turn off the AC power before replacing the robot controller.	

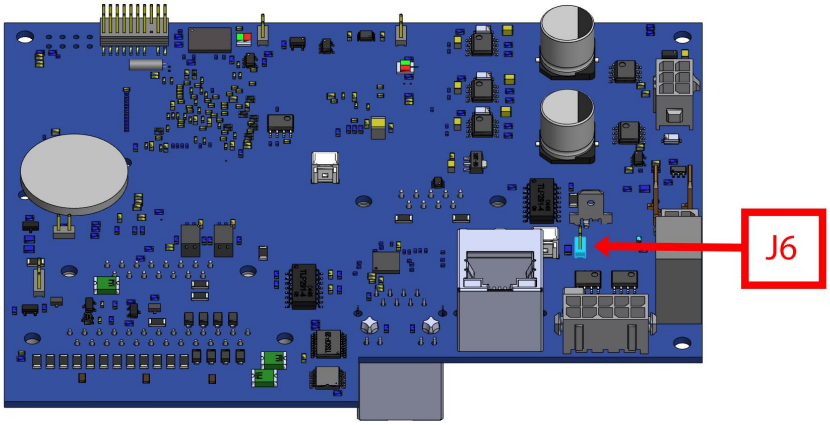
Tools Required

- 2 mm hex driver or hex L wrench
- Needle nose pliers

Spare Parts Required

- None

Step	Action
1.	On the facilities panel, turn off the robot power and unplug the AC power cord, loopback connector, and Ethernet connector. Remove the (6) M3-6 FHCS holding the panel to the robot base. 
2.	Pull the back plate away from the base housing so the J6 jumper is accessible. 

Step	Action
3.	Move the J6 jumper over one position so that the termination resistors are not connected. By moving the jumper over one position, the jumper is still available if the robot is later removed from the linear rail. 
4.	Close the back panel and secure with screws. Be careful to not pinch any wires while securing the connector panel to the robot base with the (6) M3-6 FHCS.

Replacing the J1, J3, and J4 Motors

The J1, J3, and J4 motors are not field-serviceable. These motors are designed to operate for the full service life of the robot and are not expected to require replacement in the field. Service for the J1, J3, and J4 motors must be performed through an RMA at the Brooks facility in Livermore, CA. For assistance, contact Brooks Automation Technical Support at support_preciseflex@brooks.com.

Replacing the J2 (Z- axis) Motor

DANGER Electrical Shock	
Disconnect the AC power before replacing the motor assembly.	

Tools Required

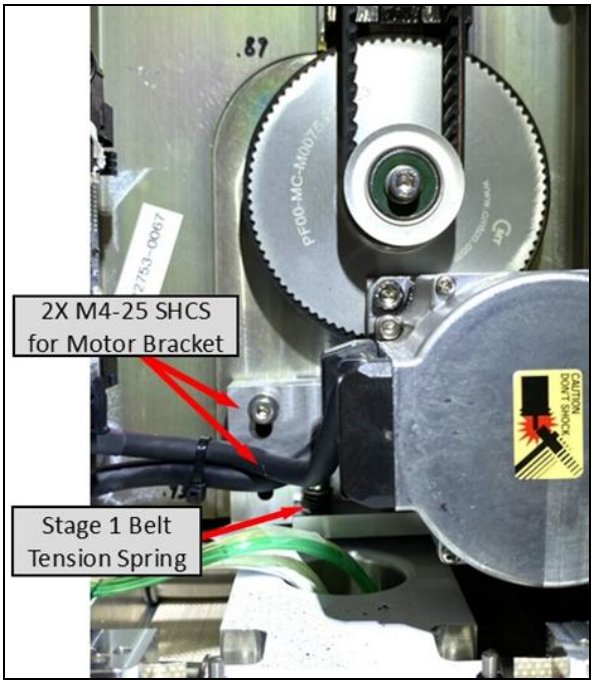
- 2.5 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench
- Loctite 243

Parts Required

- J2 Motor Assembly (PF00-MA-00028)

To replace the Z axis motor assembly, perform the following procedure.

Step	Action
1.	Turn off power to the robot, unplug the AC power plug, and remove the connectors from the base of the robot.
2.	Follow the steps in Tensioning the J2 (Z Axis) Belts to remove the top plate and front cover.

Step	Action
3.	Remove the screw compressing the J2 motor tension spring and the (2) M4-25 SHCS, flat washers, and lock washers that attach the J2 motor mount bracket to the Z column. 
4.	Slide the J2 stage 1 timing belt off the large idler pulley.
5.	Slide the J2 motor and motor mount bracket assembly out of the Z column.
6.	Remove the J2 motor assembly from the J2 motor mount bracket and replace it with the new motor, using Loctite 243 on the M5 screws holding the motor to the bracket.
7.	Replace the components in reverse order
8.	Compress the tension spring to 5.5 mm under the washer with the M4 motor bracket locking screws slightly loose, then tighten the screws.
9.	Recalibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions.

Tensioning the J2 (Z Axis) Belts

Tensioning the 1st Stage Belt

DANGER
Electrical Shock

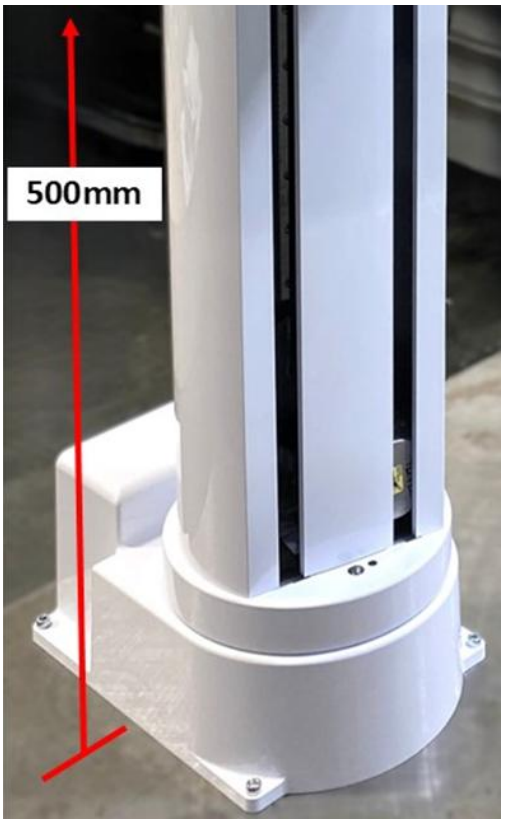
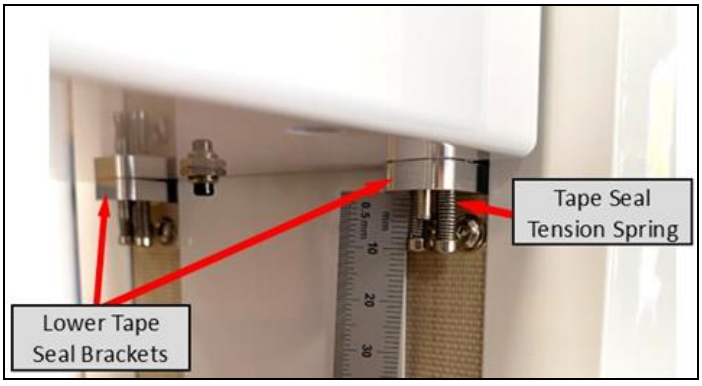
Removing the rear cover allows access to the AC power terminals. Disconnect the AC power before tensioning the belts.

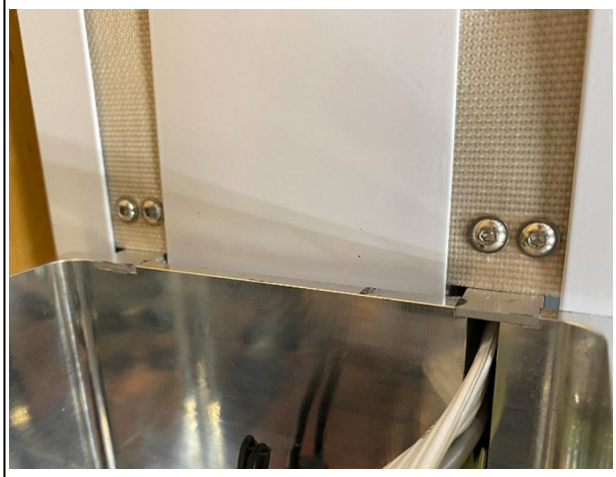
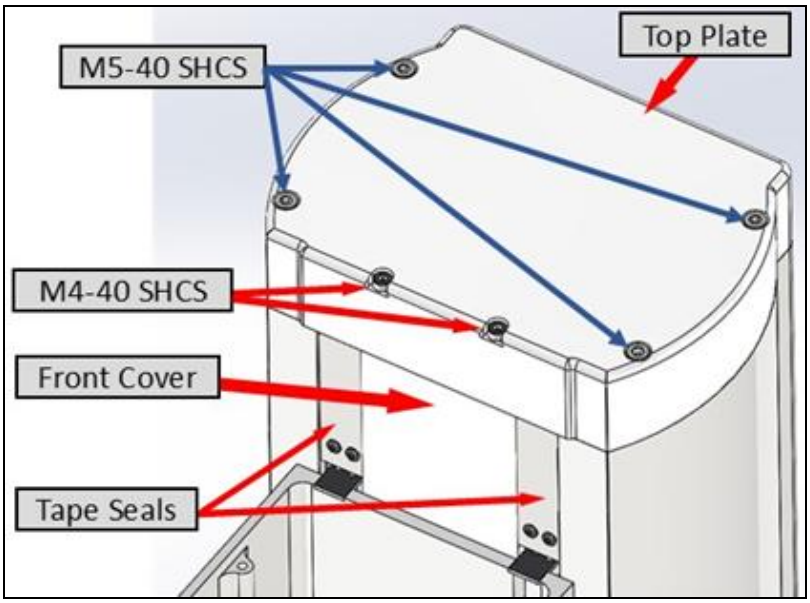
Tools Required

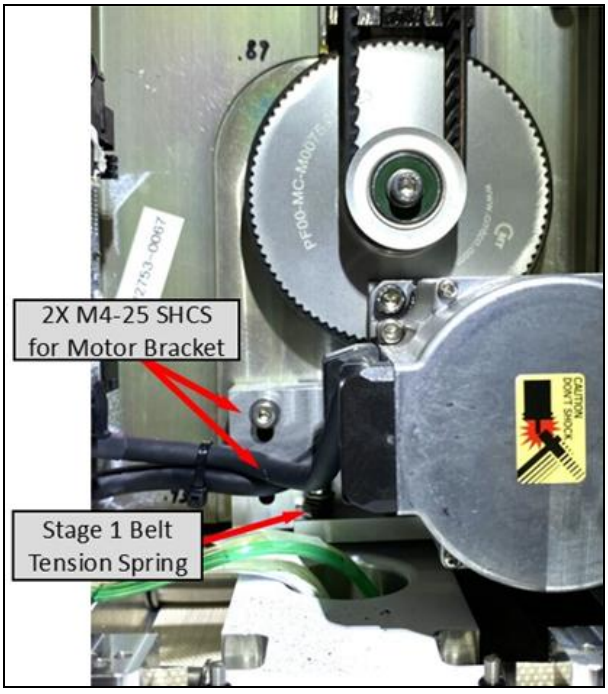
- 2.0 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench

To tension the 1st stage belt, perform the following procedure.

Step	Action
1.	Turn off the robot's power and unplug the AC power cord.

Step	Action
2.	Move the robot's arm up before accessing the inside of the Z Axis. 
3.	Measure the length of compressed spring on the four screws of the lower tape seal brackets so the tape seal tension can be set properly during reassembly. Remove the (4) M2.5-18 SHCS and (4) springs and slide the lower tape seal brackets off the 3 mm dowel pins on the bottom of inner link. 
4.	Remove the inner link cover, and disconnect the LED connector from the GSB. Set it aside.

Step	Action
5.	Remove the (4) M3-5 BHCS and washers holding the tap seal to the upper brackets on the top side of the inner link. 
6.	Remove the (4) M5-40 SHCS holding top plate to the Z-Axis extrusion. Remove the (2) M4-40 SHCS holding front cover to top plate. 
7.	Remove the top plate by pulling away from the Z-axis extrusion. The front cover must be guided carefully while the top plate is removed, ensuring the tape seals move smoothly out of the channels in the Z-axis extrusion and front cover to prevent damage.
8.	Remove the front cover, which is seated on two dowel pins on the bottom plate, and set it aside.

Step	Action
9.	Once the top plate has been moved far enough away from the Z-axis, the tape seals and lower brackets will align near the bottom plate. 
10.	Loosen the (2) M4-25 SHCS on the J2 motor adaptor bracket to allow the motor adaptor bracket to slide up and down.
11.	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. 

Step	Action
12.	After adjusting the tension screw, tighten the M4-25 SHCS to lock the assembly in place. Installation is the reverse of removal.
13.	Ensure that the tape seals are not damaged when re-installed into the channel of the front cover and the Z-axis extrusion.

Tensioning the 2nd Stage Belt

DANGER
Electrical Shock

Removing the rear cover allows access to the AC power terminals. Disconnect the AC power before tensioning the belts.

Tools Required

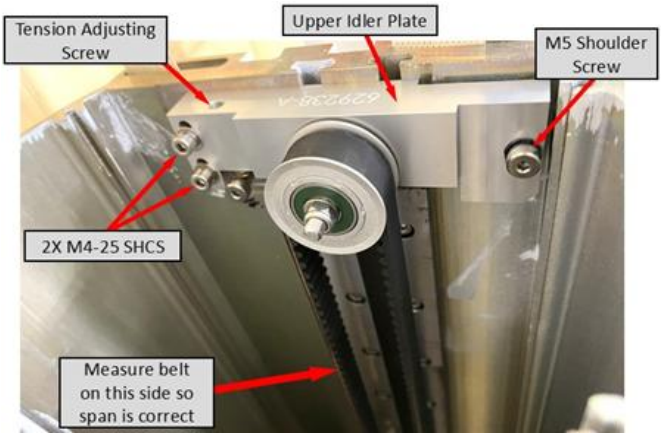
- Gates Sonic Belt Tension Meter
- 2.5 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench

Part Required

- J2 Stage two belt

To tension the 2nd stage belt, perform the following procedure.

Step	Action
1.	Turn off the robot's power, and unplug the AC power cord.
2.	Follow the steps in the previous instructions for Tensioning the 1st Stage Belt to remove top plate and front cover

Step	Action
3.	Loosen the (2) M4-25 SHCS and M5 shoulder screw on the upper idler plate. 
4.	Set the tension to the value in Belt Tensions and the Gates Tension Meter by adjusting the M5 set screw, which pushes on a spring in the Z-axis idler plate.
5.	Re-tighten the three screws and replace the front cover and top plate.
6.	**Alternate Method** For the 750 mm and 1160 mm Z-travel robots, obtaining an accurate tension reading can be challenging because the belt spans are long, measuring 880 mm and 1290 mm respectively, resulting in low vibration frequencies. 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 of the 400 mm Z-stroke when measured on the left side of the belt as shown above. With the carriage positioned to create a 530 mm span, tension can be measured on the right side of the belt for these longer Z-stroke robots, using the tension and frequency values specified for the 400 mm Z-stroke.

Replacing the J2 (Z-Axis) GSB4X

DANGER **Electrical Shock**	
Removing the front cover allows access to the AC power terminals. Disconnect the AC power before replacing the encoder battery.	

Tools Required

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

Parts Required

- GSB4X, PreciseFlex c5, c10, c8a (589629-0001)

To replace the Z axis GSB4X, perform the following procedure. See "Harness Connections and Jumpers for GSB4X" on page 102 for more information.

Step	Action
1.	Turn off power to the robot, and unplug the AC power plug.
2.	Follow the Step 1 through 6 of the procedures above for replacing the encoder battery for the Z-axis to gain access to the GSB4X.

Step	Action
3.	Remove the GSB4X by removing the (4) M3-10 mm SHCS and unplugging the cable harnesses. 
4.	Replace the GSB4X and re-attach the cable harnesses. Restrain harnesses with cable ties so the harnesses are placed in a similar position as before replacement of GSB4X.
5.	Set the jumpers correctly for the address and termination. 

Step	Action
6.	Follow the procedure for Z-axis battery replacement to install the top plate/front cover assembly and tape seals.
7.	Recalibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions. ***NOTE:*** *If the "Encoder Battery Down" error message displays, the robot must be re-calibrated after this procedure.*

Checking the Encoder Batteries Voltage

PreciseFlex c5 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.

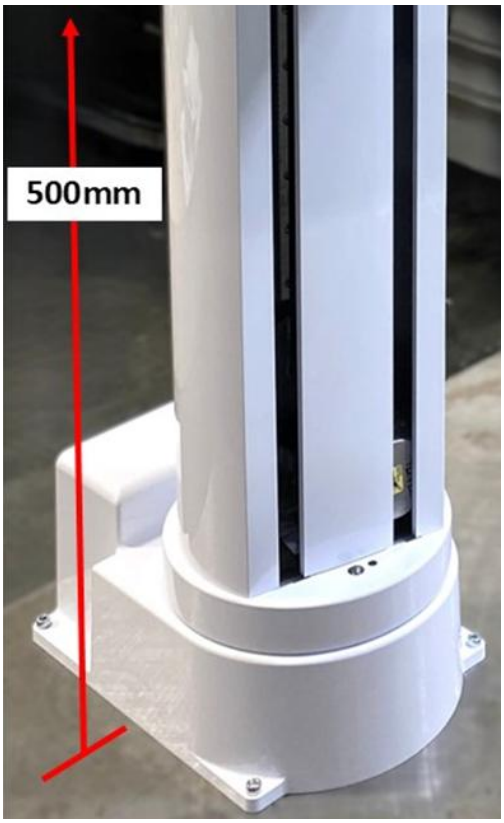
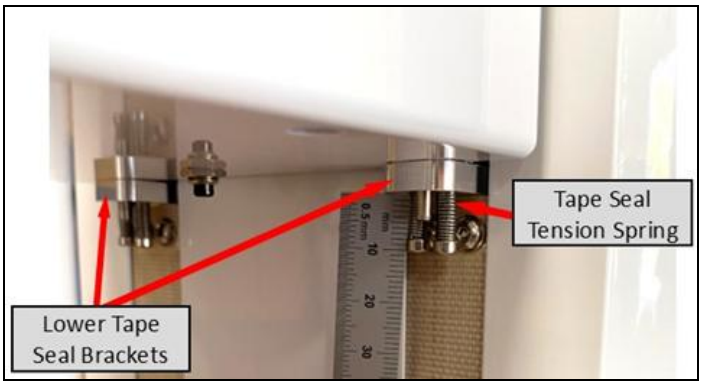
The system monitors the battery voltage. The nominal battery voltage is 3.6 V. When the battery voltage drops to 3.3 V, an error message “Encoder Battery Low” is displayed. At this level, the absolute encoder backup function will still work. However, the battery should be replaced. If the voltage drops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

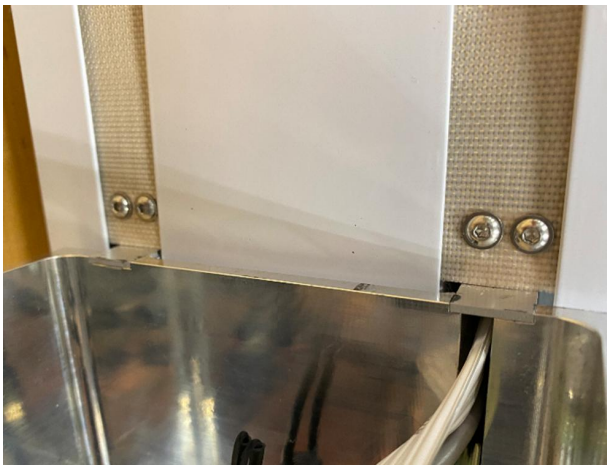
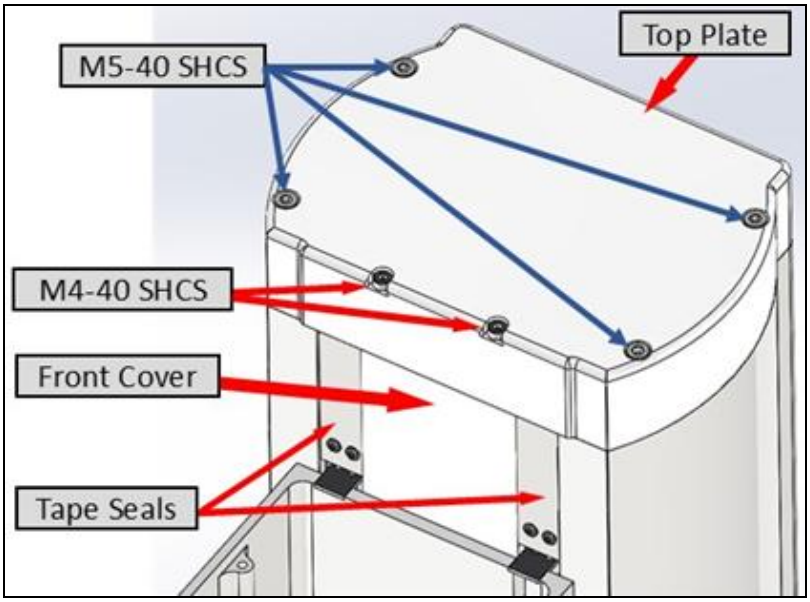
Tools Required

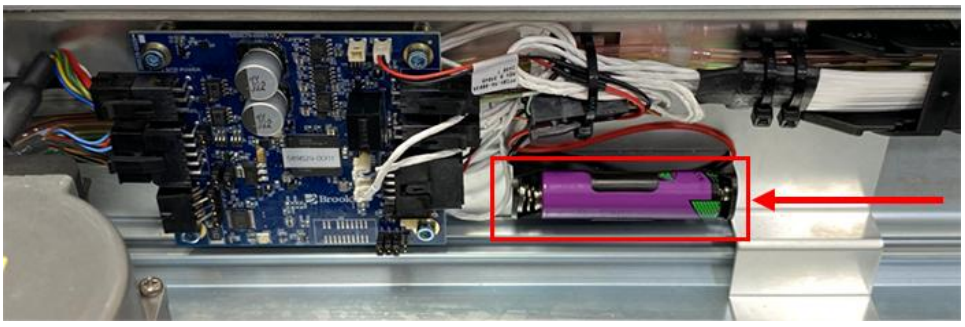
- 2.0 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench
- Voltmeter

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

Step	Action
1.	Turn off the robot's power and unplug the AC power cord.

Step	Action
2.	Move the robot's arm up before accessing the inside of the Z Axis. 
3.	Measure the length of compressed spring on the four screws of the lower tape seal brackets so the tape seal tension can be set properly during reassembly. Remove the (4) M2.5-18 SHCS and (4) springs and slide the lower tape seal brackets off the 3 mm dowel pins on the bottom of inner link. 
4.	Remove the inner link cover, and disconnect the LED connector from the GSB. Set it aside.

Step	Action
5.	Remove the (4) M3-5 BHCS and washers holding the tape seal to the upper brackets on the top side of the inner link. 
6.	Remove the (4) M5-40 SHCS holding top plate to the Z-Axis extrusion. Remove the (2) M4-40 SHCS holding front cover to top plate. 
7.	Remove the top plate by pulling away from the Z-axis extrusion. The front cover must be guided carefully while the top plate is removed, ensuring the tape seals move smoothly out of the channels in the Z-axis extrusion and front cover to prevent damage.
8.	Remove the front cover, which is seated on two dowel pins on the bottom plate, and set it aside.

Step	Action
9.	Once the top plate has been moved far enough away from the Z-axis, the tape seals and lower brackets will align near the bottom plate. 
10.	Locate the battery. **WARNING** **Possible Electrical Damage** If the battery is installed with the incorrect pole orientation, the system will overheat and may damage the board and connectors. Install the replacement battery in the original +/- orientation.  
11.	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. Alternatively, the exposed metal contacts at the ends of the holder can also serve as measurement points.

Step	Action
12.	Installation of the top plate/front cover assembly and tape seals is performed in the reverse order of removal. ***NOTE:*** *Ensure that the tape seals are not damaged when re-installed into the channel of the front cover and the Z-axis extrusion. Set the length of the springs of the tape seal brackets to the measured length from step 3 above.*

If the “Encoder Battery Down” error message displays, the robot must be re-calibrated after this procedure. See Calibrating the Robot: Setting the Encoder Zero Positions. Otherwise, it is not necessary to re-calibrate the robot.

Replacing the J2 Encoder Battery

DANGER
Electrical Shock

Removing the front cover allows access to the AC power terminals. Disconnect the AC power before replacing the encoder battery.	

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. If the battery voltage drops to 3.3 V, an error message “Encoder Battery Low” displays. 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” displays. At this point, the absolute encoder backup function will not work.

NOTE: If any motor or encoder is disconnected from the encoder battery by unplugging the encoder cable, an “Encoder Battery Low” or “Encoder Battery Down” message will appear. In this situation, the encoder battery does not need to be replaced. Only a re-calibration of the robot is required (see Calibrating the Robot: Setting the Encoder Zero Positions.

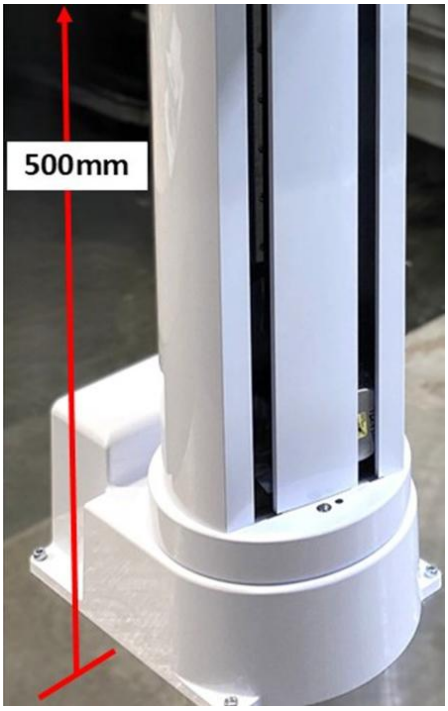
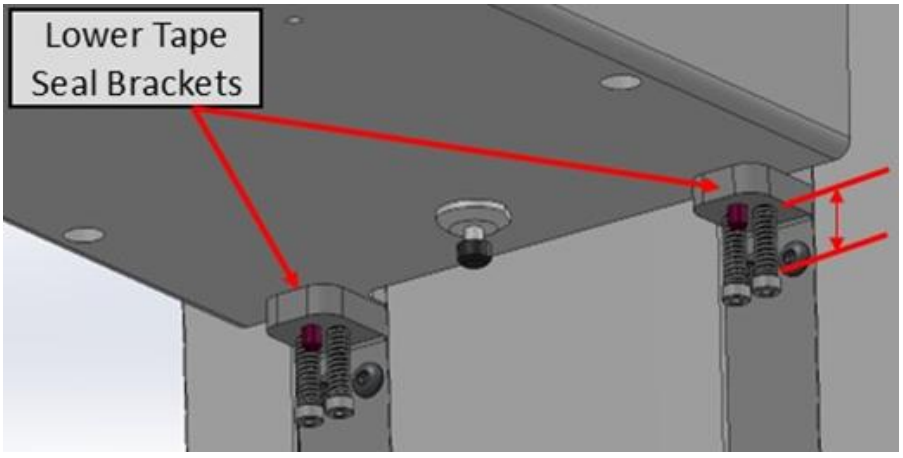
Tools Required

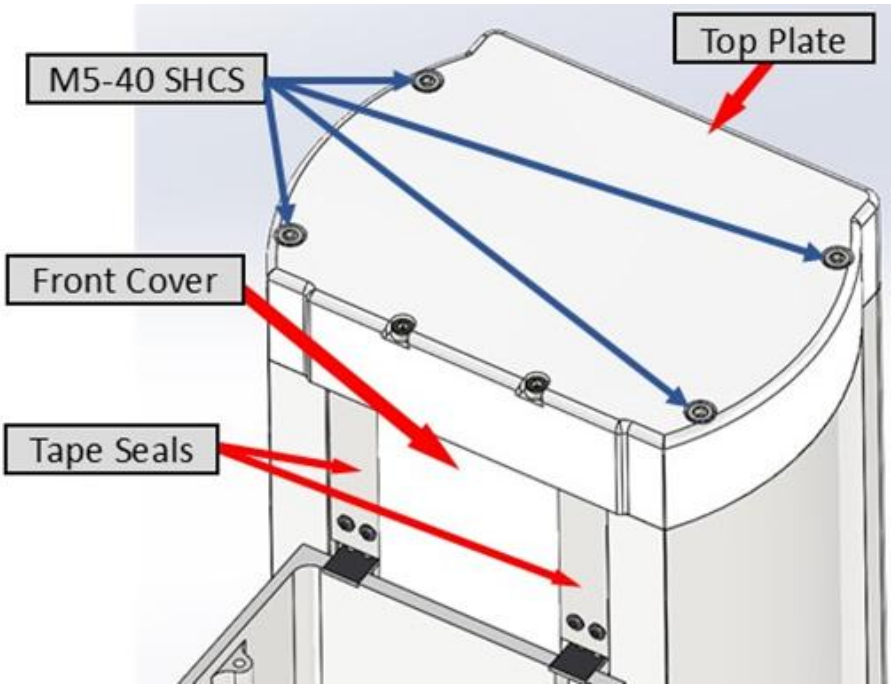
- 2.0 mm hex driver or hex L wrench

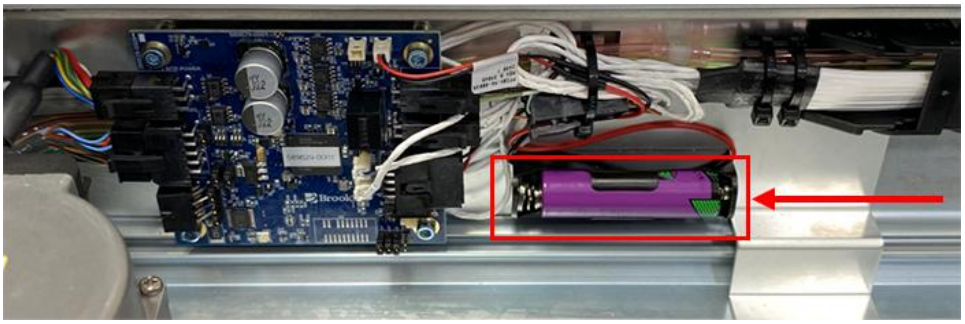
Parts Required

- New encoder battery

To replace the encoder battery for the Z axis, perform the following procedure.

Step	Action
1.	Turn off power to the robot, and unplug the AC power plug.
2.	Raise the arm before accessing the inside of the Z axis. 
3.	Measure the length of compressed spring on the four screws of the lower tape seal brackets so the tape seal tension can be set properly during reassembly. 

Step	Action
4.	Remove the (4) M2.5-18 SHCS and (4) springs and slide the lower tape-seal brackets off the 3 mm dowel pins on the bottom of inner link.
5.	Remove the (4) M5-40 SHCS holding the top plate to the Z-axis extrusion. 
6.	Remove the top plate by pulling it away from the Z-axis extrusion. Guide the front cover carefully while the top plate and front cover assembly is lifted away. Ensure the tape seals are guided out of the channels without damage.

Step	Action
7.	Once the top plate/front cover assembly has been moved far enough away from the Z-axis, the tape seals and lower brackets will be positioned near the base of the Z-axis. 
8.	Replace the battery. ***NOTE:*** *Observe the battery's +/- pole orientation. Put the replacement batteries in the same pole orientation.* **WARNING** **Possible Electrical Damage** If the battery is installed with the incorrect pole orientation, the system will overheat and may damage the board and connectors. Install the replacement battery in the original +/- orientation.  

Step	Action
9.	Installation of the top plate/front cover assembly and tape seals is performed in the reverse order of removal. ***NOTE:*** *Set the length of the springs of the tape seal brackets to the measured length from step 3 above.*

Replacing the J3 Axis GSB4X

For more information on the harness connections and jumpers for J3 Axis GSB4X. see Appendix F.

DANGER Electrical Shock	
Turn off the AC power.	

Tools Required

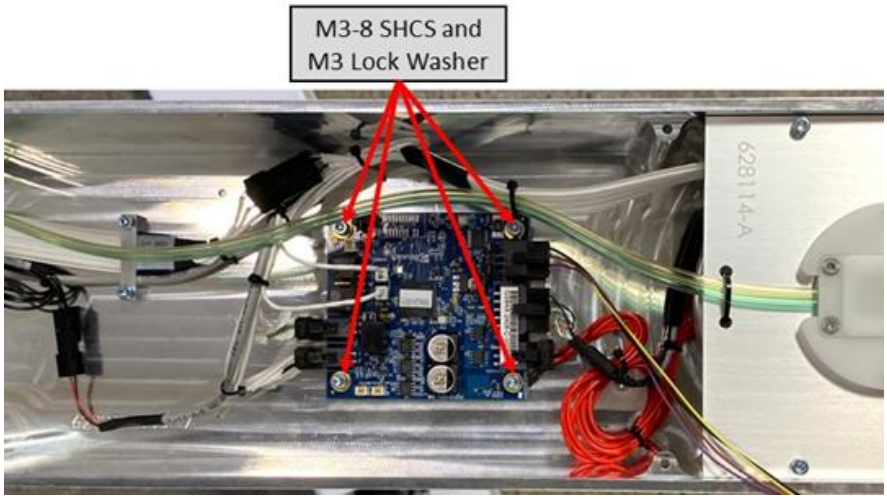
- 2.5 mm hex driver

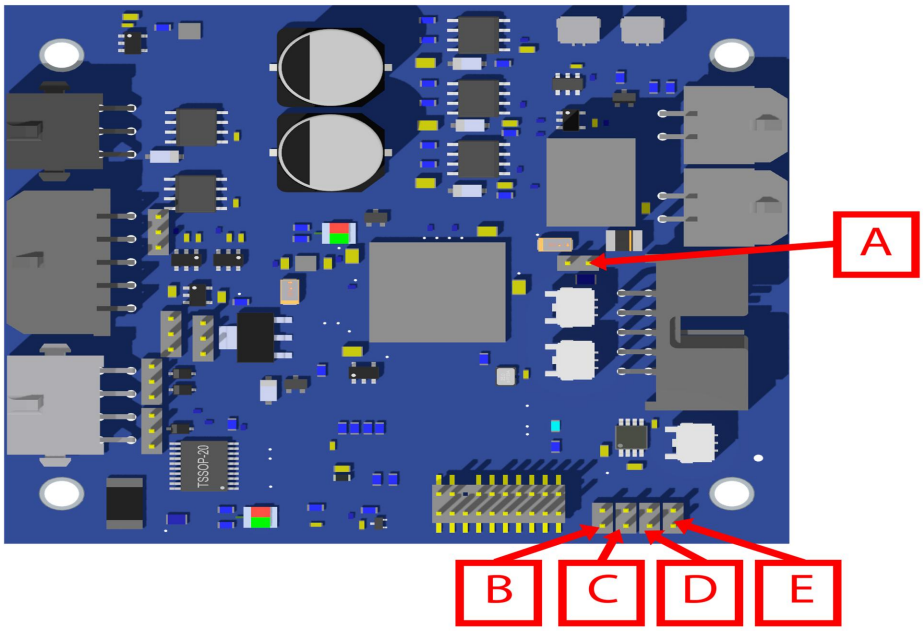
Spare Part Required

- GSB4X, PreciseFlex c5, c10, c8a (589629-0001)

To replace the J3 axis GSB4X, perform the following procedure. See "Harness Connections and Jumpers for GSB4X" on page 102 for more information.

Step	Action
1.	Turn off the robot power and unplug the AC power cord.
2.	Remove the inner link cover by removing the (4) M3-20 SHCS and washers from the bottom.
3.	Disconnect all connectors from the board.

Step	Action
4.	Remove the GSB4X by removing the (4) M3-8 SHCS and M3 lock washers. 
5.	Replace the GSB4X and re-attach the harness.

Step	Action
6.	Set the jumpers correctly for the address (J8 - J11) and termination (J6). J3 is configured as “GSB_3,” with the following jumper settings: • **J6 (Termination):** Out • **J8 (ADDR 1):** In • **J9 (ADDR 2):** Out • **J10 (ADDR 3):** In  A — Termination (J6) B — J11 C — J10 D — J9 E — J8
7.	Re-install the cover with the (4) M3-20 SHCS and lock washers.

Replacing the J4 GSB4X

DANGER Electrical Shock	
Turn off the AC power before replacing any controller.	

Tools Required

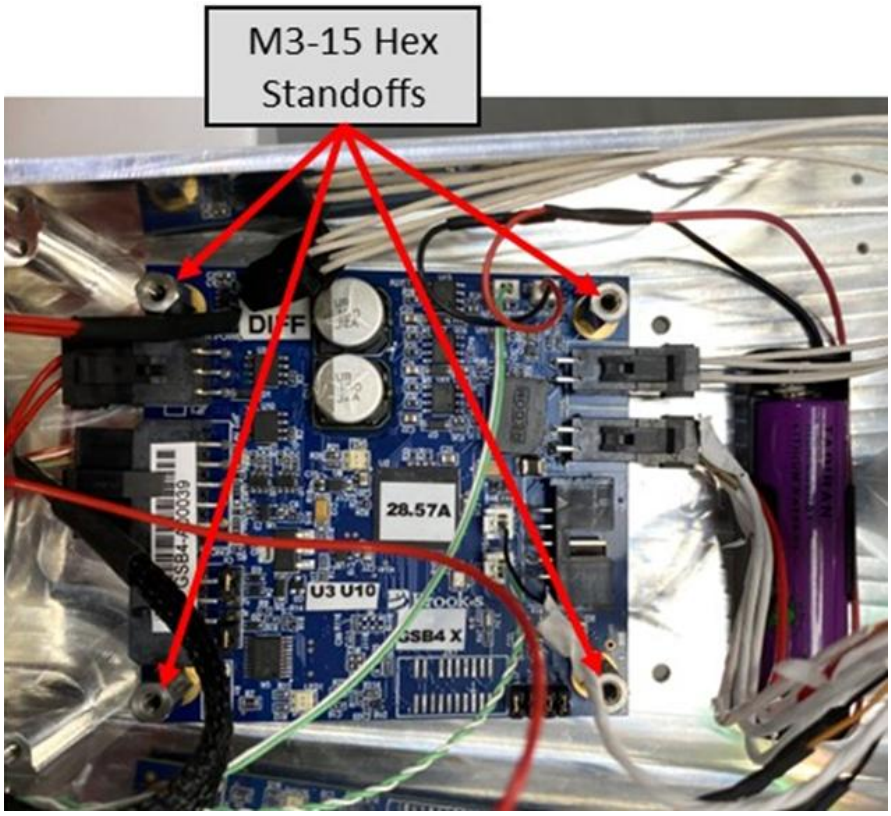
- 2.5 mm hex driver
- 5.5 mm hex driver

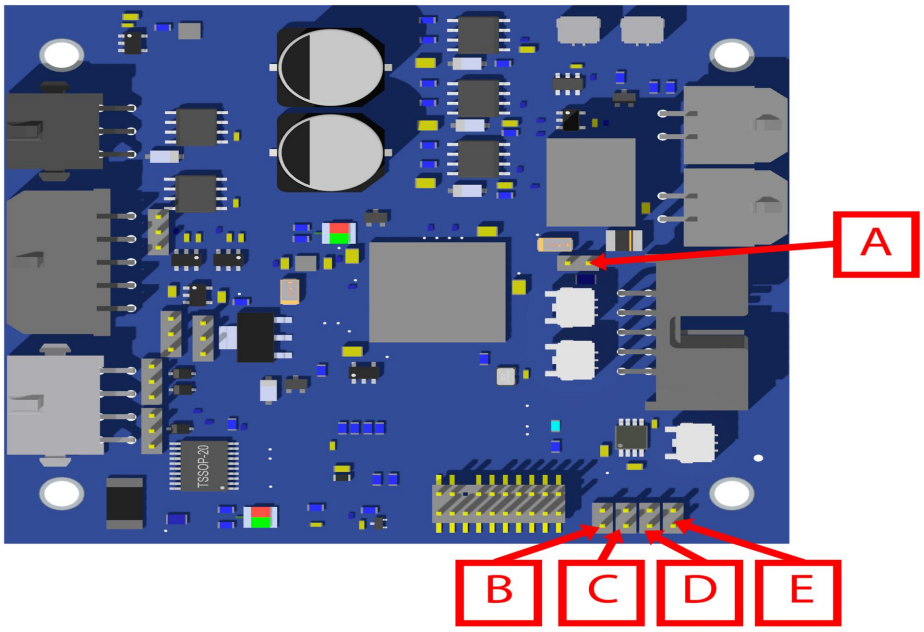
Spare Parts Required

- GSB4X board for J4 axis

To replace the J4 GSB4X, perform the following procedure. See "Harness Connections and Jumpers for GSB4X" on page 102 for more information.

Step	Action
1.	Turn off the robot power and unplug the AC power cord.
2.	Follow the steps in Replacing the Gripper GSB4X to remove the gripper 10A GSB4. Once the gripper 10A GSB4 is removed, the J4 GSB4X is accessible.

Step	Action
3.	Remove the (4) M3 x 15 hex standoffs with the 5.5 mm hex nut driver. 
4.	Disconnect all connectors on the GSB4X, and replace the J4 GSB4X.

Step	Action
5.	Set the jumpers correctly for the address (J8 - J11) and termination (J6). J4 is configured as “GSB_4,” with the following jumper settings: • **J6 (Termination):** Out • **J8 (ADDR 1):** Out • **J9 (ADDR 2):** Out • **J10 (ADDR 3):** In  A: Termination (J6) B: J11 C: J10 D: J9 E: J8
6.	Re-connect all harnesses.
7.	Install gripper GSB4.
8.	Recalibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions
9.	Re-install the cover with (4) M3-20 SHCS and lock washers.

Checking the Encoder Batteries in the Outer Link

DANGER
Electrical Shock

Removing the front cover allows access to the AC power terminals. Disconnect the AC power before replacing the encoder battery.

Tools Required

- 2.5 mm hex driver or hex L wrench
- Voltmeter

To check the encoder battery voltage for the outer link, perform the following procedure:

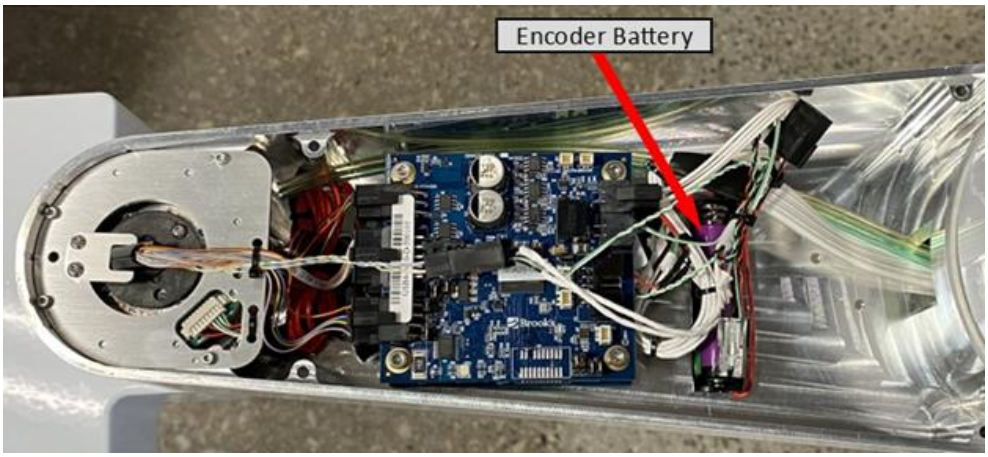
Step	Action
1.	Turn off power to the robot, and unplug the AC power plug.
2.	Remove the outer link cover by removing the (4) M3-20 SHCS and lock washers from the bottom of the cover.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3.</td><td>Locate the battery in the system.

NOTE: Observe the battery's +/- pole orientation. Put the replacement batteries in the same pole orientation.

WARNING
Possible Electrical Damage

If the battery is installed with the incorrect pole orientation, the system will overheat and may damage the board and connectors. Install the replacement battery in the original +/- orientation.

 
</td></tr>
<tr><td>4.</td><td>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.

Alternatively, the exposed metal contacts at the ends of the holder can also serve as measurement points.</td></tr>
<tr><td>5.</td><td>Replace the cover. Do not over tighten the M3-20 screws.</td></tr>
</table>

If the “Encoder Battery Down” error message displays, the robot must be re-calibrated after this procedure. See Calibrating the Robot: Setting the Encoder Zero Positions. Otherwise, it is not necessary to re-calibrate the robot.

Replacing the Encoder Batteries: Outer Link

DANGER
Electrical Shock

Removing the front cover allows access to the AC power terminals. Disconnect the AC power before replacing the encoder battery.

Tools Required

- 2.5 mm hex driver or hex L wrench

Parts Required

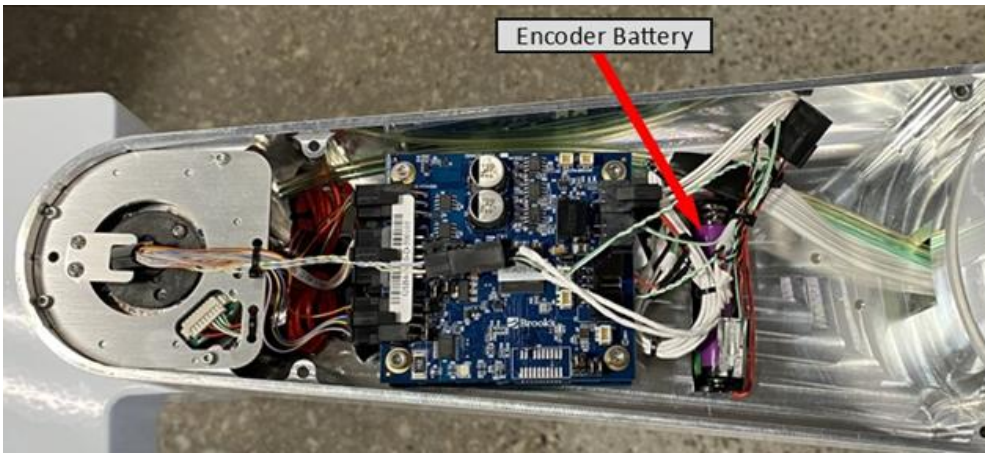
- New encoder battery

To replace the encoder battery for the outer link, perform the following procedure.

Step	Action
1.	Turn off power to the robot, and unplug the AC power plug.
2.	Remove the outer link cover by removing the (4) M3-20 SHCS and lock washers from the bottom of the cover.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3.</td><td>Replace the battery.

NOTE: Observe the battery's +/- pole orientation. Put the replacement batteries in the same pole orientation.

WARNING
Possible Electrical Damage
<table><tr><td>If the battery is installed with the incorrect pole orientation, the system will overheat and may damage the board and connectors. Install the replacement battery in the original +/- orientation.</td><td>  </td></tr></table>
 
</td></tr>
<tr><td>4.</td><td>Replace the cover. Do not over tighten the M3-20 screws.</td></tr>
</table>

If the “Encoder Battery Down” error message displays, the robot must be re-calibrated after this procedure. See Calibrating the Robot: Setting the Encoder Zero Positions. Otherwise, it is not necessary to re-calibrate the robot.

Replacing the Gripper GSB4X

DANGER Electrical Shock	
Turn off the AC power before replacing any controller.	

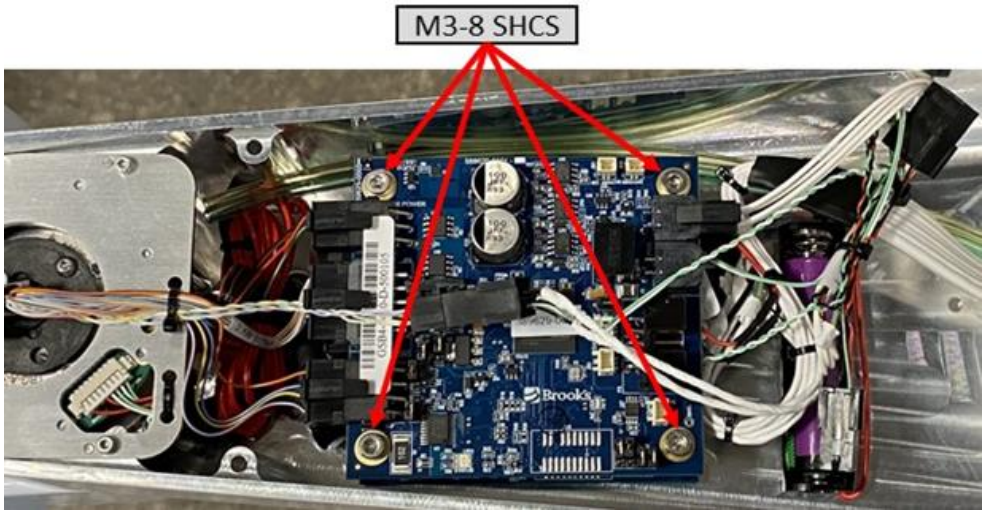
Tools Required

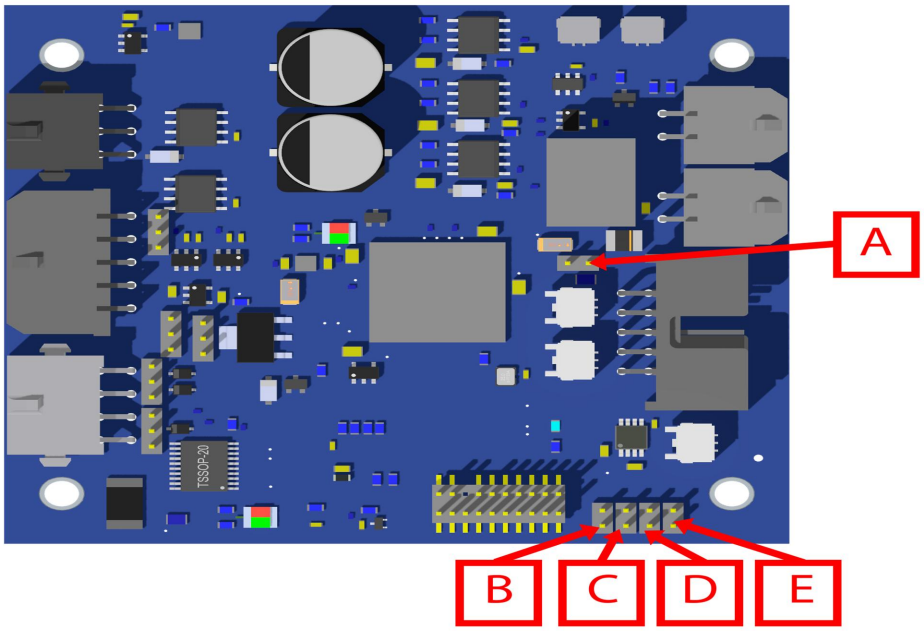
- 2.5 mm hex driver
- 5.5 mm hex driver

Spare Parts Required

- GSB4X, PreciseFlex c5, c10, c8a (589629-0001)

To replace the gripper GSB4, perform the following procedure. See "Harness Connections and Jumpers for GSB4X" on page 102 for more information.

Step	Action
1.	Turn off the robot's power, and unplug the AC power cord.
2.	Remove the outer link cover by removing the (4) M3-20 SHCS and washers.
3.	Disconnect all connectors on the GSB4.
4.	Remove the (4) M3 x 8 SHCS and replace the gripper 10A GSB4X. 

Step	Action
5.	Set the jumpers correctly for the address (J8 - J11) and termination (J6). J3 is configured as “GSB_4,” with the following jumper settings: • **J6 (Termination):** Out • **J8 (ADDR 1):** Out • **J9 (ADDR 2):** Out • **J10 (ADDR 3):** In  A — Termination (J6) B — J11 C — J10 D — J9 E — J8
6.	Recalibrate the robot. See Calibrating the Robot: Setting the Encoder Zero Positions
7.	Re-install the cover with (4) M3-20 SHCS and lock washers.

Solenoid Installation Procedure

NOTE: This procedure is not compatible if an IntelliGuide gripper is installed.

DANGER
Electrical Shock

Disconnect the AC power before replacing the motor assembly.	

Tools Required

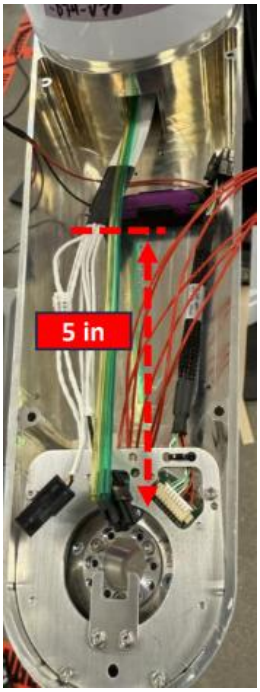
- 2.5 mm hex driver or hex L wrench
- 3.0 mm hex driver or hex L wrench
- 4.0 mm hex driver or hex L wrench
- Loctite 243

Parts Required

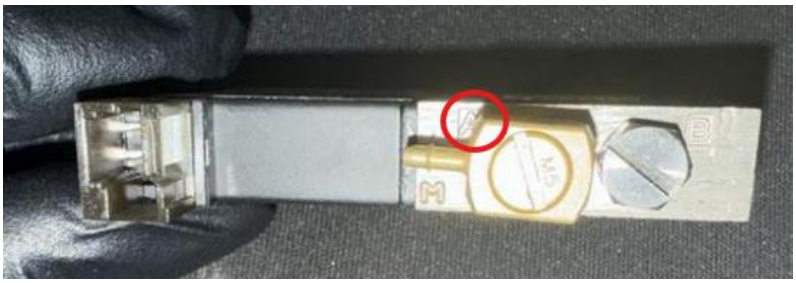
- Pneumatics-dual valve for PreciseFlex c5 (668140)

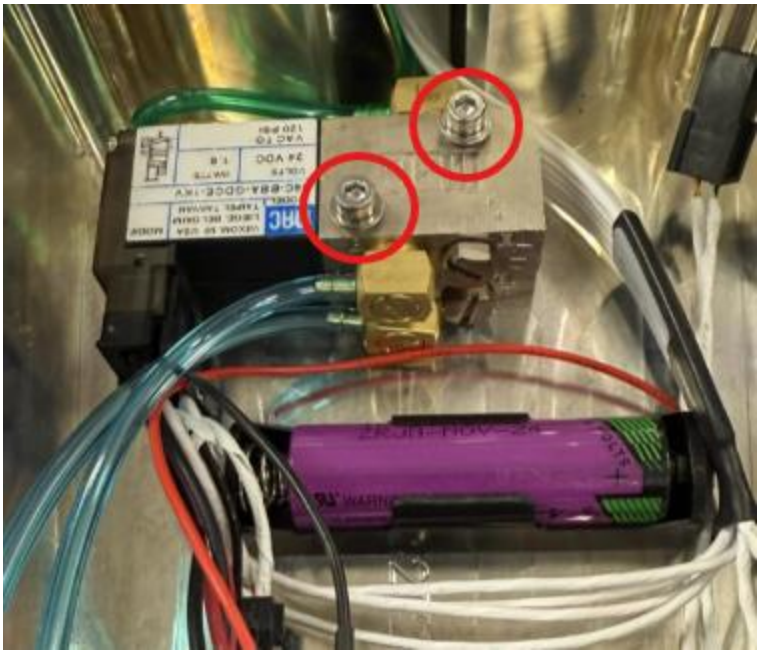
Step	Action
1.	Prepare the solenoid valves by removing the barb fittings from both solenoid kits at the locations marked “B” and installing the specified M5 air plugs in their place.  

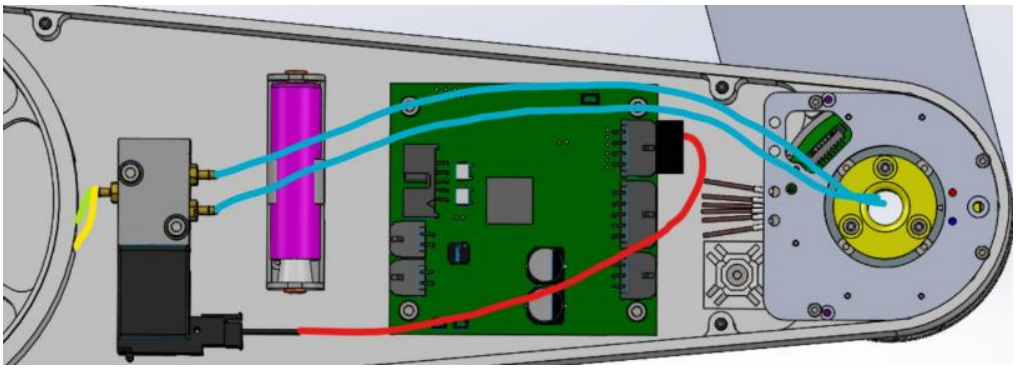
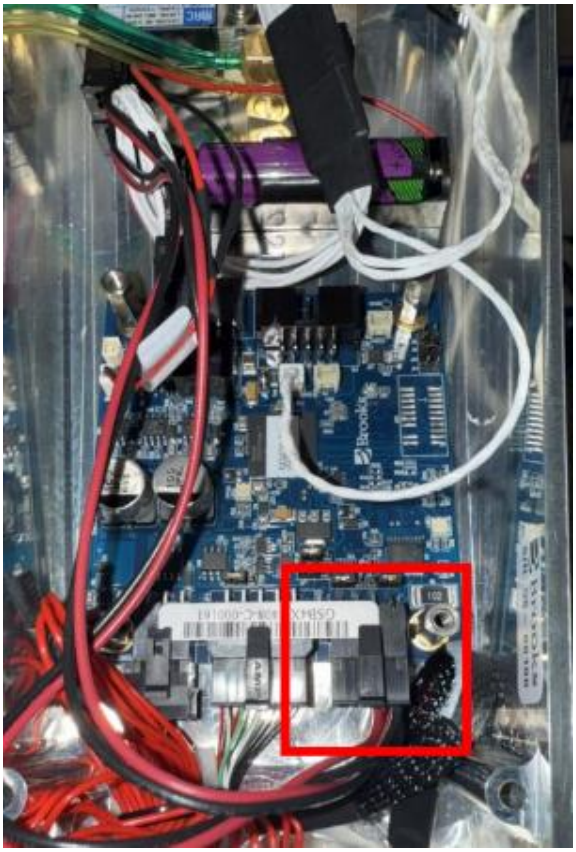
Step	Action
2.	Connect the solenoid electrical harness by attaching the dual valve cable to both solenoid kits, ensuring all connectors are fully seated. 
3.	Remove the outer link cover by removing the (4) M3-20 SHCS and washers.

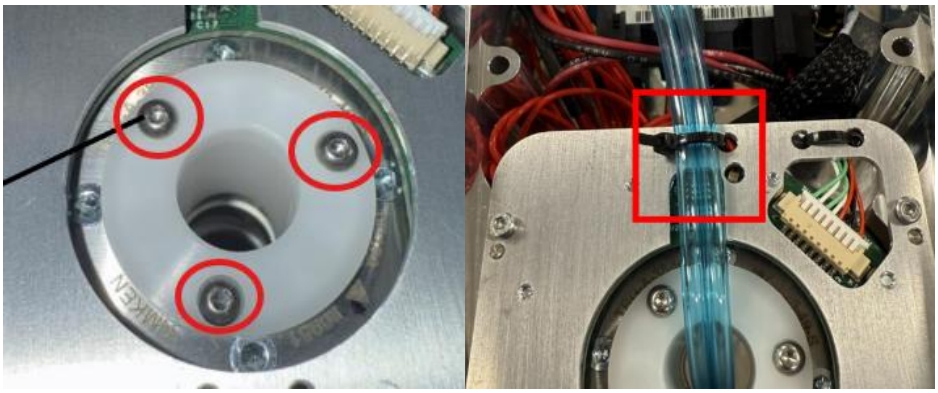
Step	Action
4.	Prepare the pneumatic tubing by cutting the (2) blue pneumatic tubes to a length of 15 in (381 mm) for use as output air lines and trimming the existing yellow and green input air lines by 5 in (127 mm). 

Step	Action
5.	Connect the input air lines by attaching the yellow and green pneumatic tubes to the solenoid ports marked “IN.” 

Step	Action
6.	Connect the output air lines by attaching both blue pneumatic tubes to the solenoid ports adjacent to the air plug marked “A.”  

Step	Action
7.	Mount the solenoid assemblies by routing the yellow and green input air lines between the J3 area and the solenoid location, stacking the solenoid kits, and securing them together using (2) M3-25 socket head cap screws with (2) flat washers and (1) lock washers, applying Loctite 222 to each fastener. 

Step	Action
8.	Connect the solenoid assembly to the controller by plugging the 8-pin connector of the dual valve cable into JP3 (IO) on the GSB4X board.  

Step	Action
9.	Install the J4 output bushing by securing the short J4 bushing with the (3) M2.5-4 button head screws, routing the blue output air line through the bushing, and securing the tubing (PF00-MC-X0086) with a cable tie. 

Encoder Operation Error

PreciseFlex c5 robots are equipped with absolute encoders that keep track of the robot position even when AC power to the robot is disconnected.

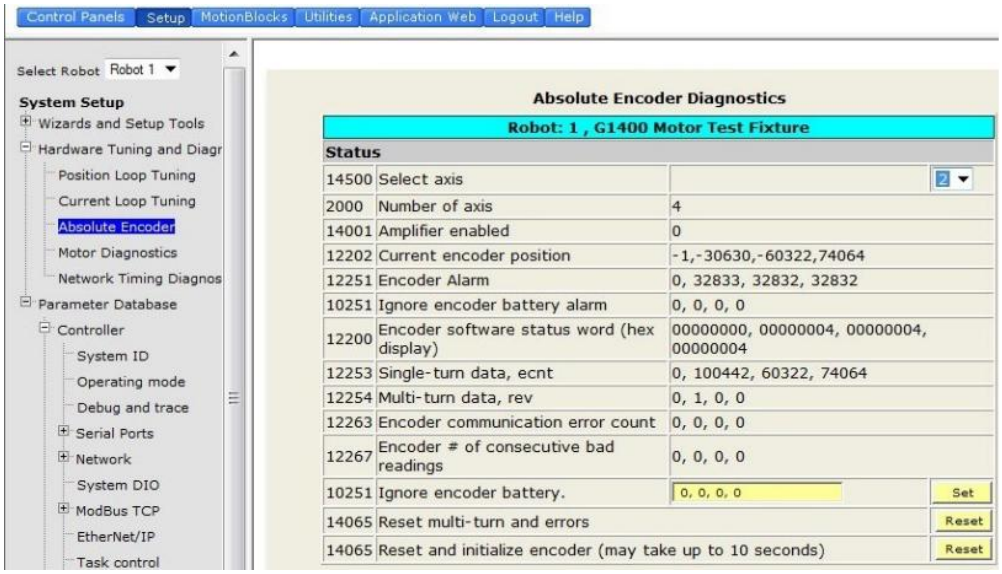
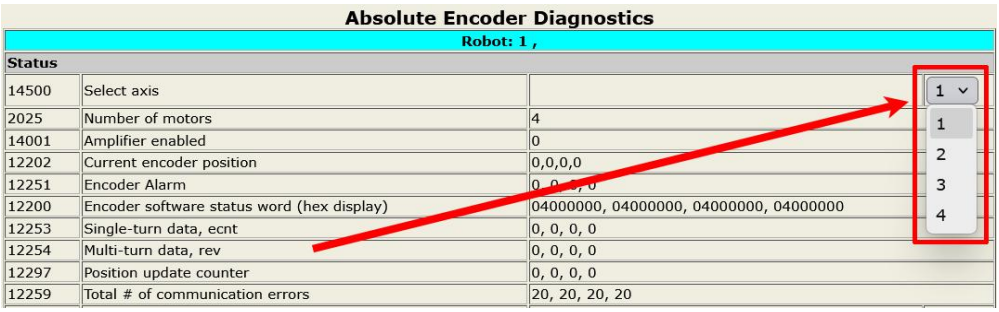
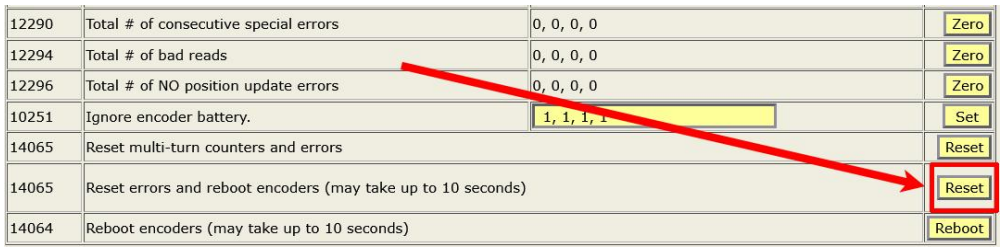
> ***NOTE:*** There are batteries in the back of the Z column of the robot and outer link that provides standby power to the encoders for the Z axis and outer link motors.

However, if an IntelliGuide gripper is installed on the PreciseFlex c5, the GSB4 associated with this gripper will be mounted in the outer link and will need a battery installed. 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^2. Even at 100% speeds the robot joints normally do not move faster than about 2,200 rpm and 1900 rad/s^2. 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 be displayed in the controller browser interface as “Encoder Operation Error” Robot 1: <axis number>.

Assuming the robot has not been damaged by the shipping process, reset this error by performing the following procedure.

Step	Action
1.	Open the controller browser.

Step	Action
2.	Go to **Admin > Setup > Hardware Tuning and Diagnostics > Absolute Encoder**. 
3.	In the drop-down menu at the top right of the screen, select the robot axis associated with the error. 
4.	Check to see if the "Overspeed" panel is yellow. 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 **Reset errors and robot encoder**. This button resets error flags, but does NOT reset the encoder counters. The robot can then be homed normally. 

Step	Action
5.	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 a good idea to move the robot to the calibration position (using the calibration pins if desired-see Calibrating the Robot) or another known position, and check the joint angles in the Virtual Pendant in the Web Operator Interface. See the Calibration Procedure in Calibrating the Robot: Setting the Encoder Zero Positions for the joint angles in the Calibration Position.
6.	If the robot joints after this procedure followed by homing are different from the above, then the robot needs to be re-calibrated. See the procedure in 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. Refer to the *PreciseFlex Library* to search for a specific error message and cause. Listed below are a few errors that may be generated by hardware failures.

Symptom	Recommended Action
System Error Message Generated	
E-stop not enabled	Check 9-pin D-sub for E-stop jumpers and E-stop D-sub plugged in.
Encoder battery low	Replace absolute encoder battery on back of column or outer link.
Encoder battery down	If encoder cable has been disconnected, recalibrate robot. If battery voltage has dropped below 2.5 V replace encoder battery and recalibrate robot.
Encoder operation error	Joint rotated too quickly with power off.
Encoder data, accel/decel limit error	Encoder cable may be damaged and encoder is getting intermittent communication, causing apparent jumps in position. Check encoder connectors. Replace motor/encoder or encoder only on DD axes.
Encoder communication error	Check encoder connectors. 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" above.
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 the robot. Check the energy dump PCA. Replace the 48 V supply.
Amplifier fault	Check harness and motor for shorts.
Amplifier over voltage	Check energy dump resistor is connected. 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.

Symptom	Recommended Action
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, check for free motion. If OK replace slip ring.
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 Updating Robot PAC Files.
Physical or Audible Problem	
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 the belt.
Loud buzzing or vibration from any joint	Re-tension the timing belts. If the timing belt will not hold tension, replace it.
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: Unpacking and Mounting the Robot

PreciseFlex robots are shipped in wooden crates with international ratings and foam inserts to protect the robots. Additionally, there is an accessory box in the box that contains:

- Power cables for North America, UK, and Europe
- One Ethernet cable
- Four M6 socket head cap screw (SHCS) mounting screws
- One M6 calibration pin.

The robots weigh 25 kg or more, so two persons should move the robot to the installation location.

CAUTION

Heavy Lift Hazard

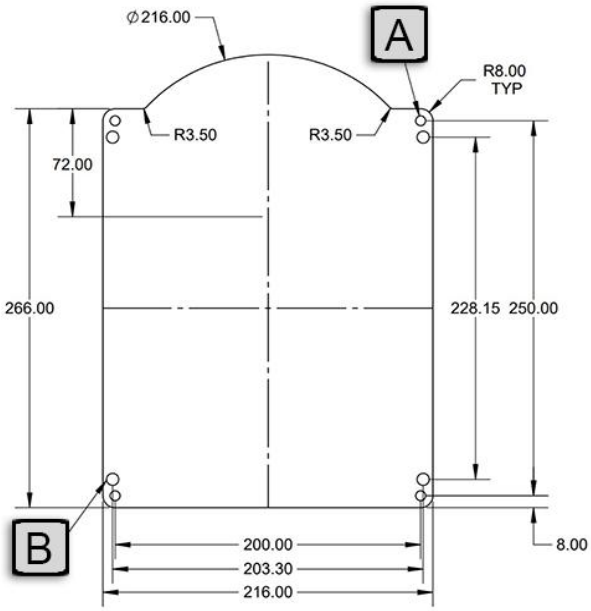
Failure to take the proper precautions before moving the robot could result in back injury and muscle strain.

- Use a lifting device and cart rated for the weight of the drive or arm.
- Only persons certified in operating lifting device should move it.

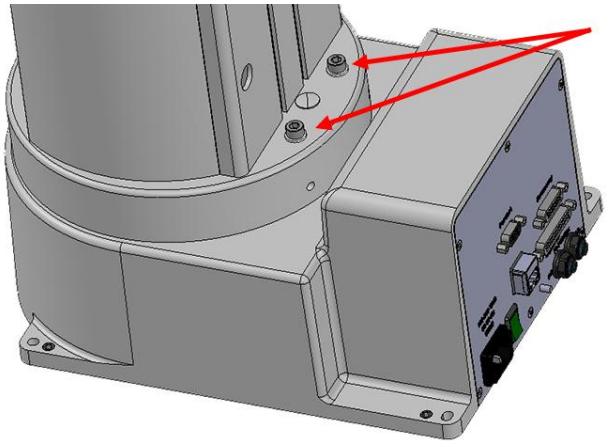
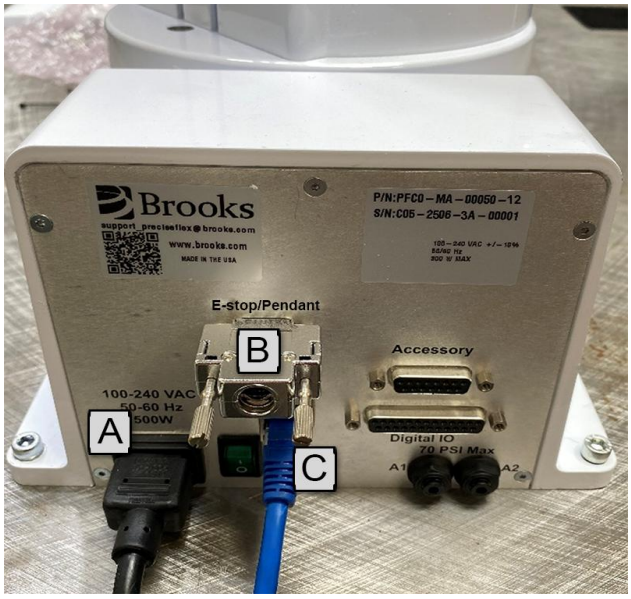
CAUTION

Damage to Components

Applying pressure to the tape seals can result in damage. Handle the area carefully.

Step	Action
1.	Prepare the robot mounting surface. Locate the clearance holes (A) on robot base for the M6 screws, in four places. Screw in the M8 leveling set screws (B) in four places 
2.	Unlatch the crate latches on all four sides of the crate and remove the crate top. 

Step	Action
3.	Using two people or more, lift the PreciseFlex robot out of the crate, remove the plastic wrapping, and carry the PreciseFlex robot to the installation location. 
4.	Set the PreciseFlex robot on the mounting surface and secure it with the four M6 screws. Keep the PreciseFlex robot supported until it is secured to the mounting surface. 

Step	Action
5.	After the PreciseFlex robot is securely mounted, remove the two anti-rotation M6-45 SHCS and two M6 Nylon washers. Retain these screws in case the PreciseFlex robot is shipped to a different location in the future. ***NOTE:*** *Remove the screws before operating the PreciseFlex robot. Always install the screws before lifting and moving the PreciseFlex robot* 
6.	Plug in the: • Power cable (A) • E-stop jumper (B) • Ethernet cable (C) 

Step	Action
7.	Remove the Velcro strap that restrains the arm. 

Appendix B: PreciseFlex c5 Robot Specifications

General Specifications

General Specification	Range
PERFORMANCE	
Payload (without gripper)	Max: 5.0 kg Rated: 3.0 kg
Max Speed at TCP	Horizontal: 1500 mm/sec Vertical: 600 mm/sec
Typical Speed at TCP	Horizontal: 750 - 1000 mm/sec
Max Joint Speed	J1 - 200°/sec J2 - 600 mm/sec J3 - 360°/sec J4 - 360°/sec
Max Acceleration	1500 mm/sec^2
Repeatability	± 0.050 mm at tool flange center
RANGE OF MOTION	
Joint 1 (base)	± 168°
Joint 2 (Z-axis)	400, 750, 1160 mm
Joint 3 (Elbow)	+10.5° to +349.5°
Joint 4	±962°
Horizontal Reach	719 mm to Tool Center Point (TCP) IntelliGuide grippers add 68.7 mm
COMMUNICATIONS	
General	100 Mb Ethernet, TCP/IP EtherNet/IP Modbus/TCP RS-232 at end-of-arm
Operator Interface	Browser-based operator interface
Digital I/O	12 inputs at 24 V 8 outputs (100 mA) at 24 V
FACILITIES	

General Specification	Range
Power	100-264 VAC, auto selecting, 50-60 Hz 100-175 watts typical operation DC power option available
E-stop	Dual channel
Controller Type	Embedded into robot base
Weight – w/o Gripper (does not include packaging)	400 mm Z-axis: 28.8 kg 750 mm Z-axis: 34.5 kg 1160 mm Z-axis: 41.9 kg
Noise Level	50db or less (LAF50)
SOFTWARE	
Programming	• *GP Flow* for no-code, point-and-click application builder • *TCS API* for controlling robot from work flow, scheduling software • *GPL (Guidance Programming Language)*: full-featured object-oriented programming language. • Programming via *Guidance Development Studio (GDS)*
Enhanced Functions	Hand-guided teaching
PERIPHERALS AND ACCESSORIES	
General	IntelliGuide s23 Servo Gripper IntelliGuide s60 Servo Gripper IntelliGuide s23D Servo Gripper (dual)
Vision	IntelliGuide v23 Vision Gripper IntelliGuide v60 Vision Gripper
Linear Rail	1.0, 1.5, and 2.0 meters travel (optional)
Pneumatics	Two 3.2 mm OD (1.7 mm ID) airlines provided for end-of-arm-tooling. 4.9 bar max (71 PSI)

Environmental Specifications

The PreciseFlex c5 Robots must be installed in a non-condensing environment with the specifications from the table below.

General Specification	Range & Features
Indoor use only	
Ambient temperature	0° C to 40° C
Storage and shipment temperature	-25º C to +55º C
Relative Humidity	10 to 75%, non-condensing, non-corrosive
Altitude	Up to 3000 m
Voltage	100-240 VAC +/- 10%, 50/60 Hz
Mains cord rating, min	16AWG, 3 conductor, 10 Amps min
Pollution Degree	2
Approved Cleaning Agents	IPA, 70% Ethanol/30% water H2O2 Vapor up to 1000 ppm
IP Rating with Tape Seal Option	52
IP Rating without Tape Seal Option	11
IK Impact Rating	IK08: 5 Joule

Appendix C: Spare Parts List

NOTE: For help replacing spare parts, email support_preciseflex@brooks.com

Description	Part Number
Cable, DC Interconnect, PreciseFlex c5	621242
Cable, AC Main, PreciseFlex c5	621361
Cable, 48 VDC Enable, PreciseFlex c5	625321
Harness, Dump Resistor, PreciseFlex c5	625322
Guidance Controller, PFD0X3	890242-0001
GSB4X, PreciseFlex c5, c10, c8a	589629-0001
LED PCBA, PreciseFlex c5	650877-0001
Power supply, 24 VDC, 150 W	PS10-EP-24150
Power supply, 48 VDC, 500W	605889
Tape Seal, Single, 400 mm travel, PreciseFlex c5	629984-0001
Tape Seal, Single, 750 mm travel, PreciseFlex c5	629984-0002
Tape Seal, Single, 1160 mm travel, PreciseFlex c5	629984-0003
J2 Motor, PreciseFlex c5	628854
Belt, J2, 400 mm, PreciseFlex c5	PF00-MC-X0023-7
Belt, J2, 750 mm, PreciseFlex c5	PF00-MC-X0023-8
Belt, J2, 1160 mm, PreciseFlex c5	PF00-MC-X0023-9
Cover, Z-axis, 400 mm, PreciseFlex c5	PF00-MA-10002-696-1
Cover, Z-axis, 750 mm, PreciseFlex c5	PF00-MA-10002-1046-1
Cover, Z-axis, 1160 mm, PreciseFlex c5	PF00-MA-10002-1456-1
Cover, Inner Link, PreciseFlex c5	628117-0001
Cover, Outer Link, PreciseFlex c5	628197-0011
Brake Release Switch	389631
Calibration Pin, J1, M6x70	91585A738 (McMaster-Carr)
Calibration Pin, J4, M3x32	91585A423 (McMaster-Carr)
Slip Rings	See IntelliGuide Spares List

Appendix D: Belt Tensions and the Gates Tension Meter

In some cases, it may be desirable to confirm the belt tension of one of the axes in the PreciseFlex robot. If it appears a belt tension is not correct, the tension can be checked with a Gates Sonic Tension Meter, Model 507C, 508C, or 550C.

Gates 550C Sonic Tension Meter

To use the tension meter, follow the procedure below.

Step	Action
1.	Turn on the power.
2.	Click **Mass** and enter the belt mass from the table below.
3.	Click **Width** and enter the belt width from the table below.

Step	Action
4.	Click **Span** and enter the belt free span from the table below.
5.	Click **Select** to record the data.
6.	Click **Measure** to take a tension reading.
7.	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.

Belt Tensions

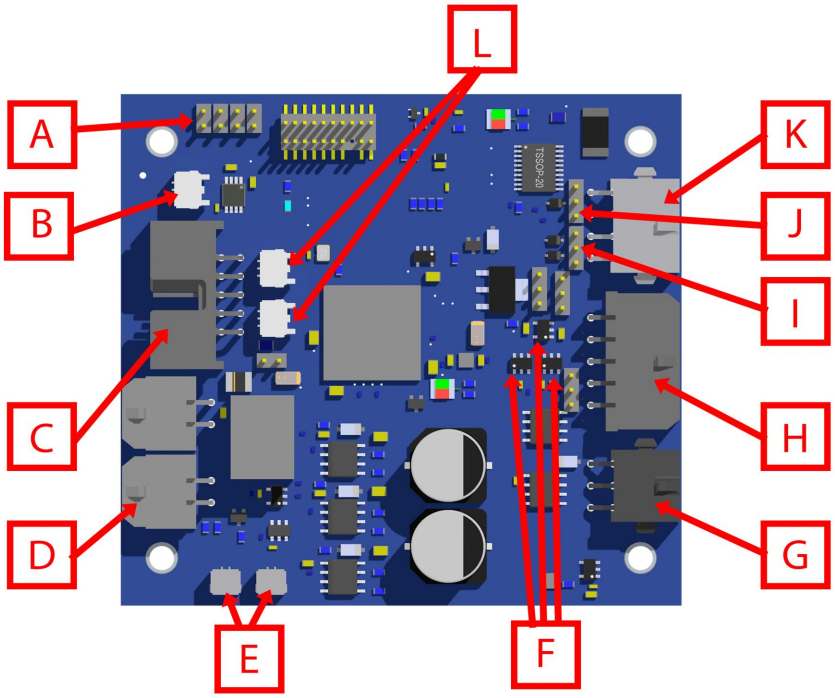
Axis	Mass (g)	Width (mm)	Span (mm)	Tension (N)
Z-Axis S2 - 500	4.8	14	620	400 - 420
Z-Axis S2 - 1000	4.8	14	1120	400 - 420
Z-Axis S2 - 1420	4.8	14	1540	400 - 420

Appendix E: Preventative Maintenance

Every one to two years, perform the following preventative maintenance procedures. For PreciseFlex robots that are continuously moving 24 hours per day, 7 days a week at moderate to high speeds, a one-year schedule is recommended. For PreciseFlex robots with low duty cycles and low to moderate speeds, these procedures should be performed at least once every two years.

	Procedure If Problem Detected
Check Z-axis belt tensions.	Re-tension if necessary.
Check the air harness tubing in the elbow if present, and the theta axis for any wear.	Replace if necessary.
Check the Z-axis belt for squeaking.	If noisy, add thick grease to front and rear edge of 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 the 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 Encoder Battery Level	Recommended when checking Z-axis Belt Tension.
Replace Slip Ring for IntelliGuide Grippers	Replace every 3rd PM cycle or 20,000 hours of operation.

Appendix F: Harness Connections and Jumpers for GSB4X



Letter	Description
A	Address Jumpers
B	RS232 Com1
C	RS485 Connector
D	24/48 VDC
E	Battery Connectors
F	Encoder Configuration Jumpers ***NOTE:*** *For the GSB4 configuration see the IntelliGuide Gripper Service Manual.*
G	Motor Power Connector
H	Encoder Connector
I	Serial Connection
J	Serial Connection
K	Digital I/O
L	RS485 Termination

Appendix G: Safety Circuits

NOTE: Note: (2 kg robot has redundant E-stop and 48 V power supply enabled)

	Safety Circuit	Startup Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety
1	Estop	Yes	Yes	Yes	99%	100	Yes	d	4

- Startup test forces E-stop, checks 48 V power disable, zero amp current.
- Dual E-stop circuits turn off amp enable and PWM.
- Dual E-stop circuits turn off 48 V power.
- Stopping robot with hand turns off amp enable, PWM, and 48 V.

	Safety Circuit	Startup Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety
2	Encoder Feedback	Yes	No	Yes	90%	59	Yes	d	4

- Start-up test checks encoder communication, prevents motor power if fault.
- Serial update at 8 kHz w checksum, comm check, accel check.
- Counter embedded in position word to confirm CPU read from FPGA,

	Safety Circuit	Startup Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety
3	CPU Monitor	Yes	Yes	Yes	99%	100	Yes	d	4

- Startup test forces CPU WD low, checks 48 V power disabled.
- Independent dual watchdog timers turn off amp enable, PWM and 48 V.
- Processor on safety board monitors main CPU. Disables 48 V if failure.

	Safety Circuit	Startup Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety

4	Position Envelope Error	Yes	Yes	Yes	90%	59	Yes	d	4

- Start-up test checks encoder communication, prevents motor power if fault.
- Serial update at 8 kHz w checksum, comm check, accel check.
- SW watchdog in servo loop turns off amp enable, PWM and 48 V.
- Counter embedded in position word to confirm CPU read from FPGA.

	Safety Circuit	Startup Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety
5	Power amp Fault	Yes	Yes	Yes	90%	100	Yes	d	4

- Startup test confirms zero current when motor power enabled (phase offset test).
- Excess current to ground or phase to phase triggers shutdown in 1 µs.
- Saturated PID current command triggers shutdown in .050 sec.
- Shorted transistor just locks up brushless motor.

	Safety Circuit	Start up Test 1	Redundant	Continuous Test	Diagnostic Coverage	MTTFdl, Years	Power Off On Failure	PL	Category Safety
6	Collab Force Limit	Yes	Yes	Yes	90%	SW	Yes	d	4

- Tests 2, 3, 4, 5 above test HW.
- Position envelope error triggers fault, turns off power at amp and 48 V.
- Current saturation triggers separate fault, turns off power at amp and 48 V.
- Monitor function with WD turns off power at amp and 48 V.
- Monitor and CPU WD tested at startup turning off 48 V.
- Asymmetric current limits limit Z force even with gravity load.

Appendix H: Electrical System Overview

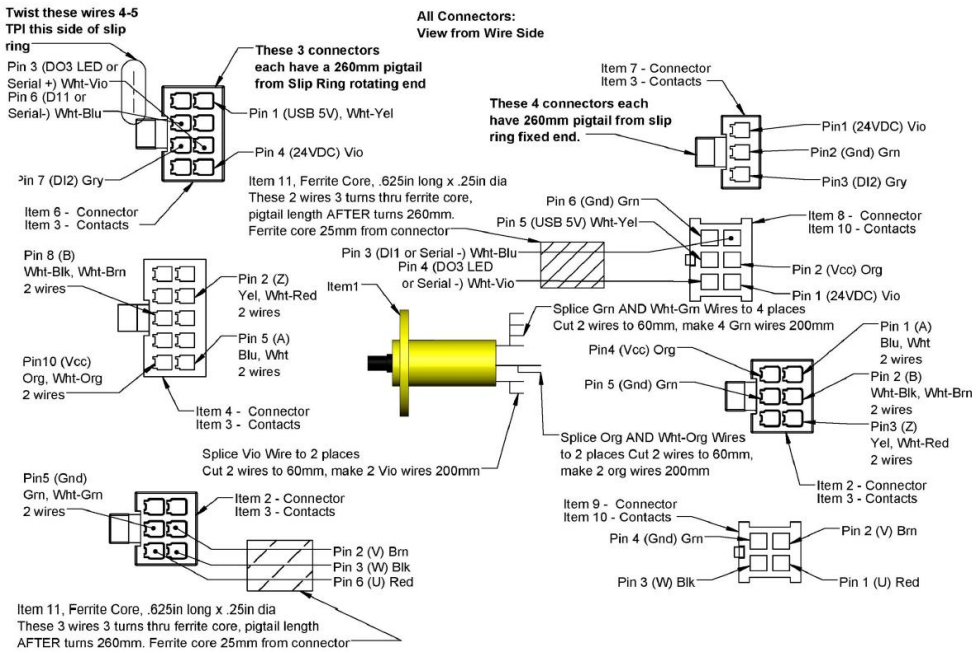
The robot has a 24 VDC and 48 VDC power supply located in the Z column. The power supplies have both over-current and over-voltage protection and are CSA, UL, and CE certified. The robot controller and electric gripper are powered by the 24 VDC supply. The main robot motors are powered by the 48 VDC supply. The 48 VDC supply is protected against over voltage bus pump up by an energy dump circuit, which connects a 75-Watt dump resistor located in the base housing 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 the controllers through a ribbon cable, which also contains three twisted pairs for RS-485 (one pair) and 100 BaseT Ethernet (two pairs).

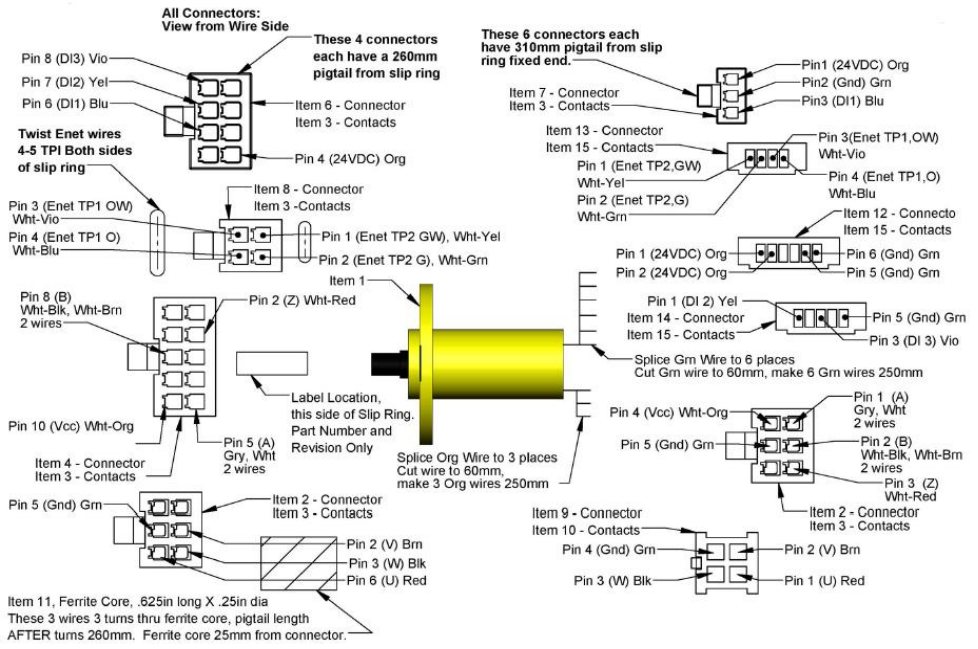
Twelve digital input and eight digital output signals from the main robot controller are available in the 25-pin D-sub on the connector panel in the base. The twelve digital output signals can be individually configured as either sourcing or sinking by software settings in the web interface. The eight digital input signals can be configured as either sourcing or sinking individually and the twelve digital inputs can be configured as sourcing or sinking in blocks of four by software settings in the web interface.

It is necessary to wire an emergency stop button to the controller. This button may be wired in series with other emergency stop contacts. The E-stop signals are available in the manual control pendant 9-pin D-sub connector that is mounted on the facilities panel. The robot is shipped with a jumper that completes the dual E-stop circuits.

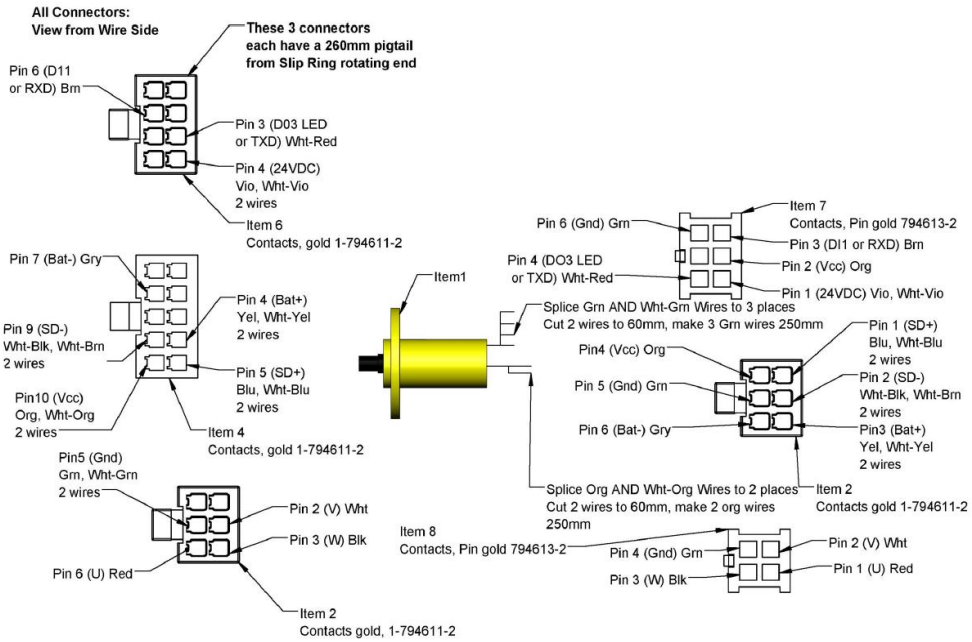
The cable from the brake release button under the shoulder plugs into the amplifier board for the Z axis motor on the base. This button provides a ground return from the Z column brake to ground bypassing the transistor that performs this function under computer power so that the brake can be released manually without motor power being enabled, as long as 24 VDC is turned on. Care should be taken to support the links of the robot when this button is pushed as the links weigh 14 kg and will drop under gravity when this button is pushed.



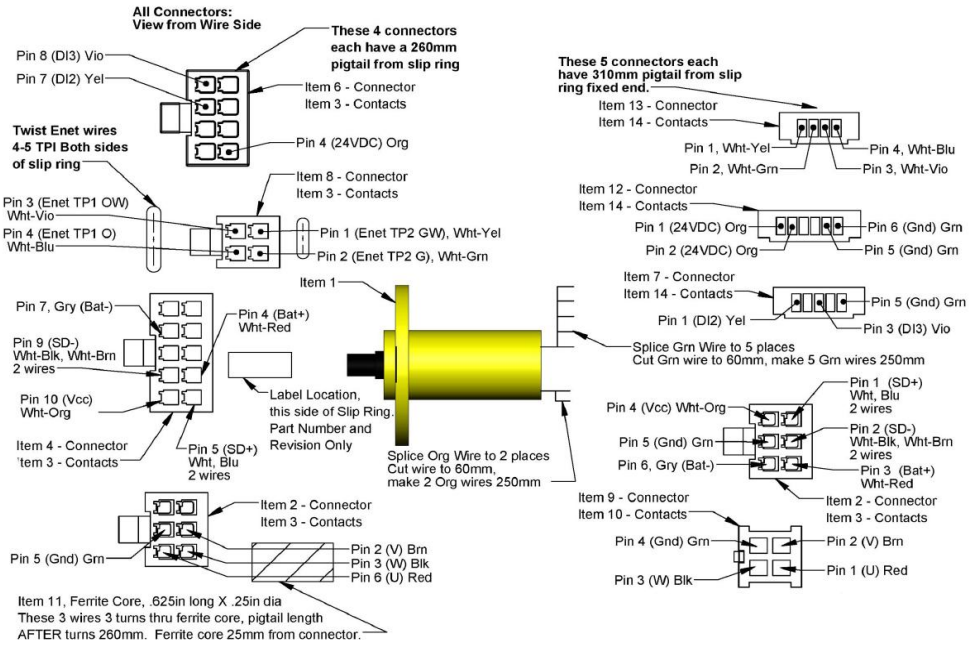
Slip Ring for IntelliGuide s23 and IntelliGuide s23D Grippers



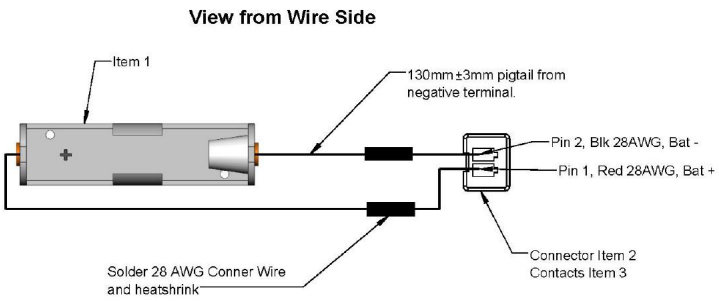
Slip Ring Harness with Sensor for IntelliGuide v23 Gripper



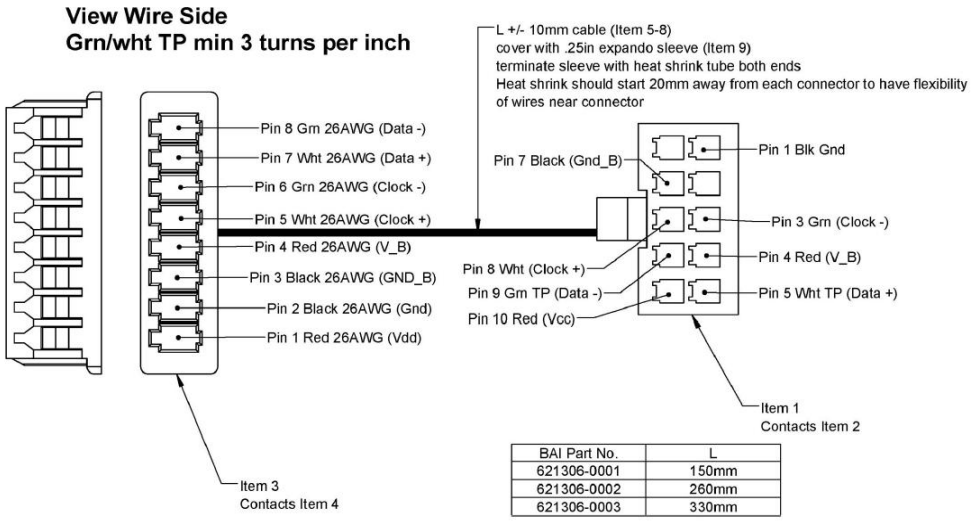
Slip Ring for IntelliGuide s60 Gripper



Slip Ring IntelliGuide v60 Gripper

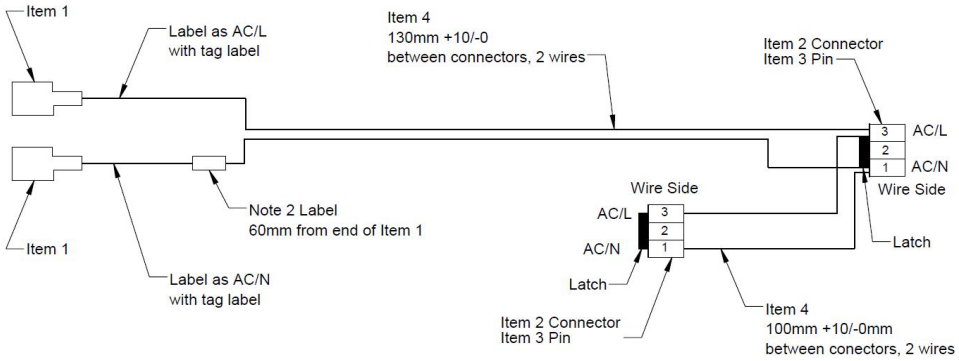


Cable, Single Battery

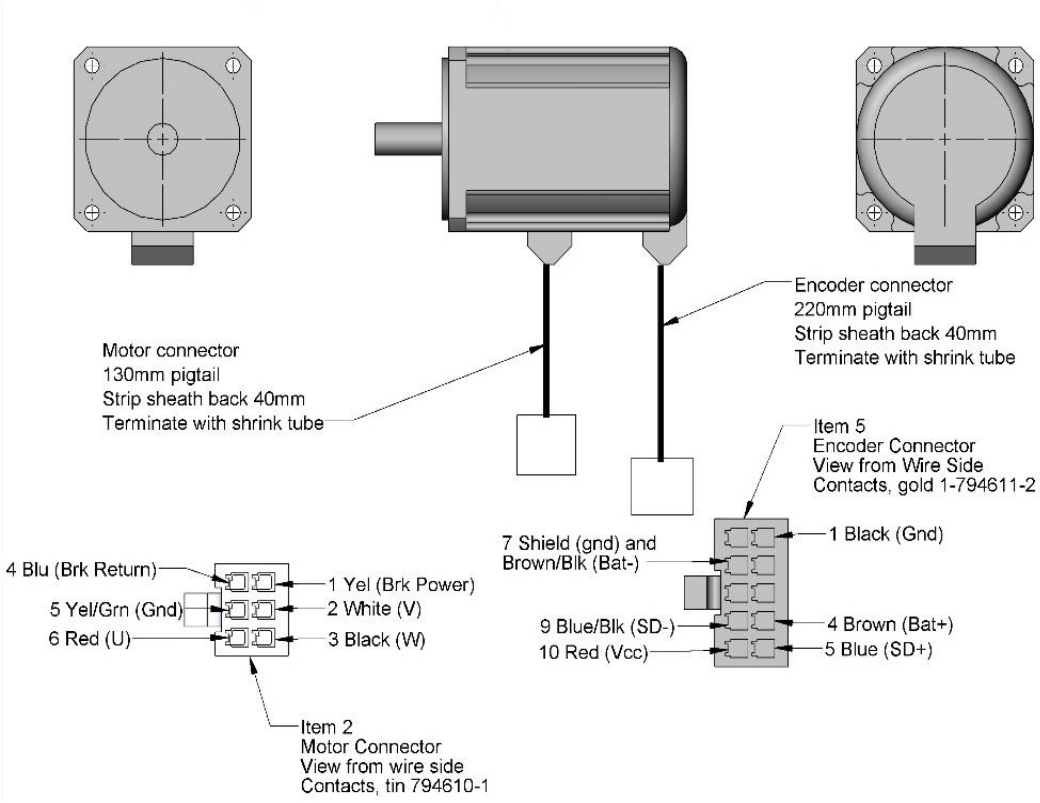


BAI Part No.	L
621306-0001	150mm
621306-0002	260mm
621306-0003	330mm

J1 Timken Encoder, PFD0X



Cable, AC Main, PreciseFlex c5



J2 Motor with Pigtail

Appendix I: Torque Values for Screws

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

Torque Values in Newton-Meters

	Zinc	SS	Zinc	SS	Zinc	SS
Screw Size M	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 J: Energy Dump Circuit

The 48 VDC supply has a regulated output and an overvoltage protection circuit that is triggered if the voltage reaches 56 Volts. Rapid deceleration of the robot motors can generate a Back EMF voltage that can pump up the motor voltage bus. In order to avoid bus pump up, an Energy Dump Circuit is included in the base controller board and connected to the 48 VDC bus.

Appendix K: 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.