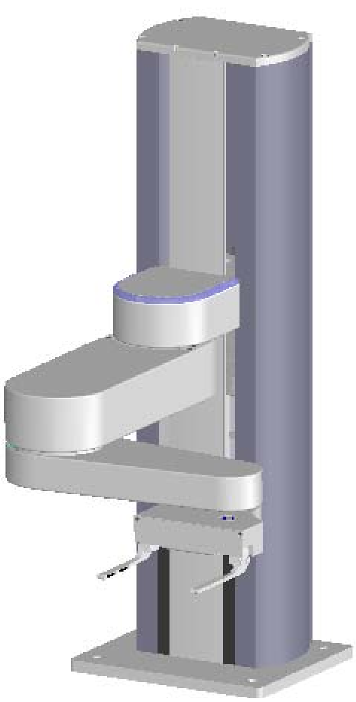
The PreciseFlex 400 Robot



Hardware Reference Manual

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Precise Automation Inc., 727 Filip Road, Los Altos, California 94024
www.preciseautomation.com

Document Content

Trademarks

Disclaimer

Precise Automation Inc.
727 Filip Road
Los Altos, California 94024
U.S.A.
www.preciseautomation.com

Warning Labels

The following warning and caution labels are utilized throughout this manual to convey critical information required for the safe and proper operation of the hardware and software. It is extremely important that all such labels are carefully read and complied with in full to prevent personal injury and damage to the equipment.

There are four levels of special alert notation used in this manual. In descending order of importance, they are:

> **WARNING:** This indicates a potentially hazardous situation, which, if not avoided, could result in serious injury or major damage to the equipment.

> **CAUTION:** This indicates a situation, which, if not avoided, could result in minor injury or damage to the equipment.

> NOTE: This provides supplementary information, emphasizes a point or procedure, or gives a tip for easier operation

Table of Contents

Introduction to the Hardware

System Overview

System Description

The PreciseFlex 400 Robot is a four-axis robot which includes an embedded Guidance 1400B four-axis motion controller, a 48VDC motor power supply, and a 24VDC logic power supply located inside the base of the robot. In addition it may optionally include an electric gripper and electric gripper controller.

The Z axis of this robot is available with a standard travel of 400 mm, and an optional travel of 750mm. The robot is designed as tabletop unit and can carry a payload of up to 500 grams in the gripper. These robots are low cost, extremely quiet and smooth, very reliable, and have excellent positioning repeatability. To achieve these results, the axes are powered by brushless DC motors with absolute encoders. With these characteristics, these robots are ideal for automating applications in the Life Sciences, Medical Products, Semiconductor, and Electronics industries.

A number of communications and hardware interfaces are provided with the basic robot. These include an RS-232 serial interface, an RS485 serial interface, an Ethernet interface, and a number of digital input and output lines. In addition, the robot can be purchased with several types of optional Precise peripherals. These include digital cameras, remote I/O, and a hardware manual control pendant.

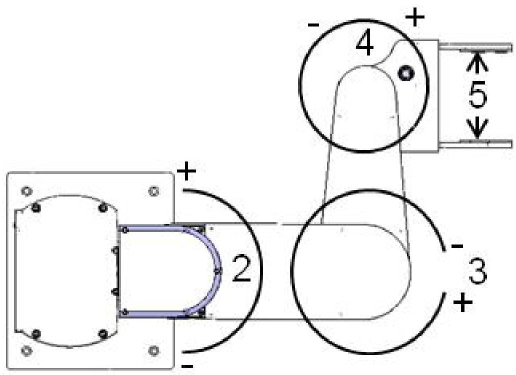
The controller is programmed by means of a PC connected through Ethernet. There are three programming modes: a Digital IO (PLC) mode, an Embedded Language mode, and a PC Control mode. When programmed in the PLC or Embedded Language mode, the PC can be removed after programming is completed and the controller will operate standalone. The PC is required for operation in the PC Control mode.

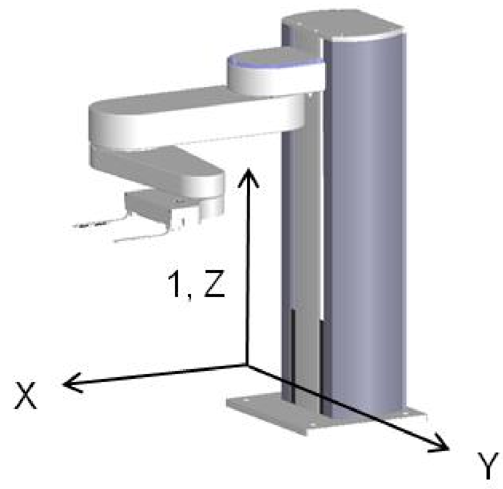
In all modes of operation, the controller includes a web based operator interface. This interface is used for configuring the system, starting and stopping execution, and monitoring its operation. The web interface can be accessed locally using a browser or remotely via the Internet. This remote interface is of great benefit in system maintenance and debugging.

The optional machine vision system, "PreciseVision", can execute either in a PC connected through Ethernet. PreciseVision requires cameras connected via Ethernet or USB, allowing any processor on the network to obtain and process information from any camera on the network, and provide the results to any networked motion controller.

System Diagram and Coordinate Systems

The major elements of the PreciseFlex robot and the orientation and origin of its World Cartesian coordinate system are shown in the diagram below.





World Coordinates

Item	Axis	Description of Motion
1	Z column	Moves Up and Down 400mm
2	Shoulder	Rotates 180 degrees
3	Elbow	Rotates 334 degrees
4	Wrist	Rotates +/- 970 degrees
5	Gripper	Opens from 77mm to 133mm Force 0 to 20N

The first axis of the robot, J1, moves the robot arm up along the Z Column, which is the Z-axis. When inner link is closest to the bottom, the Z-axis is at its 0 position in the Joint Coordinate system and Z=30mm in the World Coordinate system. As the robot arm moves upwards, both its joint position and the World Z Coordinate increase in value.

The Z column also contains the 24VDC and 48VDC power supplies and the connector panel. The Guidance controller is located inside the inner link of the robot, and the gripper controller is located inside the outer link.

When the Inner Link is centered on its range of motion the J2 axis is at its 0 joint angle. A positive change in the axis angle results in a positive rotation about the World Z-axis.

The J3 rotary axis (elbow) rotates the outer link about the world Z-Axis. A positive change in the axis angle results in a positive rotation about the World Z-axis. When the link is centered, it is at its 0 joint angle, however there is a hard stop at 10 degrees, so the link cannot reach the center position. The outer link can rotate underneath the inner link, allowing the robot to change configuration from a “left hand” robot to a “right hand” robot without swinging the J3 axis (elbow) through the zero position. This allows the robot to work in very compact workcells.

The J4 rotary axis (wrist) rotates the gripper about the World Z-axis. A positive change in the axis angle results in a positive rotation about the World Z-axis.

The outer link may include a gripper controller that provides control of the optional electric gripper. It is also possible to order the robot with a pneumatic gripper, in which case the outer link will house a solenoid to control air to the pneumatic gripper. A light bar is mounted at the top of the shoulder cover (or column for some robots) and blinks at a rate of once per second to indicate that the controller is operational and at a rate of 4 times a second when power is being supplied to the motors.

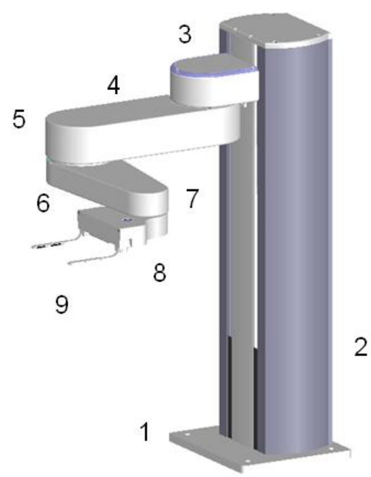
The Z-axis includes a fail-safe brake. This brake must be released to move the Z-axis up and down manually. There is a manual brake release button on the bottom of the inner link near the Z-axis. Depressing this button when 24VDC power is on will release the Z-axis brake while the button is depressed. It is not necessary for the control system to be operating for the brake release to function; the only requirement is providing 24VDC to the controller. Care should be taken to support the Z-axis when the brake release button is pushed, as the axis will fall due to gravity.

System Components

PreciseFlex 400 Robot

The PreciseFlex 400 Robot (pictured below) is a 4-axis robot that may optionally include an electric or pneumatic gripper.

Item	Name	Description
1	Base Plate	Plate to attach robot to table
2	Z Column	Vertical column
3	Shoulder	Moves up and down column, rotates Inner Link
4	Inner Link	Inner Link
5	Elbow	Joint Between Inner and Outer Links
6	Outer Link	Outer Link
7	Wrist	Joint Between Outer Link and Gripper
8	Gripper	Gripper Mechanism
9	Fingers	Fingers for Grasping Titer Plates



Mounting of Robot

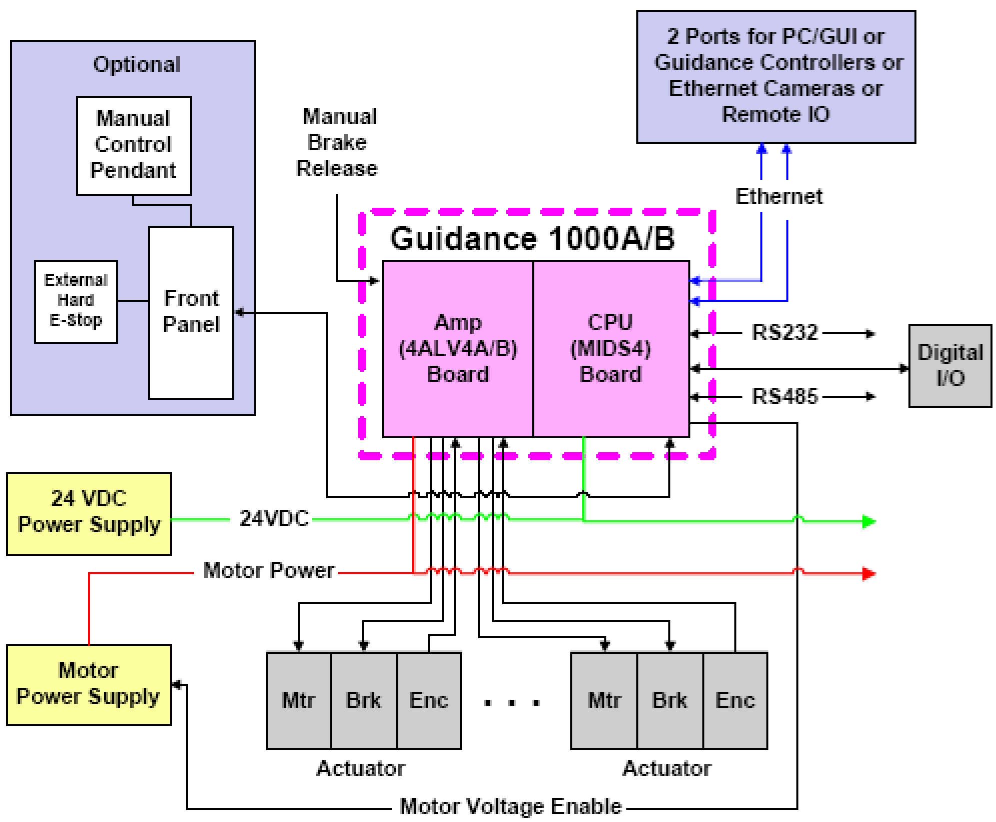
The Base Plate contains a mounting hole pattern for 4 M6 Screws along with reference surfaces for locating the robot on a table or work cell surface. See Installation section for details.

Optional Gripper

The robot may be ordered with an optional Gripper. The Gripper may be either electric or pneumatic. Several options are available.

Guidance 1400B Controller

The Guidance 1400B Controller is a four-axis general purpose motion controller that contains four motor drives and four encoder inputs. It must be attached to a heat sink. The heat sink is provided by the inner link housing. The controller includes local digital IO. It also supports RS232 and RS 485 serial communication and an optional Precise Remote IO module. It contains two Ethernet ports. The controller and power supplies are shown in the system diagram below.



For detailed information on the controller including interfacing information, please see the *"Guidance 1000A/B Controllers Manual* P/N: G1X0-DI-A0010*"*.

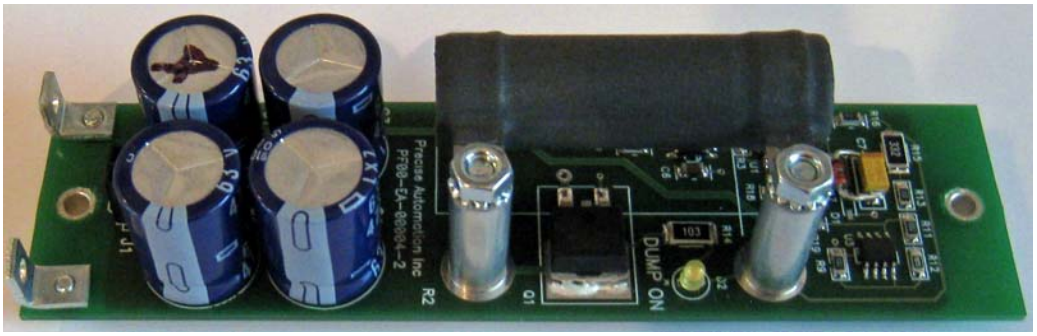
Low Voltage Power Supplies

The PreciseFlex 400 Robot has an integrated 125-watt, 24VDC Power Supply that accepts a range of AC input from 90V to 264V and an integrated 365W, 48VDC Power Supply for the motors.

> **DANGER:** In addition to exposed high voltage pins and components, **the heat sinks on the Power Supplies are not grounded and expose high voltage levels.** AC power to the robot must be disconnected prior to accessing these units.

Energy Dump Circuit

The 48 VDC supply has a regulated output and an overvoltage protection circuit that is triggered if the voltage reaches 60 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 connected to the 48 VDC bus.



Remote Front Panel, E-Stop Box and Manual Control Pendant

For users that wish to have a hardware E-Stop button, Precise offers an E-Stop Box or a portable Hardware Manual Control Pendant that includes an E-Stop button. The E-Stop box can be plugged into the green Phoenix connector in the connector panel in the base of the robot. The E-Stop box completes a circuit from the top pin, Pin 1 (24VDC) to Pin 2 (E-Stop) in this connector. If this circuit is not completed it is not possible to enable motor power to the robot. If no E-Stop box or Manual Control Pendant is connected, a jumper must be connected between these two pins to enable robot motor power. For those applications where an operator must be inside the working volume of the robot while teaching, a second teach pendant with a 3-position run hold switch is available. The Manual Control Pendants can be plugged directly into the 9 pin Dsub connector mounted on the robot's Facilities Panel in the base of the robot. The E-Stop connections are also present on the 9 pin Dsub connector and each of these units provides the hardware signals to permit power to be enabled and disabled.

Optional IO Module

For users who wish to have IO available at the base of the robot, an optional IO module may be added. This module provides 12 digital inputs and 8 digital outputs in a 25 pin Dsub connector at the robot connector panel and is connected via RS485 to the robot controller.

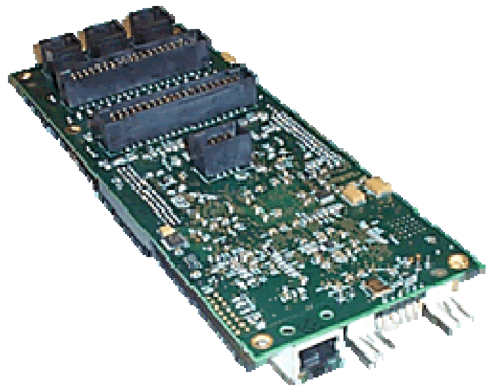
Remote IO Module (Ethernet Version)

For applications that require additional IO capability beyond the standard functions provided with every PreciseFlex robot, a Precise Remote IO (RIO) module may be purchased. The RIO interfaces to any PreciseFlex robot and its embedded Guidance Controller via 10/100 Mb Ethernet and requires 24 VDC power. Up to 4 RIO's can be connected to a controller.

The basic RIO includes: 32 isolated digital input signals, 32 isolated digital output signals and one RS-232 serial line. An enhanced version of the RIO adds 4 analog input signals, a second RS-232 port and one RS-422/485 serial port.

The Enhanced RIO module is pictured below.

> **WARNING:** The RIO contains unshielded 24 VDC signals and pins. This product is intended to be mounted in a cabinet or machine chassis that is not accessible when power is turned on.



Machine Vision Software and Cameras

The Guidance 1400 Series controllers support the PreciseVision machine vision system. This is a vision software package than can run in a PC.

Cameras must be connected via Ethernet or USB. Vendors such as DALSA already offer a variety of Ethernet machine vision cameras. In addition, other vendors offer USB cameras that are supported in PreciseVision.

Precise offers an Arm-Mounted Camera Option for certain robots. Contact Precise for details.

Machine Safety

Safety and Agency Certifications

Precise systems can include computer-controlled mechanisms that are capable of moving at high speeds and exerting considerable force. Like all robot and motion systems, and most industrial equipment, they must be treated with respect by the user and the operator.

This manual should be read by all personnel who operate or maintain Precise systems, or who work within or near the work cell.

We recommend that you read the American National Standard for Industrial Robot Systems – Safety Requirements, published by the Robotic Industries Association (RIA) in cooperation with the American National Standards Institute. The publication, ANSI/RIA R15.06, contains guidelines for robot system installation, safeguarding, maintenance, testing, startup, and operator training. We also recommend that you read the International Standard IEC 204 or the European Standard EN 60204, Safety of Machinery – Electrical Equipment of Machines, and ISO 10218 (EN 775), Manipulating Industrial Robots – Safety, particularly if the country of use requires a CE-certified installation.

Standards Compliance and Agency Certifications

The PreciseFlex robots are intended for use with other equipment and are considered a subassembly rather than a complete piece of equipment on their own. They meet the requirements of these standards:

ENISO 10218-1-2007 Robots for Industrial Environments, Safety Requirements
EN 610204-1 **S**afety of Machinery, Electrical Equipment of Machines
EN 61000-6-2 EMC Directive (Immunity)
EN 61000-6-4 EMC Directive (Emissions)

To maintain compliance with the above standards the controller must be installed and used in accordance with the regulations of the standards, and in accordance with the instructions in this user's guide.

In addition to the above standards, the Guidance 3400 has been designed to comply with the following agency certification requirements, and carries the CE mark.

CE
CSA
FCC Class A
ANSI/RIA R15.06 Safety Standard

Moving Machine Safety

The PreciseFlex robots can operate in Manual Control Mode, in which an operator directly controls the motion of the robot, or Computer Control Mode in which the robot operation is automatic. Manual Control Mode is often used to teach locations in the robot workspace. The robot's speed is limited in Manual Control Mode to a maximum of 250mm per second for safety. While the PreciseFlex 400 is a light-duty robot that can only apply approximately 20 Newtons of force, it is very important for operators to keep their hands, arms and especially their head out of the robot's operating volume. It is important that operators wear safety glasses when inside the robot's operating volume.

In Computer Mode the robot can move quickly. During Computer Mode Operation it is strongly recommended that operators be prevented from entering the robot work volume by safety barriers that are interlocked to the E-stop circuitry. Please refer to the ANSI/RIA R15.06 Safety Standard for Industrial Robots for information on recommended safe operating practices and enclosure design for robots of various sizes and payloads.

Voltage and Power Considerations

The Guidance 1400 requires two DC power supplies, a 24 VDC power supply for the processor and user IO, and a separate 48VDC motor power supply.

> **DANGER:** The Guidance 1400, the 48 VDC and the 24 VDC power supplies are all open frame electrical devices that contain unshielded high voltage pins, components and surfaces. These products are intended to be mounted in a cabinet or machine chassis that is not accessible when AC line power is turned on.

The PreciseFlex 400 power supplies have a dual input range of 90 to 132 VAC and 180 to 264 VAC 50/60 Hz. Inrush current can be as high as 100 Amps at 240 VAC for short periods of time. The power supplies are protected against voltage surge to 2000 volts. Transient over voltage (< 50 µs) may not exceed 2000 V phase to ground, as per EN61800-31996. The robot is protected against over current by two 6.3 amp, 250V slow blow fuses, for example Wickman PN 1811630000.

The robot consumes less than 200 Watts during normal operation.

The Precise controller can monitor motor power through its datalogging function. Intermittent power dropouts can be detected by setting a trigger in the data logger which can record and time-stamp power fluctuations.

Mechanical and Software Limit Stops

The Z column, shoulder, and elbow have hard limit stops at the end of travel which are factory installed. The soft-limit stops must be set within the range of these hard stops. The wrist axis has a slip ring when the electric gripper is installed, allowing unlimited rotation. However software stops limit rotation to plus or minus 970 degrees. Since the robot has absolute encoders with battery backup, even if the robot is turned off, the encoders keep track of joint position. If the wrist axis is rotated manually beyond the 970 degree software limit stops, it will be necessary to rotate it back to within the allowed software limits before the robot will run. The joint position can be viewed either on the optional Manual Control Pendant, or in the Virtual Manual Control Pendant in the Web Based Operator Interface. (See Guidance Controller Setup and Operation Quick Start Guide)

Stopping Time and Distance

The robot control system responds to two types of E-Stops.

A Soft E-Stop initiates a rapid deceleration of all robots currently in motion and generates an error condition for all GPL programs that are attached to a robot. This property can be used to quickly halt all robot motions in a controlled fashion when an error is detected. A soft E-stop is typically generated by an application program under conditions determined by the programmer.

This function is similar to a Hard E-Stop except that Soft E-Stop leaves High Power enabled to the amplifiers and is therefore used for less severe error conditions. Leaving power enabled is beneficial in that it prevents the robot axes from sagging and does not require high power to be manually re-enabled before program execution and robot motions are resumed. This function is also similar to a Rapid Deceleration feature except that a Rapid Deceleration only affects a single robot and no program error is generated.

If set, the **SoftEStop** property is automatically cleared by the system if High Power is disabled and re-enabled.

A Hard E-Stop is generated by one of several hardware E-Stop inputs and causes motor power to be disabled. However there is a parameter that determines a delay between the time the Hard E-Stop signal is asserted and the time the motor power supply relay is opened. This delay is nominally set at 0.5 seconds. It may be adjusted by an operator with administrator privileges. On the web based operator interface menu, go to Setup/Parameter Database/Controller/Operating Mode/ and set parameter 267 to the desired delay. If this delay is set to 0, the high power relay will be disabled within 1ms.

For the PreciseFlex 400 robot, the shoulder, elbow, and wrist axes do not have mechanical brakes. Therefore leaving the motor power enabled for 0.5 sec allows the servos to decelerate the robot. The servos will typically decelerate the robot at 0.12G, or 1250mm/sec^2. If the robot is moving at a speed of 500mm/sec, the distance traveled will be 100mm to reach a full stop, and the time will be 0.4sec.

Releasing a Trapped Operator: Brake Release Switch

Should a hard E-Stop be triggered, the Z brake will engage, and motor power will be disconnected from all motors. As the J2, J3, and J4 axes have no brakes, they may be freely pushed by the operator. To release the Z brake, the operator may press the brake release switch, under the inner link, as long as 24VDC is present. It is not necessary for motor power to be on for the brake release to work.

Installation Information

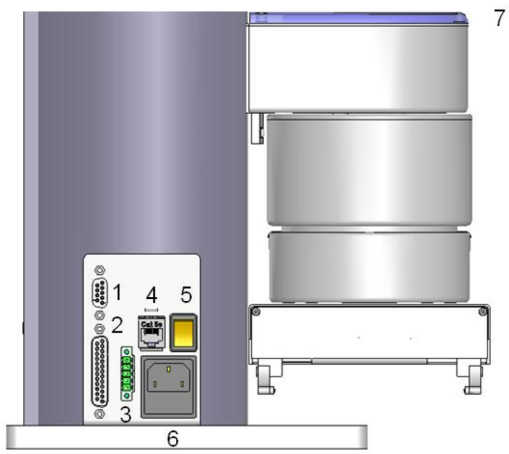
Environmental Specifications

The PreciseFlex robots must be installed in a clean, non-condensing environment. Light fluid splashing around the base of the robot is acceptable, but this robot is not intended for use in a washdown or spray environment. Please see the Environmental Specifications in Appendix B for specific environmental limits.

Facilities Connections

The Facilities Panel at the base of the robot includes:

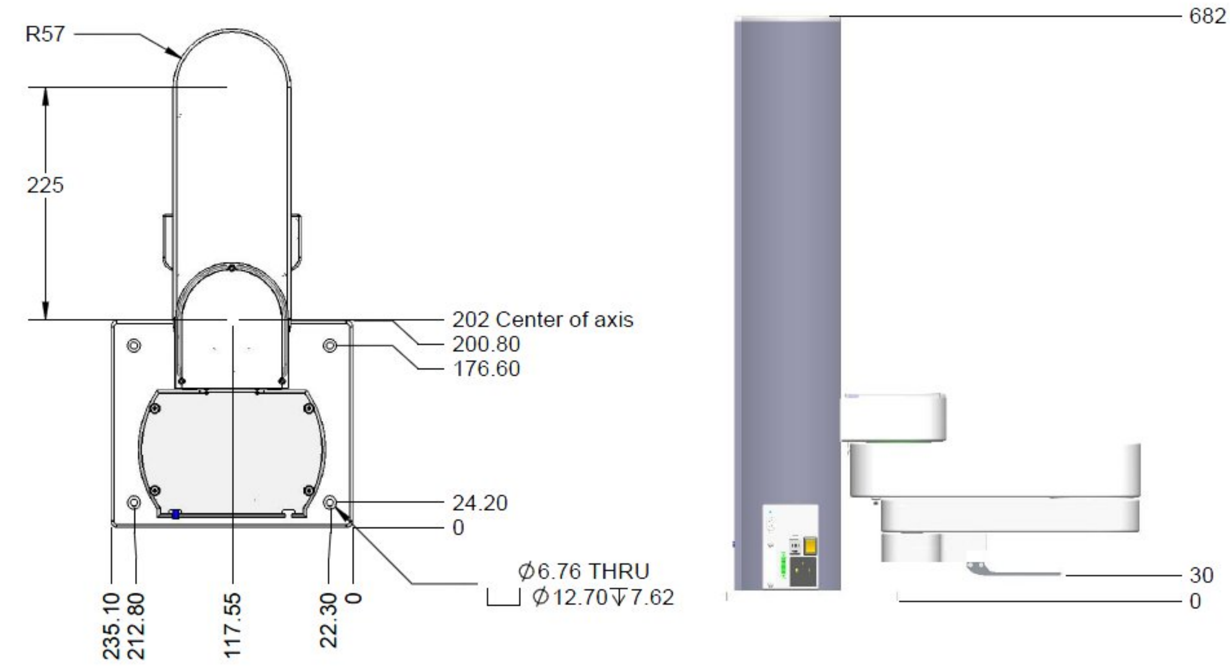
- System AC input power receptacle
- Lighted AC on/off power switch
- Connectors for controller input and output signals



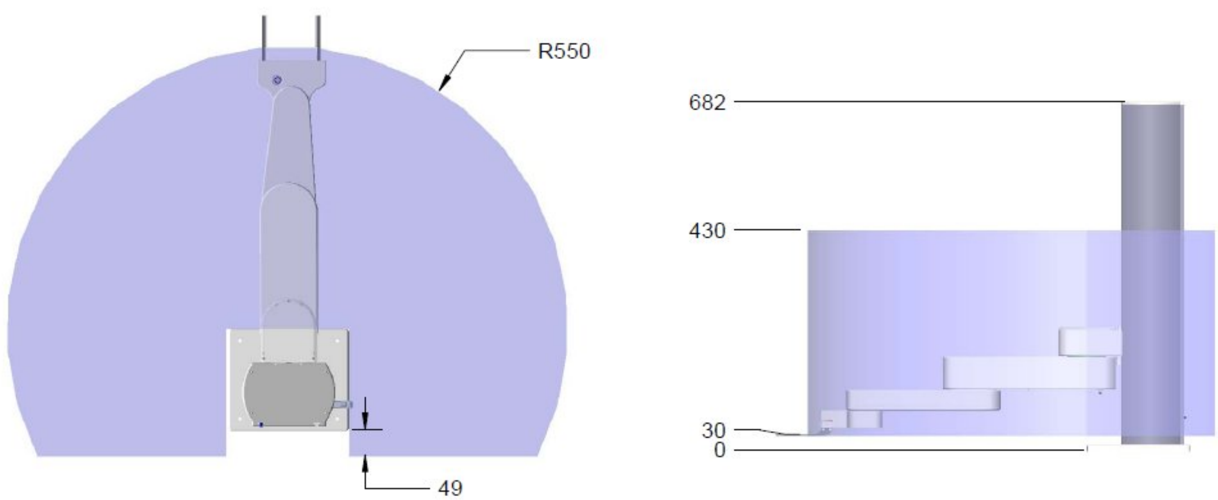
Item	Name	Description
1	9 Pin D Sub Connector	Contains RS-232 Serial Port, 24 VDC, Gnd Can be used for optional teach pendant
2	25 Pin D Sub Connector	For optional DIO module, 8 inputs, 8 outputs
3	EStop Connector	EStop and Cell Interlock Signals
4	Ethernet Connector	For Ethernet to Computer Cable
5	Power Switch	Lighted Power Switch
6	Power Entry Module	For IEC plug. Contains dual fuse drawer.
7	Power Status Light	Blinks to indicate power status

System Dimensions

Both top and right views are shown below. All dimensions are in millimeters.



Mounting Dimensions



Working Volume

Mounting Instructions

PreciseFlex robots must be attached to a rigid surface that can withstand lateral forces of 200 Newtons without moving or vibrating. The robot base has an integrated bolting pattern to accommodate 4 M6 SHCS mounting screws located as shown above.

Tool Mounting – PreciseFlex 400

The Precise Flex 400 is typically supplied with an electric gripper. In some cases a pneumatic gripper may be supplied by Precise or by the end user. However the standard robot does not include pneumatic lines, so if pneumatic tooling is needed, the robot must be ordered with pneumatic lines installed. The outer link has a flange for users to attach grippers or tooling.

To facilitate electrical interfacing to user tooling, digital I/O signals are available in the outer link. For robots with an electric gripper, the electric gripper controller in the outer link has two extra inputs and two extra outputs available for users. However it should be noted that all the wires in the 12 conductor slip ring are consumed by the electric gripper, so any additional IO wiring will have to be routed outside the robot wrist. For robots without the electric gripper, a ribbon cable from the G1400A controller is routed to the outer link. This ribbon cable provides 4 digital inputs and 4 digital outputs from the controller.

For robots where support for a pneumatic gripper or pneumatic tooling has been ordered, a 1/8in OD air hose is routed from the connector plate in the base through the robot and out to the outer link. This air hose can be connected to a solenoid mounted in the outer link for tooling control.

Accessing the Robot Controller

Although most of the controller interface signals are exposed on the Facilities Panel at the base, there are times when it may be necessary to access either the robot's controller or its power supplies. To access the robot controller, the cover on the inner link must be removed by removing 4 M3 X 20 SHCS from the bottom of the inner link

Please see the *Guidance 1000A/B Controller, Hardware Introduction and Reference Manual* for detailed information on hardware configuration and interfacing the controller using the various input and output ports such as those for digital I/O. Also, please refer to the *Guidance System Setup and Operation Quick Start Guide* for information on configuring the PC and instructions on operating the robot. Both of these manuals are available in PDF format and are also contained in the *Precise Documentation Library*.

Power Requirements

The PreciseFlex robots contain auto-ranging power supplies that operate between 90 to 132 and 180 to 264 VAC, 50 or 60Hz. The robots are equipped with an IEC electrical socket that accepts country specific electrical cords. Power requirements vary with the robot duty cycle, but do not exceed 200 watts RMS.

Emergency Stop

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 green Phoenix E-Stop connector and the Manual Control Pendant 9-pin DSub connector that is mounted on the Facilities Panel. Please see the Hardware Reference section of this manual for detailed information on the E-Stop signals.

Hardware Reference

System Schematics

System Diagram and Power Supplies

The robot has a 24VDC and 48VDC power supply located in the Z column. The AC input to these power supplies is fused, with two fuses in a pull-out fuse drawer in the IEC type power entry module. The robot controller and electric gripper are powered by the 24VDC supply. The 4 main robot motors are powered by the 48VDC supply. The 48VDC supply is protected against over voltage bus pump up by an energy dump board, which connects a 25 Watt dump resistor across the 48VDC supply output when the voltage reaches 56 volts, and disconnects the dump resistor when the voltage drops to 52 volts. This protects the power supply during high speed motor deceleration when the motor generates Back EMF voltage that adds to the power supply voltage.

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

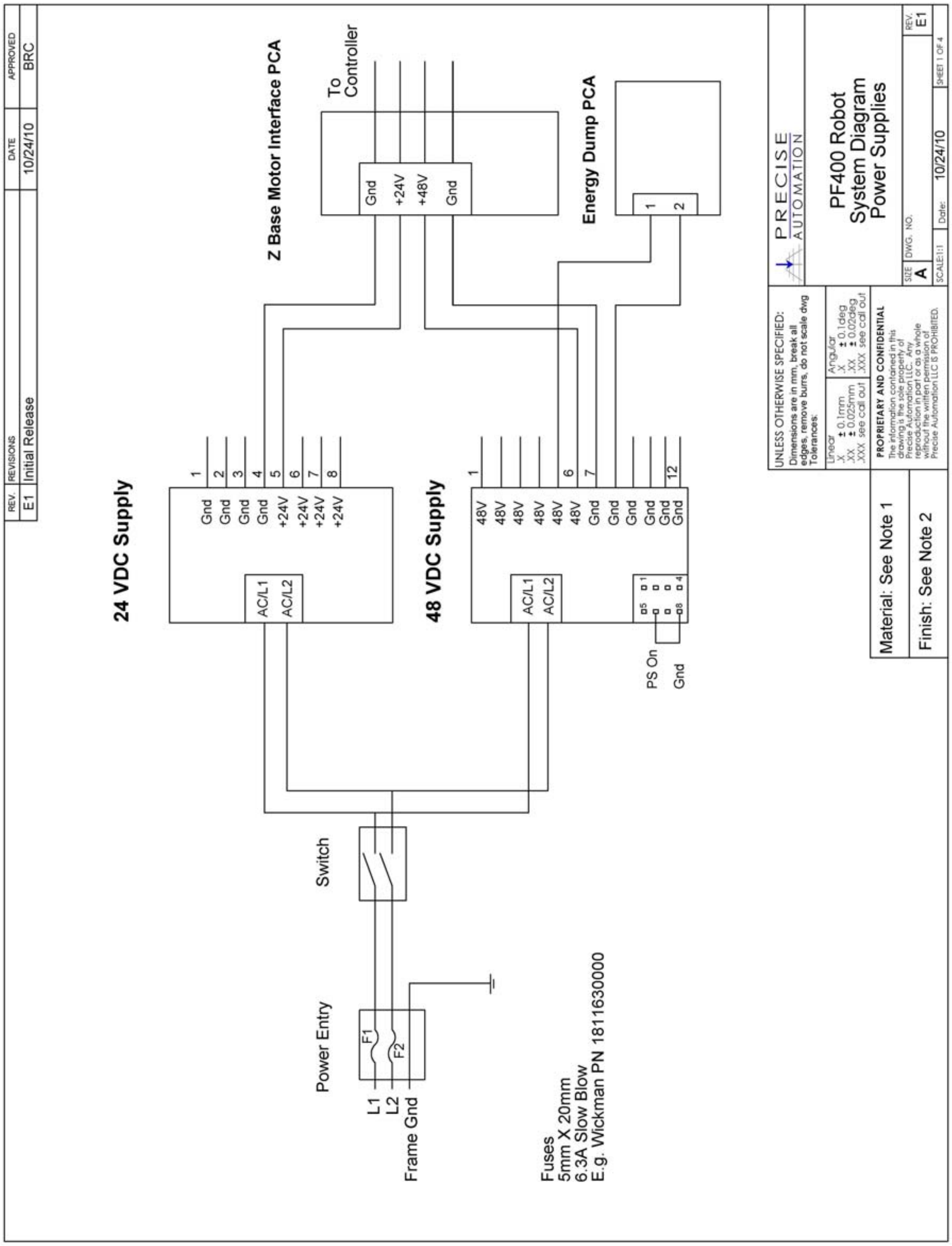
Four digital input and four digital output signals from the main robot controller are also connected to the MIDS Power Interface Board through a 10 conductor ribbon cable. One digital input signal, DI3 is routed down to the base of the robot thru the P1 ribbon cable, where it is connected to the green Phoenix Estop connector. This provides a digital input for safety interlock purposes. There is a jumper on the MIDS Power Board which jumps this signal to the P1 cable. This jumper must be installed for this connection to work. The rest of the digital inputs and outputs are daisy chained to a second connector on the MIDS board for use if needed. Some of these signals are used when the pneumatic gripper option is installed.

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

The gripper controller is connected to the main controller through an RS485 cable that is routed through the elbow, along with the power and encoder cables for the J4 motor. The RS485 cable also supplies power for the gripper controller.

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

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


REV. | REVISIONS | DATE | APPROVED
E1 | Initial Release | 10/24/10 | BRC
24 VDC Supply
AC/L1
AC/L2
Gnd
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1 2 3 4 5 6 7 8
48 VDC Supply
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+48V
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To Controller
Energy Dump PCA
1
2
Switch
Power Entry
F1
F2
L1
L2
Frame Gnd
Fuses
5mm X 20mm
6.3A Slow Blow
E.g. Wickman PN 1811630000
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
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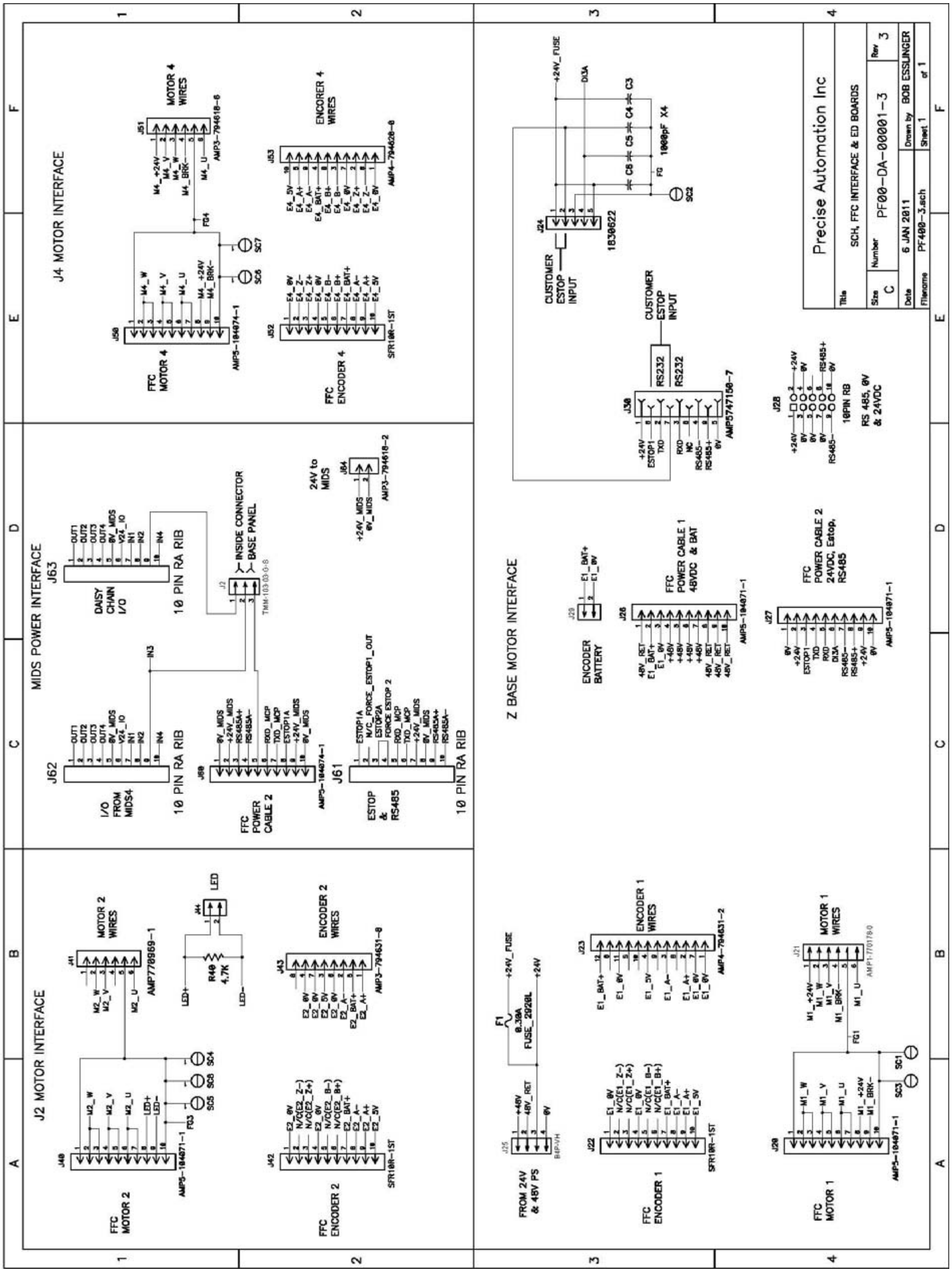
The information contained in this drawing is the sole property of Precise Automation LLC. Any reproduction in part or as a whole without the written permission of Precise Automation LLC IS PROHIBITED.
PRECISE AUTOMATION
PF400 Robot
System Diagram
Power Supplies
SIZE A
DWG. NO.
REV. E1
SCALE:1:1
Date: 10/24/10
SHEET 1 OF 4
Material: See Note 1
Finish: See Note 2


J2 MOTOR INTERFACE
MIDS POWER INTERFACE
J4 MOTOR INTERFACE
Z BASE MOTOR INTERFACE
Precise Automation Inc
SCH, FFC INTERFACE & ED BOARDS
PF00-DA-00001-3
6 JAN 2011
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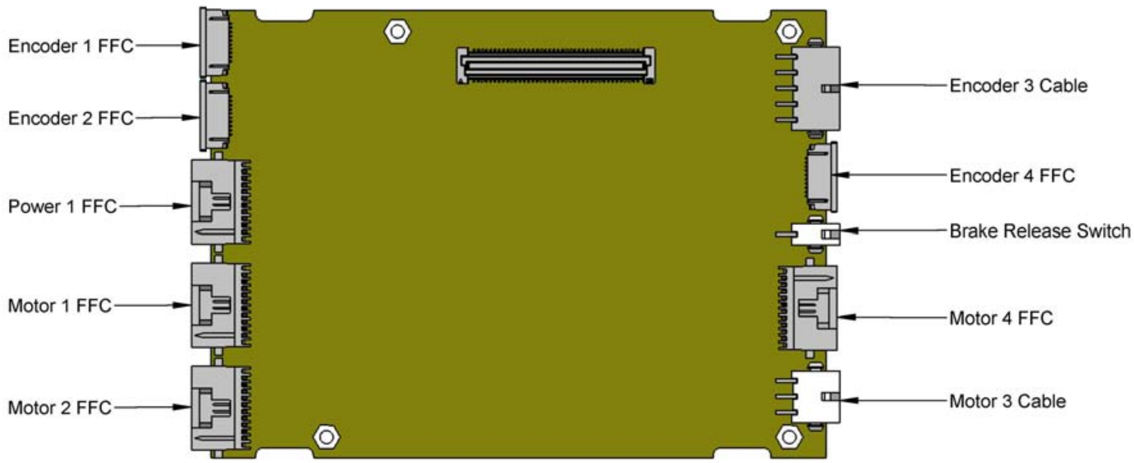
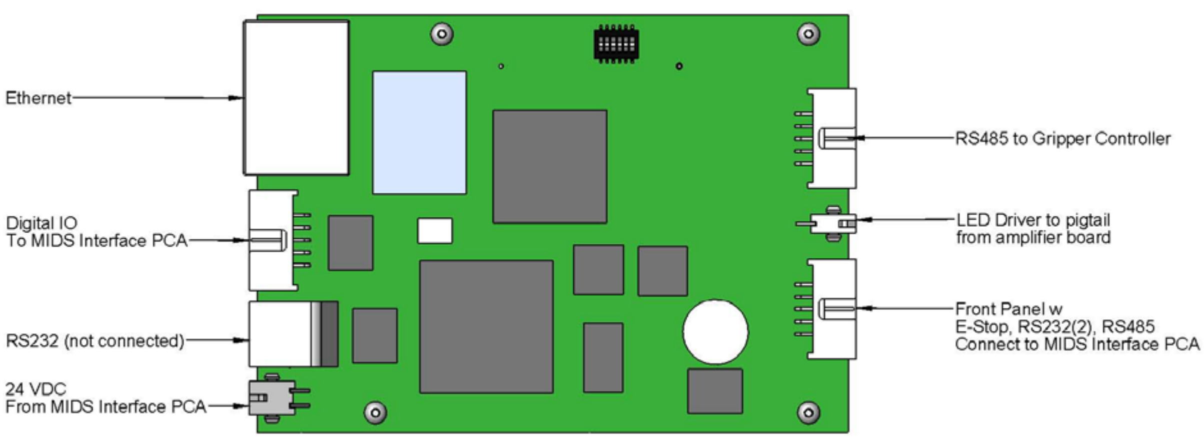
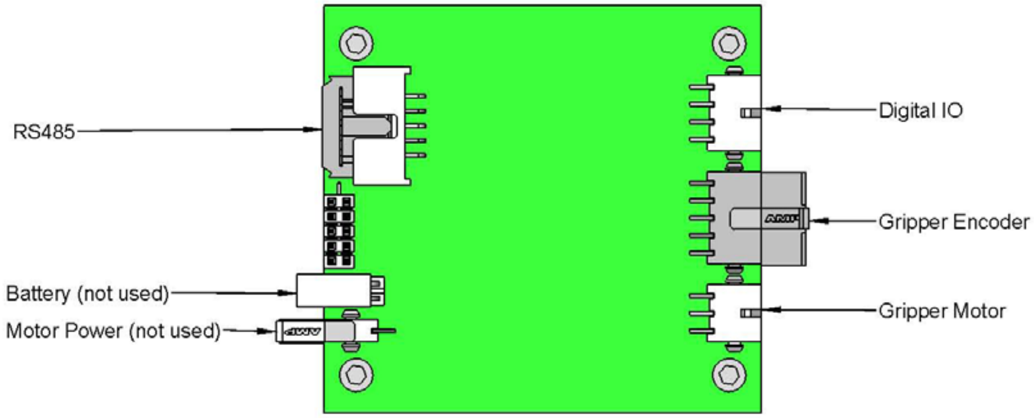


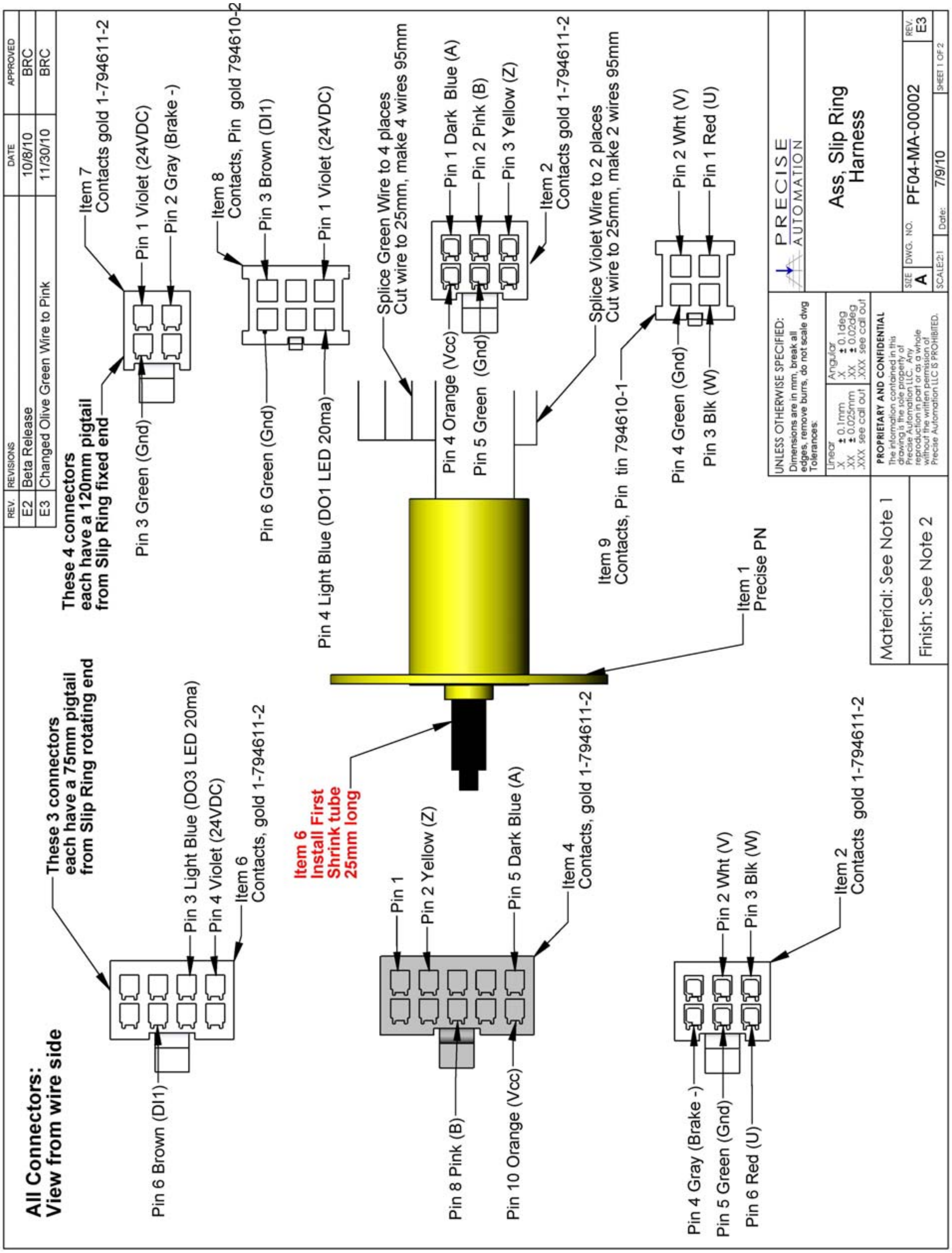
Controller Power Amplifier Connectors



Control Board Connectors



Gripper Controller Connectors


REV. | REVISIONS | DATE | APPROVED
E2 | Beta Release | 10/8/10 | BRC
E3 | Changed Olive Green Wire to Pink | 11/30/10 | BRC
All Connectors:
View from wire side
These 3 connectors
each have a 75mm pigtail
from Slip Ring rotating end
Pin 6 Brown (DI1)
Pin 3 Light Blue (DO3 LED 20ma)
Pin 4 Violet (24VDC)
Item 6
Contacts, gold 1-794611-2
Item 6
Install First
Shrink tube
25mm long
Pin 1
Pin 2 Yellow (Z)
Pin 5 Dark Blue (A)
Pin 8 Pink (B)
Pin 10 Orange (Vcc)
Item 4
Contacts, gold 1-794611-2
Pin 2 Wht (V)
Pin 3 Blk (W)
Pin 4 Gray (Brake -)
Pin 5 Green (Gnd)
Pin 6 Red (U)
Item 2
Contacts gold 1-794611-2
These 4 connectors
each have a 120mm pigtail
from Slip Ring fixed end
Pin 3 Green (Gnd)
Pin 1 Violet (24VDC)
Pin 2 Gray (Brake -)
Item 7
Contacts gold 1-794611-2
Pin 6 Green (Gnd)
Pin 3 Brown (DI1)
Pin 1 Violet (24VDC)
Item 8
Contacts, Pin gold 794610-2
Pin 4 Light Blue (DO1 LED 20ma)
Splice Green Wire to 4 places
Cut wire to 25mm, make 4 wires 95mm
Pin 4 Orange (Vcc)
Pin 5 Green (Gnd)
Pin 1 Dark Blue (A)
Pin 2 Pink (B)
Pin 3 Yellow (Z)
Item 2
Contacts gold 1-794611-2
Splice Violet Wire to 2 places
Cut wire to 25mm, make 2 wires 95mm
Item 9
Contacts, Pin tin 794610-1
Pin 4 Green (Gnd)
Pin 3 Blk (W)
Pin 2 Wht (V)
Pin 1 Red (U)
Item 1
Precise PN
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
PROPRIETARY AND CONFIDENTIAL
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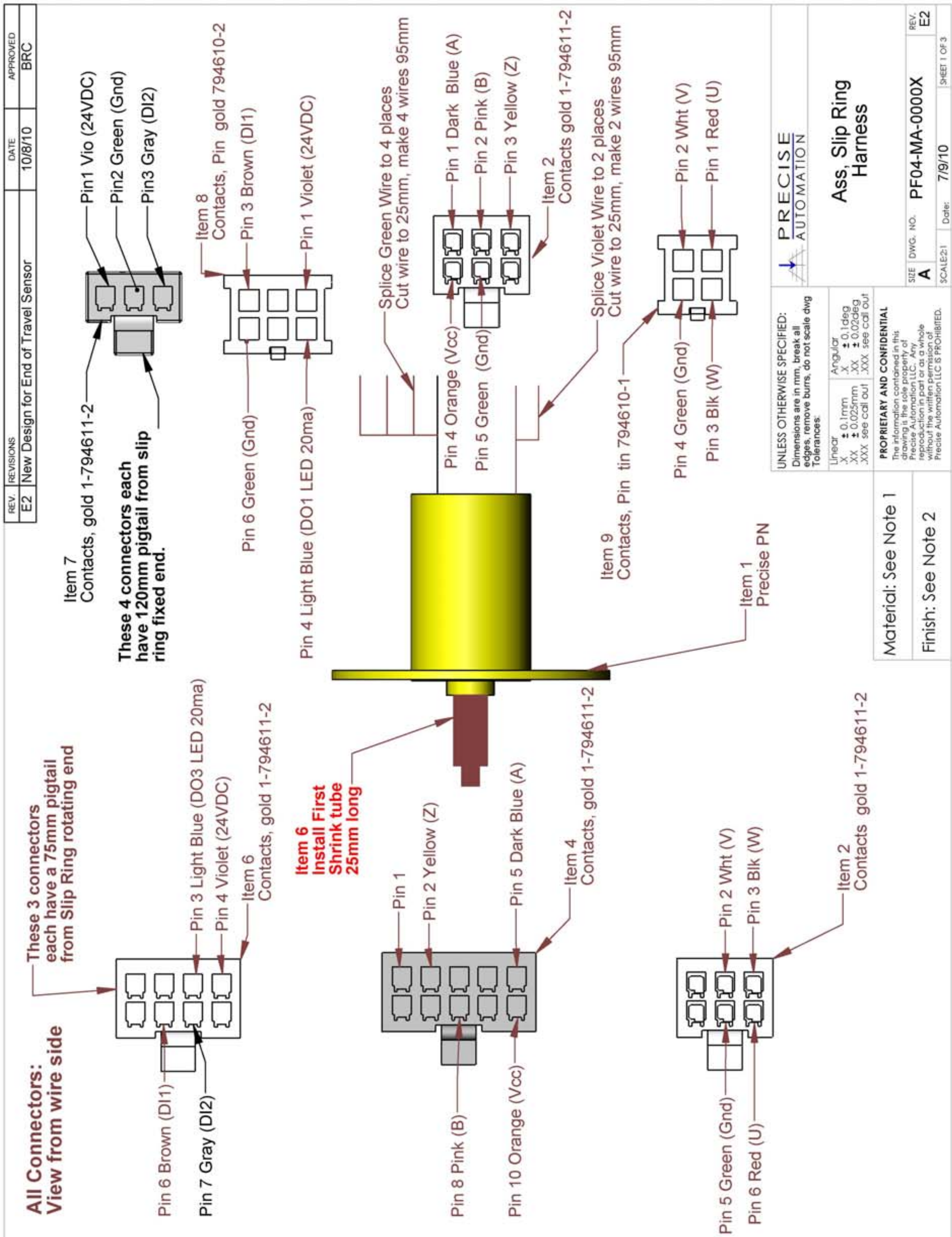
PRECISE AUTOMATION
Ass, Slip Ring Harness
SIZE A
DWG. NO. PF04-MA-00002
REV. E3
SCALE:2:1
Date: 7/9/10
SHEET 1 OF 2



All Connectors:
View from wire side
These 3 connectors each have a 75mm pigtail from Slip Ring rotating end
Pin 6 Brown (DI1)
Pin 7 Gray (DI2)
Pin 3 Light Blue (DO3 LED 20ma)
Pin 4 Violet (24VDC)
Item 6
Contacts, gold 1-794611-2
Item 6
Install First
Shrink tube
25mm long
Pin 8 Pink (B)
Pin 10 Orange (Vcc)
Pin 1
Pin 2 Yellow (Z)
Pin 5 Dark Blue (A)
Item 4
Contacts, gold 1-794611-2
Pin 5 Green (Gnd)
Pin 6 Red (U)
Pin 2 Wht (V)
Pin 3 Blk (W)
Item 2
Contacts gold 1-794611-2
REV. | REVISIONS | DATE | APPROVED
E2 | New Design for End of Travel Sensor | 10/8/10 | BRC
Item 7
Contacts, gold 1-794611-2
These 4 connectors each have 120mm pigtail from slip ring fixed end.
Pin1 Vio (24VDC)
Pin2 Green (Gnd)
Pin3 Gray (DI2)
Item 8
Contacts, Pin gold 794610-2
Pin 6 Green (Gnd)
Pin 3 Brown (DI1)
Pin 4 Light Blue (DO1 LED 20ma)
Pin 1 Violet (24VDC)
Splice Green Wire to 4 places
Cut wire to 25mm, make 4 wires 95mm
Pin 4 Orange (Vcc)
Pin 5 Green (Gnd)
Pin 1 Dark Blue (A)
Pin 2 Pink (B)
Pin 3 Yellow (Z)
Item 2
Contacts gold 1-794611-2
Splice Violet Wire to 2 places
Cut wire to 25mm, make 2 wires 95mm
Item 9
Contacts, Pin tin 794610-1
Pin 4 Green (Gnd)
Pin 3 Blk (W)
Pin 2 Wht (V)
Pin 1 Red (U)
Item 1
Precise PN
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
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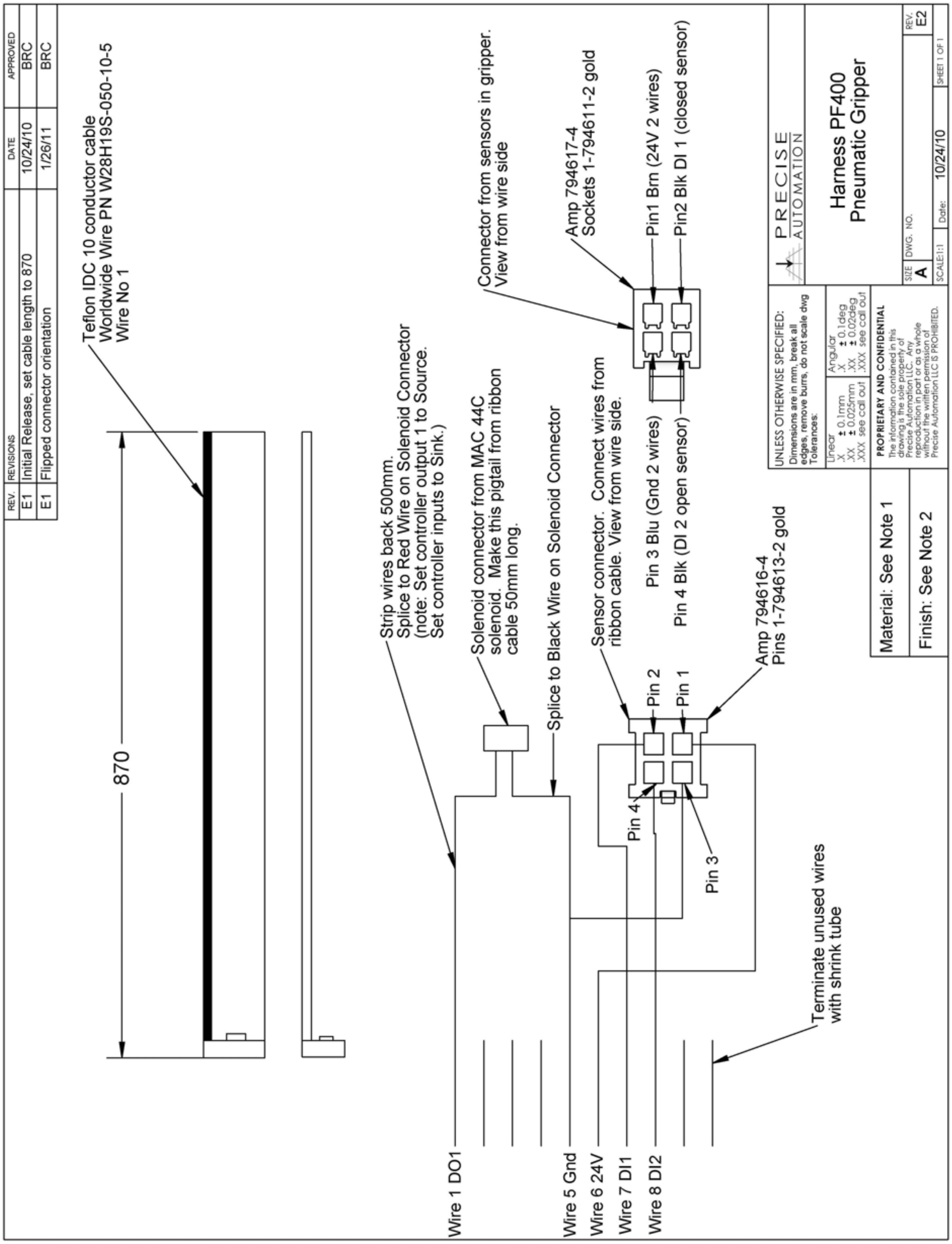
PRECISE AUTOMATION
Ass, Slip Ring Harness
SIZE A
DWG. NO. PF04-MA-0000X
REV. E2
SCALE:2:1
Date: 7/9/10
SHEET 1 OF 3


REV. | REVISIONS | DATE | APPROVED
E1 | Initial Release, set cable length to 870 | 10/24/10 | BRC
E1 | Flipped connector orientation | 1/26/11 | BRC
Teflon IDC 10 conductor cable
Worldwide Wire PN W28H19S-050-10-5
Wire No 1
870
Connector from sensors in gripper.
View from wire side
Amp 794617-4
Sockets 1-794611-2 gold
Pin1 Brn (24V 2 wires)
Pin2 Blk DI 1 (closed sensor)
Strip wires back 500mm.
Splice to Red Wire on Solenoid Connector
(note: Set controller output 1 to Source.
Set controller inputs to Sink.)
Solenoid connector from MAC 44C
solenoid. Make this pigtail from ribbon
cable 50mm long.
Splice to Black Wire on Solenoid Connector
Sensor connector. Connect wires from
ribbon cable. View from wire side.
Pin 3 Blu (Gnd 2 wires)
Pin 4 Blk (DI 2 open sensor)
Pin 2
Pin 1
Pin 4
Pin 3
Amp 794616-4
Pins 1-794613-2 gold
Terminate unused wires
with shrink tube
Wire 1 DO1
Wire 5 Gnd
Wire 6 24V
Wire 7 DI1
Wire 8 DI2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all
edges, remove burrs, do not scale dwg
Tolerances:
Linear
.X ± 0.1mm
.XX ± 0.025mm
.XXX see call out
Angular
.X ± 0.1deg
.XX ± 0.02deg
.XXX see call out
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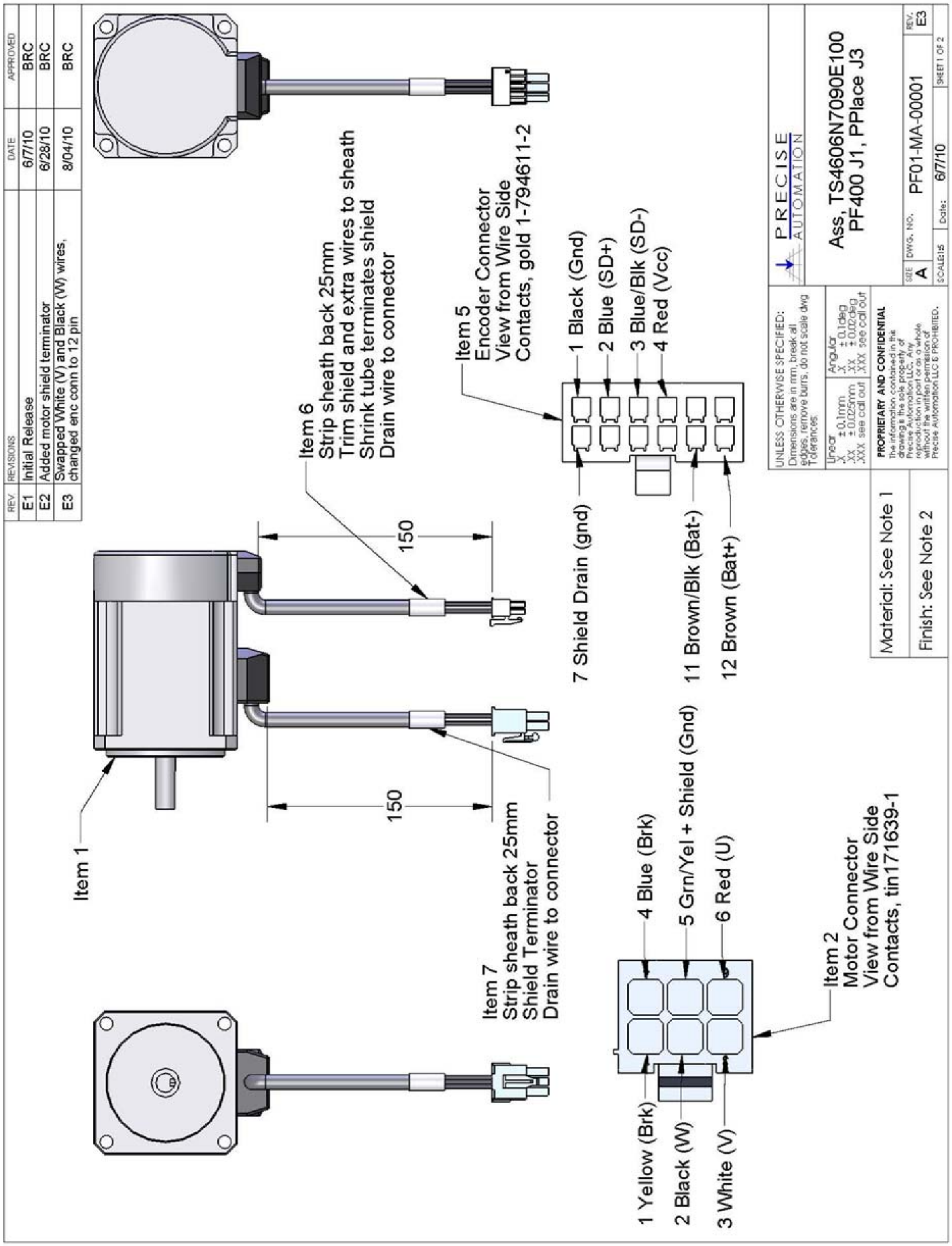
PRECISE
AUTOMATION
Harness PF400
Pneumatic Gripper
Material: See Note 1
Finish: See Note 2
SIZE A
DWG. NO.
REV. E2
SCALE:1:1
Date: 10/24/10
SHEET 1 OF 1


REV
REVISIONS
DATE
APPROVED
E1
Initial Release
6/7/10
BRC
E2
Added motor shield terminator
6/28/10
BRC
E3
Swapped White (V) and Black (W) wires, changed enc conn to 12 pin
8/04/10
BRC
Item 1
150
150
Item 7
Strip sheath back 25mm
Shield Terminator
Drain wire to connector
Item 6
Strip sheath back 25mm
Trim shield and extra wires to sheath
Shrink tube terminates shield
Drain wire to connector
Item 5
Encoder Connector
View from Wire Side
Contacts, gold 1-794611-2
1 Black (Gnd)
2 Blue (SD+)
3 Blue/Blk (SD-)
4 Red (Vcc)
7 Shield Drain (gnd)
11 Brown/Blk (Bat-)
12 Brown (Bat+)
1 Yellow (Brk)
2 Black (W)
3 White (V)
4 Blue (Brk)
5 Grn/Yel + Shield (Gnd)
6 Red (U)
Item 2
Motor Connector
View from Wire Side
Contacts, tin171639-1
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear
.X ± 0.1mm
.XX ± 0.025mm
.XXX see call out
Angular
.X ± 0.1deg
.XX ± 0.02deg
.XXX see call out
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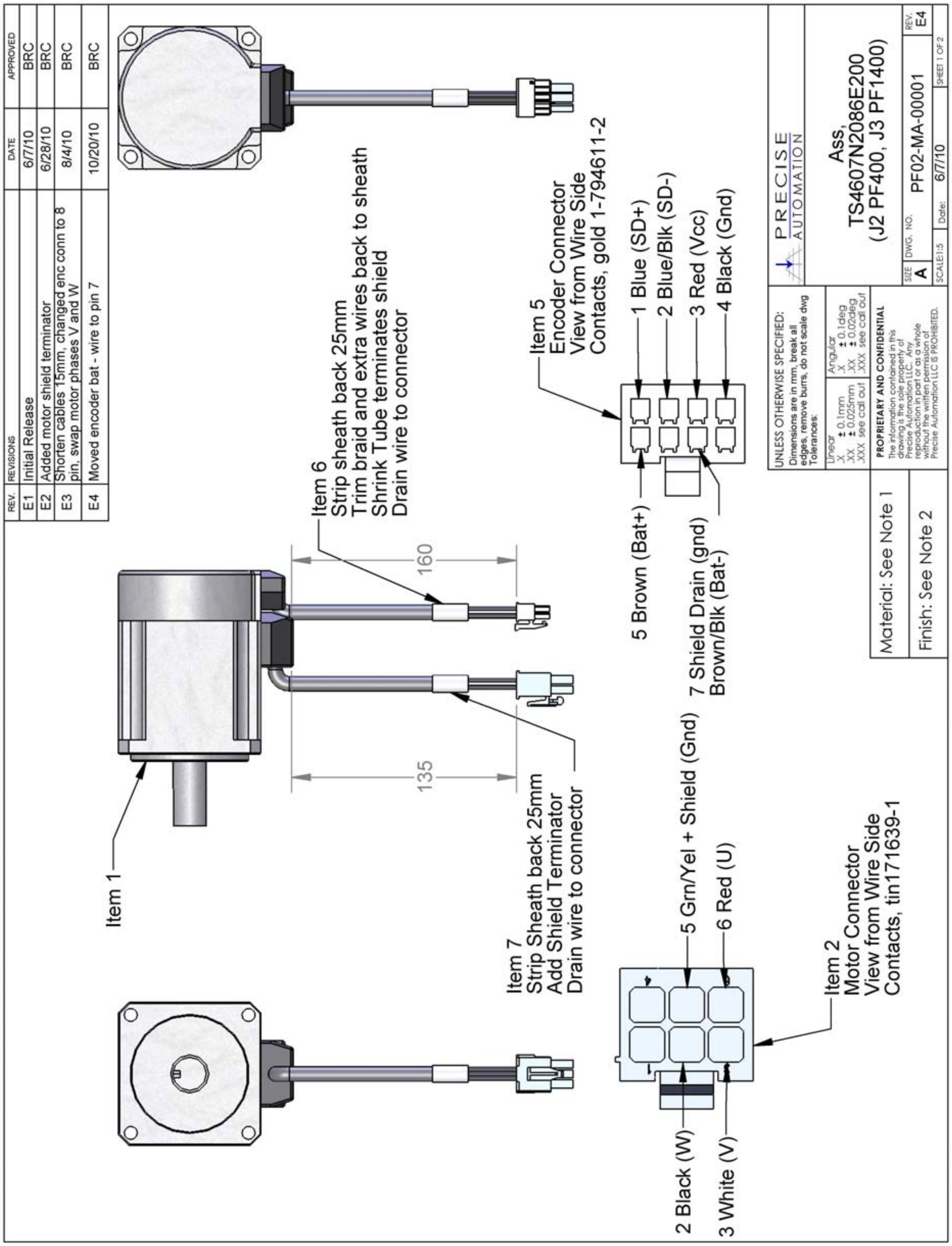
PRECISE AUTOMATION
Ass, TS4606N7090E100
PF400 J1, PPlace J3
SIZE
A
DWG. NO.
PF01-MA-00001
REV.
E3
SCALE:1:5
Date:
6/7/10
SHEET 1 OF 2


REV. | REVISIONS | DATE | APPROVED
E1 | Initial Release | 6/7/10 | BRC
E2 | Added motor shield terminator | 6/28/10 | BRC
E3 | Shorten cables 15mm, changed enc conn to 8 pin, swap motor phases V and W | 8/4/10 | BRC
E4 | Moved encoder bat - wire to pin 7 | 10/20/10 | BRC
Item 1
Item 6
Strip sheath back 25mm
Trim braid and extra wires back to sheath
Shrink Tube terminates shield
Drain wire to connector
160
135
Item 7
Strip Sheath back 25mm
Add Shield Terminator
Drain wire to connector
Item 5
Encoder Connector
View from Wire Side
Contacts, gold 1-794611-2
1 Blue (SD+)
2 Blue/Blk (SD-)
3 Red (Vcc)
4 Black (Gnd)
5 Brown (Bat+)
7 Shield Drain (gnd)
Brown/Blk (Bat-)
5 Grn/Yel + Shield (Gnd)
6 Red (U)
2 Black (W)
3 White (V)
Item 2
Motor Connector
View from Wire Side
Contacts, tin171639-1
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
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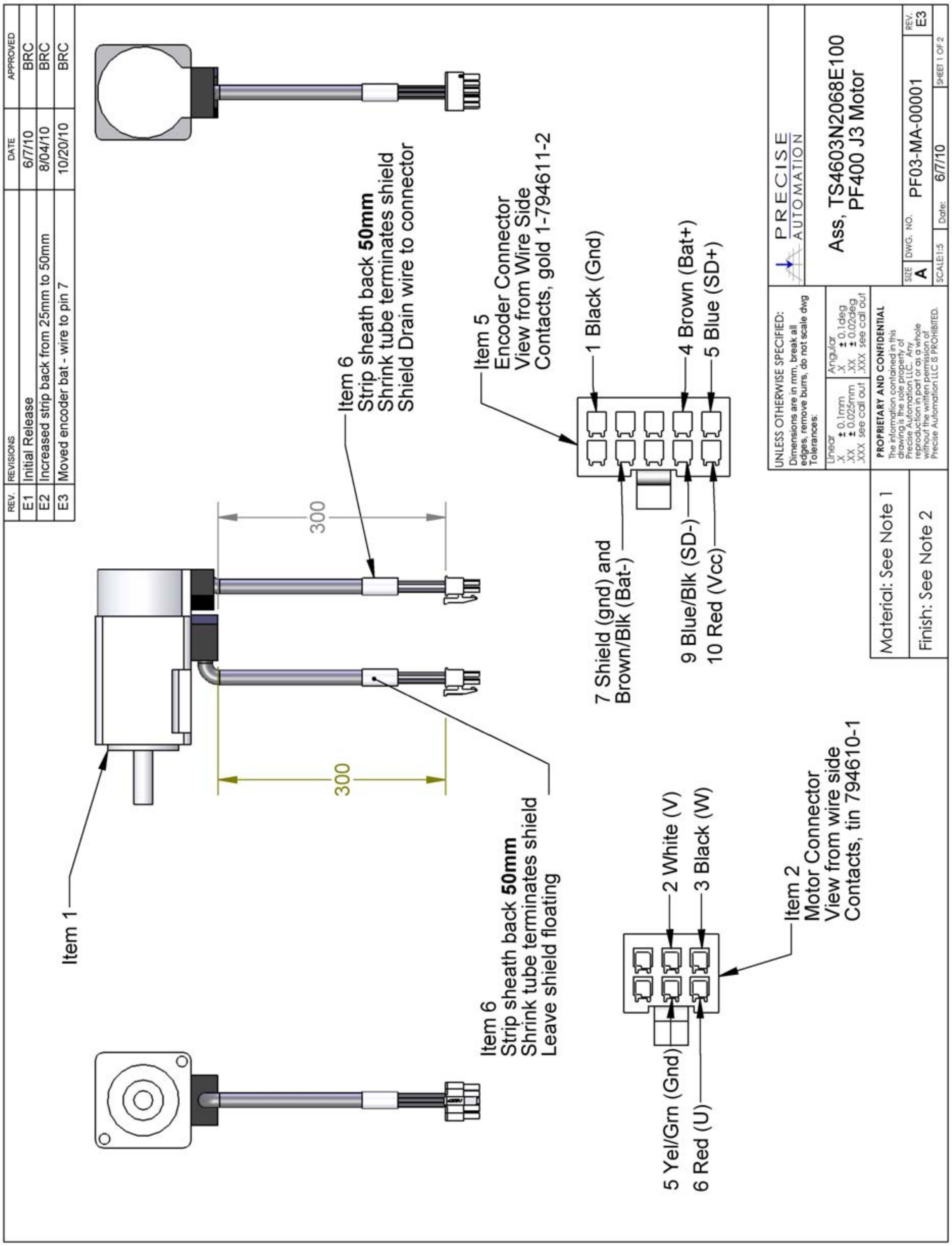
PRECISE AUTOMATION
Ass, TS4607N2086E200
(J2 PF400, J3 PF1400)
SIZE A
DWG. NO. PF02-MA-00001
REV. E4
SCALE:1:5
Date: 6/7/10
SHEET 1 OF 2



REV.
REVISIONS
DATE
APPROVED
E1
Initial Release
6/7/10
BRC
E2
Increased strip back from 25mm to 50mm
8/04/10
BRC
E3
Moved encoder bat - wire to pin 7
10/20/10
BRC
Item 1
Item 6
Strip sheath back **50mm**
Shrink tube terminates shield
Leave shield floating
300
300
Item 6
Strip sheath back **50mm**
Shrink tube terminates shield
Shield Drain wire to connector
Item 5
Encoder Connector
View from Wire Side
Contacts, gold 1-794611-2
1 Black (Gnd)
4 Brown (Bat+)
5 Blue (SD+)
7 Shield (gnd) and
Brown/Blk (Bat-)
9 Blue/Blk (SD-)
10 Red (Vcc)
5 Yel/Grn (Gnd)
6 Red (U)
2 White (V)
3 Black (W)
Item 2
Motor Connector
View from wire side
Contacts, tin 794610-1
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear
.X ± 0.1mm
.XX ± 0.025mm
.XXX see call out
Angular
.X ± 0.1deg
.XX ± 0.02deg
.XXX see call out
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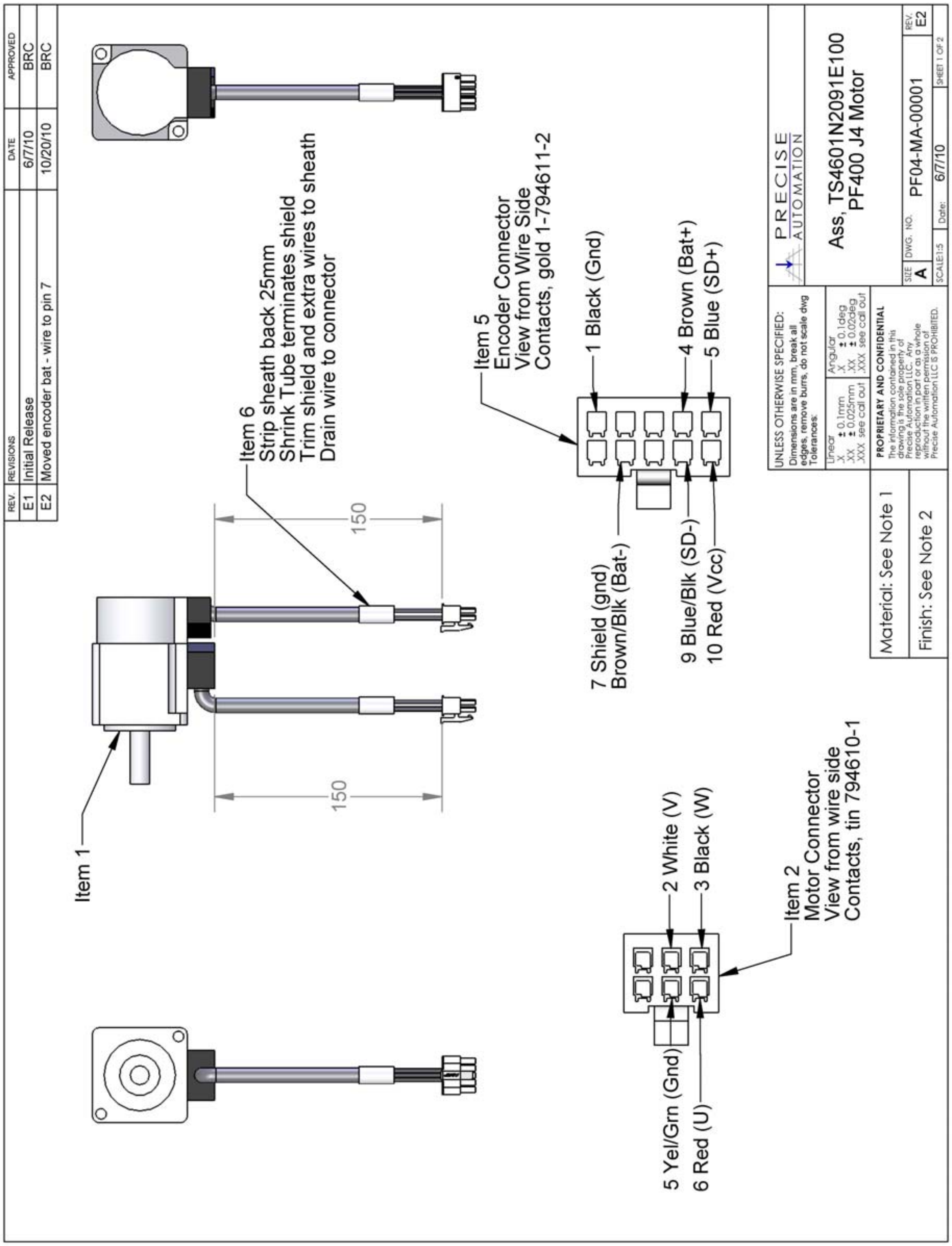
PRECISE AUTOMATION
Ass, TS4603N2068E100
PF400 J3 Motor
SIZE
A
DWG. NO.
PF03-MA-00001
REV.
E3
SCALE 1:5
Date:
6/7/10
SHEET 1 OF 2


REV. | REVISIONS | DATE | APPROVED
E1 | Initial Release | 6/7/10 | BRC
E2 | Moved encoder bat - wire to pin 7 | 10/20/10 | BRC
Item 1
150
150
Item 6
Strip sheath back 25mm
Shrink Tube terminates shield
Trim shield and extra wires to sheath
Drain wire to connector
Item 5
Encoder Connector
View from Wire Side
Contacts, gold 1-794611-2
1 Black (Gnd)
4 Brown (Bat+)
5 Blue (SD+)
7 Shield (gnd)
Brown/Blk (Bat-)
9 Blue/Blk (SD-)
10 Red (Vcc)
Item 2
Motor Connector
View from wire side
Contacts, tin 794610-1
2 White (V)
3 Black (W)
5 Yel/Grn (Gnd)
6 Red (U)
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
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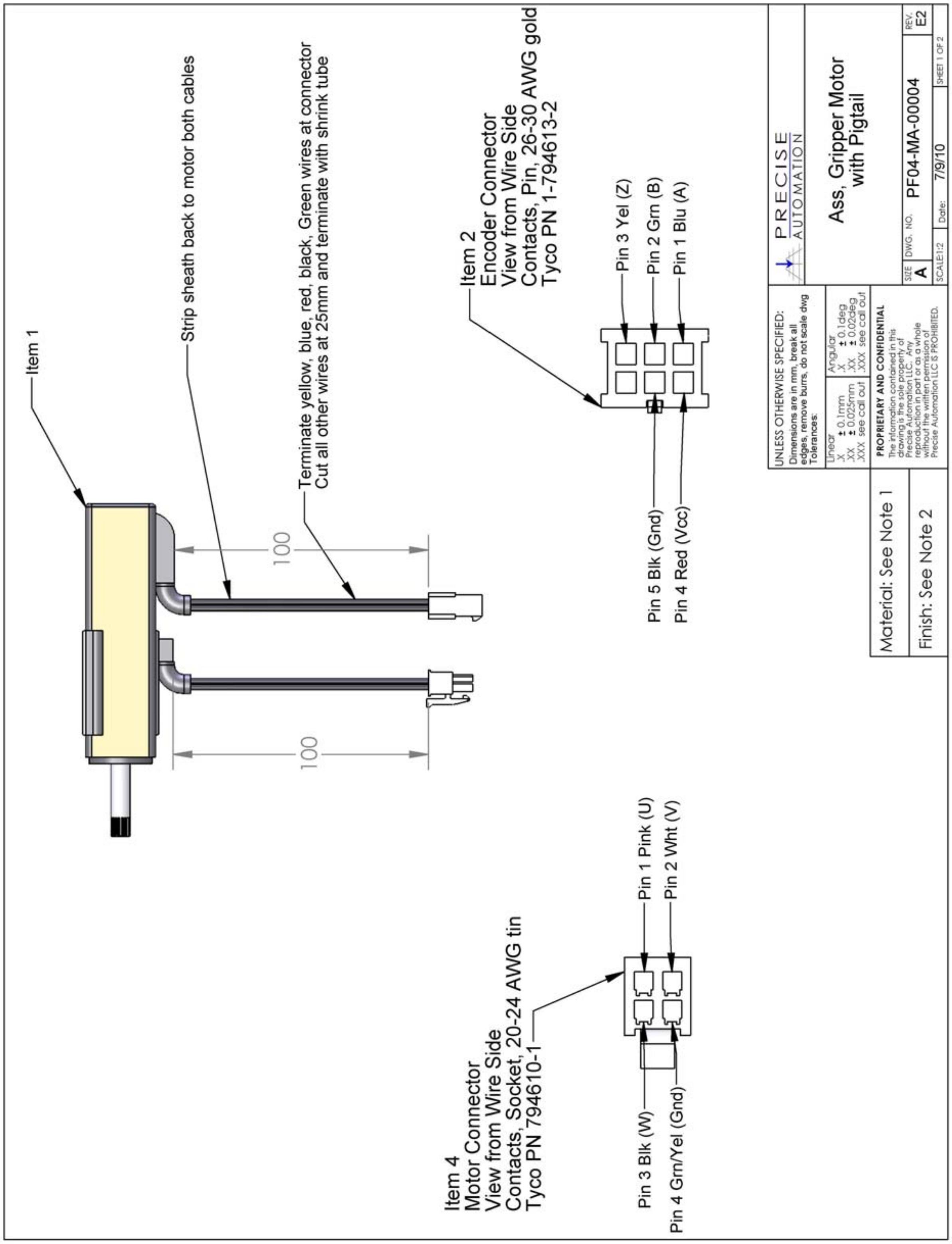
PRECISE AUTOMATION
Ass, TS4601N2091E100
PF400 J4 Motor
SIZE A
DWG. NO. PF04-MA-00001
REV. E2
SCALE:1:5
Date: 6/7/10
SHEET 1 OF 2


Item 1
Strip sheath back to motor both cables
Terminate yellow, blue, red, black, Green wires at connector
Cut all other wires at 25mm and terminate with shrink tube
100
100
Item 2
Encoder Connector
View from Wire Side
Contacts, Pin, 26-30 AWG gold
Tyco PN 1-794613-2
Pin 3 Yel (Z)
Pin 2 Grn (B)
Pin 1 Blu (A)
Pin 5 Blk (Gnd)
Pin 4 Red (Vcc)
Item 4
Motor Connector
View from Wire Side
Contacts, Socket, 20-24 AWG tin
Tyco PN 794610-1
Pin 1 Pink (U)
Pin 2 Wht (V)
Pin 3 Blk (W)
Pin 4 Grn/Yel (Gnd)
Material: See Note 1
Finish: See Note 2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear .X ± 0.1mm .XX ± 0.025mm .XXX see call out
Angular .X ± 0.1deg .XX ± 0.02deg .XXX see call out
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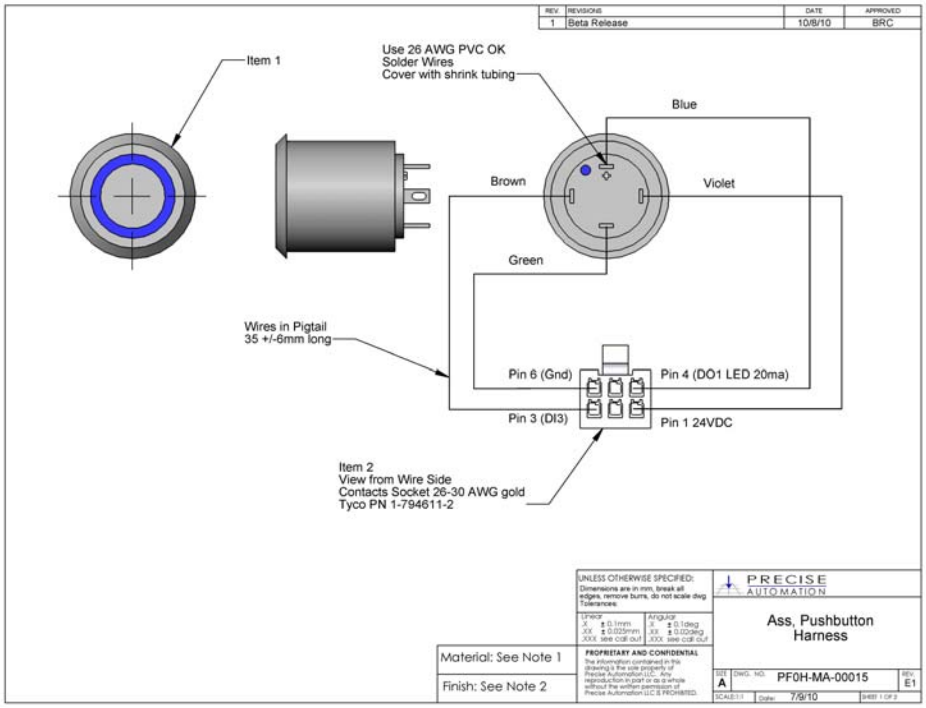
PRECISE AUTOMATION
Ass, Gripper Motor with Pigtail
SIZE A
DWG. NO. PF04-MA-00004
REV. E2
SCALE:1:2
Date: 7/9/10
SHEET 1 OF 2


REV.
REVISIONS
DATE
APPROVED
1
Beta Release
10/8/10
BRC
Item 1
Use 26 AWG PVC OK
Solder Wires
Cover with shrink tubing
Blue
Brown
Violet
Green
Wires in Pigtail
35 +/-6mm long
Pin 6 (Gnd)
Pin 4 (DO1 LED 20ma)
Pin 3 (DI3)
Pin 1 24VDC
Item 2
View from Wire Side
Contacts Socket 26-30 AWG gold
Tyco PN 1-794611-2
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear
.X ± 0.1mm
.XX ± 0.025mm
.XXX see call out
Angular
.X ± 0.1deg
.XX ± 0.02deg
.XXX see call out
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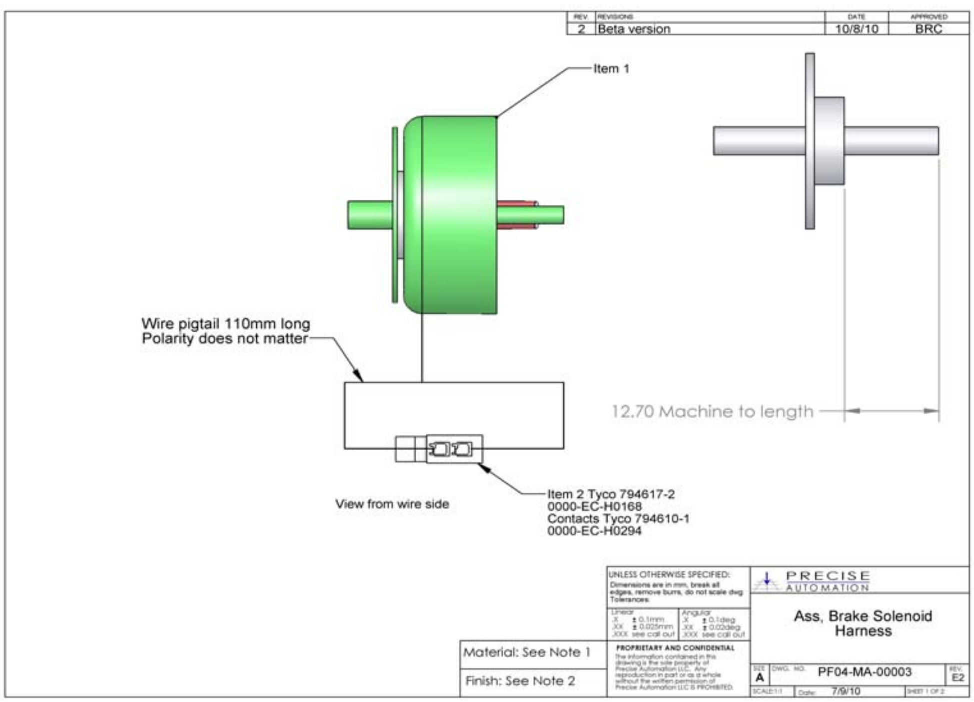
PRECISE AUTOMATION
Ass, Pushbutton Harness
Material: See Note 1
Finish: See Note 2
SIZE
A
DWG. NO.
PF0H-MA-00015
REV.
E1
SCALE:1:1
Date:
7/9/10
SHEET 1 OF 2


REV.
REVISIONS
DATE
APPROVED
2
Beta version
10/8/10
BRC
Item 1
Wire pigtail 110mm long
Polarity does not matter
12.70 Machine to length
View from wire side
Item 2 Tyco 794617-2
0000-EC-H0168
Contacts Tyco 794610-1
0000-EC-H0294
UNLESS OTHERWISE SPECIFIED:
Dimensions are in mm, break all edges, remove burrs, do not scale dwg
Tolerances:
Linear
.X ± 0.1mm
.XX ± 0.025mm
.XXX see call out
Angular
.X ± 0.1deg
.XX ± 0.02deg
.XXX see call out
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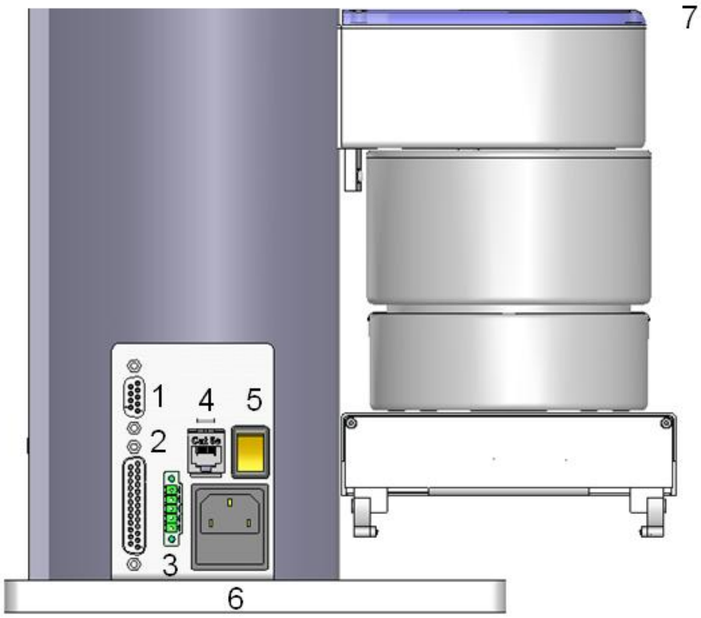
PRECISE AUTOMATION
Ass, Brake Solenoid Harness
Material: See Note 1
Finish: See Note 2
SIZE
A
DWG. NO.
PF04-MA-00003
REV.
E2
SCALE:1:1
Date:
7/9/10
SHEET 1 OF 2

Facilities Panel

The Facilities Panel is located at the base of the robot.



Item	Name	Description
1	9 Pin D Sub Connector	Contains RS-232 Serial Port, 24 VDC, Gnd Can be used for optional teach pendant
2	25 Pin D Sub Connector	For optional DIO module, 8 inputs, 8 outputs
3	EStop Connector	EStop and Cell Interlock Signals
4	Ethernet Connector	For Ethernet to Computer Cable
5	Power Switch	Lighted Power Switch
6	Power Entry Module	For IEC plug. Contains dual fuse drawer.
7	Power Status Light	Blinks to indicate power status

To simplify interfacing, most of the electrical interfaces provided by the robot's embedded Guidance Controller are available on the Facilities Panel. These include:

- Digital input signals
- Digital output signals
- Ethernet port
- Remote Front Panel / MCP / E-Stop
- RS-232 serial interface

Each of these interfaces is described in detail in the following sections. In addition, the robot's controller, which is mounted in the inner link of the robot, may contain additional interfaces (e.g. inputs or outputs). Please refer to the *Guidance 1000A/B Controllers, Hardware Introduction and Reference Manual* for additional information.

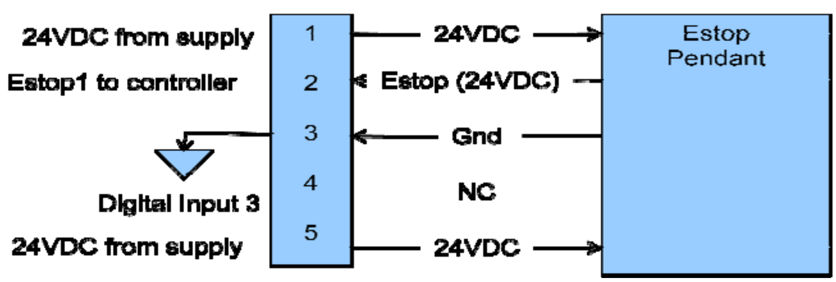
DANGER: The Guidance 1400B controller, and the 24 VDC and 48 VDC power supplies are all open frame electrical devices that contain unshielded high voltage pins, components and surfaces. . **The main AC power should always be disconnected before the Facilities Panel is removed.**

If the pneumatic gripper option is ordered one air line is routed through the interior of the robot. At the Facilities Panel, this air line is presented in a fitting on a sub plate mounted to the facilities panel. The other end of this line exits at the Outer Link. When using this line, clean, dry external air should be provided.

CAUTION: The maximum air pressure that can be conveyed by the air lines through the robot is **75 PSI**. Applying a pressure exceeding this level may disconnect interior connections or damage fittings or hoses. If a higher pressure is required, an external air line should be utilized.

E-Stop Connector

The standard E-Stop connector is the green Phoenix connector on the Facilities Panel. Note the E-Stop pins on the MCP Interface (below) are in series with the E-Stop signals on the Phoenix E-Stop connector. An E-Stop box or circuit can be plugged into either one of these two connectors. However in order for the robot to allow motor power to be enabled the E-Stop circuit must connect 24 VDC to E-Stop1 in both of these two connectors. If no E-Stop box or circuit is connected, then the circuit must be completed with a jumper from pin 1 to pin 2 on the Phoenix connector or from pin 1 to pin 6 on the MCP connector. The robot is shipped with a Phoenix jumper plug PN 1851070 and a jumper plug in the 9 pin Dsub connector that satisfy these requirements. Unlike the Digital IO circuits, the E-Stop circuit cannot be configured as “Sourcing” or “Sinking”. If a remote signal (for example from a PLC) is used to trigger E-Stop, it should be wired to a relay that closes the circuit between pins 1 and 2.



MCP / E-Stop Interface

The MCP interface includes the signals necessary to connect a Manual Control Pendant, secondary E-Stop circuit, or an external RS485 Remote IO Module. These signals are provided in a DB9 female connector mounted on the robot’s Facilities Panel.

Note the E-Stop pins on the MCP Interface are in series with the E-Stop signals on the Phoenix E-Stop connector. An E-Stop box or circuit can be plugged into either one of these two connectors. However in order for the robot to allow motor power to be enabled the E-Stop circuit must connect 24 VDC to E-Stop1 in one of these two connectors. If no E-Stop box or circuit is connected, then both circuits must be completed with jumper plugs. (The robot is shipped with a Phoenix jumper plug PN 1851070 and a Dsub jumper plug that satisfy these requirements.)

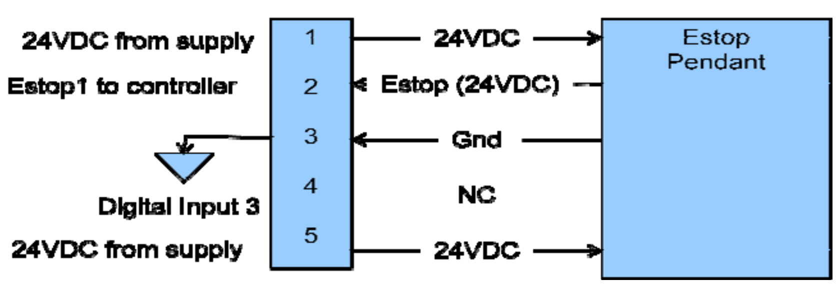
If a Manual Control Pendant is not connected to the secondary RS-232 port provided in this connector, this serial interface can be accessed via a GPL procedure as device "/dev/com2" for general communications purposes. Please note that unlike the primary serial interface, THIS SECONDARY SERIAL INTERFACE DOES NOT SUPPORT FLOW CONTROL.

The RS485 port is used internally to communicate with the gripper controller and is also be used for the Remote IO option. As such it has a dedicated protocol and is not available for general use.

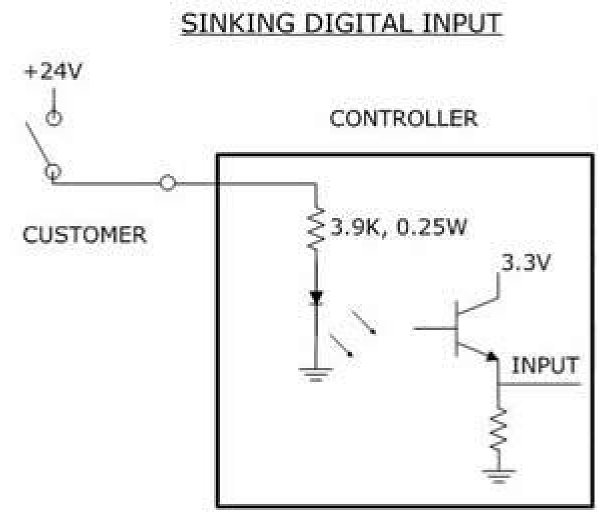
Pin	Description
1	24VDC
2	RS232 TXD
3	RS232 RXD
4	RS485-
5	Gnd
6	E-Stop1
7	E-Stop Daisy Chain
8	48VDC
9	RS485+
Interface Panel Connector Part No	DB9 Female Connector AMP 5747150-7
User Plug Part No	DB9 Male Plug Amp 1658655-1 (crimp) Pins 22-26AWG 745254-6

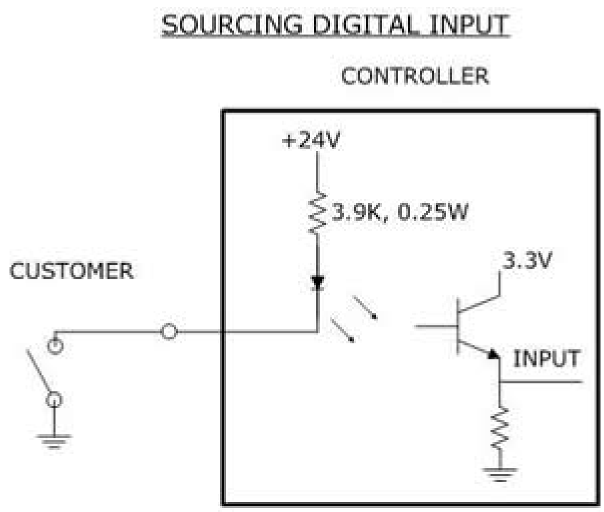
Digital Input Signals

The standard PreciseFlex 400 robot provides 1 general purpose optically isolated digital input signal at the Facilities Panel (in addition to those signals that are available at the Gripper Control Board). This line is accessed in the Phoenix 5 pin E-Stop connector and is connected to Digital Input 3 in the controller.



This input signal can be configured as "sinking" or "sourcing". If an input signal is configured as "sinking", the external equipment must pull its input high to 5VDC to 24VDC to indicate a logical high value or must allow it to float to no voltage for a logical low. This input is configured at the factory as "sinking".



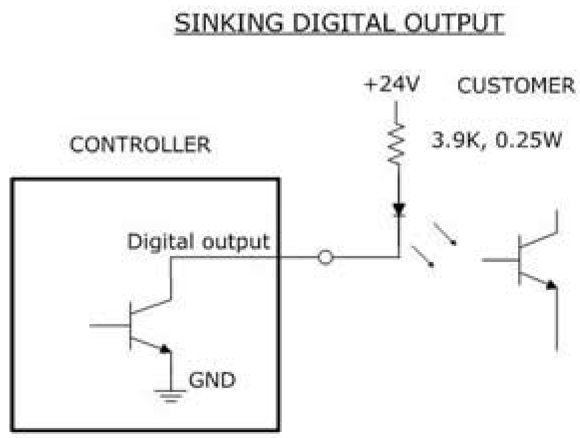


By setting Jumpers on the CPU (MIDS4) board, the four output signals can be individually configured as "sinking" or "sourcing" and the four digital inputs can be configured as a group to all operate as either sinking or sourcing. For more information on configuring the jumpers, please see the *Guidance 1000A/B Controllers, Hardware Introduction and Reference Manual.*

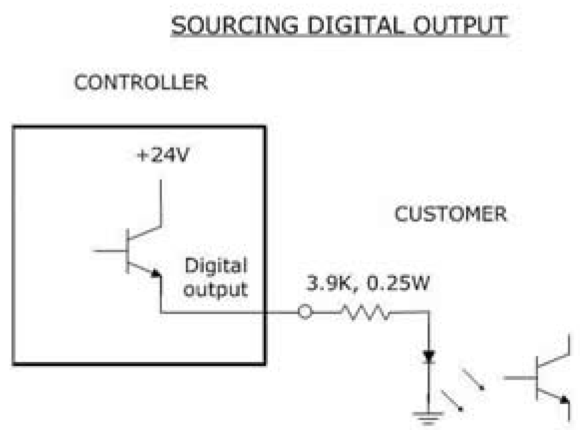
Digital Output Signals

The PreciseFlex robot provides 4 general-purpose optically isolated digital output signals at the G1400B controller.

These output signals can be configured as "sinking" or "sourcing". ***As shipped from the factory, the output signals are configured as "sinking"***, i.e. the external equipment must provide a 5VDC to 24VDC pull up voltage on an output pin and the controller pulls this pin to ground when the signal is asserted as true.



Alternately, the output signals can be configured as "sourcing", i.e. the external equipment must pull down an output pin to ground and the controller pulls this pin to 24VDC when the signal is asserted as true.



Outputs can be individually configured as sinking or sourcing signals. For more information on configuring the jumpers, please see the *Guidance Controller, Hardware Introduction and Reference Manual.*

The pin out for the G1400B Digital Input and Output Connector and the corresponding GPL signal numbers are described in the following table.

Pin	GPL Signal Number	Description
1	13	Digital Output 1
2	14	Digital Output 2
3	15	Digital Output 3
4	16	Digital Output 4
5		GND
6		24 VDC output
7	10001	Digital Input 1
8	10002	Digital Input 2

9	10003	Digital Input 3
10	10004	Digital Input 4
User Plug Part No		AMP 1658622-1 or Molex 22-55-2101 or 90142-0010. For the Molex plug, use Molex sockets 16-02-0103 or 90119-2110 and Molex crimp tool 63811-1000.

Gripper Controller Digital Inputs and Outputs

If the robot is equipped with an electric gripper, the gripper controller includes 3 sinking digital inputs and 3 sourcing digital outputs. One digital input and one digital output are dedicated for a lighted teach button on some electric grippers. The other two inputs and outputs are available in the outer link for application use.

Pin	GPL Signal Number	Description
1	200013	Digital Output 1/LED driver
2	200014	Digital Output 2
3	200015	Digital Output 3
4		24 VDC output
5		GND
6	210001	Digital Input 1
7	210002	Digital Input 2
8	210003	Digital Input 3
User Plug Part No		Amp 794617-8, crimp contacts 1-794611-2

RS485 Remote IO Module (Not released, subject to change)

Customers who need additional digital IO may order the RS485 Remote IO Module. This module installs in the base of the robot and provides 12 Digital Inputs and 8 Digital Outputs in a 25 pin Dsub connector.

The RS485 Remote IO Module (RIO) provides 12 general purpose optically isolated digital input signals and 8 general purpose optically isolated digital output signals. Two inputs, 11 and 12, can be optionally configured as analog inputs by means of jumpers J1 and J2. Connecting J1 to pins 1 and 2 (default) configures these inputs as digital and connecting pins 2 and 3 configures them as analog. These input and output signals are intended for interfacing to tooling and sensors or for general application needs. This board is connected to the controller by an RS485 serial line that allows the controller to scan the RIO I/O with a nominal period of 4 milliseconds.

The DIO signals are accessible via the DB25 female connector that is mounted on the facilities panel when this option is ordered. The DIO signals addresses are determined by a base address set by a DIP switch on the DIO board. For this robot the first switch will be set to 1 and the other 3 switches to zero. The addresses will then be as follows.

DB25 Female

Pin	GPL Signal Number	Description
1		Gnd
2		Gnd
3	310001	Digital Input 1
4	310002	Digital Input 2
5	310003	Digital Input 3
6	310004	Digital Input 4
7	310005	Digital Input 5
8	310006	Digital Input 6
9	310007	Digital Input 6
10	310008	Digital Input 8
11	310009	Digital Input 9
12	310010	Digital Input 10
13	310011	Digital Input 11/Analog Input 1 (Jumper select, J1)
14	310012	Digital Input 12/Analog Input 2 (Jumper select, J2)
15		24VDC
16		24VDC
17	300013	Digital Output 1
18	300014	Digital Output 2
19	300015	Digital Output 3
20	300016	Digital Output 4
21	300017	Digital Output 5
22	300018	Digital Output 6
23	300019	Digital Output 7
24	300020	Digital Output 8
25		24VDC
Interface Panel Connector Part No		DB25 Female Connector
User Plug Part No		DB25 Male Plug

Ethernet Interface

PreciseFlex robots include an Ethernet switch that implements two 10/100 Mbit Ethernet ports. This capability was designed to permit the controller to be interfaced to multiple Ethernet devices such as other Precise controllers or robots, remote I/O units and Ethernet cameras. The Ethernet switch automatically detects the sense of each connection, so either straight-thru or cross-over cables can be used to connect the controller to any other Ethernet device.

Due to limited space on the Facilities Panel, only one of the two Ethernet ports is available via an external RJ45 connector. This external Ethernet port is typically used to interface the robot to a PC. The second Ethernet port is only available inside the inner link of the robot. In some cases it may be used to connect an Ethernet camera that is mounted on the robot.

In this case, a PC that is connected to the Ethernet plug on the Facilities Panel can communicate with the robot’s controller as well as receive images from an arm-mounted camera. (For the initial release of this robot, arm mounted cameras are not supported.)

If a camera is mounted in the workcell, an external Ethernet switch must be added to connect these cameras and the robot to a PC.

See the *Setup and Operation Quick Start Guide* for instructions on setting the IP address for the controller.

RS-232 Serial Interface

The PreciseFlex robot includes a standard RS-232 serial line equipped with hardware or software flow control. However this port is only available on the G1400B controller in the inner link of the robot and is not brought out to any outside connector on this robot. This port can be used to communicate to the system serial console or can be connected to external equipment for general communication purposes. When used for general communications, this port is referenced as device "/dev/com1" within the Guidance Programming Language (GPL).

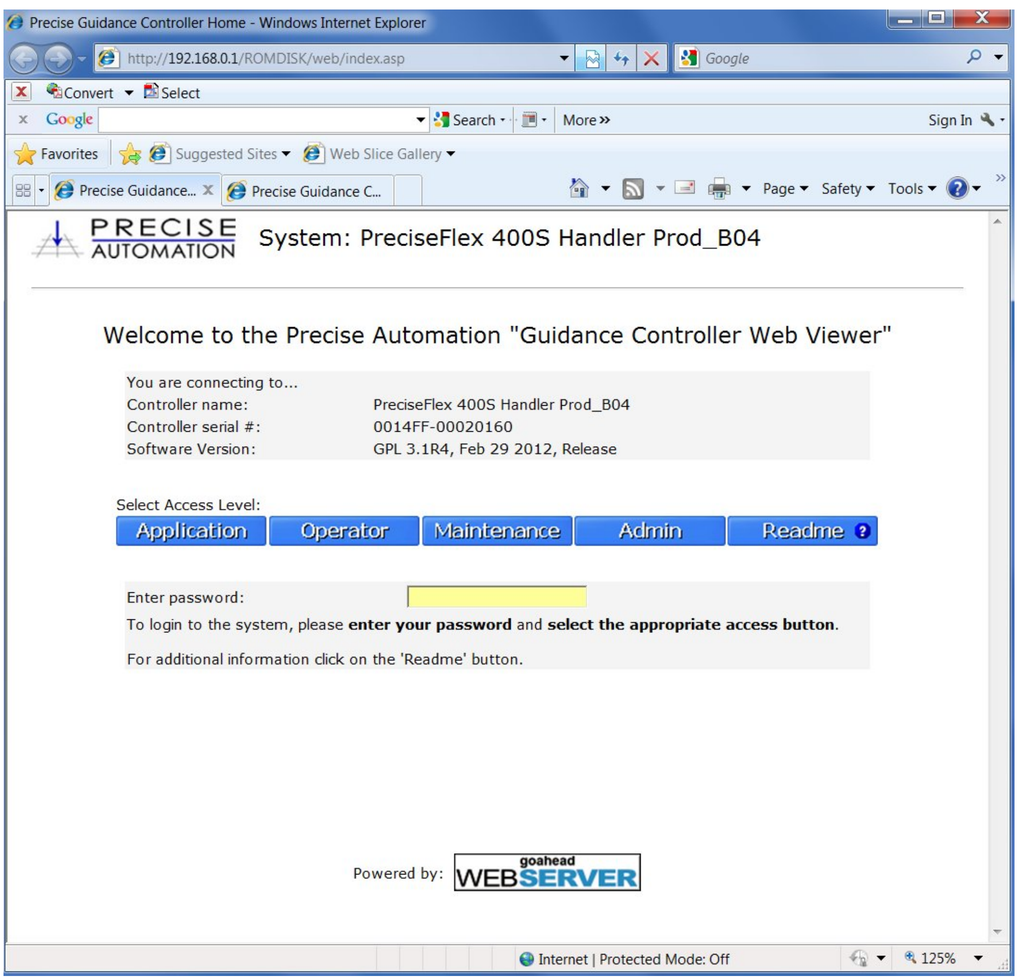
The connector for this interface is a standard RJ11 serial interface connector that has pin assignments compatible with standard PC "com" ports. For this robot it is only used for debugging and special service procedures.

Software Reference

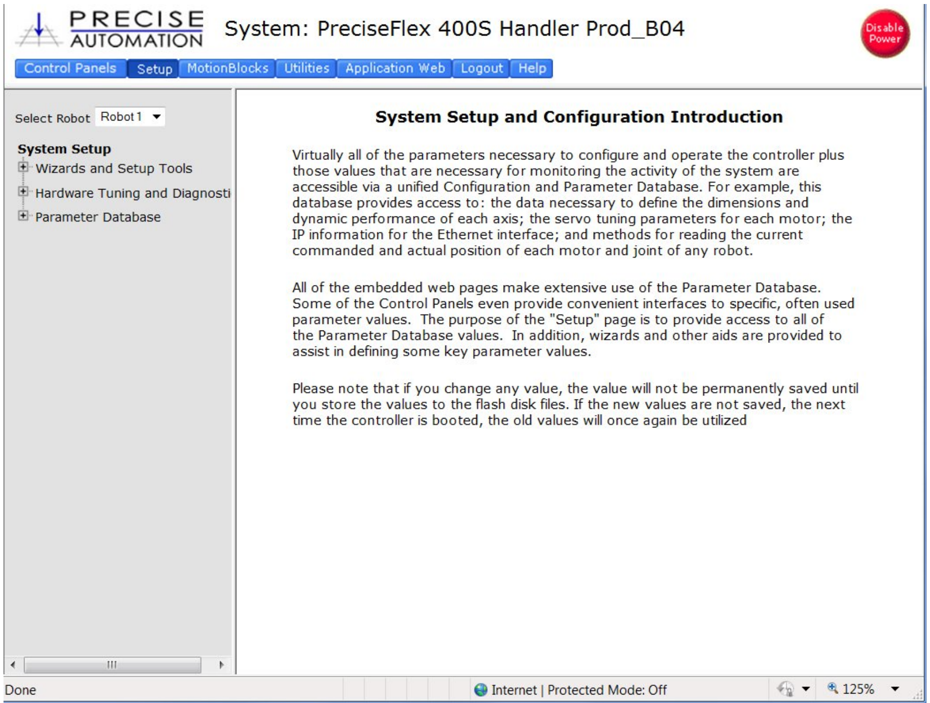
Accessing the Web Server

Many OEM customers run the PF400 using a PC to provide an application-specific operator interface. In order to update software in the controller, and view certain error messages, it is necessary to access the Web Server Interface embedded in the controller.

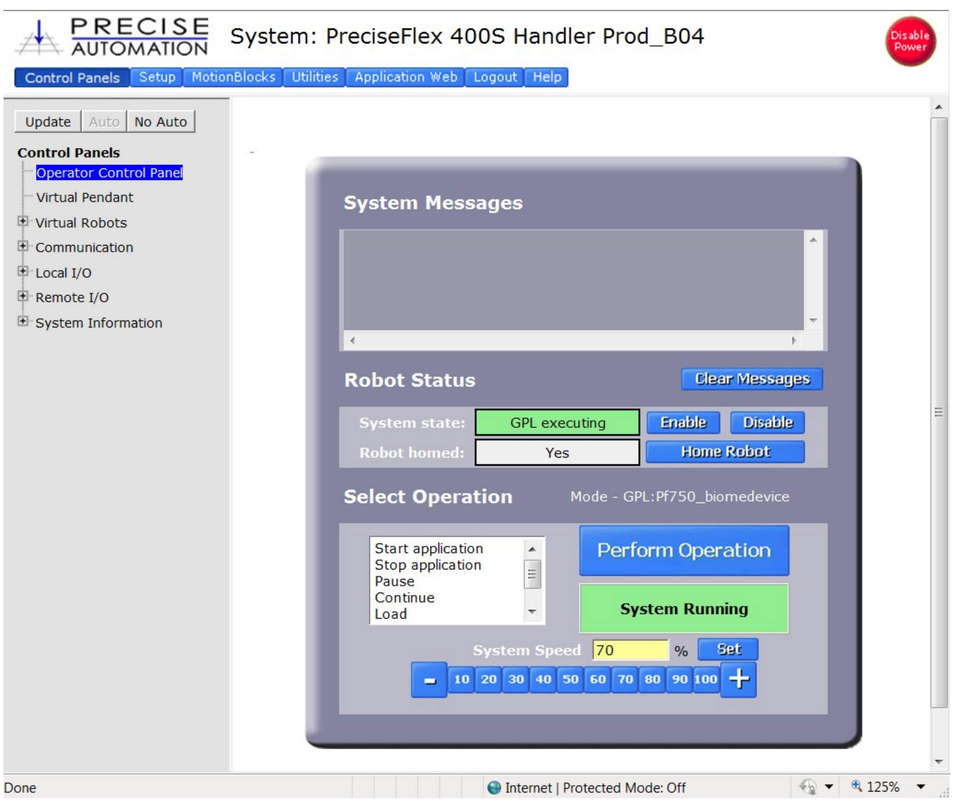
The Web Server Interface may be addressed by opening a browser (such as Internet Explorer) in a PC that is connected to the robot via Ethernet. You must know the IP address of the robot controller. Two common IP addresses are 192.168.0.1 and 192.168.0.10. The PC LAN interface address must be configured correctly (for example 192.168.0.100, with subnet mask 255.255.255.0). The Web Server Interface will come up with the window below.



It may be necessary to enter a password if your company has protected access to the Web Interface. Once the password has been entered, click on "Admin" to access all the features to perform system upgrades. The window below will open up.



Click on "Control Panels", then "Operator Control Panel". The window below will appear.



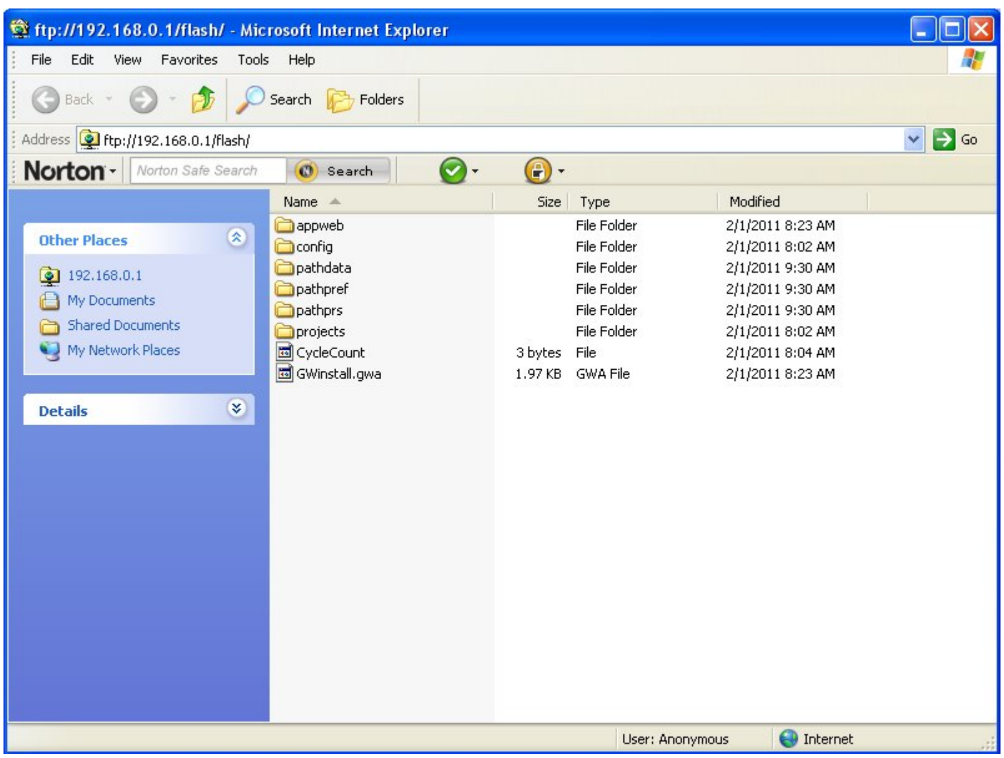
If an application is running, the “System Running” panel will display in green. In order to run diagnostics, you must stop the application from running. Click “Stop Application” and then “Perform Operation”. This will stop the application from running. You should click the “Disable Power” button to be sure motor power is off. If you need to load a new project (for example CAL_PP) you will need to click on “Unload” and then “Perform Operation” before you can load the new project into RAM.

You may now perform the procedures below.

Loading a Project (Program) or Updating PAC Files

If CAL_PP or a different program needs to be loaded into the controller from an external computer, this may be done using the Web Interface.

1. In the Web Based Operator Interface, select “Utilities/Backup and Restore
2. Click on Start File Manager. It may be necessary to hold down the Control Key to allow the pop-up. An ftp directory pop-up will come up. In the “Page” menu in Windows Internet Explorer select “Open ftp site in Windows Explorer”. Another window will open showing several folders, including “Config” and “Projects”.



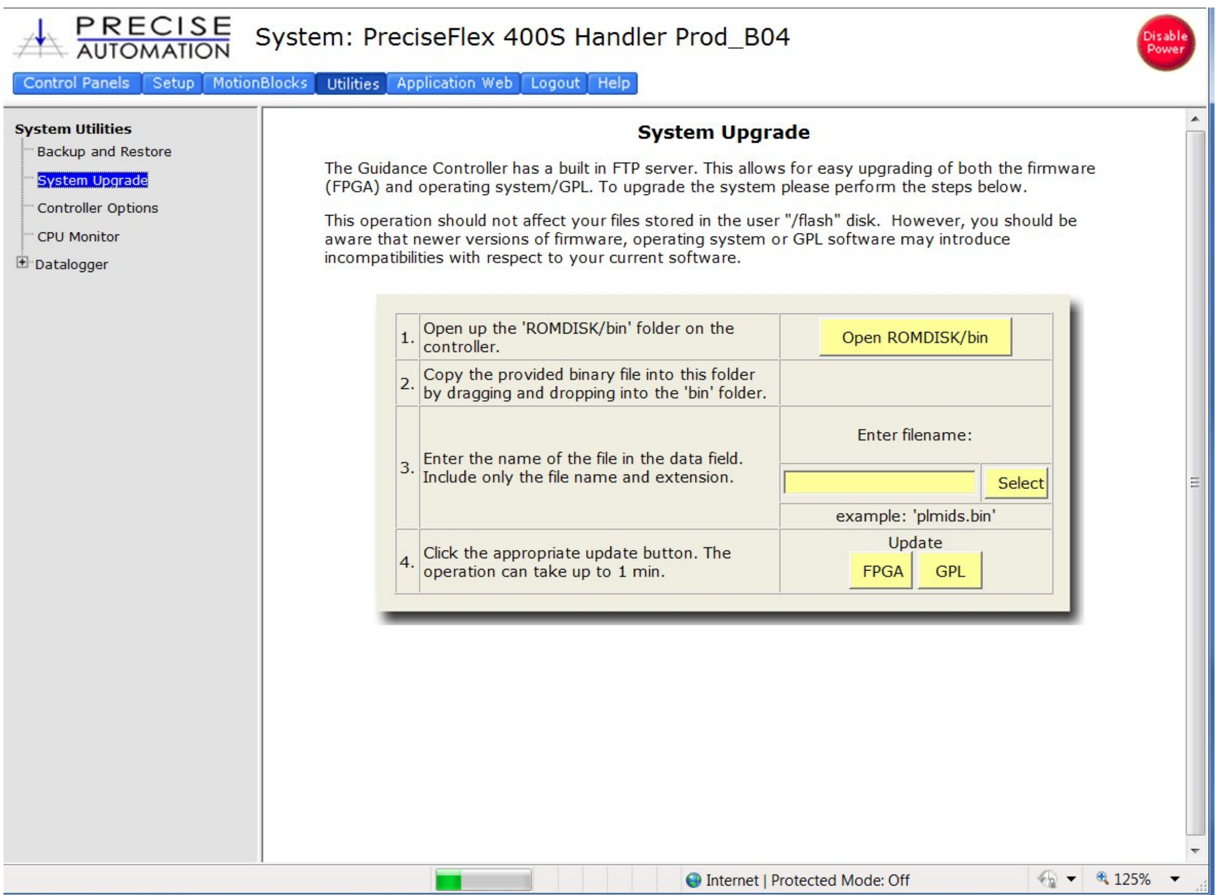
3. To load a Project, Open the “Projects” folder and paste the Project folder into this area. There may be several other projects (programs) loaded into this folder, which is stored in flash ram in the controller. A project folder is a software folder than may have several files inside it. You must load the entire folder, not just the files inside.
4. To load or update PAC files, open the “Config” folder and paste a backup copy of the PAC files into the “Config” folder. These files will all have a **.pac** extension. The robot must be re-booted after new PAC files are installed for them to take effect.

5. Once the appropriate project (for example CAL_PP) has been loaded into flash memory, it must then be loaded into dynamic memory in order to execute. See the section below on "Calibrating the Robot" for an example on how to load and execute the CAL_PP program.

Updating GPL (System Software) or FPGA (Firmware)

Both GPL (the system software) and the FPGA firmware may be upgraded in the field. To perform an upgrade:

1. Obtain the appropriate upgrade software from Precise, in the form of a .bin file.
2. In the Operator Interface, go to the Utilities/System Upgrade menu.



3. Click on Open ROMDISK/bin. This will open an FTP window. You will need to select "page" in Internet Explorer and scroll to the bottom of the page menu and click "Open site in Windows Explorer". This will open a second ftp window in Windows. Paste the appropriate GPL or FPGA .bin file in this window.
4. Under item 3 in the System Upgrade menu, click on the Select button. A pick list will open up. Highlight the upgrade code in this pick list and click on the Select button again. The name of the file will appear in the filename field.

5. Then in step 4 in the menu click on either FPGA or GPL to upgrade the appropriate file. The banner in the Upgrade menu will start flashing for about 10 seconds while the flash RAM is being written with the new file. Wait about 10 additional seconds after this banner stops flashing, then reboot the robot, and the new code will be installed.

Recovering from Corrupted PAC Files

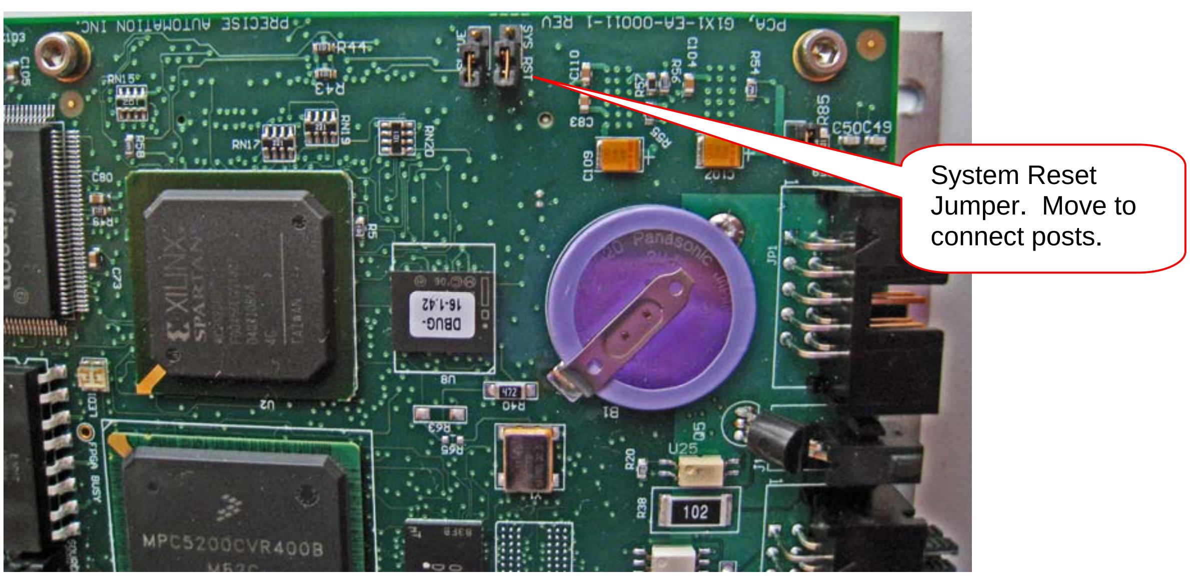
PAC files are configuration files that determine the configuration of the robot for the software, including the robot factory calibration data. These files are stored in Flash RAM. Flash RAM is also used to store robot programs. The Flash RAM requires some time for a complete write cycle. During the write cycle, the console will display a flashing warning not to turn off robot power. If robot power is turned off during the Flash RAM write cycle, the Flash data may be lost or corrupted. If this happens, it is necessary to reload both the robot PAC files and any user programs that were stored in Flash RAM. This problem should typically not be encountered by a user unless the user is changing configuration files in the robot.

Precise maintains a record of PAC files shipped with each robot Serial Number. If the PAC files have been corrupted, it is possible to get a back up copy from Precise. The backup copy will contain the factory configuration and calibration data, but will not contain any changes, including any new calibration data, made after the robot has left the factory.

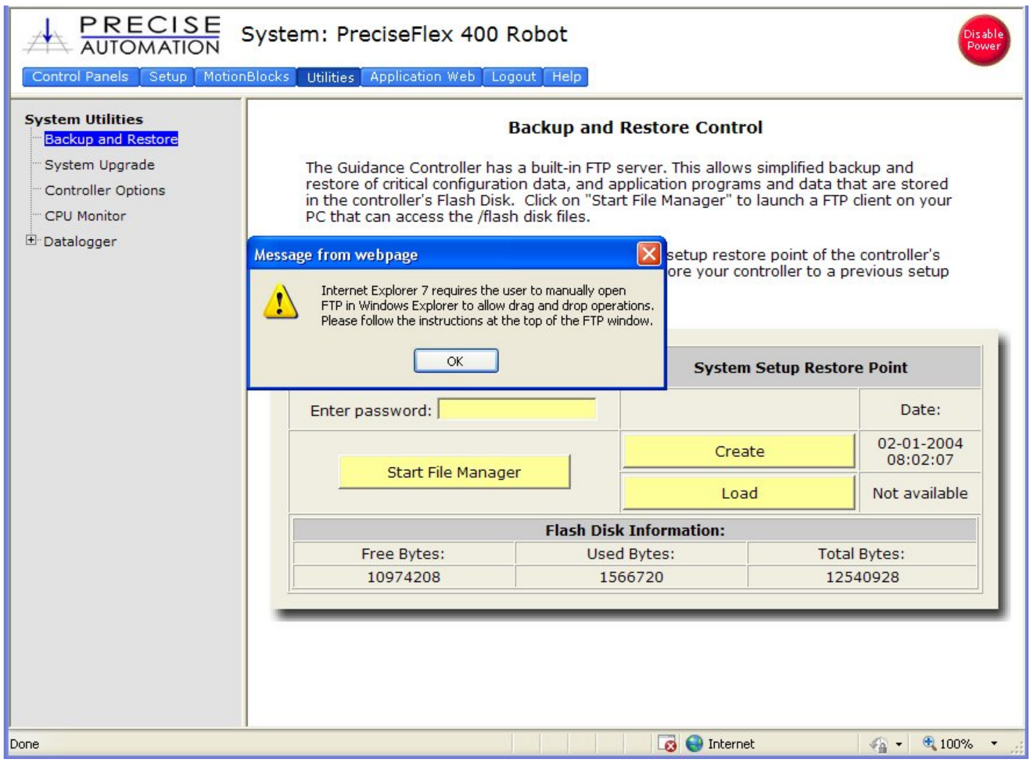
In order to allow the controller to recover from corrupted PAC files, a set of recovery boot up PAC files is loaded in a the system area of the Flash.

To configure the controller to boot up in recovery mode the user must:

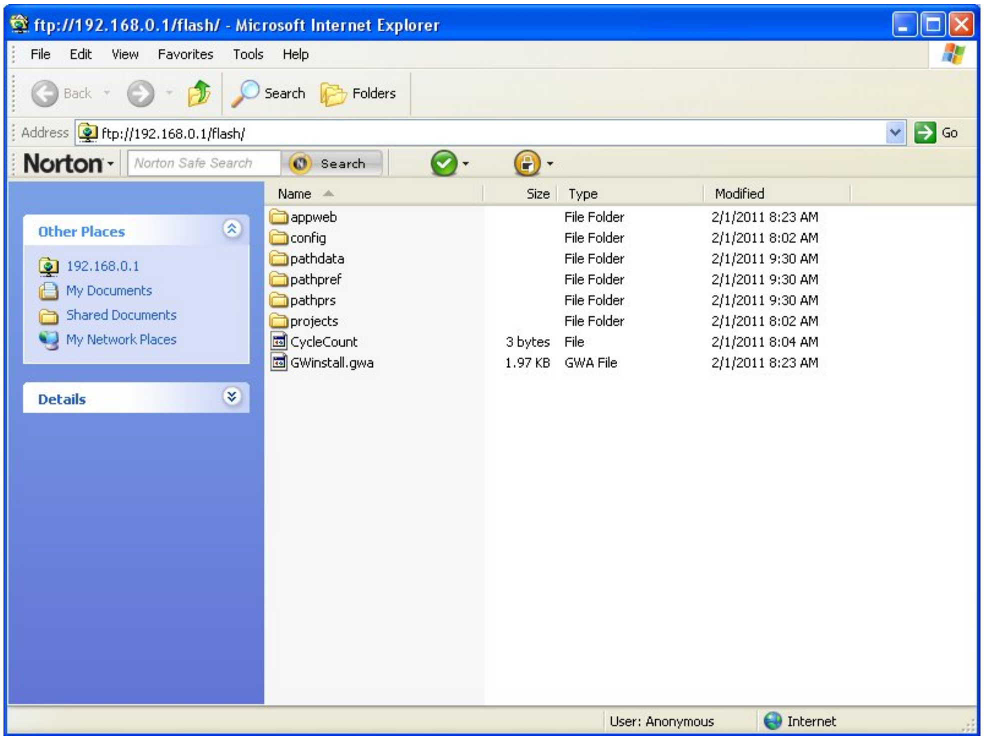
1. Obtain a set of backup PAC Files from Precise or local backup.
2. Remove the Inner Link Cover of the robot.
3. Move Jumper J8 (see figure below) so that it connects the two jumper posts. This will cause the factory default configuration files to be loaded at controller boot up.



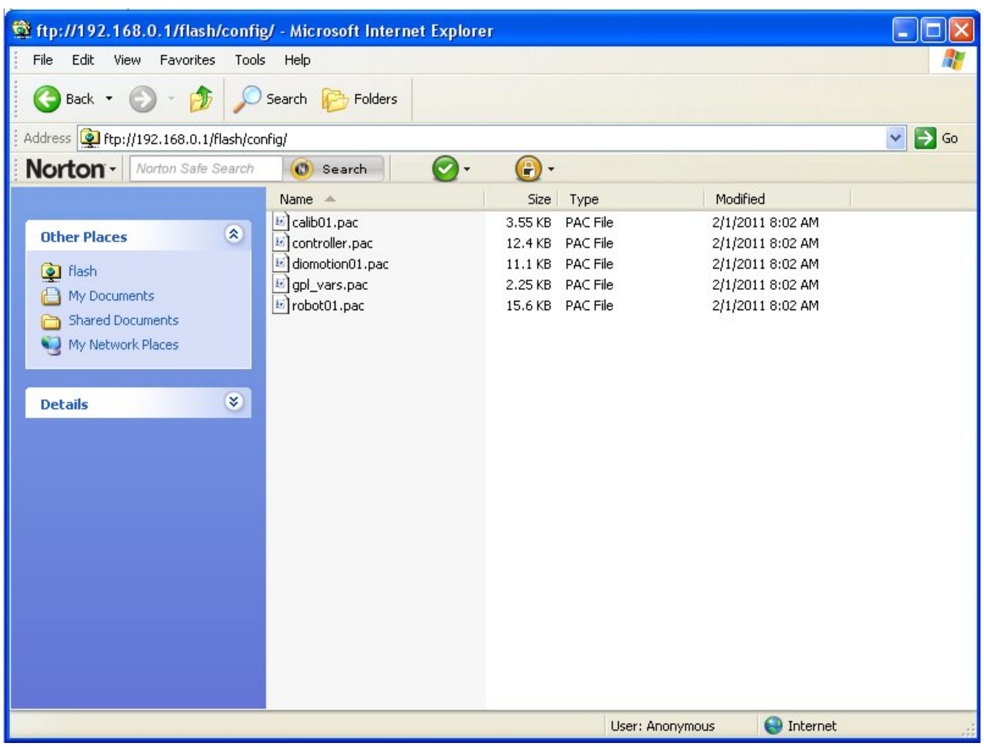
4. Cycle robot power to reboot the controller.
5. In the Web Based Operator Interface, select “Utilities/Backup and Restore



6. Click on Start File Manager. It may be necessary to hold down the Control Key to allow the pop-up. An ftp directory pop-up will come up. In the “Page” menu in Windows Internet Explorer select “Open ftp site in Windows Explorer”. Another window will open showing several folders, including “Config” and “Projects”.



7. Open the “Config” folder and paste the backup copy of the PAC files into this folder.



8. Wait until the console prompt stops flashing, about 10-15 seconds.
9. Turn off robot power.

10. Restore Jumper J8 to its previous position.
11. Reboot the robot. The PAC files should be restored and the robot should run.
12. If the robot has ever been recalibrated since the back up PAC files were created, it will be necessary to recalibrate the robot, as the calibration files will be out of date.
13. Replace the Inner Link Cover.

Controller Software Extensions

This section discusses extensions to the standard Guidance Controller software that are specific to the PreciseFlex 400 Robot.

Controlling the Precise Spring Gripper

Overview

The Precise Servo Gripper with spring return contains a brushless servo motor with an incremental encoder with both counting and motor phase tracks. At power up the encoder provides motor commutation information for a brief period, and then switches the incremental encoder A, B and Z signals onto the same set of wires. This allows the motor commutation to be initialized at startup without any motion.

The motor has a 12 tooth pinion gear cut directly on the motor shaft. This pinion drives a pair of opposing racks to open and close a set of finger mounts which are attached to linear ball slides. Various fingers can be attached to the finger mounts.

One finger mount is also attached to a spring return, which applies a continuous closing force to the finger mounts as they are coupled together by the pinion. So if power is lost the gripper will close and maintain a closing force so that it does not drop parts.

In order to avoid the gripper slamming closed from the spring force when motor power is disabled, there is a 500ms delay after an EStop or power disable command is sent before the motor power is cut off. During this period, the servo slowly closes the gripper.

In order to support “free” mode, in which the fingers can be moved back and forth freely by hand, in free mode the servo counterbalances the spring by applying an opposing force based on finger position.

Software Revision

The Spring Gripper functionality is fully supported by GPL version 3.1.P11 or later and PAC files PFlex400S_Prod_B03 110913 or later. Some slightly earlier software versions were delivered to beta customers.

Controlling the Gripper

Precise has created a GPL software routine that controls the spring gripper. This routine includes features for controlling the gripper squeeze force and detecting if a plate is present during a grip. Precise makes this routine available to customers upon request.

Gripper Squeeze (Simple Method)

The spring applies a closing force of approximately 7 Newtons at a finger opening of 103mm, which is halfway between a portrait titer plate grip at 83mm and a landscape titer plate grip at 123mm. The force is closer to 6N in portrait mode and 8N in landscape mode and 9-10N at the full open homing position. These closing forces appear adequate to prevent dropping titer plates weighing up to 200 gms, and are selected to allow enough motor torque to overcome the spring and still provide reasonable opening force for inside grips.

The motor can apply about 18N of force at its rated current of 1.26A. When closing the fingers the motor adds its force to the spring force, so a maximum closing force of about 24-26N is possible, depending on portrait or landscape gripping. When opening, the motor must oppose the spring force, so a maximum opening force of about 8- 12N is possible, depending on the opening of the fingers.

The motor squeeze force can be limited by modifying the rated current of the motor. This can be done by writing into the 5th field in Parameter Data Base # 10611. The motor current can be set once and saved into flash or modified dynamically by a GPL program using the Controller.PDbNum instruction.

The formula for determining the approximate gripper squeeze is 7N +(Rated Current/1.26Amps)X18N for squeeze and (Rated Current/1.26Amps)X18N –9N for gripper opening force.

Note that in order to home the gripper must open all the way its maximum hard stop. The spring force at this point is about 10N. So the motor current should not be set below about 12N/18NX1.26A or 0.8A for the simple method of controlling gripper squeeze, giving a range of about 18N minimum to 24N maximum squeeze.

Gripper Squeeze (Asymmetric Method)

There may be cases where 18N of squeeze is too much. In this case there is a more sophisticated method to control squeeze.

There are two parameters in the database, 10351 and 10352 that can be used to limit the torque from the PID loop in the positive and negative directions. These parameters were developed to limit the downwards force of a robot running with dynamic feedforward, where the dynamic feedforward compensates for the gravity torque of the robot. The feedforward torque is NOT limited by these parameters, only the PID torque. So for a perfectly balanced robot, setting these parameters to a low value for a gravity loaded axis limits the maximum force the axis can apply from any position error. So if the axis crashes into a hard stop, the downwards or upwards force can be limited to a small value.

These same parameters can be used to limit the gripper squeeze in an asymmetric manner. Parameter 10352 can be set to a negative value of torque counts (tcnts) to limit the torque from the PID loop in the controller in the negative direction only. Parameter 10351 can similarly be set to limit tcnts from the PID loop in the positive direction. Since the spring compensation in the gripper is treated as a feedforward torque, these parameters do not affect the spring compensation torque.

For this case it is more exact to know the exact number of tcnts to oppose the spring at various openings. For the portrait mode opening of 83mm it takes 1600 tcnts to oppose the spring. For the landscape mode opening of 123mm it takes 2200 tcnts to oppose the spring.

If the rated torque of the motor has been set to its maximum value of 1.26A, the formula for setting parameter 10352 is (Spring force at position) +((-<Contents of 10352>-<tcnts to oppose spring force>)/4378)X18N, where 4378 is the number of tcnts corresponding to 1.26A or the rated torque of the motor. For example, for portrait mode the spring force is about 6N, and if the contents of 10352 are -3200, this value will be 6N + (3200-1600)/4378)X18N or about 12.5N. If the value of 10352 is -1600, the squeeze will be 6N which is the spring force only.

In a similar manner parameter 10351 can be used to limit the gripper opening force. In this case the value for the opening force is ((<Contents of 10351>-<tcnts to oppose spring force>)/4378)X18N – (Spring force at position). For example, in landscape mode the spring force is about 8N, and if the contents of 10351 are 5200, this value will be (5200-2200)/4378X18N -8N or 4.3N. Note that 5200 is about as low a value as you would want to use in landscape mode for parameter 10351, to ensure there is enough force to oppose the spring and open the gripper all the way to the homing position. For many cases, 10351 can be left at its default value of 0, in which case it is disabled.

End of Travel Sensor

The Precise EGripper includes a sensor to detect the gripper closed to hard stop position. The spring will return the gripper to this position if power is off and there is no plate in the gripper. This sensor is wired to Digital Input 2 on the Gripper Controller Board which can be read at Digital Input 210002. This input can be viewed in the Web Browser under Control Panels/Remote IO/Servo Node 2 IO. At power up this sensor can be checked to determine if the gripper is fully closed, and thus not holding a plate. If the gripper is not fully closed it will be holding a plate, and the operator should be directed to remove the plate before homing the robot, which will open the gripper to the maximum hard stop.

Grip Test and Squeeze Check

It may be desirable to check if a plate is gripped by checking the gripping torque value. The output torque to the motor is available in Parameter 12304, value 5 in the parameter data base. For a non-spring gripper, this value varies between 0 and 4378 tcnts for a maximum gripper force of 18N. For a spring gripper, per above, for a portrait grip, the spring adds about 1600 tcnts to the squeeze and for a landscape grip, it adds about 2200 torque counts to the squeeze. Since this value is taken into account by the spring compensation and is offset from the torque commanded to the motor in Parameter 12304, when checking Parameter 12304 to determine squeeze the spring compensation must be subtracted from the torque value in Parameter 12304. For example, if the gripper is at the portrait position and not holding a plate, it must servo against the spring. In this case the value in Parameter 12304 will be about 1600 tcnts. To determine the effective squeeze torque, subtract 1600 tcnts from this value, which results in zero tcnts of squeeze force. If the value in 12304 is -2700, then the gripper motor is squeezing with -2700 tcnts, and the spring is adding -1600 tcnts, and the effective squeeze is -4300 tncts, or about 18N. The exact spring compensation value is stored in field 5 of Parameter 12331. For the best accuracy in determining effective squeeze force at any gripper opening, subtract this value from the value in 12304.

Gripper Controller Digital Inputs and Outputs

The Gripper Controller PCB adds 3 general optically isolated digital outputs and 3 general optically isolated digital inputs to the standard digital I/O found on the Guidance Controller. Like the other general inputs and outputs, they can be assigned for various control purposes during system setup, or they can be used directly by a GPL procedure.

Unlike the controller's standard digital I/O that are directly accessed on demand, these I/O are scanned by the controller. The scanning period is nominally 4 milliseconds, so your application must be able to handle a delay of up to 4 milliseconds for signal changes to propagate through the system.

The additional I/O signals are shown in the table below:

Pin	GPL Signal Number	Description
1	200013	Digital Output 1 (LED on some Electric Grippers)
2	200014	Digital Output 2
3	200015	Digital Output 3
4		24 VDC output
5		GND
6	210001	Digital Input 1 (Pushbutton on some Electric Grippers)

7	210002	Digital Input 2 (End of travel sensor option)
8	210003	Digital Input 3

G1400B Dedicated Digital Outputs

The G1400B adds one dedicated digital output to the standard dedicated signals found in the Guidance Controller, as shown in the table below.

Users normally do not need to modify the setting of the status lamp (IO 20) since the standard robot software typically manages this signal. However, if desired this signal can be manually altered under program control via the GPL SIGNAL.DIO instruction. This is controlled by DOUT signal 20. If direct control of this signal is desired, DataID 235 should be set to 0 and signal number 20 should be controlled by program control.

Signal Number	I/O	Label	Description
20	O		Outer Link status lamp. Set to 1 to turn on the lamp. Normally parameter “Power State DOUT” (DataID 235) is set to this signal number so that the Outer Link lamp displays the robot power state.

Service Procedures

Recommended Tools

The following tools are recommended for these service procedures:

1. Gates Sonic Belt Tension Meter, Model 507C for checking timing belt tension.
2. 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 6mm L Keys.
3. A set of metric hex drivers including 1.27, 1.5, 2.0, 2.5 and 3.0mm driver, for example McMaster Carr PN 52975A21.
4. A pair of tweezers or needle nose pliers.
5. A pair of side angle cutters.

Trouble Shooting

Precise robots and controllers have an extensive list of error messages. Please refer to the HTML document *Precise_Documentation_Library.chm* 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	
“ESTOP not Enabled”	Check both Phoenix plug and 9 pin Dsub for Estop jumpers.
“Encoder Battery Low”	Replace absolute encoder battery in base of robot
“Encoder Battery Down”	If encoder cable has been disconnected, recalibrate robot. If battery voltage has dropped below 2.5V replace encoder battery and recalibrate robot.
“Encoder Operation Error”	Joint rotated too quickly with power off. See Procedure below.
“Encoder Data, Accel/decel Limit Error”	Check that the FPGA code is dated Jan 25, 2012 or later. Upgrade FPGA if necessary. Encoder cable may be damaged and encoder is getting intermittent communication, causing apparent jumps in position. Check encoder connectors on flat ribbon cable. Replace cable.
“Encoder Communication Error”	Check that the FPGA code is dated Jan 25, 2012 or later. Check encoder connectors on flat ribbon cable. Replace encoder cable or motor/encoder.
"Encoder quadrature error"	Replace slip ring. Replace motor/encoder (only Gripper motor).
"Missing zero index"	See "Encoder quadrature error"
“Motor duty cycle exceeded”	Reduce speed or acceleration of robot
“Amplifier under voltage”	Motor power supply has reached current limit and shutdown. Slow down robot. Check Energy Dump PCA. Replace 48V supply.
“Amplifier Fault”	Check harness and motor for shorts.
“Amplifier Over Voltage”	Replace energy dump board. Check harness for shorts.
“Soft Envelope Error”	Make sure robot not pressing against surface
“Hard Envelope Error”	Typically means robot has crashed into something.
Pneumatic Gripper Sensor not working	Check continuity of cable through wrist. Check green lights on sensor to see if sensor is triggering.
“Time Out Nulling Error”	Check that joint is free to move with brake off. Check that joint is not vibrating or unstable. If unstable check belt tension. If Gripper, replace slip ring after checking that brake releases.
“Joint Out of Range”	The joint actual or commanded position may be beyond the software limit stop. Move joint back into range while monitoring virtual pendant or check program for commanded position.
“PAC Files Corrupted”	See recovering from corrupted PAC Files
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 belt.

Loud buzzing or vibration from any joint	Re-tension timing belts.

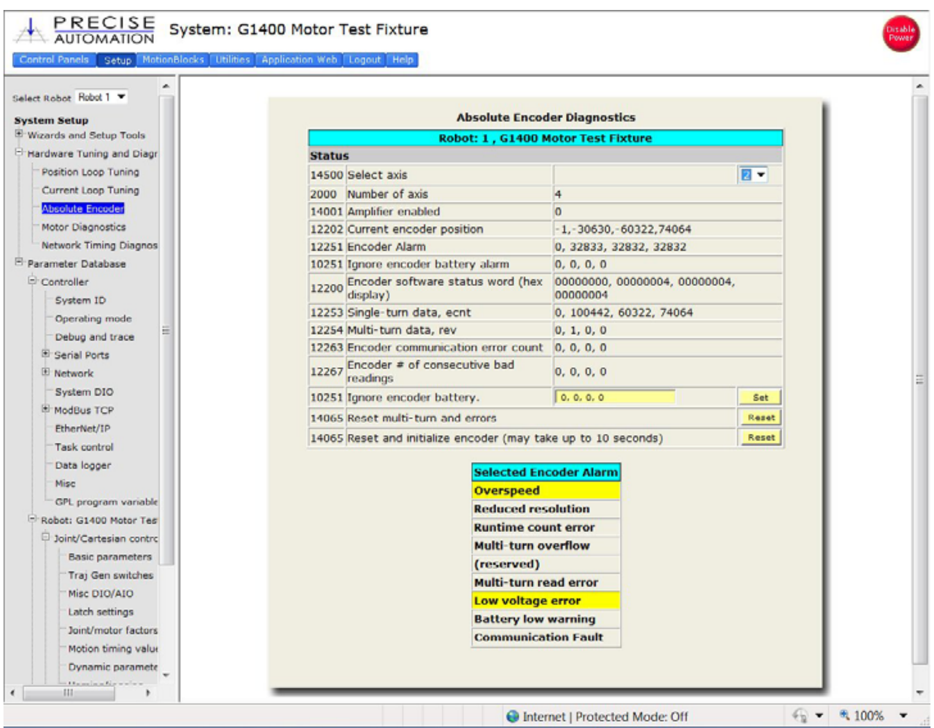
Encoder Operation Error

The PF400 robot is equipped with absolute encoders that keep track of the robot position even when AC power to the robot is disconnected. There is a battery in the base of the robot that provides standby power to the encoders. In standby mode, there is a limit on how quickly the motor can turn and still have the standby counter operate properly. The limits are 6,000 rpm and 4000 rad/s^2. Even at 100% speeds the robot joints normally do not move faster than about 2,000 rpm and 1300 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 Operator Window of the Web Interface as "Encoder Operation Error" Robot 1: <axis number>.

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

1. Access the Web Operator Interface to the robot with either "Maintenance" or "Administrator" privileges.
2. In the "Setup" menu, select "Hardware Tuning and Diagnostics", then select "Absolute Encoder". You should see a screen similar to that shown below.



3. In the pull down menu at the top right of the screen, select the robot axis that was associated with the error and check to see if the 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 and initialize encoder". This button resets error flags, but does not reset the encoder counters. The robot can then be homed normally.

4. 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. The joint angles in the Calibration Position are:

   Z Axis: -1mm (-2mm for Beta robots)
   J2 or Shoulder: -90
   J3 or Elbow: 159.66
   J4 or Wrist: -180

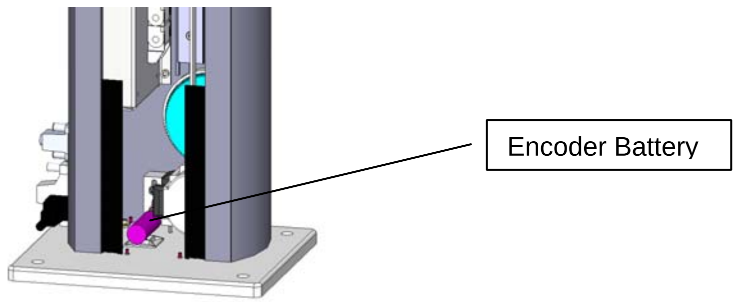
   If the robot joints after this procedure followed by homing are different from the above, then the robot needs to be re-calibrated. See procedure below.

Replacing the Encoder Battery

DANGER: Before replacing the encoder battery, the AC power should be disconnected. Removing the front cover allows access to the AC power terminals.

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

Note that if any motor/encoder is disconnected from the encoder battery by disconnecting the encoder cable, the "Encoder Battery Low" or Encoder Battery Down" message will be generated. However in this case the encoder battery does not need to be replaced. It is only necessary to re-calibrate the robot, see below.



Tools Required:

1. 3.0mm hex driver or hex L wrench

Parts Required:

1. New Encoder Battery PN PF00-EA-00002
2. 6 in long by .125 wide tie wrap

To replace the Encoder Battery the user must:

1. Turn off power to the robot and remove the AC power plug.
2. Remove the Top Plate of the robot by removing the 4 M5 low socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the Top Plate.
3. Remove the Front Cover by lifting it out vertically.
4. The Encoder Battery is located in the base of the robot behind the Z Column Front Cover. The Encoder Battery has a connector which plugs into one of two identical connectors on a pigtail. A new Encoder Battery should be plugged into the second connector before the depleted Battery is removed. This allows the procedure to be performed without robot power.
5. Attach the new Encoder Battery to the hold down with a tie wrap.
6. Replace the Front Cover and Top Plate.

If the error message “Encoder Battery Down” was generated, the robot must be re-calibrated after this procedure. Otherwise it is not necessary to re-calibrate the robot.

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.

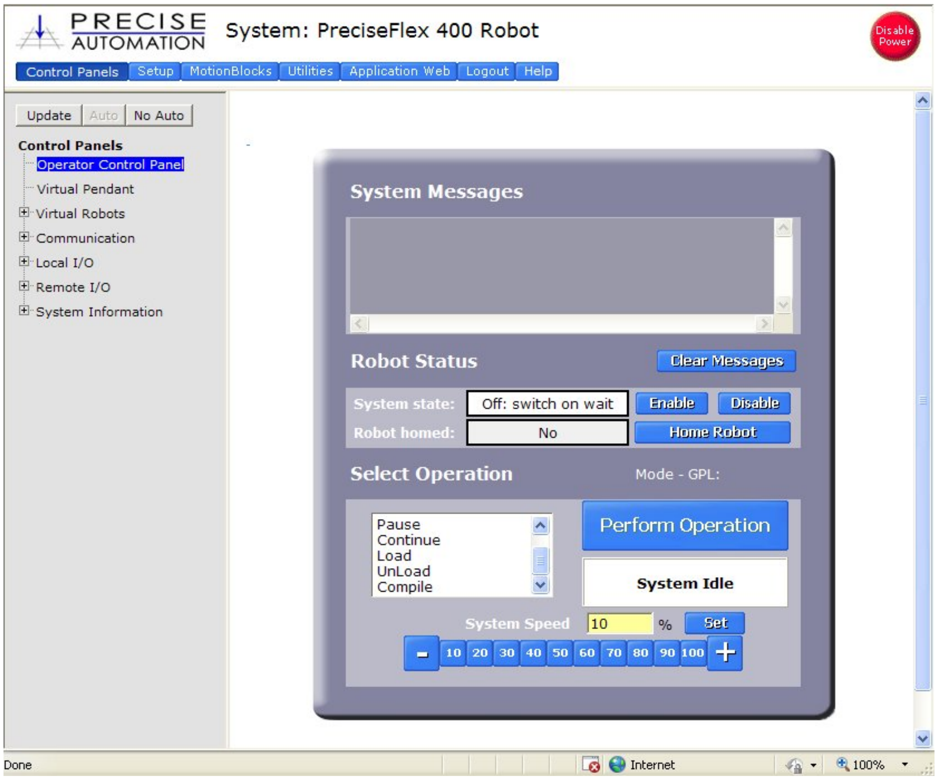
Cal_PP is supplied on the *Guidance Controller System Software CD*. To run Cal_PP, the controller must be configured to run GPL programs and Cal_PP must be loaded into the controller's memory (See Appendix D).

Tools Required:

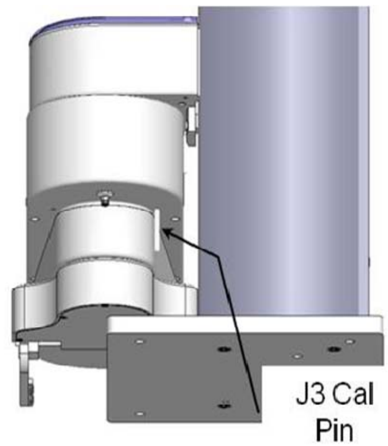
1. 2.5mm and 3.0mm hex drivers or hex L wrenchs
2. Set of 3 Calibration Dowel Pins, located in plastic bag inside the hollow slot in the front cover.

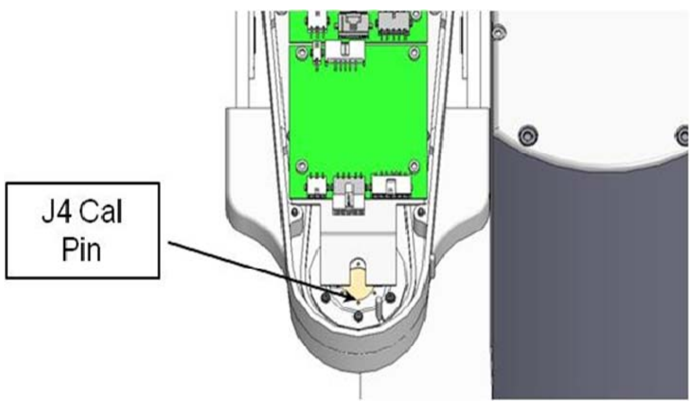
The following describes the procedure for defining the zero positions of the PrecisePlace robot axes using Cal_PP.

1. Enable power to the robot’s controller, but do not turn on power to the motors.
   (This procedure should be executed with motor power off. The robot does not move.)
2. The CALPP program is typically installed at the factory and should be loaded into flash memory. Using the Web based Operator Control Panel first unload any currently loaded programs. Select the***"UnLoad"*** item in the left scrolling window and press the "***Perform Operation***" button. This ensures that no GPL project is currently selected for execution. Select the "***Load***" item and press the "***Perform Operation***" button. This displays a popup list of Projects that are in the flash disk and available for execution. In the popup display, click on CALPP_RevXX and press "***Select***". When you are ready to execute the Project, select "***Start application***" and press the "***Perform Operation***" button. If CALPP is not loaded in the robot, first Load Cal_PP into the controller’s memory from a PC, using the web Operator Control Panel, as described above in the Software Reference Section.

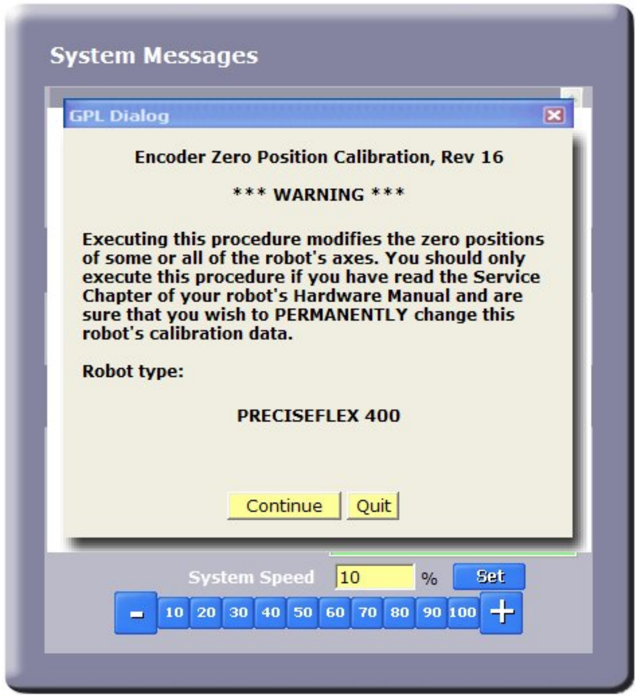


3. Manually move the robot into the configuration shown below.
    a. The top cover of the outer link will need to be removed by removing the 4 M3 X 20 SHCS that are located in counter bores under the outer link.
4. Ensure Z-axis is resting on the lower hard stop by releasing the Z axis brake by pushing on the brake release button under the shoulder while supporting the robot arm with your hand, and lowering the robot arm gently until it rests on the lower hard stop.
5. If the Calibration Pins have not already been removed from the robot, it may be necessary to remove the top cover of the robot by removing 4 M5 Low Head screws with a 3.0mm hex driver and then to remove the front cover to access the bag with the Calibration Pins which is inside the front cover extrusion at the bottom.
6. Insert a M3 X 30mm Calibration Dowel Pin into the J4 (wrist) pulley with the gripper positioned under the outer link and rotate the gripper back and forth until the pin drops into a slot in the outer link, locating the gripper under the center of the outer link.
7. Insert a tapered .5in Calibration Dowel Pin into the hole in the bottom of the shoulder. Rotate the inner link counterclockwise until it rests against this pin as shown below.
8. Insert an tapered .5in Calibration Dowel Pin into the hole on inner link as shown below. Rotate outer link clockwise until it rests against the dowel pin.

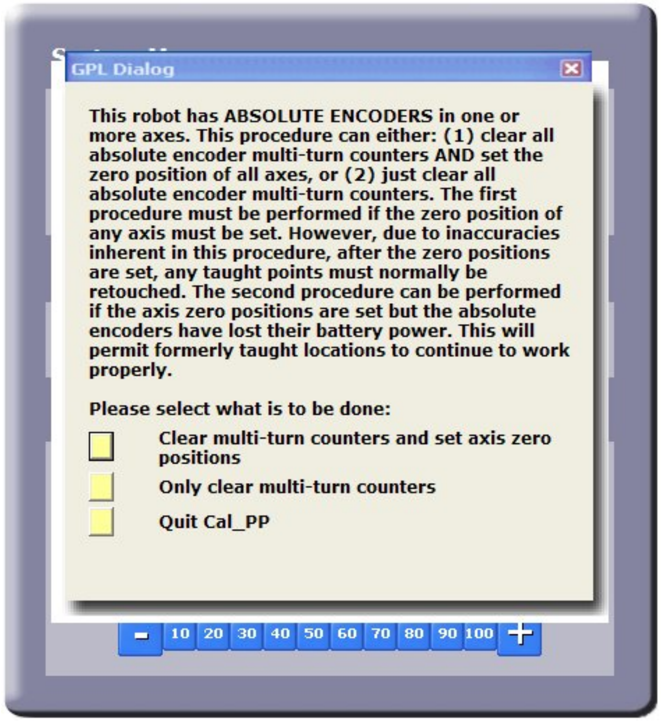




9. With the CALPP application loaded, select “Start Application”, then press “Perform Operation”
    a. Application should start and prompt user to confirm correct robot position for calibration



b. The absolute encoders have two outputs: a "single turn" value and a "multi-turn" value. The single turn value is absolute within a single turn and does not depend on battery backup. The multi-turn value represents the number of complete turns of the encoder and uses battery power to drive the counter if robot power is not present. The calibration pins locate the robot with a repeatability of a fraction of a degree. However they are not accurate enough to locate the robot to a repeatability of a single encoder count (which for this robot is a few microns). Therefore the robot is assembled with the encoder single turn value in the middle of its range when the robot is in the calibration position. If no mechanical change that would affect the relation of the motor to the robot axis has been made to the robot prior to recalibration (for example changing a timing belt or a motor) only the multi-turn value needs to be reset. Therefore, after changing the encoder battery after an "Encoder Battery Down" error, or disconnecting the controller, or unplugging a motor encoder without removing the motor, select the button "Only Clear Multi-turn Counters". This will reset the multi-turn counters to zero and will preserve the repeatability of the robot to a single encoder count. However if the mechanical relationship of the motor to the robot axis has been changed by removing a belt or a motor, or if this is the first time the robot is calibrated, select the button "Clear Multi-Turn Counters and Set Axis Zero Position". This will reset an offset value that is added to the single turn encoder value to properly calibrate the robot. After this procedure however the robot will only be re-calibrated to the repeatability of the calibration pins and positions may be off by a few encoder counts.



c. The CALPP application takes about 1 minute to run.

10. After calibration is complete, use the brake release button and move the Z-axis up from the hard stop. Failing to do this will produce an error as the robot is outside of the soft stop limits.
11. **Make sure the pins are removed.**
12. **Enable power and home the robot. Calibration does not take effect until the robot is homed.**

Replacing Belts and Motors

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

General Belt Tensioning

The PreciseFlex 400 has been designed to make belt tensioning very simple. Each axis has a spring preload system that sets the correct belt tension when the axis motor mount plate screws are loosened.

Tensioning the J1 (Z Column) Belts

> **DANGER:** Before tensioning the timing belts or replacing any motors, the AC power should be disconnected. Removing the front cover allows access to the AC power terminals.

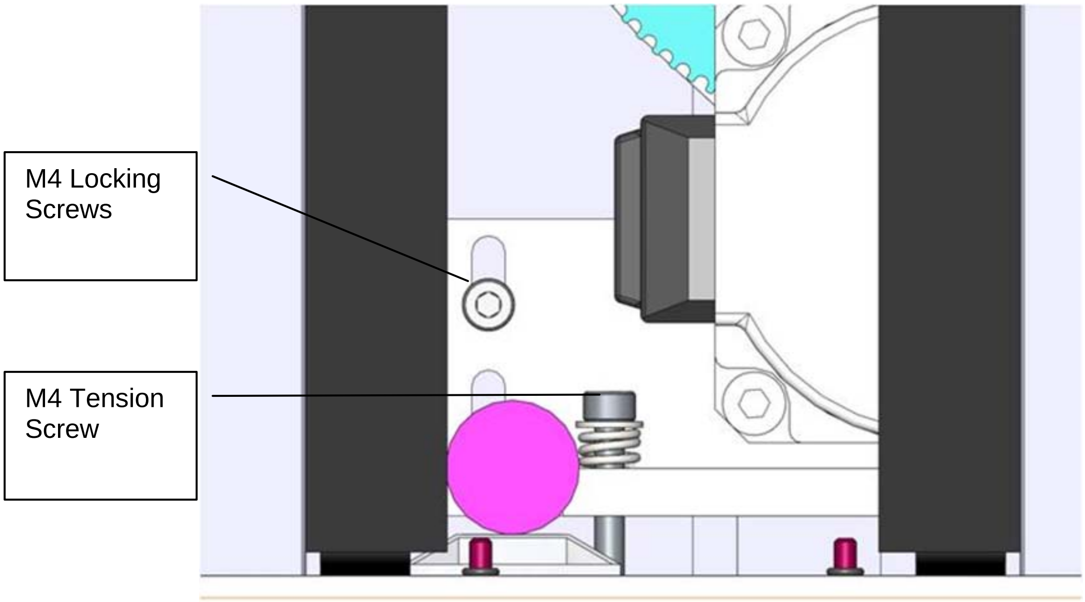
Tensioning the 1st Stage Belt

Tools Required:

1. 3.0mm hex driver or hex L wrench

To adjust tension in the 1st Stage Belt the user must:

1. Turn off robot power and remove the AC power cord.
2. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the Top Plate.
3. Remove the Front Cover by lifting it out vertically.
4. Loosen the 2 M4 locking screws on the J1 Motor Mount Bracket to allow the Mount Bracket to slide up and down.
5. Adjust the M4 Tension Screw compressing the spring assembly. The tension spring should be compressed until the spring length is 5.5mm under the washer.
6. After adjusting the Tension Screw, the M4 locking screws should be tightened to lock the assembly in place and the Front Cover and Top Plate should be replaced.



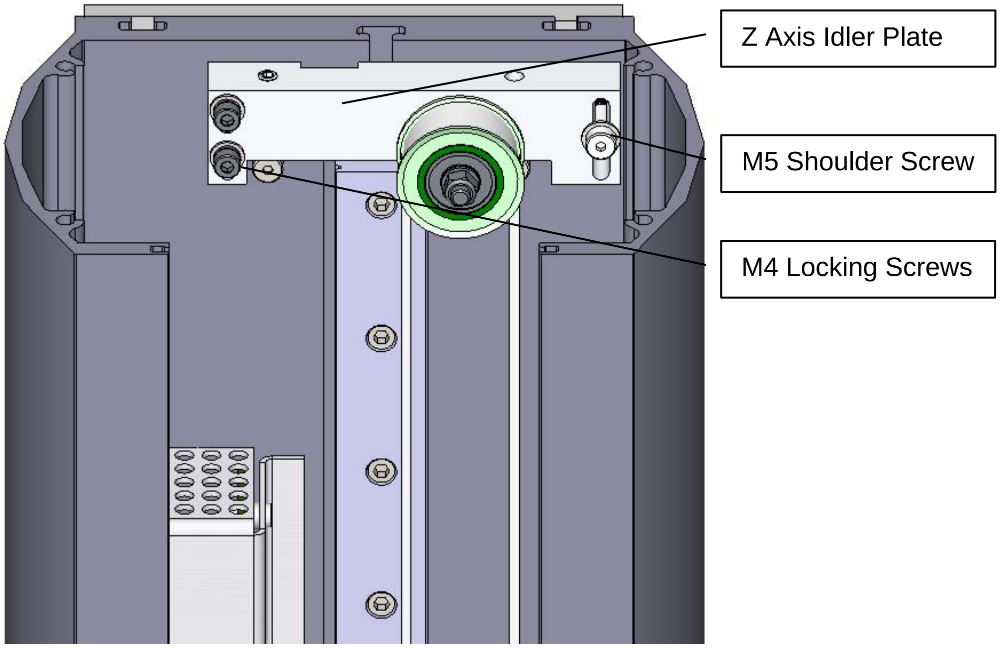
Tensioning the 2^{nd} Stage Belt

Tools Required:

1. 3.0mm hex driver or hex L wrench
2. 2.5mm hex driver or hex L wrench

To tension the 2^{nd} Stage J1 Belt the user must:

1. Turn off the robot power and remove the AC power cord.
2. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the Top Plate.
3. Remove the Front Cover by lifting it out vertically
4. Loosen the two M4 locking screws and the M5 shoulder screw on the Z idler plate.



5. Re-tighten the 3 screws and replace the Front Cover and Top Plate. The tension is set by a spring in the Z Axis Idler Plate which is pre-loaded by an M5 set screw.

Tensioning the J2 Belt

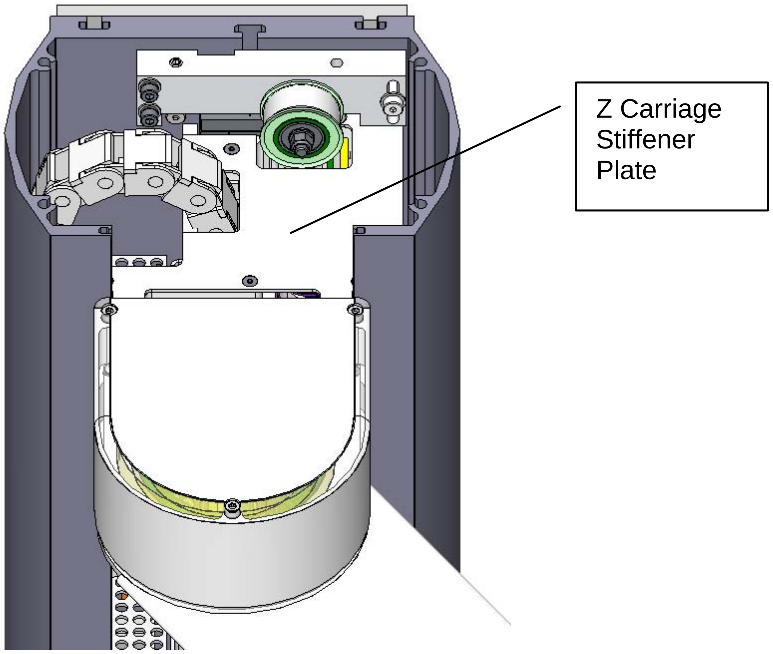
DANGER: Before tensioning the timing belts the AC power should be disconnected. Removing the front cover allows access to the AC power terminals.

Tools Required:

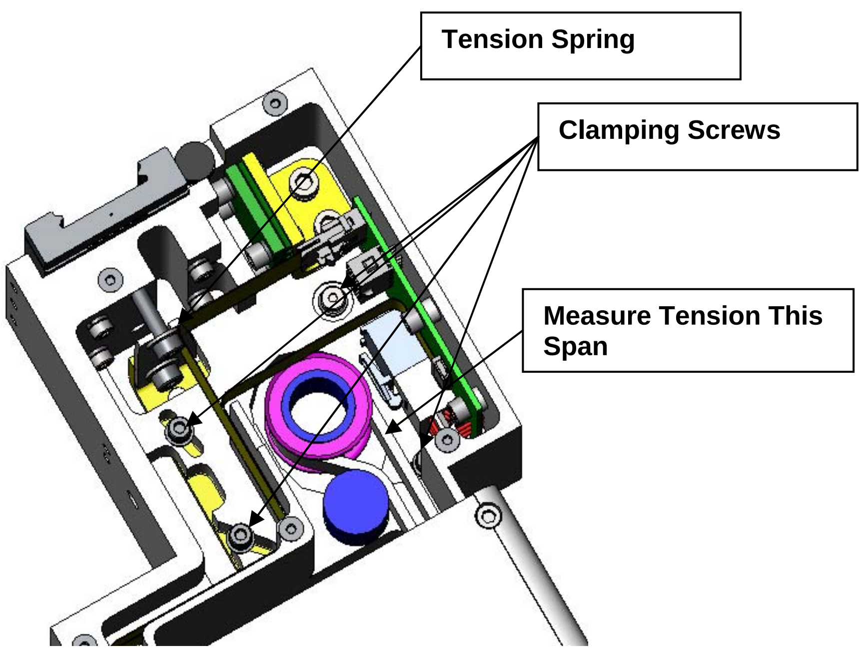
1. 3.0mm hex driver or hex L wrench
2. 2.5mm hex driver or hex L wrench
3. 2.0mm hex ball driver or hex L wrench

In order to re-tension the J2 (shoulder) Timing Belt, the user must:

1. Move the robot arm to the top of the Z Column travel.
2. Turn off the robot power and remove the AC power cord.
3. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the Top Plate.
4. Remove the Front Cover by lifting it out vertically



5. Remove the Z Carriage Stiffener Plate by removing the M3 X 6 FHCS attaching it to the Z Carriage (shoulder).



6. Loosen the 3 M3 SHCS and 1 M4 Shoulder screw clamping the J2 Motor Mount Plate to the Z Carriage. It may be necessary to remove the tie wrap securing the J2 Motor cables to the Z

carriage in order to access the clamping screw under these cables. It is best to measure the belt tension with a tension meter as described in Appendix D. If a belt tension meter is not available, the Tension Leaf Spring will automatically reset the belt tension. It is helpful to jiggle the motor a little bit to be sure any friction is overcome. The motor can be easily grasped by reaching under the Z carriage (shoulder). Then re-tighten the clamping screws. Replace the tie wrap if it was removed.

7. Replace the Z Carriage Stiffener Plate.
8. Replace the Front Cover.
9. Replace the Top Plate.

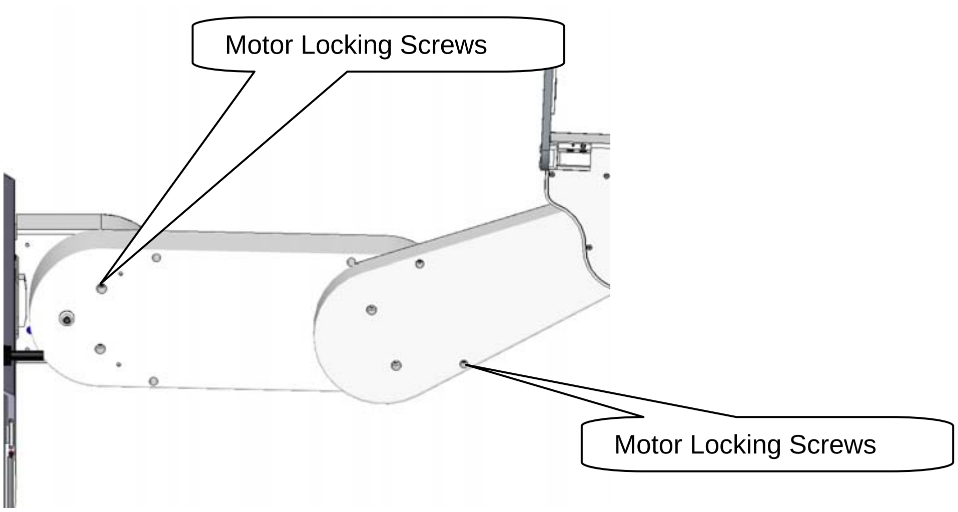
Tensioning the J3 Belt

Tools Required:

1. 3.0mm hex driver or hex L wrench
2. 2.5mm hex driver or hex L wrench

To tension the J3 Belt the user must:

1. Loosen the 2 Motor Locking Screws on the bottom of the Inner Link. One screw requires a 2.5mm driver and the second requires a 3.0mm driver.
2. Tighten the 2 screws again. The J3 belt is automatically re-tensioned.
3. The above procedure is an approximate procedure. Its accuracy is limited by the fact that the J3 belt tension will vary according the orientation of the J3 output pulley. The timing belts are very stiff. A .002 in eccentricity (which is the specified tolerance) in the output pulley can cause a 50% variation in the belt tension, depending on the orientation of the output pulley. If performing the quick tensions adjustment outlined in steps 1 and 2 above does not resolve a J3 instability (loud buzzing noise), it may be necessary to remove the controller and J3 belt cover to gain access to the J3 belt, and then set the belt tension by using a belt tension meter as described in Appendix D, while checking for the minimum belt tension every 10 degrees of rotation of the J3 output pulley. This more extensive procedure should be required only rarely.



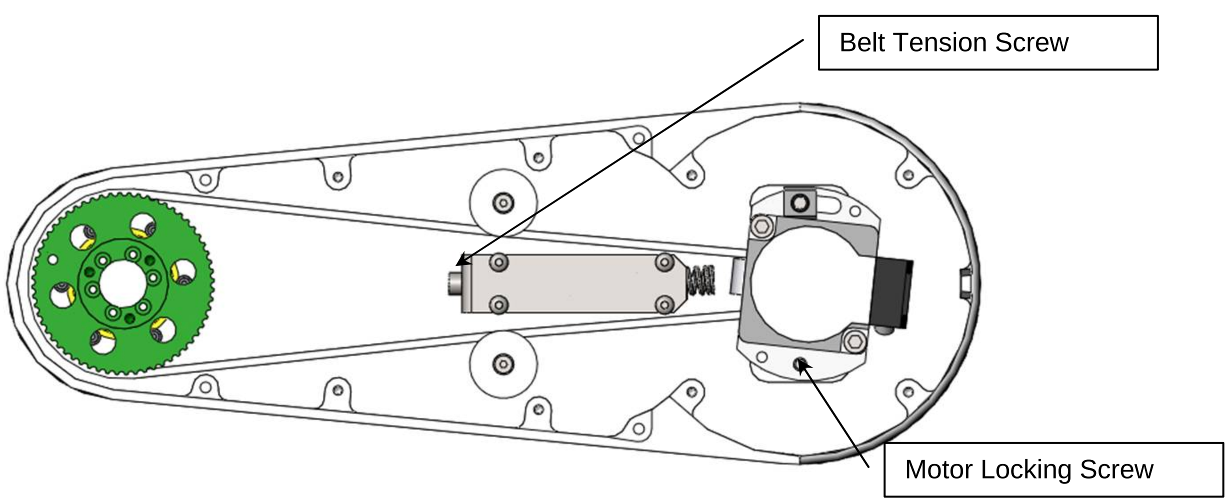
Tensioning the J4 Belt

Tools Required:

1. 3.0mm hex driver or hex L wrench
2. 2.5mm hex driver or hex L wrench

To tension the J4 Belt the user must:

1. Remove the outer link cover.
2. Remove the gripper controller PCA.
3. On robot sold before January 2012, remove the Slip Ring Clamp and remove the 4 M3 X 10 FHCS screws retaining the J4 belt cover. Tip the belt cover upwards to access the timing belt.
4. Loosen the M4 SHCS and M4 Shoulder Motor Locking Screws on the bottom of the Outer Link
5. Measure the belt tension, every 10 degrees of rotation of the gripper to find the minimum tension.
6. Adjust the minimum belt tension to the value in Appendix D. This may be possible by just releasing and re-tightening the Motor Locking Screws. It may require adjusting the Belt Tension Screw.
7. Tighten the 2 screws again.
8. For robots shipped after April 2012, an access hole has been cut in the J4 belt cover so that the tension meter head can reach the timing belt without tipping up the belt cover.



Replacing the Power Supplies, Energy Dump PCA, or J1 Stage Two (Output) Timing Belt

DANGER: Before replacing the power supplies, the AC power should be removed.

Tools Required:

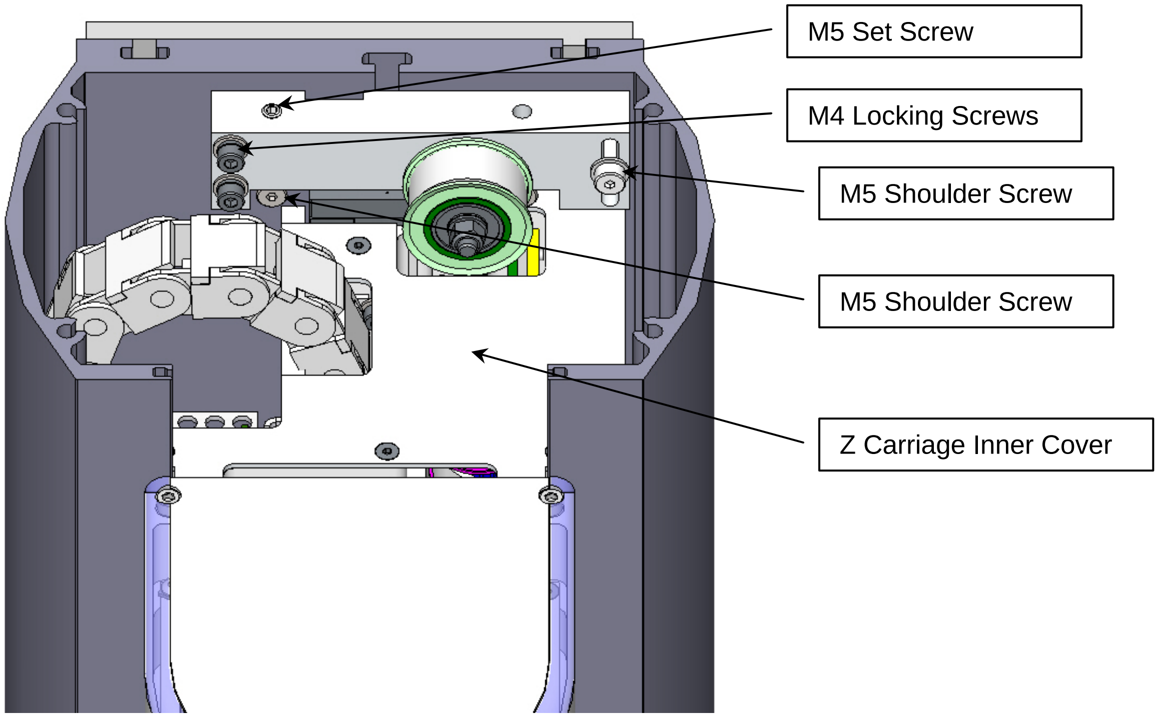
1. 3.0mm hex driver or hex L wrench
2. 2.5mm hex driver or hex L wrench

Spare Parts Required:

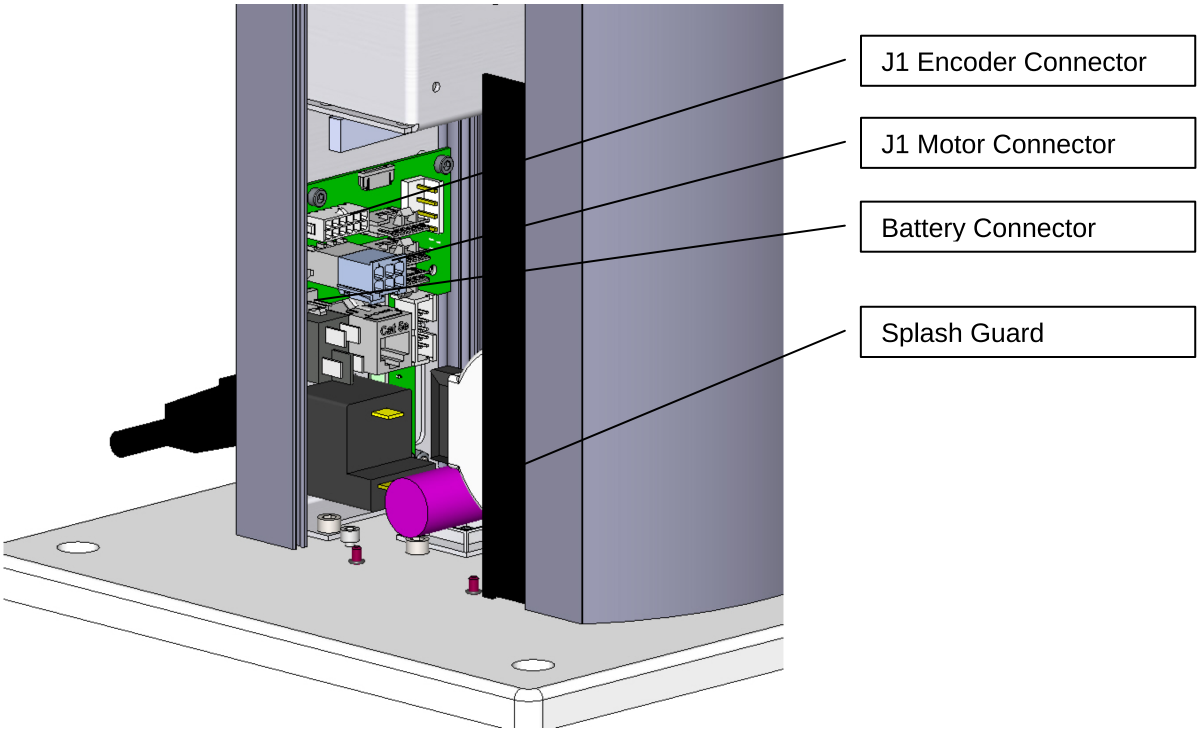
1. 24VDC power supply, PN PS10-EP-00125 or
2. 48VDC power supply, PN PS10-EP-48365 or
3. J1 Stage Two Belt, PN PF00-MC-X0022.

The user must:

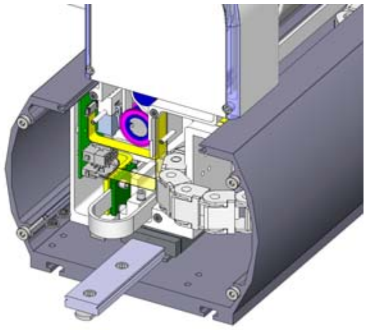
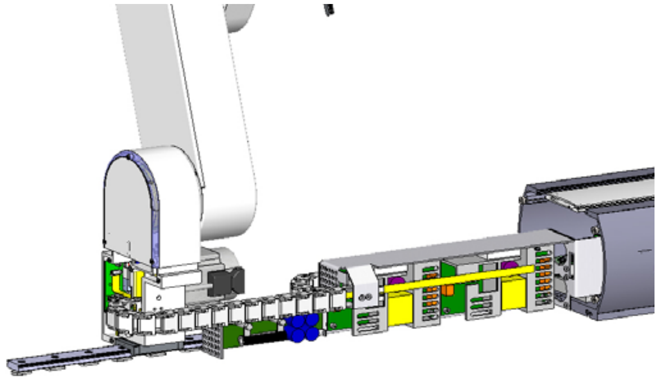
1. Move the robot arm to the top of the Z Column travel.
2. Turn off the robot power and remove the AC power cord.
3. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column. Lift up the Top Plate.
4. Remove the Front Cover by lifting it out vertically.



5. Lay the robot down on its back side on a table where there is room to work.
6. Remove the Idler Plate Assembly by removing the M5 set screw that compresses the Idler Plate Spring, the 2 M4 SHCS that clamp the Idler Plate, and the M5 Shoulder Screw that forms the Idler Plate pivot. Be careful not to drop the pressure washer and tension spring that are inside the Idler Plate assembly. The tension spring presses against an M5 shoulder screw to tension the Z axis Stage 2 belt.
7. Remove the remaining M5 shoulder screw.
8. Disengage the Z Carriage Timing Belt from the lower Drive Pulley. If it is necessary to replace the Z Carriage 2nd Stage Timing Belt, remove the the Z Carriage Inner Cover and then the Timing Belt Clamp from the Z carriage by removing 2 M4 X 12 SHCS and lock washers and replace the belt.
9. Remove the left splash guard by removing the M3 X 8 SHCS on the retaining bracket.
10. Remove the 4 screws holding the Electronic Chassis to the Z Extrusion and the 2 screws attaching the Electronic Chassis and ground wire to the Base Plate.



11. Remove the J1 motor and encoder connectors that plug into the J1 Motor Interface Board.
12. Remove the Battery connector that plugs into the J1 Motor Interface Board.
13. Loosen the M4 SHCS screws attaching the Z bearing rail to the Z Extrusion.
14. Slide the Z Rail and Z Carriage with the robot arm still attached partially out the top of the robot, far enough to expose the power supplies. It may be more convenient to slide the carriage and Z rail all the way out of the Z extrusion. Take care the bearing block does not slide off the Z rail. It may be helpful to wrap some tape around the rail to prevent this. If the bearing block slides off the rail, the bearing balls may be lost, damaging the bearing. Simultaneously slide the Electronic Chassis out of the Z Extrusion and lay both assemblies on the table.
15. Unplug the cables from the failed power supply.
16. Remove the 4 M3 X 8 SHCS and lock washers to replace the power supply or energy dump PCA. Be careful not to pull the J1 FFC encoder cable (white 14mm wide flat cable) out of the FFC connector on the J1 Motor Interface PCA. If this cable is pulled out, you must carefully release the clamping lid on the FFC cable connector on the J1 Motor Interface PCA by inserting a small flat bladed screwdriver in the notch in the clamping lid and VERY gently prying the lid out of the connector. This lid is a cam-lock type of lid, which when inserted, clamps the flat white J1 encoder ribbon cable. Re-insert the J1 flat white encoder ribbon cable into this connector and carefully press the clamping lid back into the connector. If the J1 encoder cable is disconnected during this procedure, it will be necessary to re-calibrate the robot as the absolute encoder backup power will be interrupted to the J1 absolute encoder.
17. Re-attach the power supply cables and re-assemble the robot. Be sure the bearing rail reference edge is tightly pressed against the reference boss in the Z extrusion. The top of the bearing rail should be about 35mm below the top of the extrusion and the bottom of the rail should clear the stage one Z timing belt on the large diameter pulley.
18. Recalibrate the robot.

Replacing the Robot Controller

DANGER: Before replacing the Robot Controller, the AC power should be removed.

Tools Required:

1. 2.5mm hex driver or hex L wrench
2. 2.0mm hex driver or hex L wrench
3. Small flat bladed screw driver, with 1.5mm wide blade typ
4. M5 socket driver or M5 open end wrench or pliers

Spare Parts Required:

1. Guidance G1400B Controller PN P/N G1X0-EA-B1400-1

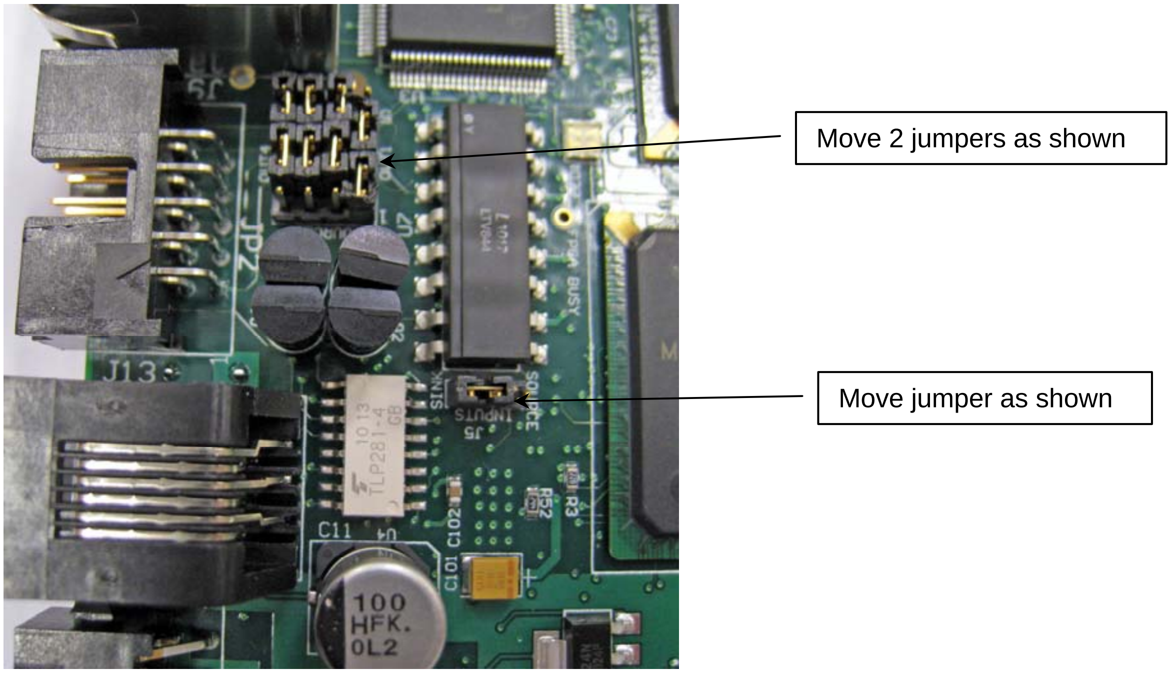
Prior to replacing the controller, the user may wish to make copies of both the robot PAC files, and any project files to a PC, using a procedure similar to that described for loading a project in the Software Reference Section.

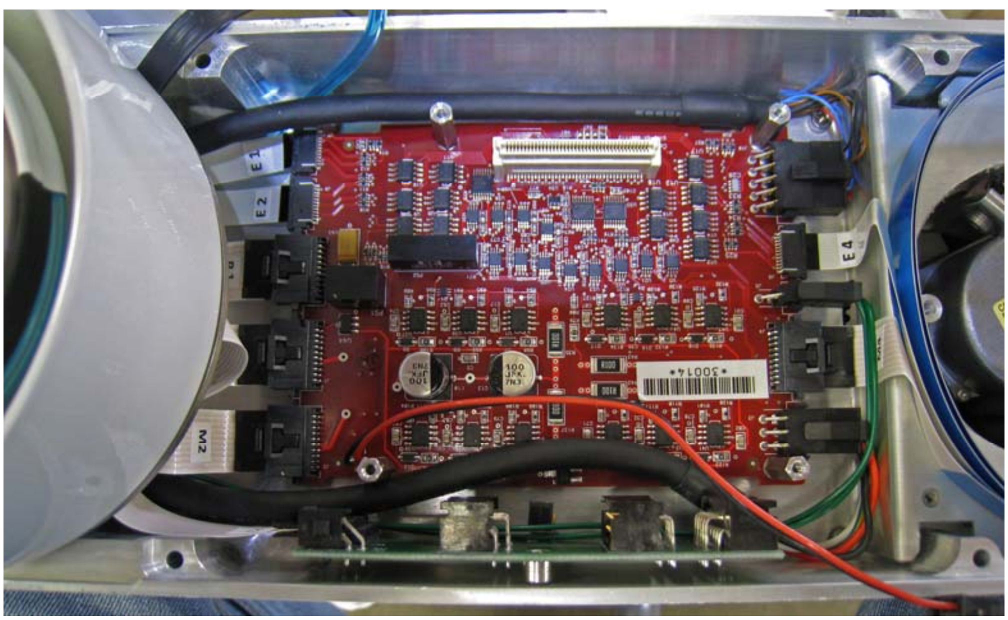
To replace the Robot Controller the user must:

1. Turn off the robot power and remove the AC power cord.
2. Remove the Inner Link Cover by removing the 4 M3 X 20 SHCS that attach the cover.
3. Remove the upper circuit board by removing 4 M2.5 X 6mm screws.
4. Unplug the cables from upper circuit board
5. Remove the lower circuit board by removing 4 M2.5 X 16mm standoffs with an M5 socket driver.
6. Unplug the cables from the lower circuit board. Use a small flat bladed screwdriver to gently release the 3 zero-insertion-force (ZIF) flat flexible cable (FFC) connector compression lids.
7. Check the jumpers on the replacement CPU board (top board) per the photo below.
8. Re-attach the harness and replace the circuit boards. Refer to the schematics section above for connector labeling on the circuit boards. Be careful that the 2 pin plug from the brake release switch plugs into the lower board and the 2 pin plug on the pigtail from the lower board plugs into

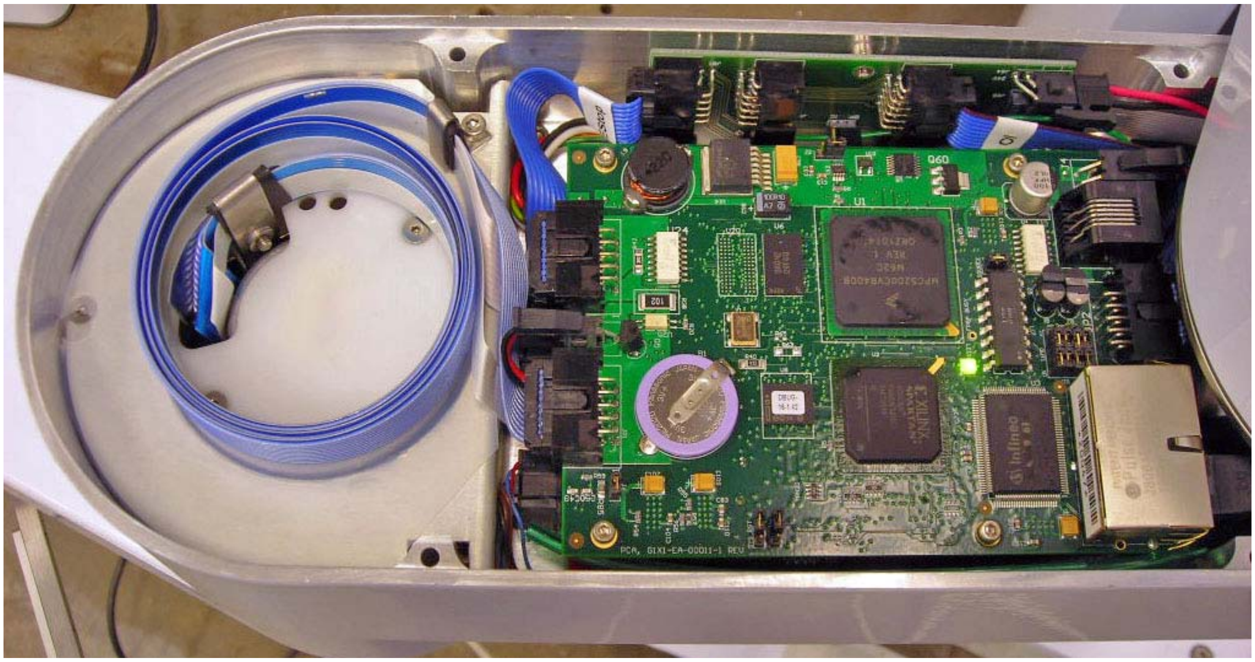
the upper board. Be careful to gently press in the compression latch on the FFC encoder connectors with your finger, not a sharp object.

9. Make sure the EtherNet cable folds back along the under the upper circuit board but does not obstruct the board to board connector.
10. Make sure no cables will be pinched by the Inner Link Cover and replace the Cover.
11. After replacing the Robot Controller the robot must be re-calibrated. See Calibrating the Robot.
12. After replacing the Robot Controller the BenchBot PAC files and BenchBot application program must be installed. (These may be pre-installed by Agilent Field Service)



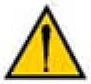


Power Amplifier Installed in Inner Link



Controller Installed in Inner Link

Replacing the Gripper Controller



DANGER: Before replacing the Gripper Controller, the AC power should be removed.

Tools Required:

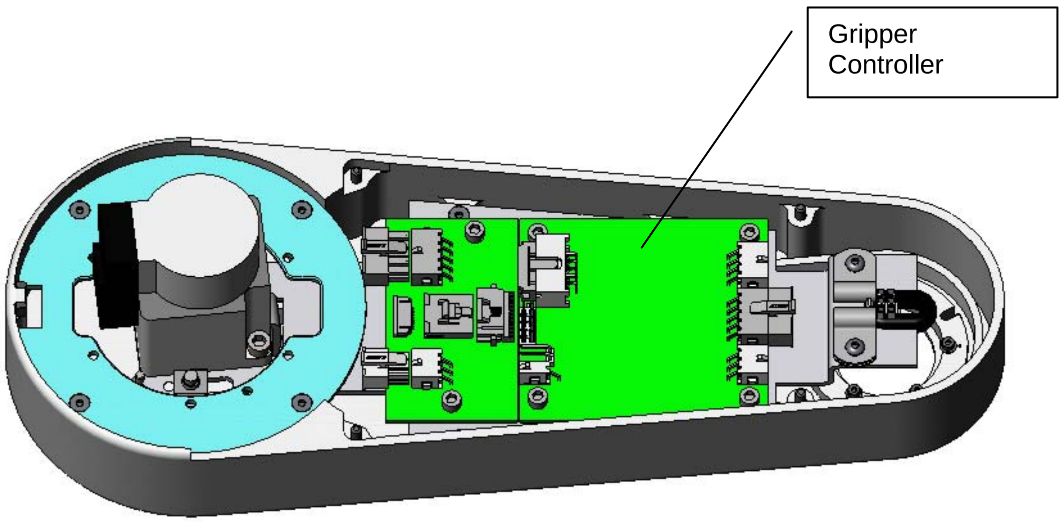
1. 2.5mm hex driver or hex L wrench

Spare Parts Required:

1. Guidance G1400B Controller PN P/N G1X0-EA-T1100.

To replace the Gripper Controller the user must:

1. Turn off the robot power and remove the AC power cord.
2. Remove the Outer Link Cover.
3. Remove the Gripper Controller by removing 4 M3 X 10mm SHCS and unplugging the cables.
4. Replace the Gripper Controller and re-attach the harness.
5. Replace the Outer Link Cover.
6. It is not necessary to recalibrate the robot after replacing the Gripper Controller.



Replacing the Gripper Finger Pads

Tools Required:

1. 1.3mm hex driver or hex L wrench

Spare Parts Required:

1. Guidance G1400B Controller PN P/N PF0A-MA-00011, set of 4 pads.

To replace the Gripper Finger Pads the user must:

1. Remove 3 M2 X 6mm FHS to remove the Spline Bumper Plates.
2. Replace the Finger Pads by pressing new pads into the Spline Bumper Plates.
3. Re-attach the Spline Bumper Plates. Do not use Loctite.

Adjusting the Gripper Backlash

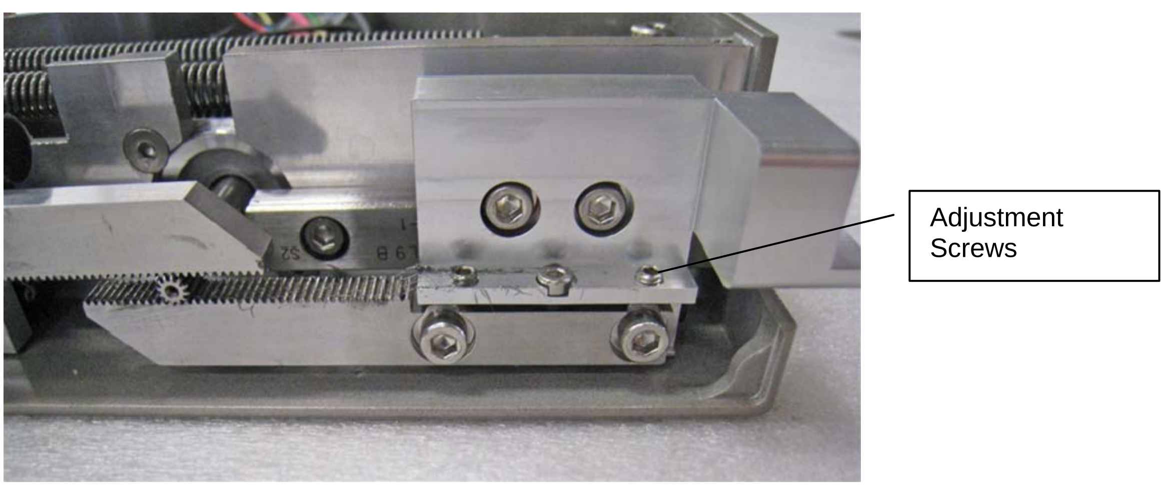
Tools Required:

1. 1.3mm “stubby” hex L wrench
2. 1.5mm “stubby” hex L wrench

Spare Parts Required: none

To adjust the gripper backlash the user must:

1. Remove the Gripper Cover by removing 6 M2 X 6mm FHCS.
2. Move the racks back and forth to determine which rack has backlash and where it is located on the rack.
3. Loosen the 2 M3 X 8 SHCS clamping the rack to the finger mount.
4. Adjust the M2 SHCS and M3 set screws to adjust the rack backlash.
5. Remove the 2 M3 X 8 SHCS one at a time, apply Loctite 222 screwlock, reinstall and tighten.



Adjusting the Gripper Brake (for Grippers with Brake)

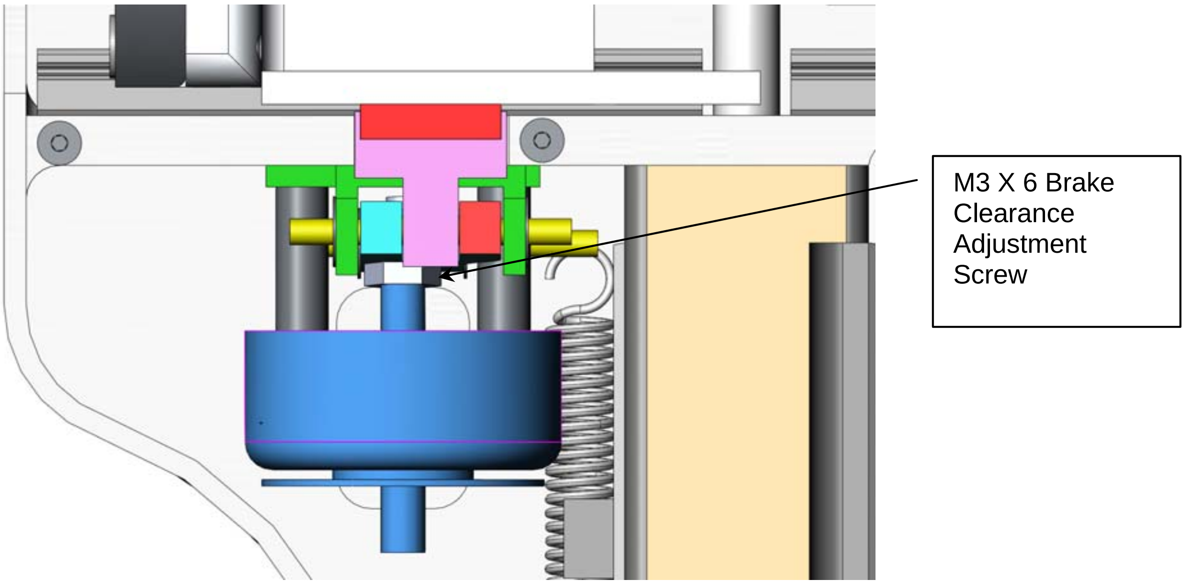
Tools Required:

1. 1.3mm hex driver
2. 5.5mm open end wrench
3. Loctite 222

Spare Parts Required: none

To adjust the gripper brake the user must:

1. Remove the Gripper Cover by removing 6 M2 X 6mm FHCS.
2. Energize the brake to activate the solenoid to release the brake.
3. Check the clearance between the brake shoe and the finger mount brake surface. This clearance should be between .1mm (.004in) and .25mm (.010in), and the gripper fingers should slide freely.
4. If necessary, use a 5.5mm open end wrench to adjust the M3 X 6mm hex head screw that adjusts the brake backlash. This screw should be backed out 2mm, Loctite 222 applied to the screw threads, and then screwed back in to the brake lever to set the brake clearance.
5. Make sure the brake pad is held up in the brake notch in the gripper wall and engage the brake.
6. Replace the cover.



Replacing the Gripper or Slip Ring Harness

DANGER: Before replacing the Gripper Harness, the AC power should be removed.

Tools Required:

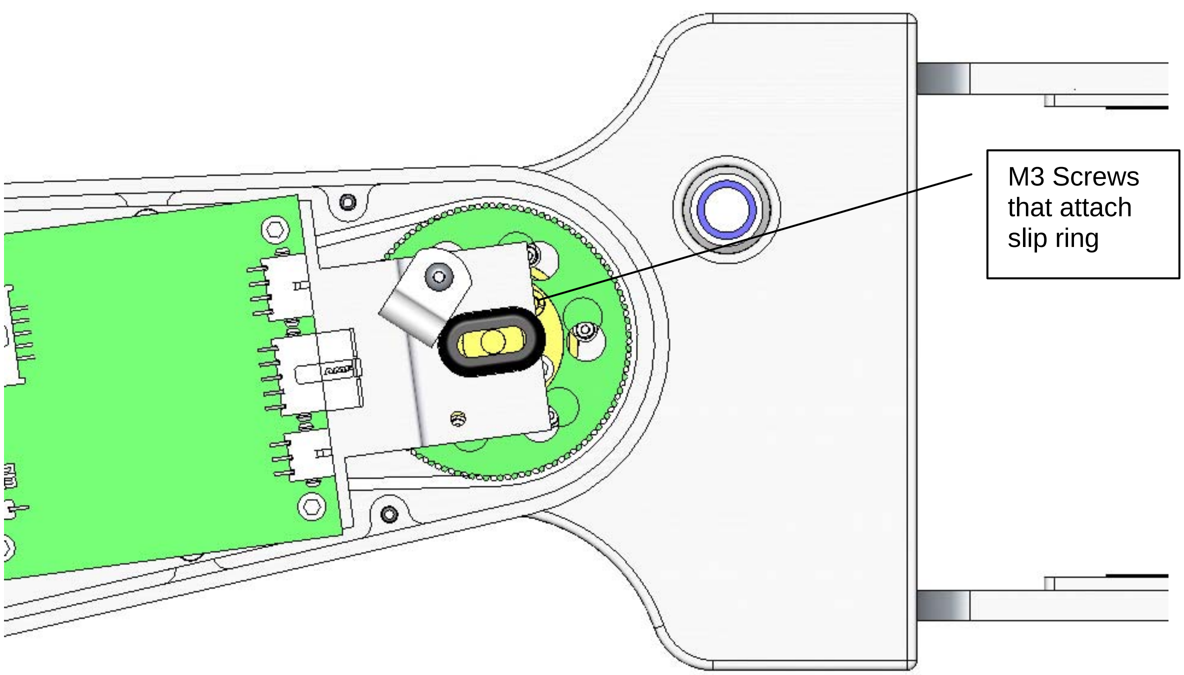
1. 2.5 mm hex driver or hex L wrench
2. 2.0 mm hex driver
3. 1.5mm hex driver
4. 1.3mm hex driver

Spare Parts Required:

1. Low Profile Electric Gripper" Precise P/N PF0A-MA-00001.

To replace the Gripper the user must:

1. Turn off the robot power and remove the AC power cord.
2. Remove the Outer Link Cover.
3. Remove the Gripper Controller and P Clamp holding the slip ring cable. Slide the grommet out of the notch in the belt cover.
4. Remove the 4 M3 FHCS that attach the belt cover. Tip up the belt cover and slide a pencil under it to hold it up to provide access to the slip ring flange.



5. Rotate the Gripper so that the 3 M3 X 6 BHCS which attach the Slip Ring to the J4 Output Pulley can be removed one by one thru the notch in the Outer Link Belt Cover.
6. Remove the bottom cover from the Gripper by removing 6 M2 X 6mm FHCS.
7. Disconnect the Slip Ring harness (4 plugs) from the Gripper harness.
8. Rotate the Slip Ring housing 30 degrees to allow access to 3 of 6 M2 X 16 SHCS. Loosen these screws. Rotate the Slip Ring housing 30 degrees in the opposite direction to access and loosen the remaining 3 screws.
9. Gently pull the Gripper down a few centimeters and slide the Slip Ring harness and connectors through the access hole in the Gripper housing.
10. At this point the slip ring harness can be replaced if necessary.
11. Replace the Gripper and re-attach the new Gripper. Be sure the dowel pin in the wrist pulley flange is located in the notch in the top of the gripper housing. Be sure the slip ring wires do not get pinched during re-assembly.
12. It is not necessary to re-calibrate the robot after replacing the Gripper.

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.

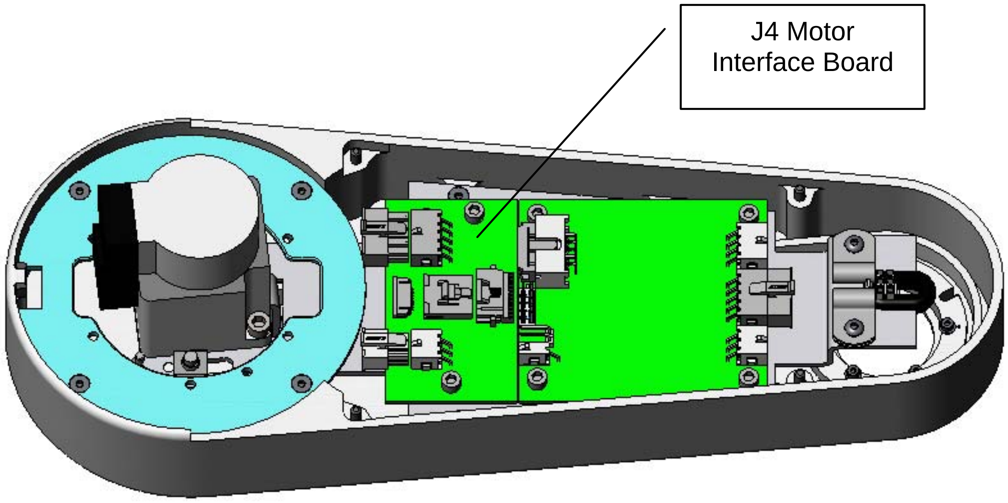
Replacing the Outer Link Harness

The Outer Link Harness is comprised of 3 cables: Harness, FFC, J4 Motor, (Precise P/N PF0H-MA-00002-02-E3), Harness, FFC, J4 Encoder (Precise P/N PF0H-MA-00005-02-E3), and Harness, Gripper Controller (Precise P/N PF0H-MA-00014).

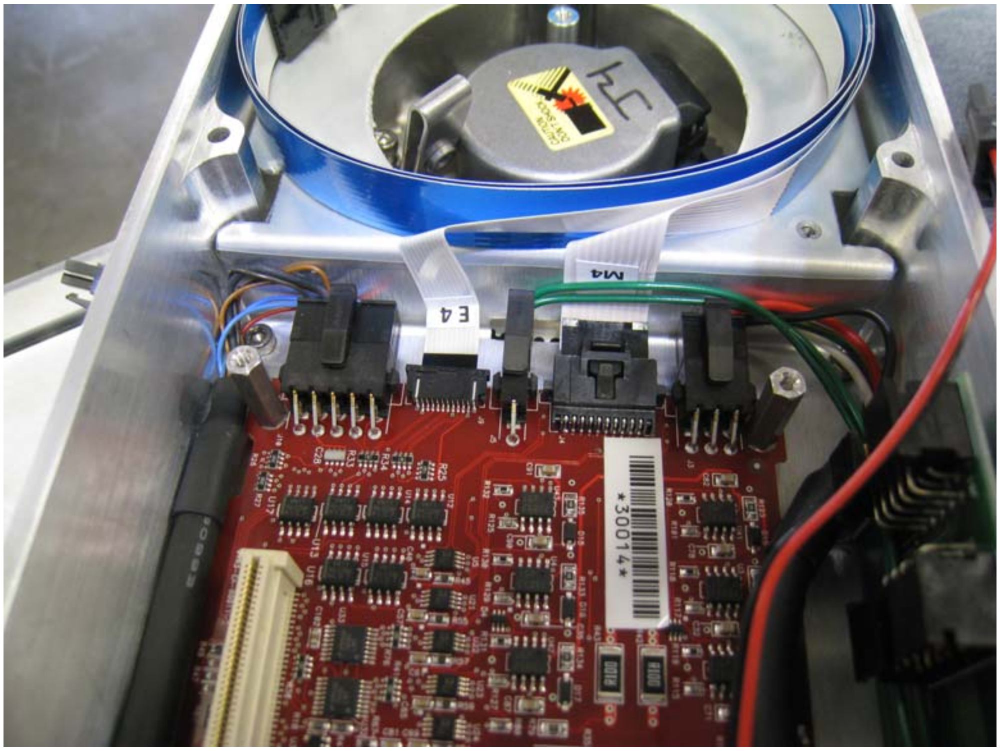
Replacing the Outer Link Harness does not require un-mounting the robot from its surface.

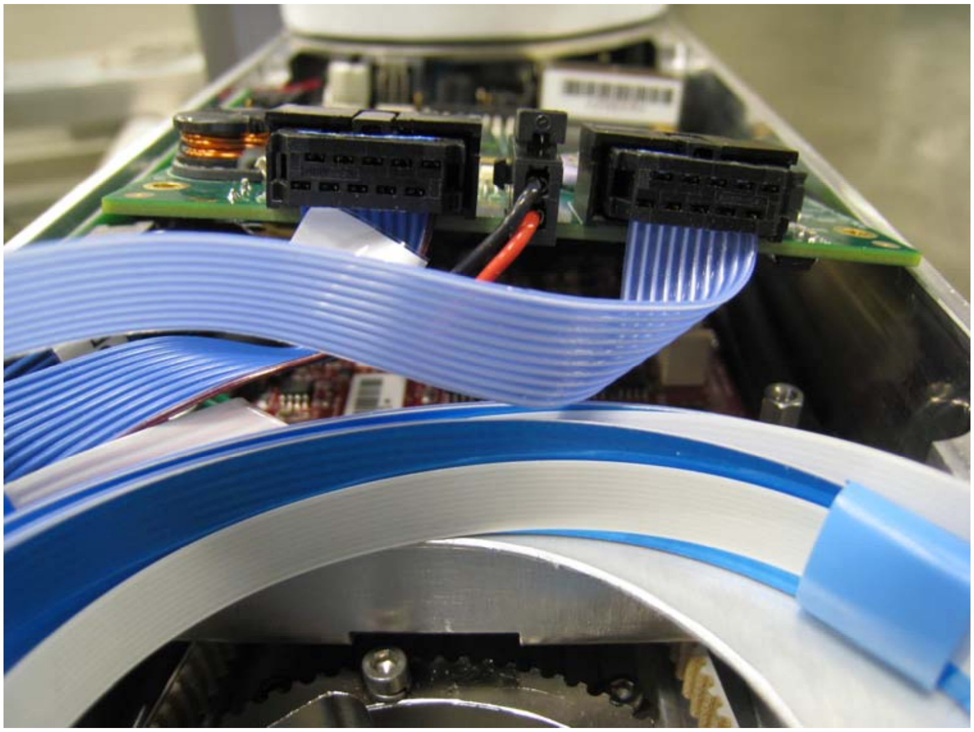
The user must:

1. Remove the Inner Link Cover.
2. Remove the Outer Link Cover.
3. Unwind the Outer Link in counterclockwise direction, looking down from above the J3 axis until it reaches the hard stop.
4. Release the J4 Motor Interface circuit board by removing 2 M3 X 10mm SHCS.



5. Disconnect the Outer Link Harness from the J4 Motor Interface PCA and the Guidance 1100C Slave Controller in the Outer Link.
6. Remove the upper circuit board in the Robot Controller by removing 4 M2.5 X 6mm screws and disconnect the harness.
7. Remove the Harness Retaining Clip from the Robot Controller Mount Plate to release the controller end of the harness.
8. Remove the 4 M2.5 X 16mm standoffs attaching the lower circuit board in the Robot Controller. Gently tip the lower circuit board upwards and disconnect the motor and encoder cables from the lower circuit board.
9. Release the Harness Retaining Clip from the J3 Output Pulley by loosening the M3 by 25 SHCS attaching the clip to the pulley. Pull the clip upwards and remove the M3 X 4 BHCS that clamps the harness to release the harness from the clip.
10. Replicate the folds on the controller end of the replacement harness.
11. Insert the replacement harness into the Robot Controller circuit boards and reattach the Robot Controller circuit boards.





12. Attach the Harness Retaining Clip near the Robot Controller to retain the Robot Controller end of the Harness.
13. Coil the replacement harness into 3 loops.
14. Fold the ends of the harness down at a right angle to replicate the replaced harness.
15. Insert the connectors down thru the Elbow into the Outer Link.

16. Attach the J3 Harness Retaining Clip with the M3 X 4 BHCS and the 1/32 in thick Neoprene rubber strain relief pad around the harness to protect it along with the bent stainless steel retaining clip that protects the harness fold.

17. Attach the J3 Harness Retaining Clip to the J3 Output Pulley.
18. Attach the connectors to the circuit boards in the Outer Link.
19. Attach the J4 Motor Interface circuit board.
20. Replace the covers.
21. After replacing the harness the robot must be re-calibrated. See Calibrating the Robot.

Replacing the Z Axis Motor Assembly

DANGER: Before replacing the Z Axis Motor, the AC power should be removed.

Tools Required:

1. 5.0mm hex driver or hex L wrench
2. 4.0mm hex driver or hex L wrench
3. 3.0mm hex driver or hex L wrench
4. 2.5 mm hex driver or hex L wrench
5. Loctite 243

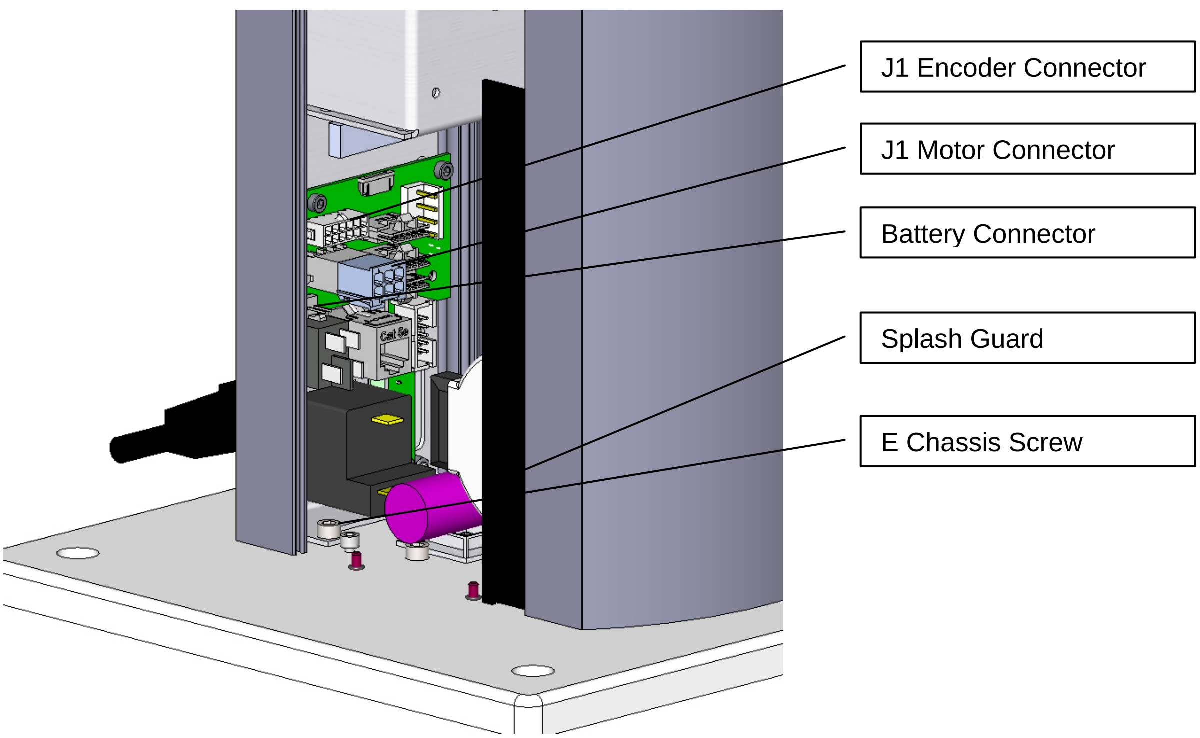
Spare Parts Required:

1. J1 Motor Assembly PN PF01-MA-00011.

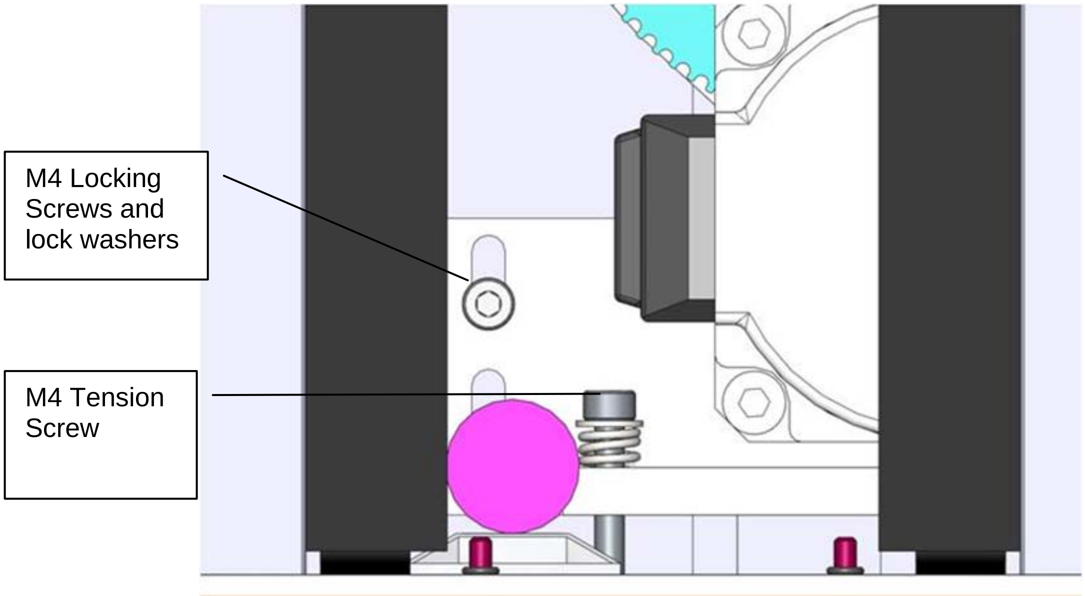
The J1 Motor Assembly is comprised of the J1 motor, connectors, and a timing belt pulley.

The user must:

1. Remove AC power and connectors from the base of the robot.
2. Unfasten the robot from its mounting surface by removing 4 M6 SHCS.
3. Lay the robot on its back, being careful the robot links do not fall over and damage the paint. It is a good idea to wrap the links with a protective cover first, such as a sheet of foam.
4. Remove the top cover by removing 4 M5 Low Head Cap Screws.
5. Remove the Front Cover by sliding it out.
6. Remove the left splash guard by removing the M3X8 SHCS and M3 star washer.
7. Remove the screws attaching the Electronics Chassis and ground lug to the Bottom Mounting Plate.
8. Unplug the Battery from the J1 Motor Interface Board.



9. Remove the screw compressing the J1 Motor Tension Spring and spring.



10. Remove the Base Mounting Plate by removing 4 M5 SHCS. The right splash guard is attached to the base mounting plate.
11. Remove the M4 Locking Screws that attach the J1 Motor Mount Bracket to the Z Column.
12. Slide the J1 Stage 1 timing belt off the large idler pulley.
13. Slide the J1 Motor and Motor Mount Bracket assembly out the bottom of the Z Column.
14. Remove the J1 Motor Assembly from the J1 Motor Mount Bracket and replace with the new motor, using Loctite 243.
15. Replace the components in reverse order. Compress the tension spring to 5.5mm under the washer with the M4 Motor Bracket Locking screws slightly loose, then tighten the screws. Use Loctite 222 or 243 on the Base Plate and Top Plate screws.
16. Before replacing the Front Cover and Top Plate, the Cal Pins should be removed from inside the Front Cover and the robot should be re-calibrated following the Calibration Procedure.

Replacing the J2 (Shoulder) Axis Motor or Timing Belt

DANGER: Before replacing the J2 Motor, the AC power should be removed.

Tools Required:

1. 5.0mm hex driver or hex L wrench
2. 4.0mm hex driver or hex L wrench

3. 3.0mm hex driver or hex L wrench
4. 2.5 mm hex driver or hex L wrench
5. 2.0mm hex driver or hex L wrench
6. Fine point tweezers
7. .06 in flat blade screwdriver

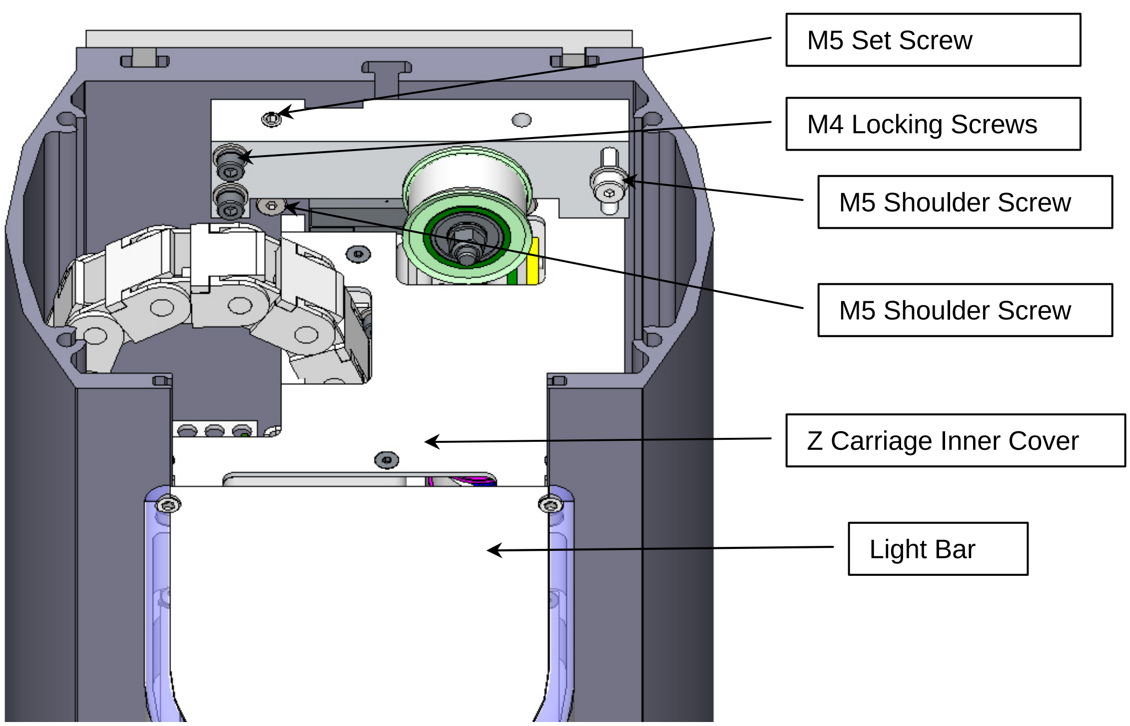
Spare Parts Required:

1. J2 Motor Assembly PN PF02-MA-00011 or J2 Timing Belt PN PF00-MC-X0005.
2. 2 1/8th by 8 in tie wraps
3. Loctite 243

The J2 Motor Assembly is comprised of the J2 motor, connectors, and a timing belt pulley.

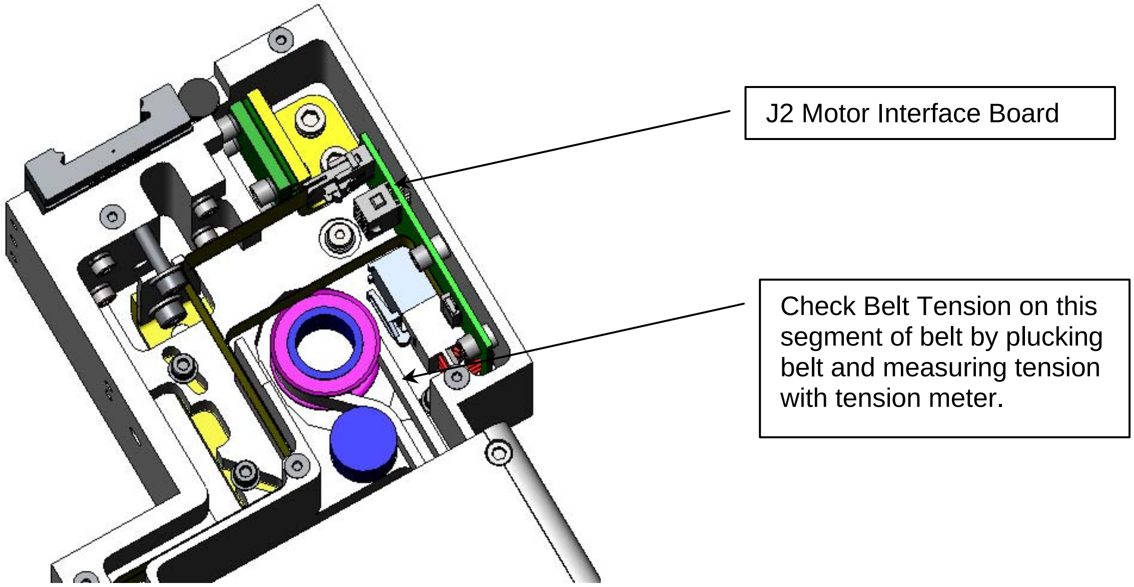
The user must:

1. Unbolt the robot from its mounting surface and set it vertically on the floor or a low surface.
2. Move the robot arm to about 2 inches below the top of the Z Column travel.
3. Turn off the robot power and remove the AC power cord.
4. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column.
5. Remove the Front Cover by lifting it out horizontally.
6. Remove the Z carriage inner cover by removing 5 M3 X 10 FHCS.

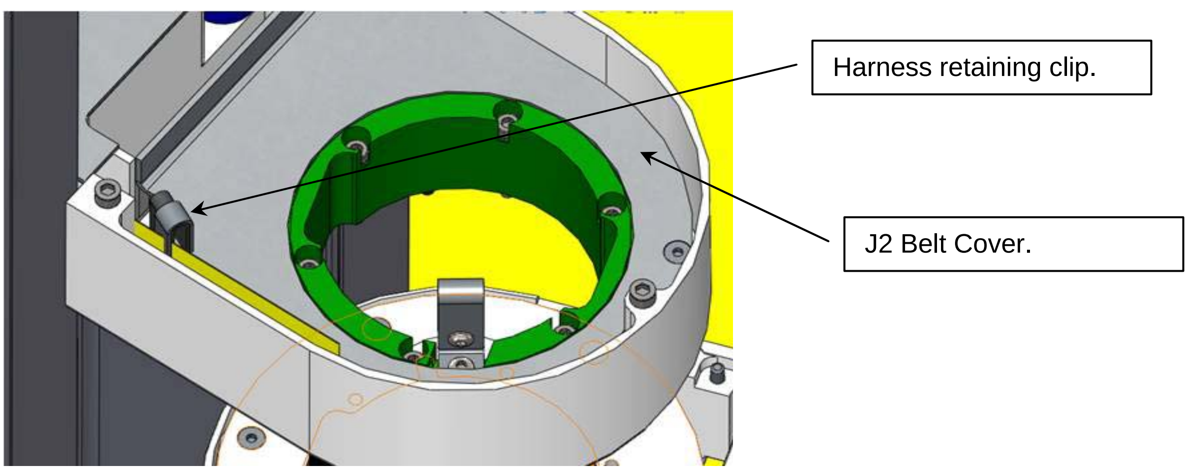


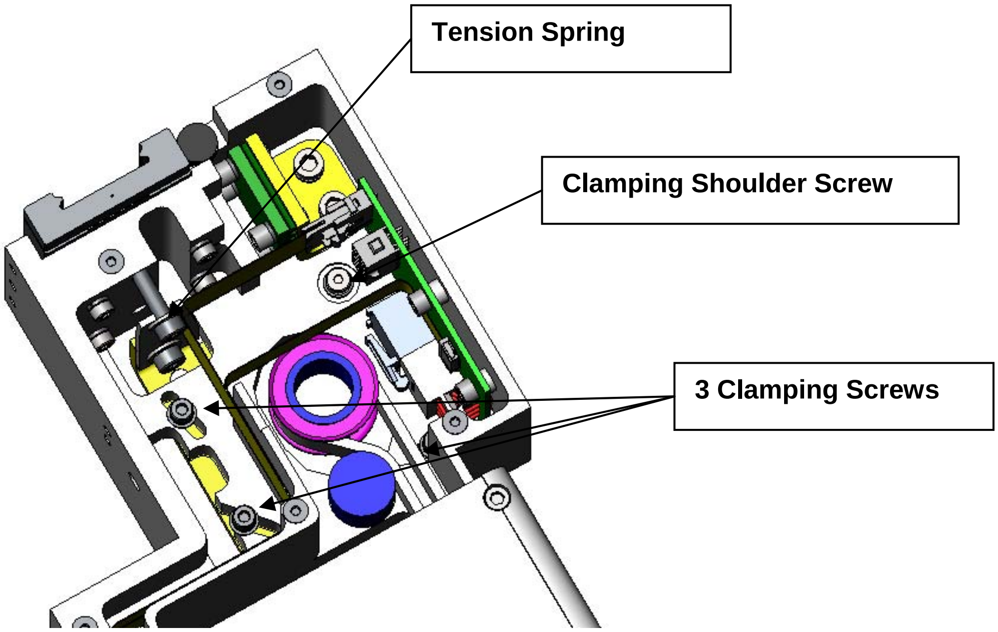
7. Remove the Light Bar by removing 3 M3 X 8 SHCS and unplugging the connector from the J2 Motor Interface PCA.
8. Remove the tie wrap securing the harness loop to the Z carriage.
9. Remove the M2 and E2 Flat Ribbon Cables from the J2 motor interface board. The E2 connector Cam lid must be VERY gently pried open with a .06 in flat bladed screwdriver.

10. Remove the J2 Motor Interface PCA by removing 2 M3 X 8 SHCS. Cut the tie wrap securing the J2 motor cables to the Z Carriage. Unplug the J2 motor and encoder cable from the J2 Motor Interface PCA.



11. Disconnect the harness retaining clip from the Z carriage, but do not remove the clips that attach the harness to the J2 pulley.
12. Uncoil the harness. One end will remain connected to the EChain and the other end connected to the J2 Pulley.
13. Remove the J2 Belt Cover by removing 3 M3 X 10 FHCS, and pull it partially up the uncoiled harness to expose the J2 timing belt.
14. Unsnap 3 or 4 of the EChain harness retaining segments, working up from the carriage, and fold the Echain and harness back over the power supply side of the robot to get it out of the way.





15. Loosen the 3 M3 SHCS and 1 M4 shoulder screw that attach the J2 motor bracket.
16. Measure and record the distance from the back of the Tension Spring to the carriage, then remove the M4 X 20 SHCD and washer that compress the Tension Spring.
17. Pull the timing belt up over the idler cam follower closest to the large J2 pulley to release belt tension and provide enough slack to remove the motor
18. If it is necessary to replace the J2 timing belt, replace the belt and reassemble the robot. Otherwise, skip this step and continue.
19. Now unscrew the 4 Screws and washers that attach the motor mount plate to the Z carriage while supporting the motor. It may be easiest to leave these screws in the carriage during this process..
20. Drop the motor assembly downwards while threading the motor cables thru the access hole in the bottom of the Z carriage, and pulling the timing belt up over the pulley flange.
21. Remove the motor from the Motor Mount Bracket by removing 4 M5 X 12 SHCS. Attach new motor to Motor Mount Bracket using Loctite 243.
22. Re-install motor, threading cables through the Z carriage first, and pulling timing belt over pulley flange. Attach motor, with 4 clamping screws. Do not tighten clamping screws all the way.
23. Re-install M4 X 20 Tension Bolt and compress Tension Spring to previous value. Tighten M4 Jam nut to lock bolt and Tension Spring. This will cause motor assembly to pivot on the shoulder screw and will apply tension to the timing belt. Before tightening the clamping screws, rotate the J2 output pulley back and forth to be sure the timing belt is running true on the output pulley.
24. Tighten the clamping screws. If a Tension Meter is available check the belt tension for a minimum tension of 150N. (See Appendix D)
25. Re-assemble the robot except for the front cover and top cover.
26. Remove the Calibration Pins from the inside of the front cover extrusion and re-calibrate the robot following the Calibration Procedure.

Replacing the J3 (Elbow) Axis Motor or Timing Belt

DANGER: Before replacing this motor, the AC power should be removed.

Tools Required:

1. 3.0mm hex driver or hex L wrench
2. 2.5 mm hex driver or hex L wrench
3. 2.0mm hex driver or hex L wrench
4. Fine point tweezers
5. .06 in flat blade screwdriver

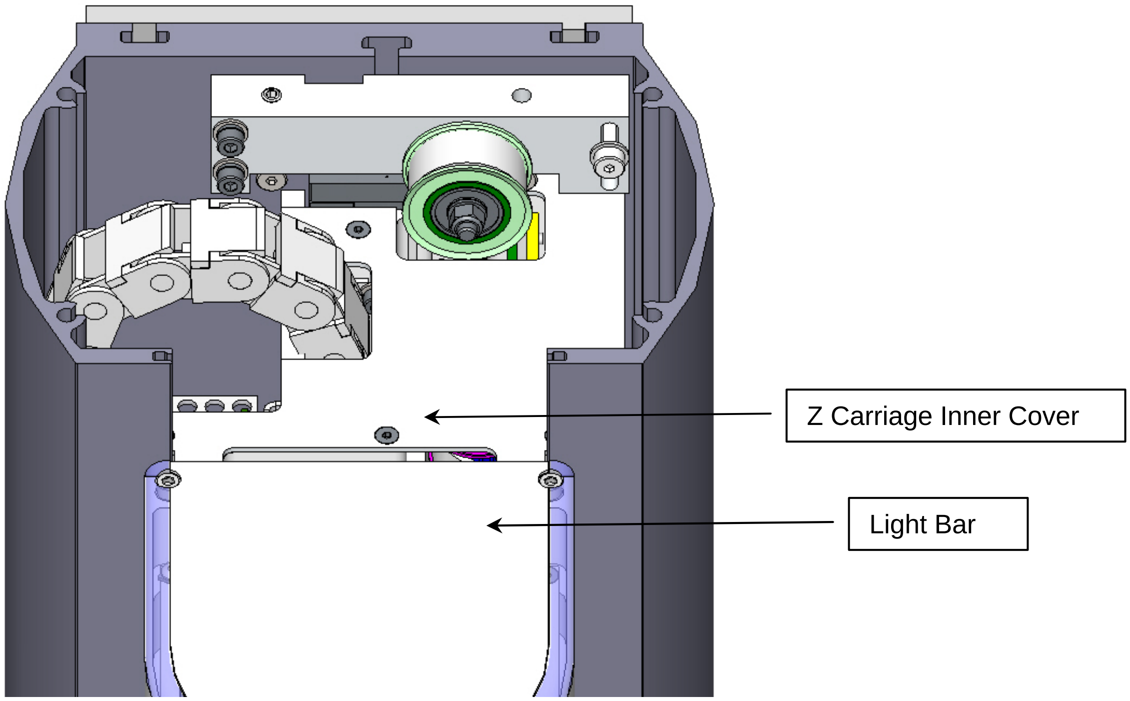
Spare Parts Required:

1. J3 Motor Assembly PN PF03-MA-00011or J3 Timing Belt PN PF00-MC-X0003.
2. 2 1/8th by 8 in tie wraps
3. Loctite 222 and 243

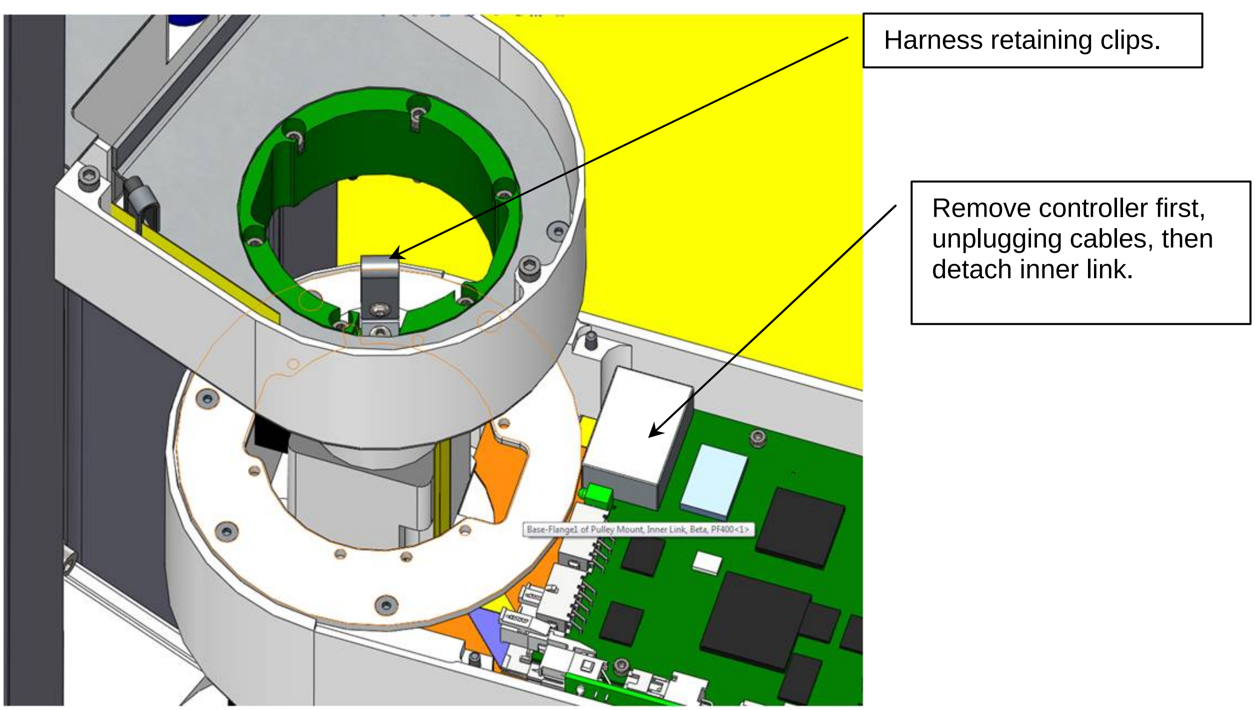
The J3 Motor Assembly is comprised of the J3 motor, connectors, and a timing belt pulley.

The user must:

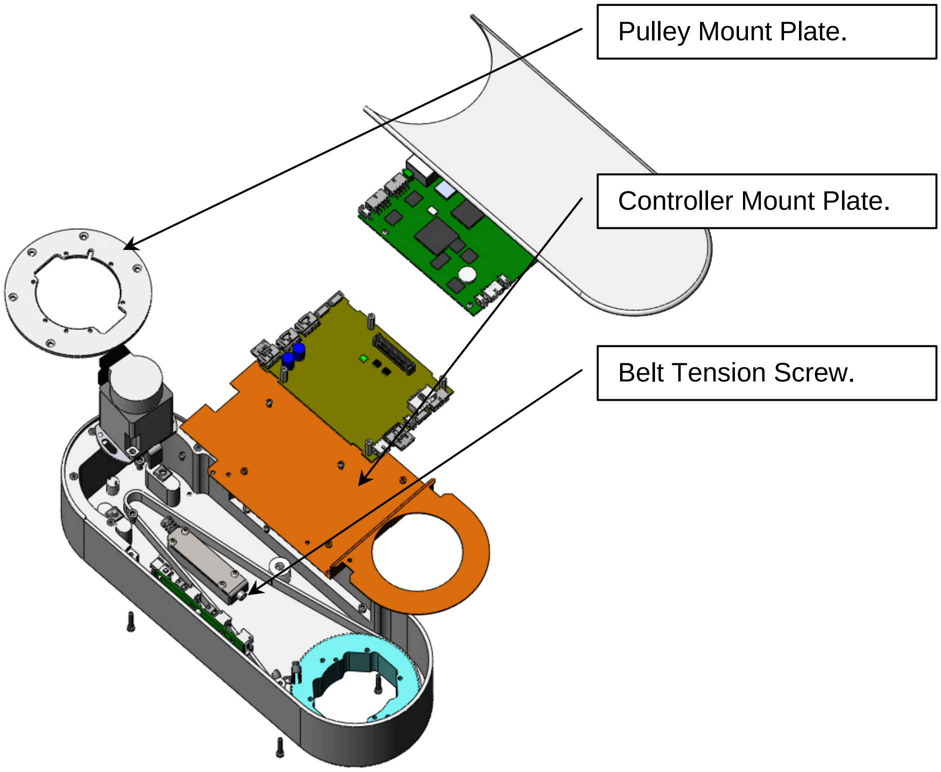
1. Unbolt the robot from its mounting surface and set it vertically on the floor or a low surface.
2. Move the robot arm to about 2 inches below the top of the Z Column travel.
3. Turn off the robot power and remove the AC power cord.
4. Remove the Top Plate of the robot by removing the 4 M5 socket head screws from the top plate of the robot that attach the top plate to the Z column.
5. Remove the Front Cover by lifting it out horizontally.
6. Remove the Z carriage inner cover by removing 5 M3 X 10 FHCS.



7. Remove the Light Bar by removing 3 M3 X 8 SHCS and unplugging the connector from the J2 Motor Interface PCA.
8. Remove controller from inner link.
9. Detach the inner link from the Z carriage by removing 6 M3 X 35 SHCS and lock washers.



10. Remove round Pulley Mount Plate from the Inner Link by removing 5 M3 X FHCS.
11. Remove the J3 Controller Mount Plate from the Inner link by removing 4 M3 X 5 SHCS.



12. Remove the J3 motor by removing the 2 M4 Screws attaching the motor to the motor mount plate, and rotate the motor up and out of the motor mount plate. This procedure will preserve the belt tension and avoid having to use a tension meter to reset the belt tension, as it preserves the position of the motor mount plate.
13. Replace the J3 motor, using Loctite 243, or optionally, replace the J3 timing belt if necessary. Since the motor mount plate has not been removed, the belt tension should not need to be adjusted.
14. If a Belt Tension Meter is available, check the belt tension per Appendix D. Check the belt tension every 10 degrees of rotation of the J3 output pulley and set the belt tension at its lowest point to the minimum value in Appendix D.
15. Replace the pulley mount plate using Loctite 222 and re-assemble the robot.
16. Re-calibrate the robot.

Replacing the J4 (Wrist) Axis Motor or Timing Belt

DANGER: Before replacing this motor, the AC power should be removed.

Tools Required:

1. 3.0mm hex driver or hex L wrench
2. 2.5 mm hex driver or hex L wrench
3. 2.0mm hex driver or hex L wrench
4. Fine point tweezers
5. .06 in flat blade screwdriver

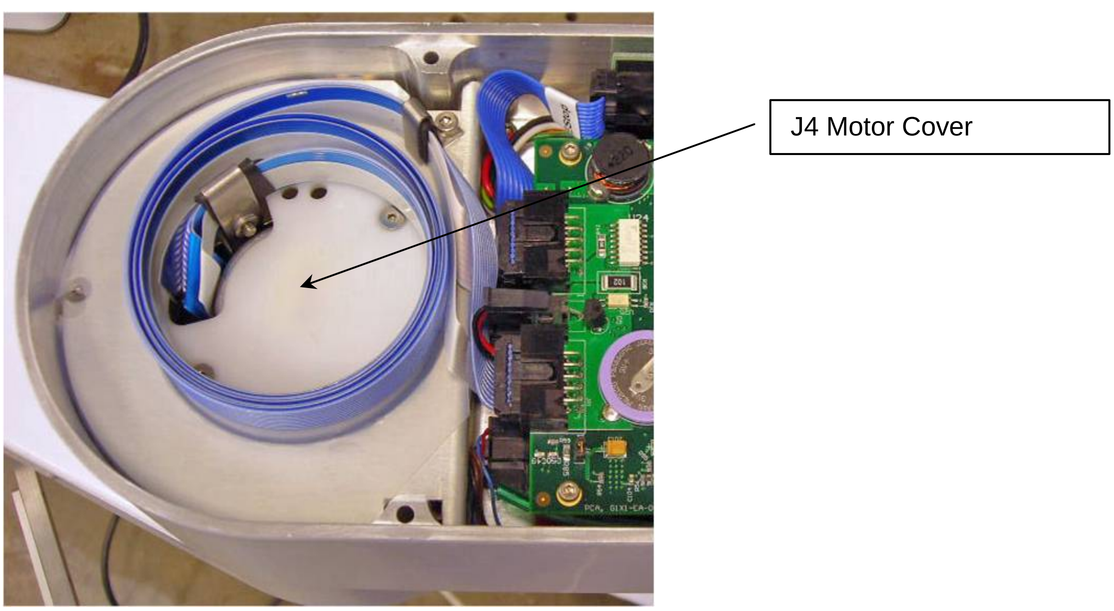
Spare Parts Required:

1. J4 Motor Assembly PN PF04-MA-00011 or J4 Timing Belt PN PF00-MC-X0004.
2. Loctite 222 and 243

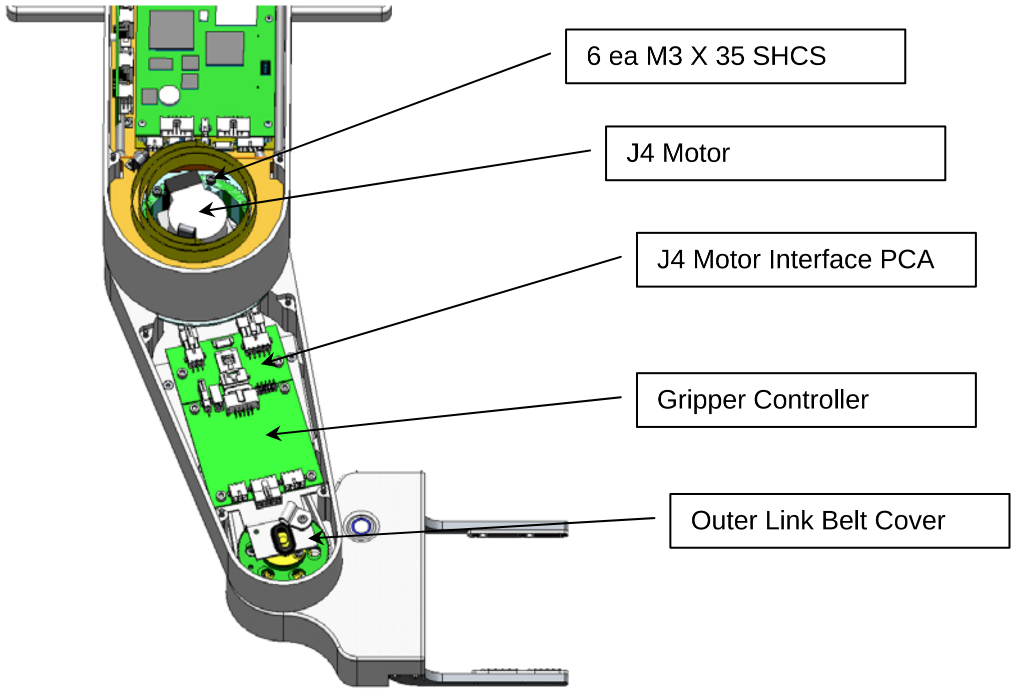
The J4 Motor Assembly is comprised of the J4 motor, connectors, and a timing belt pulley.

The user must:

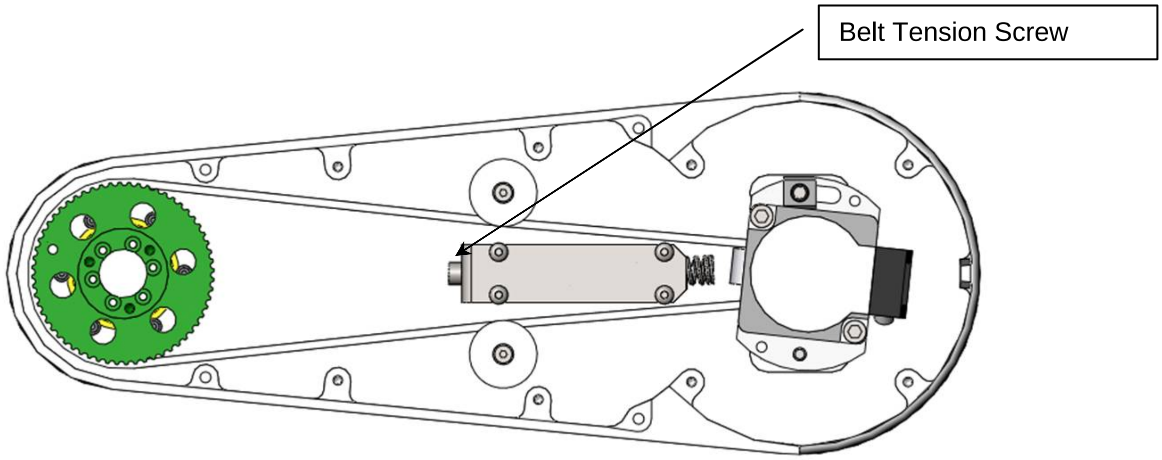
1. Move the robot arm to a convenient height on the Z column for removing the outer link.
2. Turn off the robot power and remove the AC power cord.
3. Remove the inner link cover by removing 4 M3 X 20 SHCS and lock washers.
4. Remove the outer link cover by removing 4 M3 X 20 SHCS and lock washers.
5. Remove the J4 Motor Cover in the Elbow by removing 2 M3 X 10 FHCS.



6. Rotate the Outer Link clockwise (viewing from above) until it hits the hard stop. This will expand the harness coil and the link will be position as shown below, about 10 degrees from straight out.
7. Remove the J4 Motor Interface Board in the Outer Link and unplug the cables.
8. Remove the Outer Link by removing 6 M3 X 35 SHCS in the J3 Output Pulley that attach the Outer Link.
9. Remove the Gripper Controller by unplugging the Gripper harness and removing 4 M3 X 8 SHCS.
10. Remove the Outer Link Belt Cover by removing 4 M3 X 10 SHCS.



11. Remove the J4 motor by removing the 2 M4 Screws attaching the motor to the motor mount plate, and rotate the motor up and out of the motor mount plate. This procedure will preserve the belt tension and avoid having to use a tension meter to reset the belt tension, as it preserves the position of the motor mount plate.
12. Replace the J4 motor, using Loctite 243, or optionally, replace the J4 timing belt if necessary. Since the motor mount plate has not been removed, the belt tension should not need to be adjusted.
13. If a Belt Tension Meter is available, check the belt tension per Appendix D. Check the belt tension every 10 degrees of rotation of the J4 output pulley and set the belt tension at its lowest point to the minimum value in Appendix D.
14. Replace the pulley mount plate using Loctite 222 and re-assemble the robot, with the outer link positioned as shown above so that the link is correctly oriented with respect to the hard stop.
15. Re-calibrate the robot.


Belt Tension Screw

Appendix A: Product Specifications

PreciseFlex 400 Specifications

General Specification	Range
Range of Motion & Resolution	
J1 (Z) Axis	400mm or 750mm
J2 Axis	± 90 degrees
J3 Axis	± 167 degrees
J4 Axis	+/- 970 degrees
Gripper Travel	77 to 133mm
Resolution	50 microns typical
Repeatability	+/- 0.200 mm overall in x,y & z directions at 18-22C
Performance and Payload	
Maximum acceleration	2500mm/sec^2 with 500gm payload
Maximum speed	500 mm/sec with 500gm payload
Controller	*AVAILABLE GUIDANCE CONTROLLERS*: Guidance 1400B, Guidance 1100T Slave Amp
Interfaces	
General Communications	RS-232 channel, 100Mb Ethernet
Digital I/O Channels	1 optically isolated input, available on facilities panel at base Additional 8 isolated inputs and 8 isolated outputs available as option at facilities panel. Remote I/O also available.
Pneumatic Lines	One air line, 75 PSI maximum, provided at outer link and routed internally to fittings on the Facilities Panel if Pneumatic Option selected.
Operator Interface	Web based operator interface supports local or remote control via browser connected to embedded web server.
Programming Interface	Three methods available: DIO MotionBlocks (PLC), embedded Guidance Programming Language (standalone), PC controlled over Ethernet using TCP/IP.
Required Power	Dual range: 90 to 132 VAC and 180 to 264 VAC, auto selecting, 50-60 Hz, 365 watts maximum
Weight	20 kg for 400mm travel version

Appendix B: Environmental Specifications

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

General Specification	Range & Features
Ambient temperature	5ºC to 40ºC
Storage and shipment temperature	-25ºC to +55ºC
Humidity range	5 to 90%, non-condensing
Altitude	Up to 3000m

Appendix C: Spare Parts List

Description	Part Number
Absolute Encoder Battery Assembly	PF00-EA-00002
J1 Motor Assembly	PF01-MA-00011
J1 Stage 1 Belt	PF00-MC-X0021
J1 Stage 2 Belt 400mm	PF00-MC-X0022
J1 Stage 2 Belt 750mm	PF00-MC-X0023
J2 Motor Assembly	PF02-MA-00011
J2 Belt	PF00-MC-X0005
J3 Motor Assembly	PF03-MA-00011
J3 Belt	PF00-MC-X0003
J4 Motor Assembly	PF04-MA-00011
J4 Belt	PF00-MC-X0004
Low Profile Electric Gripper	PF0A-MA-00001
Gripper Finger Pads (Set of 4)	PF0A-MA-00011
Gripper Finger Clamp Bars (Set of 2)	
Gripper Fingers (Set of 2)	
G1400B Controller	G1X0-EA-B1400
G1100T Slave Controller	G1X0-EA-T1100
24 VDC Supply	PS10-EP-00125
48 VDC Motor Supply	PS10-EP-48365
Slip Ring Harness Assembly	PF04-MA-00002-E2
Harness, FFC, J4 Motor	PF0H-MA-00002-02-E3
Harness, FFC, J4 Encoder	PF0H-MA-00005-02-E3
Harness, Gripper Controller	PF0H-MA-00014
Fuse 250 VAC 6.3A 5X20mm Time Lag	PS12-EC-F0001
J1 Motor Interface PCA	PF00-EA-00001-J1
J2 Motor Interface PCA	PF00-EA-00001-J2
MIDS Interface PCA	PF00-EA-00001-MI
J4 Motor Interface PCA	PF00-EA-00001-J4
Energy Dump PCA	PF00-EA-00001-ED
Pneumatic Outer Link Harness Assembly	PF04-MA-00006

Appendix D: Gates Tension Meter

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

To use the tension meter

1. Turn on the power
2. Press the “Mass” button and enter the belt mass from the table below.
3. Press the “Width” button and enter the belt width from the table below.
4. Press the “Span” button and enter the belt free span from the table below.
5. Press “Select” to record the data.
6. Press “Measure” to take a tension reading.
7. Place the microphone near the belt, typically within 3mm 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	***Mass (g/m)***	***Width (mm)***	***Span (mm)***	***Required Tension (N)***
Z S1	2.8	9	58	50-70
Z S2	4.1	12	530	100-120
Z S2	4.1	12	880	100-120
J2	2.8	9	108	160-180
J3	2.8	9	104	60-70
J4	2.8	9	113	35-40