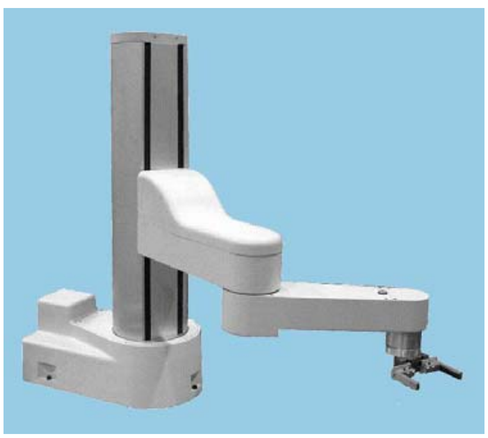
PreciseFlex 1300/1400 Robot



Hardware Introduction

and Reference Manual

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Document Content

Trademarks

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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:

DANGER: This indicates an imminently hazardous situation, which, if not avoided, will result in death or serious injury.

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 Robot Series includes the PreciseFlex 1300, a three-axis SCARA robot, and the PreciseFlex 1400, a four-axis SCARA Robot. Both robots include an embedded Guidance 2400C four-axis motion controller, a PrecisePower 300 Intelligent Motor Power Supply, and a 24VDC power supply located inside the base of the robot.

The Z-axes of these robots are available in a standard length of 300 mm. For volume OEM applications, custom lengths of up to 600 mm are possible. The robots were designed as tabletop units and can carry a payload of up to 4 Kg. 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 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 Ethernet interface, a number of digital input and output lines, and a remote front panel interface that provides IEC Category 3 safety signals. 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 robot's integrated controller includes a web based operator interface that is viewed via a standard browser. This interface is used for configuring the system, starting and stopping execution, and monitoring its operation. The web interface can be accessed over a local network or remotely via the Internet. This remote interface is of great benefit in system maintenance and debugging. It is highly recommended that first time users read the *Setup and Operation Quick Start Guide*, PN 0000-DI-00010, for instructions on interfacing a PC to the robot's controller via the web interface and for general controller operating instructions.

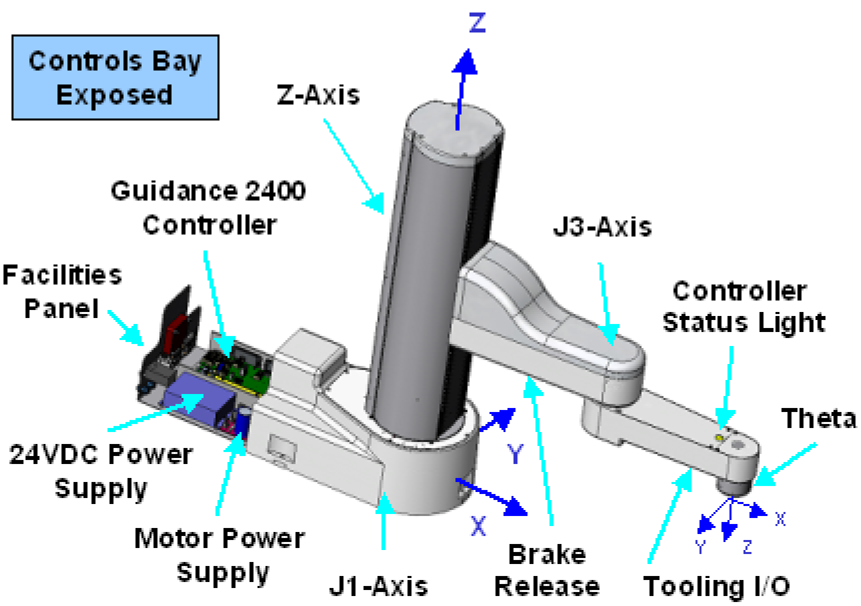
The controller is programmed by means of a PC connected through Ethernet. There are three programming modes: a Digital IO (PLC) mode, an Embedded Language mode, and a PC Control mode. When programmed in the PLC or Embedded Language mode, the PC can be removed after programming is completed and the controller will operate standalone. A PC is required for operation in the PC Control mode. For a complete description of the embedded language and its development environment, please refer to the *Guidance Programming Language, Introduction to GPL*, PN GPL0-DI-00010 and the *Guidance Development Environment, Introduction and Reference Manual*, PN GDE0-DI-00010.

The controller is designed to operate with an optional, easy-to-use machine vision software package, "PreciseVision". This vision system can be executed in a PC connected through Ethernet or (in the future) in the motion controller. It provides a complete set of image-processing, measurement, inspection and object finder tools. For more information on vision, please refer to the *PreciseVision Machine Vision System, Introduction and Reference Manual*, PN PVS0-DI-00010.

For a complete description of the robot's controller hardware, please refer to the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual*, PN G3X0-DI-00010*.*

System Diagram and Coordinate Systems

The major elements of the PreciseFlex robot and the orientations of its World and Tool Cartesian coordinate systems are shown in the diagram below.



The first axis of the robot, J1, rotates the links of the robot about the World Z-axis. The primary electronic components are mounted in a Controls Bay that slides into the base housing of the J1-axis. This bay includes the Guidance 2400 Controller, the PrecisePower 300 Intelligent Motor Power Supply and the 24 VDC logic power supply. The Guidance Controller not only controls the robot but also provides extensive hardware interfaces including Ethernet and digital IO signals.

DANGER: The Guidance 2400, the PrecisePower Motor Power Supply, and the 24VDC power supply are open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**

When the J1-axis is centered within its range of motion, the axis will be at its 0 angle. This is the position that is illustrated in the picture above. A positive change in the J1-axis angle results in a positive rotation of the robot's links about the World Z-axis.

The second axis produces a linear motion along the World Z-axis. When this axis is lowered as far as possible, the axis' position in the Joint Coordinate system will be approximately 0 and the robot's end-effector mounting flange will be at approximately Z=132mm (3-axis robot) or Z=122 (4-axis robot) in the World Coordinate system. As the Z-axis moves up, both the Z-axis joint position and the end-effector's World Z Coordinate increase in value.

The J3 (“elbow”) axis rotates the outer link about the direction of World Z. When the inner and outer links point in the same direction, J3 is at its 0 position (as pictured above). A positive change in the axis rotates the outer link in a positive rotation about the direction of the positive World Z-axis.

The optional Theta axis rotates the end-effector about the direction of the World Z-axis. A positive change in the Theta angle results in a positive rotation about the direction of the negative World Z-axis.

The outer link includes an IO board that provides electrical and air services for tooling. A yellow LED is mounted at the top the outer link and blinks at a rate of once per second to indicate that the controller is operational or 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 work, 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 1300/1400 Robots

The PreciseFlex 1300 Robot (pictured below) is a 3-axis SCARA robot composed of a J1-Axis with a rotation of +/-176°, a Z-axis with a stroke ranging from a standard travel of 300 mm to a maximum of 600 mm, and a J3-Axis with a rotation of +/-162°.

The PreciseFlex 1400 is a 4-axis version of this robot. It is configured at the factory by adding a Theta rotational axis to the PreciseFlex 1300 and a 4th motor driver to the robot's embedded controller. The PreciseFlex 1400 is visually nearly identical to the 1300 except that the tool mounting flange extends 10 mm lower. The Theta axis is beneficial in applications where the orientation of manipulated objects about the vertical axis (the World Z-axis direction) is important. The Theta axis has a range-of-travel of +/- 270 degrees.

Both robots have a 20 mm hole in the top of the outer link that extends through the center of the tool flange. This "through hole" facilitates the development of visual servoing procedures. For example, in a visual servoing application, this clear passage way permits a camera that is mounted above the outer link to look through the tool mounting flange to view parts held in the end-effector with respect to key alignment features. Alternately, this hole can be used to route cables to tooling and instrumentation attached to the end-effector.

The outer link of both robots also contains a PCB (ZIO) and connectors that route digital IO and Ethernet signals between the end-effector and the controller in the base. This DIO is available via a DB25 connector that is mounted on the bottom of the outer link.

Guidance 2400 Controller

The Guidance 2400 Controller is a four-axis general purpose motion controller that contains four motor drives and eight encoder inputs. It must be attached to a heat sink, which in the PreciseFlex robots is provided by the Controls Bay and the J1-axis base housing. This controller includes digital IO, an RS232 serial port, 10/100 Mbit Ethernet ports and an interface for an optional front panel. These interfaces can be used to connect to an optional Precise Remote IO module, an optional hardware Manual Control Pendant and other peripherals. Analog input and output interfaces are optionally available.

DANGER: The Guidance 2400, the PrecisePower Motor Power Supply, and the 24VDC power supply are open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**

In addition to the controller, a PrecisePower 300 Intelligent Motor Power Supply and a 125-watt 24VDC power supply are necessary to power the motors and electronics. All three of these components are housed in the robot's Controls Bay and are pictured in the previous System Diagram and Coordinate Systems section.

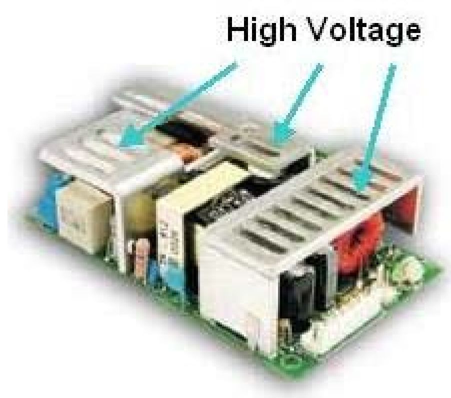
For detailed information on the controller including interfacing information, please see the *"Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual"*.

Low Voltage Power Supply

The Guidance 2400 requires 0.7 amps of 24 VDC power for its logic circuits and 2 amps for IO power, for a total of 2.7 amps. For applications using remote IO or Ethernet cameras, Precise recommends a total of 4 amps. This power is obtained from a 24 VDC power supply included with the robot.

The PreciseFlex Robots have an integrated 125-watt, 24 VDC Power Supply, Mean Well P/N PPS-125-24 that accepts a range of AC input from 90V to 264V. This power supply is shown mounted to the Controls Bay in the System Diagram and Coordinate Systems section of this document.

> **DANGER:** In addition to exposed high voltage pins and components, **the heat sinks on the 24VDC Power Supply are not grounded and expose high voltage levels.** AC power to the robot must be disconnected prior to accessing this unit.



Intelligent Motor Power Supply

The Guidance 2400 controller can accept motor power from 24 VDC to 340 VDC. The PreciseFlex robots contain a 300/600-watt motor power supply that operates with input voltages from 90 to 264 VAC 50/60 Hz and generates a nominal output of 160VDC or 320VDC depending upon the input voltage.

This intelligent power supply contains: a single relay for enabling and disabling motor power when commanded by the controller, built-in fuses, large value output filter capacitors to store deceleration energy for use when power is needed, and the ability to absorb line spikes.

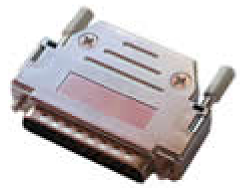
This PrecisePower unit is shown mounted to the Controls Bay in the System Diagram and Coordinate Systems section of this document.

DANGER: The PrecisePower Intelligent Motor Power Supply is an open frame electrical device that has exposed unshielded high voltage pins, components and surfaces. In addition, the power supply provides 160VDC to 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing this unit.**

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. 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 hold-to-run button is also available. Any of these units can be plugged directly into the Remote Front Panel connector mounted on the robot's Facilities Panel, which is located on the back of the J1 housing. Each of these units provides the hardware signals to permit power to be enabled and disabled.

NOTE: To enable motor power without an E-Stop Box, Hardware Manual Control Pendant or remote front panel, the jumper plug supplied with the system (pictured below) must be installed in the 25-pin Remote Front Panel connector.



In the future, Precise plans to offer a remote front panel that will contain a high power enable button, an auto/manual keyed selector switch, an E-Stop button, and a back panel connector for user E-Stops.

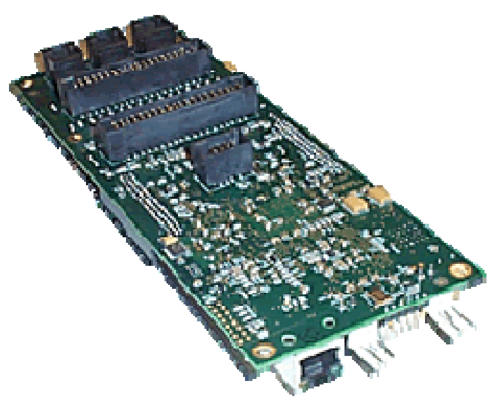
For additional information on the signals provided on the Remote Front Panel connector, please see the Hardware Reference section of this manual.

Remote IO Module

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 Mbit 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. In addition, expansion boards will soon be offered that cost effectively add additional isolated digital inputs and outputs in groups of 32 each to the basic RIO.

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.

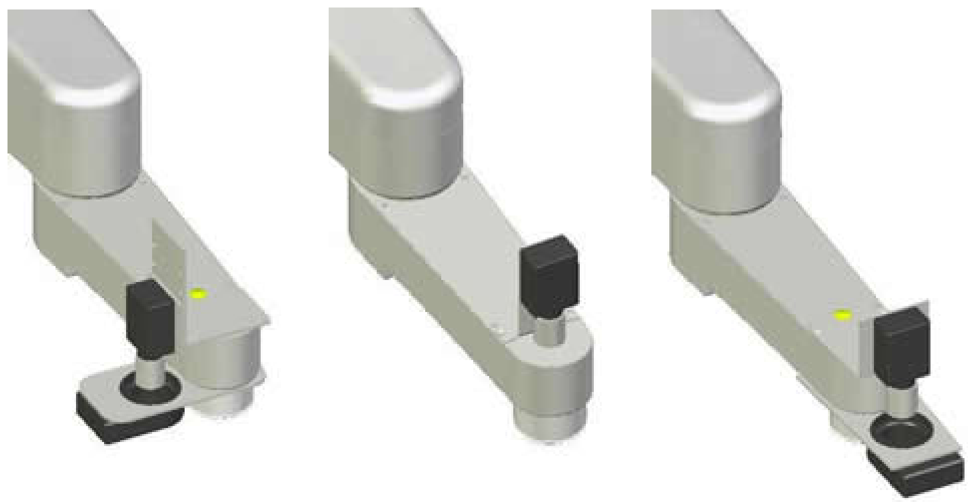


Machine Vision Software and Cameras

The Guidance 2000 Series controllers support the PreciseVision machine vision system. This is a vision software package than can run either on a PC for higher performance applications, or in the motion controller processor for simple applications (future development).

When PreciseVision is executed on a PC, it communicates with the motion controller via Ethernet and with cameras via either Ethernet or USB connections. Vendors such as DALSA offer a variety of Ethernet machine vision cameras and similar industrial USB cameras can be obtained from IDS Imaging.

While cameras are often mounted in fixed stationary positions, there are many applications where it is advantageous to mount a camera on the robot's outer link. For example, this configuration permits the same camera to view different regions of the workspace with high magnification; enables the implementation of visual servoing algorithms; and eliminates bulky stationary camera mounts. To simplify this approach, in the future, Precise will offer an optional Arm Mounted Camera Kit. This kit will permit a DALSA Genie Series Ethernet Camera to be easily attached to the PreciseFlex robot's outer link in a number of different positions.



Controller Status LED

The system includes a yellow Status LED that is mounted on the top of the outer link. This LED blinks to indicate the execution state of the controller.

If the Status LED is not visible for any reason, a general purpose digital output can be assigned to blink in synchronization with the Status LED. To configure a digital output, the "Power State DOUT" (DataID 235) must be set equal to the signal's channel number.

The execution conditions that are indicated by this LED and an output signal (if configured) are described in the following table.

Status LED	System Status	Description
Continuously Off	(1) Logic power off or (2) CPU crashed	Normally indicates that 24VDC logic power is off. In rare instances, indicates that the controller has crashed due to a system hardware or software error. The processor may be executing the firmware debugger, dBug.
Continuously On	(1) Booting or (2) CPU crashed	Typically indicates that 24VDC logic power is on and the controller is executing its startup boot sequence.

		If the LED turns on continuously after it has been blinking, the processor has crashed due to a system hardware or software error. The processor may be executing the firmware debugger, dBug.
Blinks 1 time per second	Normal operation, motor power off	The controller is executing in its standard operating mode and motor power is disabled.
Blinks 4 times per second	Normal operation, motor power on	The controller is executing in its standard operating mode and motor power is enabled.
Blinks 8 times per second	CPU overheating	The processor is overheating, motor power is off and you have 5 minutes to save any programs or data. After 5 minutes, the processor will shut down and needs to be rebooted.

Machine Safety

Voltage and Power Considerations

The Guidance 2400 requires two DC power supplies: a 24 VDC power supply for the processor and user IO, and a separate motor power supply. The motor power supply must provide the controller with a voltage between 24 VDC and 340 VDC.

DANGER: The Guidance 2400, the PrecisePower 300 Intelligent Motor Power Supply, and the 24 VDC power supply 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. In the PreciseFlex robots, these units are contained in the Controls Bay.

The PreciseFlex robots include a 300/600-watt PrecisePower Intelligent Motor Power Supply that has an input range of 90 to 264 VAC 50/60 Hz and a nominal output of 160 VDC to 320 VDC depending upon the AC input. This motor power supply contains a relay that permits the controller to enable and disable motor power.

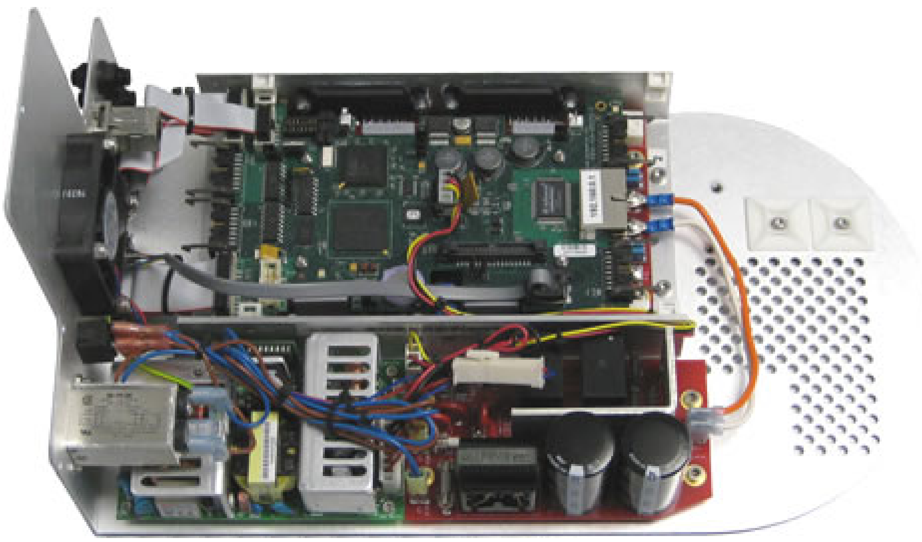
The PrecisePower Intelligent Motor Power Supply limits inrush current to 6 Amps. It is protected against voltage surge to 2000 volts by means of MOV's at the line input. Transient over voltage (< 50 µs) may not exceed 2000 V phase to ground, as per EN61800-31996. It is protected against over current by two 6.3 amp, 250V fuses, Wickman PN 1941630000.

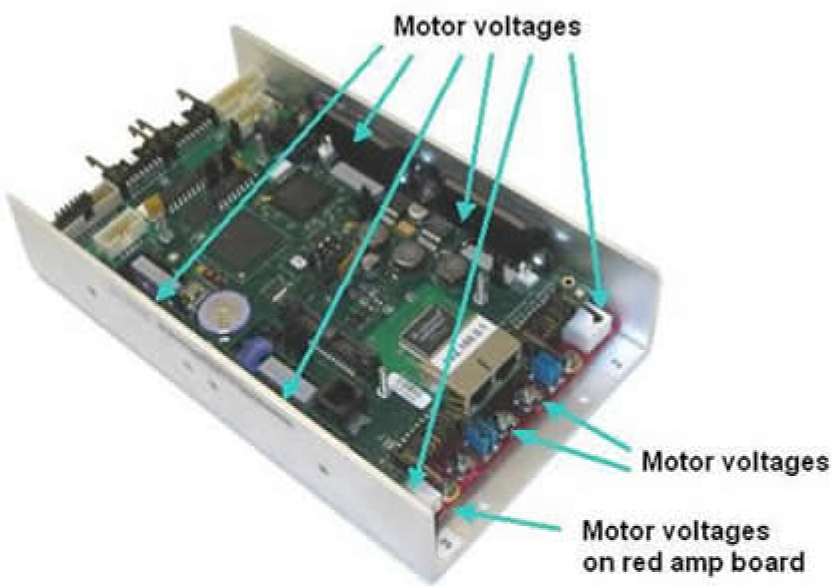
The Precise controller can monitor motor power through its datalogging function. Intermittent power dropouts can be detected by setting a trigger in the data logger which can record and time-stamp power fluctuations.

Robot Controls Bay

In the PreciseFlex robots, the Guidance 2400 and its power supplies are mounted in the Controls Bay, which should be fully inserted into the J1 Base Housing whenever power is applied to the robot.

DANGER: The PrecisePower Intelligent Motor Power Supplies are open frame supplies that provide up to 320VDC volts and take about 2 minutes to bleed down after power is disconnected. The 24VDC power supply is also an open frame supply with high voltage terminals and heat sink surfaces exposed when the Controls Bay is exposed. **The robot should not be operated if the Controls Bay is not completely inserted in the J1 Base Housing.**





> **DANGER:** The surfaces, connectors, and leads pictured in Red above and the labels indicate exposed elements of the Guidance 2400 controller that carry motor power signals. These signal levels are at voltages of up to 320 VDC.

Releasing a Trapped Operator: Brake Release Switch

Should a hard E-Stop be triggered, the Z-axis brake will engage and motor power will be disconnected from all motors. Since the J1, J3, and Theta axes do not have brakes, they may be manually repositioned by pushing on each axis. However, in order to move the Z-axis, the operator can release the Z-axis brake by pressing the brake release switch that is located on the bottom surface of the Inner Link (as shown in the System Diagram and Coordinate Systems section) as long as power to the robot's controller is enabled.

Mechanical Limit Stops

Each axis has factory installed hard limit stops at their ends of travel. In robots shipped after March 2009, if required, the J1-Axis hard stop can be moved by using the M5 Countersunk threaded holes that are provided. None of the other axes have adjustable hard stops.

If a mechanical limit stop is changed, it is important that the software "Soft stop limit" and "Hard stop limit" settings be adjusted to be inside of the new mechanical restrictions. The software limit stop values can be modified by a user with administrator privileges to the robot. To modify the software limits, the robot motor power must be disabled first. Then, the software limits may be adjusted and saved to flash memory.

E-Stop 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 method can be used to quickly halt all robot motions in a controlled fashion when an error is detected.

This function is similar to a "Hard E-Stop" except that a Soft E-Stop leaves motor power enabled and is therefore applicable to less severe error conditions. Leaving motor power enabled is beneficial in that it prevents the robot axes from sagging and does not require motor power to be re-enabled before program execution and robot motions are resumed. This method is similar to a "Rapid Deceleration" except that a Rapid Deceleration only affects a single robot and no program error is generated.

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 firmware parameter that can delay opening the motor power supply relay for a fixed amount of time after a Hard E-Stop signal is asserted. This delay is nominally set at 0.5 seconds and 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 DataID 267 to the desired delay. If this delay is set to 0, the motor power relay will be disabled within 1ms after an input signal is asserted.

For the PreciseFlex robots, the J1, J3, and Theta axes do not have mechanical brakes so if motor power is disabled while these axes are moving, they will coast for a significant distance. Leaving the motor power enabled for 0.5 sec allows the servos to perform a rapid controlled deceleration of these axes. The servos will typically decelerate the robot at 0.5G, or 4900mm/sec^2. If the robot is moving at a speed of 1000mm/sec, it will reach a full stop in 0.20sec after having only traveled a distance of 102mm.

Safety Standards Reference Material

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), *Robots for Industrial Environments – Safety Requirements*, 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 Safety 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 robot 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 robot has been designed to comply with the following agency certification requirements and carries the CE mark.

CE
CSA
UL
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 is a light-duty robot that can only apply approximately 120 Newton's of force, it is very important for operators to keep their hands, arms and especially their head out of the robot’s operating volume.

The maximum speed for manual operation is set at 250mm/sec, as required by EN ISO 10218-1-2007. This can be easily confirmed using the "Virtual Pendant" in the Web interface. After enabling power and homing the robot, select “Virtual Pendant” in the Web Control Panels Menu, then select a manual control mode such as “Joint” Mode, select Joint 1, set the speed slider to 100% and drive the X-axis 250mm and time the motion. While it is possible to change this parameter in the system, this is not recommended, and should only be done after an application risk assessment.

In Computer Mode the robot can move at speeds up to 2000mm per second. 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* or EN ISO 10218-2-2007, *Robots for Industrial Environments, Safety Requirements*, for information on recommended safe operating practices and enclosure design for robots of various sizes and payloads.

Installation Information

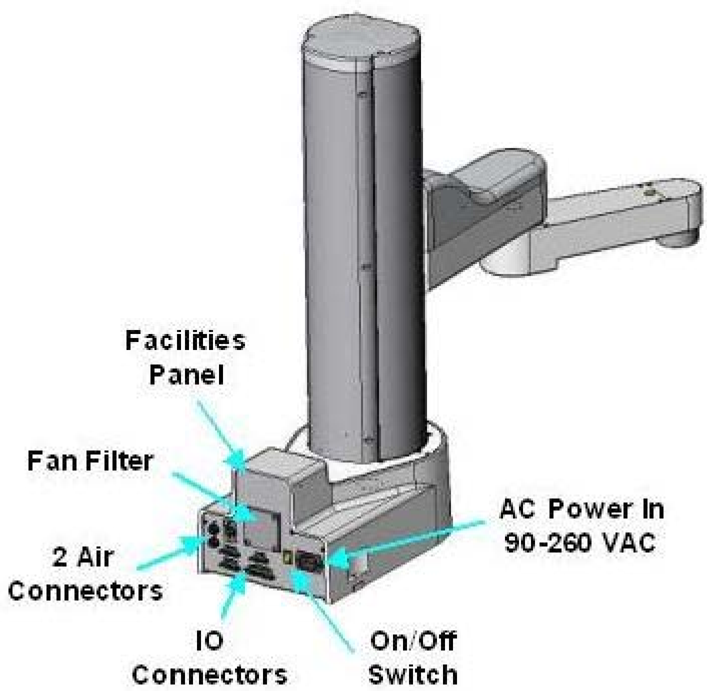
Environmental Specifications

The PreciseFlex robots are rated IP51. They can withstand mild dust and drips and should be installed in a non-condensing environment. Please see the Environmental Specifications in Appendix A for specific environmental limits.

Facilities Connections

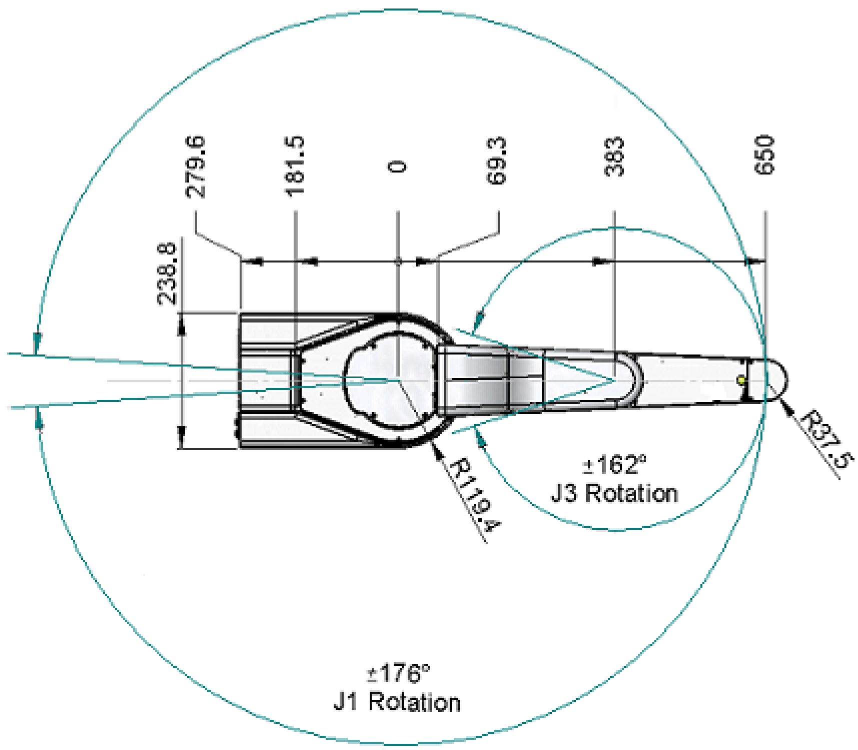
The Facilities Panel on the back of the J1-Axis housing includes the following:

- System AC input power receptacle
- Lighted AC on/off power switch
- Two 4mm OD pneumatic tubing fittings (one-touch type tube insertion)
- Connectors for controller input and output signals
- Controls Bay fan filter

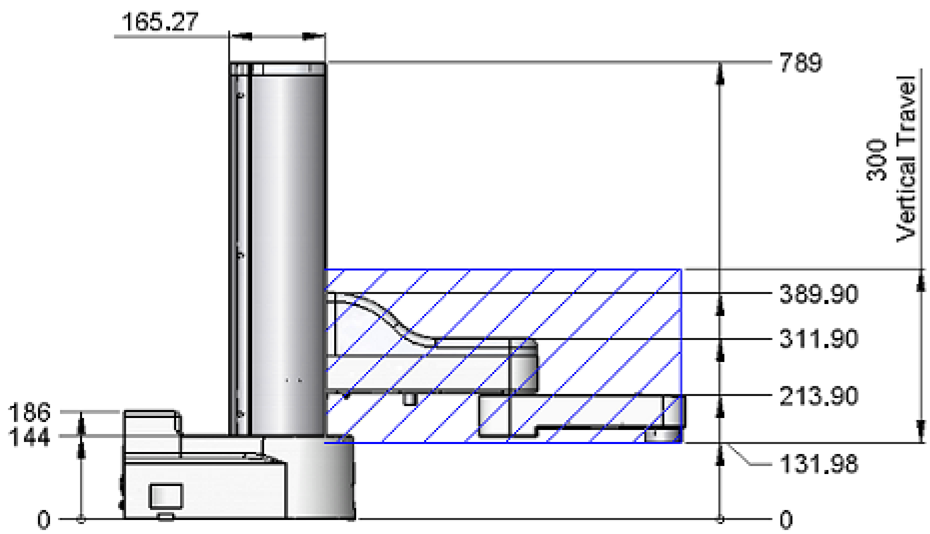


System Dimensions

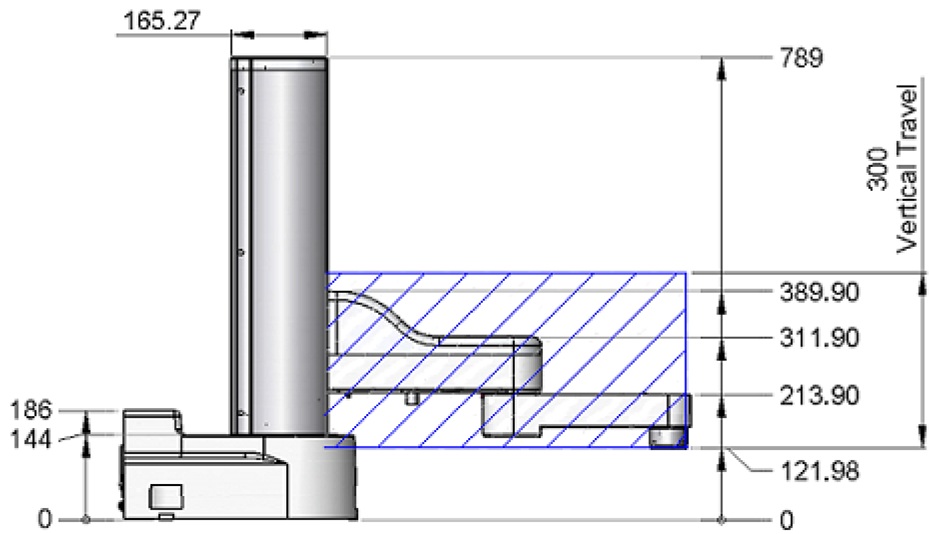
Both top and left views for the PreciseFlex 1300/1400 are shown below. All dimensions are in millimeters.



PreciseFlex 1300 and 1400 Top View



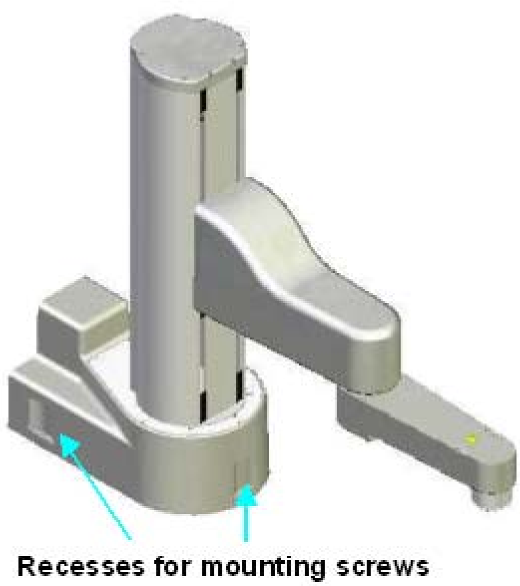
PreciseFlex 1300 Left Side View

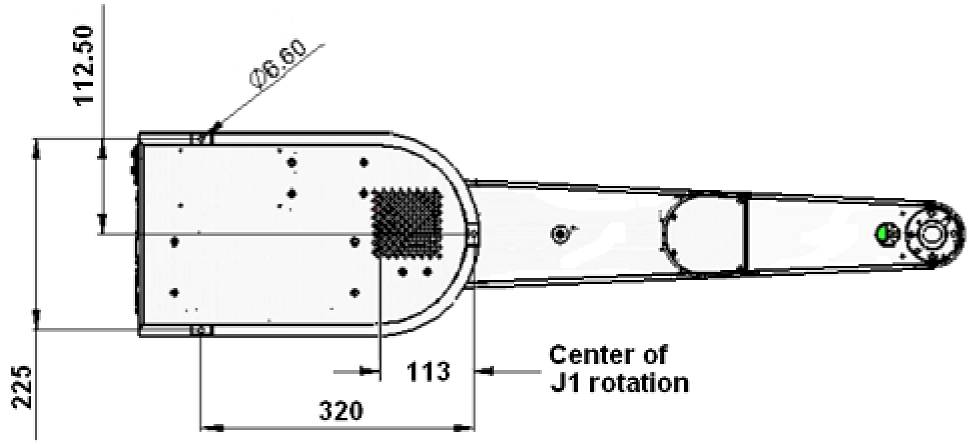


PreciseFlex 1400 Left Side View

Mounting Instructions

PreciseFlex robots must be attached to a rigid surface that can withstand lateral forces of 200 Newton's without moving or vibrating. The robot base has an integrated recessed bolting pattern that accommodates three M6 SHCS mounting screws located as illustrated below.



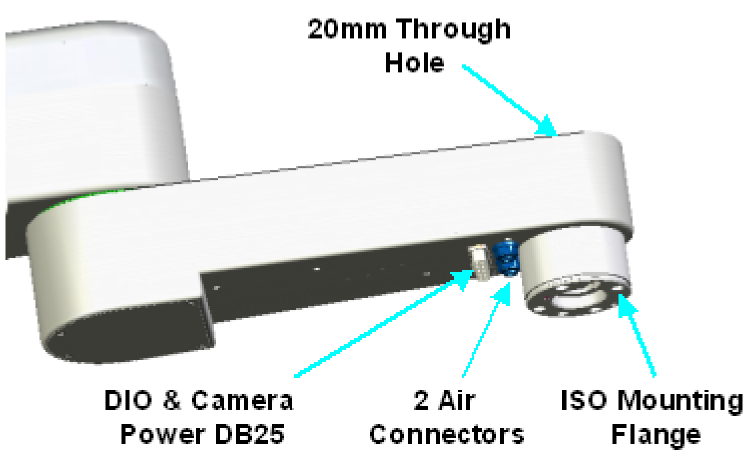


Tool Mounting - PreciseFlex 1300/1400

The PreciseFlex Outer Link has been designed to permit tooling to be easily attached and interfaced.

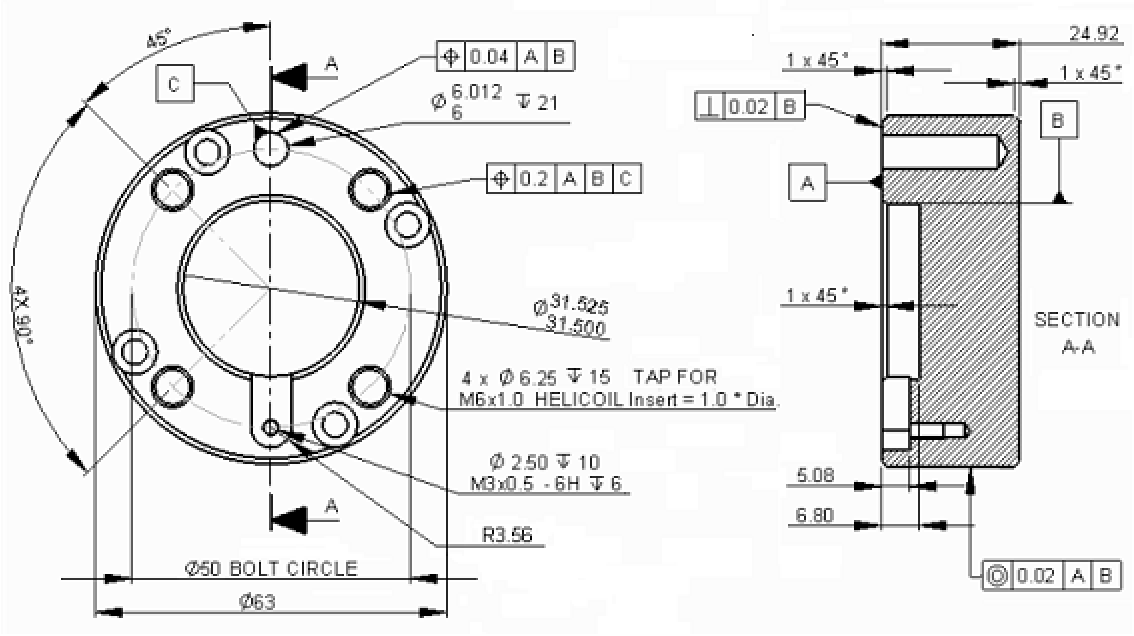
To facilitate electrical interfacing, digital I/O, camera and light power, and Ethernet signals are available on a "ZIO PCB" that is located under the Outer Link cover (this board is described in detail in a later section). The digital I/O signals and camera and light power are brought out in a DB25 connector that is mounted on the bottom of the Outer Link.

For pneumatic tools, two air lines connections (4mm OD, one-touch type tube insertion, 75 PSI maximum) are also brought out to the end of the robot. These lines are routed internally from the Outer Link through the robot and exit at pneumatic fittings on the Facilities Panel.



To simplify routing the signal and air lines to tooling, the Outer Link includes a 20mm "Through Hole" that starts at a hole in the top cover and extends to the bottom mounting flange. This hole can also be used for "visual servoing" by mounting a camera above the Outer Link that looks down through the hole and visually aligns the tooling or parts held in the end-effector with key landmarks.

Both the PreciseFlex 1300 and 1400 provide the same ISO standard mounting flange for attaching tooling and end-effectors. Shown below are the details of the tool mounting flange that conforms to ISO 9409-1. All dimensions are in units of millimeters.



Accessing the Controller and Power Supplies

Although most of the controller interface signals are exposed on the Facilities Panel on the J1-Axis housing, there are times when it is necessary to access either the robot's controller or its power supplies. To access these components, the Controls Bay must be retracted from the J1-Axis housing.

DANGER: The Guidance 2400, the PrecisePower Motor Power Supply, and the 24VDC power supply are open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides up to 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**

For safety purposes, sliding out the Controls Bay requires removal of five screws that secure the Facilities Panel to the J1-Axis housing.

Once the Controls Bay is retracted, the connectors and jumpers on the top surface of the controller, which are utilized for hardware configuration and interfacing to external equipment, and the power supplies will be exposed. Please note that the Ethernet, digital IO and RS232 signals are brought out to connectors on the Facilities Panel. However there are hardware jumpers and some additional controller signal connectors, including the optional analog IO, etc., that can only be accessed by retracting the Controls Bay.

Please see the *Guidance 3000/2000 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 analog 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 logic and motor power supplies that operate from 90 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 500 watts RMS.

The robots ship with a 300/600-watt PrecisePower Intelligent Motor Power Supply that provides a nominal output of 160VDC or 320VDC to the motors depending on the AC input voltage.

Emergency Stop

It is often desirable to wire a hardware 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 Remote Front Panel 25-pin DSub connector that is mounted on the Facilities Panel. Please see the Hardware Reference section of this manual for detailed information on the Remote Front Panel signals.

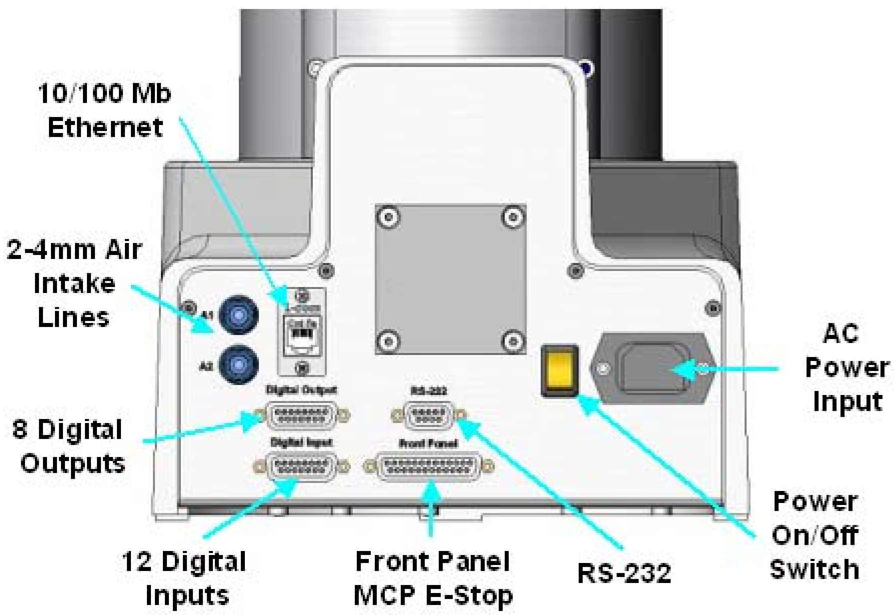
Precise sells an emergency stop button in a plastic enclosure. This E-Stop Box comes with a cable and connector that directly plugs into the Remote Front Panel connector. Alternately, you can also purchase a Precise Manual Control Pendant. The Pendant has an integrated E-Stop button and provides a convenient means for manually jogging the robot via a portable hand-held device.

Hardware Reference

J1-Axis Housing Facilities Panel

Facilities Panel

The bulkhead on the back of the J1-axis base housing is the robot's Facilities Panel. This contains plugs and connectors for AC power, pneumatic air lines and electrical interfaces.



The AC input connector is an IEC power cord connector that mates with standard cables that can provide a wide variety of AC power plugs. The supported input voltage range is 90 to 264 VAC, and the permitted input frequency is 50-60 Hz.   The AC power to the robot is controlled by a green backlit On/Off Switch.

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 behind the Facilities Panel in the Controls Bay, may contain additional optional interfaces (e.g. analog inputs or outputs). Please refer to the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual* for additional information.

> **DANGER:** The Guidance 2400, the PrecisePower 300 Intelligent Motor Power Supply, and the 24 VDC power supply are all open frame electrical devices that contain unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides up to 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **The main AC power should always be disconnected before the Facilities panel and Controls Bay is retracted.**

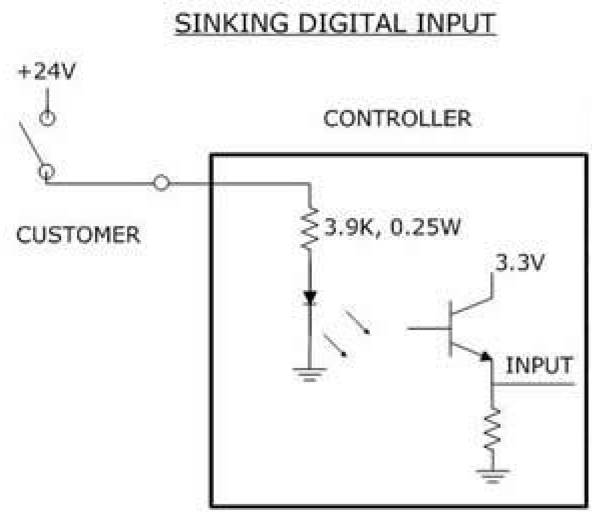
As a convenience for pneumatically powered user tooling, two air lines are routed through the interior of the robot. At the Facilities Panel, these are presented as two fittings. The other end of these lines exit at the outer link. When using these lines, clean, dry external air should be provided with a maximum pressure of 75 PSI.

> **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.

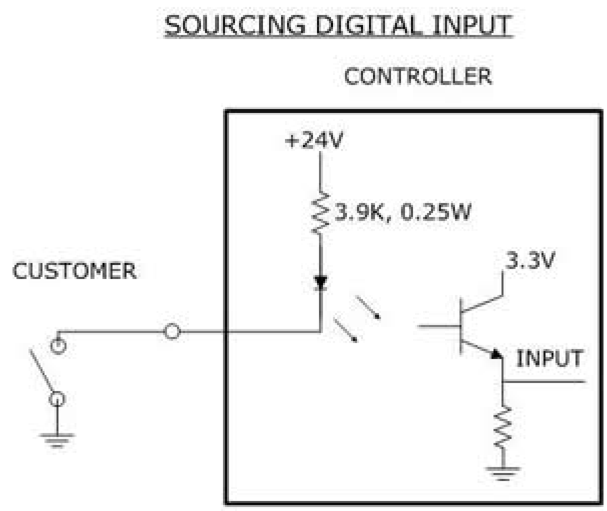
Digital Input Signals

The Facilities Panel includes 12 general purpose optically isolated digital input signals (in addition to those signals that are available at the ZIO Board in the outer link). These lines are accessed in a single DB15 connector.

These input signals 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 configuration is compatible with "sourcing" (PNP) sensors.



As shipped from the factory, the input signals are configured as "sourcing", i.e. the external equipment must pull a signal input pin to ground to indicate a logical high and must let the line float high to 24VDC to signal a logical low value. This configuration is compatible with "sinking" (NPN) sensors.



Inputs can be configured as sinking or sourcing in groups of 4 signals. To configure groups of input signals, the Controls Bay must be retracted from the J1-axis housing and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual.*

DANGER: The Guidance 2400, the PrecisePower Intelligent Motor Power Supply, and the 24 VDC power supply are all open frame electrical devices that contain unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides up to 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **The main AC power should always be disconnected before accessing the Controls Bay.**

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

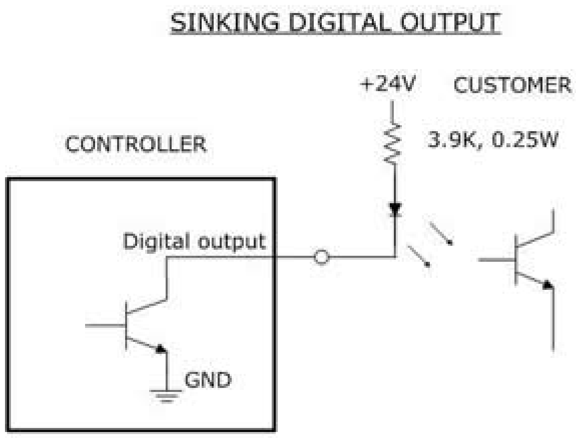
Pin	GPL Signal Number	Description
1		GND
2	10002	Digital Input 2
3	10004	Digital Input 4
4	10006	Digital Input 6
5	10008	Digital Input 8
6	10010	Digital Input 10
7	10012	Digital Input 12
8		GND
9	10001	Digital Input 1
10	10003	Digital Input 3
11	10005	Digital Input 5
12	10007	Digital Input 7
13	10009	Digital Input 9
14	10011	Digital Input 11
15		24 VDC
Interface Panel Connector Part No		DB15 Female Connector
User Plug Part No		DB15 Male Plug

Digital Output Signals

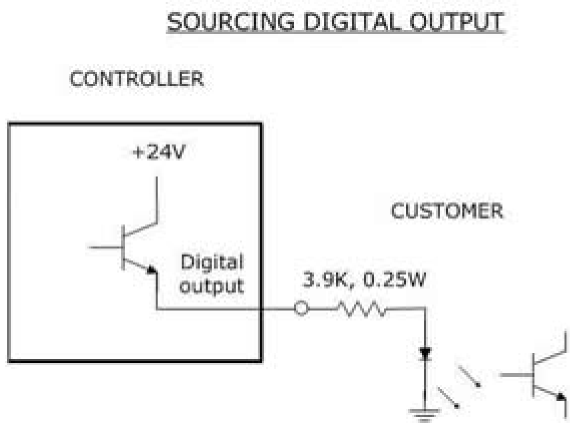
The Facilities Panel includes 8 general purpose optically isolated digital output signals (in addition to those signals that are available at the ZIO Board in the outer link). These lines are accessed in a single DB15 connector.

DB15 Female

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. This configuration is compatible with "sourcing" (PNP) devices.



Alternately, the output signals can be configured as "sourcing", i.e. the external equipment must <u>pull down an output pin to ground</u> and the controller pulls this pin to 24VDC when the signal is asserted as true. This configuration is compatible with "sinking" (NPN) devices.



Outputs can be individually configured as sinking or sourcing signals. To configure the output signals, the Controls Bay must be retracted from the J1-axis housing and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual.*

DANGER: The Guidance 2400, the PrecisePower Intelligent Motor Power Supply, and the 24 VDC power supply are all open frame electrical devices that contain unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides up to 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **The main AC power should always be disconnected before accessing the Controls Bay.**

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

Pin	GPL Signal	Description

	Number	
1	13	Digital Output 1 - This output signal can drive 500mA of current whereas Outputs 2-8 can only drive 100mA. Due to this higher drive level, even when this output is off, a small amount of current leaks. This leakage can cause some devices that are connected to this signal to always indicate that this output is on. If this occurs, a small drainage resistor should be tied to this signal.
2	15	Digital Output 3
3		24 VDC
4	17	Digital Output 5
5	19	Digital Output 7
6		Not used
7		Not used
8		Not used
9	14	Digital Output 2
10	16	Digital Output 4
11		GND
12	18	Digital Output 6
13	20	Digital Output 8
14		Not used
15		Not used
Interface Panel Connector Part No		DB15 Female Connector
User Plug Part No		DB15 Male Plug

Ethernet Interface

Precise robots are equipped with communication interface boards (MCIM's or MIDS3's) that 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.

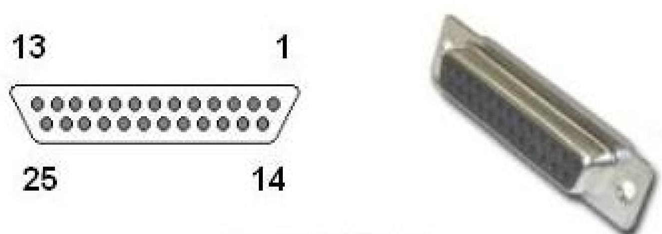
As a convenience for Ethernet devices that are mounted on the outer link of the robot, the second Ethernet port is connected to an optional Ethernet cable that is routed through the interior of the robot. One end of this cable is plugged into the robot controller's Ethernet switch and the other end is under the cover located on the outer link. Any device that is plugged into this cable, such as an Ethernet camera mounted on the outer link, can also communicated with units that are plugged into the RJ45 on the Facilities Panel. So, 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.

If an Ethernet 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.

Remote Front Panel / MCP / E-Stop Interface

The remote front panel interface includes all of the signals necessary to implement a fully compliant EC Category 3 Safety front panel that includes a Manual Control Pendant. In particular, this connector provides signals (including redundancy as necessary) for implementing an E-Stop circuit, an auto/manual switch, a high power "on" button with a high power "on" indicator lamp, and a RS-232 interface for a Manual Control Pendant (MCP). These signals are provided in a DB25 female connector mounted on the robot's Facilities Panel.



DB25 Female

In the future, Precise will offer a Remote Front Panel option that plugs into this connector. Alternatively, customers can develop their own custom front panels (please see the section on "Safety Circuits For Remote Front Panel" in the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual* for a suggested design). Or, if your application does not require a fully compliant Category 3 front panel, the robot can be operated without a front panel or with a Precise hardware MCP or a Precise E-Stop box. Both the Precise MCP and the E-Stop box can plug directly into the Remote Front Panel connector and provide a hardware emergency stop capability via the connector's redundant E-stop signals.

When a front panel, hardware MCP or E-Stop box is not utilized, the following pins on the front panel connector must be jumpered in order for the controller to operate properly. (The robot is shipped with a jumper plug that satisfies these requirements.)

1-14, 2-15, 3-16, 4-17, 5-18, 6-19, 7-20

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.

Pin	Description
1	Auto/Manual 2 (If no front panel or Auto mode, connect to pin 14). Input signal that is high to indicate that the system is being operated in a fully automatic mode or low or open for manual operation. This is normally controlled by a key switch on the Remote Front Panel of the master controller. During Manual Mode, only Jog mode motions are permitted to ensure that the system can be safely manually operated. When this signal changes from Auto to Manual, motor power is automatically turned off and must be re-enabled to move the robot. The Auto/Manual signal is daisy chained to all controllers in the servo network.
2	Auto/Manual 1 (If no front panel or Auto mode, connect to pin 15). Redundant Auto/Manual input signal.
3	ESTOP_L 2 (If no front panel or E-Stop not asserted, connect to pin 16). Input signal that is low or open to indicate that a hardware E-Stop condition has been asserted by any source. Set high if no E-Stop condition is asserted. The controller hardware will not permit motor power to be enabled when an E-Stop condition exists.
4	ESTOP_L 1 (If no front panel or E-Stop not asserted, connect to pin 17). Redundant ESTOP input signal.
5	External ESTOP_L (If no front panel or not an External ESTOP, connect to pin 18). Diagnostic input signal that is low when an E-Stop is generated from an external source. This allows the System Software to display different error messages to alert the operator as to the source of the E-Stop condition.
6	High Power Lamp Fail (If no front panel, jumper to pin 19). Input signal that is set high or open if the Remote Front Panel lamp, which indicates when motor power is enabled, has failed. When this signal is high, motor power cannot be enabled.
7	High Power Enable (If no front panel, jumper to pin 20). Input signal that must transition from low to high during the EC Category 3 power enable sequence to request that motor power be enabled. This is normally connected to a momentary contact "Enable power" push button on the Remote Front Panel.
8	Not used
9	MCP RXD. RS-232 receiver serial line from the Manual Control Pendant or external device.
10	5 VDC
11	Not used
12	Not used
13	Not used
14	24 VDC
15	24 VDC
16	Force ESTOP_L. Output signal that, when low, indicates that the Remote Front Panel should force ESTOP_L 1 and ESTOP_L 2 to be

	asserted (low). The System Software toggles this signal low at startup to verify that the ESTOP_L 1, ESTOP_L 2, and External ESTOP circuits are properly working. The System Software also uses this as a means for asserting a hardware E-Stop condition during normal operation. This signal is normally held high.
17	Force ESTOP_L. Redundant Force ESTOP_L output signal.
18	Force ESTOP_L. Redundant Force ESTOP_L output signal.
19	GND
20	GND
21	High Power Status. Output signal that is asserted (high) when high power to the motor is enabled. This is typically connected to a relay that turns on the High Power Lamp in the Remote Front Panel.
22	MCP TXD. RS-232 transmitter serial line to the Manual Control Pendant or external device.
23	5 VDC
24	Not used
25	Not used
Interface Panel Connector Part No	DB25 Female Connector
User Plug Part No	DB25 Male Plug

RS-232 Serial Interface

The Facilities Panel includes a standard RS-232 serial line equipped with hardware or software flow control. 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 female DB9 that has pin assignments compatible with standard PC "COM" ports. A straight through DB9 to DB9 cable can be used to connect the Guidance System to a PC.

The following table defines the pin assignments for this connector.

Pin	Description
1	Not used

2	TXD - Transmit data
3	RXD - Receive data
4	Not used
5	GND
6	Not used
7	CTS - Clear to send for hardware flow control
8	RTS - Request to send for hardware flow control
9	Not used
Interface Panel Connector Part No	DB9 Female Connector
User Plug Part No	DB9 Male Plug

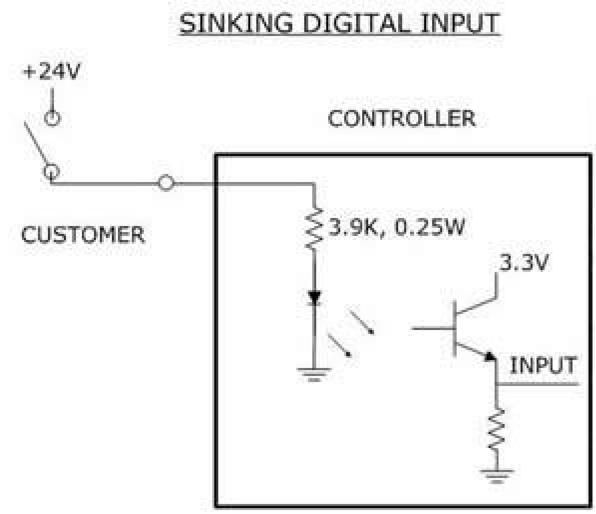
Outer Link and ZIO PCB

The Outer Link is composed of a housing, covers, optional solenoid valves, a status light, and an IO Printed Circuit Board (PFlex ZIO PCB).

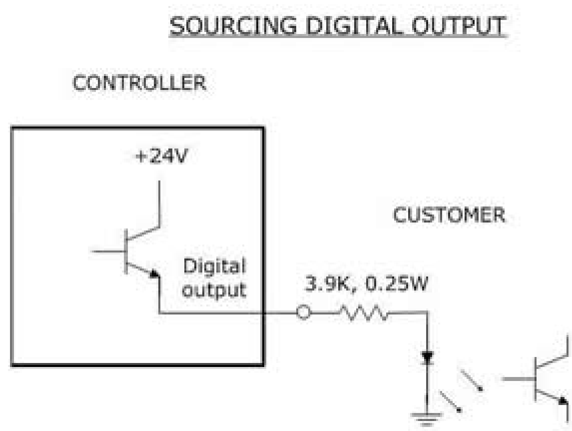
The ZIO PCB provides 8 general purpose optically isolated digital input signals and 8 general purpose optically isolated digital output signals. These input and output signals are intended for interfacing to tooling and sensors mounted on the end of the robot or for other general application needs. These signals are in addition to those available on the J1 Housing Facilities Panel of the robot. The ZIO also supports a controller status light, and an optional power supply for the arm mounted Ethernet camera and ring light option. This board is connected to the controller in the base by an RS485 serial line that allows the controller to scan the ZIO I/O with a nominal period of 4 milliseconds.

The DIO signals and the optional arm mounted camera and ring light power lines are accessible via a DB25 female connector that is mounted on the bottom of the Outer Link.

The 8 digital input signals are configured as "sinking". That is, the external equipment must pull an 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. For convenience, 24VDC is supplied on the DB25 connector. These inputs are compatible with "sourcing" (PNP) sensors.



The 8 digital output signals are configured as "sourcing". That is, the external equipment must pull down an output pin to ground and the ZIO pulls this pin to 24VDC when the signal is asserted as true. Each output signal can supply a maximum of 100mA. For convenience, ground pins are supplied on the DB25 connector. These outputs are compatible with "sinking" (NPN) devices.

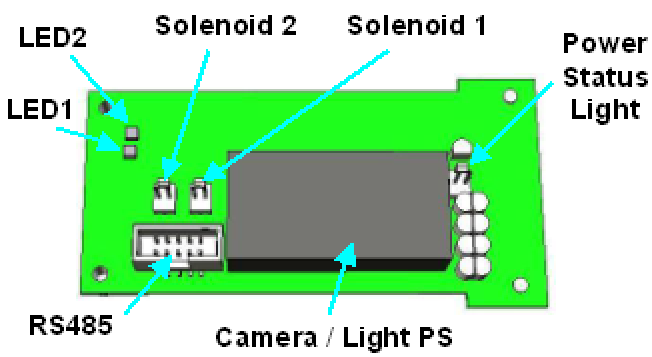


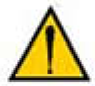
The pin assignments for the DB25 connector are defined in the following table along with the signal numbers used to reference these signals from GPL and the part information for the required hardware plug. If the robot is equipped with the optional solenoid valves that control two internal air lines, two of the digital output signals are internally pre-wired as indicated below.

Pin	GPL Signal Number	Description
1	33	Digital Output 1 (or 1st optional solenoid)
2	35	Digital Output 3
3	37	Digital Output 5
4	39	Digital Output 7
5		Ground
6		Ground

7		24 VDC
8	10033	Digital Input 1
9	10035	Digital Input 3
10	10037	Digital Input 5
11	10039	Digital Input 7
12		(Arm Mounted Camera option) 12VDC for powering camera, 1.25A. Available whenever the controller is powered on.
13	8039	(Arm Mounted Camera option) 9VDC for powering ring light, 1A. Enabled and disabled via a dedicated system IO signal or via the robot ZIO control panel in the Web Operator Interface.
14	34	Digital Output 2 (or 2nd optional solenoid)
15	36	Digital Output 4
16	38	Digital Output 6
17	40	Digital Output 8
18		Ground
19		24 VDC
20		24 VDC
21	10034	Digital Input 2
22	10036	Digital Input 4
23	10038	Digital Input 6
24	10040	Digital Input 8
25		Ground
Interface Panel Connector Part No		DB25 Female Connector
User Plug Part No		DB25 Male Plug

The following drawing illustrates the position of each of the key connectors and components on the PFlex ZIO board.





WARNING: The ZIO contains unshielded 24 VDC signals and pins. This board should only be accessed when the main AC power to the robot is disconnected.

In the following table, each of the connectors is briefly described.

Connector	Description
LED1 (Activity / Error)	Green - Blinks fast (about 10Hz) when the ZIO is not communicating with the robot's controller. Blinks slowly (about 1Hz) during normal communication. Red - Off at initial power-up and during normal communications. On if communications is lost after being established.
LED2 (Camera light)	Green - Tracks the state of the camera ring light power. Red - No currently used.
Solenoid 1 & 2	If the optional solenoids are purchased, they are mounted in the Outer Link, connected to the air lines, and wired to these connectors. These connectors permit the solenoids to be controlled via the 1st and 2nd digital output signals of the ZIO board. If the solenoids are present, the 1st and 2nd ZIO digital output signals are not available for general use.
Power Status Light	This connects to an LED mounted in the top of the Outer Link cover. (See below for more information.)
RS485	The RS485 interface is a multi-drop high speed serial interface that permits the robot controller to operate the digital input and output signals on the ZIO board.

If the yellow Outer Link status LED is configured as normally shipped from the factory, the following table describes how to interpret each light pattern.

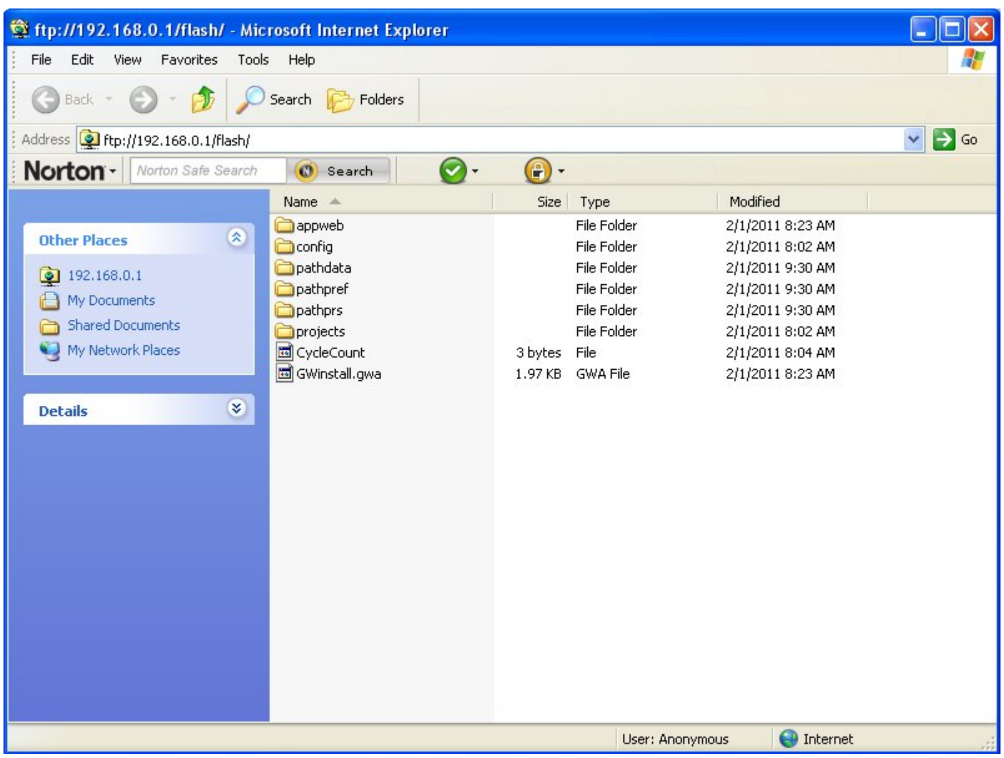
Status LED	Description
Continuously Off	AC power off or processor crashed. Either the AC power is off or the processor has crashed due to a system hardware or software error. If the processor has crashed, it may be executing the firmware debugger, dBug.
Continuously On	Booting sequence. AC power is on and the firmware and software are being loaded. The LED begins blinking when the system is up and running. Process crashed. If the LED turns on continuously after it has been blinking, the processor has crashed due to a system hardware or software error. The processor may be executing the firmware debugger, dBug.
Blinks 1 times per second	Normal operation, motor power off.
Blinks 4 times per second	Normal operation, motor power on.
Blinks 8 times per second	Processor overheating, motor power off. You have 5 minutes to save any programs or data. After 5 minutes, the processor will shut down and needs to be rebooted.

Software Reference

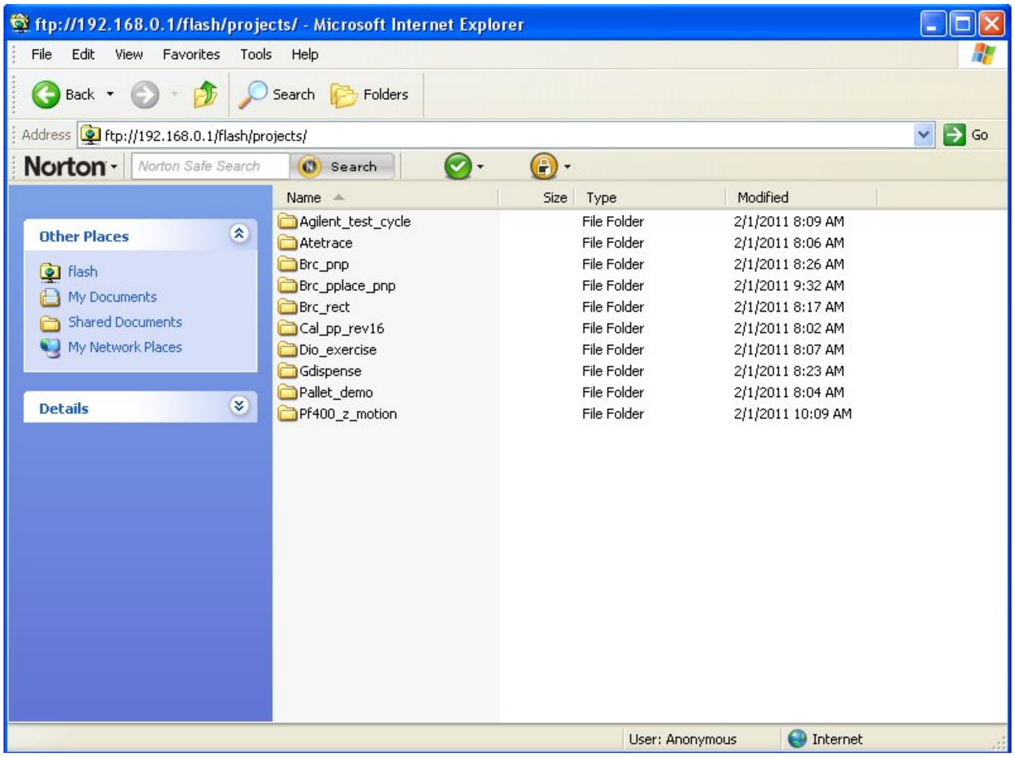
Loading a Project (Program)

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. Open the "Projects" folder and paste the backup copy of the program (such as CAL_PP) into this folder. 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. 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.

Controller Software Extensions

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

ZIO General Digital Inputs and Outputs

The ZIO PCB adds 8 general purpose optically isolated digital outputs and 8 general purpose optically isolated digital inputs to the standard digital I/O found on the Guidance Controller. These signals are accessed via a DB25 connector that is mounted below the Outer Link. 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, the ZIO I/O are scanned by the controller. The scanning period is nominally 4 milliseconds, so applications must be able to handle a delay of up to 4 milliseconds for signal changes to propagate through the system.

If your robot is equipped with the optional solenoids valves in the Outer Link that control the two internal air lines, two the digital output signals are dedicated to operating these solenoids.

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

Signal Number	I/O	Label	Description
33	O	Optional solenoid 1	Z I/O board output 1
34	O	Optional solenoid 2	Z I/O board output 2
35	O		Z I/O board output 3
36	O		Z I/O board output 4
37	O		Z I/O board output 5
38	O		Z I/O board output 6
39	O		Z I/O board output 7
40	O		Z I/O board output 8
10033	I		Z I/O board input 1
10034	I		Z I/O board input 2
10035	I		Z I/O board input 3
10036	I		Z I/O board input 4
10037	I		Z I/O board input 5
10038	I		Z I/O board input 6
10039	I		Z I/O board input 7
10040	I		Z I/O board input 8

ZIO Dedicated Digital Outputs

The ZIO PCB adds two dedicated digital outputs 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 ZIO (Outer Link) status light (IO 8040) since the standard robot software typically manages this signal.

If the robot includes the Arm Mounted Camera Kit, the Camera Light Power is controlled by a dedicated digital output signal. This signal can be manually altered via the web Robot ZIO Panel or under program control via the GPL SIGNAL.DIO instruction.

Signal Number	I/O	Label	Description
8039	O		Camera Light. If the Arm Mounted Camera Kit is installed, set to 1 to turn on the Camera Light. Set to 0 to turn off the Camera Light.
8040	O		Outer Link status light. Set to 1 to turn on the light. Normally parameter “Power State DOUT” (DataID 235) is set to this signal number so that the Outer Link light displays the robot controller's execution state.

Service Procedures

Trouble Shooting

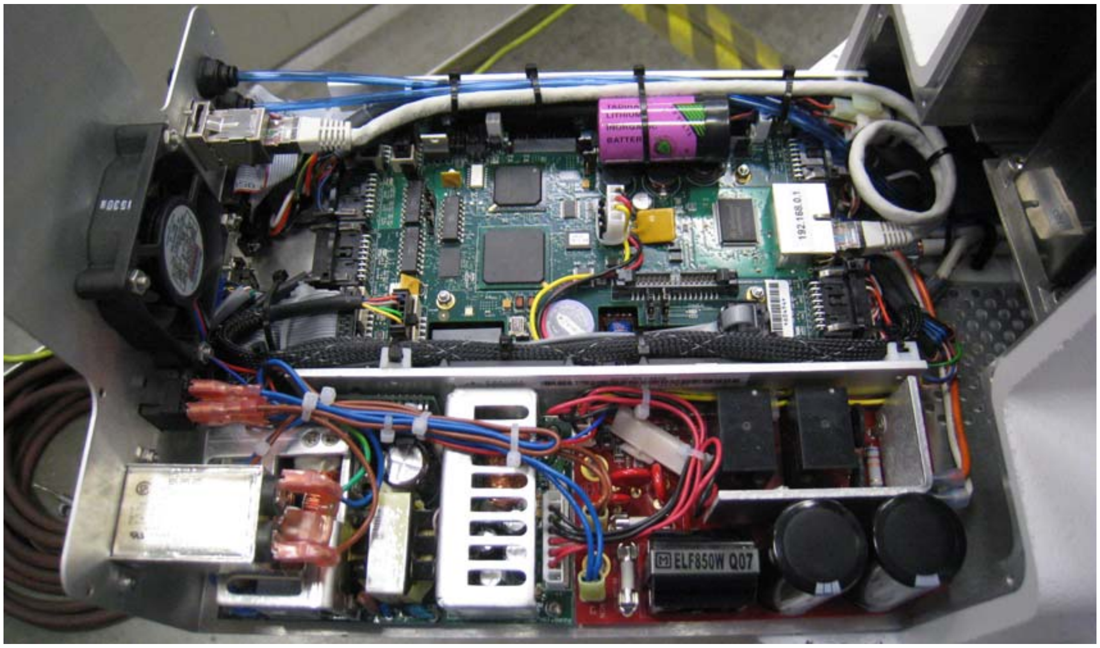
Symptom	Recommended Action
System error message generated	
“Encoder Battery Low”	Replace Battery in controller tray in base of robot.
“Encoder Battery Down”	Replace Battery and recalibrate robot.
“Amplifier Fault”	Slow down the robot. Check harness and motor for shorts.
“Motor duty cycle exceeded”	Reduce speed or acceleration of robot
“Soft Envelope Error”	Make sure robot not pressing against surface
Physical or audible problem	
Brown streaks on linear bearings	Clean with alcohol and add grease to bearing blocks. This should not be required sooner than 20,000 hours of run time.
Mechanical noise from any axis	Check axis bearings for failure

Replacing the Encoder Battery

The Encoder Battery is designed to last for several years (5 years after March 2012, SN F1X-1201-4A-00101) with robot power turned off. With robot power turned on, there is very little drain on the battery, and it will last for 10 to 20 years. 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.

The encoder battery is located in the controller tray in the base of the robot. There is a dual pigtail connector that is plugged into the controller PCA. You should plug a new battery into the second pigtail connector, and then disconnect the old battery. This avoids interrupting power to the encoders if the encoder battery voltage is still above 2.5 volts and the encoders have not lost their position data.



Setting the Encoder Zero Positions

Cal_PP is a service program that must be run to reset the zero positions of the absolute encoders on each motor. The zero positions must be reestablished if a motor is replaced, if a motor's encoder cable to the controller is disconnected, or if the encoder backup battery located at the controller is replaced.

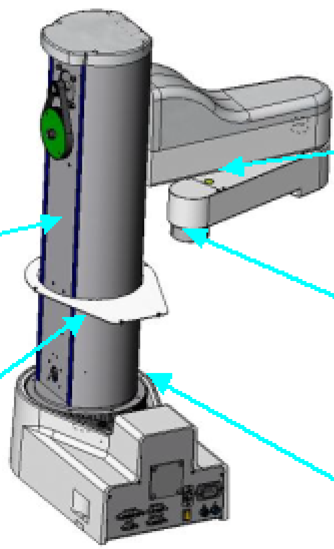
In order to execute this procedure, the following preconditions must be satisfied:

- The three calibration dowel pins that are shipped with the robot must be available.
- The service program Cal_PP must be available. Cal_PP is supplied on the *Guidance Controller System Software CD* or a copy can be obtained from Precise Automation.
- To run Cal_PP, the controller must be configured to run GPL programs and service personnel must be familiar with loading and executing GPL programs (See the *Guidance System Setup and Operation, Quick Start Guide*).
- **Cal_PP does not automatically move the robot, however, it does automatically turn on motor power at the end of the process to put the new encoder values into effect.**

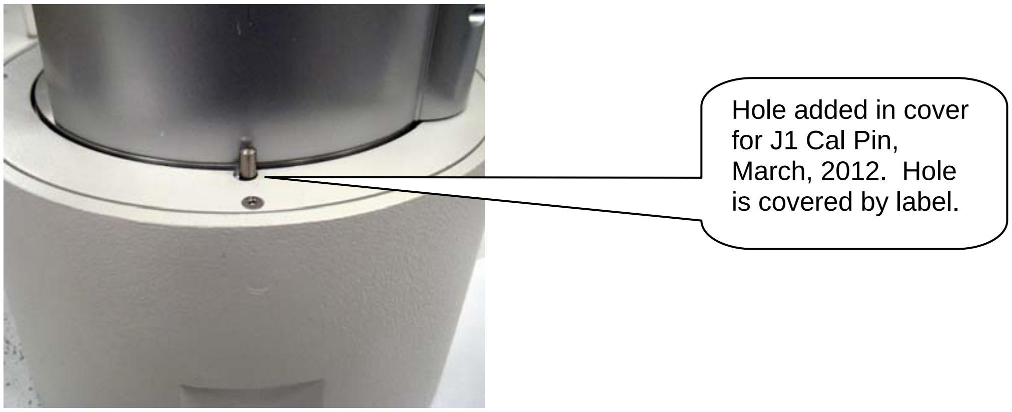
DANGER: Before this procedure can be executed, the robot must be properly mounted and the system must be such that the controller and motor power can be safely enabled.

The following describes the procedure for defining the zero positions of the PreciseFlex robot axes using Cal_PP. Cal_PP is an application program for calibrating the robot that is typically loaded in the robot flash memory. It should only be used when it is necessary to recalibrate the absolute encoders.

1. Enable power to the robot's controller, and **ensure that power to the motors is disabled.**
2. Load Cal_PP into the controller's memory using either the Guidance Development Environment (GDE) or the web Operator Control Panel. When using the Web Operator Control Panel, select "Operator Control Panel". If any programs are currently loaded, you must select "Unload program" first and click "Perform Operation". You may then select "Load Program" and click on "Perform Operation". Highlight CAL_PP from the pick list (if it does not appear you must first load it – see Loading a Project above – and click "Perform Operation".
3. Manually raise the Z-axis so that it is firmly pressed against its upper hard stop limit.
4. As shown in the following picture, Rotate the J1-axis so that the inner link is approximately rotated 90 degrees clockwise from the center position as viewed from above.

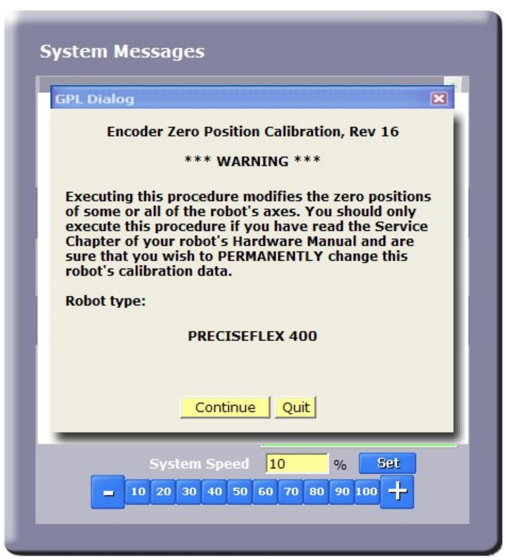


5. Remove the back cover to the Z-axis to permit the top cover of the J1-axis to be lifted. (After March 2012, starting with SN F1X-1201-4A-00101, this is no longer necessary. A hole has been added to the J1 top cover to provide access for the J1 Cal Pin.)
6. Remove the screws to the J1-axis top cover and lift the cover to gain access to the J1 turntable. . (After March 2012, starting with SN F1X-1201-4A-00101, this is no longer necessary. A hole has been added to the J1 top cover to provide access for the J1 Cal Pin.)

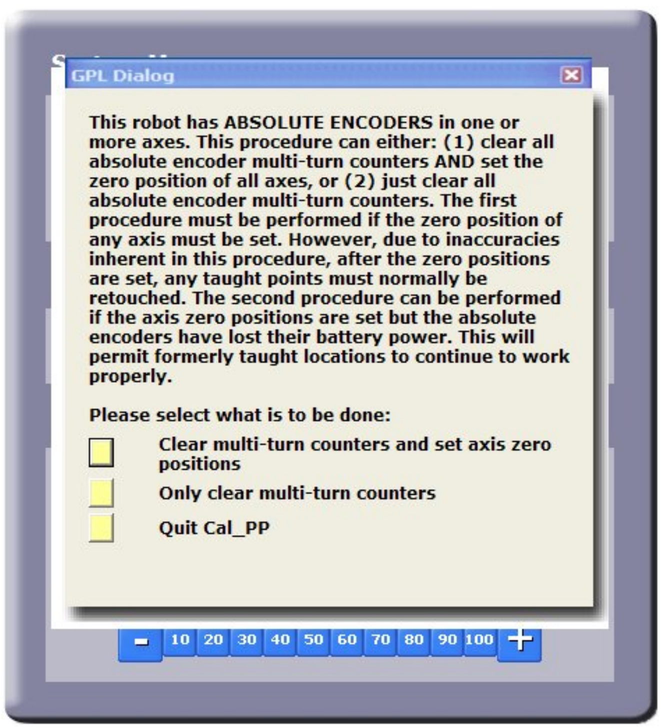


7. Insert the supplied M5x45mm or M5 X 60mm dowel pin into the J1-axis turntable and register it with the slot in the base. Rotate the J1-axis clockwise so the pin is pressed against the slot sidewall.
8. Press one of the supplied M3x40mm dowel pins (or the M3 by 13mm tapered dowel pin after SN F1X-1201-4A-00101) into the hole that is in the lower surface of the inner link. Rotate the outer link clockwise so it is pressed against the dowel pin. This should be at 160° on most robots and 90° in a few beta units.
9. If your robot is equipped with a Theta axis, insert one of the supplied M3x40mm dowel pins into the hole on the Theta flange. Rotate the flange until the pin registers with a slot in the outer link. This should center the flange within its range of travel.
10. With the CALPP application loaded, select “Start Application”, then press “Perform Operation”

- Application should start and prompt user to confirm correct robot position for calibration



- 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.



- The CALPP application takes about 1 minute to run.

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

The zero position for each of the robot's axes will now be defined and the data required by the homing operation will be stored.

General Belt Tensioning

In the following sections, specific procedures for changing and tensioning each of the robot's drive belts are provided. However, the following general comments and tensioning specifications apply to all belts.

- All belt tensioning should be performed using a Gates Sonic Tension meter such as the 507C model or equivalent
- When a tension idler exists, tensioning should always be performed on the non-idler side of the belt.

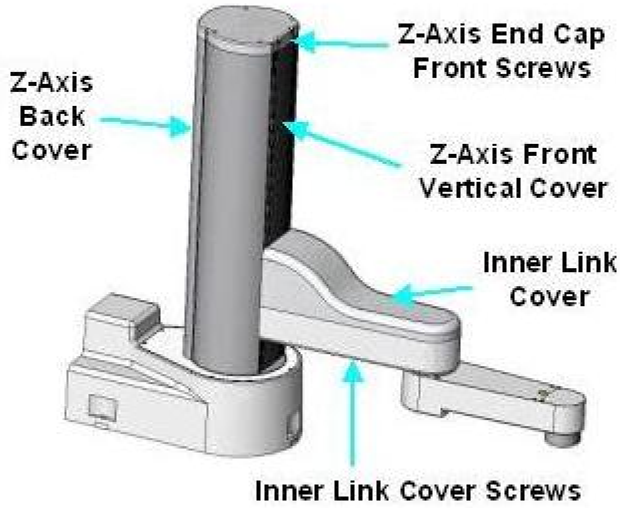
The following table contains all relevant tension values and constants needed for the Sonic Tension meter ***FOR PRODUCTION_A VERSIONS OF THE ROBOT AND LATER***.

Belt	Mass (g/m)	Width (mm)	Span (mm)	Tension (N)	Frequency (Hz)
J1 Stage 1	2.8	12	75	135	423
J1 Stage 2	4.1	25	113	425	285
Z Stage 1	2.8	12	76	68	296
Z Stage 2 (300mm Z)	2.8	20	441	289	81
Z Stage 2 (600mm Z)	2.8	20	741	289	48
J3 Stage 1	2.8	12	83	68	271
J3 Stage 2	4.1	15	152	182	179
Theta Stage 1 (2 stage)	2.8	9	257	60.5	95
Theta Stage 2 (2 stage)	2.8	9	267	147	143
Theta Stage 1 (3 stage)	2.8	9	155	60.5	158
Theta Stage 2 (3 stage)	2.8	9	93	147	411
Theta Stage 3 (3 stage)	4.1	9	267	250	154

Removing and Replacing the Front Cover and Tape Seals

In order to service items inside the Z column it is necessary to remove and then replace the front cover on the Z extrusion. This requires:

1. Disconnect the main AC power to the robot.
2. Remove the 2 M4 screws attaching the front cover to the end cap on the top of the Z column and the 4 M4 screws attaching the end cap to the column.
3. Remove the inner link cover.
4. Remove the tape seal tension bracket from the bottom of the inner link by removing the M3 screws and tension springs, releasing the tension on the belt seals.
5. Slide the Z column end cap back about 10mm and remove the front cover by sliding upwards through the inner link.
6. When replacing the front cover make sure the tape seals are completely inside the front cover slots and Z column slots.



J1-Axis Drive Procedures

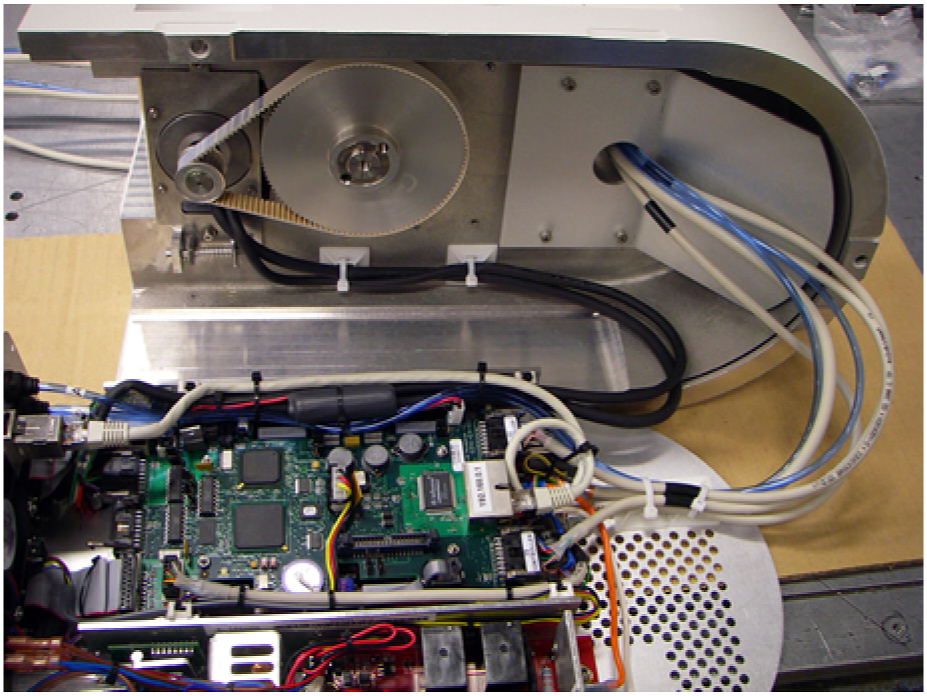
Replacing the J1-Axis Motor Assembly

The J1 Motor Assembly consists of the J1-axis motor, its mounting/tensioning plate, the drive pulley for the J1 1st Stage Belt, and a spring tensioning mechanism. The J1 Motor Assembly must be accessed from the bottom side of the J1-axis housing with the Controller Bay removed. To replace this assembly, perform the following operations:

1. Disconnect the main AC power to the robot.

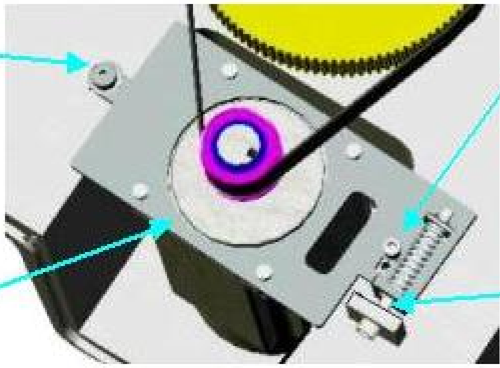
> **DANGER:** All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

2. Detach the robot from its mounting surface. The robot should be gently placed on its side on a protective layer to avoid scratching or damaging the robot's surface.
3. Remove the screws in the Facilities Panel and slide the Controls Bay out of the J1-axis housing. You do not need to disconnect the various cables, just lay the Controls Bay next to the J1 housing as shown below.



DANGER: The Controls Bay contains open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**

4. To remove the 1st Stage Belt, remove the M3x8mm Locking Screw. Then loosen the M4x45mm Spring Tension Screw to eliminate the tension on the 1st Stage Belt



5. Remove the 1st Stage Belt by sliding it off the large pulley and then the J1 Motor flanged pulley.
6. Detach the J1 Motor Assembly by removing the M4x45mm Spring Tensioning Screw and the M4 Pivot Screw; and by unplugging the J1 motor and encoder cables at the controller in the Controls Bay.
7. To install a new J1 Motor Assembly (Precise P/N PF10-MA-00048), the process must be reversed.
8. First attach the J1 Motor Assembly to the J1 housing at the pivot point (M4 Pivot Screw) using two 5mm Belleville Washers PP1A-MC-X0025 (MCM 9713K17) seated on a M5 Washer and Fastened with a M4 Shoulder Screw0000-HC-S0129 (McM 90278A319).
9. Loosely attach the Tension Screw by inserting a M4x45mm SHCS though the mounts and a Century BB-90 Spring and retain with a M4 Nut PP1D-MC-X005 (Misumi HNTTBS5-4). Ensure that the Motor Assembly can rotate through it s full range of travel without obstruction.
10. Slide the 1st Stage Belt over the J1 Motor flanged pulley and the large pulley.
11. Following the instructions in the next section for setting the 1st Stage Belt tension.
12. Lock down the rotating Motor Assembly by re-attaching the Locking Screw. This should consist of a M3-8mm SHCS, M3 washer, and a M3 lock washer.
13. Re-attach the J1 motor and encoder cables to the controller in the Controls Bay.
14. Re-install the Controls Bay into the J1 housing and re-mount the robot to the work surface.

Replacing and Tensioning the J1-Axis Belts

1st Stage Belt

To replace or tension the J1-axis drive 1st Stage Belt, the J1 Motor Assembly must be accessed. Please see the previous section for instructions on accessing this assembly by un-mounting the robot and retracting the Controls Bay.

DANGER: The Controls Bay contains open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**

To replace the belt, you must have available a Gates TruMotion belt (Precise P/N PF10-MC-X0091). Then perform the following operations:

1. Follow the instructions in the previous section to loosen or remove the Locking Screw and loosen the Spring Tensioning Screw to permit the J1 Motor Assembly to freely rotate.
2. Remove the old belt by sliding it over the large pulley and then the flanged pulley.
3. Install the new belt by placing it around the flanged pulley first and then sliding it over the large pulley.

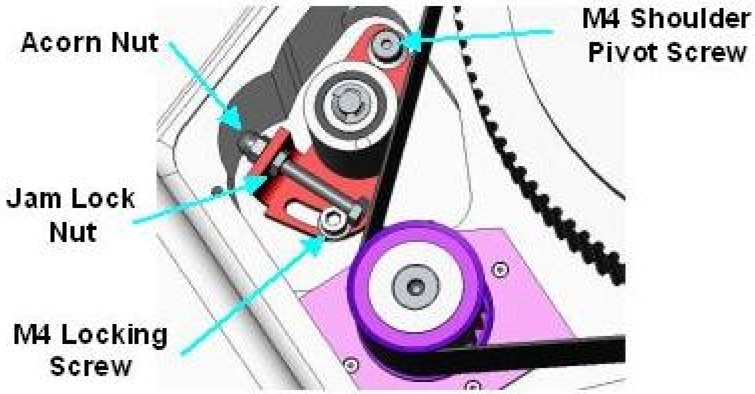
To properly adjust the tension in the belt, perform the following operations:

1. Ensure the M3x8 Locking Screw has been loosened to permit the J1 Motor Assembly to pivot.
2. Measure the belt tension using a Gates Sonic Tension Meter.
3. Compare the tension to that specified in the Belt Tensioning Table.
4. As required, adjust the belt tension by tightening or loosening the M4x45 Spring Tensioning Screw to compressing or relaxing the spring assembly.
5. Tighten the M3x8 Locking Screw to hold the tensioner assembly in place.

2nd Stage Belt

To replace or tension the J1-axis drive 2nd Stage Belt, the back cover of the robot's Z-axis must be removed. This will permit the top cover for the J1-axis to be lifted after it is unscrewed. The 2nd Stage Belt is located below the top cover of the J1-axis.

The following picture illustrates the 2nd Stage Idler and Tensioner Assembly after the J1-axis top cover is raised.



To replace the belt, you must have available a Gates TruMotion belt (Precise P/N PF10-MC-X0092). Then perform the following operations after the J1 top cover has been raised:

1. To permit the idler plate to rotate, remove the M4 Locking Screw.
2. To eliminate the tension in the belt, back off the Jam Lock Nut and the Acorn Nut.
3. When the tension is reduced, remove the M4 Shoulder Pivot Screw and lift out the Idler and Tensioner Assembly.
4. Remove the belt by applying upward pressure on alternating sides of the belt while rotating the J1-axis. This will gradually walk the belt up to a point where it can be carefully removed with a pair of pliers.
5. Lift the belt over the flanged pulley.
6. Install the replacement belt by performing the steps in the reverse order.

To properly adjust the tension in the belt, perform the following operations:

1. Start with the Idler and Tensioner Assembly in place, held by the M4 Pivot Screw. The M4 Locking Screw should still removed.
2. Adjust the Acorn Nut to push the Idler Roller against the belt.
3. Measure the belt tension using the Gates Sonic Tension Meter on the non-idler side of the belt.

4. Compare the tension to that specified in the Belt Tensioning Table.
5. As required, adjust the belt tension by adjusting the Acorn Nut position.
6. Tighten the Jam Lock Nut to retain the position of the Acorn Nut.
7. Re-install the M4 Locking Screw to hold the Idler/Tensioner Assembly in place.
8. Re-install the J1 top cover and the Z-axis back cover.

Z-Axis Drive Procedures

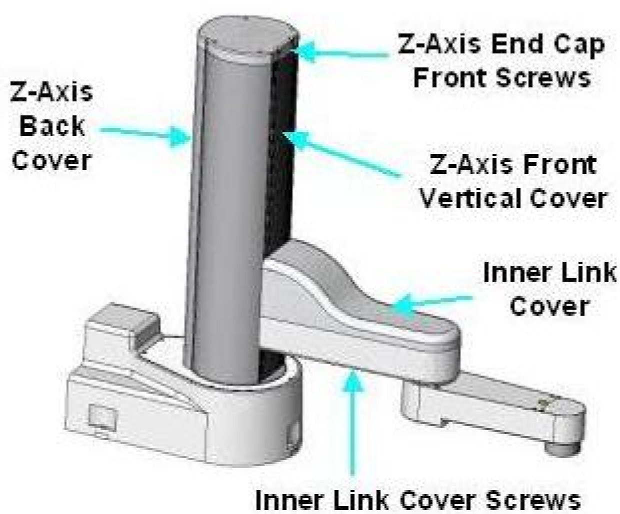
Replacing the Z-Axis Motor Assembly

The Z-Axis Motor Assembly consists of the Z-axis motor, a drive pulley mounted on the motor shaft together with belt retaining flanges. This motor assembly can be replaced while the robot is mounted in the standard vertical orientation. To replace this assembly, perform the following operations:

1. Lower the Z-axis to the bottom of its travel.
2. Disconnect the main AC power to the robot.

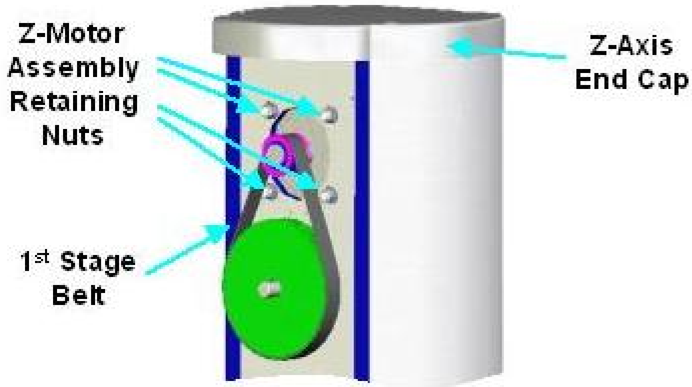
DANGER: All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

3. Remove the Z-Axis Back Cover to access the 1st Stage Belt.

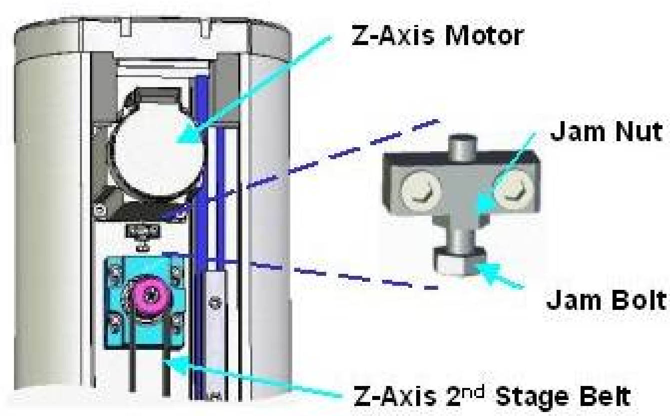


4. Remove the Inner Link Cover by removing 6 screws on the bottom edge of the Inner Link.

5. Remove the front two screws of the Z-Axis End Cap. The End Cap does not have be detached from the Z-axis.
6. Remove the Z-axis Front Vertical Cover by carefully sliding it clear of the Z-Axis End Cap and off its registration pins at the base of the Z-Axis.
7. To relieve the tension on the 1st Stage Belt, first use a 8mm open-ended wrench to loosen (but don't remove) the four nylon Z-Motor Assembly Retaining Nuts on the back of the Z-axis.



8. Using a 7mm open-ended wrench, reach into the front of the Z-axis below the motor and back off the Jam Nut that locks the Jam Bolt.



9. Using the 7mm open-ended wrench, back off the Jam Bolt that pushes the motor up and controls the 1st Stage Belt tension.
10. Remove the 1st Stage Belt by sliding it off the large pulley first and then over the flanged pulley.
11. Replace the Z-axis Motor Assembly with the new assembly (Precise P/N PF10-MA-00049).
12. Replace the 1st Stage Belt and follow the instructions in the next section for properly setting the belt tension.
13. Tighten the Jam Nut and the 4 Z-Axis Assembly Retaining Nuts and replace the covers.

Replacing and Tensioning the Z-Axis Belts

1st Stage Belt

To replace or tension the Z-Axis Drive 1st Stage Belt, the Z-Axis Motor Assembly must be accessed. Please see the previous section for instructions on accessing this assembly by removing the Z-Axis Back Cover, Z-Axis Vertical Front Cover and the Inner Link Cover.

> **DANGER:** All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

To replace the belt, you must have available a Gates TruMotion belt (Precise P/N PF10-MC-X0086). Then perform the following operations:

1. Follow the instructions in the previous section to loosen the four nylon Z-Motor Assembly Retaining Nuts and back off the Jam Nut and Jam Bolt.
2. Remove the old belt by sliding it over the large pulley and then the flanged pulley.
3. Install the new belt by placing it around the flanged pulley first and then sliding it over the large pulley.

To properly adjust the tension in the belt, perform the following operations:

1. Follow the instructions in the previous section to loosen the four nylon Z-Motor Assembly Retaining Nuts and back off the Jam Nut.
2. Measure the belt tension using a Gates Sonic Tension Meter.
3. Compare the tension to that specified in the Belt Tensioning Table.
4. As required, adjust the motor position and belt tension by turning the Jam Bolt.
5. Tighten the four nylon Z-Motor Assembly Retaining Nuts and verify that the belt tension is still correct.
6. Tighten the Jam Nut to hold the Jam Bolt in place.
7. Replace the Inner Link Cover, the Z-Axis Vertical Front Cover and the Z-Axis Back Cover.

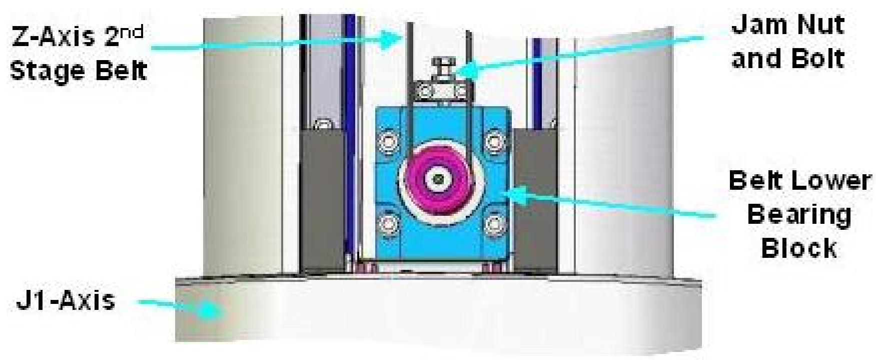
2nd Stage Belt

To replace or tension the Z-Axis Drive 2nd Stage Belt, the Z-Axis Vertical Front Cover and the Inner Link Cover must be removed. Please see the previous section for instructions on the removal of these parts.

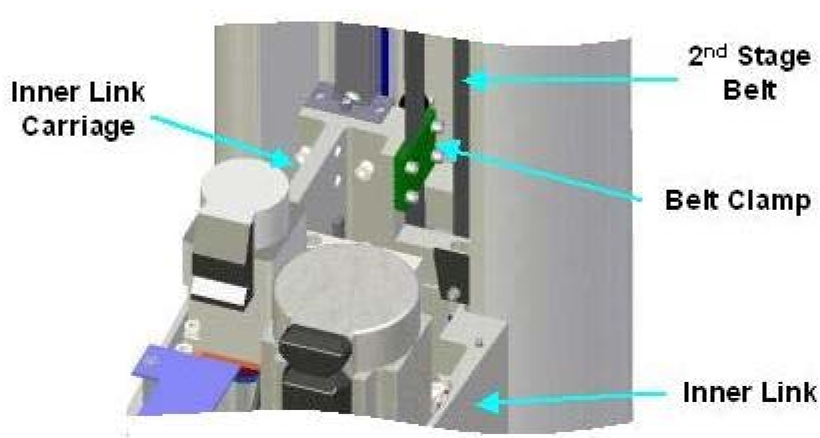
> **DANGER:** All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

To replace the belt, you must have available a Gates TruMotion Belt (Precise P/N PF10-MC-X0077). Then perform the following operations:

1. Move the Inner Link to approximately the middle of travel of the Z-Axis to permit access to the lower section of the 2nd Stage Belt.
2. Place a support under the Inner Link to prevent it from dropping when the belt tension is removed.
3. Loosen (but do not remove) the four screws that retain the Belt Lower Bearing Block. This will permit the block to slide vertically in its slots to reduce the belt tension.



4. Back off the Jam Nut and then the Jam Bolt to eliminate the tension in the belt.
5. Remove the lower bearing block to allow the belt to come off of the pulleys.
6. Slip the belt off of the upper and lower pulleys.
7. The belt is a continuous loop and is attached to the Inner Link Carriage by a Belt Clamp with four M3 SHCS. Loosen all four screws and remove two on either side in order slip out the belt.



8. Slip out the old belt and slide the new belt into the clamp.
9. Re-install the two screws for the Belt Clamp but do not tighten. Allow the belt to slip
10. Slide the belt over the top and bottom pulleys and apply a light amount of tension.
11. Reinstall the lower bearing block.

12. Manually move the Inner Link Carriage up and down to allow the belt to self-center in the clamp.
13. Tighten the four screws for the Belt Clamp to fully capture the belt.
14. Follow the instructions below to properly tension the belt and to reassemble the robot.

To properly adjust the tension in the belt, perform the following operations:

1. Ensure that the Belt Lower Bearing Block is loosely captured by its four screws and able to move vertically and that the Jam Nut has been backed off.
2. Measure the belt tension using a Gates Sonic Tension Meter on the side of the belt without the Belt Clamp.
3. Compare the tension to that specified in the Belt Tensioning Table.
4. As required, adjust the belt tension by turning the Jam Bolt to reposition the Lower Bearing Block.
5. Tighten the four screws to fix the position of the Belt Lower Bearing Block and verify that the belt tension is still correct.
6. Tighten the Jam Nut to hold the Jam Bolt in place.
7. Re-attach the Z-Axis Vertical Front Cover and the Inner Link Cover.

J3-Axis and Theta Drive Procedures

Replacing the J3-Axis or Theta Motor Assembly

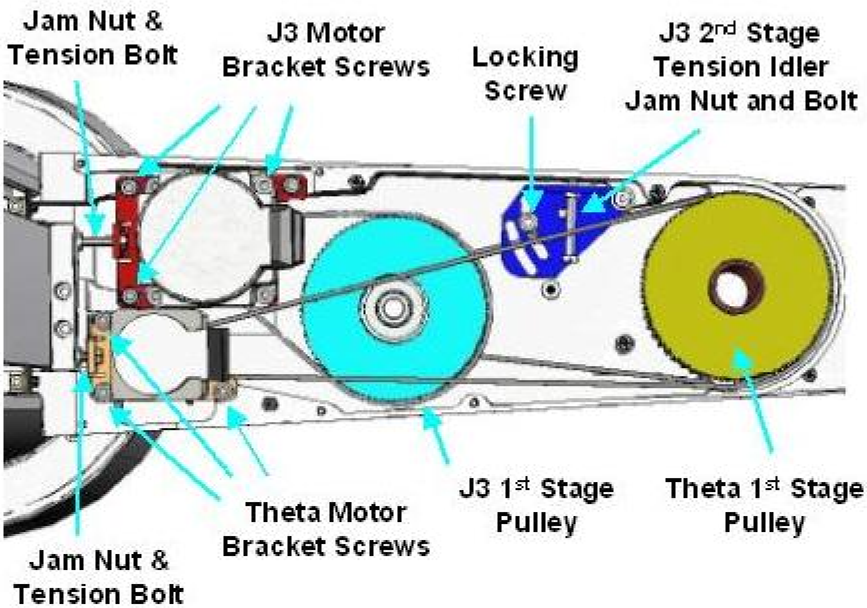
The J3-Axis and Theta Motor Assemblies consist of a motor, a drive pulley mounted on the motor shaft together with belt retaining flanges. Since these drives are similar, they are both discussed in this section.

These motor assemblies can be replaced while the robot is mounted in the standard vertical orientation. To replace either assembly, perform the following operations:

1. Disconnect the main AC power to the robot.

> **DANGER:** All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

2. Remove the Inner Link Cover by removing the 6 screws along the bottom edge of the Inner Link (as illustrated in the section on Replacing the Z-Axis Motor Assembly.
3. Remove the Inner Link Cable Cover that is under the Inner Link Cover. The Inner Link should look as follows:



4. For the motor of interest, loosen (but do not remove) the three M4 Motor Bracket Screws that mate the Motor Bracket to the Inner Link. The Motor Bracket screw holes are slotted to permit the motor to slide to control the 1st Stage Belt tension.
5. Back off the Jam Nut on the Tensioning Bolt.
6. Back off the Tensioning Bolt to eliminate the 1st Stage Belt tension.
7. Remove the belt by sliding if off of the large pulley and then the motor pulley.
8. Detach the motor from the Motor Bracket by removing either four M5 SHCS (for J3) or two M4 SHCS (for Theta).
9. Install the new Motor Assembly (Precise P/N PF10-MA-00050 for J3 or Precise P/N PF10-MA-00051 for Theta) using Loctite 222 on the M5 or M4 screws.
10. Replace the 1st Stage Belt.
11. Follow the instructions given below for tensioning the belt.
12. Lock down the Motor Bracket Screws and the Jam Nut.
13. Replace the Inner Link Cable Cover and the Inner Link Cover.

Replacing and Tensioning the J3-Axis Belts

1st Stage Belt

The 1st Stage Belt for the J3-Axis is located in the Inner Link. To replace or tension this belt, it must be accessed using the same procedures as those described in the section on Replacing the J3-Axis or Theta Motor Assembly. Please review that section prior to performing the following operations.

DANGER: All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

To replace the belt, you must have available a Gates TruMotion belt (Precise P/N PF10-MC-X0106). Then perform the following operations:

1. Follow the instructions in the previous section to remove the Inner Link Cover and the Inner Link Cable Cover.
2. Loosen (but do not remove) the J3-Axis Motor Bracket Screws and back off its Jam Nut and Tensioning Bolt.
3. Remove the old belt by sliding it over the large pulley and then the motor pulley.
4. Install the new belt by placing it around the motor pulley first and then sliding it over the large pulley.

To properly adjust the tension in the belt, perform the following operations:

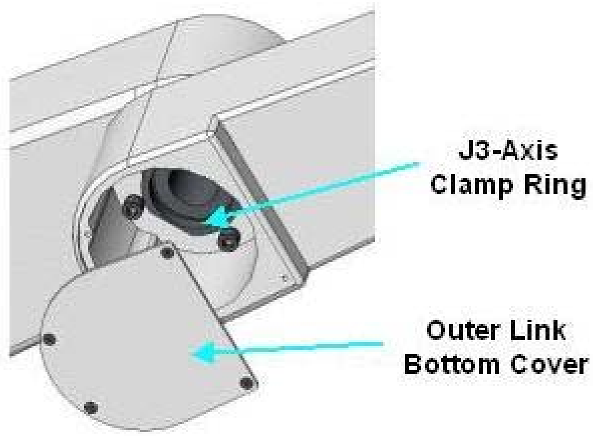
1. Follow the instructions in the previous section to loosen the J3-Axis Motor Bracket Screws and back off the Jam Nut.
2. Measure the belt tension using a Gates Sonic Tension Meter on the more accessible side of the belt.
3. Compare the tension to that specified in the Belt Tensioning Table.
4. As required, adjust the motor position and belt tension by turning the Tensioning Bolt.
5. Tighten the three Motor Bracket Screws and verify that the belt tension is still correct.
6. Tighten the Jam Nut to hold the Tensioning Bolt in place.
7. Replace the Inner Link Cable Cover and the Inner Link Cover.

2nd Stage Belt (3-Axis Robot Only)

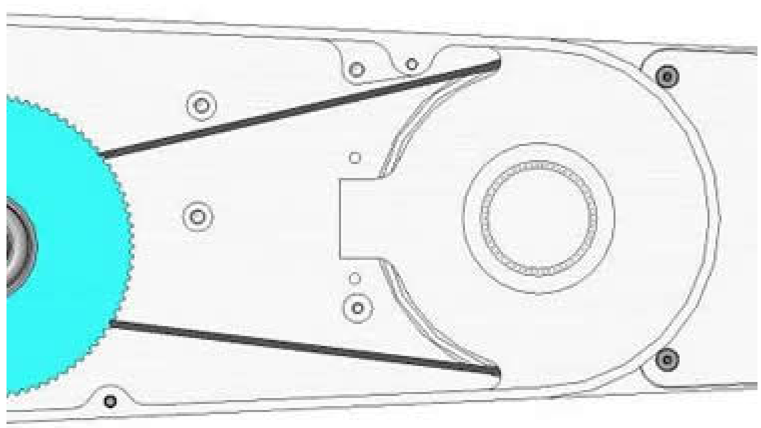
The J3-Axis 2nd Stage Belt is located in the Inner Link. The 2nd Stage Belt drives a large pulley that is affixed to the Outer Link at the robot's elbow and protrudes up through a circular hole in the bottom of the Inner Link. To remove the belt, the Outer Link and large pulley must be dropped relative to the Inner Link. To replace this belt, you must have available a Gates TruMotion Belt (Precise P/N PF10-MC-X0079) and the J3 Removal Tool (Precise P/N PF10-MT-M0001). Then perform the following operations:

> **DANGER:** All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

1. Remove the J3-Axis 1st Stage Belt by following the instructions in the previous section.
2. Remove the J3-Axis 2nd Stage Tension Idler assembly (pictured in Replacing the J3-Axis or Theta Motor Assembly). This can be done by removing the M4 Locking Screw, backing off the Jam Nut and Bolt, and removing the M4 Shoulder screw that retains the pivoting assembly.
3. Remove the Outer Link Bottom Cover to gain access to the J3 Clamp Ring. This threaded shaft screws into the Inner Link from below and clamps the J3-Axis output bearings to the Inner and Outer Links at the robot's elbow.



4. When the Clamp Ring is installed, Loctite is applied to its threads to lock it to the threads of the Inner Link. To loosen the Clamp ring, use the J3 Removal Tool and a large adjustable wrench to apply enough torque to break the Loctite.
5. While supporting the Outer Link, unscrew the Clamp Ring and slide the Clamp Ring down so that it clears the inner races of the J3-Axis output bearings in the elbow.
6. Carefully lower the Outer Link so that the large J3-Axis 2nd Stage Belt pulley clears the Inner Link and frees the belt.
7. Remove the J3-Axis 2nd Stage Belt by slipping it over 1st Stage pulley.
8. Install the new belt by sliding it over the lower flanged pulley and around the posts as shown below.



9. Carefully slide the Outer Link upwards at an angle so that the large pulley is inserted back into the Inner Link and partially engages the belt. Rotate the Outer Link back and forth until the large pulley fully engages the 2nd Stage Belt.
10. Carefully apply a small amount of Loctite 242 to the threads in the Inner Link. <u>Make sure that no Loctite contacts the J3-Axis bearings</u>.
11. Slide the Clamp Ring and spring through the bearings from below.
12. Tighten the Clamp Ring using the J3 Removal Tool. Tighten down until the threads have bottomed out. This ensures the proper preload by the spring into the elbow bearings.

13. Verify that the Outer Link rotates smoothly without an excessive amount of friction.
14. Re-install the Outer Link Bottom Cover, the J3-Axis 2nd Stage Tension Idler assembly and the J3-Axis 1st Stage Belt.
15. Follow the instructions below to properly tension the belt and to reassemble the robot.

To properly adjust the tension in the belt, perform the following operations:

1. Ensure that Inner Link Cover and the Inner Link Cable Cover are removed, that the J3-Axis 2nd Stage Tension Idler Jam Nut is backed off and that the Idler Locking Screw is removed.
2. Measure the belt tension using a Gates Sonic Tension Meter on the side of the belt without the Idler.
3. Compare the tension to that specified in the Belt Tensioning Table.
4. As required, adjust the belt tension by turning the Jam Bolt to reposition the Idler wheel.
5. Tighten the Idler Locking Screw and verify that the belt tension is still correct.
6. Tighten the Jam Nut to hold the Jam Bolt in place.
7. Re-attach the Inner Link Cable Cover and the Inner Link Cover.

Replacing and Tensioning the Theta Belts

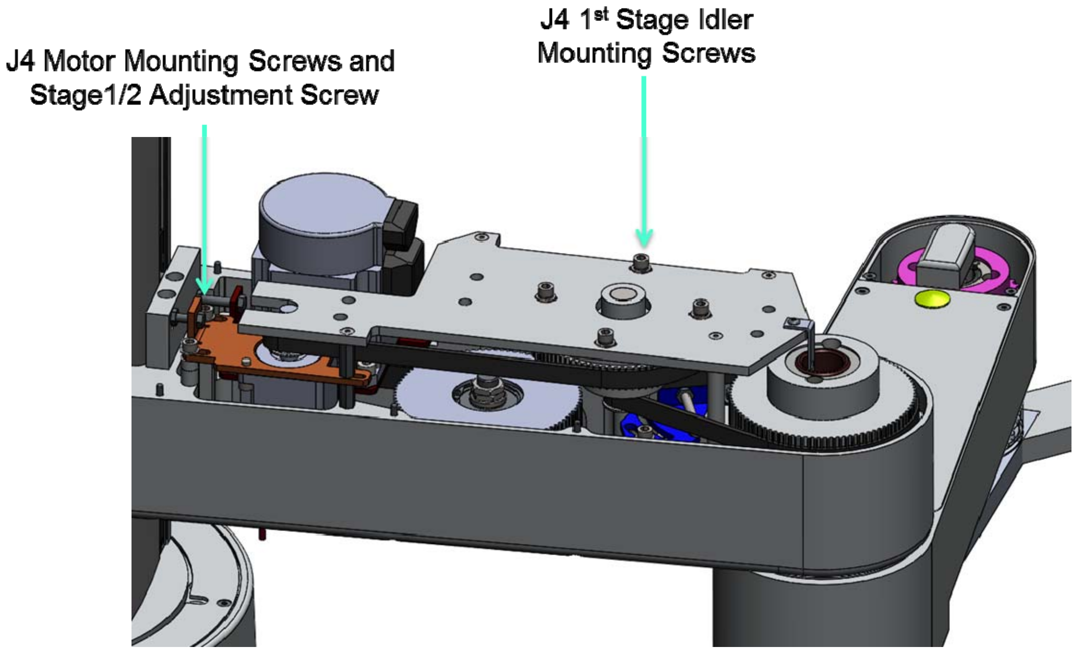
1st Stage Belt

The 1st Stage Belt (and second stage belt for 3-stage theta drives) for the Theta-Axis is located in the Inner Link. To replace or tension this belt, it must be accessed using the same procedures as those described in the section on Replacing the J3-Axis or Theta Motor Assembly. Please review that section prior to performing the following operations.

DANGER: All of the motors for the PreciseFlex robot are operated at between 160VDC and 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

To replace the belts, you must have available a Gates TruMotion belt (Precise P/N PF10-MC-X0143) for the first stage and a Gates TruMotion belt (Precise P/N PF10-MC-X0078) for the second stage belt. Then perform the following operations:

1. Follow the instructions in the previous section to remove the Inner Link Cover and the Inner Link Cable Cover.
2. Loosen (but do not remove) the Theta Motor Bracket Screws and back off its Jam Nut and Tensioning Bolt.
3. Loosen (but do not remove) the J4 1^{st} Stage Idler Mounting Screws.
4. Remove the 2^{nd} stage belt then remove the 1^{st} stage belt.
5. Replace the 1^{st} stage belt and then the second stage belt.



To properly adjust the tension in the stage 1 belt, perform the following operations:

1. Follow the instructions above to loosen the Theta Motor Bracket Screws and back off the Jam Nut. Measure the belt tension using a Gates Sonic Tension Meter on the more accessible side of the belt.
2. Compare the tension to the minimum specified in the Belt Tensioning Table. The tension should not drastically exceed the minimum at the lowest point of tension in the range of rotation. As required, adjust the motor position and belt tension by turning the Tensioning Bolt.
3. Measure the tension on the 2nd stage belt and determine if it needs to be adjusted to account for influence of the 1st stage belt adjustment. If so, follow instructions for 2nd stage belt tensioning and account for influence of 1st stage belt.
4. Tighten the three Motor Bracket Screws and verify that the belt tension is still correct.
5. Tighten the Jam Nut to hold the Tensioning Bolt in place.
6. Replace the Inner Link Cable Cover and the Inner Link Cover.

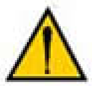
To properly adjust the tension in the stage 2 belt for robots which have 3 stage belt reductions for theta, perform the following operations:

1. Follow the instructions above to loosen the Theta Motor Bracket Screws and back off the Jam Nut.
2. Loosen the 1st stage idler mounting screws.
3. Adjust the Stage 1/2 adjustment screw and compare the tension to the minimum specified in the Belt Tensioning Table. The tension should not drastically exceed the minimum at the lowest point of tension in the range of rotation. As required, adjust the motor position and belt tension by turning the Tensioning Bolt.
4. Tighten the four 1st stage idler mounting screws.

Final Stage Belt

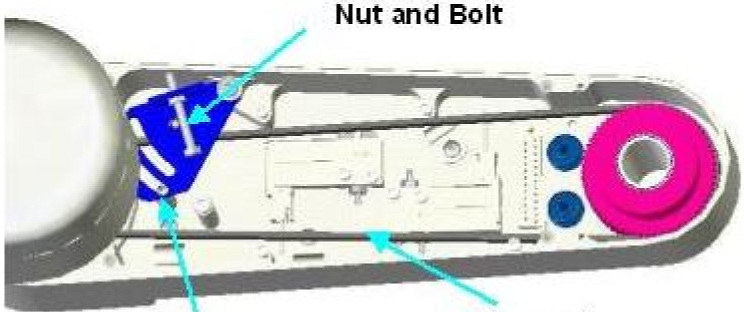
The final Stage Belt of the Theta-Axis is located in the Outer Link. To replace this belt, you must have available a Gates TruMotion Belt (Precise P/N PF10-MC-X0159). Then perform the following operations:

1. Disconnect the main AC power to the robot.



WARNING: The ZIO contains unshielded 24 VDC signals and pins. This board should only be accessed when the main AC power to the robot is disconnected.

2. Remove the two Outer Link Covers.
3. Unplug all connections to the ZIO board contained in the Outer Link and remove this board. The Outer Link should look as follows.



4. Loosen the M4 Tension Idler Locking Screw to permit the Idler to move.
5. Back off the Tension Idler Jam Nut and Jam Bolt to eliminate the tension on the belt.
6. Remove the old belt from the larger pulley first and then the smaller pulley below the J3-Axis.
7. Install the new belt by placing it around the small pulley first and then sliding it over the large pulley.
8. Follow the instructions below to properly tension the belt and to reassemble the robot.

To properly adjust the tension in the belt, perform the following operations:

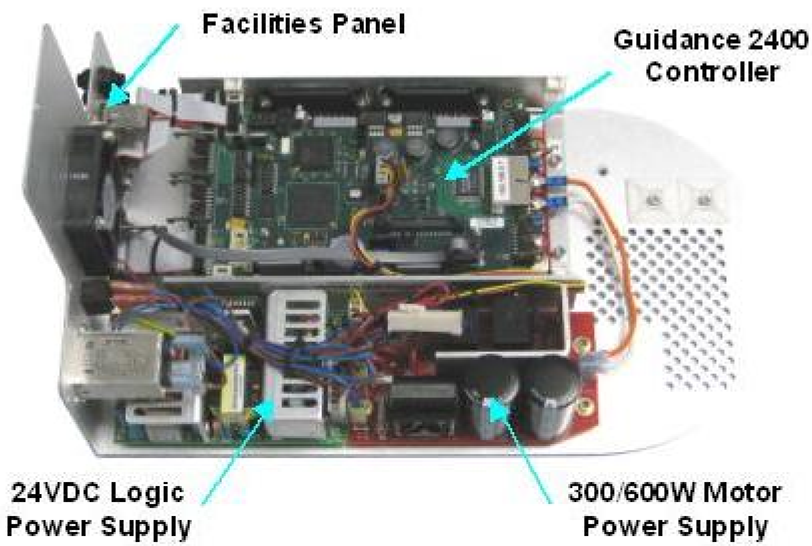
1. Ensure that the Outer Link Covers and ZIO board are removed and the Idler Locking Screw is loosened and the Tensioner Nut is backed off.
2. Measure the belt tension using a Gates Sonic Tension Meter on the side of the belt without the Idler.
3. Compare the tension to that specified in the Belt Tensioning Table.

4. As required, adjust the belt tension by turning the Jam Bolt to reposition the Idler wheel.
5. Tighten the Idler Locking Screw and verify that the belt tension is still correct.
6. Tighten the Jam Nut to hold the Jam Bolt in place.
7. Re-attach and cable the ZIO board and re-install the Outer Link Covers.

Replacing Control Electronics Components

All of the robot's primary control electronics components are mounted within the Controls Bay. This bay slides into the bottom of the J1-Axis housing. To access the Controls Bay, remove the screws that attach the Facilities Panel to the back of the J1-Axis housing and then slide out the bay.

DANGER: The Controls Bay contains open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the motor power supply provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing the Controls Bay.**



Guidance 2400 Controller

To replace the controller, disconnect all cabling to the controller and remove any zip ties that hold the cabling in place. Then unscrew the four M4x8 SHCS that hold the controller in place in the Controls Bay. During installation of the replacement controller, Loctite 222 should be applied on the screws. All cabling should be installed and tied down to the appropriate cable tie mounts.

24VDC Logic Power Supply

To replace the 24VDC supply, disconnect all cabling to this device and remove any zip ties that hold the cabling in place. Then unscrew the four M3x12 SHCS that hold the supply in place. During installation of the replacement supply, Loctite 222 should be applied to the screw threads. <u>Be sure to re-install the</u>

standoffs between the bottom of the power supply and the Controls Bay sheet metal. All cabling should be installed and tied down to the appropriate cable tie mounts.

300/600-Watt Motor Power Supply

To replace the 300/600W supply, disconnect all cabling to the supply and remove any zip ties holding the cabling in place. Then unscrew the four M4x10 SHCS that hold the supply in place. During installation of the replacement supply, Loctite 222 should be applied to the screw threads. All cabling should be installed and tied down to the appropriate cable tie mounts.

High Flow Rate Fan

To replace the fan, disconnect the fan by unplugging the connector that is wired to the 24VDC power supply. The replacement fan should be reconnected to the same plug and the wires should be routine in a manner similar to the original fan. The fan is mounted to the Facilities Panel using four M4x25 FHCS and nylon nuts

Appendix A: Product Specifications

PreciseFlex 1300/1400 Specifications

General Specification	Range
Range of Motion & Resolution	
J1-Axis	+/- 176 degrees
Z-Axis	Configurations from 300 mm (standard) to 600 mm (optional)
J3-Axis	+/- 162 degrees
Optional Theta Axis	+/- 270 degrees
Resolution	+/- 0.005 mm in X-Y plane
Repeatability	+/- 0.050 mm, 68-78 degrees F, limited by aluminum structure expansion
Performance and Payload	
Maximum acceleration	2G with 2kg payload 1.3G with 4kg payload
Maximum speed	1000 mm/sec with 4kg payload
Z Force	Maximum Z down force - 200N
Payload	PreciseFlex 1300: 5 kg PreciseFlex 1400: 4 kg
Controller	
Embedded Controller	*AVAILABLE GUIDANCE CONTROLLERS*: Guidance 2410C (G2XD-EA-C2410 Standard), Guidance 2410B (G2XD-EA-B2410), Guidance 2414B (G2XD-EA-B2414), Guidance 2416B (G2XD-EA-B2416)
Interfaces	
General Communications	RS-232 channel, 10/100 Mbps Ethernet port, remote front panel
Digital Input Channels	12 general purpose optically isolated inputs, configurable in groups of four as sinking or sourcing, signals transition to a high or low in 4 usec, available on J1-Axis housing Facilities Panel. 8 additional slower isolated inputs configured as sinking provided on the Outer Link. 5VDC to 24VDC for logic high if sinking 24VDC supplied for logic high if sourcing Additional remote I/O available via Precise RIO modules, 3rd party MODBUS/TCP devices, or 3rd party EtherNet/IP devices
Digital Output Channels	8 general purpose optically isolated outputs, individually configurable as sinking or sourcing, turn on in 2 usec and turn off in 40 usec, available on J1-Axis housing Facilities Panel. 8 additional slower isolated outputs configured as sourcing

	provided on the Outer Link. 24VDC maximum pull up if sinking 24VDC supplied if sourcing 100mA maximum per channel for all channels, except 500mA maximum for channel 1 in Facilities Panel. Additional remote I/O available via Precise RIO modules, 3rd party MODBUS/TCP devices, or 3rd party EtherNet/IP devices
Analog I/O Channels	2 analog inputs optionally available on controller 4 or 6 analog outputs optionally available on controller
Pneumatic Lines	Two air lines, each 75-PSI maximum, provided at Outer Link and routed internally to fittings on J1-Axis housing Facilities Panel.
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.
General	
Required Power	Input range: 90 to 264 VAC single phase, 50-60 Hz, 500-watts maximum.
Weight	34 kg typical, will vary with size

PreciseFlex 1300/1400 Environmental Specifications

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

General Specification	Range & Features
Ambient temperature	5ºC to 40ºC
Ingress protection	IP51. Protected against light dust and water drips.
Storage and shipment temperature	-25ºC to +55ºC
Humidity range	5 to 90%, non-condensing
Altitude	Up to 3000m

Appendix B: FAQ

Frequently Asked Questions

This section contains a compilation of frequently asked questions related to PreciseFlex 1300/1400 robots.

A. Robot Hardware

1. How do you operate the robot when plugged into a GFI circuit?

A. Robot Software

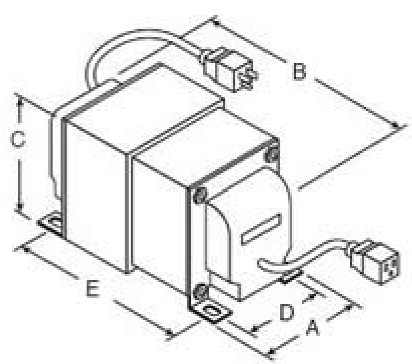
None

Robot Hardware

How do you operate the robot when plugged into a GFI circuit?

In almost all situations, to power a Precise robot, all that is required is that the robot be plugged into a standard AC service. However, if you plug the robot into an electrical service that has a GFI (Ground Fault Interrupter) circuit, the GFI may be tripped when motor power is enabled. If this occurs, the problem can be easily remedied by plugging the robot into an isolation transformer that is capable of supplying at least 500 VA and plugging the isolation transformer into the GFI circuit.

Isolation transformers of this type are readily available and cost approximately $100-$150. For example, the following transformer, a Hammond 171E is available from www.mouser.com as part number 546-171E for $130.



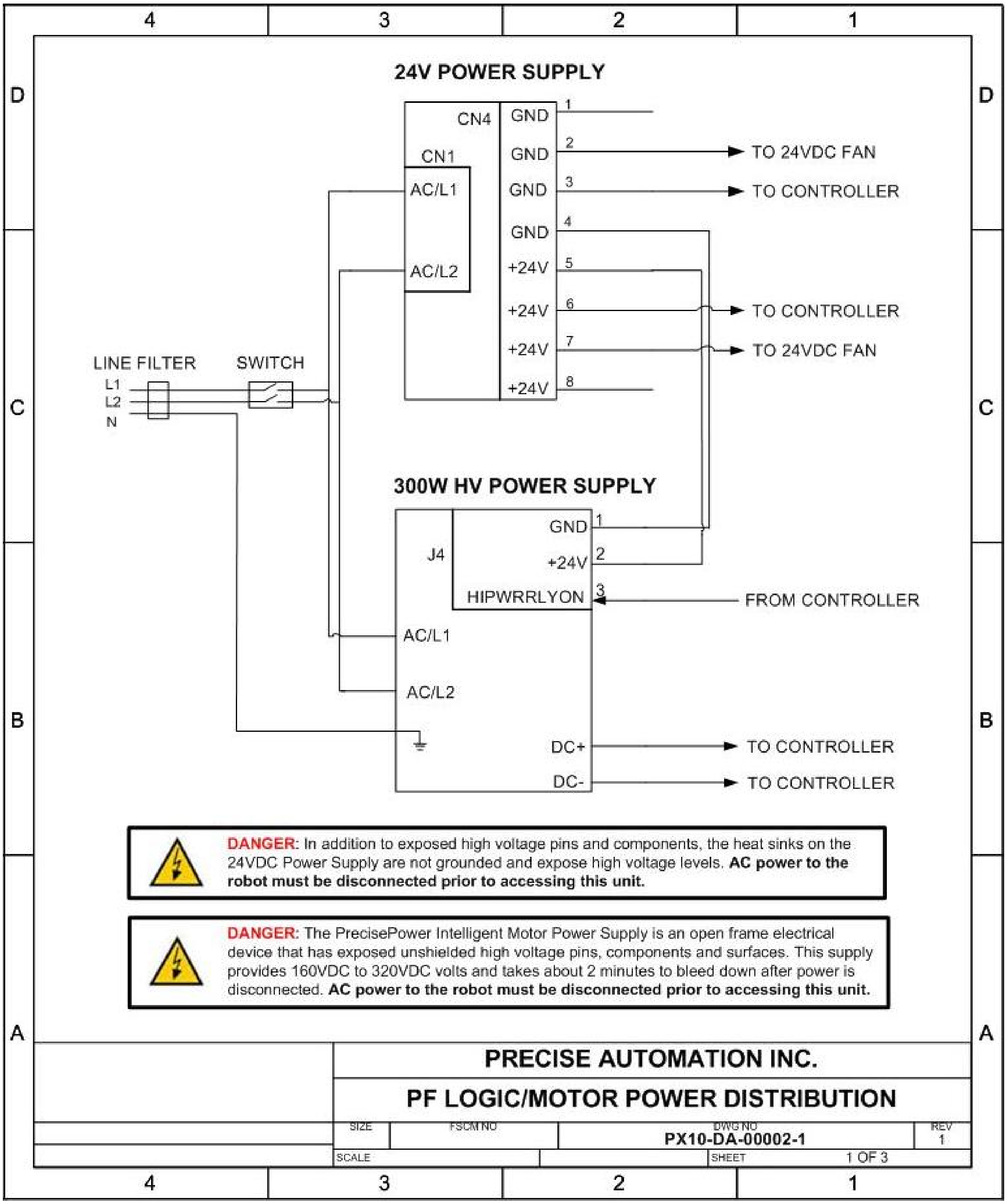
Appendix C Spare Parts Price List

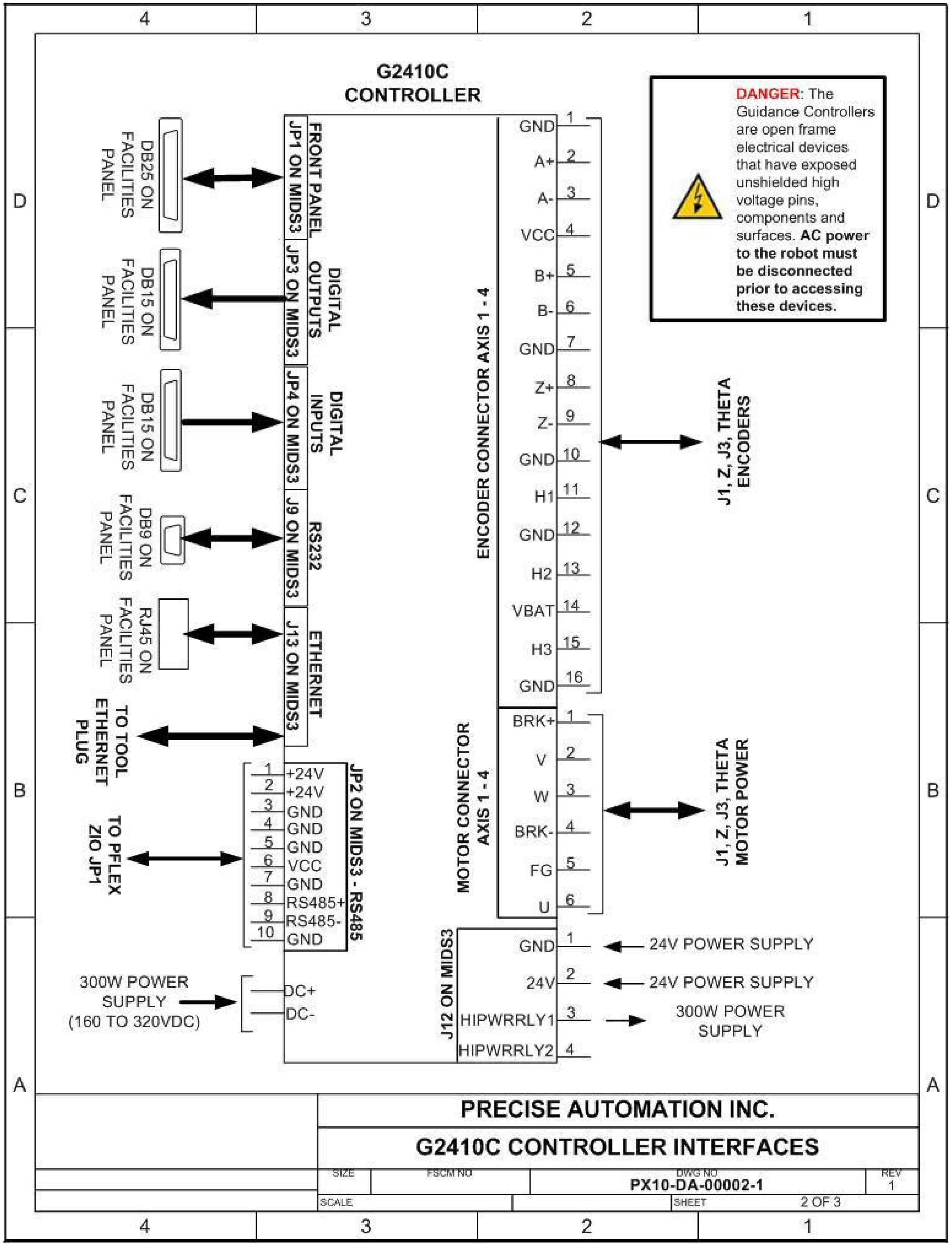
PF10-MA-01300/PF10-MA-01400

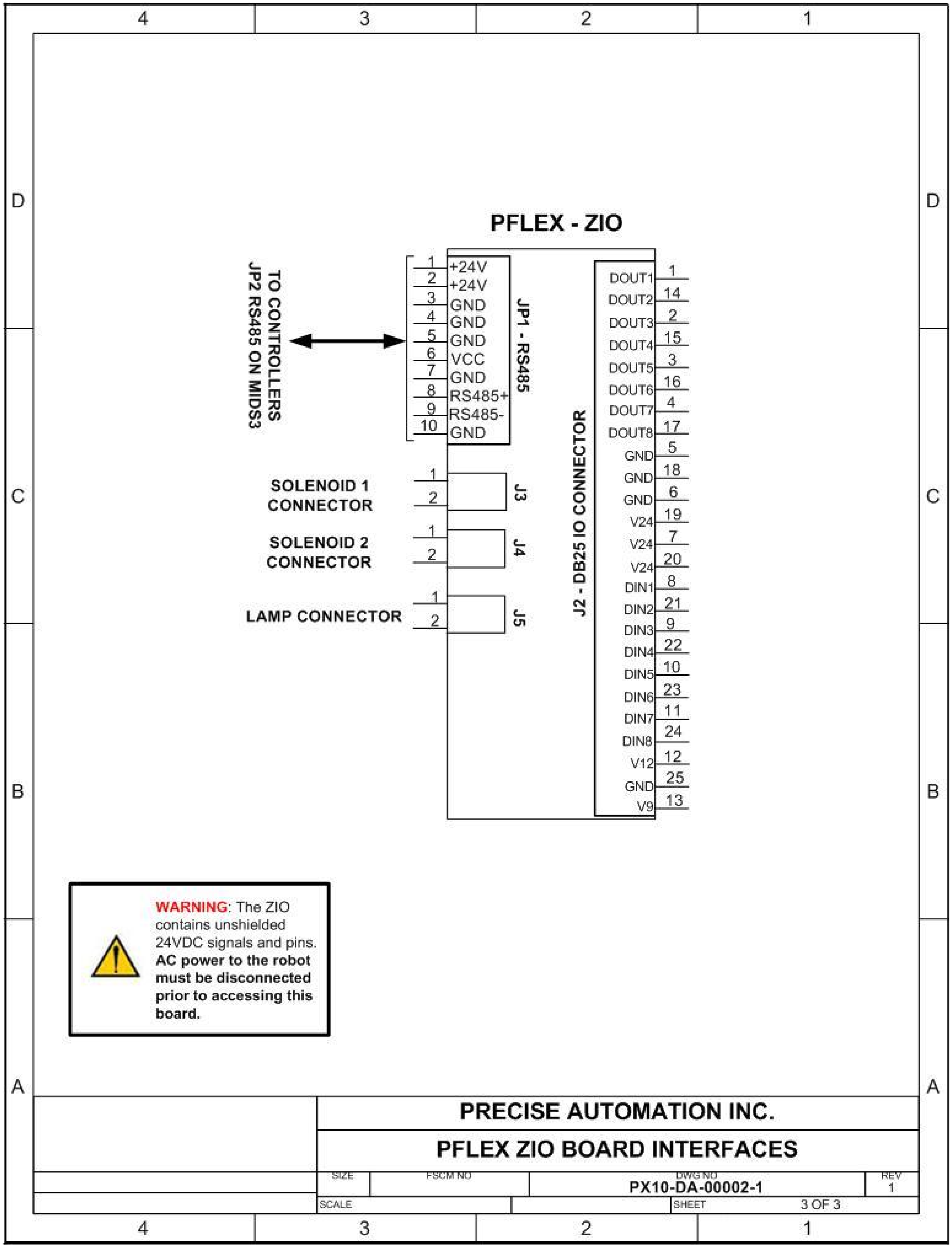
Revised November 24, 2013

Description	Part Number
J1 Motor Assembly	PF10-MA-00048
J1 Stage 1 Belt	PF10-MC-X0091
J1 Stage 2 Belt	PF10-MC-X0092
G2410C Controller with Advanced Kinematic License	G2XF-EA-C2410
125W 24VDC Power Supply	PS10-EP-00125
PrecisePower 300W Intelligent Motor Power Supply	PS1D-EA-00300
Fuse, PrecisePower 300W Motor Power Supply	Wickman PN 1941630000
24 VDC Fan	PF10-MC-X0088
PFlex ZIO Board	PF13-EA-00001
Z-Axis Motor Assembly	PF10-MA-00049
Z-Axis Stage 1 Belt	PF10-MC-X0086
Z-Axis Stage 2 Belt (300 mm Z)	PF10-MC-X0077
Z-Axis Stage 2 Belt (600 mm Z)	PF10-MC-X0158
Z-Axis Lower Idler Assembly	PF10-MA-00080
Z axis Upper Idler Assembly	PF10-MA-00081
J3 Motor Assembly	PF10-MA-00050
J3 Stage 1 Belt	PF10-MC-X0106
J3 Stage 2 Belt	PF10-MC-X0079
J4 Motor Assembly	PF10-MA-00051
J4 Stage 1 Belt	PF10-MC-X0143
J4 Stage 2 Belt	PF10-MC-X0078
J4 Stage 3 Belt	PF10-MC-X0158

Appendix D: System Schematics




G2410C
CONTROLLER
FRONT PANEL
JP1 ON MIDS3
DB25 ON FACILITIES PANEL
DIGITAL OUTPUTS
JP3 ON MIDS3
DB15 ON FACILITIES PANEL
DIGITAL INPUTS
JP4 ON MIDS3
DB15 ON FACILITIES PANEL
RS232
J9 ON MIDS3
DB9 ON FACILITIES PANEL
ETHERNET
J13 ON MIDS3
RJ45 ON FACILITIES PANEL
TO TOOL ETHERNET PLUG
JP2 ON MIDS3 - RS485
1 +24V
2 +24V
3 GND
4 GND
5 GND
6 VCC
7 GND
8 RS485+
9 RS485-
10 GND
TO PFLEX ZIO JP1
300W POWER SUPPLY (160 TO 320VDC)
DC+
DC-
ENCODER CONNECTOR AXIS 1 - 4
GND 1
A+ 2
A- 3
VCC 4
B+ 5
B- 6
GND 7
Z+ 8
Z- 9
GND 10
H1 11
GND 12
H2 13
VBAT 14
H3 15
GND 16
J1, Z, J3, THETA ENCODERS
MOTOR CONNECTOR AXIS 1 - 4
BRK+ 1
V 2
W 3
BRK- 4
FG 5
U 6
J1, Z, J3, THETA MOTOR POWER
J12 ON MIDS3
GND 1
24V 2
HIPWRRLY1 3
HIPWRRLY2 4
24V POWER SUPPLY
24V POWER SUPPLY
300W POWER SUPPLY
DANGER: The Guidance Controllers are open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. AC power to the robot must be disconnected prior to accessing these devices.
PRECISE AUTOMATION INC.
G2410C CONTROLLER INTERFACES
SIZE
FSCM NO
DWG NO
PX10-DA-00002-1
REV
1
SCALE
SHEET
2 OF 3
4
3
2
1
D
C
B
A


4
3
2
1
D
C
B
A
PFLEX - ZIO
TO CONTROLLERS
JP2 RS485 ON MIDS3
1 +24V
2 +24V
3 GND
4 GND
5 GND
6 VCC
7 GND
8 RS485+
9 RS485-
10 GND
JP1 - RS485
SOLENOID 1 CONNECTOR
J3
SOLENOID 2 CONNECTOR
J4
LAMP CONNECTOR
J5
J2 - DB25 IO CONNECTOR
DOUT1 1
DOUT2 14
DOUT3 2
DOUT4 15
DOUT5 3
DOUT6 16
DOUT7 4
DOUT8 17
GND 5
GND 18
GND 6
V24 19
V24 7
V24 20
DIN1 8
DIN2 21
DIN3 9
DIN4 22
DIN5 10
DIN6 23
DIN7 11
DIN8 24
V12 12
GND 25
V9 13
WARNING: The ZIO contains unshielded 24VDC signals and pins. AC power to the robot must be disconnected prior to accessing this board.
PRECISE AUTOMATION INC.
PFLEX ZIO BOARD INTERFACES
SIZE
FSCM NO
DWG NO
PX10-DA-00002-1
REV
1
SCALE
SHEET
3 OF 3