# PrecisePlace 2300/2400 Robot

Hardware Introduction and Reference Manual

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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

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System Overview

System Description

The PrecisePlace Robot Series includes the PrecisePlace 2300, a three-axis XYZ Cartesian robot, and the PrecisePlace 2400, a four-axis XYZTheta Cartesian Robot. Both robots include an embedded Guidance 3400 four-axis motion controller, a PrecisePower 300 Intelligent Motor Power Supply and a 24VDC power supply located inside the X-axis of the robot.

The X and Y axes of these robots are available in a number of different lengths with the X ranging from 500 mm to 1 M and the Y from 200 mm to 600 mm. The robots were designed as tabletop units and can carry a payload of 5 Kg in the 3-axis configuration or 3.5 Kg in the 4-axis configuration (Y-axis lengths greater than 400mm reduce the maximum payloads by 1 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 and employ an innovative traction drive method (U.S. Pat 7,343,684). 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, two analog input channels, 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 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 three axes PrecisePlace robot and the orientation and origin of its World Cartesian coordinate system are shown in the diagram below.
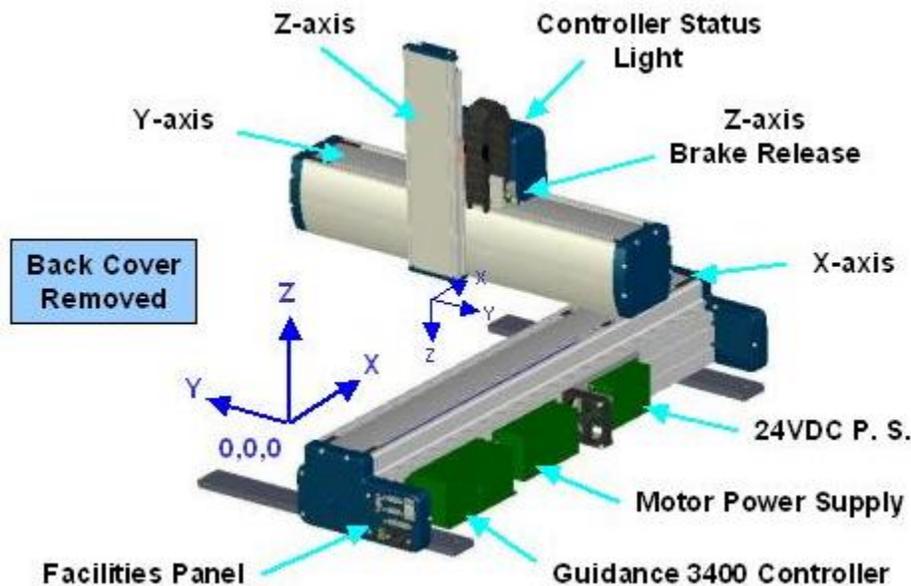
The first axis of the robot moves in the World X direction and provides the mounting points for the robot. The primary electronic components are contained beneath the back cover for the X-axis. This includes the Guidance 3400 controller, the PrecisePower Intelligent Motor Power Supply and the 24 VDC logic power supply. The Guidance controller not only controls the robot but also provides extensive hardware interfaces including Ethernet and digital and analog IO.

> **DANGER:** The Guidance 3400, 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 removal of the rear cover.**

When the X-carriage (and the Y-axis mounted to it) is closest to the Facilities Panel, the X-axis is approximately at its 0 position and at X=0 in the World coordinate system. As the X-carriage moves away from the Facilities Panel, both its joint position and the World X coordinate increase in value.

The second axis moves the tool of the robot along the Y-axis. When the Y-carriage (and the Z-axis mounted to it) is closest to the X-axis, the Y-axis is approximately at its 0 position and at Y=0 in the World

coordinate system. As the Y-carriage moves away from the X-axis, both its joint position and the World Y coordinate increase in value.

The final linear axis moves the tool up and down in Z. When the Z-axis is elevated as high as possible, it is approximately at its 0 position and at Z=0 in the World coordinate system. When this axis moves down, while its joint position increases in value, its World Z coordinate becomes more negative.

The Z-axis carriage (the section connected to the Y-axis) includes an IO board that provides electrical and air services for both a 4th axis and end-of-arm tooling. A yellow lamp is mounted at the top of the Z-axis carriage cover 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 rear of the Z-axis cover, near the E-chain. 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

PrecisePlace 2300/2400 Robots

The PrecisePlace 2300 Robot (pictured below) is a 3-axis robot composed of an X-axis, with a stroke ranging from a minimum of 500 mm to a maximum of 1 M, a Y-axis with a stroke ranging from a minimum of 200 mm to a maximum of 600 mm, and a Z-axis with a stroke of 240mm. The Z-axis carriage contains a PCB (Z-Axis IO PCB) with connectors for driving a fourth motor/brake/encoder, connectors to route digital IO signals back to the controller, and an Ethernet connector that is routed back to the controller.
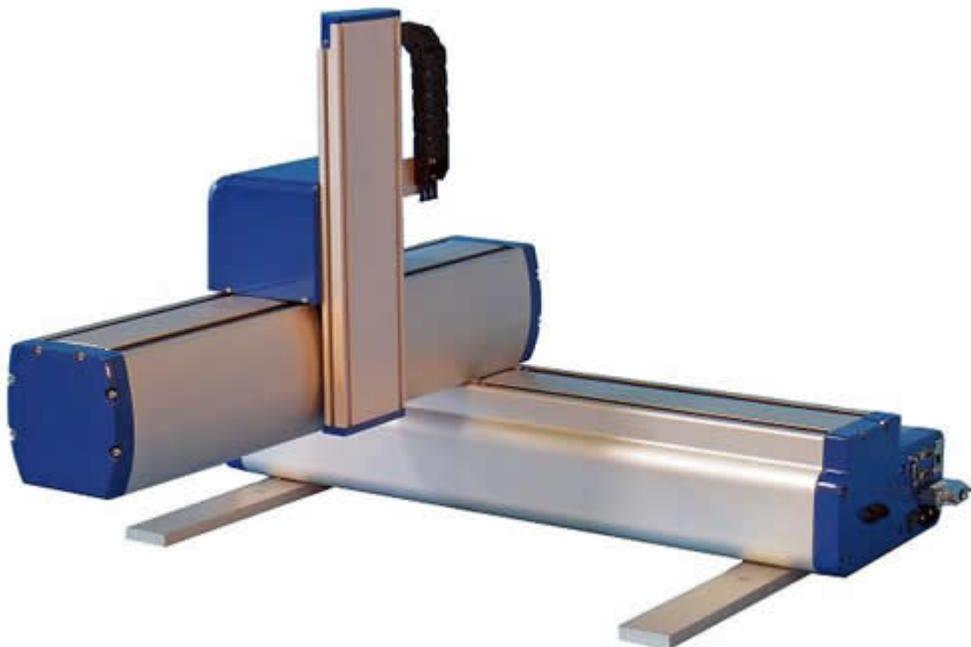
PrecisePlace_2300_2400_Robot

The PrecisePlace 2400 Robot (pictured below) is a 4-axis robot that is constructed by adding an optional Theta axis to the PrecisePlace 2300 Robot and a 4th motor driver to the robot's controller. The theta axis has a range-of-travel of +/- 270 degrees. The theta axis is utilized in applications where the Z angle of parts is not fixed and objects must be re-oriented as they are being handled.
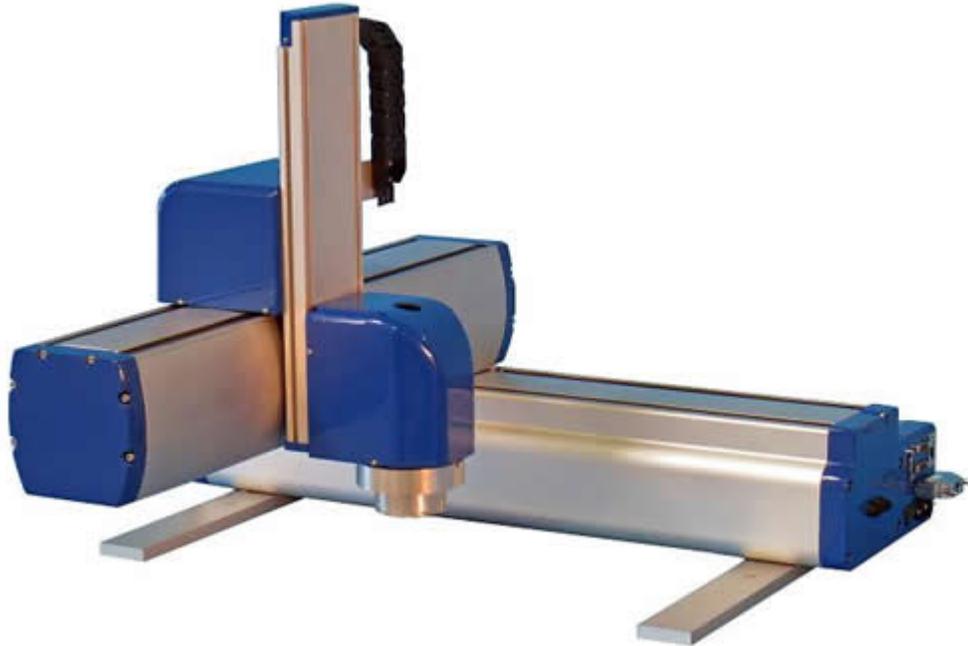
Mounting Plates and Risers

Two shipping/mounting plates are provided with the PrecisePlace Robots. The Standard Mounting Plates can support the overhanging load of the robot without the need to bolt the robot to a table or other structure.

For connecting the robot to the Standard Mounting Plates or other mounting structures, M5 mounting holes are provided in the base of the robot on 75mm centers, spaced 150mm apart. The hole spacing allows the robot to be attached to a piece of structural T slot extrusion, for example 80/20 Inc. PN 25-5010 or PN 25-2576, by means of M5 bolts and T nuts. Risers and connectors in this same series of extrusion can be ordered from 80/20 Inc. and used to elevate the robot if desired.

Theta   Axis

An optional Theta Axis may be purchased and attached to the Z-axis. The Theta Axis may be installed at the factory or in the field. This axis has +/- 270 degrees of rotation.

The Theta Axis has a 20 mm through hole (pictured below) that allows a camera mounted above on the Z-axis to view the tool tip. Alternately, cables can be routed through the hole in the cover and the axis to tooling and instrumentation attached to the Theta Axis.

Guidance 3400 Controller

The Guidance 3400 Controller is a four-axis general purpose motion controller that contains four motor drives and up to eight encoder inputs. It must be attached to a heat sink. In the PrecisePlace robots, the heat sink is provided by the X-axis extrusion. This controller includes local digital and analog 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.

In addition to the controller, a PrecisePower 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 X-axis and are pictured in the previous System Diagram and Coordinate Systems section.

> **DANGER:** The Guidance 3400, the PrecisePower Intelligent 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 removal of the rear cover.**

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 3400 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 PrecisePlace 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 integrated X-axis heat sink 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.

High Voltage

Intelligent Motor Power Supplies

The Guidance 3400 controller can accept motor power from 24 VDC to 340 VDC. Most PrecisePlace robots contain a 300/600-watt supply that has an input range of 90 to 264 VAC 50/60 Hz and generates a nominal output of 160VDC or 320VDC depending on the input voltage. Some older PrecisePlace robots include a 500-watt PrecisePower Intelligent Motor Power Supply. This device is auto-ranging with dual input ranges of 90 to 132 VAC and 180 to 264 VAC 50/60 Hz with a 320 VDC nominal output.

These intelligent power supplies contain: 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 integrated X-axis heat sink in the System Diagram and Coordinate Systems section of this document.

DANGER: The PrecisePower Intelligent Motor Power Supplies are open frame electrical devices that have exposed unshielded high voltage pins, components and surfaces. In addition, the power supplies provide 160VDC or 320VDC volts and take about 2 minutes to bleed down after power is disconnected. **AC power to the robot must be disconnected prior to accessing these units.**

PrecisePower 500W
Motor Power Supply
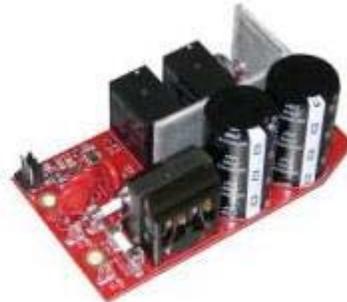
PrecisePower 300/600W
Motor Power Supply

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. (The Facilities Panel is on the end of the X-axis.) Each of these units provides the hardware signals to permit power to be enabled and disabled.

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.

> 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.

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 PrecisePlace robot, a Precise Remote IO (RIO) module may be purchased. The RIO interfaces to any PrecisePlace 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 3000 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 Z-axis. 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, Precise offers an Arm Mounted Camera Kit as an option. This kit permits a DALSA Genie Series Ethernet Camera and a ring light to be easily attached to the PrecisePlace robot's Z-axis.
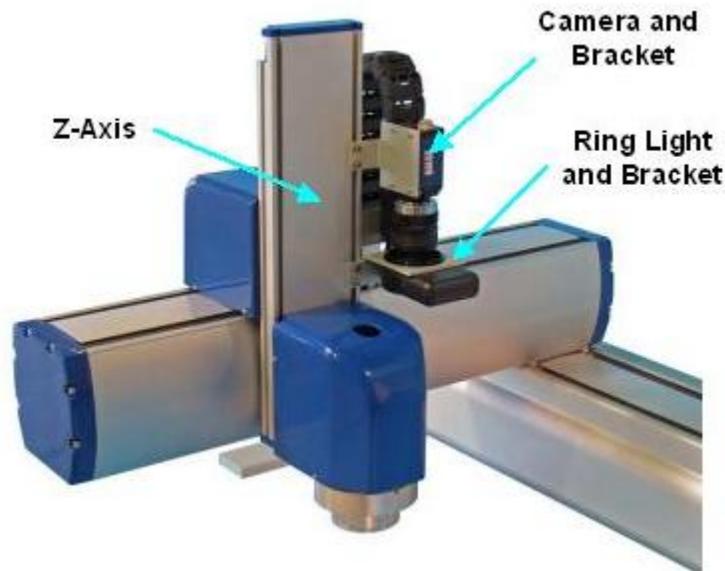
This kit includes an Ethernet camera and ring light power supply installed on the Z-axis IO board, a camera bracket, a ring light with a mounting bracket, an Ethernet cable to connect the camera to the robot's Ethernet harness, and power cables for connecting the camera and ring light to the Z-axis IO board power supply. This option is typically factory installed, but can be installed in the field if necessary.

Machine Safety

Voltage and Power Considerations

The Guidance 3400 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 a voltage to the controller between 24 VDC and 340 VDC. For the PrecisePlace robots, its PrecisePower Intelligent Motor Power Supply delivers between 160 VDC and 320 VDC to the controller depending upon the Power Supply type and the input AC voltage.   The motors will operate correctly throughout this range of DC voltages.

> **DANGER:** The Guidance 3400, the PrecisePower Intelligent Motor Power Supplies, 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 PrecisePlace robots, these units are mounted beneath the robot's back cover.

The PrecisePlace robots include either: a 300/600-watt PrecisePower Intelligent Motor Power Supply with a input range of 90 to 264 VAC 50/60 Hz and a nominal 160 VDC or 320 VDC output depending upon the AC input; or a 500-watt auto-ranging motor power supply with a dual input range of 90 to 132 VAC and 180 to 264 VAC 50/60 Hz that can be configured to supply 320 VDC for either AC input range. These motor power supplies contain relays that permit the controller to enable and disable motor power.

The PrecisePower Intelligent Motor Power Supplies limit inrush current to 6 Amps. They are 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. They are protected against over current by two 6.3 amp, 250V fuses, either Wickman PN 1941630000 (300/600W supply) or PN 1811630000 (500W supply).

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 Back Cover

In the PrecisePlace robots, the Guidance 3400 and its power supplies are mounted in the X extrusion under a cover that should be in place 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 robot cover is removed. **The robot should not be operated without the back cover in place.**

⚠ **DANGER:** The surfaces, connectors, and leads pictured in Red below indicate exposed elements of the Guidance 3400 controller that carry motor power signals. These signals levels are 320 VDC.
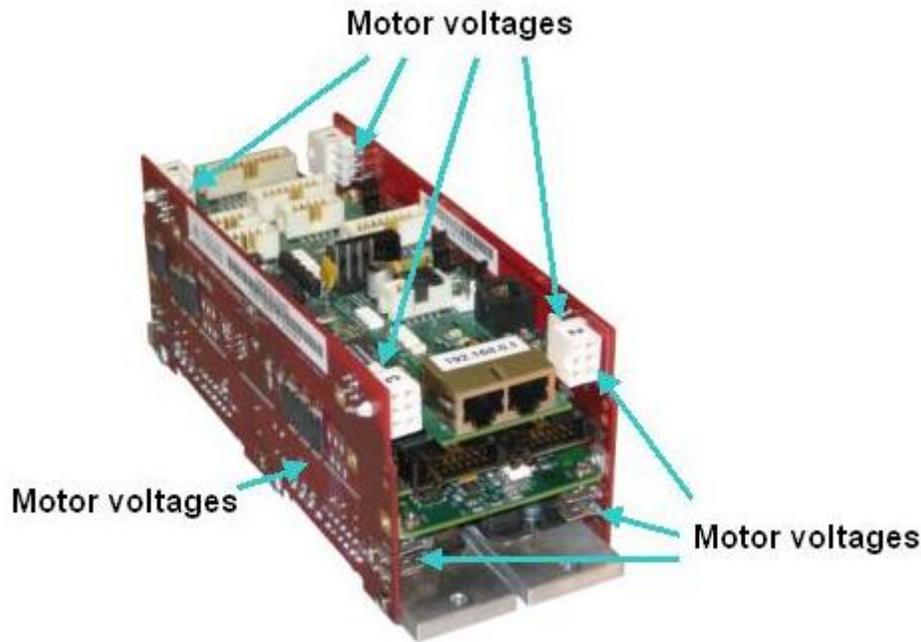
Releasing a Trapped Operator: Brake Release Switch

Should a hard E-Stop be triggered, the Z-axis brake will engage and motor power will be disconnected from all motors. Since the X, Y, 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, shown in the previous System Diagram and Coordinate Systems section, as long as power to the robot's controller is enabled.

Mechanical Limit Stops

If desired, it is possible to add mechanical limit stops to each axis. For the X and Y axes, the top cover must be removed and a machined block containing a rubber stop similar to the existing rubber stop can

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be screwed on top of the bearing rail. To install the new stop block, remove one or two of the existing bearing rail mounting screws and use longer screws to mount the new block to the bearing rail. The new block should be designed so that the rubber stop contacts the carriage, not the bearing slider.

In the case of the Z-axis, external mechanical stop blocks can be attached to the Z extrusion T slots on the sides of the Z-axis.

If mechanical limit stops are added, it is important that the software "Soft 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.

It is also important that the software "Hard stop limit" values be adjusted for any new mechanical stops. If the zero positions of the axes ever need to be reset using the factory calibration program, Cal_PP, the software hard limit stop values must be correctly defined in order for the zero position of each axis to be properly set.

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 PrecisePlace robots, the X, Y, 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 0.4G, or 3920mm/sec^2. If the robot is moving at a speed of 1000mm/sec, it will reach a full stop in 0.26sec after having only traveled a distance of 127mm.

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 PrecisePlace 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 PrecisePlace 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 PrecisePlace 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 PrecisePlace 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 right (Facilities) end cap of the X-Axis extrusion 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
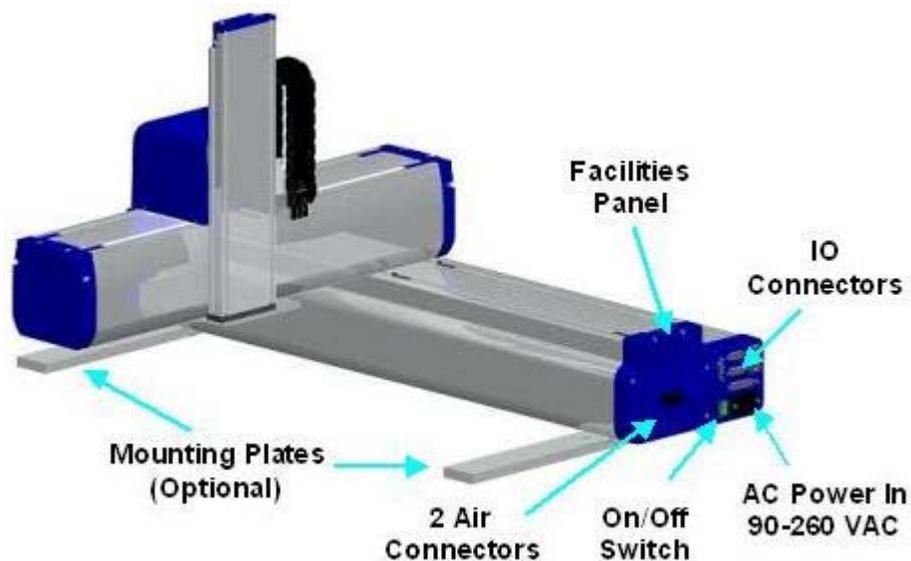
System Dimensions

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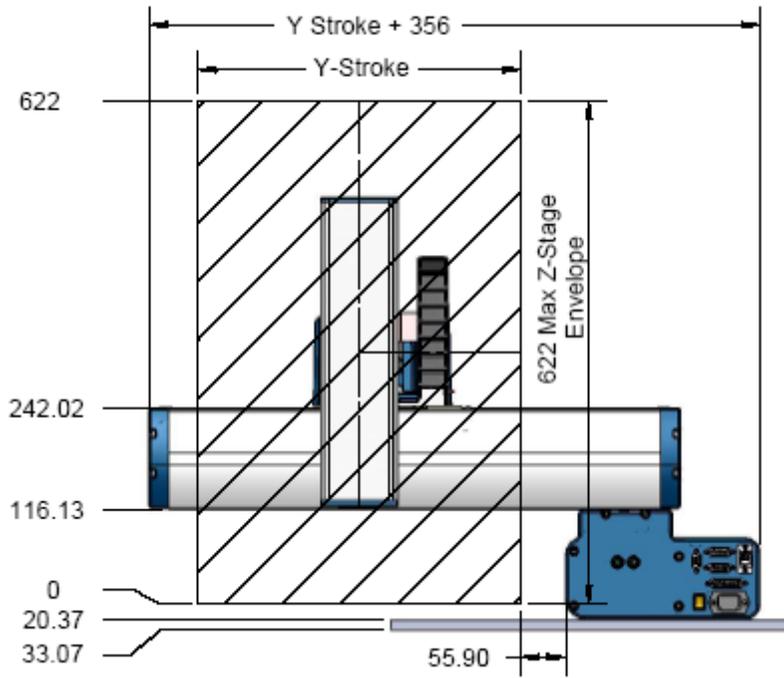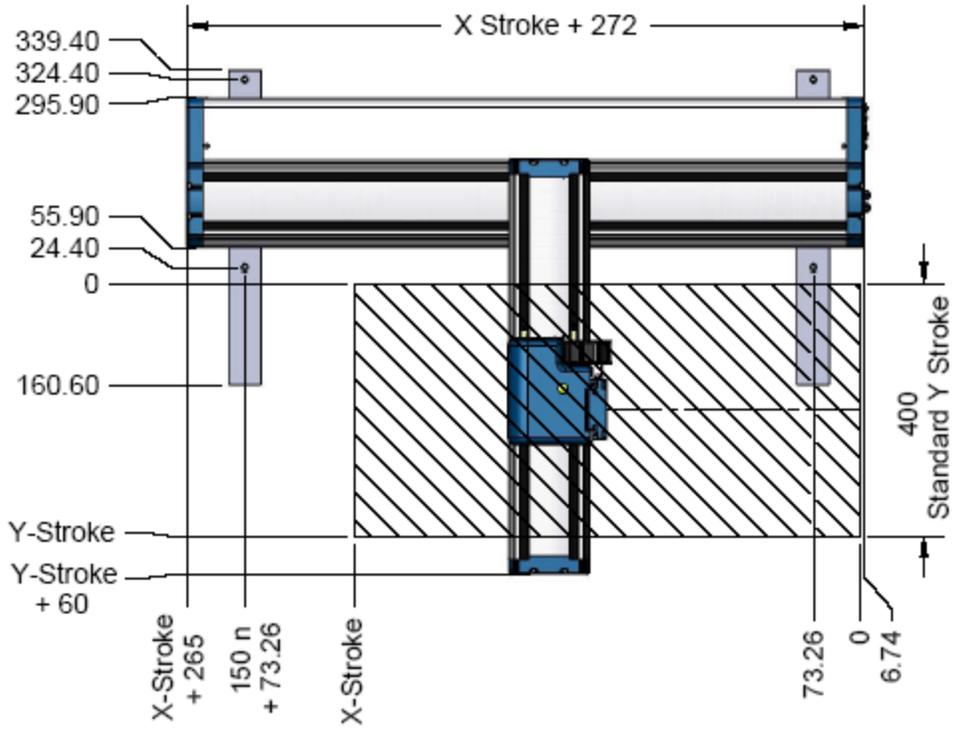
Mounting Instructions

PrecisePlace robots must be attached to a rigid surface that can withstand lateral forces of 200 Newton's without moving or vibrating. The robot is shipped with Standard Mounting Plates that are attached to the X extrusion with M5 by 25mm screws. M5 mounting holes are provided in the base of the robot on 75mm centers, spaced along the bottom of the X-axis.
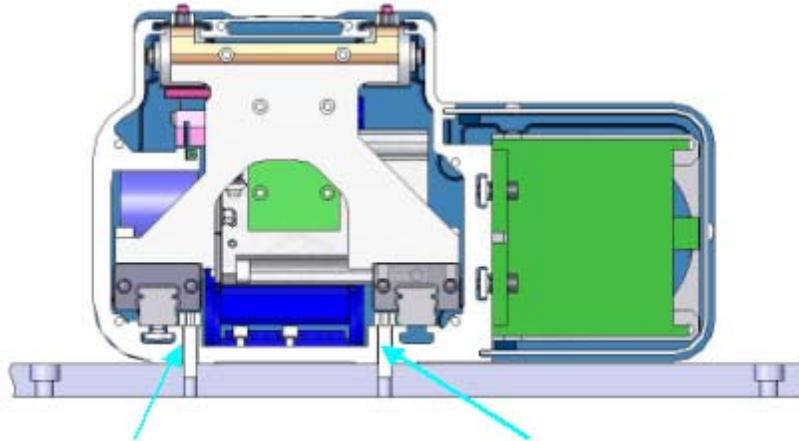
X-axis mounting hole pattern every 150mm along X-axis. 75mm BC for M5 by 25mm SHCS. Remove X cover to install mounting screws

It is recommended that there be a mounting support at least every 300mm under the robot. The locations of the mounting holes on the X extrusion for a 800mm stroke robot are shown below.

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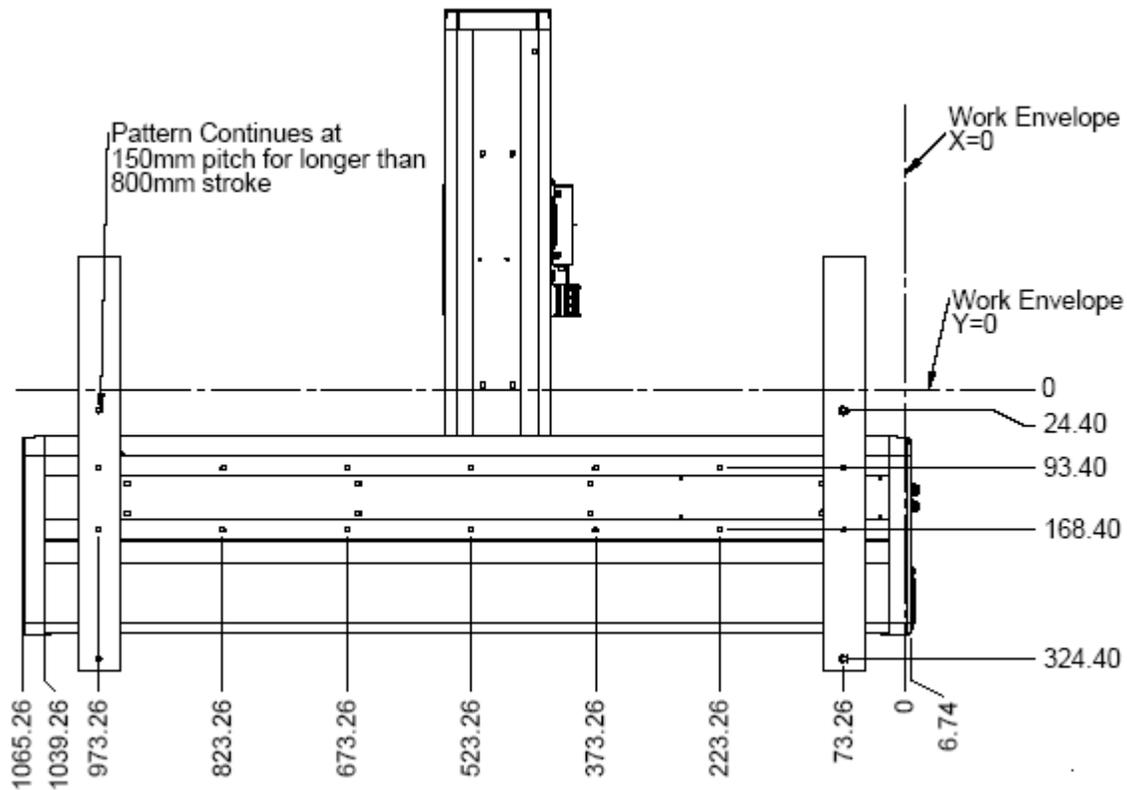
The Standard Mounting Plates that are shipped with the robot are shown below. These plates can be detached by removing the X-axis cover. Removal of the end caps is not required. See the Hardware Reference X and Y Axis section for instructions on removing the cover.
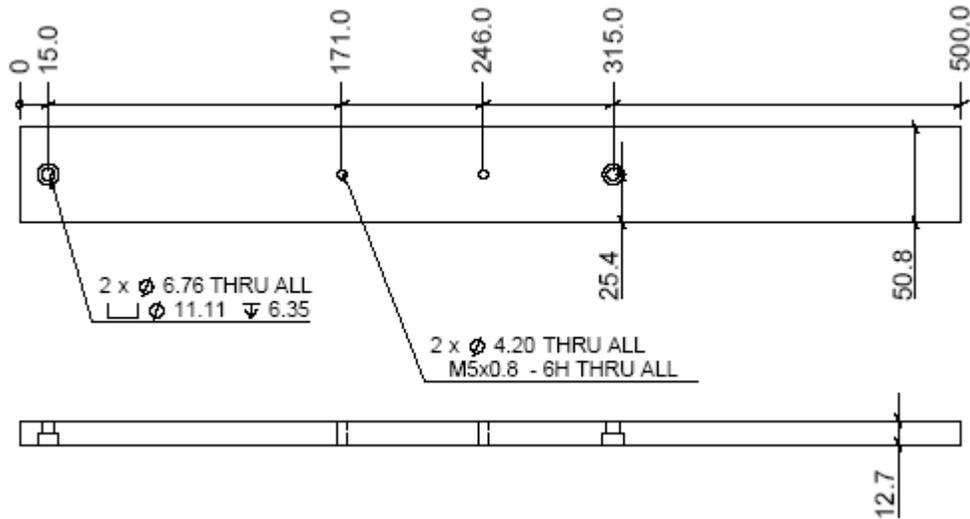
The 75mm hole spacing allows the robot to be attached to structural T slot extrusion. For example, 80/20 Inc. supplies this type of extrusion as PN 25-5010 or PN 25-2576, which can be attached to the robot using M5 bolts and T nuts. Risers and connectors in this same series of extrusion can be ordered from 80/20 Inc. and used to elevate the robot. For risers up to 115mm in height, this extrusion can be cut off and M5 screws up to 140mm long (available from Misumi) can be run directly thru the M5 holes into M5 tapped holes on the mounting surface. The M5 holes in the extrusion may need to be drilled out to M5.2 or so for screw clearance.
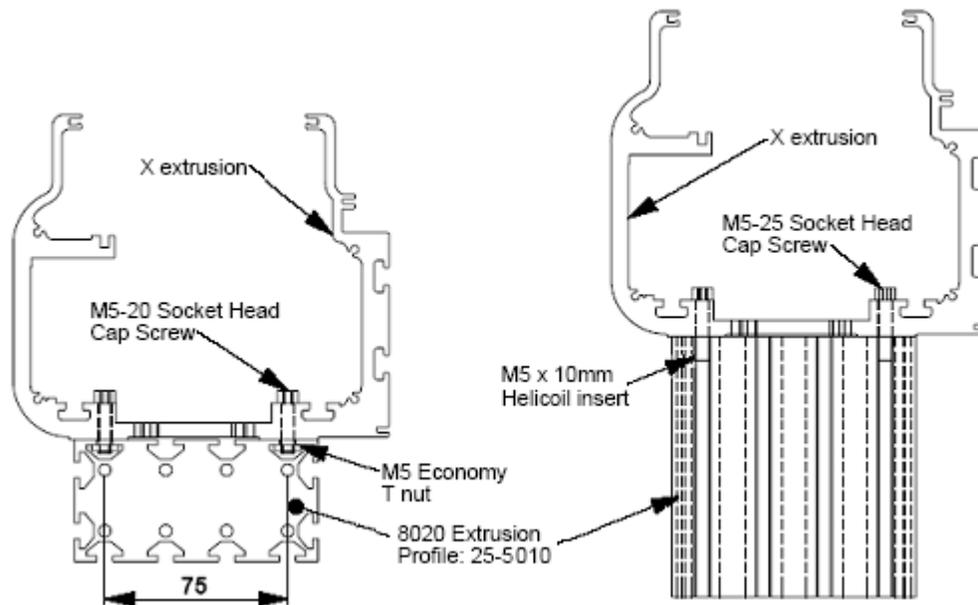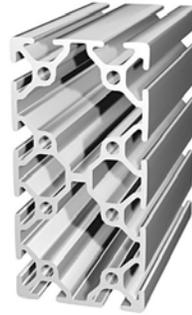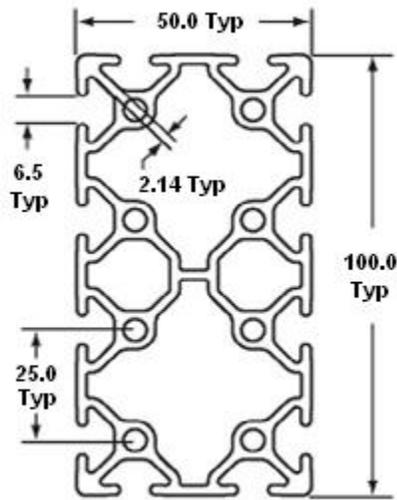
25-5010 is a 50mm x 100mm T-slotted profile made from 6105-T5 aluminum. This profile has twelve open T-slots with 25mm center-to-center distances and is compatible with all 25 Series fasteners and accessories.

Tool Mounting - PP2300

The PrecisePlace 2300 Z-Axis has been designed to permit tooling to be easily attached. The face of the Z-Axis has two vertical slots that can be used to mount an optional Theta Axis, syringe operators, grippers, cameras, or other user items. Two additional slots are available on the edges of this axis. Precise supplies four M4 nuts for these slots. A commercial compatible M4 nut is the Misumi HNTTBS5-4.

To facilitate electrical interfacing to user tooling, digital I/O and Ethernet signals are available on a "Z-Axis IO PCB" that is located under the Z-axis motor cover (this is described in a later section). For pneumatic tools, air lines with connections (4mm OD, 75 PSI maximum) are also brought out to the Z-axis. These lines are routed internally through the robot and exit at pneumatic fittings on the robot's x-axis Facilities Panel.
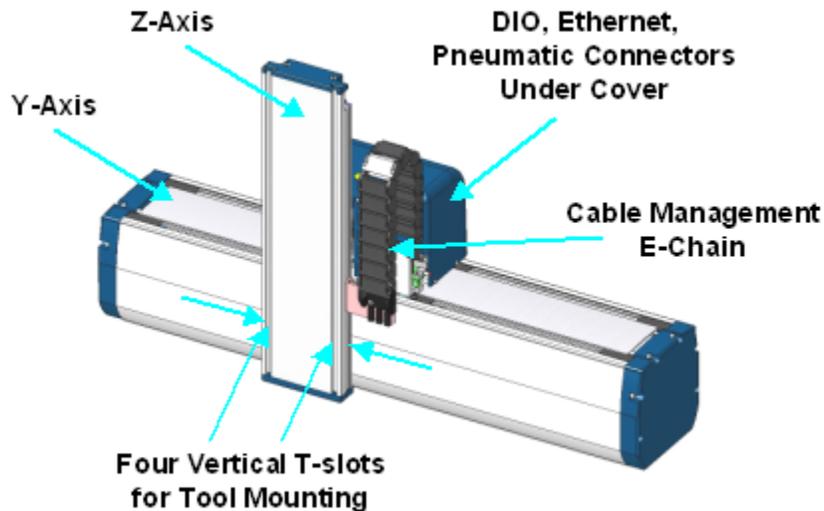
Shown below are the details of the mounting slots of the Z-Axis as viewed from above. All dimensions are in units of millimeters.
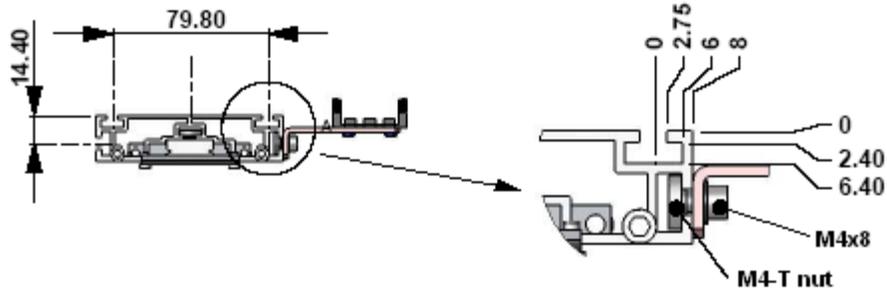
Tool Mounting - PP2400

The PrecisePlace 2400 Robot is constructed by adding a Theta axis to the PrecisePlace 2300 Robot and a fourth motor driver to the robot's controller. Tooling for the PrecisePlace 2400 Robot must be mounted to the standard tooling flange for the Theta unit that is pictured below.
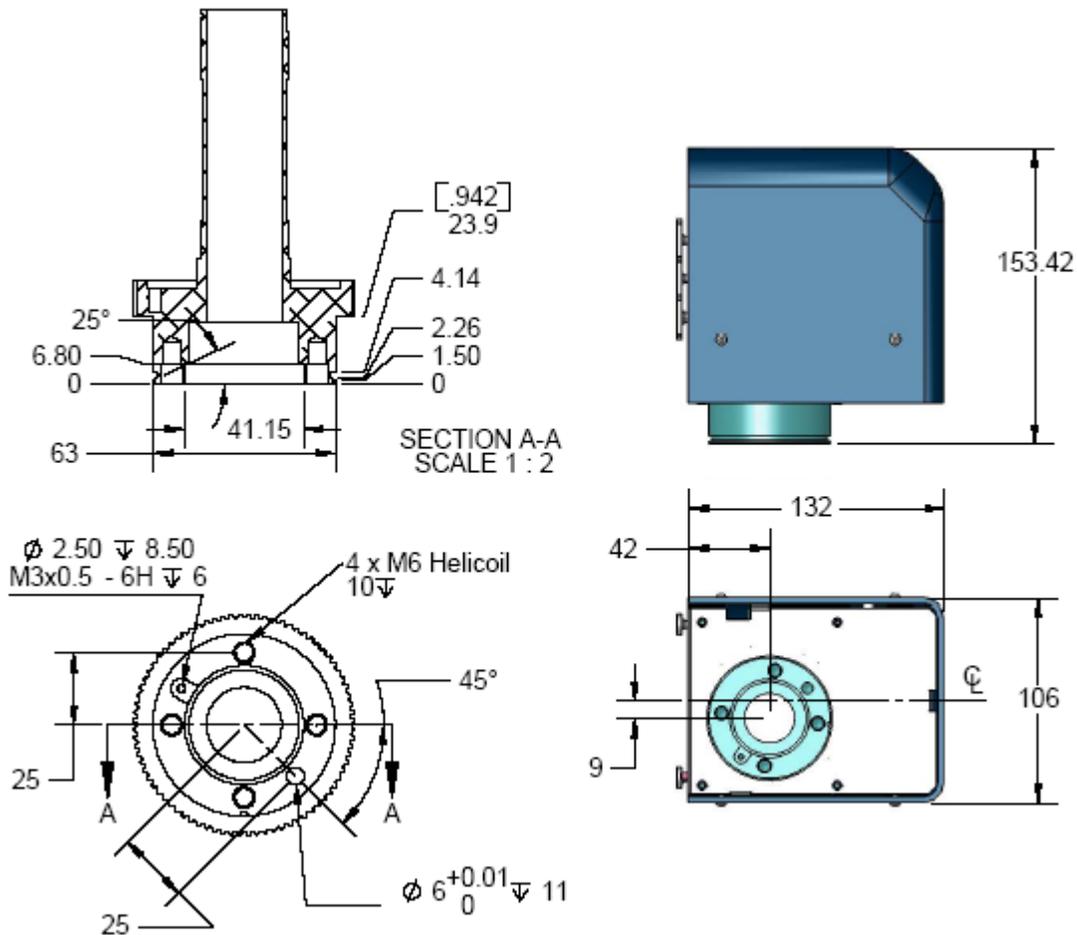
The Theta unit is mounted to the Z-Axis of the PrecisePlace 2400 using the T-slots in the face of the Z-axis as shown below. If required, the Theta unit can be vertically repositioned on the Z-axis, although this will change the Z-height of any taught locations.
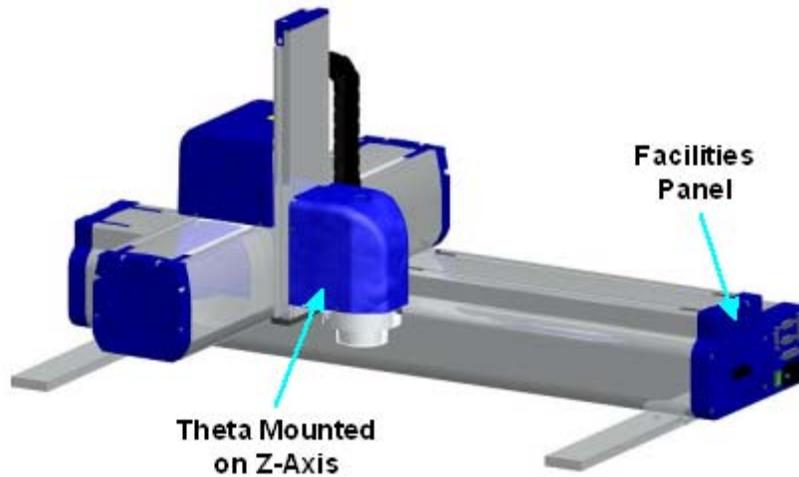
Accessing the Controller and Power Supplies

Although most of the controller interface signals are exposed on the Facilities Panel on the right end cap of the X-axis, there are times when it is necessary to access either the robot's controller or its power supplies. To access these components, the rear cover of the robot must be removed.

> **DANGER:** The Guidance 3400, the PrecisePower Intelligent 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 removal of the rear cover.**

For safety purposes, detaching the rear cover requires removal of four M4 screws that secure the cover to the X-axis end caps.

Once the rear cover is removed, 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 analog IO, optional DAC signals, etc that can only be accessed by removing the back cover.

Please see the *Guidance 3000/2000 Controllers, 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 PrecisePlace robots contain logic and motor power supplies that operate between 90 to 132 and 180 to 264 VAC, 50 or 60Hz. The robots are equipped with an IEC electrical socket that accepts country specific electrical cords. Power requirements vary with the robot duty cycle, but do not exceed 500 watts RMS.

Most 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.

In some cases the robot is equipped with a 500W PrecisePower Intelligent Motor Power Supply. This power supply is normally factory configured to operate the robot's motors at 320 VDC, which can be automatically generated with either of the AC input ranges. However, the robot's motors can optionally be operated at 160 VDC by selecting an alternate setting on the motor power supply provided that the input power is 90 to 132 VAC.

At the right end of the PrecisePower 500W Intelligent Motor Power Supply, there are three sets of jumper pins labeled "90-132V", "Auto", and "180-264V". A jumper must be placed across one of these sets of pins to select the power supply operating mode. The power supply includes a voltage doubling circuit. This circuit is activated when the jumper is placed across the "90-132V" pins, disabled when the "180-264V" jumper is installed, and automatically activated when a jumper is placed across the "Auto" mode pins. The output voltage range for each jumper is illustrated in the following table. This PrecisePower 500W supply is normally shipped with the jumper on the "Auto" setting to allow the robot to operate worldwide with the factory setting.

The following are the jumper settings for the PrecisePower 500W Intelligent Motor Power Supply:

AC input	90-132V Jumper	Auto Jumper	180-264V Jumper
90 to 132 VAC	253-372 VDC	253-372 VDC	127-186 VDC
180 to 264 VAC	Invalid setting	253-372 VDC	253-372 VDC

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 X-axis 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

X-Axis Facilities Panel

Facilities Panel

The right end-cap of the X-axis is the robot's Facilities Panel. This contains plugs and connectors for AC power, pneumatic air lines and electrical interfaces.
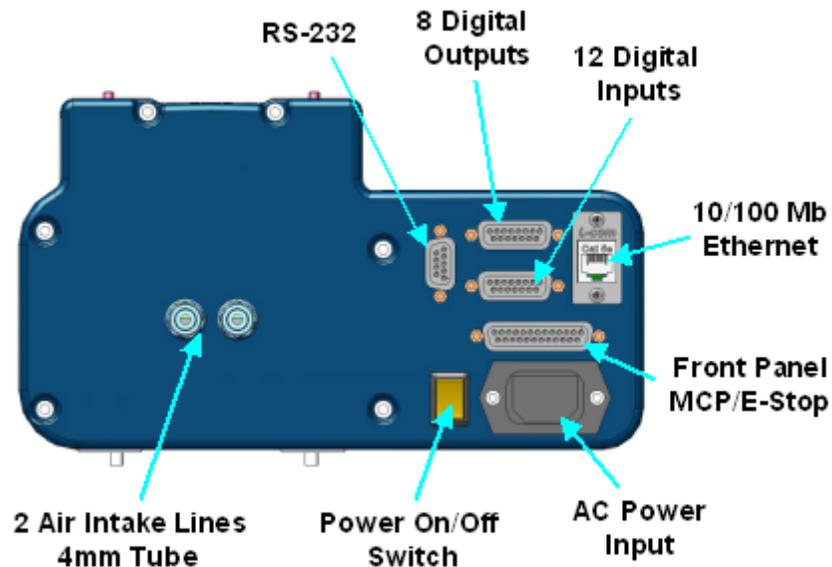
The AC input connector is an IEC power cord connector that mates with standard cables that can provide a wide variety of AC power plugs. The supported input voltage ranges are 90 to 132 VAC and 180 to 264 VAC, auto selecting, and the permitted input frequency is 50-60 Hz.   The AC power to the robot 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 under the X-axis rear cover, may contain additional 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 3400, 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 the back cover of the X-axis is removed.**

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 Z-axis E-Chain. 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 Z-Axis IO Board). These lines are accessed in a single DB15 connector.
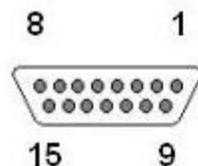
DB15 Female

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.

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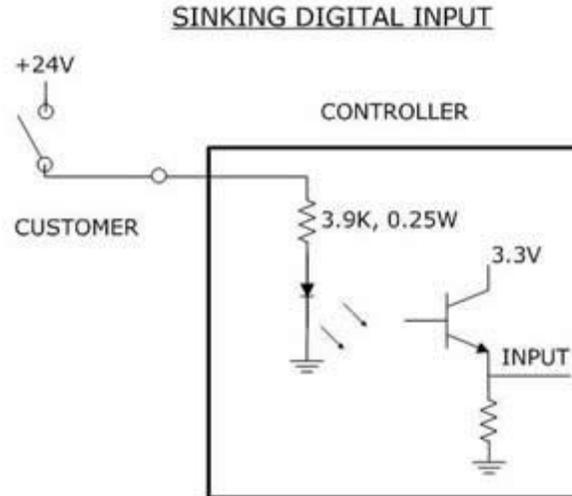
As shipped from the factory, the input signals are configured as "sourcing", i.e. the external equipment must pull a signal input pin to ground to indicate a logical high and must let the line <u>float high to 24VDC</u> to signal a logical low value. This configuration is compatible with "sinking" (NPN)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

SOURCING DIGITAL INPUT
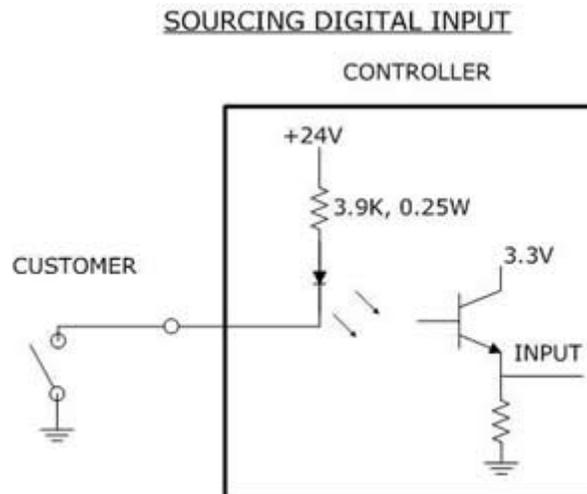
Inputs can be configured as sinking or sourcing in groups of 4 signals. To configure groups of input signals, the X-axis rear cover must be removed and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual.*

> **DANGER:** The Guidance 3400, 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 the back cover of the X-axis is removed.**

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 Z-Axis IO Board). 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.

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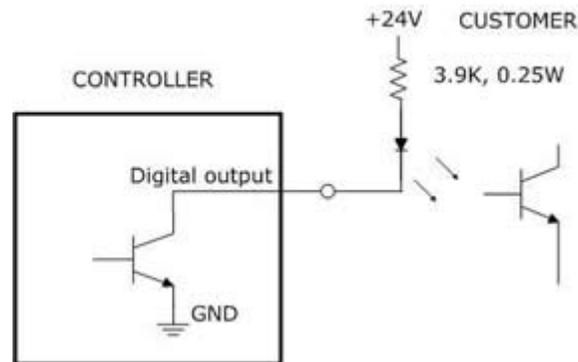
Alternately, the output signals can be configured as "sourcing", i.e. the external equipment must <u>pull down an output pin to ground</u> and the controller pulls this pin to 24VDC when the signal is asserted as true. This configuration is compatible with "sinking" (NPN) devices.

SOURCING DIGITAL OUTPUT
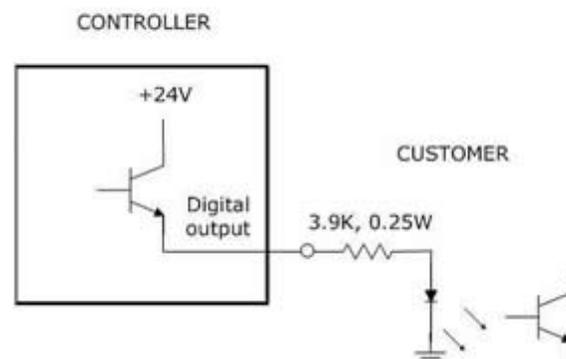
Outputs can be individually configured as sinking or sourcing signals. To configure the output signals, the X-axis rear cover must be removed and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference Manual.*

> **DANGER:** The Guidance 3400, 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 the back cover of the X-axis is removed.**

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) 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 X-Axis 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 Z-axis 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 for the Z-axis motor. Any device that is plugged into this cable, such as an Ethernet camera mounted on the Z-axis, 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
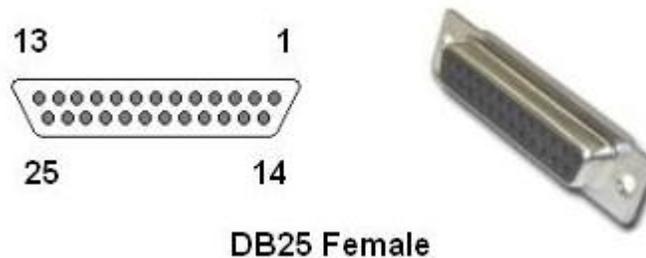
In the future, Precise will offer a Remote Front Panel option that plugs into this connector. Alternatively, customers can develop their own custom front panels (please see the section on "Safety Circuits For Remote Front Panel" in the *Guidance 3000/2000 Controllers, Hardware Introduction and Reference 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.

DB9 Female

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

X and Y Axes

The X and Y axes are each composed of an extrusion, a motor carriage, a linear encoder, linear bearings, covers, and end caps. Each motor carriage employs an innovative traction drive (U.S. Pat 7,343,684) and bearings (that are lubricated for the life of the product) to move along an extrusion. Each motor includes a rotary encoder for motor commutation. Separate linear encoders attached to the X and Y extrusions are used to determine the position of these axes. These linear encoders contain a periodic calibration code that is read when the axis is moved just a few millimeters during the robot "homing" process.

Each motor is attached to a friction wheel that is spring loaded against an extrusion. The spring tension is adjusted by means of a M4 Socket Head Cap "Tension Screw", shown below. Nominal tension is set at 5 complete turns of this screw for the X-axis and 4 turns for the Y-axis beyond the point where the friction wheel first touches the drive surface and the springs begins to compress. This provides about 100 Newton's of traction on the Y-axis and 160 Newton's of traction on the X-axis before the drive slips. Under normal operation, motor thrust should not exceed 80 Newton's peak on the Y-axis and 120 Newton's peak on the X-axis. After extended periods of time, it may be necessary to increase the spring load by one or two additional turns to compensate for friction wheel wear. This will be application dependent, but typically should not occur before 10,000 hours of operation. If the drive does slip, high power will be turned off automatically, and the robot will stop. In this case, the robot does not lose the homing reference, however, high power must be re-enabled. To continue from that point either a lower acceleration must be employed or the spring load may be adjusted. Commanding accelerations that result in more than these traction forces may cause slipping. These traction forces will allow about 0.6G of acceleration for the X-axis, and about 1G of acceleration for the Y-axis with a payload of 3kg.

The robot's wire and air harness is routed through the motor carriages. At each carriage, the motor and encoder signals for that carriage are terminated and all other lines are continued to the next axis.

The X-axis motor carriage and tension screw are shown below. The Y-axis carriage is very similar but only mates to a single linear bearing. To access either the X or Y carriage, its top cover must first be removed.

To remove the cover for either the X-axis or Y-axis to gain access to the motor carriage, perform the following steps:

1. Slide the carriage to one end of its travel.
2. Remove four screws in the end caps that attach the top cover extrusion to the end caps.
3. Slide the cover to one side to release the edge of the tape seal on the opposite side. The grooves in the cover that capture the tape seals are cut deep for this purpose.
4. Slide the cover in the opposite direction over the tape seal and extract the cover.

> **DANGER:** All of the motors for the PrecisePlace robot are operated at 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.
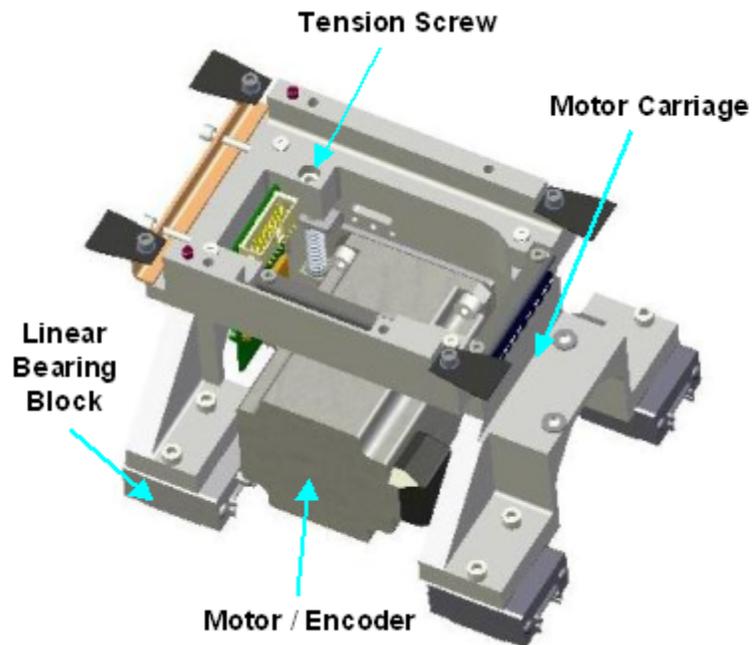
Z-Axis and Z-Axis IO PCB

The Z-axis is composed of a motor carriage, an extrusion, end caps, a sliding cover, and an IO Printed Circuit Board (Rev 2 version of the ZIO, "ZIO2"). The Z motion drive consists of a timing belt reduction

and main drive belt attached to the Z stage. The Z motor includes a fail-safe brake that can be manually released by pressing a button on the side of the ZIO2 Board.

The ZIO2 PCB serves as a connector board for motor and encoder signals and provides 8 isolated user digital input and 8 isolated user digital output signals. It also supports a robot power status light, and an optional power supply and connectors for the arm mounted Ethernet camera and ring light option. For I/O control, this board is connected to the robot's controller by an RS485 serial line that allows the I/O to be scanned with a nominal period of 4 milliseconds.

The following drawing illustrates the position of each of the key connectors on the board.

DANGER: A motor connector that provides a bus voltage of 320 VDC is positioned near the ZIO2. As such, accessing this board represents a high-risk and should only be performed when the main AC power to the robot is disconnected.
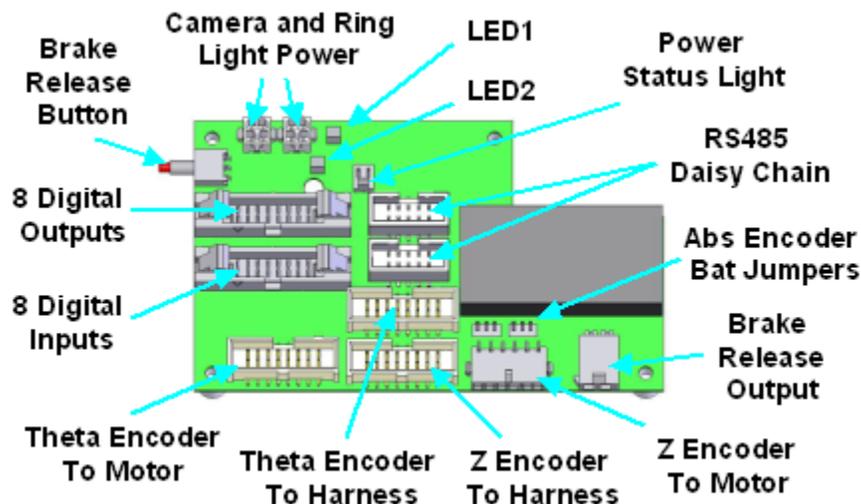
In the following table, each of the connectors is briefly described. For application interfaces, such as the digital output signals, pin assignments are described in detail in subsequent tables.

Connector	Description
Abs Encoder Bat Jumpers	On newer boards, these jumpers are present and are factory set depending upon whether the Z-axis has hall effect sensors or an absolute encoder that requires battery power.
Brake Release Button / Output	The Brake Release Output is wired to the fail-safe brake on the Z-axis motor. This brake prevents the axis from falling when power is off. Normally, this brake is automatically controlled by the system software. If the Brake Release Button is pressed, the brake can be manually released so long as power is provided to the robot's controller.
Camera Power / Light Power	If the optional Arm Mounted Camera Kit is purchased, these connectors provide power to the camera and the camera's ring light. The camera power is always available whenever the

	robot's controller is powered on. The ring light power can be turned on and off via software control. Two identical connectors are provided to simplify wiring.
Digital Inputs / Digital Outputs	These provide 8 optically isolated user input and 8 optically isolated user output signals. These signals are available to interface to tooling and sensors mounted on the end of the robot. These signals are described in detail below.
LED1 (Activity / Error)	Green - Blinks fast (about 10Hz) when the ZIO2 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.
Power Status Light	This connects to an LED mounted in the top of the Z-axis cover. When controller is first powered on, the LED will blink approximately once per second. When motor power is enabled, the blink rate will increase to 4 times per second.
RS485 Daisy Chain	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 ZIO2 board. Two identical connectors are provided to permit the RS485 signals to be daisy-chained to other RS485 devices mounted on the end of the robot.
Theta Encoder To Harness/Motor	These are two pass through connectors that interface the Theta (4th) axis encoder to the appropriate signals in the robot harness. The Theta encoder internal harness connector should be plugged into the "To Harness" board connector. If a Theta axis is present, its encoder should be plugged into the "To Motor" connector.
Z Encoder To Harness/Motor	These are two pass through connectors that interface the Z (3rd) axis encoder to the appropriate signals in the robot harness. The Z-axis encoder internal harness connector should be plugged into the "To Harness" board connector. The Z-axis encoder should be plugged into the "To Motor" connector.

The 8 isolated digital input and 8 isolated digital output signals provided on the ZIO2 are intended for interfacing to tooling and sensors mounted on the end of the robot or for other general application needs. These DIO signals are in addition to those available on the X-axis Facilities Panel of the robot. These signals are provided in two 16-pin connectors:
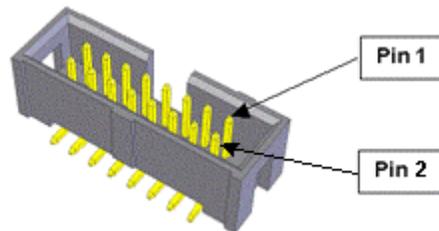
The 8 digital input signals are configured as "sinking". That is, the external equipment must pull an input high to <u>5VDC to 24VDC</u> to indicate a logical high value or must allow it to float to no voltage for a logical

low. For convenience, 24VDC is supplied on the digital input signal connector. These inputs are compatible with "sourcing" (PNP) sensors.
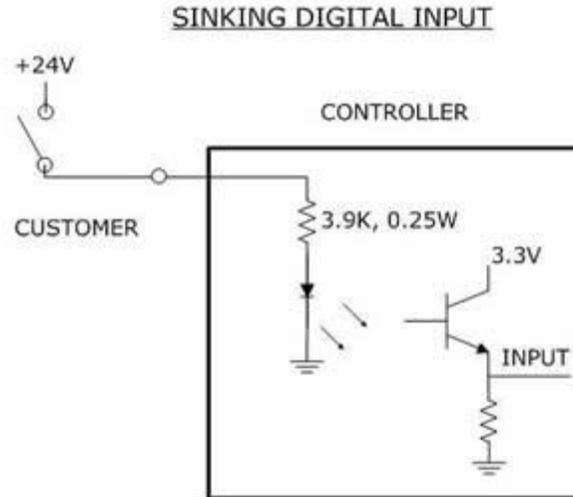
The 8 digital output signals are configured as "sourcing". That is, the external equipment must <u>pull down an output pin to ground</u> and the ZIO2 pulls this pin to 24VDC when the signal is asserted as true. Each output signal can supply a maximum of 100mA. For convenience, ground pins are supplied on the digital output signal connector. These outputs are compatible with "sinking" (NPN) devices.
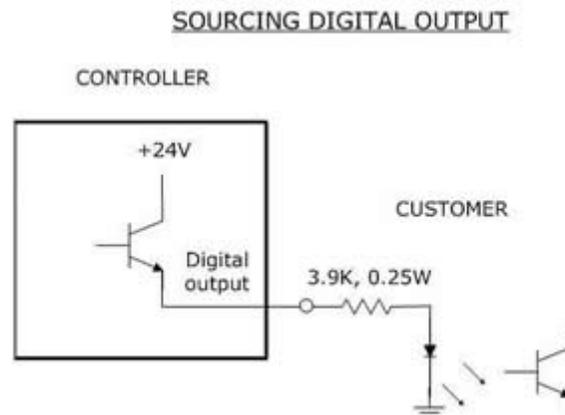
The pin assignments for these two connectors are defined in the following tables along with the signal numbers used to reference these signals from GPL and the part number for the required hardware plugs.

> NOTE: As of November 2008, the ZIO board's Digital Input 8 failed the CE 10 volts per meter Radiated RF Immunity test. Therefore, until this has been corrected, for CE applications, only ZIO inputs bits 1-7 may be used

Pin	GPL Signal Number	Description
1	10033	Digital Input 1

2	10037	Digital Input 5
3	10034	Digital Input 2
4	10038	Digital Input 6
5	10035	Digital Input 3
6	10039	Digital Input 7
7	10036	Digital Input 4
8	10040	Digital Input 8
9 to 16		24 VDC
User Plug Part No		Amp 746285-3 or Molex 22-55-2161 or Molex 90142-0016. For the Molex plugs, use Molex pins 16-02-0103 and Molex crimp tool 63811-1000.
High Flex Cable		A high flex cable should be used to ensure long life. We recommend 3M Round Conductor High Flex Life Flat Cable, 28 AWG stranded, PVC, 3319/16 or Amphenol Spectra-Flex high flex life flat cable 843-191-2811-016.

Pin	GPL Signal Number	Description
1	33	Digital Output 1
2	37	Digital Output 5
3	34	Digital Output 2
4	38	Digital Output 6
5	35	Digital Output 3
6	39	Digital Output 7
7	36	Digital Output 4
8	40	Digital Output 8
9 to 16		Ground
User Plug Part No		Amp 746285-3 or Molex 22-55-2161 or Molex 90142-0016. For the Molex plugs, use Molex pins 16-02-0103 and Molex crimp tool 63811-1000.
High Flex Cable		A high flex cable should be used to ensure long life. We recommend 3M Round Conductor High Flex Life Flat Cable, 28 AWG stranded, PVC, 3319/16 or Amphenol Spectra-Flex high flex life flat cable 843-191-2811-016.

There are two four-pin connectors that provide power for an Ethernet camera and camera ring light if the Arm Mounted Camera Kit is installed.
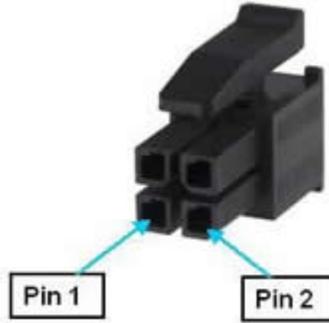
The pin assignments for these connectors are defined in the following table along with the part number for the required plug type.   Two connectors provide identical signals as a wiring convenience.

Pin	GPL Signal Number	Description
1		12VDC for powering camera, 1.25A total current is shared between two connectors.
2		Ground
3	8039	9VDC for powering ring light. Enabled and disabled via a dedicated system IO signal or via the robot ZIO control panel in the Web Operator Interface. 1A total current is shared between two connectors.
4		Ground
User Plug Part No		AMP 794617-4. Use an AMP 91501-1 hand crimp tool and AMP 794610-3 sockets for wiring to the plug.

Arm Mounted Camera Kit

In applications where it is advantageous to mount a camera on the Z-axis of the PrecisePlace robot, Precise offers an optional Arm Mounted Camera Kit for mounting an Ethernet camera. This kit includes the following items:

- A ring light that has both a power switch and a brightness potentiometer
- A mounting bracket for the ring light
- A mounting bracket for an Ethernet camera (the camera and its lens must be ordered separately)
- An enhanced ZIO board that includes power supplies for the ring light and camera
- Power cables from the enhanced ZIO to the ring light and camera
- A short Ethernet cable and coupler to interface the camera to the Ethernet plug available under the ZIO cover
- Mounting hardware

The camera mounting bracket and the ring light with mounting bracket are pictured below.

Camera and lens sold separately
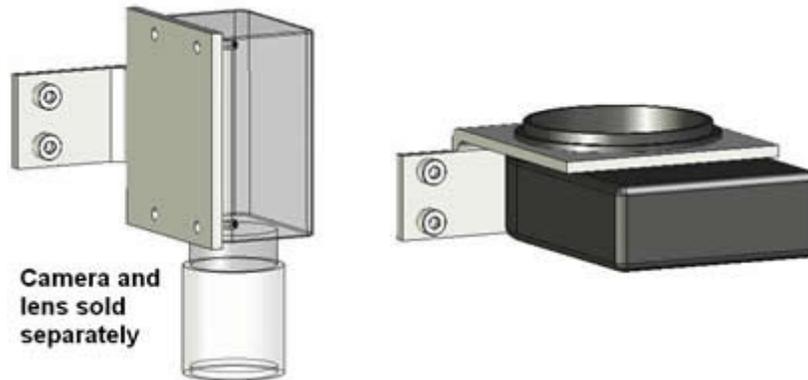
The enhanced ZIO board includes two identical connectors that provide 12VDC, 9VDC and ground for powering the camera and ring light. The camera and ring light power cables can be plugged into either connector. The 9VDC power for the ring light is enabled by a software IO signal (8039), and can be turned on and off under GPL program control. This signal can also be controlled via the robot ZIO panel in the Web Operator Interface.

A short Ethernet cable and coupler are provided for interfacing the camera to the Ethernet plug available under the ZIO cover. If a metal coupler is used, the metal shell will be grounded, and this shell should be insulated with vinyl tape or shrink tubing to prevent it from contacting any circuits on the ZIO board.

All cables should be routed through the E-Chain provided on the Z-axis, and tied down at both ends.

The most common method for attaching an arm-mounted camera is shown below. In this configuration, the camera is offset from the center of the Z-axis to avoid having the robot's tooling obstruct the camera's field of view. The camera bracket is attached to the T-slots on the face of the Z-axis and extended outboard of the Z-axis. The ring light and its bracket are attached to the T-slots under the camera bracket.
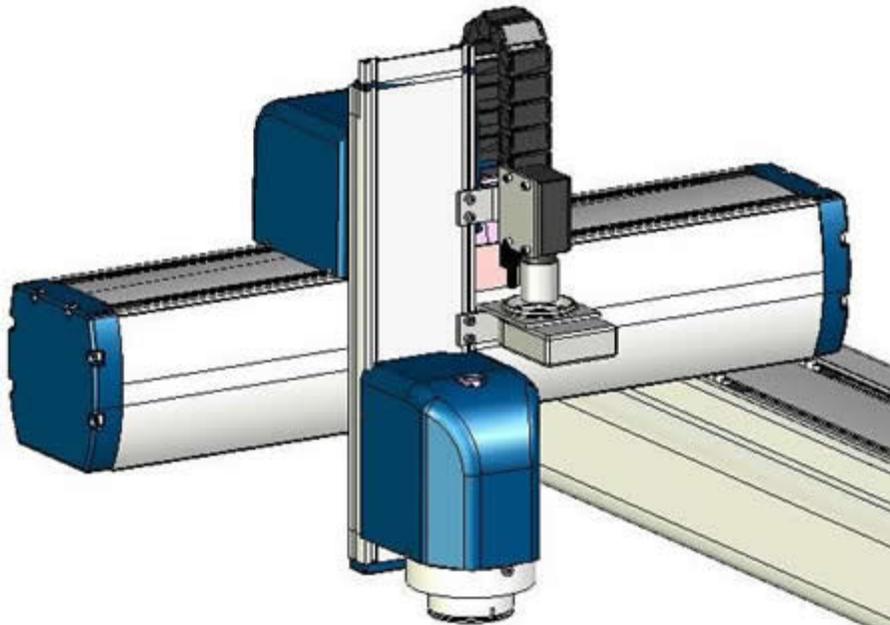
An alternative configuration for mounting the arm-mounted camera is shown below. In this scheme, the camera is mounted directly over the through hole in the Theta axis and can look through the Theta axis. The camera is attached to its mounting bracket that is in turn attached to the T-slots on the front face of the Z-axis. In this case, the bracket extends towards the center of the Z-axis.
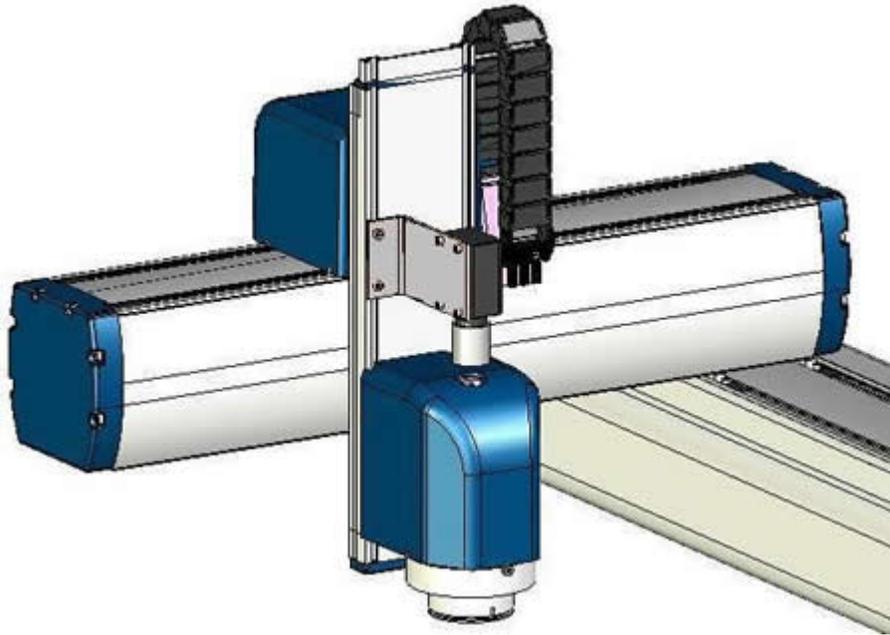
This configuration is used for high-precision alignment of small parts where both the part and key features required for its alignment must be viewed by the camera in the same image at the same time (visual servoing). In this configuration, the ring light typically cannot provide adequate lighting if it is placed above the Theta axis, and often some special lighting must be implemented. The normal field of view is very small due to the Theta axis hole size and the typical desire for very high accuracy.

Software Reference

Controller Software Extensions

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

Z-Axis General Digital Inputs and Outputs

The Z-Axis IO (ZIO2) 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. 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.

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

Signal Number	I/O	Label	Description
33	O		Z I/O board output 1
34	O		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

Z-Axis Dedicated Digital Outputs

The Z-Axis IO (ZIO2) 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 Z-axis status lamp (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		Z-axis status lamp. Set to 1 to turn on the lamp. Normally parameter "Power State DOUT" (DataID 235) is set to this signal number so that the Z-axis lamp displays the robot power state.

Service Procedures

Trouble Shooting

Symptom	Recommended Action
System error message generated	
"Amplifier Fault"	Slow down the robot. Check harness and motor for shorts.
"Encoder quadrature error"	For errors on the X or Y axis (joints 1 or 2): Clean linear scale with denatured alcohol
	Replace the motor/encoder
"Excessive dual encoder slippage"	Tighten M4 Tension screw one turn, lower acceleration
"Illegal zero index"	See "Encoder quadrature error"
"Missing zero index"	See "Encoder quadrature error"
"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.
"Clunking" when reversing direction	Remove carriage. Check motor suspension plate mounting screws. Screws should be tight enough to allow motor spring tension to work, but not loose. If loose, apply Loctite and re-tighten.
Mechanical noise from carriage	Check carriage bearings for failure

Setting the Encoder Zero Positions

Cal_PP is a service program that must be run to set the zero positions of the X and Y axis linear scales, and the Z and Theta motor encoders. The zero positions must be re-established if the X or Y axis linear scales or the Z or Theta motors are replaced or if the absolute encoders for the Z or Theta motors lose battery power.

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

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

1. Enable power to the robot's controller, but do not turn on power to the motors. **This procedure should initially be executed with motor power disabled.**
2. Load Cal_PP into the controller's memory using either the Guidance Development Environment (GDE) or the web Operator Control Panel.
3. Manually move the X and Y axes to a position more than one zero index away from their lower hard stop limits. As you face the robot with the power cord on the right, the X-axis lower stop limit is to the far right, the Y-axis lower stop limit is with the axis fully retracted, and the Z-axis lower stop limit is with the axis all of the way up. For the X and Y axes, a zero index distance is approximately 10 mm. Positioning an axis further away will not cause a problem but a shorter distance may cause this procedure to fail.
4. Manually move the X, Y and Z axes to their lower hard stop limits. This motion will ensure that at least one zero index for the X and Y axes is detected by the controller. The final location of each axis will define the physical position that will correspond to their lower hard stop positions.
5. If the robot is equipped with a Theta axis, remove the theta axis cover and align the hole in the large pulley with the hole in the frame by inserting a 4mm diameter dowel pin through both holes. This will define the zero position for the Theta axis. This dowel pin is supplied with the Belt Theta Axis.

Calibration dowel pin. Sets zero position of Theta for CalPP
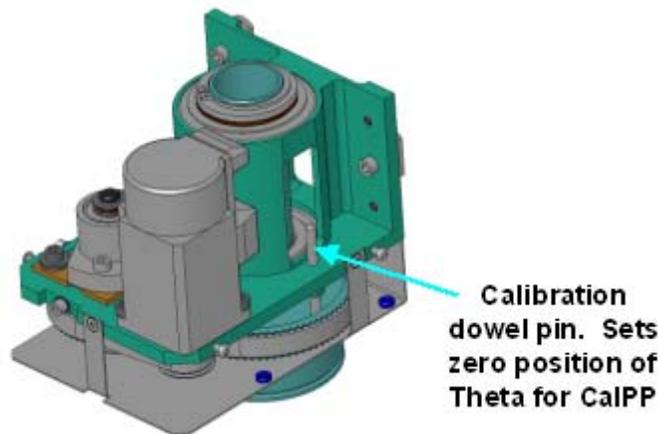
6. Execute the Cal_PP program using GDE or the web Operator Control Panel. This program will execute in just a few minutes. During this time, it will compute the data required by the homing operation and will initialize the homing data stored on the flash disk and in the multiple turn counters for any absolute encoders. **While this program is executing, several pop-up displays will appear either within GDE or on the Operator Control Panel.** Please follow the provided instructions and correct any errors that may occur.
7. Enable the power to the robot's motors and execute the homing sequence. The new encoder zero positions will take effect when 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 in the controller's flash memory and the multiple turn counters for any absolute encoders.

Replacing the Absolute Encoder Battery

For newer robots, the Z-axis and Theta-Axis motors have absolute encoders. These devices accurately retain the position of their associated axes even when the robot is powered down. For this function, the encoders must be provided with power from a battery when AC power to the robot is off. This battery is located in the controller section behind the X-axis beneath the rear cover. This battery should provide 3 years of backup power to the absolute encoders with the robot powered off. If this battery voltage drops to a certain threshold, the system generates a warning message on the console stating "Low battery voltage". At this point the battery should be replaced within one or two weeks.

The following are the instructions for replacing the battery.

> **DANGER:** The Guidance 3400, the PrecisePower Intelligent 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 removal of the rear cover.**

1. After AC power has been off for a sufficient period to permit the high voltage capacitors to bleed down, remove the rear cover of the X-axis to expose the control components.
2. The encoder battery is a C cell plugged into one of two pigtail connectors in a short harness that plugs into the controller. Plug a new C cell into the free pigtail connector first, then unplug the old battery. This procedure ensures that battery power is always connected to the encoders and avoids needing to reset the zero position of the absolute encoders.
3. Replace the rear cover of the X-axis.

X & Y Linear Scale Cleaning and Replacement

Excessive dust or oil on the linear encoder scales can cause Quadrature or Zero Index Errors. The scales can be cleaned with a lint-free cloth and denatured alcohol. The scales can usually be cleaned without removing them.

> NOTE: Do not use rubbing alcohol as this typically contains 30% water and can leave a film as it evaporates.

The scales can be removed and replaced by removing the vinyl spline retaining the scale in the extrusion. A new scale may be cut to length with a pair of scissors. When a scale is replaced, care must be taken that the emulsion side is facing the back side of the robot on the X-axis (the controller side) and facing the side of the Y-axis opposite the Z-axis. The emulsion side is the side from which the Precise Automation label can be read correctly. It is opposite the stainless steel band side. So in the case of the X-axis, you should be able to read the Precise Automation label when standing behind the robot by the controller and, in the case of the Y-axis, when standing on the side facing the Z-axis. In both cases, the vinyl spline should be pressing against the side with the stainless steel band.

To install an encoder scale, move the carriage to one end of its travel and slide the scale into the groove in the extrusion and through the carriage. You may need to wiggle the scale a bit as it goes through the carriage to get the scale through the encoder read head gap. Once the scale is lying in the encoder groove, position the scale so that the read head does not run off the end of the scale at either extreme of travel of the carriage. Then install the spline by pressing it down into the groove on the non-emulsion side of the scale.

> NOTE: Press the spline down vertically, don't stretch it by running your thumb down the spline – this can cause the scale to creep.

The spline can be installed in several pieces. Typically the carriage is moved to one end of travel and a length of spline installed in the groove that is not under the carriage, then the carriage is moved down and a second piece of spline installed in the groove that was under the carriage.

When a linear scale is removed, it is necessary to re-establish the encoder zero positions in order for the homing sequence to work properly. See the section below for instructions on executing the Cal_PP program to set the encoder zero positions.

Removing the X-Axis Carriage

In order to change the motor or bearings on the X carriage, it is necessary to remove the X carriage. This can be done without removing the Z-axis and Y carriage from the Y-axis.

Prior to performing this procedure, you should obtain four 15mm bearing ball retainer blocks from Precise Automation customer service.

> **DANGER:** All of the motors for the PrecisePlace robot are operated at 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 remove the X carriage, perform the following steps:

1. Remove the X and Y covers by removing four M4 screws from the end caps. (For detailed instructions, please consult Hardware Reference > X and Y Axes.)
2. Remove the two M3 screws holding the tape seal tension bars against both the X carriage and the Y carriages.
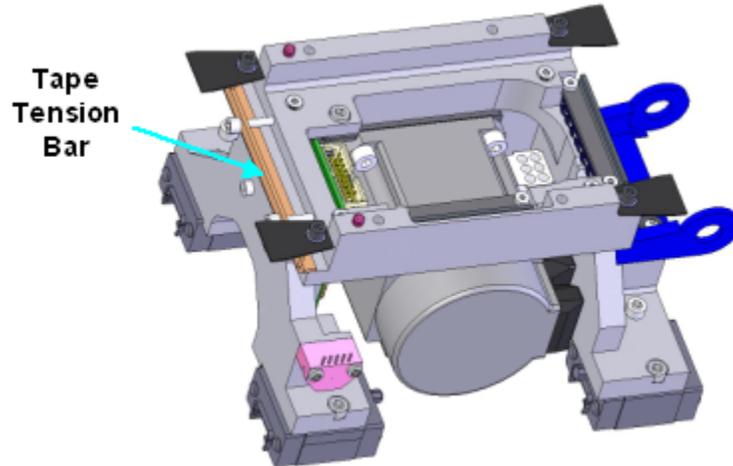
Tape Tension Bar

3. Remove the tape seals from the tension bars.
4. Remove the left X end cap (opposite the power cable) by removing four M4 SHC machine screws.
5. Remove the Y end cap closest to the X-axis.
6. Place a support under the Y-axis so it does not drop when it is detached from the X-axis.
7. Remove the Y-axis from the X carriage by removing four M4 X 12mm Socket Head Cap Screws.
8. Slide the Y-axis forward away from the X-axis taking up slack in the harness service loop in the Y-axis.
9. Remove the X-axis carriage cover by removing four M3 X 6mm Button Head Screws.
10. Unplug the X motor and X encoder from the harness.
11. Remove the input harness clamp where the harness enters the X carriage by removing two M3 X 12mm Socket Head Cap Screws.
12. Remove the output harness clamp from the X carriage by removing two M3 X 10mm Socket Head Cap Screws.
13. Lift the harness out of the X carriage.
14. Pick up the entire Y, Z and Theta axis assembly and lay it down in front of the X-axis with the end of the Y-axis close to the left end of the X-axis. This will allow the harness to lay flat as it comes out of the end of the X-axis.
15. Slide the X carriage out of the left end of the X-axis, inserting four 15mm bearing ball retainer blocks into the bearings as the carriage bearing blocks slide off the linear rails

Installing and Adjusting the X-Axis Carriage

To install the X-axis Carriage into the X-axis, perform the following procedure.

> **DANGER:** All of the motors for the PrecisePlace robot are operated at 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. In preparation for installing the X-carriage into the X-axis, first verify that the M4 Socket Head Cap "Tension Screw" (illustrated in Hardware Reference > X and Y Axes) is backed out enough so that the friction wheel is not in compression when the carriage is installed. The X motor should be able to slide against the end of the adjustment slot in the motor mounting tab and the tension screw should not project more than 2 mm beyond the back of the motor tension flange.
2. Slide the X carriage into the X-axis, removing the bearing retainer blocks as the carriage slides onto the linear rails.
3. When the carriage is installed and the motor friction wheel is not engaged, it should be possible to push the carriage along the axis with between 5 to 10 Newton's (1 to 2 lbs) of force. If the force is higher than this, it is likely the bearings are not aligned properly.
4. To engage the traction drive, the motor tension adjusting screw should be tightened until the friction wheel touches the drive surface and the spring starts to compress, and then turned 5 more full turns.

Once the robot has been reassembled, the tension adjustment and friction can be checked by turning on the robot and pushing on the X-axis quickly (less than 2 seconds) with a force gauge with a force of 120 Newton's or 24lbs. The X motor should resist this peak force for a period of 2 seconds, and then a "Duty Cycle Exceeded" Error will be generated and power should be automatically turned off. If the friction wheel slips before 120 Newton's of force is reached, the tension screw should be tightened one half turn at a time.

Removing and Installing the Y-Axis Carriage

In order to remove the Y-axis carriage, perform the following procedure.

Note, prior to performing this procedure, you should obtain two 24mm bearing ball retainer blocks from Precise Automation customer service.

> **DANGER:** All of the motors for the PrecisePlace robot are operated at 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 Z-axis cover.
2. Unplug the Z-axis cables.
3. Remove the three M4 Screws attaching the Z-axis to the Y-axis carriage and detach the Z-axis.
4. Remove the Y-axis cover. (For detailed instructions, please consult Hardware Reference > X and Y Axes.)
5. Remove the two M3 screws holding the tape seal tension bars against the Y carriage. (See Removing the X-Axis Carriage for an illustration.)
6. Remove the tape seals from the tension bars.
7. Remove the Y end cap opposite the X-axis.
8. Remove the harness from the Y carriage in a manner similar to the X carriage.
9. Slide the Y carriage out the end of the Y-axis, inserting two 24mm bearing ball retainer blocks into the bearings as the carriage bearing blocks slide off the linear rails.

Installing the Y carriage is similar to installing the X carriage, however the Y force is typically 80 Newton's.

Replacing the X and Y Motors

The X and Y motors are similar. The X motor is a 200-watt motor and Y motor is a 100-watt motor. These motors can be replaced by first removing the appropriate carriage and then removing the four M5 bolts attaching the motor to the motor suspension plate.

> **DANGER:** All of the motors for the PrecisePlace robot are operated at 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.

Replacing the X and Y Encoder Read Heads

The X and Y axes use a dual encoder system with one encoder read head on the motor carriage for position information and a second encoder/read head in the motor for motor commutation and control. These two encoder read heads each has a cable terminated in a 5-pin connector. These two connectors plug into a 10-pin header mounted on a PCB that is attached to the motor carriage. The motor read head connector plugs into the header pins furthest away from the PCB and closest to the motor. The linear encoder read head connector plugs into the pins closest to the surface of the PCB.   Pin 1 for both 5-pin connectors (denoted by small arrows on the connectors) is plugged into the pins closest to the encoder end of the motor.
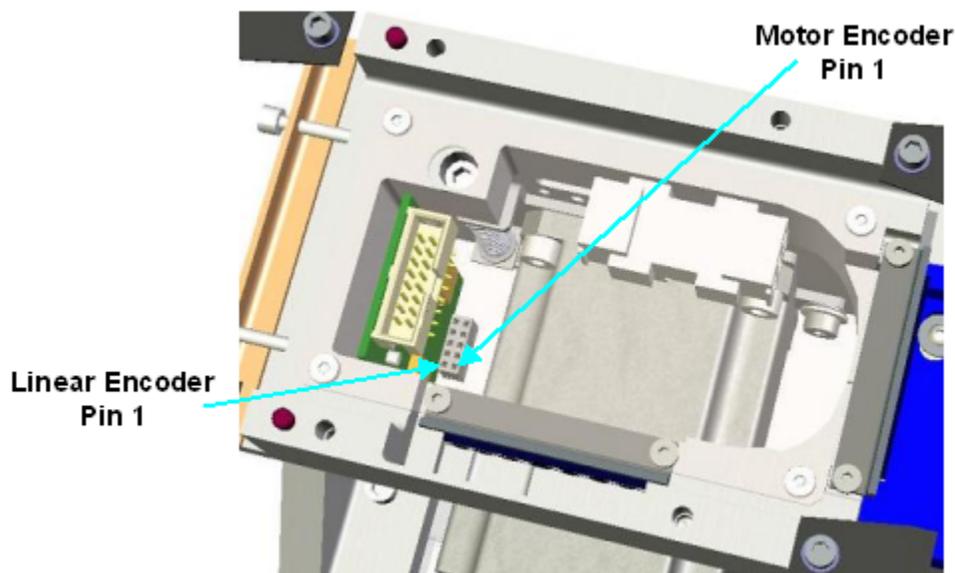
> **DANGER:** All of the motors for the PrecisePlace robot are operated at 320 VDC. As such, the motor wires present a high-risk and unshielded pins and conductors should not be touched unless the main AC power to the robot is first disconnected.

Replacing the X and Y Axis Bearings

The X-axis includes two 15mm square bearing rails mounted on the extrusion and four bearing blocks attached to the carriage. The rails are secured by M4 screws and T nuts. In the unlikely event that it is necessary to replace these bearings rails, perform the following procedure.

1. Remove the X carriage. (See the section on Removing the X-Carriage for details.)
2. Remove the linear bearings.
3. Remove the bearing blocks from the carriage.
4. Install new bearing blocks on the carriage with the bearing blocks pressed against the reference bosses on the bearing mounting flanges. This sets the bearing spacing and alignment and ensures the bearing blocks are parallel to each other.
5. Install the linear rails with the linear rail at the front of the robot (farthest from the control section) pressed against the reference boss to align it. The linear rails have a small arrow engraved on the top surface that indicates the reference edge of the linear rail. This is the edge that should be pressed against the reference boss.
6. Set the spacing of the second rail by sliding the carriage along the rails and tightening the second rail.

When properly installed and aligned, there should be no binding as the X carriage slides along the rails.

The Y bearings run on a single rail that rests on a reference boss and are replaced in a similar manner to the X-axis.

Replacing and Adjusting the Z Motor and Z-Axis Bearings

The Z-axis is driven by timing belts. The Z motor assembly includes a motor, brake, encoder and timing belt drive pulley in a single unit. It can be replaced by loosening the motor bracket retaining screws, loosening the timing belt tensioning screw and removing four M5 screws from the motor tensioning bracket.

The tension for the motor timing belt should be set at 6lbf or about 27N, using a belt tension meter. As an alternative to using a belt tension meter, the belt should deflect 3mm when an 18N (4lb) force is applied halfway between the two pulleys. The tension of the 40mm wide final drive belt should be set at 27lbf or 122N. As an alternative to using a belt tension meter, with the Z axis at the top of its stroke, you may insert a flat blade behind the middle of the 40mm wide belt, and press on the blade at a distance of 150mm with a force of 18N (4lb). The middle of the belt should deflect about 6mm.

> ⚠ **DANGER:** All of the motors for the PrecisePlace robot are operated at 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.
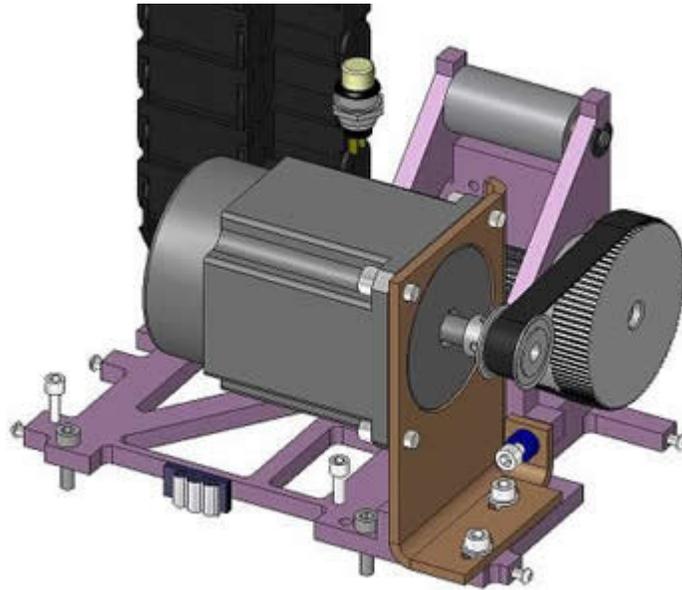
The Z drive main belt tension can be adjusted by tightening two tensioning screws in the upper Z end cap. If the Z belt or Z bearing needs to be replaced, these screws must be removed. Then the upper Z end cap must be removed. At this point the Z bearing block and Z linear rail may be removed and replaced.

Z Belt Tension Screws   Z Belt Clamp

Z Bearing Screws
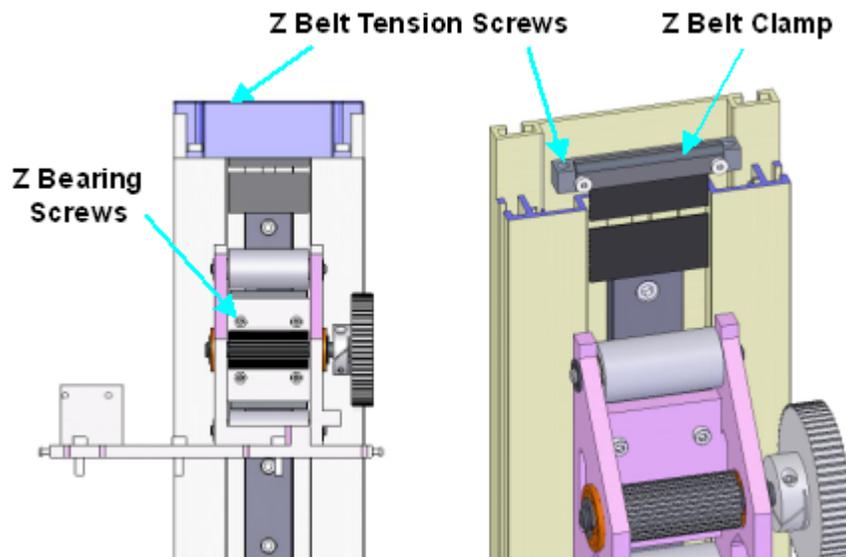
Appendix A: Product Specifications

PrecisePlace 2300/2400 Specifications

General Specification	Range
Range of Motion & Resolution	
X-Axis	Configurations from 500 mm to 1000 mm
Y-Axis	Configurations from 200 mm to 600 mm
Z-Axis	240 mm
Optional Theta Axis	+/- 360 degrees
Resolution	+/- 0.008 mm in X, Y, and Z standard +/- 0.002 mm in X, Y, and Z available with high resolution option
Repeatability	+/- 0.050 mm, 68–78 degrees F, limited by aluminum structure expansion
Performance and Payload	
Maximum acceleration	0.6G
Maximum speed	2000 mm/sec
Z Force	Continuous upwards Z force - 60N Continuous downwards Z force - 80N
Payload	PrecisePlace 2300: 5 kg for Y lengths <= 400mm, 4 kg for Y > 400mm PrecisePlace 2400: 3.5 kg for Y lengths <= 400mm, 2.5 kg for Y > 400mm
Controller	
Embedded Controller	*AVAILABLE GUIDANCE CONTROLLERS*: Guidance 3410A (G3XD-EA-A3410), Guidance 3414A (G3XD-EA-A3414), Guidance 3416A (G3XD-EA-A3416)
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 X-axis end cap. 8 additional slower isolated inputs configured as sinking provided on the Z-axis. 　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 X-axis end cap. 8 additional slower isolated outputs configured as sourcing provided on the Z-axis.
	  24VDC maximum pull up if sinking
	  24VDC supplied if sourcing
	  100mA maximum per channel for all channels, except 500mA maximum for channel 1 on X-axis end cap.
	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 included on controller 4 or 6 analog outputs optionally available on controller
Pneumatic Lines	Two air lines, each 75-PSI maximum, provided at Z-axis drive and routed internally to fittings on the X-axis end cap.
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	30 kg typical, will vary with size

PrecisePlace 2300/2400 Environmental Specifications

The PrecisePlace 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 PrecisePlace 2300/2400 robots.

A. Robot Hardware

A. Robot Software

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.
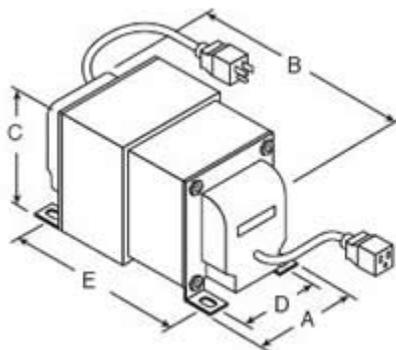
Robot Software

How do you switch between a 3 and 4 axis configuration?

The Theta axis for the PrecisePlace robot is designed to be easily added or removed from the robot in the field. You may need to do this if you find that your application unexpectedly needs to accommodate part rotations or if you need additional Z payload capability and the theta is not required.

The procedure for mechanically installing or removing the Theta axis is described elsewhere. This document presents instructions for reconfiguring the software for this change.

The system software that is already loaded into your controller will operate either the PrecisePlace 2300 or 2400 robot. To change the robot type, you simply need to provide new configuration information in the form of the "Configuration and Parameter Database Disk Files", i.e. the PAC files.

Before superseding the configuration files in a controller, it is strongly recommended that you first either copy the controller's configuration to a host computer or use the web interface to create a backup set of configuration files in the flash disk.

When you are ready to load the new configuration files to your controller, please perform the following procedure.

1. Obtain the PAC files for the new robot configuration. These can normally be found on the "Guidance Controller System Software CD" that came with your system. The files are located in the PAC folder in the subfolder with the name of the robot that you wish to configure. Alternately, you can contact Precise for the appropriate files.
2. Start up GPL on your Guidance controller.
3. Connect to the controller using a web browser and login.
4. Click on the tab labeled "Utilities".
5. Click on the words "Backup and Restore" in the left-hand panel.
6. Click the button "Start File Manager" to open a FTP window. This should open the /flash/ folder.
7. Double click the "config" folder to display its contents.
8. Open the folder that you identified in Step #1 that contains the new configuration files.
9. Drag the **"robot01.pac"** and the **"calib01.pac"** file from the host computer folder to the controller's FTP window and drop them.
10. Wait until the copy operation is completed.

> **WARNING: Always wait 10 seconds after writing to the flash before you power down the controller, otherwise, you may corrupt the flash disk.**

11. Close the FTP window and return to the "Backup and restore" panel.
12. Restart the controller to put the new configuration information into effect.

At this point, your robot will be operational, but the zero positions for each of the axes will be incorrect. To set the zero positions, please see the *"PrecisePlace 2300/2400 Robot, Hardware Introduction and Reference Manual"* for instructions on executing the Cal_PP procedure.

Appendix C: Spare Parts Lists

Description	Part Number
805mm Linear Encoder Scale Assembly	PP20-MA-E0001
1090mm Linear Encoder Scale Assembly	PP20-MA-E0002
Linear Encoder Read Head Assembly	PP20-MA-E0003
X Motor Assembly	PP2A-MA-00003
Y Motor Assembly	PP2A-MA-00004
Z Motor Assembly (with Absolute Encoder)	PP23-MA-00011
Theta Motor Assembly (with Absolute Encoder)	PP24-MA-00003
15mm X Carriage Bearing Block	PP11-MC-B0000
15mm Bearing Ball Retainer Block	PP11-MC-B0004
15mm X Linear Bearing Rail (specify stroke)	PP11-MC-B0001
24mm Y Bearing Block	PP22-MC-B0002
24mm Bearing Ball Retainer Block	PP22-MC-B0003
Y Linear Bearing Rail	PP22-MC-B0001
Z 24mm Carriage Bearing Block	PP23-MC-B0001
Z 24mm Bearing Ball Retainer Block	PP23-MC-B0003
Z 24mm Linear Bearing Rail	PP23-MC-B0002
G3410A Controller (G3410A, G3414A or G3416A)	G3XD-EA-A3410, G3XD-EA-A3414 or G3XD-EA-A3416
PrecisePower 500W Intelligent Motor Power Supply	PS10-EA-00500
PrecisePower 300W Intelligent Motor Power Supply	PS1D-EA-00300
125 Wt 24VDC Power Supply	PS10-EP-00125
PP 2300 ZIO Board	PP13-EA-00001
Dual Encoder Buffer Board	PP1A-EA-00001
Encoder Battery with Pigtails (size C cell)	PF10-EA-00002
Fuse, PrecisePower 500W Motor Power Supply	Wickman PN 1811630000
Fuse, PrecisePower 300W Motor Power Supply	Wickman PN 1941630000
Z-axis T nuts, M4	Misumi PN HNTTBS5-4
Mounting Plate	PP11-MC-M0006

Appendix D: System Schematics

24V POWER SUPPLY

CN4	GND	1	
	GND	2	→ TO 24VDC FAN
CN1	GND	3	→ TO CONTROLLER
AC/L1	GND	4	
	+24V	5	
AC/L2	+24V	6	→ TO CONTROLLER
	+24V	7	→ TO 24VDC FAN
	+24V	8	

LINE FILTER   SWITCH
L1
L2
N

300W/500W HV POWER SUPPLY

J4	GND	1	
	+24V	2	
	HIPWRRLYON	3	← FROM CONTROLLER
AC/L1			
AC/L2	DC+		→ TO CONTROLLER
	DC-		→ TO CONTROLLER
	DC+		→ TO CONTROLLER
	DC-		→ TO CONTROLLER

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.**

DANGER: The PrecisePower Intelligent Motor Power Supply is an open frame electrical device that has exposed unshielded high voltage pins, components and surfaces. This 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.**

PRECISE AUTOMATION INC.

PP LOGIC/MOTOR POWER DISTRIBUTION

| SIZE | FSCM NO | DWG NO PX10-DA-00001-1 | REV 1 |
| SCALE | | SHEET 1 OF 5 | |

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G3410 CONTROLLER

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.

G3410 CONTROLLER INTERFACES

SIZE	FSCM NO		DWG NO PX10-DA-00001-1	REV 1
SCALE			SHEET	2 OF 4

ZIO BOARD

JP1/JP2 - RS485

1	+24V
2	+24V
3	GND
4	GND
5	GND
6	VCC
7	GND
8	RS485+
9	RS485-
10	GND

TO CONTROLLER RS485 JP8

J2

1	+12V	CAMERA POWER
2	GND	
3	+9V	RING LIGHT POWER
4	GND	

J3

1	+12V	CAMERA POWER
2	GND	
3	+9V	RING LIGHT POWER
4	GND	

JP4 - Z-AXIS ENCODER
JP5 - THETA AXIS ENCODER

1	GND
2	A+
3	A-
4	VCC
5	B+
6	B-
7	GND
8	Z+
9	Z-
10	GND
11	H1
12	GND
13	H2
14	VBAT
15	H3
16	GND

TO CONTROLLER ENCODER CONNECTORS

JP6 - THETA AXIS ENCODER

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

TO THETA AXIS ENCODER BOARD

BRAKE CONNECTOR

J4

1	
2	

LAMP CONNECTOR

J5

1	
2	

JP3 - Z-AXIS ENCODER

GND	1
A+	2
A-	3
VCC	4
B+	5
B-	6
GND	7
Z+	8
Z-	9
H1	10
H2	11
H3	12

TO Z-AXIS ENCODER

DANGER: A motor connector that provides a bus voltage of 320 VDC is positioned near the ZIO. As such, accessing this board represents a high risk. **AC power to the robot must be disconnected prior to accessing this board.**

PRECISE AUTOMATION INC.

Z-AXIS IO (ZIO) BOARD INTERFACES

SIZE	FSCM NO	DWG NO PX10-DA-00001-1	REV 1
SCALE		SHEET 3 OF 5	

ENCODER BOARD

TO CONTROLLER OR ZIO

J1 - HARNESS SIDE

1	GND
2	A+
3	A-
4	VCC
5	B+
6	B-
7	GND
8	Z+
9	Z-
10	GND
11	H1
12	GND
13	H2
14	VBAT
15	H3
16	GND

J2 - MOTOR SIDE

GND	1
RZ	3
RA	5
VCC	7
RB	9
GND	2
LZ	4
LA	6
VCC	8
LB	10

TO MOTOR

DANGER: A motor connector that provides a bus voltage of 320VDC is positioned near the Encoder Boards. As such, accessing these boards represents a high risk. **AC power to the robot must be disconnected prior to accessing these boards.**

PRECISE AUTOMATION INC.

ENCODER BOARD

SIZE	FSCM NO	DWG NO	REV
		PX10-DA-00001-1	1
SCALE		SHEET	4 OF 5