PRECISE AUTOMATION

The Guidance System

Hardware Introduction and Reference Manual

Version 2.1.0, Jan. 16, 2009
P/N: G3S0-DI-00010

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

Document Content

Trademarks

Disclaimer

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

Warning Labels

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

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

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

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

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

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

Table Of Contents

Introduction to the Hardware

System Overview

System Description

The Guidance System is a complete 4-axis vision guided motion control system in a compact enclosure. This unit includes a Precise Guidance Controller with integrated motor drives, a PrecisePower 500 Intelligent Motor Power Supply, a low voltage logic power supply, an internal fan and filters for cooling, and rugged metal shell connectors. For customers who desire an enclosed unit that can be externally mounted, the Guidance System provides a convenient, ready-to-use alternative to purchasing, mounting and wiring a motion controller and other components.

The entire unit is very compact and has been designed for easy mounting on a linear axis, under a workstation or other locations where space is a premium. Its compact size allows it to be attached very close to the mechanism, thus eliminating extra control cabinets and reducing cable lengths.

As with all Precise controllers, the Guidance System is compatible with an optional, easy-to-use machine vision software package. For applications requiring more than 4-axes of control, this system can be networked with other Precise controllers over Ethernet.

The embedded PrecisePower Intelligent Motor Power Supply generates 320VDC, which can power a wide range of brushless motors. The motors can be equipped with either incremental encoders or a number of serial absolute encoders (e.g. Panasonic A4, Yaskawa Sigma II, Tamagawa SA35-17/33Bit-LPS and Bosch linear axis motors, etc.). Since many robot applications require substantial torque at low speed and relatively little power when the motors achieve their full rated speed, the built-in 500W Intelligent Power Supply is able to operate most small to moderate sized robots at full speed. For example, this system is being used to operate a 3rd party 4-axis Cartesian robot, which is driven by a set of motors rated at 750W, 400W, 200W and 100W (1450W total).

The four-axes of this system plus any additional networked axes can be grouped into “robots”, where each robot is defined by a geometric (“kinematic”) model. This kinematic model allows the robots to be taught and programmed in Cartesian coordinates. This is extremely beneficial for geometries like the SCARA robot or rotary wafer-handling robots.

The Guidance System can have several types of peripherals attached to it. These include cameras, remote I/O, a hardware manual control pendant, and a remote front panel.

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

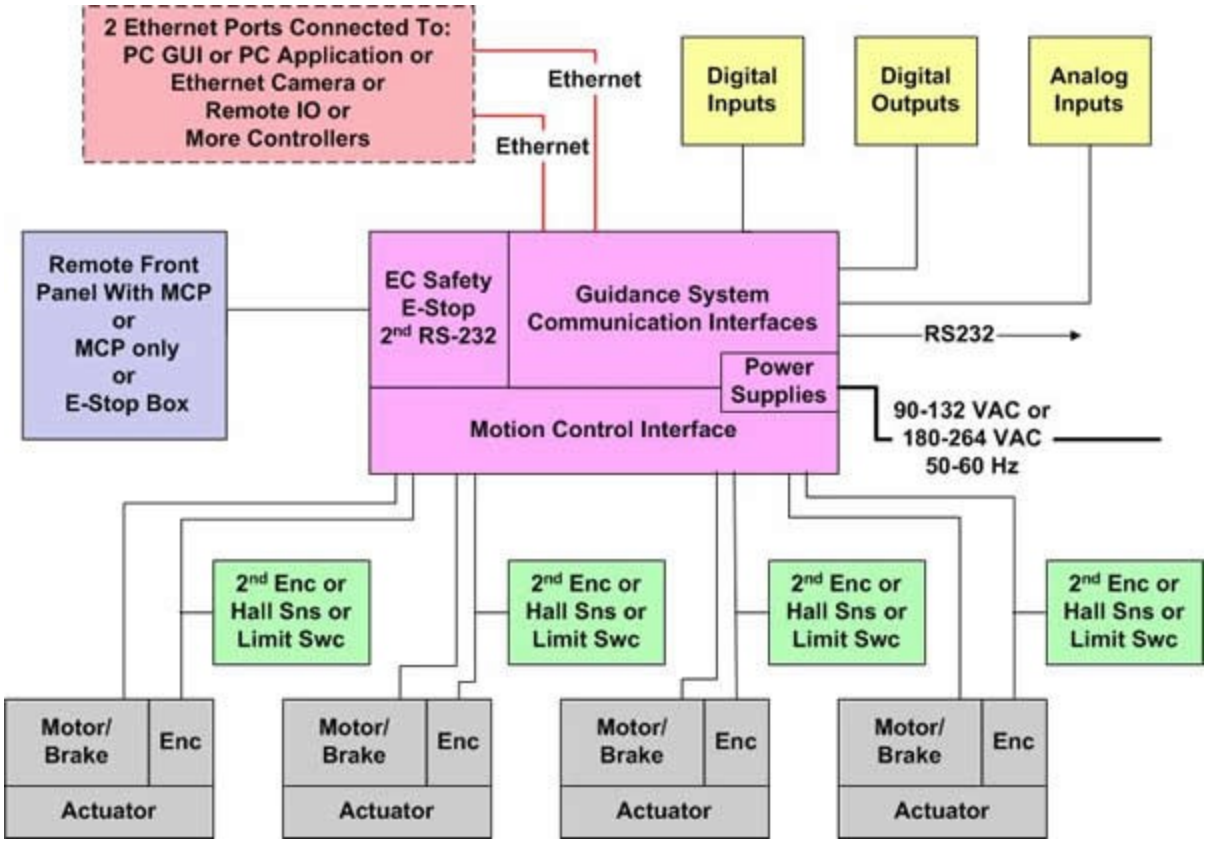
The system is programmed by means of a PC connected through Ethernet. There are three programming modes: a Digital IO (PLC) mode, an embedded language (GPL) mode, and a PC Control mode. When programmed in the PLC or GPL mode, the PC can be removed after programming is completed and the system will operate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

An optional machine vision system, “PreciseVision”, is easily interface to the system and can execute either in a PC connected through Ethernet or (in the future) in the motion controller. PreciseVision requires cameras connected via Ethernet, allowing any processor on the network to obtain and process information from any camera on the network, and provides the results to any networked motion system. 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 system's controller hardware, please refer to the *Guidance 3000/2000 Controllers Hardware Introduction and Reference Manual*, PN G3X0-DI-00010.

System Diagram

The Guidance System diagram is shown below. The system can directly drive four motors and includes interfaces for up to 8 encoders. If fewer encoder interfaces are required, four of these interfaces can be configured for Hall sensor inputs or limit and home switch inputs.



The system includes extensive communications facilities including support for digital input and output signals, analog input signals, an RS-232 line and two Ethernet ports. The Ethernet ports can be connected to a PC for the web based GUI or to communicate with a PC application that is commanding the operation of the system. Alternately, the ports can interface to Ethernet cameras, a Remote I/O module that provides additional communications facilities, or other Precise controllers.

This system also includes a full EC Category 3 compliant remote front panel interface. This includes redundant E-stop inputs, a second RS-232 port to connect to a hardware Manual Control Pendant (MCP) and all other required safety signals. If a full Category 3 front panel is not required, a Precise MCP or E-Stop box can be directly connected.

System Components

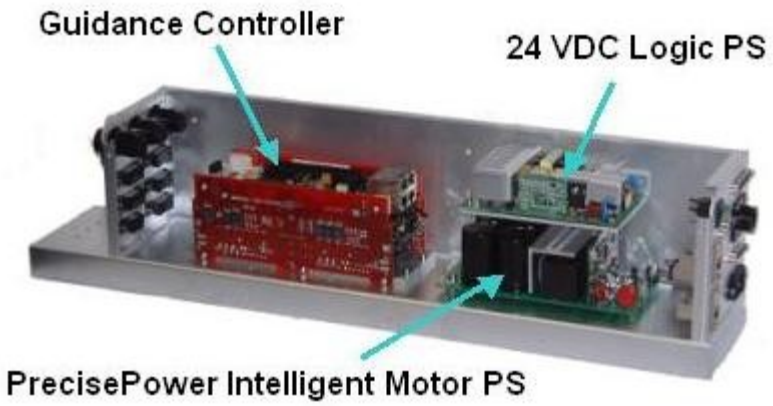
Major Components

The Guidance System is pictured below. The right and left Interface Panels contain the power on/off button and the interface connectors for the motors, encoders, and general communications (Ethernet, digital and analog I/O signals, RS-232, and remote front panel / MCP / E-stop). Mounted on the top of the unit is a button for manually releasing the motor brakes. Next to the brake release button is an indicator light that blinks at a slow rate when the controller is operating and blinks at a fast rate when a motion program is executing. The extension platform on the bottom left is provided for cable management and attaching an e-chain.

The picture below shows the Guidance System with its cover detached and the cables and fan removed. This illustrates the mounting of the major components (the Guidance controller, the logic power supply and the PrecisePower 500 Intelligent Motor Power Supply).

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

disconnected. **AC power to the system must be disconnected prior to removal of the cover.**



Guidance 34xx Controller

The Guidance System includes one of several models of the Precise Guidance Controller: a G3410A with 10A peak current motor drives or a G3420A with 20A peak current motor drives. Except for the differences due to the permitted motor currents, these controllers are identical and offer the same extensive set of features.

DANGER: The Guidance Controller is an open frame electrical device that has exposed unshielded high voltage pins, components and surfaces. **AC power to the system must be disconnected prior to removal of the enclosure cover.**

The Guidance 34x0 Controller is a four-axis general purpose motion controller that contains four motor drives and eight encoder inputs. If all eight encoder inputs are not required, up to four encoder channels

can be reconfigured in software to function as hall-effect inputs or home and limit stop inputs. Typically, incremental encoders are interfaced to the controller. However, an option is available that supports selected absolute encoders (e.g. Yaskawa Sigma II, Panasonic A4, Tamagawa SA35-17/33Bit-LPS and certain Bosch models) as well as analog sinusoidal encoders.

The controller's standard input and output capabilities include 12 optically isolated digital input signals, 8 optically isolated digital output signals, two +/- 10VDC analog input channels, an RS-232 serial port, and four Ethernet ports (of which two are exposed on the right Interface Panel). In addition, the controller has a Remote Front Panel interface that provides dual E-stop inputs and a second RS-232 line for communicating with a hardware manual control pendant.

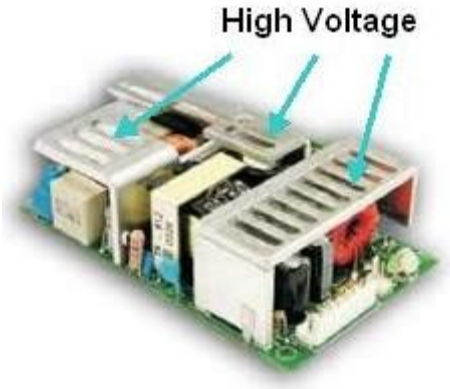
In order for the Guidance Controller to operate correctly, it must be attached to a heat sink and properly cooled. In the Guidance System, the heat sink is provided by the sheet metal enclosure and additional cooling is generated by an internal fan.

For detailed information on the controller including additional information on its interfaces, please see the *"Guidance Controller Hardware Introduction and Reference Manual"*.

Low Voltage Power Supply

The Guidance Controller requires 0.7 amps of 24 VDC power for logic power 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 5 amps. Within the Guidance System, this requirement is met by an internally mounted 125-watt, 24 VDC Power Supply (shown below) that accepts AC input from 90V to 264V.

DANGER: The 24VDC logic power supply is an open frame electrical device that has exposed unshielded high voltage pins, components and surfaces. In addition, **the heat sinks on the 24VDC Power Supply are not grounded and expose high voltage levels. AC power to the system must be disconnected prior to removal of the enclosure cover.**



Intelligent Motor Power Supply

The Guidance Controllers can accept motor power from 24 VDC to 340 VDC. Built into the Guidance System is a 500 watt PrecisePower Intelligent Motor Power Supply (shown below). This is auto-ranging unit with dual input ranges of 90 to 132 VAC and 180 to 264 VAC 50/60 Hz and a 320 VDC output.

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

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

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 Guidance System's right Interface Panel. 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 and interlocks.

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.

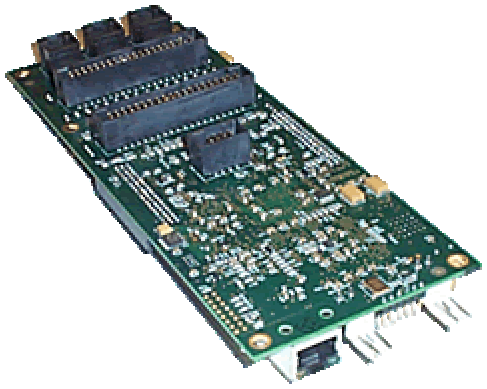
Remote IO Module

For applications that require additional IO capability beyond the standard functions provided with the Guidance System, a Precise Remote IO (RIO) module may be purchased. The RIO is designed to be remotely mounted and requires 24 VDC for its logic power. This device can be positioned any where within the Guidance System's network and communicates via 10/100 Mb Ethernet. 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.

The Enhanced RIO module is pictured below.

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



Machine Vision Software and Cameras

All Guidance Systems 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 (available in the future).

Cameras are connected to the vision processor via Ethernet. Vendors such as DALSA offer a variety of Ethernet machine vision cameras. In addition, vendors such as Pleora offer RS 170 to Ethernet converter boxes (iPORT PT-1000 ANL1/2/E) that allow a large variety of standard cameras to be connected to the Guidance network.

Machine Safety

Voltage and Power Considerations

The Guidance 34x0 requires two DC power supplies, a 24 VDC power supply for the processor and user IO, and a separate motor power supply. The motor power supply must provide the controller with a voltage between 24 VDC and 340 VDC. For the Guidance System, the PrecisePower Intelligent Motor Power Supply delivers 320 VDC to the controller to power the motors.

DANGER: The Guidance 34x0, 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. 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 Guidance System, these units are mounted beneath the enclosure cover.

The Guidance System includes a 500-watt auto-ranging PrecisePower Intelligent Motor Power Supply with a dual input range of 90 to 132 VAC and 180 to 264 VAC 50/60 Hz and a 320 VDC output. This motor power supply contains a relay that permits the controller to enable and disable motor power.

The PrecisePower Motor Power Supply limits inrush current to 6 Amps. It is protected against voltage surge to 2000 volts by means of MOV's at the line input. Transient over voltage (< 50 µs) may not exceed 2000 V phase to ground, as per EN61800-31996. It is protected against over current by two 6.3 amp, 250V time lag fuses, Wickman PN 1811630000.

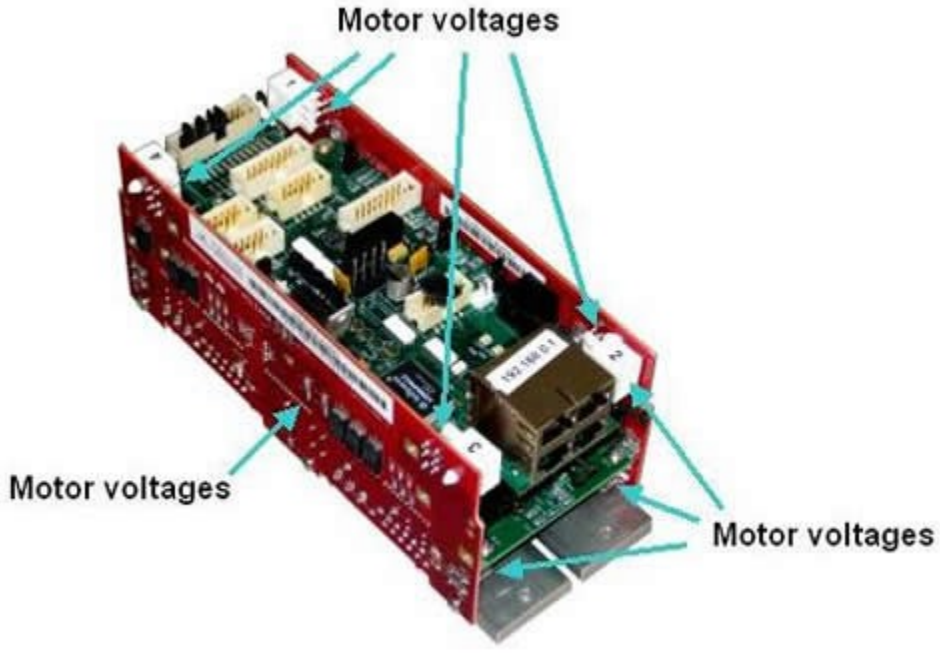
The Guidance System can monitor motor power through its datalogging function. Intermittent power dropouts can be detected by setting a trigger in the data logger which can record and time-stamp power fluctuations.

Guidance System Cover

In the Guidance System, the Guidance 34x0 and its power supplies are mounted under a cover that should be in place whenever power is applied to the control system.

DANGER: The PrecisePower Intelligent Motor Power Supply is an open frame supply that provides 320VDC volts and takes about 2 minutes to bleed down after power is disconnected. The 24VDC power supply is also an open frame supply with high voltages terminals exposed when the system cover is removed. The control system should not be operated without the cover in place.

DANGER: The surfaces, connectors, and leads pictured in Red below indicate exposed elements of the Guidance 34x0 controller that carry motor power signals. These signals levels are at 320 VDC.



E-Stop Stopping Time and Distance

The 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 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.

If an axis does not have a mechanical brake and motor power is disabled while the axis is moving, it may 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. For example, if a linear axis is moving at a speed of 1000mm/sec and the servos decelerate it at 0.4G (3920mm/sec^2), the axis will reach a full stop in 0.26sec after having only traveled a distance of 127mm.

If a gravity loaded axis does have a mechanical brake but the brake takes some time to engage, if motor power is disabled immediately when a Hard E-Stop is signaled, the axis will drop before the brake takes effect. In this case, delaying for a short period of time before disabling motor power allows time for the brake to engage and prevents the axis from dropping.

Safety Standards Reference Material

The Guidance System can control mechanisms that are capable of moving at high speeds and exerting considerable force. Like all robot and motion systems, and most industrial equipment, these systems 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 Guidance System is intended for use with other equipment and is considered a subassembly rather than a complete piece of equipment on its own. It meets the requirements of these standards:

EN 61000-4-2 Electrostatic Discharge (8KV air, 6KV contact)
EN 61000-4-3 Radiated Electromagnetic Field Immunity (3V/m, 27-500MHz)
EN 61000-4-4 Electrical Fast Transient/Burst Immunity (2KV)
EN 61000-4-5 Surge Immunity Test (1KV differential, 2KV common mode)
EN 61000-4-6 Conducted Disturbances Immunity (RF: 150KHz – 80MHz)
EN 50081-2 Electromagnetic Compatibility General Emissions Standard

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

In addition to the above standards, the Guidance System has been designed to comply with the following agency certification requirements (certification of compliance with these standards is currently in process):

CE
CSA
UL
ANSI/RIA R15.06 Safety Standard

Moving Machine Safety

The Guidance System drives robots that can operate in Manual Control Mode, in which an operator directly controls the motion of the robot, or in 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 should be limited in Manual Control Mode to a maximum of 250mm per second for safety as required by EN ISO 10218-1-2007.

This speed setting 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 "World" Mode, select the "X" axis, set the speed slider to 100% and drive the axis 250mm and time the motion. While it is possible to set a high manual control speed, this is not recommended, and should only be done after an application risk assessment.

While some light-duty robots (like the PrecisePlace) can only apply moderate forces, it is always very important for operators to keep their hands, arms and especially their head out of the robot's operating volume.

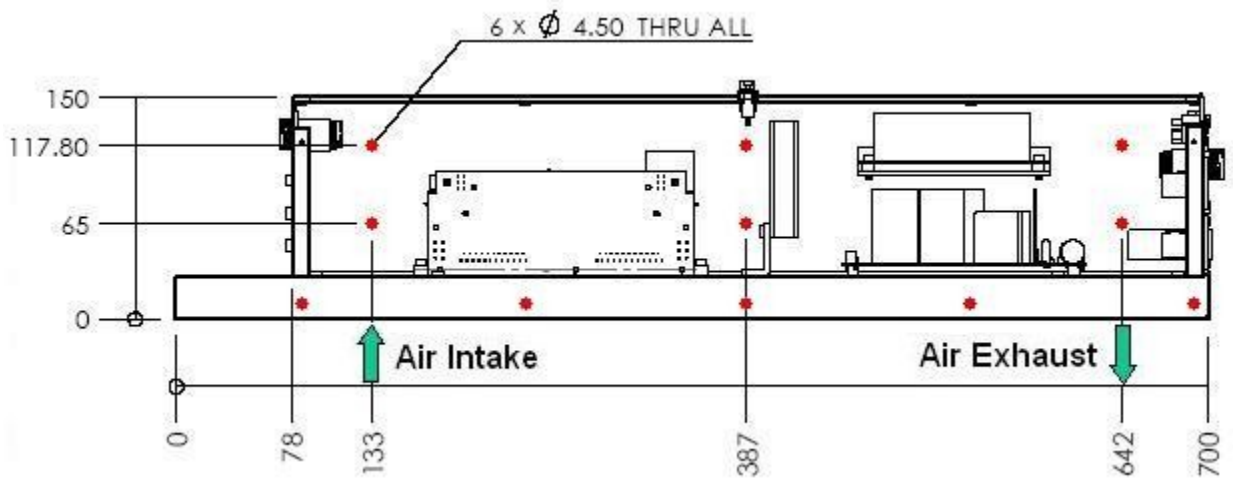
In Computer Mode, robots can achieve speeds of 2000mm per second or even greater. During Computer Mode Operation it is strongly recommended that operators be prevented from entering the robot work volume by safety barriers that are interlocked to the E-stop circuitry. Please refer to the ANSI/RIA R15.06 *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

Mounting and Airflow

The Guidance System is very compact and has been designed for easy mounting on a linear axis, under a workstation or other locations where space is a premium. Its compact size allows it to be attached very close to the mechanism, thus eliminating extra control cabinets and reducing cable lengths.

To facilitate mounting this unit, there are a number of holes in the back sheet metal. As indicated in the drawing below, these mounting holes (in **RED**) are located in the enclosed section of the system and along the bottom edge. In order to access the enclosed section, the cover of the system must first be removed.



DANGER: The Guidance Controller, the PrecisePower Intelligent Motor Power Supply, and the 24VDC logic 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 system must be disconnected prior to removal of the cover.**

In the Guidance System, the enclosure serves as a heat sink for the controller and the power supplies. To provide additional cooling, this system includes an internal fan with filters. In order for the cooling system to operate properly, **the air intake and exhaust vents in the bottom of the enclosure must be kept clear and ambient air must freely flow below the system.** If the Guidance System is placed on a table or other surface that could restrict air flow, standoffs should be added below the unit to ensure unobstructed air flow.

Recommended Motor and Encoder Wiring

Wiring Overview

With the pressure to design high power motor drive electronics with low power losses, switching motor drive amplifiers now have edges that switch 400 volts as fast as once each 100 nS. While this helps to keep switching losses down, it has made receiving logic level signals from encoders and sensors very difficult. This is because every PWM edge must charge and discharge the motor wiring capacitance. The current spikes to do this can be as large as 4 amperes. This current flow causes the motor frame to have ground bounce on it due to the inductance of the ground return back to the amplifier. This ground bounce and the coupling between motor harness wire and encoder harness wires can introduce noise into the system. This section describes wiring techniques that will reduce the interference between motors and encoders.

It is very important that the wiring guidelines in this section be followed in order to avoid encoder quadrature errors, zero index errors, and other noise related problems.

Motor Cables

UL recommends the following current ratings for 80° C wire.

Wire Size AWG	28	26	24	22	20	18	16
Amperes	0.6	1.0	1.6	2.5	4.0	6.0	10.0

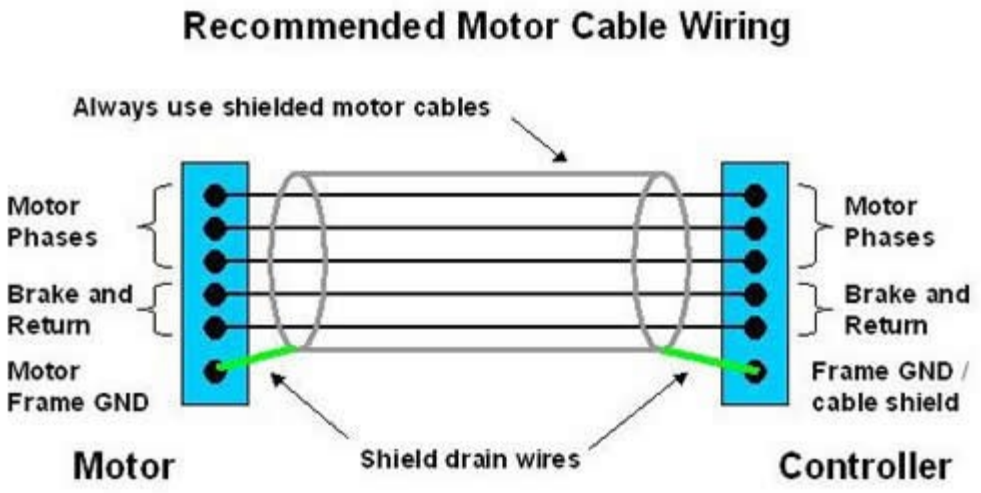
The ***motor wire should always be shielded*** and have a rating of 600 volts. The typical wires that are shown in the table below have a 105° C rating. These wires do not have a drain wire, so a drain connection must be soldered to the shield.

	Alpha 16 AWG	Alpha 18 AWG	Beldon 16 AWG	Beldon 20 AWG
High Flex	85603CY	85803CY		
No Flex	3247	3242	9953	9963

Motor Wiring Path

To minimize noise generation, the motor cable should always be shielded and the shield should be properly grounded. In addition, to deal with cases where the distance between the motor frame and the amplifier are greater than 0.5 meters or situations where there is no common chassis between the motor and the amplifier, the Guidance System internally contains "ferrite cores" around the motor and brake lines to reduce the charging current spikes and the resulting ground bounce.

The following picture illustrates how the motor cable should be wired at both ends.



Encoder Considerations

The preferred encoder should have a differential cable driver built in. The differential signal will cancel out much of the common mode noise that encoder wiring can pick up and, when used with twisted pair wire, will cancel out the magnetic pick up from the motor harness.

Some encoders have an open collector output or an output with a 10K pull up resistor only. These encoders should only be used with a cable driver IC such as a DS26C31 mounted nearby the encoder.

If an encoder's code wheel or linear mask is made with etched metal or other conductive material, **the encoder should not be used** if it is mounted to any housing or chassis that has ground bounce on it. For example, if such an encoder is directly mounted to a motor frame without electric insulation, its use could result in quadrature errors and other noise problems.

Encoder Cables

It is highly recommended that the encoder cable be shielded and contain 4 twisted pairs with a gage of AWG 24 or AWG 26. See the table below for recommended cables.

Unshielded encoder wiring should never be run next to unshielded motor wiring .

	Alpha 24 AWG	Alpha 26 AWG	Beldon 24 AWG	Beldon 26 AWG
High Flex	86604CY	86504CY		
No Flex	5494C 5272C		88104	

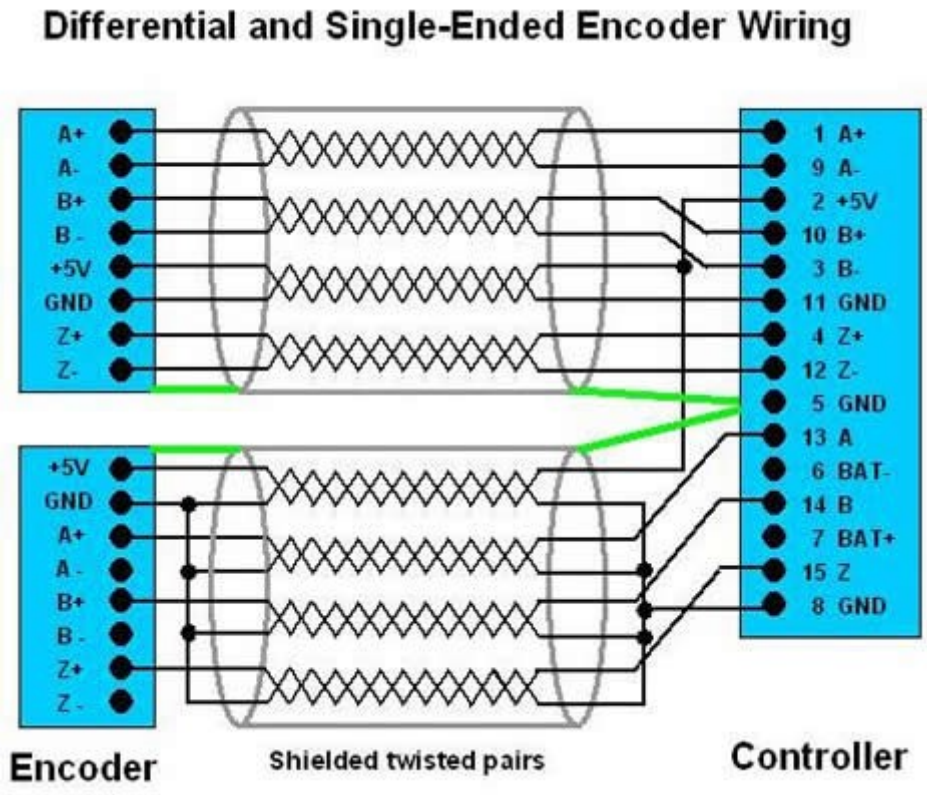
One of the twisted pairs should be used for power and ground, one pair for A+ & A-, one pair for B+ & B- and one pair for Z+ & Z-. (See the next section for specific pin assignments.) **Connect the cable shield to the body of the DSub connector that mates with the Guidance System.** This can be achieved by soldering a drain wire between the DSub connector and the shield. On some encoders that are in a metal box with a metal shell connector, on the encoder end of the cable, connect the shield to the metal shell of the mating connector.

Encoder Wiring and Pin Assignments

The encoder connectors on the Guidance System can each be cabled to a differential encoder and an optional single-ended encoder. If a single-end encoder is not interfaced, these pins can be configured for use with hall effect sensors or end-of-travel switches and a home switch. Given a choice for wiring an encoder, the differential encoder input should always be used instead of the single-end encoder input to achieve greater noise immunity.

If a single-end encoder is wired, a shielded twist pair cable should still be used to ensure the best possible signals and avoid crosstalk between the signals. In this case, the low side of each twisted pair should be connected to ground and the low side of a differential encoder output should be left floating.

The following drawing illustrates how to interface to both the differential and the single-ended encoder input signals.



Hardware Reference

Motor, Encoder and Communications Interfaces

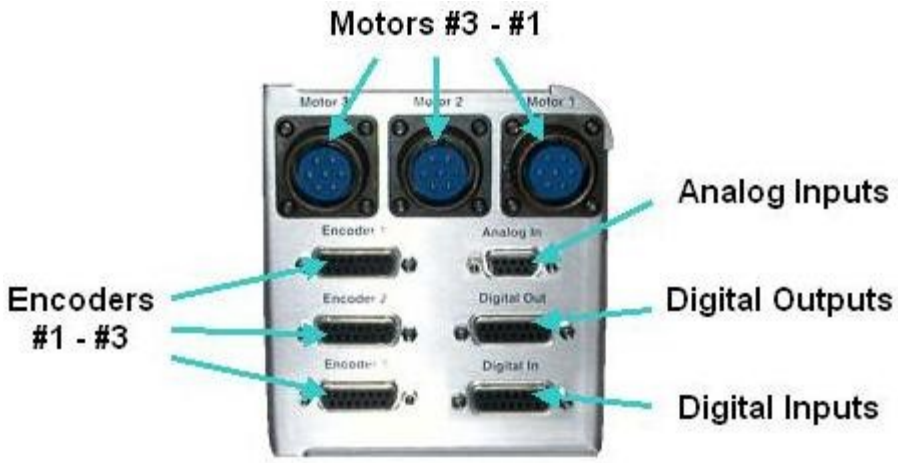
In addition to providing interfaces for four motors and up to eight encoders, the Guidance System provides extensive communication services. The connectors for each of these interfaces is described in detail in this section. The list of the provided functionality is as follows:

- Analog input signals
- Digital input signals
- Digital output signals
- Encoder interfaces
- Ethernet ports
- Motor/brake interfaces
- Remote front panel / MCP / E-stop
- RS-232 serial port

To simplify mounting and cabling the Guidance System, all of the interface connectors are provided on the enclosure right and left Interface Panels.

The following illustrates the connectors, plugs and switches that are mounted on the **Right Interface Panel**. To jump to the detailed information for a specific connector, click on the connector interface name or the connector in the following picture.

The following illustrates the connectors that are mounted on the **Left Interface Panel**. To jump to the detailed information for a specific connector, click on the connector interface name or the connector in the following picture.



Analog Input Signals

The Guidance System provides two general purpose analog input channels. These signals are conveyed though a single DB9 connector. In this connector, pin 4 is the input for the first +/- 10VDC analog channel and pin 3 is the input for the second channel.

The Analog to Digital Converter has a 12-bit resolution and a conversion delay of 3.2 microseconds. The two ADC channels are alternately scanned, so a new reading is available for each channel every 6.4 microseconds. The input impedance of the analog conversion circuit is 20,000 ohms. There is a 4 KHz noise filter on each input.

DB9 Female

The following table details the pin out for the analog input connector.

Pin	Description
1	24 VDC
2	24 VDC
3	+/- 10 VDC input signal, channel 2
4	+/- 10 VDC input signal, channel 1
5	GND
6	24 VDC
7	GND
8	GND

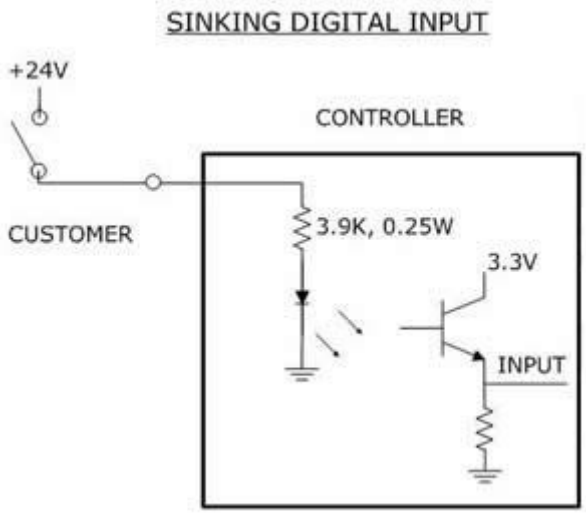
9	GND
Interface Panel Connector Part No	DB9 Female Connector
User Plug Part No	DB9 Male Plug

Digital Input Signals

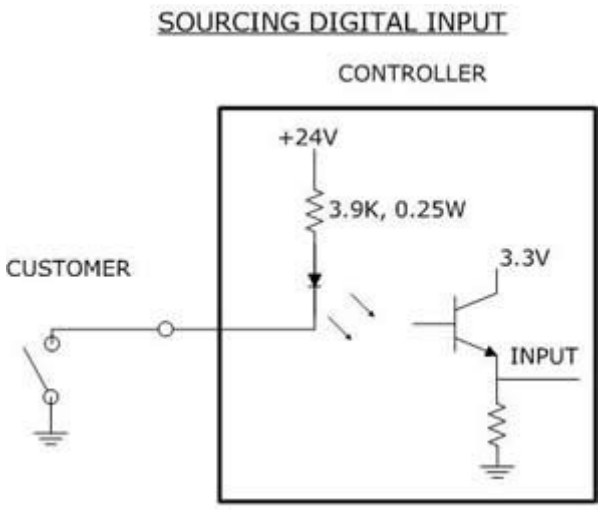
The Guidance System provides 12 general purpose optically isolated digital input signals. These lines are accessed in a single DB15 connector.

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.



As shipped from the factory, the input signals are configured as "sourcing", i.e. the external equipment must pull a signal input pin to ground to indicate a logical high and must let the line float high to 24VDC to signal a logical low value.



Inputs can be configured as sinking or sourcing in groups of 4 signals. To configure groups of input signals, the cover of the controller must be removed and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance Controller, Hardware Introduction and Reference Manual.*

DANGER: The Guidance Controller, the PrecisePower Intelligent Motor Power Supply, and the 24VDC logic 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 system must be disconnected prior to removal of the cover.**

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

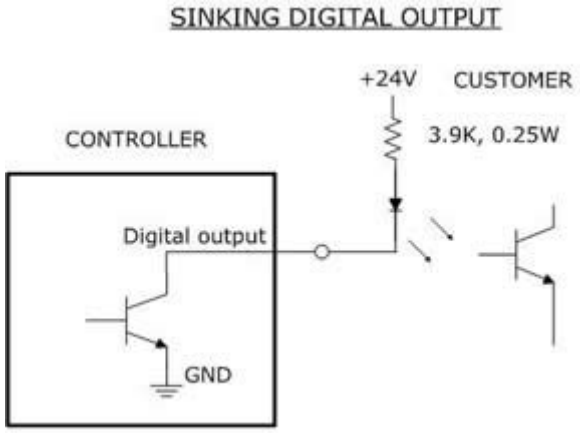
13	10009	Digital Input 9
14	10011	Digital Input 11
15		24 VDC
Interface Panel Connector Part No		DB15 Female Connector
User Plug Part No		DB15 Male Plug

Digital Output Signals

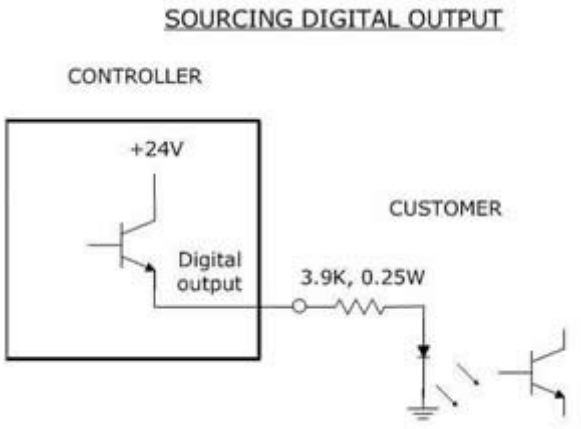
The Guidance System provides 8 general purpose optically isolated digital output signals. These lines are accessed in a single DB15 connector.

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.



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



Outputs can be individually configured as sinking or sourcing signals. To configure the output signals, the cover of the controller must be removed and jumpers on the Guidance Controller must be changed. For more information on configuring the jumpers, please see the *Guidance Controller, Hardware Introduction and Reference Manual.*

DANGER: The Guidance Controller, the PrecisePower Intelligent Motor Power Supply, and the 24VDC logic 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 system must be disconnected prior to removal of the cover.**

The yellow light that is mounted on the top of the Guidance System is internally driven by the eighth general digital output signal. If this signal is needed for general control functions, the blinking function can be disabled by setting the Parameter Database value "Power State DOUT" (DataID 235) to 0. By default, it is set to "20" to blink the yellow light.

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

Pin	GPL Signal Number	Description
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 (By default, this controls the yellow blinking light mounted on the top of the enclosure and must be configured as sinking for the light to operate properly.)
14		Not used
15		Not used
Interface Panel Connector Part No		DB15 Female Connector
User Plug Part No		DB15 Male Plug

Encoder Interfaces

There are four identical encoder connectors located on the system Interface Panels. Each connector contains a set of three differential input signals for interfacing to an incremental or absolute encoder. In addition, each connector provides three single-ended input signals that can be used to interface to an additional incremental encoder or hall effect sensors or limit and home switches. The encoder connectors are numbered on the Interface Panels although the correspondence between connector number and logical encoder can be reassigned in software.

DB15 Female

The Guidance System includes a standard Guidance Controller that supports a wide variety of digital incremental encoders. These are encoders that output 0 or 5VDC and generate a phase A, phase B, and zero index signal. If absolute or analog encoder support is desired, an Enhanced Guidance Controller can be purchased. Currently, the Enhanced controller supports the following absolute encoders:

1. 16-bit, 17-bit and 20-bit Yaskawa Sigma II encoders
2. Panasonic A4 Serial Incremental/Absolute encoders
3. Absolute encoders provided by Bosch with their line of industrial linear modules
4. Tamagawa SA35-17/33Bit-LPS-5V Absolute encoders and 17-bit serial incremental encoders

See the "Third Party Equipment" section of the *Controller Hardware Manual* for information on connecting supported absolute encoders.

For analog sine encoders, the Enhanced controller includes 12-bit ADC's that can digitize these signals. These ADC's can also interpolate analog encoder signals to increase the effective resolution of these devices.

If the set of three single-ended signals is configured for a second encoder, the single-ended encoder can be used independently of the differential input encoder or the two encoders can be used together to implement dual encoder loop servo control of an axis of motion. Alternately, these three digital inputs can be configured for hall-effect sensors or two over-travel sensors plus a homing sensor. When configured for these functions, these inputs should be treated as 5VDC sourcing digital inputs connections.

The following table defines the connector pin outs. The second column should be used when the 3 digital inputs are configured for hall-effect sensors or over-travel switches and a homing sensor. The third column describes the pin outs when a second, single-ended encoder is utilized.

Pin	3 Digital Inputs (5 VDC)	2nd Encoder (5 VDC)
1	Encoder 1 A+ (Digital or Analog)	
2	5VDC provided to power encoders. The sum of the current drawn from all four encoder connectors is limited to 1 amp.	
3	Encoder 1 B- (Digital or Analog)	
4	Encoder 1 Z+ (Digital)	
5	Gnd	
6	Gnd (Reserved for Abs Encoder Bat Gnd)	
7	Vcc (Reserved for Abs Encoder Bat Pwr)	
8	Gnd	
9	Encoder 1 A- (Digital or Analog)	
10	Encoder 1 B+ (Digital or Analog)	
11	Gnd	
12	Encoder 1 Z- (Digital)	
13	Digital Input #1 Hall #1 or Homing Switch	Encoder 2 A+
14	Digital Input #2 Hall #2 or Positive Over-Travel	Encoder 2 B+
15	Digital Input #3 Hall #3 or Negative Over-Travel	Encoder 2 Z+
Interface Panel Connector Part No	DB15 Female Connector	
User Plug Part No	DB15 Male Plug	

Ethernet Interface

All Guidance Systems include Guidance Controllers that have communication interface boards (MCIM's) that are revision 6 or later. These boards include an Ethernet switch that fully implements four 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, 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.

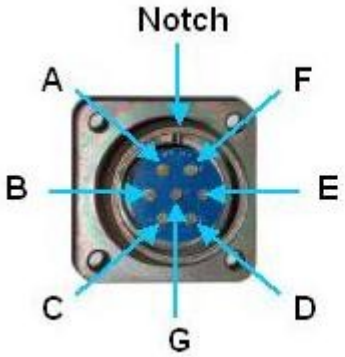
Due to limited space on the Interface Panels, only two of the four Ethernet ports are available as external RJ45 connectors on the Guidance System.

Either Ethernet port can be used to interface to the Guidance System. If the two ports are connected to external equipment that are communicating with each other but not the controller, the switch automatically routes the traffic between the two ports and does not send this information to the controller. For example, if an Ethernet camera is connected to one port and a PC is connected to the other port, the camera image data will not burden the controller CPU.

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

Motor/Brake Connectors

There are four identical motor/brake connectors located on the system Interface Panels. Each connector provides the 3 drive phases for a single motor, a 24VDC brake signal, a brake signal return line, and a frame ground. The connectors are numbered on the Interface Panels although the correspondence between connector number and logical axis can be reassigned in software.



DANGER: The Motor/Brake connectors and their leads contain high voltage pins. The plug for this connector should always have its back shell properly in place and the plug should only be inserted into the connector when the AC line power is turned off.

Please note that although all of the motor/brake connectors have a brake signal, this is only provided as a wiring convenience. The Guidance System currently turns all brakes on and off at one time, so independent brake control for each motor is not supported via the dedicated IO lines available in this connector.

The following table defines the pin assignments for this connector. Please see the Installation Section for additional recommendations on wiring and grounding for this connector.

Pin	Description
A	Motor Phase U
B	Unused
C	Brake Power Return
D	Brake Power 24VDC, maximum current 2A total for all brakes
E	Motor Phase W
F	Motor Phase V
G	Motor Frame Ground/Cable Shield
Interface Panel Connector Part No	Amphenol 97-3102A-16S-1S Box Mount Receptacle, 7 pin
User Plug Part No	Amphenol 97-3106A/B-16S1P, wires must be soldered

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 right Interface Panel of the Guidance System.

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 *Controller Hardware Manual* for a suggested design). Or, if your application does not require a fully compliant Category 3 front panel, the controller 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 controller 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 and the servos restrict the axes to special "Manual mode max torque %" and "Manual mode speed limits" 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 system 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 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

Appendix A: Product Specifications

Guidance System Specification

General Specification	Range & Features
Software	
Programming Interface	Three programming methods available: DIO MotionBlocks (PLC) Embedded Guidance Programming Language (GPL) PC/Unix controlled over Ethernet
Operator Interface	Web based operator interface supports local or remote control via browser connected to embedded web server
Motion Control	Extensive robotic and low-level motion control available Continuous path following, s-curve profiling Straight-line and circular motions Torque and velocity control Control of 4 axes extensible by networking additional Precise Controllers Optional conveyor belt tracking (future development) Optional kinematic models for various robot geometries
Machine Vision	Robot vision guidance and part inspection supported via interface to optional PreciseVision executing on a PC
Motion Control	
Motor Drives	Four integrated motor drives: Standard: 10A peak/5.5A RMS/3.5A stall per channel Higher current option: 20A peak/9.5A RMS/6.5A stall per channel Bus voltage: 320 VDC Total power for all 4 drives: 500 watts RMS. Can power most robot systems whose motors are rated at a total of 2KW.
Position Sensors Interface	Four differential digital encoder interfaces Four configurable single-ended digital encoder interfaces Support for selected absolute encoders (requires "Enhanced" controller) Support for analog incremental encoders with interpolation for increased resolution (requires "Enhanced" controller)
Control Signals	Configurable limit stop, home, hall-effect, and brake signals
Communications Interfaces	
General Communications	Two 10/100 Mbps Ethernet ports RS-232 port with hardware flow control Remote front panel interface with second RS-232 port (no

	hardware flow control), compliant with IEC Category 3 safety standards
Digital Input Channels	12 general purpose optically isolated inputs, configurable as sinking or sourcing in groups of four 5VDC to 24VDC for logic high if sinking 24VDC supplied for logic high if sourcing Additional remote I/O available via Precise RIO modules or 3rd party MODBUS/TCP devices.
Digital Output Channels	8 general purpose optically isolated outputs, individually configurable as sinking or sourcing, 24VDC maximum pull up if sinking 24VDC supplied if sourcing 100mA maximum per channel Additional remote I/O available via Precise RIO modules or 3rd party MODBUS/TCP devices.
Analog I/O Channels	2 analog +/- 10VDC 12-bit inputs standard
Dimensions	
Size	112 mm (W) x 700 mm (L) x 150 mm (H)
Input AC	
Input Voltage	Dual range: 90 to 132 VAC and 180 to 264 VAC auto selecting
Frequency	Frequency: 50 - 60 Hz
Environmental	
Ambient temperature	5ºC to 40ºC
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 the Guidance System products.

How do you connect a robot power enable button?

If you wish to connect a momentary contact button to enable robot power, you can wire the button to either a general digital input signal or use the dedicated input signal provided in the Remote Front Panel Connector.

If you connect the button to a general DIN, the number of the DIN signal should be set as the "Power enable DIN" (DataID 242) parameter database value. If you connect the button to the Remote Front Panel Connector "High Power On" input, the value of the dedicated input signal (DIN 18007) should be set as the value of DataID 242.

In either case, power will be enabled when the signal toggles from the OFF to the ON state.

How do you release the motor brakes in a 1 or 2 axis system?

For the integrated motor amplifiers of the Guidance System, the brake signals that are presented in the four motor connectors are all tied together internally and are operated by the software that controls the 3rd axis/motor. This works correctly for 3 or 4 axis systems where the 3rd axis is the one that is affected by gravity.

If your system only has one or two axes, to configure the first or second axis to control the brake signals, set the "Auxiliary brake release DOUT channel" (DataID 10625) Parameter Database value for the appropriate axis to "8331". "8331" is the DOUT channel number for the dedicated DIO that controls the brake signal.

Why should grippers be wired to release when digital signals are ON?

Grippers or other tooling should always be wired to digital output signals such that an active (ON) state will release a part. This is an important practice since if the controller loses power and is restarted, all

output signals are turned OFF by default. If a gripper is wired to release a part with an OFF signal, any parts left in a gripper from a previous operation would be dropped when the controller is restarted.