# Guidance Controller Quick Start Guide

## User Manual

**Part Number 609638, Revision A**

# Brooks Automation

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# Revision History

Part Number: 609638

| Revision | ECO | Date | Action | Author |
|---|---|---|---|---|
| A | PH | Today's date | Initial completion of the manual template. | K. Forscher |

This procedure was created using QMS101044 Rev. E.

# Table of Contents

# 1. Safety

## Safety Setup

Brooks uses caution, warning, and danger labels to convey critical information required for the safe and proper operation of the hardware and software. Read and comply with all labels to prevent personal injury and damage to the equipment.

**DANGER**

**Read the Safety Chapter**

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

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

## Authorized Personnel Only

This product is intended for use by trained and experienced personnel. Operators must comply with applicable organizational operating procedures, industry standards, and all local, regional, national, and international laws and regulations.

# Explanation of Hazards and Alerts

This manual and this product use industry standard hazard alerts to notify the user of personal or equipment safety hazards. Hazard alerts contain safety text, icons, signal words, and colors.

## Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard
- State the consequences if the hazard is not avoided
- State how to avoid the hazard.

## Safety Icons

- Hazard alerts contain safety icons that graphically identify the hazard.
- The safety icons in this manual conform to ISO 3864 and ANSI Z535 standards.

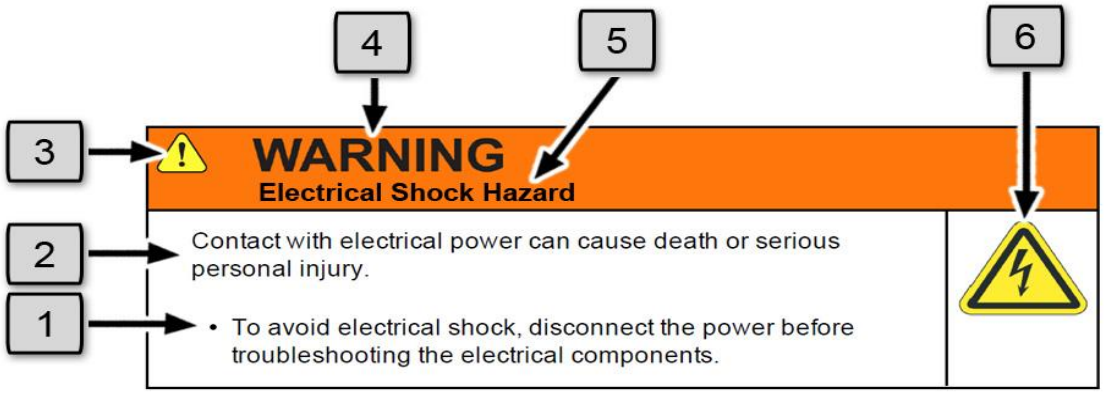
## Signal Words and Color

Signal words inform of the level of hazard.

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

## Alert Example

The following is an example of a Warning hazard alert.




| Number | Description |
|---|---|
| **1.** | How to Avoid the Hazard |
| **2.** | Source of Hazard and Severity |
| **3.** | General Alert Icon |
| **4.** | Signal Word |
| **5.** | Type of Hazard |
| **6.** | Hazard Symbol(s) |

# General Safety Considerations

**WARNING**

**Software**

Software is not safety rated. Unplanned motion can occur as long as power is supplied to the motors. Maximum torque could be momentarily applied that may cause equipment damage or personal injury.

- Only operate the robot with its covers installed.
- Guarantee that safety controller features are in place (for example, an emergency stop button and protective stop).
- Regularly test safety components to prove that they function correctly.

**WARNING**

**Robot Mounting**

Before applying power, the robot must be mounted on a rigid test stand, secure surface, or system application. Improperly mounted robots can cause excessive vibration and uncontrolled movement that may cause equipment damage or personal injury.

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

**WARNING**

**Do Not Use Unauthorized Parts**

Using parts with different inertial properties with the same robot application can cause the robot's performance to decrease and potentially cause unplanned robot motion that could result in serious personal injury.

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

## WARNING

**Magnetic Field Hazard**

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

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

## CAUTION

**Unauthorized Service**

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

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


## CAUTION

**Damaged Components**

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

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

## CAUTION

**Inappropriate Use**

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

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

**CAUTION**

**Seismic Restraint**

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

- The user is responsible for determining whether the product is used in an earthquake prone environment and installing the appropriate seismic restraints in accordance with local regulations.

# Mechanical Hazards

**CAUTION**

**Pinch Point**

Moving parts of the product may cause squeezing or compression of fingers or hands resulting in personal injury.

- Do not operate the product without the protective covers in place.

**WARNING**

**Automatic Movement**

Whenever power is applied to the product, there is the potential for automatic or unplanned movement of the product or its components, which could result in personal injury.

- Follow safe practices for working with energized products per the facility requirements.
- Do not rely on the system software or process technology to prevent unexpected product motion.
- Do not operate the product without its protective covers in place.
- While the collaborative robotics system is designed to be safe around personnel, gravity and other factors may present hazards and should be considered.

**CAUTION**

**Vibration Hazard**

As with any servo-based device, the robot can enter a vibratory state resulting in mechanical and audible hazards. Vibration indicates a serious problem. Immediately remove power.

- Before energizing, ensure the robot is bolted to a rigid metal chamber or stand.

# Electrical Hazards

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

**DANGER**

**Electrical Shock Hazard**

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

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

**WARNING**

**Electrical Burn**

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

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

**WARNING**

**Electrical Fire Hazard**

All energized electrical equipment poses the risk of fire, which may result in severe injury or death. Fires in wiring, fuse boxes, energized electrical equipment, computers, and other electrical sources require a Class C extinguisher.

- Use a fire extinguisher designed for electrical fires (Class C in the US and Class E in Asia).
- It is the facility's responsibility to determine if any other fire extinguishers are needed for the system that the robot is in.

**NOTICE**

Improper handling of the power source or connecting devices may cause component damage or equipment fire.

- Connect the system to an appropriate electrical supply.
- Turn off the power before servicing the unit.
- Turn off the power before disconnecting the cables.

## Ergonomic Hazards

**CAUTION**

**Heavy Lift Hazard**

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

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


**CAUTION**

**Tipover Hazard**

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

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

**CAUTION**

**Trip Hazard**

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

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

# Emergency Stop Circuit (E-Stop)

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

**WARNING**

**Emergency Stop Circuit**

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

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

# Recycling and Hazardous Materials

Brooks Automation complies with the EU Directive 2002/96/EU Waste Electrical and Electronic Equipment (WEEE).

The end user must responsibly dispose of the product and its components when disposal is required. The initial cost of the equipment does not include cost for disposal. For further information and assistance in disposal, please email Brooks Automation Technical Support at support_preciseflex@brooksautomation.com.

# 2. Introduction

## Quick Start Guide Overview

The Guidance family of motion controllers incorporates a distributed control architecture that utilizes Ethernet for real-time communication. This *Quick Start Guide* uses the Guidance 1400 Controller for examples.

The controllers include integrated motor drives. The controllers require an external 24 VDC supply for the logic and IO, and each controller model requires a separate external motor power supply. For example, the Guidance 1400 is a low-power motion controller that uses 48 volts for the external motor supply. These motion controllers are compact and intended to be placed near the point of use, which in many cases means they will be installed inside the machine rather than in an external control cabinet.

Motion axes can be grouped into "robots" defined by a geometric (kinematic) model. A robot has a master controller that executes the kinematic model and sends axes position commands to any slave controllers. The logical grouping of axes into robots is independent of the physical configuration of the motion controllers. For example, two single-axis controllers and one four-axis controller can be logically grouped into a six-axis robot with one of the controllers designated as the master and the other two as slaves. Motion can also be coordinated among robots on the same network. For example, a four-axis robot can be coordinated with a two-axis robot.

Each Guidance Controller can have several types of peripherals attached to it. These include cameras, a remote I/O, a hardware manual-control pendant, and a remote front panel. Only one front panel is required per networked group of controllers.

The controller includes a web-based operator interface 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.

A computer, connected to the controller via Ethernet cable, can be used to program the controller.

There are three programming methods:

- A programming language communicating with the controller via the Guidance Controller’s TCP/IP command server

- The Guidance Controller's simplified MotionBlocks resource
- The Guidance Controller's embedded Guidance Programming Language (GPL)

When programmed in the 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.

This *Quick Start Guide* provides the following procedures:

- Connecting the controller to a computer
- Turning on the controller
- Setting the IP address on the controller and computer so they can talk to each other
- Moving a robot in manual control
- Generating a simple program to drive a robot between several positions automatically

Once familiar with these procedures, read the related material in the *PreciseFlex™ PreciseFlex Library*, and explore the Guidance Controller's full functionality. If integrating the Guidance Controller into a new mechanical system for the first time, see the **PreciseFlex™ PreciseFlex Library > Controller Software > Software Setup instructions** on integrating the controller with the mechanism. Get the Guidance Configuration Utility, which is part of the Guidance Development Suite (GDS). The GDS provides wizards that follow the Software Setup to guide the user through the controller integration process.

Download the *PreciseFlex™ PreciseFlex Library* from https://www.brooks.com/solutions/collaborative-robotic-solutions/support/latest-software-updates/. The library includes a complete description of the controller's web interface, its native Guidance Programming Language (GPL), and the Guidance Development Environment (GDE).

The manuals for the GPL and GDE are also available as individual PDF files as the *Guidance Programming Language, Introduction to GPL* (PN GPL0-DI-S0010), and the *Guidance Development Environment, Introduction and Reference Manual* (PN GDE0-DI-S0010).

Before proceeding with this guide, complete the following steps:

| Step | Action |
|---|---|
| **1.** | Mount the robot securely. |
| **2.** | Install and test all required safety interlocks, if applicable. |
| **3.** | Connect the power. |

# 3. Setup

## Connecting the Controller to a PC

The Guidance Controller includes all the software necessary to operate the robot. However, the user must use a PC or other computer or tablet as the graphical user interface (GUI) to manually operate and program the robot.

The only application software required on the host computer is a web browser. However, a copy of the Guidance Development Suite (GDS) is required if the controller's IP address must be changed. Download the GDS from https://www.brooks.com/solutions/collaborative-robotic-solutions/support/latest-software-updates.

For the best results, Brooks suggests using the following:

- A 500 MHz or faster PC running Windows 10 or a later operating system
- A 10/100 Ethernet interface and a standard Ethernet cable

Connect the controller to a computer directly or via a hub or switch. If connecting to a robot or Guidance Controller, plug the cable into the RJ45 port on the Facilities Panel. The user can plug the cable into any of the controller's RJ45 ports if directly connecting to a controller.

## Starting the Controller

There are two types of power supplied to the controller:

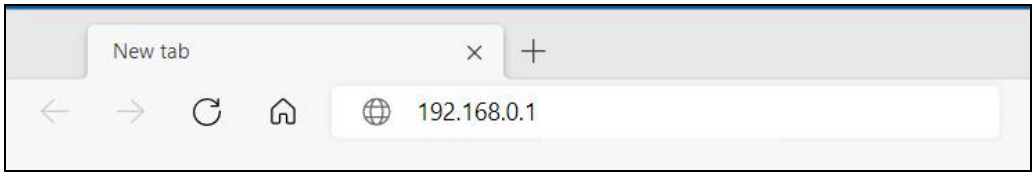
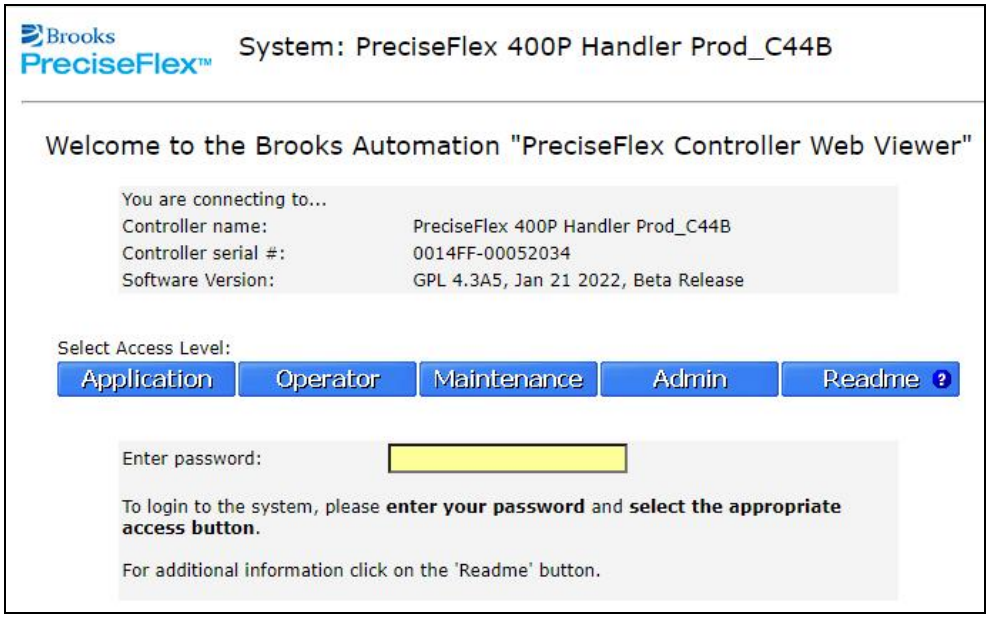
- Low-voltage power for the printed circuit board
- High-voltage power for the motors

Only the low voltage (24 VDC) is enabled when the controller is first turned on. The controller enables the motor's higher voltage.

With the controller connected to a PC, plug the controller into a power source, and turn on the power switch. The controller will execute its start-up sequence. When the sequence is complete, a green

LED on the top board of the controller (if visible) or an LED mounted on the robot will blink. This indicates that the controller is loaded correctly and is ready to accept instructions.

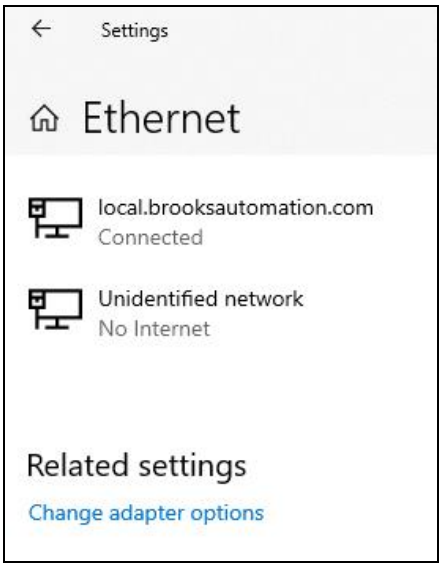
## Displaying the Controller Home Screen

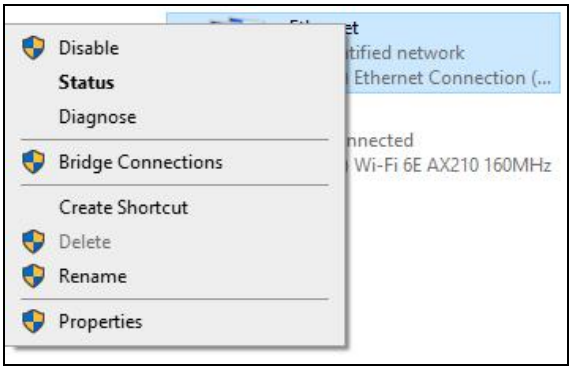
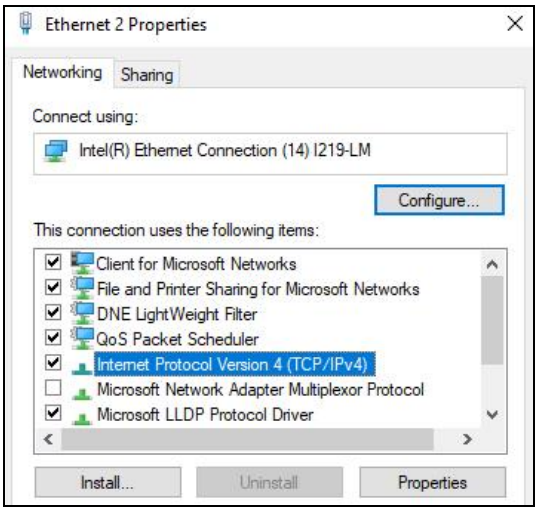
| Step | Action |
|---|---|
| **1.** | The computer and the controller each have their own IP address. With the controller connected to a computer, open a web browser. |
| **2.** | Enter the controller's Ethernet IP address into the browser's address bar. The IP address 192.168.0.1 is the default.<br>  |
| **3.** | Click **Return** (Mac) or **Enter** (PC) to display the controller's home screen.<br>  <br>If the home screen does not display, the controller's IP address and the computer's IP address may be incompatible. Either the controller's IP address and subnet mask need to match the IP address and subnet mask of the computer or the computer's IP address and subnet mask need to match the IP address and subnet mask of the controller. Change either one.<br>***NOTE:*** *If nothing displays, there may also be a network issue. Disable all other network drivers -- every other network connected to the device, including Wi-Fi -- and try again. Once the controller is visible and the IP address is changed, drivers may be re-enabled.* |

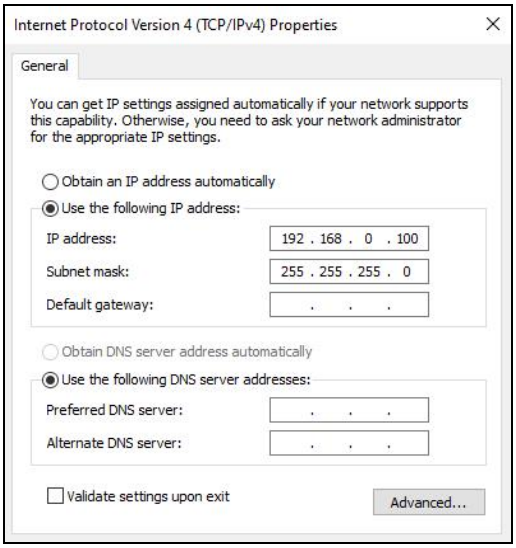
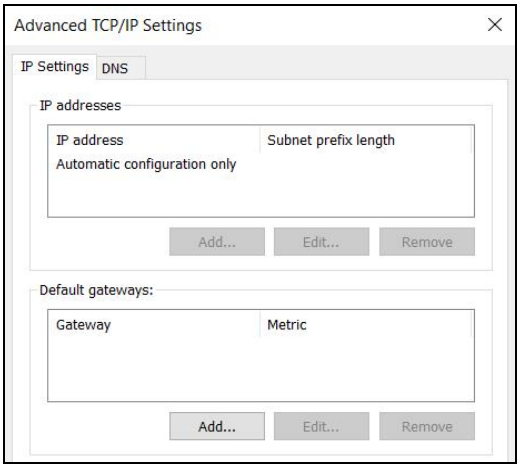
# Changing the Computer's IP Address and Subnet Mask

***NOTE:*** This procedure is applicable to Windows 10.

By default the Guidance Controller is factory configured with IP address 192.168.0.1 and subnet mask 255.255.255.0. The computer must be compatible with this IP information. To change the computer's IP address and subnet mask, perform the following procedure:

| Step | Action |
|---|---|
| 1. | Go to **Start** > **Settings** > **Network & Internet** > **Ethernet** and click **Change adapter options**.<br>  |
| 2. | Right-click the Ethernet card connected to the controller.<br>  |

| Step | Action |
|---|---|
| 3. | Select **Properties**.<br>  |
| 4. | Select and highlight **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.<br>  |

| Step | Action |
|---|---|
| **5.** | If the PC is using Dynamic Host Configuration Protocol (DHCP) and is not compatible with the controller, select the **Use the following IP address** option, and enter a compatible IP address and subnet mask.<br>  <br><br>Once connected to the controller, the IP address and subnet mask of the controller can be changed to be compatible with a network. |
| **6.** | If the PC is using a static IP address, the IP address does not need to be changed. Click **Advance**. |
| **7.** | In the *Advanced TCP/IP Settings* window, click **Add** and enter a compatible PC IP address and subnet mask.<br>  <br> |

# Changing the Controller's IP Address and Subnet Mask

To change the controller's IP address and subnet mask, the user must have the Guidance Development Suite (GDS) installed on their PC, and the controller must use the Guidance Programming Language (GPL) version 2.0 or later. Download the GDS from https://www.brooks.com/solutions/collaborative-robotic-solutions/support/latest-software-updates, and follow the installation instructions.

After installing the GDS, go to **Windows Start** > **Programs** > **Precise Automation** > **Guidance Discovery**.

## One Controller on the Network

If there is only one controller on the network, click **Change IP and Subnet**.


**Figure 3-1: Guidance Discovery Screen**

The *Change Controller IP Address* screen displays.

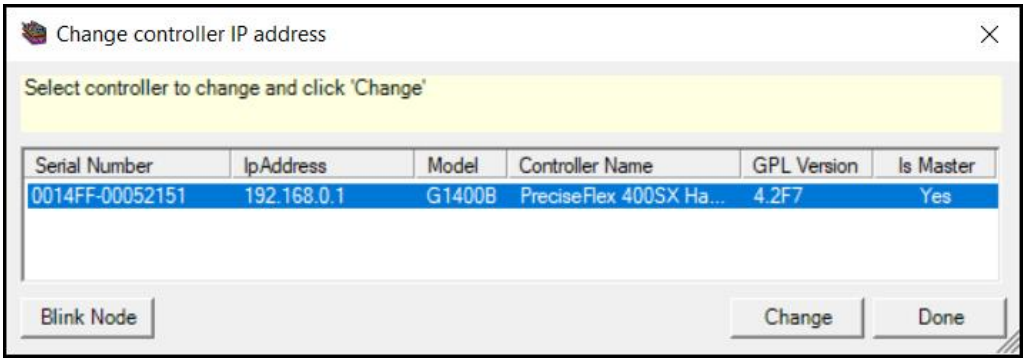
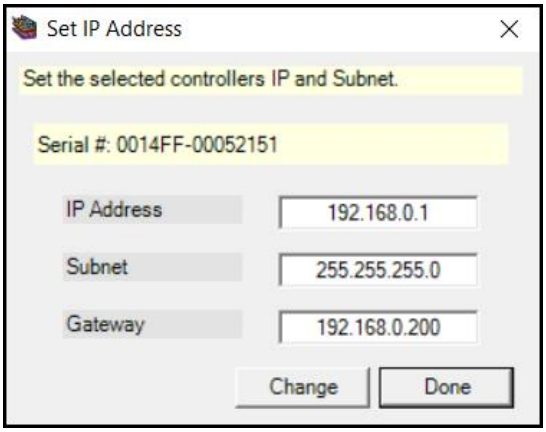



**Figure 3-2: Change Controller IP Address Screen**

To change the controller IP address, perform the following procedure:

| Step | Action |
|---|---|
| **1.** | Select the IP address, and click **Change**. |
| **2.** | The *Set IP Address* screen displays. Enter an IP address for the controller into the **IP Address** field.<br>  |
| **3.** | Enter a subnet mask into the **Subnet** field. |
| **4.** | Enter a gateway address into the **Gateway** field. |
| **5.** | Click **Change**. |

## More Than One Controller on the Network

If there is more than one controller on the network, click **Scan for Controllers** in the *Guidance Discovery* screen.

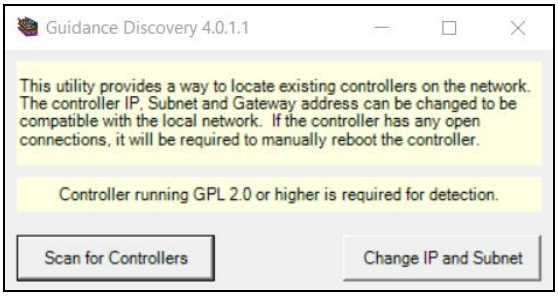



**Figure 3-3: Guidance Discovery Screen**

The *Change Controller IP Address* screen displays each controller connected to the PC. If unsure of which controller to change, click **Blink Node**. An LED will blink on the selected controller.

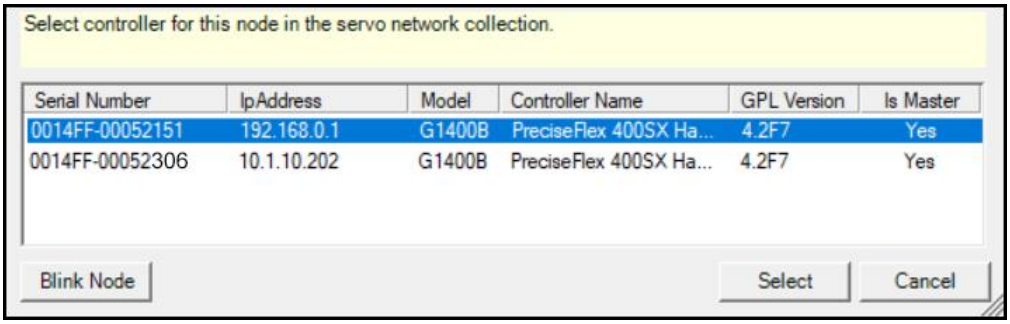



**Figure 3-4: Change Controller IP Address Screen**

Click **Select** to see information about the selected controller.

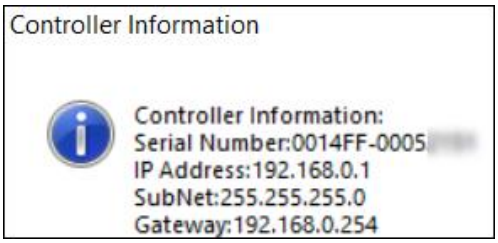



**Figure 3-5: The Controller Information Screen**

After determining which controller to change, return to the *Guidance Discovery* screen by clicking **Start** > **Programs** > **Precise Automation** > **Guidance Discovery**. See "One Controller on the Network" on page 23 for instructions on how to change the controller's IP address.

# Using the Controller Home Screen

Click **Maintenance** or **Admin** on the controller's home screen.

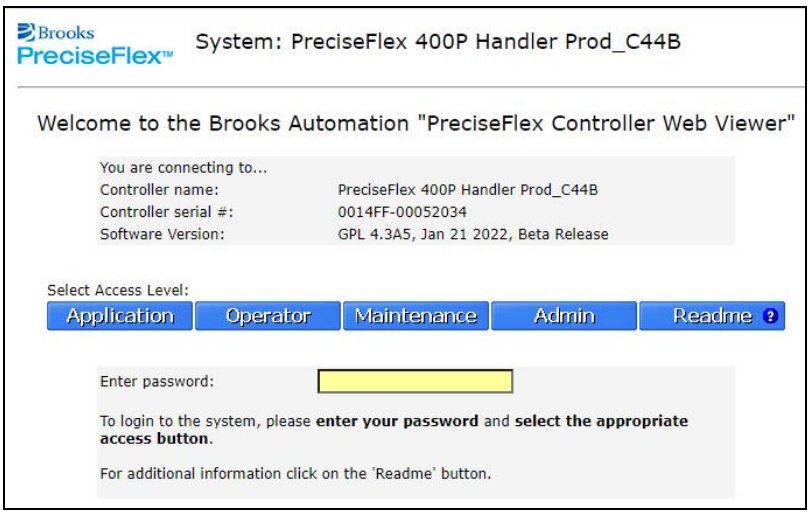



**Figure 3-6: Controller Home Screen**

Seven buttons display across the top of the screen, as shown below.

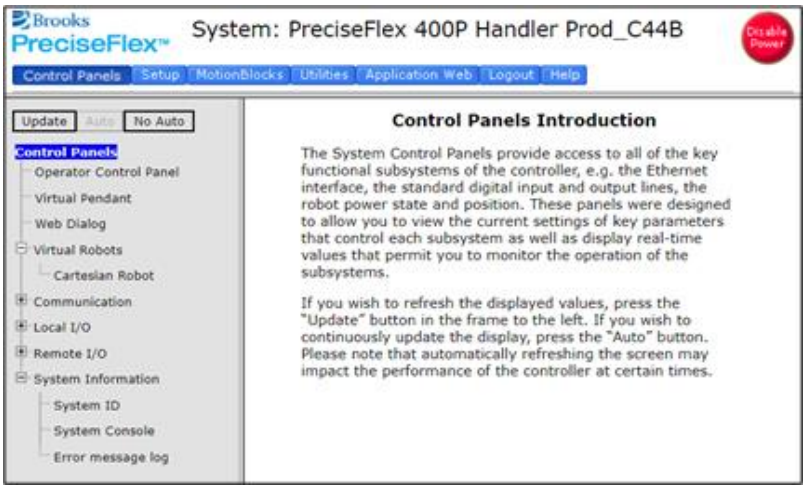



**Figure 3-7: Control Panels**

The following table describes the function of each button.

**Table 3-1: Main Navigation Bar Summary**

| | |
|---|---|
| Control Panels | **Control Panels** contain virtual Control Panels that operate the controller and monitor the system status. Actions include starting and stoping programs, manually running the robot, and modifying the values of digital input and output signals. |
| Setup | **Setup** provides system configuration aids and access to the system parameters and dynamic system data values that can be monitored. This group of screens is typically only accessed to configure the controller and perform maintenance operations. |
| MotionBlocks | **MotionBlocks** provides an easy method for programming the robot to execute a sequence of operations. MotionBlocks do not require programming experience. |
| Utilities | **Utilities** allows the user to perform operations such as copying disk files to and from the controller's flash disk, upgrading the controller with new system software, and executing methods for collecting various types of information. |
| Application Web | **Application Web**pops up Guidance Motion, a graphical programming interface. |
| Logout | **Logout** logs the user out of the main screen and returns them to the login screen. |
| Help | **Help** displays helpful information and links to other useful sites. |

In the screen's upper-right corner is a red **Disable Power** button, shown below, which cuts off power to the robot's motors.


**Figure 3-8: Disable Power Button**

***NOTE:*** Do not confuse the onscreen **Disable Power** button with a physical hardware E-Stop button, which instantly cuts off power to the motors.

# 4. Operation

## Overview

Two types of pendant controls can be used to operate the robot: the Virtual Manual Control Pendant (V_MCP) and the Hardware Manual Control Pendant (H_MCP). See "Hardware Manual Control Pendant" on page 39 for more information. The V_MCP is a software-based graphical user interface. The H_MCP is a physical controller. Both the V_MCP and the H_MCP allow the user to power up the motors, home the robot, move the robot manually, and execute programmed instructions.

## The Virtual Manual Control Pendant (V_MCP)

Select **Control Panels** > **Virtual Pendant** to display the Virtual Manual Control Pendant (V_MCP), shown below.

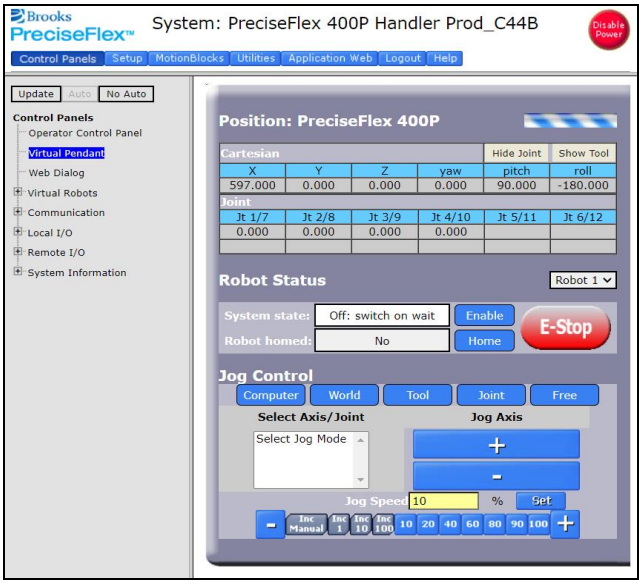



**Figure 4-1: Virtual Pendant**

The *Position* section of the V_MCP screen, shown below, displays each of the robot's axes' positions in Cartesian coordinates. Distances display in millimeters and angles display in degrees. Initially, the values typically display as zero since the system has not yet determined the absolute position of each axis. A striped animation rotates in the upper-right corner while the V_MCP is connected to the controller.


**Figure 4-2: Position Section of the Virtual Pendant**

The *Robot Status* section indicates the system state and whether the robot is homed. The **Enable** button enables power to the motors; for the Guidance 1400 Controller, it turns on the 48-volt power supply to the amplifiers. The red **E-Stop** button cuts off power to the motors.

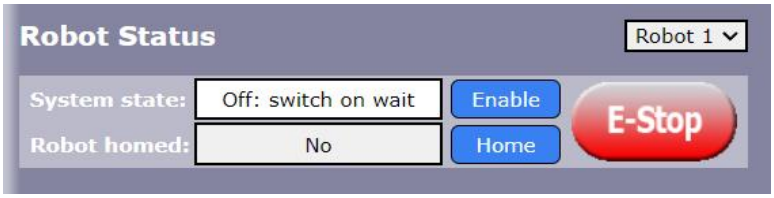



**Figure 4-3: Robot Status Section of the Virtual Pendant**

## Jog Control

The *Jog Control* section allows the user to move the robot in various modes manually.

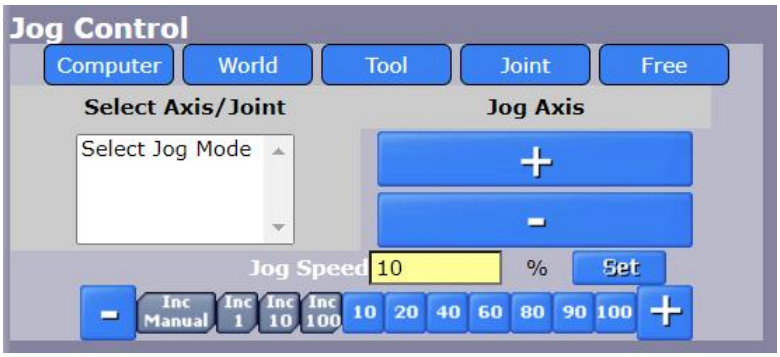



**Figure 4-4: Jog Control Section of the Virtual Pendant**

## Enabling Motor Power

Click **Robot Status** > **System state** > **Enable** to enable power to the motors.

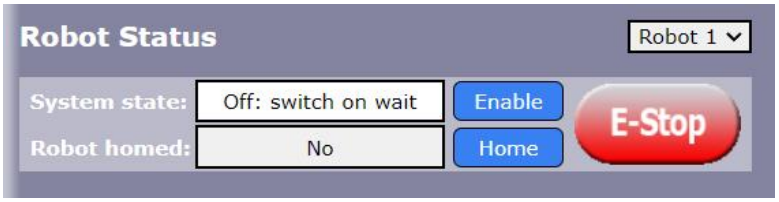



**Figure 4-5: System State > Enable Button**

The system will cycle as it enables power, and display a progress message as it cycles.

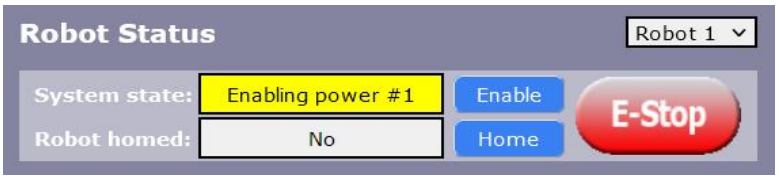



**Figure 4-6: System State Progress Message**

When motor power is enabled, the**System state** field displays the message “GPL ready.”


**Figure 4-7: System State "GPL ready" Message**

When motor power is enabled, the LED on the top of the controller or Brooks robot will blink to indicate that motor power is enabled. For some robots, the first time that motor power is enabled after the controller is restarted, the system will also commutate each motor, moving each axis a small distance to determine the alignment of the phases of the motor windings.

## Homing the Robot

Before using the robot, “home” each axis to mark its position. For most robots, each axis must be homed to determine its position relative to a fixed reference point. This permits each axis to be set to an absolute position that allows formerly taught programs to be repeated. The homing method varies from robot to robot and axis to axis. Some axes are equipped with special homing sensors. Others rely upon a travel limit signal or hard stop to reestablish the absolute position.

No matter how many times power has been enabled and disabled (**Enable**and **E-Stop**) from the controller to the amplifiers, the commutation and homing only need to be performed when the entire robot system is powered off and restarted.

Click **Robot Status** > **Robot homed** > **Home** to start the homing sequence. The system will cycle as it homes, and display a progress message as it cycles.


**Figure 4-8: Robot Homing Message**

When the cycling sequence ends, the **Robot homed** field displays “Yes.”

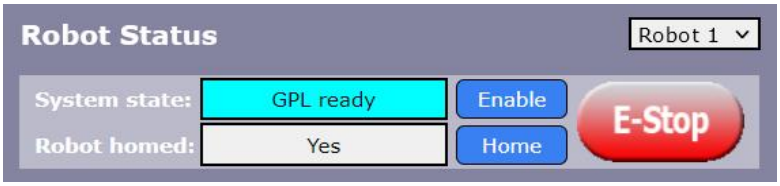



**Figure 4-9: Robot Homed Message**

## Safety Zones

For all robot types, “Safety Zones” can be defined that disable motor power and halt the motion of the robot if its tool center point (TCP) violates the requirements of a user defined 3D volume.

### Types of Safety Zones

These 3D safety zones can be used to:

1. Approximately model the volume of stationary objects or personnel working areas to prevent the robot from inadvertently entering this volume and causing a collision (“keep out zones”).

2. Reduce the normal working volume of the robot to prevent the robot from reaching beyond prescribed boundaries and causing a collision (“stay within zones”).
3. Verify that the robot’s TCP speed (when in a specified volume) is below a specified limit so that the robot can be safely decelerated and stopped before it might pin an operator’s hand to a hard surface with too high a force (“speed restrict zones”).

As currently implemented, the “keep out zones” and “stay within zones” are provided as general safety features, but they do not meet the stringent Category 3 safety standards that require fail safe redundant logic. However, the “speed restrict zones” do provide the requisite redundancy and are in the process of being Category 3 certified. The “keep out zones” and “stay within zones” are collectively referred to as “uncertified zones” and the “speed restrict zones” are referred to as “certified zones”.

The supported zone shapes are rectangular volumes, cylinders and spheres. To define a safety zone, the type of safety zone must be specified along with its origin and dimensions.

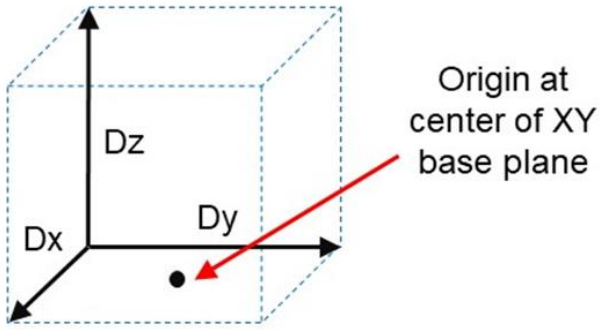



**Figure 4-10: Rectangular Volume**

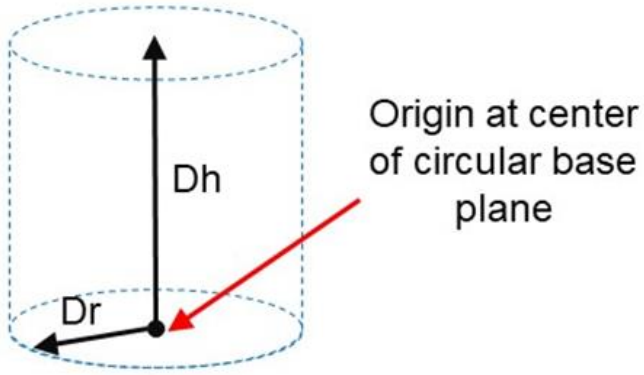



**Figure 4-11: Cylinder**

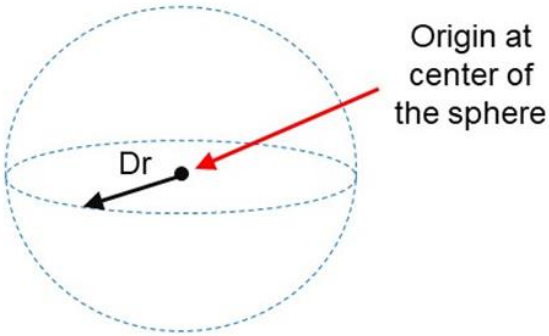



**Figure 4-12: Sphere**

For increased generality, uncertified zones can be arbitrarily positioned and rotated in all three dimensions. Due to implementation limitations, certified zones must be non-rotated rectangular volumes, which can be arbitrarily positioned. Up to 10 zones can be defined for each robot and any mix of certified and uncertified can be specified. Due to safety requirements, any new or modified zone specifications only go into effect after the controller is rebooted.

## Safety Zone Violation Detection and Clearing

Uncertified safety zones are active in the following circumstances:

- Continuously during program-controlled motions of all types (straight line or arc Cartesian and joint interpolated).
- Continuously during manual (jog) control modes: World, Tool and Joint, but not free.
- Motion planning (final destinations only).
- Location object.KineSol method during conversions to either Cartesian or joint Locations.

Certified safety zones are only active during program-controlled motions (of all types) since this is the only circumstance where higher TCP speeds are possible.

When motor power is enabled and the robot's TCP is in violation of an uncertified safety zone, a program-controlled motion cannot be initiated. This condition can be cleared by disabling motor power and manually repositioning the robot or by manually jogging the TCP in World, Tool or Joint modes, so long as the jog motion reduces the safety zone violation distance. That is, jogging motions that increase the violation of a safety zone are not permitted.

> ***NOTE:*** Safety zone testing is based on the TCP of the robot. Therefore, it is very important that the position of the tool center point relative to the robot's tool mounting flange is set correctly. Please see the Robot.Tool property for information on defining the TCP.

## Certified Speed Restrict Safety Zones

While the uncertified safety zones perform conventional tests on just the position of the TCP, there are two certified safety zones and these perform special tests to detect if the speed of the TCP exceeds a limit while the TCP is within the zone. The first certified safety zone tests if the Z downward speed of the TCP exceeds a specified limit. This safety zone was implemented for the PreciseFlex 400 and PreciseFlex 3400 robots since their only intrinsically non-safe motion is a high-speed downward Z motion that could trap a person's hand between the tooltip and a fixed object or horizontal surface. The second certified safety zone tests if the horizontal, XY planar, speed of the TCP exceeds a specified limit. This test was developed for the PreciseFlex™ DD robots since robots can generate excessive speeds when moving horizontally.

For both of these tests, in order to satisfy the computational redundancy requirement of the Category 3 safety regulations, the shapes of these safety zones are limited to non-rotated rectangular volumes.

Please consult the user manuals for these PreciseFlex™ robots for when speed restrict safety zones must be defined to safely operate these mechanisms.

## Configuring Safe Zones

Up to 10 safety zones can be defined per robot. Each of these zones is specified by filling in one of the Parameter Database IDs 16900 to 16909, which are labeled "Safety Zone: type, x/y/z/y/p/r, dim 1/2/3". Any combination of certified and uncertified safety zones can be specified. Each of these DataIDs consists of an array of 10 numbers and the first value defines the safety zone "type". Any DataID that has a zero "type" is ignored. Table 4-1 describes the possible safety zone types:

**Table 4-1: Safety Zone Types**

| Safety Zone Type | Description |
|---|---|
| **0.** | Undefined safety zone |
| **1.** | Rectangular volume, keep out zone |
| **2.** | Cylinder, keep out zone |
| **3.** | Sphere, keep out zone |
| **4.** | Rectangular volume, stay within zone |
| **5.** | Cylinder, stay within zone |
| **6.** | Sphere, stay within zone |
| **7.** | Non-rotated rectangular volume, Z downward speed restrict zone |
| **8.** | Non-rotated rectangular volume, XY speed restrict zone |

Table 4-2 describes the safety zone DataIDs. When any of these DataIDs are modified, the controller must be rebooted for the change to be put in effect.

**Table 4-2: Data IDs**

| DataID | Parameter Name | Description |
|---|---|---|
| 16900 to 16909 | Safety Zone: type, x/y/z/y/p/r, dim 1/2/3 | Each safety zone definition consists of an array of 10 values. The first value is the safety zone “type”. The next six values define the position of the origin of the volume of interest and its orientation. This is specified as a standard Location value:<br>x, y, z, yaw, pitch, roll.<br>The final three values define the size of the volume of interest. For the permitted shapes, this is interpreted as:<br>volume: Dx, Dy, Dz<br>Cylinder: Dh, Dr, 0<br>Sphere: Dr, 0, 0<br>For example, for a downward Z non-rotated rectangular volume speed restrict safety zone, a single DataID should be specified as follows:<br>7, x, y, z, 0, 0, 0, Dx, Dy, Dz<br>Where x, y, z are the coordinates of the center of the base of the rectangular volume and Dx, Dy, Dz are the dimensions of the volume, all in mm. |

In addition, the DataID in Table 4-3 must be initialized to establish the maximum speed limits for the certified safety zones:

**Table 4-3: Data IDs**

| DataID | Parameter Name | Description |
|---|---|---|
| 2740 | Certified safety zone, max Z/XY spd mm/sec | These parameters define the maximum speeds that are permitted for the Certified Speed Restrict Safety Zones. The first value is the maximum downward Z speed (when within the safety zone) in mm/sec. Since this is a downward speed, it should be a negative value and defaults to -200. The second value is the maximum permitted speed in the horizontal XY plane (when within the safety zone), and defaults to 200 mm/sec. |

# Moving the Robot in Manual Control Mode

After enabling robot power, commutating the motors, and homing the axes, the robot can be manually repositioned. Use the modes in the *Jog Control* screen to move the robot.

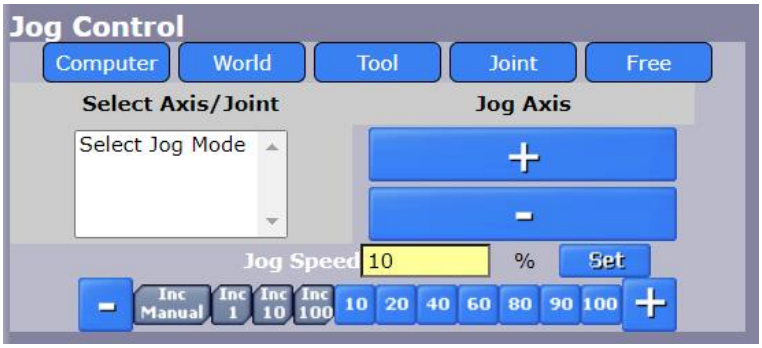

**Figure 4-13: Jog Control Screen**

The following table describes the function of each mode.

**Table 4-4: Manual Control Modes**

| | |
|---|---|
| Computer | **Computer** mode is used to run a program. Selecting **Computer** mode enables a program to take control of the robot and move its axes. Select this mode when finished moving the robot in a Jog Mode of World, Tool, Joint, or Free. |
| World | **World** mode moves the robot in a coordinated fashion so that the gripper travels in a straight path along – or rotates around – the X, Y, or Z axes of the robot's base reference frame. |
| Tool | **Tool** mode is similar to World mode, except that the robot's gripper orientation determines the reference frame. For example, if the gripper is aligned with a hole skewed at an angle, moving down and up in Tool Z will move the gripper into and out of the hole. |
| Joint | **Joint** mode moves individual joints one at a time. Even if a joint is beyond its limit stops, this mode can be used to drive the joint back into the operating range. |
| Free | **Free** mode allows one or more joints to be removed from position control mode to allow the axis to move freely. For lightweight robots, Free allows the operator to grip an axis and manually reposition it. The user can free multiple joints simultaneously without using the **Jog Speed** setting. Each time an axis is selected, and the plus (+) button is clicked, the axis is freed until the user clicks the minus (-) button to place the axis back into position control mode. |

To move a single joint in manual mode, perform the following procedure:

| Step | Action |
|---|---|
| **1.** | In the *Jog Control* section, click **Joint**.<br>  |
| **2.** | Select a robot joint to move (Joint 1, for example). |
| **3.** | In *Jog Control*, select a slow **Jog Speed** (10%, for example). If the jog speed is set to 5% or lower, the robot will move a discrete increment and stop rather than move continuously. If the user releases the plus (+)" or minus (-) button and clicks it again, the robot will move another increment. This is convenient for the fine positioning of the robot. |
| **4.** | Move the axis in the positive or negative direction by clicking the plus (+) or minus (-) buttons. |
| **5.** | Click **Computer** to disable **Joint** and permit the programs to take control of the robot. |

***NOTE:*** For some PCs and network environments, the robot may occasionally stop momentarily due to other applications running on the PC or excessive network traffic. For some robots, Free mode may be disabled for some or all of the axes to avoid potential damage to the robot.

# Hardware Manual Control Pendant

A Brooks Hardware Manual Control Pendant (H_MCP) can be used to operate the controller in the same way as the Virtual Manual Control Pendant. See "The Virtual Manual Control Pendant (V_MCP)" on page 28 for more information. The H_MCP must be connected directly to the controller's Remote Front Panel Interface or through a front panel.

The V_MCP and the H_MCP can be used with the same controller, although as a safety precaution, only one Manual Control Pendant (MCP) can be in manual control mode at any time. In its background mode, the H_MCP's display indicates the system's power status or the manual control mode currently in effect. In addition, the Liquid Crystal Display (LCD) can display user prompts, the error log, system ID data, and the current position of the selected robot.

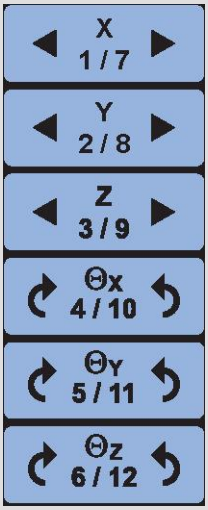
The top row of buttons controls the H_MCP's primary operational functions. The following table describes each button's function.


**Table 4-5: Hardware MCP - Major Mode Buttons**

| | |
|---|---|
|   | The **Home** button initiates the execution of the homing sequence for all robots. The LED in the corner blinks during the homing sequence and is solid when power is enabled and all robots are homed. |
|   | The **App** button switches between GPL application control and standard H_MCP operation, similar to the Virtual Pendant's Computer and Jog Control modes. The LED in the corner of the button is solid when an application is in control and blinks when an operator is in control. |

When the H_MCP is in one of the manual control modes, the buttons described in the following table control the robot's movement. The selected mode, speed, and robot number display on the LCD.

**Table 4-6: Manual Control Mode Buttons**

| | |
|---|---|
|  | The **Slower** and **Faster** buttons decrease and increase the speed for World, Tool, and Joint modes. As with the V_MCP, below 5% speed, the motion switches from continuous movement to discrete steps. |
|  | Six buttons move the selected axis in a positive or negative direction for World, Tool, and Joint modes. Only one axis can be moved at a time. For Free mode, these buttons lock and unlock selected axes. Multiple axes can be simultaneously unlocked. |

Clicking the following buttons displays information on the LCD. The displays supersede the background data (such as power sequence state and manual control mode). To end the displays, click **Quit**.

**Table 4-7: Operator Display Functions**

| | |
|---|---|
|  | The **F1** button dynamically displays the robot position in Cartesian coordinates: X, Y, Z, Yaw, Pitch, and Roll. For systems with multiple robots, the location of the robot selected for manual control displays. |
|  | The **F2** button dynamically displays the robot axes positions in millimeters or degrees. For robots with more than six axes, press this button a second time to show the second set of six axes. For systems with multiple robots, the location of the robot that is selected for manual control displays. |
|  | The **F3** button displays the most recent entry in the system Error Log. The **PREV** and **NEXT** buttons can pressed to sequence through entries in the log. If the **DEL** button is pressed, all entries in the Error Log are cleared. |
|  | The **F4** button displays system identification information. If this button is pressed a second time, the controller's Ethernet IP address and mask display along with the IP address for the associated machine vision server. |

# 5. Guidance Programming Language (GPL)

## Overview of the Guidance Programming Language (GPL)

The Guidance Programming Language (GPL) is a full-featured programming language -- embedded in the controller -- that closely resembles Microsoft Visual Basic.NET with built-in classes and objects to support general motion control. It provides additional capabilities beyond what can be done with MotionBlocks.

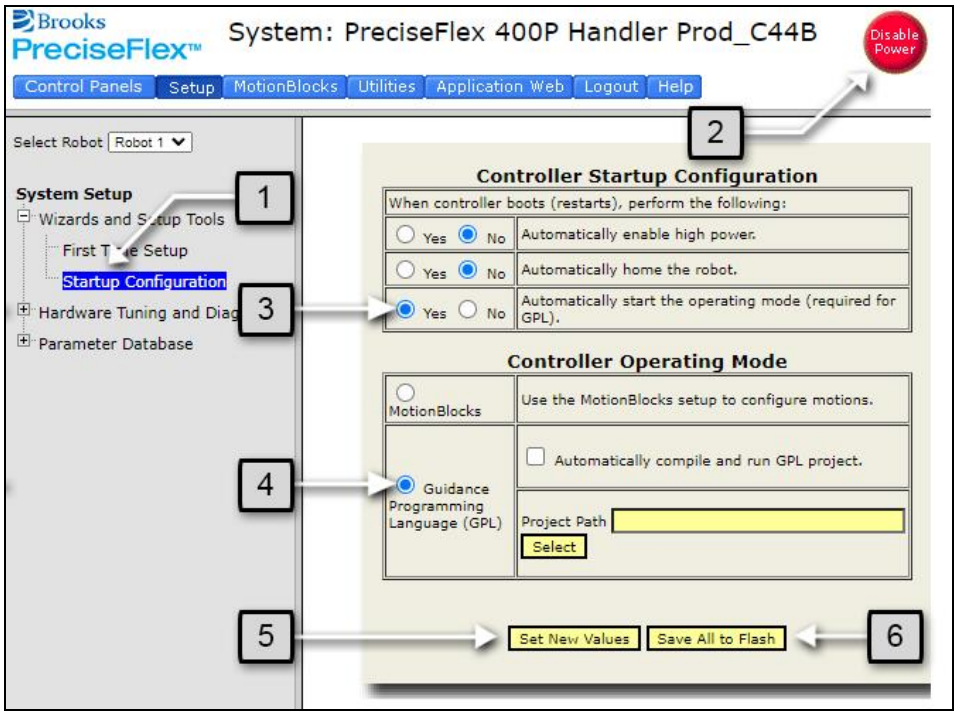
Rather than execute a program, GPL's basic executable entity is a Project, which consists of two or more text files stored within a disk folder/directory. Each text file is a standard human-readable ASCII file. The folder name and the GPL Project name are synonymous. Console commands are provided for loading, compiling, and executing a GPL Project. While programming in GPL is relatively easy, creating a GPL Project requires a basic knowledge of programming and software development tools.

Writing a new GPL Project is beyond the scope of this *Quick Start Guide*. For more information on GPL, see the *Guidance Programming Language, Introduction to GPL*. For details on developing GPL Projects, see the *Guidance Development Environment, Introduction, and Reference Manual*. Both documents are part of the *PreciseFlex™ PreciseFlex Library*, available for download from https://www.brooks.com/solutions/collaborative-robotic-solutions/support/latest-software-updates/

If a GPL Project has been previously developed, it is easy to load it and start its execution. Loading a GPL Project into memory or copying it from memory or between disk units is equivalent to copying a file folder and its contents. Multiple GPL Projects can be present in memory, although only one GPL Project can be executed at any given time. See "Loading and Executing a GPL Project " on page 45 for more information.

## Configuring a GPL Project

To configure the controller to execute a GPL Project, perform the following procedure:

| STEP | ACTION |
|---|---|
| **1.** | In the browser, click **Setup** > **Wizards and Setup Tools** > **Startup Configuration**.<br>  |
| **2.** | Click the red **Disable Power** button. This is required because changes are not permitted when power to the robot is enabled. |
| **3.** | Click **Yes** in **Automatically start the operating mode**. |
| **4.** | Select **Guidance Programming Language (GPL)** in the *Controller Operating Mode* section. With steps 3 and 4 enabled, each time the robot's power is implemented, the controller is put into a state where it is ready to allow a GPL Project to take control of a robot.<br><br>System Messages displayed in the Virtual Manual Control Pendant (V_MCP) depend on which controller operating mode – GPL or MotionBlocks – is selected. |
| **5.** | Click **Set New Values** to store this setting in memory. |
| **6.** | Click **Save All to Flash** to store this setting in the flash disk. This setting will remain in effect if the controller is restarted. The button will flash as the data is being written. See "Copying a GPL Project to the Flash Disk" on page 43 for more information<br>***NOTE:*** *Do not turn off the controller while the button is blinking; it may corrupt the flash disk.* |

The robot must be homed for the controller to operate the robot in an automatic mode. Assuming that the robot is homed, the controller is now ready to execute a GPL Project. Execution is controlled from the Operator Control Panel.

# Copying a GPL Project to the Flash Disk

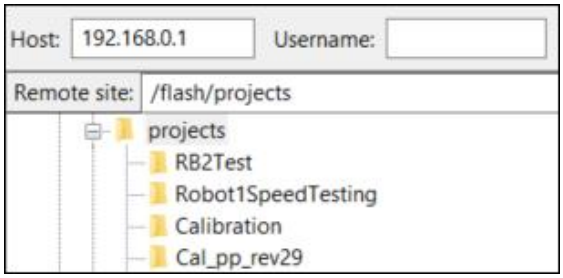
> ***NOTE:*** If the GPL project to execute is already stored in the flash disk, skip the remainder of this section.

The controller includes an FTP server that permits any FTP client software package to access the flash disk. There are two ways to copy a GPL project into the flash disk:

1. **The Guidance Controller's built-in FTP client**. If a copy of the Guidance Development Environment (GDE) Guidance Development Suite (GDS) has been purchased, use the Guidance Development Environment (GDE) to drag and drop a GPL Project from a PC's hard drive into the flash disk. For a free 30-day trial of the GDS, visit https://www.brooks.com/solutions/collaborative-robotic-solutions/support/. To purchase a license, contact sales_preciseflex@brooksautomation.com.
2. **A standard FTP client**. If using a standard FTP client software package, access the controller by its IP address (typically 192.168.0.1) in Anonymous mode with no password, and navigate to the /flash/projects folder to copy GPL projects into the flash disk. Otherwise, use the FTP client built into most browsers to drag and drop GPL projects into the Flash disk.

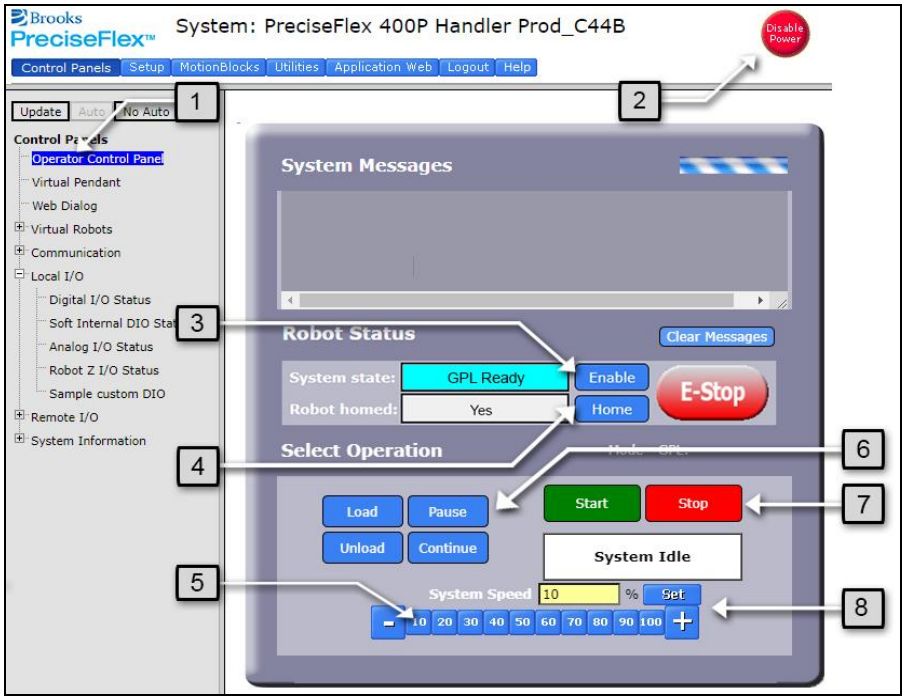
To use the Guidance Controller's built-in FTP client, perform the following procedure:

| STEP | ACTION |
|---|---|
| **1.** | In the browser, click **Utilities** > **System Utilities** > **Backup and Restore**. The *Backup and Restore Control* window will display, as shown below. |
| **2.** | Click **Backup and Restore Control** > **FTP Client** > **Start File Manager**. This forces the browser to launch an FTP client. Follow the instructions if the browser displays an intermediate window with instructions on bringing up and opening flash in FTP.<br>***NOTE:*** *The browser may present options to select an FTP utility.* |
| **3.** | FTP to 192.168.01/flash/. |

| STEP | ACTION |
|---|---|
| 4. | An FTP client window displays the names of the top-level folders in the flash disk. Click and open the Projects folder.<br><br>All GPL projects are in the Projects folder. In most cases, each folder in Projects will contain a single complete GPL project. A GPL project can contain multiple files to help organize the software and its global data. In the graphic below, Cal_pp_rev29 is the standard GPL utility program executed to calibrate the zero positions of each axis.<br><br>  |
| 5. | To copy a GPL project into the controller's flash disk, drag and drop it into the Projects folder of the flash disk. |
| 6. | After copying a GPL project into the flash disk, load it into memory, and execute it. |

# Loading and Executing a GPL Project

After configuring the GPL project (See "Guidance Programming Language (GPL) " on page 41 for more information), perform the following procedure to load and execute the project:

| STEP | ACTION |
|---|---|
| **1.** | In the browser, click **Control Panels** > **Control Panels** > **Operator Control Panel.**<br>  |
| **2.** | Click **Disable Power** to halt any robot motion. The power must be re-enabled to continue. |
| **3.** | Click **Enable** to provide power to the motors. |
| **4.** | Click **Home** to start the homing sequence. When the sequence ends, **Robot homed** displays "Yes." |
| **5.** | Click **10** in **System Speed**. This operates the robot at 10% of the average program speed. |

| STEP | ACTION |
|---|---|
| **6.** | • Click **Load** to display a list of GPL Projects in the flash disk that are available for execution.<br>• Click **UnLoad** to ensure that no GPL Project is currently selected for execution.<br>• Click **Pause** to pause rather than stop. The GPL Project terminates at the end of the currently executing statement or motion.<br>• Click **Continue** to continue. A GPL Project that was paused will continue from the point it paused. |
| **7.** | Click **Stop** to stop the GPL Project. The GPL Project terminates at the end of the currently executing statement or motion. Once a GPL Project has been stopped, start it from the beginning. |
| **8.** | Once the program is operating correctly, gradually increase the speed by doing any of the following:<br>• Clicking the "**+**" button.<br>• Clicking one of the speed buttons.<br>• Typing a speed into the **System Speed** field. The speed can be increased as the robot is running. |