PEAKROBOTICS
A Directech Company

User's Manual

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KX-2 Robot - User's Manual

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1.0 Introduction

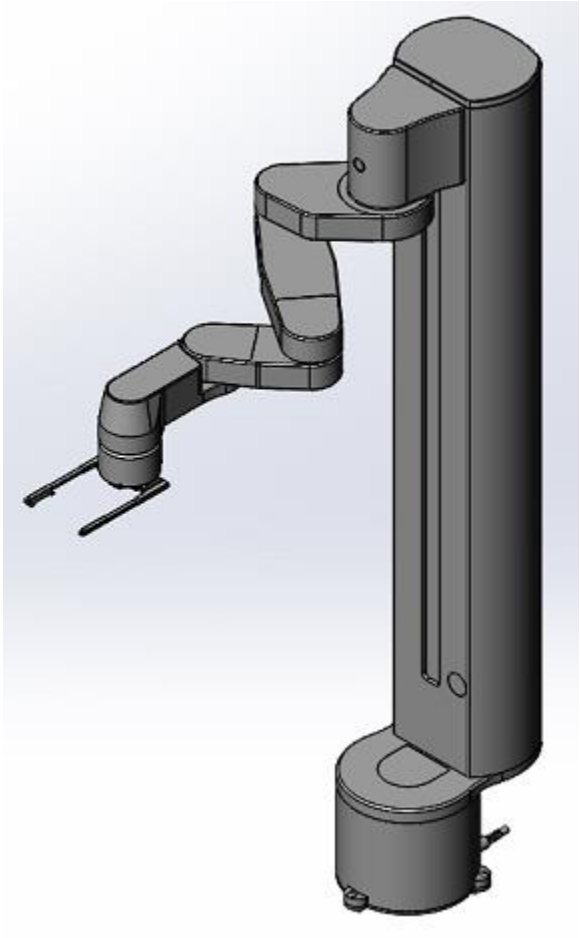
1.1 Thank you for purchasing a KX-2 Laboratory Robot. This robot was developed specifically for challenging laboratory environments. It incorporates proven technology that was developed for the demanding semiconductor industry.

1.2 Reference Guide: This manual is intended to be a reference guide for the engineer and maintenance technician responsible for installation and maintenance of the KX-2 Robot.

1.3 Setup Guidelines: This manual includes information on how to install the robot, how to bring it online, teach it, and then diagnose and rectify any problems. These steps are critical to ensure a successful installation and long-term reliability. Peak Robotics suggests keeping a written history of all settings, changes, and results.

1.4 Experienced Personnel: Although this robot can be run by non-technical personnel, installation and troubleshooting should be performed by technicians with good electrical, mechanical, and computer skills.

1.5 Software Instructions: Please refer to the KX-2 Software Instructions manual for detailed information on software and PC control of the robot.



KX-2 750 Robot

2.0 Warnings

2.1 Symbols: The following symbols are used in this manual.

 Warning	This icon accompanies text and/or other international symbols dealing with hazards to personnel. When present, it indicates that a potential hazard to personal safety exists if information stated within the **"WARNING"** paragraph is not adhered to or procedures are executed incorrectly.
 Caution	This icon accompanies text and/or other international symbols dealing with potential damage to equipment. When present, it indicates that there is a potential danger of equipment damage, software program failure or that a loss of data may occur if information stated within the **"CAUTION"** paragraph is not adhered to or procedures are executed incorrectly.
 Warning	**HIGH VOLTAGE** This icon accompanies text and/or other international symbols indicating that a potential hazard to personal safety exists from a high voltage source. In this document, the **"WARNING"** icon will accompany this symbol. To reduce risk of electrical shock, all high-voltage devices employ a three-wire electrical cable and plug to connect the equipment to earth ground. Ensure that the wall outlet receptacle is wired properly, and **earth grounded.** **DO NOT use a three-to-two wire plug adapter.** **DO NOT use a two-wire extension cord or a two-wire multiple-outlet power strip.** **Disconnect power to the system before performing maintenance.** **DO NOT remove any panels; panels should be removed only by qualified service personnel.**
 Warning	**SHARP OBJECTS/MOVING PARTS** This icon accompanies text and/or other international symbols dealing with hazards to personnel from unblunted corners or other appendages on the outside or inside of the equipment. In this document, the **"WARNING"** icon will accompany this symbol. To avoid injury due to moving parts, observe the following: **Keep loose clothing and hair away from moving parts.** **Never attempt to physically restrict movement of moving parts.**

2.2 Installation: This product is sold as a component to be installed in a complete system using good engineering practices. Care must be taken by the system integrator to ensure that this product, as well as the other products in the system, are installed and used in a safe manner according to local and international safety laws and regulations, as well as any safety standards required by the end-user.

2.3 Component Selection: This document and other information from Peak Robotics, Inc. and authorized distributors provide product information for users having technical expertise. The user is solely responsible for making the final selection of the system components and ensuring that all performance, safety, and warning requirements are satisfied.

2.4 High Speed: This high-performance product can produce rapid movement and high forces. Unexpected motion may occur, especially during the development of control sequences. Never enter the working envelope of the robot and never touch any part of the equipment while it is in operation.

2.5 Protection: If the equipment is used in any manner that does not conform to the instructions given in this user's manual, then the protection provided by the equipment may be impaired.

3.0 Safety Precautions

3.1 General Precaution: The KX-2 robot operates under computer control. As with most computer-controlled and robotic devices, there is always the potential for injury or damage from moving components whenever the device is in motion.


Warning

Warning: Never reach into the robot's working envelope when the unit is moving.

3.2 High Force: The KX-2 robot can generate enough force to cause injury to a person who obstructs the motion of the robot. Peak Robotics recommends that the robot be mounted inside an enclosure with safety-interlocked doors or light curtains that do not allow the robot to run when open or interrupted. Alternatively, the integrator can perform a risk assessment per ISO 10218-2:2011 to determine whether the application is suitable for collaborative operation of the robot.


Caution

Important: Ensure that no extraneous objects can inadvertently enter the robot's working envelope when powered up.


Safety Glasses Required

Safety Glasses Required: All personnel who are working within close proximity of an unguarded robot shall wear safety glasses at all times that meet or exceed ANSI Z87.1–2015.

3.3 Emergency Stop: The robot is equipped with an emergency stop button which, when pressed, will decelerate the robot to a controlled stop, after which power to the motors will be disabled. This allows the operator to stop the robot in an emergency. If the emergency stop button is pressed while the robot is motion, the robot will continue moving a short distance as the motors decelerate to a stop. If the robot is integrated with other moving devices, a *master* emergency stop button should be installed that disables all equipment simultaneously. Consult the factory for E-Stop wiring options.


Warning

Important: Avoid having multiple emergency stop buttons that serve varying purposes, as this can lead to confusion in a panic situation.

3.4 Robot Damage: The robot can be damaged if made to collide with external equipment, especially if the robot is moving at a high rate of speed. The robot is also capable of damaging other equipment if made to collide with it.


Caution

Recommendation: When testing new sequences, run the robot slowly the first time through. If a collision occurs, the position error tracking feature of the robot motor drives may stop the robot. If this happens, move the robot away from the obstruction by hand and then re-initialize.

3.5 Teaching the Robot: The robot software has no provisions for avoiding surrounding equipment automatically. The robot merely executes the commands sent to it.


Caution

Note: It is the responsibility of the teaching operator/programmer to create sequences that avoid obstacles.


Warning

3.6 Electrical Hazard: Do not disassemble any portion of the robot or control box when the control box is connected to an AC power source. Note: All voltage internal to the robot is 57VDC or less; however, 57 volts is hazardous, and the voltage potential can damage sensitive components inside the robot. High-voltage AC power (115 or 230VAC) is present inside the robot power supply box.

3.7 Collaborative Applications: The KX-2 robot has been designed for use in collaborative applications, in accordance with ISO 10218-1:2011 and ISO/TS 15066. This does not, however, automatically ensure that the robot will be safe for collaborative use in all applications. It is the responsibility of the system integrator and the end user to verify that the application meets the requirements of ISO 10218-2:2011, Robots and Robotic Devices—Safety Requirements for Industrial Robots—Part 2: Robot Systems and Integration. It is also the responsibility of the system integrator and the end user to verify that the application meets all internal company safety policies and applicable international and local laws and regulations.

4.0 Compliance with Standards

4.1 The KX-2 robot complies with the following standards:

Standard	Description
CISPR11/FCC Class B	Emission Standard for Industrial Environments (EMC)
EMC Directive 2014/30/EU	IEC 61326-1:2012, Electrical Equipment for Measurement, Control and Laboratory Use (EMC)
IEC 61010-1:2016	Safety Requirements for Laboratory Equipment
ISO 10218-1:2011	Robots and Robotic Devices—Safety Requirements for Industrial Robots, Part 1: Robots
ISO/TS 15066	Robots and Robotic Devices—Collaborative Robots
ISO 13849-1:2015	Safety of Machinery—Safety-related Parts of Control Systems, Part 1: General Principles for Design
ISO 13849-2:2012	Safety of Machinery—Safety-related Parts of Control Systems, Part 2: Validation
2011/65/EU	RoHS2—Restriction of Hazardous Substances
2006/42/EC	Machinery Directive (CE)

4.2 Clause 5.8.4 of ISO 10218:1-2011 states that the pendant or teaching control device shall have an emergency stop function. A PC application or a game controller can be used to teach the KX-2 robot. These controls do not have an integrated emergency stop function. Peak Robotics has made the determination that an integrated emergency stop function is not necessary due to compliance of the robot with ISO/TS 15066.

4.3 Clause 5.7.1 of ISO 10218:1-2011 states that operational modes shall be selectable with a mode selector. The KX-2 robot does not have a mode selector. Peak Robotics has made the determination that a mode selector is not necessary due to compliance with ISO/TS 15066.

4.4 Clause 5.6 of ISO 10218:1-2011 describes the requirements for speed control. Peak Robotics has made the determination that speed control, as described in ISO 10218:1-2011 is not necessary due to compliance with ISO/TS 15066. The speed of the KX-2 is controlled in the following ways:

- Each individual motor drive is programmed with a maximum speed limit for the attached motor. The motor drive will disable the motor if the speed limit is exceeded.
- The software is configured with individual motor speed limits as well as speed limits for linear motion.
- The power supply and motors are sized such that they are not physically capable of attaining speeds that are significantly higher than the limits imposed by the motor drives and software.

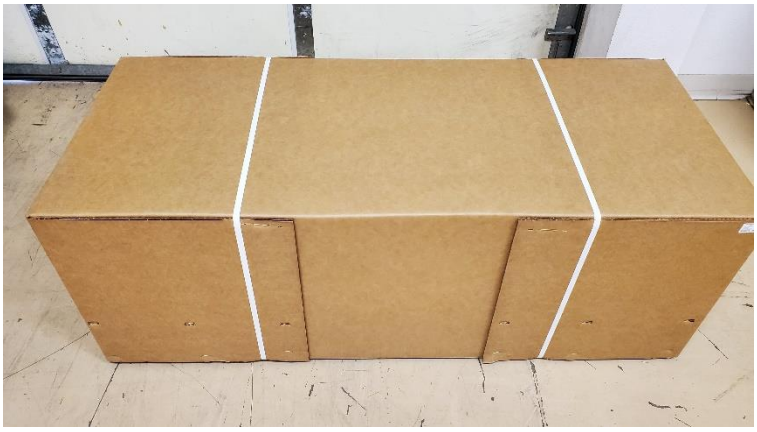
5.0 Contents and Packaging Instructions

5.1 Package Contents

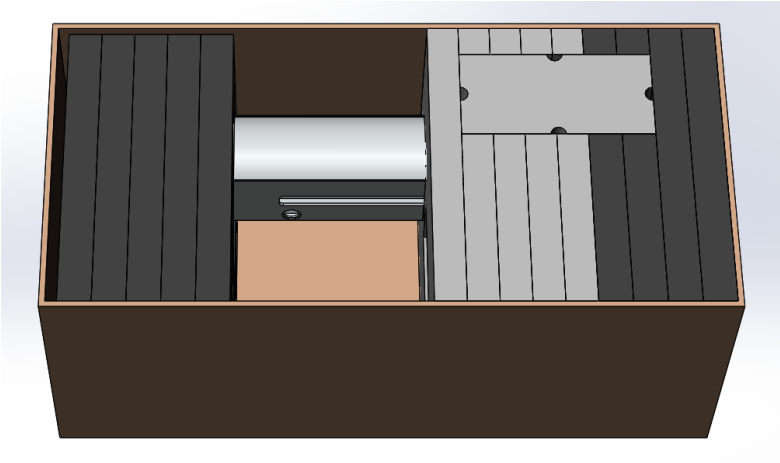
- Robot in plastic bag
- Power Supply & AC Power Cord
- E-Stop with Cable
- USB Cable – Robot to User PC Connection
- Barcode Reader Cable – Robot to User PC Connection
- USB/Serial Adapter for Barcode Reader Cable
- Mounting Screws & Dowel Pins
- Side-Grip and Top-Grip finger sets
- Gripper Sensor Adjustment Screwdriver & Instructions
- Teach Plate
- USB drive with software & documentation
- Printed card with software & documentation download links

5.2 Use the following procedure when unpacking the robot:

Step 1) Cut off the straps from the box.

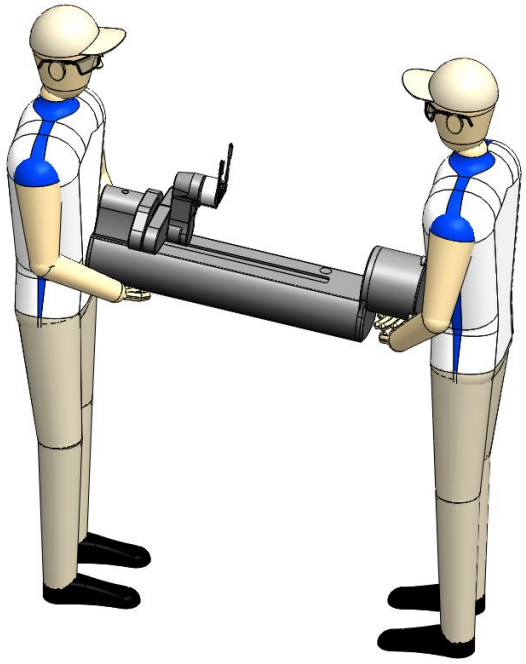


Step 2) Lift the cover off the box.



Step 3) Remove the two large pieces of foam that cover the two ends of the robot.

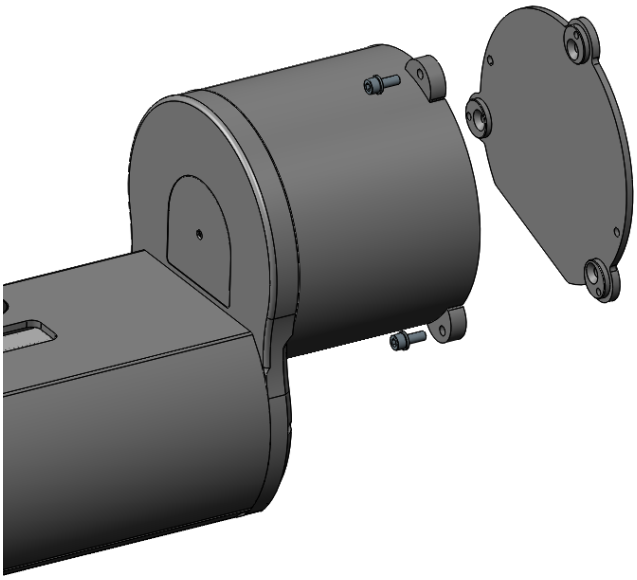
Step 4) With the help of an assistant, lift the robot out of the box Lift via the two ends of the robot. Rotate the robot so that the arm is pointing upward. If the arm is positioned downward, it will extend under its own weight, making it difficult to handle.



Step 5) Lay the robot on its back on a piece of foam or bubble wrap to protect the finish.

Step 6) Remove the plastic bag from the robot.

Step 7) Detach the Robot Mount Plate from the bottom of the robot by removing the three screws and flat washers securing it to the Shoulder.



Step 8) Attach the Robot Mount Plate to the table in the desired location using the three included M6 flathead screws. Refer to the Installation & Setup section for mounting hole dimensions.

Step 9) With the help of an assistant, lift the robot and set it on top of the Robot Mount Plate. Reinstall the three screws and flat washers while the assistant is holding the robot to ensure it does not topple over.

CAUTION: The robot is not stable on its own and may tip over. Do not stand it up and leave it unattended without attaching it to a table. The robot should be left lying on its back on a soft surface if provisions for mounting it are not yet available.

Step 10) Remove the power supply and accessories from the foam inserts.

6.0 Product Description

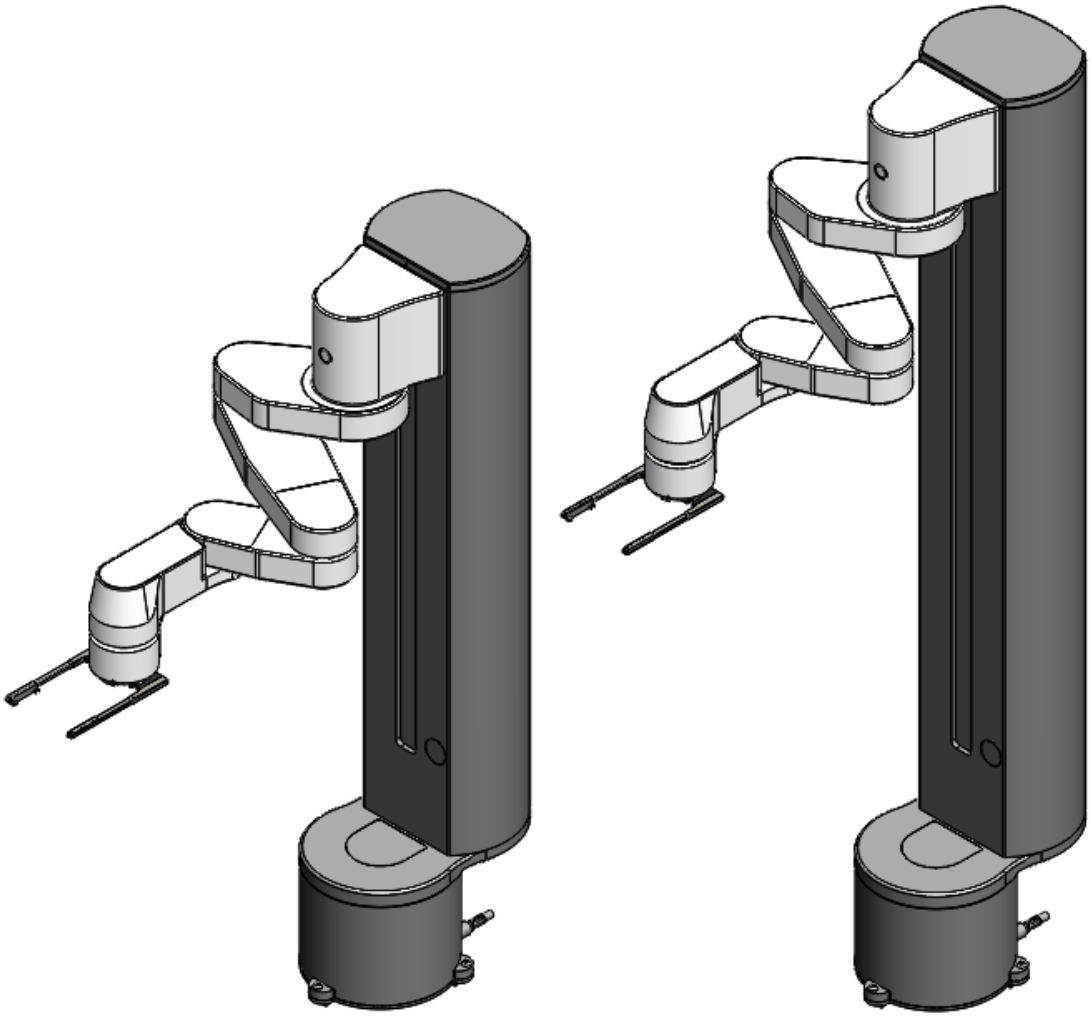
6.1 Description: The KX-2 is a tabletop cylindrical robot designed for laboratory and light industrial applications.

6.2 Technology: The robot has four axes of motion and incorporates a combination zero-backlash harmonic drive gearboxes and belt drives driven by DC servomotors. Motion control is accomplished via true absolute encoders and distributed motor drives. The vertical Z axis contains a counterweight to minimize required thrust and to eliminate the need for a Z brake.

6.3 Work Envelope: The two rotary joints of the robot have unlimited travel, allowing the robot to access all locations around it with no dead zones.

6.4 Telescoping Arm: The robot achieves extreme reach and is also highly compact thanks to a multilink arm design. Radial motion of the arm eliminates the operating complexity and awkwardness inherent in a typical SCARA two-link robot arm.

6.5 Standard Models: There are two standard heights available. The KX-2 500 has 500mm of vertical travel, and the KX-2 750 has 750mm of vertical travel. The arm has 677mm of horizontal reach (center of shoulder to center of wrist). An electric gripper comes standard on the robot and has the following finger options: Top-Grip (TGF), Side-Grip (SGF), and Portrait-Jog Side-Grip (SGJF). Side-Grip fingers add 110mm to the horizontal reach of the arm, and Portrait-Jog Side-Grip fingers add 116mm.



KX-2 500 KX-2 750

6.6 User Inputs/Outputs: There are three digital inputs, two analog inputs, and three digital outputs available at base of the robot. These are described in more detail later in this document.

6.7 Internal Motor Drives: All joints and gripper are servo-driven with drives mounted inside the robot next to each motor. A USB/CANOpen adapter is mounted inside the robot and provides a USB interface between the robot and PC.

6.8 Barcode Reader: A 1D barcode reader is integrated into the gripper.

6.9 User-Supplied PC: A standard PC with Windows 7 or newer is required to control the robot. The robot connects to the PC via a USB 2.0 port. An RS232 serial port is required for the barcode reader (a serial/USB adapter is provided with the robot).

6.10 Power: The robot uses 57 VDC for motor power, and 24VDC for logic power. The two DC power supplies are mounted inside the power supply box.

Power Supply Box

6.11 Universal DLL: A universal .NET 4.0 DLL (provided with robot) is to be used by the top-level sequencing program, which typically is written in VB, C++, C#, etc.

6.12 Scheduling Software: As an option, PAA Overlord can be used for synchronizing the robot with other equipment. Please see www.paa-automation.com for more information.

6.13 Gripper: The robot comes standard with an electric gripper. There are no air lines inside the robot, so a pneumatic gripper is not an option.

6.14 Serial Number Tag: A serial number tag is located on the rear of the shoulder housing. A second serial number tag is located on the side of the power supply box.

Serial Number Tag

7.0 Specifications

7.1 General Specifications

Max Payload	500g (1.1lb)
Radial Stroke	525mm (20.7in)
Radial Reach	787mm (31in) w/Side-Grip Fingers, 677mm (26.6in) to Wrist Center
Radial Compactness	190mm (7.47in) with Gripper Facing Inward
Travel:	
Shoulder	360° Unlimited
Z	500mm (19.69in) or 750mm (29.53in)
Elbow	525mm (20.7in)
Wrist	360° Unlimited
Gripper	26.15mm (1.03in) per finger
Speed (Max):	
Shoulder	145 deg/s
Z	750 mm/s (29.5 in/sec)
Elbow	467 mm/s (18.4 in/sec) avg.
Wrist	500 deg/s
Gripper	47 mm/s (1.85 in/sec)
Torque/Thrust:	
Shoulder	14.5Nm (128 in-lb) Peak, 7.3Nm (64 in-lb) Continuous
Z	43.3N (9.7 lbs) Peak, 21.7N (4.9 lbs) Continuous
Elbow	11.3Nm (100 in-lb) Peak, 5.7Nm (50 in-lb) Continuous
Wrist	1.22Nm (10.8 in-lb) Peak, 0.61Nm (5.4 in-lb) Continuous
Gripper	22N (5 lbs)
Encoder Resolution	
Shoulder	8,388,608 counts/revolution
Z	3998 counts/mm
Elbow	13,375 counts/mm avg.
Wrist	16,384 counts/revolution
Gripper	3183 counts/mm (motion of single finger)
Repeatability:	
Arm Extend	+/- 0.1mm (.004in)
Vertical	+/- 0.1mm (.004in)
Weight:	**KX-2 500:** 29.5 kg (65 lbs), **KX-2 750:** 31.8 kg (70 lbs)
Height:	**KX-2 500:** 925mm (36.4in), **KX-2 800: 1174**mm (46.22in)
Power:	
Input Power:	100-240 VAC), 1Φ, 47-63Hz, 5.6A Max @ 115VAC (2.8A Max @ 230VAC)
Output to Robot:	57VDC/5.3A/300W Max, 24VDC/3A/80W Max
Power Supply Dims:	240mm x 160mm x 90mm (9.5in x 6.3in x 3.5in)
Safety	Current & Position Error Sensing, Emergency Stop Button (Stop Cat. 1)
User I/O	3 Digital Inputs, 2 Analog Inputs, 3 Digital Outputs

Encoders	Magnetic Absolute on robot joints, Incremental on gripper
Teaching	Drag-to-teach-point, one-touch teach button on robot
Gripper Options	Top-Grip, Side-Grip, Side-Grip-Portrait-Jog, Custom
PC Interface	USB 2.0

7.2 Environmental Conditions

Condition	Limits
Operating Ambient Temperature	5° to 40°C (41° to 104°F)
Storage Temperature	-20° to 49°C (-4° to 120°F)
Maximum Non-condensing Humidity	90%
Maximum Operating Altitude	2,000m (6,562 feet)

7.3 Ventilation, Cleaning and Decontamination

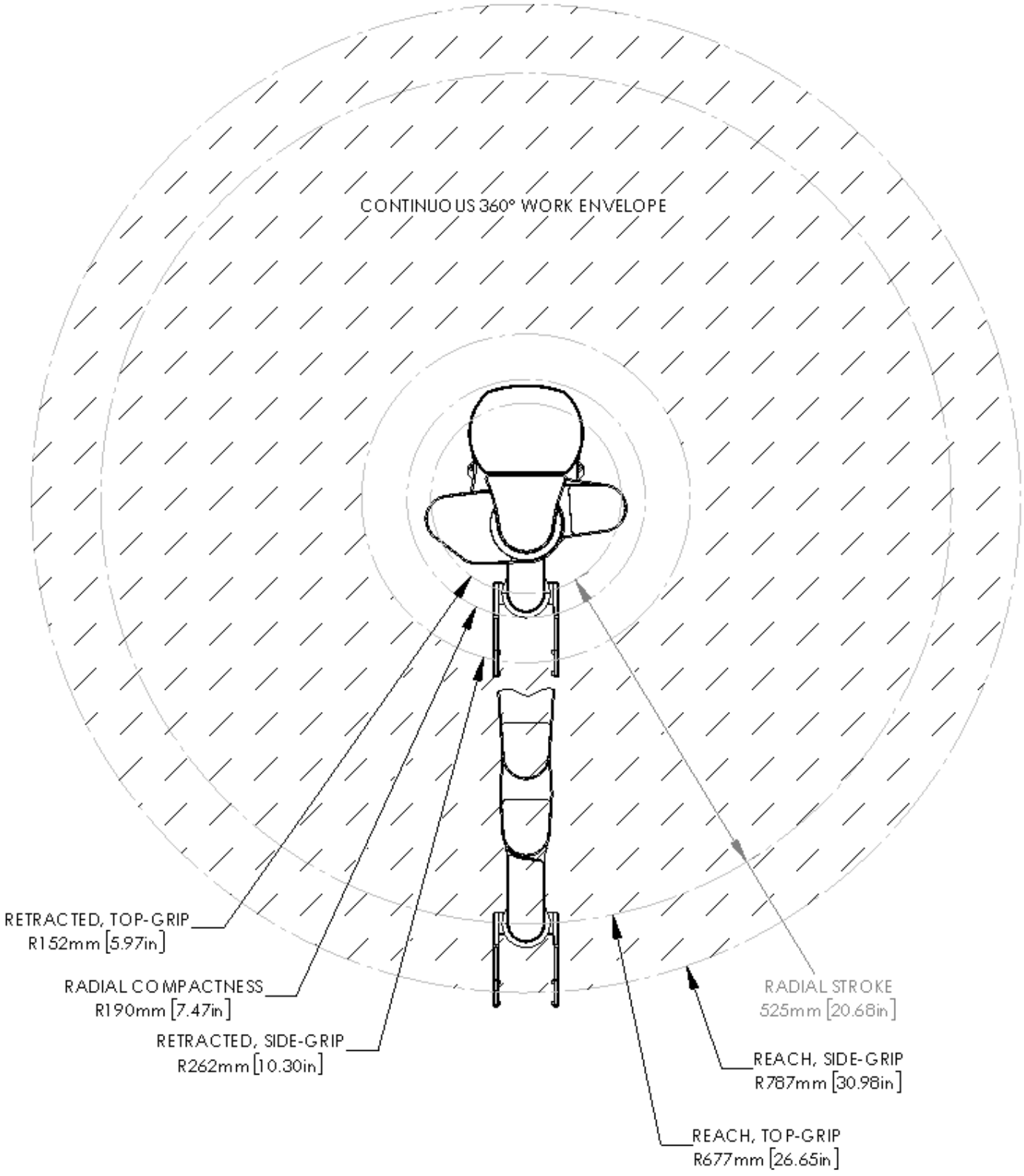
7.3.1 Ventilation of the space containing the robot should be adequate to maintain the environmental conditions listed above.

7.3.2 The robot should not be sprayed with any liquid. Inadvertent contact with the occasional droplet of non-corrosive liquid is acceptable but should be minimized.

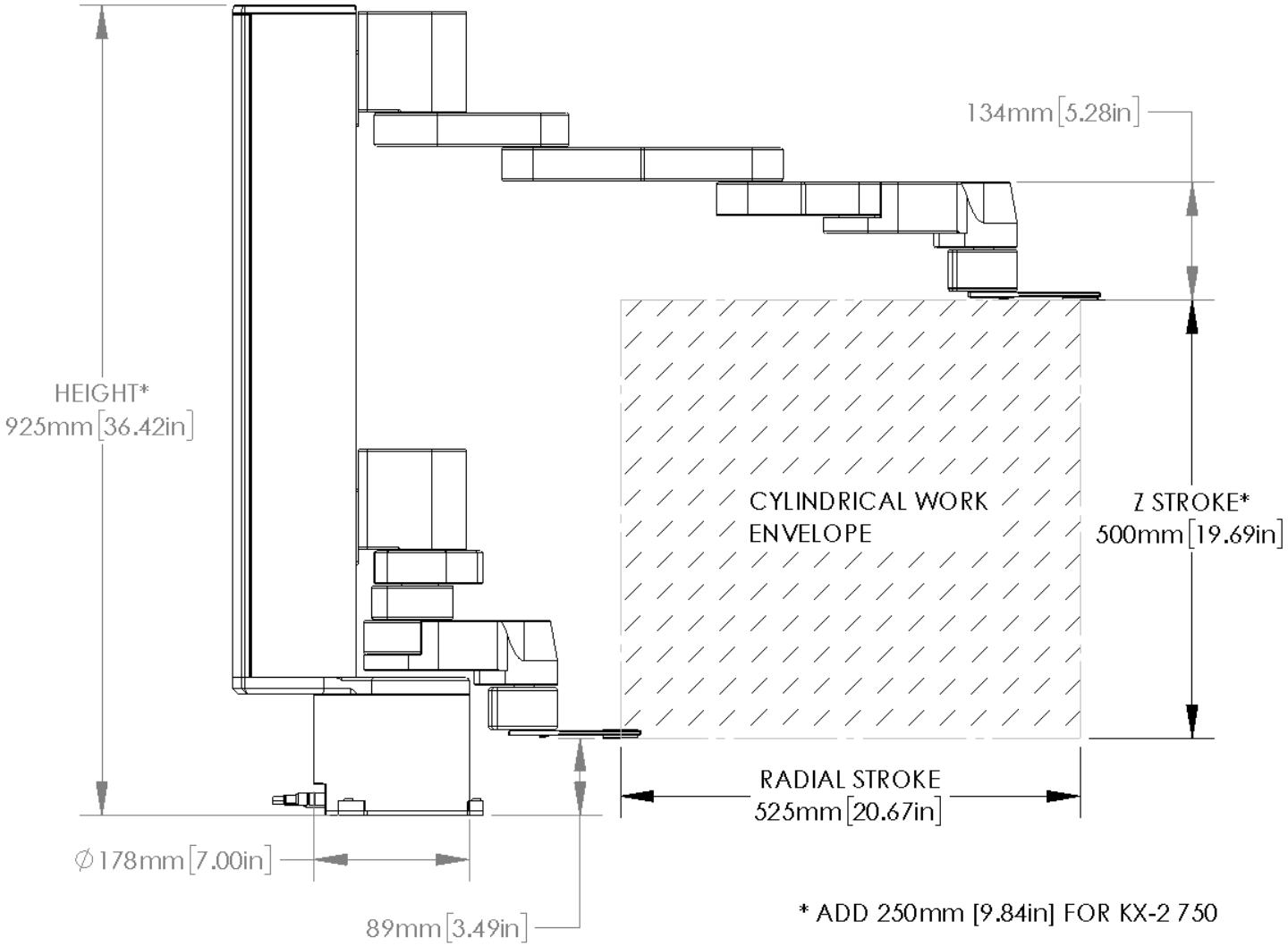
7.3.3 The robot should be cleaned by wiping with a microfiber cloth or paper towel partially saturated in isopropyl alcohol. Power should be disconnected from the robot prior to cleaning, and the robot should be left to dry for at least 15 minutes prior to reconnecting power.

7.3.4 The robot should not be decontaminated with any type of gas that may cause corrosion of metal or deterioration of plastic.

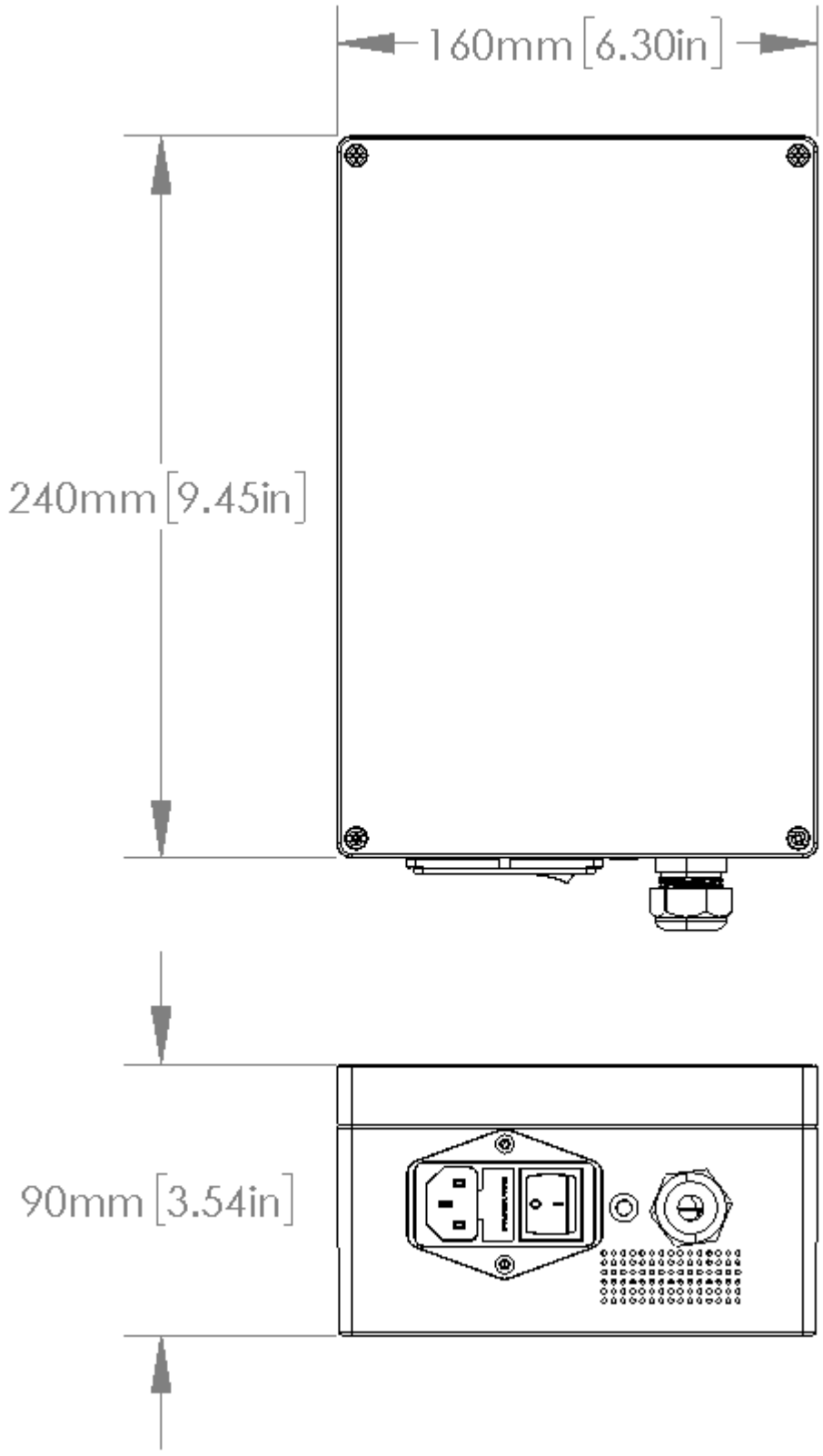
7.4 Robot Dimensions, Top View:



7.5 Robot Dimensions, Side View (KX-2 500 shown):

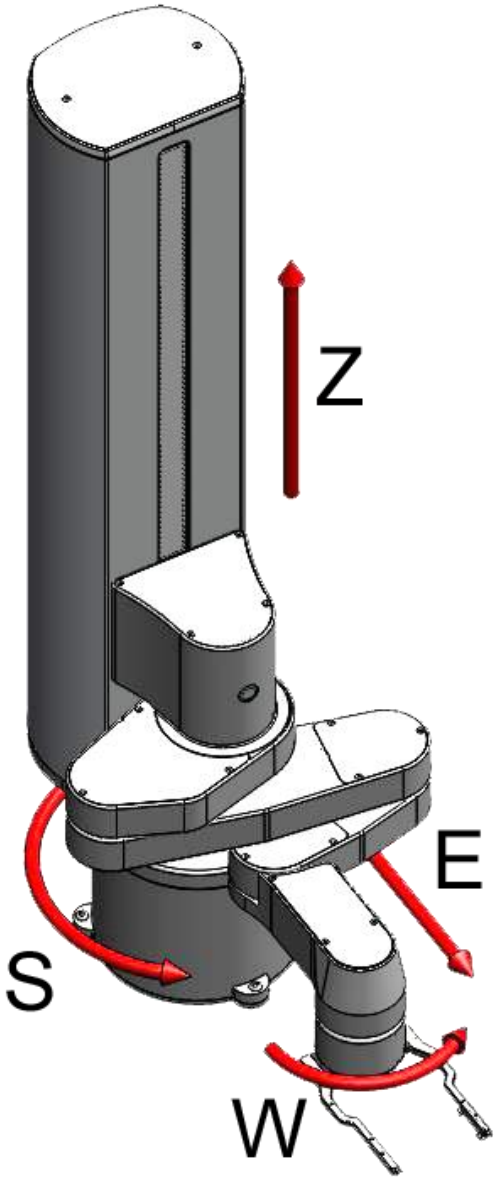


7.6 Power Supply Dimensions:



7.7 Axis Naming Definitions:

Name	Designation	Description
Axis 1	"S"	Shoulder Motor, Shoulder Rotate
Axis 2	"Z"	Z Motor, Vertical Axis
Axis 3	"E"	Elbow Motor, Arm Extend
Axis 4	"W"	Wrist Motor, Wrist Rotate



KX-2 Axis Naming Definitions

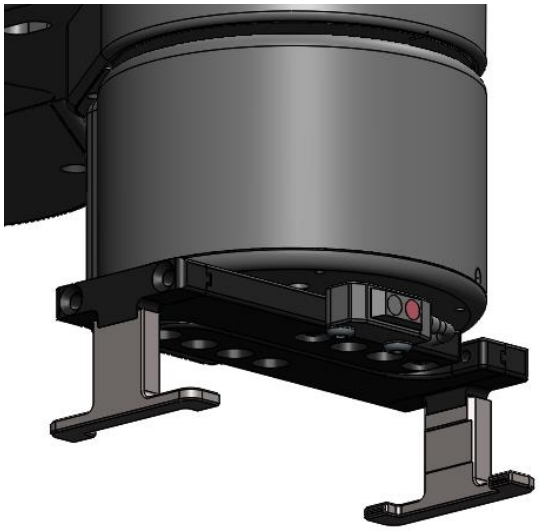
8.0 Gripper

8.1 Description: The base model KX-2 robot comes standard with an electric gripper. The robot can be operated without a gripper, if need be. It is not possible to route a pneumatic hose through the KX-2, so a pneumatic gripper is not an option.

8.2 Gripper Control: The gripper is controlled via the same CANOpen network that controls the robot joints, so no additional PC connection or software is required. The gripper uses force feedback to verify a successful gripping operation. The gripper jaws can be moved by hand when the motor is disabled.

8.3 Microtiter Plate Handling: The KX-2 is available with three standard finger options to grip plastic SBS microtiter plates used in bio/pharma research. All three styles of fingers are compatible with the standard gripper and include an optical sensor for detecting the presence of a microtiter plate in the gripper, or for searching in a stack for the top plate.

8.4 Top-Grip: This gripper finger style is used typically with First-In-Last-Out (FILO) Portrait Plate Stacks as shown below. The fingers have enough depth to pick up two standard depth plates simultaneously, if desired.

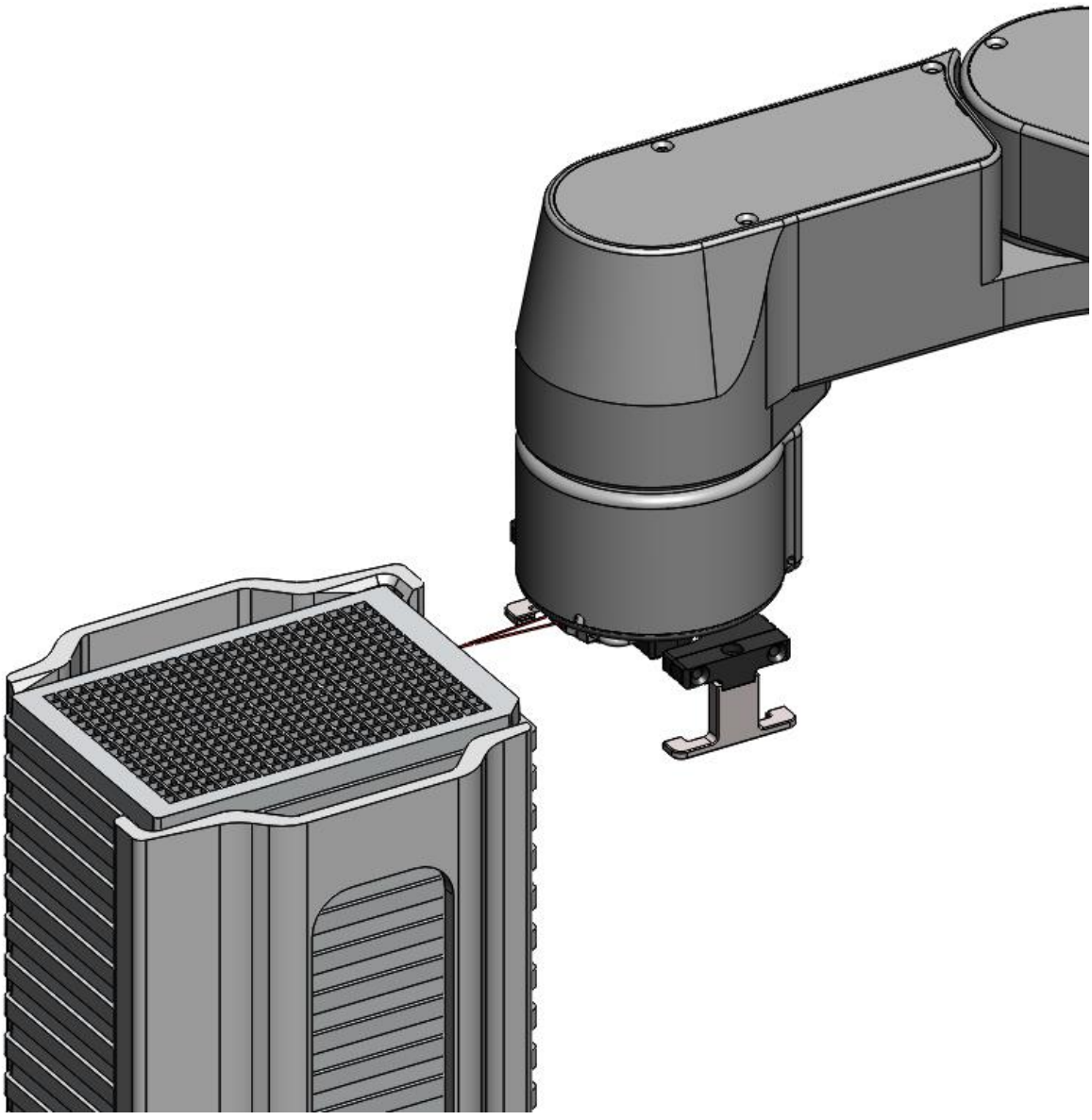


TGF Top-Grip Fingers

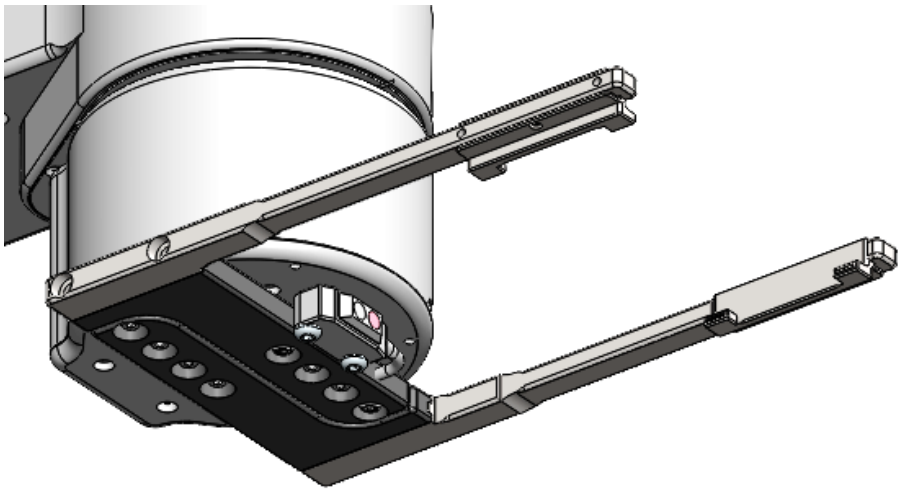
SS-TP Sequential Stack

8.5 A forward-facing retro-reflective optical sensor is located on the front of the gripper. This sensor is used for counting the number of plates in a FILO stack. Due to location of this sensor, it is not used for determining the presence/absence of a plate in the gripper. This is achieved by the servo gripper motor via force feedback.

8.6 When using the sensor to count the number of plates in a FILO stack, the gripper must be positioned outside stack, as shown below. This is achieved by using the YOffset parameter in the ScanStack() and RemovePlateFromPitchStack() functions. The recommended value for YOffset is -125mm. See the KX-2 Software Instructions manual for more information.



8.7 Side-Grip: Side-grip Universal, 110mm Offset (grips either portrait or landscape). This gripper finger style is used typically with Side-Grip Landscape FILO Stacks and Random-Access Portrait & Landscape Hotels, as shown below.

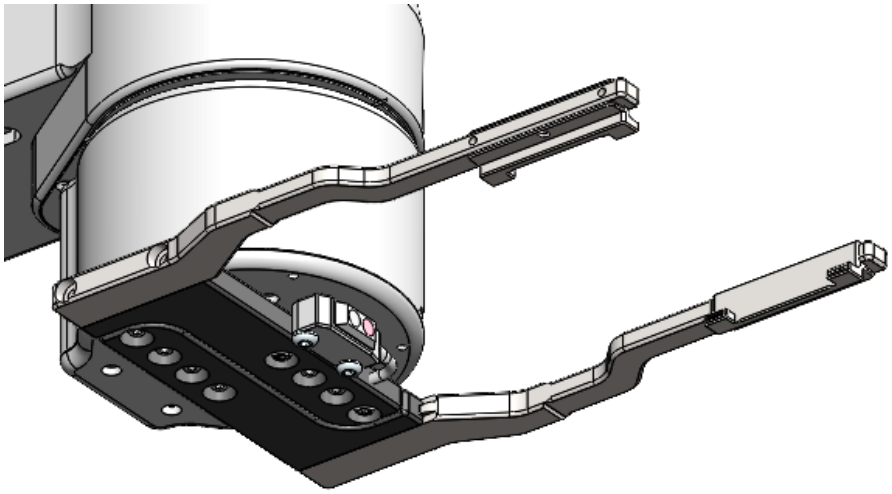


SGF Side-Grip Fingers

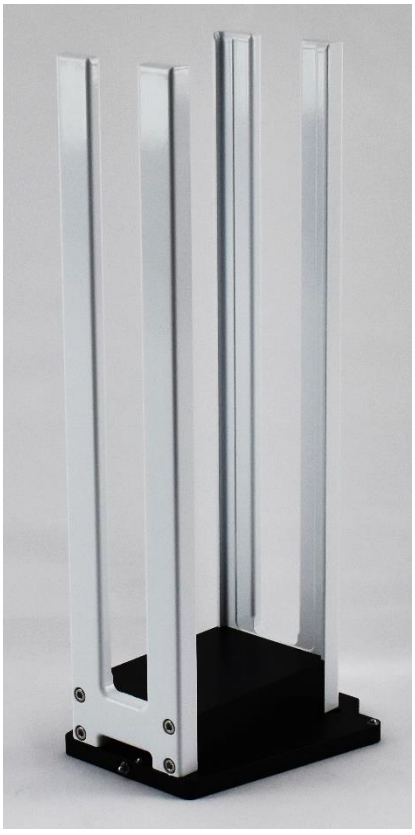
SS-SL Stack

HR-SU Hotel

8.8 Side-Grip Portrait-Jog: Side-grip Universal, 116mm Offset (grips either portrait or landscape). This gripper finger style is used typically with Side-Grip Portrait FILO Stacks, as shown below (jogged fingers are required for clearing the stack uprights).

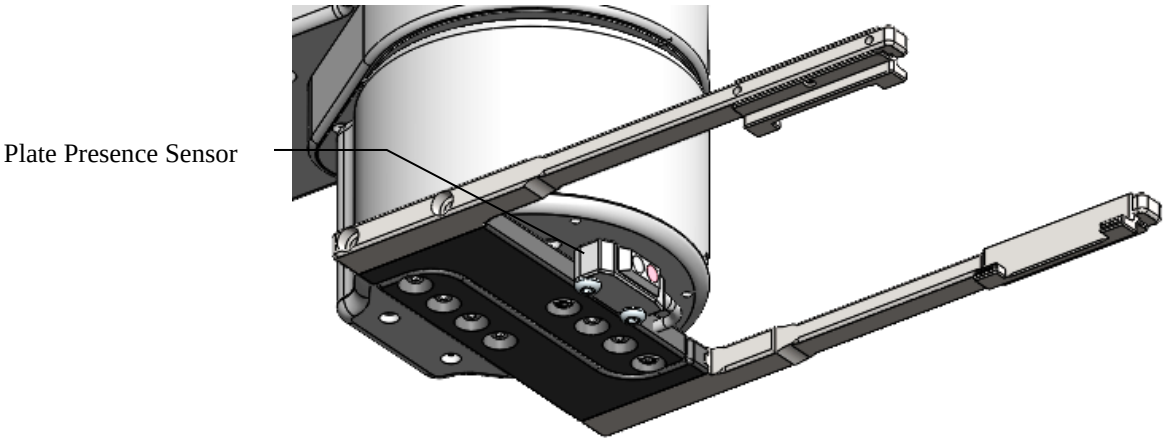


SGJF Side-Grip Portrait-Jog Fingers

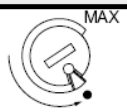
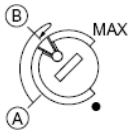
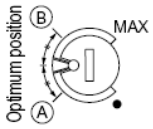


SS-SP Stack

8.9 Side-Grip Sensor Adjustment: The plate presence sensor for the Side-Grip and Side-Grip Portrait-Jog grippers is located under the gripper housing as shown here. Depending on the type of microplate being used, the sensor may need to be adjusted per the table shown below. The sensor must be detached from the gripper to access the adjustment screw.



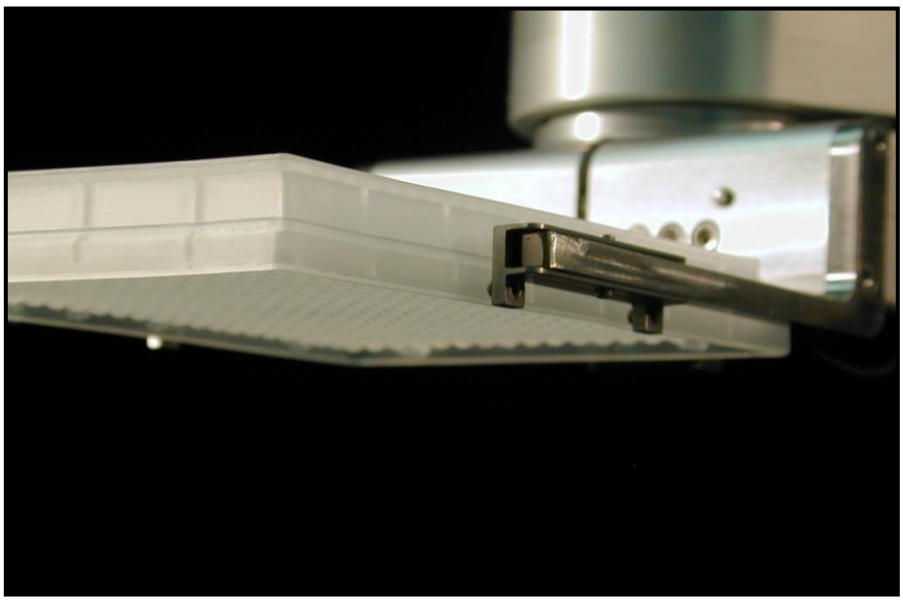
Sensitivity adjustment

Step	Sensitivity adjuster	Description
①		Turn the sensitivity adjuster fully counterclockwise to the minimum sensitivity position (• mark).
②		In the light received condition, turn the sensitivity adjuster slowly clockwise and confirm the point Ⓐ where the sensor enters the 'Light' state operation.
③		In the dark condition, turn the sensitivity adjuster further clockwise until the sensor enters the 'Light' state operation and then bring it back to confirm point Ⓑ where the sensor just returns to the 'Dark' state operation. If the sensor does not enter the 'Light' state operation even when the sensitivity adjuster is turned fully clockwise, this extreme position is point Ⓑ.
④		The position at the middle of points Ⓐ and Ⓑ is the optimum sensing position.

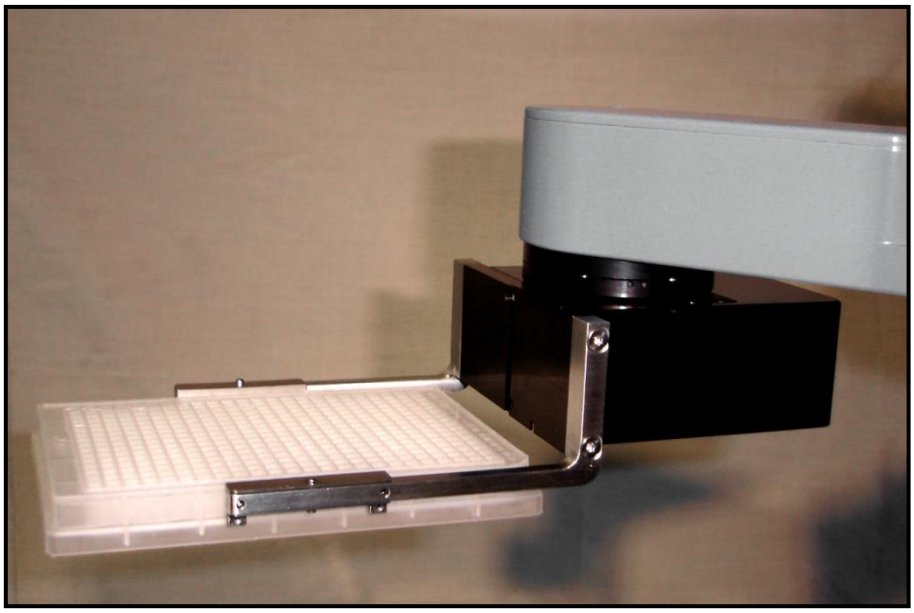
Notes: 1) Use the attached adjusting screwdriver to turn the adjuster slowly. Turning with excessive strength will damage the adjuster.

Plate Presence Sensor Adjustment

8.10 Gripping on Skirt: All KX-2 grippers are designed to grip plates with or without lids; however, in some installations, it may be advantageous to grip very low on the plate as shown below.



Gripping Plate on Skirt - Low

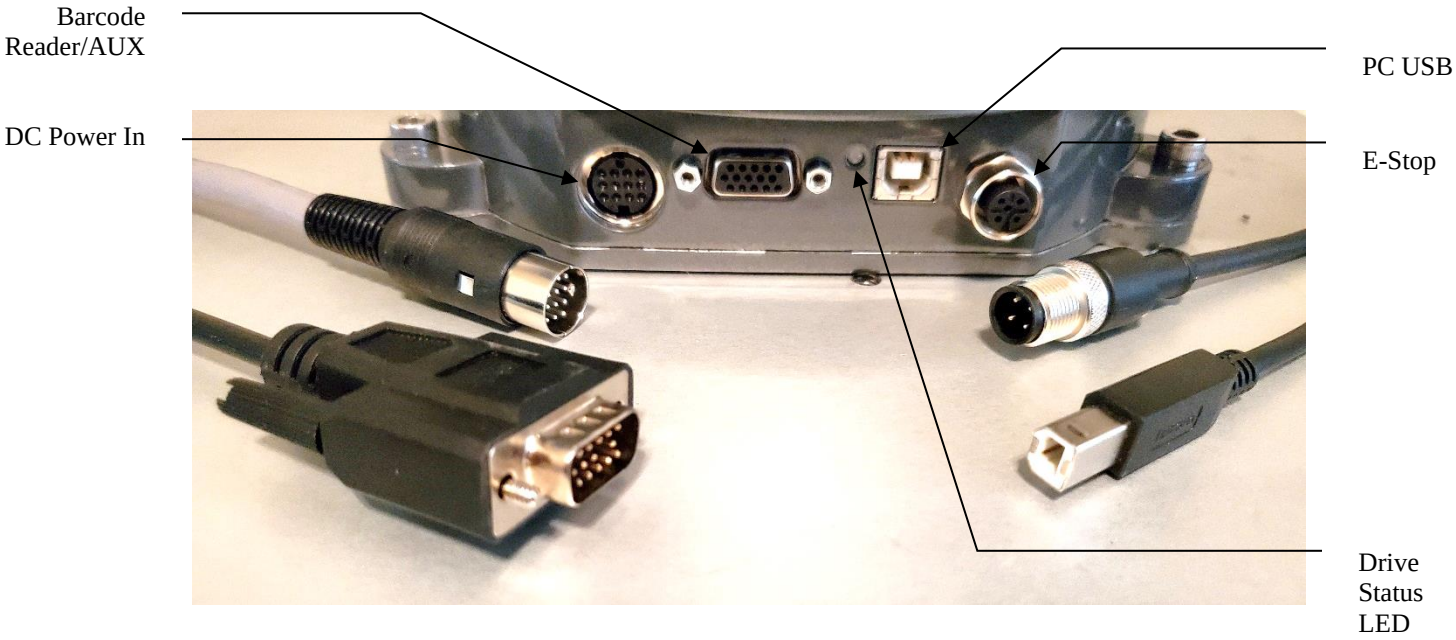


Gripping Plate above Skirt - Normal

9.0 Electrical Description

9.1 Power: The robot is powered by standard residential single-phase AC power (see Specifications section). The AC power cord plugs into the power supply box. The power supply box contains a 57VDC power supply and a 24VDC power supply. A cable with a 13-pin mini-DIN connector connects the power supply box to the robot and supplies the robot with DC power used by the motor drives, sensors, and indicator lights.

9.2 CANOpen Network: A USB/CANOpen adapter is located inside the robot shoulder. It connects the PC to the robot via the provided 6ft USB cable. The adapter uses CANOpen protocol to communicate with the five motor drives mounted inside the robot.



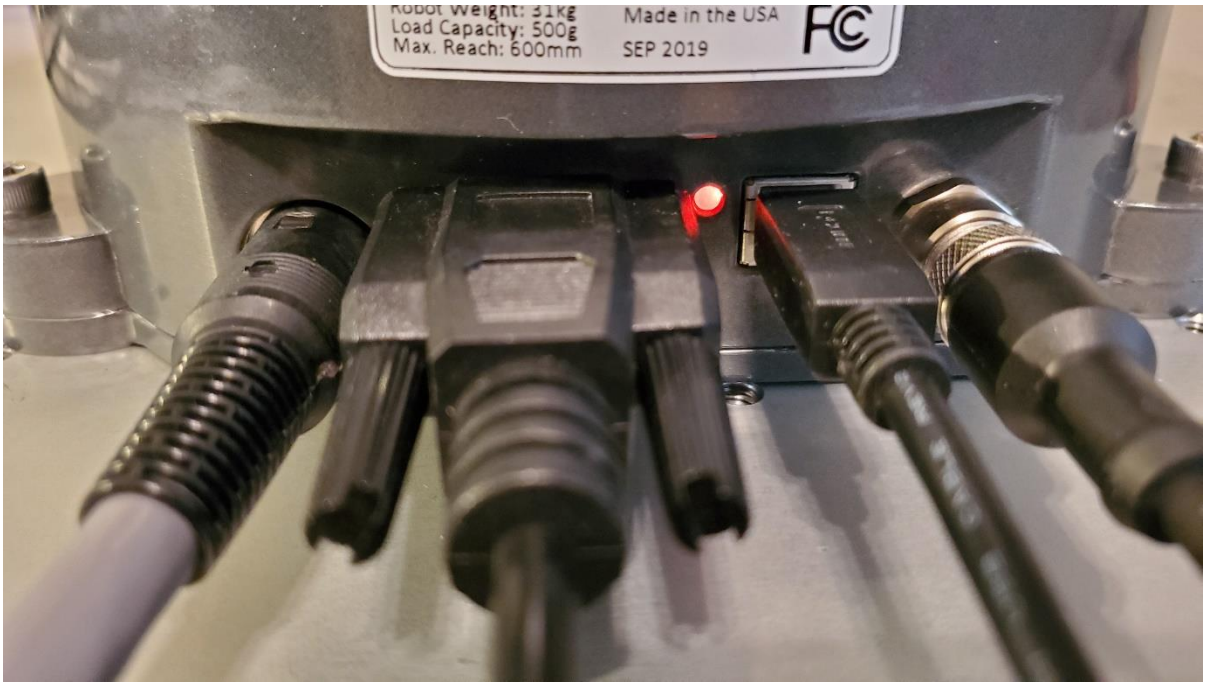
Robot Cable Connections

9.3 Emergency Stop Wiring: A button for stopping the robot in emergency situations is plugged into the robot. Actuating the Intelligent E-Stop circuitry by pressing the E-Stop button stops the robot but keeps the motor drive logic circuits powered. Restarting the robot after an E-Stop requires a deliberate input by the operator on the controlling computer. Note: Shutting off AC power to the robot will require re-homing of the gripper.

E-Stop Button

9.4 Auxiliary Connector: A 15-pin female high-density d-sub connector is located on the robot shoulder. This connector provides the user with access to digital inputs, analog inputs, digital outputs, and the RS232 communication lines for the barcode reader that is integrated into the gripper.

9.5 Status LED: If the E-Stop button is popped up, power is applied to the robot, and no Shoulder drive errors are present, then the Drive Status LED located on the Shoulder connector panel should be green. If the LED is red, then either the E-Stop button is pressed or disconnected, or a Shoulder drive error is present. If the LED is off, then either the power is disconnected or the fuse inside the Shoulder is blown.



Shoulder Drive Status LED

9.6 Power LED: If AC power is connected to the power supply box and the AC power switch is in the "on" position, the blue LED powered by 24V should be on. If this LED is not on, then the fuses inside the power entry module may be blown.

Unplug the AC power cord from the power supply box before removing the fuse cover!

9.7 Controlling PC: A standard PC must be supplied to control the robot. The PC must be equipped with Windows 7 or higher and must have two USB 2.0 ports available for main PC communication as well as the supplied USB/Serial adapter for the barcode reader.

9.8 DLL: The robot control software is a universal .NET 4.0 DLL. For debugging and teaching the robot, a graphical user interface is provided (KX-2 Teach Pendant) and is described later in this document.

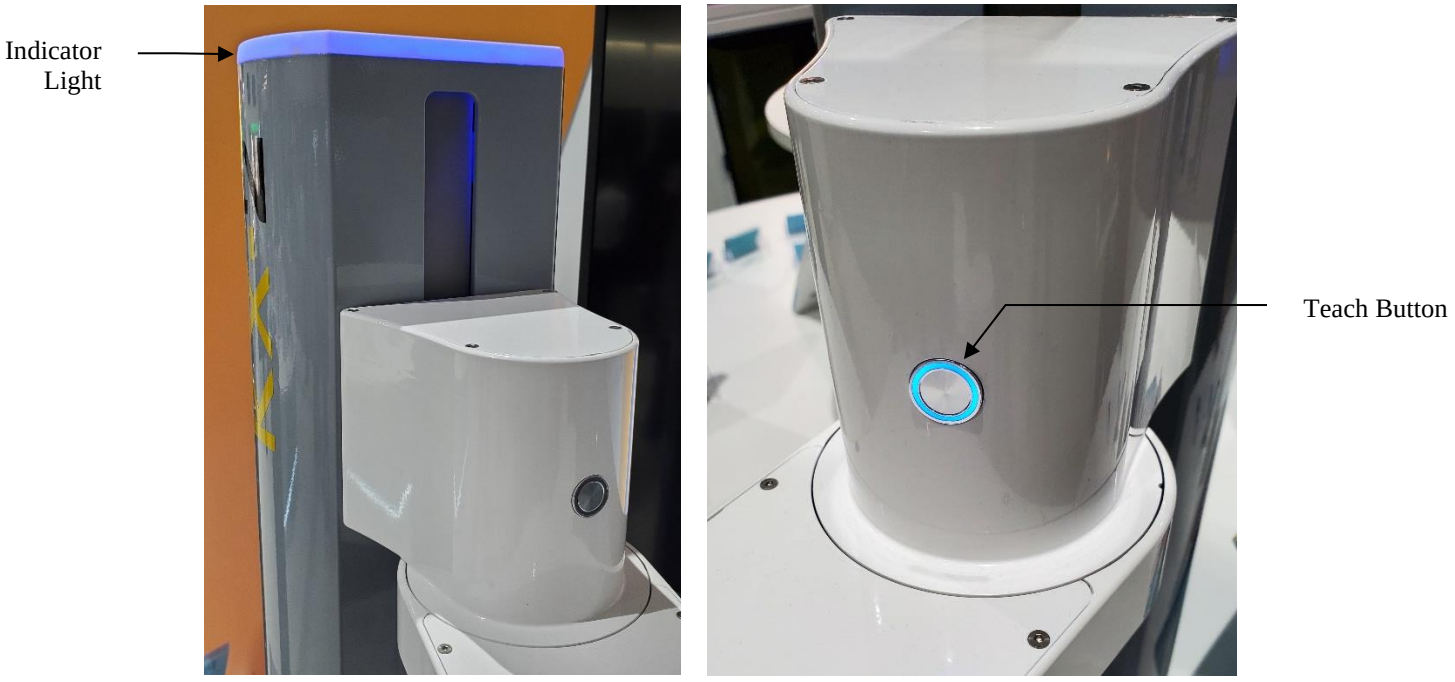
9.9 Robot I/O: Each of the five motor drives inside the robot is equipped with digital inputs, digital outputs, and analog inputs, some of which are available to the user at the Auxiliary connector on the Shoulder connector panel. Refer to the User I/O & Circuit Boards section for more information.

9.10 Axis Zero Positions: The robot motors use magnetic absolute encoders that do not require homing upon power-up. The encoders are not battery powered. A rotating magnet induces enough electrical current to power the encoder circuits when main power is disconnected. The zero position of each absolute encoder is calibrated at the factory. If an axis is disassembled or replaced, the zero position for that axis will most likely be changed and will require recalibration.

9.11 Gripper Zero Position: The gripper uses an incremental encoder and requires homing upon power-up to establish the zero position. The zero position is lost each time power is disconnected from the robot. The gripper moves to the fully open position during homing to establish the zero position.

9.12 Teach Button: To reduce the number of trips back and forth between the robot and PC during teaching, an auto-teach button is built into the robot arm. When the robot is in auto-teach mode, pressing the button causes the button to flash and the robot buzzer to beep in confirmation. A teach point is then created automatically, and the position of the robot is stored (see Teach Pendant/AutoTeach).

9.13 Motion Alert: If desired, the robot software can be configured to flash the indicator lights and beep the buzzer before motion begins after an extended time period with no motion (see Teach Pendant/Options/Miscellaneous – Warning Before Move).



Backlit Teach Button & Indicator Lights

10.0 Installation and Setup

10.1 Setup: The procedures described in this section are used to install and configure the robot. These procedures, or a portion of them, may need to be followed whenever any of the following occur:

- When the robot is first installed into the system.
- After disassembly or service of the robot.
- After moving the system.
- When equipment that interfaces with the robot is serviced, moved, or replaced.
- When the robot base mounting bolts are loosened & retightened.
- After a severe robot collision.

10.2 Installing and Anchoring the Robot:

10.2.1 Sub-Frame: Because of the high speed and center of mass of the robot, the robot must be anchored to ensure stability and repeatability. This requires providing a flat, stable, and rigid mounting surface for the robot as well as for all devices that the robot will be accessing. The mounting surface must be continuous and attached to a highly rigid metal frame such as the system shown below.

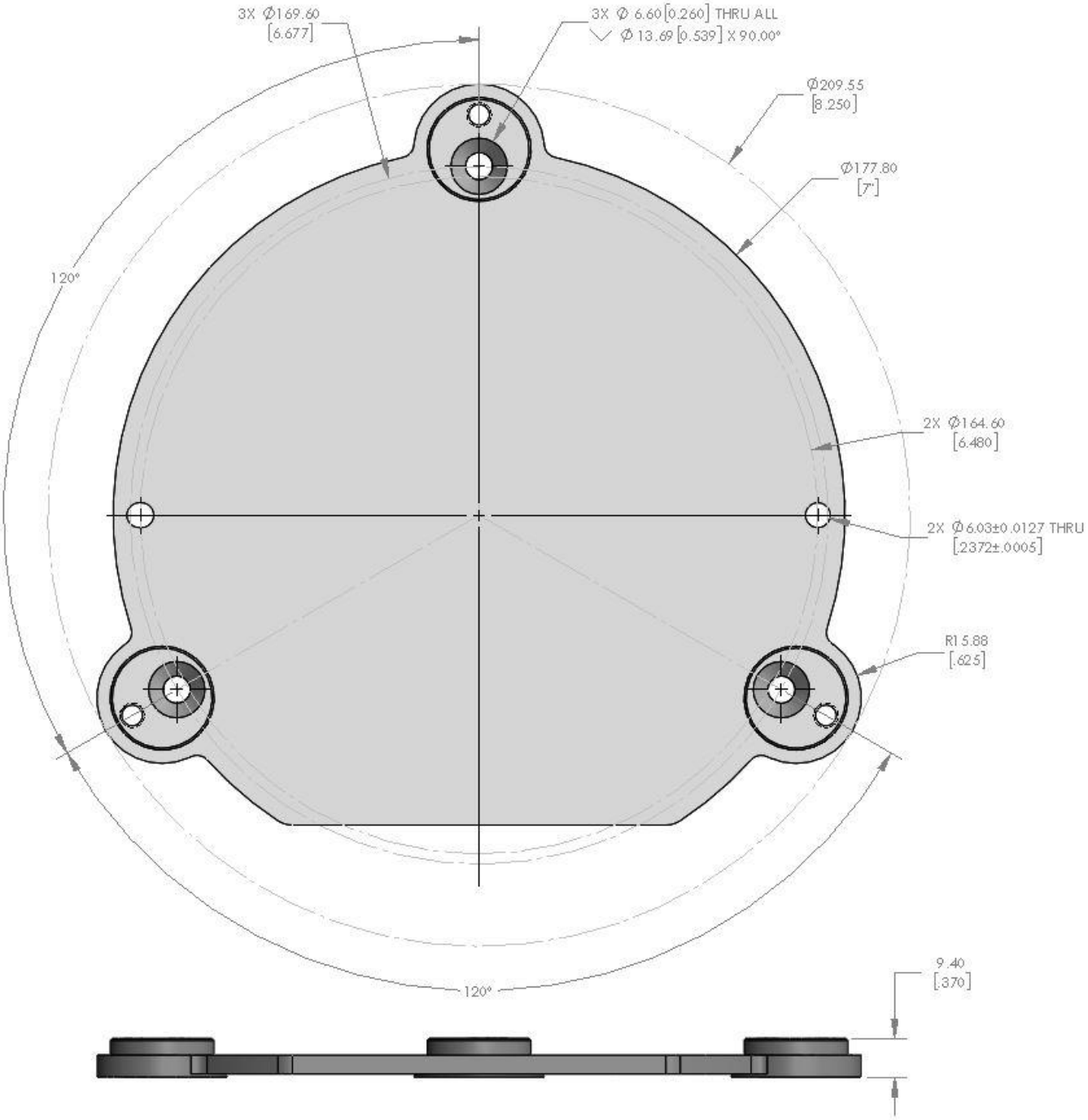
Rigid Metal Table

Important Note: Most problems with the robot such as non-repeatability can be traced to either a non-rigid installation or improper teaching methods! All equipment that is accessed by the robot must be mounted rigidly to the same mounting surface as the robot to ensure the position of the equipment (relative to the robot) is stable!

10.2.2 Mounting Surface: The recommended mounting surface for the robot and all devices is 10mm (3/8") thick (minimum) aluminum tooling plate. The aluminum can be powder coated or epoxy coated to resist most chemicals. If plastic must be used, a minimum thickness of 25mm (1") is highly recommended; ensure that it is fully supported by and fastened to a rigid metal frame underneath. Braces should be positioned strategically directly under the robot and the devices so that flexing of the mounting surface is minimized.

10.2.3 Attachment: The robot is attached to the table via a removable plate. The plate is anchored by three screws (M6 or ¼" FHCS) in a triangular pattern. The three screws are in the middle of three raised pads providing stable 3-point mounting. The robot attaches to the plate via three M6x18 SHCS screws & washers. Two dowel pin holes are provided for installations requiring occasional removal of the plate. An optional adapter plate is available for attaching the robot to standard optical tables with 1" or 25mm spacing.

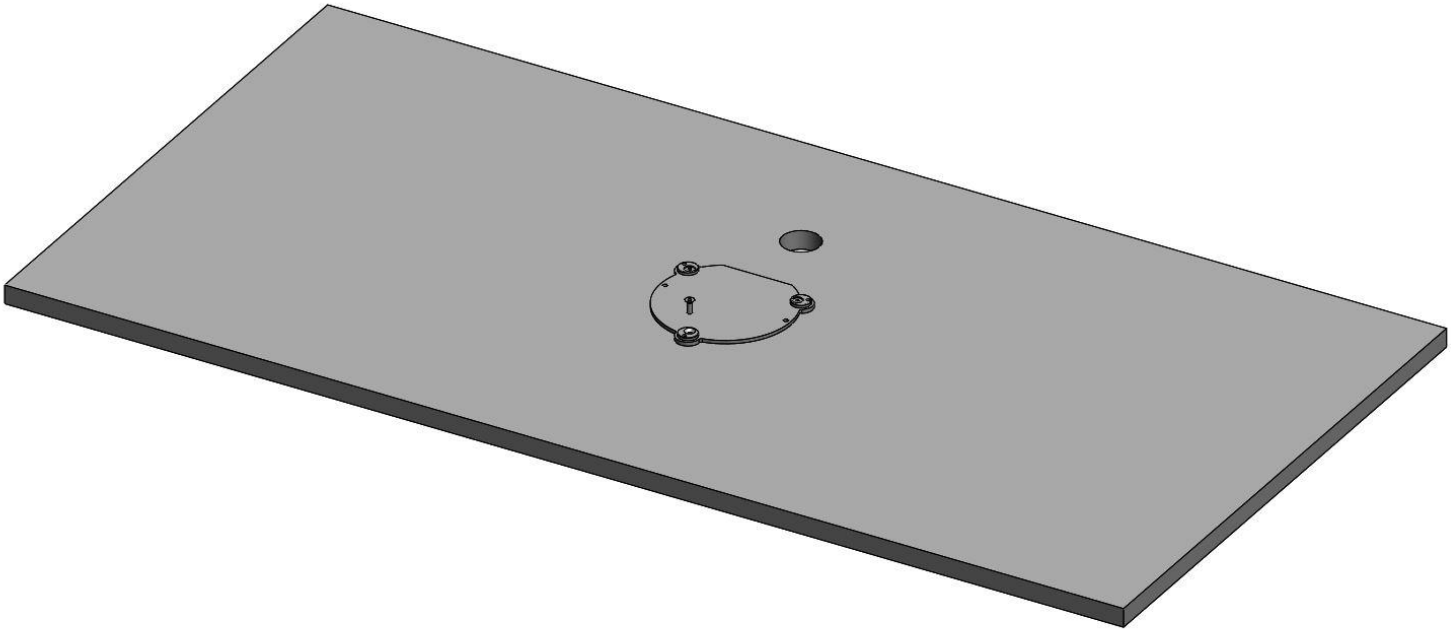
10.2.4 Mounting Screws: There is only a small amount of clearance in the screw holes, so it is critical that the anchoring threaded holes be drilled and tapped accurately and perpendicular to the mounting surface. If a milling machine is *not* available for this purpose, it is recommended that the Robot Mount Plate be used as a jig for marking the mounting-hole locations with a transfer punch. The holes should then be drilled using a drill guide to ensure the holes are perpendicular to the mounting surface.



Robot Mount Plate, Top & Side Views

10.2.5 Mounting the Robot to the Table:

1) Attach the Robot Mount Plate to the table with three M6x18 or 1/4x3/4" flat-head cap screws. Choose the desired orientation for optimal cable routing. If the screw holes in the table are threaded, then ensure the screws are long enough to have at least 9mm (3/8") of thread engagement. Use removable-strength thread locker such as Loctite 242. If the holes are not threaded, then use longer screws with washers and locking nuts on the underside of the table. Tighten the fasteners very firmly (8 Nm).
2) If the cables are to be routed through a large hole in the table, position the hole an adequate distance away from the robot connector panel so that the cables are not required to be bent sharply in order to pass through the hole.



3) If alignment dowel pins are being used, insert two M6 dowel pins into the corresponding holes in the table.
4) With the help of an assistant, stand the robot up on the table. While standing on the table, lift the robot up and set it on top of the Robot Mount Plate. Align the three bosses with the three cutouts on the underside of the robot. Orient the connector panel with the flat side of the Robot Mount Plate.

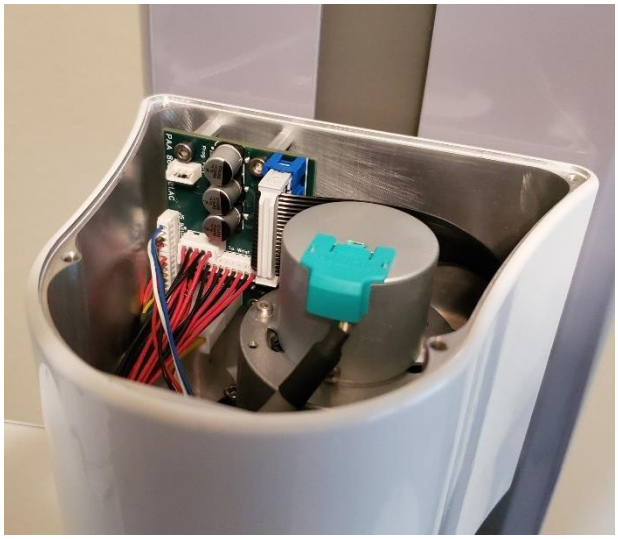
Stabilize the robot by hand, as it will fall over easily if left unattended!

5) Have an assistant hold the robot so that it does not tip over. Extending the arm about halfway will help to stabilize the robot. Install three M6x16 SHCS (each with a flat washer positioned against the head and with the rounded edge facing downward) through the mounting ears on the bottom of the robot, and thread them into the Robot Mount Plate. Tighten the mounting screws very firmly (8 Nm). Removable-strength thread locker such as Loctite 242 is recommended.

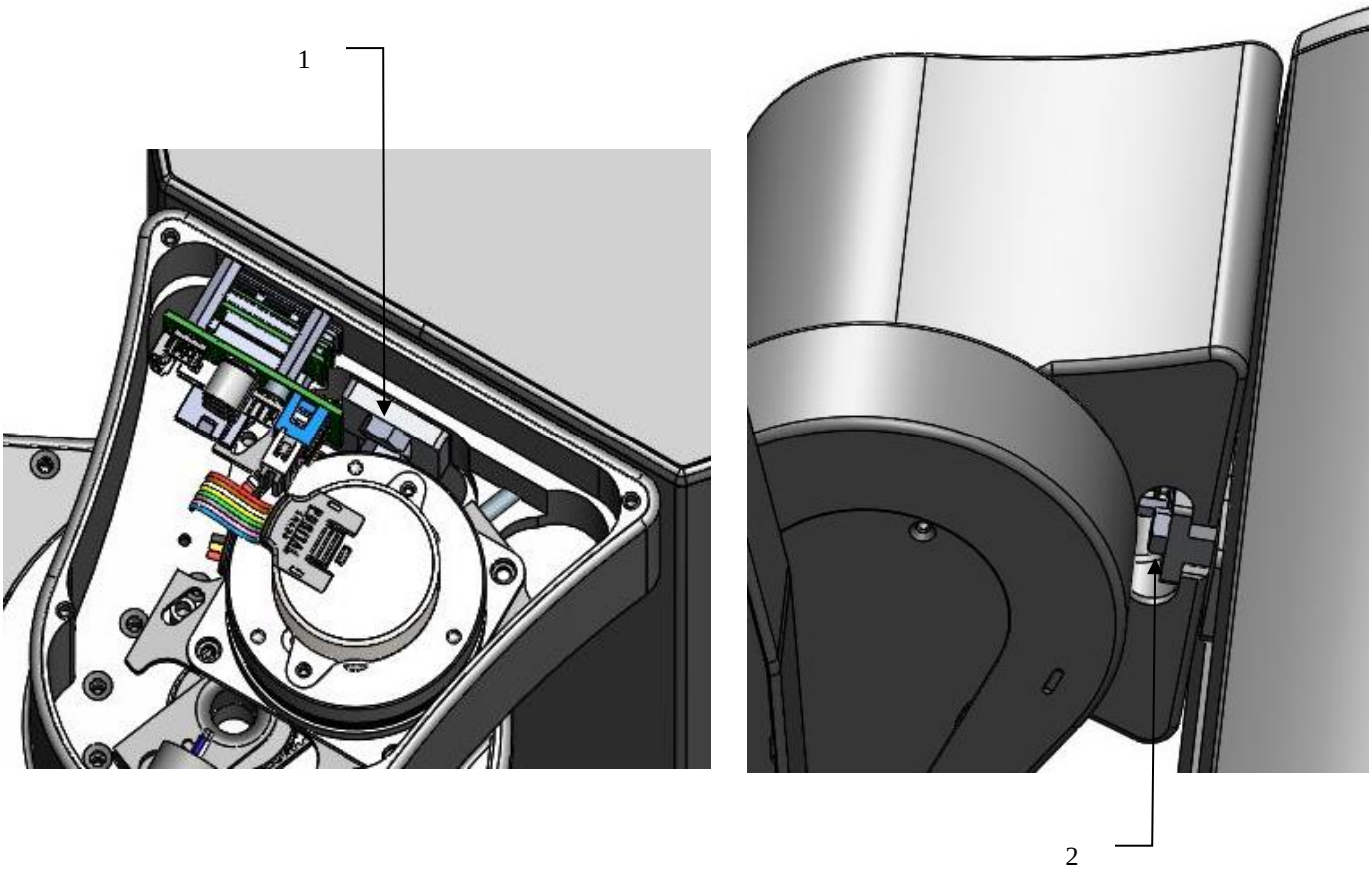
10.3 Removal of the Arm & Counterweights:

10.3.1 If an assistant is not available to help lift and install the robot, then it may be necessary to detach the arm from the Z axis and remove the Z counterweights to reduce the weight of the robot, as follows:

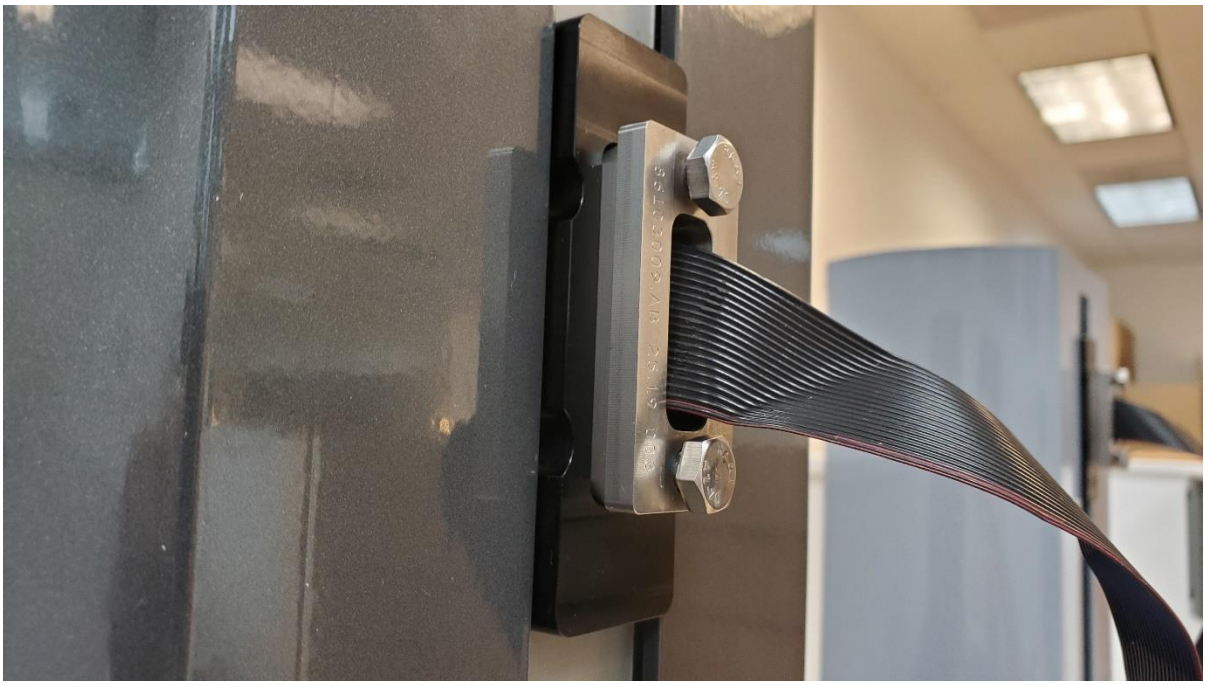
- Remove the four M3x6 FHCS screws from the Elbow top cover and remove the cover. A small flathead screwdriver can be inserted into the notch in the cover to simplify removal.



- Unplug the black ribbon cable from the blue connector on the PCB.
- Use a 10mm open-end wrench to loosen the two M6x25 Hex Head screws securing the Arm to the Z Axis. Loosen each screw about half a turn.

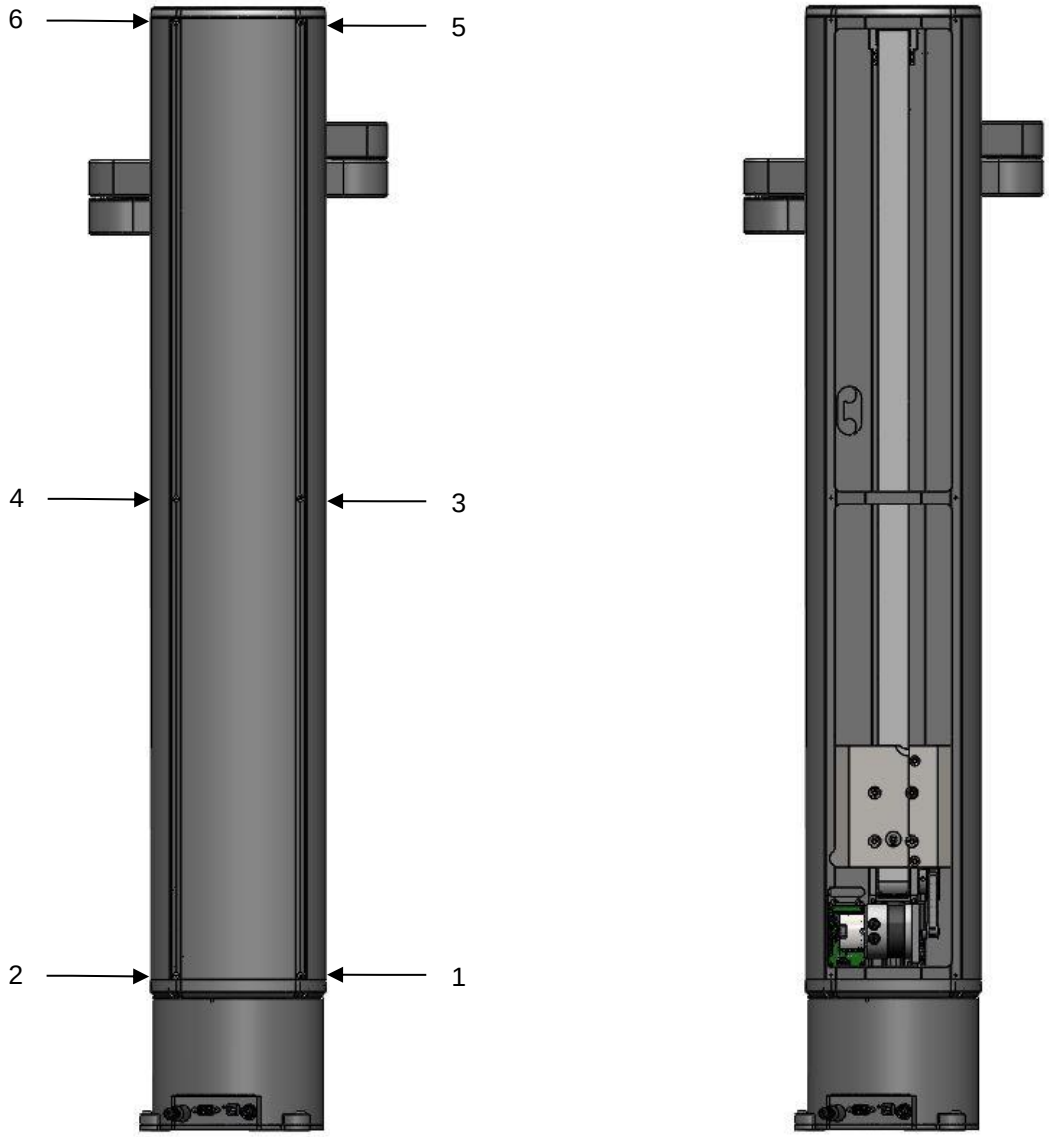


- Raise the Z Axis to the top end of travel.
- Support the Arm assembly securely with two hands. Slide it upward and off the clamp. Continue lifting the Arm assembly until the ribbon cable has exited the Elbow housing. The ribbon cable may snag on the housing and may require some manipulation to allow it to exit smoothly. Do not tug on the ribbon cable.

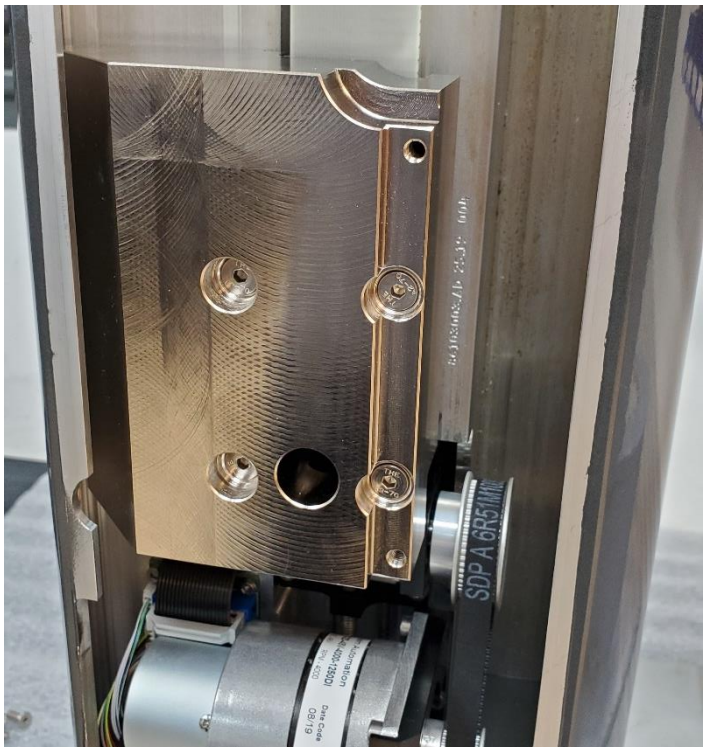


- Set the Arm assembly down on a soft surface.

- Remove the six M3x6 SHCS screws from the large cover on the back of the Z Axis. Remove the two top screws last. This will help support the cover while the screws are being removed. Remove the cover and set on a soft surface.



- Remove the two M5x16 FHCS screws from the smaller section of the counterweight on the right side. Slide the smaller section of the counterweight upward and out of the Z Axis.



- Remove the four M5x30 FHCS screws from the remaining larger section of the counterweight. Slide the counterweight upward and out of the Z Axis.

- The weight of the robot is reduced significantly at this point and can be lifted onto a table by one person.
- Assembly is the reverse of disassembly. Apply Loctite 242 to all removed screws prior to reinstallation.

10.4 Cable Connections:

10.4.1 The power supply box must be positioned within 2.75m (9ft) of the robot shoulder due to cable length limitations (EMC).

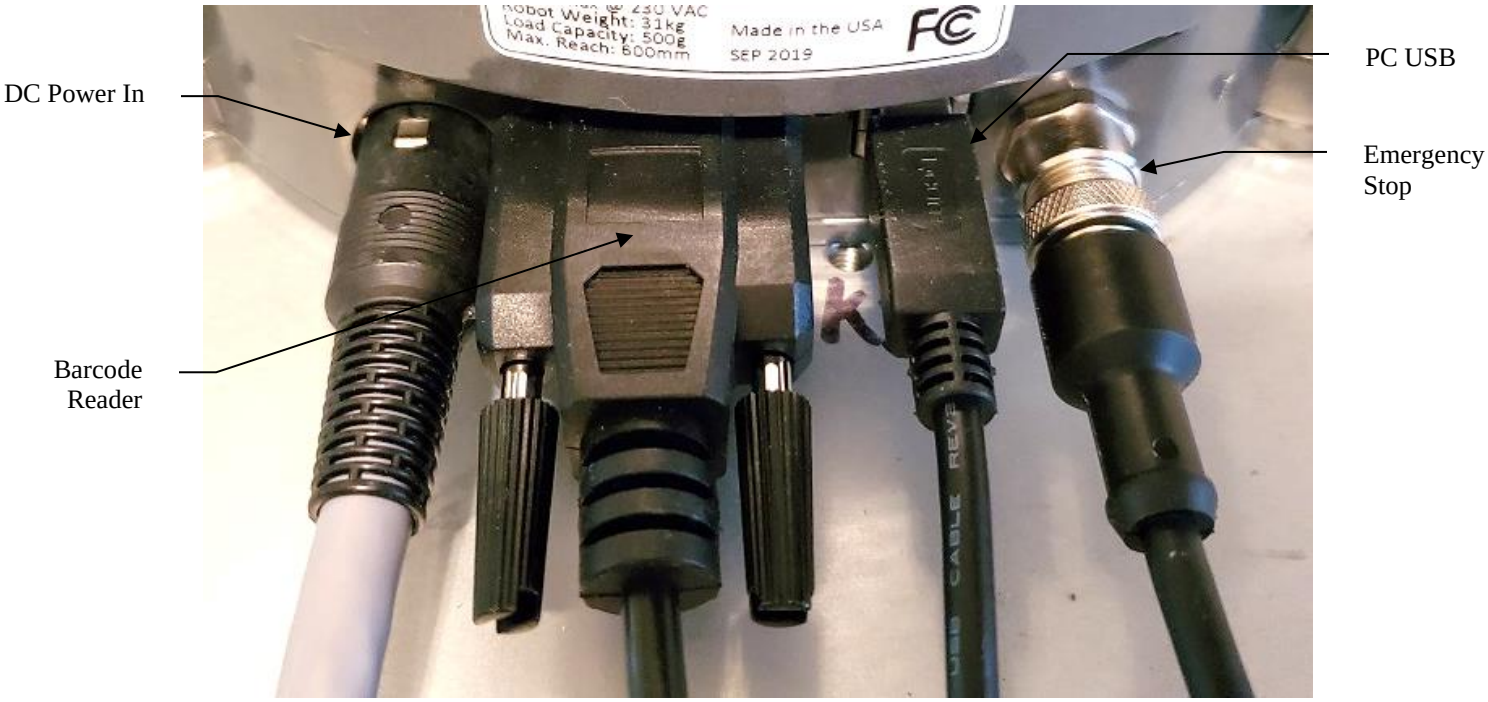
Make sure AC power is <u>not</u> connected to the power supply box before proceeding.

10.4.2 Plug the DC power cable into the recessed round connector in the Shoulder connector panel with the notches lined up.

10.4.3 Plug the USB cable into the Type B (square) socket on the Shoulder connector panel. Plug the other end (Type A) into an available USB 2.0 port on the PC.

10.4.4 Plug the Emergency Stop button into the Shoulder connector panel. Twist the metal portion of the plug clockwise until it is threaded firmly into the connector. Twist the red e-stop button clockwise to make sure it is popped out in the 'Run' position.

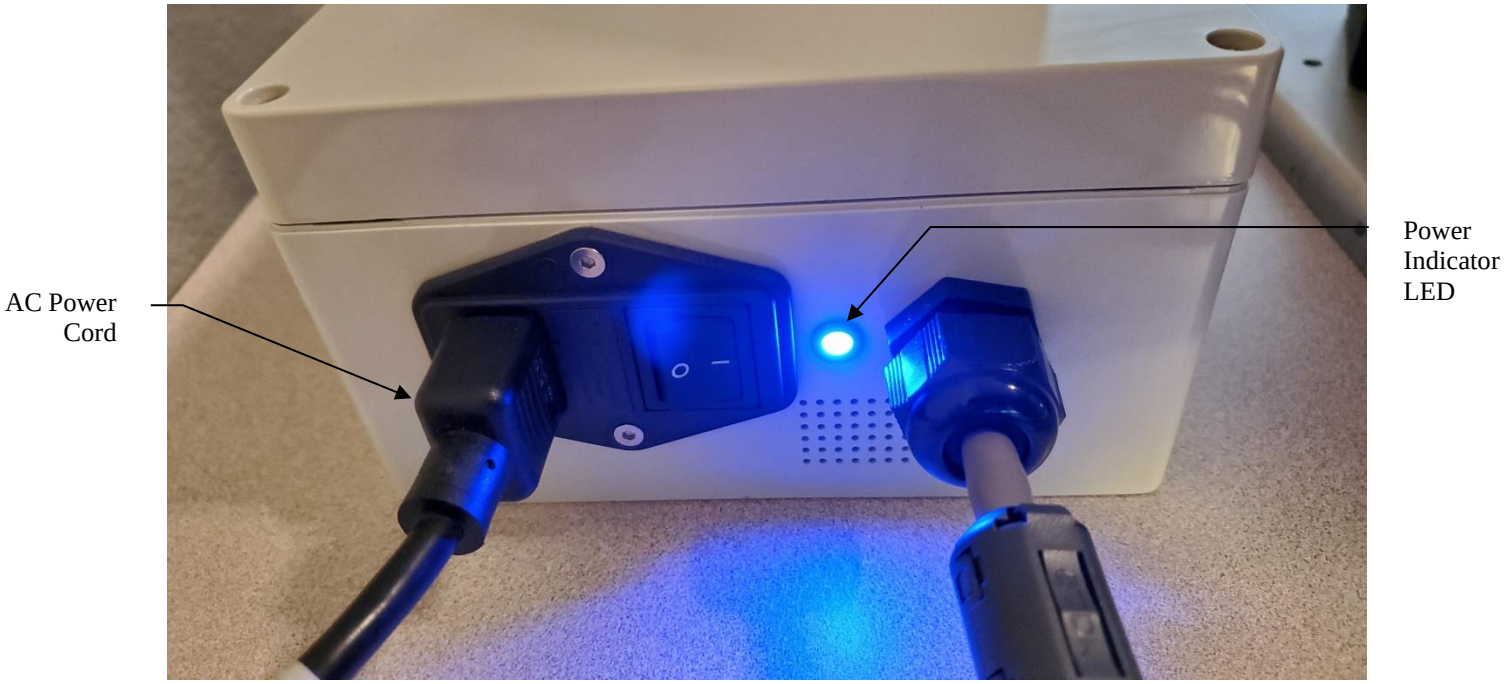
10.4.5 Plug the male 15-pin end of the Barcode Reader cable into the 15-pin D-Sub connector on the Shoulder connector panel. Tighten the two thumb screws lightly.



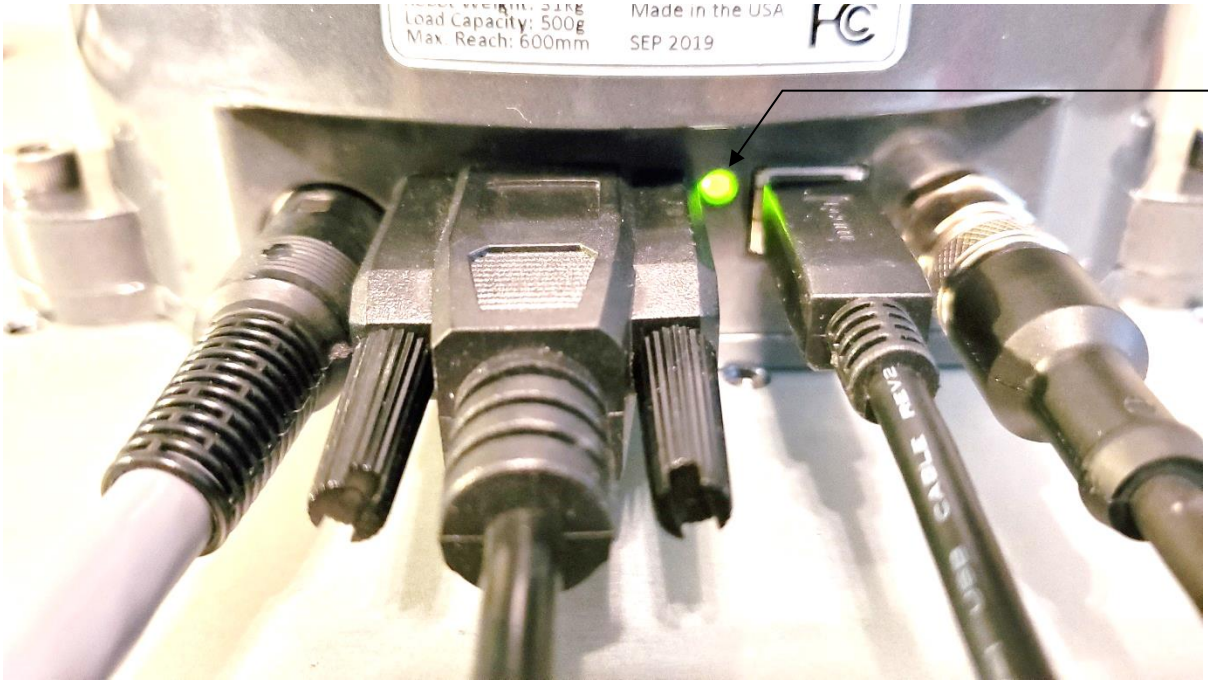
10.4.6 Connect the other end of the Barcode Reader cable to the supplied Prolific USB/Serial adapter. Tighten thumb screws lightly. Plug the adapter into an available USB 2.0 port on the PC.

10.4.7 Plug the AC power cord (Volex 17661) into the power supply box.

10.4.8 Plug the other end of the AC power cord into a standard grounded North American residential 110V outlet. If this type of outlet is not available, refer to the specifications section to ensure an appropriate AC power source is used. The supplied Volex 17661 cord can be replaced with a suitable grounded power cord that has a 10A minimum rating, shielding, and an IEC 60320 C13 plug on the end that connects to the power supply box.



10.4.9 Apply AC power to the power supply box by flipping the switch on the AC power entry module to the 'I' position. The blue power indicator LED on the box should light up. The Shoulder drive status LED should also light up. It should be red initially and should then change to green after a few seconds. If it stays red, verify that the emergency stop button is popped up.



10.5 Software Installation:

10.5.1 The following items are included on the USB memory stick shipped with the robot:

- KX2 Robot Control DLL – Teach Pendant / KX2 Robot Control DLL vX.X.X Setup.zip
- CAN-USB Adapter Driver / Peak-System_Driver_Setup.zip

10.5.2 DLL: Extract the file named "KX2 Robot Control DLL vX.X.X Setup.zip". The latest version can be downloaded from https://app.box.com/v/KX2-Software.

10.5.3 Run the extracted file by double-clicking it and follow the on-screen instructions.

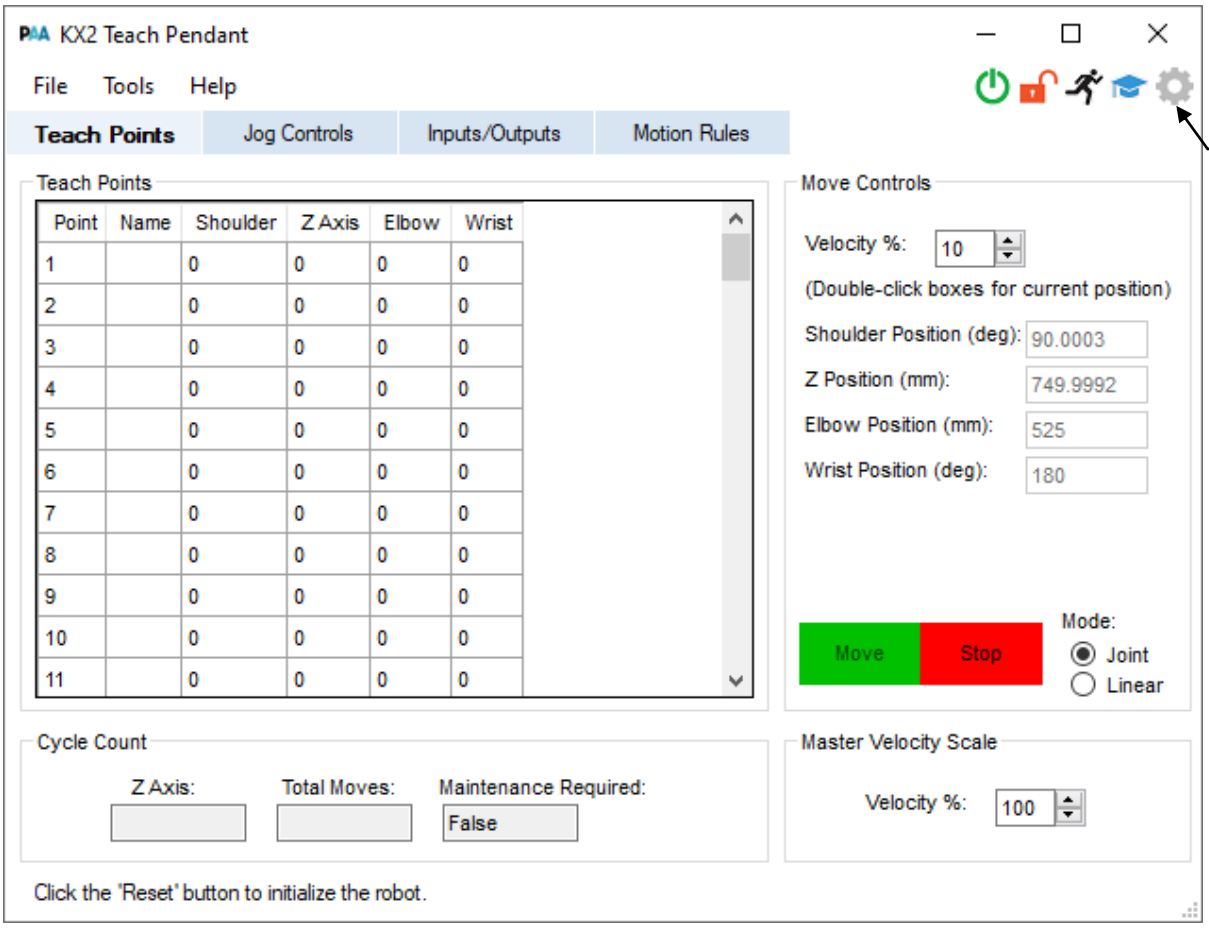
10.5.4 USB/CANOpen adapter: Extract the file named "Peak-System_Driver_Setup.zip".

10.5.5 Run the extracted PeakOemDrv.exe file by double-clicking it and follow the on-screen instructions. Use all default installation settings.

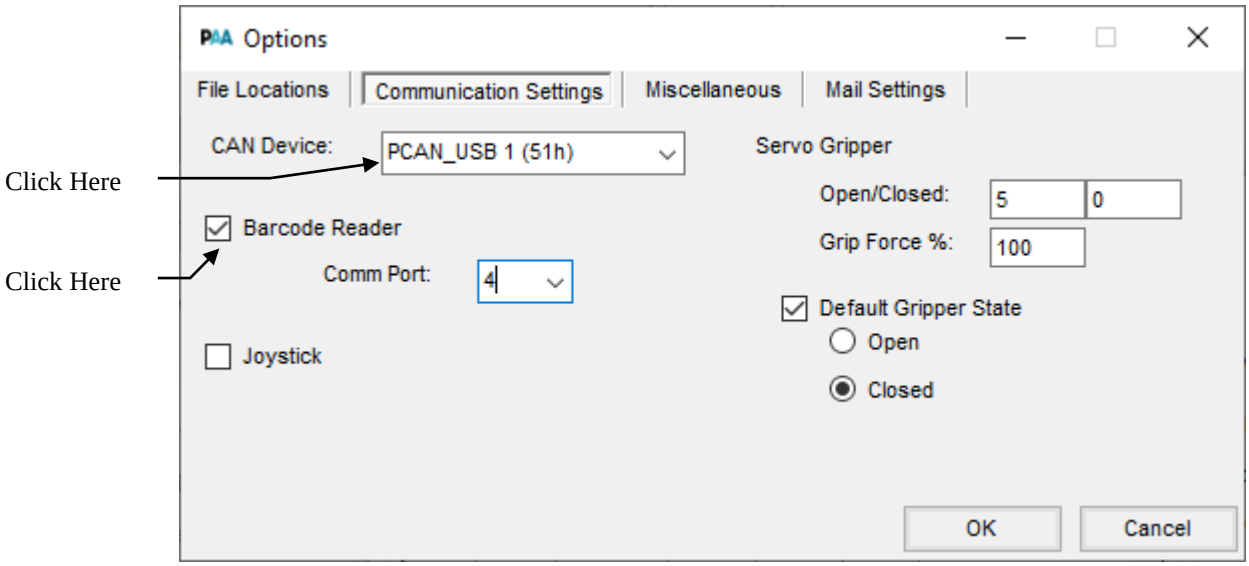
10.5.6 If multiple robots are to be controlled from one PC, then a unique Device ID must be assigned to each USB/CANOpen adapter. Use Peak System Tools/PCAN-View to set the Device ID of each adapter to a unique value.

10.5.7 Launch the KX2 Teach Pendant application from the Windows Start Menu (All Programs/PAA/KX2 Teach Pendant).

10.5.8 Open the Options window by clicking on the gear icon in the upper right corner of the window.



10.5.9 Open the "Communication Settings" tab, click the "CAN Device" list and verify the desired device is selected. Also verify "Barcode Reader" is checked and the correct Comm Port is selected.



10.6 Initializing the Robot:

10.6.1 Make sure the robot is clear of any obstructions before initializing. All four axes of the robot can be moved away from obstructions carefully by hand prior to powering up.

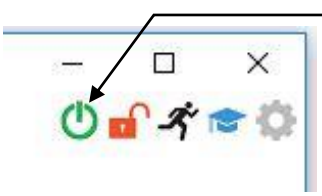
10.6.2 Boot up the controlling computer.

10.6.3 Make sure the E-Stop button is popped up by twisting it in the clockwise direction.

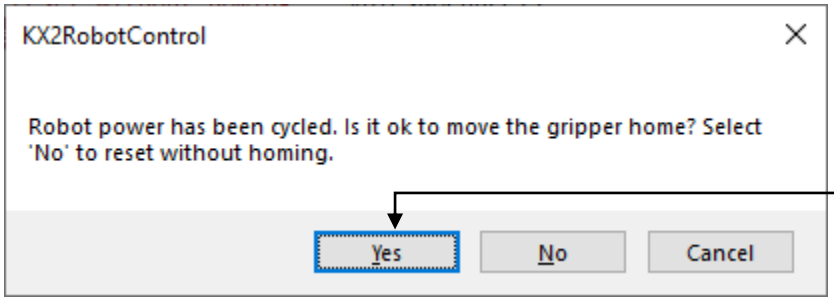
10.6.4 The robot power supply box should be powered up, and the LEDs should be in the correct states, as described previously.

10.6.5 Open the KX2 Teach Pendant from the Start/All Programs/PAA/ menu.

10.6.6 Initialize the robot by clicking the Reset Robot icon on the Teach Pendant.



The following message box will be displayed:



10.6.7 Click 'Yes' to move the gripper home. The gripper will open all the way until it hits the end of travel. It will then search for the encoder index pulse, and then it will move to the default state, as specified in Options/Miscellaneous.

10.6.8 The robot should then be ready to operate, with all motors energized and the indicator light illuminated blue.

10.6.9 The emergency stop button can be pressed to remove power from the motors.

10.6.10 Subsequent re-initialization or resetting of the robot will *enable* the motors but will not move the gripper to its home position unless robot power has been cycled.

11.0 System Software

11.1 The robot is controlled by a universal .NET 4.0 DLL that provides the end-user with a list of general robot commands (initialize, move to teach point, run sequence, etc.), and converts these general commands into individual coordinated axis commands and sends them to the robot.

11.2 The DLL includes a virtual teach pendant for teaching and naming teach points, and for moving the robot manually. The robot I/O and encoder positions can also be controlled and queried.

11.3 Robot Sequence: The following options are available for top-level robot sequence control:

11.3.1 Sequence Editor: A simple sequencer is included in the DLL, but for real-world applications, a top-level control sequencer or scheduler that can coordinate all the peripheral instruments as well as the robot should be used.

11.3.2 Custom Sequence: A basic approach for system control is a dedicated solution where the controlling code and operator's GUI are custom written specifically for the application. Common platforms for this are Visual Basic, C#, C++, or Java. This approach is good for the following types of systems:

1) Simple and/or non-changing sequence
2) An application where a specific look and feel is desired for the interface
3) Multiple reproduced systems, e.g., OEM system that will be built the same way every time.

11.3.3 Universal Scheduler: A more advanced approach is to use a universal scheduler for the front end. This is good for flexible systems with the following requirements:

1) The end user wants to change protocols on a regular or even semi-regular basis
2) When multiple systems will be built, but each one might have a different instrument configuration
3) Laboratory instruments will be synchronized with the robot, requiring complex or numerous instrument drivers

11.4 Universal schedulers are standard products (development is done) but there is a license cost associated for each system because the supplier is maintaining the SW along with a large base of instrument drivers (SW interface to the various instruments). There is usually a one-time cost to write a driver for a new instrument but once it's in their library, it's then available.

11.5 PAA offers a universal scheduler named Overlord. See www.paa-automation.com for more information.

11.6 Data Acquisition: An application such as LabView can be used when a large amount of data collection and/or manipulation is required.

11.7 Please refer to the document "KX-2 Robot Control Software Instructions" for additional detailed information on the robot DLL control software interface.

12.0 Teach Pendant

12.1 Multiple robot position orientations can be named and saved. These saved orientations are called "Teach Points" and are used to create robot sequences.

Important Note: It is imperative to use a logical and methodical approach to teaching the robot to ensure long-term operation without repeatability problems. This is explained in the "Teaching Routine" section.

12.2 Teach Points are saved in a text file on the PC. The TeachPoints.ini file contains names and numerical data associated with Teach Points created by the user.

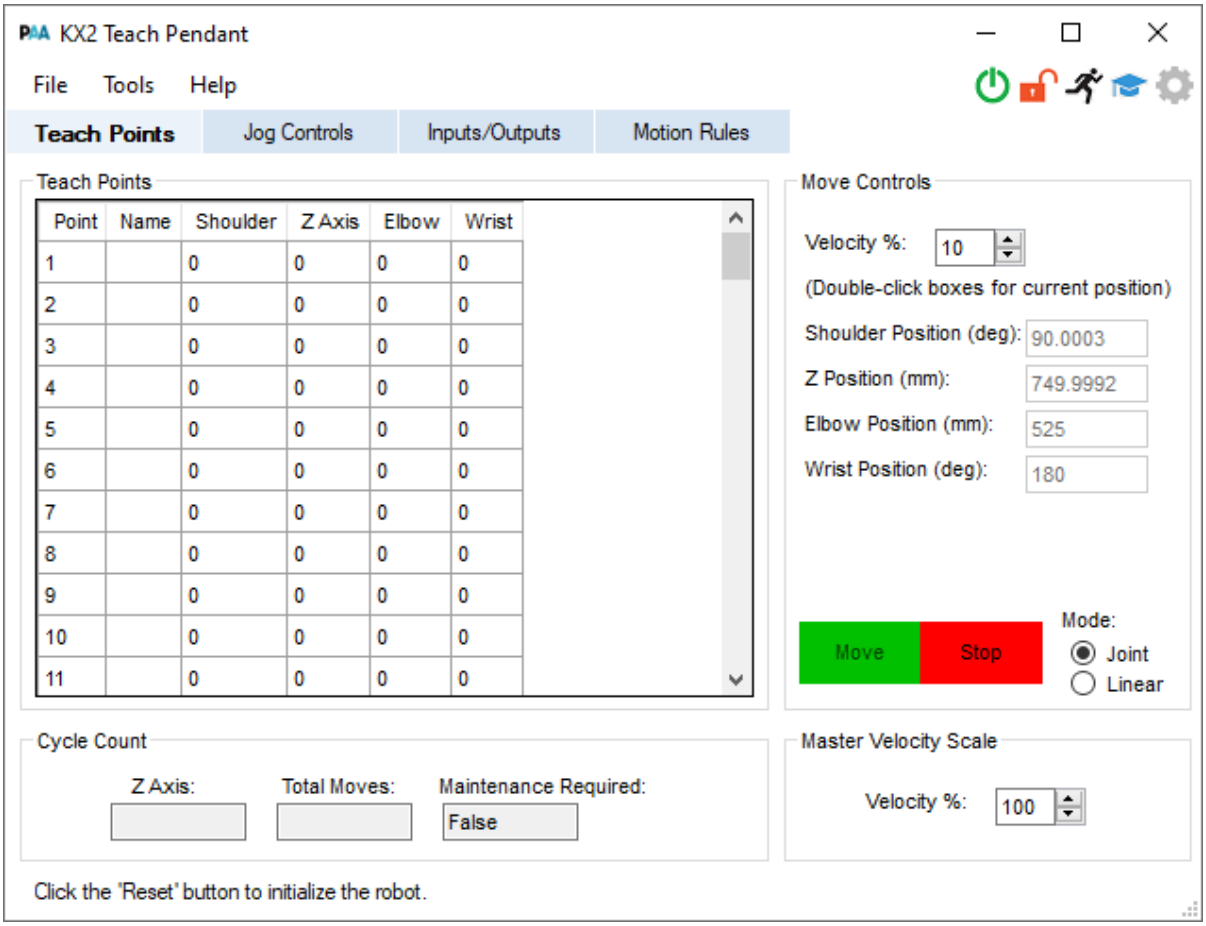
Important Note: Most non-repeatability problems with the installed robot can be traced to either a non-rigid installation of the robot and/or devices, or improper teaching methods.

12.3 Prior to teaching, ensure the robot and all peripheral devices have been properly and securely installed. This is highly critical.

Important Note: If the system is not securely installed, any time spent teaching will be wasted.

12.4 There are four tabs on the "Teach Pendant" screen shown on the following pages. These tabs are used to navigate the Teach Pendant and perform functions such as: naming teach points, jogging the arm, accessing the digital inputs and outputs, and defining motion rules.

12.5 Teach Points Tab: This tab displays the following window:



Teach Pendant Window, "Teach Points" Tab

12.6 The Teach Points Tab provides the ability to perform the following operations:

12.6.1 Teach Points: Use the following procedure to create a Teach Point:

12.6.1.1 Select the desired Teach Point number in the "Teach Points" list. The positional data associated with this Teach Point, if existing, will be displayed in the "Move Controls" textboxes.

12.6.1.2 Double-click the "Name" field and enter the desired text name. If the name is to be purely numerical, it must be longer than three characters ("50" is an invalid name, but "tp50" is ok). This step can be skipped if the teach point already has the desired name.

12.6.1.3 Move the robot to the desired orientation using one of the methods described later.

12.6.1.4 Once the robot is in the desired position, right-click the line of the teach point to be taught and select "Teach" from the context menu that appears. The current orientation of the robot will now be saved.

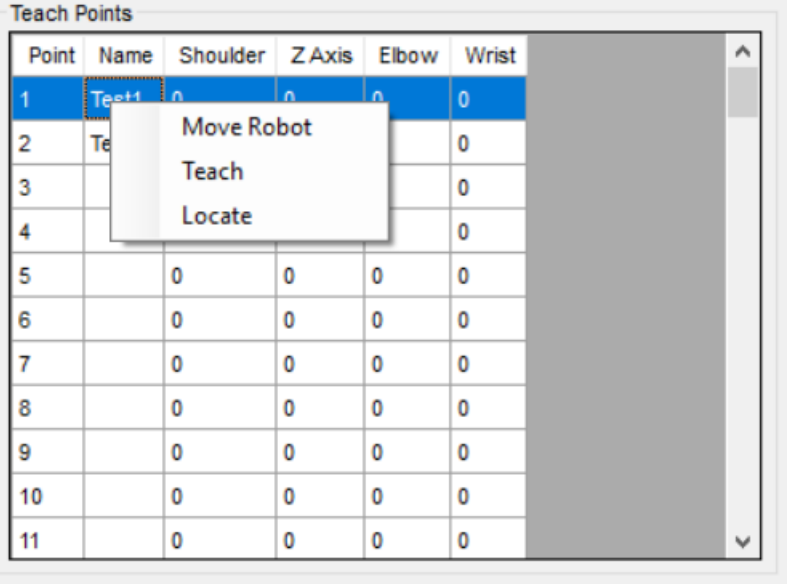
12.6.1.5 Clearing the "Name" field will erase a previously taught Teach Point. The Teach Point is then cleared from memory.

12.6.1.6 The axis positions associated with a Teach Point can be modified manually by entering the desired values into the Shoulder, Z Axis, Elbow, and Wrist columns.

12.6.1.7 Drag and drop Teach Points in the list to rearrange the order in which they are displayed in the list.

12.6.1.8 Right-click anywhere in the Teach Points list and select "Locate" to find the Teach Point that represents the current position of the robot. If the robot is currently positioned at a Teach Point, then that Teach Point will be highlighted.

12.6.1.9 By default, there are 100 Teach Points in the list. This can be adjusted by modifying the [Settings] Count value in the TeachPoints.ini file.



Teach Points Right-Click Context Menu

12.6.2 Move Controls: Use these controls to move the robot manually:

12.6.2.1 To move to a previously taught Teach Point, select the Teach Point in the "Teach Points:" list. Then select the desired velocity at which to move to the Teach Point in the "Move Controls". Press the "Move" button. The robot can also be moved to a Teach Point by right-clicking on the desired Teach Point, followed by selecting "Move Robot" in the context menu that appears.

12.6.2.2 The robot can be moved to any orientation by typing the desired position values into the "Move Controls" textboxes followed by pressing the "Move" button. The velocity is specified by the "Velocity %" textbox.

12.6.2.3 Press "Stop" at any time to halt a move.

12.6.2.4 Double-click inside any position textbox to display the current position of that axis.

12.6.2.5 To move only one axis to a desired position, right-click on one of the position textboxes, and select 'Move Single Axis' in the context menu that appears.

12.6.2.6 Motion Mode: If "Joint" is selected, each joint will move the shortest distance when executing a move. If "Linear" is selected, the end of the arm will follow a linear path when executing a move.

12.6.3 Cycle Count: Robot usage statistics are displayed in the lower left corner of the window.

12.6.3.1 The box labeled "Z Axis" displays the total distance (m) traveled by the Z Axis.

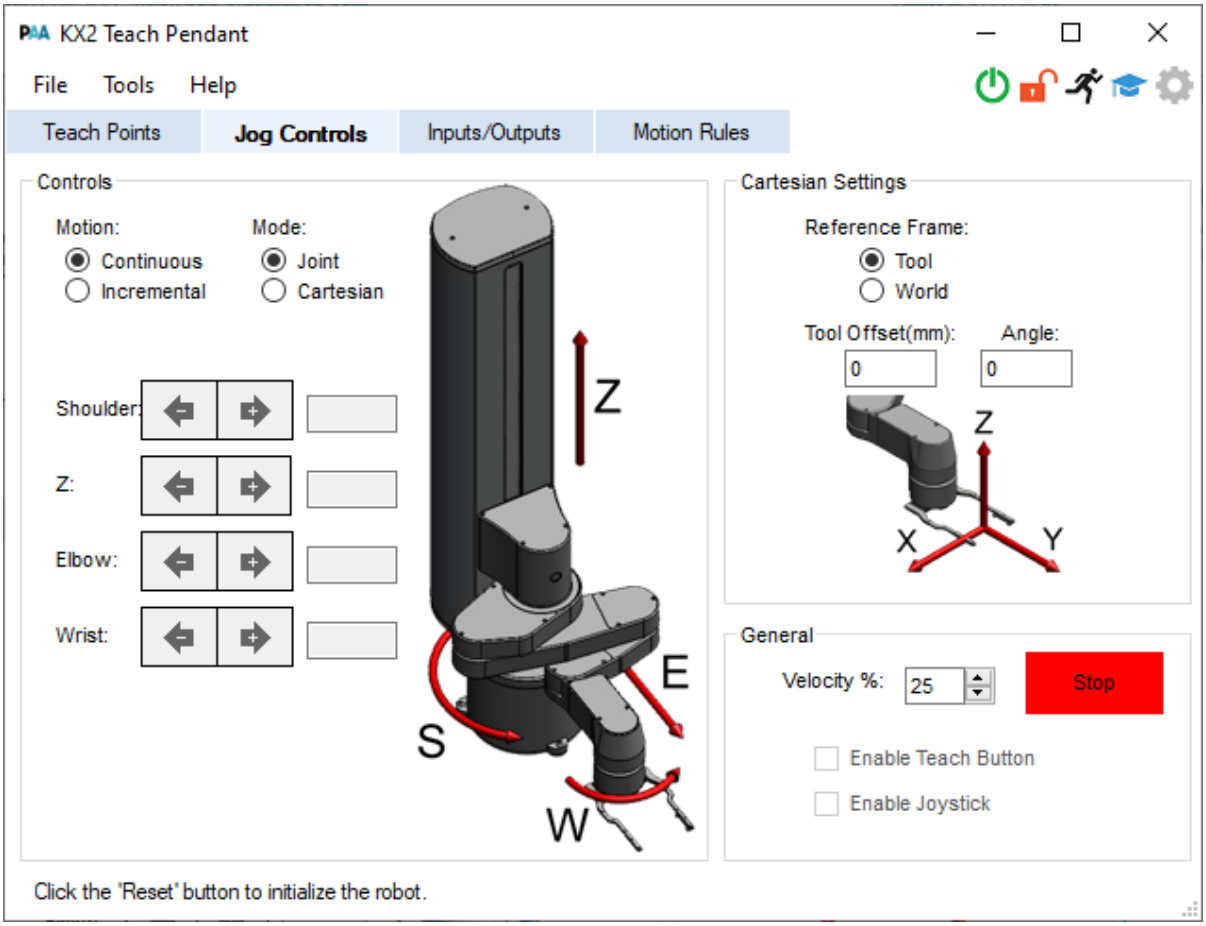
12.6.3.2 The box labeled "Total Moves" is the total number of move commands executed by the robot, regardless of the distance of those moves.

12.6.3.3 The box labeled "Maintenance Required" indicates whether the robot requires periodic maintenance. Double-clicking this box will reset the status to "False". Do this only after actually performing periodic maintenance.

Note: Cycle Count data is stored temporarily on the PC while the robot is initialized and in use. Data accumulated on the PC will be saved to the robot internal memory when the Teach Pendant is closed or when the DLL ShutDown function is called. It is important to perform a clean shutdown prior to disconnecting power from the robot in the case where the robot will be transferred to another PC. Failure to do so will result in a loss of the Cycle Data that has accumulated since the previous clean shutdown.

12.6.4 The "Master Velocity Scale" value specifies a scaling factor for all move commands sent to the robot, both from the Teach Pendant and from the host application. This is useful for testing new robot sequences at a reduced velocity to minimize damage that could result from a collision.

12.7 Jog Controls Tab: This tab displays the following window:



Teach Pendant Window, "Jog Controls" Tab

12.7.1 The "Jog Controls" tab provides the ability to perform various jogging operations as detailed below. Clicking the corresponding button (arrow) in the "Jog Controls" window will jog the robot:

12.7.1.1 Select the desired "Motion" type:

- Continuous—Clicking and holding a jog button will cause the axis to move continuously until the jog button is released or until the travel limit has been reached. This motion type is good for quick and approximate positioning of the robot.
- Incremental—Each click of a jog button will cause the axis to move the distance specified in the textbox that will be displayed under the "Incremental" option. The units of the increment are in millimeters or degrees, depending on whether the axis is rotary or linear. This motion type is good for precise positioning of the robot.

12.7.1.2 Select the desired "Mode" type:

- Joint—Individual joints will be jogged independently in a joint coordinate system, as shown in the image of the robot next to the jog controls.
- Cartesian—The end of the arm will move along a linear path.

12.7.1.3 The speed of movement is set in the lower right corner (General) by selecting a percentage value, which is a percentage of the maximum velocity. The maximum allowed velocity for jogging is 25%.

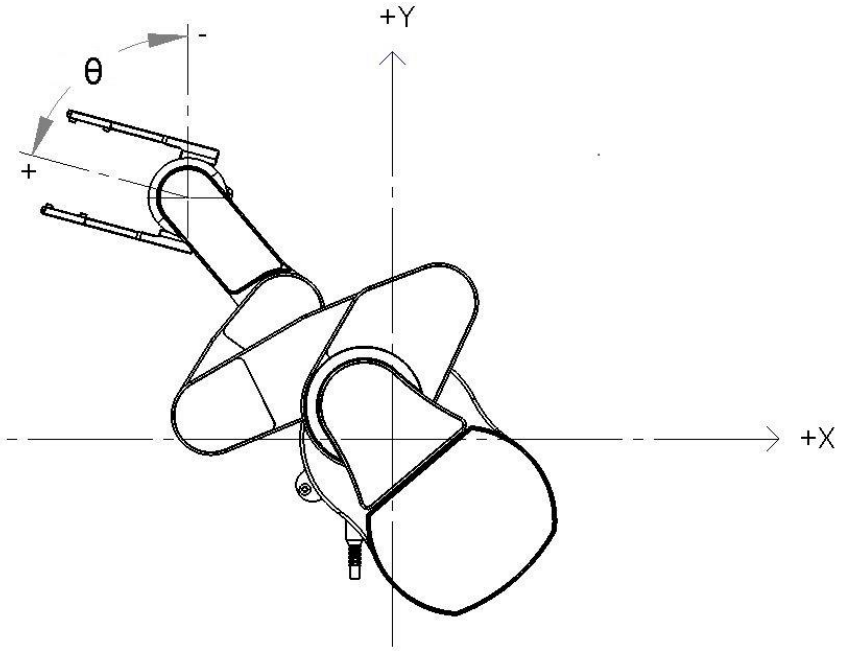
12.7.1.4 The smallest move increment for the Jog Controls is "0.01". If a smaller move than this is required, use the "Move Controls" under the "Teach Points" tab. Small moves are helpful for final positioning.

12.7.1.5 Press the "Stop" button to abort motion. This can be useful for halting a long incremental move has been commanded at a very low speed.

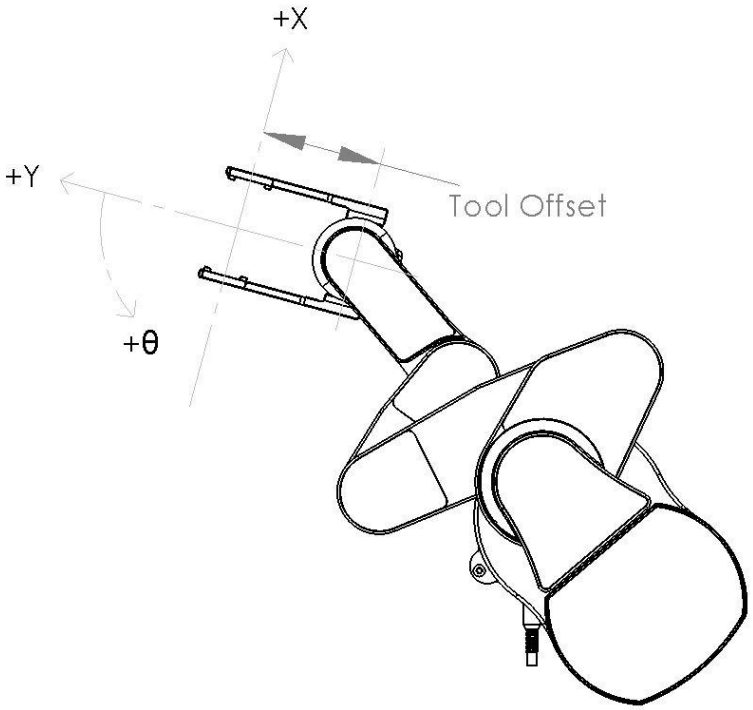
***Important Note**: If there is truly an emergency that requires the robot to stop immediately, press the mechanical emergency stop button that disables the robot. The robot will then need to be re-initialized by selecting the "Reset Robot" icon.*

12.7.1.6 Cartesian Settings: If Cartesian Mode is selected, the jog buttons will move the robot in the X, Y, Z or θ directions, and the Cartesian Settings will be used, as follows:

- Reference Frame—Two coordinate reference datum frames are selectable: World or Tool. The World reference frame is fixed to the center of the robot. The tool reference frame is fixed to the gripper, and its orientation changes as the wrist is rotated. Tool Reference Frame jogging is useful when attempting to adjust the final position of a microplate into a nest, especially if the nest is at an odd angle compared to the robot's World Cartesian coordinate system.
- Tool Offset—This specifies the distance along the Tool Reference Frame Y axis, in millimeters, from the center of rotation of the wrist, to the center of the object being gripped in the gripper (the offset for a standard side-grip gripper is 110mm). The tool offset causes the robot to rotate about the center of the object in the gripper when jogging in the Theta direction.
- Angle—If the gripper is mounted to the robot in a non-standard orientation and does not face forward when the wrist is at zero, then the angle of the gripper relative to the wrist can be specified here.



World Reference Frame, Cartesian Coordinates, Top View

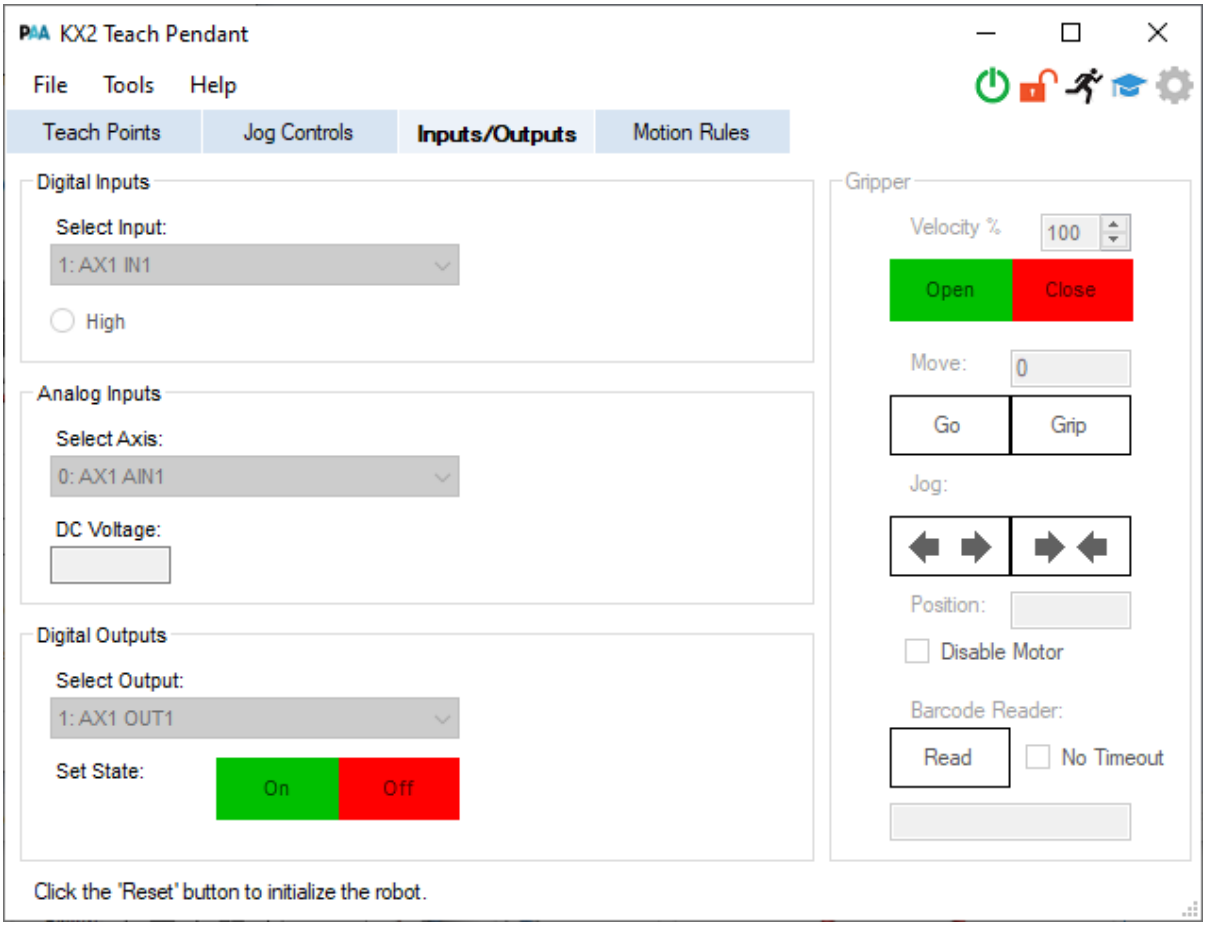


Tool Reference Frame, Cartesian Coordinates, Top View

12.7.1.7 Enable Joystick—Check this box to allow the use of a game controller (not provided) for jogging the robot. Use of a game controller is described later.

12.7.1.8 Enable Teach Button—Check this box to allow the use of the teach button located on the front of the Elbow housing. If each robot joint is positioned within three millimeters or degrees of a previously taught Teach Point, that Teach Point will be retaught to the current position of the robot when the teach button is pressed. If the robot is not positioned near a previously taught point, the buzzer will sound a long tone indicating the failure to reteach a point. If the PC has a speaker, success or failure will be announced over the speaker, including the name of the teach point that has been retaught successfully.

12.8 Inputs/Outputs Tab: This tab displays the following window.



Teach Pendant Window, "Inputs/Outputs" Tab

12.8.1 The Inputs/Outputs Tab provides the ability to perform the following operations:

12.8.1.1 Digital Inputs: Select the desired input in the "Select Input:" pull-down. The "High" indicator will be marked with a dot if the input is high and blank if the input is low. The gripper sensor, teach button, and the auxiliary inputs can all be monitored.

12.8.1.2 Analog Inputs: Select the desired axis in the "Select Axis" pull-down. The voltage (0-10 VDC range for AIN1, 0-4095 proportional to a 0-3 VDC range for AIN2) will be displayed.

12.8.1.3 Digital Outputs: Select the desired output in the "Select Output:" pull-down. Press either the "On" or "Off" button to set the desired state of the selected output. The teach button LED, RGB indicator lights, and buzzer can be activated.

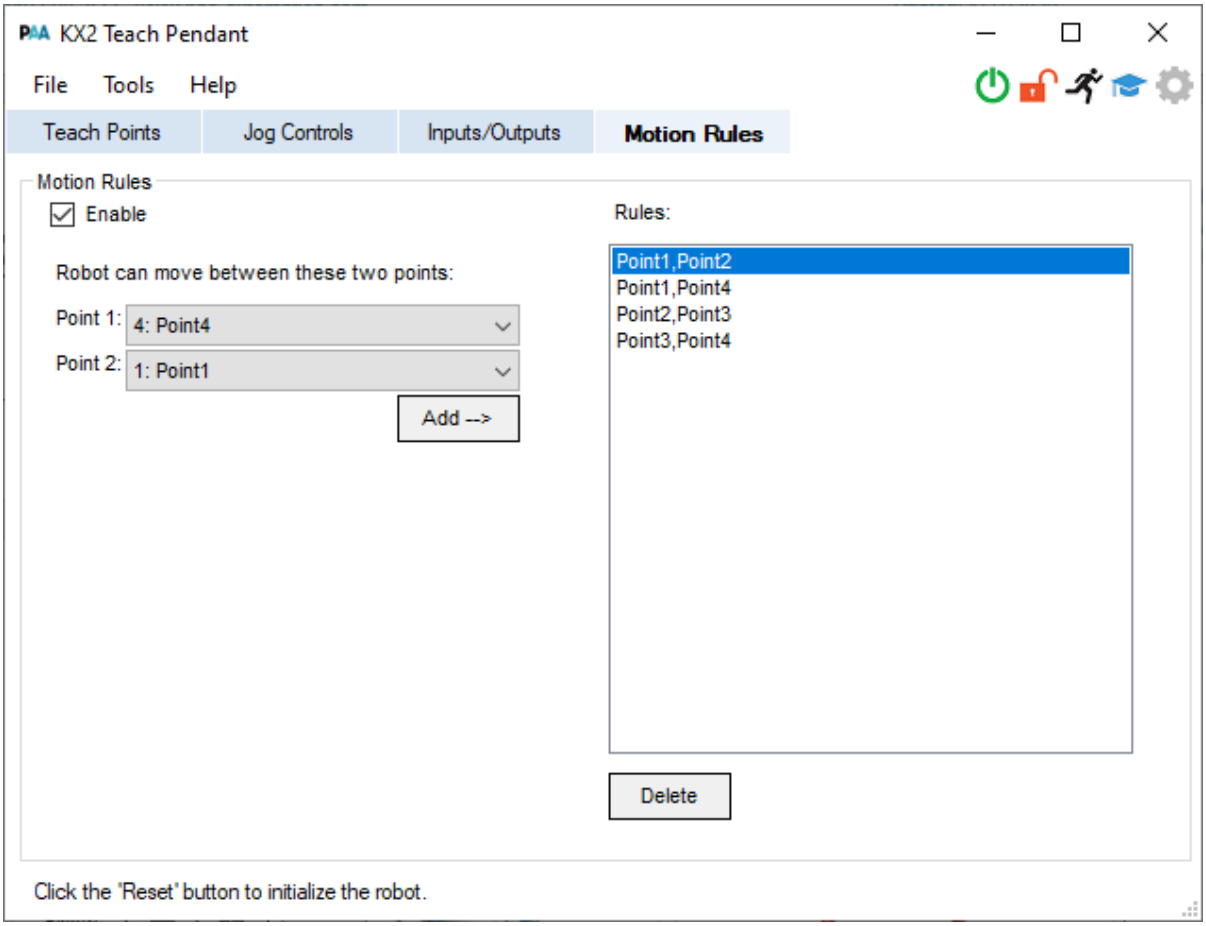
12.8.1.4 Gripper: If the robot is equipped with a gripper, then the Gripper controls will be visible.

- The "Velocity %" box can be used to adjust the velocity for all gripper controls below.
- The "Open" and "Close" buttons will move the gripper to the positions specified in the "Open Position" and "Closed Position" boxes in the Options/Communication Settings tab.
- If the "Close" button is pressed, and there is no plate for the gripper to grab, an error will be displayed, stating, "Servo Gripper was able to move all the way to the closed position, which indicates the absence of an object in the gripper." The gripper expects to encounter resistance while closing.
- The "Go" button can be used to set the gripper in a desired position (specified in "Move" box). Do not use this command for gripping a plate.
- The "Grip" button can be used to close the gripper to a desired position (specified in "Move" box).
- The "Jog" buttons can be used to move the gripper manually.
- The current position of the gripper is displayed in the box below the "Jog" buttons.
- The "Disable Motor" checkbox will turn off the gripper motor, allowing the gripper fingers to be moved by hand.

12.8.1.5 Barcode Reader: Functionality of the barcode reader can be tested by clicking the "Read" button. The barcode reader will attempt to read a barcode for up to one second unless the "No Timeout" option is checked. If the barcode reader reads a barcode successfully, the value will be displayed in the textbox.

Barcode Reader

12.9 Motion Rules Tab: This tab displays the following window:



Teach Pendant Window, "Motion Rules" Tab

12.9.1 The "Motion Rules" tab is used for defining pairs of teach points between which the robot can move safely. Once motion rules are defined, and the "Enable" box is checked, motion between two teach points not in the "Rules" list will not be allowed when moving the robot using the controls under the "Teach Points" tab.

12.9.2 Motion rules are defined as follows:

12.9.2.1 Select two points in the "Point 1" and "Point 2" lists between which it is safe for the robot to move.

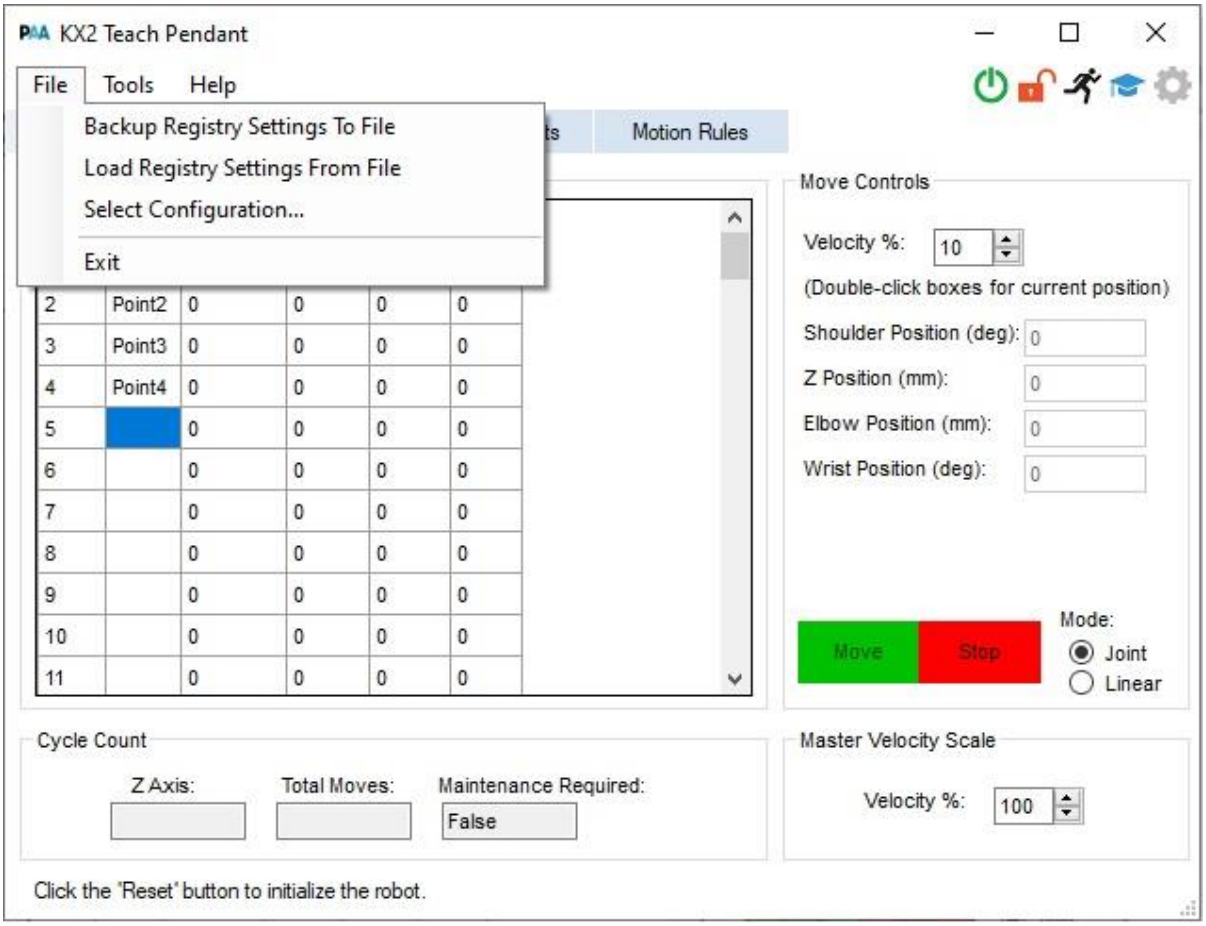
12.9.2.2 Press the "Add" button to place the two points in the "Rules" list.

12.9.2.3 To delete an unwanted rule, select the rule in the list and press the "Delete" button.

12.9.3 Motion will be allowed in either direction between two points specified in a single rule.

12.10 The drop-down menus at the top left corner of the Teach Pendant window contain the following commands:

12.10.1 File Menu:



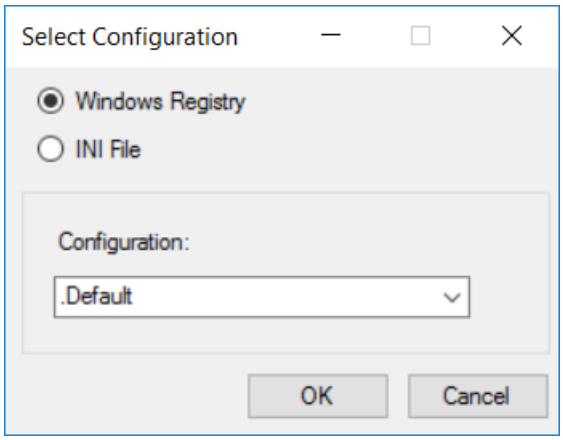
2	Point2	0	0	0	0
3	Point3	0	0	0	0
4	Point4	0	0	0	0
5		0	0	0	0
6		0	0	0	0
7		0	0	0	0
8		0	0	0	0
9		0	0	0	0
10		0	0	0	0
11		0	0	0	0

Teach Pendant File Drop-Down Menu

12.10.1.1 "Backup Registry Settings To File" will display a file-browsing window for creating a text file that contains all of the settings that are stored in the Windows Registry by the KX-2 software. These settings include items like the teach points file path, and other items displayed in the Options window, joystick settings, etc. Backing up the settings to a file can be useful when transferring settings to another computer or to a different Windows User account on the same computer.

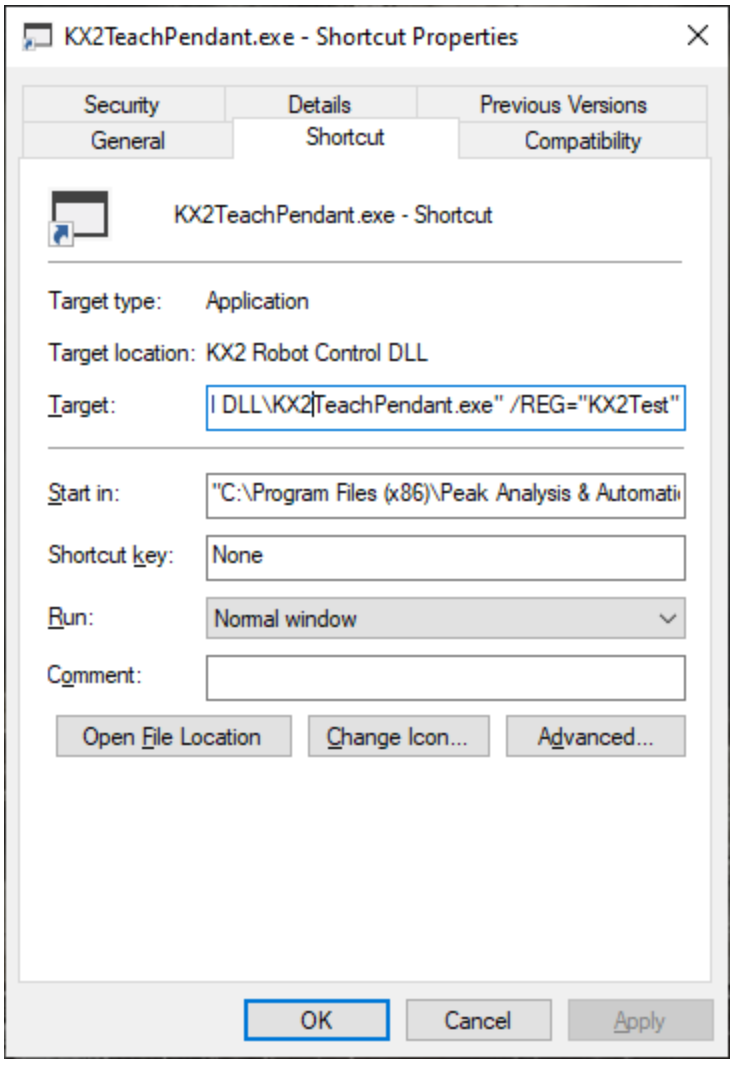
12.10.1.2 "Load Registry Settings From File" will display a file-browsing window for selecting a registry backup file that will then be loaded into the Windows Registry.

12.10.1.3 "Select Configuration..." will display the following window:



Select Configuration Window

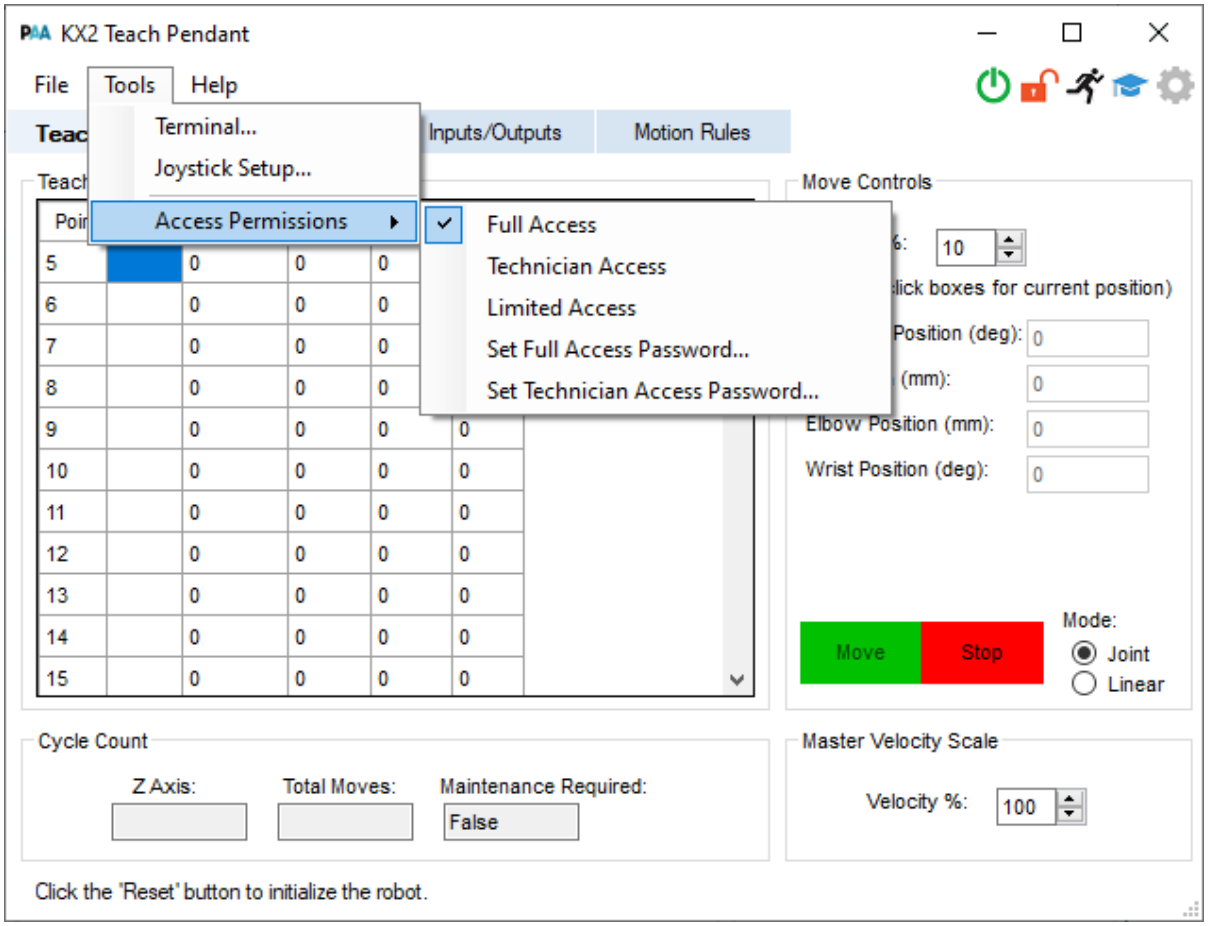
- Windows Registry—This is the standard setting. Select ".Default" from the "Configuration" list to use the standard "HKEY_CURRENT_USER\Software\VB and VBA Program Settings\KX2 Robot Control\" location in the Windows Registry for software settings storage. If multiple robots are being controlled by a single computer, then it will be necessary to store the settings for each robot in a separate location. In this case, type a new name into the "Configuration" list.
- INI File—The settings used by the software can be stored in a text file instead of the Windows Registry. This can be useful when multiple Windows User accounts must be able to access shared robot settings. Be sure to place the file in a location that is accessible with full read/write privileges by all users.
- The configuration selected will not be permanent. The next time the Teach Pendant is opened, it will revert to the default configuration. In order to make the change permanent, do the following:
    - Create a shortcut to KX2TeachPendant.exe.
    - Right-click on the shortcut and select "Properties."
    - Select the "Shortcut" tab.
    - Enter one of the following command line arguments at the end of the "Start in:" box, after the last double-quote. Do not delete any of the existing text in the box. Be sure to add a blank space between the existing last double-quote and the new command line argument.
        - /REG="ConfigurationName" (replace ConfigurationName with a descriptive name of the robot)
        - /INI="SettingsFilePath" (replace SettingsFilePath with the full file path and name of the settings file)



Shortcut Properties

12.10.1.4 "Exit" will close the Teach Pendant window.

12.10.2 Tools Menu:



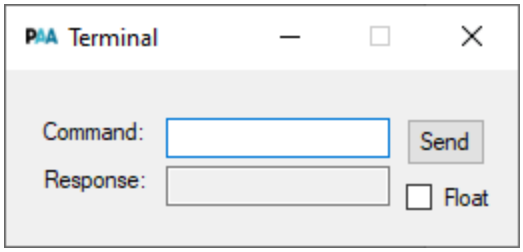
Teach Pendant Tools Drop-Down Menu

12.10.1.1 "Terminal..." opens a window that is used for communicating directly with the motor drives using two-letter commands. Commands are constructed from the following elements:

- Two-letter command (e.g., PX for position, MS for motion status, EC for error code)
- Array index, which is in the form of a number surrounded by square brackets, such as [1]. Can be omitted for commands that do not require an array index.
- Value, which is used only by commands that are setting a value.
- Examples:

  PX.4 queries the position of the wrist encoder
  IB[5].2 queries the state of input 5 on the Z axis
  MO.3=1 enables the elbow motor

- Select the "Float" checkbox if a decimal value is being set or queried.
- Contact Peak Robotics for a complete listing of available commands.



Teach Pendant Tools/Terminal Window

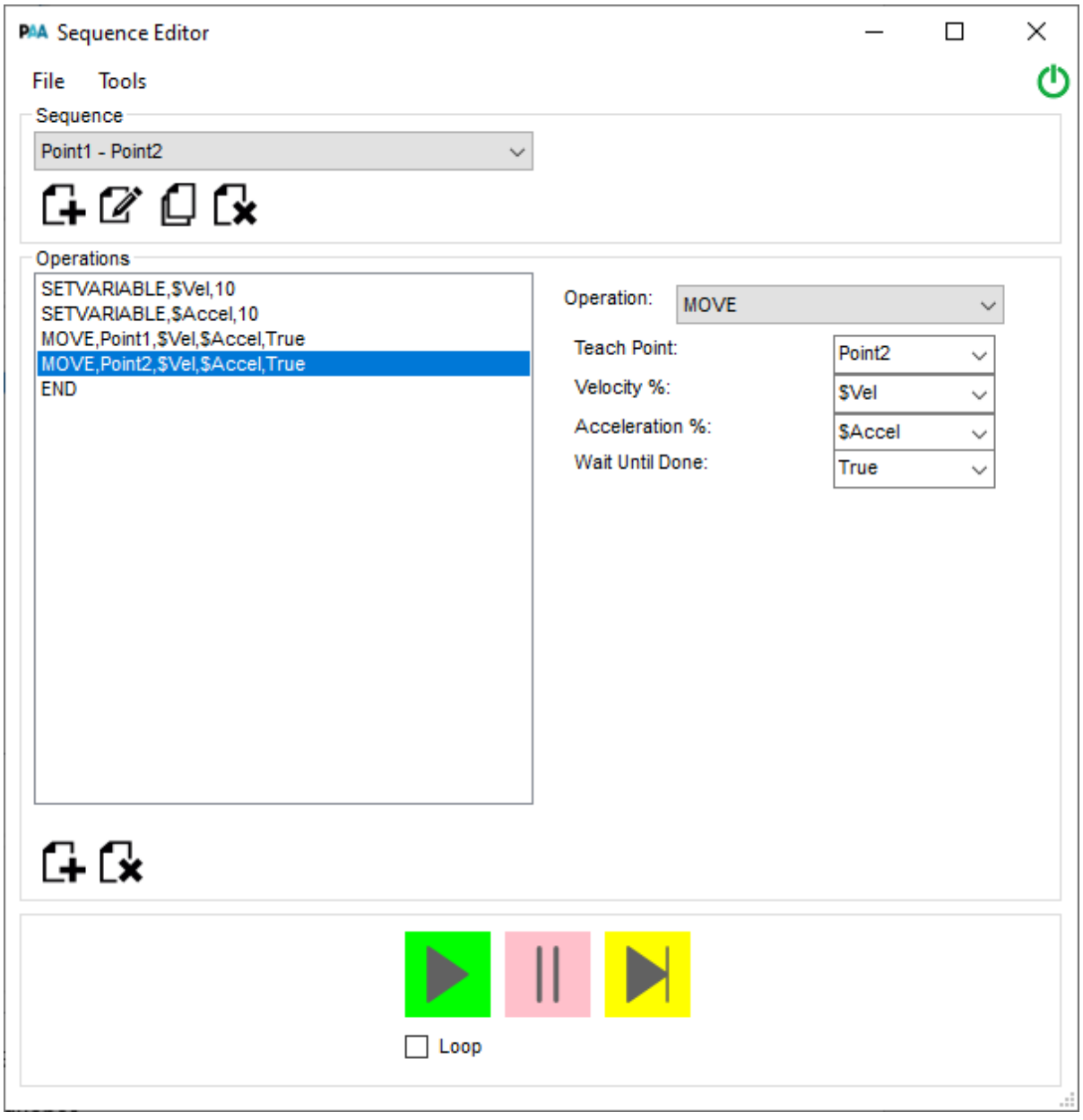
12.10.2.2 Joystick Setup displays a window for testing and configuring a joystick that can be used for jogging the robot axes remotely. This item will only be visible if the "Joystick" option is selected under Options…/Communication Settings. More details are provided later in this section.

12.10.2.3 "Access Permissions" displays a submenu containing the following items:

- Full Access—This is the default level for the Teach Pendant. All controls are visible.
- Technician Access—Teach Points cannot be renamed or deleted, but they can be taught. The robot can be moved manually. The File menu is hidden.
- Limited Access—The robot can be moved and reset, but no settings can be changed. The Options and Sequence Editor windows are not accessible.
- Set Full Access Password—Displays a window in which the Full Access password is entered. This option is available only in Full Access mode.
- Set Technician Access Password—Displays a window in which the Technician Access password is entered. This option is available only in Full Access mode.
- If the passwords are forgotten, open regedit.exe, and browse to "HKEY_CURRENT_USER\Software\VB and VBA Program Settings\KX2 Robot Control\Settings" and change the value of TeachPendantAccessLevel to 0. The next time the Teach Pendant is opened, it will be in Full Access mode. The passwords can then be modified.

12.11 Disable Motors—Click the Unlock icon at the top of the Teach Pendant to allow positioning of the arm by hand. The motors will be disabled. The encoders are still powered and will keep track of the robot position as it is moved. Click the icon again to re-enable the motors. Disabling the motors and enabling the Teach Button simultaneously allows existing teachpoints to be retaught quickly.

12.12 Sequence Editor – Clicking the 'running man' icon at the top of the Teach Pendant will open the following window, which can be used to create robot sequences.



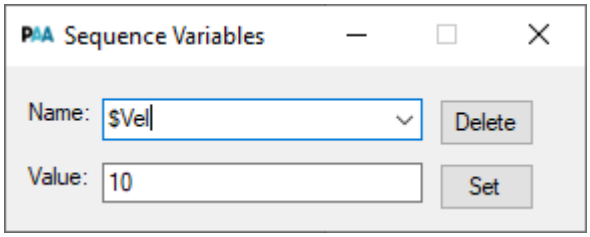
Sequence Editor Window

12.12.1 Creating a Sequence

- Click the "Add Sequence" button underneath the "Sequence" list. Enter the desired name in the "Add Sequence" window.
- Select the "END" line in the "Operations box.
- Click the "Add Operation" button to add an operation to the sequence. A default operation will be added. Alternatively, right-click on the line where the new operation is to be inserted, and select "Add" in the context menu, and then select the desired operation from the list. The "Add Recent" context menu item will be populated as operations are added.
- Select the desired operation and specify the desired parameter values. Refer to the Software Manual for definitions of the available operations.

12.12.2 Using Variables

- Variables can be used for any of the operation parameter values.
- Variable names must start with "$" (e.g., $Vel, $Accel, etc.).
- Create a variable either by using it in a SETVARIABLE operation, or by using the "Sequence Variables" window, which is opened by selecting "Tools/Edit Variables…". Type in the desired name and value and click the "Set" button.
- Variable values can be monitored using the "Sequence Variables" window. The displayed value of the selected variable will update as the value changes due to variable manipulation by a running sequence.
- Simple arithmetic operators can be used in the "Value" parameter of the SETVARIABLE command (+, -, *, /). This can be used to increment or decrement the value of a counter (Name = $PlateCount, Value = $PlateCount – 1).



Sequence Variables Window

12.12.3 Running a Sequence

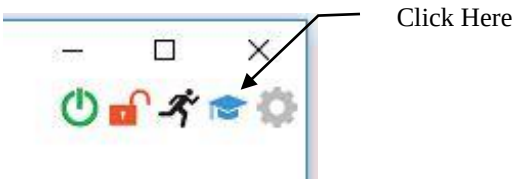
- Select the desired sequence from the Sequence list.
- Make sure the robot is in the correct startup position, and that all plates are in the correct locations.
- Click the "Run" button to start the sequence. The sequence will start at the first line if no line is currently selected. If a line is selected, a warning will be displayed, providing the option to start at the selected line.
- Click the "Stop" button to stop the sequence before it is finished (stops after the current operation).
- Click the "Pause" button to pause execution on the current line.
- If a sequence is either paused or stopped, the "Single Step" button can be used to execute a single line. If the sequence is paused, the line at which the sequence is paused will execute. If the sequence is not running, the currently selected line will execute.
- Checking the "Loop" option will cause the sequence to restart automatically once it has finished. If the box next to "Loop" is left empty,

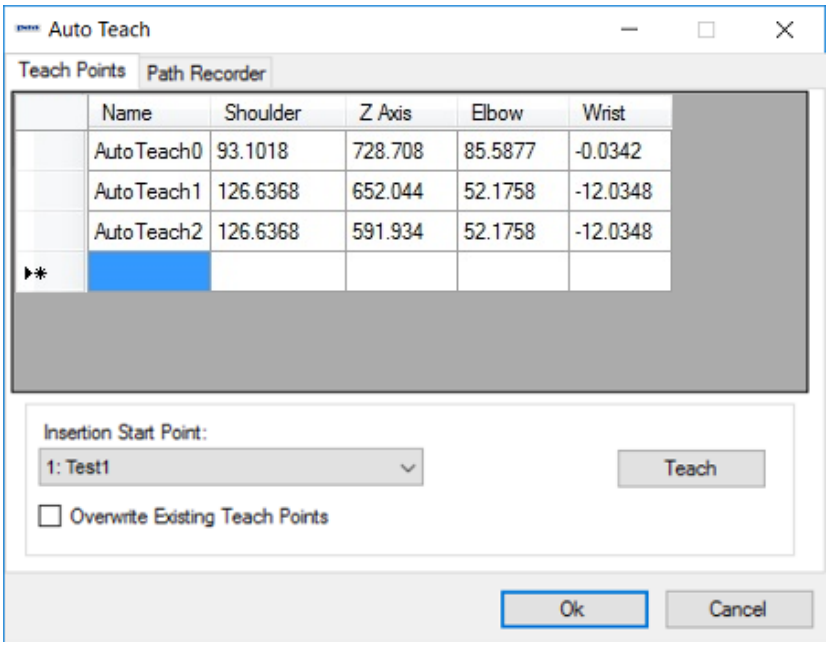
the sequence will loop indefinitely. Enter a numeric value in the box to specify a finite number of loops.

12.12.4 Editing a Sequence

- An existing sequence can be renamed, copied, or deleted using the buttons directly underneath the Sequence list.
- An existing operation can be edited by selecting the operation line. The parameters will then be displayed on the right side of the window.
- The position of an operation can be shifted up or down in the sequence by clicking and dragging the operation to the desired new position. The mouse button must be held down for a moment before dragging the operation.
- Right-clicking on an operation will display a quick-pick menu with the following commands: Cut, Copy, Paste, Delete, Add, and Edit.
- The keyboard Ctrl+C, Ctrl+V, and Ctrl+X shortcuts can be used to copy, paste, and cut operations.
- Multiple lines can be selected simultaneously by clicking and dragging downward quickly to select the desired lines. Multiple lines can also be selected by clicking while holding down the Ctrl key. Clicking one line and then clicking another line while holding down the Shift key will select the first line, last line, and all lines in between.
- The Del key will delete any selected lines.
- The Esc key will deselect all selected lines

12.13 AutoTeach – Clicking the 'graduation cap' icon opens a window that creates teach points automatically each time the button on the top of the arm is pressed.

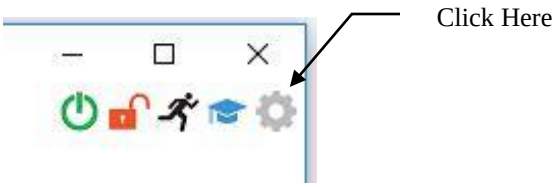




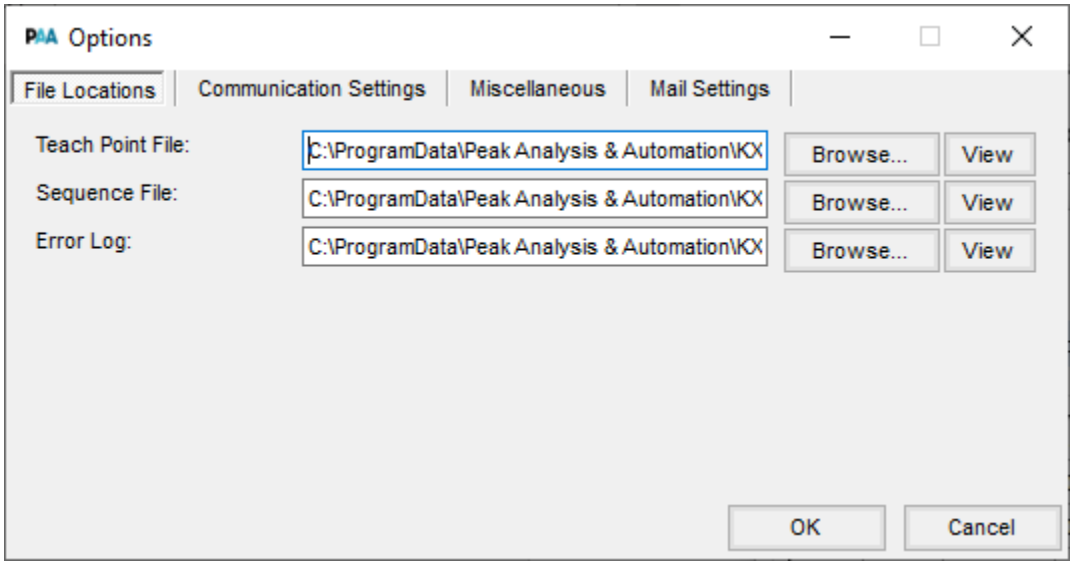
AutoTeach Window

12.13.1 When the AutoTeach window is opened, the motors are disabled so the robot can be moved by hand.
12.13.2 Move the robot to the desired position and press the teach button on the front of the Elbow. The button will flash, and the buzzer will emit a short beep. The "Teach" button on the window can also be pressed.
12.13.3 The joint positions will be read, and a point named AutoTeach0 will be added to the list.
12.13.4 Repeat the process for all points that are to be taught.
12.13.5 Select the desired "Insertion Start Point" from the list. This is the location in the main teach points list where the new AutoTeach points will be inserted.
12.13.6 The auto-generated names can be modified directly in the list.
12.13.7 If it is desired that the new AutoTeach points overwrite existing teach points, then select the "Overwrite Existing Teach Points" option.
12.13.8 Press "Ok." The motors will re-enable, and the AutoTeach points will be added to the main list of teach points.

12.14 Options – Clicking the 'gear' icon opens the following window where robot settings can be modified.



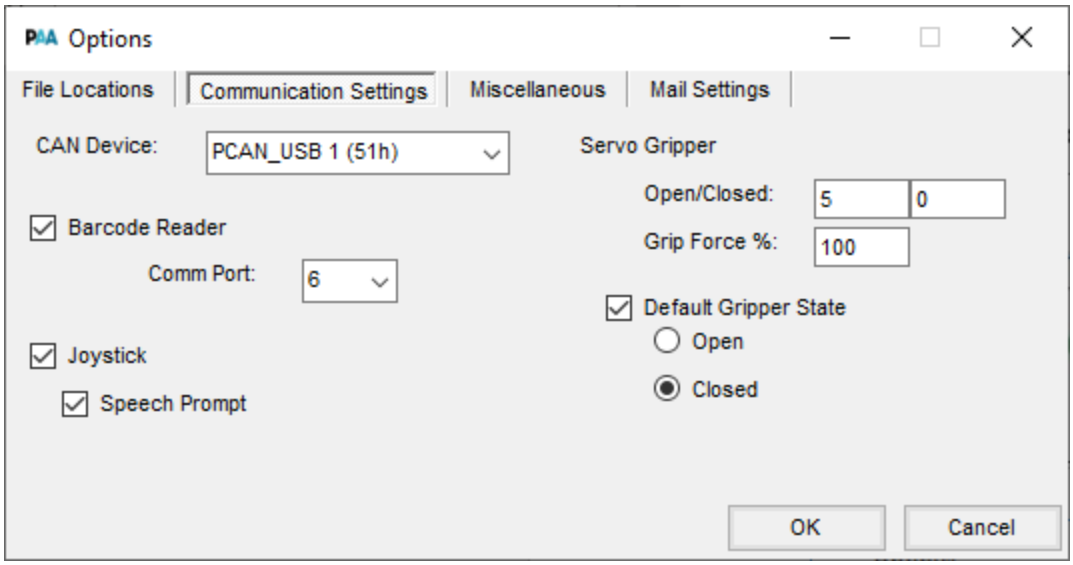
12.14.1 The first Options tab is "File Locations".



Options Window, File Locations Tab

- Teach Point File—When KX2 Robot Control DLL is installed, a blank Teach Point file will be placed in the C:\ProgramData\Peak Analysis & Automation\KX2 Robot Control DLL\ directory. The location of this file is specified in the "Teach Point File:" textbox. The location of the file can be modified, if desired.
- Sequence File— When KX2 Robot Control DLL is installed, a blank Sequence file will be placed in the C:\ProgramData\Peak Analysis & Automation\GX Robot Control DLL\ directory. The location of this file is specified in the "Sequence File:" textbox. The location of the file can be modified, if desired.
- Error Log File—Each time a robot error occurs, the error description, along with date and time, will be saved in the Error Log file. The location of this file is specified in the "Error Log File:" textbox. The location of the file can be modified, if desired.

12.14.2 The second Options tab is "Communication Settings".

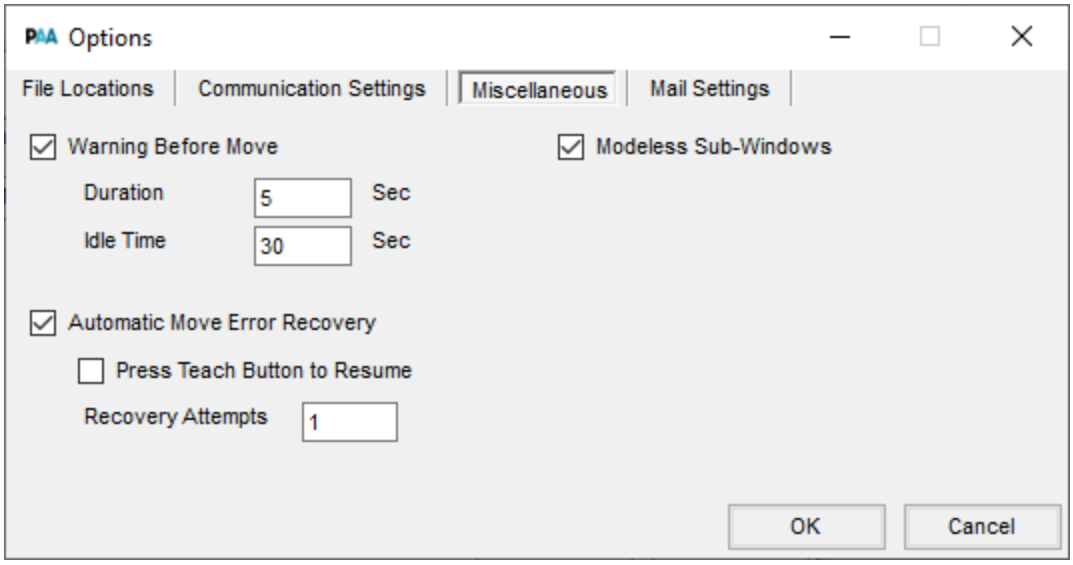


Options Window, Communication Settings Tab

- CAN Device—The Device ID of the CAN/USB adapter inside the robot is specified here. The ID of the adapter may need to be changed if multiple robots are connected to the same PC. Instructions for changing the ID can be found in the Software Installation section. This setting in the Options window does not change the Device ID. It is simply reporting the Device ID to the software.
- Barcode Reader—This setting provides the ability to disable the barcode reader, if desired. Select the Comm Port to which the barcode reader cable is connected. The Windows Device Manager can be used to determine the port number.
- Joystick—A game controller for remote jog control can be used with the robot (not provided). Select this option to enable the game controller. Once this option is selected, a new item will be added to the Tools menu titled "Joystick Setup." If the PC is outfitted with speakers, then select the "Speech Prompt" option to have the software announce the jog settings as they are changed when pressing the game controller buttons.
- Servo Gripper—If the robot is equipped with a servo gripper, then this option will be displayed automatically. The standard KX-2 gripper uses the robot CANOpen network for communication. The grip force percent must be specified. The "Open" position should be a large enough value (26.15mm max.) to allow the gripper to open wide enough to release the microplate, but small enough to allow the gripper fingers to fit inside all instrument nests. The "Closed" position should be small enough (0mm min.) that the gripper fingers will contact the microplate before reaching the closed position. Unique open and closed positions can also be specified in the gripper commands in applications where multiple open and closed positions are required.

- Default Gripper State —Check this option to have the gripper either open or close during initialization. To leave the gripper in its current state, uncheck this option. Setting the default position to 'Closed' helps reduce the chance of dropping a plate that was left in the gripper from a previous operation.

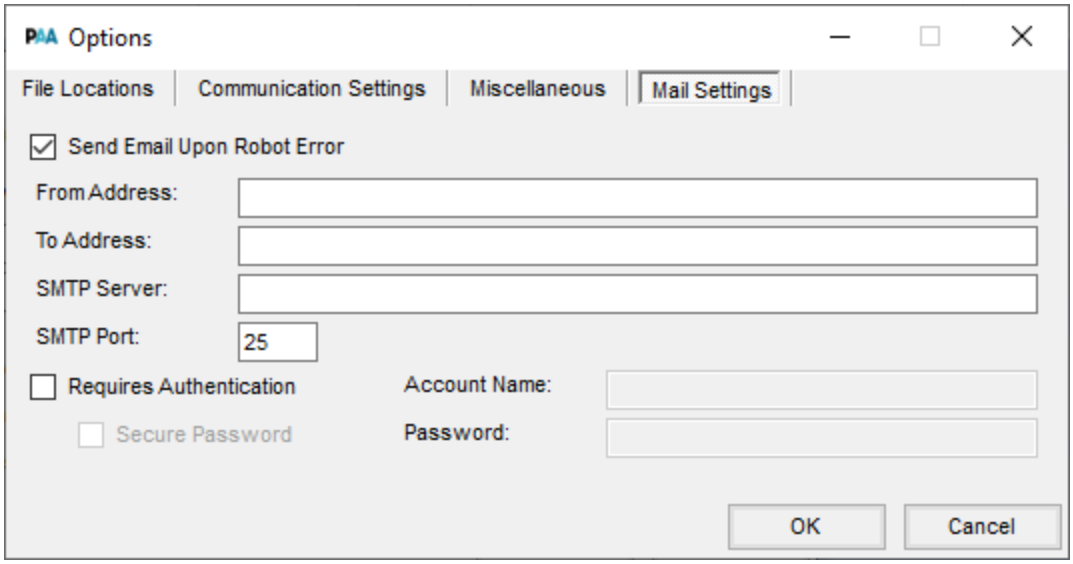
12.14.3 The third Options tab is "Miscellaneous".



Options Window, Miscellaneous Tab

- Warning Before Move—Check this option to have the buzzer beep and the blue indicator light flash prior to moving after an idle period longer than the time specified in the "Idle Time" box. Specify the duration of the warning in the "Duration" box.
- Automatic Move Error Recovery—Check this option to allow the software to reinitialize automatically after a robot move error occurs. If the "Press Teach Button to Resume" option is checked, then a recovery attempt will occur only after the teach button on the arm is pressed. Press the e-stop button to abort automatic error recovery. If "Press Teach Button to Resume" is not checked, then the desired number of automatic error recovery attempts can be specified. Automatic Move Error Recovery works only with move commands that have Wait Until Done = True.
- Modeless Sub-Windows—Check this option to allow accessing multiple windows at the same time. This option may need to be unchecked if the Teach Pendant is being opened via the DLL interface by another application that doesn't support modeless windows.

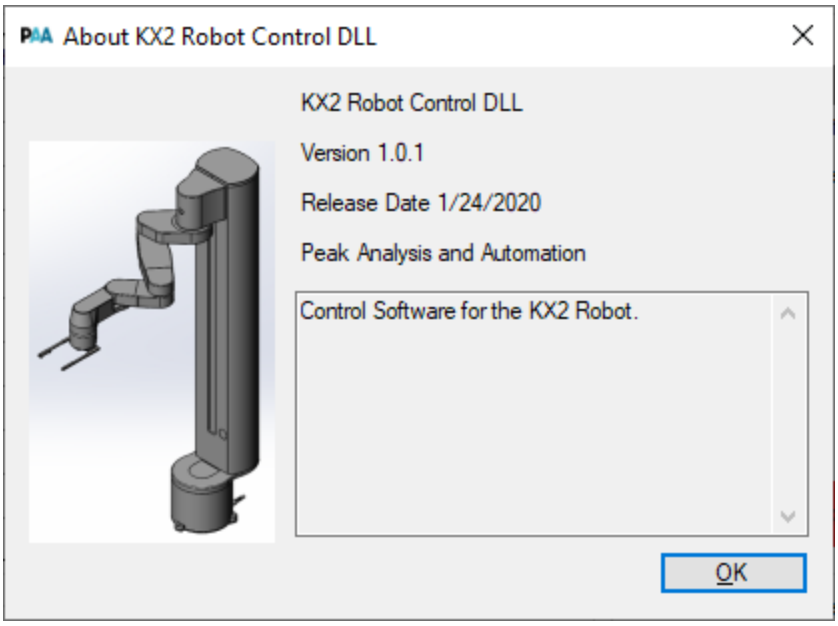
12.14.4 The fourth Options tab is "Mail Settings".



Options Window, Mail Settings Tab

- Send Email Upon Robot Error—This option sends an email to the "To Address" each time the robot generates an error. A POP3 email account is required.
- From Address—Enter the address that will show up as the sender of the email.
- To Address—Enter the address of the email recipient.
- SMTP Server—Enter the SMTP server being used to send the email.
- SMTP Port—Enter the SMTP port number.
- Requires Authentication—Check this option if the SMTP server requires authentication.
- Secure Password—Check this option if the SMTP server requires a secure password.
- Account Name—Enter the SMTP account name. This is usually the same as the "From" address.
- Password—Enter the SMTP password. This is usually the same password that is used to logon to the email account.

12.15 Help Menu: *About*…—A window will open, displaying the current version and release date of GX Robot Control.

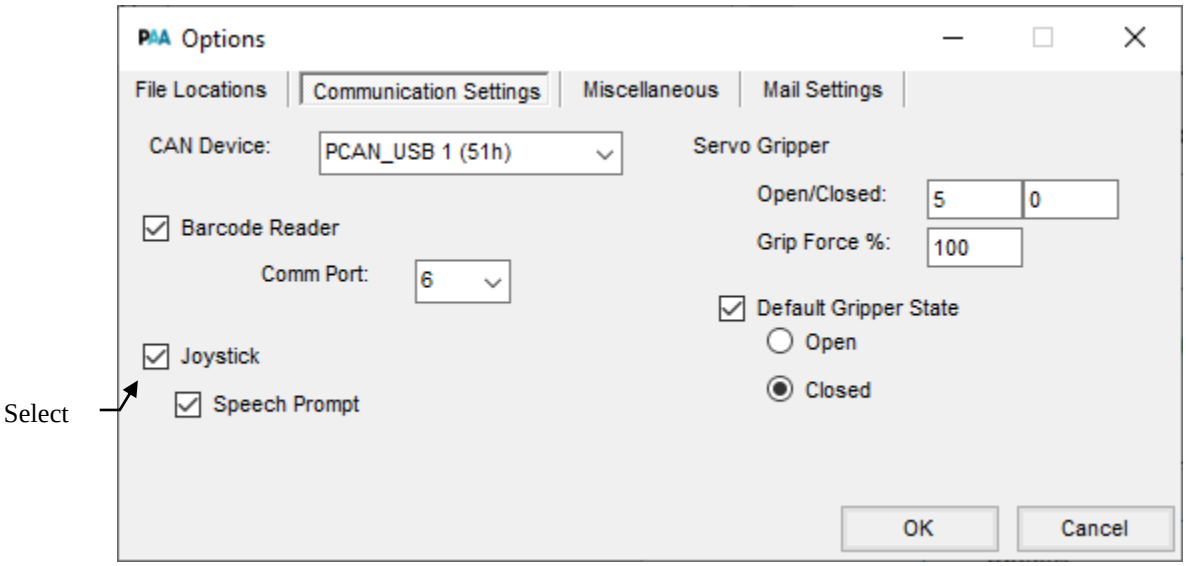


Help/About… Window

12.16 Joystick Control

12.16.1 A game controller (Logitech Gamepad F310, P/N 940-000110 recommended) can be used to control the robot. Most Windows-compatible joysticks or game controllers can be configured to work with the KX-2 robot.

12.16.2 To enable Joystick control, open the Teach Pendant, click the "Options" icon, and click on the "Communication Settings" tab.



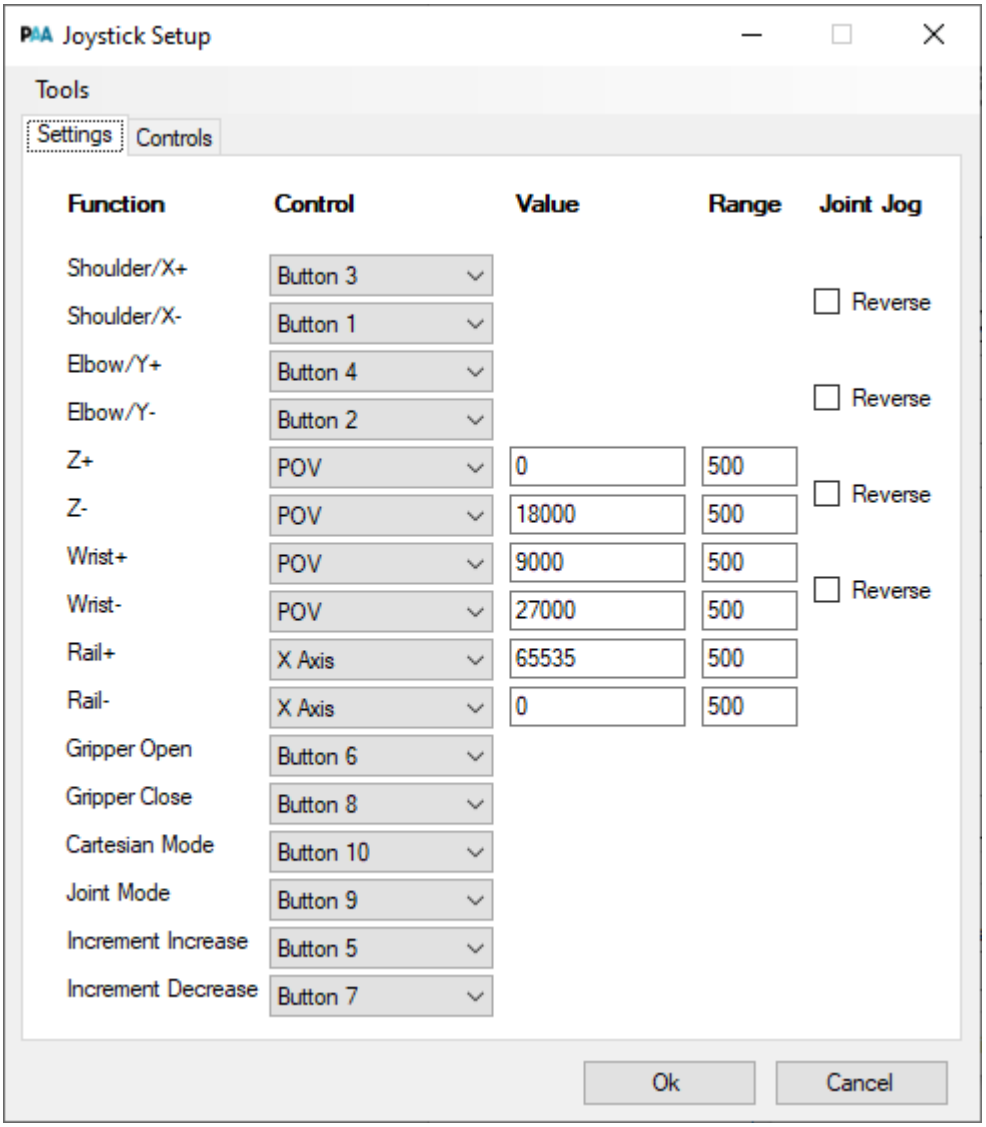
Options Window, Communication Settings Tab

12.16.3 Check the "Joystick" option. Then press "OK". Plug the joystick into the PC, and install drivers, if requested by the operating system. Click the "Reset Robot" icon and wait for the robot to initialize. The joystick should now be ready to use.

12.16.4 If multiple game controllers are connected to the PC, or sometimes even if another game controller was connected in the past, it may be necessary to modify the HKEY_CURRENT_USER\SOFTWARE\VB and VBA Program Settings\KX2 Robot Control\Joystick\JoyNum value in the Windows Registry. The default value is 0. If the Teach Pendant doesn't respond to the game controller, then try changing this value to 1 or 2.

12.16.5 The default mapping of robot functions to the joystick controls are as follows:

12.16.6 To remap robot functions to different joystick controls, go to the "Tools" menu, and select "Joystick Setup…" The following window will open.



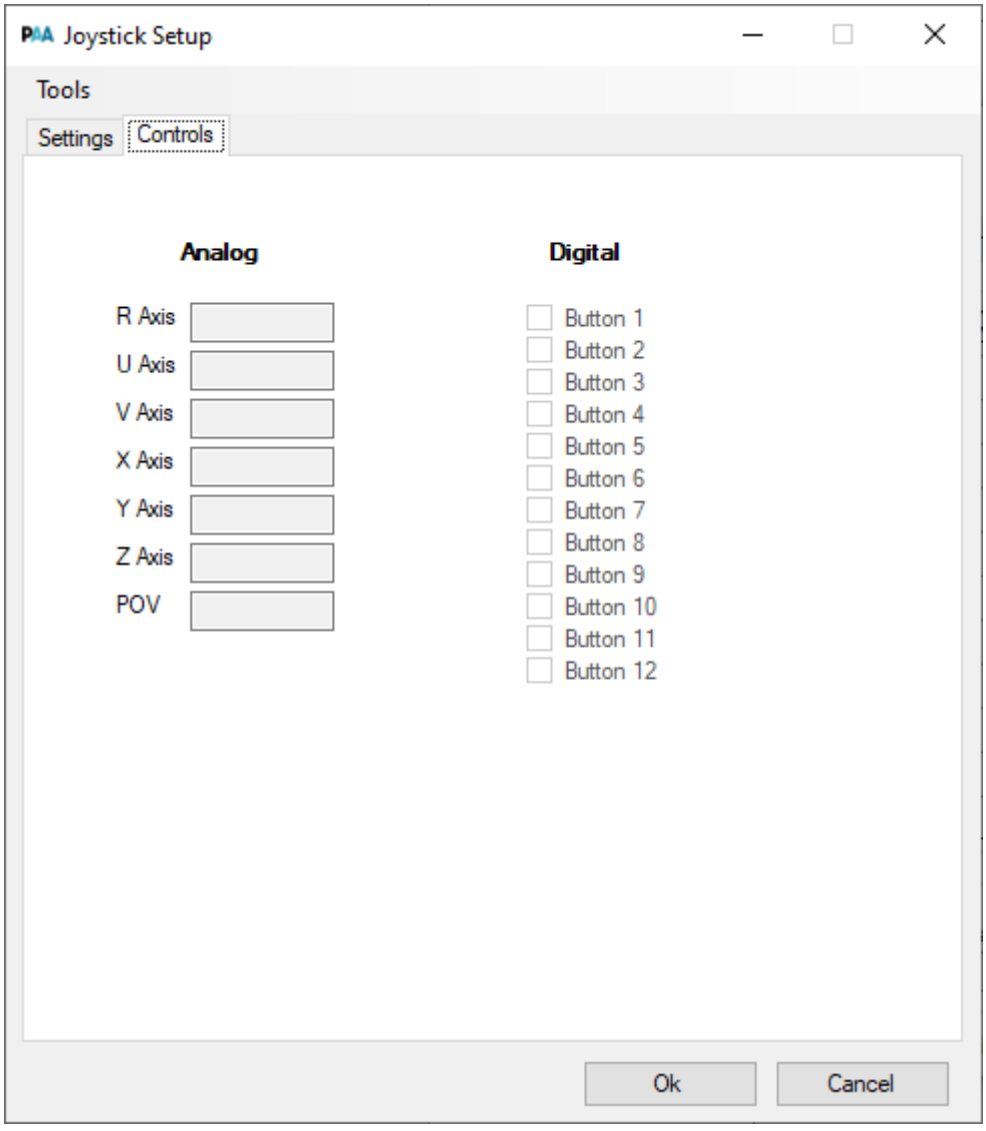
Joystick Setup – Settings Tab

12.16.6.1 Each robot function can be controlled either by a button, a joystick, or a POV (point of view) control. Joysticks and POV controls are analog devices, so an analog value must be specified for each function that is controlled by an analog control. To capture the desired value of an analog control, hold the control in the desired position, and double-click the corresponding "Value" textbox. The current value of that control will be entered into the "Value" textbox automatically. A default range of 500 will be used but can be adjusted manually if more or less sensitivity is needed.

12.16.6.2 Check any of the "Reverse" options to reverse the direction of Joint jogging without reversing the direction of Cartesian jogging.

This is especially useful for the Shoulder/X directions since the positive Shoulder direction causes the robot to move in the opposite direction from the positive X direction.

12.16.7 To monitor the states of the various joystick controls, click on the "Controls" tab.



Joystick Settings - Controls

12.10.1.1 As the joystick controls are manipulated, their current values will be displayed live on the screen.

12.16.8 Default settings are available in the "Tools" menu for the Logitech Precision, Logitech Dual Action, and Logitech Gamepad F310 controllers.

12.16.9 The joystick can be used only when the Teach Pendant window is open, and the "Enable Joystick" box on the Jog Controls window is checked.

13.0 Teaching Routine

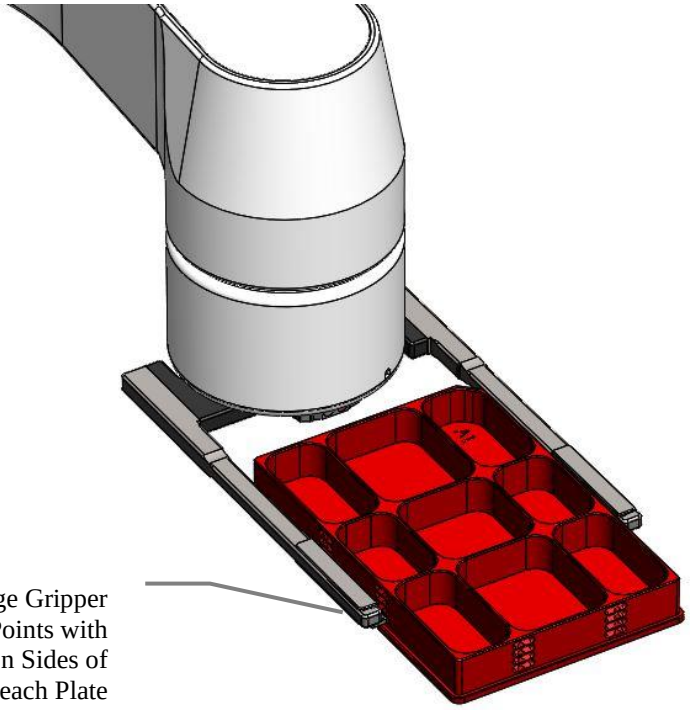
13.1 The following instructional guidelines assume that the user's sequence will be using microtiter plates, although the same techniques apply to almost any installation.

Important Note: Most non-repeatability problems with the installed robot can be traced to either a non-rigid installation or improper teaching methods.

13.2 Prior to teaching, ensure that the robot and all peripheral devices have been properly and securely installed.

Important Note: If the system is not securely installed, any time that is spent teaching will be wasted.

13.3 An SBS footprint Teach Plate is included with the robot for use in place of a plastic microplate during the teaching process. This setup standard is very precise and simplifies many of the subjective alignment processes associated with robot teaching. It has special centering features for all standard Peak Robotics robot fingers and eliminates much of the variability inherent with trying to use common plastic plates for teaching.



TCH3 Universal Teach Plate

13.4 The procedure outlined below assumes the Teach Plate is being used.

13.5 The Teach Plate has several sets of gripper alignment indentations. There are four different gripping heights for both portrait and landscape orientations. Select the position that matches the desired gripping location on the plastic microplates that will be used in the system. All teaching

from this point forward must be done with the Teach Plate gripped in the same set of indentations. It is recommended that a felt-tip pen be used to mark the indentations being used.

1) Insert the Teach Plate into the robot gripper as follows. Use the Teach Pendant to open the gripper by clicking the "Open" button. Select "Disable Motor". Hold the Teach Plate between the gripper fingers and close the fingers by hand. De-select "Disable Motor" and click the "Close" button to grip the plate firmly. Make sure the gripping pads on the gripper are aligned with the indentations on the sides of the Teach Plate. Make sure the Teach Plate is not tilted in the gripper.
2) Click the Teach Pendant "AutoTeach" icon to open the AutoTeach window. As an alternative, click the "Unlock" icon at the top right corner of the window, but this method requires manually entering and recording the teach points. Another option is to move the robot under its own power by using the jog controls or a game controller.
3) With the Teach Plate gripped by the robot, move the robot to the first instrument to be taught, centering the microplate inside the nest. Line the Teach Plate up with the nest so that it is as on-center and parallel as possible. Any misalignment will typically cause scraping of the sides of the microplate and may cause the microplate to scrape when being placed in another correctly taught instrument after being removed from a poorly taught instrument. Position the robot in the Z direction so that the Teach Plate is just barely touching the bottom of the nest.
4) When satisfied with the robot's position, save the position to a teach point, as follows:
    - If using AutoTeach, simply press the teach button located on the top of the arm. The new teach point will then be displayed in the AutoTeach window. Modify the name of the teach point, as desired (for example, "Instrument1Nest"). Renaming the teach points can be done at the end of the teaching process to eliminate the need to move back and forth between the robot and PC.
    - If AutoTeach is not being used, then go to the Teach Points list and enter the desired name for the new teach point in a blank line (for example, "Instrument1 Nest"). Right-click the line and select "Teach".
5) Each nest point taught needs a point taught directly above it. This is used to clear the nest before approaching or departing from the instrument. When moving to pick or place a microplate, the robot must be instructed first to move to this "approach" point directly above the pick or place location. The robot can then move straight down into the nest. This will keep the robot from colliding with the nest or equipment surrounding the nest.
6) Next, raise the arm straight up, far enough for the plate to fully clear the nest sides. Teach this point as, for example, "Instrument1Approach".

Important Note: If the Teach Plate ever gets shifted in the gripper or dropped at any time during the teaching process, you must re-center the plate in the gripper before proceeding. The plate must be returned precisely to its original position in the gripper. Otherwise all previously taught positions will have to be re-taught.

7) Repeat the previous steps for all instruments. Teach all remaining points using the continuously gripped plate. Ensure the plate does not get jarred or dropped during the entire teaching process. If so, re-grip it in precisely the same position as before prior to proceeding.
8) Create a "Safe" teach point located in a neutral position. This point should be in a location that allows the robot to move between it and all "Approach" positions. This "Safe" position will allow a plate to be transferred between any two instruments without the risk of collision. On more complicated systems it may be necessary to create multiple "Approach" points in order to reach hard-to-access instruments from the "Safe" teach point. It may also be necessary to create multiple "Safe" positions between which the robot can move without the risk of collision.

13.6 Teaching Plate Stacks:

13.6.1 The KX-2 Robot is often used in conjunction with optional plate stacks. This type of plate storage is a first-in-last-out (FILO) arrangement where plates are placed directly on top of each other. When a plate is removed, the plate on top of the stack must be removed first. Stacks are useful in applications where plates are processed in bulk batches, and where ease of manual plate loading is desired.

SS30TP *SS30SP* *SS30SL*

Optional Plate Sequential Stacks

13.6.2 When teaching a plate stack, <u>two teach points must be taught</u>: one for the bottom position of the stack and one for the top position in the stack. Teaching these two points will compensate for the inevitable non-parallelism between the Z axis of the robot and the stack uprights.

13.6.2.1 Teach the bottom position with no plates in the stack except for the Teach Plate in the gripper. Ensure the plate is centered within the stack to within 0.25mm (.010").

13.6.2.2 Teach the top position of the stack with the stack completely full and where the top plate in the stack is the Teach Plate in the gripper. If the pitch-based DLL stack functions are being used, then the stack does not need to be filled with plates, and the top teach point should be taught near the top of the stack, but the height is not critical.

13.6.2.3 Determine the "Stack Top Clearance" value, which is the vertical distance the top plate must be lifted to clear the top of the stack. This value depends on the thickness of the microplates being used. This value will be used later when creating a robot sequence (see RemovePlateFromStack and PlacePlateInStack

method definitions in the Software manual). Note: When moving to and from stacks, the robot must be at least as high as the top teach point of the stack plus the "Stack Top Clearance" value. This is to avoid the possibility of the robot being commanded to move to above a stack starting from too low of a position, which would cause the robot to hit the top of the stack on its way there.

13.6.3 Use the stack-tilt-accommodating DLL functions PlacePlateInStack() & RemovePlateFromStack(),or PlacePlateInPitchStack() & RemovePlateFromPitchStack(), which interpolate between the top and bottom teach points in a stack when moving in the stack.

13.7 Teaching Plate Hotels

13.7.1 The KX-2 Robot is often used in conjunction with optional plate hotels. This type of plate storage is a random-access arrangement where plates are placed on individual shelves. Each plate can be accessed at any time, independent of other plates. This is useful for applications that require retesting or the tracking of specific plates.

HR15SP *HR15SL*

Optional Plate Hotel Racks

13.7.2 Three teach points must be taught for each hotel, as follows:

- Bottom Teach Point—Teach this point with the Teach Plate positioned on the bottom shelf of the hotel.
- Top Teach Point—Teach this point with the Teach Plate positioned on the top shelf of the hotel.
- Retracted Teach Point—Teach this point at the same Z height as the Top Teach Point, but with the Teach Plate retracted away from the shelf. Position the front edge of the Teach Plate approximately 10mm from the front edge of the hotel shelf.

13.7.3 Determine the "Lift Height" value, which is the vertical distance the plate must be lifted to clear the pocket in the hotel shelf. Select a value that sets the clearance between the bottom of the plate and the top of the shelf equal to the clearance between the tops of the gripper fingers and the underside of the next shelf up. This value will be used later when creating a robot sequence (see RemovePlateFromHotel and PlacePlateInHotel method definitions in the Software manual).

13.7.4 Use the hotel-tilt-accommodating DLL functions PlacePlateInHotel() and RemovePlateFromHotel(), which interpolate between the top and bottom teach points in a hotel when moving in the hotel. Call the SetMovePathMode(eMovePathMode.Linear) function prior to calling either of the hotel functions so that the robot will move straight into and out of the hotel. This will help prevent the fingers from hitting the plate while moving in and out of the hotel especially if the hotel isn't facing directly toward the center of the robot.

13.8 Move Path

13.8.1 Two Move Path Modes are available for robot motion:

- Joint – Each rotary joint moves the shortest distance required to reach the commanded position.
- Linear – The end of the arm follows a linear path to reach the commanded position. Fully extended arm positions should be avoided during a linear move, as sudden high acceleration can result.

13.9 Unlimited Rotation

13.9.1 The Shoulder and Wrist of the KX2 robot have unlimited rotation. This allows the robot to move the shortest distance between two points without the need to unwind the joints.

13.9.2 In some cases, it may be desired to have one or more joints rotate the long way around. If this is the case, it may be necessary to split the move into two smaller moves, each of which are less than 180° for each joint, but together are greater than 180°. The SetMoveJointDirection() function can also be used to force each joint to move a specific direction, as follows:

- Shortest Way—The rotary axis will move the direction that results in the smallest required angular displacement. For example, if the wrist is currently at 355° and the commanded position is 5°, the wrist will move a relative distance of -10° and will pass over the 360°/0° rollover point.
- CCW—The rotary axis will move in the counterclockwise direction regardless of the distance to be traveled. For example, if the wrist is currently at 2° and the commanded position is 1°, the wrist will move a relative distance of 359° in the positive (CCW) direction.
- CW—The rotary axis will move in the clockwise direction regardless of the distance to be traveled. For example, if the wrist is currently at 1° and the commanded position is 2°, the wrist will move a relative distance of -359° in the negative (CW) direction.
- Normal—The rotary axis will move in the direction that avoids passing through the 360°/0° rollover point. This is useful in applications where there is an obstruction that blocks the Shoulder from moving through a certain region. The robot should be installed in an orientation where the 0° position of the shoulder is facing the obstruction.

13.10 Buffered Move Commands

13.10.1 If several moves are executed in a row, the pause time between moves can be reduced by setting WaitUntilDone=False on all the moves except for the last move. This will allow the move commands to be pre-calculated and queued more efficiently. Automatic Move Error Recovery is not possible for moves commanded with WaitUntilDone=False.

14.0 User I/O & Emergency Stop

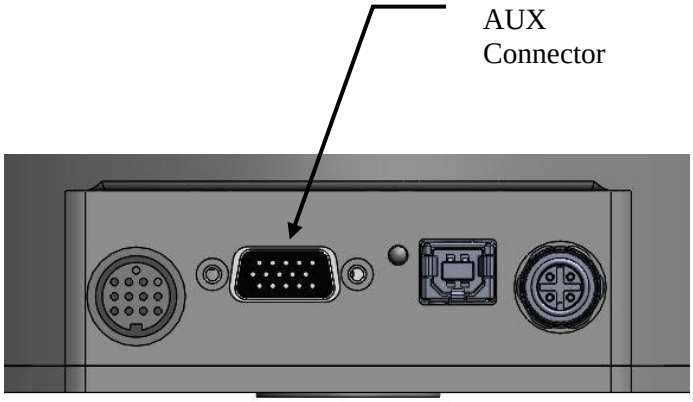
14.1 The robot contains digital inputs, analog inputs, and digital outputs that are available to the user, and are controlled through the robot control software (DLL). They can be monitored and toggled using the Teach Pendant Inputs/Outputs tab described in the previous sections.

14.2 All User I/O are accessed via the female high-density 15-pin d-sub Auxiliary connector on the Shoulder connector panel. The Barcode Reader uses this connector, so it will be necessary to build a splitter cable that plugs into the Auxiliary connector on one end (Norcomp 180-015-103L001 or equivalent) and into the Barcode Reader cable on the other end (Norcomp 180-015-203L001 or equivalent). This splitter cable will need to pass through the three lines specific to the Barcode Reader (BCR, listed below).

14.3 The following I/O are available on the Auxiliary connector:

- 3 digital inputs (non-opto-isolated and sinking, each has a 10k inline resistor, and can be used with 24VDC PNP sensors)
- 2 analog inputs, 12-bit resolution
- 3 digital outputs (non-opto-isolated, sourcing)
- +24VDC source (1A max. with servo gripper, 2A without)

AUX PIN	FUNCTION
1	Shoulder AN1+, +/-10V
2	Shoulder OUT2, 5V/10mA MAX
3	Shoulder IN3
4	Shoulder IN1
5	+24VDC OUT, 1A MAX
6	Shoulder AN1- (Use with AN1+)
7	Shoulder OUT3, 3.3V/8mA MAX
8	Shoulder OUT1, 5V/10mA MAX
9	Shoulder IN2
10	0VDC (used by BCR)
11	BCR Tx
12	BCR Rx
13	Shoulder AN2, 0-3V
14	Reserved (Shoulder OUT4)
15	Reserved (Rail Decel)



Shoulder AUX Connector

14.4 Emergency Stop

14.4.1 The robot is equipped with an emergency stop button that, when pressed, will cause the robot to decelerate to a controlled stop. Power is then removed from the motors after a 750ms delay. Power will not be restored to the motors until after the emergency stop button is popped back up by twisting it clockwise, and an Initialize command has been sent via the software.

14.4.2 The emergency stop function is Stop Category 1, per IEC 60204-1.

14.4.3 The emergency stop function is designed and built to meet PL=d (Performance Level), as required by ISO 10218-1:2011 and defined by ISO 13849-1:2015. PL=d is defined as having a probability of dangerous failure of less than 10^-6 failures per hour.

14.4.4 The emergency stop function is designed and built meet fault resistance Category 3, as required by ISO 10218:1-2011 and defined by ISO 13849-1:2015. Category 3 specifies that a single fault will not lead to loss of safety function, and the fault is detected. No fault exclusions have been made.

14.4.5 If modifications are made to the emergency stop function and its associated hardware, The PL=d and Category 3 ratings may be compromised, leading to a condition where the robot may not stop when the emergency stop function is activated. Refer to ISO 13849-1:2015 for more information.

14.4.6 The operating limits of the emergency stop function are the same as defined in the Specifications/Environmental Conditions section. The emergency stop function must not be modified to perform functions other than the functions described in this section.

14.4.7 The emergency stop function, as provided by the emergency stop button, must not be muted at any time.

14.4.8 The emergency stop function has only one control mode.

14.4.9 Consult Peak Robotics if any internal parts of the emergency stop function must be replaced.

14.4.10 The Shoulder connector panel should be oriented in a location that allows its drive status LED to be viewed easily, and without having to enter the robot workspace.

14.4.11 When the emergency stop button is pressed, a signal is sent to the robot via digital inputs 5 and 6 on the shoulder motor drive, which initiates a controlled deceleration of all motors. The safety rated STO1 and STO2 motor drive inputs receive a delayed signal 750 milliseconds later, and power is removed from the motors. The following table lists the maximum distance each axis may travel during controlled deceleration, assuming the axes are all at their peak velocity when the emergency stop button is pressed. Some axes may continue to coast a short distance past the stated distance at a very low velocity.

Axis	Velocity	Deceleration	Time	Distance
Shoulder	145 deg/s	300 deg/s^2	0.48s	35 deg
Z	750 mm/s	1250 mm/s^2	0.6s	225mm
Elbow	80 deg/s	180 deg/s^2	0.44s	18 deg
Wrist	500 deg/s	1000 deg/s^2	0.5s	125 deg

14.4.12 The emergency stop button plugs into the E-Stop connector on the Shoulder connector panel.

J3 Pin	Wire	Function
1	Blue	+5VDC OUT
2	Black	E-Stop2
3	Brown	+5VDC OUT
4	White	E-Stop1

14.4.13 The emergency stop button contains two sets of normally closed contacts that open when the button is pressed. The robot is permitted to operate when E-Stop1 and E-Stop2 are connected to fuse-protected +5VDC supplied by the Shoulder motor drive via the closed contacts.

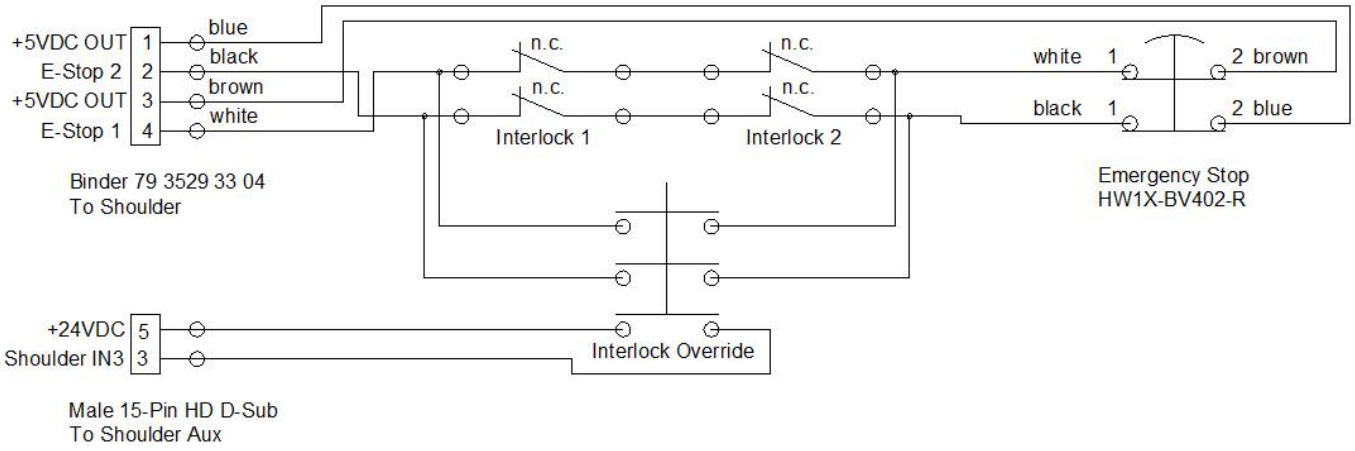
14.4.14 The state of the emergency stop function is displayed via a bicolor LED located on the Shoulder connector panel. The LED reports the following states based on its color:

Green—Emergency stop button is popped up, and the robot is permitted to operate.

Red—Emergency stop button is pushed down, and robot motion is inhibited. If the LED remains red after the emergency stop button is popped up, and will only return to green if power is cycled, then this indicates a fault in the emergency stop function, which must be investigated before the robot is returned to service. See Periodic Maintenance section for more information.

Off—The 1/10A fuse inside the Shoulder may be blown.

14.4.15 If it is determined by the system integrator or end user that the robot must be shielded by safeguarding, then it will be necessary to connect safeguard interlock switches in series with the emergency stop button. A method of overriding the interlock switches will be required so that a technician can access the robot to adjust teachpoints. The recommended method of connecting interlock switches is shown below.



14.4.16 The interlock(s) can be spliced into the middle of the emergency stop button cable by cutting the cable in the middle.

14.4.17 Any interlocks that are added to the system must be evaluated, according to ISO 13849:1-2015, to ensure that PL=d and Category 3 ratings are preserved.

14.4.18 If the Interlock Override is connected to a digital input as shown above, then the Windows Registry settings for the KX-2 software can be configured so that the input will be monitored, and will limit the velocity of the robot when the input is high:

- Settings\VelLimEnabled=1
- Settings\VelLimInputAxis=1
- Settings\VelLimInputNum=3
- Settings\VelLimInputState=1
- Settings\VelLimMax=10

See the Registry Keys section of the GX Robot Control Software Instructions document for more information.

15.0 Troubleshooting & Replacement

15.1 Important Notes:

15.1.1 A thorough understanding of the operation of the robot is required to perform a proper setup.

15.1.2 The following information is meant as a general guide only. Common sense must be applied to adjustments or when troubleshooting.

15.1.3 The KX-2 robot is a high-precision machine. It is imperative that it be installed, set up, and taught correctly to ensure trouble-free operation. Failure to run reliably day-to-day can usually be traced to improper installation or teaching.

15.2 Error Handling in the Code: reading the error messages that are returned by the software when an error is encountered can identify many types of problems. If the robot stops moving for a long period of time, check to see if there are any error messages. This should give a good indication of the source of the problem.

15.2.1 Error messages are saved in a text file named ErrorLog.txt. The default location for this file is in the C:\ProgramData\Peak Analysis & Automation\KX2 Robot Control DLL\ directory. To open this file from the Teach Pendant, select Options, and click on the "View" button next to the Error Log file path.

15.3 Manual Operation: All mechanical functions can be tested individually from the Teach Pendant program provided with the robot. This is a good way to pinpoint a problem to a certain operation. Motors can be jogged, and outputs can be actuated. To check the functionality of individual sensors, look for the light on the sensor to illuminate at the proper time.

15.4 General Troubleshooting: If an error condition exists with the robot, there are several potential sources of the problem that should always be checked first. These include:

15.4.1 Ensure there is no mechanical interference with the motion. Check for any backlash in bearings.

15.4.2 Check for proper function of sensors and ensure sensors are triggering. This type of error will generally show up during start-up.

15.4.3 Listen for new and unusual noises being produced by the robot.

15.5 Failure to Initialize: Check the following items if the robot is unable to complete initialization successfully:

15.5.1 If the robot does not move, the motors make no audible humming noise, check the following items:

- Emergency-stop button is popped up, and cable is plugged into the robot.
- Power supply box is connected to AC source, and power switch is in the 'I' position. The blue power LED on the power supply box should be on.
- The 'Drive Status' LED on the Control Box is green.
- USB cable is plugged into the robot at one end and the PC at the other end.
- Press Ctrl + Alt + Del to open the Task Manager, and make sure there aren't multiple instances of the Teach Pendant process running simultaneously.

15.6 Robot Stops Randomly: This type of error can be extremely difficult to debug. Possible causes include the following:

15.6.1 Insufficient PC hardware resources (100% CPU usage, more RAM needed, etc.). Use Windows Task Manager to monitor hardware performance. Remove unnecessary software that is using up resources. Upgrade PC, if necessary.

15.6.2 Power outage. If occurring frequently, install a UPS.

15.6.3 Old software version being used with newer motor & controller firmware versions. Install the latest version of robot software.

15.6.4 Slip ring failure. Consult factory.

15.6.5 Robot internal component or wiring degradation. Consult factory.

15.6.6 In some cases, it can be helpful to use a video camera to capture robot errors that happen during motion.

15.7 For time-critical applications, Peak Robotics recommends having a spare robot on site in the event of a failure. This can prevent long downtime and allows debugging of problems offline.

15.8 Please contact Peak Robotics for information on available service plans.

15.9 If a problem arises, contact Peak Robotics immediately for assistance. Contact info is listed at the beginning of this manual.

16.0 Periodic Maintenance

16.1 Periodic maintenance should be performed every time the Z axis has completed the equivalent of 1000 kilometers linear travel. Maintenance should be performed at least every two years even if 1000 kilometers of linear travel has not been reached.

16.1.1 The software logs the total accumulated travel of each axis. The cycle data can be found on the Teach Pendant window.

16.1.2 If the controlling software is written to monitor the "maintenance required" event, it is recommended that a window be made to pop up when the event is received, indicating maintenance is required.

16.1.3 If the controlling software does not monitor this event, then the Teach Pendant should be checked every few months, depending on use. Check for Maintenance Required = true or false. If true, perform the maintenance and then change to "false" by double-clicking on "true".

Grease, adjust, or replace as necessary:

16.1.4 Check all axes of the robot arm for bearing wear. Arm and joints should feel snug with no discernible play. A bad collision can damage the arm and cause mechanical looseness.

16.1.5 Check gripper contact pads for wear or damage. Replace or adjust if necessary.

16.1.6 Check tightness of robot mounting screws. If loose, then re-tighten. Teach points may need to be re-taught.

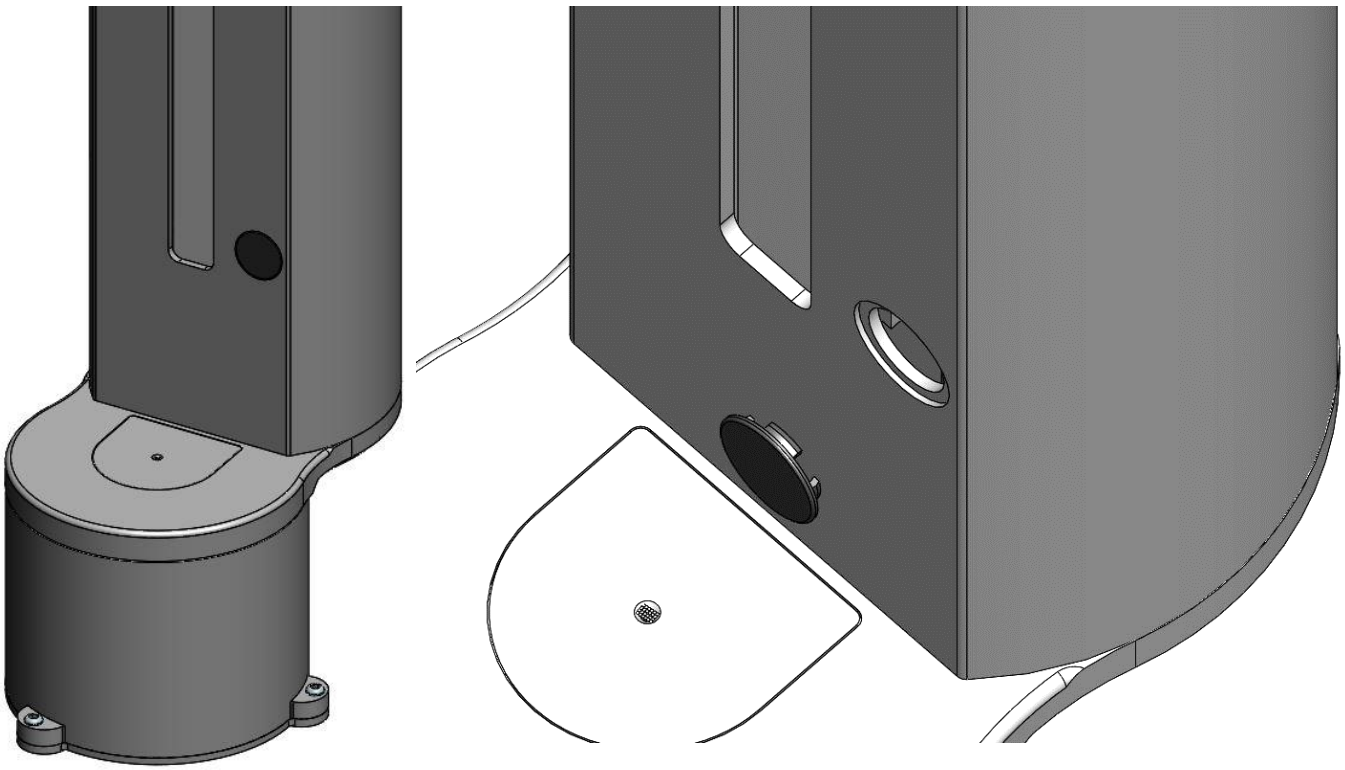
16.1.7 A grease gun with a standard grease zerk fitting is required for greasing the Z Axis arm-supporting linear bearing block and the counterweight-supporting bearing block.

Grease Gun (GreaseTek 910101 Shown)

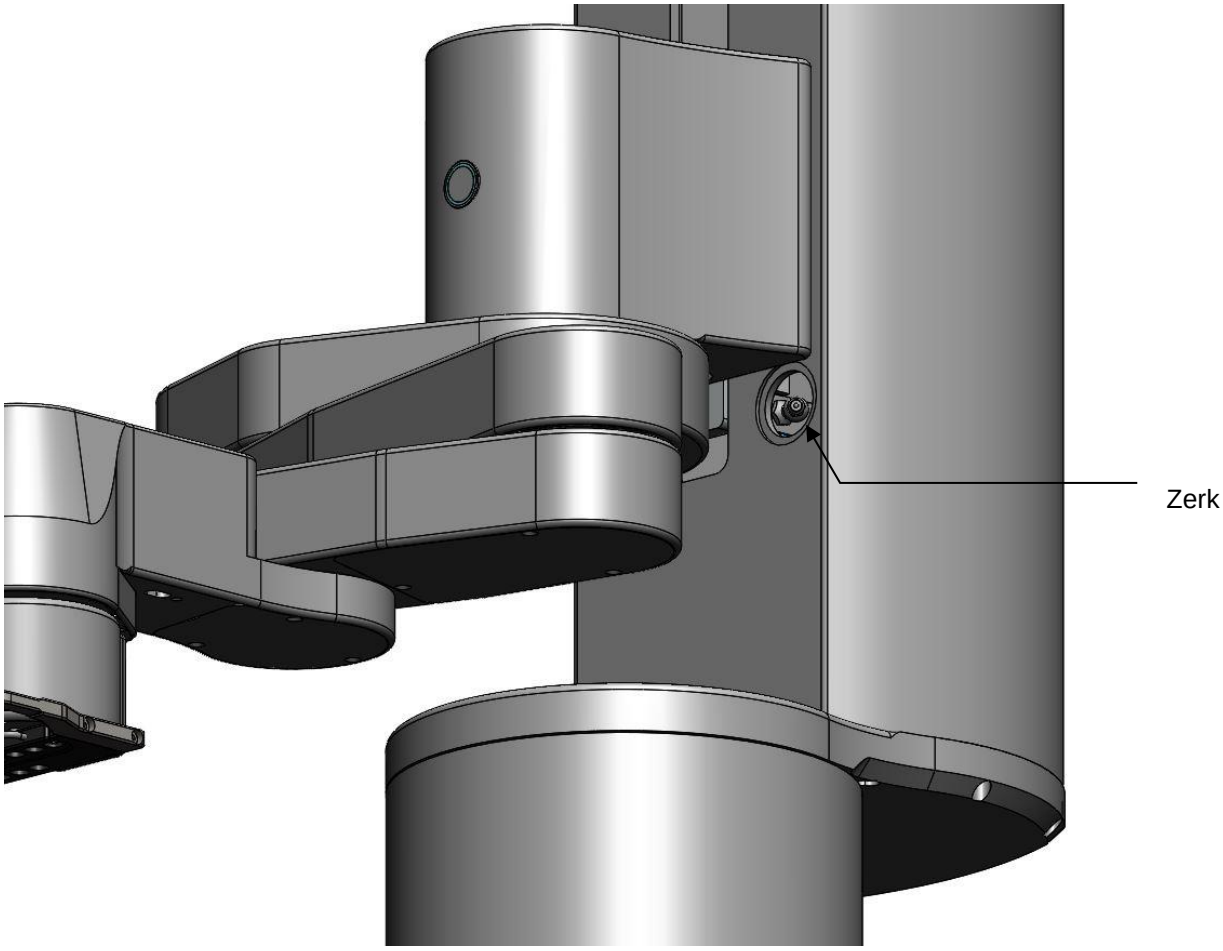
16.1.8 Use Castrol Tribol GR 100-2 PD grease (14-oz. cartridge is part number 157C88-14OZ).

16.1.9 Grease the Z Axis arm support bearing, as follows:

- Raise the Z Axis to the top of its travel
- Pop the round black plastic cap out of the access hole on the front of the Z housing. Insert a finger past the drive belt and push outward on the back of the cap.



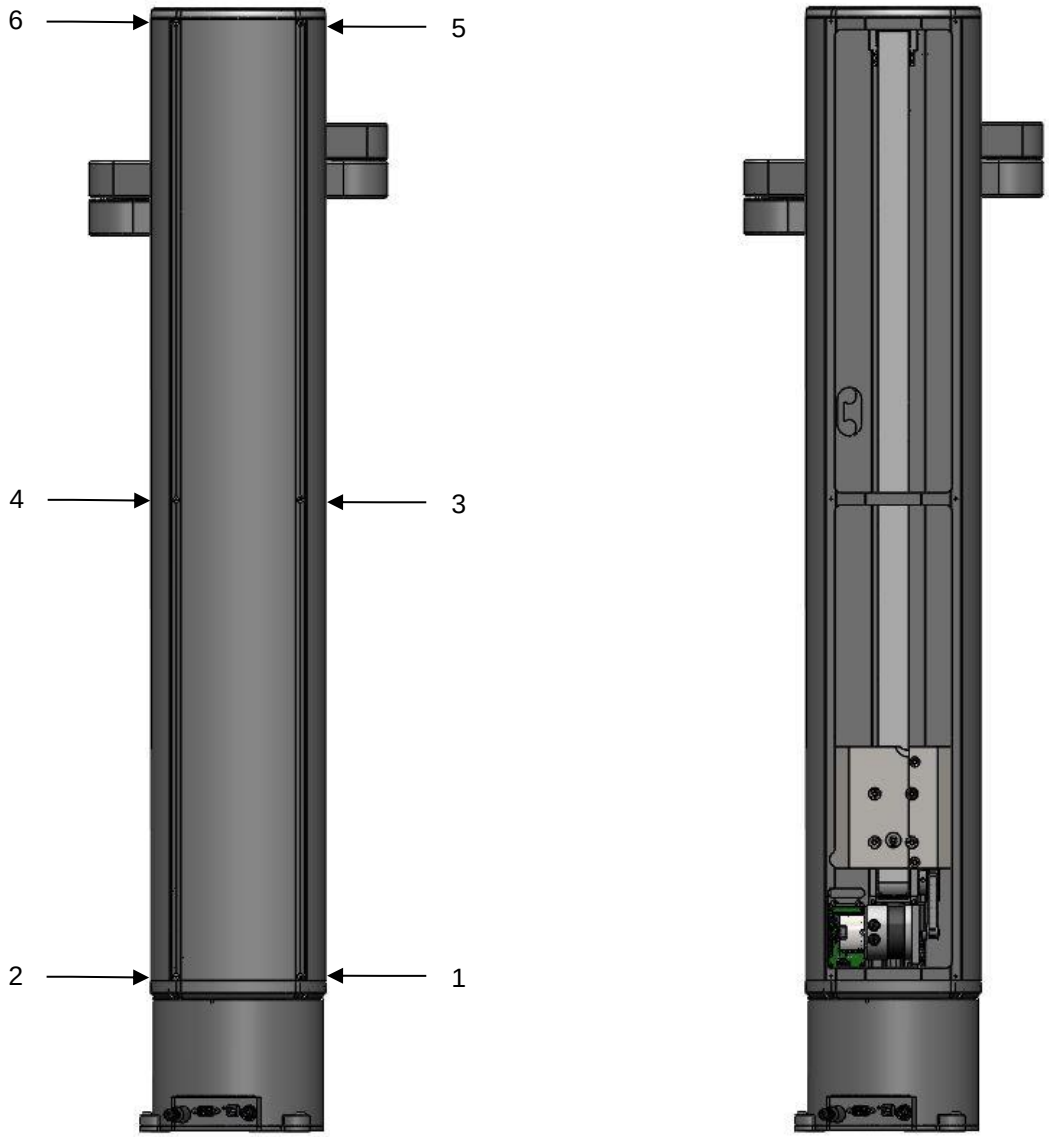
- Lower the Z Axis to the bottom of its travel. Extend the arm part way so that it doesn't block the access hole.



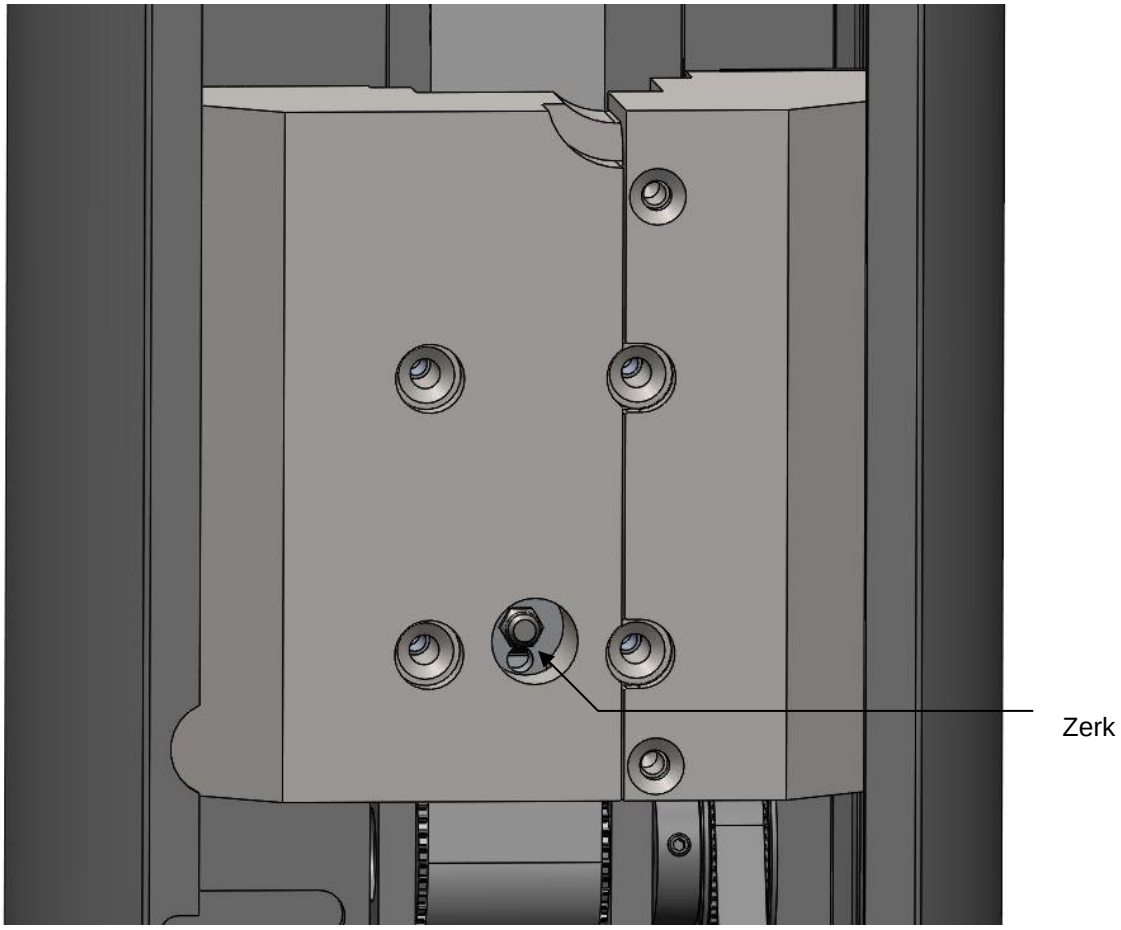
- Attach the grease pump to the zerk. The arm support bearing needs 1.4 cubic centimeters (0.05oz) of grease added to it at each maintenance interval. The GreaseTek gun shown above pumps a volume of 0.025oz per pump, so two full pumps of the handle will deliver the correct volume. Pump in half of the grease, then move the Z Axis through its full range of travel once before pumping in the second half of the grease. Do not pump more grease than is required, as excess grease will escape past the bearing seals and will make a mess.
- Reinstall the access hole cap.

16.1.10 Grease the Z Axis counterweight support bearing, as follows:

- Remove the six M3x6 SHCS screws from the large cover on the back of the Z Axis. Remove the two top screws last. This will help support the cover while the screws are being removed. Remove the cover and set on a soft surface.



- The counterweight support bearing grease zerk is accessed via a hole in the counterweight.



- Attach the grease pump to the zerk. The counterweight support bearing needs 0.4 cubic centimeters (0.014oz) of grease added to it at each maintenance interval. The GreaseTek gun shown above pumps a volume of 0.025oz per pump, so approximately half a pump of the handle will deliver the correct volume. Do not pump more grease than is required, as excess grease will escape past the bearing seals and will make a mess.

16.1.11 After both bearing blocks have been greased, move the Z axis slowly through its full range of travel a few times to distribute the grease within the bearing blocks.

16.1.12 Once the Z bearing has been greased, open the Teach Pendant, reset the robot, and double-click on the 'Maintenance Performed' box to set it to 'True'. Close the Teach Pendant to save the setting to the robot.

16.2 Emergency Stop Maintenance

16.2.1 To maintain the rated safety level of the emergency stop function, the user shall perform a diagnostic test periodically, as follows:

1) With the emergency stop button popped up in its normal position, the Drive Status LED located on the Shoulder connector panel must be green.

2) The emergency stop button should then be pressed down, and the Drive Status LED must transition to red.

3) The emergency stop button should then be popped back up, and the Drive Status LED must transition back to green.

16.2.2 For SIL 2 the diagnostic test must be performed at least once per year.

16.2.3 For SIL 3 the diagnostic test must be performed at least once every 24 hours.

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Revision History

Revision	Date	Line	Description
1	1/28/2020	All	Initial Release
2	7/27/2020	5.1	Robot shipped with both Side-Grip & Top-Grip fingers
		8.5-6	Instructions for scanning a stack with Top-Grip fingers
3	3/3/2021	10.5.1	Added folder names in addition to file names