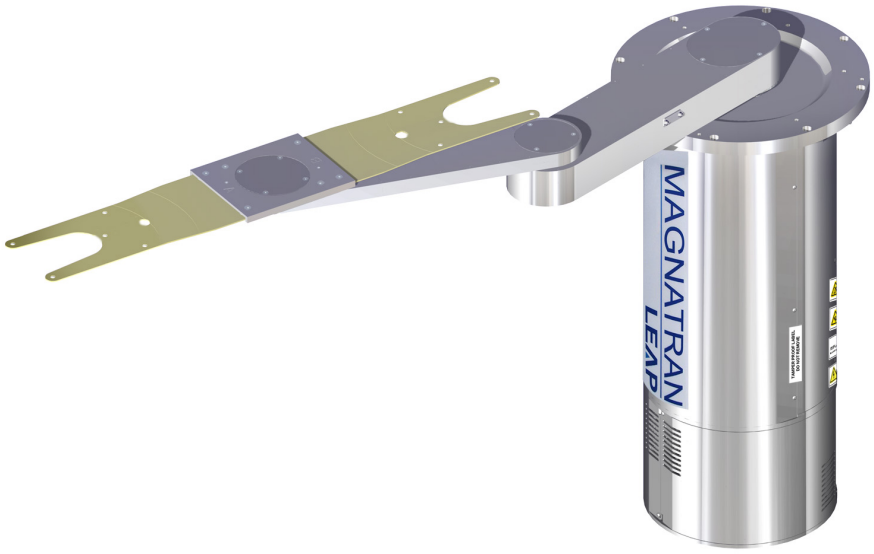


MagnaTran® LEAP™

User Manual

Part Number: 605563 Revision A

Brooks Automation, Inc.

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1. Safety

DANGER

Read the Safety Chapter

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

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



Authorized Personnel Only

The MagnaTran LEAP is intended for use by trained and experienced semiconductor fabrication plant personnel. Operators are advised to comply with applicable organizational standard operating procedures, industry standard guidelines, and all local, regional, national, and international laws and regulations.

Explanation of Hazard Alerts

This manual and this product use industry standard hazard alerts to notify the user about personal or equipment safety hazards. Hazard alerts contain Safety Text, Safety Icons, Signal Words, and Color.

Safety Text

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

- Identify the type and source of the hazard.
- State the severity of the consequences if the hazard is not avoided.
- State how to avoid the hazard.

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Safety Icons

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

Signal Words and Colors

Signal Words inform of the level of hazard.

	Danger indicates a hazardous situation which, if not avoided, **WILL RESULT IN DEATH OR SERIOUS INJURY**. Danger signal word is white on a red background with an iconic exclamation point inside a yellow triangle with a black border.
	Warning indicates a hazardous situation which, if not avoided, **COULD RESULT IN DEATH OR SERIOUS INJURY**. Warning signal word is black on an orange background with an iconic exclamation point inside a yellow triangle with black border.
	Caution indicates a hazardous situation or unsafe practice which, if not avoided, **MAY RESULT IN MINOR OR MODERATE PERSONAL INJURY**. Caution signal word is black on a yellow background with an iconic exclamation point inside a yellow triangle with black border.
	Notice indicates a situation or unsafe practice which, if not avoided, **MAY RESULT IN EQUIPMENT DAMAGE**. Notice signal word is white on blue background with no icon.

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Alert Example

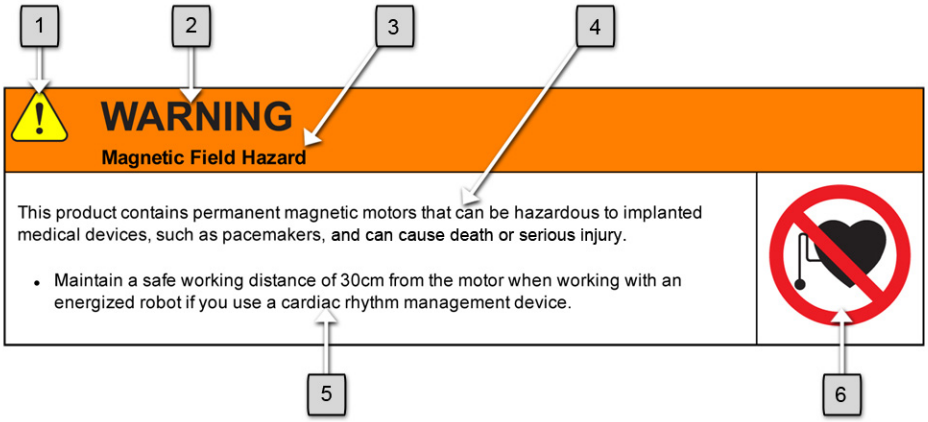


Figure 1-1: Components of a Safety Alert

Table 1-1: Components of a Safety Alert - Description

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

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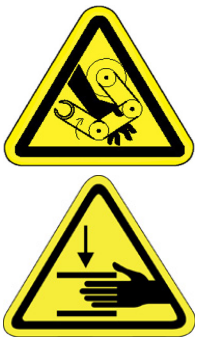
General Safety Considerations

WARNING

Software

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

- Only operate the robot with covers installed.
- Use physical barriers to prevent human access to the robot path during all powered operation where the arms are not contained in a chamber that prevents human contact.
- Ensure safety controller features are in place (ex: emergency stop, protective stops, etc.)
- Regularly test safety components to ensure they function correctly.



WARNING

Pinch Points

If the servo system fails, the maximum torque could be momentarily applied. Significant power levels are present that may cause death, serious injury, or equipment damage.

- Use physical barriers to prevent human access to the robot path during all powered operation where the arms are not contained in a chamber that prevents human contact.
- Operate the robot only with covers installed.



WARNING

Robot Mounting

The robot must be mounted in a rigid test stand or system application before applying power. Improperly mounted robots can cause excessive vibration and uncontrolled robot movement which may cause death or serious injury.

- Always mount the robot in a secure test stand or system before applying power.



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WARNING

Decontamination Chemical Hazard

The robot may be used in equipment that is exposed to chemical hazards. When removing the robot from the equipment for transport, refurbishing, disposal, etc., users can be exposed to chemicals that may result in death or serious injury.

- Decontaminate the robot per applicable regulations when removing the robot from system/equipment.
- Read and understand the safety information for the equipment where the robot is used.
- Know the location of the Safety Data Sheets (SDS) in your facility (formerly referred to as Material Safety Data Sheets - MSDS)
- Become familiar with the proper handling of material in the environment of the robot.



WARNING

Do Not Use Unauthorized Parts

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

- Do not use unauthorized parts.
- Confirm that the correct robot application is being used.
- Always have Brooks Automation update the robot application if new parts are changed or added to the robot.



WARNING

Legacy Teach Pendants

Legacy Teach Pendants do not comply with the ISO 10218-1 standard because they do not have a liveman switch.

- Brooks recommends using liveman teach pendants when working on any robot or system.
- Never enter the robot workspace when operating the robot with a legacy teach pendant.



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WARNING

Magnetic Field Hazard

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

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



WARNING

Reduced Speed

Implementation of reduced speed during teach or manual modes is not safety-rated. Always use a liveman teach pendant when operating inside the robot workspace.



CAUTION

Personal Protective Equipment

This product contains heavy objects that may cause personal injury.

- Use safety shoes and head protection when installing or maintaining the product.
- Wear protective eyewear when setting up or testing the system.



CAUTION

Unauthorized Service

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

- Only qualified personnel are allowed to transport, assemble, operate, or maintain the Product.
- Properly qualified personnel are those who have received certified training and have the proper qualifications for their jobs.



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CAUTION

Damaged Components

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

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



CAUTION

Trip Hazard

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

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



CAUTION

Inappropriate Use

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

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



CAUTION

Seismic Restraint

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

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



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NOTICE

Emergency Off Required

This product is not provided with an Emergency Off (EMO) device. The user is accountable for the EMO circuit.

NOTICE

Never Remove Robot Covers

Never remove covers from the robot drive. Removing covers from the robot drive adds new hazards not present when the covers are properly in place.

Removing covers triggers a tamper detect that disables power to the robot motors. Re-installation of the covers does not reset the tamper detect. Contact Brooks technical support for recovery of motor power

NOTICE

Never Remove External Controller Covers

Never remove covers from the external controller. Removing covers from the external controller adds new hazards not present when the covers are properly in place.

Removing covers triggers a tamper detect that disables power to the robot motors. Re-installation of the covers does not reset the tamper detect. Contact Brooks technical support for recovery of motor power.

NOTICE

Never Remove Arm Covers

Never remove the arm covers. Arm Covers are structural elements of the arm.

NOTICE

Intended Use

The MagnaTran LEAP robot is intended to be used for wafer handling in semiconductor fabrication processes inside a vacuum chamber. It is not intended to be used in automatic mode without an enclosure.

Because of its design as a vacuum robot, the MagnaTran LEAP robot is not intended to be used as a collaborative robot. The MagnaTran LEAP is not designed for synchronized motion with other robots.

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Illustration of Hazard Locations

A pinch point is any location on the MagnaTran LEAP between two moving parts or a moving part and a stationary part, where a person's body part may become caught or trapped and result in injury.

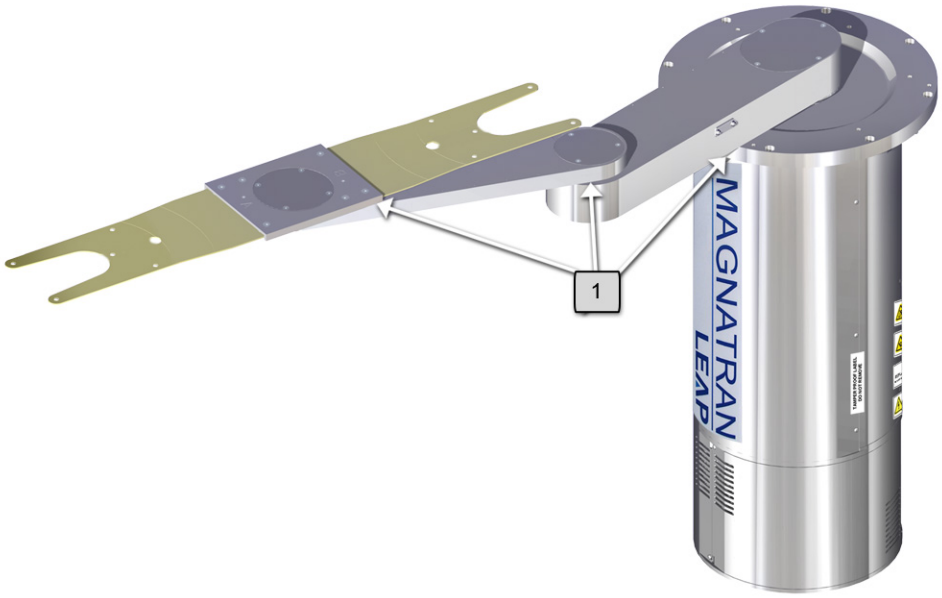


Figure 1-2: Locations of Pinch Points on the MagnaTran LEAP with Dual Pan SCARA Armset

1	Pinch point general location

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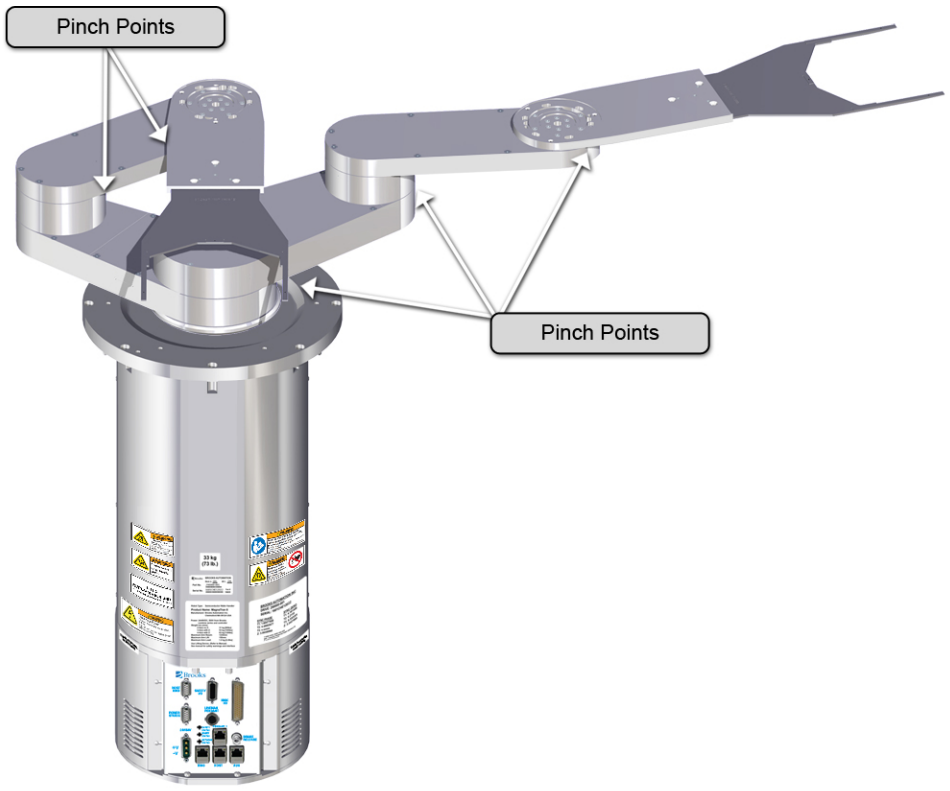


Figure 1-3: Locations of typical Pinch Points on the MagnaTran LEAP with Radius armset

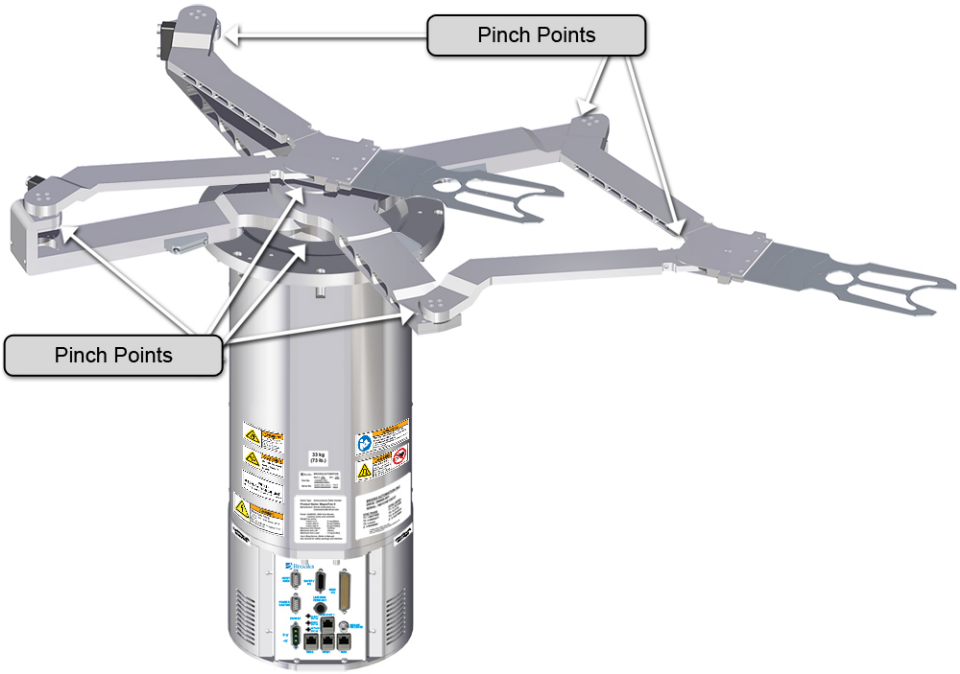


Figure 1-4: Locations of typical Pinch Points on the MagnaTran LEAP with LeapFrog armset

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CAUTION

Pinch Point

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

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

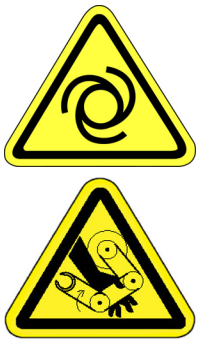


WARNING

Automatic Movement

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

- Know the product's range of motion and stay out of the product's range of motion when the product is energized.
- Place physical barriers to prohibit others from entering the working range of the product.
- Follow safe practices for working with energized products per the facility requirements.
- Do not rely on the system software or process technology to prevent unexpected product motion.



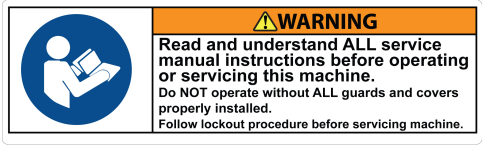
Safety Alert and Informational Labels

Table 1-2 lists the labels that are placed on the robot drive and external controller to alert personnel to hazards on or within the equipment, and to provide information. Figure 1-5 shows the approximate location of each label on the drive. Figure 1-6 shows the location of each label on the external controller. To replace a lost or damaged label, contact Brooks Automation Technical Support.

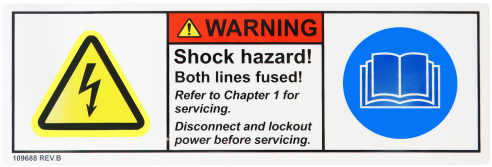
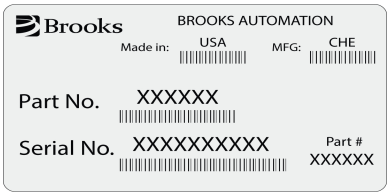
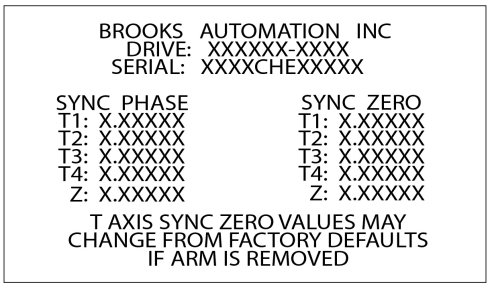
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Labels on the MagnaTran LEAP

Table 1-2: Labels Attached to the Robot Drive

	LABEL,WARNING,HEAVY OBJECT,2.75X1.35,RC6 WARNING - Heavy Object P/N 145749 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel Possible injuries: Muscle strain or back injury How to avoid the Hazard: Use lift aid and proper lift techniques.
	LABEL,PINCH,HAZARD,HANDS,2.75 X 1.35 WARNING - Crush hazard P/N 130189 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel Possible injuries: Crushed and cut hands How to avoid the Hazard: Keep hands away from robot while in operation.
	LABEL,WARNING - HAZARDOUS VOLTAGE,2.75X1.35,POLY WARNING- Hazardous Voltage P/N 106957 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel Possible injuries: Electric shock or burn. How to avoid the Hazard: Disconnect and lockout power before servicing.
	LABEL,WARNING,MAGNETIC FIELD,PACEMAKER WARNING - Magnetic Field P/N 211452 Qty: 1 Location: • K Drive - On front panel • All other robot drives - Near I/O panel How to avoid the Hazard: Pacemaker wearers stay back 30 cm (12 in).
	LABEL,WARNING,READ MANUAL Warning - Read Manual P/N 211451 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel How to avoid the Hazard: Read all applicable robot manuals.

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	LABEL,WARNING,BOTH LINES FUSED,SHOCK HAZARD,RC6 Warning - Shock Hazard P/N 109688 Qty: 1 Location: On top cover of LEAP external controller How to avoid the Hazard: Disconnect and lockout power before servicing.
	LABEL,WARNING,HAZARDOUS VOLTAGE,ANSI/ISO,RC6 Warning - Hazardous Voltage P/N 129706 Qty: 1 Location: On top cover of LEAP external controller How to avoid the Hazard: Disconnect and lockout power before servicing.
	LABEL,FRU,2.75" X 1.35" Field Replaceable Unit label P/N 130165 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel This label indicates that there are no serviceable parts inside the robot.
	LABEL,ENCODER,TAMPER PROOF,2.1X.59 Tamper Proof Encoder Seal P/N 121891 Qty: Varies by robot Location: Across removable covers (varies by robot) Do not tamper with the seal. Robot operation and performance will be affected if the covers are removed.
	LABEL,STANDARD SERIAL NUMBER Serial Number Label P/N 196635 Qty: 2 Location: • K Drive - On front panel • All other robot drives- Near I/O panel • LEAP External controller - On front panel
	Robot Calibration Label P/N: 255839 Qty: 1 Location: • K Drive - On front panel • All other robot drives - Near I/O panel

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Manufacturer: Brooks Automation Inc. Chelmsford MA USA Robot Type: Semiconductor Wafer Handler Product Name: MagnaTran® LEAP™ Compact Maximum Mass with Arm: 50 kg Maximum Arm Reach: 1.5 m Maximum Arm lift: 150mm Maximum Arm Load: 1.0 kg Rated Voltage: 24 VDC +/- 1 V Full Load Current: 30 A, SCCR: 40 A Nominal Power: 0.5 kW Use lifting device, see manual Label # 341982	(2,3,4-axis C-Series Version Example) Robot Specifications Label P/N: Varies (See the bottom right corner of the label on the drive for the accurate part number) Qty: 1 Location: Above the I/O panel
Manufacturer: Brooks Automation Inc. Chelmsford MA USA Robot Type: Semiconductor Wafer Handler Product Name: MagnaTran® LEAP™ M-Series Maximum Mass with Arm: 100 kg Maximum Arm Reach: 2.0 m Maximum Arm lift: 150mm Maximum Arm Load: 1.0 kg Rated Voltage: 48 VDC +/- 1 V Full Load Current: 30 A, SCCR: 40 A Nominal Power: 0.5 kW Use Lifting Device, see manual Label # 344745	(4-axis M-Series Version Example) Robot Specifications Label P/N: Varies (See the bottom right corner of the label on the drive for the accurate part number) Qty: 1 Location: Above the I/O panel
Manufacturer: Brooks Automation Inc. Chelmsford MA USA Robot Type: Semiconductor Wafer Handler Product Name: MagnaTran LEAP OPTIMAX Maximum Mass with Arm: 250 kg Maximum Arm Reach: 2.3 m Maximum Arm lift: 160 mm Maximum Arm Load: 1.0 kg Rated Voltage: 48 VDC +/- 1 V Full Load Current: 16 A MAX Nominal Power: 0.77 kW Use Lifting Device, see manual Label # 369485	(6-axis LEAP OPTIMAX Version Example) Robot Specifications Label P/N: Varies (See the bottom right corner of the label on the drive for the accurate part number) Location: • K Drive - On front panel • H Drive- Above the I/O panel.

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Manufacturer: Brooks Automation Inc. Chelmsford MA USA Robot Type: Semiconductor Wafer Handler Product Name: MagnaTran® LEAP™ Compact Maximum Mass with Arm: 50 kg Maximum Arm Reach: 1.5 m Maximum Arm lift: 150mm Maximum Arm Load: 1.0 kg Use lifting device, see manual Label # 376679	(Drive with External Controller Version) Robot Specifications Label P/N: 376679 Location: Above the I/O Panel
Manufacturer: Brooks Automation Inc. Chelmsford MA USA Voltage: 100–240 VAC Freq: 50 / 60 Hz Phase: 1 Phase Current: 10A Fuse: Fast Blow 10 A 250 VAC Weight: 12 kg Largest Motor Current: 10A peak SCCR: 5000 amperes	LEAP External Controller Specifications Label P/N: 376681 Location: Top controller cover
WARNING: This product can expose you to chemicals including Lead, which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov. 310730-0001 Rev. B	LABEL,CA PROP 65,LEAD,2 HAZ CA Prop 65 Label P/N 310730-0001 Qty: 1 Location: • K Drive - On front panel • All other robot drives- Near I/O panel

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Approximate Location of Labels on the MagnaTran LEAP

NOTE: The number of labels applied and their relation to the I/O panel may vary by robot.

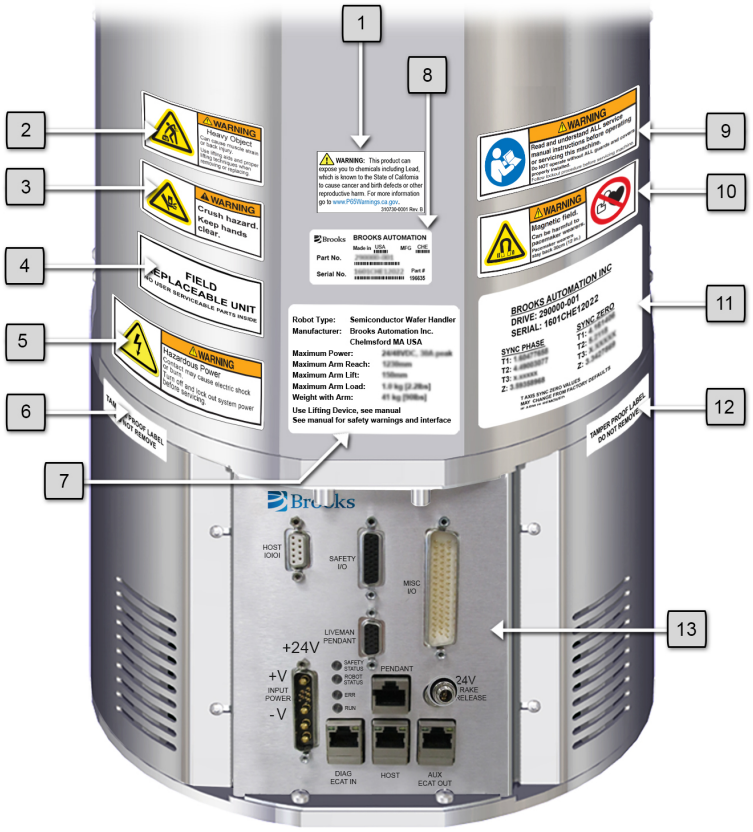


Figure 1-5: Labels on the Outside of the MagnaTran LEAP

Table 1-3: Labels on the Outside of the MagnaTran LEAP - Explanation

Number	Explanation	Number	Explanation
1	CA Prop 65 Label	8	Serial Number Label
2	Heavy Object Warning	9	Read Manual Warning
3	Crush Hazard Warning	10	Magnetic Field Warning
4	Field Replaceable Unit Label	11	Robot Calibration Label
5	Hazardous Power Warning	12	Tamper Proof Seal
6	Tamper Proof Seal	13	I/O Panel Label
7	Specifications Label		

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Location of Labels on the MagnaTran LEAP External Controller

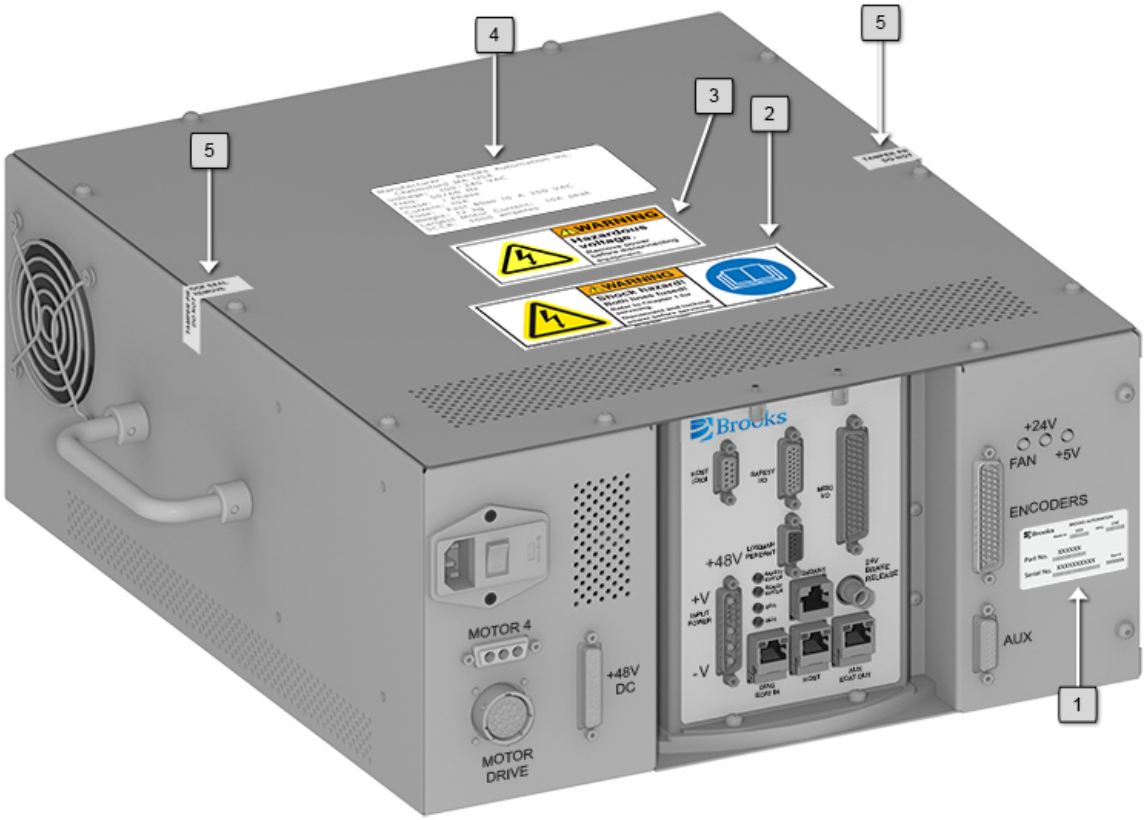


Figure 1-6: Labels on the Outside of the MagnaTran LEAP External Controller

Table 1-4: Labels on the Outside of the MagnaTran LEAP External Controller - Explanation

Number	Explanation	Number	Explanation
1	Serial Number Label	4	Specifications Label
2	Shock Hazard Label	5	Tamper Proof Seal
3	Hazardous Voltage Label		

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Safety Interlocks and Disconnect Devices

The LEAP controller contains an embedded safety controller for convenient attachment of emergency stop switches, protective interlocks and mode selection. Outputs of the embedded safety controller are designed to interface with a higher level (system) safety controller. It is the responsibility of the system integrator to locate and install safety switches to protect the user.

Disconnect Devices

The facility/robot integrator is responsible for the robot's main disconnect device and for ensuring it complies with the correct electric codes.

Personnel servicing this equipment are responsible for the status of the robot's main disconnect device as specified on the facilities' Lockout/Tagout procedure.

WARNING

Emergency Off (EMO)

This device is not equipped with an EMO disconnect device. Using this product without an Emergency Off (EMO) circuit may cause death or personal injury.

- The integrator and user are responsible for installation of the EMO disconnect device that complies with the mandated safety codes.
- Personnel servicing this product are responsible for disconnecting power as specified by the facility Lockout/Tagout procedures.



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Lockout/Tagout

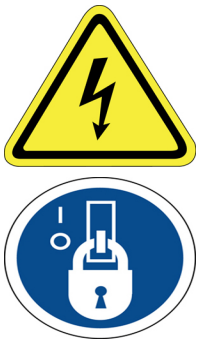
It is the responsibility of the tool owner to create a Lockout/Tagout procedure that ensures safety to personnel and equipment.

WARNING

Lockout / Tagout

Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury.

- All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.



Interlocks

Safety Interlocks

The MagnaTran LEAP robot contains an embedded safety rated controller. Safety interlocks are mandated by regulatory standards ISO 60204-1, ISO10218-1 for moving machinery and robots.

NOTICE

As stated by ISO/TR 24119, it is possible for multiple interlocking devices connected serially to mask faults in the interlocking system. The fault masking probability is a function of the number of movable guards and their frequency of use. Consult ISO/TR 24119 for guidance when designing an interlocking system connected to the MagnaTran LEAP robot.

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Table 1-5: Safety Interlocks

Type	Connector Location	Type/Name	Safety Rated	Required by Standards
Safety Controller	Safety I/O	Emergency Stop	Yes	Yes
		Protective Stop	Yes	Yes
		Mode Inputs	Yes	Yes
Legacy	MISC I/O	Tool Interlock	No	Advised
Software	None	Assignable	No	Advised

The legacy interlocks are presented in the section on the MISC I/O interface.

The term “Safety Rated Controller” is a subset of the overall robot motion controller. The function of the Safety Rated Controller is limited to enabling and removing power to the motors. If an interlock is opened during robot motion, a controlled stop is executed followed by removal of motor power.

The safety rated controller embedded in the MagnaTran LEAP robot will only apply power to the robot motors if all the interlocks on the Safety Controller the MISC I/O interface are satisfied, and then only upon issuing an action command.

The term “legacy” is used to signify a design carried over from the MagnaTran 7 and MagnaTran 8 robot families. The Embedded Safety Controller should be fully implemented in all new vacuum systems. If the MagnaTran LEAP is being put into an existing vacuum system that already has adequate safety that meets the required standards, the Embedded Safety Controller can be muted by a simple muting plug on the Safety IO connector.

The MISC I/O interlock provides only single conductor protection and should not be relied upon for human safety.

Software interlocks, if employed, are not safety rated and should never be relied upon for human safety. Only the firmware resident in the safety controller is safety rated.

WARNING

Safety Interlocks

Overriding the safety interlocks could cause personal injury or death.

- Always use the safety interlocks.



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Over Temperature Interlock

Each robot motor is equipped with a thermal sensor. If motor temperature approaches a design limit, it will first transmit a warning to the host controller. If the motor temperature ultimately exceeds the design limit, a controlled stop will be automatically executed and motor power will be removed. A message is sent to the host indicating an over-temperature event.

WARNING

Interlock Override

Overriding interlocks may cause death or serious injury.

- Do not override interlocks.
- Become familiar with the interlocks and their function.



Table 1-6: Operational Interlocks

Interlock	Type	Function
Customer wired EMO	Customer Provided	Customer provided per requirements of the facility where the MagnaTran LEAP robot is installed.
Customer wired E-Stop	Customer Provided	E-Stop circuit provided on the Safety I/O connector on the robot I/O panel.
High Voltage Interlock	Lockout/Tagout	Ensures the primary circuit breakers are OFF in order to remove the high voltage box covers when accessing the interior of the high voltage assembly.

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Emergency Stop Circuit (E-Stop)

An Emergency Stop Switch must be provided by the integrator of the robot. For more information on the Emergency Stop Circuit, please see "Embedded Safety Controller" on page 147.

Stopping time and distance is a function of the armset configuration, load, end-effector weight, robot mode, and velocity of the arm at the moment the E-stop is activated. Because of the variability on loads and configurations, this manual does not cite specific stopping times or distances. Brooks Automation recommends testing the robot with the intended armset configuration, load, end-effector(s), robot mode, and velocity if stopping time and distance is critical for an application.

WARNING

Emergency Stop Circuit

Using this product without an emergency stop circuit may cause death or personal harm.

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



NOTICE

Brooks requests placing cables for the E-stop and/or liveman in conduit or flexible metal cabling.

Safety System

For more information on the MagnaTran LEAP Safety System, please see "Embedded Safety Controller" on page 147.

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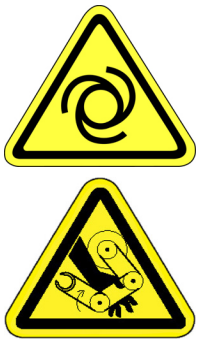
Mechanical Hazards

WARNING

Automatic Movement

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

- Know the product's range of motion and stay out of the product's range of motion when the product is energized.
- Place physical barriers to prohibit others from entering the working range of the product.
- Follow safe practices for working with energized products per the facility requirements.
- Do not rely on the system software or process technology to prevent unexpected product motion.

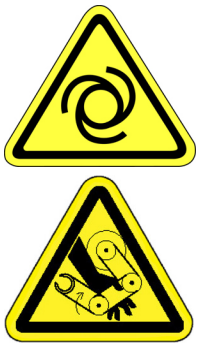


WARNING

Unplanned Robot Motion

Motion software and electrical drives are not not provided by Brooks Automation. The robot integrator must take action to protect themselves and others from unplanned or faulty automatic robot motion which may cause death or serious injury.

- Be aware that unplanned robot motion may occur.
- Know and stay out of the robot’s range of motion.
- Place physical barriers to prohibit others from entering the working range of the robot.
- Follow safe practices for working with energized robots.
- Do not rely on the system software or processor technology to prevent unexpected robot motion



CAUTION

Tipover Hazard

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

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



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CAUTION

Trip Hazard

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

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



Electrical Hazard

The robot is a hazardous low voltage device. Power between the controller and the robot is 48VDC or 24VDC. Power supplies converting facility power may be operating at higher levels of AC in close proximity to the robot.

WARNING

Electrical Burn

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

- Maximum power consumption for the robot is +48VDC at 20 Amps and 1000 Watts.
- Always provide the robot with the proper power supply connectors, and ground that are compliant with appropriate electrical codes.



WARNING

Electrical Fire Hazard

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

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



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NOTICE

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

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

Ergonomic Hazard

Robot

CAUTION

Heavy Lift Hazard

The weight of the product is between 23 kg (50 lbs) and 251.2 kg (554 lbs), depending on the configuration

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

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



Depending on the configuration, the 4-axis version of the MagnaTran LEAP can weigh up to 68 kg (150 lbs) without shipping fixtures, whereas the 6-axis version can have a maximum weight of 251.2 kg (554 lb) without shipping fixtures.

Brooks Automation recommends using lifting devices rated for lifting 1000 lb (450 kg) or more when lifting the MagnaTran LEAP.

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Lift Points

Brooks Automation recommends different ways of lifting the robot depending on the mounting flange and if the arm is attached.

- Arm is not attached to drive: Overhead lifting device via eyebolts or lift fixture attached to the flange (dependent on drive type).
- Arm is attached to drive: Overhead lifting device via a lifting fixture installed onto the flange (fixture dependent on arm and drive type).
- Bottom mount flange - Scissor Lift Table.

The recommended lift points of the MagnaTran LEAP robot are shown below in Figure 1-7, Figure 1-8, Figure 1-9, and Figure 1-10.

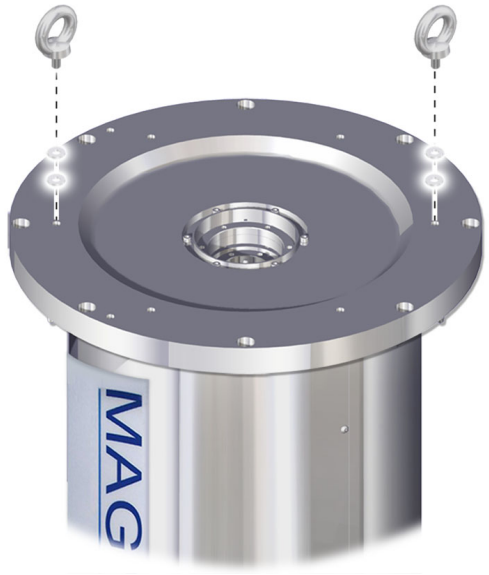


Figure 1-7: Eyebolt Lift Points for MagnaTran LEAP without Arm Attached

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Figure 1-8: Lift Fixture and Lift Point for X-Large MagnaTran LEAP without Arm Attached



Figure 1-9: MagnaTran LEAP with Arm and Lifting Fixture Attached with Lifting Device

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Figure 1-10: Cart Lift for Bottom Mount MagnaTran LEAP

Teach Pendant

The Teach Pendant does not pose any ergonomic hazards.

Environmental Hazards

Noise Emission

The robot provides no direct noise hazard during operation. The robot produces a noise level that is less than 80 dB during normal operation.

Vibration

The robot provides no direct vibration hazard during normal operation. Any vibrations produced during normal operation are minimal and cause no hazardous conditions.

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CAUTION

Vibration Hazard

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

Contact Brooks Automation for Technical Support .

- Before energizing, ensure the robot is bolted to a rigid metal chamber or stand.
- Ensure the robot is configured with the correct arm application.
- Ensure arm state is correct (Arms ON / Arms OFF) .
- Ensure the arm style matches the configuration .



Recycling and Hazardous Materials

Lubricants that are considered hazardous may be located in arm and drive bearings. If the armset or the drive is removed or replaced, it must be handled following all Federal, State, Local, and Facility's procedures for the disposal of hazardous materials.

Decommissioning and Disposal

WARNING

Corrosive and/or Toxic Materials

The robot in its intended use may be exposed to corrosive and/or toxic materials during its operation. Failure to properly decontaminate the robot or wear adequate personal protective equipment during its removal can expose personnel to toxic corrosive and/or toxic substances.

- Wear appropriate personal protective equipment when handling robots that have not been properly decontaminated.
- Ensure appropriate decontamination procedures are followed before handling the robot without personal protective equipment or placing the robot within reach of personnel that may be not be properly warned or protected such as shipping personnel.
- Do not dispose of the robot or its parts without having properly decontaminated it.



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

The obligation for disposal for the product and the components are passed to the end user for responsible disposal. No cost for disposal is included in the initial cost of the equipment.

For further information and assistance in disposal, please contact the Brooks Automation Service Department.

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Safety Data Sheets - SDS

NOTICE

Safety Data Sheets

The facility where this product is used is responsible for the maintenance and distribution of each Safety Data Sheet (SDS).

Hazardous materials may be present during the operation of the MagnaTran LEAP or during maintenance. Hazardous material distributors provide a Safety Data Sheet (SDS) for all materials they supply. The SDS provides information pertaining to the use of the hazardous material. Ensure that there is a copy in each workplace for all hazardous materials involved in the operation and maintenance of the robot.

Table 1-7 identifies the hazardous materials that may be present on or in the MagnaTran LEAP robot. Obtain the SDS for isopropyl alcohol and any other cleaning agents from the supplier.

A copy of the SDS for each hazardous material is included in Appendix D: "Safety Data Sheets" on page 216.

NOTE: Safety Data Sheets were previously known as Material Safety Data Sheets, usually abbreviated to MSDS.

Table 1-7: Hazardous Material Identification

Material	Use	Where Used
Krytox	Flourinated High Vacuum Grease	T1, T2, and optional T3, and T4 armsets
Bracote 803	Perflouraoether High Vacuum Grease	armset
NYE TORR 5200	Bearing Radial grease	T1, T2, and optional T3, and T4 bearings

Other Hazards

The Brooks Automation MagnaTran LEAP robot does not directly pose any of the following hazards:

- Laser Hazards
- Gas Hazards
- Chemical Hazards
- Thermal Hazards
- Vacuum Hazards

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WARNING

Other Hazards

The MagnaTran LEAP robot may be used in equipment that exposes users to hazards that may cause death or serious injury.

- Read and understand the safety information for the equipment where the robot is used.
- Know the location of the Safety Data Sheets.



Emergency Information

Fire Fighting Equipment

The MagnaTran LEAP robot does not impose special requirements on firefighting equipment. However, fire extinguishers for electrical fires are preferred due to its proximity to equipment that may function with voltages that may pose a hazard to fire fighting personnel. Final determination of the fire fighting equipment to be used shall be made by the end-user based on the processes and equipment with which the MagnaTran LEAP robot is used.

Robot Movement Without Drive Power

The MagnaTran LEAP robot is designed so that all axes, except for the Z-axis, are capable of being moved by a single-person without the use of drive power in emergency or abnormal situation. See "Emergency Z-Axis Brake Release Procedure" on the facing page for instructions on moving the Z-axis during emergency and/or abnormal situation.

CAUTION

Crush Hazard

Releasing the Z-axis brake causes the Z-axis to fall due to gravity which may crush extremities or fingers.

- Only properly trained personnel should perform the Z-axis Brake Release Procedure.
- Fully support the Z-axis during release to avoid additional hazards.
- Only perform the brake release for testing or emergencies.



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Emergency Z-Axis Brake Release Procedure

CAUTION

For Emergency Use Only

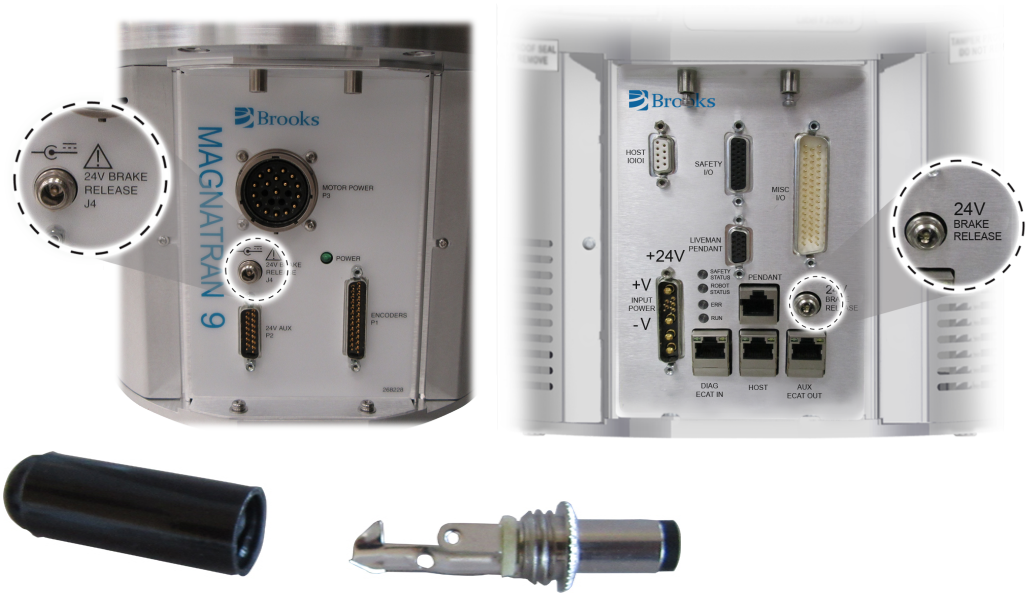
Entrapment by this product can cause serious injury to extremities. The Emergency Z-axis Brake Release procedure should only be used in emergencies. This procedure assumes the following:

- A dedicated 24V power supply with a compatible connector that is available to personnel for emergencies.



For more information on the Z-axis Brake, see "Z-Axis Brake Release" on page 74.

In the event that the Z-axis needs to be moved with power removed, perform the following steps:

Step	Action
1.	Support the robot arm so that it does not fall due to gravity when the Z-axis brake is released.
2.	Plug the user supplied Switchcraft 760 connected to a 24VDC power supply into the Brake Release connector on the robot I/O panel. 

Step	Action
3.	Turn on the Brake Release power supply. The Z-axis is now free to move.
4.	Remove the person or object that is trapped.
5.	Turn off the power to the emergency power supply and disconnect from the controller.

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2. Overview

The MagnaTran LEAP robot is a vacuum robot that can have 2 or more axes, intended to be used for semiconductor fabrication processes inside a vacuum chamber. There are many possible robot drive, arm, and end effector combinations. The MagnaTran LEAP robot is a drop-in replacement for both MagnaTran 7 and MagnaTran 8 robots.

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MagnaTran LEAP Components

The MagnaTran LEAP robots are made up of four sub-assemblies that are based on system application.

- Robot Drive
- Armset
- LEAP Controller/Passthrough I/O Panel
- End Effector

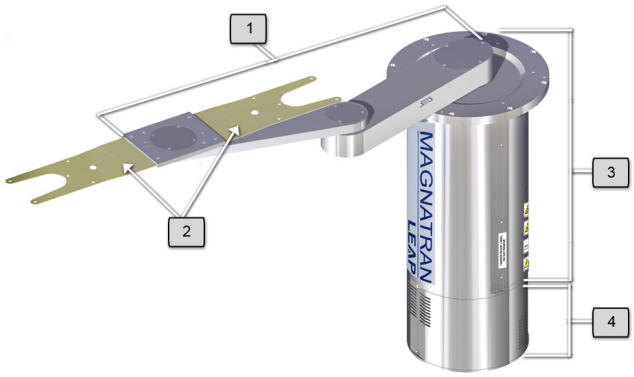


Figure 2-1: MagnaTran LEAP Robot with Dual Pan SCARA

Table 2-1: MagnaTran LEAP Robot with Dual Pan SCARA - Explanation

Number	Explanation
1	Armset
2	End Effectors
3	Robot Drive
4	I/O Panel

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Robot Drive Overview

The MagnaTran LEAP is a semiconductor wafer-handling robot designed to pick and place wafers in a vacuum environment. The drive is the portion of the robot that contains the robot controller, servo motors, vacuum interface, and a mechanical attachment to a vacuum transport chamber. In summary, the robot drive is the entire robot except the arms and a DC power source.

The MagnaTran LEAP robot is available in multiple configurations and sizes. The robots can be configured with two, three, or four radial/theta motors to support different arm styles and applications. The MagnaTran LEAP further supports multiple lengths of Z-axis travel.

Table 2-2: MagnaTran LEAP Sizes

Robot Size	Letter Designation	Theta Axes
Small	C	2-3
Medium	M	2-3
Large	P	3
Large	H	4
X-Large	K	4

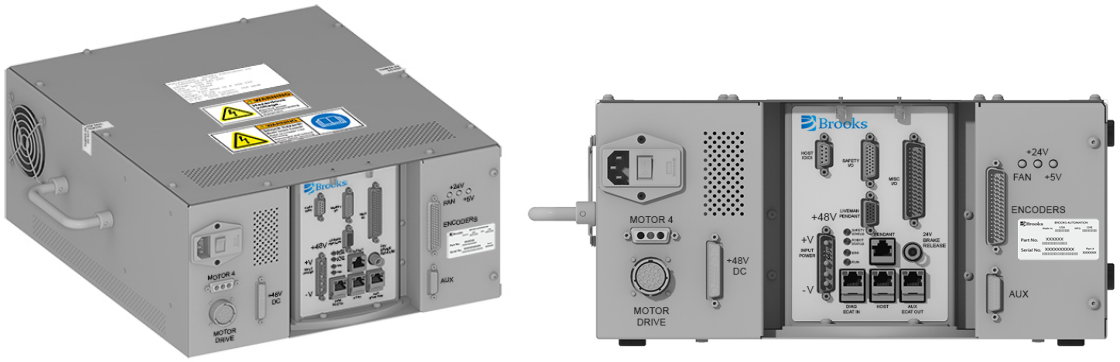


Figure 2-2: MagnaTran LEAP External Controller

Table 2-3: MagnaTran LEAP External Controller Dimensions

Length	Width	Height	Weight
16.00" (406.4 mm)	14.00" (355.6 mm)	6.26” (168.1 mm)	26.45 lbs (12.0 kg)

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The mechanical design and operation of the robot uses a minimum number of moving parts to ensure minimal maintenance requirements.

The robot is controlled by either a highly integrated and compact on-board controller that resides in the base of the robot drive or by an external controller that is independent from the robot. The controllers require only DC power and a communication connection to the host.The on-board controller provides power and communcation directly to the robot whereas the external contoller must be connected to the robot by a series of additional cables that provide power and communication. The controller receives high level commands from an external system host computer and the robot controller interprets and disassembles the command into smaller instructions.

The robot drive is powered by either 24VDC or 48VDC. The operating voltage is part of the robot configuration defined by Brooks Automation's factory settings. The power supply requirement is listed on the robot nameplate label. Never operate a 24V robot from 48V and never operate a 48V robot at 24VDC. For more information see "Power Supply" on page 69.

The [[[Undefined variable MyVariables.ProductName1]]] External Controller is designed for use with 48V robots and is powered by 85-264 VAC at 47-63 Hz.

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Flange and Drive Shaft Configurations

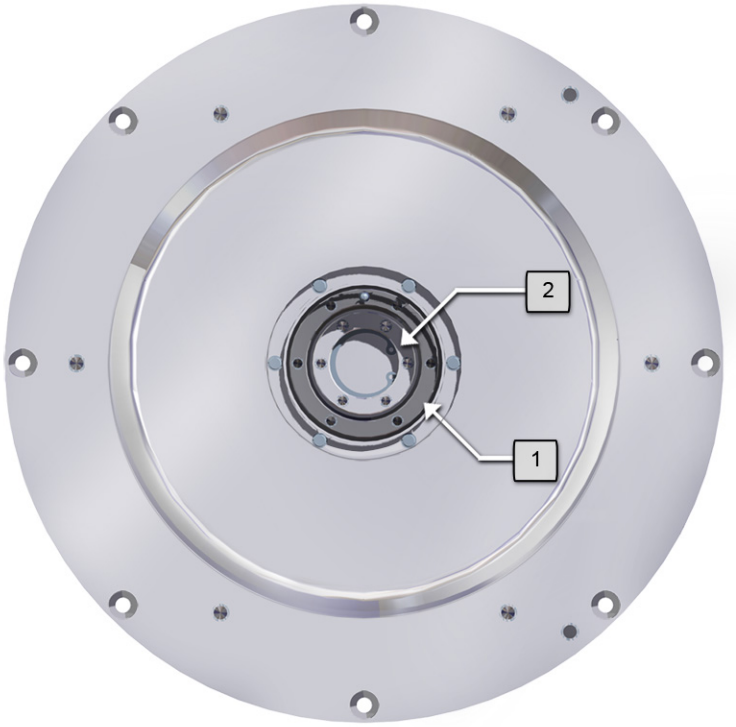


Figure 2-3: Top View of MagnaTran LEAP Two Theta Axis Drive

Table 2-4: Top View of MagnaTran LEAP Two Theta Axis Drive - Explanation

Number	Explanation
1	Theta 1 (T1)
2	Theta 2 (T2)

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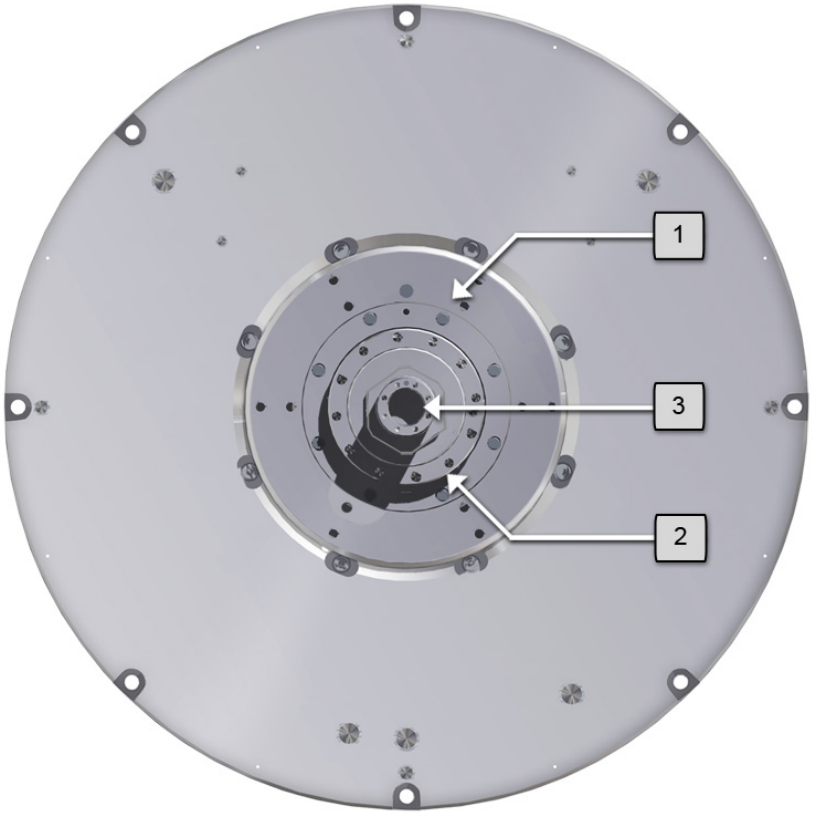


Figure 2-4: Top View of MagnaTran LEAP Three Theta Axis Drive

Table 2-5: Top View of MagnaTran LEAP Three Theta Axis Drive - Explanation

Number	Explanation
1	Theta 1 (T1)
2	Theta 2 (T2)
3	Theta 3 (T3)

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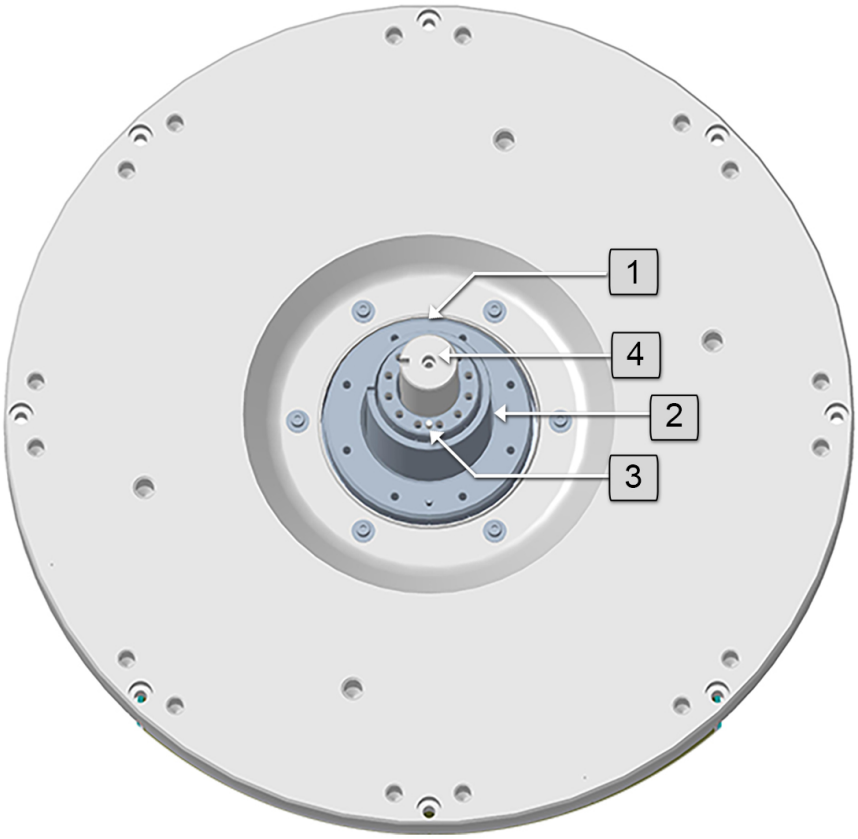


Figure 2-5: Top View of MagnaTran LEAP Four Theta Axis

Table 2-6: Top View of the MagnaTran LEAP Four Theta Axis - Explanation

Number	Explanation
1	Theta 1 (T1)
2	Theta 2 (T2)
3	Theta 3 (T3)
4	Theta 4 (T4)

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Armset Overview

Depending on the robot configuration, the armset is shipped mounted to the drive or as a separate unit. If shipped separately, the arms can be installed before or after the drive has been mounted into the robot central vacuum transport chamber, depending on the configuration.

Some armsets require the robot to be equipped with a Z-axis while some arms do not.

Robots containing two theta motors are considered coaxial drives, robots with three motors are labeled tri-axial drives, and robots with four theta motors are considered quadaxial drives.

All MagnaTran LEAP armsets consist of an upper arm, forearm, wrist, and end effector. In order to meet specific requirements, most end effectors are custom designed.

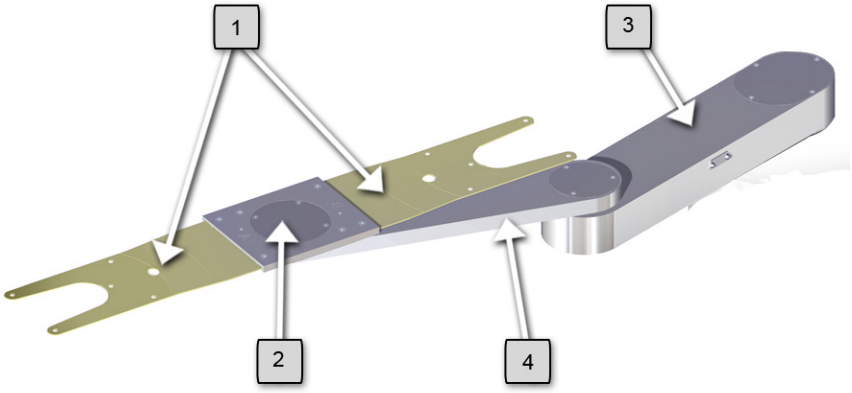


Figure 2-6: Parts of a Typical (Dual Pan) SCARA Armset

Table 2-7: Parts of a Typical (Dual Pan) SCARA Armset - Explanation

Number	Explanation
1	End Effectors
2	Wrist
3	Upper Arm
4	Forearm

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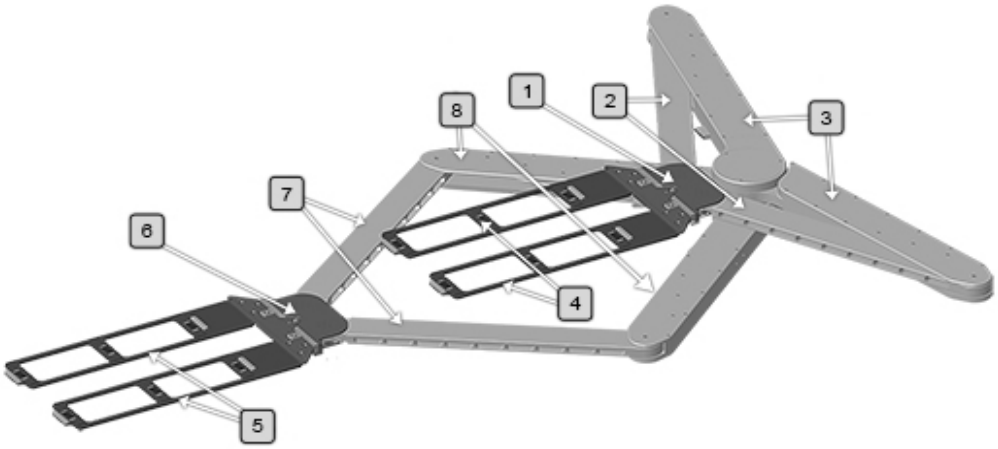


Figure 2-7: Parts of a Dual Independent Frogleg Armset

Table 2-8: Parts of a Dual Independent Frogleg Armset - Explanation

Number	Explanation
1	Wrist Plate, Arm A
2	Forearms, Arm A
3	Upper Arms, Arm A
4	End Effector, Arm A
5	End Effector, Arm B
6	Wrist Plate, Arm B
7	Forearms, Arm B
8	Upper Arms, Arm B

NOTE: Body, wrist, and end effector designs can vary between Frogleg Armset styles.

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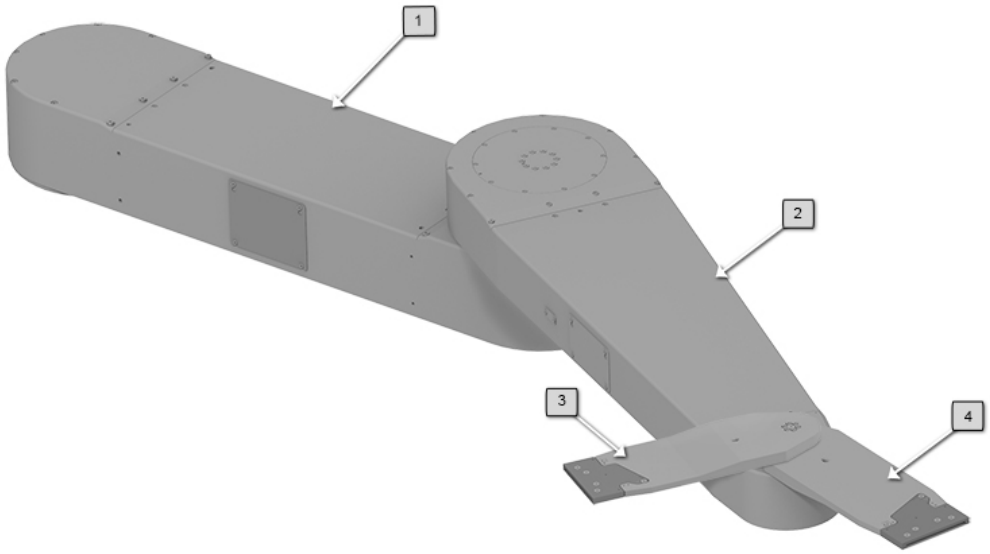


Figure 2-8: Parts of an OPTIMAX Armset

Table 2-9: Parts of a Typical (Dual Pan) SCARA Armset - Explanation

Number	Explanation
1	Upper Arm
2	Forearm
3	Wrist A
4	Wrist B

NOTE: The End Effectors are not shown in Figure 2-8 so that other parts of the armset are not obscured.

MagnaTran LEAP Software Controls Overview

MagnaTran LEAP Software Controls are the fully integrated software controls for the MagnaTran LEAP robot. MagnaTran LEAP software supports many of the same commands as the MagnaTran 7 and MagnaTran 8 WAVE II Controls.

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End Effectors

There are many different types of end effectors used with the MagnaTran LEAP. End effectors may be provided by Brooks, or can be customer supplied. Many different types of materials can be used to create end effectors. Always handle end effectors with care and verify flatness before use.

Field Replaceable Units (FRUs)

The MagnaTran LEAP system consists of sub components that may be replaced as Field Replaceable Units or FRUs.

There are four primary FRUs for MagnaTran LEAP robots:

- Drive
- Armset
- End effectors
- External controller

Contact Brooks Technical Support to determine the available FRUs for your system. For more information on contacting Brooks Technical Support, please see "Contact Brooks Automation Technical Support".

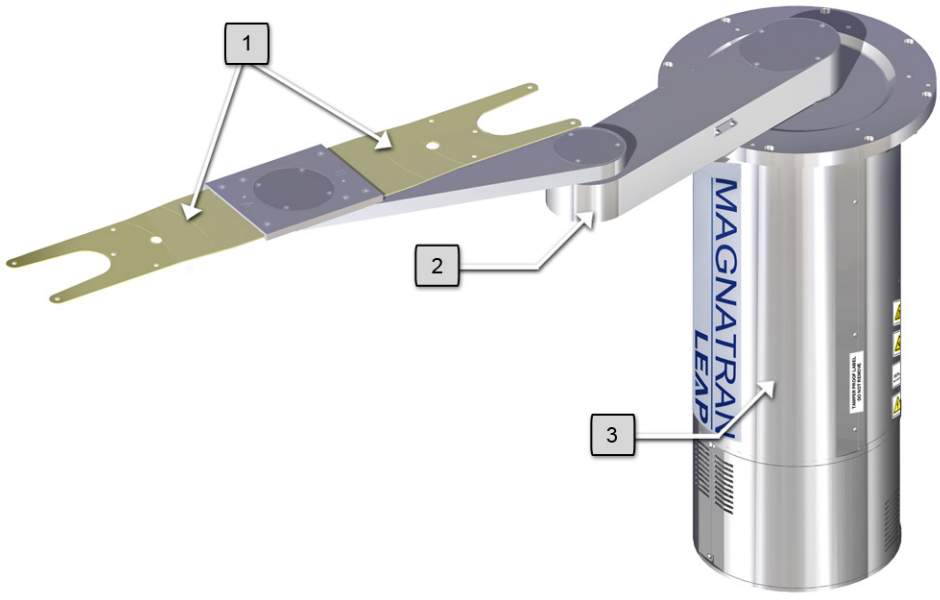


Figure 2-9: MagnaTran LEAP Field Replaceable Units

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Table 2-10: MagnaTran LEAP Field Replaceable Units - Explanation

Number	Explanation
1	End Effectors
2	Armset
3	Robot Drive

Brooks Product Training

Brooks Automation offers training courses on safety and operation as well as maintenance and troubleshooting. For more information on training courses go to www.brooks.com/education or contact your Brooks representative.

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Regulatory Compliance

Declaration of Incorporation

The MagnaTran LEAP meets the requirements of the European Union's Machinery Directive 2006/42/EC as a partially completed machine. In accordance with the Directive, Brooks Automation has issued a Declaration of Incorporation and MagnaTran LEAP robots do not have a CE mark affixed. It is the responsibility of the party integrating the robot into a system to acquire CE approval.

The Declaration of Incorporation below is a sample. Please contact Brooks Automation if a copy of the Declaration of Incorporation is needed.

Brooks	**Declaration of Incorporation of Partly Completed Machinery For the European Union**	**Document #: 287634 Rev. C**

Description: MagnaTran LEAP
Function: Semiconductor Vacuum Robot
Part Number: 29[illegible]-xx, 29[illegible]-xx, 265[illegible]-##-###
Serial Number:

SAMPLE

Business name and full address of the manufacturer of the partly completed machinery:
Brooks Automation Inc., 15 Elizabeth Drive, Chelmsford, MA, USA 01824

Name and address of the person, established in the Community, authorized to compile the relevant technical documentation:
Brooks Automation (Germany) GmbH, Ernst-Ruska-Ring 11, 07745 Jena, Germany

The manufacturer declares:

- That the following essential requirements of Machinery Directive 2006/42/EC are applied and fulfilled and that the relevant technical documentation is compiled in accordance with part B of Annex VII:
  - *Annex I sections: 1.1.2, 1.1.3, 1.1.5, 1.2.1, 1.2.3, 1.2.4, 1.2.6, 1.3.1, 1.3.2, 1.3.4, 1.3.6, 1.3.7, 1.3.8, 1.3.9, 1.4.1, 1.4.2, 1.5.1, 1.5.2, 1.5.4, 1.5.6, 1.5.8, 1.5.9, 1.5.10, 1.5.11, 1.5.13, 1.6.1, 1.6.2, 1.6.4, 1.6.5, 1.7.1, 1.7.2*

- That this partly completed machinery conforms with the provisions of Electromagnetic Compatibility Directive 2014/30/EU.
  - *EU Standards: EN 55011/EN 55022, EN 61000-6-4:2007, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6*

- We will transmit, in response to a reasoned request by a national authority, relevant information on the partly completed machinery, on paper or in electronic form, without prejudice to our intellectual property rights.

The partly completed machinery must not be put into service until the final machinery into which it is incorporated has been declared in conformity with the provisions of Directive 2006/42/EC



David Jarzynka
Senior Vice President & General Manager - Automation

14-August-2017
Chelmsford, Massachusetts, USA

Form: QMS100362 Rev E

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3. Specifications and Site Requirements

Site Requirements

Environment

Table 3-1: Site Requirements

Requirement	Specification
Clean Room	ISO 14644-1 Class ISO 6 or better cleanroom ambient
Temperature:	10° C to 50° C (50° F to 122° F)
Humidity	30% to 55% (relative, non-condensing)
Lighting	Standard lighting provided in the cleanroom environment. Additional lighting is not required for normal operation. Installation and maintenance may require a user supplied service lamp.

Other

- Trained personnel
- Lifting apparatus
- Chamber or rigid stand for support
- Requirement to protective flange sealing surface
- 24V or 48V power supply (depending on robot configuration/application)
- 100-240 VAC input for external controller configuration

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WARNING

Potential System Movement

The system has the potential for motion that may cause death or serious injury.

- Avoid working inside the path of the motion components.
- Use physical barriers to prevent injury when working in the path of moving components.
- Operate the system only with covers installed.
- Do not operate the robot if it is not securely bolted to the system or test stand.



Access

The MagnaTran LEAP robot requires space for service access and for proper operation. It is the responsibility of the robot integrator to ensure that there is adequate space for service, cables, and the teach pendant. Ensure ambient temperatures do not exceed robot design limits and there is adequate airflow for the robot internal cooling fan.

Robot Specifications

NOTICE

The nameplate data label on the robot covers represent the typical operating limits for the MagnaTran LEAP robot. It is designed to provide guidance for general lifting and safeguarding.

Table 3-2: Robot Parameters

Parameters	Value
R (Radial) Axis	Extension distance dependent upon armset and arm angle.
T(Rotational) Axis	Infinite, continuous rotation
Operating Temperature	10°C to 50°C (283.15K to 323.15K / 50°F to 122°F)
Storage Temperature	-25°C to 55°C (-13F to 131F), up to 65°C (149°F) for 24 hrs.
Shipping Temperature	-25°C to 55°C (-13°F to 131°F), up to 65°C (149°F) for 24 hrs.
Humidity	30% to 55% (relative, non-condensing).
Altitude	The robot operation is not affected by altitude (atmospheric/barometric pressure).

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Parameters	Value
Materials Exposed to Vacuum	• Stainless steel (300 Series, 416, AM350) • AM356-T6 • Aluminum • Nickel • Titanium • Magnetic materials • Quartz • Glass • Eligiloy • Viton • Perfluoroelastomer • Molybdenum • Ceramic • Vacuum compatible grease • PEEK
Helium Leak Rate, Maximum:	< 1 x 10^{-9} std. cc/sec He
Base Pressure, Maximum	< 5 x 10^{-7} Torr (< 6.66^{-5} Pa)
Robot Weight without Arm	Minimum: [[[Undefined variable MyVariables.Mag9 Weight]]] Maximum: 190 kg (419 lb)
Robot Weight with Arm	Varies by drive and armset
Nominal Current[1]	5A to 10A @ 24V/48V (armset dependent) 10A @ 220 VAC (external controller)
Peak Current[1]	20A @ 24V/48V (armset dependent) 35A @ 60 VDC (armset dependent)
Nominal Power[1]	100W to 500W (armset dependent)
Peak Power[1]	24V: 480W 48V: 2100W
Operating Voltage	24 VDC+/-2% 48 VDC+/-2%
Maximum Voltage	Permanent damage to the controller and drive may occur if voltage goes above these values: • 24V configuration: 34V • 48V configuration: 68V • 24V MISC I/O Power Supply: 26V
Accessories	Custom designed end effectors
SCCR (Short-Circuit Current Rating)	40A for On-Board Controller configuration 5 kA for External Controller configuration Brooks does not recommend current protection sizing to be based on the SCCR. Brooks recommends a 20A circuit breaker or fuse with a medium delay.

[1]Consult Brooks Product Support concerning the nominal and peak current/power for your specific robot application.

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Parameters	Value
Maximum Cable Length Between External Controller and Robot Drive	10 meters

Robot Dimensions

Drive, arm, and end effector dimensions depend on the combination of drive, arm link length, wrist, and end effector. Refer to the layout drawing document in the documentation package that is part of your system materials.

Robot Weights

The weight of the robot varies by robot configuration. Refer to Name Plate Data Label, Interface Drawings or contact Brooks Technical Support for approximate weights of the drive. For more information on contacting Brooks Technical Support, please see "Contact Brooks Automation Technical Support".

Robot Part Numbers

The part and serial numbers can be found on the Standard Serial Number Label, attached to the robot drive near the I/O panel.

Robot Workspace

The robot workspace is the available range of motion for the robot arm. The workspace of the robot is a horizontal cylindrical volume. The radius of the cylinder defined from the center of the robot drive to the tip of the end effector when the arm is fully extended. Refer to the robot and system Interface drawings for more information.

The robot workspace must be safeguarded from personnel and external objects when the robot is powered.

Refer to the specifications label on the robot drive for the maximum reach and height of the armset to determine the workspace of the robot.

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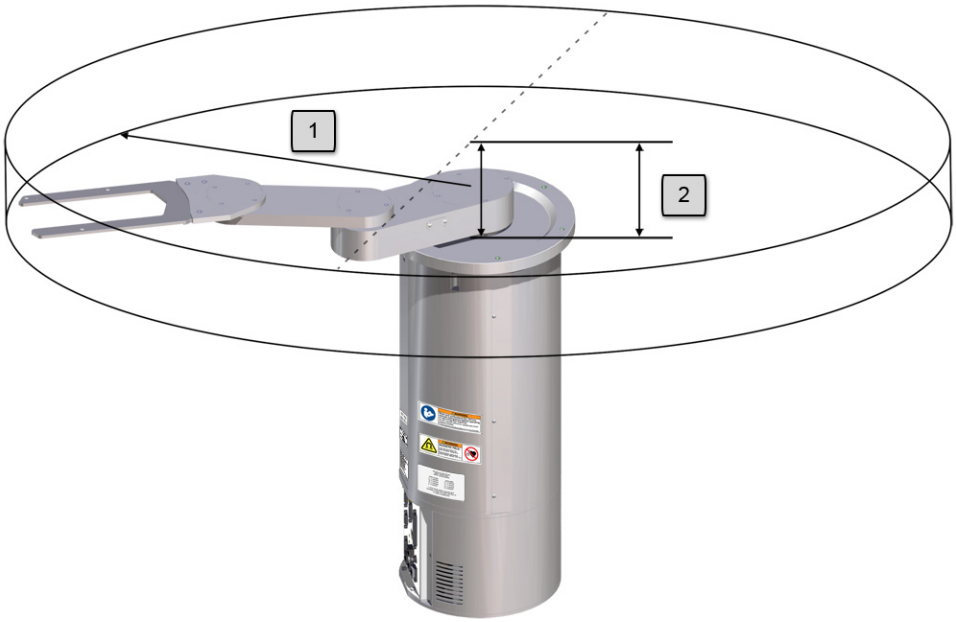


Figure 3-1: Robot Workspace

Table 3-3: Robot Workspace- Explanation

Number	Explanation
1	Radius
2	Height

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Robot I/O

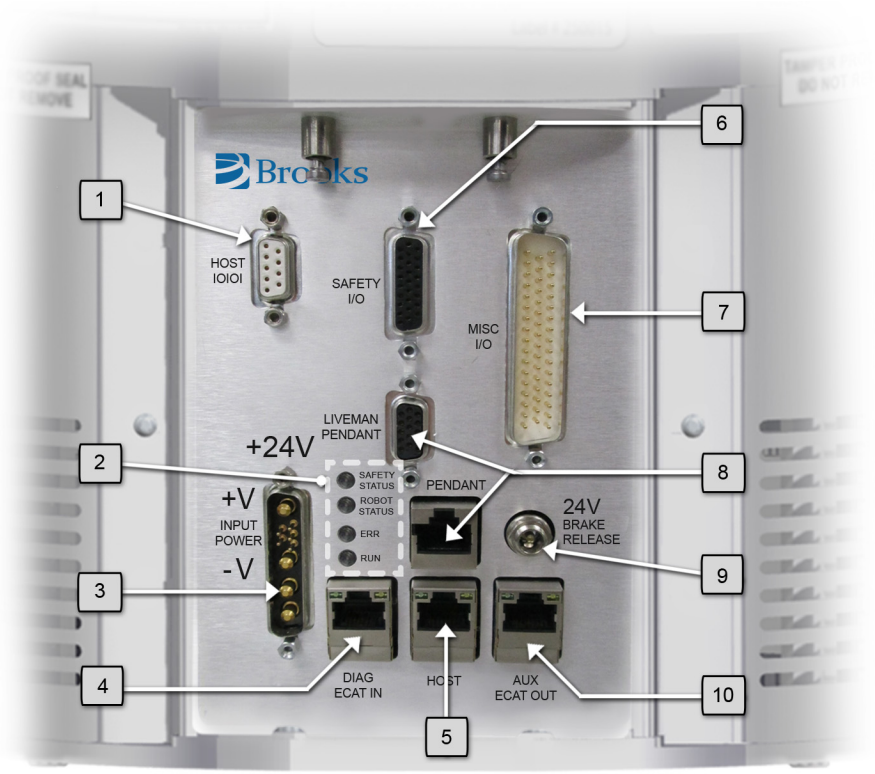


Figure 3-2: 24V Robot I/O Panel

Table 3-4: 24V Robot I/O Panel - Explanation

Number	Explanation	Number	Explanation
1	Host I/O (Serial)	6	Safety I/O
2	Safety / Robot / Err / Run Status LEDs	7	Miscellaneous I/O
3	Power Connection	8	Teach Pendant Connections
4	Diagnostics (Ethernet)	9	Brake Release
5	Host I/O (Ethernet)	10	Auxiliary (Ethernet)

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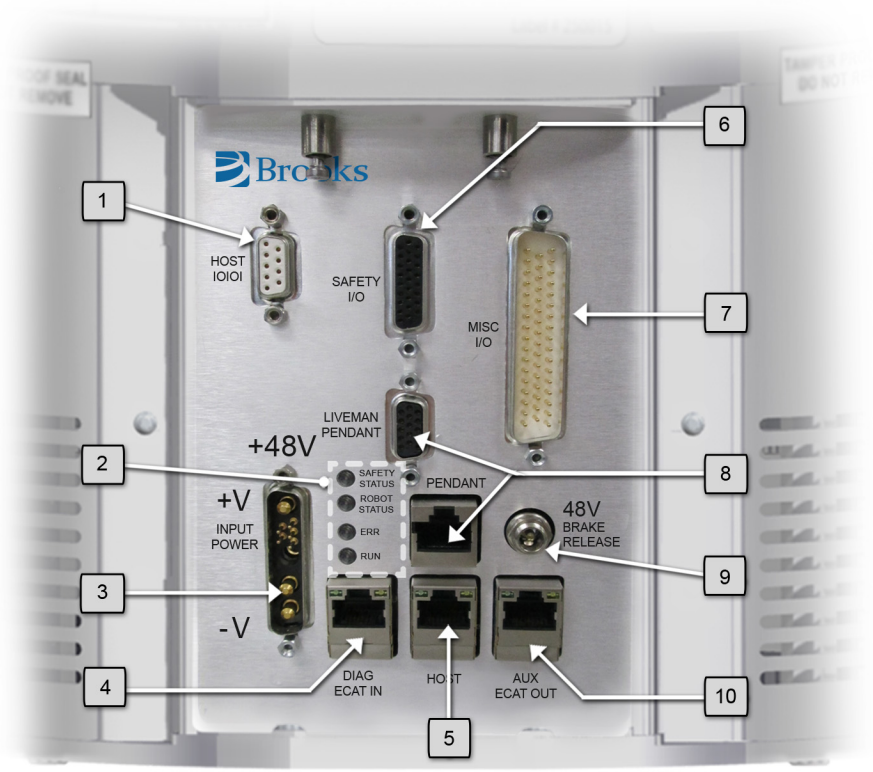


Figure 3-3: 48V Robot I/O Panel

Table 3-5: 48V Robot I/O Panel - Explanation

Number	Explanation	Number	Explanation
1	Host I/O (Serial)	6	Safety I/O
2	Safety / Robot / Err / Run Status LEDs	7	Miscellaneous I/O
3	Power Connection	8	Teach Pendant Connections
4	Diagnostics (Ethernet)	9	Brake Release
5	Host I/O (Ethernet)	10	Auxiliary (Ethernet)

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Figure 3-4: Offboard Controller Robot Passthrough I/O Panel

Table 3-6: Offboard Controller Robot Passthrough I/O Panel - Explanation

Number	Explanation	Number	Explanation
1	Encoders (To external controller)	3	Motor Power (To external controller)
2	24V AUX (To external controller)	4	24V Brake Release

NOTE: Most images of the I/O panel in the manual are of the 24V Robot.

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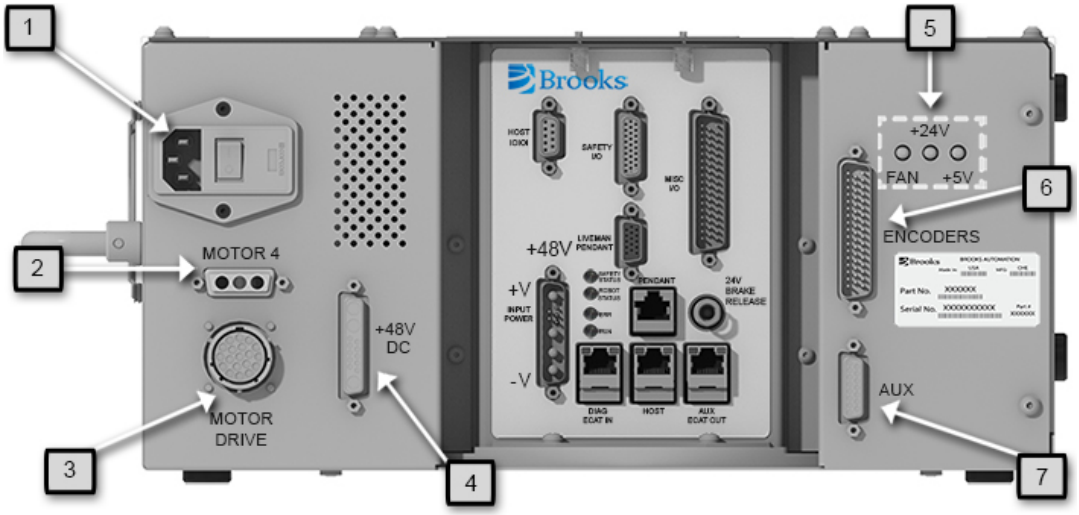


Figure 3-5: External Controller Front Panel

Table 3-7: External Controller Front Panel - Explanation

Number	Explanation	Number	Explanation
1	Power Entry Module/Power Switch	5	Status LEDs
2	Motor 4 Power	6	Encoders (To robot passthrough I/O)
3	Motor Drive Power (To robot passthrough I/O)	7	AUX (To robot passthrough I/O)
4	+48V DC		

NOTE: Use only cables provided by Brooks Automation to connect offboard controller robots to external controllers.

Table 3-8: Robot Connectors

Label	Function	Mating Connection Type	Link/Page
Host	Connects Robot to Host Computer	D-Sub 9 Socket Connector	"Host" on page 65
24V	Power Connection	D-Sub Combo-D, female (Mate - Molex) FCI: DB9W4SA00LF (power contacts separate) NorComp: 680M9W4203L201 ITT Cannon: DBMN9H4SNA197	"Power Connection" on page 69

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Label	Function	Mating Connection Type	Link/Page
48V	Power Connection	D-Sub Combo-D, female (Mate - Molex) FCI: DB13W3SA00LF (power contacts separate) NorComp: 680S13W3203L401 ITT Cannon: DBM-13H3S-N-A197	"Power Connection" on page 69
Safety I/O	Additional Safety Features	D-Sub 26 pin connector	"Safety I/O" on page 71
Pendant	Legacy MAG7/MAG8 Teach Pendants	RJ-45	"Legacy Teach Pendants" on page 73
Liveman Pendant	Live-Man Teach Pendant	High Density D-Sub 15 pin connector	"Liveman Teach Pendant" on page 73
24V Brake Release	Z Axis Brake Release	Miniature Power Jack(Mate: Swichcraft 760)	"Z-Axis Brake Release" on page 74
Misc I/O	Customer Interface Connection	D-Sub 50 pin connector	"Misc I/O" on page 76
DIAG	Diagnostics connections	RJ-45	"Diagnostics" on page 88
HOST	Connects robot to host computer	RJ-45	"Ethernet" on page 65
AUX	Auxiliary connections	RJ-45	"Auxiliary" on page 88

Host

Communication between the robot and a host controller can be accomplished by connecting the robot over a Serial I/O RS232 communication port or by using an Ethernet port. The Host communication selection is made based on customer preference so the robot is factory set to the desired state. Only one Host communication interface can be enabled at a time and it can be changed as desired using the teach pendant.

NOTE: Customers must use Ethernet cables with ferrite protection when making the connection to the robot.

Ethernet

The MagnaTran LEAP robot has a 10/100BASE-T Ethernet for Host communications.

Network communications using the Ethernet communications protocol provides the ability to connect a number of different devices to a factory controller using a single communications cable, which simplifies wiring. Ethernet communication allows the MagnaTran LEAP Controller to send and receive data faster than with a serial communication connection. Each device connected to the

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cable has a unique network device address. Only communications addressed to a specific device through the network will be received by that device.

Network communications allows the host controller to communicate with the LEAP Controller using the commands detailed in the *MagnaTran LEAP Controller Software Manual* (605651). In situations where the Remote Service Interface and the Host Controller are unavailable, a personal computer running a network communications application may be connected to the HOST network port on the LEAP I/O panel using an Ethernet cable that includes ferrite protection.

The connection to the MagnaTran LEAP Controller from the host controller uses standard Ethernet network communications protocols and wiring. The configuration for the controller's external network communications is defined by the facility where the MagnaTran LEAP robot is installed. Note that if more than one MagnaTran LEAP robot will be connected to the same network the IP address of each additional system must be changed to avoid IP conflicts.

The MagnaTran LEAP Controller can use Ethernet to communicate with additional devices within the controlled environment. The configuration for the internal network communications is described in the table below.

Table 3-9: Internal Network Communications Configuration

Setting	Value
Factory Default IP Address	20.20.249.2
Mask	255.255.255.0
Telnet Port	23
File Transfer Protocol (FTP) Port	21
LEAP Controls Port	1102
LEAP Diagnostics Port	1103

In most cases, the default IP address is changed to a customer preferred IP address prior to shipment. For more information on configuring the IP address, see the *MagnaTran LEAP Controller Software Manual* (605651).

The Ethernet cables used are standard network cable (UTP-Cat5) with an 8-pin RJ-45 connector that plugs into the robot I/O Panel. The pin-out for this connection is provided below. Note that pins not identified with a signal name are not used. Refer to Figure 3-2 on page 61 for the location of this connection.

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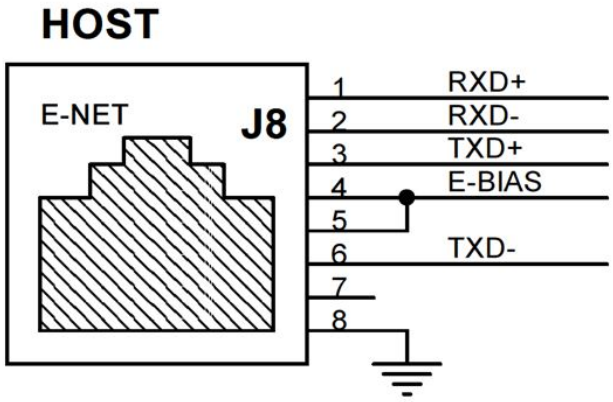


Figure 3-6: Host Ethernet Connection

NOTE: To establish a direct communications link to the MagnaTran LEAP Controller using Ethernet either a crossover cable or an Ethernet Switch is needed.

Host IOIOI

As an alternative, the MagnaTran LEAP Controller can use a conventional RS232 serial communications port for connection to a host controller. Serial communications provides the ability to connect the LEAP Controller to a host controller using a simple 3-wire cable. Using the serial connection requires each device within a system have its own serial communications cable.

Serial communications allows the host controller to communicate with the MagnaTran LEAP Controller using the commands detailed in the Wavecode Manuals. No additional control, or “handshaking”, wires are used. The Baud Rate can be set from 9600 BAUD to 115200 BAUD as defined by the protocol standard.

The connector on the controller is the industry standard DB9 connector. The mating connector would contain male contacts.

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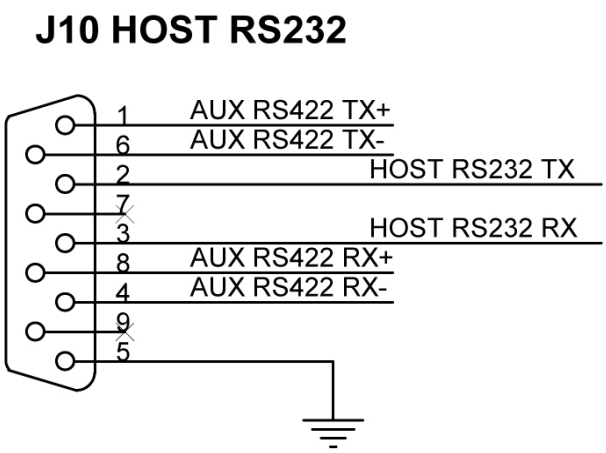


Figure 3-7: Host Serial Connection

The setup and selection are made using the teach pendant.

The Host IOIOI connector also contains an RS422 interface. The actual application use of the RS422 interface remains held in reserve.

The serial communications cable uses a standard 9-pin female “D” connector that plugs into the MagnaTran LEAP Controller on the robot I/O panel.

The serial communications cable for Host Control and PC Control uses a standard 9-pin male “D” connector at the end that plugs into the robot in the connector labeled “HOST IOIOI”. The pin-out for this cable is provided in Table 3-10 on page 68. Note that pins not identified with a signal name are to be left unconnected.

Table 3-10: RS-232 Pin Assignments S101

Pin ID	RS-232 Signal Name
1	AUX RS422 TX+
2	HOST RS232 TX
3	HOST RS232 RX
4	AUX RS422 RX-
5	GND
6	AUX RS422 TX-
7	Unused
8	AUX RS422 RX+
9	Unused

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Power Connection

WARNING

Hazardous Voltage

The MagnaTran LEAP robot relies on PELV to protect personnel against hazardous touch voltages. To ensure that PELV is provided observe the following:

- Follow the power supply wiring instructions included in this manual.
- In particular, ensure the DC return is connected to protective earth at the output of the power supply.
- Ensure the power supply either: includes a safety isolating transformer in accordance with IEC 61558-1 and IEC 61558-2-6; or is an electronic power supply conforming to appropriate standards specifying measures to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed 60VDC.



Power Supply

The MagnaTran LEAP robot is designed to operate from a 24VDC or 48VDC power supply. Brooks Automation tests and tunes all MagnaTran LEAP robots using the COSEL ADA750F-24V or the COSEL ADA750F-48V.

Use Table 3-2: "Robot Parameters" on page 57 to help select a power supply based on power and voltage requirements. Selecting a different power supply based on cost or size should first be fully characterized by the user in all combinations of arm movement.

This power supply has been selected based on reliability, fault tolerance, and on peak power requirements common in the servo-motion industry.

Power requirements vary from one application to another. Contact Brooks Automation to determine which power supply voltage best meets a specific wafer transport application.

Power Supply Wiring for MagnaTran LEAP Robot

The LEAP robot power supply should be wired to meet all required safety standards. A sample checklist is included below. This list is a general checklist and may not contain all the requirements required by the safety standards:

- Conductors and insulation must be sized correctly
- Primary and secondary wiring should not be bundled together
- Use circuit protection where required to permit downsizing of conductors
- Reference DC RETURN protective earth with an appropriately rated wire
- Ensure primary circuits have appropriately sized disconnect devices
- Primary power should be provided with an Emergency Off device

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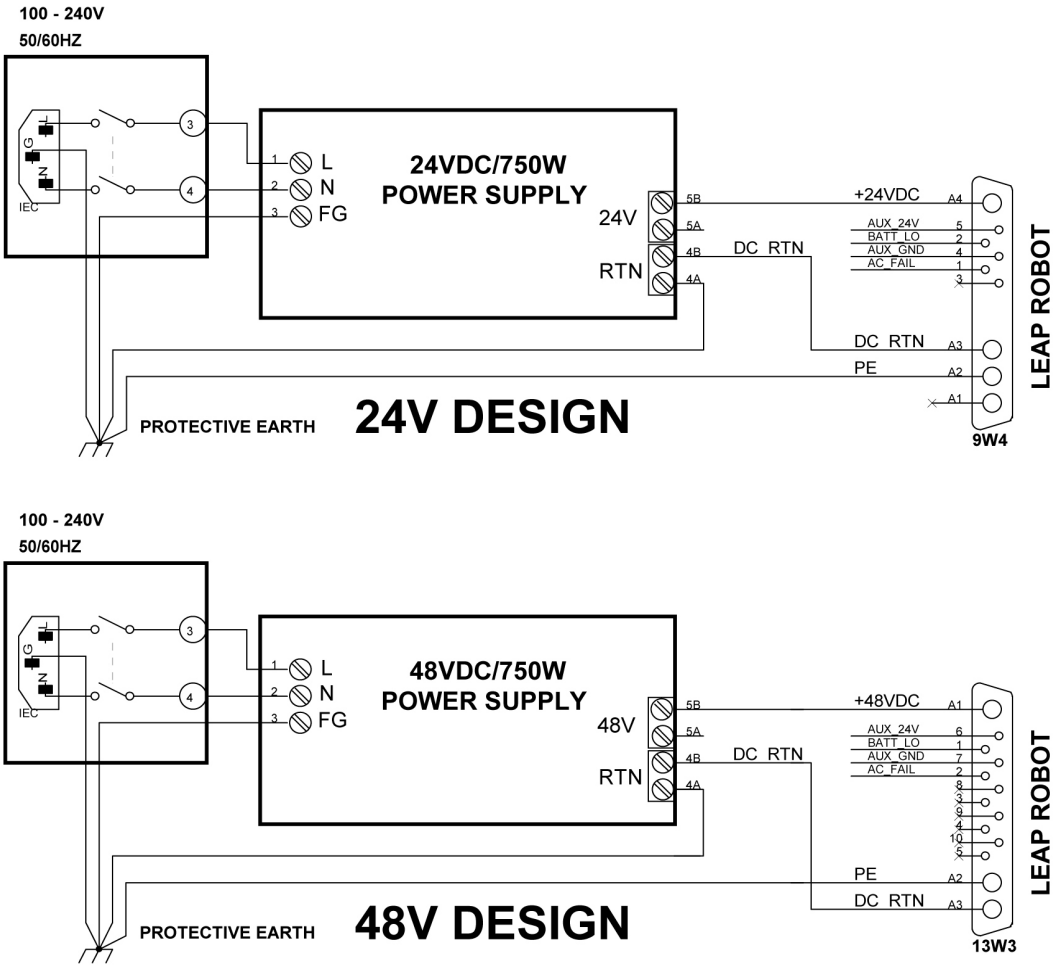
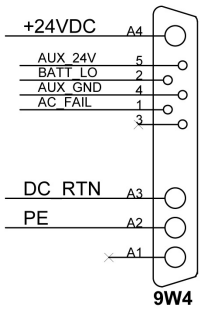


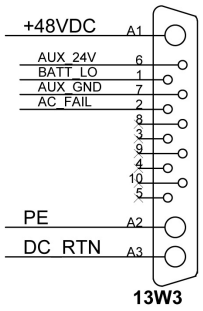
Figure 3-8: Basic 24V and 48V Power Supplies

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NAME	PIN#	FUNCTION
+24V	A4	+ ROBOT POWER
RTN	A3	- ROBOT POWER
PE	A2	PROTECTIVE EARTH
AUX 24V	5	Interface to UPS or System Power Controller
BATT LO	2	
AUX GND	4	
AC FAIL	1	

24V LEAP ROBOT POWER CONNECTOR



NAME	PIN#	FUNCTION
+48V	A1	+ ROBOT POWER
RTN	A3	- ROBOT POWER
PE	A2	PROTECTIVE EARTH
AUX 24V	6	Interface to UPS or System Power Controller
BATT LO	1	
AUX GND	7	
AC FAIL	2	

48V LEAP ROBOT POWER CONNECTOR

Figure 3-9: 24V and 48V Power Connectors

Safety I/O

Brooks MagnaTran LEAP robots contain an embedded controller designed to help customers meet the requirements of EN ISO 10218-1:2011 and EN ISO 13849-1:2008 Category 3, PL d. The Embedded Safety Controller connects to the robot through the safety I/O port on the robot I/O panel. For more information , see "Embedded Safety Controller" on page 147.

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Status Indicators

The status indicator colors and states align with the IEC 60402-1 color definitions (Green = normal, Yellow = abnormal, Blue = mandatory action) and the blinking indicates a transitory or action required. They also align with EN 60073 and ANSI 40-203 for coding principles for indicators and for blink meanings.

> ***NOTE:*** Do not rely entirely on the LED status indicators. Always verify the mode of robot operation using software queries. Contact Brooks Service if the LED colors do not match the software responses.

For more information on status indicators, please see "Embedded Safety Controller" on page 147.

The status LEDs have three blink rates and a constant:

- Slow Blink - 1Hz (1 blink per second)
- Fast Blink- 4Hz (5 blink per second)
- Flicker Blink - 10Hz (10 blinks per second)
- Constant - LED is on and is not blinking

Table 3-11: Safety System Status

Mode	Color	Blink Rate	Motor Power	Comment
Automatic	Green	Solid	Motor power is applied	Normal high speed operation
	Yellow	Solid	Motor is off. Motor power will be applied on next motion command	On hold with motor power off, and waiting for command.
	Yellow	Blinking 4Hz	Motor power is off.	Open interlock or Emergency Stop
Emergency STOP	Yellow	Solid	Motor power is off	Motor power is off. Motion is not possible.
Manual	White	Solid	Motor Power is applied	Slow speed motion possible.
	Yellow	Solid	Motor power is off. Motor power will be applied on the next motion command.	Holding with motor power off. Motion is possible on next motion command.
	Yellow	Blinking 4Hz	Motor Power is off.	Open interlock Emergency Stop. Motion not possible.
Legacy Teach Pendant	Blue	Solid	Motor Power is applied	Slow speed motion possible. E-Stops are satisfied.
	Yellow	Solid	Motor Power is off, will be applied on next motion command	Holding with motor power off. Motion not possible.
	Yellow	Blinking 4Hz	Motor power is off.	Open Emergency Stop

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Mode	Color	Blink Rate	Motor Power	Comment
Liveman Teach Pendant	Blue	Solid	Motor power is applied only if liveman button is gripped.	Slow speed motion is possible. E-Stops are satisfied.
	Yellow	Solid	Motor power is off, will be applied on next motion command if liveman button is gripped.	Holding with motor power off. Motion is not possible.
	Yellow	Blinking 4Hz	Motor Power is off.	Open Emergency Stop
Error	Red	1Hz	Motor Power is off.	Safety Wiring, channel A and channel B mismatch.

NOTE: The Robot Status indicator and the Network Status indicators (ERR and RUN) are reserved and will be defined at a later date.

Liveman Teach Pendant

The MagnaTran LEAP robot uses a Liveman Teach Pendant for increased safety. The 3-position Liveman Switch only allows robot movement when it is properly engaged. The Liveman Teach Pendant connects to the robot using a high density D-Sub 15 pin connection. For more information please see "Teach Pendant" on page 173.

NOTICE

Brooks requests placing cables for the E-stop and/or liveman in conduit or flexible metal cabling.

Legacy Teach Pendants

MagnaTran 7 and MagnaTran 8 Teach Pendants can be used with the MagnaTran LEAP robot if certain system safety conditions are met. Legacy Teach Pendants connect to the robot using an RJ45 connection. For more information on using Legacy Teach Pendants with your MagnaTran LEAP robot, please see "Teach Pendant" on page 173 and the "Embedded Safety Controller" on page 147.

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WARNING

Legacy Teach Pendants

Legacy Teach Pendants do not comply with the ISO 10218-1 standard because they do not have a liveman switch.

- Brooks recommends using liveman teach pendants when working on any robot or system.
- Never enter the robot workspace when operating the robot with a legacy teach pendant.



Z-Axis Brake Release

See "Emergency Z-Axis Brake Release Procedure" on page 41.

The Z-axis is equipped with a brake that holds the Z-axis in position whenever power to the brake is off.

- When power is applied to the brake, the brake releases and the Z-axis can move.
- When power is removed from the brake, the brake holds the Z-axis and prevents Z movement.

When conditions require that the Z-axis is moved when the drive power is off, the Emergency Brake Release circuit may be used to release the internal Z-axis brake.

The Z-axis Brake Release requires a separate 24VDC 500mA power supply with a floating power source or earth referenced negative terminal and a Switchcraft™ 760 Mini Power Plug power output connector.

CAUTION

Crush Hazard

Releasing the Z-axis brake causes the Z-axis to fall due to gravity which may crush extremities or fingers.

- Only properly trained personnel should perform the Z-axis Brake Release Procedure.
- Fully support the Z-axis during release to avoid additional hazards.
- Only perform the brake release for testing or emergencies.



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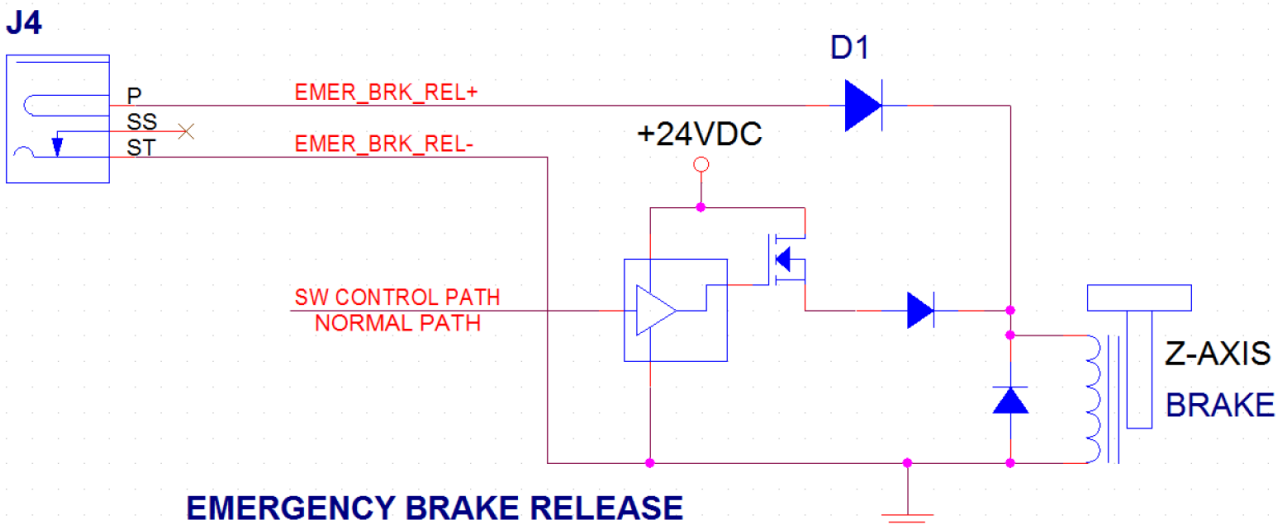


Figure 3-10: Emergency Z-axis Brake Release Wiring Diagram

Input Signal: DC21-30V @ 1/2A, center pin is positive.



Figure 3-11: Switchcraft 760

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Misc I/O

MISCELLANEOUS I/O Operation Interface

Discrete I/O provides monitoring and control of external device functions using individual 24V pins for each function. No additional controls or “handshaking” is required. Inputs and outputs are assigned for implementation by the system integrator.

Discrete I/O interface can be configured as high-side or low-side. The safety standards advise the high side application. A high side application is asserted as a connection to the 24V power supply, while the low side application is asserted by a connection to ground. When performing a risk assessment for a broken wire, the broken wire is more likely to contact ground than +24V. The short to ground would provide a false assertion with the low-side configuration. Regardless, it is required that each system integrator perform a risk assessment to determine which configuration is the most reliable and therefore the safest for their given design.

In its simplest form, using mechanical switches, high-side and low-side operation are described below.

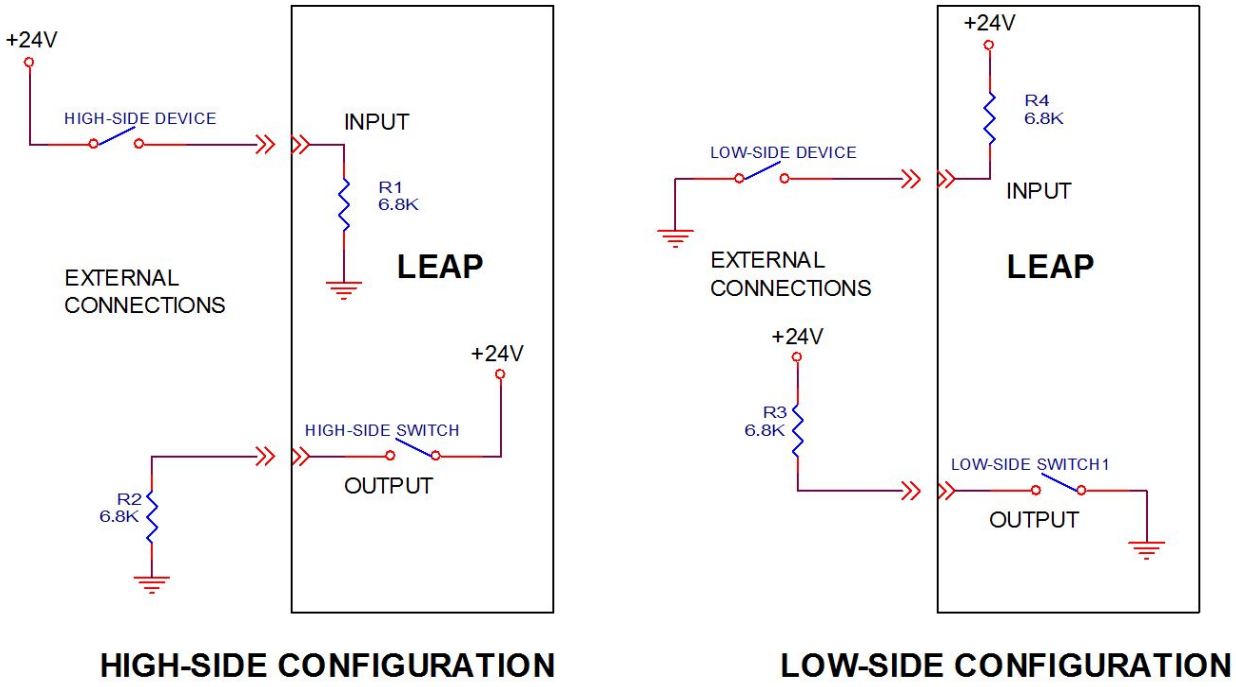


Figure 3-12: High-Side and Low-Side Configuration

The miscellaneous I/O connector is located on the robot front panel. It is the DB50 male connector J1 located on the upper left. Connection of external devices to the MagnaTran LEAP robot is accomplished through the miscellaneous I/O. There are 22 inputs and 20 output lines.

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NOTE: It is not possible to split the inputs or outputs between high-side and low-side.



Figure 3-13: Miscellaneous I/O on the Robot I/O Panel

Selection Between High-Side or Low-Side Hardware

Selection of high-side or low-side hardware interface is performed at Brooks. Customer must specify high-side or low-side operation, and communicate the requirement to Brooks.

High-Side Inputs:

External devices must be capable of sourcing 4.4mA from 24V. Hysteresis is ~6V.

Input High ≥ 17V
Input Low ≤ 8V

Absolute maximum ratings:

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Input High: 28V
Input Low: -0.6V

Wiring Information - High-Side Inputs

Inputs 0 through 21 are located on connector P1. MISC Inputs start at pin 1 through pin 22 as shown in the wiring diagram below. A sample connection is shown to IN21.

NOTE: The high-side connection from the external device forms a connection to +24V.

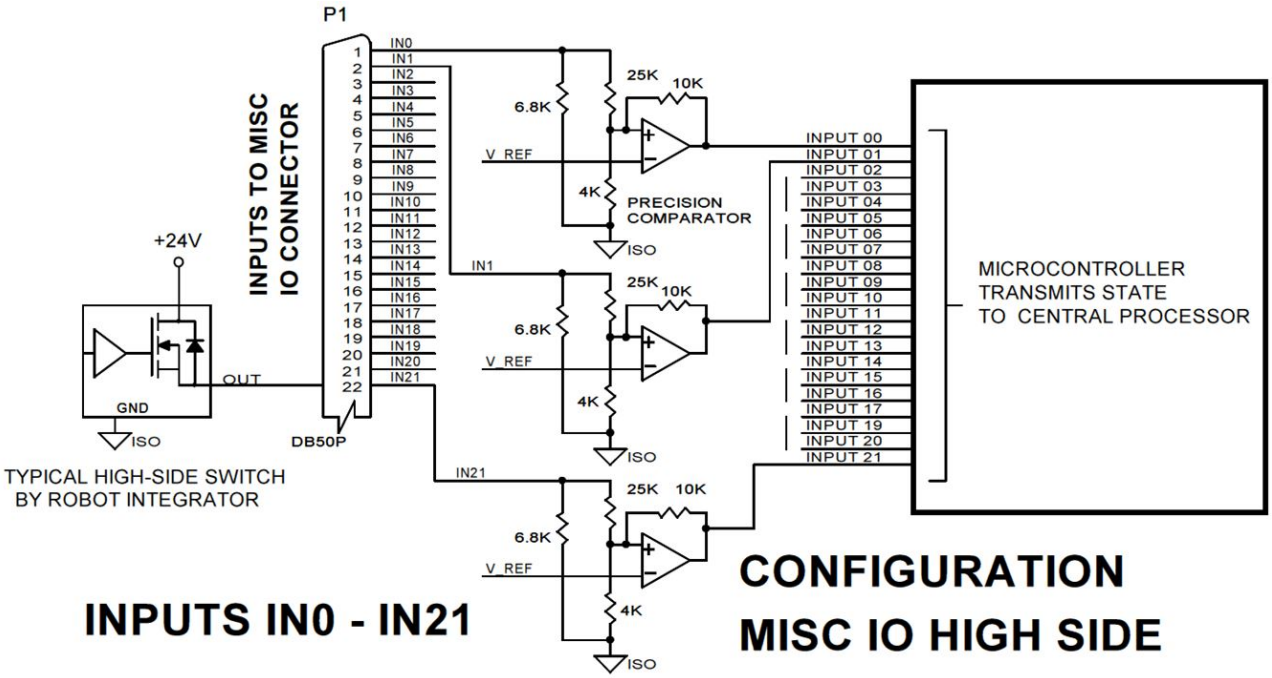


Figure 3-14: Configuration Misc I/O High Side - Inputs 0 - 21

High-Side Outputs

High-side outputs, when asserted, form a connection to +24V. A load resistor may be required to observe the logic low state.

a. Output Type: High-side output drive, MOSFET connection to +24V.
   - A high-side switch is designed to connect the output to a positive power source.
   - Logic “1” is a connection to +24V.

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- Logic “0’ is a disconnect from 24V.
- Some type of LOAD may be required to ensure logic “0” goes to ground.

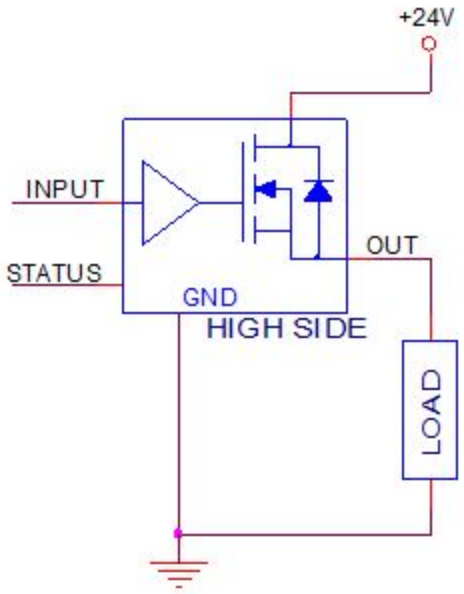


Figure 3-15: High-Side

b. Power Budget: Total 24V current for all the outputs combined should be less than 700mA. Up to 100mA can be drawn from a single output.
c. Connection of any discreet output bit to a large capacitor may damage the controller or impact other 24V outputs. Failure to follow this rule may expose personnel to hazards that may include injury or death.

WARNING

Connection to a Large Capacitor

Connection of any discreet output bit to a large capacitor may damage the controller or impact other 24V outputs potentially leading to death or personal injury.

- Do not connect any discreet output bit to a large capacitor.



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Wiring Information - High-Side Outputs

Outputs 0 through 19 are likewise located on connector P1. MISC Outputs are pinned sequentially starting at pin 31 and ending at pin 50. See the wiring diagram below. A sample connection is shown for pin 31.

NOTE: The MagnaTran LEAP Controller outputs +24V to the external device.

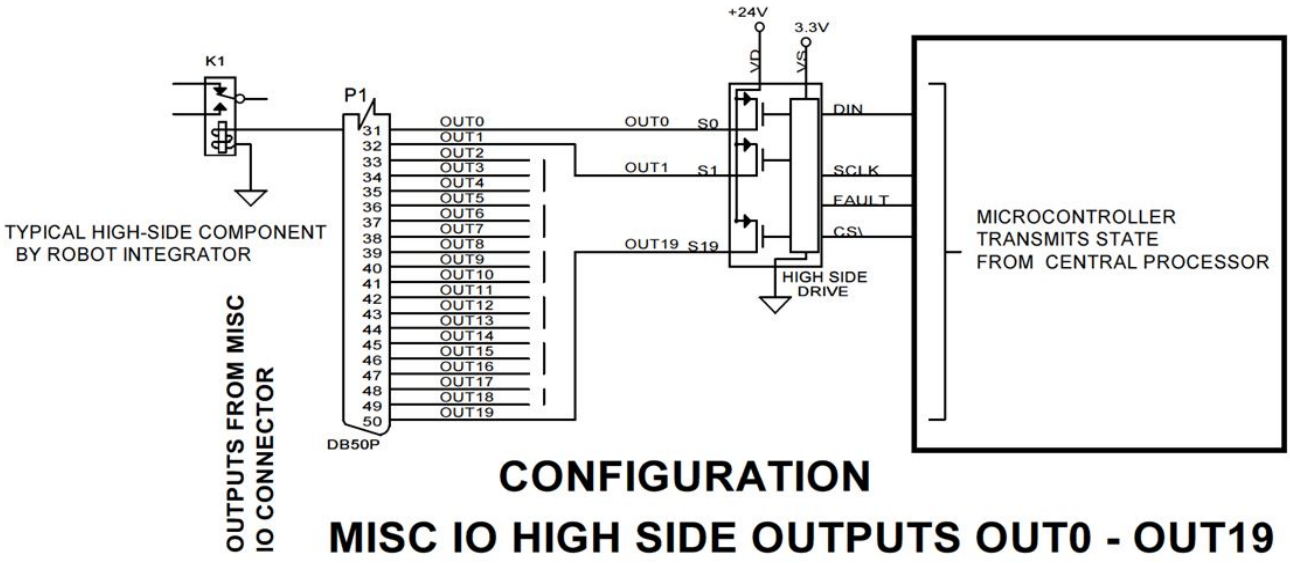


Figure 3-16: Configuration Misc I/O High Side - Outputs 0 - 19

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Low-Side Inputs

CAUTION

Unintended Input

When using low side interface, a shorted connection wire creates an unintended active signal which may cause improper or unsafe system operation.

- Use active-high interface whenever possible.



External devices must be capable of sinking 4mA to ground. Hysteresis is ~6V.

Input High ≥ 16V
Input Low ≤ 8V

NOTE: The pull-up resistor on the input bit will only pull-up to 19.5V. If a higher level is needed an external pull-up is required

Absolute maximum ratings:

Input High: 28V
Input Low: -0.6V

Wiring Information - Low-Side Inputs

Low-side inputs 0 through 21 are located on connector P1. MISC Inputs start at pin 1 and count sequentially through pin 22 as shown in the wiring diagram below. A sample connection is shown to IN21.

NOTE: The low-side connection from the external device forms a connection to ground.

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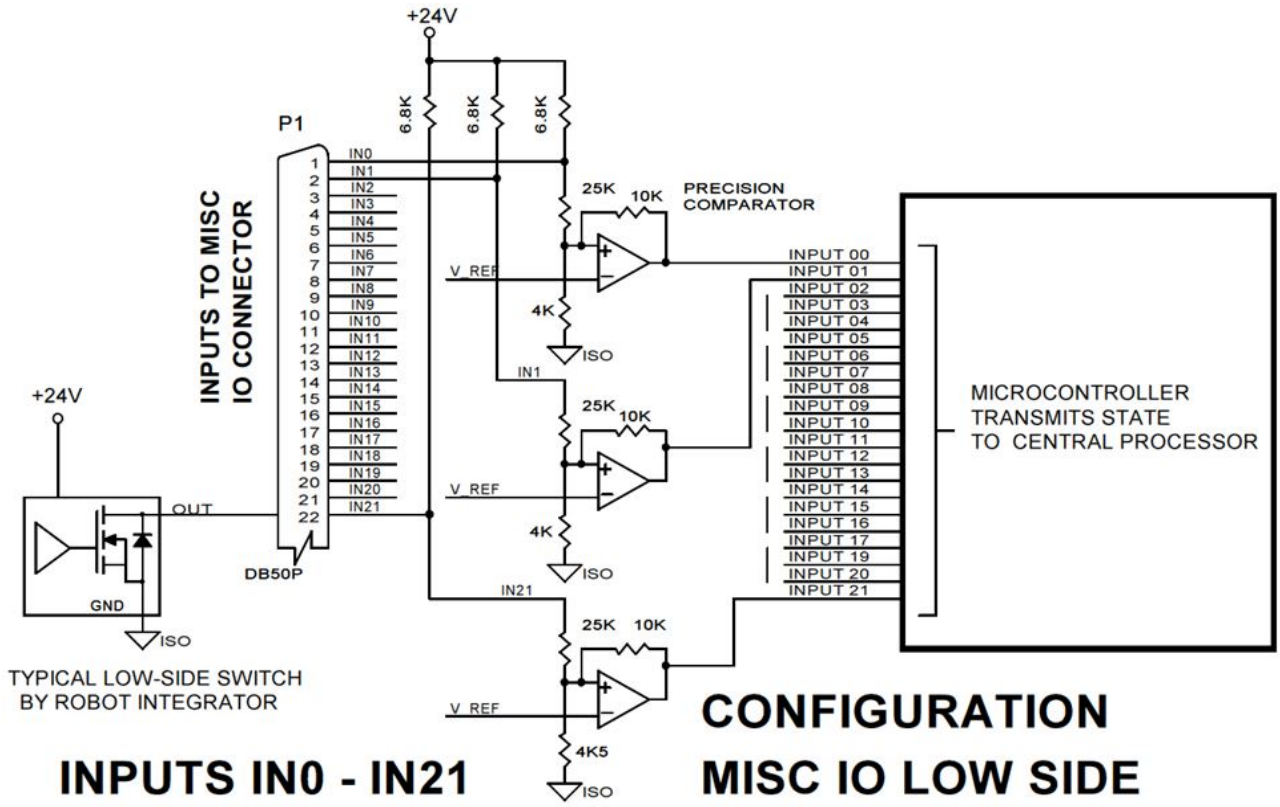


Figure 3-17: Configuration Misc I/O Low-Side - Inputs 0 - 21

Low-Side Outputs

Low-side outputs are open drain devices. An external load resistor may be required to pull up to +24V.

a. Output Type: low-side output drive, MOSFET connection to ground.
   - A low-side switch is designed to connect the output to ground.
   - Logic “0” is a connection to ground.
   - Logic “1’ is a disconnect from ground where the load will be seen to pull up to 24V.
   - Some type of LOAD may be required to ensure a logic “1” goes to +24V.
   - Is not considered as safe as a high-side design.

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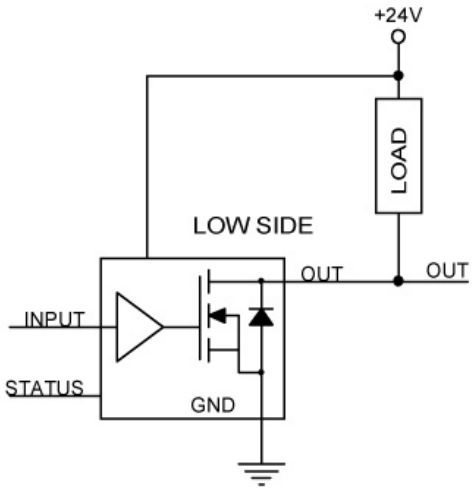


Figure 3-18: Low-Side

b. Power Budget: Total 24V current for all the outputs combined should be less than 700mA. Up to 100mA can be drawn from a single output.

c. Connection of any discreet output bit to a large capacitor may damage the controller or impact other 24V outputs. Failure to follow this simple rule may expose personnel to hazards that may include injury or death.

WARNING

Connection to a Large Capacitor

Connection of any discreet output bit to a large capacitor may damage the controller or impact other 24V outputs potentially leading to death or personal injury.

- Do not connect any discreet output bit to a large capacitor.



Wiring Information - Low-Side Outputs

Outputs 0 through 19 are likewise located on connector P1. MISC Outputs are numbered sequentially starting at pin 31 and ending at pin 50. See the wiring diagram below. A sample connection is shown for pin 31.

NOTE: The LEAP Controller outputs a ground connection to the external device.

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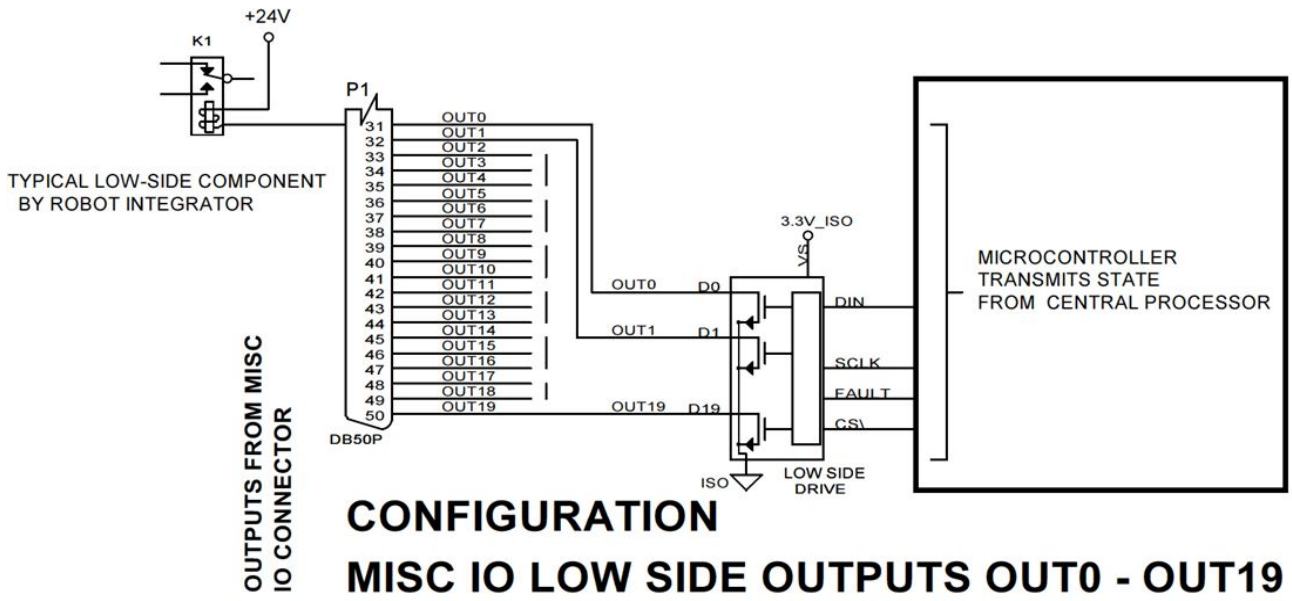


Figure 3-19: Configuration Misc I/O Low-Side - Outputs 0 - 19

Miscellaneous I/O Power, Differences between MagnaTran 7/8 and MagnaTran LEAP

Location: Robot I/O Panel, MISC I/O Connector, DB50 male.

High-side and low-side MISC I/O interfaces are designed to operate from 24VDC nominal. The integrator of the robot, in making connection to the interface, selects to power the robot I/O interface either from an external 24V power supply or from the 24V power supply internal to MagnaTran LEAP controller.

Like the Series 7 and Series 8 MagnaTran robots, the MISC I/O connector has both power input and power output pins to provide connection to either user-supplied power or controller-supplied power. User-supplied external power ensures isolation of the critical components inside the controller.

There is a difference between how the 24V power is applied to the MISC I/O sensors and drivers.

Series 7 and 8 users: If the user of the MISC interface wanted to use 24V power from the robot, there was no wiring necessary. A relay internal to the robot automatically routed power to the interface. If the user desired to use separate 24V power, then it require wiring.

The next diagram illustrates the Series 7/8 power interface on the DB50 MISC I/O Connector.

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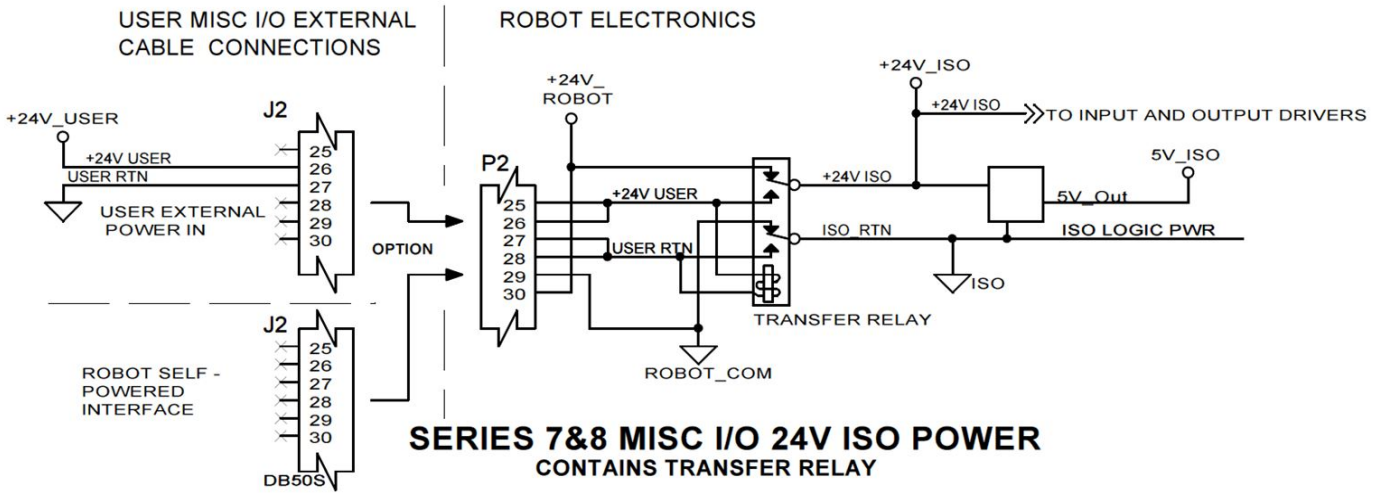


Figure 3-20: MagnaTran 7 and 8 Miscellaneous I/O 24V ISO Power

The above design (Figure 3-20) presented a problem for some users of the external power option. When external power was removed, the transfer relay would switch and apply 24V robot power to the interface. Automatic transfer of power violated the purpose of using isolated power and presented an unintended condition where removal of external power did not remove power from the interface circuits.

The MagnaTran LEAP Controller solves this problem by eliminating the transfer relay and by a requirement (if selected) to hard-wire the internal power supply.

The following diagram (Figure 3-21) demonstrates how the LEAP connection is wired for guaranteed isolation or for guaranteed connection to the internal power supply.

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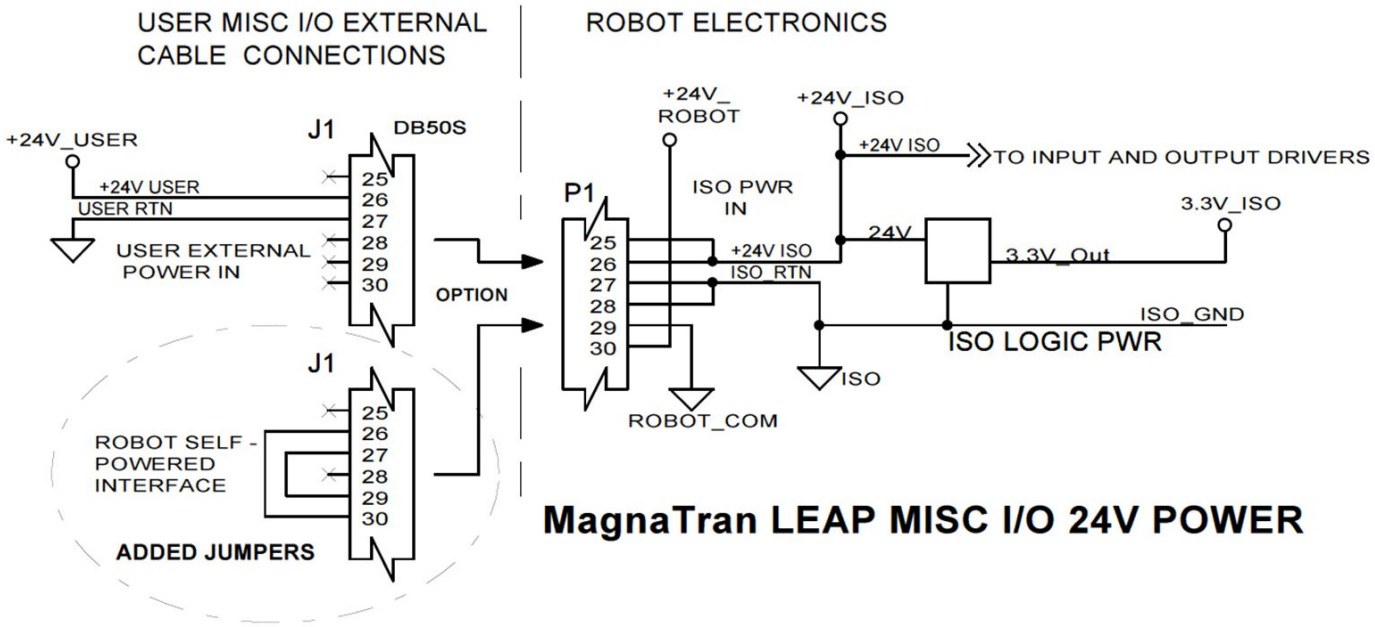


Figure 3-21: MagnaTran LEAP Miscellaneous I/O 24V Power

There is no change for users who chose to supply external 24V to power the MISC I/O interface. However there is a minor functional change to operation. Removal of external power now removes power from the MISC I/O interface and all its output drivers. The original MagnaTran 7/8 design had a transfer switch that maintained power to the interface as long as the robot was powered.

There is a required change to wiring for users who power the MISC I/O interface from the robot. The user must now add two wires to their MISC I/O connector to power the interface from the internal robot power supply. The jumpers are shown in the above diagram.

Summary

There is a product change when migrating from MagnaTran 7 & 8 controllers to MagnaTran LEAP controllers. Users who elected not to supply external power for the 24V MISC I/O interface are now required to install two jumpers to their MISC I/O cable.

- For controller-supplied power, jumper +24VDC from pin 30 to pin 25 and 24V_RTN from pin 29 to pin 27.

For additional information please contact Brooks Automation.

Miscellaneous I/O Connector Pin Out

Discrete I/O provides monitoring and control of external device functions using individual I/O pins for each function with no additional control, or “handshaking” lines.

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Table 3-12: I/O Assignments

Pin #	Operational Interlock	Pin #	Operational Interlock
1	EXT_IN0 (input 1)	26	+PWR_ISOL
2	EXT_IN1 (input 2)	27	+PWR RET ISOL
3	EXT_IN2 (input 3)	28	+PWR RET ISOL
4	EXT_IN3 (input 4)	29	+24V RET
5	EXT_IN4 (input 5)	30	+24VDC
6	EXT_IN5 (input 6)	31	DRV_OUT0 (output 1)
7	EXT_IN6 (input 7)	32	DRV_OUT1 (output 2)
8	EXT_IN7 (input 8)	33	DRV_OUT2 (output 3)
9	EXT_IN8 (input 9)	34	DRV_OUT3 (output 4)
10	EXT_IN9 (input 10)	35	DRV_OUT4 (output 5)
11	EXT_IN10 (input 11)	36	DRV_OUT5 (output 6)
12	EXT_IN11 (input 12)	37	DRV_OUT6 (output 7)
13	EXT_IN12 (input 13)	38	DRV_OUT7 (output 8)
14	EXT_IN13 (input 14)	39	DRV_OUT8 (output 9)
15	EXT_IN14 (input 15)	40	DRV_OUT9 (output 10)
16	EXT_IN15 (input 16)	41	DRV_OUT10 (output 11)
17	EXT_IN16 (input 17)	42	DRV_OUT11 (output 12)
18	EXT_IN17 (input 18)	43	DRV_OUT12 (output 13)
19	EXT_IN18 (input 19)	44	DRV_OUT13 (output 14)
20	EXT_IN19 (input 20)	45	DRV_OUT14 (output 15)
21	EXT_IN20 (input 21)	46	DRV_OUT15 (output 16)
22	EXT_IN21 (input 22)	47	DRV_OUT16 (output 17)
23	Safety Interlock	48	DRV_OUT17 (output 18)
24	Safety Interlock	49	DRV_OUT18 (output 19)
25	+PWR_ISOL	50	DRV_OUT19 (output 20)

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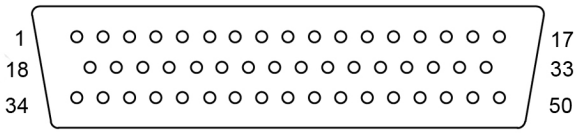


Figure 3-22: I/O Assignment Pin Locations

Power Status

This connection port is reserved for future use.

Diagnostics

The diagnostics connection is a optional feature on the MagnaTran LEAP robot that performs health monitoring and fault-diagnostics. Health monitoring assesses the performance of the robot and reports when a problematic condition is identified. Fault-diagnostics aids in troubleshooting to determine error codes, fault location, and fault severity.

For more information on the diagnostics feature of your MagnaTran LEAP, please contact your Brooks representative.

Auxiliary

The auxiliary connection on the Robot I/O panel provides an additional Ethernet port on the MagnaTran LEAP robot.

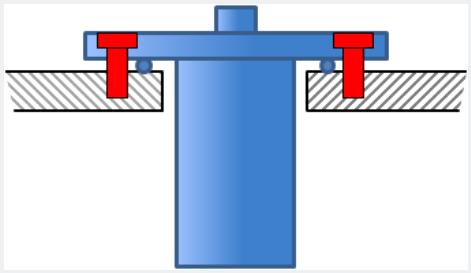
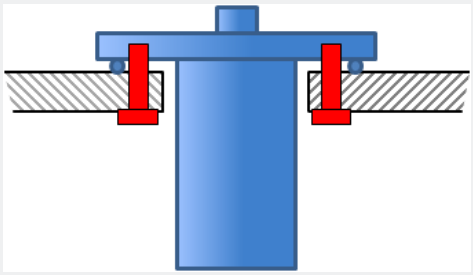
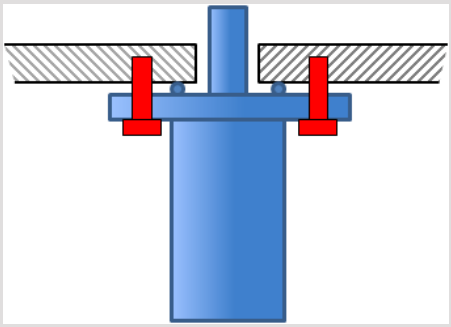
Center Of Gravity

The Center of Gravity for each robot depends on the specific drive, armset, and end effector configuration. Refer to interface drawings or contact Brooks Technical Support for the specific Center of Gravity of your robot. For more information on contacting Brooks Technical Support, please see "Contact Brooks Automation Technical Support".

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Robot Mounting

Table 3-13: Robot Mounting Configurations

	Top Bolt	Bottom Bolt
Top Mount		
Bottom Mount		

Brooks Automation does not provide mounting hardware or a mounting flange o-ring/gasket for MagnaTran LEAP robots. It is the responsibility of the robot integrator to mount the robot to a chamber.

The typical MagnaTran LEAP Mounting Flange has threaded holes and alignment pins for mounting the robot to a chamber. The robot should be aligned in the system so the drive I/O panel is accessible.

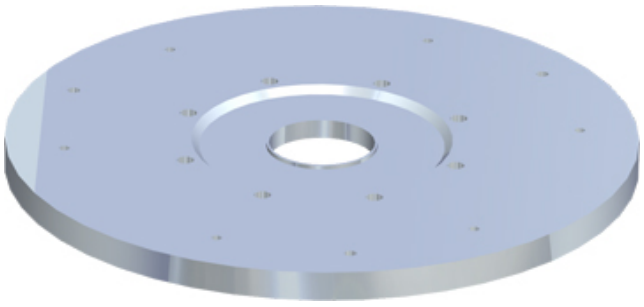


Figure 3-23: Top of Robot Mounting Flange

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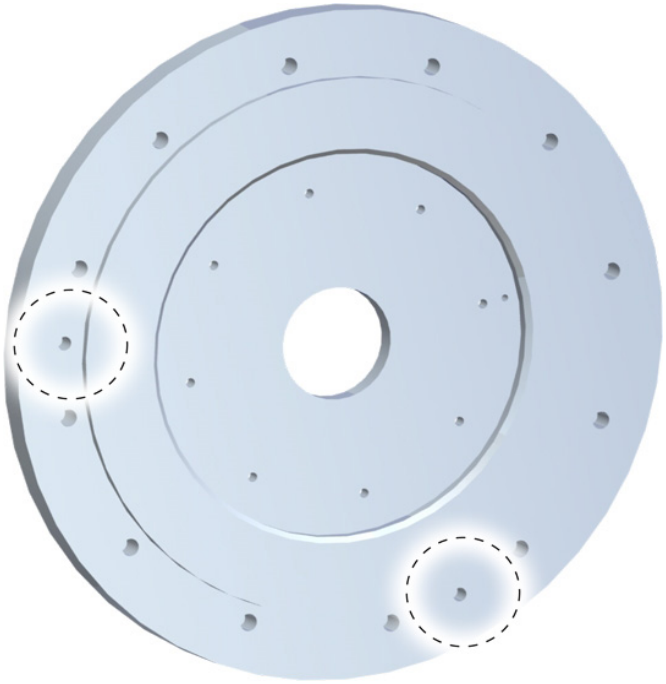


Figure 3-24: Sample Alignment Pin Locations

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4. Armsets

Depending on the MagnaTran LEAP robot configuration, the armset is shipped mounted to the drive or as a separate unit. If shipped separately, the arms are installed after the drive has been mounted into the robot central vacuum transport chamber.

Robots containing two theta motors are considered coaxial drives, robots with three motors are labeled tri-axial drives, and robots with four theta motors are considered quadaxial drives.

Table 4-1: Definitions

Term	Definition
Radial Motion (R Motion)	Movement of the robot's end effector towards or away from the center of the robot.
Theta Motion (T Motion)	Rotation of the robot end-effector about the center of the robot.
CW/CCW	CW: Clockwise CCW: Counter Clockwise. Sometimes called "anti-clockwise"
Z Motion	Movement of the robot arm up or down.
Robot Cycle	A sequence of motion which extends one of the robot's arms into and then retracts it out of a station. For example, each pick or place operation is counted as a cycle.
Arm A/B	An arm is a set of mechanical linkages which is capable of carrying material. If the robot has multiple arms which are stacked, the conventional designation is that ARM A is above ARM B. If the robot has multiple arms which are placed horizontally, ARM A is aligned with the zero of the theta axis.
Shoulder Joint	A joint which permits the first linkage to rotate relative to the robot mounting flange.
Elbow Joint	A joint which permits the second linkage to rotate relative to the first linkage.
Wrist Joint	A joint which permits the end-effector to rotate relative to the previous linkage to control the orientation of the end-effector. Depending on the robot arm design, the wrist joint may be passive or actively driven by a motor.

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Term	Definition
Upper Arm	The first linkage of an arm from the center of the robot to the elbow joint. The upper arm rotates about the shoulder joint. Typically, if the upper arm linkage is rotated by itself, the arm will execute a theta motion.
Forearm	Typically, the second linkage of an arm from the second joint to the wrist. The forearm rotates about the elbow joint. Typically, the forearm is rotated in conjunction with the upper arm to execute a radial motion.
Wrist Plate	The first part of the final linkage upon which end-effectors are mounted. The wrist plate rotates about the wrist joint.
End Effector (Pan)	The second part of the final linkage which carries the material. The end effector is mounted onto the wrist plate.
Batwing	Wrist plate upon which two end-effectors are mounted, side-by-side.

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5. Set-up and Operation

Basic Set-up Procedure

This Basic Set-Up Procedure is a walk-through from starting up the MagnaTran LEAP robot, cycling wafers, and finally shutting down the robot. Each step is linked to a section for more details and explanations.

WARNING

Robot Mounting

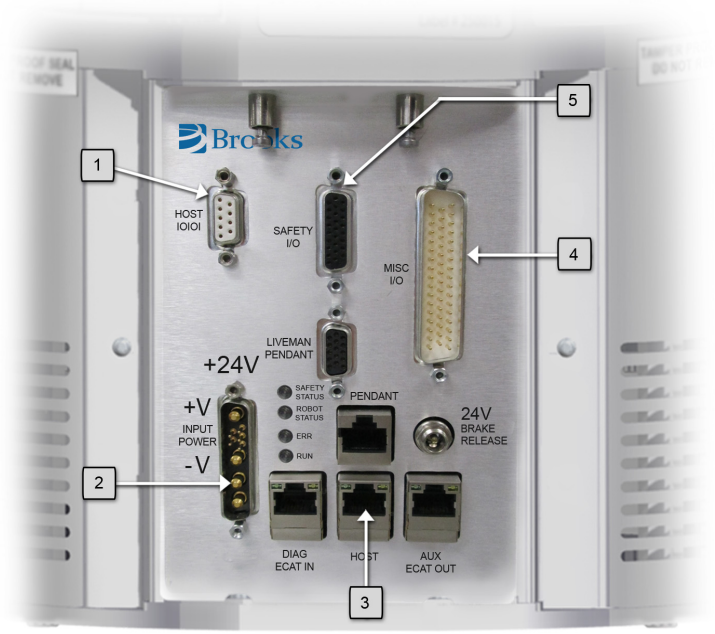
The robot must be mounted in a rigid test stand or system application before applying power. Improperly mounted robots can cause excessive vibration and uncontrolled robot movement which may cause death or serious injury.

- Always mount the robot in a secure test stand or system before applying power.



Step	Action
1.	Confirm that the robot has been properly mounted in the system.

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Step	Action
2.	Confirm connections to the I/O panel are properly installed: • An Ethernet cable or serial cable from the Host System Controller (or from a laptop running RSU) is plugged into the HOST IOIOI or Ethernet port. If necessary, use the CDM to select the desired HOST interface for your configuration. • An HD-Sub 26 Pin Connector from the completed/satisfied safety controller or a jumper (Brooks PN 248841) is plugged into Safety I/O. • A D-Sub 50 Pin Connector from a completed/satisfied Miscellaneous I/O circuit or a jumper (Brooks PN 250343) is plugged into the Misc I/O. • A D-Sub Combo-D female Connector (Molex FM3W3S-K121 or equivalent) power connection cable from a 24V or 48V power source is plugged into the Power Connection Port.  For more information on the connections to the I/O panel, please see "Host Communication" on page 102 "Host Communication" on page 102, "Embedded Safety Controller" on page 147, "Misc I/O" on page 76, and "Power Connection" on page 69.

Number	Explanation
1	Host I/O (Serial)
2	Power Connection
3	Host I/O (Ethernet)
4	Miscellaneous I/O
5	Safety I/O

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<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3.</td><td>Confirm any additional/optional connections to the I/O panel are properly installed:

• A Diagnostics Ethernet cable from a laptop into the Diagnostics port.
• A cable from an auxiliary device into the Auxiliary port.

<table>
<tr><th>Number</th><th>Explanation</th></tr>
<tr><td>1</td><td>Diagnostics (Ethernet)</td></tr>
<tr><td>2</td><td>Auxiliary</td></tr>
</table>
For more information on the optional connections to the I/O Panel, please see "Power Status" on page 88, "Diagnostics" on page 88, and "Auxiliary" on page 88.</td></tr>
<tr><td>4.</td><td>Robot Start-Up:

Turn on the customer supplied 24V or 48V Power Source to apply power to the robot.

For more information, please see "Start-Up" on page 99.</td></tr>
</table>

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Step	Action

5.	Load the Robot Application:
	a. Request the current Robot Application by entering the command:
	`RQ CONFIG`
	b. Compare the Robot Application Number against the Quality Record (QR) document.
	Example: *G116A-C062-BW013-QF009-W001-L3150P*
	c. If Robot Application Number is different than the QR document, load the correct Robot Application Number by entering the following command:
	`CONFIG ROBOT APLIC` *application_id* (where *application_id* is the proper application identification for the robot configuration being used, similar to the example above, including hyphens)
	If the Robot Application ID cannot be loaded, contact Brooks Automation Technical Services.
	d. Check the arm configuration by entering the command:
	`RQ ARMS`
	e. If the Request Arms command reports that the arm is off send the command:
	`SET ARMS ON`
	
	For more information, please see "Robot Application Number" on page 104 and "Arms On/Off" on page 105.

6.	If creating a new Home Position, enter the Find Zero command. In most cases, only the Radial and Theta Positions will be set to a customer-desired location.
	a. Enter the Request Sync Zero command:
	`RQ SYNC ZERO ALL`
	b. Record the results of the Sync Zero All command.
	c. Deservo the robot with the command:
	`SET SERVOS OFF`
	d. Install the Zeroing Fixture for your tool configuration.
	e. Enter the command:
	`FIND ZERO T`
	The T1, T2, (and optional T3 and T4) positions are set.
	f. Enter the Request Sync Zero command again:
	`RQ SYNC ZERO ALL`
	g. Record the second set of results from the Sync Zero All command.
	h. Remove the Zeroing Fixture.
	i. Home the robot with the command:
	`HOME ALL`
	j. If the home position is correct, send the command:
	`STORE SYNC ZERO ALL`
	
	For more information and/or to change the Z home position, please see "Zero Position" on page 107.
	NOTE:
	The MagnaTran LEAP has absolute encoders. Find Zero T takes effect immediately, independent of arm type. The armset needs to be positioned at the correct home position prior to the Find Zero T command. This is different than the procedure used for the Magnatran 7 and Magnatran 8 encoders.

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Step	Action
7.	Enter the Home command: `HOME ALL` The robot moves to the Home position. For more information, please see "Homing the Robot" on page 106.
8.	Create Stations using either the Teach Pendant or the Command Line. For more information, please see "Station Setup" on page 108.
9.	Cycle wafers. For more information, please see "Cycling and Transferring Wafers" on page 145.
10.	Shut down the robot if necessary or desired. For more information, please see "Shut-Down" on page 146.

Theory of Operation

The MagnaTran LEAP robot provides control for either a single arm or dual semi-independent arms through a single concentric shoulder-shaft mechanism. The shoulder shaft mechanism provides the drive to the left and right arm mechanisms on both the single and dual arms. The single arm, referred to as “Arm A”, and the dual arms, referred to as “Arm A” and “Arm B,” are configured in software for full motion in three axes: Radial (R), Rotational (T), and, Vertical (Z).

A station coordinate system provides a convenient shorthand for commanding the robot where to move. Each station is identified by its Theta position, its Radial position (amount of arm extension), and its Z position (vertical distance from Home). By defining the stations in this manner it is only necessary to provide the robot with the station number instead of the complete coordinate set each time a command is issued to the robot.

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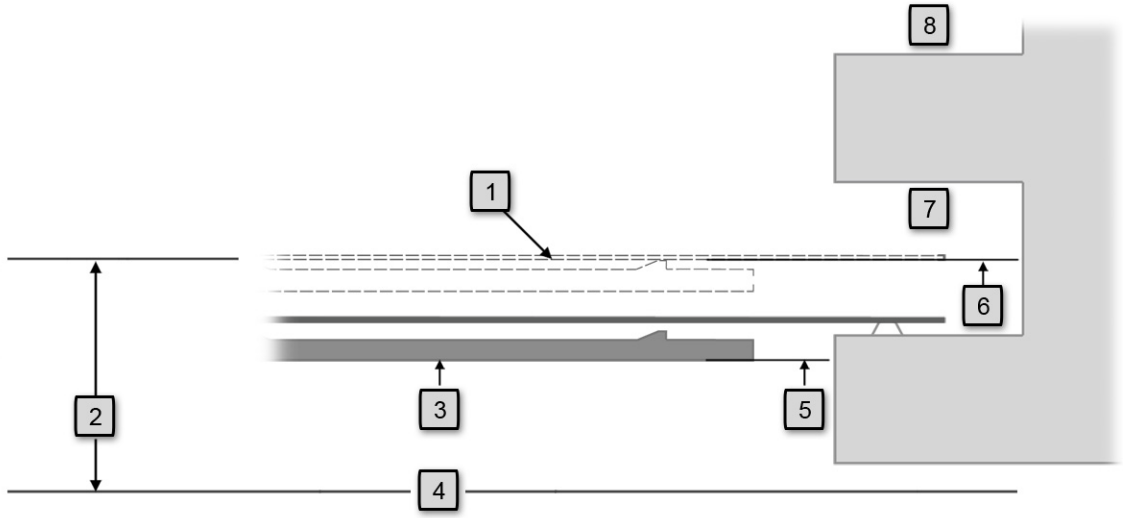


Figure 5-1: MagnaTran LEAP Z Axis Parameters

Table 5-1: MagnaTran LEAP Z-axis Parameters - Explanation

Number	Explanation
1	Wafer Transport Plane (WTP) - Bottom surface of wafer
2	Base Transfer Offset (BTO)
3	End Effector
4	Robot Home (Z-axis)
5	Lower
6	Center Line
7	Slot #1
8	Slot #2

When the Z-axis is used there are a number of additional parameters that the user must define. The Base Transfer Offset (BTO) provides the vertical distance from the robot's Home position to the systems Wafer Transfer Plane (WTP). The Lower parameter provides the distance from the WTP that the robot must move down to deposit a wafer, which also defines the height that the robot must enter a module to pick up a wafer.

The Slot parameter is used to define the number of slots in a station (the default is one) and to specify the slot the robot's operation will be performed on (if none is specified the default is assumed). The Pitch parameter is used to define the distance between slots. When using the Slot and Pitch parameters, the total number of slots may not exceed the vertical distance that the robot is capable of traveling.

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Start-Up

The MagnaTran LEAP robot is started by applying power. When power is applied, the robot goes through it start-up procedure , which can take up to a minute. Once this is done, the robot is ready to operate. The robot will accept commands through the Host serial port or the Host Ethernet port. If the teach pendant has been turned on, the robot will only accept commands from the keypad entries.

NOTICE

All communication connections and power connections should be made before power is applied.

NOTE: Once power is applied, the robot will enter a “start-up” state, which assumes that wafers are present on the end effectors. The speed of all arm motions are governed by this start-up state until the robot is either commanded to “place” the wafers or instructed that the end effectors are empty using the “LOAD” command.

WARNING

Automatic Movement

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

- Know the product's range of motion and stay out of the product's range of motion when the product is energized.
- Place physical barriers to prohibit others from entering the working range of the product.
- Follow safe practices for working with energized products per the facility requirements.
- Do not rely on the system software or process technology to prevent unexpected product motion.



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CAUTION

Training and Unauthorized Service

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

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



Single Point of Control (Host Interface or Teach Pendant)

The MagnaTran LEAP robot may be operated in either of two ways: Directly by the Host Interface or through the use of the hand-held teach pendant. The robot cannot be controlled by two sources at the same time.

NOTE: This manual uses the term “teach pendant.” Teach pendants are commonly referred to as Control/Display Module (CDM).

When being operated by the Host Interface, the robot will respond to the software commands it receives through the Ethernet port or the serial communications port. When being operated by the teach pendant, the robot responds directly to the commands entered manually on the teach pendant.

The Teach pendant takes priority when it is plugged in and turned on. When the teach pendant is in use it locks out motion communication with the Host Interface; the Host communication can only query the controller. If a command is sent from the Host Interface while the teach pendant is in control the host will receive an unsolicited error message “Teach pendant has control of the robot”.

Understanding Command Syntax

Commands are shown as `MONOSPACE TEXT` and should be typed into the user interface at the command prompt.

Information (data) can be specified for entry in several ways.

Specific Entries

`Fixed Keywords - CAPITAL LETTERS`

Text in capital letters defines the exact text required as an input to the system.

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Example: `RQ VERSION`

Version is a request command that responds with the version number of the robot software. The system requires "`RQ VERSION`" to be entered exactly as shown.

User Provided Arguments - *lowercase italicized text*

Lowercase italicized text defines the name of the variable or integer required as an input to the system. Enter the value for that variable. Lowercase italicized text is also used in the syntax of command responses to show variables.

Example:`RQ STN station ALL`

The Request Station command requests the parameters from a specific station. The argument ALL requests all the parameters associated with that station. Type `RQ STN` exactly as shown and then enter the appropriate station number: `RQ STN 1 ALL`.

Selectable Arguments(Parenthesis)

Text in parenthesis "( )" separated by a vertical line "|" defines a set of options, one of which is required as an input to the system. Do not type the parenthesis or the vertical line.

Example: `RQ STN station ARM (A|B) ALL`

The Request Station command requests the parameters from a specific station. If the robot has more than one arm/end effector, the user must specify the arm. To request all the parameters for station 1 for arm A, type: `RQ STN 1 ARM A ALL`.To request all the parameters for station 1 but for arm B, type: `RQ STN 1 ARM B ALL`.

Optional Entries

Optional Arguments [Brackets]

Text in brackets is optional. A single item may appear in brackets as an optional entry, "[EXAMPLE]", or a group of options may appear in brackets, "[EX1 | EX2 | EX3]". If there is more than one option listed in the brackets, only one item should be entered.

Example: `RQ STN station [[ARM] (A|B)]`

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Multiple Selection Arguments {Braces}

Text in brackets “[ ]” defines an optional entry. Text in braces “{ }” within brackets defines a set of options, one or more of which is required as an input. Do not type the braces or the brackets.

Example:`HOME [(ALL) | {R|T|Z|S|W|WA|WB}]`

The `HOME` command allows the user to home all robot axes, or to choose specific axes. `HOME R T` will home the Radial and Theta axes, while not moving the Z or any other axis.

Sending Commands

Commands should be followed by a carriage return (Enter) to indicate that the command should be executed. Commands are completed when either a "_RDY" or "_DONE" is received, depending on the communication mode. “_RDY” and “_DONE” indicate that a new command can be sent.

Host Communication

To switch control between the serial and Ethernet connections use the command:

```
RESET TO(SERIAL|ENET)
```

Serial

Serial communication between the robot and a Host Controller is accomplished by connecting a 3 wire serial communications cable from port “HOST |O|O| on the robot I/O to a serial I/O port on the Host Controller.

The connection to the MagnaTran LEAP robot from the external controller uses RS-232 serial communications. The configuration for the robot’s serial communications protocol for all serial connectors is described in Table 5-2.

Table 5-2: RS-232 Protocol

Default Port Configuration	RS-232
Baud Rate	9600
Data Bits	8
Parity	None
Stop Bits	1

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Ethernet

The MagnaTran LEAP robot can be operated by an external controller through Ethernet communications. Connect the cable for Ethernet communications to the connector on the bottom of the drive on the robot I/O panel.

NOTE: Customers must use Ethernet cables with ferrite protection when making the connection to the robot.

Table 5-3: Ethernet Communications

IP (Default Setting)	SubNet	Port
20.20.249.2	255.255.255.0	1102

The IP address is often customized by the OEM.

To request the IP address of the robot, enter the command:

```
RQ ENET IP
```

To change the IP address of the robot, enter the command:

`CONFIG ENET IP` *ipaddress* `MASK` *mask*

Examples:

```
CONFIG ENET IP 20.20.249.2 MASK 255.255.255.0
RQ ENET IP
IP 20.20.249.2 MASK 255.255.255.0
```

Basic Communication Settings

Communication settings are typically customized for the OEM.

Communication settings can be requested by entering the command:

```
RQ COMM ALL
```

Communications can be set to packet mode by entering the command:

```
SET COMM M/B PKT
```

Sequential mode can be achieved by entering the command:

```
SET COMM FLOW SEQ
```

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For more information on setting and requesting additional communication settings, contact your Brooks representative. Please see "Contact Brooks Automation Technical Support".

Robot Application Number

MagnaTran LEAP robots can be equipped with many arm types. Whether arms handle one, two or four wafers, arm geometries vary considerably in length, weight, and location of the wafer. To ensure robot performance, Brooks Automation assigns an Application Number to each robot design. The Application Number contains data required by the Brooks-proprietary motion engine.

The Brooks application number means:

- Convenient consolidation of motion parameters
- No requirement for on-site robot tuning
- Consistent robot accuracy and repeatability
- Virtually identical throughput on a given tool platform

WARNING

Do Not Use Unauthorized Parts

Uncontrolled Motion will likely occur if the robot drive, robot arm(s), and end-effector do not agree with the robot application number. Maximum torque could be momentarily applied. Significant power levels are present that may cause death, serious injury, or equipment damage.

Always verify the part number for the robot drive, the robot arms and the end-effectors match the application number loaded into the robot controller. Use the QR document shipped with the robot to verify part numbers and the application number.

- Do not use unauthorized parts.
- Confirm that the correct robot application is being used.
- Always have Brooks Automation update the robot application if new parts are changed or added to the robot.



To request the Robot Application being used enter either of the following two commands:

```
RQ ROBOT APPLIC

RQ CONFIG
```

The commands return an ID number. Have this ID number ready when contacting Brooks Technical Support. For more information on contacting Brooks Technical Support, please see "Contact Brooks Automation Technical Support".

An example ID number is: G001-C001-P001-DS001-W001-L3100M.

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Load an Application

Step	Action
1.	Request the current Robot Application by entering the command: `RQ CONFIG`
2.	Compare the Robot Application Number against the Quality Report (QR) document.
3.	If Robot Application Number is different than the QR document, load the correct Robot Application Number by entering the following command: `CONFIG ROBOT APLIC` *application_id* ***NOTE:*** *Ensure that hyphens are included when typing in a Robot Application.* If the Robot Application ID cannot be loaded, contact Brooks Automation Technical Services.
4.	Confirm the arm configuration is correct.
5.	If the Request Arms command reports that the arm is off send the command: `SET ARMS ON`

Arms On/Off

In some circumstances, the MagnaTran LEAP may be powered on and operated without an armset installed. Use the Set Arms command to configure the robot to arms on or off, and use the Mount command to find, set, request, and store the axes positions for arm installation.

Set Arms Format:

`SET ARMS` (`ON`|`OFF`)

Mount Format:

`MOUNT`

`FIND MOUNT`

`SET MOUNT` [(`R`|`T`|`Z`|`W`|`S`|`WA`|`WB`) *value*]]

`SET MOUNT` <`ARM`> `B` [(`R`|`T`) *value*]]

`RQ MOUNT`

`STORE MOUNT`

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Homing the Robot

The robot enables motor power and then enables the servos (starts applying power to the motors to hold the robots current position), releases the Z brake, and then moves into the position of the minimum radius.

Sequence for multi-axis homes:

- R axis (moves toward retract position)
- T axis (moves to Theta = 0)
- Z axis (moves to lowest z position)

The Home command is most often used immediately after start-up, when recovering from a motion error, and before shut down in order to place the arm in a safe location.

All axes can be homed by entering the command:

```
HOME ALL
```

Individual axes can be homed by entering the Home command followed by the specific axis:

```
HOME R

HOME T

HOME Z
```

Robot Zero and Home Positions

Home

The Brooks default home position is the position of the arm that achieves the smallest possible radius for theta motion. The Brooks default home position for the standard drive orients end effector A at 90° counter-clockwise from the interface panel.

The Home position can be defined by customer application by setting the zero positions.

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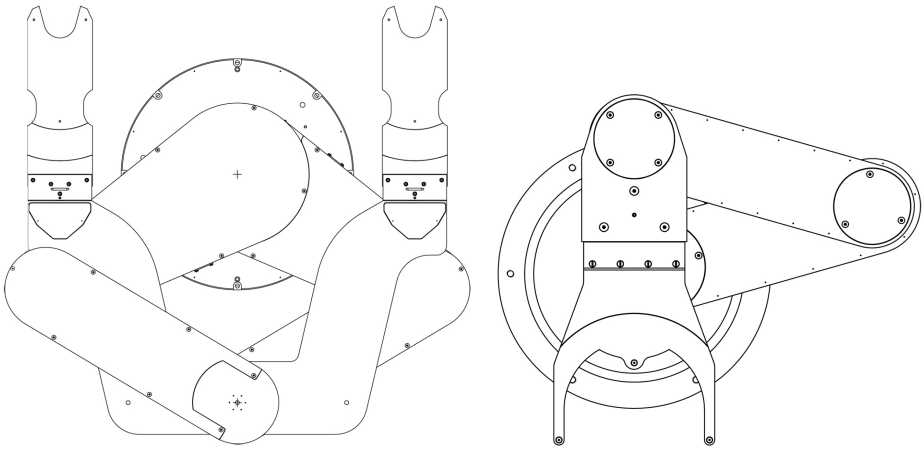


Figure 5-2: Typical Home Positions

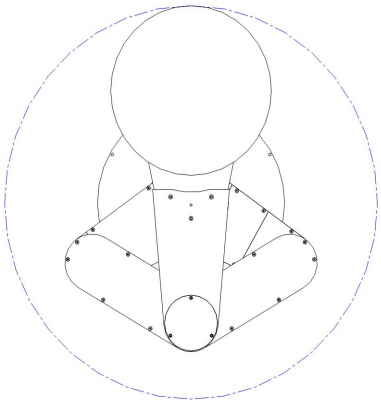


Figure 5-3: Typical Home Position for Radius arm

Zero Position

NOTICE
Always Zero the robot if hardware has been changed. Always use a zeroing fixture if the Theta 0 position is being changed.

The Home position is set relative to the Zero positions of the Theta axes. The Home position can be defined by customer application by changing the Zero position.

For SCARA Armsets, a new Zero Position can be established by moving the robot into the Arm Over Arm position (the Forearm is directly over the Upper Arm) with the End Effector in the desired

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direction, and then issuing the Find Zero or Set Sync Zero commands. The Find Zero command will change the Theta Axis, while the Set Sync Zero command will change T1, T2, Z, or All axes.

The Zero commands can find, set, request, and store the Zero position of the robot.

```
FIND ZERO (T|Z)

SET SYNC ZERO (T1|T2|Z)position

RQ SYNC ZERO [ALL| (T1|T2|Z)]

STORE SYNC ZERO [ALL| (T1|T2|Z)]
```

NOTE: The MagnaTran LEAP has absolute encoders. Find Zero T takes effect immediately, independent of arm type. The armset needs to be positioned at the correct home position prior to the Find Zero T command.

Operational Modes

The MagnaTran LEAP Safety System provides three modes of operation: Automatic, Stop, and Manual. The Operational Mode Selector allows the user to change Modes. Teaching the robot and using the Teach Pendant must be done in Manual Mode. For more information, please see "Operational MODE Inputs" on page 160.

Station Setup

Stations are assigned numbers to represent their location coordinates inside a system. Instead of telling a robot the radial, theta, and z units each time we want it to go to a station, we simply tell a robot to go to Station 1. All station numbers are dependent upon the specific system configuration. Stations are typically numbered in a clockwise direction around the robot. Assigning a station number for each module connected to the system allows a convenient shorthand for directing all robot motion and ensures that all wafer movement to and from the stations remains consistent. All arms must be separately taught each station. If only Arm A has been taught Station 1, Arm B is incapable of going to Station 1.

Each station represents a module connected to the system. A module may be a Vacuum Cassette Elevator, a load lock, an InLigner, a wafer flipper, a customer's process module, etc. A single module may have more than one station assigned to it. For example, a Dual Stacked Load Lock has two shelves, an upper and a lower. The stations will have the same Theta and Radial coordinates, but different Z coordinates. Any modules with more than one station are numbered on a second clockwise circuit around the robot. In Figure 5-4 below, if the Process Modules all had two shelves, the upper shelves would be on the second clockwise circuit. Process Module A would have Station 3 and Station 7, Process Module B would have Station 4 and Station 8, and Process Module C would have Station and Station 9, and Process Module D would have Station 6 and Station 10.

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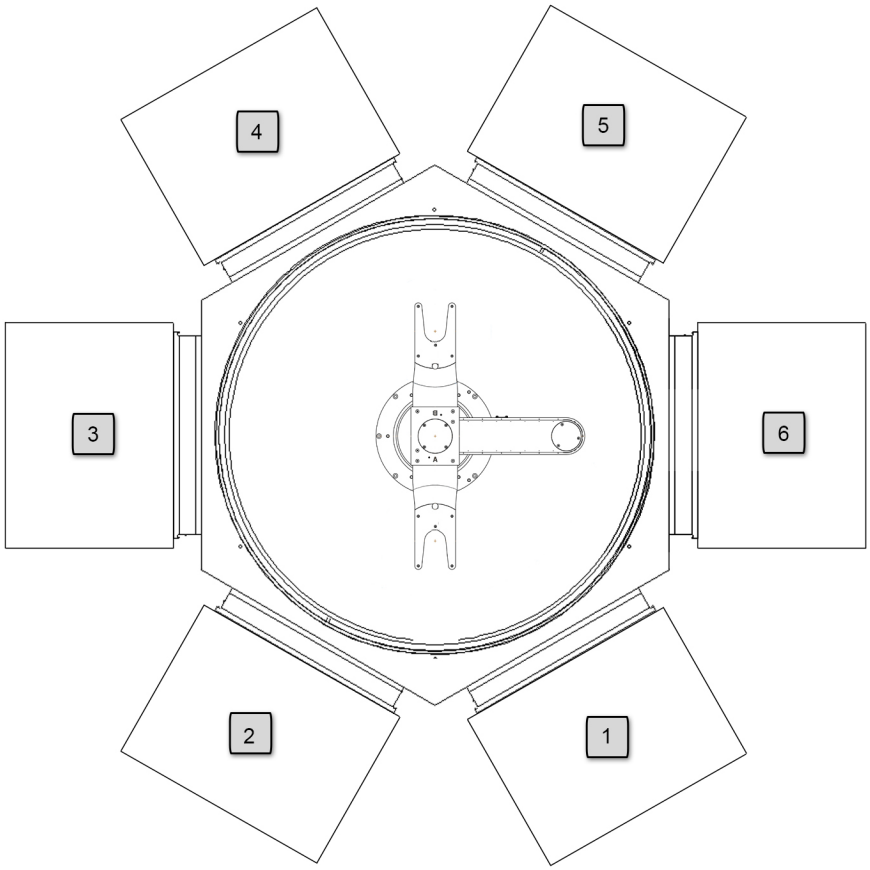


Figure 5-4: Example of Station Numbering and the Corresponding Modules

Table 5-4: Example of Station Numbering and the Corresponding Modules - Explanation

Number	Explanation
1	Station 1
2	Station 2
3	Station 3
4	Station 4
5	Station 5
6	Station 6

Defining Stations

Each station is identified by its Theta position (angle from Home), its Radial position (amount of arm extension), and its BTO/Z position (vertical distance from Home) and Lower (the vertical distance

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the arm must travel to place a wafer). By identifying the stations in this manner, it is only necessary to provide the robot with the station number instead of the complete coordinate set each time a command is issued to the robot. The shorthand system assigns a coordinate location for T, R, Z up and Z down.

Assigning Station Coordinates (per arm)

Stations are defined by each robot arm. Arm B cannot automatically go to a station created using Arm A and vice versa. Station coordinates for Arm B must also be taught before the robot can go to, pick, and place wafers with Arm B at that station.

For more information on station setup, contact your Brooks representative. Please see "Contact Brooks Automation Technical Support".

Assigning a Station with Known Coordinates

If the exact station coordinates are known, assigning stations can be done using the Command Line. Enter the commands Set Station, Request Station, and Store Station:

```
SET STN station <<(ARM).[(A|B)] [R rVal] [T tVal] [Z zVal] [LOWER lowDist] [Z_WAF
zWafVal] [NSLOTS numSlots] [PITCH pitch]
```

```
RQ STN station <<(ARM)> [(A|B)> ALL
```

```
STORE STN ALL
```

The following procedure uses a MagnaTran LEAP robot. The stations being created are Station 1 and Station 2. The coordinates of the station are:

- Station 1
  - R: 600000
  - T: 90000
  - Z: 20000
  - Lower: 6000
- Station 2
  - R: 600000
  - T: 10000
  - Z: 20000
  - Lower: 6000

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Step	Action
1.	Enter the Set Station command for Station 1 Arm A: `SET STN 1 ARM A R 600000 T 90000 Z 20000 LOWER 6000`
2.	Enter the Set Station command for Station 1 Arm B: `SET STN 1 ARM B R 600000 T 10000 Z 20000 LOWER 6000`
3.	Enter the Set Station command for Station 2 Arm A: `SET STN 2 ARM B R 600000 T 10000 Z 20000 LOWER 6000`
4.	Enter the Set Station command for Station 1 Arm B: `SET STN 1 ARM B R 600000 T 90000 Z 20000 LOWER 6000`
5.	Store all of the station parameters by entering Store Station command: `STORE STN ALL`
6.	Confirm all stations have been stored correctly by entering the Request Station command for each station: `RQ STN 1 ARM ALL`

Teaching a Station with the Liveman Teach Pendant - Function Keypad

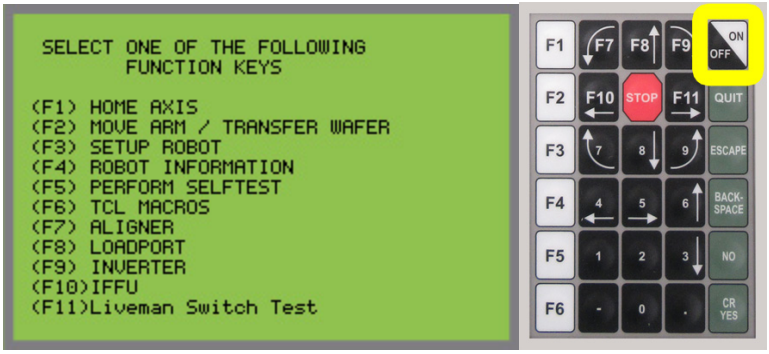
The following procedure is an example of teaching a station by jogging the end effector into position using the Liveman Teach Pendant with the function style keypad. The exact R/T/Z coordinates of the station are not known. The procedure uses Arm A of a MagnaTran LEAP.

> ***NOTE:*** The teach pendant screen images in the procedure may differ from the actual teach pendant screen.

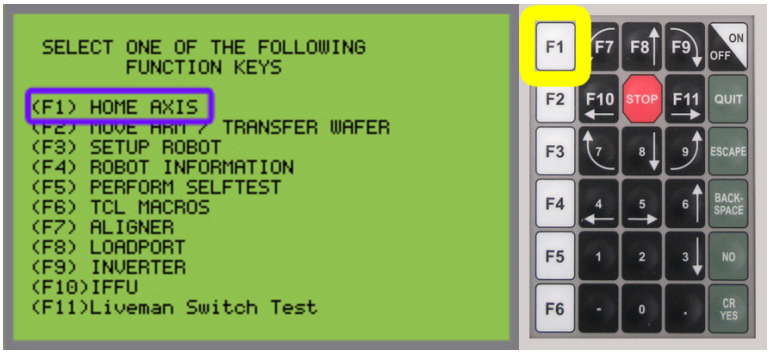
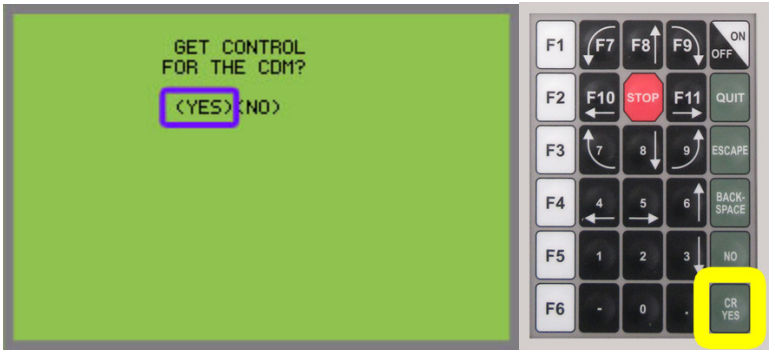
In order for the robot to move, the Liveman switch must be in the engaged position. The engaged position is the midpoint of the switch, between fully released, and fully pressed. For more information on the Liveman Switch operation, please see "Liveman Teach Pendant 3 Position Design" on page 179.

Step	Action
1.	Confirm that the MagnaTran LEAP robot is powered on.
2.	Turn the mode selector to Teach Mode.
Connect the Teach Pendant to the Robot:	

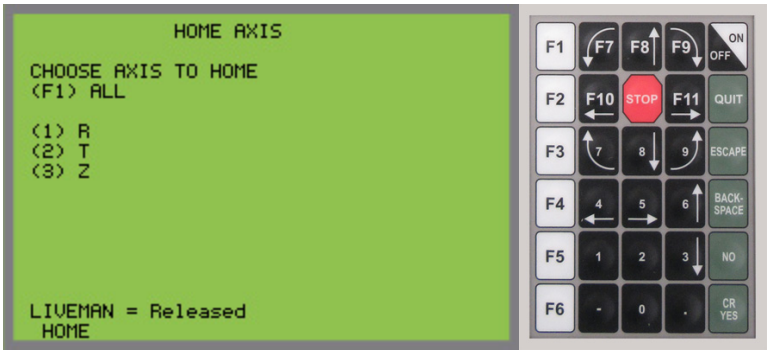
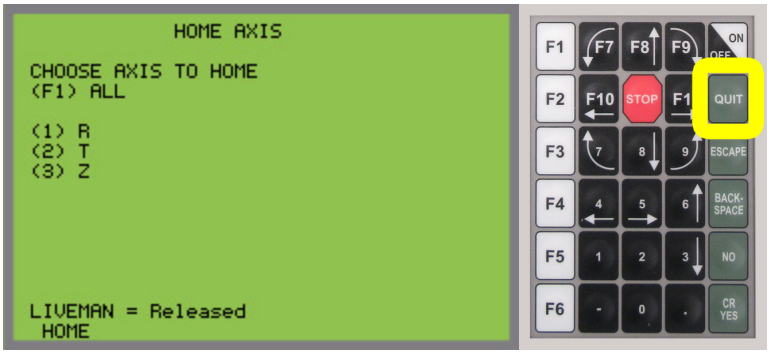
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Step	Action
3.	Connect the cable from the teach pendant to the robot. 
4.	Confirm that the E-Stop button on the teach pendant is released.
5.	Turn the teach pendant on by selecting **On**. The teach pendant turns on and the *Function* screen is displayed. 
Establish Local Control of the Robot:	
6.	Fully release the liveman switch before choosing a function.

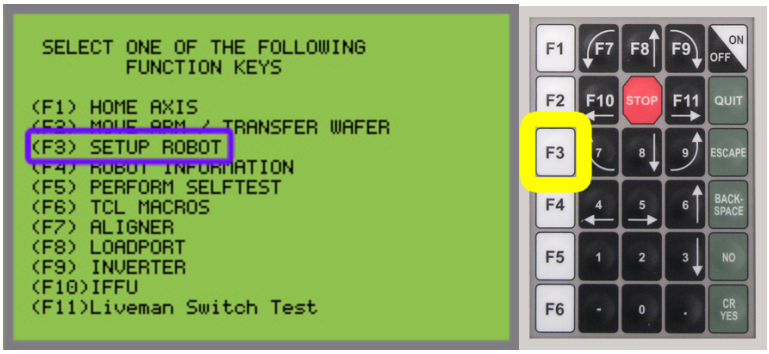
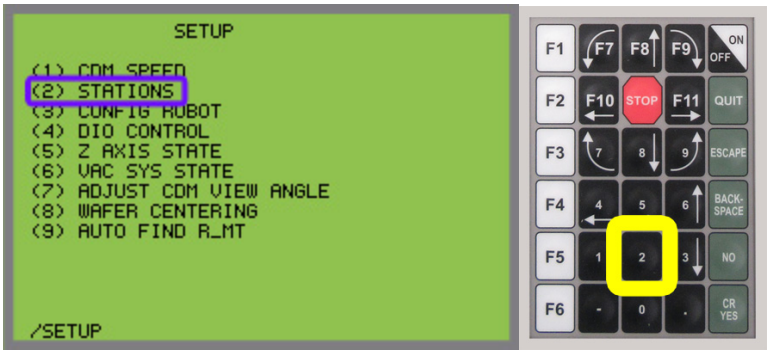
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Step	Action
7.	Select **(F1) Home Axis** from the *Function* screen by pressing the **F1** button on the keypad. The *Get Control* screen is displayed. 
8.	Select **YES** from the *Get Control* screen by pressing **CR YES** on the keypad. The *Home Axis* screen appears. 
Home the Robot:	
9.	Engage the liveman switch. The LIVEMAN status changes from released to engaged on the screen. 

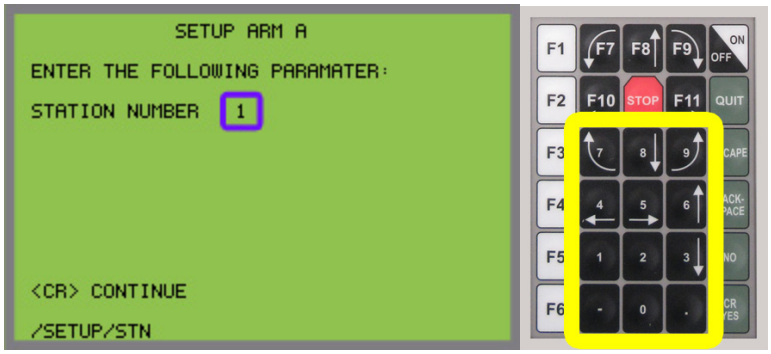
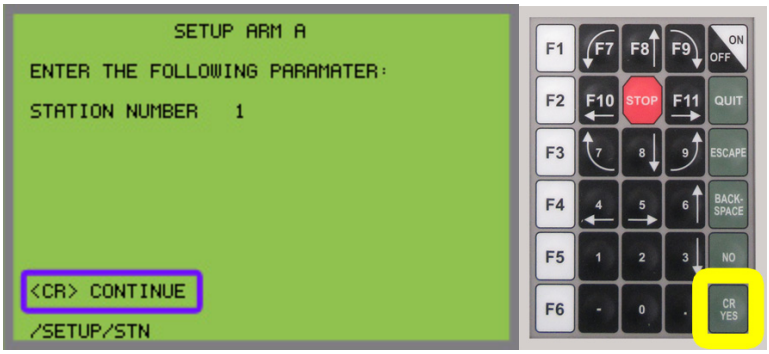
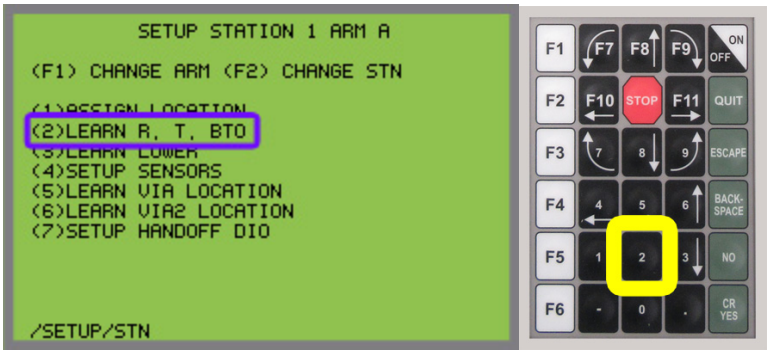
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Step	Action
10.	Select **All** by pressing the **F1** button on the keypad. Keep the liveman switch engaged the entire time the robot is homing or the robot will stop and an error message will appear on the screen. 
11.	When the robot has finished homing the teach pendant makes a beeping sound. Release the liveman switch. 
12.	Press **QUIT** on the keypad to go to the *Function* screen. 
Enter the Robot Setup Mode to Teach the Station Location:	

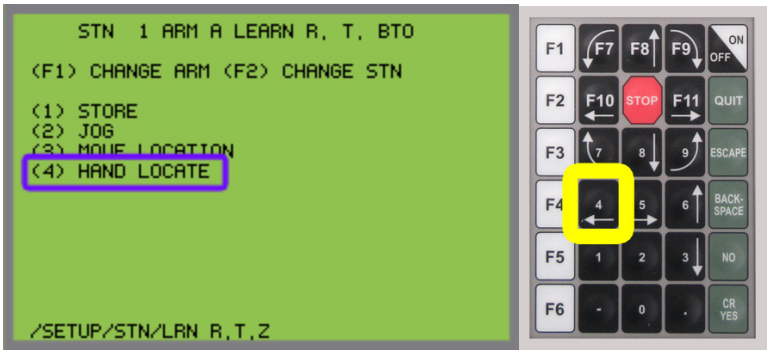
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Step	Action
13.	Select **Setup Robot** on the *Function* screen by pressing the **F3** button on the keypad. The *Setup* screen is displayed. 
14.	Select **(2) Stations** on the *Setup* screen by pressing **2** on the keypad. The *Arm Selection* screen is displayed. 
Specify the Arm and Station to be Taught:	
15.	Select the arm to be taught from the *Arm Selection* screen. The *Setup Arm A* screen is displayed. For single arm configuration, this step is skipped. 

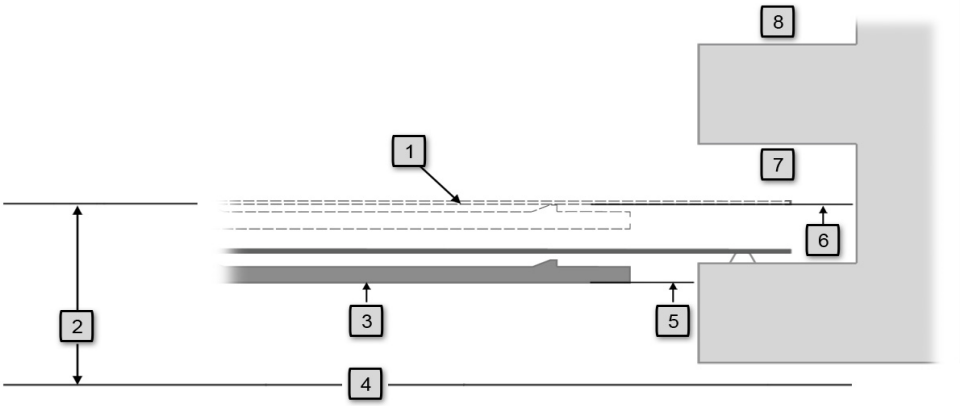
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Step	Action
16.	From the *Setup Arm A* screen enter the station number to be taught (these examples will use “Station 1”). 
17.	Press the **CR YES** button on the keypad to confirm station number. Press **CR**. The *Teach Selection* screen is displayed. 
Teach the Robot the Station by Jogging the End Effector to the Station Location Using the Motion Control Keys on the Teach Pendant Keypad:	
18.	Select **(2) Learn R, T, BTO** from the *Setup Station 1 Arm A* screen by pressing **2** on the keypad. The Teach Options screen is displayed. 

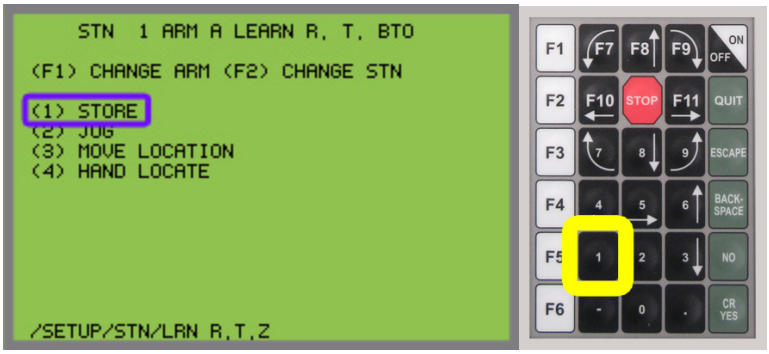
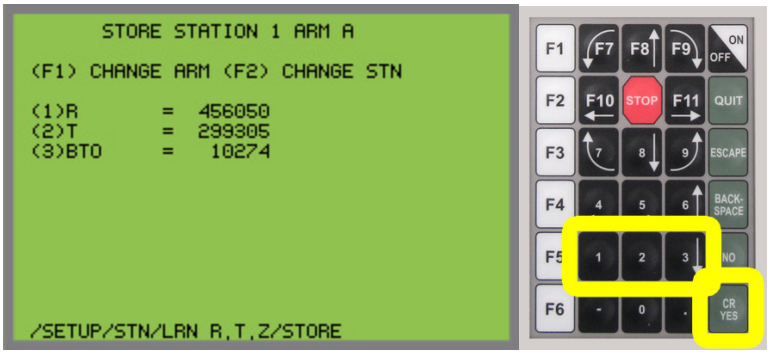
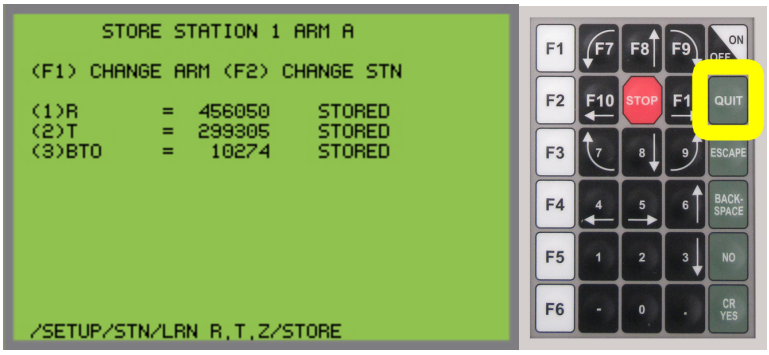
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Step	Action
19.	Select **(4) Hand Locate** from the Learn R, T, BTO Screen by pressing **4** on the keypad. The *Hand Locate* screen is displayed. Position the end effector in the station by hand. Skip to Step 23. If the system is already in vacuum and the robot arm cannot be manipulated by hand, select **(2) Jog** by pressing **2** on the keypad. The *Jog Arm* screen is displayed. 
20.	Engage the liveman switch before selecting the action.

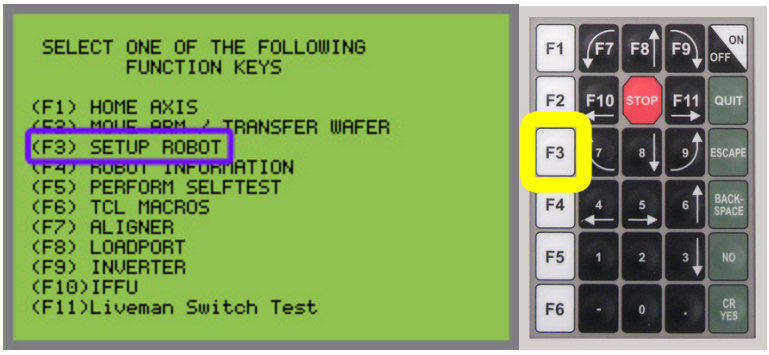
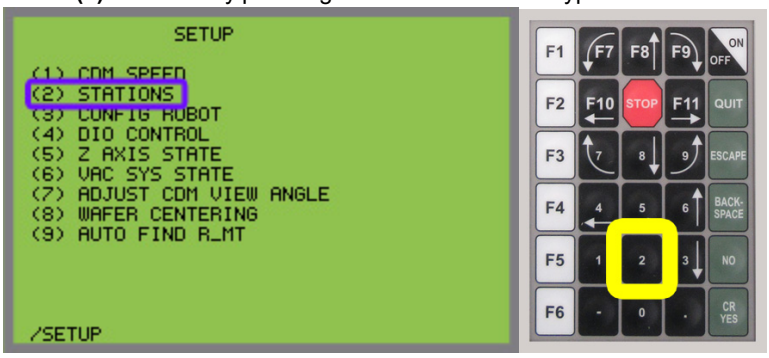
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Step	Action
21.	Move the end effector by using the keypad on the teach pendant. The position display on the *Jog Status* screen is updated with the end effector's current position.   **Number** / **Explanation** 1 — Wafer Transport Plane (WTP) - Bottom surface of wafer 2 — Base Transfer Offset (BTO) 3 — End Effector 4 — Robot Home (Z-axis) 5 — Lower 6 — Center Line 7 — Slot #1 8 — Slot #2
22.	Release the liveman switch when the end effector is properly located in the station.
23.	Press the **ESCAPE** button on the keypad to go back to the Learn R, T, BTO screen. (Or press the **F3** button to automatically jump to the *Store Location* screen).

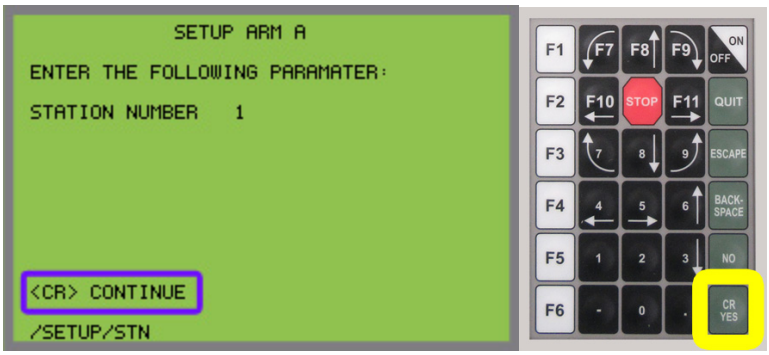
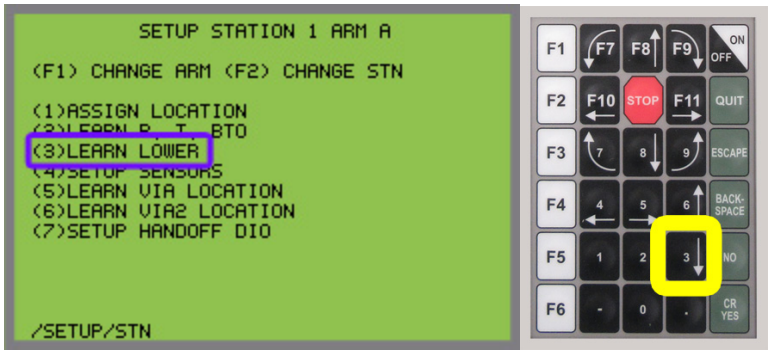
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Step	Action
Store the Taught Location of the Station:	
24.	Select **(1) Store** by pressing the **1** button on the keypad. The *Store* screen is displayed. 
25.	Select each axis to be stored by pressing the corresponding button on the keypad, or press **CR YES** to store all axes. STORED is displayed after the axis once it is stored.  NOTE: 2-axis robots will not have the Z-axis displayed.
26.	When all axes have been stored, press the **QUIT** button on the keypad to return to the Function screen. (Alternatively, press the **ESCAPE** button to return to the previous screens until you return to the *Setup Station* screen and then skip to Step 32.) 
Teach the Z-axis Lower Position for the Station:	

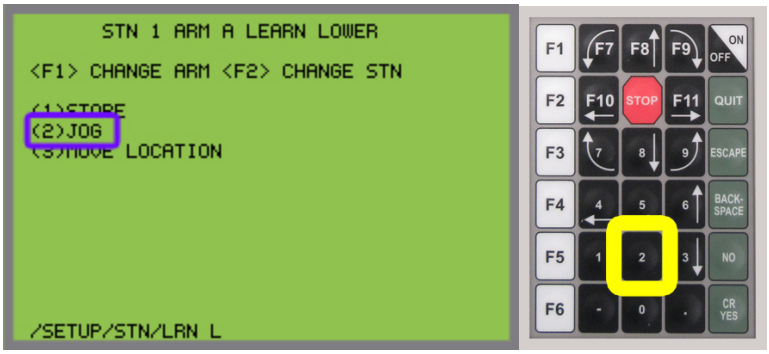
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Step	Action
27.	Select **(F3) Setup Robot** by pressing the **F3** button on the keypad. The *Setup* screen is displayed. 
28.	Select **(2) Stations** by pressing the **2** button on the keypad. The *Arm Selection* screen is displayed. 
29.	From the *Arm Selection* screen select the arm to be taught (these examples will use Arm A). The *Station Selection* screen is displayed. 

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Step	Action
30.	From the *Station Selection* screen enter the station to be taught (these examples will use Station 1). 
31.	Confirm the station number by pressing **CR YES** on the keypad. 
32.	From the *Teach Selection* screen select **(3) Learn Lower** by pressing the **3** button on the keypad. The *Teach Options* screen is displayed. 

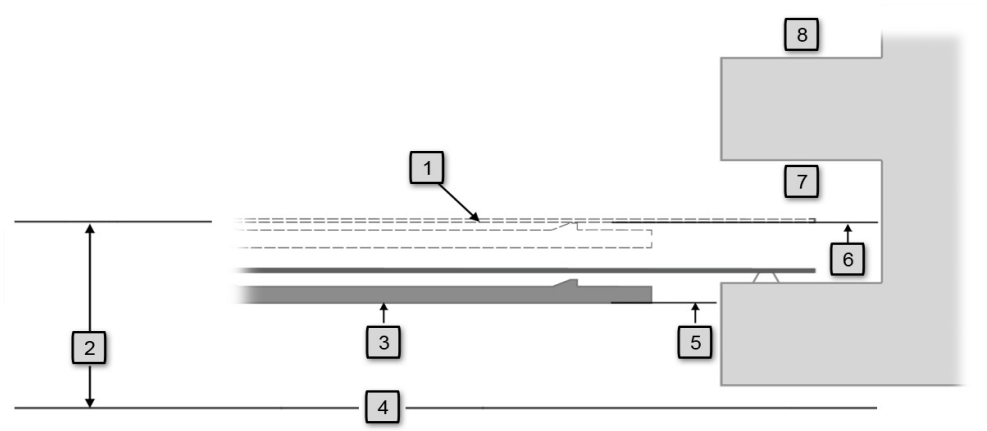
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Step	Action
33.	From the *Teach Options* screen select **(2) Jog** by pressing the **2** button on the keypad. The *Jog Z Status* screen is displayed. 
34.	Engage liveman switch before performing action.

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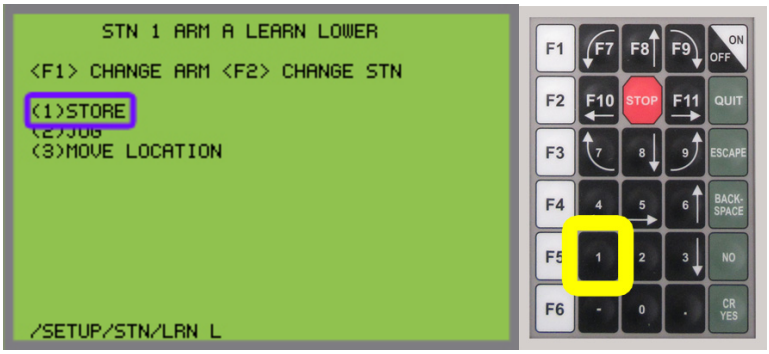
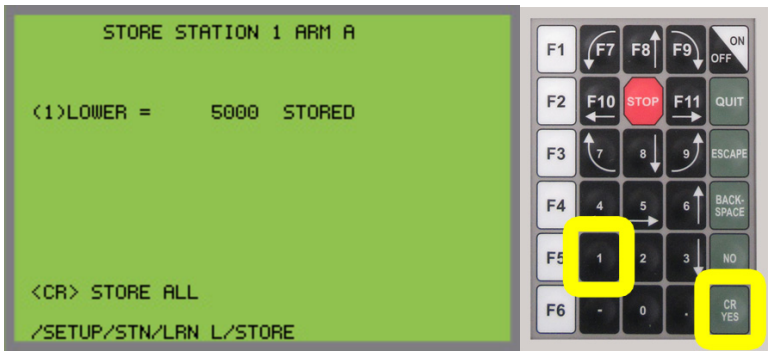
Step	Action
35.	Move the end effector down to the lower position (where the end effector will fully clear the wafer when it is retracted out) by using the keypad on the teach pendant. The position display on the Jog Status screen is updated with the end effector's current position in the Z-axis and the distance between the BTO (Z) and the current position.
36.	Release the liveman switch.



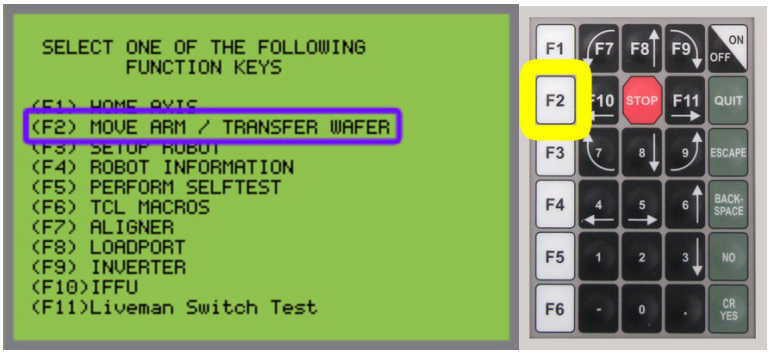
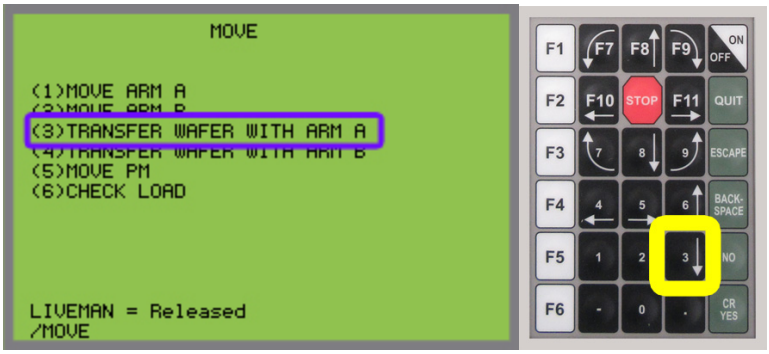
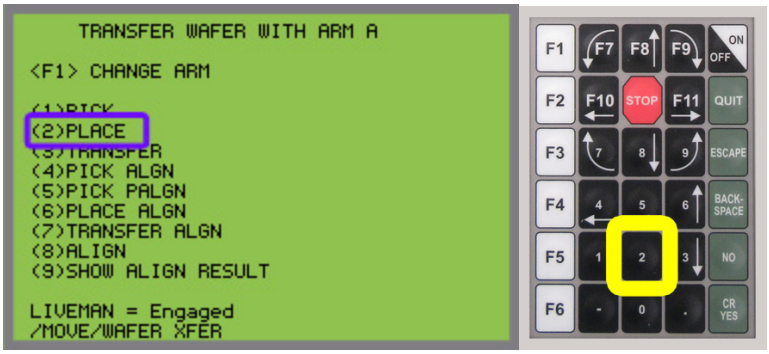


Number	Explanation
1	Wafer Transport Plane (WTP) - Bottom surface of wafer
2	Base Transfer Offset (BTO)
3	End Effector
4	Robot Home (Z-axis)
5	Lower
6	Center Line
7	Slot #1
8	Slot #2

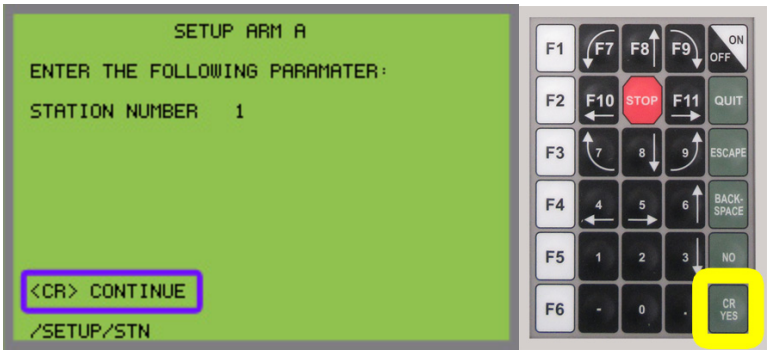
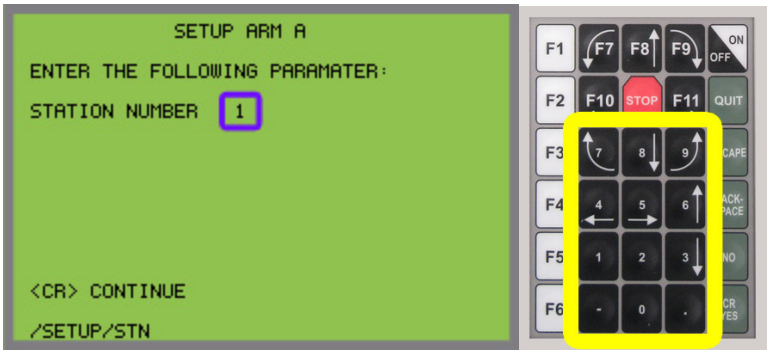
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Step	Action
37.	When the end effector is properly located in the station, select **ESCAPE** (or press **F3** on the keypad to jump to the *Store* screen) The *Teach Options* screen is displayed. 
38.	Select **(1) Store** by pressing the **1** button on the keypad. The *Store* screen is displayed. 
39.	Select **(1) Lower** by pressing the **1** button on the keypad (or select **<CR> STORE ALL** by pressing the **CR YES** button on the keypad. STORED is displayed once the lower value is stored. 
40.	Select **QUIT**. The *Function* screen is displayed.
Verify the Taught Location of the Station:	

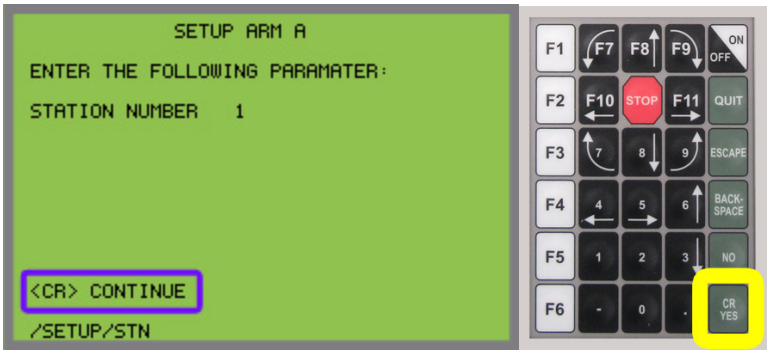
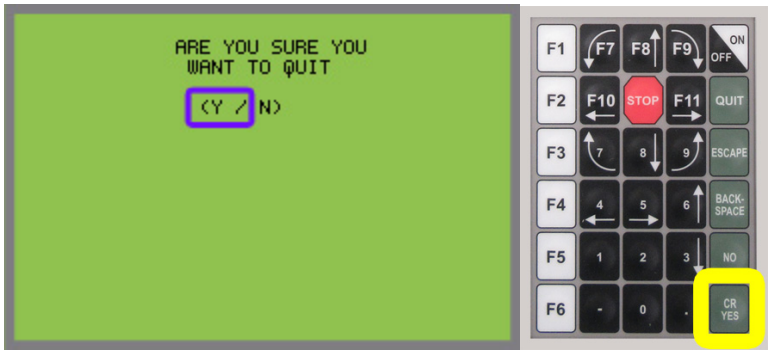
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Step	Action
41.	Place a test wafer on Arm A's end effector. Ensure that the wafer is properly centered on the end effector.
42.	Select **(F2) Move Arm / Transfer Wafer** by selecting the **F2** button on the keypad. The *Arm Selection* screen is displayed. 
43.	Select **(3) Transfer Wafer with Arm A** by pressing the **3** button on the keypad. The *Transfer Wafer With Arm A* screen is displayed. 
44.	Select **(2) Place** by pressing the **2** button on the keypad. The *Pick with Arm A* screen appears. 
45.	Engage the liveman switch.

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Step	Action
46.	Select the station number for the robot to pick from. 
47.	Select **<CR> Continue** by pressing the **CR YES** button on the keypad. The *Place With Arm A* Screen appears. 
48.	Select the station number for the robot to place to. 

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Step	Action
49.	Select **<CR> Continue** by pressing the **CR YES** button on the keypad. The *Transfer Wafer with Arm A* screen appears as the robot transfers the wafer. 
50.	The robot places the wafer in the station.
51.	Press **QUIT** on the keypad to return to the *Function* screen.
Return Control of the Robot to the Host Controller.	
52.	Select **Quit**. The *Function* screen is displayed
53.	Select **Off**. The *Quit* screen is displayed.
54.	Select **Y**. Control is returned to the Host Controller and the teach pendant shuts off. 
55.	Disconnect the cable from the teach pendant to the robot.
56.	Store the teach pendant in a secure location. ***NOTE:*** *When the teach pendant is not plugged in it must be removed from the area where the robot is located to avoid the attempted use of the E-Stop during an emergency.*

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Teaching a Station with the Liveman Teach Pendant - Coordinate Keypad

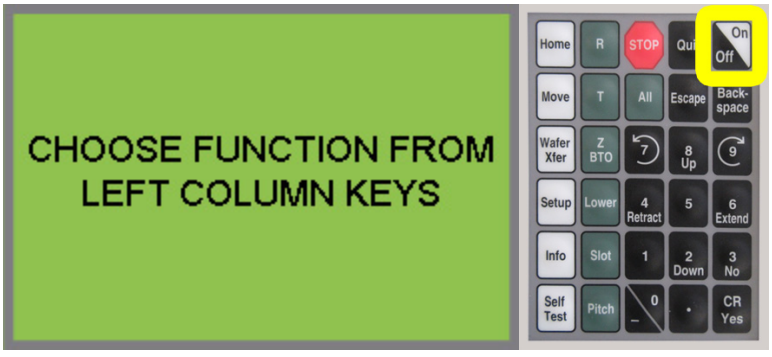
The following procedure is an example of teaching a station by jogging the end effector into position using the Liveman Teach Pendant with Coordinate style keypad. The exact spacial coordinates of the station is not known. The procedure uses Arm A of a MagnaTran LEAP with Dual SCARA.

> ***NOTE:*** The teach pendant screen images in the procedure may differ from the actual teach pendant screen.

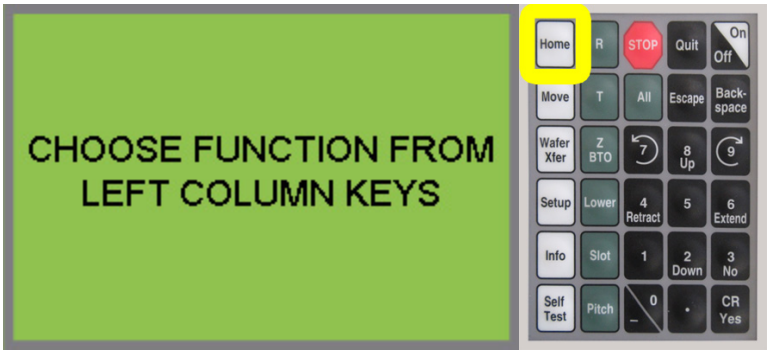
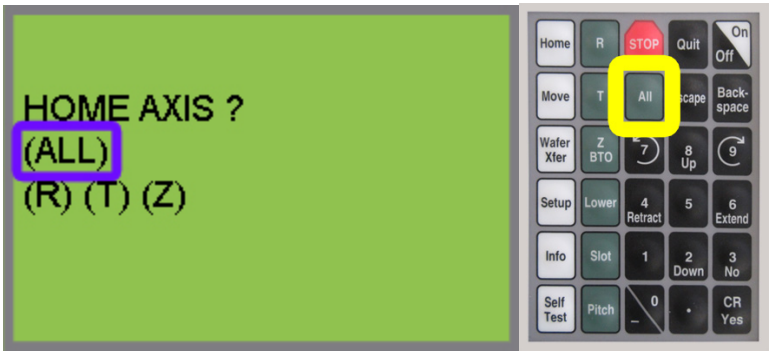
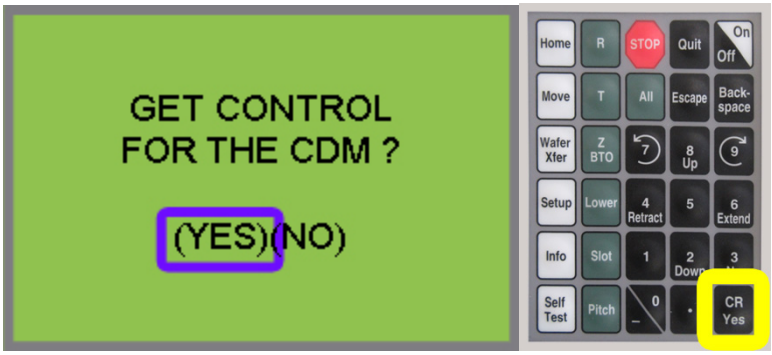
In order for the robot to move, the Liveman switch must be in the engaged position. The engaged position is the midpoint of the switch, between fully released, and fully pressed. For more information on the Liveman Switch operation, please see "Liveman Teach Pendant 3 Position Design" on page 179.

Step	Action
1.	Confirm that the MagnaTran LEAP robot is powered on.
2.	Turn the mode selector to Teach Mode.
Connect the Teach Pendant to the Robot:	

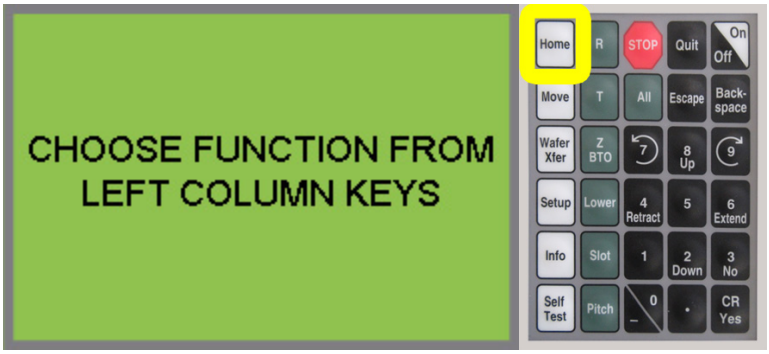
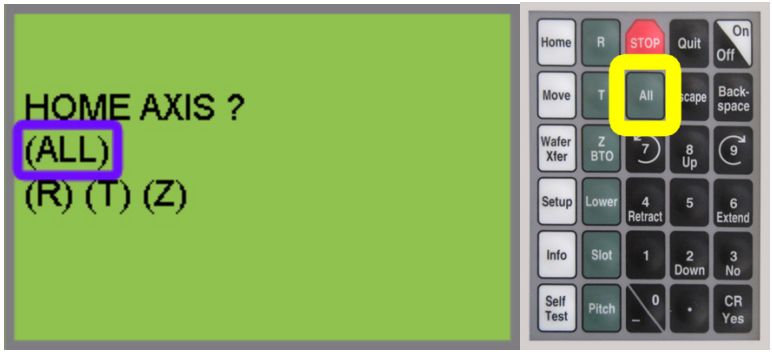
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Step	Action
3.	Connect the cable from the teach pendant to the robot. 
4.	Confirm that the E-Stop button on the teach pendant is released.
5.	Turn the teach pendant on by selecting **On**. The teach pendant turns on and the *Function* screen is displayed. 
Establish Local Control of the Robot:	
6.	Fully release the liveman switch before choosing a function.

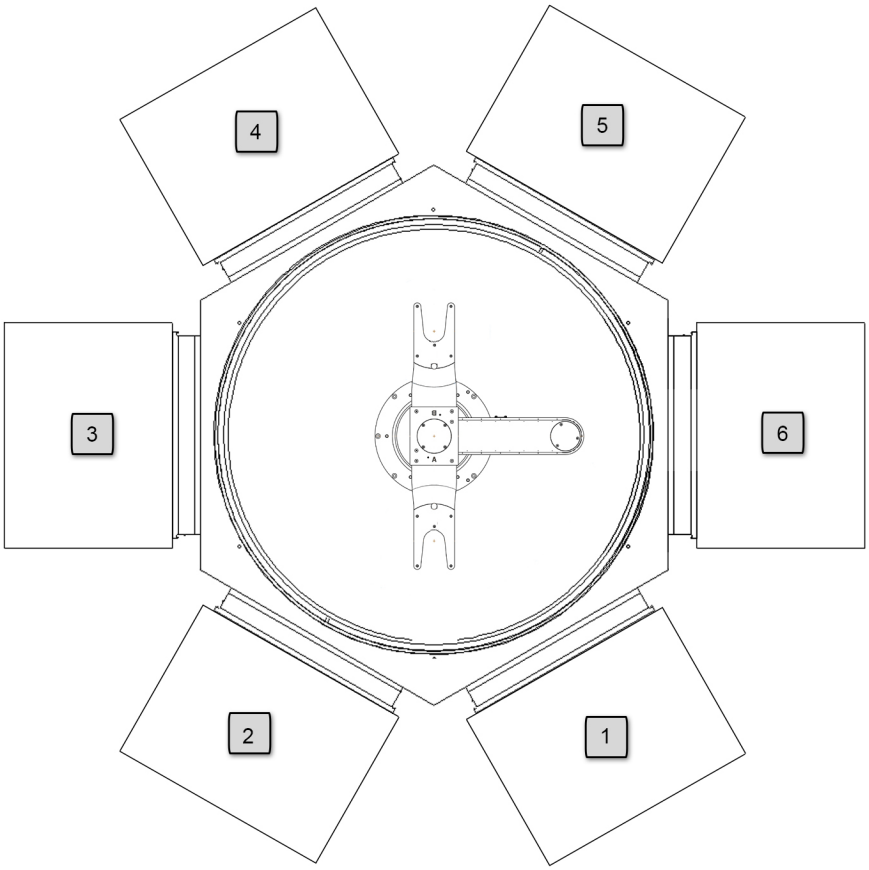
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Step	Action
7.	Press the **Home** button on the keypad. The *Home Axis* screen is displayed. 
8.	Press the **All** button on the keypad. The *Get Control* screen appears. 
9.	Press the **CR YES** button on the keypad. The teach pendant takes control of the robot. 
10.	Press the **Quit** button on the keypad to return to the *Function* screen.
Home the Robot:	

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Step	Action
11.	Press the**Home** button on the keypad. The *Home Axis* screen is displayed. 
12.	Engage the liveman switch. The LIVEMAN status changes from “Released” to “Engaged” on the screen.
13.	Press the **All** button on the keypad. Keep the liveman switch engaged the entire time the robot is homing or the robot will stop and an error message will appear on the screen. 

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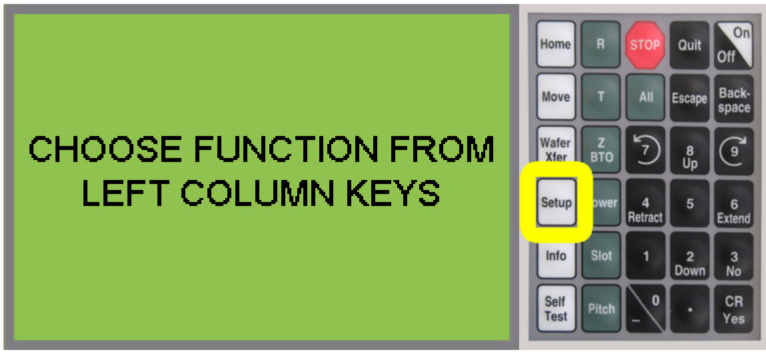
Step	Action
14.	When the robot has finished homing the teach pendant makes a beeping sound. Release the liveman switch. The image below shows a MagnaTran LEAP robot in the home position inside a vacuum back end.  **Station** / **Explanation** 1 — Station 1 2 — Station 2 3 — Station 3 4 — Station 4 5 — Station 5 6 — Station 6
15.	Press **Quit** on the keypad to go to the *Function* screen.

Enter the Robot Setup Mode to Teach the Station Location:

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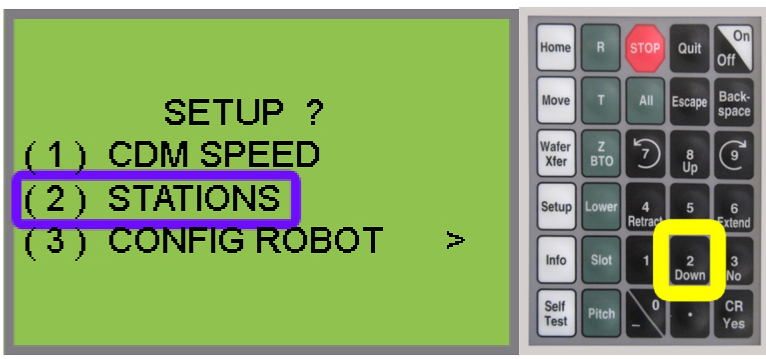
<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>16.</td><td>

Press the **Setup** button on the keypad. The *Setup* screen is displayed.



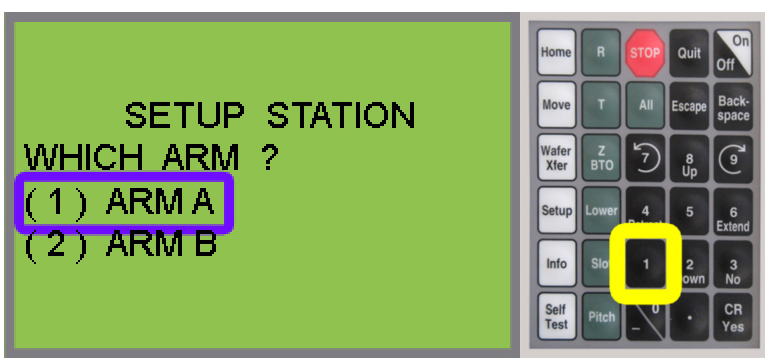
</td></tr>
<tr><td>17.</td><td>

Select **(2) Stations** on the *Setup* screen by pressing **2** on the keypad. The *Arm Selection* screen is displayed.



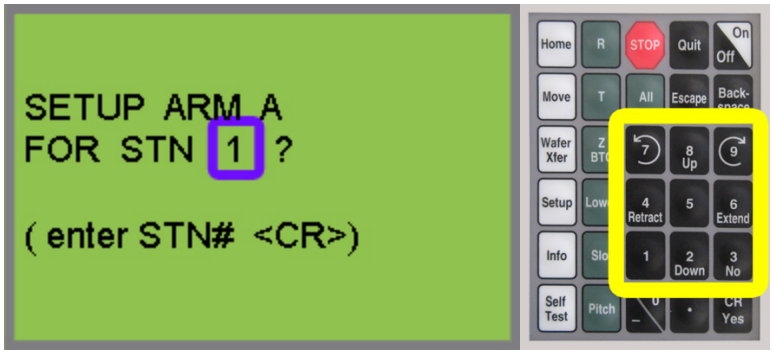
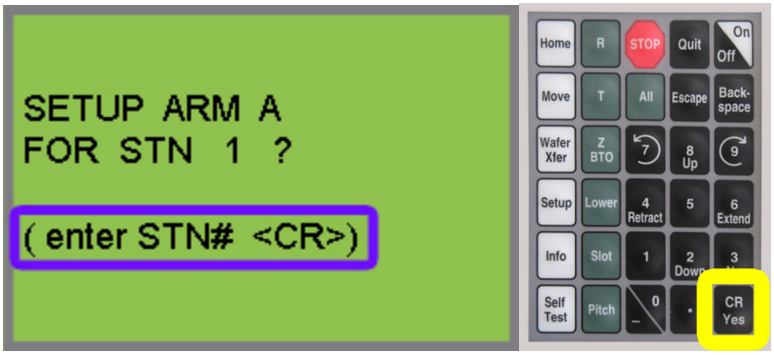
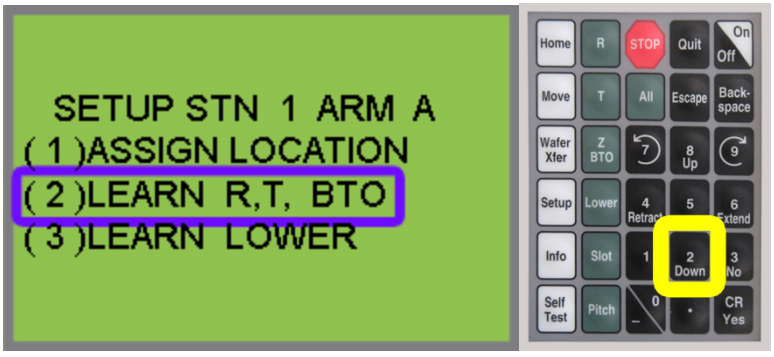
</td></tr>
<tr><td colspan="2">Specify the Arm and Station to be Taught:</td></tr>
<tr><td>18.</td><td>

Select the arm to be taught from the *Arm Selection* screen. The *Setup Arm A* screen is displayed. For single arm configuration, this step is skipped. (This procedure uses “Arm A”)

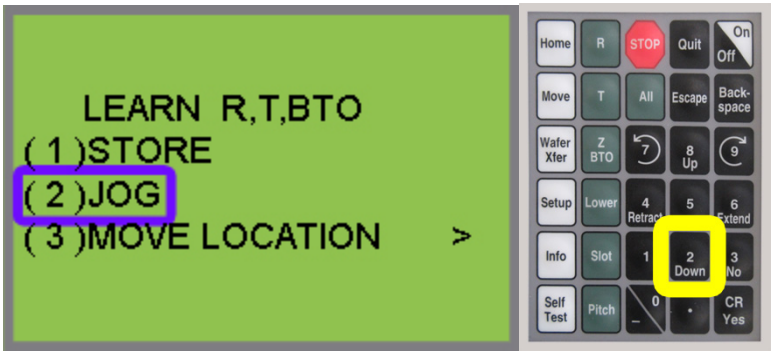


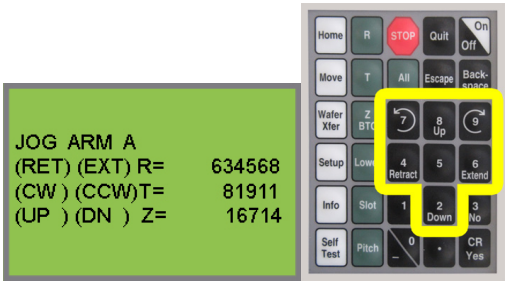
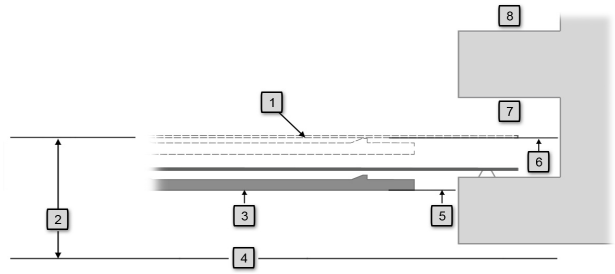
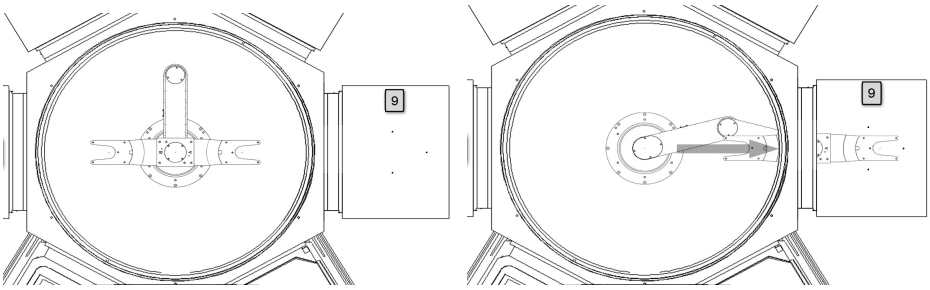
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</table>

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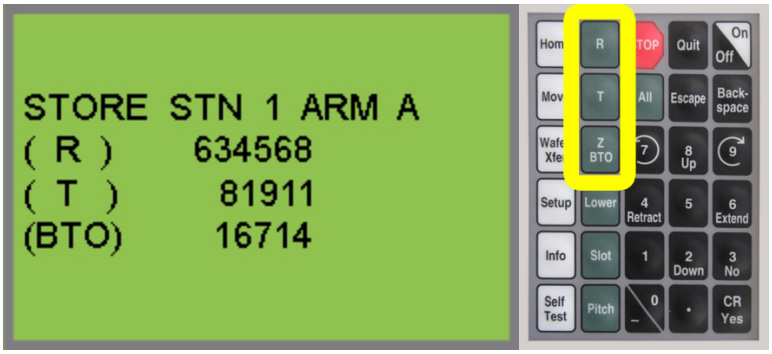
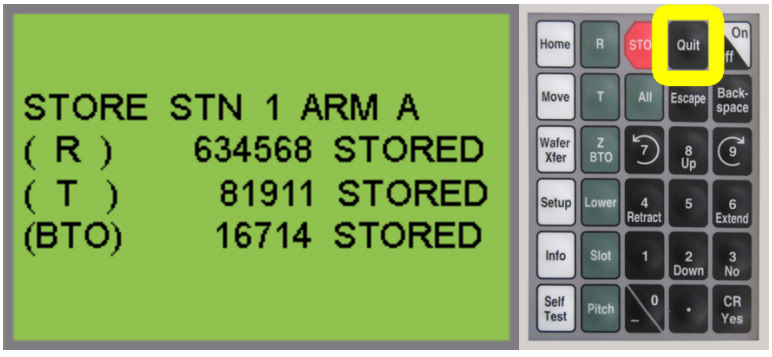
Step	Action
19.	From the *Setup Arm A* screen enter the station number to be taught. (This procedure uses “Station 1”) 
20.	Press the **CR Yes** button on the keypad to confirm station number. The *Teach Selection* screen is displayed. 
Teach the Robot the Station by Jogging the End Effector to the Station Location Using the Motion Control Keys on the Teach Pendant Keypad:	
21.	Select **(2) Learn R, T, BTO** from the *Setup Station 1 Arm A* screen by pressing **2** on the keypad. The *Teach Options* screen is displayed. 

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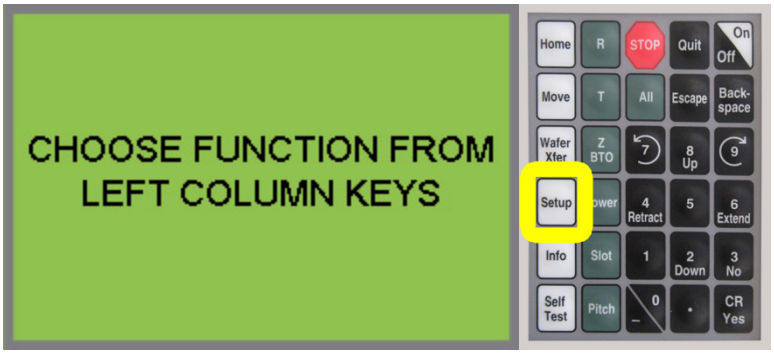
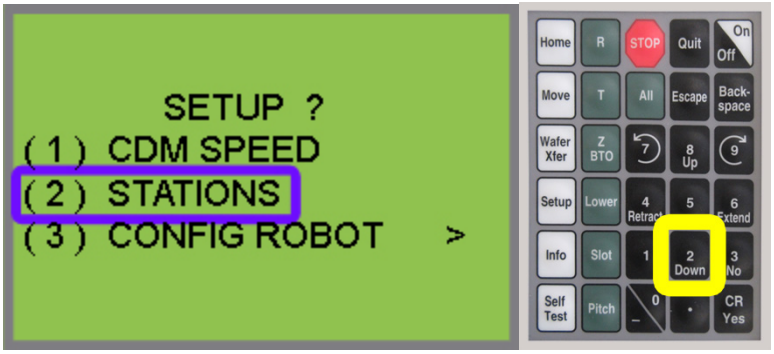
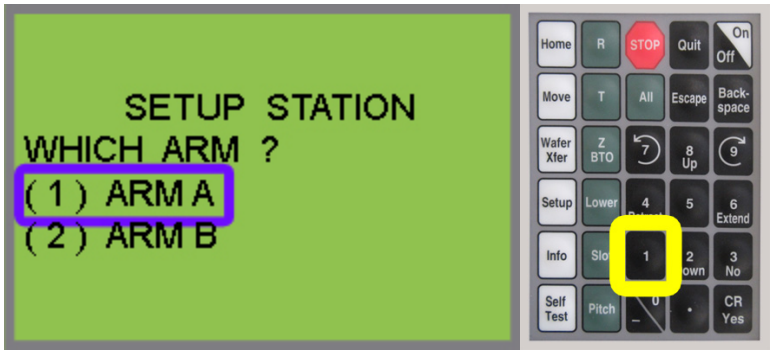
Step	Action
22.	Select **(2) Jog** from the Learn R, T, BTO Screen by pressing **2** on the keypad. The *Jog Status* screen is displayed. 
23.	Engage the liveman switch.

Step	Action
24.	Move the end effector by using the jog buttons on the keypad. The R, T, and Z coordinates of the end effector are displayed on the teach pendant's screen.    **Number** / **Explanation** 1 — Wafer Transport Plane (WTP) - Bottom surface of wafer 2 — Base Transfer Offset (BTO) 3 — End Effector 4 — Robot Home (Z-axis) 5 — Lower 6 — Center Line 7 — Slot #1 8 — Slot #2 9 — End Effector Retracted and Extended at Process Module D (Station 6 and 10)
25.	Release the liveman switch when the end effector is properly located in the station.

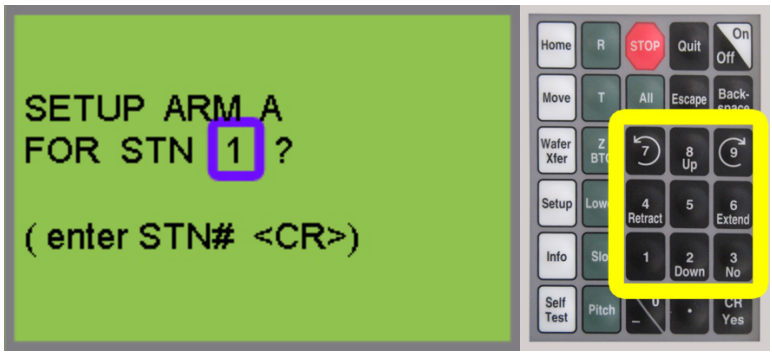
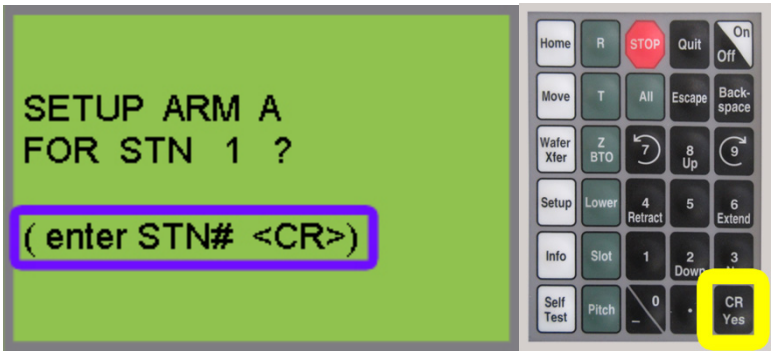
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Step	Action
26.	Press the **Escape** button on the keypad to go back to the *Learn R, T, BTO* screen.
Store the Taught Location of the Station:	
27.	Select **(1) Store** by pressing the **1** button on the keypad. The *Store* screen is displayed. 
28.	Select each axis to be stored by pressing R, T, and Z BTO buttons on the keypad. STORED is displayed once the axis stored.  NOTE: 2-axis robots will not have the BTO displayed.
29.	When all axes have been stored, press the **Quit** button on the keypad to return to the *Function* screen. 

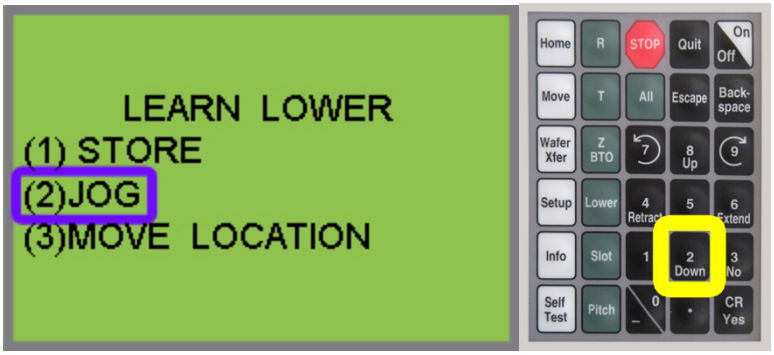
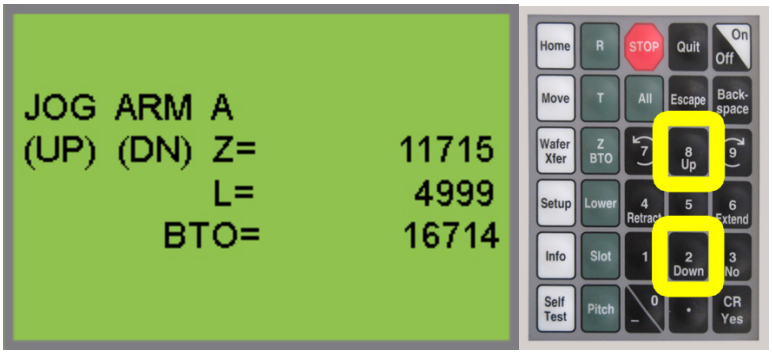
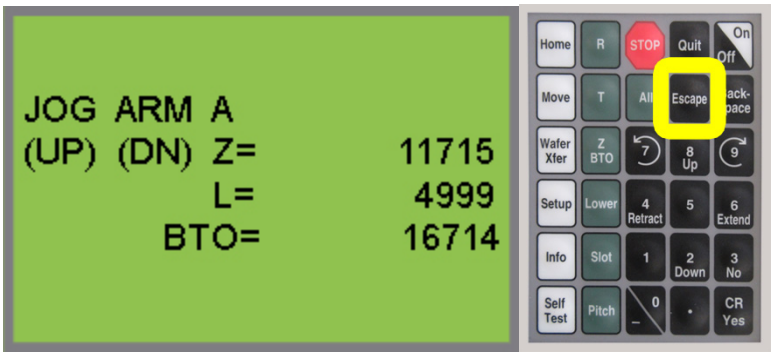
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Step	Action
Teach the Z-axis Lower Position for the Station:	
30.	Press the **Setup** button on the keypad. The *Setup* screen is displayed. 
31.	Select **(2) Stations** by pressing the **2** button on the keypad. The *Arm Selection* screen is displayed. 
32.	From the *Arm Selection* screen select the arm to be taught (these examples will Arm A). The *Station Selection* screen is displayed. 

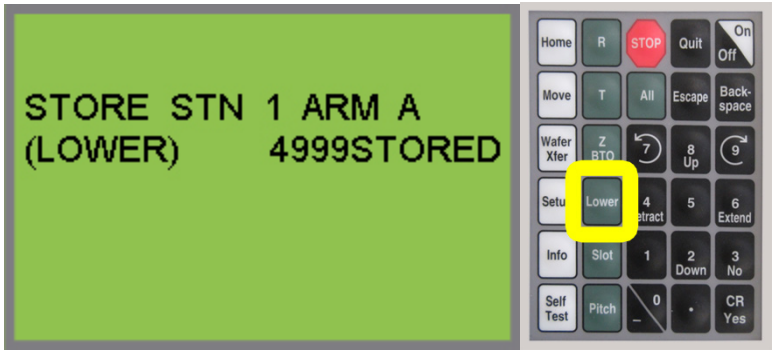
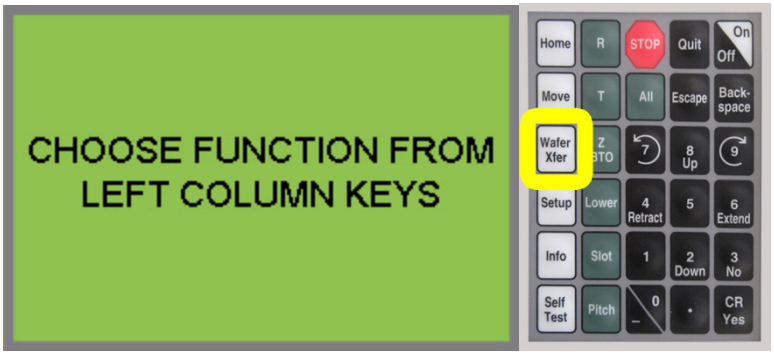
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Step	Action
33.	From the *Station Selection* screen enter the station to be taught (these examples use Station 1). 
34.	Confirm the station number by pressing **CR YES** on the keypad. 
35.	From the *Teach Selection* screen select **(3) Learn Lower** by pressing the **3** button on the keypad. The *Teach Options* screen is displayed. 

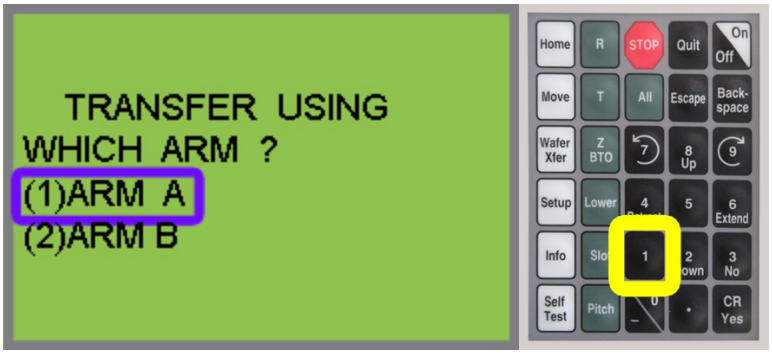
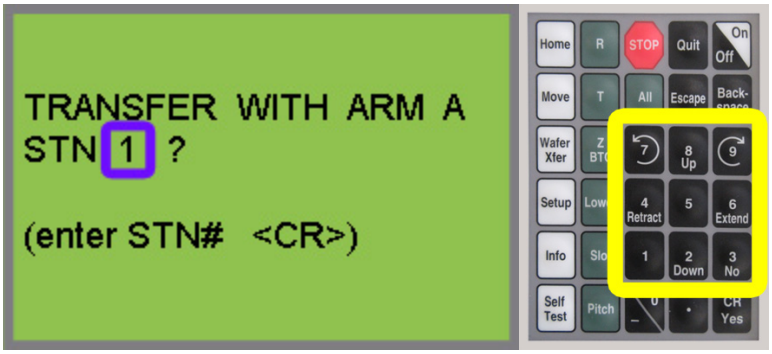
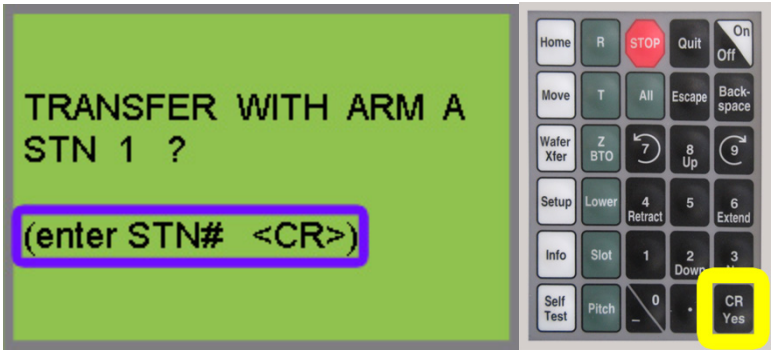
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Step	Action
36.	From the Teach Options screen select **(2) Jog** by pressing the **2** button on the keypad. The *Jog Z Status* screen is displayed. 
37.	Engage the liveman switch.
38.	Move the end effector down to the lower position by using the **Down** button on the keypad. The Z, Lower, and BTO coordinates are displayed on the teach pendant's screen. 
39.	Release the liveman switch.
40.	When the end effector is properly located in the station, press **Escape** to go back to the *Learn Lower* screen. 

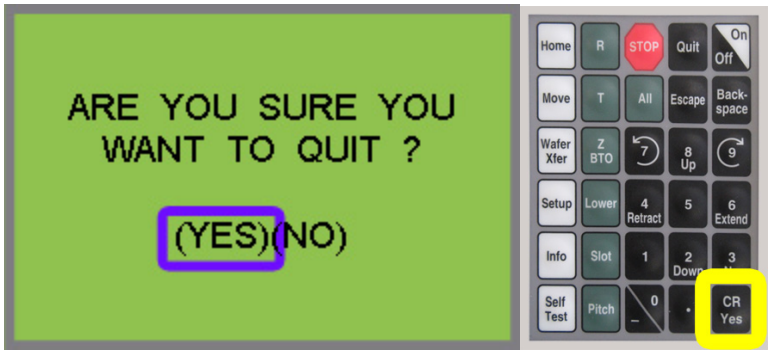
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Step	Action
41.	Select **(1) Store** by pressing the **1** button on the keypad. The *Store* screen is displayed. 
42.	Press the **Lower** button on the keypad to store the Lower value. STORED is displayed once the Lower value is stored. 
43.	Select **Quit**. The *Function* screen is displayed.
Verify the Taught Location of the Station:	
44.	Place a test wafer on Arm A's end effector. Ensure that the wafer is properly centered on the end effector.
45.	Press the **Wafer Xfer** button on the keypad. The *Move Using Which Arm* screen is displayed. 

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Step	Action
46.	Select **(1) Arm A** by pressing the **1** button on the keypad. The *Transfer Wafer with Arm A* screen is displayed. 
47.	Select the station number for the robot to pick from. 
48.	Confirm the station number by pressing **CR YES** on the keypad. 
49.	Engage the liveman switch.

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Step	Action
50.	Select **(2) Perform Place** by pressing the **2** button on the keypad. The robot places the test wafer in the station. 
51.	Release the liveman switch.
52.	Press **Quit** on the keypad to return to the *Function* screen.
Return Control of the Robot to the Host Controller.	
53.	Select **Quit**. The *Function* screen is displayed
54.	Press the **Off** button on the keypad. The *Quit* screen is displayed.
55.	Select **Yes**. Control is returned to the Host Controller and the teach pendant shuts off. 
56.	Disconnect the cable from the teach pendant to the robot.
57.	Store the teach pendant in a secure location. ***NOTE:*** *When the teach pendant is not plugged in it must be removed from the area where the robot is located to avoid the attempted use of the E-Stop during an emergency.*

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Example of Teaching a Station with the Teach Pendant

- Suppose the operator knows that Station #3 is located at about 270° but wishes to adjust it visually. The operator would first select Setup, and indicate Station #3. The operator would then choose Learn, then T, then Go To.
- If an approximate location, such as 270°, is entered the robot arm would physically rotate to 270°. The operator can then select Jog, which causes the arm to move in small increments by pressing the circular arrow keys for rotational motion. Holding the key down causes continual motion until it is released; the actual position of the arm is displayed as it moves.
- When the operator has adjusted the arm to the desired position, the Store option should be selected to indicate that the value should be stored as the value of Theta for Station #3. Pressing Store returns to the previous menu, giving the operator the opportunity to establish another variable.
- The operator might then select R to set the extended position of the arm. The operator can then select Jog and hold down the Extend or Retract key until the arm is extended to the proper distance, then press Store, which would store that value of R as the extended position for Station #3 and return to the previous menu.
- Suppose the values of the other station parameters are already known. The operator might then press Escape to return to the previous menu, where Assign can be selected and the remaining parameters for Station #3 can be entered directly.
- Finally, pressing Quit will end the station setting session and return to the main menu.
- At this point, the operator should issue a Move-Station command to the station just set to check that the values learned are correct. The operator should then use Setup-Station-Assign to make any required minor adjustments, and again check the position using a Move-Station command.

Station Parameters

Table 5-5: Station Parameters

Station Storable Parameters	Description
R	The full radial extension in increments of 1 micron (0.001 mm).
T	The rotational position, Theta, in increments of 0.001 degrees over a range of 360°.
Z	The Z axis location, in microns, of the Wafer Transfer Plane, which is also the Up position of the robot arm in Station 1.
LOWER	The distance in microns below the Wafer Transfer Plane at which the Down position of the robot arm is located.
NSLOTS	The number of slots at that station.
PITCH	The uniform distance, in microns, between the slots.

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Cycling and Transferring Wafers

Basic Transfer Commands and Their Movements

The typical movement of a MagnaTran LEAP robot is a series of the commands GoTo, Pick, and Place.

a. GOTO - The robot moves to a specified station-referenced location so it is ready to complete another Pick or Place command.

GOTO[N *station*] <<(ARM)>[(A|B)]> <CW|CCW>

a. the robot simultaneously turns in theta to the station and moves in Z to the Z-Down position.
b. and waits for the next command to be issued.

b. PICK - The robot picks a wafer from a specified station and slot number.

PICK *station* [SLOT *slot*] <<(ARM)>[(A|B|AB)]>

a. the robot simultaneously turns in theta to the station and moves in Z to the Z-Down position.
b. extends an end effector radially to the R-Extend position under a wafer.
c. moves the Lower distance vertically up in Z to pick up a wafer
d. retracts out to the Z-Up, R-Retract position.

c. PLACE - The robot places a wafer at a specified station and slot number.

PLACE *station* [SLOT *slot*] <<(ARM)>[(A|B|AB)]>

a. the robot simultaneously turns in theta to the station and moves in Z to the Z-Up position.
b. extends an end effector radially to the R-Extend position over the station.
c. moves the Lower Distance vertically down in Z to place a wafer.
d. retracts out to the Z-Down, R-Retract position.

Example Wafer Transfer Cycle

INIT:

```
“HOME ALL”
“SET LOAD A OFF”
“SET LOAD B OFF”
```

CYCLE:

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```
“PICK 1 A”
“PICK 2 B”
“PLACE 4 B”
“PLACE 3 A”
“PICK 3 A”
“PICK 4 B”
“PLACE 1 A”
“PLACE 2 B”
```

END:

```
HOME ALL
SET LOAD A OFF
SET LOAD B OFF
```

Shut-Down

The MagnaTran LEAP robot does not require special shut-down procedures. Once use of the robot is complete, power can be removed.

- Ensure that the robot has completed all transfer operations and that there are no wafers left on the end effectors.
- Send the Home ALL command to the robot before removing power.
- Send the command SHUTDOWN SUP to the robot.
- If the host controller is to be shut off, the robot should be shut-down first.
- SET commands only load parameter values into RAM. These values will be reset to default values if power is removed. If permanent storage of values is desired, STORE values using appropriate commands before shut-down.
- If necessary, complete the shipping procedure before transporting the MagnaTran LEAP robot. Contact Brooks Technical Support. For more information on contacting Brooks Technical Support, please see "Contact Brooks Automation Technical Support".

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6. Embedded Safety Controller

Overview

Brooks MagnaTran LEAP robots contain an embedded controller designed to help customers meet the requirements of EN ISO 10218-1:2011, EN ISO 13849-1:2008 Category 3, PL d., and SEMI S2-0715. It is important to note that additional connections are required before motor power and motion can be enabled.

The MagnaTran LEAP robot fully supports the MagnaTran 7 and MagnaTran 8 MISC I/O interface, hereafter known as the “legacy” interface. The legacy MISC I/O interface provides a non-safety rated single channel emergency-stop input. It should be used only where backward compatibility requires only a non-safety rated functional stop.

It is incumbent on the robot integrator to determine an approach for safety that provides an appropriate mitigation to the risks identified in their individual assessment.

WARNING

Identifying Safety Risks

Operating the MagnaTran LEAP robot without safety guards in place may cause death or serious injury. It is incumbent on the robot integrator to determine an approach for safety that provides an appropriate mitigation to the risks identified in their individual assessment.

- Do not operate the MagnaTran LEAP Robot without appropriate safety guards.



This section:

- Presents a method to upgrade MagnaTran 7 and MagnaTran 8 robots with MagnaTran LEAP robots.
- Is intended for use as a guide and will illustrate a variety of potential implementations. The integrator is responsible for implementation of the embedded safety controller.
- Provides detailed diagrams for implementation of safety related controls.

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LEAP Safety Controller Supported Regulatory Features:

- **Emergency Stop**: Brings the robot to a controlled stop (through non-safety rated software) and removes power (through safety-rated controller) to implement a Stop category 1 per EN 60204-1.
- **Automatic Mode**: Per ISO 10218-1, this mode allows full speed operation of the robot, assuming interlock and emergency stop inputs are satisfied.
- **Stop Mode**: Per ISO 10218-1, prevents all robot motion.
- **Manual Mode**: Per ISO 10218-1, limits robot velocity to 250mm/sec at the center of the wafer. Caution is required as the velocity of the linkages can exceed 250mm/sec. In addition, this mode allows software-selection of Teach Mode, described in "Manual Mode" on page 162.
- **Teach mode**: A subset of Manual Mode, this directs the single source of control to a hand-held teach pendant. This mode ignores protective interlock inputs.

WARNING

Appropriate Safety Hardware

Brooks Automation Inc supplies a safety system that is intended to facilitate interface of Emergency Stops and Protective Stops to the robot. It is the responsibility of the system integrator to select appropriate safety hardware and locate that hardware to ensure human and equipment safety.



Safety Overview

The design is a redundant safety controller which monitors protective safety switches, ensures circuit integrity, enables motor power, and outputs status.

a. Emergency Stop and Protective Stops require redundant dual circuits connected to the robot.
b. Emergency Stops and Protective stops are grouped separately.
c. Mode Selector (Automatic/Stop/Manual) provides operation according to ISO 10218-1.
d. Outputs controller states and indicates with safety status with a single multi-color lamp.
e. Provides motor power enable/disable and further monitors motor power for successful application and removal of motor power.
f. It provides discreet output bits for ease of interface into a larger system. The robot safety controller is designed to be implemented within a higher level safety system.

NOTE: The Safety I/O Connector implements redundant circuits; however, the interlock loop in the Misc I/O connector are not redundant (Refer to "Miscellaneous I/O Interlocks" on page 157).

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Hardware Connections for Operation

There are multiple layers of wiring required to satisfy the safety controller before motion can occur. These are as follows:

a. Emergency Stop:
   - Designed to be implemented as a series loop of normally closed switches. Interruption of the loop's continuity commands a Category 1 stop.

b. Protective Stop:
   - Provides a function implemented similarly to emergency stop on an independent circuit. . Protective stops are intended to prevent access to moving components and other hazards.
   - Can be muted in Liveman Teach Pendant mode.

c. Mode Selector Operation:
   - Per ISO 10218-1, selects Manual mode, Stop mode, or Automatic mode.

d. MISC I/O Legacy Operation:
   - Supports legacy mode (MagnaTran 7 or MagnaTran 8) operation.
   - Useful for single wire tool protection.

The first three wiring requirements are found on the MagnaTran LEAP safety I/O connector. The fourth is located on the MISC I/O connector interface.

The safety I/O and the MISC I/O connectors contain stops/interlocks. The safety I/O is a full safety dual channel. The MISC I/O is a single wire interlock.

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Figure 6-1: Safety I/O and Miscellaneous I/O

Table 6-1: Safety I/O and Miscellaneous I/O - Explanation

Number	Explanation
1	Safety I/O
2	Miscellaneous I/O

NOTICE

Brooks Automation supplies a safety system that facilitates interface of Emergency Stops and Protective Stops. It is the responsibility of the system integrator to select appropriate safety hardware and to locate that hardware so as to ensure human and equipment safety.

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MagnaTran LEAP Safety I/O Connector

The following diagram is an overview of the MagnaTran LEAP embedded safety controller. The diagram is presented as an introduction, where the internal robot hardware is shown connected to the safety I/O connector. There are inputs to the connector, outputs from the connector, and limited 24VDC power. For safety, the I/O connector contains two identical circuits (Controller A and Controller B) coupled to hardware-based comparison checks to ensure redundancy. Almost every signal input or output is present on the connector has a connection on the “A” side and an identical connection on the “B” side. This ensures that any single fault will be detected and motion will not be possible when a fault occurs. It also requires the integrator to select redundant switches and wire them appropriately.

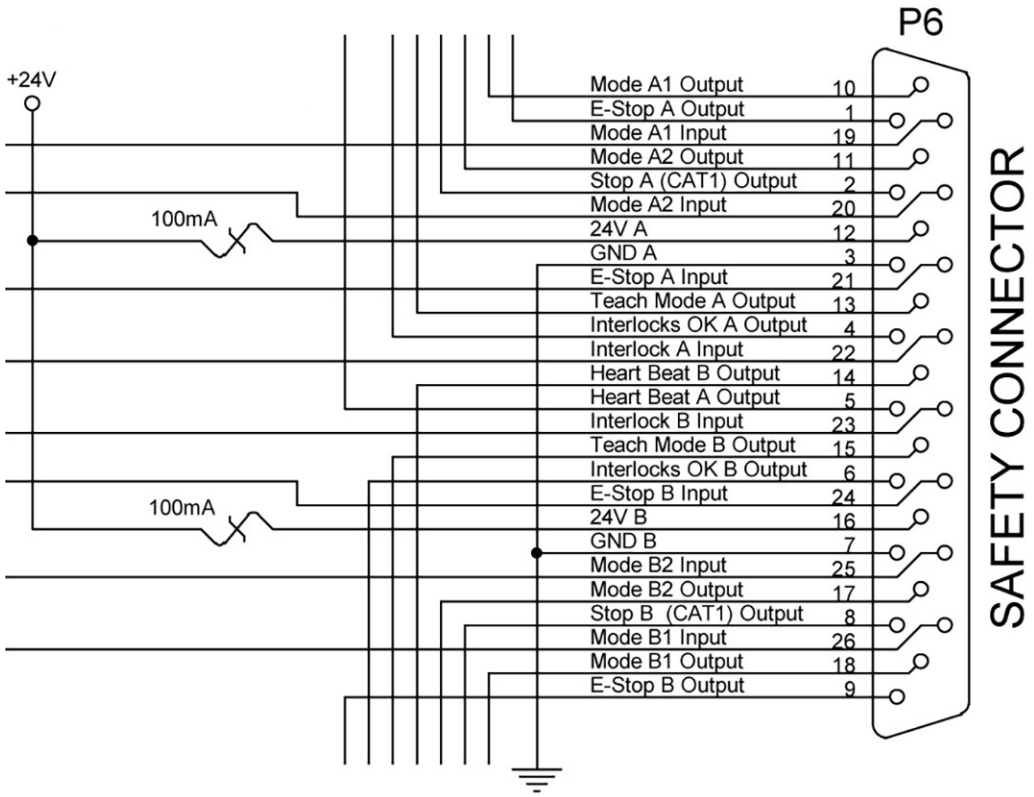


Figure 6-2: Embedded Safety Controller with Redundant Channels A and B

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Safety Connector Pinout

The MagnaTran LEAP safety I/O connector is located on the robot I/O panel. This connector is used to bring all the signals to a common location.

Description: HD-Sub 26-position female connector.

Mating connectors:

- Amphenol 17EHD-026-P-AA-0-00
- Norcomp 180-026-103L001
- TE Connectivity 1757823-8

Table 6-2: Safety Pin-out: D-Sub 26 Position Female Connector

Pin			Direction	Assignment	Channel
1			Out	Emergency Stop A	
	10		Out	Mode A1 Output	
		19	In	Mode A1 Input	
2			Out	Stop A (CAT1) Output	
	11		Out	Mode A2 Output	
		20	In	Mode A2 Input	
3			Ground (A)	GND	Channel A
	12		Power (A)	24V 100mA	
		21	In	E-STOP A Input	
4			Out	Interlocks OK A Output	
	13		Out	Teach Mode A Output	
		22	In	Interlock A Input	
5			Out	Heartbeat_10Hz_A	

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Pin			Direction	Assignment	Channel
	14		Out	Heartbeat_10Hz_B	
		23	In	Interlock B Input	
6			Out	Interlocks OK B Output	
	15		Out	Teach Mode B Output	
		24	In	E-Stop B Input	
7			Ground (B)	GND	
	16		Power (B)	24V 100mA	Channel B
		25	In	Mode B2 Input	
8			Out	Stop B (CAT1)	
	17		Out	Mode B2 Output	
		26	In	Mode B1 Input	
9			Out	Emergency Stop B	
	18		Out	Mode B1 Output	

Emergency Stop Safety Switches

The safety standards require, without exception, an emergency stop switch conforming to EN418 and equipped with redundant contact blocks. At a minimum the switch must contain:

- A mushroom-shaped-head that is red in color.
- When depressed, the switch must have a latching mechanism that is maintained.
- Can only be reset with a “twist to release” function.
- Have a dual set of contacts that are positive opening when the mushroom head is depressed.
- The background surrounding the switch must be yellow.

The switches must be located so that they are easily accessible to operators and support staff.

The switches must be connected in series such that any depressed switch will stop the robot.



Figure 6-3: Example of an Emergency Stop Switch

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Figure 6-4 on page 154 is a diagram for installing emergency stop switches. Note the switches contain two sets of contacts to ensure redundancy. The MagnaTran LEAP safety controller uses 24V/1mA signals for emergency stop. For reliable operation, use switches with gold-plated contacts.

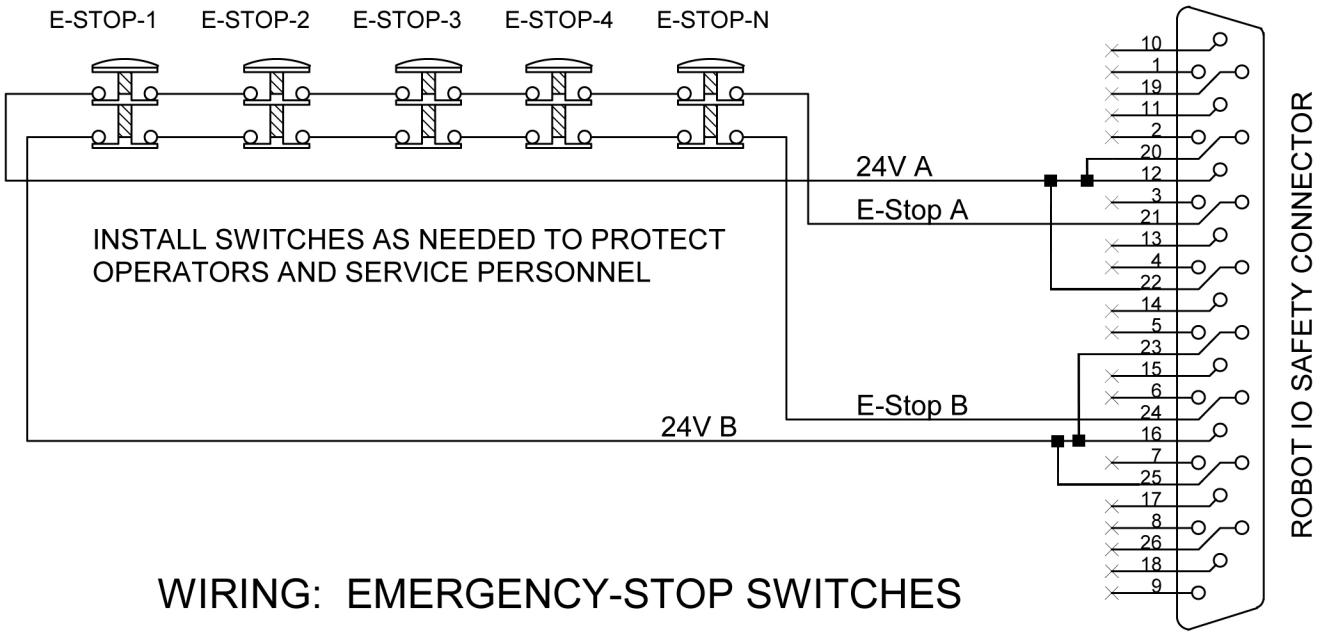


Figure 6-4: Emergency Stop Switch Wiring

NOTICE

As stated by ISO/TR 24119, it is possible for multiple interlocking devices connected serially to mask faults in the interlocking system. The fault masking probability is a function of the number of movable guards and their frequency of use. Consult ISO/TR 24119 for guidance when designing an interlocking system connected to the MagnaTran LEAP robot.

Please Observe the Following:

Never attach emergency stop (E-Stop) conductors to other voltage sources or capacitive loads. Failure to comply could damage the safety controller interface and/or modify operation of the safety circuits.

- Depression of any emergency stop switch will launch an E-Stop event, causing arm motion to come to a controlled stop and the removal of power from the robot motors.
- There are two separate circuits for redundancy: Channel A and Channel B
- There are two separate 24V supply circuits (A and B). Both are current limited at 100mA and shared among three circuits: emergency stop, protective stops, and mode selectors.
- Circuit “A” starts with P6 pin 12 (24V-A) and terminates with E-Stop A on P6 pin 21
- Circuit “B” starts with P6 pin 16 (24V-B) and terminates with E-Stop B on P6 pin 24

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- To ensure operational integrity, both circuits A and B track each other and report any mismatch as a failure. If a failure is detected, motion is stopped and motor power is removed.
- As shown in the wiring diagram, multiple emergency stop switches are connected in series.
- The number and placement of emergency stop switches is defined by the system integrator based on the requirement to safeguard personnel.

The above wiring diagram is complete for the emergency stop function. Motion is not possible unless the protective stop switches are installed, the mode selector is installed, and the MISC I/O tool-related interlock is closed. Please see "Protective Emergency Switches" on page 155 for additional wiring requirements for protective stops (interlocks), tool-related interlocks, and for a MODE selector.

Protective Emergency Switches

Protective Stops are used to protect personnel from entering the robot workspace or any other hazardous location. For reliable operation, use switches with gold-plated contacts. Protective switches once opened should remain open until manually reset.

Protective stops differ from emergency stops as they can be muted when in liveman teach pendant mode.

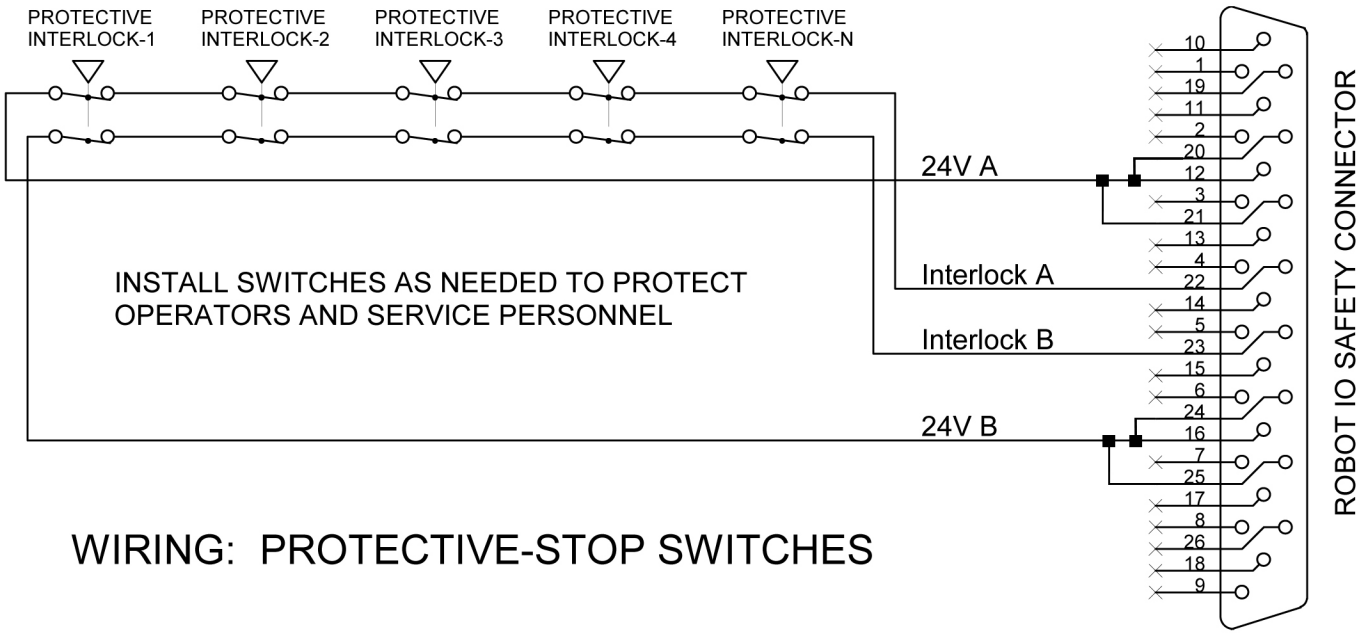


Figure 6-5: Protective-Stop Switches Wiring

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NOTICE

As stated by ISO/TR 24119, it is possible for multiple interlocking devices connected serially to mask faults in the interlocking system. The fault masking probability is a function of the number of movable guards and their frequency of use. Consult ISO/TR 24119 for guidance when designing an interlocking system connected to the [[[Undefined variable MyVariables.RobotName]]] robot.

When implementing protective stops, follow the same rules as the emergency stop. Please note the circuits terminate to different pins on the P6 connector; pin 22 for A and pin 23 for B circuits.

The above wiring diagram is not complete and will not permit motion. In addition to emergency stop and protective stop, there are additional requirements for a MODE selector and for tool interlocks. See "Operational MODE Inputs" on page 160.

Please observe the following:

- Never attach protective stop conductors to other voltage sources or capacitive loads. Failure to comply could damage the controller interface or modify operation of the safety circuits.
- The actuation of any protective stop switch will launch a category 1 stop event, bring the robot to a controlled stop, and remove power from the robot motors.
- There are two separate circuits for redundancy: Channel A and Channel B
- There are separate 24V supply circuits (A and B). Both are current limited at 100mA and shared among emergency stop, protective stops, and mode selectors.
- Circuit “A” starts with P6 pin 12 (24V-A) and terminates with Interlock A on P6 pin 22
- Circuit “B” starts with P6 pin 16 (24V-B) and terminates with Interlock B on P6 pin 23
- To ensure operational integrity, both circuits A and B will track each other
- Multiple protective stop switches are connected in series.
- The number and placement of protective stop switches is defined by the system integrator based on the requirement to safeguard personnel.

Figure 6-5 wiring diagram is not complete and will not permit motion. In addition to emergency stop and protective stop, there are additional requirements to complete an interlock on the Miscellaneous I/O connector and to install a MODE selector. See "Miscellaneous I/O Interlocks" on page 157.

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Redundant Input Fault Detection

The embedded safety controller is capable of detecting faults in the redundant safety channels. If the safety controller detects only one channel requesting a safety function, the safety function is implemented as usual. However, the servos cannot be re-enabled until the problem in the safety circuit has been addressed and the robot has been power cycled. The safety status LED blinks RED to indicate a mismatch in the redundant channels. The safety controller has the capability to withstand a single-failure and still implement safety functions when requested.

Example: A dual-pole E-Stop button has been pressed. One of the contacts is stuck in the closed position despite the user pressing the button. Only one contact opening is sufficient to invoke the safety function. The user is made aware of the failure by the safety status LED blinking red. Continuing to operate with the faulty switch could make the system unsafe if the remaining operational contact were to also fail. The embedded safety controller does not allow robot operation/movement until the E-Stop button has been fixed, and the robot has been power cycled.

Miscellaneous I/O Interlocks

Miscellaneous I/O switches provide a convenient location to install single-conductor tool switches. By definition this interlock is not redundant and should not be relied upon for human safety. This interlock was the primary safety interlock on the legacy MagnaTran 7 and MagnaTran 8 controllers. It exists on the MagnaTran LEAP for connection of single wire tool switches. Like the emergency stop and protective stop switches, motion cannot occur until this connection is satisfied.

There are three possible applications for the MISC I/O interlock:

a. Installation of tool single wire switches for protection against robot motion.
   Example: To prevent the robot arm from extending into a closed slot valve

b. As a straight wired jumper indicating the MISC I/O external cable is installed
   Example: The MISC I/O cable must be plugged into the robot before motion is possible.

c. MagnaTran 7 & 8 retrofit: Re-use of existing MagnaTran 7 & 8 where there resides a higher level safety system.

NOTE: The legacy MISC I/O interface provides a non-safety rated single channel emergency-stop input. Use only in legacy applications where backward compatibility and a non-safety rated functional stop are all that is required.

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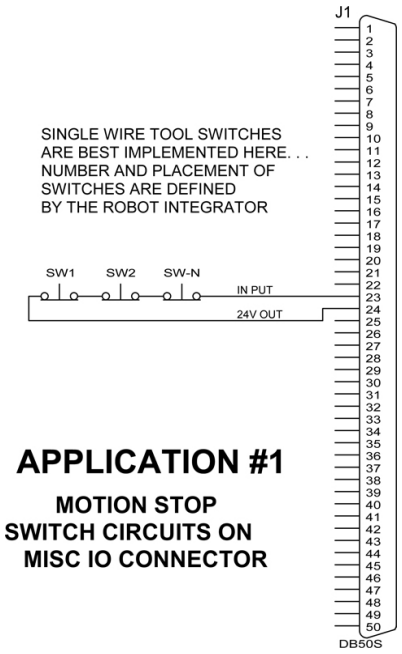


Figure 6-6: Miscellaneous I/O Interlock Application #1

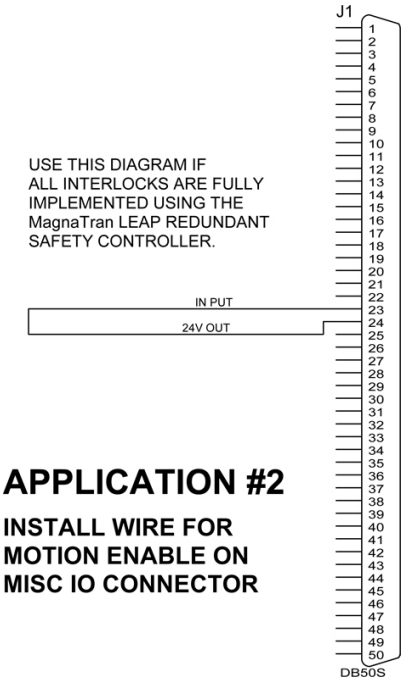


Figure 6-7: Miscellaneous I/O Interlock Application #2

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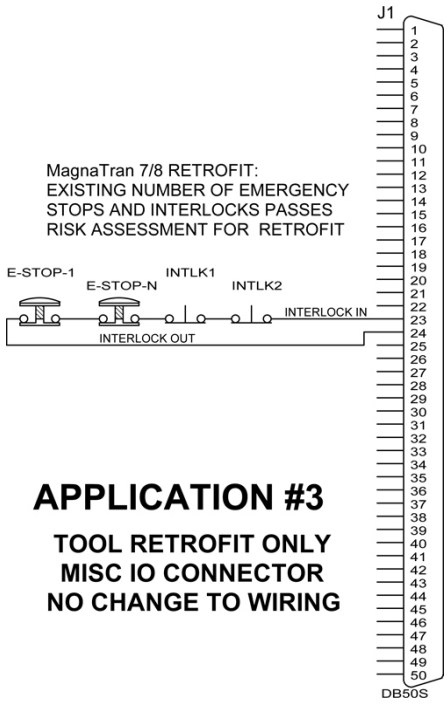


Figure 6-8: Miscellaneous I/O Interlock Application #3

The above wiring diagrams are not complete and will not yet permit motion. In addition to emergency stop, protective stop, and tool switches, there is an additional requirement for a MODE selector and tool interlocks. See "Operational MODE Inputs" on page 160.

Miscellaneous I/O Connector

Unlike the MagnaTran 7 and MagnaTran 8 Misc I/O interface which defaulted to operation with robot power, the MagnaTran LEAP controller requires the integrator to define the use of either internal robot power or use of an external power supply. When operating with robot power, jumpers are required. Figure 6-9: "Internal and External Robot Power" on the next page.

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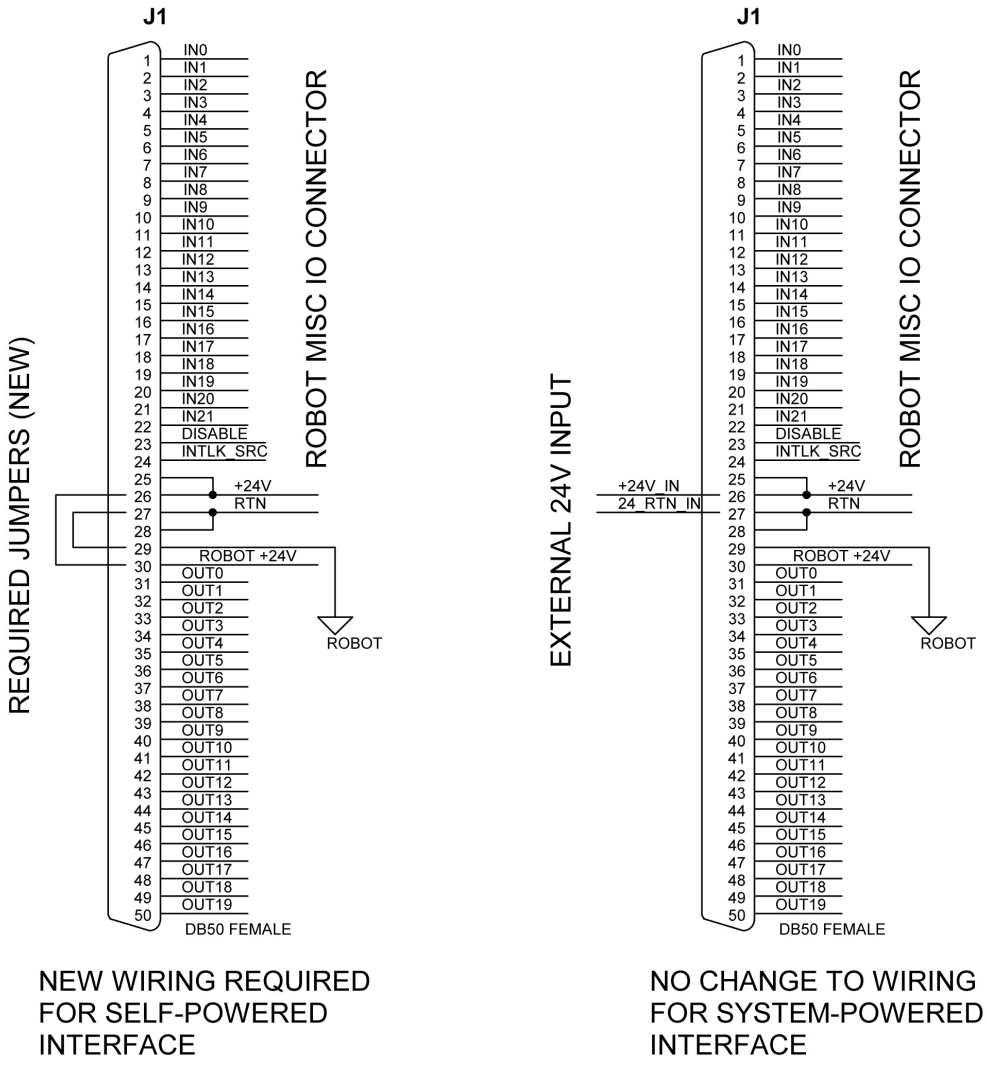


Figure 6-9: Internal and External Robot Power

Operational MODE Inputs

The MagnaTran LEAP robot safety controller provides a mode selection interface for the system integrator. This section defines operation of the MODE inputs and further describes how they can be used in a larger system.

MODE inputs can be used to select robot modes: Automatic, stop, or manual. Automatic mode is the normal mode of operation, where the host controller sequences the robot to pick and place as directed by upper level software. Manual mode is used by trained personnel to teach the robot, debug errors, recover from failure, and more generally, is intended for use during system maintenance.

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To transition between Manual mode and Automatic mode, the embedded safety controller must sequence through the Stop mode. This ensures the robot is not in motion before entering the next operational mode and complies with the machinery directive.

Figure 6-10 and Table 6-3 show the mode selection inputs and truth table.

Table 6-3: MODE Selection Inputs Truth Table

Modes	Channel A Mode Inputs		Channel B Mode Inputs	
	A1	A2	B1	B2
Automatic	0	1	1	0
Stop	1	0	1	0
Manual	1	0	0	1
Mute	0	1	0	1
Fault	X	X	0	0
	X	X	1	1
	0	0	X	X
	1	1	X	X

0 = No Connection
1 = 24VDC A or B respectively

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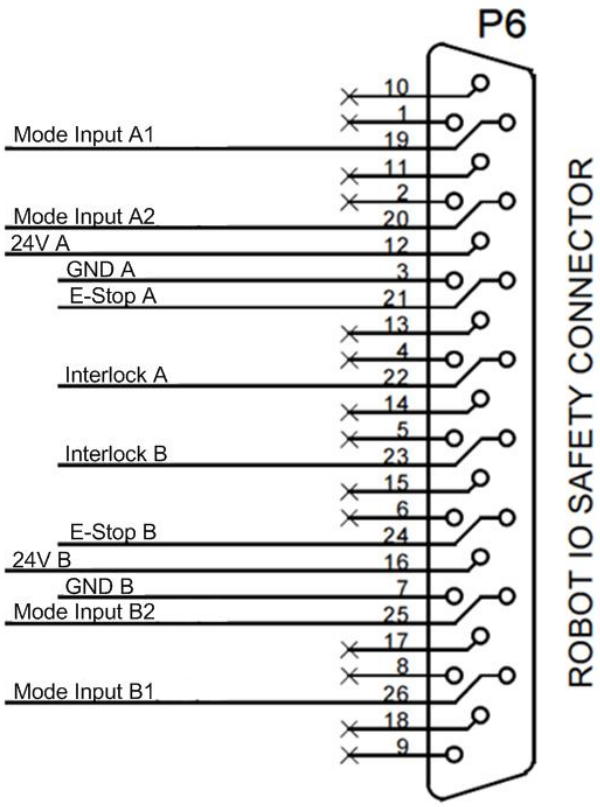


Figure 6-10: MODE Selection Inputs

Manual Mode

Manual mode is intended for use by trained technical employees as the exposure to hazards is higher. Manual mode is used to teach the robot station positions, recover from faults, and for system maintenance.

WARNING

Trained Personnel Only

To gain access to hardware, manual mode may permit the trained technical personnel to remove protective stops.

- To reduce the possibility of accidental contact with robot arms, the controller sets safe speed mode. Safe speed limits the velocity to 250mm/sec at the robot end effector.

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WARNING

End-Effector Velocity

Even though the end-effector velocity is limited to 250mm/second, in safe speed mode, arm linkages may operate significantly faster. Only operate the teach pendant outside of the robot workspace.



WARNING

Reduced Speed

Implementation of reduced speed during teach or manual modes is not safety-rated. Always use a liveman teach pendant when operating inside the robot workspace.



Manual mode enables operation of the teach pendant. The teach pendant will not operate in Stop mode or in Automatic mode. Only operate the teach pendant outside of the robot workspace. A liveman teach pendant is available for purchase which permits operation inside the robot workspace.

The MagnaTran LEAP controller permits use of two different categories of pendant styles: legacy teach pendants and Liveman Teach Pendants. The legacy teach pendants are not fully recognized by EN/ISO10218 as they do not have the required liveman switch. Use of the legacy pendant is permitted only on retrofitted systems. It should not be used in new designs.

WARNING

Legacy Teach Pendant

Never use the legacy teach pendant in the robot workspace. It lacks a Live Man switch and does not contain redundant safety circuits.



In addition to the MODE inputs described above, the robot safety controller also has MODE outputs bits that are useful in extending functionality of the safety controller. The term “monitor bits” is used

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to describe the discreet output bits of the safety controller. These bits are useful for integration of the robot safety controller into a larger system environment.

NOTICE

The output bits for the safety controller are not monitored.

Safety System Teach Pendant

The MagnaTran LEAP uses a custom LivemanTeach Pendant that is compliant to the EN/ISO 10218 standard. The pendant has a liveman switch and applies redundant technology to emergency stop and liveman switches.

The pendant operates only in the Manual mode and contains a liveman safety switch. The liveman switch meets the safety requirement with redundant switches and a 3-position switch: off, gripped, and panic. Motion is permitted only in the gripped (center) position.

For more information of the Liveman Teach Pendant, please see the "Embedded Safety Controller" on page 147.



Figure 6-11: MagnaTran Liveman Teach Pendants

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Basic Completed Wiring

The wiring diagram below (Figure 6-12) represents a completed design for the MagnaTran LEAP Safety System. The number of safety switches can vary, but this design is otherwise complete.

The completed design consists of three separate wiring segments: Emergency Stop, Protective Stop, and Mode Selector. These are shown below (Figure 6-12).

A fourth segment is the tool interlock. See "Miscellaneous I/O Interlocks" on page 157.

Assuming the emergency stops, protective stops and miscellaneous tool interlocks are complete, the safety system will permit the robot motion in either the manual or automatic modes.

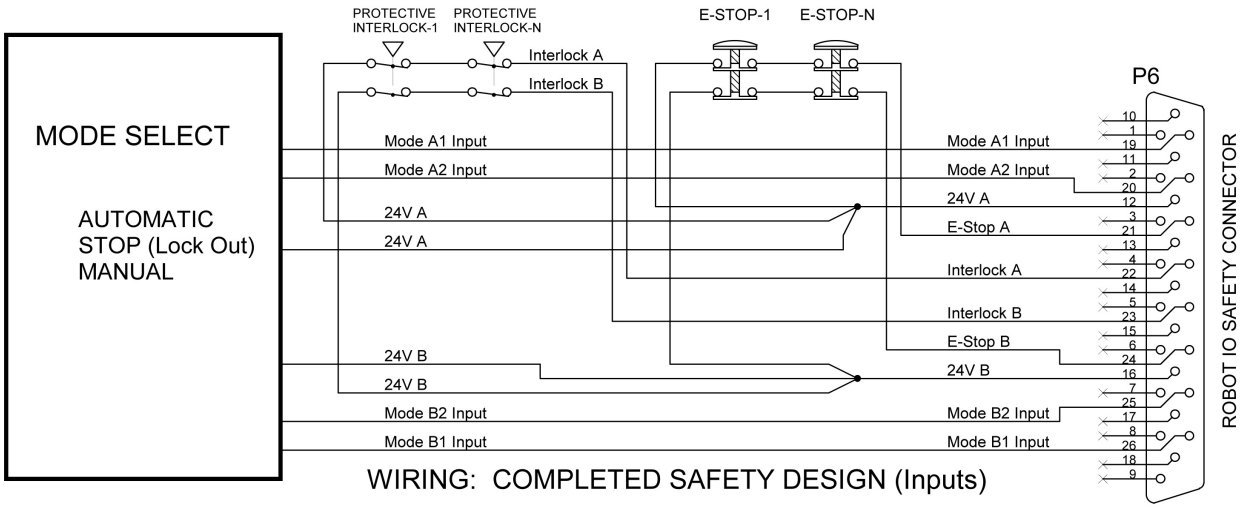


Figure 6-12: Basic Completed Wiring

See Table 6-3 on page 161 for additional information on MODE Inputs.

Advanced Safety Connector Implementation

Monitor Bits

The MagnaTran LEAP safety controller also provides status of the inputs bits described in the previous section. For most input bits there is a corresponding output bit. The output bits can be used to indicate status or to extend the safety operation to the larger semiconductor manufacturing tool.

The discreet monitor bits require functional definition and further definition of electrical parameters.

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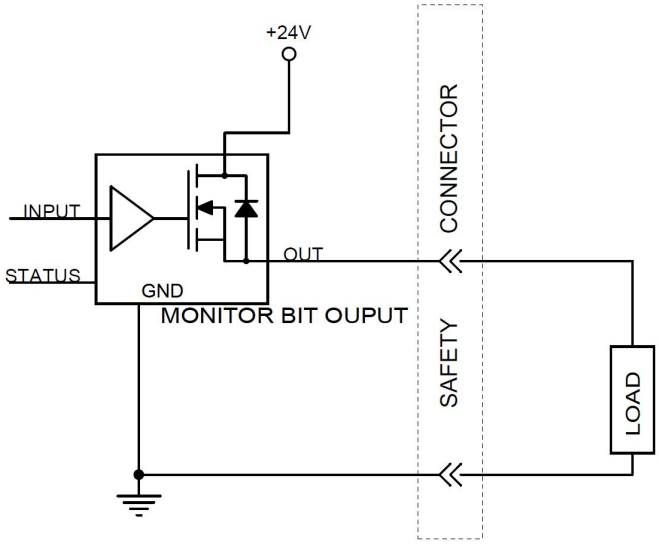


Figure 6-13: High-Side Output

a. Output Type: high-side output drive, P-channel FET connection to +24V.
   - A high-side switch is designed to connect the output to a positive power source.
   - Logic “1” is a connection to +24V.
   - Logic “0’ is a disconnect from 24V.
   - Some type of load is required to ensure a logic “0” goes to ground.

b. Power Budget: total 24V current for all the outputs combined should be less than 500mA total.

   Example: 250mA for Channel A, 250mA for Channel B).

NOTE: 24V-A and 24V-B on the safety connector diagrams are exclusively for inputs to the connector. They are not used for the monitor bits

c. Connection of monitor bits to capacitors may:
   - Expose personnel to hazards, including injury and death.
   - Override the operation of the safety controller.
   - Damage the controller

d. (If Used) Outputs require a resistive load to their respective ground.
   - Channel A outputs require a resistor to Ground A
   - Channel B outputs require a resistor to Ground B
   - Typical resistor loads would range from 1K to 24Kohm

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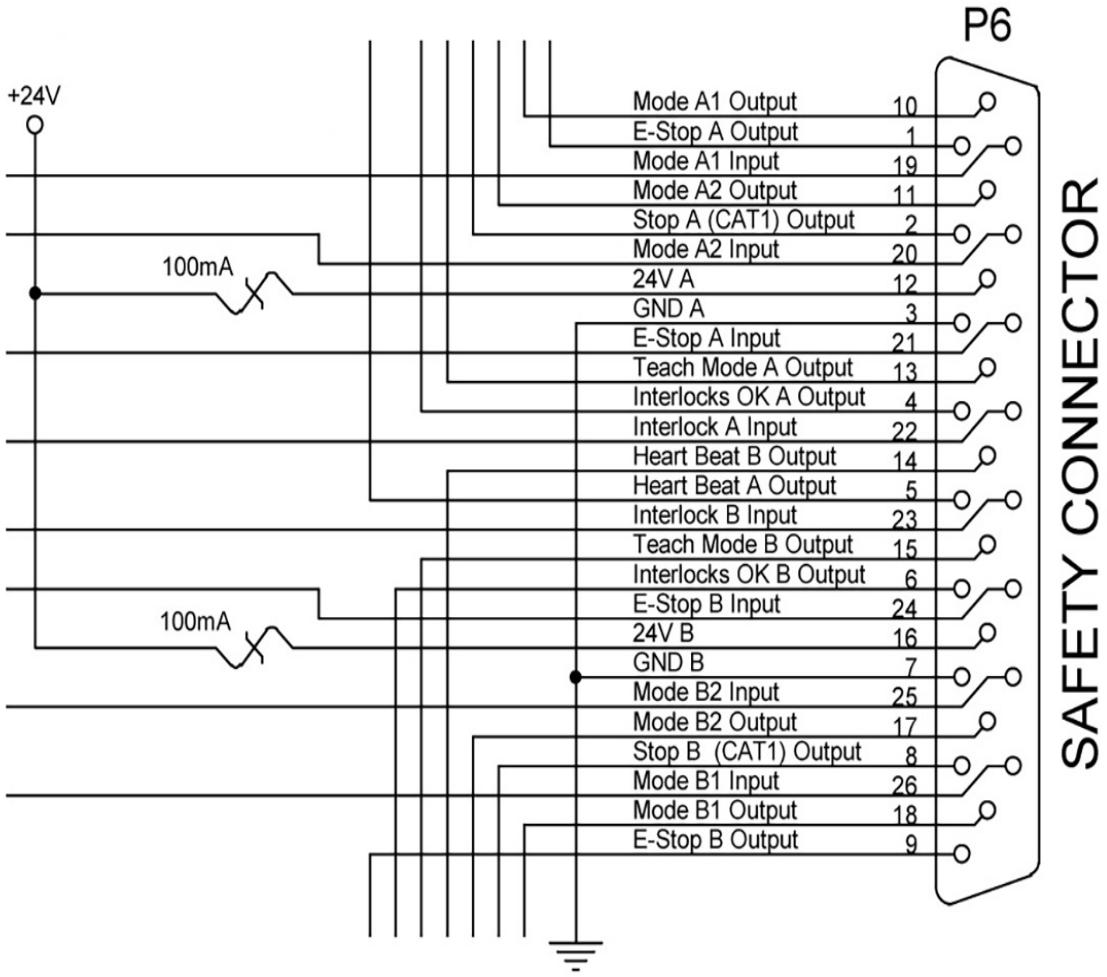


Figure 6-14: Simplified Diagram of the Safety Controller

Observations

- Safety controllers are redundant and data are processed by hardware with a mode dependent response time that varies from 200ms ± 40ms for manual mode to 2s ± 0.4s in automatic mode.
- The monitor bits are discreet data output bits to the robot safety connector.
- Monitor bits are intended for use by the integrator to implement a system-wide safety controller.
- The integrator should never compromise safety with wiring that connects both A and B controllers inputs together.

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Table 6-4: Monitor Bits and Function

Monitor Bit Name	Pin	Function
Emergency Stop A Output	1	0 = E-Stop or other interlocks are not satisfied for channel A. 0 = May also indicate a fault in the controller safety system: example, an open conductor on the safety switch wiring 1 = Indicates robot will accept motion commands and robot can move 1→0 = Transition indicates a launch of a robot STOP command. Removal of motor power is imminent: 200ms ± 40ms if in Manual mode or 2s ± 0.4s if in Automatic mode.
Stop A (CAT1) Output	2	0 = E-Stop or other interlocks are not satisfied for channel A. 0 = May also indicate a fault in the controller safety system: example, an open conductor on the safety switch wiring 1 = Indicates robot will accept motion commands and robot can move 1→0 = Transition indicates the robot has completed a robot STOP and disconnected motor power (either after 200ms ± 40s in Manual mode or 2s ± 0.4s in Automatic mode).
Interlocks OK A Output	4	0 = Protective stops (interlocks) are not satisfied. 0→1 = Safety controller “A“ senses that external requirements for protective stop switches are satisfied (closed). This is one of many interlocks required before motion can be commanded. 1 = All channel “A” Protective switches are satisfied, (closed).
Heartbeat A Output	5	A 10Hz clock which indicates channel A of the Safety System is alive and operational.
Teach Mode A Output	13	1= Teach Pendant is in control 0= Indicates teach pendant is not active.
Mode A1 Output	10	This output is the same as the input bit of the same name on pin 19 Exception: If a fault is detected, this bit will not be asserted as a “1”
Mode A2 Output	11	This output is the same as the input bit of the same name on pin 20 Exception: If a fault is detected, this bit will not be asserted as a “1”
Mode B1 Output	18	This output is the same as the input bit of the same name on pin 26 Exception: If a fault is detected, this bit will not be asserted as a “1”
Mode B1 Output	17	This output is the same as the input bit of the same name on pin 25 Exception: If a fault is detected, this bit will not be asserted as a “1”
Teach Mode B Output	15	1 = Teach pendant is in control. 0 = Indicates teach pendant is not active.
Interlocks OK B Output	6	0 = Protective Stops (interlocks) are not satisfied. 0→1 = Safety controller “B” senses that external requirements for protective stop switches are satisfied (closed). This is one of many interlocks required before motion can be commanded. 1 = All channel “B” protective switches are satisfied, (closed).
Heartbeat B Output	14	A 10Hz clock which indicates channel B of the Safety System is alive and operational.

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Monitor Bit Name	Pin	Function
Emergency Stop B Output	9	0 = E-Stop or other interlocks are not satisfied for channel B. 1 = Indicates robot will accept motion commands and robot can move 1→0 = Robot is executing a robot STOP command. Removal of motor power imminent (200ms ± 40ms if in Manual mode) or (2s ± 0.4s if in Automatic mode).
Stop B (CAT1) Output	8	0 = E-Stop or other interlocks are not satisfied for channel B. 1 = Indicates robot will accept motion commands and robot can move 1→0 = Robot has completed a robot STOP and disconnected motor power (either after 200ms ± 40s in Manual mode or 2s ± 0.4s if in Automatic mode).

Muting the Safety I/O Connector

There may be instances where it is necessary to operate the robot without an external operating safety environment. While Brooks Automation cannot conceive of a single instance where interlocks and Emergency Stops cannot be installed to protect personnel and equipment, a provision has been made for such operation.

WARNING

Emergency And Protective Stops

Bypassing the safety system puts everyone in danger.

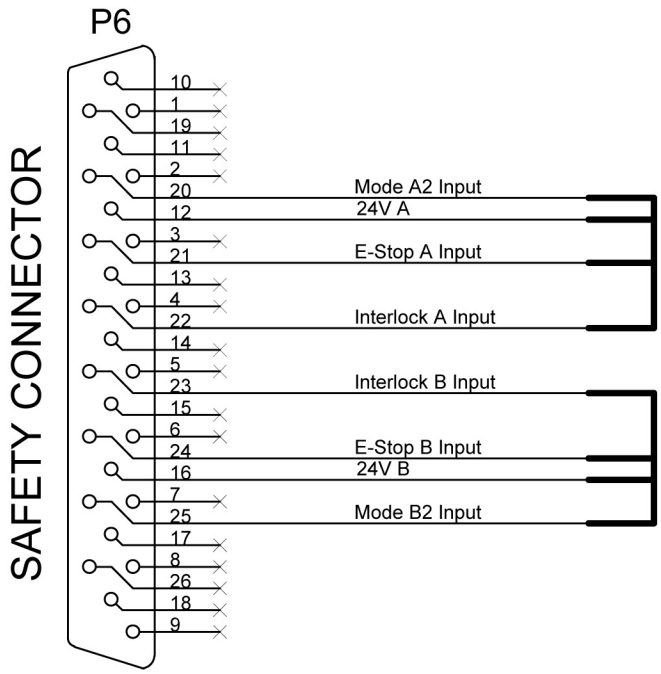
- Assess personnel and equipment safety hazards that are created from bypassing interlocks before proceeding.
- Brooks Automation advises against operation or test without safety interlocks in place.



Brooks Automation offers a safety muting connector for use when retrofitting a MagnaTran 7 or MagnaTran 8 robot with a MagnaTran LEAP robot. If the risk assessment determines the pre-existing safety system is adequate, it is possible to use a connector assembly to mute the new features of the MagnaTran LEAP safety controller.

Please note the MagnaTran 7 and MagnaTran 8 places the interlocks on the robot MISC I/O connector.

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MUTING SAFETY CONNECTOR
USE ONLY IF OTHER SAFE GUARDS ARE IN PLACE
Brooks Autmation Part Number 248841

Figure 6-15: Safety Controller Mute/Legacy Mode Diagram



Figure 6-16: Muting Connector

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MagnaTran 7 Retrofit

Brooks Automation has provided a migration path from MagnaTran 7 and MagnaTran 8 to MagnaTran LEAP robots and controls. Consult Brooks for a part number that provides the desired upgrade to MagnaTran LEAP robots.

The dual redundant safety system included with the MagnaTran LEAP controller is not available in the MagnaTran 7 or the MagnaTran 8 robot. The system integrator responsible for the MagnaTran LEAP replacement should first review current safety standards. The system integrator should repeat or conduct a new risk assessment to ensure the system meets current safety standards prior to retrofit. It may be necessary to upgrade the safety system.

Brooks Automation strongly advises migration to the Liveman Teach Pendant as it significantly reduces the likelihood of injury.

If the existing safety system is determined adequate, the MagnaTran LEAP retrofit can be as simple as physically replacing the existing robot with the MagnaTran LEAP robot but with a few electrical adapters.

Sample retrofit procedure:

a. Contact Brooks Automation:
   - Provide Brooks with the part number of the robot targeted for upgrade to MagnaTran LEAP.
   - Confirm if the robot arm and end effectors are to be part of the retrofit program.
   - Provide the logs for all existing WAVE II setups and commands being used and a list of RSU screen shots and commands. Confirm which version of MagnaTran LEAP software is required for compatibility.
   - Consider upgrading to a Liveman Teach Pendant, otherwise confirm that the existing legacy teach pendant will work with the new MagnaTran LEAP robot.
   - Request a new part number for the replacement robot and appropriate kits.

b. Order the replacement robot.

c. Receive the upgrade package: unpack, inspect, and use the existing tooling for testing. The electrical adapters may be needed at this time.

d. Remove the MagnaTran 7 robot using established procedures:
   - Unplug the MagnaTran 7 from the power supply, host, and MISC I/O connectors.
   - Remove the arms if required.
   - Unbolt the MagnaTran 7 robot and remove from vacuum chamber.

e. Install MagnaTran LEAP robot and bolt in place.

f. Plug in 248841 muting connector if the safety system was deemed adequate.

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NOTE: Two jumpers are required if the Misc IO interface is internally powered. See "Miscellaneous I/O Interlocks" on page 157.

g. Plug in the existing host and MISC I/O and power supply.
h. If the arms are not installed, check the emergency stop and associated switch-based interlocks.
i. Test robot without arms if that is the existing protocol, otherwise mount arms.
j. Mount arms.
k. Test and teach MagnaTran LEAP robot using the teach pendant.

NOTE: If the teach pendant is updated some modifications to the existing procedure may be required.

l. Close up the system and test according to existing protocol.

Notify Brooks Automation of any issues with the installation.

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7. Teach Pendant

Four types of teach pendants can be used with the MagnaTran LEAP robot:

- MagnaTran LEAP Liveman Teach Pendant: Coordinate Style
- MagnaTran LEAP Liveman Teach Pendant: Function (Soft Key) Style
- MagnaTran 7 Legacy Teach Pendant
- MagnaTran 8 Legacy Teach Pendant

The MagnaTran LEAP Liveman Teach Pendant comes in two keypad styles: Coordinate and Function. Teach pendants with the coordinate style keypad are typically used with robots that have a single arm with 1 or 2 end effectors. Teach pendants with the function (soft key) style keypad are typically used with robots that have multiple arms and end effectors.

Teach Pendant Safety

The MagnaTran LEAP uses a custom LivemanTeach Pendant that is compliant to the EN/ISO 10218 standard. The pendant has a liveman switch and applies redundant technology to emergency stop and liveman switches.

Whenever possible, manual mode operation should be performed with all persons outside the robot’s workspace.

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Figure 7-1: MagnaTran LEAP Liveman Teach Pendant

NOTICE

Brooks requests placing cables for the E-stop and/or liveman in conduit or flexible metal cabling.

The Liveman Teach Pendant is designed to provide increased safety. It is intended for use with the MagnaTran LEAP robot and controller. The Liveman Teach Pendant will only operate when the operational mode selector is set to Manual mode.

The liveman pendant provides a redundant E-stop switch and a 3-position switch: off/fully released, gripped, and panic/fully pressed. Motion is permitted only in the gripped (center) position.

The MagnaTran LEAP controller also supports legacy MagnaTran 7 and MagnaTran 8 teach pendants. The legacy teach pendant does not provide the same level of safety as the Liveman Teach Pendant. Never use a legacy teach pendant while operating in the robot workspace.

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WARNING

Legacy Teach Pendants

Legacy Teach Pendants do not comply with the ISO 10218-1 standard because they do not have a liveman switch.

- Brooks recommends using liveman teach pendants when working on any robot or system.
- Never enter the robot workspace when operating the robot with a legacy teach pendant.



Figure 7-2: Legacy Teach Pendant

Legacy teach pendants are not intended for use within the robot workspace. Never enter the robot workspace as you are not protected by a liveman switch.

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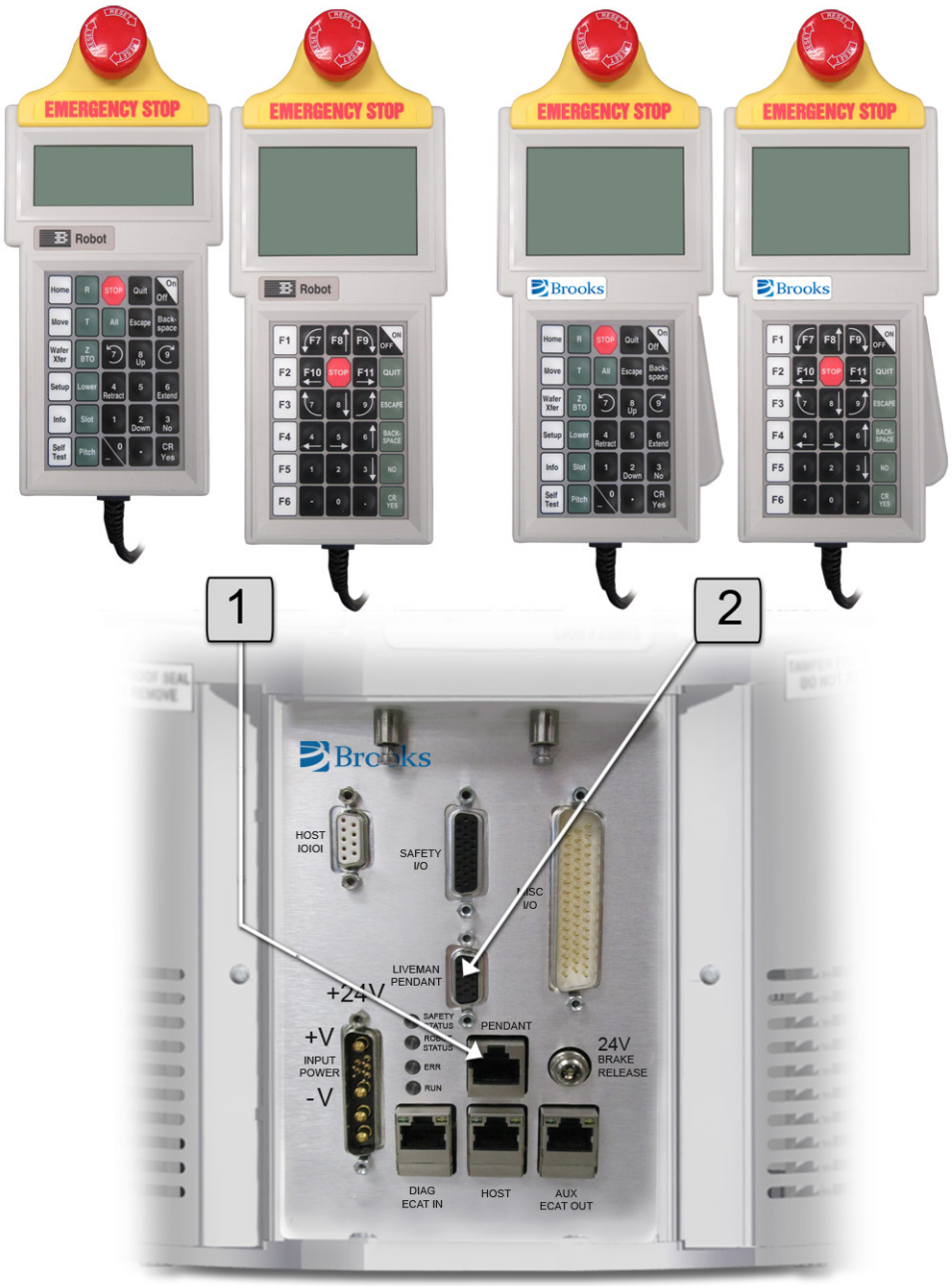


Figure 7-3: Legacy and Liveman Teach Pendants Connections

Table 7-1: Legacy and Liveman Teach Pendants Connections - Explanation

Number	Explanation
1	Legacy Teach Pendants connect to the Robot I/O Panel with an RJ45 Connector
2	The MagnaTran LEAP Teach Pendant connects to the robot using a high density D-Sub 15 pin connection.

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Teach Pendant Emergency Stop and Liveman Test

Always test the emergency stop and the liveman switch before using the teach pendant, before robot first use, and before the robot is placed into production.

Step	Action
1.	Issue a move command via the teach pendant and while the robot is still in motion, press the emergency stop button. If the robot stops, clear the error and continue use.
2.	Issue a move command via the teach pendant and while the robot is still in motion, fully release the liveman switch. If the robot stops, clear the error and continue use.
3.	Issue a move command via the teach pendant and while the robot is still in motion, fully press the liveman switch. If the robot stops, clear the error and continue use.
4.	If the robot does not stop during any of these tests, DO NOT USE the teach pendant. Contact Brooks for troubleshooting.

Teach Pendant Operation

Teach pendants are designed to be a single-point of control terminal to assist personnel in commanding the robot. Teach pendants operate the robot at a slow teaching speed and have an Emergency stop button for safety. The MagnaTran LEAP Liveman Teach Pendant has been designed to be easy to use and self explanatory. All major functions available through the robot's control software are available through the teach pendant.

Liveman Teach Pendants only operate when correctly mated to the LIVEMAN PENDANT DB15 connection on the robot I/O Panel. Non-liveman teach pendants only operate when correctly mated to the PENDANT RJ 45 connection on the robot I/O panel. For safety reasons, non-liveman teach pendants and Liveman Teach Pendants connections cannot be switched.

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Figure 7-4: Legacy Teach Pendant with Emergency Stop



Figure 7-5: Liveman Teach Pendant with Emergency Stop

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Liveman Teach Pendant 3 Position Design

The 3-position design of the Liveman Teach Pendant provides a closed circuit when pressed to the mid-point. A fully released or fully pressed switch opens the switch circuit, which will cause the robot to stop operation.



Figure 7-6: Liveman 3 Position Design

Table 7-2: Liveman 3 Position Design - Explanation

Number	Explanation
1	Fully Released / Unengaged
2	Engaged
3	Fully Pressed / Panic

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Teach Pendant Emergency Stop

An emergency stop button is located on the top of the teach pendant. To initiate an emergency stop, press the E-Stop button.

Pressing the emergency stop button executes a software based halt command. Stopping distance is related to the armset configuration, load, and speed of the arm at the moment the E-stop is activated. Users should familiarize themselves with the stopping distance taken by their particular applications. Stopping time is typically around 500ms in Teach Mode. The robot typically takes more time to stop, and has a larger stopping distance, while in Automatic Mode.

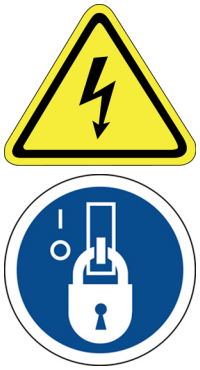
The emergency stop button will halt any robot motion currently in progress and release servo control of the robot arms. An error number and description will be displayed on the teach pendant screen (if the teach pendant is turned on) and be sent to the host controller. All arm position data and arm referencing will remain.

WARNING

Electrical Shock

The emergency stop button removes power to the motors. It does not remove DC power to the robot. Electrical hazards still exist when the emergency stop circuit is active, which could cause death or serious injury .

- All power to the MagnaTran LEAP must be disconnected per the facilities' lockout/tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.



NOTICE

The teach pendant does not need to be in control of the robot for the emergency stop button to work; nor does it have to be on. The teach pendant needs only to be plugged into the robot to allow access to the emergency stop function.

While the emergency stop circuit is active, the encoders remain powered. This allows the arms to be physically moved but remain referenced. The current arm position will be updated on the teach

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pendant. When control of the robot is regained, the robot is able to recover from its physical position without having to home the robot.

Releasing the Emergency Stop Button

To release the emergency stop button: press down and turn the button clockwise.

Function/Softkey Teach Pendant Key Descriptions

Table 7-3: Function/Softkey Teach Pendant Key Descriptions

Key	Description
	On-Off key turns the teach pendant on or off.
	Quit key returns the teach pendant display to main menu.
	Stop key brings all robot actions to controlled stop.
	Escape key moves teach pendant display back one menu.
	Backspace key allows entered characters to be deleted.
	Enters “-”
	Enters “.”
	Enters “0”

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Key	Description
	Enters “1”
	Enters “2”
	Enters “3” Moves the screen selection down (dependent on screen). Jogs down (dependent on screen).
	Enters “4” Moves the screen selection to the left (dependent on screen).
	Enters “5” Moves the screen selection to the right (dependent on screen).
	Enters “6” Moves the screen selection up (dependent on screen). Jogs up (dependent on screen).
	Enters “7” Jogs the arm clockwise.
	Enters “8” Moves the screen selection to the right (dependent on screen).
	Enters “9”. Jogs the arm counter clockwise.
 through 	Selects an option presented on the screen.
	Selects an option presented on the screen. Jogs the wrist counter-clockwise.

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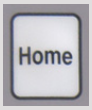
Key	Description
	Selects an option presented on the screen. Moves the screen selection (dependent on screen). Jogs up, (dependent on screen).
	Selects an option presented on the screen. Jogs the wrist clockwise.
	Selects an option presented on the screen. Moves the screen selection left (dependent on screen).
	Selects an option presented on the screen. Moves the screen selection right (dependent on screen).
	Indicates numerical entry is complete. Responds “Yes” to prompts.

Coordinate Teach Pendant Key Descriptions

Table 7-4: Coordinate Teach Pendant Key Descriptions

Key	Description
	On-Off key turns the teach pendant on or off.
	Quit key returns teach pendant display to main menu.
	Stop key brings all robot actions to controlled stop.
	Escape key moves teach pendant display back one menu.
	Backspace key allows entered characters to be deleted.

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Key	Description
	Selects the Home menu.
	Selects the Move menu.
	Selects the Wafer Transfer menu.
	Selects the Setup menu.
	Selects the Information menu.
	Selects the Self Test menu.
	Specifies the R-axis for data entry or query.
	Specifies the T-axis for data entry or query.
	Specifies the Z-axis for data entry or query, Specifies BTO for data entry or query.
	Lower key is used to specify the lower value for a specific station for data entry or query.
	Specify the slot number for a specific station for data entry or query.
	Specify the pitch between slots for a specific station for data entry or query.

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Key	Description
	Specify all values for data entry or query.
	Enters “1”
	Enters “2” Jogs down
	Enters “3” Responds “No” to prompts.
	Enters “4” Retracts arm in jog mode.
	Enters “5”
	Enters “6” Extends arm in jog mode.
	Enters “7” Jogs counter clockwise
	Enters “8” Jogs up.
	Enters “9” Jogs clockwise
	Enters “0” Sets value to a negative number
	Enters ”.”

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Key	Description
	Used to indicate numerical entry is complete. Responds “Yes” to prompts.

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8. Preventive Maintenance

DANGER

Read the Safety Chapter

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

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



WARNING

Read the Safety Chapter

The MagnaTran LEAP robot presents mechanical and electrical hazards which, if not properly handled, may result in death or serious injury.

- Only trained and qualified personnel should work on the MagnaTran LEAP.
- Do not perform maintenance procedures on the MagnaTran LEAP robot unless you have read and understand the information in the Safety Chapter, starting on Page 10.



Preventive Maintenance Schedule

The MagnaTran LEAP robot may be cleaned and the system may be checked for errors or faults when the equipment is shut down for maintenance.

Before beginning any cleaning or maintenance procedure, read and understand the Safety Chapter, starting on Page 10.

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NOTE: The preventive maintenance schedule is based on the robot operating in a certified clean and dry environment. The user should adjust the maintenance duties to account for any deviations from this environment.

Brooks Automation strongly recommends that a record be kept to document conformance to any required procedures. Failure to perform required procedures may void the warranty.

Table 8-1: Preventive Maintenance Schedule

Interval	Action
Daily	Ensure the unit is functioning as expected
As Required	Clean the robot, armset, and end effectors. Test the emergency stop and safety circuit.
6-Months	Inspect end effectors. Clean residue as required. Inspect all connections.

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Robot Cleaning

The robot may be cleaned to remove contaminates from the process and other sources.

Table 8-2: Robot Cleaning Category and Materials

Item	Description
Electrical Category	Type 1 - Equipment is fully de-energized.
Tools and Materials	Isopropyl alcohol properly diluted with Deionized water Deionized (DI) water Cleanroom wipes

WARNING

Chemical Hazard

The robot may be used in equipment that exposes users to chemical hazards which, if not properly handled, may result in death or serious injury.

- Read and understand the safety information for the equipment where the robot is used.
- Know the location of the Safety Data Sheets (SDS) in your facility. (also known as Material Safety Data Sheets - MSDS)
- Become familiar with the proper handling of material in the environment of the robot.

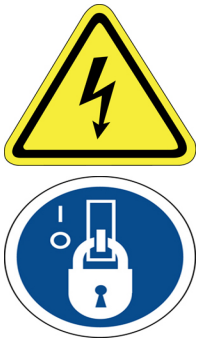


WARNING

Lockout / Tagout

Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury.

- All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.



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Cleaning Procedure

WARNING

Fire Hazard

Flammable cleaning products such as Isopropyl alcohol may cause fire if used on hot parts which may lead to death or personal injury.

- Allow the product to completely cool before using flammable cleaning products for maintenance procedures.



NOTICE

Wipes used for cleaning with liquids must be moistened only. Do no saturate. Squeezing the wipe must not cause liquid to drip.

Do no allow isopropyl alcohol to contact perflouroelastomer pads, bearing, seals, etc.
Do not allow water to contact bearings, seals, etc.

Step	Action
1.	Remove any hazardous material from the robot's surfaces following the facilities procedures for those materials.
2.	Clean all exposed surfaces using cleanroom wipes moistened with isopropyl alcohol.
3.	Once all contaminates are removed, use cleanroom wipes moistened with DI water to remove any residue.
4.	Once all residue is removed, use dry cleanroom wipes to dry all surfaces.

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End Effector Cleaning and Inspection

Contaminants on the end effector pad surface may cause wafer slippage. For proper robot and system performance, pads should be cleaned as a part of normal servicing.

NOTE: Cleaning procedures depend on the type of pads.

Table 8-3: Robot Cleaning Electrical Category and Materials

Item	Description
Electrical Category	Type 1 - Equipment is fully de-energized.
Tools and Materials	**Elastomeric pads**: Use de-ionized water **Stainless Steel pads**: Use Isopropyl alcohol **Quartz pads**: Use Isopropyl alcohol Lint-free, cleanroom wipes Cleanroom gloves

NOTICE

The MagnaTran LEAP may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Safety Data Sheets for those materials to determine proper handling.

NOTICE

Wipes used for cleaning with liquids must be moistened only. Do not saturate. Squeezing the wipe must not cause liquid to drip.
Do not let alcohol contact Elastomeric pads, bearings, seals, etc.
Do not let water contact bearings, seals, etc.

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Cleaning Elastomeric Pads Procedure

Step	Action
1.	Dampen a cleanroom wipe with de-ionized water.
2.	Clean the entire end effector, paying special attention to the Elastomeric pads. Do not apply excessive pressure or force to the pads while cleaning. Excessive force may dislodge pads or bend the end effector.
3.	Once all residue is removed, use dry cleanroom wipes to dry all surfaces.

Cleaning Stainless Steel or Quartz Pads Procedure

Step	Action
1.	Dampen a cleanroom wipe with Isopropyl alcohol.
2.	Clean the entire end effector, paying special attention to the pads. Do not apply excessive pressure or force to the pads while cleaning. Excessive force may bend the end effector.
3.	Once all residue is removed, use dry cleanroom wipes to dry all surfaces.

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End Effector Pad Inspection

Over time, repeated wafer transfers wears away the surface of the Elastomeric wafer support pads, and decreases its effectiveness. It is necessary to inspect these pads to prevent wafer slippage and loss of repeatability.

NOTICE

The MagnaTran LEAP may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Safety Data Sheets for those materials to determine proper handling.

NOTICE

Wipes used for cleaning with liquids must be moistened only. Do not saturate. Squeezing the wipe must not cause liquid to drip.
Do not let alcohol contact Elastomeric pads, bearings, seals, etc.
Do not let water contact bearings, seals, etc.

Pad Inspection Procedure

Step	Action
1.	Extend the end effector into the load lock or process module.
2.	Visually inspect the surface of the pads for excessive wear or damage.
3.	If any of the pads show signs of wear or damage, replace the pads. See"Pad Replacement" on page 194.

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Pad Replacement

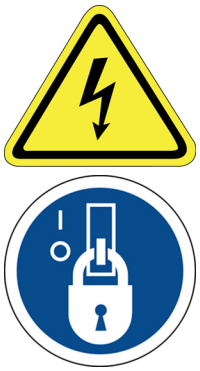
Replace the wafer supports if they show significant wear or damage. This procedure provides directions to replace grommet-style supports.

WARNING

Electrical Shock

Working with energized equipment may cause electrical shock and may result in death or serious injury.

- All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing.
- Follow the Lockout/Tagout procedures specified by the local facility.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.
- Refer the units specifications for the actual system power requirements and use appropriate precautions.



Pad Replacement Procedure

Step	Action
1.	Perform the appropriate procedure to shut down the system
2.	Render the system safe per the facility Lockout/Tagout procedures
3.	Remove damaged or worn pads by pulling the pad out of the end effector. Do not allow the end effector to bend or distort.
4.	Clean the end effector. Dry the area with clean wipes. The area where the pad goes must be completely free of debris ***NOTE:*** *Do not allow alcohol to come in contact with Elastomeric type pads. Alcohol will reduce the coefficient of friction and cause wafer slippage. Clean the pads with DI water only. See "End Effector Cleaning and Inspection" on page 191.*
5.	Press the small end of the new pad, by hand, into holes in the end effector.

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9. Troubleshooting

The MagnaTran LEAP robot does not have a traditional controller. It is the responsibility of the robot integrator to develop and provide software troubleshooting, as well as diagnostics and error messages.

Troubleshooting Overview

Depending on the error type, three troubleshooting options are described for the MagnaTran LEAP robot:

a. Troubleshooting specific error codes: failures that generate an error code identified by a number. For example, the robot generates an error such as, “ERR 10009: Hard tracking error, T1 motor”. These types of failures are listed in the following section: "Error Codes" on page 197.

b. Troubleshooting commands: The MagnaTran LEAP has three commands that provide additional information from the robot that is useful in troubleshooting. These commands are:

`RQ HISTORY` - this command displays the errors and non-action commands executed by the robot.

`SET ERRLVL 5` - this command sets the robot’s error level response to a range of 1 through 5, where 1 yields the least number of error messages and 5 yields the maximum number of error messages. The Brooks default error level is 2. For maximum wafer throughput, the error level must be set at “2” after troubleshooting by using the command SET ERRLVL 2 and STORE ERRLVL.

`SET COMM SEQ` or `SET COMM BKG+` - The MagnaTran LEAP robot must either be in the “sequential” or “background+” communication flow setting to generate error code messages. The MagnaTran LEAP robot will not generate error code messages when operating in the “background” communication flow setting. The robot must be returned to the original communication flow setting after troubleshooting.

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c. Troubleshooting observed symptoms: failures that are observed by the operator but do not generate an error code identified by a number. The specific symptoms for each failure type can be categorized. These types of failures are listed in the following section:

Table 9-1: Symptoms of Observed Error Types

Observed Symptoms	Page
Communication • No response from robot using PC. • No response from robot using teach pendant.	"Communication" on page 197
Power • Safety LED not illuminated. • Failure for robot to operate. • No communication using PC or teach pendant.	"Power" on page 198
Radial Motion • Armset has jerky motion. • Armset oscillates. • Armset overshoots taught position. • Armset sways from side to side during motion. • Robot is unable to move in the R direction.	"Radial Motion" on page 202
Theta Motion • Armset has jerky motion. • Armset oscillates. • Armset overshoots taught position. • Armset sways from side to side during motion. • Robot is unable to move in the T direction.	"Theta Motion" on page 203
Z Motion • Armset has jerky motion. • Armset oscillates. • Armset overshoots taught position. • Robot is unable to move in the Z direction • Robot hits Z hard stops during operation in Z. • Robot hits Z hard stops during homing in Z.	"Z-Axis Motion" on page 204
Find Phase • ”Command Failed” error occurs. • T1/T2 shafts do not move together while pinging in theta direction.	"Find Phase" on page 206
Homing Z-axis • ”Command Failed” error occurs.	"Home Errors" on page 200

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Appendix A: Error Codes

Refer to the *MagnaTran LEAP Software Manual* (605651) for a list of error codes.

Communication

Troubleshooting communication requires that the MagnaTran LEAP has power and is turned on.

Symptoms	Possible Cause	Corrective Action
No response using computer No ":" or "_RDY"	Incorrect settings	Verify settings on computer 9600, N, 8, 1.
		Verify PC communication port.
		Verify robot com settings are proper using RQ COMM ALL.
		Verify RS-232 on Personality PC board is set properly.
	Teach pendant interference	Verify teach pendant is off. Verify on pendant that robot is not set to Ethernet.
	Bad ground	Confirm robot is properly grounded.
	DOC on PC104 has failed	"Contact Brooks Automation Technical Support" for further troubleshooting. Processor board replacement.
	Bad cables	Check cables for proper configuration, connection and continuity.
No response using teach pendant. Screen remains blank when turned on.	Bad cable or connectors	Check teach pendant cables. Check teach pendant is connected to correct port.
	Bad teach pendant	Confirm teach pendant works - swap with another teach. pendant or try on different unit.

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Power

Table 9-2: Power Related Troubleshooting

Symptoms	Causes	Corrective Actions
LED is off	No input power	Check F1 on [[[Undefined variable MyVariables.ProductName1]]]. Check facilities power source and system circuit breakers. Check power cables.
Fuse for Input power blows immediately at power up.	Faulty component in the power or control circuit.	Check input voltage.
		"Contact Brooks Automation Technical Support" for further troubleshooting.
MagnaTran LEAP does not power up LED is off.	Robot internal issue	"Contact Brooks Automation Technical Support" for further troubleshooting. Replace robot.
	MagnaTran LEAP constantly blows a fuse	Disconnect outputs and power up the MagnaTran LEAP. Troubleshoot fuse circuit and remote devices for fuse that blows. "Contact Brooks Automation Technical Support" for further troubleshooting.
MagnaTran LEAP does not boot up LED is on.	Improper MODE setting. DIO - Serial - Ethernet - LON works.	Connect with RS232 if in DIO mode. Enter command DIO STOP. Change communications mode to match system requirements.
		Connect with teach pendant if not DIO mode. Change communications mode to match system requirements.
MagnaTran LEAP boots up and LED is on. No power to motors.	Fuses to motors are blown	"Contact Brooks Automation Technical Support" for further troubleshooting.
	Fuses to motors constantly blow	"Contact Brooks Automation Technical Support" for further troubleshooting.
	Bad DC power	Check input power to MagnaTran LEAP Resolve input power if required.
MagnaTran LEAP boots up. Cannot move any axis.	Error being generated	Check for error code. Follow error code corrective actions.

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Motion Errors

See also: vibration, errors for specific axis motion, and error code 10009.

Table 9-3: Motion Errors

Symptoms	Causes	Corrective Action
Motion error at specific station or location	Improper teaching of stations	Re-teach station and via locations. Reteach stations and locations. Replace robot drive if no problems found.
	Incorrect application code	Confirm proper robot arm, end effector, and application. Enter proper application. Do EEPROM. RESET.
Motion error at any speed and at any location	Improper application for robot, arm, and end effector	Confirm proper robot application. Enter proper application. Do EEPROM. RESET.
	Incorrect sync phase values	Request sync phase values from robot and compare to QR document. Perform FIND SYNC PHASE and compare to QR document. Re-teach sync phase values as required.
	Incorrect arm installation	Remove / reinstall armset. Check torque on mounting screws.
Wrong location or hits something	Incorrect application code	Confirm current application code. Check against system requirements. If incorrect, reload application. If OK, check taught values.
	Incorrect taught station values	Check values for stations. Reload backup file. Re-teach stations.

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Symptoms	Causes	Corrective Action
Grinding sounds	Bearing failure	Manually move arm with servo lock off. Feel for rough motion or loose components. Replace arm or robot assembly as required.

Home Errors

Table 9-4: Home Errors

Symptoms	Causes	Corrective Actions
All axes will not home	E-Stop circuit is open.	Check E-Stop circuitry to confirm that robot has power.
	Improper or corrupted application data	Confirm proper robot application. Enter proper application. Do EEPROM. RESET.
	Bad calibration	Check sync phase values. Find new sync phase values. Compare new values to original values and to stored values. Enter new values if they are in range and are different from stored values.
	Robot arm mounted incorrectly	Check arm mounting. Remove and remount arm.
	Arm bearings defective	Check arm and robot drive for smooth motion. Replace arm or robot drive if movement problems are found.
Specific axis does not home	E-Stop circuit is open.	Check E-Stop circuitry to confirm that robot has power.
	Improper teaching of stations	Re-teach station and via locations. Replace robot drive if no problems found.
	Improper application	Confirm proper robot arm, end effector, and application. Enter proper application. Do EEPROM. RESET.

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Vibration

Table 9-5: Vibration Troubleshooting

Symptoms	Causes	Corrective Action
Constant vibration	Improper or corrupted application data	Confirm proper robot application. Enter proper application. Do EEPROM. RESET.
	Bad calibration	Check sync phase values. Find new sync phase values. Compare new values to original values and stored values. Enter new values if they are in range and are different from stored values.
	Robot arm mounted incorrectly	Check arm mounting. Remove and remount arm.
	Arm bearings defective	Check robot arm and drive for smooth motion. Replace arm or robot drive if movement problems are found.
Vibration at specific station or location	Improper teaching of stations	Re-teach station and via locations. Replace robot drive if no problems found.
	Improper application	Confirm proper robot arm, end effector, and application. Enter proper application. Do EEPROM. RESET.
Vibration at high speed	Improper application for robot, arm, and end effector	Confirm proper robot application. Enter proper application ID. EEPROM. RESET.

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Radial Motion

Troubleshooting motion requires that the system is fully booted up.

Table 9-6: Radial Motion

Symptoms	Possible Cause	Correction Action
Constant	Improper or corrupted application data	Confirm proper robot application. Enter proper application Do EEPROM. RESET
	Bad calibration	Check SYNC PHASE VALUES Find new Synch Phase values Compare new values to original values and to stored values. Enter new values if they are in range and are different from stored values.
Arm has jerky motion Arm oscillates Arm overshoots destination Arm sways side to side during motion	Application number incorrect	Verify application number that the robot is using is correct. Re-enter application number.
	Physical obstruction	Correct any physical obstruction.
	Repeatability issue	Perform Position Repeatability Test.
	System alignment improper	Verify system alignment.
	End effector hitting	Level end effector. Reteach stations and vias.
	Arm installed incorrectly	Verify arm is installed properly. Reinstall arm. Confirm proper fastener torque.
	Arm bolts incorrect torque	Tighten arm mounting bolts to recommended torque.
	Elbow or shoulder bearings failing	Manually extend, retract, move arm. Feel for rough travel. If arm motion is rough, replace arm.

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Symptoms	Possible Cause	Correction Action
Robot does not move in radial direction	T1, T2, or optional T3, or T4 not operating properly	Check sync phase and encoder values.
Vibration or hard track during R or T motion at pan speed	Voltage issue	Measure power supply voltage during a commanded move. If voltage drops more than 10%, power is faulty.

Theta Motion

Troubleshooting motion requires that the system is fully booted up.

Table 9-7: Theta Motion

Symptom	Possible Cause	Corrective Action
Constant	Improper or corrupted application data	Confirm proper robot application. Enter proper application Do EEPROM. RESET
	Bad calibration	Check SYNC PHASE VALUES Find new Synch Phase values Compare new values to original values and to stored values. Enter new values if they are in range and are different from stored values.

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Symptom	Possible Cause	Corrective Action
Arm has jerky motion Arm oscillates Arm overshoots destination Arm sways side to side during motion	Application number incorrect	Verify application number that the robot is using is correct. Re-enter application number.
	Physical obstruction	Correct any physical obstruction
	Repeatability issue	Perform position repeatability test.
	System alignment improper	Verify system alignment.
	End effector hitting	Level end effector. Reteach stations and vias.
	Arm installed incorrectly	Verify arm is installed properly. Reinstall arm. Confirm proper fastener torque.
	Arm bolts incorrect torque	Tighten arm mounting bolts to recommended torque.
	Elbow or shoulder bearings failing	Manually extend, retract, move arm. Feel for rough travel. If arm motion is rough, replace arm.
Robot does not move in theta direction	T1, T2, or optional T3, or T4 not operating properly	Check sync phase and encoder values.
Vibration or hard track during R or T motion at pan speed	Voltage issue	Measure power supply voltage during a commanded move. If voltage drops more than 10%, power is faulty.

Z-Axis Motion

Troubleshooting motion requires that the system is fully booted up.

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Table 9-8: Z Axis Motion

Symptom	Possible Cause	Corrective Action
Constant	Improper or corrupted application data	Confirm proper robot application. Enter proper application. Do EEPROM. RESET.
	Bad calibration	Check sync phase values. Find new sync phase values. Compare new values to original values and to stored values. Enter new values if they are in range and are different from stored values.
Arm has jerky motion Arm oscillates Arm overshoots destination Arm sways side to side during motion	Application number incorrect	Verify application number that the robot is using is correct. Re-enter application number.
	Physical obstruction	Correct any physical obstruction.
	Repeatability issue	Perform position repeatability test.
	System alignment improper	Verify system alignment
	End effector hitting	Level end effector. Reteach stations and vias.
	Z Axis is binding	Perform Z binding test using the trace command.
	Z Brake is binding	Perform Z brake binding test
	Arm improperly installed	Verify arm is installed properly. Reinstall arm. Confirm proper fastener torque.
Robot does not move in Z-axis direction	Application number incorrect	Verify application number that the robot is using is correct. Re-enter application number.

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Symptom	Possible Cause	Corrective Action
Robot hits Z hard stop during operation in Z-axis Robot hits Z hard stop during homing in Z-axis	Over travel switches not operating properly	Verify that Z-axis actuates the over travel switches.
	Over travel switches or hard stop not adjusted properly	Verify proper operation of the over travel switches and hard stop
	Application number incorrect	Verify application number that the robot is using is correct. Re-enter application number.
Vibration or hard track during Z motion at pan speed	Power supply issue	Measure Z duty cycle using Z binding test and trace command. If duty cycles is saturated 97% or more, replace power supply.

Find Phase

Table 9-9: Find Phase

Symptom	Possible Cause	Corrective Action
Command failed error during Z-axis motion.	Lower the Z-axis microswitch appears engaged	Check position of lower Z-axis micro switch
		Check continuity of lower Z-axis micro switch
T1 and T2 shafts do not move together while pinging the Theta axis.	Obstruction to theta axis	Check for obstructions. Correct obstructions. Check for smooth motion of T1 and T2 shafts
	T1 or T2 drive issues	Check MagnaTran LEAP output. Replace MagnaTran LEAP.

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10. Recommended Spare Parts

The entire MagnaTran LEAP robot is a Field Replaceable Unit (FRU). There are very few recommended spare parts for that reason. It is recommended to keep spare end effectors and spare end effector pads. The specific amounts of spare parts should be determined by the robot owner.

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11. MagnaTran LEAP Controller and Software

The robot is controlled by the MagnaTran LEAP Controller. For more information on this controller and software, please contact your Brooks representative. Please see "Contact Brooks Automation Technical Support".

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Appendices

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Contact Brooks Automation Technical Support

Have the following information available when contacting Brooks Automation Technical Support.

a. Part number and serial number from the product.
b. Installed location of the product.
c. Name, e-mail address, and telephone number of the person to contact.
d. List of error codes received during the failure.
e. Prepare a detailed description of the events relating to the error.
    - Time that the equipment has been in operation
    - Work that was done on the equipment prior to the error
    - Functions that the equipment was performing when the error occurred
    - Actions taken after the error and the results of those actions
    - Other information that may assist the Specialist
f. Contact Brooks Automation Technical Support at these numbers:

Location	Contact Number	Website
North America	+1-800-447-5007 (Toll Free) +1-978-262-2900 (Local)	http://www.brooks.com/
Europe	+49 800 000 9347 (Toll Free Germany) +49 364 176 9999 6 (Has Toll)	http://www.brooks.com/
Japan	+81 120-255-390 (Toll Free) +81 45-330-9005 (Local)	http://jp.brooks.com/
China	+86 400 627 6657	http://cn.brooks.com/
Taiwan	+886 080-003-5556 (Toll Free) +886 3-5525258 (Local)	http://tw.brooks.com/
Korea	1800-5116 (Toll Free)	http://kr.brooks.com/
Singapore	+65 1-800-4-276657 (Toll Free) +65 6309 0701 (Local)	http://www.brooks.com/

For additional contact information, please send an E-mail to techsupport@brooks.com.

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Appendix B: Functional Safety

The MagnaTran LEAP includes an embedded safety controller that complies with ISO 13849-1 as required by ISO IEC 10218-1.

The safety controller implements safety functions that remove power and drive from the robot motors in the case of a safety event such as an emergency stop (E-Stop), removal of a protective safety guard, or an operating mode change. The safety controller implements two redundant channels that receive redundant inputs from external emergency stop devices, the liveman pendant, external safety barriers, and a mode selector. For the purpose of extending the safety controller to an integrator-supplied Host Safety Controller with monitoring, the LEAP safety controller provides output bits that echo inputs and status of the safety controller.

Safety Controller Constraints

The LEAP safety controller is compliant when used in the intended application and is installed and operated according to the environmental constraints listed in Table 3-1 on page 56. In addition, the safety controller shall not be exposed to vibration beyond the limits below:

- 5 Hz ≤ f ≤ 8.4 Hz: 3.5 mm peak amplitude
- 8.4 Hz ≤ f ≤ 150 Hz : 1.0g peak acceleration

The LEAP controller is not qualified against shock. The LEAP robot shall not be exposed to shock as it will adversely affect performance.

An external supply that follows the requirements set forth in the manual is critical to avoid failures; the system is not intended for connection to distributed DC networks. The system has been evaluated as a DC system; mitigation against AC EMC phenomena shall be provided by the integrator.

The legacy pendant and the legacy inputs in the MISC I/O connector are not rated for functional safety.

- Category Structure: 3
- Hardware Fault Tolerance: 1
  - The controller can stand one single fault and still operate safely.
- Diagnostic test interval: 1 second
- Periodic proof test requirements: None

Failure Rate

The LEAP safety controller has been analyzed for failure rate. The mean time to dangerous failure and diagnostic coverage of the safety controller are:

MTTFd	DC
100 years	65%

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Safety Controller Features

- Redundant safety inputs and redundant safety outputs on J6.
- Redundant Liveman Teach Pendant inputs on J18.
- *Automatic*, *Stop*, and *Manual Mode* selector input states on J6 including dedicated output status bits for the integrator supplied host controller to validate and monitor the mode setting. Illegal mode input states are recognized, and in such cases power to the robot motors is removed.
- Redundant outputs for providing status to the integrator-supplied host controller. If the integrator plans to use these outputs for safety functions, monitoring them is required; they are not monitored internally by the LEAP safety controller.
- Any single point of failure within the LEAP safety controller will result in the removal of power to the robot motors.

The table below lists the human safety hazards and the relevant data for each hazard.

Hazard	Constraints	SAFETY CONTROLLER Safety Failure Detectable?
Upon loss (or short) of an external conductor from the integrator's E-Stop or protective stop (interlock) switches, the robot SAFETY CONTROLLER removes power to the all robot motors. The SAFETY CONTROLLER outputs redundant E-Stop and interlock status bits on J6 to the HSC. The robot integrator is responsible for the incorporation of these outputs into their system-wide safety system (HSC).	None	Y
Upon activation of the E-Stop or interlock input on J6, the SAFETY CONTROLLER will go into STOP mode and remove power to all robot motors. The SAFETY CONTROLLER outputs redundant E-Stop and interlock status bits to the HSC. The robot integrator is responsible for the incorporation of these outputs into their system-wide safety system (HSC).	None	Y
The SAFETY CONTROLLER provides inputs on J6 for connection to a mode select switch. The SAFETY CONTROLLER senses the position of the integrator-provided mode selector (AUTO/STOP/MANUAL) and uses dedicated mode outputs on J6 to echo the setting received by the SAFETY CONTROLLER. The HSC must validate that the switch setting matches the setting returned by the SAFETY CONTROLLER.	None	Y
When the SAFETY CONTROLLER detects the system mode selector is set to AUTO, the SAFETY CONTROLLER mode outputs echo the mode selector input setting. The SAFETY CONTROLLER validates all integrator-supplied E-Stop and interlock inputs. Once satisfied, the SAFETY CONTROLLER allows power to flow to the robot motors.	None	Y

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Hazard	Constraints	SAFETY CONTROLLER Safety Failure Detectable?
When the SAFETY CONTROLLER detects the system mode select switch is set to STOP, the SAFETY CONTROLLER removes power to all robot motors. SAFETY CONTROLLER mode outputs are provided for validation by the integrator-supplied HSC	None	Y
When the SAFETY CONTROLLER detects the system-supplied mode select switch is set to MANUAL, the SAFETY CONTROLLER validates all E-Stop and interlock inputs on J6 before permitting power to flow to the robot motors. As before, SAFETY CONTROLLER mode outputs are provided for validation by the integrator-supplied HSC.	None	Y
As an extension of the MANUAL mode, the SAFETY CONTROLLER detects connection of a TEACH pendant on J18. Upon detection of the pendant, the SAFETY CONTROLLER outputs redundant “pendant present” status bits to the integrator-supplied HSC for system-level integration. The SAFETY CONTROLLER checks redundant “gripped” Liveman switch inputs states on J18 before power is allowed to flow to the robot motors.	None	Y
The SAFETY CONTROLLER provides redundant, monitored motor power disconnect. On Channel-A (CHA) The SAFETY CONTROLLER removes power to the motors using a solid state switch. Removal of power is monitored, and any mismatch results in a fault. On Channel-B (CHB) the SAFETY CONTROLLER removes all PWM signals to the electronically commutated motors. It monitors and verifies all H-bridge driver circuits are off, and any mismatch results in a fault. No robot motion is possible as power is removed from the motors.	None	Y

For more information, refer to "Embedded Safety Controller" on page 147.

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Appendix C: Safety Function Tests

After initial setup or exchange of the controller field-replaceable unit, Brooks advises the following tests on the safety function to be performed.

Table 11-1: Safety Function Tests

#	Action	Outcome
1.	Provide E-Stop and Protective Stop connections to the robot as explained in Figure 6-4 on page 154 and Figure 6-5 on page 155. Rather than using dual pole switches, use individual switches for this test. Label the lines coming out of each switch contact as A and B for the Estop connection and C and D for the Protective Stop connection.	Safety I/O connector should have four switches connected.
2.	Provide a jumper at J1 as shown by Figure 6-7 on page 158.	J1 will have a jumper installed.
3.	Connect the liveman pendant to the robot.	Pendant is connected to live-man pendant connector.
4.	Refer to section Chapter 11: Set-up and Operation to learn how to home the robot or teach stations.	
5.	Home the robot. While the robot is moving, press the liveman switch to position 3 as shown in Figure 7-6 on page 179.	The robot should come to a stop within 200ms.
6.	Home the robot. While the robot is moving, release the liveman switch to position 1 as shown in Figure 7-6 on page 179.	The robot should come to a stop within 200ms.
7.	Home the robot or command it to move between two stations; while moving open switch A.	Robot should come to a stop within 200ms (if in teach mode) or in less than 2s (if in automatic mode). It should not be possible to re-enable motion.
8.	Power-cycle the robot. Home the robot or command it to move between two stations; while moving open switch B.	Robot should come to a stop within 200ms (if in teach mode) or in less than 2s (if in automatic mode). It should not be possible to re-enable motion.
9.	Power-cycle the robot. Home the robot or command it to move between two stations; while moving open switch C.	Robot should come to a stop within 200ms (if in teach mode) or in less than 2s (if in automatic mode). It should not be possible to re-enable motion.

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#	Action	Outcome
10.	Power-cycle the robot. Home the robot or command it to move between two stations; while moving open switch D.	Robot should come to a stop within 200ms (if in teach mode) or in less than 2s (if in automatic mode). It should not be possible to re-enable motion.
11.	Power-cycle the robot. With the pendant connected and in manual mode attempt to set CDM speed higher than 250mm/s.	Robot speed cannot be set above 250mm/s while in manual mode.

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Appendix D: Safety Data Sheets

Safety Data Sheets are presented below. Ensure that there is a copy in each workplace for all hazardous materials involved in the operation and maintenance of the robot. If needed, print out the following SDSs and make them available in the workplace.

> ***NOTE:*** Safety Data Sheets were previously known as Material Safety Data Sheets, usually abbreviated to MSDS.

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SAFETY DATA SHEET

1. Identification

Product identifier **NYETORR 5200**

Other means of identification

Product Code NyeTORR 5200

Recommended use Lubricating Grease

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name Nye Lubricants, Inc.

Address 12 Howland Road
Fairhaven, MA 02719 US

Telephone 508-996-6721

E-mail Not available.

Emergency phone number CHEMTREC 1-800-424-9300

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word Not available.

Hazard statement Not available.

Prevention Not available.

Response Not available.

Storage Not available.

Disposal Not available.

Hazard(s) not otherwise classified (HNOC) Not classified.

3. Composition/information on ingredients

Mixtures

CLP: Regulation No. 1272/2008.
DSD: Directive 67/548/EEC.
#: This substance has workplace exposure limit(s).
PBT: persistent, bioaccumulative and toxic substance.
vPvB: very persistent and very bioaccumulative substance.

4. First-aid measures

Inhalation If symptoms develop, remove affected person from source of exposure into fresh air. Get immediate medical attention. Call a physician if symptoms develop or persist.

Skin contact Wash off with soap and water. Get medical attention if symptoms occur. Wash clothing separately before reuse.

Eye contact Immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation develops or persists. Get immediate medical attention.

Ingestion If ingestion of a large amount does occur, seek medical attention. Do not induce vomiting without medical advice. If vomiting occurs naturally, have victim lean forward to reduce risk of aspiration. Never give anything by mouth to a victim who is unconscious or is having convulsions. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed Not available.

General information If you feel unwell, seek medical advice (show the label where possible). Show this safety data sheet to the doctor in attendance.

5. Fire-fighting measures

Suitable extinguishing media	Water Fog. Foam. Carbon dioxide (CO2). Dry chemical.
Unsuitable extinguishing media	Water. Do not use a solid water stream as it may scatter and spread fire. Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	Not applicable.
Special protective equipment and precautions for firefighters	Wear suitable protective equipment.
Fire-fighting equipment/instructions	Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask. Move containers from fire area if you can do it without risk. Move containers from fire area if you can do so without risk. Use water spray to cool unopened containers.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Observe precautions from other sections. Keep unnecessary personnel away. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Keep people away from and upwind of spill/leak.
Methods and materials for containment and cleaning up	Large Spills: Stop the flow of material, if this is without risk. Soak up with inert absorbent material. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Clean contaminated surface thoroughly. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills in original containers for re-use. For waste disposal, see section 13 of the MSDS. Clean up spills immediately, observing precautions in Protective Equipment section. Sweep up and shovel into suitable containers for disposal.
Environmental precautions	Prevent further leakage or spillage if safe to do so. Prevent entry into waterways, sewers, basements or confined areas.

7. Handling and storage

Precautions for safe handling	Do NOT pressurize, cut, heat, or weld containers. Empty product containers may contain product residue. Avoid prolonged or repeated skin contact with this material. DO NOT handle, store or open near an open flame, sources of heat or sources of ignition. Protect material from direct sunlight. Do not handle or store near an open flame, heat or other sources of ignition. Avoid breathing gas/vapors/mist/fumes. Do not take internally. Do not taste or swallow. Avoid contact with eyes. Wash thoroughly after handling. Handle and open container with care.
Conditions for safe storage, including any incompatibilities	Keep away from heat, sparks and open flame. Keep away from heat and sources of ignition. Store in cool place. Store in a closed container away from incompatible materials. Use care in handling/storage.

8. Exposure controls/personal protection

Occupational exposure limits	No exposure limits noted for ingredient(s).
Biological limit values	No biological exposure limits noted for the ingredient(s).
Exposure guidelines	No Exposure standards allocated.
Appropriate engineering controls	Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear safety glasses; chemical goggles (if splashing is possible).
Hand protection	Not normally needed.
Other	Wear suitable protective clothing. Wear nitrile, neoprene, PVC or viton gloves.
Respiratory protection	No personal respiratory protective equipment normally required. An air purifying respirator with an organic vapor cartridge may be used under certain circumstances where airborne concentrations are expected to exceed exposure limits, or if irritation or symptoms are experienced. Respiratory protection must be provided in accordance with 29 CFR 1910.134.
Thermal hazards	Not available.
General hygiene considerations	When using, do not eat, drink or smoke. Handle in accordance with good industrial hygiene and safety practice. Wash hands thoroughly after handling. Launder contaminated clothing before reuse.

9. Physical and chemical properties

Appearance	Not available.
Physical state	Liquid.

Form	Liquid. Semi-solid
Color	White, Smooth
Odor	Slight
Odor threshold	Not available.
pH	Not available.
Melting point/freezing point	Not available.
Initial boiling point and boiling range	Not available.
Flash point	Not available.
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	Not available.
Solubility(ies)	Not available.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Density	1.05 g/cm³
Flash point class	Combustible IIIB
Shelf life	4 years

10. Stability and reactivity

Reactivity	None known.
Chemical stability	Material is stable under normal conditions. Stable.
Possibility of hazardous reactions	Not available.
Conditions to avoid	Heat, flames and sparks. Avoid temperatures exceeding the flash point.
Incompatible materials	Strong acids, alkalies and oxidizing agents. Alkaline metals. Alkaline earth metals. Powdered metals. Halogenated compounds.
Hazardous decomposition products	Carbon monoxide, carbon dioxide and/or low molecular weight hydrocarbons. Hydrogen fluoride. Carbonyl fluoride.

11. Toxicological information

Information on likely routes of exposure

Ingestion	Not classified.
Inhalation	Not classified.
Skin contact	Classification not possible.
Eye contact	Classification not possible.
Symptoms related to the physical, chemical and toxicological characteristics	Not available.

Information on toxicological effects

Acute toxicity	Not available.

Skin corrosion/irritation	Classification not possible.
Serious eye damage/eye irritation	None known. Classification not possible.
Respiratory sensitization	Classification not possible.
Skin sensitization	Classification not possible. None known.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic. Classification not possible.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA. Classification not possible. This product does not contain any carcinogens or potential carcinogens as listed by ACGIH and IARC. This product does not contain any carcinogens or potential carcinogens as listed by IARC. This product does not contain any carcinogens or potential carcinogens as listed by OSHA, IARC and NTP.
Reproductive toxicity	Classification not possible. Not classified.
Specific target organ toxicity - single exposure	Classification not possible.
Specific target organ toxicity - repeated exposure	Classification not possible.
Aspiration hazard	Classification not possible.
Chronic effects	Not expected to be hazardous by WHMIS criteria.
Further information	This product has no known adverse effect on human health.

12. Ecological information

Ecotoxicity	This product has no known eco-toxicological effects. This material is not expected to be harmful to aquatic life.
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	Not available.
Mobility in soil	Not available.
Other adverse effects	Not available.

13. Disposal considerations

Disposal instructions	Under RCRA, it is the responsibility of the user of the product to determine, at the time of disposal, whether the product meets RCRA criteria for hazardous waste. Contract with a disposal operator licensed by the Law on Disposal and Cleaning. Collect and reclaim or dispose in sealed containers at licensed waste disposal site. This product, in its present state, when discarded or disposed of, is not a hazardous waste according to Federal regulations (40 CFR 261.4 (b)(4)). Under RCRA, it is the responsibility of the user of the product to determine, at the time of disposal, whether the product meets RCRA criteria for hazardous waste. Dispose in accordance with all applicable regulations. When your own wastewater treatment plant is not available, collect entire waste and then charge to a licensed industrial waste management professional with manifests for industrial waste.
Hazardous waste code	Not regulated.
Waste from residues / unused products	Dispose of in accordance with local regulations.
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as a hazardous material by DOT.

IATA

Not regulated as a dangerous good.

IMDG

Not regulated as a dangerous good.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	This substance/mixture is not intended to be transported in bulk.

15. Regulatory information

US federal regulations	This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200. All components are on the U.S. EPA TSCA Inventory List. CERCLA/SARA Hazardous Substances - Not applicable.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

SARA 304 Emergency release notification

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories	Immediate Hazard - No Delayed Hazard - No Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No
SARA 302 Extremely hazardous substance	No
SARA 311/312 Hazardous chemical	No

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA)	Not regulated.
Food and Drug Administration (FDA)	Not regulated.

US state regulations This product does not contain a chemical known to the State of California to cause cancer, birth defects or other reproductive harm.

US. Massachusetts RTK - Substance List

Not regulated.

US. New Jersey Worker and Community Right-to-Know Act

Not regulated.

US. Pennsylvania RTK - Hazardous Substances

Not regulated.

US. Rhode Island RTK

Not regulated.

US. California Proposition 65

Not Listed.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	No
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	No
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	No
New Zealand	New Zealand Inventory	No
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date February-20-2014

Revision date	September-27-2014
Version #	05
Further information	HMIS® is a registered trade and service mark of the NPCA.
HMIS® ratings	Health: 0 Flammability: 0 Physical hazard: 0
NFPA ratings	Health: 3 Flammability: 0 Instability: 0
References	ACGIH EPA: AQUIRE database NLM: Hazardous Substances Data Base US. IARC Monographs on Occupational Exposures to Chemical Agents Korea. Accidental Release Prevention Substances (Presidential Decree of Toxic Chemical Control Law, Executive Order No. 19203) Korea. Dangerous Substances Threshold Quantity (Presidential Decree of Dangerous Substances Safety Management Act No. 18406, Schedule 1) Korea. Harmful Substances Prohibited from Manufacturing (Presidential Decree on the Industrial Safety and Health Act (No. 13053), Article 29) Korea. Harmful Substances Requiring Permission for Manufacture or Use (Presidential Decree on the Industrial Safety and Health Act (No. 13053), Article 30) Korea. Non-Toxic Chemicals List (National Institute of Environment Research (NIER) Public Notice No. 1997-10, as amended) Korea. Observational Chemicals (Ministerial Decree of TCCL Article 6) Korea. OELs. Regulation for Permitted Concentration of Hazardous Substances (Ministry of Labor (MOL) Public Notice No. 1986-45, as amended) Korea. Prohibited Chemical Substances (TCCL Article 11) Korea. Regulated volatile organic compounds (VOCs) (MOE Notice No. 2001-36, March 8, 2001, as amended) Korea. Restricted Chemical Substances (TCCL Article 11) Korea. Toxic Chemical Control Law (TCCL), Existing Chemicals Inventory (KECI) Korea. Toxic Chemical Control Law (TCCL), pre-1997 List Korea. Toxic Chemicals (TCCL Article 10) Korea. Toxic Release Inventory (TRI) Chemicals (TCCL Article 14) Taiwan. Dangerous Materials (Rules on Hazard Communication of Dangerous Materials and Toxic Materials) Taiwan. Industrial Precursor Chemicals (Categories and Regulations Governing Inspection and Declaration of Industrial Precursor Chemicals, MOEA Decree No. 87, as amended) Taiwan. OELs. (Standards on Workplace Atmosphere of Dangerous and Hazardous Materials) Taiwan. Toxic Chemical Substances (TCS) (List of Toxic Chemical Substances announced by the Environmental Protection Administration) Taiwan. Toxic Materials (Rules on Hazard Communication of Dangerous Materials and Toxic Materials) HSDB® - Hazardous Substances Data Bank JIS Z 7250: 2005 Safety data sheet for chemical products-Part 1:Content and order of sections JCIA GHS Guideline, October 2008 IARC Monographs. Overall Evaluation of Carcinogenicity National Toxicology Program (NTP) Report on Carcinogens ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices Japan Society for Occupational Health, Recommendation of Occupational Exposure Limits
Disclaimer	The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication . The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release. Nye Lubricants, Inc. makes no warranty with respect thereto and disclaims all liability with respect thereon. This safety data sheet was prepared in accordance with the Safety Data Sheet for Chemical Products (JIS Z 7250:2005). Additional information is given in the Material Safety Data Sheet. The information in the sheet was written based on the best knowledge and experience currently available.
Revision Information	Product and Company Identification: Product and Company Identification

DuPont™ Krytox® PFPE/PTFE Greases (GPL 20(X) Series)

Version 4.0 (replaces: Version 3.2)
Revision Date 11.07.2014 Ref. 150000001170

This Safety Data Sheet adheres to the standards and regulatory requirements of the Republic of Ireland and may not meet the regulatory requirements of other countries.

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product name : DuPont™ Krytox® PFPE/PTFE Greases (GPL 20(X) Series)

Types : GPL: 200, 201, 202, 203, 204, 205, 206, 207, 207-500
XHT-S, XHT-SX, XHT-SZ
FG: 20, 22, 24, 26
NRT: 8900, 8904, 8906, PLSS
Sealant: ST-45, ST-63
EG-2000, EG-3000
LVP, LS-23, AUT 2045, UM 04 PGL, TLC Grease
KDP 4935

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture Lubricant

1.3. Details of the supplier of the safety data sheet

Company : Du Pont de Nemours (Nederland) B.V.
Baanhoekweg 22
NL-3313 LA Dordrecht
Netherlands

Telephone : +31-(0)-78-630-1011

Telefax : +31-(0)-78-630-1181

E-mail address : sds-support@che.dupont.com

1.4. Emergency telephone number

Emergency telephone number : +44 (0) 8456 006 640

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Not a classified substance or mixture according to Regulation (EC) No. 1272/2008.

Not a hazardous substance or mixture according to EC-directives 67/548/EEC or 1999/45/EC.

2.2. Label elements

Not a classified substance or mixture according to Regulation (EC) No. 1272/2008.

2.3. Other hazards

The hazards of this product are associated mainly with its processing.
The thermal decomposition vapours of fluorinated polymers may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.
Repeated episodes of polymer fume fever may result in persistent lung effects.

SECTION 3: Composition/information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

Registration number	Classification according to Directive 67/548/EEC	Classification according to Regulation (EU) 1272/2008 (CLP)	Concentration (% w/w)
Perfluoroalkylether (CAS-No.60164-51-4)			
			55 - 85 %
Polytetrafluoroethylene (CAS-No.9002-84-0)			
			15 - 45 %

The above products are REACH compliant; Registration number(s) may not be provided because substance(s) are exempted, not yet registered under REACH or are registered under another regulatory process (biocide uses, plant protection products), etc.

SECTION 4: First aid measures

4.1. Description of first aid measures

General advice : When symptoms persist or in all cases of doubt seek medical advice.

Inhalation : Move to fresh air in case of accidental inhalation of fumes from overheating or combustion.

Skin contact : Wash with water and soap as a precaution.

Eye contact : Rinse with plenty of water. If eye irritation persists, consult a specialist.

Ingestion : Never give anything by mouth to an unconscious person. DO NOT induce vomiting unless directed to do so by a physician or poison control center.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms : Inhalation may provoke the following symptoms:, Inhalation of fluorinated compounds may cause lung irritation and pulmonary oedema., The thermal decomposition vapours of fluorinated polymers may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

: Eye contact may provoke the following symptoms:, Blurred vision, Discomfort, Lachrymation

: Skin contact may provoke the following symptoms:, Irritation, Redness

4.3. Indication of any immediate medical attention and special treatment needed

Treatment : Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : The product itself does not burn.

: Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

5.2. Special hazards arising from the substance or mixture

Specific hazards during firefighting : In fire conditions, toxic decomposition products may be formed. (see also section 10)

5.3. Advice for firefighters

Special protective equipment for firefighters : Wear full protective clothing and self-contained breathing apparatus.

Further information : Standard procedure for chemical fires.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

Personal precautions : Refer to protective measures listed in sections 7 and 8.

6.2. Environmental precautions

Environmental precautions : Prevent material from entering sewers, waterways, or low areas.

6.3. Methods and materials for containment and cleaning up

Methods for cleaning up : Shovel into suitable container for disposal. Sweep up to prevent slipping hazard.
Wipe up with absorbent material (e.g. cloth, fleece). Pick up and transfer to properly labelled containers. Do not flush with water. Do not let product enter drains.

6.4. Reference to other sections

For personal protection see section 8., For disposal instructions see section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Advice on safe handling	:	Avoid breathing vapors from overheated material. Do not store or consume food, drink or tobacco in areas where they may become contaminated with this material.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storage areas and containers	:	No special storage conditions required. Keep container closed to prevent contamination.
Other data	:	No decomposition if stored and applied as directed.

7.3. Specific end use(s)

no data available

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

If sub-section is empty then no values are applicable.

8.2. Exposure controls

Engineering measures	:	In the event that the polymer is heated above 300°C (572 F) local ventilation should be used to avoid exposure to fumes.
Eye protection	:	Wear safety glasses. Eye protection complying with EN 166.
Hand protection	:	Impervious gloves Protective gloves complying with EN 374. Please observe the instructions regarding permeability and breakthrough time which are provided by the supplier of the gloves. Also take into consideration the specific local conditions under which the product is used, such as the danger of cuts, abrasion, and the contact time.
Skin and body protection	:	Long sleeved shirt and long pants
Hygiene measures	:	General industrial hygiene practice. Keep away from food and drink. Keep away from tobacco products. Wash hands and face before breaks and immediately after handling the product.
Respiratory protection	:	In the case of hazardous fumes caused by overheating, wear self-contained breathing apparatus.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Form	:	grease

Colour	: white
Odour	: none
pH	: neutral
Melting point/range	: 320 °C
Flash point	: Method: Pensky-Martens closed cup - PMCC does not flash
Thermal decomposition	: 300 °C
Relative density	: 1.89 - 1.93 at 24 °C
Water solubility	: insoluble

9.2. Other information

no data available

SECTION 10: Stability and reactivity

10.1. Reactivity	: Stable under recommended storage conditions.
10.2. Chemical stability	: Stable under normal conditions.
10.3. Possibility of hazardous reactions	: Stable under recommended storage conditions.
10.4. Conditions to avoid	: Decomposition temperature : 300 °C
10.5. Incompatible materials	: no data available
10.6. Hazardous decomposition products	: Fluorinated compounds

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute oral toxicity

ALD - Approximate Lethal Dose / Rat > : 11,000 mg/kg

- Perfluoroalkylether
  LD50 / Rat : > 11,000 mg/kg
- Polytetrafluoroethylene
  LD50 / Rat : > 11,280 mg/kg

Acute inhalation toxicity

no data available

- Polytetrafluoroethylene
  The thermal decomposition vapours of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

Acute dermal toxicity

no data available

- Perfluoroalkylether
  LD50 / Rabbit : > 17,000 mg/kg

Skin irritation

Rabbit
Classification: Not classified as irritant
Result: slight irritation

- Perfluoroalkylether
  Rabbit
  Classification: Not classified as irritant
  Result: No skin irritation

- Polytetrafluoroethylene
  Rabbit
  Classification: Not classified as irritant
  Result: No skin irritation

  human
  Classification: Not classified as irritant
  Result: No skin irritation

Eye irritation

Rabbit
Classification: Not classified as irritant
Result: slight irritation

- Perfluoroalkylether
  Rabbit
  Classification: Not classified as irritant
  Result: No eye irritation

Sensitisation

Guinea pig
Result: Animal test did not cause sensitization by skin contact.

- Perfluoroalkylether
  Guinea pig Buehler Test
  Classification: Does not cause skin sensitisation.
  Result: Does not cause skin sensitisation.
  Method: OECD Test Guideline 406

- Polytetrafluoroethylene
  human
  Classification: Not a skin sensitizer.
  Result: Does not cause skin sensitisation.
  Patch test on human volunteers did not demonstrate sensitisation properties.

Repeated dose toxicity

- Perfluoroalkylether
  Oral Rat
  No toxicologically significant effects were found.

  Inhalation Rat
  No toxicologically significant effects were found.

- Polytetrafluoroethylene
  Oral - feed Rat
  No toxicologically significant effects were found.

Mutagenicity assessment

- Perfluoroalkylether
  Did not cause genetic damage in cultured bacterial cells.

- Polytetrafluoroethylene
  Tests on bacterial or mammalian cell cultures did not show mutagenic effects.

Carcinogenicity assessment

- Perfluoroalkylether
  no data available

- Polytetrafluoroethylene
  Not classifiable as a human carcinogen.

Toxicity to reproduction assessment

- Perfluoroalkylether
  no data available

- Polytetrafluoroethylene
  No toxicity to reproduction

Assessment teratogenicity

- Perfluoroalkylether
  no data available

Human experience

Excessive exposures may affect human health, as follows:

Eye contact

Irritation, Discomfort, Blurred vision

SECTION 12: Ecological information

12.1. Toxicity

Toxicity to fish

- Perfluoroalkylether
  LC50 / 96 h / Oncorhynchus mykiss (rainbow trout): > 1,000 mg/l

- Polytetrafluoroethylene
  The substance is a polymer and is not expected to produce toxic effects.

Toxicity to aquatic plants

- Perfluoroalkylether
  ErC50 / 72 h / Pseudokirchneriella subcapitata (green algae): > 1,000 mg/l

  NOEC / 72 h / Pseudokirchneriella subcapitata (green algae): > 1,000 mg/l

Toxicity to aquatic invertebrates

- Perfluoroalkylether
  EC50 / 48 h / Daphnia magna (Water flea): > 100 mg/l

12.2. Persistence and degradability

Biodegradability

Not readily biodegradable.

12.3. Bioaccumulative potential

no data available

12.4. Mobility in soil

no data available

12.5. Results of PBT and vPvB assessment

no data available

12.6. Other adverse effects

Additional ecological information

No data is available on the product itself.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Product	:	Dispose of as hazardous waste in compliance with local and national regulations. Dispose of in accordance with the European Directives on waste and hazardous waste. Do not contaminate ponds, waterways or ditches with chemical or used container.
Contaminated packaging	:	Contaminated/not cleaned containers should be treated/handled like product waste. Do not allow rinsate from cleaning of equipment or disposed material to enter surface or groundwater.

SECTION 14: Transport information

ADR

14.1. UN number:	Not applicable
14.2. UN proper shipping name:	Not applicable
14.3. Transport hazard class(es):	Not applicable
14.4. Packing group:	Not applicable
14.5. Environmental hazards:	none
14.6. Special precautions for user: no data available	

IATA_C

14.1. UN number:	Not applicable
14.2. UN proper shipping name:	Not applicable
14.3. Transport hazard class(es):	Not applicable
14.4. Packing group:	Not applicable
14.5. Environmental hazards:	none
14.6. Special precautions for user: no data available	

IMDG

14.1. UN number:	Not applicable
14.2. UN proper shipping name:	Not applicable
14.3. Transport hazard class(es):	Not applicable
14.4. Packing group:	Not applicable
14.5. Environmental hazards:	none
14.6. Special precautions for user: no data available	

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Not applicable

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

Other regulations	:	Take note of Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work.

15.2. Chemical Safety Assessment

A Chemical Safety Assessment/Chemical Safety Report may not be required because: substance(s) are exempted from being registered under REACH, are not yet registered under REACH, are registered under another regulatory process (biocide uses, plant protection products), the volume is below the 10 tons/year threshold specified under Art. 14(1) of REACH, the concentration of substance(s) in a mixture is/are below the limits specified under Art. 14(2) of REACH.

SECTION 16: Other information

Other information professional use

Abbreviations and acronyms

ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
ATE	Acute toxicity estimate
CAS-No.	Chemical Abstracts Service number
CLP	Classification, Labelling and Packaging
EbC50	Concentration at which 50% reduction of biomass is observed
EC50	Median effective concentration
EN	European Norm
EPA	Environmental Protection Agency
ErC50	Concentration at which a 50% inhibition of growth rate is observed
EyC50	Concentration at which 50 % inhibition of yield is observed
IATA_C	International Air Transport Association (Cargo)
IBC	International Bulk Chemical Code
ICAO	International Civil Aviation Organization
ISO	International Standard Organization
IMDG	International Maritime Dangerous Goods
LC50	Median Lethal Concentration
LD50	Median Lethal Dose
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest observed effect level
MARPOL	International Convention for the Prevention of Marine Pollution from Ships
n.o.s.	Not Otherwise Specified
NOAEC	No Observed Adverse Effect Concentration
NOAEL	No observed adverse effect level
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
OECD	Organisation for Economic Co-operation and Development
OPPTS	Office of Prevention, Pesticides and Toxic Substances
PBT	Persistent, Bioaccumulative and Toxic
STEL	Short term exposure limit
TWA	Time Weighted Average (TWA):
vPvB	very Persistent and very Bioaccumulative

Restrictions on use

Do not use DuPont materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless the material has been provided from DuPont under a written contract that is consistent with DuPont policy regarding medical applications and expressly acknowledges the contemplated use. For further information, please contact your DuPont representative. You may also request a copy of the DuPont POLICY Regarding Medical Applications and DuPont CAUTION Regarding Medical Applications.

Significant change from previous version is denoted with a double bar.

DuPont™ Krytox® PFPE/PTFE Greases (GPL 20(X) Series)

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The above information relates only to the specific material(s) designated herein and may not be valid for such material(s) used in combination with any other materials or in any process or if the material is altered or processed, unless specified in the text.

Material Safety Data Sheet

1. Chemical product and company identification

Product name BRAYCOTE 803

MSDS # 25019-AM

Code 25019-AM

Product use Lubricant

Manufacturer Castrol Industrial North America, Inc.
150 W. Warrenville Road
Naperville, IL 60563

Supplier SPI-Chem™ SPI Supplies Division Structure Probe, Inc.
P.O. Box 656 West Chester, PA 19381-0656 USA
Phone: 1-(610)-436-5400 Fax: 1-(610)-436-5755
E-mail: spi3spi@2spi.com WWW: http://www.2spi.com

EMERGENCY SPILL INFORMATION: 1 (800) 424-9300 CHEMTREC (USA)

2. Composition/information on ingredients

This product does not contain any hazardous ingredients at or above regulated thresholds.

3. Hazards identification

Physical state Solid.

Color White Grease.

Emergency overview CAUTION!

MAY CAUSE EYE IRRITATION.
MAY CAUSE SKIN IRRITATION.
MAY CAUSE RESPIRATORY TRACT IRRITATION.

Inhalation of decomposition products (occurs if heated > 260 C) or of smoke from contaminated tobacco products may cause respiratory irritation and induce Polymer Fume Fever condition. Symptoms of exposure to decomposition products are: lung irritation, pulmonary edema, flu-like symptoms (example - fever chills). Avoid contact with eyes, skin and clothing. Keep container closed. Use with adequate ventilation. Wash thoroughly after handling.

Routes of entry Dermal contact. Eye contact. Inhalation.

Potential health effects

Eyes May cause eye irritation.

Skin May cause skin irritation.

Inhalation May cause respiratory tract irritation.

Ingestion Ingestion may cause gastrointestinal irritation and diarrhea.

Medical conditions aggravated by over-exposure None identified.

See toxicological information (section 11)

4. First aid measures

Eye contact — In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation develops.

Skin contact — Immediately wash exposed skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.

Inhalation — If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion — Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention if symptoms appear.

5. Fire-fighting measures

Flammability of the product — May be combustible at high temperature.

Products of combustion — These products are carbon oxides (CO, CO_2), halogenated compounds, hydrogen fluoride.

Unusual fire/explosion hazards — Non-explosive in the presence of the following materials or conditions: open flames, sparks and static discharge, heat, shocks and mechanical impacts and oxidizing materials.

Fire-fighting media and instructions — In case of fire, use water spray (fog), foam or dry chemicals.

Protective clothing (fire) — Fire-fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear.

Special remarks on fire hazards — Inhalation of decomposition products (occurs if heated > 260 C) or of smoke from contaminated tobacco products may cause respiratory irritation and induce Polymer Fume Fever condition. Symptoms of exposure to decomposition products are: lung irritation, pulmonary edema, flu-like symptoms (example - fever chills). A NFPA health hazard rating of "3" is assigned due to due to toxicity of thermal decomposition products and fluorine (HF); otherwise, the material itself warrants a health hazard rating of "1".

6. Accidental release measures

Personal precautions — Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (See Section: "Exposure controls/personal protection"). Follow all fire fighting procedures (See Section: "Fire-fighting measures").

Environmental precautions and clean-up methods — If emergency personnel are unavailable, contain spilled material. For small spills add absorbent (soil may be used in the absence of other suitable materials) scoop up material and place in a sealed, liquid-proof container for disposal. For large spills dike spilled material or otherwise contain material to ensure runoff does not reach a waterway. Place spilled material in an appropriate container for disposal. Avoid contact of spilled material with soil and prevent runoff entering surface waterways. See Section 13 for Waste Disposal Information.

Personal protection in case of a large spill — Splash goggles. Full suit. Boots. Gloves. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

7. Handling and storage

Handling — Avoid contact with skin and clothing. Avoid contact with eyes. Use only with adequate ventilation. Wash thoroughly after handling. Decomposes and releases toxic gases when exposed to high temperature or when burning.

Storage — Keep container tightly closed. Keep container in a cool, well-ventilated area. Empty containers may contain harmful, flammable/combustible or explosive residue or vapors. Do not cut, grind, drill, weld, reuse or dispose of containers unless adequate precautions are taken against these hazards.

8. Exposure controls/personal protection

Occupational exposure limits

This product does not have any assigned OELs.

Control Measures No special ventilation requirements. Good general ventilation should be sufficient to control airborne levels. If this product contains ingredients with exposure limits, use process enclosures, local exhaust ventilation, or other engineering controls to keep worker exposure below any recommended or statutory limits.

Hygiene measures Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing.

Personal protection

Eyes Avoid contact with eyes. Safety glasses with side shields or chemical goggles.

Skin and body Avoid prolonged or repeated contact with skin. Wear suitable protective clothing.

Respiratory Use only with adequate ventilation.

Hands Wear suitable gloves.

Not available.

Consult local authorities for acceptable exposure limits.

9. Physical and chemical properties

Physical state Solid.

Odor Odorless.

Color White Grease.

Heat of combustion Not available.

Specific gravity 1.8 to 2

Solubility insoluble in water.

10. Stability and reactivity

Stability and reactivity The product is stable.

Conditions to avoid Decomposes on heating to high temperature.

Incompatibility with various substances Reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products These products are halogenated compounds, hydrogen fluoride.

Hazardous polymerization Will not occur.

11. Toxicological information

Chronic toxicity

Carcinogenic effects No component of this product at levels greater than 0.1% is identified as a carcinogen by ACGIH or the International Agency for Research on Cancer (IARC). No component of this product present at levels greater than 0.1% is identified as a carcinogen by the U.S. National Toxicology Program (NTP) or the U.S. Occupational Safety and Health Act (OSHA).

Mutagenic effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as a mutagen.
Reproductive effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as a reproductive toxin.
Teratogenic effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as a reproductive toxin.

12. Ecological information

Ecotoxicity No testing has been performed by the manufacturer.

13. Disposal considerations

Waste information Avoid contact of spilled material and runoff with soil and surface waterways. Consult an environmental professional to determine if local, regional or national regulations would classify spilled or contaminated materials as hazardous waste. Use only approved transporters, recyclers, treatment, storage or disposal facilities.

Consult your local or regional authorities.

14. Transport information

Not classified as hazardous for transport (DOT, TDG, IMO/IMDG, IATA/ICAO)

15. Regulatory information

U.S. Federal regulations US INVENTORY (TSCA): In compliance.

This product is not regulated under Section 302 of SARA and 40 CFR Part 355.

SARA 311/312 MSDS distribution - chemical inventory - hazard identification: BRAYCOTE 803: Immediate (Acute) Health Hazard

SARA 313

Form R - Reporting requirements This product does not contain any hazardous ingredients at or above regulated thresholds.

Supplier notification This product does not contain any hazardous ingredients at or above regulated thresholds.

CERCLA Sections 102a/103 Hazardous Substances (40 CFR Part 302.4):: This material is not regulated under CERCLA Sections 103 and 107.

State regulations Pennsylvania RTK:Polytetrafluoroethylene (generic environmental hazard)

WARNING: This product contains a chemical known to the State of California to cause cancer. Tetrafluoroethylene, inhibited

Inventories AUSTRALIAN INVENTORY (AICS): Not listed.

CANADA INVENTORY (DSL): Not listed.

CHINA INVENTORY (IECS): In compliance.

EC INVENTORY (EINECS/ELINCS): In compliance.

JAPAN INVENTORY (ENCS): In compliance.

KOREA INVENTORY (ECL): Not listed.

PHILIPPINE INVENTORY (PICCS): In compliance.

16. Other information

Label requirements

CAUTION!

MAY CAUSE EYE IRRITATION.
MAY CAUSE SKIN IRRITATION.
MAY CAUSE RESPIRATORY TRACT IRRITATION.

HMIS® Rating :

Health	**1**
Flammability	**1**
Physical Hazard	**0**
Personal protection	**B**

National Fire Protection Association (U.S.A.)



Other special considerations

A NFPA health hazard rating of "3" is assigned due to due to toxicity of thermal decomposition products and fluorine (HF); otherwise, the material itself warrants a health hazard rating of "1".

History

Date of issue 06/01/2005.

Date of previous issue 06/01/2005.

Prepared by Product Stewardship

Notice to reader

All reasonably practicable steps have been taken to ensure this data sheet and the health, safety and environmental information contained in it is accurate as of the date specified below. No warranty or representation, express or implied is made as to the accuracy or completeness of the data and information in this data sheet.

The data and advice given apply when the product is sold for the stated application or applications. You should not use the product other than for the stated application or applications without seeking advice from us.

It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. The BP Group shall not be responsible for any damage or injury resulting from use, other than the stated product use of the material, from any failure to adhere to recommendations, or from any hazards inherent in the nature of the material. Purchasers of the product for supply to a third party for use at work, have a duty to take all necessary steps to ensure that any person handling or using the product is provided with the information in this sheet. Employers have a duty to tell employees and others who may be affected of any hazards described in this sheet and of any precautions that should be taken.