Motoman GP8 EduCart
System Manual

Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and keep for future reference.
For Your Safety

Robots generally have requirements which are different from other manufacturing equipment, such as larger working areas, high-speed operation, rapid arm movements, etc., which can pose safety hazards.

Read and understand the instruction manuals and related documents, and observe all precautions in order to avoid the risk of injury to personnel and damage to equipment.

Carelessness contributes to serious accidents in the work area.

It is the user’s responsibility to ensure that all local, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions are met and followed.

DANGER

- Teaching, operations, and maintenance of the Robot must conform to:
  - Industrial Safety and Health Law
  - Order for Enforcement of the Industrial Safety and Health Law
  - Industrial Safety and Health Regulations
  - Technical Standards for Electrical Facilities

Other related laws and regulations are:
  - Occupational Safety and Health Act in USA
  - Factory Act (Gewerbeordnung) in Germany
  - Health and Safety at Work, etc. Act in UK
  - EC Machinery Directive 2006/42/EC

- Prepare:
  - SAFETY WORK REGULATIONS
    based on concrete policies for safety management complying with related laws and regulations.

- Observe:
  - JIS B 8433-1: 2015 “Robots for industrial environments-Safety requirements” (ISO 10218-1: 2011) for safe operation of the robot. (JIS B 8433 is for Japan only)

- Reinforce:
  - SAFETY MANAGEMENT SYSTEM
    by designating authorized operators and safety managers for the Robot, as well as giving continuing safety education and training.

- Teaching, operation, and maintenance of the Robot are specified as “Hazardous Operations” in the Industrial Safety and Health Act (for Japan only). Personnel engaged in these operations must receive special training offered by YASKAWA.
We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems (ANSI/RIA R15.06-2012). You can obtain this document from the Robotic Industries Association (RIA) at the following address:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
www.roboticsonline.com

Ultimately, well-trained personnel are the best safeguard against accidents and damage that can result from improper operation of the equipment. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the equipment.

We recommend approved YASKAWA training courses for all personnel involved with the operation, programming, or repair of the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
WARNING

- Safe operation of this equipment is the user's responsibility.
  - The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06-2012 safety standards, and other local codes that may pertain to the installation and use of this equipment.

Not following all national codes, safety standards and local codes can result in death or serious injury.

- Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location.
  - The following safety equipment is provided as standard:
    - Safety barriers
    - Door interlocks
    - EMERGENCY STOP button

Not providing additional safety measures as required can result in death or serious injury.

- Check all safety equipment frequently for proper operation.
  - Repair or replace any non-functioning safety equipment immediately.

If safety equipment does not operate properly, death or serious injury can result.

CAUTION

- Only trained personnel familiar with the operation, manuals, electrical design, and interconnections of this equipment should program, or maintain the system.

Any personnel involved with the operation of the equipment must understand potential dangers of operation.

NOTICE

- The drawings and photos in this manual are examples. Differences may exist between them and the delivered product.
- YASKAWA may modify this model without notice due to product improvements, modifications, or changes in specifications. If such modification is made, the manual number will also be revised.
- Some operations require standard passwords and while others require special passwords.
- If a manual is damaged or lost, contact Customer Support to order a new copy. Make sure to tell Customer Support the Part Number listed on the front cover.
Notes for Safe Operation

Read this manual carefully before installing, operating, maintaining, or inspecting the system.

In this instruction, Safe Operations are classified as “DANGER”, “WARNING”, “CAUTION” or “NOTICE”.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![DANGER]</td>
<td>Indicates an imminently hazardous situation which, if not avoided, <strong>WILL result in death or serious injury.</strong></td>
</tr>
<tr>
<td>![WARNING]</td>
<td>Indicates a potentially hazardous situation which, if not avoided, <strong>MAY result in death or serious injury.</strong></td>
</tr>
<tr>
<td>![CAUTION]</td>
<td>Indicates a hazardous situation, which if not avoided, <strong>MAY result in minor to moderate injury.</strong></td>
</tr>
<tr>
<td>![CAUTION]</td>
<td>Indicates a situation which if not avoided <strong>may result in equipment damage.</strong></td>
</tr>
<tr>
<td>![NOTICE]</td>
<td>Indicates <strong>practices not related to personal injury.</strong></td>
</tr>
</tbody>
</table>

**NOTICE**

To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as “DANGER”, “WARNING” or “CAUTION”.
EduCart Explanation of Safety Labels

The following labels are attached to the EduCart. Always follow these safety labels.

**Fig. : EduCart Safety Labels Location**

1. Weight Limit Label

![CAUTION]

**CAUTION**

**DO NOT LEAN ON PANEL**

**10LB WEIGHT LIMIT**

This label notifies that if someone leans on the panels damage can occur.

2. Moving Parts

![WARNING]

**WARNING**

MOVING PARTS MAY CAUSE INJURY

This label indicates that moving parts are present and there is a warning that severe injury or death can occur.

3. Robot Labels

Refer to Robot Documentation for details.
Safety
EduCart Explanation of Safety Labels

🔍 Machine Nameplate Date

<table>
<thead>
<tr>
<th>MACHINE NAMEPLATE DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACHINENAMEPLATE</td>
</tr>
<tr>
<td>DATA</td>
</tr>
<tr>
<td>EDCART INTERFACE</td>
</tr>
<tr>
<td>RATED VOLTAGE</td>
</tr>
<tr>
<td>NUMBER OF PHASES</td>
</tr>
<tr>
<td>FREQUENCY</td>
</tr>
<tr>
<td>FULL LOAD CURRENT</td>
</tr>
<tr>
<td>AMPLIFIED RATING OF LARGEST MOTOR OR LOAD</td>
</tr>
<tr>
<td>SHORT CIRCUIT CURRENT RATING</td>
</tr>
<tr>
<td>ELECTRICAL DIAGRAM NUMBER</td>
</tr>
</tbody>
</table>

The Machine Nameplate Data supplies important electrical information that is required for installation.

🔍 Shock Hazard

This label indicates that hazardous voltages are present and there is a danger of getting electrical shock.

🔍 Controller Labels

Refer to Controller Documentation for details.
Installation and Wiring Safety

Review the Robot and Controller Instructions for details on installation and wiring.

In planning installation, adapt an easy to observe arrangement to ensure safety. Take safety into consideration when planning the installation. Observe the following when installing the Robot:

**DANGER**

- Maintenance and inspection must be performed by specified personnel.
  Failure to observe this caution may result in electric shock or injury.
- For disassembly or repair, contact Customer Support.
- Do not remove the motor, and do not release the brake.
  Failure to observe these safety precautions may result in death or serious injury from unexpected motion of the Robot's arm.
- Any person who programs, teaches, operates, maintains or repairs the included system MUST be trained and demonstrates competence to safely perform assigned tasks.
  Failure to observe these safety precautions may result in death or serious injury from unexpected movements.

**WARNING**

- Run the piping, wiring, and cables for the Controller, Robot, Positioner control panel, peripheral devices, etc. in a pit so that they are not stepped on by personnel or run over by a forklift.

Failure to observe this Warning may cause personnel to trip over exposed piping, wiring, or a cables, which may result in personal injury. Additionally it may also cause damage to piping, wiring, or cables, and unexpected movement of the Robot, which may result in personal injury and/or equipment damage.
CAUTION

- Make sure all covers and shields are installed correctly before operating.
  - Some drawings in this manual may have protective covers or shields removed to show details.

Not having all covers and shields installed correctly can result in injury.

- When installing the Robot system, avoid interference with buildings, structures, utilities, other machines.

Not avoiding these items may create trapping or pinch points.

- Do not make unauthorized modifications.

Unauthorized modifications can result in injury or equipment damage and will void the warranty.

- Inspect:
  - For problems with movement
  - Damages to external wires

Repair any problems immediately and perform all necessary procedures. If problems are not repaired or procedures are not fixed unexpected results can occur causing injury.

NOTICE

- If supplying a supplementary audible means for Robot operation, it shall exceed the ambient noise at the end-use of the application.

- Any changes or additions to the applicable information as provided by the manufacturer is to be provided by the party that makes the change or addition to the Robot system.
Ensure Safety

**DANGER**

- When the power supplies of the Robot and Controller are turned ON at start-up, be sure to confirm the following:
  - Safety protection devices such as the E-STOP circuit, door interlocks, etc. operate normally.
  - Each axis operates normally in TEACH mode.
  - Robot operates normally at the speed limit or less in the TEACH mode. (Speed limit: 250 mm/s at the TCP or the flange)
  - The teaching function and the playback function operate normally.
- The Robot may stop movements while waiting for a condition to be satisfied during operation.
  Once meeting the condition, the Robot starts movement causing a danger that will cause death or severe injury.
- Make sure to clearly indicate when the Robot is in operation:
  - Use a pilot lamp and/or an audible alert or
  - The Robot stops operation if the operator comes close.
- Install a safety fence around the Robot to prevent any accidental contact with the Robot when power is applied.
  - Display a warning sign stating “Off-Limits During Operation” at the entrance of the safety fence.
  - The gate of the safety fence must be equipped with a safety interlock to turn the servo power OFF when the gate opens.
  - Make sure interlocks operate properly before use.
- For areas not enclosed by safety fences, use a photoelectric sensor, a safety light curtain, etc. to make sure that the Robot stops its operation if the operator enters its operating range.

Failure to observe this Danger notice will result in death or serious injury due to contact with the Robot.
**WARNING**

- Turn OFF servo power before operating.
  - Press the EMERGENCY STOP to turn off SERVO POWER. When servo power is OFF, the SERVO ON LED on the Programming Pendant is OFF.

Severe injury or death may result during an emergency if the EMERGENCY STOP (s) do not work correctly. Do not use if the EMERGENCY STOP (s) do not perform correctly.

*Fig. : EMERGENCY STOP*

- Clear the cell of all items which could interfere with the operation before releasing the EMERGENCY STOP.

Injury may result from unintentional or unexpected motion.

*Fig. : Release of EMERGENCY STOP*

- Make sure no person is in the operating range and the operator is in a safe location before:
  - Turning ON power to the Controller
  - Moving the Robot with the Programming Pendant
  - Running the system in the TEACH mode
  - Performing automatic operations

Personal injury may result if a person enters the operating range during operation. Immediately press an EMERGENCY STOP whenever there is a problem.
All personnel working with the Robot (safety administration, installation, operation, and maintenance personnel) must always be prepared and “Safety First” minded, to ensure the safety of all personnel.

**WARNING**

- In the vicinity of the area where the Robot is installed, avoid any dangerous actions, such as entering the Robot's operating range without due care.

Failure to observe this instruction may cause contact with the Robot or peripheral equipment, which may result in death or serious injury.

- Strictly observe the safety precautions and signs in the factory, such as “Flammable”, “High Voltage”, “Danger”, “Off-limits to Unauthorized Personnel”.

Failure to observe this instruction may result in death or serious injury due to fire, electric shock, caused by contact with the Robot or other equipment.

- Strictly observe the following precautions about clothing:
  - Always wear approved work clothes (no loose-fitting clothes).
  - To prevent mis-operation, do not wear gloves when operating the Robot.
  - Do not allow underwear, shirts, or neckties hang out from the work clothes.
  - Do not wear accessories, such as earrings, rings, or necklaces.
  - Always wear protective safety equipment, such as hard hats, safety shoes (with slip-proof soles), face shields, safety glasses, and gloves as necessary.

Failure to observe this instruction may result in death or serious injury.

- The following must be understood and strictly observed by all personnel as rules:
  - Unauthorized personnel other than the operator must not approach the area where the Robot is installed.

Failure to observe this instruction may cause contact with the Robot, Controller, control panel, workpiece, or Positioner, etc., may result in death or serious injury.
Safety
Ensure Safety

**CAUTION**

- All operators, programmers, maintenance personnel, supervisors, and anyone working near the system must be familiar with the operation of this equipment.
  - All personnel involved with the operation of the equipment must understand potential dangers of operation.
- General safeguarding tips:
  - Place system in E-STOP mode whenever it is not in use.
  - Use lockout/tagout procedures during equipment maintenance in accordance with ANSI/RIA R15.06-2012, section 4.2.5, Sources of Energy. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).
  - Only trained personnel familiar with the operation of this equipment, the operator's manuals, the system equipment, and options and accessories can operate equipment.

Improper operation can result in personal injury and/or damage to the equipment.

- If the light in the operator's working space is not bright enough, provide the space with appropriate lighting.

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**CAUTION**

- Store industrial tools, etc. in a safe location outside the Robot's operating range.

If an industrial tool, etc. is left unattended on the Robot, on a fixture, or on the floor, etc., the Robot may come in contact with the industrial tool left unattended, which may result in damage to the Robot and/or the fixture.
Operation Safety

DANGER

- Personnel engaged in teaching or inspection, etc. of the Robot must receive special training required by applicable laws and regulations.
- While performing inspection and maintenance, wiring, or attaching a tool to the Robot, etc., make sure to turn OFF the power supply of the Controller and the tool, and keep the switch of the power supply locked so that unauthorized personnel cannot turn ON the power supply. In addition, display a warning sign stating “Energizing Prohibited”.

Turning ON the power supply without due care during inspection and maintenance, etc., may cause electric shock or unexpected movement of the Robot, which may result in personal injury.

- Use the Robot only within the specifications described in the manuals for the Robot. Failure to observe this instruction may result in personal injury and/or equipment damage.
- Observe the following precautions when performing a teaching operation within the Robot's operating range:
  - Be sure to perform lockout by putting a lockout device on the safety fence when going into the area enclosed by the safety fence. In addition, the operator of the teaching operation must display a sign that an operation is being performed so that no other person closes the safety fence.
  - View the Robot from the front whenever possible.
  - Always follow the predetermined operating procedure.
  - Always keep in mind emergency response measures against the Robot’s unexpected movement toward a person.
  - Ensure a safe place to retreat in case of emergency.
Failure to observe this instruction may cause improper or unintended movement of the Robot, which may result in personal injury.
DANGER

• Before operating the Robot, make sure the servo power is turned OFF by performing the following operations. When the servo power is turned OFF, the SERVO ON LED on the Programming Pendant is turned OFF.
  – Press the EMERGENCY STOP buttons on the front door of the Controller, on the Programming Pendant, on the external control device, etc.
  – Disconnect the safety plug of the safety fence. (when in PLAY mode or REMOTE mode)

If operation of the Robot cannot be stopped in an emergency, personal injury and/or equipment damage may result.

• Make sure that all safety protection devices are activated before starting a job in PLAY mode.

• Confirm that no person is present in the Robot's operating range and that the operator is in a safe location before:
  – Turning ON the Controller
  – Moving the Robot by using the Programming Pendant
  – Running the system in the TEACH mode
  – Performing automatic operations

Personal injury may result if a person enters the Robot's operating range during operation

• Immediately press an EMERGENCY STOP button whenever there is a problem.
WARNING

• Read “Safety” of the Controller instructions before operating. Not reading and understanding chapter 1 of the Controller instruction can result in death or serious injury.

• Read and understand all Warning Labels before operating. Not reading and understanding all Warning Labels can result in death or serious injury.

• Confirm that no person is present in the P-point maximum envelope of the Robot before:
  – Turning on the power for the Controller.
  – Moving the Robot with the Programming Pendant.
  – Running the system in TEACH mode.
  – Performing automatic operations.

Injury may result if anyone enters the working envelope of the Robot during operation. Always press an EMERGENCY STOP button immediately if there are problems.

• Observe the following when performing teaching operation within the operating range:
  – Lockout by putting a lockout device on the safety fence when going into the area enclosed by the safety fence.
  – Display a sign that operations are being performed so no other person closes the safety fence.
  – View from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Always keep in mind an emergency response measures against unexpected movement toward a person.
  – Ensure a safe place to retreat in case of emergency.

Failure to observe this precautions may cause improper or unintended movement, which may result in personal injury.

• Maintenance and inspection must be performed by specified personnel.

Failure to observe this Warning may result in electric shock or injury.

• Contact Customer Support for disassembly or repairs.

Not contacting Customer Support can result in electrical shock or injury.
CAUTION

- Do not operate the Robot when a [COOLING FAN2 ERROR] appears on the Programming Pendant. If operation continues with a warning message, equipment damage can occur.
- During high speed continuous operation the Robot temperature may rise quickly depending on ambient temperature and operation pattern. If a warning message displays stop operations or equipment damage may occur.
  - Monitor warning messages on the Programming Pendant. Not monitoring warning messages may cause equipment damage.
  - Refer to the Controller Concurrent I/O manual for details on the signal output. Not referring to Controller Concurrent I/O manual can result in equipment damage.
Maintenance Safety

WARNING

• Make sure equipment has no potentially hazardous conditions.
  – area is clean and free of water, oil, debris, etc.
  – all safeguards are in place.
  – all safety equipment work correctly. Repair or replace any non-functioning safety equipment immediately.
  – Check the EMERGENCY STOP button(s) for proper operation before programming. The equipment must be in E-STOP mode when not in use.

If a hazardous condition is present death or serious injury may occur.

• Use care when modifying software.
  – The equipment allows modifications to the software for maximum performance.

All modifications made to the software will change the way the equipment operates and may cause death or serious injury, as well as damage parts of the system.

• Make sure all modifications did not make create a hazardous or dangerous condition in all modes.

All modifications made to the software will change the way the equipment operates and may cause death or serious injury, as well as damage parts of the system.

• Disconnect and lockout/tagout all sources of energy before making modifications or connections.

Not disconnecting and doing lockout/tagout of all sources of energy can result in death or serious injury.

• Read and understand all maintenance procedures before completing procedures.

Not reading and understanding maintenance procedure may result in death or serious injury.
Safety
Notes for Moving and Transferring the Robot

CAUTION

• Do not modify the Controller.
  Making modifications without written permission from YASKAWA will void the warranty.
  • Back up all programs and jobs onto suitable media before program changes are made.
  To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.
  • Use proper replacement parts only.
  Not using proper replacement parts can cause damage to equipment.
  • All connections must be made within the standard voltage and current ratings of the equipment.
  Improper connections can damage the equipment.

Notes for Moving and Transferring the Robot

DANGER

• When relocating, transferring, or selling the Robot, make sure that the Robot is always accompanied by its manuals so that all users have access to necessary manuals.
  See the Bill of Material for a list of the manuals.
  If any of them are missing, contact Customer Support. The telephone numbers of our offices are listed on the back cover of this manual.
  • If a warning label on the Robot or the Controller is dirty and unreadable, clean the label to make it clearly readable. If a warning label has come off, put the label back in place. Note that some local laws and regulations may prohibit equipment operation if safety labels are not in place.
  Contact Customer Support if requiring a new warning labels.
  • After the Robot is relocated, inspection by Customer Support is recommended.
  If installation or wiring of a device is incorrect, personal injury and/or equipment damage may result.
Safety
Definition of Terms Used Often in This Manual

Definition of Terms Used Often in This Manual

The Robot is a YASKAWA industrial robot product.

The Robot usually consists of a Robot, Controller, Programming Pendant, and Robot cables.

In this manual, the equipment is designated as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP8 EduCart</td>
<td>Cart</td>
</tr>
<tr>
<td>YRC1000micro controller</td>
<td>Controller</td>
</tr>
<tr>
<td>YRC1000micro Programming Pendant</td>
<td>Programming Pendant</td>
</tr>
<tr>
<td>GP8 Manipulator</td>
<td>Robot</td>
</tr>
<tr>
<td>Cable between the Robot and the Controller</td>
<td>Robot cable</td>
</tr>
</tbody>
</table>
Descriptions of the Programming Pendant keys, buttons, and displays are shown as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Manual Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Pendant</td>
<td>Character Keys /Symbol Keys The keys which have characters or symbols printed on them are denoted with [ ]. e.g. [ENTER]</td>
</tr>
<tr>
<td>Axis Keys /Numeric Keys</td>
<td>[Axis Key] and [Numeric Key] are generic names for the keys for axis operation and number input.</td>
</tr>
<tr>
<td>Keys pressed simultaneously</td>
<td>When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them, e.g. [SHIFT][COORD].</td>
</tr>
<tr>
<td>Mode Switch</td>
<td>Mode Switch can select three kinds of modes that are denoted as follows: REMOTE, PLAY or TEACH. (The switch names are denoted as symbols)</td>
</tr>
<tr>
<td>Button</td>
<td>The three buttons on the upper side of the Programming Pendant are denoted as follows: START, HOLD, or EMERGENCY STOP. (The button names are denoted as symbols)</td>
</tr>
<tr>
<td>Displays</td>
<td>The menu displayed in the Programming Pendant is denoted with { }. e.g. {JOB}</td>
</tr>
</tbody>
</table>

Registered Trademark

In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or bland names for each company or corporation. The indications of © and ™ are omitted.
Robot Disposal

WARNING

- Take precautionary measures to prevent the Robot from overturning, such as anchoring it firmly, etc., even when temporarily storing it before disposal.

Failure to observe this instruction may cause overturning of the Robot, which may result in personal injury.

CAUTION

- Do not modify the Robot or the Controller

Failure to observe this instruction can cause fire, mechanical failure, or malfunction, which may result in personal injury and/or equipment damage.

NOTICE

- When disposing of or recycling the Robot, follow the applicable national/local laws and regulations.
- This symbol is applicable in some locations.

The wheelie bin symbol on this product, manual or its packaging indicates that at the end of life the product should enter the recycling system. It must be disposed at an appropriate collection point for electrical and electronic equipment (EEE) and should not be put in the normal waste stream.
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1 Introduction

1.1 Purpose

This manual is intended to supply information for:

- Uncrating GP8 EduCart, see “GP8 EduCart READ ME”
- “Assembly of GP8 EduCart” see chapter 2
- “Powering Up GP8 EduCart” see chapter 3
- “Moving Robot to Home Position” see chapter 4
- “Configuration of the Programming Pendant” see chapter 5
- “Alarms and Messages” see chapter 6
- “Replacement Parts” see chapter 7
- “Parts List” see chapter 8

1.2 System Overview

Make sure the following items are included with the new Motoman GP8 EduCart shipment.

- GP8 EduCart
- GP8 EduCart READ ME
- Teaching Pointers
- MotoSim Software Package and USB Dongles
- Technical Documentation

1.2.1 GP8 EduCart Components

1.2.1.1 Gripper

An electronic gripper is included with each GP8 EduCart (Cart). The gripper is controlled by digital outputs from the YRC1000 micro Controller.

- Input 1 indicates gripper open
- Input 2 indicates gripper closed
- Output 1 opens the gripper
- Output 2 closes the gripper

The gripper has a dial to change gripping force. It is configured to operate at 50% of the peak gripping force from the factory.

During an E-Stop Condition the gripper stops current operation and allows manual opening and closing of the grippers to resolve any unexpected condition.
1 Introduction

1.3 Tools Required

1.2.1.2 Table Surface

This Cart is developed with the mindset for customization. The table surface is a steel whiteboard. It is possible to design customized graphic layouts per each instructor's lesson plan.

Any whiteboard marker may be used on the working surfaces for demonstrations and may be cleaned or wiped off using a dry cloth.

The system includes a default magnetic teaching template with hole cut outs to locate the block nests and optional camera post. The instructor may create magnetic templates as required to support various lessons.

A good source for custom magnetic templates is Magnetic Graphix

Magnetic Graphix, Inc.
17880 Toledo Blade Blvd.
Port Charlotte, FL 33948
Phone: 800-966-0975
Fax: 800-966-0917
Email: sales@magnetking.com

The default template for the table top is available from YASKAWA: part # 186955-1.

1.3 Tools Required

The following items may be required to unpack and assemble the GP8 EduCart:

- Screw Driver/Power Drill
- Phillip bits
- Square bits
- Utility Knife
1.4 System Overview and Variations

The Cart design accommodates a single robot with an electric gripper. The Cart is guarded by an area scanner when the system operates in PLAY mode. The design of the cart places a controller within the structure of the Cart. Care is taken to redirect airflow away from the users, but also provide proper airflow to cool the internal parts of the controller.

The robot comes with an electric gripper attached to the robot. This gripper can be used to grab things using:

- internal grip mode - this holds the TCP pointer or a marker
- external grip mode - this captures the block

The Cart solution supports a Programming Pendant. A user can interact with the virtual I/O while in PLAY mode using the Programming Pendant. More details on this is covered in chapter 5 “Configuration of the Programming Pendant”.

In PLAY mode, an area scanner monitors access to the Cart. If a person or object violates the monitored area, the area scanner will change output states to an E-Stop condition. Removing the obstruction automatically resets the area scanner but leaves the servo off. To continue the operational cycle restart the cycle by pressing [SERVO ON] and then the START button on the Programming Pendant.
1.4.1 System Teaching

**WARNING**

- Review the Risk Assessment prior to any interactions with the Cart. Failure to observe this warning can potentially be a hazardous situation which results in death or serious injury.

The Robot can be programmed by entering the area guarded by the area scanner. In PLAY mode the area scanner’s status is muted allowing the programmer to move close to the robot.

1. Place the selector switch on the Programming Pendant to TEACH.

**NOTICE**

Having the selector switch in the TEACH position limits all Robot and external axes speeds to 250mm/sec.

**CAUTION**

- Only the programmer holding the Programming Pendant can be within the teaching perimeter.
  - Other user’s or students are not to be within the teaching perimeter. Only the programmer holding the Programming Pendant is allowed in the operating range of the robot.
  - Additional safety devices are required for additional user’s or students to be within the teaching perimeter.
  - Review RIA 15.06-2012 requirements for teaching robots.

If someone other than the programmer enters the teaching perimeter may result in minor to moderate injury.

- Avoid hazards while programming.

If not avoided injury can occur because the robot is free to rotate as commanded from the Programming Pendant without regard to door status or light curtain violations.

2. Turn Robot servo motors on by pressing and holding the “Enable” switch on the Programming Pendant.

3. Place selector switch to PLAY when done with teaching.
1.4.2 System Operation

**WARNING**

- Check all programs, safety functions, and EduCart interactions before operating in an automatic operation.

Failure to observe this warning can potentially be a hazardous situation which results in death or serious injury.

Place the Cart into automatic operation by completing the following:

1. Place the mode switch on the Programming Pendant to PLAY.
2. Remove obstructions around the Cart being sensed by the area scanner.

**NOTICE**

The area scanner indicators on the tabletop indicate “green” when there are no obstructions.

3. Select the (MASTER) job on the Programming Pendant.
4. Press the [SERVO ON] button on the Programming Pendant.
5. From the Main Menu select JOB → AUTO.
6. Press the START button on the Programming Pendant to begin the execution of the INFORM job.

**NOTICE**

- Normal operation begins with the assumption that the Robot is in the home position, although other jobs or curriculum requirements may require that the robot starts in different position. Functional Safety Unit (FSU) Robot Range Limits ensure that the Robot operates in areas that are clear.
- If a person or object violates the monitored area, the area scanner changes output state for the Controller to a category 1 E-Stop.
1.4.3 Key Safety Devices

1.4.3.1 Controller with FSU software functions:

- Dual channel Programming Pendant EMERGENCY-STOP
- Dual channel Programming Pendant “Enable” switch
- Functional Safety Unit (FSU) software features

**NOTICE**

I/O interface for the Functional Safety Unit (FSU) is NOT included.

1.4.3.2 Area Scanner

The cart is provided with a Sick microScan3 laser area scanner for detecting persons/items entering an area around the cart. The scanner’s feedback operates similar to a safety gate - it is used as a safety function in PLAY Mode. Therefore, in TEACH Mode the status condition of the safety scanner is not used.

- Red scanner area with minimum radius of 1804 mm from the robot: Robot stops when the area is violated in PLAY Mode.

Looking at the scanner it is possible to determine the status. When the scanner's protected area is violated the indicator is red.

When the scanner's protected area is clear of obstructions indicator is green.
Grey areas are unmonitored areas

Orange zone is the monitored area

The electrical interface between the area scanner and controller are dual channel transistor outputs. These outputs interface with a safety relay to send the proper signal to the Controller safety inputs.
1.4.4 Safety Logic Implementation

1.4.4.1 Teach/Play Mode

In TEACH or PLAY mode, FSU-based “Robot Range Limiting” ensures safe operation of the cart. The purpose for this robot motion restriction is to prevent someone from reaching over the cart. It will also limit motion to prevent collisions with the rear safety panels and work table top. This limitation is used in both TEACH and PLAY mode to prevent programming of points in TEACH mode that are not accessible later in PLAY mode, therefore the file is always active. If the user tries to disable this safety system, a user alarm triggers preventing operation of the Cart.

- Robot Range Limit File Overview

<table>
<thead>
<tr>
<th>FILE</th>
<th>REL. CHECK</th>
<th>STATUS</th>
<th>RANGE</th>
<th>CPU LOAD</th>
<th>CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>2</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>3</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>4</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
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<td>5</td>
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<td>01</td>
<td>A</td>
<td>1</td>
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<tr>
<td>6</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
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<tr>
<td>7</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
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<tr>
<td>8</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>9</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
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<td>A</td>
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<td>A</td>
<td>1</td>
<td>01</td>
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<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
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<tr>
<td>14</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
<tr>
<td>15</td>
<td>01</td>
<td>01</td>
<td>A</td>
<td>1</td>
<td>01</td>
</tr>
</tbody>
</table>

- Robot Range Limit File #1 Settings:
1.4.4.2 PLAY Mode

In PLAY mode, the Controller monitors that the Area Scanner is clear ensuring that someone is not accessing the Cart work area. This is wired directly into a Machine Safety Unit’s dedicated inputs for a safety gate.

---

- Definition of access is NOT allowed by the robot in the Cart. This is to keep the Robot out of the area of potential operators reaching over.
1.5 Reference Documents

Review the following information before installing or operating the system:
- GP8 EduCart Read Me First
- READ FIRST YRC1000micro
- READ FIRST Safety Requirements
- YRC1000micro Instructions
- YRC1000micro Operator’s Manual
- YRC1000micro Options Instruction for Inform Language
- YRC1000micro Option Instructions for Concurrent I/O
- YRC1000micro Brake Release Function Manual
- YRC1000micro Maintenance Manual
- YRC1000micro Alarm Codes
- Motoman-GP8/AR700, -GP7/AR900 Instructions
- Third Party Manuals

1.6 Customer Support Information

If assistance is needed with any aspect of the system, please contact Customer Support at the following 24-hour telephone number:

(937) 847-3200

Customer Support also has an e-mail address for routine technical inquiries, to contact Customer Support through e-mail use the following address:

technicalsupport@motoman.com

When using e-mail to contact Customer Support, please provide a detailed description of the issue, along with complete contact information. Please allow approximately 24 to 36 hours for a response to the inquiry.

WARNING

- Maintenance and inspection must be performed by specified personnel.
  Failure to observe this caution may result in electric shock or injury.

- For disassembly or repair, contact Customer Support.
- Do not remove the motor, and do not release the brake.
  Failure to observe these safety warnings may result in death or serious injury from unexpected turning of the Robot's arm.
1 Introduction
1.6 Customer Support Information

**NOTICE**

Use e-mail for *routine* inquiries only. If there is an urgent or emergency need for service, replacement parts, or information, contact Customer Support at the telephone number shown above.

Have the following information ready before calling Customer Support:

<table>
<thead>
<tr>
<th>Information</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>GP8 EduCart</td>
</tr>
<tr>
<td>Primary Application</td>
<td>Teaching</td>
</tr>
<tr>
<td>Controller</td>
<td>YRC1000micro</td>
</tr>
<tr>
<td>Software Version</td>
<td></td>
</tr>
</tbody>
</table>

*Access this information on the Programming Pendant’s LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - {VERSION}*

<table>
<thead>
<tr>
<th>Information</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot Serial Number</td>
<td>Located on the Robot data plate</td>
</tr>
<tr>
<td>Robot Sales Order Number</td>
<td>Located on the Controller data plate</td>
</tr>
</tbody>
</table>
2 Assembly of GP8 EduCart

1. Unpack the shipping crate and set the GP8 EduCart on the floor.

2. Inspect the cell for any damaged components, particularly the aluminum structure, clear blue panels, or gripper fingers.

3. Unpack all cardboard boxes and do an inventory while checking for any damaged items. Items shipped in cardboard boxes include:
   - Programming Pendant
   - Six teaching blocks and two nests
   - Fixed Teaching Pointer (TCP) pointer and TCP for the gripper
   - System documentation (See section 1.3 “GP8 EduCart Components” on page 1-2)

4. Roll the cell into position for set up, and set the wheel brakes.

NOTICE

Each wheel has a brake, it is recommended all brakes be set before operating the robot.
5. Remove the locking pins holding the two folding rear panels together.

6. Open a rear folding panel and lift the drop panel so it will rest on the rear folding panel.
2-3

2-3

7. Insert a lock pin, securing the rear folding panel to each side of the drop panel.

8. Reach under the drop panel and swing the panel brace out. Slightly lift the drop panel to lock the panel brace in position.

9. Connect the Programming Pendant cable to the Programming Pendant.

10. Remove shipping brackets from the robot.
3 Powering Up GP8 EduCart

The GP8 EduCart is designed to run on 120 VAC, 15 amp circuit.

**WARNING**

- Read and follow all local and federal regulation when connecting the cart to the required power sources.

Not reading and following all local and federal regulation when connecting power source may cause death or serious injury.

1. Double check the jumper is installed in the appropriate location on the Step up/down transformer.

2. Plug the Cart power strip into an independent 120 VAC, 15 amp circuit and turn the power strip ON.
3. Jog the Robot to the “second HOME” position. See section 8.2.2 Procedure for the Second Home Position Setting (Check Point) in the YRC1000micro Instructions.

NOTICE

Normally the cart ships with the transformer and Robot Controller power switches in the ON position. If the Robot Controller does not power up when turning ON the power strip, make sure the transformer and Robot Controller are in the ON position.
4 Moving Robot to Home Position

**WARNING**

• Before operating the Robot, make sure the SERVO ON LED is turned OFF when the EMERGENCY STOP on the Programming Pendant is pressed.

Injury or damage to machinery may result if the Robot cannot be stopped in case of an emergency.

• Observe the following precautions when performing teaching operations within the Cart:
  – View the Robot from the front whenever possible.
  – Always follow the predetermined operating procedure.

Improper or unintended Robot operation may result in injury.

• Confirm that no person is present in the cart before:
  – Turning ON the Controller.
  – Moving the Robot with the Programming Pendant.

Injury may result if anyone enters the cart during operation. Always press the EMERGENCY STOP immediately if there is a problem.

**CAUTION**

• Always perform the following inspection prior to conducting Robot teaching.
  – Check for problems in Robot movement.
  – Check for damage to insulation and outer materials of external wires.

If a problem is found, correct the problem and implement all other necessary measures immediately.

If the problem is not corrected or the inspection is not completed personal injury may occur.
1. Using the Programming Pendant, place the Robot in a safe position by pressing the ROBOT button on the {Main Menu}.

**NOTICE**

If the ROBOT button is not seen on the {Main Menu} press ROBOT button.
2. Press the **SECOND HOME POS** button once the JOB LIST displays.

3. Observe the SECOND HOME POS screen appears. (The screen will look similar to the screen shot below besides the values will differ).
4. Move Robot to the HOME position by pressing and holding the Enable switch, FAST button, and FWD button until the CURRENT column is selected and released.

**NOTICE**

While pressing the Enable switch **DO NOT** press the switch too hard or it will not work.
5. Using the outlines on the template for guidance place the Block Nests onto the template.

6. Install the teaching pointer (TCP) to the gripper mount using two thumb screws.

7. Place the fixed pointer in either nest with the rubber tip pointing up.

The GP8 EduCart is now ready!
5 Configuration Of The Programming Pendant

5.1 Programming Pendant

1. Press the {I/F Panel} on the Programming Pendant display.

2. Place the “OPERATION” switch to “PERM” by pressing the [INTERLOCK] key on the keypad and pressing the “OPERATION” switch on the display of the Programming Pendant.

3. To set up an interface with the “Input *** Control” switch press the [INTERLOCK] key on the keypad and pressing the “Input *** Control” switch on the display of the Programming Pendant and observe the input status changes.
5 Configuration Of The Programming Pendant

5.1 Programming Pendant

4. Confirm only the selected “INPUT *** CONTROL” switch is set on the “GENERAL PURPOSE INPUT” screen by pressing the {DISPLAY}.

5. Set the output either from the INFORM job or by manually setting on the “GENERAL PURPOSE OUTPUT” screen, make sure the I/F Panel is updated correctly.

NOTICE

In this example, “INPUT 402 CONTROL” switch is used.

NOTICE

On this example, the General Purpose Output screen Output #403 and #404 are set.
5 Configuration Of The Programming Pendant
5.1 Programming Pendant

6. Observe the “OUTPUT *** STATUS” are filled in, indicating active status.
6 Alarms and Messages

6.1 Cell Messages

<table>
<thead>
<tr>
<th>Message</th>
<th>Cause</th>
<th>Suggested Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAFETY AREA SENSOR VIOLATED</td>
<td>A person or object is detected within the monitored protection zone of the safety sensor.</td>
<td>1. Check for obstructions. 2. Refer to safety sensor documentation to determine location of interference.</td>
</tr>
<tr>
<td>ROBOT RANGE LIMIT FILE 1 DISABLED</td>
<td>Robot Range Limit File #1 has been disabled by the user. To operate the system software, this file must be active.</td>
<td>1. Enable Robot Range Limit File #1.</td>
</tr>
</tbody>
</table>

6.2 Cell Alarms

<table>
<thead>
<tr>
<th>Message</th>
<th>Cause</th>
<th>Suggested Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS CRITICAL FSU FUNCTION DISABLED</td>
<td>Robot Range Limit File #1 must be enabled</td>
<td>1. Enable Robot Range Limit File #1.</td>
</tr>
<tr>
<td>COLLISION DETECT MUST BE ENABLED</td>
<td>Collision detect settings was disabled</td>
<td>1. Enable Collision Detect from SHOCK SENS LEVEL Menu</td>
</tr>
</tbody>
</table>
7 Replacement Parts

7.1 Common Replacement Parts

The following table is a list of common parts that may be required at some point with the GP8 EduCart.

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Qty/ System</th>
</tr>
</thead>
<tbody>
<tr>
<td>186622-1</td>
<td>Finger, Gripper, Pet-G</td>
<td>1</td>
</tr>
<tr>
<td>187258-1</td>
<td>Cable Assy, Upper Arm, GP8, Gripper</td>
<td>1</td>
</tr>
<tr>
<td>186377-1</td>
<td>Gripper, Parallel, Electric 24 VDC</td>
<td>1</td>
</tr>
<tr>
<td>186955-1</td>
<td>Panel, Teach Grid, Standard Education (Magnetic)</td>
<td>1</td>
</tr>
<tr>
<td>171179-1</td>
<td>Block, Training</td>
<td>6</td>
</tr>
<tr>
<td>171180-1</td>
<td>Block, Nest Training</td>
<td>2</td>
</tr>
<tr>
<td>185966-1</td>
<td>Robot, Calibration Pointer Assy</td>
<td>1</td>
</tr>
</tbody>
</table>

7.2 Recommended Electrical Spare Parts

<table>
<thead>
<tr>
<th>System Component</th>
<th>Manufacturers Part Number</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection for 24 VDC Power Supply</td>
<td>Bussman GMA 2.5</td>
<td>2</td>
</tr>
<tr>
<td>Protection for Gripper</td>
<td>Littlefuse 235002P</td>
<td>2</td>
</tr>
<tr>
<td>Protection before 24 VDC Distribution</td>
<td>Littlefuse 235005P</td>
<td>1</td>
</tr>
</tbody>
</table>
8 Parts List

8.1 Robot Gripper Kit

<table>
<thead>
<tr>
<th>Item</th>
<th>P/N</th>
<th>Title</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>479154-3</td>
<td>CLAMP, CABLE SUPPORT</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>186378-1</td>
<td>CABLE ASSY, PIGTAIL, BASE, USER, I/O, 20 CONTACT CONN, FLYING LEADS, GP8 STEM</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>479296-6</td>
<td>SCREW, SHC, M5X16, CLASS 12.9,</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>182519-1</td>
<td>WASHER, CONICAL SPRING, HEAVY LOAD, M5, JIS B, TYPE 2</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>479296-5</td>
<td>SCREW, SHC, M5X12, CLASS 12.9,</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>186622-1</td>
<td>FINGER, GRIPPER, EGP 50, GP8, EDUCART</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>130429-3</td>
<td>NUT, HEX JAM, M5, ZP</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>186377-1</td>
<td>GRIPPER, PARALLEL, ELECTRIC, 24VDC, EGP 50-N-N-B</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>186322-1</td>
<td>BRACKET, GRIPPER, STEM, GP8, EDUCART</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>187258-1</td>
<td>CABLE ASSY, UPPER ARM, GP8 STEM, GRIPPER</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix A

A.1 Glossary

3D Graphic Display Function
The 3D Graphic Display Function (henceforth described as 3D Display Function) is that, a 3D model of the robot is displayed on the programming pendant window, and the current value of the robot can be confirmed. By using the multi-window function, the job's teaching position displayed in the job content can also be confirmed on the 3D display window. When the functional safety function is valid, the functional safety range can also be displayed.

A Absolute Data (ABSO Data)
Absolute Data (ABSO Data) is a correction factor for data that establishes an indicated value of zero when the robot is at the predetermined Home (calibration position).

Accuracy
Accuracy is the measurement of the deviation between the command characteristic and the attained characteristic (R15.05-2), or the precision with which a computed or calculated robot position can be attained. Accuracy is normally worse than the arm's repeatability. Accuracy is not constant over the workspace, due to the effect of link kinematics.

Active Compliant Robot
An active compliant robot is one in which motion modification during the performance of a task is initiated by the control system. The induced motion modification is slight, but sufficient to facilitate the completion of a desired task.

Actual Position
The position or location of the tool control point. Note that this will not be exactly the same as the demand position, due to a multitude of unsensed errors, such as link deflection, transmission irregularity, tolerances in link lengths, etc.

Actuator
A power mechanism used to effect motion, or maintain position of the robot (for example, a motor which converts electrical energy to effect motion of the robot) (R15.07). The actuator responds to a signal received from the control system.
ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems
This standard provides guidelines for the manufacture and integration of Industrial Robots and Robot Systems with emphasis on their safe use, the importance of risk assessment and establishing personnel safety. This standard is a national adoption of the International Standards ISO 10218-1 and ISO 10218-2 for Industrial Robots and Robot Systems, and offers a global safety standard for the manufacture and integration of such systems.

ArcWorld
Robotic welding systems delivering flexible integrated robotics into the welding processes. ArcWorlds can be configured with multiple robots, a heavy-duty positioner or servo-controlled external axes for coordinated motion.

Arm
An interconnected set of links and powered joints comprising a robot that supports and/or moves a wrist and hand or end-effector through space. The arm itself does not include the end-effector. See "Manipulator", "End-effector" and "Wrist".

Articulated Manipulator
A Robot with an arm that is broken into sections (links) by one or more joints. Each of the joints represents a degree of freedom in the Robot system and allows translation and rotary motion.

Articulation
Describes a jointed device, such as a jointed manipulator. The joints provide rotation about a vertical axis, and elevation out of the horizontal plane. This allows a robot to be capable of reaching into confined spaces.

Assembly Robot
A robot designed specifically for mating, fitting, or otherwise assembling various parts or components into completed products. Primarily used for grasping parts and mating or fitting them together, such as in assembly line production.

Automatic Measurement Function
For optimal robot motion, the mass properties of the end-effector should be specified. These properties can be derived from a CAD model of the tool. The Automatic Measurement Function is an alternative to a CAD model, and it uses the robot arm itself to measure the tool properties. With this function, the user can register the load of tool, the position of the tools center of gravity and the moment of inertia at the center of gravity.

Automatic Mode
See "Play Mode".

Axis
A direction used to specify the robot motion in a linear or rotary mode. (ISO 8373)

Axis Interference
The Axis Interference Area is a function that judges the current position of each axis and outputs a signal based on whether the current position is within a predefined range.
Appendix A
A.1 Glossary

Base
The stable platform to which an industrial robotic arm is attached.

Base Coordinate System
The Base Coordinate System (sometimes referred to as World Coordinate System) defines a common reference point for a cell or application. This is useful when using multiple robots or devices as positions defined in Base Coordinates will be the same for all robots and devices.

Base Link
The stationary base structure of a robot arm that supports the first joint.

Burn-in
Burn-In is a robot testing procedure where all components of the robot are operated continuously for an extended period of time. This is done to test movement and movement programming of the robot at early stages to avoid malfunctions after deployment.

Bypass Kit
Hardware that allows individual encoder and/or brake signal cables (enclosed in the manipulator cable) to be replaced separately. Used to replace a failed encoder or a brake cable.

Computer Aided Design (CAD)
Computer Aided Design (CAD). Computer graphic applications designed to allow engineering of objects (or parts), which are to be manufactured. A computer is used as a tool to design schematics and produce blueprints, which enable the accurate production of the object. The CAD system enables the three dimensional drawings of basic figures, exact sizing and placement of components, making lines of specified length, width, or angle, as well as satisfying varying geometric shapes. This system also allows the designer to test a simulated part under different stresses, loads, etc.

Carousel
A rotating platform that delivers objects to a robot and serves as an object queuing system. This carousel delivers the objects, or work pieces, to the loading/unloading station of the robot.

Cartesian Coordinates
Cartesian Coordinates is a type of coordinate system that specifies the location of a point in two dimensional space by a pair of numerical numbers, which further specify the distance to fixed axes that are perpendicular to each other. In simple terms, an XY graph represents a two dimensional Cartesian Coordinate System. When a point is specified in a three dimensional space (XYZ graph), it constitutes a three dimensional Cartesian coordinate system. A robot’s TCP position is specified in a Cartesian Coordinate.

Cartesian Manipulator
A Cartesian Manipulator is a robot arm with prismatic joints, which allows movement along one or more of the three-axes in the X, Y, Z coordinate system.
Appendix A
A.1 Glossary

**Cartesian Topology**
A topology, which uses prismatic joints throughout, normally arranged to be perpendicular to each other.

**Cartesian-coordinate Robot**
A Cartesian-coordinate Robot is a robot whose manipulator-arm degrees of freedom are defined by Cartesian Coordinates. This describes motions that are east-west, north-south and up-down, as well as rotary motions to change orientation.

**Category 3 (Cat3)**
Category 3 (Cat 3) means that the safety related parts of the control system will be designed so that:
- Single faults will not prevent the safety function from working correctly.
- Single faults will be detected at or before the next demand of the safety function.
- When a single fault does occur, a safe state shall be maintained until the detected fault is corrected.
- All reasonably foreseeable faults are detected.

**Caution**
Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury. It may also be used without the safety alert symbol as an alternative to “NOTICE”.

**Centrifugal Force**
When a body rotates about an axis other than one at it’s center of mass, it exerts an outward radial force called centrifugal force upon the axis, which restrains it from moving in a straight tangential line. To offset this force, the robot must exert an opposing torque at the joint of rotation.

**Circular Motion Type**
A calculated path that the robot executes, and is circular in shape.

**Clamp**
An end-effector which serves as a pneumatic hand that controls the grasping and releasing of an object. Tactile, and feed-back force sensors are used to manage the applied force to the object by the clamp. See "End-effector".

**Clamping**
The maximum permissible force acting on a body region, resulting from a robot collision where the period of contact results in a plastic deformation of a person’s soft tissue.

**Clamping Force**
When contact can cause a body part(s) to be clamped.

**Closed-loop**
Control achieved by a robot manipulator by means of feedback information. As a manipulator is in action, its sensors continually communicate information to the robot’s controller, which is used to further guide the manipulator within the given task. Many sensors are used to feed back information about the manipulator’s placement, speed, torque, applied forces, as well as the placement of a targeted moving object, etc. See "Feedback".
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Collaborative Robot
Term used to describe a robot system designed to operate in one or more of the four collaborative modes.
- "Safety Monitored Stop"
- "Hand Guiding"
- "Speed and Separation Monitoring"
- "Power and Force Limiting (PFL)"

Command Interpreter
A module or set of modules that determines what the received command means. The command is broken down into parts (parsed) and processed.

Command Position
The endpoint position of a robot motion that the controller is trying to achieve.

Compliance
Displacement of a manipulator in response to a force or torque. A high compliance means the manipulator moves a good bit when it is stressed. This is called spongy or springy. Low compliance would be a stiff system when stressed.

Compliant Robot
A robot that performs tasks, with respect to external forces, by modifying its motions in a manner that minimizes those forces. The indicated or allowed motion is accomplished through lateral (horizontal), axial (vertical) or rotational compliance.

Configuration
The arrangement of links created by a particular set of joint positions on the robot. Note that there may be several configurations resulting in the same endpoint position.

Connector Panel
Junction plate that allows the manipulator cables to connect to the robot’s internal harness. See “Internal Harness”.

Contact Sensor
A device that detects the presence of an object or measures the amount of applied force or torque applied on the object through physical contact with it. Contact sensing can be used to determine location, identity, and orientation of work pieces.

Continuous Path
Describes the process where by a robot is controlled over the entire path traversed, as opposed to a point-to-point method of traversal. This is used when the trajectory of the end-effector is most important to provide a smooth movement, such as in spray painting etc. See "Point-to-Point".

Control Algorithm
A monitor used to detect trajectory deviations in which sensors detect such deviations and torque applications are computed for the actuators.
Control Command
An instruction fed to the robot by means of the human-to-machine input device. See Pendant (Teaching). This command is received by the robot's controller system and is interpreted. Then, the proper instruction is fed to the robot's actuators, which enable it to react to the initial command. Many times, the command must be interpreted with the use of logic units and specific algorithms. See "Input Devices" and "Instruction Cycle".

Control Device
Any piece of control hardware providing a means for human intervention in the control of a robot or robot system, such as an emergency-stop button, a start button, or a selector switch. (R15.06)

Control Mode
The means by which instructions are communicated to the robot.

Controllability
The property of a system by which an input signal can take the system from an initial state to a desired state along a predictable path within a predetermined period of time.

Controller
An information processing device whose inputs are both the desired and measured position, velocity or other pertinent variables in a process and whose outputs are drive signals to a controlling motor or actuator. (R15.02)

Controller Operator Handle
Power switch on the controller. Turns on the controller and provides power to the robot.

Controller System
The robot control mechanism is usually a computer of some type, which is used to store data (both robot and work environment), and store and execute programs, which operate the robot. The Controller System contains the programs, data, algorithms; logic analysis, and various other processing activities, which enable it to perform. See "Robot".

Coordinate System or Frame
A Coordinate System (or Frame) defines a reference position and orientation from which a robot position can be measured. All robot positions are defined with reference to a Coordinate System. YASKAWA robots utilize the following Coordinate Systems:

- "Base Coordinate System"
- "Robot Coordinate System"
- "User Coordinate System"
- "Cartesian Coordinates"

Central Processing Unit (CPU)
The Central Processing Unit (CPU) is the main circuit board and processor of the Controller System.

Cubic Interference Area
This area is a rectangular parallelepiped, which is parallel to the base coordinate, robot coordinate or user coordinate. The YRC1000 controller judges whether the current position of the manipulator's TCP is inside or outside this area, and outputs this status as a signal.
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**Cycle**
A single execution of a complete set of moves and functions contained within a robot program. (R15.05-2)

**Cyclic Coordinate System**
A coordinate system that defines the position of any point in terms of an angular dimension, a radial dimension and a height from a reference plane. These three dimensions specify a point on a cylinder.

**Cyclo Drive**
A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major (larger) axis.

**Cylindrical Topology**
A topology where the arm follows a radius of a horizontal circle, with a prismatic joint to raise or lower the circle. Not popular in industry.

**D**

**Danger**
Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Safety Signs identified by the signal word DANGER should be used sparingly and only for those situations presenting the most serious hazards.

**Dead Man Switch**
Deprecated term. See "Enabling Device".

**Degrees of Freedom**
The number of independent directions or joints of the robot (R15.07), which would allow the robot to move its end effector through the required sequence of motions. For arbitrary positioning, six degrees of freedom are needed: three for position (left-right, forward-backward and up-down), and three for orientation (yaw, pitch and roll).

**Direct-drive**
Joint actuation, including no transmission elements (i.e., the link is bolted onto the output of the motor.)

**Downtime**
A period of time, in which, a robot or production line is shut down, due to malfunction or failure. See "Uptime".

**Drive**
A speed (gear) reducer to convert high speed low torque to low speed high torque. See "Harmonic Drive", "Cyclo Drive" and "Rotary Vector Drive (RV)".

**Drop Delivery**
A method of introducing an object to the workplace by gravity. Usually, a chute or container is so placed that, when work on the part is finished, it will fall or drop into a chute or onto a conveyor with little or no transport by the robot.
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**Dynamics**
The study of motion, the forces that cause the motion and the forces due to motion. The dynamics of a robot arm are very complicated as they result from the kinematical behavior of all masses within the arm's structure. The robot arm kinematics are complicated in themselves.

**Emergency Stop**
The operation of a circuit using hardware-based components that overrides all other robot controls, removes drive power from the robot actuators, and causes all moving parts to stop. (R15.06)

**Enable Switch**
See "Enabling Device".

**Enabling Device**
A manually operated device which when continuously activated, permits motion. Releasing the device shall stop robot motion and motion of associated equipment that may present a hazard. (R15.06)

**Encoder**
A feedback device in the robot manipulator arm that provides current position (and orientation of the arm) data to the controller. A beam of light passes through a rotating code disk that contains a precise pattern of opaque and transparent segments on its surface. Light that is transmitted through the disk strikes photo-detectors, which convert the light pattern to electrical signals. See "Feedback", "Closed-loop" and "Feedback Sensor".

**Envelope**
Is the range of movement available. This range is determined by the length of a robot's arm and the design of its axes. Each axis contributes its own range of motion.

**EOAT**
See "Gripper" or "End-effector".

**End-effector**
An accessory device or tool, specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot to perform its intended task. (Examples may include: gripper, spot weld gun, arc weld gun, spray point gun or any other application tools.) (R15.06)

**Endpoint**
The nominal commanded position that a manipulator will attempt to achieve at the end of a path of motion. The end of the distal link.

**Error**
The difference between the actual response of a robot and a command issued.

**Expandability**
Being able to add resources to the system, such as memory, larger hard drive, new I/O card, etc.
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External Force Limit
The threshold limit where the robot moves to or retains position, even when external forces are applied (provided that forces do not exceed limits that would cause an error).

Feedback
The return of information from a manipulator or sensor to the processor of the robot to provide self-correcting control of the manipulator. See "Feedback Control" and "Feedback Sensor".

Feedback Control
A type of system control obtained when information from a manipulator or sensor is returned to the robot controller in order to obtain a desired robot effect. See "Feedback", "Closed-loop" and "Feedback Sensor".

Feedback Sensor
A mechanism through which information from sensing devices is fed back to the robot's control unit. The information is utilized in the subsequent direction of the robot's motion. See "Closed-loop" and "Feedback Control".

Flexibility
The ability of a robot to perform a variety of different tasks.

Force Feedback
A sensing technique using electrical signals to control a robot end-effector during the task of the end-effector. Information is fed from the force sensors of the end-effector to the robot control unit during the particular task to enable enhanced operation of the end-effector. See "Feedback", "Feedback Sensor" and "Force Sensor".

Force Sensor
A sensor capable of measuring the forces and torque exerted by a robot and its wrist. Such sensors usually contain strain gauges. The sensor provides information needed for force feedback. See "Force Feedback".

Forward Kinematic Solution
The calculation required to find the endpoint position, given the joint positions. For most robot topologies this is easier than finding the inverse kinematic solution.

Forward Kinematics
Computational procedures which determine where the end-effector of a robot is located in space. The procedures use mathematical algorithms along with joint sensors to determine its location.

Frame
A coordinate system used to determine a position and orientation of an object in space, as well as the robot's position within its model.
Functional Safety Unit (FSU)
The Functional Safety Unit (FSU) is a component of the YASKAWA robot controller that provides programmable safety functions that enable collaborative operation of the robot. As these safety functions are programmable, the FSU allows the minimization of nearby overall equipment footprint, as well as human accessible areas. The FSU consists of two parallel Central Processing Units (CPUs) run concurrently, thereby providing dual channel checking. In addition, the FSU acquires robot position from its encoders independently from the motion control system of the robot. Based on this feedback, the FSU monitors the manipulator and tool’s position, speed and posture.

G

Gantry
An adjustable hoisting machine that slides along a fixed platform or track, either raised or at ground level along the X, Y, Z axes.

Gantry Robot
A robot which has three degrees of freedom along the X, Y and Z coordinate system. Usually consists of a spooling system (used as a crane), which when reeled or unreeled provides the up and down motion along the Z axis. The spool can slide from left to right along a shaft which provides movement along the Z axis. The spool and shaft can move forward and back along tracks which provide movement along the Y axis. Usually used to position its end effector over a desired object and pick it up.

Gravity Loading
The force exerted downward, due to the weight of the robot arm and/or the load at the end of the arm. The force creates an error with respect to position accuracy of the end effector. A compensating force can be computed and applied bringing the arm back to the desired position.

Gripper
An end effector that is designed for seizing and holding (ISO 8373) and “grips” or grabs an object. It is attached to the last link of the arm. It may hold an object using several different methods, such as: applying pressure between its “fingers”, or may use magnetization or vacuum to hold the object, etc. See “End-effector”.

H

Hand
A clamp or gripper used as an end-effector to grasp objects. See “End-effector”, and “Gripper”.

Hand Guiding
Collaborative feature that allows an operator to hand guide the robot to a desired position. This task can be achieved by utilizing additional external hardware mounted directly to the robot or by a robot specifically designed to support this feature. Both solutions will require elements of functional safety to be utilized. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.
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**Harmonic Drive**
Compact lightweight speed reducer that converts high speed low torque to low speed high torque. Usually found on the minor (smaller) axis.

**Harness**
Usually several wires, bundled together to deliver power and/or signal communications to/from devices. For example, the robot motors are connected to the controller through a wire harness.

**Hazardous Motion**
Unintended/unexpected robot motion that may cause injury.

**Hold**
A stopping of all movements of a robot during its sequence, in which some power is maintained on the robot. For example, program execution stops, however power to the servo motors remain on, if restarting is desired.

**Home Position**
A known and fixed location on the basic coordinate axis of the manipulator where it comes to rest, or to an indicated zero position for each axis. This position is unique for each model of manipulator. On Motoman® robots there are indicator marks that show the Home position for the respective axis.

**IEC**
International Electrotechnical Commission

**Inductive Sensor**
The class of proximity sensors, which has half of a ferrite core, whose coil is part of an oscillator circuit. When a metallic object enters this field, at some point, the object will absorb enough energy from the field to cause the oscillator to stop oscillating. This signifies that an object is present in a given proximity. See "Proximity Sensor".

**Industrial Robot**
A re-programmable multi-functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks (R15.06). The principle components are: one or more arms that can move in several directions, a manipulator, and a computer controller that gives detailed movement instructions.

**INFORM**
The robot programming language for YASKAWA robots. INFORM language allows the robot user to: instruct the robot to use its basic capabilities to fulfill a defined set of expectations and also to describe to the robot, through a definition of parameters and conditions, what the expectations are in some given situations or scenarios. In simple terms, the INFORM programming language allows the user to instruct the robot on what to do, when to do it, where to do it and how to do it.
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Input Devices
A variety of devices, which allow a human to machine interface. This allows the human to program, control, and simulate the robot. Such devices include programming pendant, computer keyboards, a mouse, joy-sticks, push buttons, operator panel, operator pedestal etc.

Instruction
A line of programming code that causes action from the system controller. See "Command Position".

Instruction Cycle
The time it takes for a robot controller system’s cycle to decode a command or instruction before it is executed. The Instruction Cycle must be analyzed very closely by robotic programmers to enable speedy and proper reaction to varying commands.

Integrate
To fit together different subsystems, such as robots and other automation devices, or at least different versions of subsystems in the same control shell.

Integrator
A company that provides value added services that results in creation of automation solutions by combining a robot and other automation and controls equipment to create an automation solution for end users.

Intelligent Robot
A robot that can be programmed to make performance choices contingent on sensory inputs with little or no help from human intervention. See "Robot".

Interference Area
Interference Area is a function that prevents interference between multiple manipulators or the manipulator and peripheral device. The areas can be set up to 64 areas. Three types of methods to use each interference area are as follows: Cubic Interference, Outside of Cubic Area and Axis Interference.

Internal Harness
Collection of cables bundled inside the main body of the manipulator. The cables run from the base of the robot to each motor.

Interpolation
The method by which endpoint paths are created. In general, to specify a motion a few knot points are defined before all the intermediate positions between them are calculated by mathematical interpolation. The interpolation algorithm used therefore has a dramatic effect of the quality of motion.

ISO
International Organization for Standardization

ISO 10218-1 Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots
A robot specific safety specification that addresses manufacturer requirements, functionality, required safety performance, hazards, protective measures and documentation for the robot itself.
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ISO 10218-2 Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration
A companion document to ISO 10218-1. This safety specification provides guidance to both end users and robot integrators as it pertains to the safe design, Installation and commissioning of robot systems, as well as recommended procedures, safeguarding and information required for use.

ISO TS 15066(ANSI RIA 15.606): Robots and robotic devices - Collaborative robots
Provides detailed guidance not found in ISO 10218 parts 1 or 2 for the safe use of industrial robots operating collaboratively.

J

Jacobian matrix
The Jacobian matrix relates the rates of change of joint values with the rates of change of endpoint co-ordinates. Essentially it is a set of algorithm calculations that are processed to control the positioning of a robot.

JOB
JOB is the YASKAWA name for a robot program created using YASKAWA’s INFORM robot programming language. Typically, a JOB consists of instructions that tell the robot controller what to do and data that the program uses when it is running.

Joint
A part of the manipulator system, which allows a rotation and/or translational degree of freedom of a link of end-effector.

Joint Interpolated Motion
A method of coordinating the movement of the joints, such that all joints arrive at the desired location simultaneously. This method of servo control produces a predictable path regardless of speed and results in the fastest pick and place cycle time for a particular move.

Joint Motion Type
Also known as Point-to-Point Motion, Joint Motion Type is a method of path interpolation that commands the movement of the robot by moving each joint directly to the commanded position so that all axis arrive to the position at the same time. Although the path is predictable, it will not be linear.

Joint Space
a. Joint Space (or Joint Coordinates) is just a method of defining the position of the robot in terms of the value of each axis instead of as a TCP position. For example, the Home Position of a robot is often defined in Joint Space as each axis being at 0 degrees.
b. The set of joint positions.

Joints
The parts of the robot arm which actually bend or move.
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**Kinematics**
The relationship between the motion of the endpoint of a robot and the motion of the joints. For a Cartesian Robot this is a set of simple linear functions (linear tracks that may be arranged in X, Y, Z directions), for a revolute topology (joints that rotate) however, the kinematics are much more complicated involving complicated combinations of trigonometry functions. The kinematics of an arm is normally split into forward and inverse solutions.

**Ladle Gripper**
An end-effector, which acts as a scoop. It is commonly used to scoop up liquids, transfer it to a mold and pour the liquid into the mold. Common for handling molten metal under hazardous conditions. See "End-effector".

**Laser**
Acronym for Light Amplification by Stimulated Emission of Radiation. A device that produces a coherent monochromatic beam of light which is extremely narrow and focused but still within the visible light spectrum. This is commonly used as a non-contact sensor for robots. Robotic applications include: distance finding, identifying accurate locations, surface mapping, bar code scanning, cutting, welding etc.

**Lifting Bracket**
A lifting fixture factory-shipped installed on the manipulator. It contains hoist rings used for lifting by a chain sling. The lifting bracket is not rated for lifting by forklift. It must be lifted by chain sling only.

**Limit Switch**
Prevents the manipulator from moving past overrun positions. Provided for the S, L, and U axes.

**Linear Interpolated Motion**
Is a method of path interpolation that commands the movement of the robot by moving each joint in a coordinated motion so that all axis arrive to the position at the same time. The path of the Tool Control Point (TCP) is predictable and will be linear.

**Linear Motion Type**
Is a method of path interpolation that commands the movement of the robot by moving each joint in a coordinated motion so that all axis arrive to the position at the same time. The path of the Tool Control Point (TCP) is predictable and will be linear.

**Link**
A rigid part of a manipulator, which connects adjacent joints.

**Links**
The static material, which connects the joints of an arm together. Thereby a kinematical chain is formed. In a human body, the links are the bones.

**Load Cycle Time**
A manufacturing or assembly line process term, which describes the complete time to unload the last work piece and load the next one.
Magnetic Detectors
Robot sensors that can sense the presence of ferromagnetic material. Solid-state detectors with appropriate amplification and processing can locate a metal object to a high degree of precision. See "Sensor".

Manipulator
A machine or robotic mechanism usually consisting of a series of segments (jointed or sliding relative to one another) for the purpose of grasping and/or moving objects (pieces or tools), usually in several degrees of freedom. The manipulator may be controlled by an operator, a programmable electronic controller or any logic system (for example cam device, wired, etc.) (ISO 8373)
See "Arm", "Wrist" and "End-effector"

Manipulator Cables
A collection of cables that connect the base of the robot to the controller through the connector panel.

Manual Mode
See "Teach Mode".

Material Handling
The process by which an industrial robotic arm transfers materials from one place to another.

Material Processing Robot
A robot designed and programmed so that it can machine, cut, form or change the shape, function or properties of materials it handles between the time the materials are first grasped and the time they are released in a manufacturing process.

Mirror Shift Function
With the Mirror Shift Function, a job is converted to the job in which the path is symmetrical to that of the original job. This conversion can be performed for the specified coordinate among the X-Y, X-Z or Y-Z coordinate of the robot coordinates and the user coordinates. The Mirror Shift Function is classified into the following three: the Pulse Mirror Shift Function, the Robot Coordinates Mirror Shift Function and the User Coordinates Mirror Shift Function.

Mode Switch
As per safety standards, an industrial robot has three distinct modes of operation. These are Teach (also called Manual) and Play (also called Automatic) and Remote. Switching between these modes is performed using a key switch on the "Programming Pendant" and is called Mode Switch.

Modularity
The property of flexibility built into a robot and control system by assembling separate units, which can be easily joined to or arranged with other parts or units.

Module
Self-contained component of a package. This component may contain sub-components known as sub-modules.
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**Motion Axis**
The line defining the axis of motion either linear or rotary segment of a manipulator.

**Motor**
See "Servo Motor".

**Muting**
While testing a robot program, the deactivation of any presence sensing safeguarding devices during the full robot cycle or a portion of the cycle.

**Notice**
NOTICE is the preferred signal word to address practices not related to personal injury. The safety alert symbol should not be used with this signal word. As an alternative to “NOTICE”, the word “CAUTION” without the safety alert symbol may be used to indicate a message not related to personal injury.

**Off-line Programming**
A programming method where the task program is defined on devices or computers separate from the robot for later input of programming information to the robot. (ISO 8373) A means of programming a robot while the robot is functioning. This becomes important in manufacturing and assembly line production due to keeping productivity high while the robot is being programmed for other tasks.

**Operator**
The person designated to start, monitor and stop the intended productive operation of a robot or robot system. An operator may also interface with a robot for productive purposes. (R15.06)

**Operator Handle, Controller**
Power switch on the controller. Turns on the controller and provides power to the robot.

**Optical Encoder**
A detection sensor, which measures linear or rotary motion by detecting the movement of markings past a fixed beam of light. This can be used to count revolutions, identify parts, etc.

**Optical Proximity Sensors**
Robot sensors which measure visible or invisible light reflected from an object to determine distance. Lasers are used for greater accuracy.

**Orientation**
The angle formed by the major axis of an object relative to a reference axis. It must be defined relative to a three dimensional coordinate system. Angular position of an object with respect to the robot’s reference system. See "Roll", "Pitch" and "Yaw".
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Palletizing
The process of stacking packages (i.e., boxes, bags, containers, etc.) in an organized fashion on a pallet.

PAM Function – Position Adjustment by Manual
Position Adjustment by Manual allows position adjustment by simple operations while observing the motion of the manipulator, and without stopping the manipulator. Positions can be adjusted in both teach mode and play mode.

Parallel Shift Function
Parallel Shift refers to the shifting of an object from a fixed position in such a way that all points within the object move an equal distance. In the model for Parallel Shift shown in the following, the shift value can be defined as the distance L (three dimensional coordinate displacement). The Parallel Shift Function is relevant to the actual operation of the manipulator because it can be used to reduce the amount of work involved in teaching by shifting a taught path (or position). In the example in the figure below, the taught position A is shifted in increments of the distance L (this is actually a three dimensional XYZ displacement that can be recognized by the robot).

Path
The continuous locus of positions (or points in three dimensional space) traversed by the tool center point and described in a specified coordinate system. (R15.05-2)

Payload - Maximum
The maximum mass that the robot can manipulate at a specified speed, acceleration/deceleration, center of gravity location (offset), and repeatability under continuous operation over a specified working space. Maximum payload is specified in kilograms. (R15.05-2)

Pendant [Programming Pendant]
A hand-held input device, linked to the control system with which a robot can be programmed or moved. (ISO 8373) This enables the human operator to stand in the most favorable position to observe, control and record the desired movements in the robot's memory.

Pendant Teaching
The mapping and recording of the position and orientation of a robot and/or manipulator system as the robot is manually moved in increments from an initial state along a path to a final goal state. The position and orientation of each critical point (joints, robot base, etc.) is recorded and stored in a database for each taught position the robot passes through on its path toward its final goal. The robot may now repeat the path on its own by following the path stored in the database.

Performance Level d (PLd)
ISO Performance Level (PL) “d” means that the average probability of dangerous failure per hour of the safety related parts of the control system falls within = 10^-7 to < 10^-6. Additionally, other factors such as proper installation, maintenance and protection against environmental factors also apply. This is the minimum performance level specified in ISO 10218-2 section 5.2.2, unless a risk assessment would allow a lower value to be used.
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Performance Level e (PLe)
ISO Performance Level (PL) “e” means that the average probability of dangerous failure per hour of the safety related parts of the control system falls within $10^{-8}$ to $<10^{-7}$. Additionally, other factors such as proper installation, maintenance and protection against environmental factors also apply.

Pick and Place Cycle
The amount of time it takes for a manipulator to pick up an object and place it in a desired location, then return to its rest position. This includes time during the acceleration and deceleration phases of a particular task. The robot movement is controlled from one point location in space to another in a Point-to-Point (PTP) motion system. Each point is programmed into the robot's control memory and then played back during the work cycle.

Pick-and-Place Task
A repetitive part transfer task composed of a picking action followed by a placing action.

Pinch Points
A pinch point is any point at which it is possible for a person or part of a person’s body to be caught between moving parts of a machine, or between the moving and stationary parts of a machine, or between material and any part of the machine. A pinch point does not have to cause injury to a limb or body part, although it might cause injury – it only has to trap or pinch the person to prevent them from escaping or removing the trapped part from the pinch point.

Pitch
Rotation of the end-effector in a vertical plane around the end of the robot manipulator arm. See "Roll" and "Yaw".

Play Mode
After a robot is programmed in Teach Mode, the robot controller can be switched to Play Mode to execute the robot program. In Play Mode, the robot program is played back. This is the mode in which robots are used in production.

Playback Operation
Playback is the operation by which the taught job is played back. This function is used to decide where to resume the playback on the start operation after suspending the playback and moving the cursor or selecting other jobs. 0: Starts operation where the cursor is located in the job displayed at the moment. 1: The playback continuation window appears. Select “YES” and the playback resumes where the cursor has been located when the playback suspended. If “NO” is selected, the playback resumes where the cursor is located in the job displayed at the moment. Modes Switch on the programming pendant: PLAY – job is started up by [START] on the programming pendant and REMOTE job is started by a peripheral device (external start input).

Point-to-Point
Robot motion in which a limited number of points along a projected path of motion is specified. The manipulator moves from point to point rather than a continuous smooth path.
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**Pose**
Alternative term for robot configuration, which describes the linear and angular position. The linear position includes the azimuth, elevation and range of the object. The angular position includes the roll, pitch and yaw of the object. See "Roll", "Pitch" and "Yaw".

**Position**
The definition of an object's location in 3D space, usually defined by a 3D coordinate system using X, Y and Z coordinates.

**Position Level**
The position level is the degree of approximation of the manipulator to a taught position. The position level can be added to move instructions MOVJ (joint interpolation) and MOVL (linear interpolation). If the position level is not set, the precision depends on the operation speed. Setting an appropriate level moves the manipulator in a path suitable to circumferential conditions and the workpiece.

**Position Variables**
Position Variables are used in a robot program (JOB) to define a location in 3D space, usually defined by a 3D coordinate system using X, Y and Z coordinates. As it is a variable, the value can change depending on conditions or on information passed to the JOB.

**Power and Force Limiting (PFL)**
Collaborative feature that allows both the operator and robot to work in proximity to one another by ensuring the robot will slow down and stop before a contact situation occurs. In order for this feature to be safely implemented, functional safety and additional detection hardware must be used. A risk assessment shall be used determine if any additional safeguarding is necessary to mitigate risks within the robot system.

**Presence-sensing Safeguarding Device**
A device designed, constructed and installed to create a sensing field to detect an intrusion into such field by people, robots or objects. See "Sensor".

**Programmable Logical Controller (PLC)**
A solid-state control system, which has a user programmable memory for storage of instructions to implement specific functions such as: I/O control logic, timing, counting arithmetic and data manipulation. A PLC consists of a central processor, input/output interface, memory and programming device, which typically uses relay equivalent symbols. The PLC is purposely designed as an industrial control system, which may perform functions equivalent to a relay panel or a wired solid-state logic control system, and may be integrated into the robot control system.

**Programmable Robot**
A feature that allows a robot to be instructed to perform a sequence of steps and then to perform this sequence in a repetitive manner. It can then be reprogrammed to perform a different sequence of steps if desired.

**Programming Pendant**
A hand-held control box, which is used by an operator to remotely guide a robot through the motions of its tasks. The motions are recorded by the robot control system for future playback. Modern industrial robots come with programming pendants, which not only allow robot teaching, but also support full feature robot programming and safety user interface.
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Proximity Sensor
A non-contact sensing device used to sense when objects are a short distance away, and it can determine the distance of the object. Several types include: radio frequency, magnetic bridge, ultrasonic and photoelectric. Commonly used for: high speed counting, sensing metal objects, level control, reading coding marks and limit switches. See "Inductive Sensor".

Pulse Coordinates
YASKAWA robots define robot joint axes position in degrees for revolute joints. Pulse is also another way to specify robot joint position, and it does so in robot motor encoder pulse counts.

Quality Assurance (QA)
Describes the methods, policies and procedures necessary to conduct quality assurance testing during design, manufacturing and delivery phases of creating, reprogramming, or maintaining robots.

Quasi-static Clamping
A type of contact between a person and part of a robot system where the body part can be clamped between the moving part of the robot system & another fixed or moving part of the robot cell

Range of Motion
The full movement potential of the robot.

Reach
The volume of space (envelope), which a robot's end-effector can reach in at least one orientation.

Real-time System
A computer system in which the computer is required to perform its tasks within the time restraints of some process simultaneously with the system it is assisting. The computer processes system data (input) from the sensors for the purpose of monitoring and computing system control parameters (outputs) required for the correct operation of a system or process. The computer is required to do its work fast enough to keep pace with an operator interacting with it through a terminal device (such as a screen or keyboard). The operator interacting with the computer has access, retrieval and storage capability through a database management system. System access allows the operator to intervene and alter the system's operation.

Record-playback Robot
A manipulator for which the critical points along desired trajectories are stored in sequence by recording the actual values of the joint-position encoders of the robot as it is moved under operational control. To perform the task, these points are played back to the robot's servo-system. See "Servo-system".
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**Rectangular-Coordinate Robot**
A robot whose manipulator arm moves in linear motions along a set of Cartesian or rectangular axis in X, Y and Z directions. The shape of the work envelope forms a rectangular figure. See "Work Envelope".

**Reliability**
The probability or percentage of time that a device will function without failure over a specified time period or amount of usage (R15.02). Also called: the robot's uptime or the Mean Time Between Failure (MTBF).

**Remanufacture**
To upgrade or modify robots to the revised specifications of the manufacturer. (R15.06)

**Remote Mode**
Remote Mode is a type of Play Mode where the automatic execution of robot program is initiated from an external device (not the Programming Pendant). During this mode, the use of the Programming Pendant is disabled.

**Repeatability**
A measure of how close an arm can repeatedly obtain a taught position. For instance: once a manipulator is manually placed in a particular location and this location is resolved by the robot, the repeatability specifies how accurately the manipulator can return to that exact location. The degree of resolution within the robot control system determines the repeatability. In general, an arm's repeatability can never be better than its resolution. See "Teach" and "Accuracy".

**Resolution**
The amount of robot joint motion required for the position sensing to change by one count. Although the resolution of each joint feedback sensor is normally constant, the resolution of the endpoint in world coordinates is not constant for revolute arms, due to the non-linearity of the arm's kinematics.

**Revolute Joint**
The joints of a robot, which are capable of rotary motion.

**Risk Assessment**
The process of evaluating the intended use of a machine or system for foreseeable hazards and then determining the level of risk involved for the tasks identified.

**Risk Mitigation**
A secondary step in the risk assessment process that involves reducing the level of risk for the identified tasks, by applying risk reduction measures in order to eliminate or mitigate the hazards.

**Robot**
A re-programmable, multi-functional manipulator designed to move material, parts, tools or specified devices through variable programmed motions for the performance of a variety of tasks. Common elements which make up a robot are: controller, manipulator and end-effector. See "Manipulator", "Controller" and "End-effector".
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Robot Coordinate System
The Robot Coordinate System is defined in the base axis of a Robot, and points in the Robot Coordinate System will be relative to the base of the robot. Note that by default the Base Coordinate System and Robot Coordinate System are the same.

Robot Integrator
See "Integrator".

Robot Programming Language
An interface between a human user and a robot, which relates human commands to the robot.

Robot Range Limit Monitoring
Monitors the manipulator arm or its tool to be in the designated safety area.

Robot Simulation
A method for emulating and predicting the behavior and the operation of a robotic system based on the model (i.e., computer graphics) of the physical system. (R15.07)

Roll
Rotation of the robot end effector in a plane perpendicular to the end of the manipulator arm. See "Pitch" and "Yaw".

Rotary Joint
A joint which twists, swings or bends about an axis.

Rotary Vector Drive (RV)
A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major (larger) axis. See "Cyclo Drive" and "Harmonic Drive".

Rotational Motion
A joint which twists, swings or bends about an axis. An example of this is the elbow of a human arm.

Safeguard
A barrier guard, device or safety procedure designed for the protection of personnel. (R15.06)

Safety Integrity Level
Safety Integrity Level (SIL) is IEC’s method for determining the performance level of a safety system. SIL 2 corresponds to ISO Performance Level “d”, and SIL 3 corresponds to ISO Performance Level “e”. ISO 10218 allows for the use of either.

Safety Logic Circuit
The safety logic circuit monitors safety critical external devices such as the light curtains and FSU generated signals. The safety logic circuit is programmed via an intuitive user interface that is supported on the YASKAWA programming pendant. It enables to set up the logical operations, such as stopping the manipulator or outputting a signal if the servos are on.
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Safety Monitored Stop
Collaborative feature designed to allow safe human-robot interaction. Only when robot motion ceases can the human safety enter the collaborative workspace. Servos can remain energized in accordance with a category 2 stop in accordance with ISO 10218-1:2011, 5.4. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.

SCARA Robot
A cylindrical robot, having two parallel rotary joints (horizontally articulated) and provides compliance in one selected plane. (ISO 8373)

Second Home Position
Apart from the "home position" of the manipulator, the second home position can be set up as a check point for absolute data. The initial value of the second home position is the home position (where all axes are at pulse 0). The second home position can be changed.

Security Mode
Levels of operator modes on YASKAWA robot controllers, include: Operation Mode, Edit Mode, Management Mode, Safety Mode and One Time Management mode.

Sensor
Instruments used as input devices for robots, which enable it to determine aspects regarding the robot's environment, as well as the robot's own positioning. Sensors respond to physical stimuli (such as heat, light, sound, pressure, magnetism and motion), and they transmit the resulting signal or data for providing a measurement, operating a control or both. (R15.06)

Sensory Feedback
Variable data measured by sensors and relayed to the controller in a Closed-loop System. If the controller receives feedback that lies outside an acceptable range, then an error has occurred. The controller sends an error signal to the robot. The robot makes the necessary adjustments in accordance with the error signal.

Servo Control
The process by which the control system of the robot checks if the attained pose of the robot corresponds to the pose specified by the motion planning with required performance and safety criteria. (ISO 8373)

Servo Motor
An electrical power mechanism used to effect motion or maintains position of the robot (for example, a motor which converts electrical energy to effect motion of the robot) (R15.07). The motor responds to a signal received from the control system and often incorporates an encoder to provide feedback to the control loop.
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**Servo Pack**
An alternating, current electrical power mechanism that is controlled through logic to convert electrical supply power that is in a sine wave form to a Pulse Width Modulated (PWM) square form, delivered to the motors for motor control: speed, direction, acceleration, deceleration and braking control.

**Servo-controlled Robot**
The control of a robot through the use of a Closed-loop Servo-system, in which the position of the robot axis is measured by feedback devices and is stored in the controller's memory. See "Closed-loop" and "Servo-system".

**Servo-system**
A system in which the controller issues commands to the motors, the motors drive the arm, and an encoder sensor measures the motor rotary motions and signals the amount of the motion back to the controller. This process is continued many times per second until the arm is repositioned to the point requested. See "Servo-controlled Robot".

**Shipping Brackets**
A collection of parts used as a back-up safety assembly to the motor brake. Locks the robot in place during transport.

**Shipping Skid**
A custom-made platform used to ship the manipulator and the controller. It is included with the shipping assembly. It can be returned to YASKAWA for a rebate.

**Shock Detection Function**
Shock detection is a function supported by the YASKAWA robot controller that reduces the impact of a robot collision by stopping the manipulator without any external sensor when the tool or the manipulator collide with a peripheral device.

**Shoulder**
The first or second axis of a robot is sometimes referred to as a shoulder axis as it somewhat resembles a human shoulder. This is often used in describing humanoid or dual-arm systems such as the YASKAWA Motoman® SDA10D.

**SIL**
See "Safety Integrity Level".

**Simulation**
A graphical computer program that represents the robot and its environment, which emulates the robot's behavior during a simulated run of the robot. This is used to determine a robot's behavior in certain situations, before actually commanding the robot to perform such tasks. Simulation items to consider are: the 3D modeling of the environment, kinematics emulation, path-planning emulation and simulation of sensors. See "Sensor", "Forward Kinematics" and "Robot".
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Singularity
A configuration where two joints of the robot arm become co-axial (aligned along a common axis). In a singular configuration, smooth path following is normally impossible and the robot may lose control. The term originates from the behavior of the Jacobian matrix, which becomes singular (i.e., has no inverse) in these configurations.

Smart Pendant
A Programming Pendant that readily adapts to the user’s style for easy operation. Its patented, built-in Smart Frame technology determines the user’s orientation relative to the robot. This eliminates the use of conventional coordinate (X,Y,Z) frames and utilizes human coordinate references for easy command of robot movement.

SLURBT
SLURBT are terms that YASKAWA Motoman uses to describe each axis of the robot for convenience. The definition of each value is as follows:
S – Swing or Swivel
L – Lower Arm
U – Upper Arm
R – Rotate
B – Bend
T – Twist

Softlimit Setting Function
The Softlimit Setting Function is a function to set the axis travel limit range of the manipulator motion in software.

Soft Pendant
Is software, that is a digital version of the Programming Pendant that can be run on a Windows operating system. See Programming Pendant for more details.

Speed and Separation Monitoring
Collaborative feature that allows both the operator and robot to work in proximity to one another by ensuring the robot will slow down and stop before a contact situation occurs. In order for this feature to be safely implemented, functional safety and additional detection hardware must be used. A risk assessment shall be used to determine if any additional safeguarding is necessary to mitigate risks within the robot system.

Spline
A smooth, continuous function used to approximate a set of functions that are uniquely defined on a set of sub-intervals. The approximating function and the set of functions being approximated intersect at a sufficient number of points to insure a high degree of accuracy in the approximation. The purpose for the smooth function is to allow a robot manipulator to complete a task without jerky motion.

Spline Motion Type
A calculated path that the robot executes which may be parabolic in shape. A spline motion may also accomplish a free form curve with mixtures of circular and parabolic shapes.

System Integrator
See “Integrator”.
Teach
To program a manipulator arm by manually guiding it through a series of motions and recording the position in the robot controller memory for playback.

Teach Lock
While the Teach Lock is set, the mode of operation is tied to the Teach Mode and the machines cannot be played back using either [START] or external input. For safety purposes, always set the mode switch to "TEACH" before beginning to teach.

Teach Mode
A robot controller mode in which a robot manipulator is programmed by manually guiding it through a series of motions and recording the position in the robot controller memory for playback. Industrial robots that do not have an active Power and Force Limiting Function require the use of a Three Position Enabling Device in Teach Mode.

Teach Pendant
See "Programming Pendant"

Teaching Window
Teaching Window is a user interface screen on the programming pendant. This window contains the JOB CONTENT window and teaching is conducted within this window. The JOB CONTENT window contains the following items: line numbers, cursor, instructions, additional items, comments, etc.

Through-beam
An object detection system used within a robot's imaging sensor system. A finely focused beam of light is mounted at one end and a detector at the other. When the beam of light is broken, an object is sensed.

Time Measuring Function
Time measuring function measures the execution time for the specified section in the job or the signal output time of the specified signal.

Tool
A term used loosely to define a working apparatus mounted to the end of the robot arm, such as a hand, gripper, welding torch, screw driver, etc. See "Arm", "Gripper" and "End-effector".

Tool & Arm Interference
In a system with one controller and multiple manipulators, the Tool & Arm Interference Check Function can be used to detect possible interference to avoid collision during operation. The following three patterns can be checked:
- Arm against arm
- Arm against tool
- Tool against tool
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**Tool Against Tool**
Interference is checked by using a cylinder that is slightly larger than the arm or tool. A sphere is placed on both ends of the cylinder. If the cylinder and spheres of one manipulator have any contact with those of the other while moving, the manipulators stop because interference was detected.

**Tool Center Point (TCP)**
The Tool Center Point (TCP) defines the tip of the current tool as defined relative to the tool flange. For example, for a welding robot, the TCP will generally be defined at the tip of the welding gun. After defining and configuring the TCP, the robot motion will be defined relative to this frame (i.e., rotation in the Rx direction would cause rotation around the X-axis and positions will be taught in this frame).

**Tool Control Point**
See "Tool Center Point (TCP)"

**Tool Coordinates**
When the tool attached to the robot moves, so does its tool coordinate system in reference to a fixed coordinate system, for example, world coordinates. In general, the tool coordinates do not align with the world XYZ coordinates.

**Tool Frame**
A coordinate system attached to the end-effector of a robot (relative to the base frame).

**Touch Sensor**
Sensing device, sometimes used with the robot's hand or gripper, which senses physical contact with an object, thus giving the robot an artificial sense of touch. The sensors respond to contact forces that arise between themselves and solid objects.

**Trajectory Generation (Calculation)**
The computation of motion functions that allow the movement of joints in a smooth controlled manner.

**Transducer**
A device that converts energy from one form to another. Generally, a device that converts an input signal into an output signal of a different form. It can also be thought of as a device which converts static signals detected in the environment (such as pressure) into an electrical signal that is sent to a robot's control system.

**U**

**Uptime**
A period of time in which a robot or production line is operating or available to operate, as opposed to downtime.

**User Coordinate Setting**
User coordinates are defined by three points that have been taught to the manipulator through axis operations. These three defining points are ORG, XX, and XY, as shown in the diagram below. These three points of positional data are registered in a user coordinate file. ORG is the home position, and XX is a point on the X-axis. XY is a point on the Y-axis side of the user coordinates that has been taught, and the directions of Y- and Z-axes are determined by point XY.
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**User Coordinate System**
The User Coordinate System is any reference point that a user has defined for their application. This is often attached to an object such as a pallet and allows a user to teach points relative to this object. For example, a set of position could be taught relative to a User Coordinate System attached to a pallet and then easily transferred to a different User Coordinate System on another pallet. This allows for positions to be reused efficiently. See also, “User Coordinate Setting”

**Vacuum Cup Hand**
An end-effector for a robot arm which is used to grasp light to moderate weight objects, using suction, for manipulation. Such objects may include glass, plastic; etc. Commonly used because of its virtues of reduced object slide slipping while within the grasp of the vacuum cup. See “End-effector”.

**Vision Guided**
Control system where the trajectory of the robot is altered in response to input from a vision system.

**Vision Sensor**
A sensor that identifies the shape, location, orientation, or dimensions of an object through visual feedback, such as a television camera.

**Warning**
Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury. Hazards identified by the signal word WARNING present a lesser degree of risk of injury or death than those identified by the signal word DANGER.

**Work Envelope**
The set of all points which a manipulator can reach without intrusion. Sometimes the shape of the work space, and the position of the manipulator itself can restrict the work envelope.

**Work Envelope (Space)**
The volume of space within which the robot can perform given tasks.

**Work Home Position**
The Work Home Position is a reference point for manipulator operations. It prevents interference with peripheral device by ensuring that the manipulator is always within a set range as a precondition for operations such as starting the line. The manipulator can be moved to the set Work Home Position by operation from the programming pendant, or by signal input from an external device. When the manipulator is in the vicinity of the Work Home Position, the Work Home Position signal turns ON.

**Work Piece**
Any part which is being worked, refined or manufactured prior to its becoming a finished product.

**Workspace**
The volume of space within which the robot can perform given tasks.
World Coordinates
A reference coordinate system in which the manipulator arm moves in linear motions along a set of Cartesian or rectangular axes in X, Y, and Z directions. The shape of the work envelope forms a rectangular figure. See "Rectangular-Coordinate Robot".

World Model
A three dimensional representation of the robot's work environment, including objects and their position and orientation in this environment, which is stored in robot memory. As objects are sensed within the environment the robot's controller system continually updates the World Model. Robots use this World Model to aid in determining its actions in order to complete given tasks.

Wrist
A set of rotary joints between the arm and the robot end-effector that allow the end-effector to be oriented to the work-piece. In most cases the wrist can have degrees of freedom which enable it to grasp an object with roll, pitch, and yaw orientation. See "Arm", "End-effector", "Roll", "Pitch", "Yaw" and "Work Piece".

Wrist [Secondary Axis]
An interconnected set of links and powered joints between the arm and end-effector, which supports, positions and orientates the end effector. (ISO 8373)

X

Y

Yaw
Rotation of the end-effector in a horizontal plane around the end of the manipulator arm. Side to side motion at an axis. See "Roll" and "Pitch".

Z

Zeroing Kit
Hardware and sensor mounted to robot. Automatically restores the home position data for the robot.