adept mobilerobots

pioneer lx

User's Guide

Rev. A
November, 2013

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Chapter 1: Introduction

This manual covers the setup, operation, and user maintenance of your Adept MobileRobots Pioneer LX mobile robot.

1.1 Product Description

The Adept MobileRobots Pioneer LX is a general-purpose, indoor mobile robot platform, designed and sized to carry loads up to 60 kg (132 lb) while working around people. With the included ARNL software, it is self-guided and self-charging, with an automated charging station. The platform's size and drive assembly are designed to work in any wheelchair-accessible environment.

The Pioneer LX includes a complete robot control system and embedded computer (PC), differential drive system with encoder feedback, as well as a laser rangefinder sensor, ultrasonic (sonar) sensors, and a bumper panel.

ARNL software provides the capability to know where the robot is located within an indoor workspace (localization), and to navigate safely and autonomously to any accessible destination within that workspace (navigation), continuously and without human intervention.

A complete C++ SDK is provided to develop software using the Pioneer LX.

The Pioneer LX provides a variety of interfaces and power connections to support your application-specific sensors and accessories. Refer to Connectivity on page 61, for information on the available connectors..

For some projects, you may want to customize the Pioneer LX with a payload, attached to the top of the platform, such as sensors, manipulators, extra structure. Refer to Payloads on page 53 for general information on designing a payload.

MTX Generation and Pioneer Compatibility

The Pioneer LX is the first in a new generation of robots from Adept MobileRobots, the MTX type robots.

In most ways, the Pioneer LX remains compatible with Pioneer 3 and other Adept MobileRobots platforms: it uses a compatible protocol for essential communication with software, and the Pioneer SDK including ARIA C++ API remains compatible with all MobileRobots platforms, including Pioneer LX. (Support for the Pioneer LX was added in ARIA 2.8.0 and ARNL 1.8.0.)

The Pioneer LX does differ from previous Pioneer robots in a few ways, however, including:

- The robot controller uses a new firmware implementation, MARCOS
- Some components are connected directly to the embedded computer, rather than managed via the robot controller (sonar, display, battery information). However, ARIA's ArRobotConnector class will automatically connect to these components by default, and continue to provide data via the ArRobot class, so all software using ARIA and ArRobotConnector will continue to work with the LX.

- Some Pioneer commands are not implemented on the Pioneer LX, such as:
  - ENCODER command and Encoder packets
  - GYRO calibration commands
  - PID commands (ROTK... and TRANSK...)
  - General purpose digital and analog IO is done via embedded computer operating system and ArMTXIO class, not through robot connection or IO packets.

Body, Drive and Control

The Adept Pioneer LX is medium-sized, lightweight, and highly maneuverable. It has a strong aluminum chassis and solid construction that makes it very durable. It is insulated against water splashes and dust, with an IP rating of IP-40.

The Pioneer LX platform is a two-wheel, differential-drive vehicle, with spring-loaded passive casters in front and rear, and independent drive-wheel spring-suspension for balance. Its solid, foam-filled wheels are at the mid-line of the platform, so that it can turn in place with zero turn radius.

The Pioneer LX has two degrees of freedom, and is controlled from software by requesting translational velocity (forwards/backwards), and a separate, simultaneous rotational velocity (clockwise/counterclockwise). The robot's controller will automatically control the robot's drive system to achieve those requested velocities (using requested acceleration and deceleration parameters).

The Pioneer LX controller uses encoders to automatically integrate wheel odometry, accurately maintain requested velocity, and, combined with data from an internal gyroscopic sensor, computes an estimated pose of the robot: a point (X, Y) in a cartesian coordinate system, plus an orientation θ. This pose estimate is provided to software along with other robot state information every 100ms (10hz).

For more information about robot programming and communication, see See **Programming** on page 49.

What's Included - Basic Components

- One fully-assembled Pioneer LX, including:
  - laser rangefinder,
  - front bumper panel
  - front- and rear-facing sonar sensors
  - MTX-Lynx Core, a module containing robot controller and power management, and a user-accessible computer (Intel PC) with either Linux or Windows and all software preinstalled and ready to use.
  - Removable plastic skins
  - Top plate with operator panel, controls and connectors
  - Equipment mounting deck
- One fully-charged battery

  This is shipped separately from the platform, due to air shipping regulations.
- Automated charging station (docking station)

Allows the platform to charge itself, without user intervention. This includes a wall-mount bracket and a floor plate, for a choice of installation methods. See Installing the Charging Station on page 24.

A manual charging cord is included, so you can charge the battery or a spare battery outside of the platform.

- Joystick

  Used for manually controlling the platform, mostly when making a scan to be used for generating a map.

- Pioneer SDK including ARIA open source C++ API, and ARNL Laser Navigation Libraries and example servers.

- Documentation

Optional Accessories, Parts, Components and Attachments (partial list)

Contact sales@mobilerobots.com for more information on purchasing any of the following accessories or parts. Check http://www.mobilerobots.com or contact sales for updates on any new accessories now available.

- Pan/Tilt/Zoom digital ethernet camera
- Spare batteries
- Extra mounting deck, top plate, body skins, other parts.
- Extra docking station(s)
- More

User-Supplied Components / System Requirements

PC with Microsoft Windows® or Linux

- Ethernet (wireless preferred)
- 100 megabytes of available hard-disk storage
- Power outlet for docking station (115VAC or 220VAC)

Software Overview

The Pioneer LX comes with the following software preinstalled and ready to use.

Software packages are also provided on the included CDROM, and may be downloaded from http://robots.mobilerobots.com.

See **Programming** on page 49 for more information on writing software.

MARCOS Controller Firmware

A microcontroller running MARCOS firmware handles the details of mobility, including maintaining the platform's drive speed and heading, as well as acquiring data from the encoders and gyroscope, and managing the platform's emergency stop systems, bumper, and joystick. The MARCOS firmware computes and reports an estimate of the platform's pose (X, Y, θ), as well as other aspects of robot status.

MobileRobots may provide MARCOS updates in the future to fix problems or add features.

Computer Operating System

The embedded computer is provided with either Ubuntu Linux or Windows 7 preinstalled. The operating system selected when ordered has been preinstalled along with all other software included, and a selection of useful system and software development tools. Other operating systems may be used on the embedded computer but are not specifically supported by MobileRobots.

ARIA

ARIA is the core development library or SDK for use with the robot. It is an open source C++ library (with interfaces also available for Python, Java and Matlab).

ARIA is available with all robots.

On Linux ARIA can be found at /usr/local/Aria, and on Windows at C:\Program Files\MobileRobots\Aria and in the Start Menu. ARIA includes full API reference documentation in

its doc subdirectory, as well as example programs in the examples directory, and full source code distributed as free software under the terms of the GNU General Public License. ARIA libraries can be compiled and used with standard C++ development tools: GNU C++ compiler (G++) on Linux and Microsoft Visual C++ on Windows.

ARIA updates and additional information are available for download at http://robots.mobilerobots.com/wiki/ARIA.

ARNL Laser Navigation and Localization Libraries

ARNL is a development library or SDK for including accurate indoor laser localization and flexible, reliable autonomous navigation capabilities in your software.

ARNL can be found installed on Linux at /usr/local/Arnl, and on Windows at C:\Program Files\MobileRobots\ARNL. The ARNL installation includes the localization and navigation libraries, as well as compatible ARIA libraries. It includes a full API reference manual in the doc subdirectory, as well as example programs in the examples directory.ARNL

ARNL includes arnlServer, an ArNetworking server program which can be used with MobileEyes or custom client software to interactively send the robot to autonomously navigate to goal points.

Refer to ARNL's README.txt, API reference manual, and the guide **Getting Started with ARNL Laser Navigation** for more information.

ARNL updates and additional information are available for download at http://robots.mobilerobots.com/wiki/ARNL.

Mapper3

Mapper3 is an application used for converting and editing maps for use with ARNL, MOGS and MobileSim.

Mapper3 is available for download at http://robots.mobilerobots.com/wiki/Mapper3.

MobileSim

MobileSim is the MobileRobots simulator. If you run MobileSim first, ARIA will automatically connect to MobileSim instead of the real robot. This allows software to be tested with the simulator on any computer before using the real robot, without recompilation or any changes.

MobileSim is available for download at http://robots.mobilerobots.com/wiki/MobileSim.

MobileEyes

MobileEyes is a graphical application for remote visualization, teleoperation, and software configuration. It communicates with onboard robot software via the wireless network and the ArNetworking system (included with ARIA), and can run on any PC or laptop.

MobileEyes is used as the user interface to arnlServer, provided with ARNL. Use MobileEyes to view the status of the robot, send it to goals, teleoperate the robot, modify ARNL and robot configuration parameters, and send custom commands.

MobileEyes is available for download at http://robots.mobilerobots.com/wiki/MobileEyes.

ArVideo

ArVideo is a library for acquisition of images from cameras, and optional ArNetworking server components that provide images to MobileEyes or other ArNetworking client software.

ArVideo is available at http://robots.mobilerobots.com/wiki/ArVideo.

Software for Accessory Devices

Additional development libraries for use with some accessory devices and options are provided by MobileRobots or the original manufacturer of the device. These libraries can be downloaded from http://robots.mobilerobots.com/wiki/Software. All other accessory devices are supported in ARIA.

1.2 Operating Environment

The Pioneer LX is designed to operate in an environment that is wheelchair accessible. Care must be taken to avoid:

- glass doors and walls
- pits without railings or low bumpers
- floors with access panels removed
- loose cables, hoses, etc.
- large, highly-reflective objects

Floors must provide good traction, typical of good walking conditions.

- Slope up to 1:12
- Step traversal up to 15 mm (0.6 in.)
- Gap traversal up to 15 mm (0.6 in.)
- Temperature 5° to 40° C (41° to 104° F)
- Humidity 5 to 95%, non-condensing

The Pioneer LX is not intended for use in hazardous environments (explosive gas, water, dust, oil mist). It has an IP rating of IP-40.

1.3 Dangers, Warnings, Cautions, and Notes

There are six levels of special alert notation used in Adept manuals. In descending order of importance, they are:

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

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

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

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

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

NOTE: Notes provide supplementary information, emphasize a point or procedure, or give a tip for easier operation.

1.4 Safety Precautions

Read all installation and operation instructions before using the equipment.

- Do not ride on the Pioneer LX.
- Do not exceed the maximum weight limit.
- Limit operation to a 1:12 slope.
- Do not drop the platform, run it off a ledge, or otherwise operate it in an irresponsible manner.
- Do not get the platform wet. Do not expose the platform to rain or moisture.
- Do not use power extension cords with the charging station unless properly rated.
- Do not continue to run the platform after hair, yarn, string, or any other items have become wound around the platform's axles or wheels.
- Never access the interior of the platform with the charger attached.
  Immediately disconnect the battery after opening the battery compartment door.
- Do not use parts not authorized by Adept.
- Do not use any charger not supplied by Adept.

1.5 What to Do in an Emergency

Press the E-Stop button (a red push-button on a yellow background/field) and then follow the internal procedures of your company or organization for an emergency situation. If a fire occurs, use a type D extinguisher: foam, dry chemical, or CO_2.

1.6 Additional Safety and Standards Information

Adept provides other sources for more safety information:

Adept Robot Safety Guide

The *Adept Robot Safety Guide* provides detailed information on safety for Adept robots. It also gives resources for more information on relevant standards. The Adept Robot Safety Guide is also available from the Adept Download Center at http://www.adept.com/support/downloads/file-search

1.7 Help, Documentation and Support

Adept MobileRobots provides a customer support website at **http://robots.mobilerobots.com**. This website provides downloads of all manuals, software and device drivers, a searchable knowledge base of information, tips, links to more information and resources on the web, and answers to frequently asked questions.

For public questions and discussions on use of ARIA and other MobileRobots-provided software with users of MobileRobots platforms, MobileRobots provides the aria-users mailing list. See **http://robots.mobilerobots.com/wiki/aria-users** for archives of past discussions and instructions on joining the mailing list.

For public questions and discussions on robot hardware and general robotics topics with other users of MobileRobots platforms, MobileRobots provides the pioneer-users mailing list. See **http://robots.mobilerobots.com/wiki/pioneer-users** for archives of past discussions and instructions on joining the mailing list.

To contact MobileRobots' customer support specialists regarding any questions not answered in this documentation, or to troubleshoot problems with your robot, visit **http://-/robots.mobilerobots.com/wiki/Contact_Support**, or email **support@mobilerobots.com** describing your problem. Include your robot's serial number and a detailed description of your problem or question.

The robot's serial number can be found on a label on the battery door at the rear of the robot. Remove the rear plastic body skin panel to access the battery door.

> **Note**: Do not contact Adept industrial products service, support, or applications support for help with the Pioneer LX, always contact MobileRobots support at **mobilerobots.com** first.

Factory Repairs

If after reading this manual, you are having hardware problems with your Adept MobileRobots system and are sure that it needs repir, contact us at:

support@mobilerobots.com

In the body of your e-mail message, provide your robot's serial number and describe the problem you are having in as much detail as possible.

We will try to resolve the problem through communication. If the robot must be returned to the factory for repair, obtain a Repair Authorization Code and shipping instructions from us first.

Chapter 2: Setup

This chapter describes unpacking and assembling the Pioneer LX.

Optional accessories ordered with the robot may require additional assembly and configuration. Refer to additional documentation provided for instructions.

2.1 Transport and Storage

Platform

The Pioneer LX must be shipped and stored in a temperature-controlled environment, between 5° and 70° C (41° to 158° F). The recommended humidity range is 5 to 95%, non-condensing. It should be shipped and stored in the Adept-supplied shipping container, which is designed to prevent damage from normal shock and vibration. You should protect the container from excessive shock and vibration.

Use a forklift, pallet jack, or similar device to transport and store the shipping crate.

The platform must always be stored and shipped in an upright position in a clean, dry area that is free from condensation. Do not lay the crate on its side or any other non-upright position. This could damage the platform.

The crate with pallet for the platform measures 1219 x 711 x 762 mm (48 x 28 x 30 in.), and weighs 95 kg (210 lb).

Battery Storage

NOTE: If you purchased spare batteries, this section applies to them, also.

The battery is shipped in a separate container, not inside the Pioneer LX. Its crate with pallet measures 457 x 279 x 406 mm (18 x 11 x 16 in.), and weighs 27 kg (60 lb).

Store the battery at temperatures between 5° and 70° C (41° to 158° F).

The battery should start storage fully-charged. If the battery will be stored for an extended period, it should be recharged periodically to avoid total discharge, which will damage the battery. Recharging a battery every six months is sufficient to keep it charged enough to avoid damage.

2.2 Before Unpacking the Platform

Carefully inspect all shipping containers for evidence of damage during transit. If any damage is indicated, request that the carrier's agent be present at the time the container is unpacked.

2.3 Unpacking

Before signing the carrier's delivery sheet, compare the actual items received (not just the packing slip) with your equipment purchase order. Verify that all items are present and that the shipment is correct and free of visible damage.

- If the items received do not match the packing slip, or are damaged, do not sign the receipt.
- If the items received do not match your order, please contact Adept immediately.

Retain the crates and packaging materials. These items may be necessary to settle claims or, at a later date, to relocate the equipment.

The Pioneer LX comes packed in a wooden crate, lined with foam. It is mounted on a pallet, with a wooden cover. See the following two figures.

The charging station, joystick, and platform are shipped in the same crate. The joystick is in the smaller compartment on the near side in the previous figure.

The battery is shipped in a separate crate.

Additional optional accessories including cameras, arms, etc. are shipped in a separate box.

Unpacking the Pioneer LX:

1. Remove the lag screws that attach the crate cover to the pallet.
2. Lift off the crate cover to reveal the crate, pallet, and contents.
3. Remove the two wing nuts and washers holding the back panel of the crate to the crate.

   Retain the two wing nuts and washers for reassembly.
4. Remove the back panel of the crate.

   Retain the back panel.
5. Remove the charging station.
6. Remove the tie-downs (not shown here) that hold the platform in place.

Figure 2-1. Side View of Charging Station, Platform, and Joystick in Crate

Figure 2-2. Pioneer LX in Shipping Crate, on Pallet, with Crate Cover

Lifting the Platform

CAUTION: You can damage the platform if you lift it incorrectly.

- Use two people to lift the platform out of its crate.
- Lift ONLY at the points shown.

Front Lifting Points

Lift on each side of the laser, under the upper side of the laser slot.

Do not lift at the center, where the laser is located. There is no frame support there.

Lift the metal frame behind the plastic body panels, not the plastic body panel.

Do not lift anywhere else! Refer to the following figure:

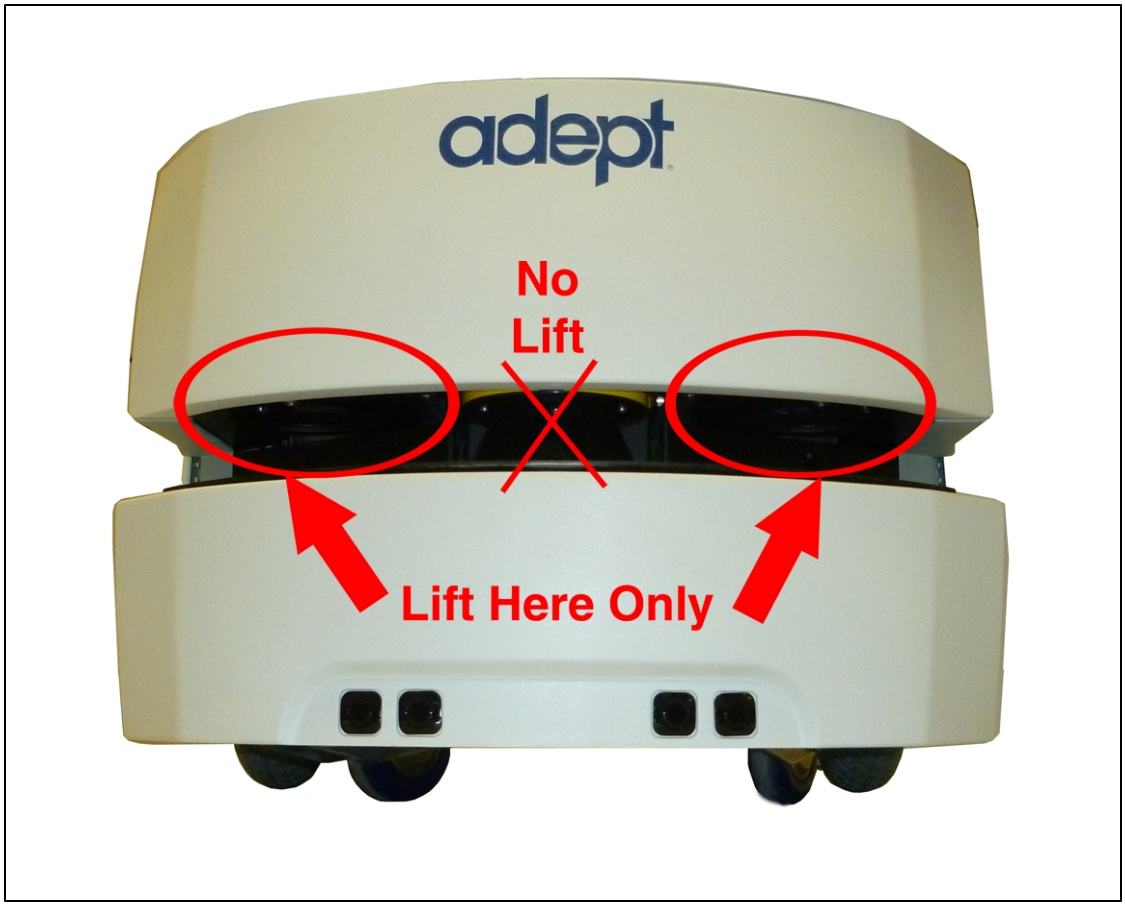


Figure 2-3. Upper Side of Laser Slot, at Sides, NOT at Center

Rear Lifting Points

Lift near the center of the platform, where the cover has a raised section.

Do not lift anywhere else.

Lift the metal frame behind the plastic body panels, not the plastic body panel.

Refer to the following figure:

Figure 2-4. Bottom of Inner Rear Cover. Lift from the Frame, not the Cover.

The following split photo shows a platform being lifted out of its crate:

1. Lift the platform out of the crate.
2. Re-install the crate back panel, using the two wing nuts and washers.

2.4 Repacking for Relocation

If the platform or other equipment needs to be relocated, reverse the steps in the installation procedures in this chapter. Reuse the original packing crate and materials and follow all safety notes used for installation. Improper packaging for shipment will void your warranty.

The platform must always be shipped in an upright orientation.

2.5 Installing a Pioneer LX System

Installing the Battery

Your Adept Pioneer LX comes fully-assembled, but with battery packed separatey. The battery is fully-charged before shipping.

> **NOTE**: Air shipping regulations require that the platform be shipped without the battery installed.

Refer to Removing and Installing Covers in the Maintenance section for cover removal and installation.

1. Remove the inner rear platform cover.
2. Unlatch and open the battery compartment door, at the back of the platform.

   The battery compartment door is capable of being locked. You may need to unlock it.

Figure 2-5. Battery Compartment Door (keys are zip-tied for shipping)

3. Lift and slide the new battery into the platform body.

   The battery weighs 20 kg (44 lbs).

   There are recesses at the front and the back of the battery, to aid in lifting it.

Figure 2-6. Battery Recesses, for Gripping

The battery is designed to be lifted and replaced by one person, using one hand in each of the grips, as shown in the following figure.

Figure 2-7. Lifting the Battery

The connectors for power and data go toward the rear of the platform.

4. Attach the battery power and data cables to the connectors at the rear of the battery.
5. Close the battery compartment door to secure the battery in place.

The battery compartment is designed to hold the battery tightly, so that it will not move within the compartment, once the door is closed.

6. Reinstall the inner rear platform cover.

Attaching Optional Accessories

You may need to attach any accessories that were shipped separately or detached for safety. Refer to supplemental documentation for information on attaching those accessories.

Installing the Charging Station

The automated charging station (dock) can be used for either manual or automated charging of your platform's battery.

The charging station sits on the floor. It can be attached to a wall with the wall bracket, attached directly to the floor with screws through its base, or can sit stand-alone on the floor with the floor plate, all of which will keep the charging station from moving when the platform docks. Both the wall bracket and floor plate are included with each charging station.

CAUTION: It is very important that the charging station be mounted with one of these methods, or the platform will simply move the charging station when it tries to dock, rather than docking successfully.

For all mounting methods:

- Locate the charging station near an AC outlet with 1 - 2 meters (3.25 - 6.5 ft) of clear space in front.
- The top of the charging station foot is spring-loaded, and lifts off of the bottom of the foot slightly to accommodate variations in the floor surface. The weight of the Pioneer LX will push the top of the foot down.

Requirements

- 100 to 240 VAC, 50 to 60 Hz, 8 A (source voltage automatically detected)
- Ambient operating temperature: 5° to 40° C (41° to 104° F)
- 5 to 95% humidity, non-condensing

Wall Bracket Mount

Attach the charging station mounting bracket to a wall, with the bottom edge of the bracket 98 ± 20 mm (3.8 ± 0.8 in.) above the floor, using user-supplied anchors and screws.

Refer to the following figure:

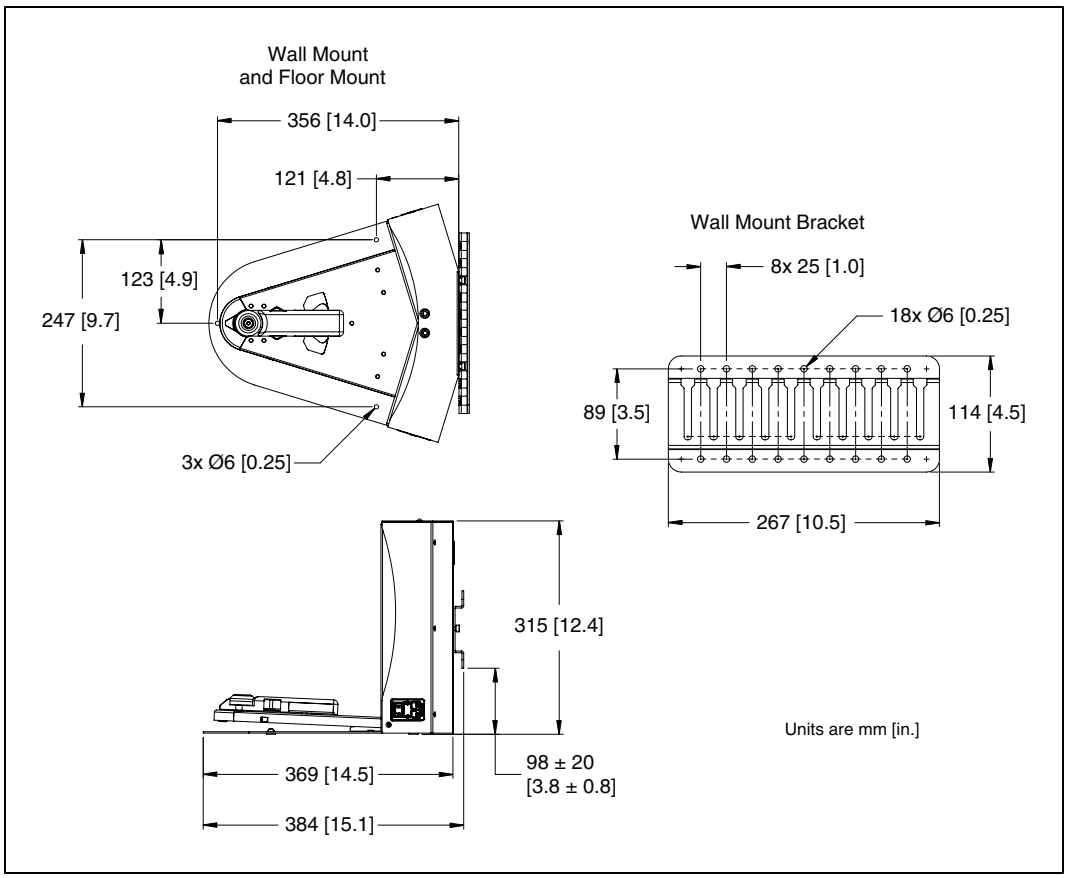


Figure 2-8. Charging Station, Wall Mount

2. Screw the two shoulder bolts, each with a washer, into the rear of the charging station. The shoulder bolts are M5 x 4, stainless steel. Their locations are shown in the following figure. Tighten to 9 N-m (80 in-lb).

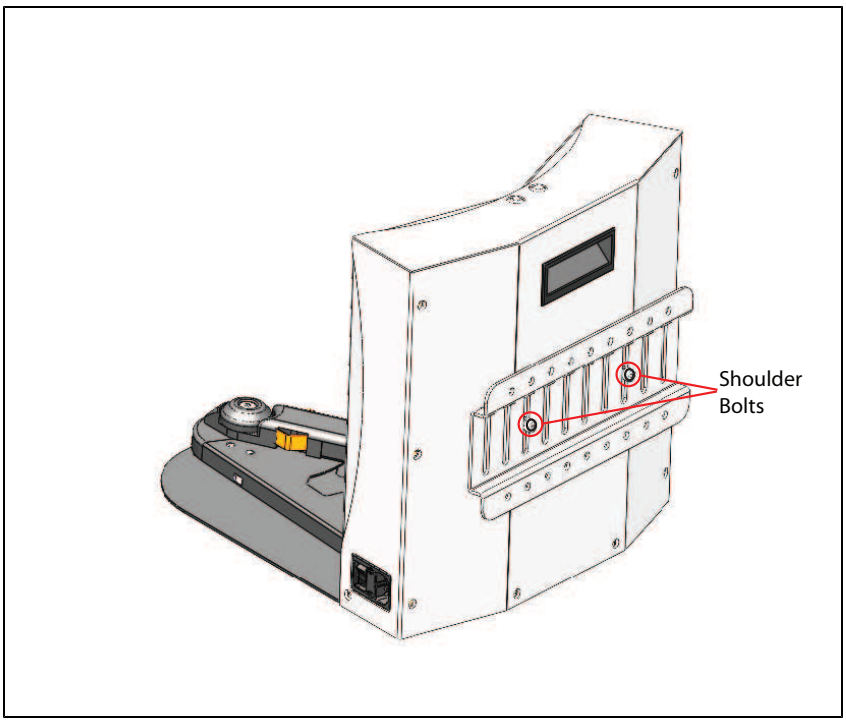


Figure 2-9. Rear View of Charging Station and Wall Bracket

3. Lower the charging station down, so the two bolts on the back of the charging station slide into the bracket, to secure the charging station to the wall.

Floor-mount, without Floor Plate

Screw the base of the charging station directly to the floor, using three user-supplied screws. For dimensions of the available holes in the base, refer to Figure 2-8. Adept recommends M5 self-tapping or M4 sheet rock screws for this.

Floor-mount, with Floor Plate

This mounting method uses the floor plate. The floor plate is not shipped attached to the charging station, so you must attach it for this type of mount. It will be in the crate with the platform, right behind the charging station.

Attaching the Floor Plate

Refer to the following figures.

1. Tip the charging station onto its back, so you can access the underside.
2. Remove the two lowest screws (M4 x 12 flat-head), if present.

   In the following figure, these screws are circled. The location of the third screw hole is also circled.
3. Attach the floor plate to the base of the charging station with three M4 x 12 flat-head stainless steel screws.

   The floor plate comes with three screws, so you will have two spares.

The charging station and floor plate do not need to be attached to the floor, as the weight of the robot on the floor plate will keep the charging station from moving.

Figure 2-10. Underside of Charging Station Foot, Showing Screw Locations

NOTE: These are the three locations for the M4 x 12 flat-head screws. Two are already in place, and need to be removed before attaching the plate.

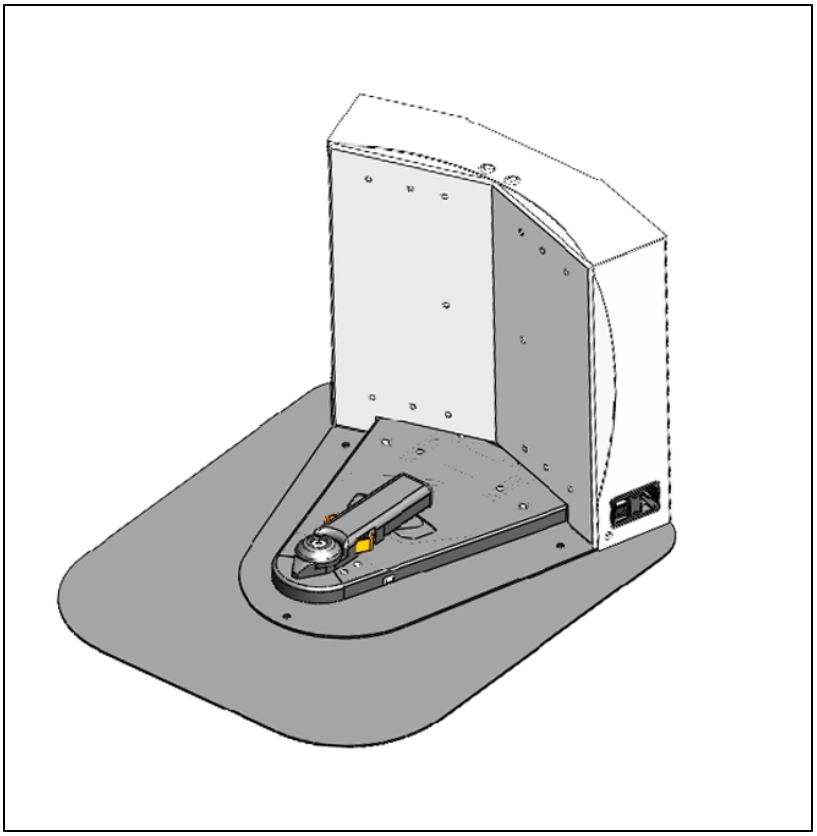


Figure 2-11. Charging Station, Mounted on Floor Plate

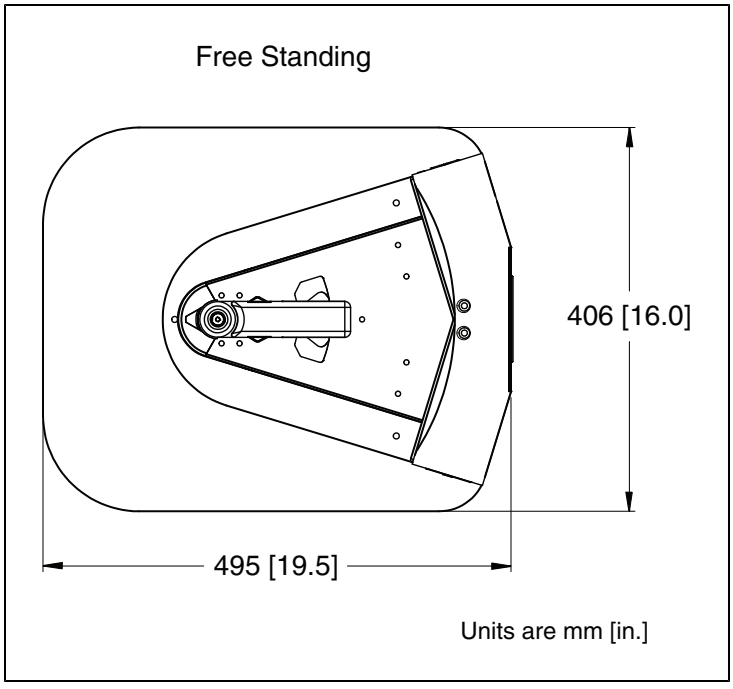


Figure 2-12. Charging Station Floor Plate Dimensions

All mounting methods

Install the power cord and turn the power switch to ON. The power switch is next to the power plug. The blue power LED indicator should light.

Charging Station Contact Adjustment

The contacts on the charging station have five height settings. The station is shipped with the height in the middle setting, which should be correct in most cases.

> **NOTE**: Squeeze and keep the platform foot against the bottom of the foot to make this adjustment easier.

Adjust the height of the contacts by using the pull-knob on the bottom of the dock. The height changes by 4 mm (0.15 in.) for each notch. See the following figure.

The height of the contacts should be set so that the roller is high enough to stay in contact with the platform as it is docking, but low enough so that the bi-level of the roller guides the paddle under the platform.

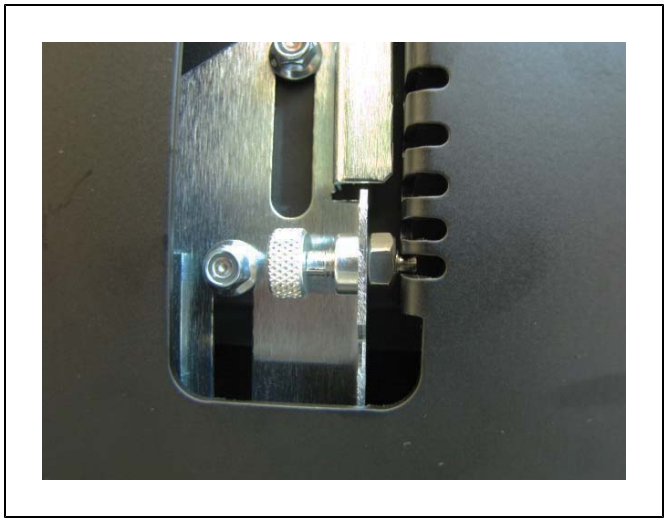


Figure 2-13. Charging Station Contact Adjusting Pull-Knob, Underneath bottom of station.

2.6 Embedded Computer Setup

Logging In

The embedded computer may be accessed by attaching keyboard, mouse and monitor, or by remote connection over the network.

If the onboard computer is running Linux, you can select text-only mode or GUI/graphical desktop mode on the console at boot.

If the onboard computer is running Linux, you can log in as **guest** (normal unprivileged user) or **root** (privileged administrative account).

The default password for the guest and root users on Linux, and the Administrator account on Windows, is **mobilerobots**.

We recommend changing these default passwords..

Passwords are changed in Linux using the **passwd** command.

New users can be added using the adduser command or the “Users and Groups” utility in the “Administration” section of the “System” menu.

Remote Access

If the onboard computer is running Linux, a remote login connection can be made using **ssh** (Secure Shell). Files may be copied using **sftp** (Secure FTP) or **scp** (Secure Copy). To establish an ssh connection from Windows to the onboard Linux computer, use the **Putty** application. To establish an ssh connection from Mac OSX to the onboard Linux computer, run **ssh** from the Terminal. To establish an sftp/scp connection from Windows to the onboard Linux computer, use the **WinSCP** application.

If the onboard computer is running Windows, a remote connection can be made using Remote Desktop.

Networking

The computer's network interfaces have been configured with the following default settings:

Wireless Network Interface (wlan0)	ESSID: "Wireless Network" Static Address Address: 10.0.126.32 Netmask: 255.255.255.0
External Ethernet Connection ("Maintainence LAN", eth1)	Static Address Address: 10.0.125.32 Netmask: 255.255.255.0
Internal Device/Accessory Ethernet Connection ("USER LAN", eth0)	Static Address Address: 192.168.0.32 Netmask: 255.255.255.0 This subnet matches the default configuration of Axis ethernet cameras, SICK LMS-100 laser rangefinders, and some other ethernet devices. When connecting ethernet device(s) or user-supplied computer(s) to this ethernet interface, configure its static IP settings to match this subnet, or reconfigure this interface on the Pioneer LX embedded computer to match your added device(s) or computer(s).

(See also http://robots.mobilerobots.com/wiki/Default_Network_Configuration)

You may need to change the settings of the wireless network interface and external ethernet connection to match your existing network. Consult with your institution IT department or network maintainer for details on specific settings required for your network.

Configuring Linux Network Settings

You may configure wireless and wired network settings by starting graphical/desktop mode (see above), opening the **System Settings** tool from the launcher panel, and opening **Network**.

See http://robots.mobilerobots.com/wiki/Linux_Network_Configuration for more information on configuring Linux network settings.

Configuring Windows Network Settings

To change network settings in Windows, open Contol Panel from the Start menu. Open the **Network** or **Network and Sharing Center** control panel, and choose **Change adapter settings**.

See http://robots.mobilerobots.com/wiki/Windows_Network_Configuration for more information on configuring Windows network settings.

Chapter 3: Software Demonstrations and Quick Start

This section will walk you through running some example programs from ARIA and MOGS.

You can run these examples either on the robot embedded computer, or, you can simulate the robot on your own laptop or desktop workstation, by first simply running the MobileSim simulator and selecting the pioneer-lx robot type (however, not all hardware features and devices are simulated.)

ARIA Demo

ARIA includes an example called demo. This is as simple text mode program that connects to the robot and other devices and displays information read from them. You may also drive (teleoperate) the robot using the keyboard, test movement of a pan/tilt camera, etc.

Onboard Computer Running Linux:

1. If using simulation, install MobileSim and ARIA from the CD or from http://robots.mobilerobots.com/wiki/Software. Run MobileSim and select the "pioneer-lx" robot type.
2. If using the actual robot, log in to the onboard computer using ssh, or log in at the console and start a terminal session. Log in as **guest** with password **mobilerobots**.
3. Change to the ARIA examples directory with the following command:

   ```
   cd /usr/local/Aria/examples
   ```

4. Run demo with the following command:

   ```
   ./demo
   ```

Onboard Computer Running Windows:

1. If using simulation, install MobileSim and ARIA from the CD or from http://robots.mobilerobots.com/wiki/Software. Run MobileSim and select the "pioneer-lx" robot type.
2. If using the actual robot, log in to the onboard computer using Remote Desktop, or log in at the console. Log in as **Administrator** with password **mobilerobots**.
3. Double click the ARIA Demo icon on the desktop to run ARIA Demo, or run it from the Start menu (All Programs -> MobileRobots -> ARIA -> demo).
4. Or, to run it from a command prompt:
   1. Open a command prompt (Start->All Programs->Accessories->Command Prompt)
   2. Change to the ARIA programs directory with the following command: cd "\Program Files\MobileRobots\ARIA\bin"
   3. Run demo with the following command: .\demo.exe

Demo will connect to the robot, displaying information about the connection and the robot such as Name and Subtype.

Demo starts in teleoperation/drive mode. Use the arrow keys or robot joystick to drive the robot. Use the space bar to stop.

Ensure there is adequate clearance (at least 5 meters) on all sides of the robot before driving. The robot can move fast!

The robot's E-Stop button must be released, and motors enabled (E key) before driving.

Use other keys on the keyboard to switch to different modes. Press ? for a list of modes. For example, laser mode (L key) connects to the laser and displays information read from it. Direct command mode (D key) lets you send individual commands directly to the robot controller (See See **Communication Packet Protocol** on page 113 for list of commands).

Press Control-C or Escape to exit.

ARNL Demo Server and MobileEyes

ARNL includes an example server which can be used with the MobileEyes remote graphical user interface to observe and control the robot. You can use the source code of the example server to integrate ARNL into your own software.

To use MobileEyes on your laptop or other computer, download and install MobileEyes from the CD or from http://robots.mobilerobots.com/wiki/MobileEyes.

Onboard Computer Running Linux:

1. If using simulation, install MobileSim and ARIA from the CD or http://robots.mobilerobots.com/wiki/Software. Run MobileSim and select the "pioneer-lx" robot type.
2. If using the robot, log in to the onboard computer using ssh, or log in at the console and start a terminal session. Log in as **guest** with password **mobilerobots**.
3. Change to the Arnl examples directory with the following command:

   ```
   cd /usr/local/Arnl/examples
   ```

4. Run arnlServer with the following command:

   ```
   ./arnlServer
   ```

Onboard Computer Running Windows:

1. If using simulation, install MobileSim and ARIA from the CD or from http://robots.mobilerobots.com/wiki/Software. Run MobileSim and select the "pioneer-lx" robot type.
2. If using the actual robot, log in to the onboard computer using Remote Desktop, or log in at the console. Log in as **Administrator** with password **mobilerobots**.
3. Double click the arnlServer icon on the desktop to run arnlServer, or run it from the Start menu (All Programs -> MobileRobots -> ARNL-> arnlServer).
4. Or, to run it from a command prompt:
   1. Open a command prompt (Start->All Programs->Accessories->Command Prompt)

2. Change to the ARNL programs directory with the following command: cd "\Program Files\MobileRobots\ARNL\bin"
3. Run demo with the following command: .\arnlServer.exe

The server will connect to the robot and other devices, displaying information about the connection and the robot such as Name and Subtype. When it finishes connecting to the robot, laser, and other configured devices, it will indicate that it has opened a server port for remote connections.

5. Next, run MobileEyes on your laptop.
6. For Robot Server, enter the address of the onboard computer, e.g. 10.0.125.32 (no user name or password are necessary, leave these fields empty) and click Connect.

MobileEyes will connect to the server. The robot is represented as a red oval. Readings from the laser rangefinder are represented by dots. Data about the robot (position, velocity, debugging information) are displayed in the Details windows, to open these enable Details and Custom Details in the View menu. Battery level and other indicators are shown in the status bar at the bottom of the MobileEyes window.

To navigate autonomously, the robot requires a map, and initialization of ARNL. Refer to the ARNL introduction for mapping instructions: http://robots.mobilerobots.com/docs/all_docs/ARNL-introduction.pdf

Quick reference instructions on creating maps for ARNL is available in the ARNL docs directory (Mapping.txt).

Once a map is loaded into arnlServer, use the Localize to Point button in MobileEyes to manually perform the initial localization. Once localized, ARNL is ready to navigate autonomously to goals and points.

Before ARNL is initialized, it is in a "Lost" state. When lost, you cannot drive the robot in Safe Drive Mode. To disable unsafe drive mode, click the Safe Drive button in the toolbar in MobileEyes. You can then use the drive controls in MobileEyes to drive the robot, however, no checking for collisions using the laser rangefinder is performed when in unsafe drive mode!

NO COLLISION DETECTION is performed using sensing when in Unsafe drive mode.

Ensure there is adequate clearance (at least 5 meters) on all sides of the robot before driving. The robot moves fast!

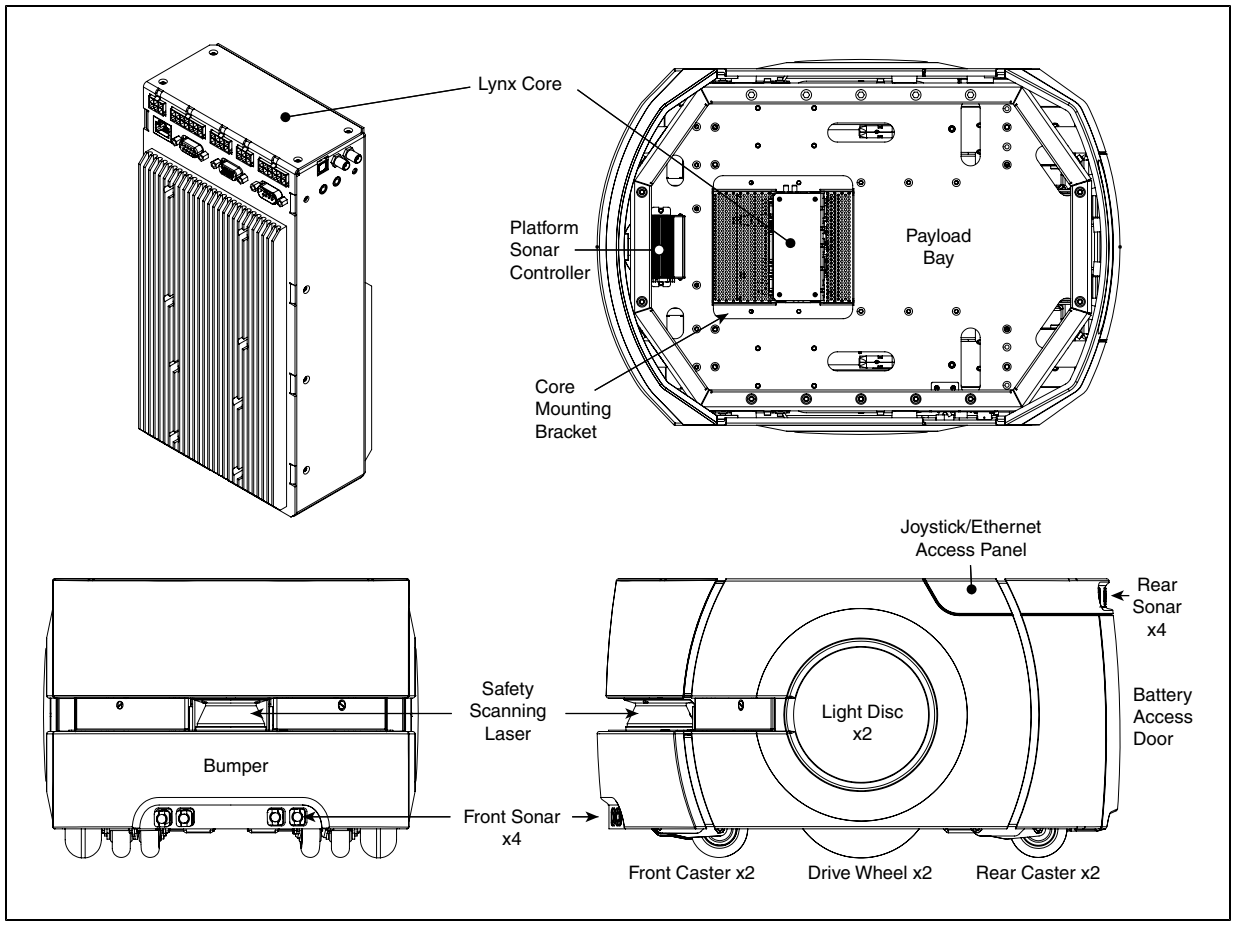
The robot's E-Stop button must be released and motors enabled before it can drive.

Press Control-C to exit from arnlServer.

Note, if the remote connection to the robot is closed, then arnlServer will automatically quit as well. For information about running arnlServer or other programs in the background, rather than attached to a remote connection terminal in Linux, see http://robots.mobilerobots.com/wiki/Running_A_Linux_Program_In_The_Background.

Chapter 4: Components and Operation

Note, before proceeding, you need to have performed the steps covered in the Setup and Getting Started chapters.



4.1 Operating Environment

The Pioneer LX is designed to operate in an environment that is wheelchair accessible. Care must be taken to avoid:

- glass doors and walls
- pits without railings or low bumpers
- floors with access panels removed
- loose cables, hoses, etc.
- large, highly-reflective objects

Floors must provide good traction, typical of good walking conditions.

- Slope up to 1:12
- Step traversal up to 15 mm (0.6 in.)
- Gap traversal up to 15 mm (0.6 in.)
- Temperature 5° to 40° C (41° to 104° F)
- Humidity 5 to 95%, non-condensing

The Pioneer LX is not intended for use in hazardous environments (explosive gas, water, dust, oil mist). It has an IP rating of IP-40.

4.2 Typical Operation

During normal startup, Pioneer LX powers on all its onboard systems, including its embedded computer.

The computer system may be optionally configured to run example or user-created software at startup (See http://robots.mobilerobots.com/wiki/Running_a_Program_at_Linux_Startup), otherwise you may log in remotely or by attaching keyboard, mouse and display.

See **Setup** on page 17 for more information on configuring the computer system.

See See **Programming** on page 49 for more information on writing software using the included Pioneer SDK and ARNL navigation libraries.

See See **Software Demonstrations and Quick Start** on page 33 and the separate guide **Getting Started with ARNL Laser Navigation** for information on running the ARNL laser navigation servers and using them for autonomous operation of the robot.

4.3 Startup and Shutdown

Press and hold the power ON button, then release. It takes about a minute for the robot and computer to start.

To turn the system off, press and hold the OFF button. It is recommended that you shut down the computer operating system first if possible. On Linux, use the Shutdown command in the system menu, or the `shutdown -h now` command as root. On Windows, use the **Shutdown** command in the Start menu.

To reboot the system (including onboard computer), power the system off using the OFF button, then start it using the ON button.

> **Note**: The Pioneer LX is always powered on when attached to the charging station, and will not turn off if the OFF button is pressed. To power off the Pioneer LX, hold the BRAKE RELEASE button and carefully move it off the charging station.

4.4 Power and Charging

The robot's battery module supplies power for all robot components including the motors, electronics, and accessories.

The battery ships separately from the platform The battery is shipped fully-charged. The battery is sealed.

For instructions on installing and removing the battery module, See **Setup** on page 17.

Battery recharging is performed by placing the robot in its "dock" or recharging station. Battery charging is completely managed by the platform. All onboard systems function continuously while the battery recharges.

Run-time, with no load, is approximately 13 hours. This will vary depending on use and accessory power consumption.

Recharge time is approximately 3.5 hours.

Battery Indicators and Controls

The battery module has one push-button and four LEDs. From left to right, they indicate:

LED	Color	Meaning
1	Red	Error condition
	Green	25% state of charge
2	Green	50% state of charge
3	Green	75% state of charge
4	Green	100% state of charge

Figure 4-1. Battery LEDs, Push-Button, Power Cable, and Data Cable

The push-button "wakes up" the battery, so it displays its state of charge. This can be useful when a battery is in storage, and you need to know its state of charge.

Charging Station

The charging station, or "dock", is both a manual and an automated means for recharging your Pioneer LX.

During autonomous operation using ARNL, if Auto Dock is enabled (via MobileEyes and "Auto Dock" configuration parameter), the robot can automatically recharge itself when idle or if at a low state of charge, using the charging station. The robot will navigate to a special Dock indicator object in the map (place this Dock point approximately 1-2 meters away from the charging station in the map, pointing towards it), use the laser rangefinder to detect the shape of the charging station, and then turn around and back onto the charging station to charge.

Note, there may be up to a 10-second delay between when a robot docks and when the charging LED turns on. If the robot is fully charged, the Charging LED will also turn off.

Powering ON or OFF the robot, or connecting and disconnecting the robot with network and onboard clients will not disturb the charging state. (Moving the robot will, of course.) The station supplies ample power for all onboard systems while charging its battery, so you can continue operating those systems while charging.

If the robot is powered off, it will turn on automatically when it is pushed onto the charging station. The platform cannot be turned off while on the charging station.

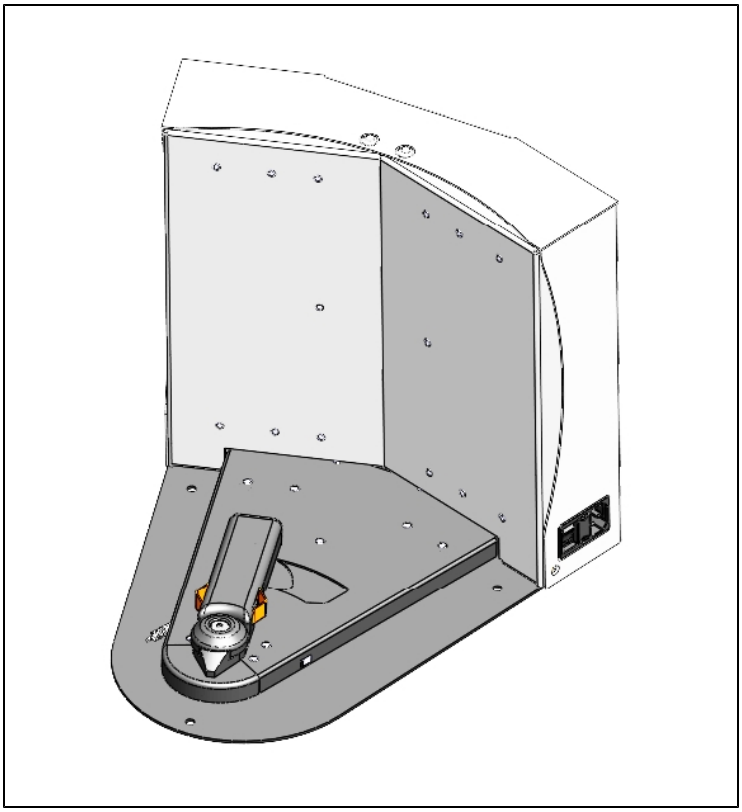


Figure 4-2. Charging Station

Indicators, Controls, and Connections

The charging station has a power switch and two LEDs:

- blue indicates that power is available.
- yellow indicates that a charge is in progress.

The power plug for AC supply is on the right side of the station, as viewed from the front. Power requirements are 100 - 240 VAC, 50 - 60 Hz, and 8 A.

The plug for connecting the manual charging cable is on the left side of the station, as viewed from the front.

Environmental Requirements

- Ambient temperature range: 5° to 40° C (41° to 104° F)
- Humidity: 5 to 95% non-condensing

Maintenance

The charging station contacts should be cleaned quarterly with isopropyl alcohol. See Charging Station Contacts on page 85.

The guide roller can be replaced in the field. See Charging Station Roller and Bearing on page 94.

Contact/Foot Height Adujstment

If necessary, the height of the charging station contacts can be adjusted. See Charging Station Contact Adjustment on page 29.

Manually Charging the Battery

Inside the Platform

To manually place the platform on the dock for recharging, first engange the E-STOP button. While holding the Brake Release button down, slowly push the robot backwards, so that the rear of the platform slides over the contacts of the charging station.

> **NOTE**: You will need to press and hold the brake release button while pushing the robot.

Outside the Platform

A battery can be manually charged outside of the platform, by using the connector on the left side of the charging station with the provided charging cable. This method may be used for charging a spare battery, while the second battery is still in the platform, and the platform is in use.

There is up to a 10-second delay between when you connect the battery cable and when the charging LED turns on.

> **NOTE**: The charging station cannot charge a platform and a separate battery at the same time. If a platform is at the station, the power to the manual charge connector is cut off.

4.5 Operator Control Panel

The Operator control panel comprises a screen, an E-Stop button, ON and OFF buttons, a brake-release button, and a keyswitch.

The operator panel is located on the top plate at the rear of the robot. It may be removed from the top plate and repositioned if a customized payload is added.

ON Button

The ON button is used for restoring power after the OFF button has been pressed, and the software has finished shutting down the robot.

It can also be used to restore power after an E-Stop has been pressed.

OFF Button

The red OFF button removes power from all systems except the charging hardware circuits. The platform's software systems prevent loss of data on shutdown, and save the platform's last known location so it automatically localizes when it is next powered on.

NOTE: The OFF button can be disabled by the keyswitch, which can be locked.

Screen

The first screen, during boot-up, will be similar to the following:

Figure 4-3. Initial HMI Boot Screen

Software can display text and other information on the screen.

E-Stop Button

When pressed, the red, latching push-button removes power from the platform's motors and from the E-Stop-controlled power port after a 1 second delay. To reset the E-Stop, twist the button slightly, so it pops up.

When the E-Stop button is pressed, the robot's motors will be disabled, and must be re-enabled by software (using the ENABLE command). The ARIA and ARNL example programs show how to detect whether motors are disabled, whether the E-Stop button was pressed, and how to re-enable the motors.

Brake-release Button

The brake-release is used when you need to manually move the platform.

Keyswitch

The keyswitch can be used to disable the OFF button. The key can be removed in either the locked or unlocked positions.

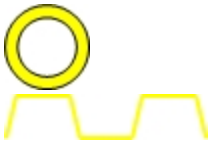
4.6 Other Controls and Indicators

Light Discs, Light Tower

Circular lights on the sides of the platform are used by software to indicate status or state. A user-supplied light tower can also be added for extra signaling.

Several modes are available with different colors and patterns displayed on the light discs and light tower. Software can set a mode using the WHEEL_LIGHT command (See Programming and Protocol). ARIA and ARNL contain example programs that show how to send the wheel light command to set different modes.

The light disc always changes to mode 2 when the E-Stop button is pressed. The other modes are not automatic and must be set by software.

Mode	Description	light discs	Light Tower Outputs on
1	"Busy". Blue arcs rotate back and forth.		OUT1 (green), OUT2 (orange), OUT3 in turn.
2	"Error". Flashing red.		OUT3 (red) periodic.
3	"Warning". Flashing yellow.		OUT2 (orange) periodic.
4	"Motion+Caution". Blue arcs rotate, rest of disc flashing orange.		OUT1(green) periodic. OUT2 (orange) periodic alternating with OUT1. OUT4 (buzzer)

Mode	Description	light discs	Light Tower Outputs on
			periodic with OUT1.
5	"Busy+Caution". Orange arcs rotate back and forth.		OUT2 (orange) periodic.
6	"Progress/Clock". Green arcs rotate over a given percentage of the disc (0%, 25%, 50%, 75% or 100%)		none
7	"Warning Motion". Orange arcs rotate.		OUT1 (green) and OUT2 (orange) alternate. OUT4 (buzzer) periodic with OUT1.
8	"Motion+Turn Signal". Blue arcs rotate, orange segment flashes on right or left side.		OUT1 (green) periodic. OUT4 (buzzer) periodic.
9	"Motion". Blue arcs rotate.		OUT1 (green) periodic. OUT4 (buzzer) periodic.
10	"Ready". Pulse blue slowly (0.25 Hz).		OUT1 (green) on.

Joystick

The joystick plugs into the left side of the Pioneer LX, under the small access panel at the upper-right corner of the platform.

It may be used with running software (such as ARIA demo or ARNL arnlServer) to manually drive the robot. (For example, when creating a map for ARNL.)

Figure 4-4. Joystick GO Button

Hold down the GO button to drive. Turn the SPEED control counter clockwise to reduce speed. Always start at a slow speed, and increase speed by turning clockwise if desired.

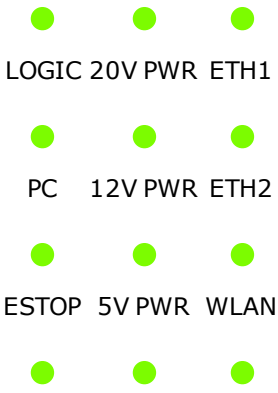
NOTE: The Joystick handle should be facing you, not away from you.

The joystick's GOAL button (secondary button) is for marking positions while making a map scan for ARNL.

WARNING: The Pioneer LX may not sense obstacles while manually operated with the joystick, unless running software does so..

MTX-Lynx Core Diagnostic Indicators

The left end of the Core has 12 indicator lights. The following table gives their meanings:



DRIVE VBATT DISK

Indicator	Meaning
LOGIC	The robot controller has power
PC	The computer and the robot controller are communicating
DRIVE	The motors are enabled and the drive wheels are under servo control
ESTOP	E-Stop button engaged
20V	20 V power is available
12V	12 V power is available
5V	5 V power is available
VBAT	Raw battery power is available
ETH1	The internal device ethernet ("USER LAN") interface is showing activity
ETH2	The external ethernet ("Maintenance Ethernet") interface is showing activity
WLAN	The wireless ethernet interface is showing activity
DISK	The disk is showing activity

4.7 Sensors

Laser Rangefinder

The onboard SICK LMS300 laser rangefinder is a very precise scanning sensor. The laser provides 500 readings in a 250 degree field of view, with a typical maximum range of 15 m (49.2 ft). The laser operates in a single plane, positioned at about 191 mm (7.5 in.) above the floor. In most environments, the sensor will provide highly-accurate data.

Glass, mirrors, and other highly-reflective objects cannot be reliably detected by the laser. Caution must be exercised when operating the platform in areas that have these types of objects. If the platform will need to drive in close proximity of these objects, Adept recommends that you use a combination of markings on the objects, such as tape or painted strips, and also use forbidden sectors in the map, so that the platform knows to plan paths safely around these objects.

ARNL will use this laser as its primary sensor. Software can also use ARIA to obtain sensed obstacle data from the laser.

Sonar

The Pioneer LX contains four short-range sonar for extra sensing near the floor in front of the robot, and behind the robot when backing up.

Bumper

One bumper panel, with two pairs of sensors, is mounted at the front of the platform, should the obstacle-avoidance systems fail to detect an obstacle. The Pioneer LX indicates a left bumper hit (0) to software if only the left side of the bumper panel is triggered, a middle

bumper hit (1) if both sides of the bumper panel are triggered, and a right bumper hit (2) if the right side is triggered.

Aditional user-supplied bumper switches can be added using the User Bumper connector on the rear upper core, in the payload bay.

Internal Sensors

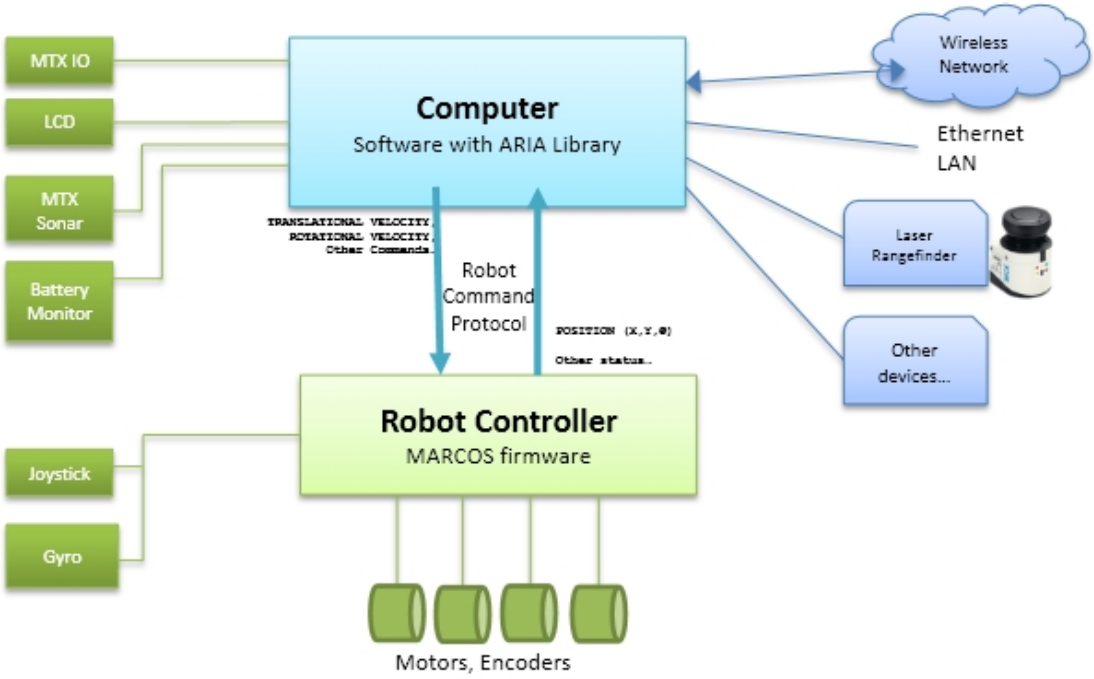
Encoders and Gyroscope

Each wheel has an encoder that tells the robot controller how far the wheel has turned, and in which direction. Each wheel also has a Hall sensor. The core contains a gyroscopic sensor as well, to measure rotation.

The robot's controller uses these internal sensors for feedback as it maintains requested velocities, and when it estimates robot position and velocity, which are provided to the software.

Chapter 5: Programming

All MobileRobots platforms use a two-tier architecture. Pioneer LX's microcontroller with embedded MARCOS firmware manages all the details of the robot's mobility and internal systems including implementing velocity control of the robot platform, coordinating the motors, receiving encoder data, integrating encoder and gyro data to determine an estimate for robot position, managing power to all components, and more. MARCOS unifies the mobile robot base into a single system with one interface channel through which software on the onboard computer can communicate and control the mobile robot base Software running on the onboard PCs communicates with MARCOS to receive data and send commands.



5.1 ARIA

Software communicates with MARCOS via a simple packet-based protocol (See **Communication Packet Protocol** on page 113) via a serial connection between the robot and the embedded computer.

To support development of software, MobileRobots provides a C++ development library called ARIA which implements this protocol, provides interfaces to many accessory devices, and also includes many useful tools for robotics and cross-platform programming. It is also possible to use ARIA in Python and Java via wrapper libraries and Matlab via a MEX/C interface layer. ARIA installation packages can be found on the CD included with your robot, preinstalled on the onboard computer and the latest version as well as all future updates can be downloaded at http://robots.mobilerobots.com/wiki/ARIA. ARIA can be used on Linux with the standard GNU C++ compiler and linker (g++), or on Windows with Microsoft Visual C++ (either Visual Studio 2003, 2008 or 2010). ARIA is provided as open-source software, under the terms of the GNU General Public License (GPL). Full reference documentation is included.

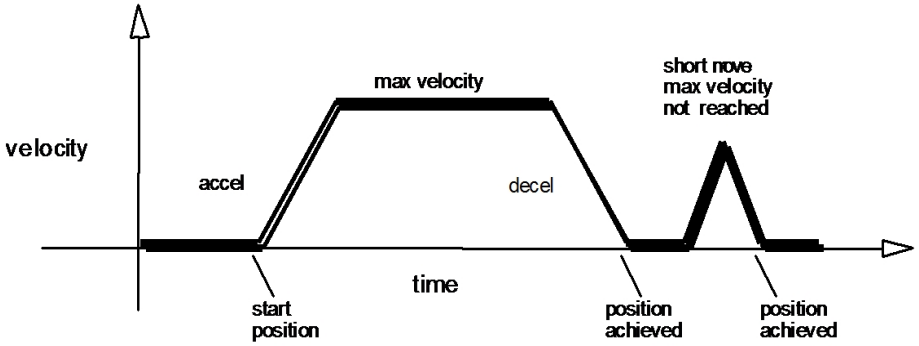
In addition to the ARIA library, MobileRobots provides additional development libraries, including the ArNetworking framework for network programming over TCP and UDP, and the ARNL intelligent navigation library. Useful tools for robot development also include the MobileSim simulator, the MobileEyes user interface application, and the Mapper3 map editing tool. This software can be found on the CD provided with the robot, and at http:/-/robots.mobilerobots.com/wiki/Software.

ARIA automatically handles all communication with the robot components and many accessory devices, including but not limited to the laser rangefinder, the robot's sonar and bumper sensors, LCD display, pan/tilt cameras and pan/tilt units, and more. To communicate with the robot, ARIA sends and receives messages with the robot's embedded firmware. When using ARIA or other development software, however, you do not need to implement this protocol directly. (See **Communication Packet Protocol** on page 113 for a description of this protocol.)

5.2 Robots in Motion

When Pioneer LXreceives a motion command, it accelerates or decelerates the robot according to acceleration or deceleration parameters previously set until the platform either achieves the requested speed (for velocity commands) or nears the requested movement distance (when performing MOVE, HEAD and DHEAD commands). Rotation headings and translation setpoints are achieved by a trapezoidal velocity function, which MARCOS recomputes each time it receives a new motion command.

MARCOS automatically limits velocities, acceleration and deceleration to client-modifiable limits and ultimately by absolute limits. These limits take effect on subsequent commands, not on the current translation or rotation activity, and are reset when the client disconnects or the robot system is reset.



The orientation position commands (setHeading(), setDeltaHeading()) turn the robot with respect to its internal dead-reckoned angle to an absolute heading (0-359 degrees), relative to its immediate heading, or relative to its current heading setpoint (achieved or last commanded heading), respectively.

The STOP command is equivalent to requesting both translation and rotation velocities of 0; the robot will decelerate to 0. The E-STOP command #55 overrides normal deceleration and abruptly stops the robot in the shortest distance and time possible. Accordingly, the robot brakes to zero translational and rotational velocities with very high deceleration and remains stopped until it receives a subsequent translation or rotation velocity command from the client.

Position Integration

MobileRobots platforms track their position and orientation based on wheel motion sensed by encoder readings and from the integrated gyroscope.

On start-up, the robot position is initialized to (0mm, 0mm, 0°), pointing along the positive X-axis at 0 degrees. As the robot moves, the position is updated with reference to this initial coordinate frame, and the latest calculated position estimate is reported in the standard SIP data packet (see below) as XPos, YPos and Theta. X and Y coordinates are provided in millimeters. Angles vary between -179 to 180 degrees. ARIA uses these position estimates to update its own stored position, which may optionally have transformations automatically applied to place the robot in any coordinate system, or to make corrections.

Be aware that registration between external and internal coordinates deteriorates rapidly with movement due to gearbox play, movement in robot suspension, wheel imbalance, wheel slip, accumulated small errors in encoder sensing, and many other real-world factors. You can rely on the dead-reckoning ability of the robot for a short range—on the order of several meters and one or two revolutions, depending on the surface. (ARNL addresses this problem by using additional sensing and sophisticated localization algorithms to correct the position of the robot with respect to features within a known and mapped environment.)

You may translate and rotate the robot into a new coordinate system in ARIA using the ArRobot::moveTo() function. All subsequent position updates received by ARIA from the robot will then continue to use that coordinate system to reflect movement of the robot.

5.3 Device Interfaces

The robot controller and and other devices are connected to the embedded computer via serial connections through which commands can be sent and data received. These serial connections use USB interfaces of the onboard computer.

ARIA has been preconfigured on the Pioneer LX embedded computer to connect to the robot controller via the correct interface and using the correct baud rate as shown in the table below. Once connected to the Pioneer LX, ArRobotConnector will, by default, automatically connect to the robot controller, sonar, battery, and LCD (operator panel) using the correct interfaces as shown below. On Pioneer LX, ArLaserConnector will, by default, connect to the laser rangefinder using the correct interface as shown below.

Component	Linux Interface	Windows Interface	Serial Type	Baud Rate
Robot Controller (MARCOS)	/dev/ttyUSB0	TBD	RS-232	57600
Battery Data Monitor	/dev/ttyUSB1	TBD	RS-232	115200
Sonar	/dev/ttyUSB2	TBD	RS-422	115200
Laser Rangefinder	/dev/ttyUSB4	TBD	RS-422	230400
LCD Panel	/dev/ttyUSB8	TBD	RS-422	115200
User/Accessory Serial Port 1 (RS-232 1)	/dev/ttyUSB9	TBD	RS-232	-

Component	Linux Interface	Windows Interface	Serial Type	Baud Rate
User/Accessory Serial Port 2 (RS-232 2)	/dev/ttyUSB10	TBD	RS-232	-

Optional accessory devices will be connected to external serial or USB ports. Refer to the accessory device's supplementary documentation for information on how it is connected to the onboard computer and ARIA.

5.4 Futher Programming Information

For further information about programming with ARIA, read the ARIA README.txt file, LICENSE.txt file, and the ARIA API Reference Documentation.

When ARIA is installed on Linux, the ARIA API Reference Documentation can be read by opening /usr/local/Aria/Aria-Reference.html in a web browser.

When ARIA is installed on Windows, the ARIA API Reference Documentation can be read by opening C:\Program Files\MobileRobots\Aria\Aria-Reference.html

Also look at the ARIA examples, installed in /usr/local/Aria/examples on Linux and C:\Program Files\MobileRobots\Arnl\examples on Windows.

For further information about programming with the ARNL laser navigation and localization libraries, read BaseArnl-README.txt, ARNL-README.txt file, LICENSE.txt file, and the BaseArnl API Reference Documentation and Arnl API Reference Documentation.

When ARNL is installed on Linux, the API reference documentation can be read by opening /usr/local/Arnl/doc/BaseArnl-Reference.html and /usr/local/Arnl/doc/Arnl-Reference.html in a web browser.

When ARNL is installed on Windows, the API reference documentation can be read by opening C:\Program Files\MobileRobots\Arnl\doc\BaseArnl-Reference.html and C:\Program Files\MobileRobots\Arnl\doc\Arnl-Reference.html.

The ArNetworking library, used for remote command and monitoring with ARIA and/or ARNL also includes an API reference manual and example programs. ArNetworking is installed as a subdirectory of the Aria directory.

Any additional libraries installed to support optional accessories will be found as subdirectories in the Aria installation directory, and will contain their own documentation and examples.

For discussion and questions about programming with ARIA and ARNL, join the aria-users discussion email forum. See the following link for more information

http://robots.mobilerobots.com/wiki/aria-users

Chapter 6: Payloads

Everything that you attach to the Pioneer LX is referred to as the payload.

The Pioneer LX provides the mobility and navigation you will need, as well as power and I/O connections between the platform and your payload, so the two can work effectively together.

Your payload may be added to the equipment mounting deck, or you may replace the deck and/or top plate with your payload.

TODO insert top plate/deck options photos here.

6.1 Considerations

The main factors to consider in designing a payload are the size, weight, and center of gravity of the payload, and power requirements. Adding weight to the Pioneer LX tends to have less effect on run-time than adding electrical power requirements. Additional weight will have more effect on carpet than on hard surfaces.

Weight

Increased payload weight will decrease your robot's run-time. This will be most noticeable if you are driving the robot up an incline. On level ground, a certain amount of extra weight will not shorten the robot's run-time very much. When adding a payload with substantial weight, the center of gravity of the entire robot needs to be considered. This is particularly important if you intend to equip the Pioneer LX with a robot arm, which would be lifting items off-center from the Pioneer LX.

A heavy payload, with most of its weight concentrated just above the Pioneer LX, will be much more stable than the same weight payload in which the weight is either off-center or high above the top of the platform.

> **NOTE**: The weight of your payload added to the weight of the parts it is carrying must not exceed 60 kg (132 lb).

Power Consumption

Using devices on your payload that consume significant power will noticeably shorten the run-time of the robot. You should try to minimize such power consumption whenever possible.

Examples of power-consuming payloads would be one with a robot arm attached, or any motorized fixture as part of the payload. The standard Operator screen and light discs consume some power, but are not significant compared to the rest of the platform.

The battery is rated at 1500 W*hr (1.5 kWh). Unloaded, the platform uses from 80 - 107 W. With a full load, this increases to 94 - 125 W. (The range for each reflects the speed at which the platform is driven.) You can use the wattage of any accessories you add to your payload, added to these typical values, to calculate the expected run-time per charge.

NOTE: In the following table, 50% is 900 mm/sec., 100% is 1800 mm/sec.

Table 6-1. Typical Watts Drawn

	% Speed	
kg	**50**	**100**
0	80	107
60	94	125

To calculate your estimated run-time:

1. Find the closest match to your payload weight and average driving speed, as a percentage of full speed.

   This will be a value in Watts.

2. Add the power used by all electrical devices on your payload, in Watts.

   It is unlikely that any electrical device on your payload will operate continuously, so you need to figure out what average percent of the time it will operate, and multiply that by the Watts of the drain to get an average drain factor.

3. Divide 1500 W*hr by that value, in Watts.

   This will yield your estimated run-time, in hours.

Example Calculation

If your payload weighs 60 kg, and you expect to run at an average of 50% full speed, you would use the value of 94 from the table.

If your payload includes a device that draws 150 watts half of the time, add 75 (150*50%) to 94, to get 169 Watts, total.

Dividing 1500 W*hr by 169 Watts yields:

1500 W*hr/169 W = 8.87 hr of estimated run-time.

Payload Bay Access

The area beneath the top plate is the payload bay. You will occasionally need to access the Pioneer LX and the connectors in the payload bay. This is where you can access all of the platform power and I/O connectors. It's a good idea to provide for access to this when designing your payload.

Dimensions

You must keep your payload no wider and no longer than the Pioneer LX.
The most common payload is a vertical extension of the platform, adding whatever features are needed by your application above the platform itself.

Take care to keep all of the payload higher than the top of the Pioneer LX. If any of the platform's sensors get blocked, it won't be able to function normally. This is critical in the case of the laser rangefinder.

The height of your payload will affect the center of gravity, covered in the next section.

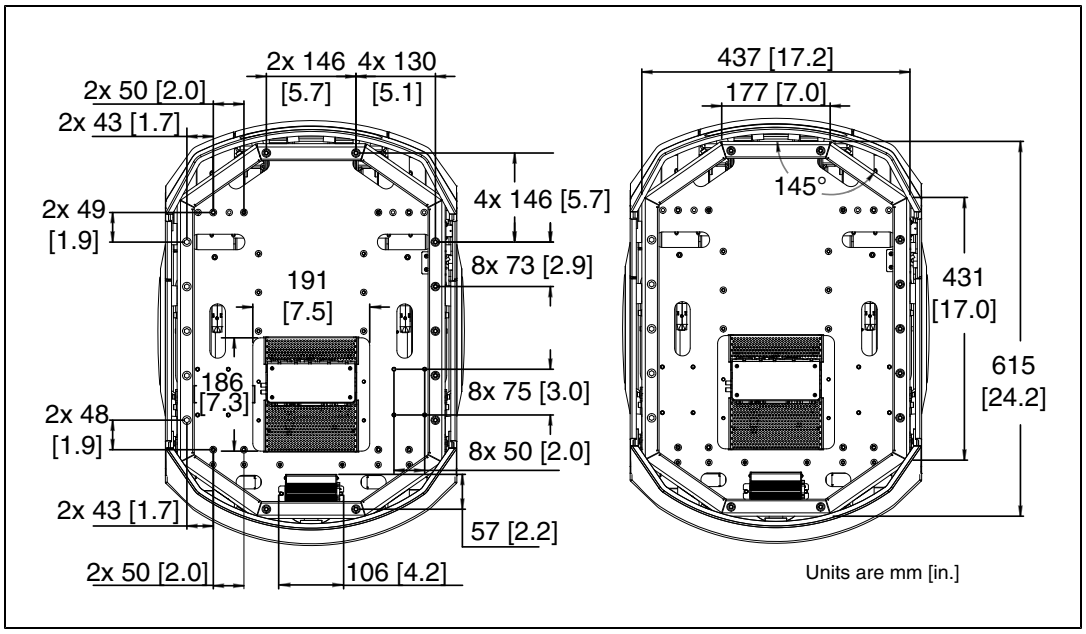


Figure 6-1. Platform Frame Dimensions, for Attaching Payload

Center of Gravity

As much as possible, you should keep the payload center of gravity centered on the Pioneer LX, and as low (close to the platform top) as possible. This will give you the best stability, particularly when crossing thresholds or irregularities in the floor.

The following figure shows the center of gravity of the platform, without payload.

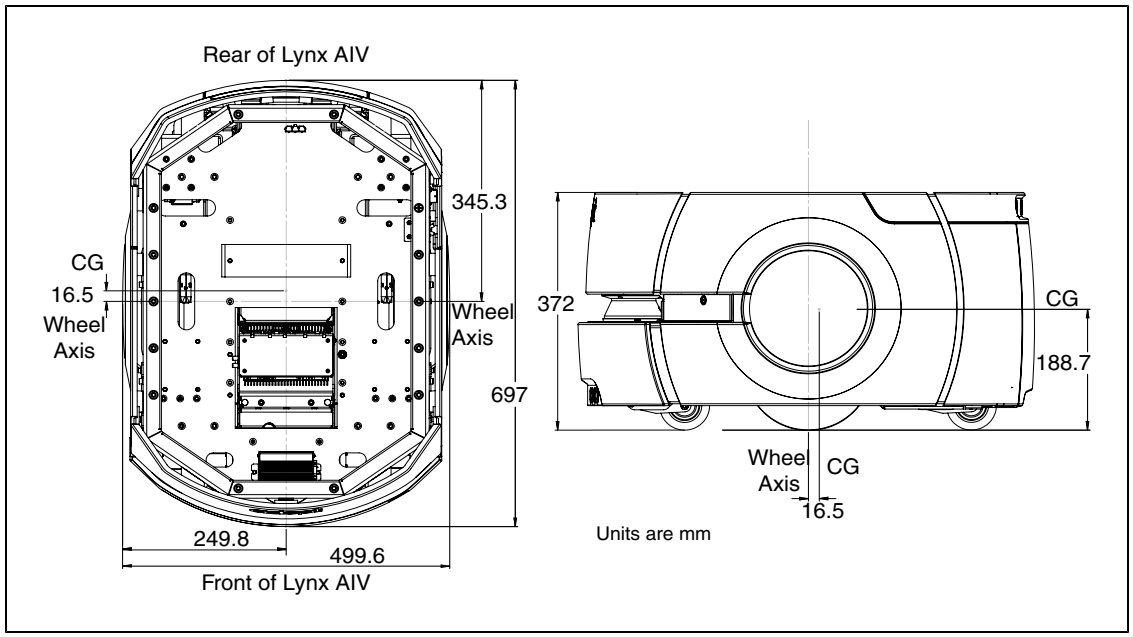


Figure 6-2. Center of Gravity of Platform

The three following figures show the calculations of safe placements for the center of gravity for payloads with the weights listed. The center of gravity, in each instance, needs to be within the area shown. All units are mm.

> **NOTE**: These figures show the limits of where the payload center of gravity can be placed. You should try to keep your CG as close to the center of these figures as possible.

In the following three figures, light blue represents the payload, while dark blue represents the Pioneer LX.

10 kg

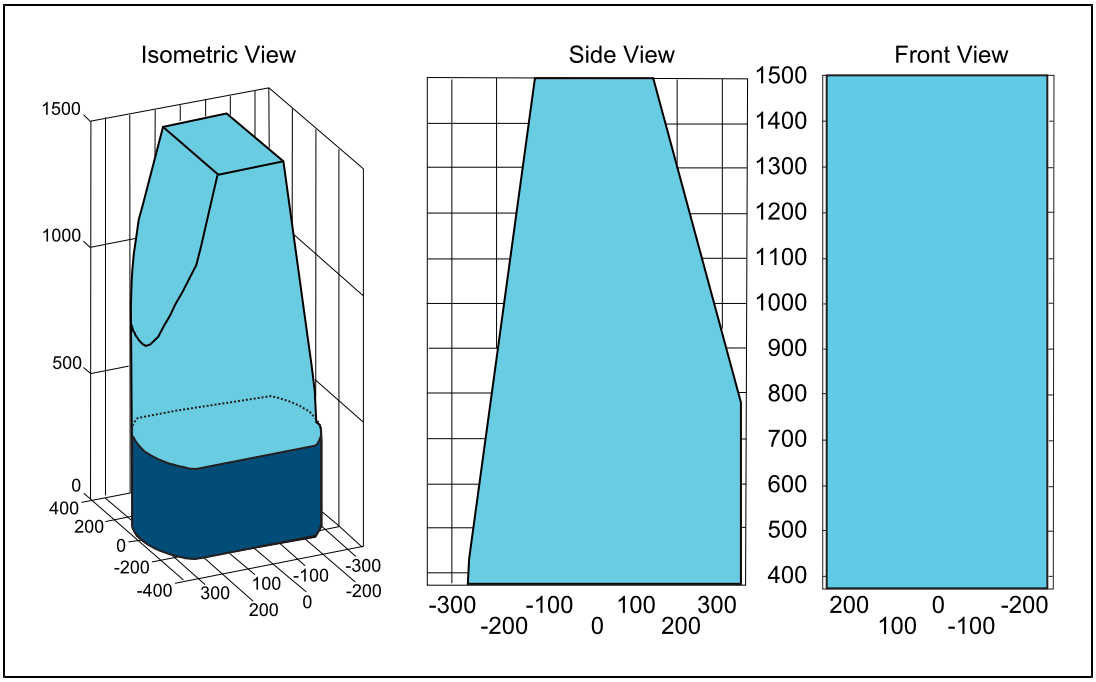


Figure 6-3. Center of Gravity Graphs, 10 kg

30 kg

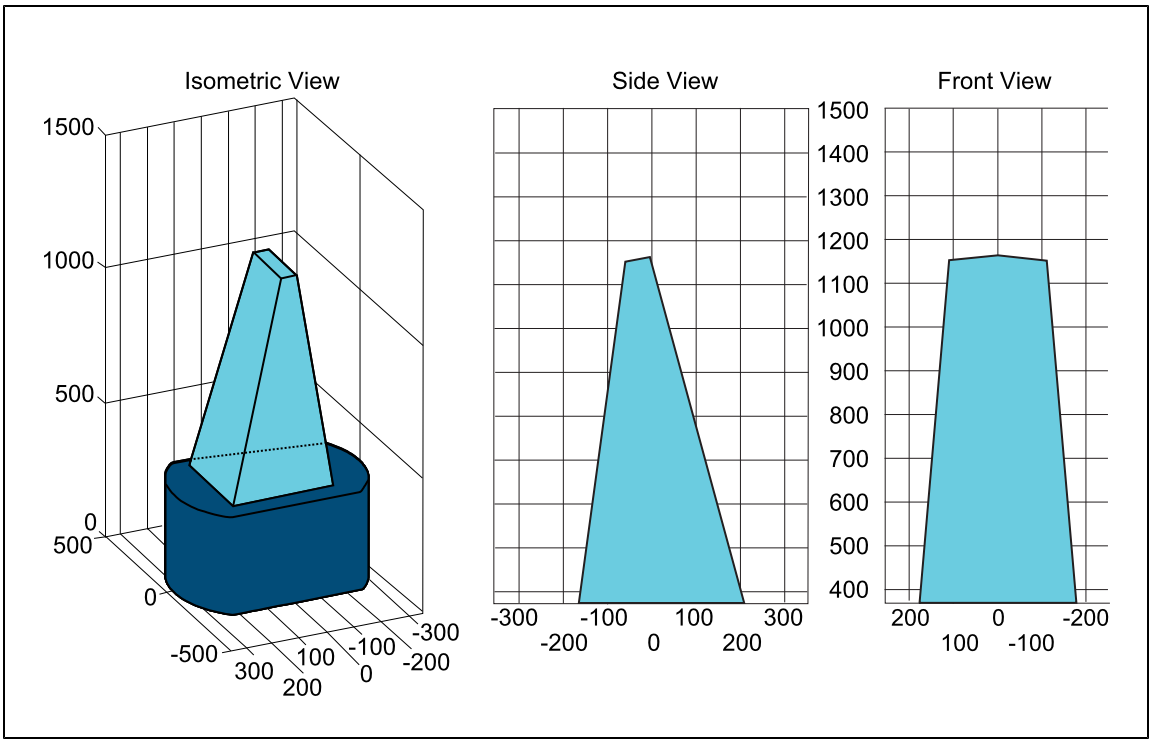


Figure 6-4. Center of Gravity Graphs, 30 kg

60 kg

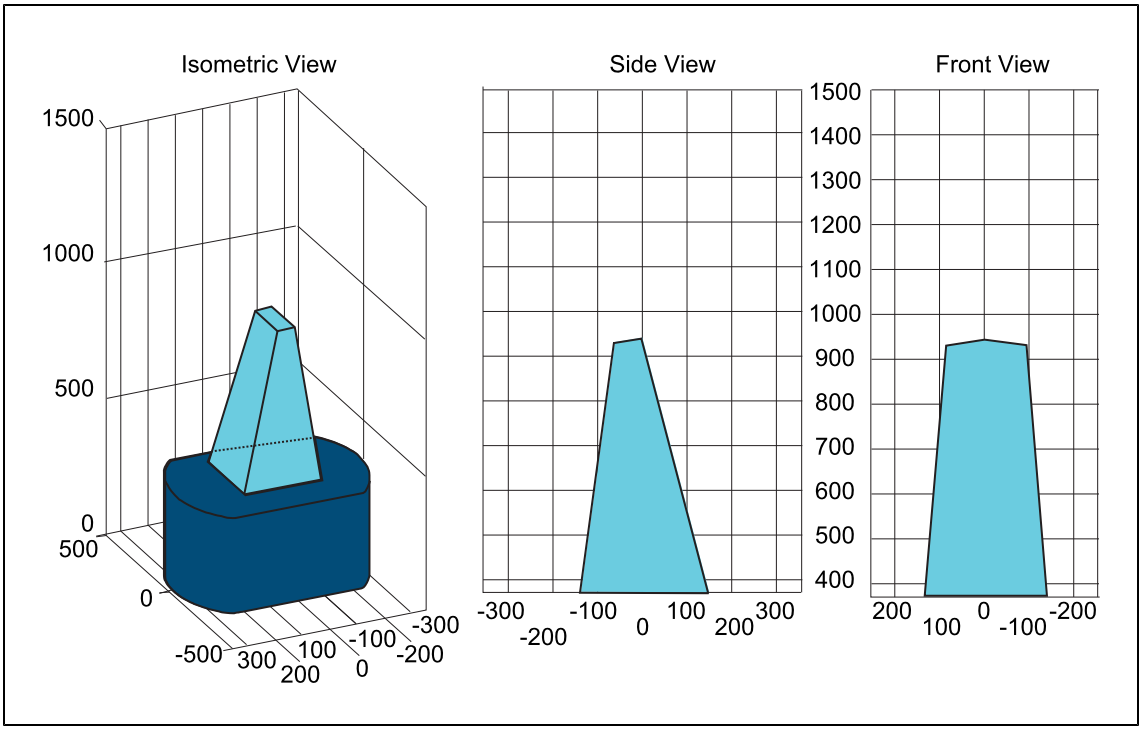


Figure 6-5. Center of Gravity Graphs, 60 kg

6.2 Mounting Deck

The mounting deck is used for easy addition and removal of MobileRobots-supplied accessories or your own devices and equipment. The deck contains a 5cm grid of mounting holes pretapped for 5mm metric screws (M5 screws), as well as one 1/4" hole in the center, as well as locations to attach a camera mounting plate via three M3 screws.

The mounting deck is attached to the frame of the Pioneer LX via M5 screws on each side and may be removed to access the interior payload bay or to remove equipment for maintainence or changes for different projects.

Always carefully start screws by hand before tightening with tools to protect threads from damage.

6.3 Connections Between Platform and Payload

The Pioneer LX provides a variety of I/O and power connections, which you can use to make your robot more effective.

The Operator screen, E-Stop, Brake-release, ON, and OFF may be relocated if desired. This allows you to add the robot controls somewhere on your payload with just one cable.

The cutout needed for mounting the Operator interface is shown in the following figure:

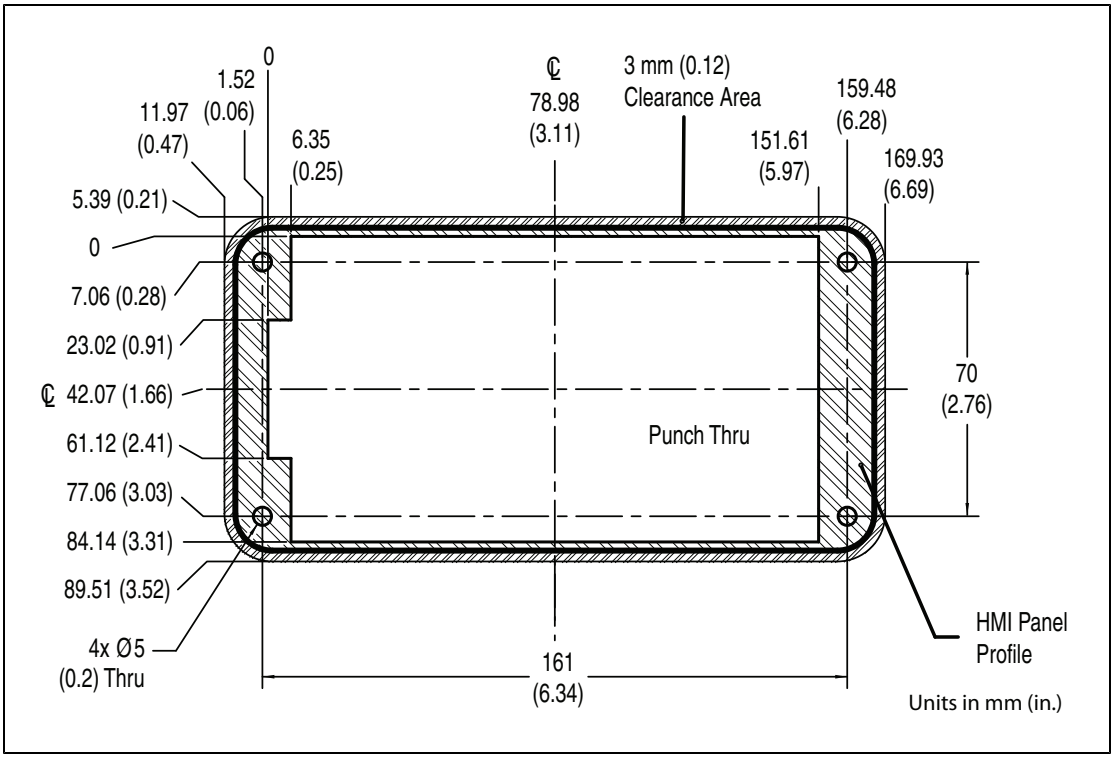


Figure 6-6. Operator Interface Cutout Dimensions

Many other options are available. Details and specifications of the connections available are covered in Connectivity on page 61.

Chapter 7: Connectivity

7.1 User Connections Summary

Connection	Location	Description
Joystick port	Side access panel	The Joystick port is located under the small access panel on the left side of the platform, in the upper-right corner. This is internally connected to the Joystick on the MTX Core.
External ethernet port	Side access panel	The external ethernet port is located under a small access panel on the left side of the platform, in the upper-right corner. This port may be used to connect the robot to a network for updates and maintainence. The external ethernet port is internally connected to the Maintenance Ethernet port on the MTX Core in the payload bay.
Wireless Ethernet	Side access panel	The Pioneer LX includes two antennas for wireless ethernet networking (wifi). The antennas are internally connected to the wifi antenna connectios on the side of the MTX Core inside the payload bay.
USB	Top plate, and core	Three USB connectors are provided for the embedded computer on the top plate at the rear of the robot. These are internally connected to the computer USB ports on the MTX Core.
VGA Monitor	Top plate	A VGA display connector for the embedded computer is located on the top plate at he rear of the robot. This is internally connected to the computer VGA port on the MTX Core.
Serial ports, User/General Purpose.	Top plate, and core	Two 9-pin DSUB connectors are located on the top plate at the rear of the robot. These are internally connected to the embedded computer via USB-serial interfaces.
Analog and digital I/O	Core	A connector for analog and digital I/O is located inside the robot on the MTX Core. A breakout board with screw terminals and cable are also provided which connect to this port.
User/Aux Power	Core	Connectors for user and auxiliary power are located on the MTX Core.

Other connections on the MTX Core and inside the robot are used for essential robot components. Do not remove these connections unless necessary.

7.2 MTX Core User Connections

The MTX Core is inside the robot, under the top plate. The Core contains the robot control system and embedded computer. These connections are available for use with Adept- and user-supplied accessories.

MTX-Lynx Core Front, Upper

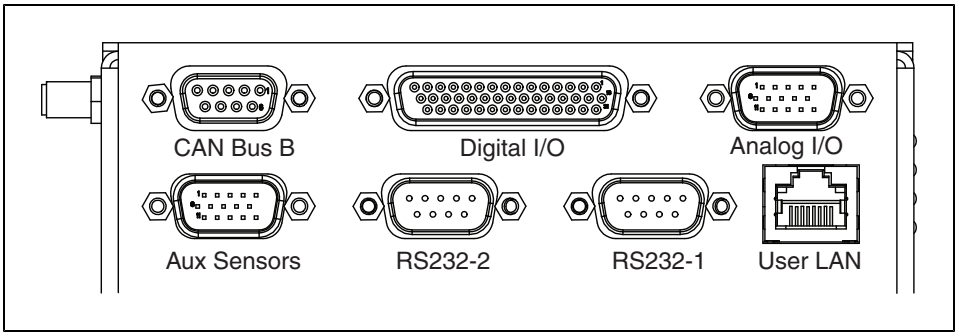


Figure 7-1. Front Upper Core

Connection	Type	Description
Ethernet	RJ45, Shielded	General (USER LAN), Auto-MDIX.
RS-232 (Aux Sensors)	HDB15M	Optional vertical lasers
RS-232 x 2	DB9M	Port 1 and Port 2, general use
CAN Bus B	DB9F	Reserved for future Adept components.
Digital I/O (HDB44F)	HDB44F	16 digital inputs, in 4 banks of 4. Each bank can be wired as active high or active low depending on the connection of the BANK# terminal. V_{IN} range for each input is 0 to 30 V. The input is ON when V_{IN} > 4 V, OFF when V_{IN} < 1.3 V.
		16 digital outputs, protected low-side (open-drain) drivers. 500 mA output each. May be used with loads connected to VBAT, AUX_20V, _12V, or _5V. You must stay within the allowed current capacity of the VBAT or AUX power supplies.
Analog I/O	HDB15M	General use

CAN Bus B

Connector type DB9F

Use CAN Bus

Pin No.	Designation	Notes
1, 4, 8	No Connection	

Pin No.	Designation	Notes
2	CANL_B	CAN Communication differential pair
3, 6	GND	Direct GND
5	SHIELD GND	Bead filter to GND
7	CANH_B	CAN Communication differential pair
9	CANB_12V_OUT_SW	12 V @ 0.5 A Max (switched in SW)

Digital I/O

Connector type HDB44F

	Designation		
Pin No.	Hardware	Software	Notes
1	INPUT_1.1	Input_1.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
2	INPUT_1.2	Input_1.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
3	INPUT_1.3	Input_1.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
4	INPUT_1.4	Input_1.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
5	BANK1		Common for INPUT_1.X
6	INPUT_2.1	Input_2.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
7	INPUT_2.2	Input_2.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
8	INPUT_2.3	Input_2.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
9	INUIT2.4	Input_2.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
10	BANK2		Common for INPUT_2.X
11	INPUT_3.1	Input_3.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
12	INPUT_3.2	Input_3.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
13	INPUT_3.3	Input_3.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
14	INPUT_3.4	Input_3.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
15	BANK3		Common for INPUT_3.X
16	INPUT_4.1	Input_4.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
17	INPUT_4.2	Input_4.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
18	INPUT_4.3	Input_4.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
19	INPUT_4.4	Input_4.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
20	BANK4		Common for INPUT_4.X
21	OUTPUT_1	Output_1	

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
22	OUTPUT_2	Output_2	
23	OUTPUT_3	Output_3	
24	OUTPUT_4	Output_4	
25	OUTPUT_5	Output_5	
26	OUTPUT_6	Output_6	
27	OUTPUT_7	Output_7	
28	OUTPUT_8	Output_8	
29	OUTPUT_9	Output_9	
30	OUTPUT_10	Output_10	
31	OUTPUT_11	Output_11	
32	OUTPUT_12	Output_12	
33	OUTPUT_13	Output_13	
34	OUTPUT_14	Output_14	
35	OUTPUT_15	Output_15	
36	OUTPUT_16	Output_16	
37	VBAT_IO_OUT4		VBAT @ 0.5 A Max (shared with light pole)
38	VBAT_IO_OUT3		VBAT @ 0.5 A Max
39	VBAT_IO_OUT2		VBAT @ 0.5 A Max
40	VBAT_IO_OUT1		VBAT @ 0.5 A Max
41, 42, 43, 44	GND		

Table 7-1. Digital Input Specifications

Parameter	Value
Operational voltage range	0 to 30 VDC
OFF state voltage range	0 to 1.3 VDC
ON state voltage range	4 to 30 VDC
Operational current range	0 to 7.5 mA
OFF state current range	0 to 0.5 mA
ON state current range	1.0 to 7.5 mA
Impedance (V_{in}/I_{in})	3.9 kΩ minimum
Current at V_{in} = +24 VDC	$I_{in} \leq 6$ mA

NOTE: The input current specifications are provided for reference. Voltage sources are typically used to drive the inputs.

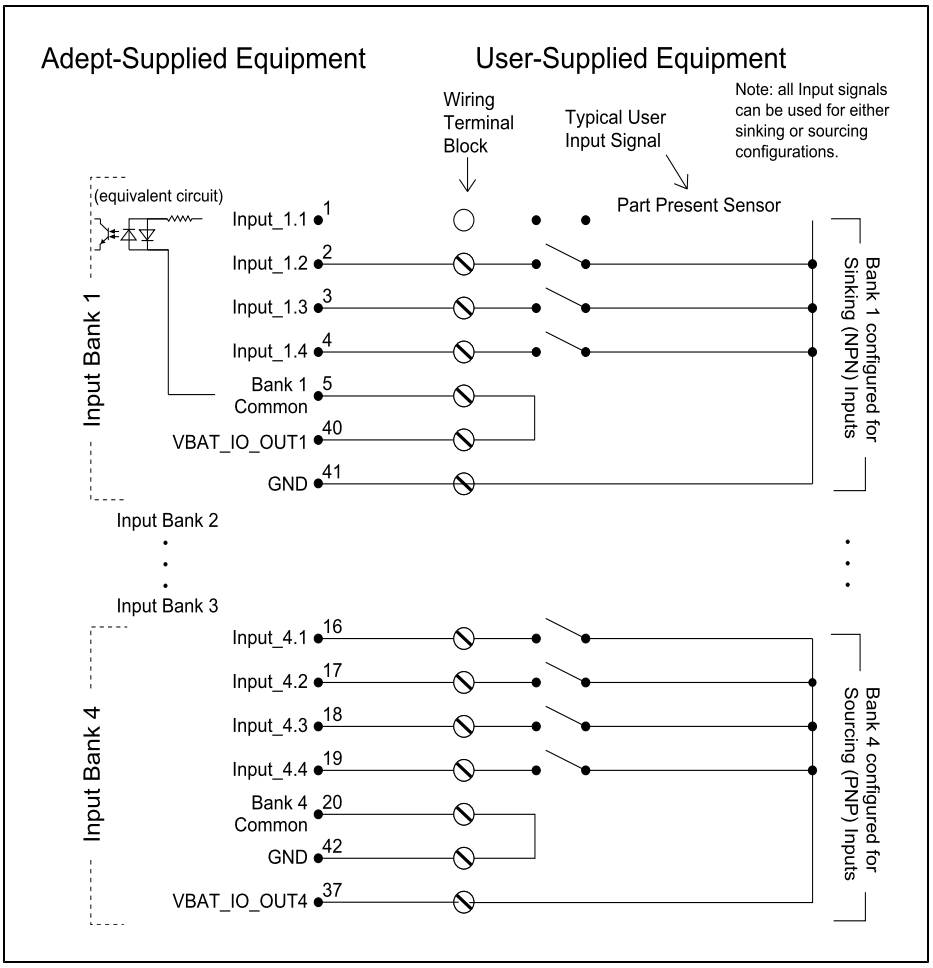


Figure 7-2. Typical Digital Input Wiring Example

Table 7-2. Digital Output Specifications

Parameter	Value
Power supply voltage range	5 - 30 VDC
Operational current range, per channel	$I_{out} \leq 500$ mA
ON state resistance (I_{out} = 0.5 A)	$R_{on} \leq 0.14\ \Omega$ @ 85° C
Output leakage current	$I_{out} \leq 5\ \mu A$
DC short circuit current limit	$0.7\ A \leq I_{LIM} \leq 1.7\ A$

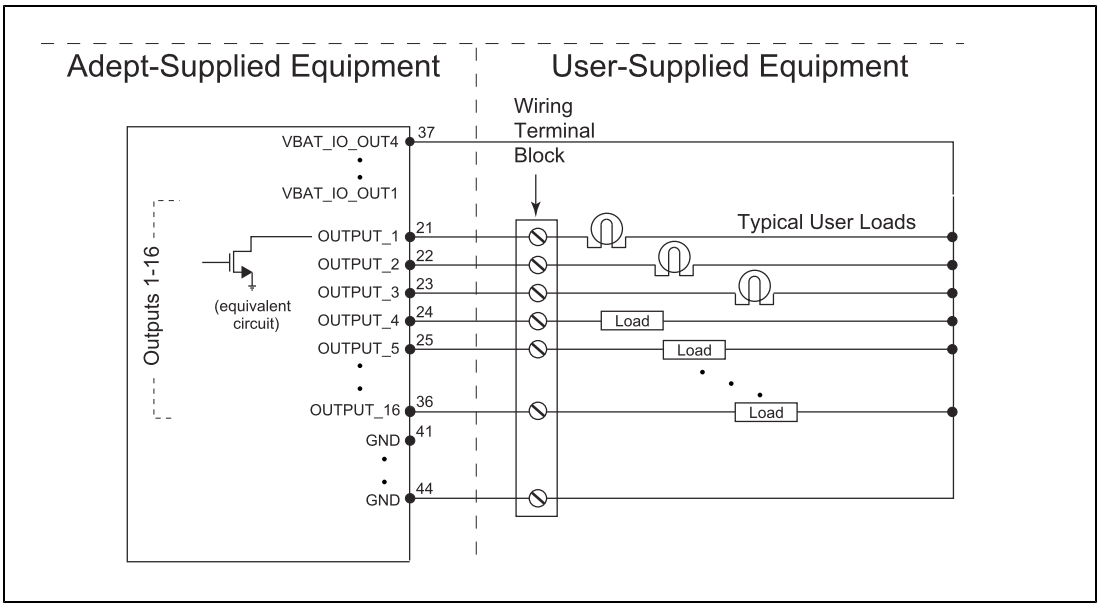


Figure 7-3. Typical Digital Output Wiring Example

Analog I/O

Connector type HDB15M

Pin No.	Designation	Notes
1	ANALOG_IN1	0 – 10 V Range, R_{in} = ~35 kΩ
2	ANALOG_IN2	0 – 10 V Range, R_{in} = ~35 kΩ
3	ANALOG_IN3	0 – 10 V Range, R_{in} = ~35 kΩ
4	ANALOG_IN4	0 – 10 V Range, R_{in} = ~35 kΩ

Pin No.	Designation	Notes
5	ANALOG_IN5	0 – 30 V Range, R_{in} = ~110 kΩ
6	ANALOG_IN6	0 – 30 V Range, R_{in} = ~110 kΩ
7	ANALOG_IN7	0 – 30 V Range, R_{in} = ~110 kΩ
8	ANALOG_IN8	0 – 30 V Range, R_{in} = ~110 kΩ
9	ANALOG_OUT1	0 – 20 V Range, +/-10 mA, Ro = ~200 Ω
10	ANALOG_OUT2	0 – 20 V Range, +/-10 mA, Ro = ~200 Ω
11	ANALOG_OUT3	0 – 20 V Range, +/-10 mA, Ro = ~200 Ω
12	ANALOG_OUT4	0 – 20 V Range, +/-10 mA, Ro = ~200 Ω
13, 14, 15	GND	

Serial Ports (RS232, user/general purpose) 1 & 2

Connector type DB9M

Use Port 1 and 2, General Use

The user serial ports use/dev/ttyUSB9 and /dev/ttyUSB10 device interfaces on Linux.

Pin No.	Designation	Notes
1, 4, 6, 9	No Connection	
2	RS232_USR#_RXD	#=1 or 2
3	RS232_USR#_TXD	#=1 or 2
5	GND	
7	RS232_USR#_RTS	#=1 or 2
8	RS232_USR#_CTS	#=1 or 2

MTX-Lynx Core Rear, Upper

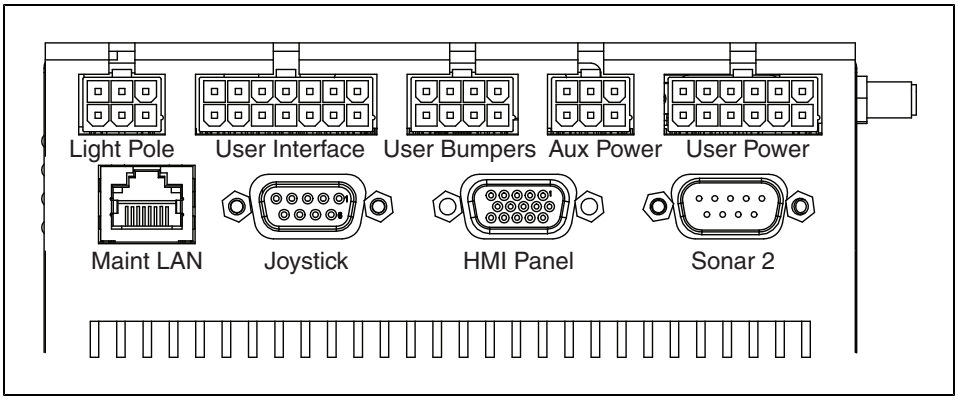


Figure 7-4. Rear Upper Core

Connection	Type	Description
Light Pole	Mini-Fit2 x 3	Connects to a user-supplied light tower with 3 lights and 1 buzzer, using a default configuration
User Interface	Mini-Fit2 x 7	Additional user-supplied brake release
		Additional user-supplied ON button; same function as Operator Panel ON
		Additional user-supplied OFF button; same function as Operator Panel OFF
		Additional user-supplied E-Stop
User Bumpers	Mini-Fit2 x 4	Payload bumpers, user-supplied, connected between ESTOP_SRC and USER_BMP# (for each of the 6 inputs). Contacts should be 12 V @ 10 mA.
Aux Power	Mini-Fit2 x 3	5, 12, and 20 VDC Outputs
User Power	Mini-Fit2 x 6	Battery and switched battery power
Maintenance Ethernet	RJ45, Shielded	Connected to the externally-mounted ethernet port on side of platform, Auto-MDIX.
Joystick	DB9F	Connected to the externally-mounted Joystick port on side of platform.
HMI Panel	HDB15F	Operator screen, E-Stop, Brake_Rel, ON, OFF
Sonar #2	DB9M	Optional sonar (x8) for payload

Power Connections

The Pioneer LX provides conditioned 5, 12, and 20 VDC, and raw (battery) 22 - 30 VDC power to the platform's and accessory electronics, including the onboard Core and laser rangefinder.

All power connectors are Mini-Fit®.

Nominal	Qty	Actual	Maximum Current	Description
5 VDC	1	5 VDC	1 A	Switched Aux power
12 VDC	1	12 VDC	1 A	Switched Aux power
20 VDC	1	20 VDC	1 A	Switched Aux power
22 - 30 VDC	2	battery	4 A	Switched
22 - 30 VDC	1*	battery	10 A	Switched
22 - 30 VDC	1*	battery	10 A	Safe, Switched
* 10 A Switched and 10 A Safe, Switched share the 10 A of current.				

Each supply has an associated LED which, when lit, indicates that the port is actively powered. See MTX-Lynx Core Diagnostic Indicators on page 45.

The Safe 22 - 30 VDC supply automatically gets disconnected when the E-Stop button is pressed, an obstacle is detected, or the bumper touches something.

Light Pole (user-supplied)

Connector type Mini-Fit® 3 x 2

Use Light tower

Pin No.	Designation	Notes
1	GND	
2	LIGHT_P1	
3	LIGHT_P2	
4	VBAT_IO_OUT4	VBAT @ 0.5A Max (shared with DIO)
5	LIGHT_P3	
6	LIGHT_P4	

NOTE: Light 4 is the buzzer on the light tower.

User Interface

Connector type Mini-Fit® 7 x 2

Use Additional user-added brake release, ON, OFF, and E-Stop buttons

Pin No.	Designation	Notes
1, 2, 3	FBAT_ALWAYS	Fused VBAT @ 500 mA
4	ESTOP_USR_1L	Short 4 & 11 to close ESTOP_USR_1
5	ESTOP_USR_2L	Short 5 & 12 to close ESTOP_USR_2
6	ESTOP_OUT_1L	Pins 6 & 13 short when ESTOP_CH1 is closed
7	ESTOP_OUT_2L	Pins 7 & 14 short when ESTOP_CH2 is closed
8	OFF_BUTTON	Short to FBAT_ALWAYS to signal OFF (min 1 s pulse)
9	START_BUTTON	Short to FBAT_ALWAYS to signal ON (min 1 s pulse)
10	MOTOR_BRAKE	Short to FBAT_ALWAYS for manual brake release
11	ESTOP_USR_1H	Short 4 & 11 to close ESTOP_USR_1
12	ESTOP_USR_2H	Short 5 & 12 to close ESTOP_USR_2
13	ESTOP_OUT_1H	Pins 6 & 13 short when ESTOP_CH1 is closed
14	ESTOP_OUT_2H	Pins 7 & 14 short when ESTOP_CH2 is closed

NOTE: Either an E-Stop jumper or a user-supplied E-Stop button must be attached to the E-STOP port on the User Interface connector for the platform to function. The jumper is provided as part number 12730-000L. An E-Stop button would be user-supplied. See the following figure.

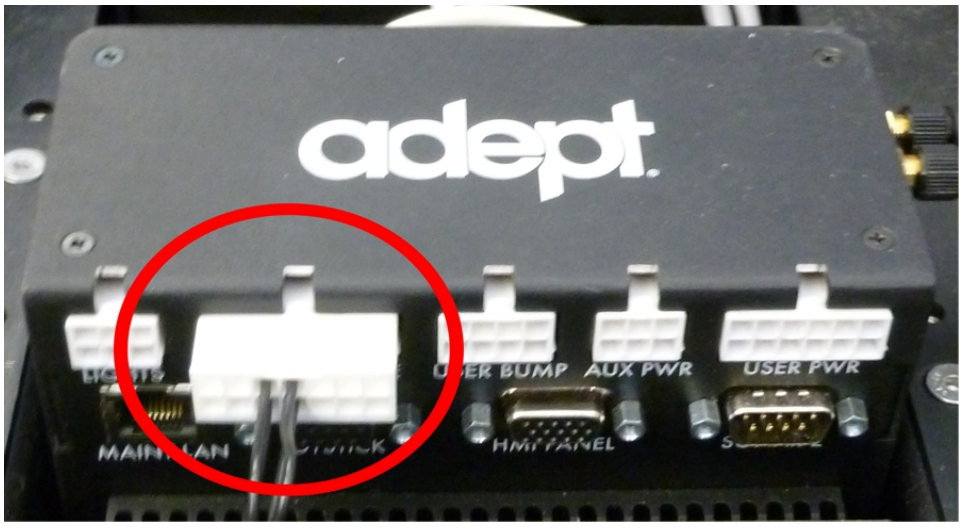


Figure 7-5. E-Stop Jumper on Lynx Core

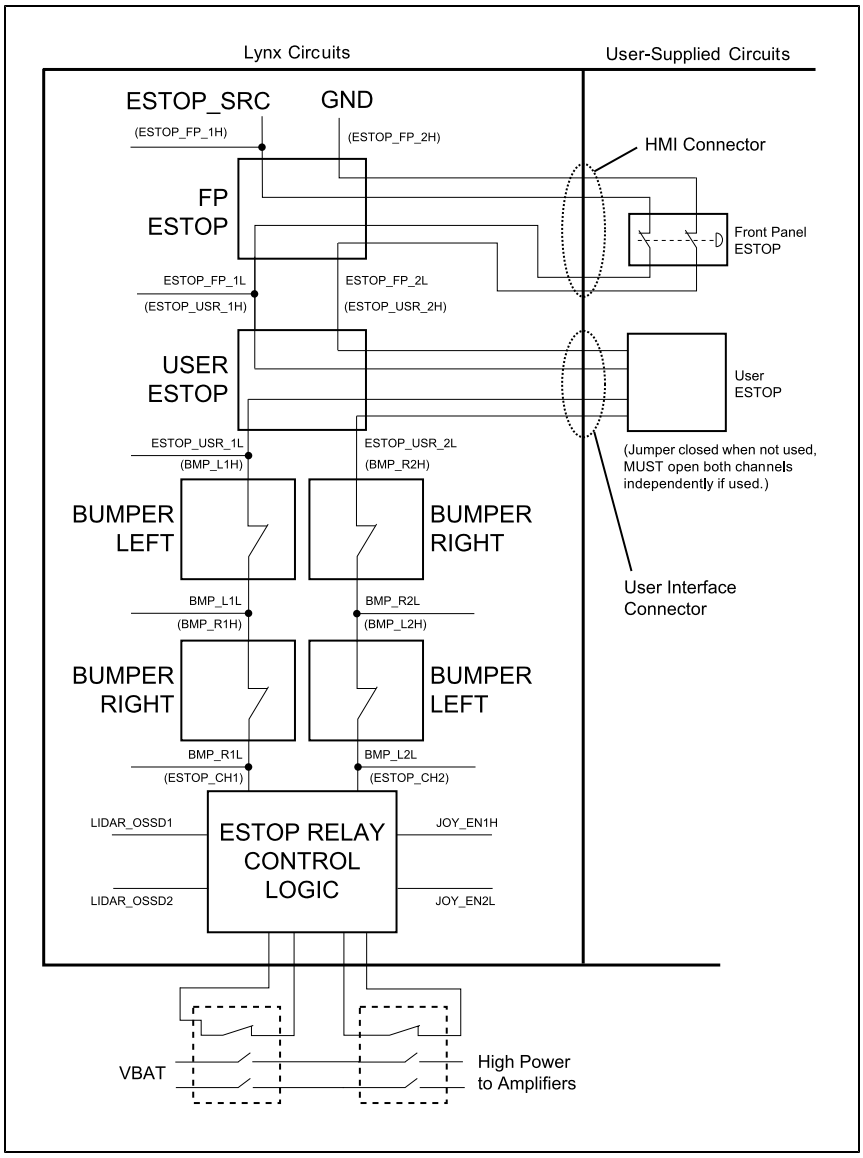


Figure 7-6. E-Stop Chain Diagram

User Bumper

Connector type Mini-Fit® 4 x 2

Use Optional bumper (x8) for payload

Pin No.	Designation	Notes
1	USER_BUMPER_1	Short to ESTOP_SRC to signal bumper hit
2	USER_BUMPER_2	Short to ESTOP_SRC to signal bumper hit
3	USER_BUMPER_3	Short to ESTOP_SRC to signal bumper hit
4	USER_BUMPER_4	Short to ESTOP_SRC to signal bumper hit
5	USER_BUMPER_5	Short to ESTOP_SRC to signal bumper hit
6	USER_BUMPER_6	Short to ESTOP_SRC to signal bumper hit
7, 8	ESTOP_SRC	12 V ESTOP Source Output @ 10 mA

Aux Power

Connector type Mini-Fit® 3 x 2

	Designation		
Pin No.	Hardware	Software	Notes
1, 2, 3	GND		
4	AUX_5V_OUT	Aux_5V	5 V @ 1 A max
5	AUX_12V_OUT	Aux_12V	12 V @ 1 A max
6	AUX_20V_OUT	Aux_20V	20 V @ 1 A max

User Power

Connector type Mini-Fit® 6 x 2

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1, 2, 3, 4, 5, 6	GND		Limit to < 5 A per pin
7	SW_VBAT_OUT1	Battery_Out_1	VBAT @ 5 A max (switched in SW)
8	SW_VBAT_OUT2	Battery_Out_2	VBAT @ 5 A max (switched in SW)
9, 10	SW_VBAT_OUT34	Battery_Out_3_and_4	VBAT @ 10 A max (switched in SW). Limit to < 5 A per pin.
11, 12	SAFE_VBAT_OUT		SW_VBAT_OUT34 gated by dual-channel ESTOP relays.

Joystick

Connector type DB9F

Use Joystick

Pin No.	Designation	Notes
1	JOY_XAXIS	Analog X input
2	JOY_YAXIS	Analog Y input
3	JOY_SPEED	Analog SPEED input
4	JOY_GOAL	Goal Button Input
5	JOY_EN_1H	Enable channel 1
6	JOY_EN_2L	Enable channel 2
7	No Connection	
8	GND	
9	5V	5 V @ 100 mA

HMI Panel

Connector type HDB15F

Use Operator screen, E-Stop, Brake_Rel, ON, OFF

See Programming on page 49for more information on connecting with software.

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1	RS422_HMI_TX+		Connections to Adept HMI Panel
2	RS422_HMI_TX-		
3	MOTOR_BRAKE		
4, 5	ESTOP_FP_1H, _2H		
6	RS422_HMI_RX+		
7	RS422_HMI_RX-		
8	START_BUTTON		
9, 10	ESTOP_FP_1L, _2L		
11	HMI_5V_SW	HMI_Power	
12, 14	GND		
13	OFF_BUTTON		
15	FBAT_ALWAYS		

Core, Side

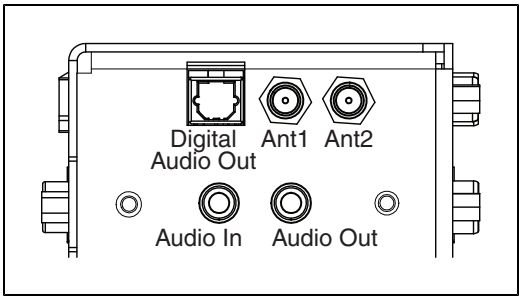


Figure 7-7. Right Side of the Core

7.3 Internal Pioneer LX Core Connections

The following connections are for internal use by the robot system, and not normally available for the user. They are listed here so that you can reconnect them in the event that they need to be disconnected for parts replacement.

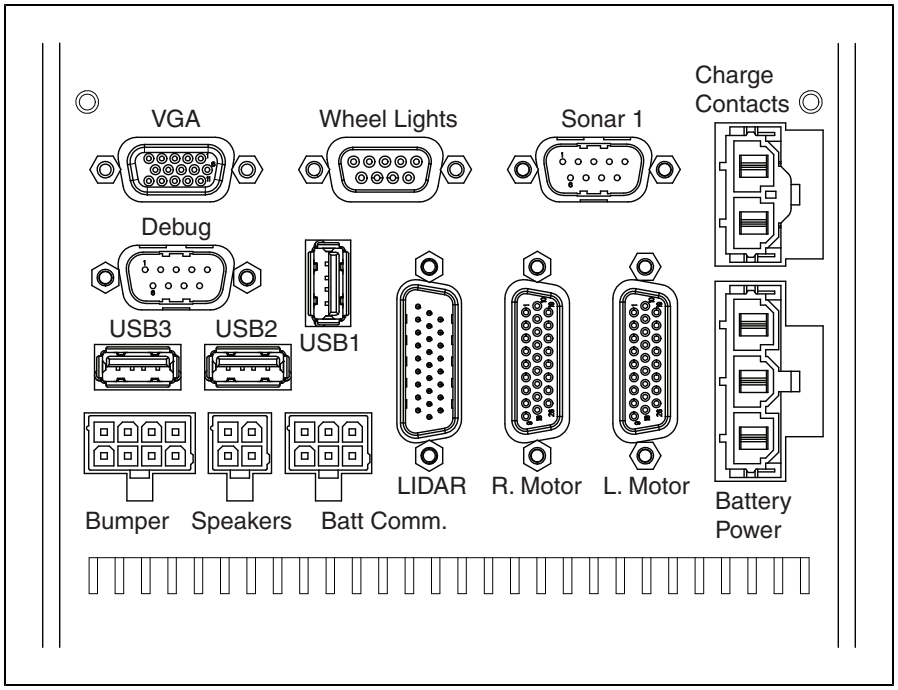


Figure 7-8. Internal Connectors on the MTX-Lynx Core (Front)

Connection	Type	Description
Wheel Lights	DB9F	Motion and status indicator light discs on the platform sides
Sonar #1	DB9M	Connection to sonar module and bumpers
Sonar #2	DB9M	Reserved for future accessories
Aux Sensors		Reserved for future accessories
Charge Contacts	Mini-Fit Sr., 2-pin	For docking station. Located underneath robot at rear.
Debug	DB9M	Reserved
LIDAR	HDB26M	Laser Rangefinder
Right Motor	HDB26F	**NOTE**:The Right and Left Motor connectors use the same type of plug. Take care not to reverse them.
Left Motor	HDB26F	
Battery Power	Mini-Fit Sr., 3-pin	Battery VDC; connects to battery
Bumper Switches	Mini-Fit 2 x 4	Connect to standard bumper contacts
Speakers	Mini-Fit 2 x 2	Drives built-in speakers
Battery Comm.	Mini-Fit 2 x 3	Battery communication/control

Lynx Internal Data Pinouts

Wheel Lights (Light Discs)

Connector type DB9F

Use Motion and status indicator light discs on the platform sides

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1, 2	CANL_A		CAN Communication differential pair
3, 4	GND		Direct GND
5	SHIELD GND		Bead filter to GND
6, 7	CANH_A		CAN Communication differential pair
8, 9	SW_12V_WHEEL	WheelLight_Power	12 V @ 1 A Max (switched in SW)

NOTE: Sonar 1 is covered at the end of Core, Upper Rear.

Laser Rangefinder

Connector type DB26M

Use Front laser rangefinder

The laser rangefinder data communications interface to the embedded computer for Linux is /dev/ttyUSB4. See Programming on page 49for more information on connecting with software.

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1	RS422_LIDAR_RX+		
2	RS422_LIDAR_RX-		
3	OSSD1		
4	OSSD2		
5	WF_OUT		
6	O3_OUT		
7	STANDBY		
8	EDM		
9	No Connection		
10, 18	SW_20V_LIDAR	Main_Laser_Power	Connections to Adept-Supplied LIDAR
11 thru 17	GND		
19	RS422_LIDAR_TX+		
20	RS422_LIDAR_TX-		
21	IN_A1		
22	IN_A2		
23	IN_B1		
24	IN_B2		
25	IN_C1		
26	IN_C2		

Pin 10 + 18: Current < 600 mA

Pioneer LX Internal Power Pinouts

Bumper

Connection Mini-Fit® 4 x 2

Connector type DB9F

Use Front bumpers

Pin No.	Designation	Notes
1	BUMPER_R2L	Right, Channel 2, Low
2	BUMPER_R1L	Right, Channel 1, Low
3	BUMPER_L2L	Left, Channel 2, Low
4	BUMPER_L1L	Left, Channel 1, Low
5	BUMPER_R2H	Right, Channel 2, High
6	BUMPER_R1H	Right, Channel 1, High
7	BUMPER_L2H	Left, Channel 2, High
8	BUMPER_L1H	Left, Channel 1, High

Speakers

Connector type Mini-Fit® 2 x 2

Use Speakers

Pin No.	Designation	Notes
1	RIGHT+	Right Speaker
2	RIGHT-	
3	LEFT+	Left Speaker
4	LEFT-	

Batt Comm.

Connector type Mini-Fit® 3 x 2

Use Battery control

The battery communications interface to the embedded computer on Linux is /dev/ttyUSB1. See Programming on page 49for more information on connecting with software.

Pin No.	Designation	Notes
1	GND	Connections to the Adept-Supplied Battery
2	RS232_BATT_RXD	
3	RS232_BATT_TXD	
4	FBAT_ALWAYS	
5	START_BUTTON	
6	OFF_BUTTON	

Sonar 1 & 2

Connector type DB9M

Use Platform sonar sensors

The sonar communications interfaces to the embedded computer on Linux are /dev/ttyUSB2 and /dev/ttyUSB3.

	Designation	
Pin No.	Hardware	Software Identifier
1, 4, 8	No Connection	
2	RS422_SNR_RX+	
3	RS422_SNR_TX+	
5	GND	
6	RS422_SNR_RX-	
7	RS422_SNR_TX-	
9	SW_12V_SNR	Sonar_1_Power, Sonar_2_Power

Aux Sensors

Connector type HDB15M

Use Reserved for future accessories

Pin No.	Designation	Notes
1	AUXS_A_TXD	
2	AUXS_B_TXD	
3	AUXS_C_TXD	
4	5V_SW1	5 V @ 1 A,shared with USB port 1
5, 10	SW_20V_A	20 V @ 300 mA
6, 7, 8	GND	
9	5V_SW2	5 V @ 1 A, shared with USB port 2
11	AUXS_A_RXD	
12	AUXS_B_RXD	
13	AUXS_C_RXD	
14	5V_SW3	5 V @ 1 A, shared with USB port 3
15	SW_20V_C	20 V @ 150 mA

Chapter 8: Maintenance

This chapter covers periodic maintenance and user-serviceable parts replacement for the Pioneer LX and the charging station.

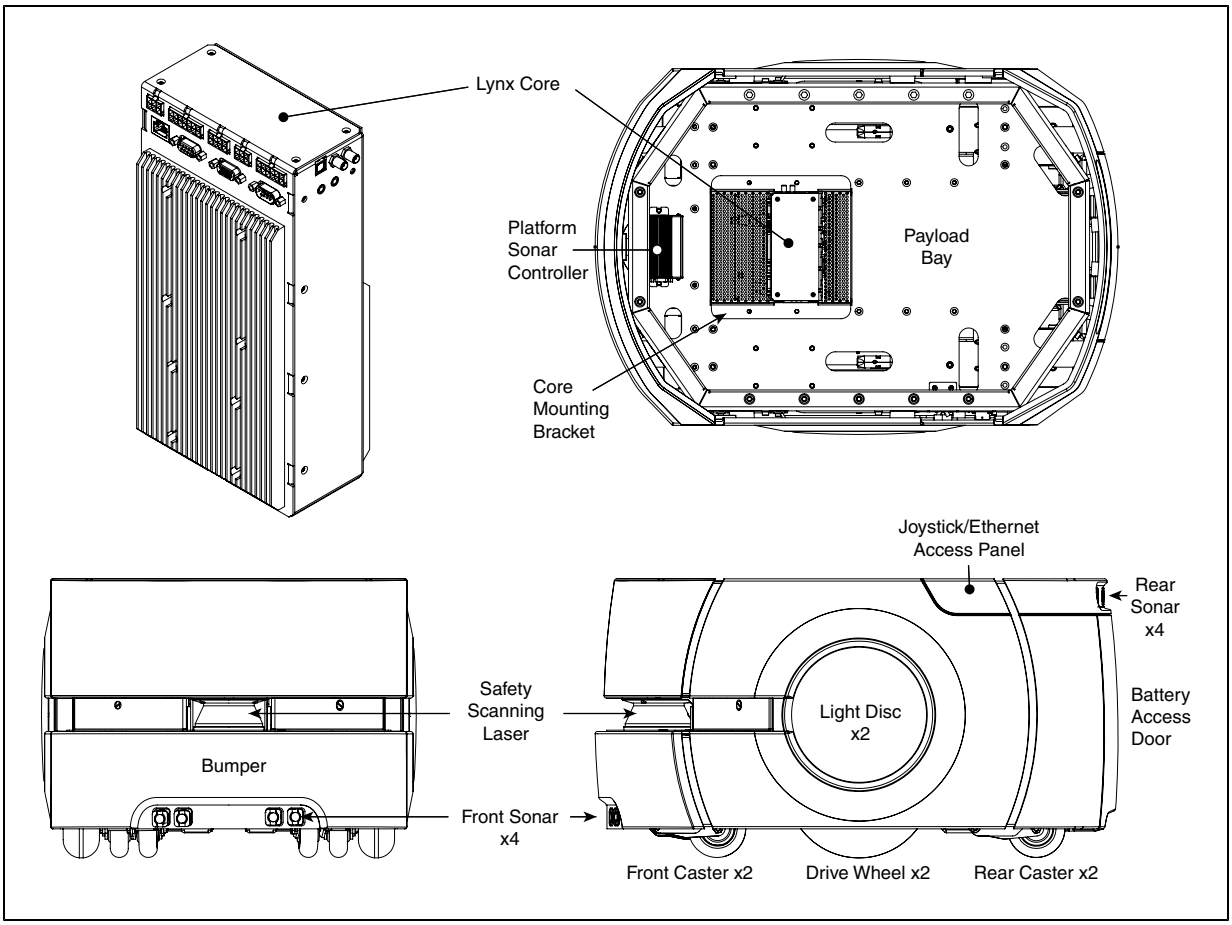


Figure 8-1. Location of Parts on the Platform

8.1 Safety Aspects While Performing Maintenance

DANGER: During maintenance and repair, the power to the charging station must be turned off. Remove and lock up the power cord to prevent unauthorized third parties from turning on power. The access covers on the charging station are not interlocked.

DANGER: Only skilled or instructed persons, as defined in the *Adept Robot Safety Guide*, should perform the procedures and replacement of parts covered in this section.

DANGER: During maintenance and repair of the platform, disconnect the battery as soon as possible. Avoid shorting the terminals of the battery.

8.2 Periodic Maintenance Schedule

The drive motors and gearbox are sealed and permanently lubricated, so they do not require periodic maintenance.

Cleaning

The following table gives a summary of cleaning procedures for the Pioneer LX.

Table 8-1. Cleaning

Item	Period	Reference
Clean charging station contacts	3 months	Charging Station Contacts on page 85
Clean axles and tires	As needed	Tires on page 84
Clean laser rangefinder lens - wipe clean	6 months/ as needed	Lasers on page 85

NOTE: The frequency of these procedures will depend on your particular system, its operating environment, and the amount of usage. Operating in an environment with a lot of dust or dirt will require more frequent cleaning. Use the intervals in this section as guidelines, and modify the schedule as needed.

Tires

Occasionally clean the tires with a mild soapy solution. Remove any dirt or debris that may accumulate on the tires, because these can degrade the robot's performance.

This applies to both the drive wheels and to the casters.

Axles

Keep the axles free of carpet, hair, string, or anything that may wrap around and bind up the platform's drive.

Lasers

Occasionally clean the lenses of the laser rangefinder and the vertical lasers, if used. Use only alcohol-based, non-abrasive cleaners, and wipe thoroughly.

Charging Station Contacts

The two charging station contacts occasionally need to be cleaned. The suggested interval is 3 – 6 months, depending on frequency of charging.

WARNING: Unplug power from the charging station before starting.

Remove the power cord at the charger.

Clean the contacts with isopropyl alcohol.

CAUTION: Do not lubricate the charging station paddle. Lubrication will reduce the life of the paddle.

8.3 Removing and Installing Covers

Many of the maintenance procedures require removing some of the platform's covers. Most covers are held in place with just magnets. The rear cover has an additional brace for support, the bumper cover uses screws and magnets, and the access panel uses a push-push latch.

CAUTION: Pinch hazard. The magnets holding the covers in place are strong enough to pinch you if you are not careful.

NOTE: In general, it is better to install the payload first, and then the covers.

The covers are:

- Rear Inner (Battery)
- Access Panel
- Left Side

  Both side covers include a light disc and cover.
- Right Side

- Front Upper
- Bumper
- Rear Outer

With the exception of the bumper cover, no tools are needed for either the removal or installation of the covers.

Cover Removal

NOTE: After removing covers, place them inner-side down, so the outer surfaces don't get scratched.

The covers can be removed in the order in which they are listed above.

- The rear outer must wait for the rear inner and the two side covers.
- The front upper must wait for the two side covers.
- The two sides, the rear inner, and the bumper cover can all be removed without removing any other covers, except that the left cover must wait for the access panel.

NOTE: The light disc covers are not covered here because they are only removed from the side covers to replace one of the light disc controllers.

Rear Inner Cover (Battery)

This provides access to the battery compartment door.

1. Pull the bottom of the cover away from the platform chassis.

   This is easiest if you grip it with two hands, toward the center.

2. Lower the cover down, so its top tab clears the rear outer cover.

Joystick and External Ethernet Port Access Panel

This provides access to the Maintenance Ethernet and the Joystick ports.

1. Push the left (front) side of the panel in, and the latch will release it.

   Pushing the panel a second time will reattach it to the platform.

2. Pull the left side out, and slide the panel to the left.

   The panel is attached with a lanyard, to prevent getting lost.

You will need to place this panel out of the way when removing the left side cover.

Side Covers

1. For the left side cover, put the access panel out of the way.
2. Pull the bottom of the cover, near both sides, away from the chassis.
3. Work your way up the edges of the cover, pulling it away from the chassis as you go.

4. Remove the cover a few inches from the chassis.

   The light disc wires plug into connectors on the inner side of each side cover.

5. Unplug the light disc connector, and move the side cover away from the platform.

Repeat for the other side cover.

Front Upper Cover

This cover is held onto the chassis the most tightly of any of the covers.

1. Grip the cover at the two outer edges.
2. Pry the cover away from the chassis.

Bumper Cover

This is the only cover that requires tools to remove.

1. Remove the screws at the sides of the cover.

   Retain the screws for installing the new bumper cover.

2. Pull the cover off of the bumper.

   It is held on with magnets, as well as screws.

Rear Outer Cover

This cover houses the four rear sonar units, which must be disconnected once the cover is part-way off the chassis.

1. Pull the top of the cover away from the chassis a few inches.

   The cover will pivot on the metal brace at its bottom edge.

2. Pull the four sonar wires, with their connectors, out of the chassis holes.

   Refer to the following two figures.

Figure 8-2. Sonar Leads, with Connectors Still in Chassis

3. Unscrew all four sonar connectors.

   Ensure that both sides of all connectors are labeled, and match. If not, label them.

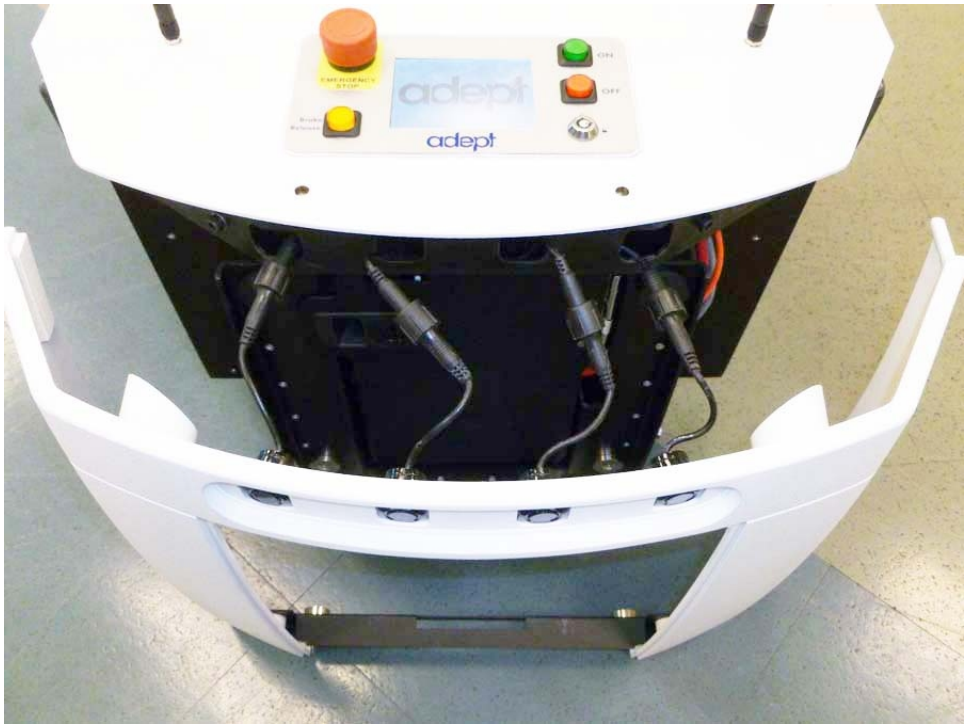


Figure 8-3. Sonar Connectors, with Connectors Exposed

4. Tilt the cover down to about 45°, and slide the brace on the bottom of the cover out of

its clip.

This will separate two pairs of magnets, so you will feel some resistance at first.

Cover Installation

The covers can be installed in the reverse of the order in which they are listed above.

- The front upper and rear outer covers must be installed first and second.
- The access panel must wait for the left side cover.

Bumper Cover

This is the only cover that requires tools to install.

1. Place the cover on the bumper.

   It is held on with magnets, as well as screws.

2. Install the screws, removed during the cover removal, at the sides of the cover.

Front Upper Cover

1. Grip the cover at the two outer edges.
2. Align the bottom edge of the cover so it slides under the chassis support.
3. Tilt the top of the cover into position.

Rear Outer Cover

This cover houses the four rear sonar units, which must be reconnected once the metal brace across the bottom is in the clip just below the battery access hole.

1. Slide the metal brace into the clip in the chassis.

   Watch the two magnets on the bottom of the cover, to align them with their mating magnets on the chassis. This is your best guide for getting this cover in its proper place.

   These are inboard of the clip holding the brace, so you will have to look on each side of the cover to check their alignment.

2. When the magnets at the bottom are lined up, tilt the cover up to within a few inches of the chassis.
3. Pull the sonar connectors out of the chassis, if they are not already out.
4. Screw the four sonar connectors to their corresponding sonar leads.

   Ensure that the labels for the connectors and leads match.

5. Tuck the connectors into the four holes in the chassis, until just an inch of sonar lead is sticking out.
6. Tilt the top of the cover up to meet the chassis.

Side Covers

1. Move the cover to within a few inches of the chassis, and plug in the light disc connector.

   The light disc is connected to a connector, accessible on the inner side of the side cover.

2. Place the top edge of the cover on the chassis, so the magnets hold it there.

   Make sure the gaps on each side of the cover are the same width.

3. Tilt the bottom edge of the cover down.

4. Check each side of the cover to ensure that the cover edges on each side of the gap stick out the same amount away from the chassis.

   This is most likely to be uneven near the top of the cover.

5. If either edge sticks out more than the neighboring cover, pull the neighboring cover away from the side cover slightly, and release.

   This should allow the side cover to snap into place, so both sides of the gap stick out the same amount.

Repeat for the other side cover.

Figure 8-4. Right Side Cover, Showing Even Gaps at Edges

NOTE: The gaps between the side covers and the bumper cover will be smaller than the other gaps, and will not be even.

Access Panel

1. Slide the panel to the right, so its tab goes under the left side cover.

   The panel is attached with a lanyard, to prevent getting lost.

2. Press the left (front) side of the panel in, and the latch will hold it.

   This is a toggle latch - pressing it once engages it, pressing it a second time releases it.

Rear Inner Cover (Battery)

1. Slide the cover up, so its top tab fits under the rear outer cover.

CAUTION: Pinch hazard. This cover is the most likely to pinch you if you are not careful, particularly at its bottom edge. Hold the cover at the bottom, in the center, with two hands.

2. Holding the cover near the center, with both hands, tilt the bottom of the cover down, towards the platform chassis.

8.4 Replacing Periodic Parts

Battery

The battery is expected to last for approximately 7 years of 16 hours/day, 5 days/week. Life expectancy for 19/7 is 4 years. (19 hours/day is full-time, with time-out to recharge.)

NOTE: There are no serviceable parts inside the battery case. Do not open it.

WARNING: Replace the battery only with an Adept battery.

Dispose of the battery according to all local and national environmental regulations regarding electronic components. Refer to:
http://www.adept.com, under Contacts.

DANGER: Follow appropriate ESD procedures during the removal/replacement phases.

Before removing or installing a battery, remove the rear inner platform cover. Refer to Removing and Installing Covers on page 85.

Removal

WARNING: The battery is heavy (20 kg/44 lbs). Observe safe lifting practices when removing or installing the battery.

1. Unlatch and open the battery compartment door, at the back of the platform.

   The battery compartment door is capable of being locked. You may need to unlock it before opening.

2. Disconnect the power and data cables before removing the battery.

   See the following figure.

Figure 8-5. Battery Cable Connectors

3. Slide the battery back and out of the platform.

   There is a hand grip at the front and the rear of the battery, to help you lift it.

Installation

Refer to Removing and Installing Covers in the Maintenance section for cover removal and installation.

1. Remove the inner rear platform cover.
2. Unlatch and open the battery compartment door, at the back of the platform.

   The battery compartment door is capable of being locked. You may need to unlock it.

Figure 8-6. Battery Compartment Door (keys are zip-tied for shipping)

3. Lift and slide the new battery into the platform body.

   The battery weighs 20 kg (44 lbs).

   There are recesses at the front and the back of the battery, to aid in lifting it.

Figure 8-7. Battery Recesses, for Gripping

The battery is designed to be lifted and replaced by one person, using one hand in each of the grips, as shown in the following figure.

Figure 8-8. Lifting the Battery

The connectors for power and data go toward the rear of the platform.

4. Attach the battery power and data cables to the connectors at the rear of the battery.
5. Close the battery compartment door to secure the battery in place.

   The battery compartment is designed to hold the battery tightly, so that it will not move within the compartment, once the door is closed.
6. Reinstall the inner rear platform cover.

8.5 Replacing Non-Periodic Parts

All of the following parts are replaced on an as-needed basis.

Charging Station Roller and Bearing

The roller, which guides the robot onto the charging station, may be subject to wear after extended use. The time to replace the roller should be based on your visual inspection and judgement of when it is too worn. Adept does not specify a quantitative measure for this.

Refer to the following figure for the location of the roller.

WARNING: Unplug power from the charging station before starting.

Remove the power cord at the charger.

The roller is held to the charging station with a shoulder bolt.

1. Remove the shoulder bolt from the center of the roller. Retain the shoulder bolt.
2. Remove the roller and bearing from the charging station.
3. Install the new roller and bearing, using the retained shoulder bolt.

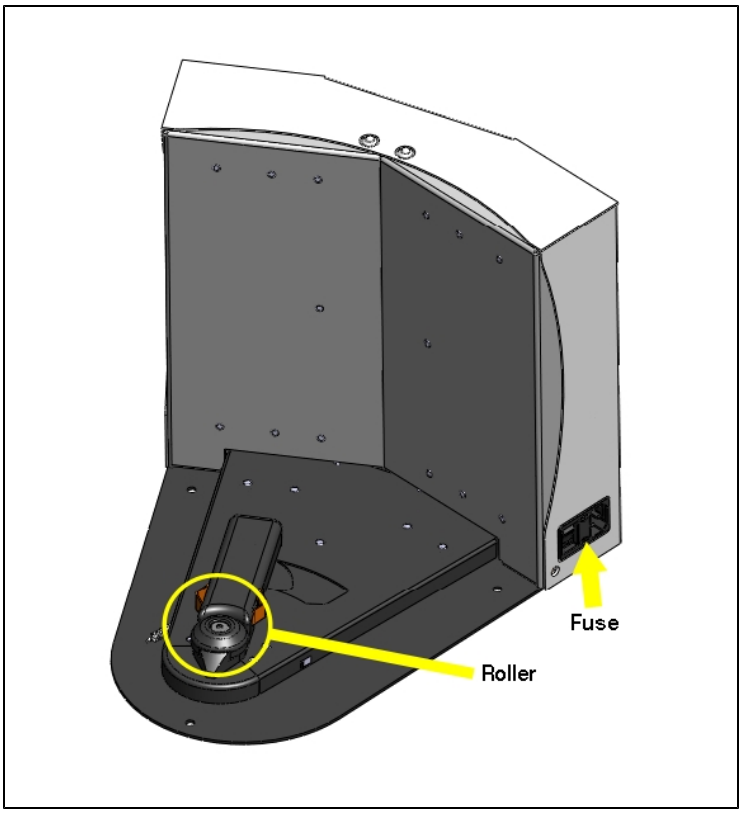


Figure 8-9. Charging Station Roller and Fuse Locations

Charging Station AC Power Fuse

The only user-serviceable fuses are in the charging station. The two external AC fuses are located between the power switch and the AC power plug.

Symptoms: When the charging station is switched on, the blue power light does not come on. (Verify that the unit is plugged into AC power.)

WARNING: Unplug power from the charging station before starting.

Remove the power cord at the charger.

The fuse assembly can be removed by squeezing the two tabs toward each other, and pulling it away from the charging station. The fuses are p/n 04563-000. See the following figure.

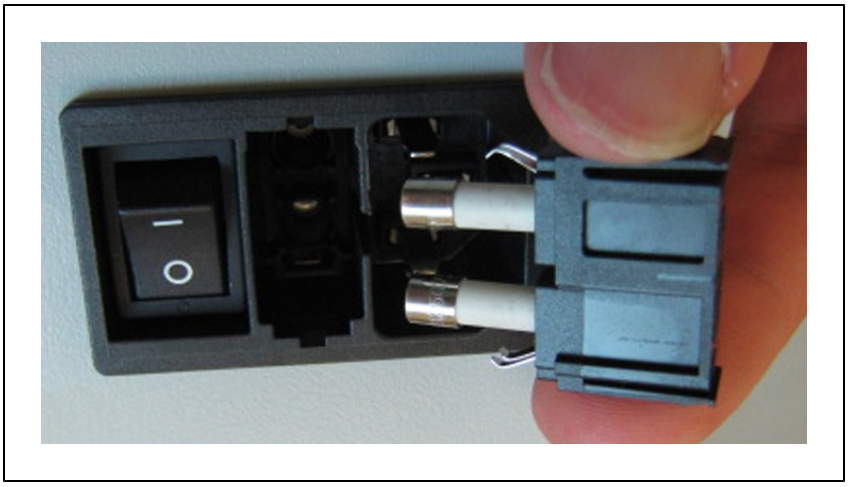


Figure 8-10. Charging Station Fuse

Charging Station Internal Fuse

Symptoms: When the charging station is switched on, the blue power light does not come on, but the charging station can charge a battery manually.

WARNING: Unplug power from the charging station before starting.

The charging station cover is NOT interlocked. Remove the power cord at the charger.

1. Remove the ten screws from the back cover of the charging station.

   Two of these are on the sides, near the bottom.

Figure 8-11. Charging Station Rear Cover Screws (8 of 10)

Retain the screws for reassembly.

2. Remove the rear cover of the charging station.
3. Locate the in-line fuse.

   It will be near the top of the charging station, just to the right of the central terminal bar.
4. Remove the old fuse, and replace it with a new fuse.

   The fuse is p/n 13091-000.
5. Replace the charging station rear cover, and secure with the ten screws previously removed.

Rear Sonar Units

The platform's four rear sonar units can be replaced individually.

1. Remove the inner and outer rear covers from the platform. Refer to Removing and Installing Covers on page 85.
2. Unscrew the connection between the sonar cable and the sonar unit's lead.

   Ensure that both the connectors and leads are labeled, and match. If not, label them.
3. Compress the two flat springs holding the sonar unit, and remove it from the cover.
4. Press the new sonar unit through the hole in the rear outer cover, from the outside.
5. Connect the sonar cable to the new sonar unit's lead.
6. Reinstall the rear covers.

Front Sonar Units

The front sonar units are housed in the bumper. They can be replaced, individually, without removing the bumper or its cover. No tools are required for this replacement.

1. Reach under the bumper cover, and compress the two flat springs holding the sonar unit.

   Push it out of the bumper cover, away from the chassis, to remove it from the cover.
2. Unscrew the connection between the sonar cable and the sonar unit's lead.

   Ensure that both the connector and lead are labeled, and match. If not, label them.
3. Connect the sonar cable to the new sonar unit's lead.
4. Tuck the cable and lead through the sonar unit's hole in the bumper cover, and press the new sonar unit through the hole, from the outside.

Sonar Controller

The sonar controller is located in the payload bay. One is used for the standard front/rear sonar.

- The controller is plugged into the Sonar 1 connector on the Core. This connector is not accessible from the payload bay, but does not need to be unplugged for this procedure.
- The controller will be at the very front of the payload bay, screwed into the payload bay

deck with two screws.

1. Unscrew the controller from the payload bay deck by removing two screws.

   Retain the screws for mounting the replacement controller.

2. Unplug the larger cable from the sonar controller.

   Be careful not to let the cable end slip into the chassis.

3. Unplug the eight sonar unit cables from the controller.

   These are the smaller cables that go to the individual sonar units.

   Make sure these are labeled and tied up, so they can't slip into the chassis.

4. Remove the controller from the payload bay, and replace it with the new one.

5. Connect the eight sonar unit cables to the new controller.

   Ensure that the cable labels match the controller labels.

6. Plug the larger cable into the new controller.

7. Screw the new controller to the payload bay deck, using the two screws removed from the old controller.

Light Discs

The two light disc assemblies and their controllers are single units, so replacing a controller also replaces all of the lights on that side of the platform.

1. Remove the side cover, on the side that needs the light disc assembly replaced.

   Refer to Removing and Installing Covers on page 85.

2. Unscrew the four screws holding the light disc PCA to the side cover.

   Retain the screws and round cover for installing the new assembly.

3. Remove the light disc PCA.

4. Screw the new assembly and retained round cover to the side cover, using the screws retained from the old assembly. The PCA is keyed so that it can only be installed in one orientation.

5. Reinstall the side cover, connecting the cable to the new light disc PCA.

6. Dispose of the old light disc PCA according to local and national regulations concerning electronic components.

Operator Control Panel

The Operator control panel is normally located on the top plate, at the rear of the robot. You may move it if neccesary. It plugs into the "HMI Panel" connector on the Core. See **Payloads** on page 53 for more information on relocating the Operator control panel

Drive Assemblies

The platform drive assemblies have been designed to be field-replaceable. This will replace the drive motor, gearbox, encoder, and wheel/tire assembly.

Removal

1. Remove the inner rear cover.
2. Unlatch and open the battery compartment door, at the back of the platform.

   The battery compartment door is capable of being locked. You may need to unlock it before opening.
3. Disconnect battery power by unplugging the two cables at the rear of the battery.
4. Remove the side cover a small distance from the platform on the side where you want to replace the drive assembly. Refer to Removing and Installing Covers on page 85.

   The light disc PCA cable will still be attached.
5. Disconnect the cable from the light disc PCA, so the side cover can be moved completely away from the platform.

   This will expose the drive assembly.
6. Lift the drive wheel up, compressing its springs, enough so that you can insert a Ø6 x 10 mm (Ø0.24 x 0.4 in.) pin into the hole on the rear side of the assembly (there is a hole on each side). This will keep the springs compressed (the wheel will be in the up position), and make removal easier. An M5 x 10 screw works well for this.

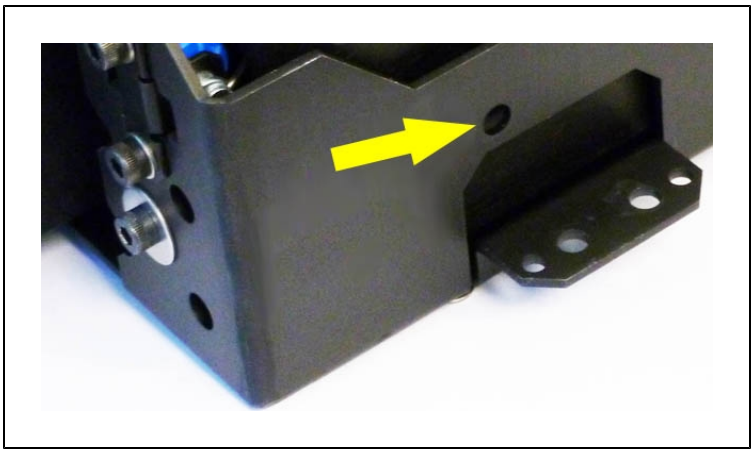


Figure 8-12. Spring-Compression Hole

7. The drive assembly is held in place with three nuts on studs across the top, and two sets of two screws at each side, near the bottom of the assembly.

   Remove the three nuts and four screws (and their washers) holding the drive assembly to the platform.

   Retain these nuts, screws, and washers for attaching the new drive assembly.

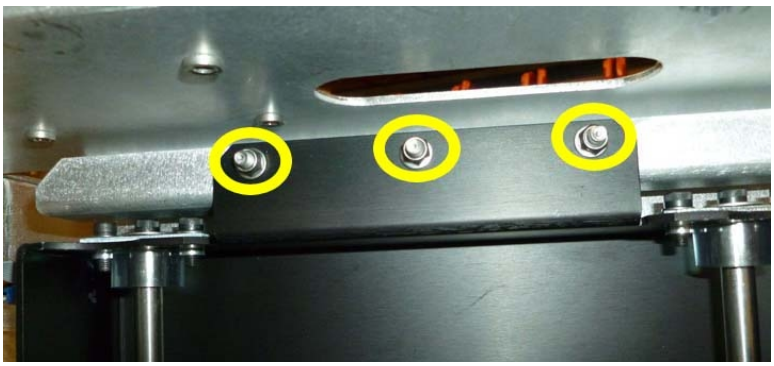


Figure 8-13. Mounting Studs and Nuts at top of Drive Assembly

Figure 8-14. Mounting Screws at Bottom-Right of Drive Assembly

8. Remove the drive assembly from the platform.

   The motor cable to the Core will still be attached.

9. Disconnect the motor cable at the drive assembly.

Installation

1. Compress the springs of the new drive assembly by pushing the drive wheel up. When it is in the up position, insert a Ø6 x 10 mm (Ø0.24 x 0.4 in.) pin into the rear hole on the side of the assembly. There is a hole on each side.

   NOTE: Make sure that the pin is short enough so that you can pull it out after the assembly is in place. An M5 x 10 screw works well for this.

2. Connect the motor cable to the new drive assembly.

3. Install the new drive assembly over the three studs at the top of its bracket.

4. Attach the drive assembly to the chassis with three nuts at the top, and two screws at each side, near the bottom.

   Use the nuts, screws, and washers you removed from the old drive assembly.

5. Remove the pin or screw you used to hold the wheel in the up position.

6. Put the side cover next to the platform, and attach the light disc cable to the light disc PCA.

7. Reinstall the side cover.

8. Connect the battery power and data cables, and close the battery compartment door.

9. Reinstall the rear cover.

Front or Rear Casters

All four casters are identical, and are mounted to the platform in the same way.

> **NOTE**: If you have a means to lift the chassis of the platform enough to access the screws that hold on the caster, you can avoid removing the payload and the battery, which are only necessary to tilt the platform on its side.

1. Move the payload out of the way.

   If the payload can be completely removed, do so. This step is to enable you to tip the Pioneer LX on its side, so you have access to the casters underneath.

2. Remove the inner rear cover.

3. Unlatch and open the battery compartment door, at the back of the platform.

   The battery compartment door is capable of being locked. You may need to unlock it before opening.

4. Disconnect the battery by unplugging the two cables at the rear of the battery.

5. Remove the battery from the platform.

6. Remove the side covers.

7. Lay the body of the platform on its side, exposing the casters.

8. Remove the four screws and washers holding the caster to the platform.

   Retain these screws and washers for attaching the new caster.

Figure 8-15. Rear Caster, Two Screws and Washers

9. Remove the caster from the platform.
10. Put the new caster in place, and attach with the four screws and washers you removed from the old caster.
11. Return the platform to its upright position.
12. Reinstall the battery, connect the power and data cables, and close the battery compartment door.
13. Reinstall the inner rear cover.
14. Reinstall the side covers.
15. Reinstall the payload.

Laser Rangefinder

1. While supporting the laser, unscrew the two screws and washers from the bracket holding the laser, to remove the laser from the platform chassis.

   Retain these screws and washers for installing the new laser.
2. Unscrew the four screws holding the black plate on top of the laser.

   Retain the four screws for reassembly.

   You will use this top cap on the new laser. Do not unplug it from the platform chassis.

Figure 8-16. Top of Laser Rangefinder

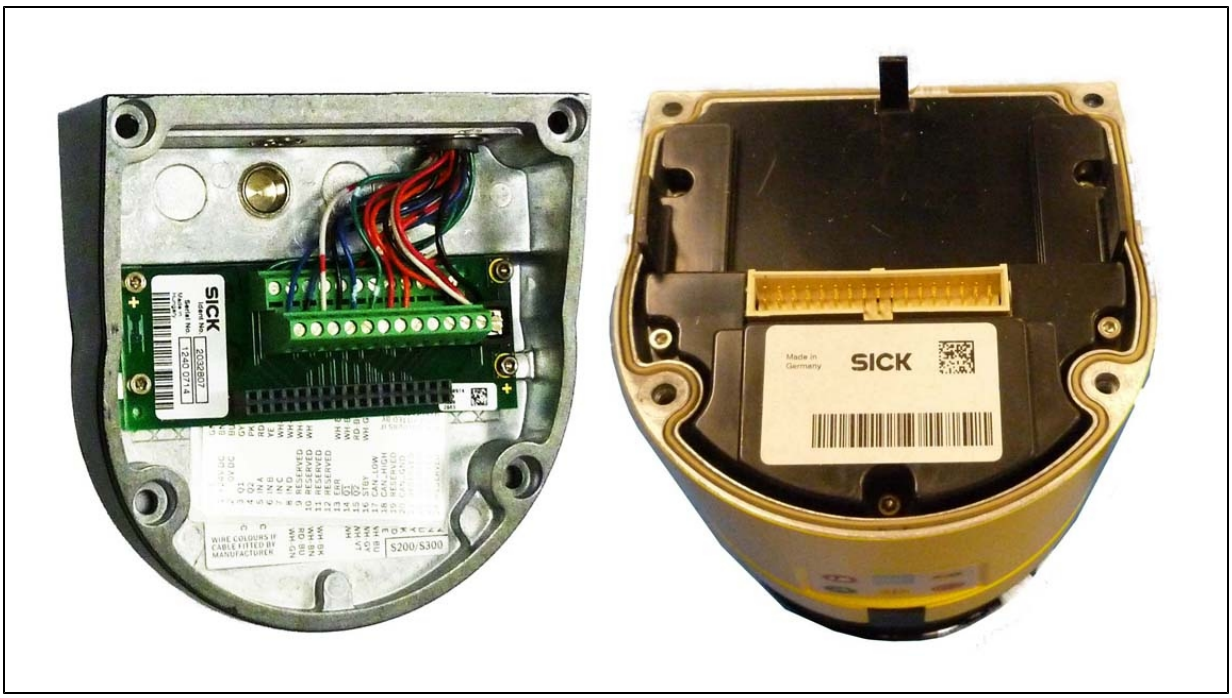


Figure 8-17. Connectors Inside Laser Cap

The underside of this plate has a connector that makes an electrical connection with a mating connector inside the laser.

3. Put the existing laser top onto the top of the new laser.

   You will feel slight resistance as the two connectors plug into each other.

4. Connect the black top plate to the new laser, using the four retained screws.

5. Attach the laser to the chassis using the two screws and washers from the old laser.

   NOTE: The laser orientation can be adjusted. Be careful to mount the laser horizontal with respect to the floor.

Core

The MTX-Lynx Core is a sealed unit, with internal fans as the only moving parts.

1. Remove the inner rear cover. Unlatch and open the battery compartment door, at the rear of the platform. The battery compartment door is capable of being locked. You may need to unlock it.

2. Disconnect the battery power and data cables from the rear of the battery.

3. Disconnect all of the cables that are attached to the top portion of the Core.

   Refer to MTX Core User Connections on page 61.

4. Remove the core mounting bracket from around the Core.

This is two pieces, held in place with four screws down into the chassis, with four more going sideways into the Core itself. Retain all of these screws for installing the new Core.

See the following figure:

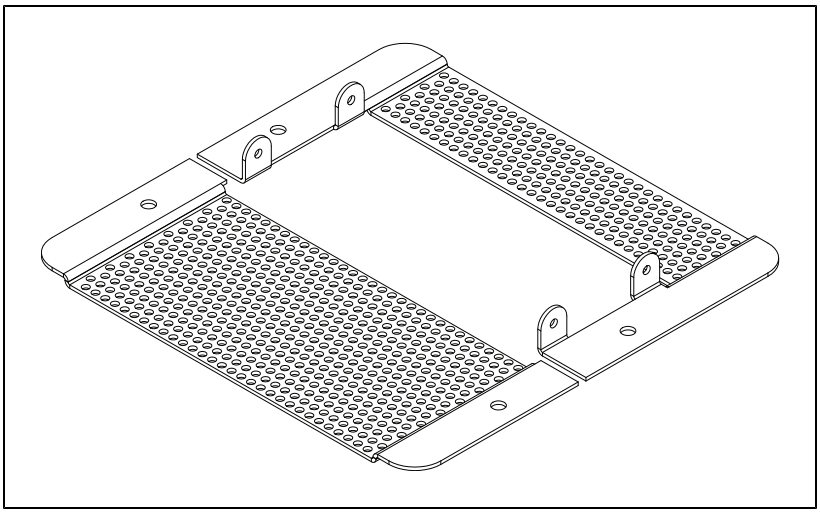


Figure 8-18. Core Mounting Bracket

5. Remove the Sonar 1 cable from the core.

   This cable is too short to allow the core to be lifted, until the cable is removed.

6. Gently lift the Core up, until you have access to the internal connections.

7. Remove all of the cables that are attached to the internal Core connector panel.

   The Left Motor and Right Motor connectors use the same type of plug, and can be inadvertently reversed. Ensure that you can identify the left from the right.

   See Internal Pioneer LX Core Connections on page 75.

8. Remove the old Core.

9. Connect all of the cables that were attached to the internal Core connector panel to the new core internal connector panel. See Figure 7-8.

   Wait until after the next step to reconnect the Sonar 1 cable.

10. Put the core into the chassis.

11. Connect the Sonar 1 cable to the core.

12. Install the core mounting brackets around the new Core.

    Using the screws and washers you removed from the old core, put four screws into the sides of the Core, with four more going down into the platform chassis.

13. Reconnect all of the cables to the top portion of the Core.

    Refer to MTX Core User Connections on page 61.

14. Reconnect the battery power and data cables to the battery.

15. Close and latch the battery compartment door.
16. Reinstall the inner rear cover.
17. Reinstall the payload.
18. Dispose of the old core according to local and national regulations concerning electronic components.

8.6 Spare Parts List

Contact support@mobilerobots.com for information on ordering spare parts. Include the serial number of your robot.

Part Number	Description
Bundles, Major Components	
12907-000	Assembly, Joystick
	Assembly, Pioneer LX Hinged Top Plate
Charging Station, Docking	
12477-000	Charging Station (Dock)
13091-000	Fuse, 1 A, 3AG (¼ x 1¼), Internal Charging Station fuse
04563-000	Fuse, 8 A, 5 x 20 mm, External Charging Station fuses, x 2
12438-000	Fuse Drawer, 5 x 20 mm, Charging Station power entry side
12416-000	Roller, Charging Station
12417-000	Contact, Paddle, Charging Station (x 2)
12872-000	Assembly, Frame, Docking Funnel
Covers, Latches, Body	
MCH2181	Pioneer LX Equipment Mounting Deck
AMRPLX-12804-100	Cover: bumper (lower front)
AMRPLX-12804-200	Cover: front (upper front)
12804-350	Cover: Right panel + light disc
12804-450	Cover: Left panel + light disc
12804-600	Cover: Hatch (Access Panel to Maint. Ethernet, Joystick)
12855-000	Push Latch, 3 kg retaining force, Black (Access Panel latch)
AMRPLX-12804-700	Cover: Rear
AMRPLX-12804-800	Cover: Battery door
12168-000	Latch, locking, flush, ABS Battery latch (contains the key)
Operator Panel	

Part Number	Description
12800-000	Assembly, HMI Panel
12410-000	Push Button, Green, Panel Mount, Round
12411-000	Push Button, Red, Panel Mount, Round
12412-000	Push Button, Yellow, Panel Mount, Round
12413-000	Switch, Keylock, 2 Keypull Positions, 90° (contains HMI key)
Sonar, Laser	
11711-000	Assembly, Sonar Controller
11714-000	Sensor, Piezo Ultrasonic,40 KHz, with Cable (Sonar Units x 8)
12170-000	Safety Laser, S300, Expert, 270 Degree
12718-000L	Cable, SICK LIDAR Laser
Suspension, Drive, and Battery	
12745-000	Assembly, Right Drive Train
12746-000	Assembly, Left Drive Train
12072-000	Assembly, Battery
12150-000	Casters, Shock Absorbing, Absorbing Pad 87, Shore A
Miscellaneous	
12330-000	Speaker, 3.5 in., 80 W
12312-000	Micro Switch, Positive Opening Contacts (Front Bumper x 4)
12730-000L	Jumper, User ESTOP

Chapter 9: Technical Specifications

9.1 Dimension Drawings

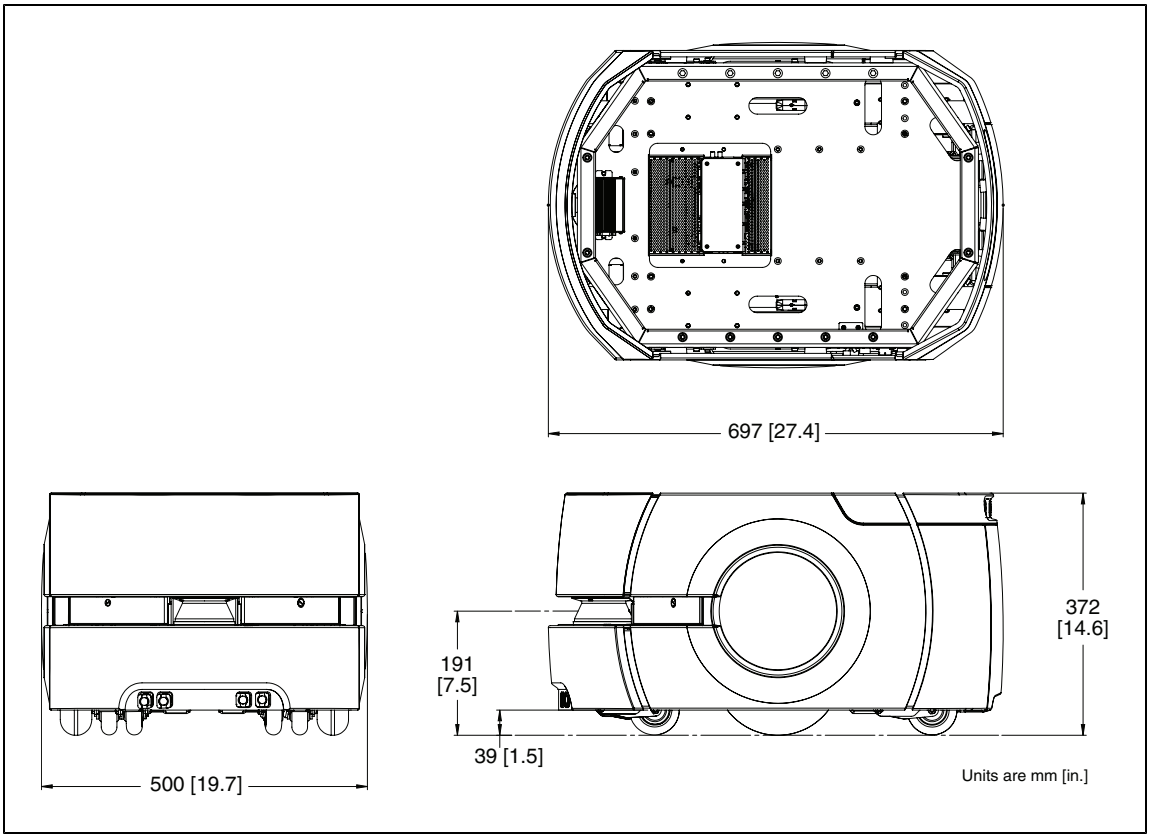


Figure 9-1. Pioneer LX Top, Side, and Front Dimensions

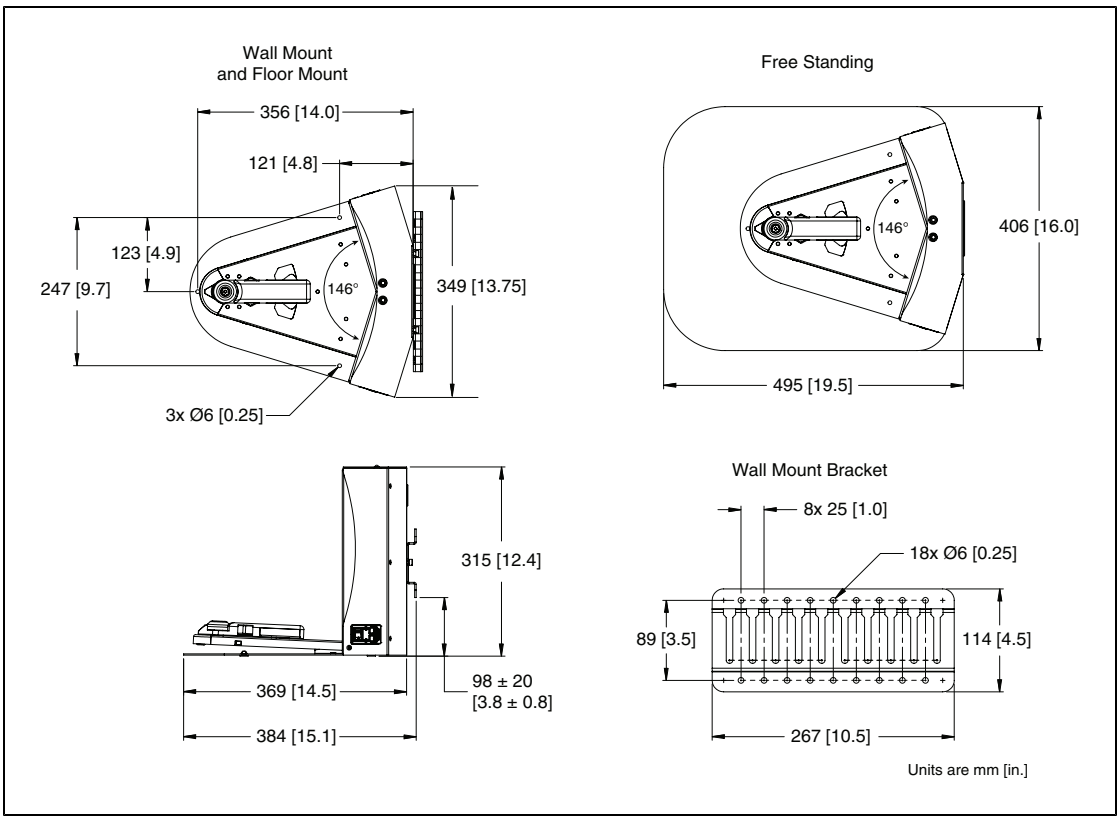


Figure 9-2. Charging Station Dimensions

9.2 Platform Specifications

Description	Specification
Physical - platform only	
Length	686 mm (27 in.)
Width	483 mm (19.0 in.)
Height (body)	371 mm (14.6 in.)
Body clearance	38 mm (1.5 in.)
Weight (with battery)	60 kg (132 lb)
Rating	
IP Rating	IP-40
Cleanroom rating	Fed Class 100, ISO Class 5
Drive Train	
Drive wheels	2 grey non-marking foam-filled rubber
Wheel diameter	200 x 50 mm (7.9 x 2.0 in.) nominal)

Description	Specification
Passive Casters	2 front, 2 rear, spring-loaded
Brakes	2 (one each axle)
Steering	Differential
Gear ratio	30:1

Description	Specification
Performance	
Max payload weight – level	60 kg (132 lb)
Swing radius	343 mm (13.5 in.)
Turn radius	0 mm
Translational speed, max	1800 mm/sec (67 in./sec)
Rotational speed, max	300 degrees/sec
Traversable step, max	15 mm (0.6 in.)
Traversable gap, max	15 mm (0.6 in.)
Climb grade	1:12
Traversable terrain	All wheelchair accessible
Battery	
Run-time	13 hours, approx., no payload
Duty cycle	80%
Weight	20 kg (44 lb)
Voltage	22 - 30 VDC
Capacity	60 Ah
Energy	1.5 kWh nominal
Recharge time	3.5 hours, approx.
Life span	7 years, approx., 16 hrs/day, 5 days/wk 4 years, approx., 19/7 (full-time)
Sensors	
Laser Rangefinder	1 at front of platform, 191 mm (7.5 in.) height 250°, 15 M range, Class 1, eye-safe PLd Safety per ISO-13849
Sonar	2 sensors (transmit, receive pair) at rear of platform.

Description	Specification
	2 sensors (transmit, receive pair) at front of platform.
Position encoders	2 x 512 quadrature (one each wheel) 2 x Hall sensors Internally read by robot controller with gyroscrope to perform platfrom velocity control and compute position estimates.
Analog gyroscope (Core)	320 degree/sec max rotation Internally read by robot controller with encoders to compute position estimates.
Bumper	1 panel at front of platform, 2 pairs of sensors (left, right)

9.3 Charging Station Specifications

Description	Specification
Current	8 A 8 A fuse at power plug/switch
Contacts	2
Voltage	100 to 240 VAC, 50 to 60 Hz
Power consumption	800 W
Humidity	5 to 95% non-condensing
Temperature	5° to 40° C (41° to 104° F)
Dimensions - WxDxH with Floor plate	349 x 369 x 315 mm [13.75 x 14.5 x 12.4 in.] 495 x 495.5 x 317 mm [16 x 19.5 x 12.5 in.]
Weight	8.2 kg (18 lbs)
Mounting	Wall bracket, directly to floor, or on floor with floor plate
Indicators	Power on - blue Charging - yellow
Connector	For out-of-platform battery charging

Chapter 10: Communication Packet Protocol

All MobileRobots mobile robot controllers implement the same Pioneer protocol and are compatible. All versions of MARCOS firmware are backwards-compatible with previous versions.

The protocol is a bidirectional byte stream, in which sequences of byte packets represent individual commands (when sent from client software to the robot controller), or Server Information Packets, or SIPs or simply packets, (when sent from the robot controller back the client software). Packets consist of five main elements: a two-byte header, a one-byte count of the number of subsequent packet bytes, a one-byte command or packet type identifier followed by packet data, and finally a two-byte checksum.

10.1General Packet Format

Field	Size (bytes)	Value	Description
header	2	0xFA, 0xFB	Packet header; same for client and server
byte count	1	...	Number of command/argument bytes plus Checksum's two bytes, but not including Byte Count itself or the header bytes. Maximum of 249.
packet type or command identifier	1	0 - 255	Packet type or command identifier (see below for lists).
packet data	...	...	Packet or command data (if any)
checksum	2	...	Packet integrity checksum

Packet data is divided into one or more value fields. The meaning and sequence of fields are specific to each packet or command type. Each field has a data type which determines the size of that field (in bytes). Integer data values contained in a packet may be signed and unsigned, and are 16-bit (2-byte) integers, least-significant byte first. Single-byte values are one 8-bit byte. Strings may be either length-prefixed or NULL terminated (depending on packet type).

10.1 Packet Checksum

Calculate the client-server packet Checksum by successively adding data byte pairs (most-significant byte first) to a running checksum (initially zero), disregarding sign and overflow. If there are an odd number of data bytes, the last byte is XORed to the low-order byte of the checksum.

NOTE: The checksum integer is at the end of the packet, with its bytes in the reverse order of that used for data; that is, b_0 is the high byte and b_1 is the low byte.

```
// packetBuf is a character buffer char[] containing one data packet
// read from the robot

int i;
unsigned char n;
int c = 0;
i = 3;
n = packetBuf[2] - 2; // data length

while (n > 1)
```

```
{
    c += ((unsigned char)packetBuf[i]<<8) | (unsigned char)packetBuf[i+1];
    c = c & 0xffff;
    n -= 2;
    i += 2;
}

if (n > 0)
  c = c ^ (int)((unsigned char) packetBuf[i]);
```

ARIA automatically verifies packet checksums when receiving and parsing robot packets from the robot controller, and automatically provides correct checksums with client commands sent to the robto controller.

10.2 Server Information Packets

Once a client establishes a connection and sends the OPEN command, the robot controller automatically and periodically sends a set of Server Information Packets (SIPs) over the connection back to the connected software. The SIP period is 100ms (10Hz. One type of packet, the Standard SIP (also referred to just as "SIP", or as "Motors Packet"), is always sent. In addition to the Standard SIP, other types of information packets may be requested via client commands to include accessory or additional data. These packets are sent immediately before or after the Standard SIP. The Standard SIP has priority, it will be sent first on each cycle.

ARIA contains classes which serve as interfaces to the data received by these packets. See the ARIA reference documentation and examples for details.

10.3 Standard SIP contents

"byte" indicates a single byte value (usually unsigned). "int" indicates a signed 16-bit (2-byte) integer value (LSB). "uint" indicates an unsigned 16-bit (2-byte) integer value (LSB).

Some items in the SIP are provided by other MobileRobots platforms but are not relevant or implemented in Pioneer LX (these are shown in grey italic in the table below).

The standard SIP is automatically received and the data stored by ARIA's ArRobot class.

File	Size	Description	ARIA Function
Packet Header	2 bytes	Exactly 0xFA (250), 0xFB (251)	
Packet Byte Count	byte	Number of packet bytes that follow, which includes 2 bytes for checksum (does not include preceding header or this byte count)	
Packet Type	byte	0x32 when motors stopped or 0x33 when robot moving.	
XPOS	int	Estimated robot position coordinates (from 0,0 at robot startup) in millimeters (DistConvFactor[1] = 1.0).	ArRobot::getX(), ArRobot::getPose() with pose tranform applied. ArRobot::getRawEncoderPose() without transformation.
YPOS	int		ArRobot::getY(), ArRobot::getPose() with pose tranform applied.

[1] ARIA stores conversion factors in its robot parameter files for different types of robots in robot parameter files and automatically applies the conversion when SIP is received

File	Size	Description	ARIA Function
			ArRobot::getRawEncoderPose() without transformation.
THPOS	int	Orientation (theta) in angular units of 2π/4096 radians (AngleConvFactor[1] = 0.001534).	ArRobot::getTh(), ArRobot::getPose() with pose tranform applied. ArRobot::getRawEncoderPose() without transformation.
L VEL	int	Average velocity of left side of robot in millimeters per second (used by ARIA to determine translational and rotational velocity components)	ArRobot::getLeftVel() ArRobot::getVel() for robot translational velocity (speed)
R VEL	int	Average velocity of right side of robot in millimeters per second (used by ARIA to determine translational and rotational velocity components)	ArRobot::getRightVel() ArRobot::getVel() for robot traslational velocity (spee)
BATTERY	byte	Not provided in SIP packet on Pioneer LX, But available via ArRobot::getBatteryVoltage() if ARIA connected to MTX battery. (See also BATTERYX10 and STATEOFCHARGE fields below)	ArRobot::getBatteryVoltage()
STALL	uint	Motor stall indicators: Bit — Condition if set (1) 0 — Set if any bumper hit ("left" or "right" stall in ARIA) 1-3 — Bit set if bumper hit (left, center, right) 5-7 — Unused on Pioneer LX 8 — Set if any bumper hit ("left" or "right" stall in ARIA) 9-15 — Unused on Pioneer LX	ArRobot::getStallValue() ArRobot::isLeftMotorStalled() ArRobot::isRightMotorStalled() ArBumpers class
CONTROL	int	unused	
FLAGS	uint	General status flags: Bit — Condition if set (1) 0 — Motors enabled 1 — Pioneer sonar array #1 enabled (N/A on Pioneer LX) 2 — Pioneer sonar array #2 enabled (N/A on Pioneer LX) 3 — Pioneer sonar array #3 enabled (N/A on Pioneer LX) 4 — Pioneer sonar array #4 enabled (N/A on Pioneer LX) 5 — E-Stop button pressed 6 — Pioneer E-stall engaged (N/A	ArRobot::getFlags() ArRobot::areMotorsEnabled() ArRobot::isEStopPRessed()

File	Size	Description	ARIA Function
		on Pioneer LX)	
		7 (unused on Pioneer LX)	
		8 (unused on Pioneer LX)	
		9 (unused on Pioneer LX)	
		10 (unused on Pioneer LX)	
		11-15 Reserved	
COMP	byte	unused	
Pioneer Sonar Readings Count	byte	Unused on Pioneer LX (always 0).	
GRIP_STATE	byte	Pioneer gripper state (unused in PatrolBot, Pioneer LX, Seekur, Seekur JRr, always 0.)	
ANPORT	byte	Selected Pioneer analog I/O Port (see ADSEL command) (unused in PatrolBot, Pioneer LX, Seekur, Seekur Jr, always 0.)	
ANALOG	byte	Pioneer analog input value (0-255=0-5 VDC) (unused in PatrolBot, Pioneer LX, Seekur, Seekur Jr.always 0)	
DIGIN	byte	Pioneer digital input (unused in PatrolBot, Pioneer LX, Seekur, Seekur Jr.: always 0)	
DIGOUT	byte	Pioneer digital output (unused in PatrolBot, Pioneer LX, Seekur, Seekur Jr.: always 0)	
BATTERYX10	int	Pioneer battery voltage. Not provided in SIP on Pioneer LX. (But available via ArRobot::getRealBatteryVoltage() if ARIA connected to MTX battery.).	ArRobot::getRealBatteryVoltage()
RECHARGESTAGE	byte	Recharge stage:	ArRobot::getChargeState()
		Unknown/Invalid -1	
		Not Recharging 0	
		Charging (Bulk) 1	
		Charging (Ovecharge) 2	
		Charging (Float) 3	
		Charging (Balance) 4	
ROTVEL	int	Current rotational velocity in units of degrees X 10 per sec.	ArRobot::getRotVel()
FAULTFLAGS	uint	Various internal control errors.	ArRobot::hasFaultFlags() ArRobot::getFaultFlags()
LATVEL	int	Current Seekur lateral (sideways) velocity (mm/s). (Seekur only)	ArRobot::hasLatVel() ArRobot::getLatVel()

File	Size	Description	ARIA Function
TEMPERATURE	byte	Reading from internal temperature sensor, in deg. C, or -127 if unavailable.	ArRobot::hasTemperature() ArRobot::getTemperature()
STATEOFCHARGE	byte	Amount of remaining battery charge, 0-100% (unused in Pioneer, PatrolBot)	ArRobot::hasStateOfCharge() ArRobot::getStateOfCharge()
CHECKSUM	2 bytes	checksum	

10.4 Client Commands

Client commands are packets sent from client software to MARCOS. The packet ID indicates the command, and depending on the command, argument data may follow.

ARIA's ArRobot and other classes which serve as interfaces to the robot which will send commands and requests. ARIA's ArRobot class also contains functions to easily send any command with arguments.

Not all commands listed below are implemented by Pioneer LX. These are indicated in grey italic.

A command's argument may be a two-byte (16-bit) integer, ordered as least-significant byte first (little endian). The integer absolute value is provided in the packet; whether it should be interpreted as a positive or negative number is indicated by the argument type byte (0x3B or 0x1B). The argument may also be a string or buffer of up to a maximum of 200 bytes, prefaced by a length byte and may or may not be NULL terminated. Some commands have other command-specific argument formats as well. How exactly a command's argument should be interpreted is documented with commands is specified in the list of commands below.

Command Packet Format

Field	Size (bytes)	Value	Description
header	2	0xFA, 0xFB	Packet header; same for client and server
byte count	1		Number of command/argument bytes plus Checksum's two bytes, but not including Byte Count itself or the header bytes. Maximum of 249.
packet type or command identifier	1	0 - 255	Packet type or command identifier (see below for lists).
data type	1	0x3B (positive integer), 0x1B (negative or unsigned integer), 0x2B (string)	0x3B indicates that a 16-bit (2-byte) integer follows. 0x1B indicates that a 16-bit (2-byte) integer follows, whose value should be negated 0x2B indicates that a length-prefixed string follows. The length prefix is one byte.
data	n		Argument data
checksum	2		Packet integrity checksum

Connection Initialization and Maintenance Commands:

"byte" indicates a single byte value (usually unsigned). "int" indicates a signed 16-bit (2-byte) integer value (LSB). "uint" indicates an unsigned 16-bit (2-byte) integer value (LSB).

During Connection Initialization Handshake:

Command	#	Args	Description
SYNC0	0	none	Start connection. Send in sequence. ARCOS echoes
SYNC1	1	none	synchronization commands back to client, and
SYNC2	2	none	robot-specific auto-synchronization after SYNC2.

After Established Connection:

PULSE	0	none	Reset server watchdog timeout. Send this command periodically if not sending any other commands to maintain connection and prevent watchdog from triggering. (See below.)
OPEN	1	none	Start sending data.
CLOSE	2	none	Stop sending data and close client connection.
RESET	253	none	Force reset of the microcontroller.

Robot Motor, Velocity and Position Control:

See Robots in Motion discussion below on page 42. To stop the robot, send STOP, or VEL, RVEL commands with 0 argument values.

Command	#	Args	Description	ARIA Function (s)
ENABLE	4	int	1=enable; 0=disable the motors.	ArRobot::enableMotors() ArRobot::disableMotors()
VEL	11	int	Set velocity for forward/backward translation (mm/sec). May be combined with RVEL for simultaneous motion. Maximum speed is limited with SETV and stored firmware parameter.	ArRobot::setVel() or use ArAction objects
RVEL	21	int	Set rotation velocity (degrees/sec). Positive argument values rotate counter-clockwise, negative value rotate clockwise. May be combined with VEL for simultaneous motion. Maximum speed is limited with SETRV and stored firmware parameter. (This command replaces ROTATE; commands are equivalent.)	ArRobot::setRotVel() or use ArAction objects

Command	#	Args	Description	ARIA Function (s)
ROTATE	9	int	See RVEL.	
HEAD	12	int	Turn to given absolute heading. (+ = counter-clockwise). Speed used is given by SETRV.	ArRobot::setHeading() or use ArAction objects
DHEAD	13	int	Turn to given offset from current heading (degrees) (+) counter- or (–) clockwise. Speed is given by SETRV.	ArRobot::setDeltaHeading() or use ArAction objects

Configure Acceleration and Deceleration Parameters

See Robots in Motion discussion on page 42.

SETA	5	int	If positive, set acceleration used for VEL, VEL2, MOVE commands, in mm/sec^2	ArRobot::setAccel()
			If negative, set rotation deceleration used for VEL, VEL2, MOVE commands, in mm/sec^2	ArRobot::setDecel()
				or use ArAction objects
SETRA	23	int	If positive, set rotation acceleration used for RVEL, ROTATE, HEAD, DHEAD commands, in degrees/sec^2	ArRobot::setRotAccel()
			If negative, set rotation deceleration used for RVEL, ROTATE, HEAD, DHEAD commands, in degrees/sec^2	ArRobot::setRotDecel()
				or use ArAction objects

Configure Maximum Speeds

See Robots in Motion discussion on page 42.

These limits will be used until changed using these commands, or until the end of the client session. They are reset to defaults in new client connections or if the controller is reset.

SETV			Sets maximum translation velocity, which is also used by MOVE command. Degrees/sec.	ArRobot::setMaxVel() or use ArAction objects
SETRV	10	int	Sets maximum turn rotation velocity, which is also used by HEAD, DHEAD commands; degrees/sec.	ArRobot::setMaxRotVel() or use ArAction objects

Reset Position

SETO	7	none	Reset position estimate given in standard SIP to 0,0,0..	ArRobot::moveTo()

Joystick

Use the ArJoyHandler class in ARIA.

JOYDRIVE	47	int	1=allow joystick drive from port while connected with a client; 0 (default) disallows.	Use ArJoyHandler object
JOY-REQUEST	17	int	Request one or continuous stream (>1) or stop (0) joystick packets	

Additional SIP Requests

CONFIG	18	none	Request one robot configuration SIP. See CONFIGpac description below.

Other

BATTEST	250	int	Artificially set the battery voltage; argument in tens volts (100=10V); 0 to revert to real voltage

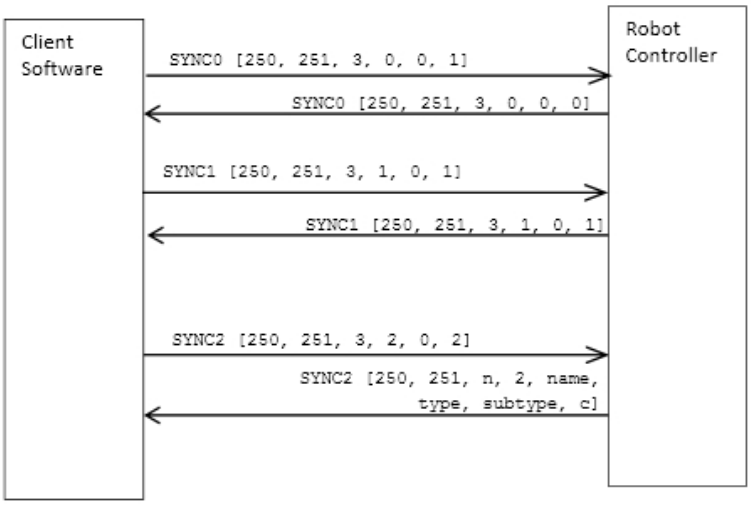
10.5 Command Packet Errors

The robot controller ignores a client command packet whose Byte Count exceeds 204 (total packet size of 207 bytes) or has an erroneous Checksum. The client should similarly ignore erroneous SIPs.

It is intended that client software will typically continually request its desired motion state by sending motion commands (e.g. VEL, RVEL) on each SIP cycle. ARIA does this via its “state reflection” task cycle. See the ARIA API Reference Documentation for more information.

10.6 Establishing the connection

When first started or reset, the robot controller is in a waiting state, listening for communication packets to establish a client-server connection. To establish a connection, the client application must open the serial connection, then send a series of three synchronization packets containing the SYNC0, SYNC1 and SYNC2, waiting for response from the robot controller after each packet, before sending the next. The robot controller echoes each SYNC packet verbatim back to the client. The client should listen for the returned packets and only issue the next synchronization packet after it has received the appropriate echo response.



The response to the last synchronization packet, SYNC2, also includes robot identifying information as three NULL-terminated character strings: robot name, robot class or type, and robot subclass or subtype. For the Pioneer LX, the class is always “MTX” and the subclass is "marc_devel" in early versions of the robot, or "pioneer-lx" in later versions. Clients use these identifying strings to configure their own operating parameters. ARIA, for instance, uses the Subclass to identify the robot subtype and load the matching parameter file found in the Aria/params directory (e.g. for subclass “pioneer-lx” ARIA loads “pioneer-lx.p”), followed by a custom robot parameter file corresponding to the name, if one exists (e.g. for name "myrobot", ARIA would load "myrobot.p", overriding parameters from "pioneer-lx.p" and its built-in defaults).

Opening the session—OPEN

Once it’s established a connection, the client should send the OPEN command #1 (250, 251, 3, 1, 0, 1, which causes the controller to begin transmitting information to the client.

When first connected, the motion commands are disabled. Depending on the robot, motor power may be disabled, and mechanical or electric brakes may be engaged. To enable the motors and release brakes, send the ENABLE command #4 with an integer argument of one. Send ENABLE with an argument of zero to disable motors.

Keeping the Beat—PULSE

A safety watchdog expects that, once connected, it receives at least one command packet from the client program every WatchDog seconds, as defined in the controller's built-in parameters. (default is 2 seconds). Otherwise, it assumes the client-server connection is broken and stops the robot. Use the PULSE command (0) to prevent the watchdog process from disstopping the robot anif no commands are otherwise being sent.

Some clients—ARIA-based ones, for instance—use the good practice of sending a PULSE client command #0 (250, 251, 3, 0, 0, 0) just after OPEN. And if your client application will be otherwise distracted for some time, have it periodically issue the PULSE command to let your robot server know that your client is indeed alive and well. It has no other effect.

If the robot shuts down due to lack of communication with the client, it will revive upon receipt of a client command and automatically accelerate to the last-specified speed and heading.

Closing the connection—CLOSE

To close the client-server connection, which automatically disables the motors and other server functions, simply issue the CLOSE command #2. Most of the controller's operating parameters return to their configured default values upon disconnection with the client.

ARIA automatically uses OPEN and CLOSE at start and end of session, and will send a PULSE command on every SIP cycle if there are no other pending commands to send.

10.7 CONFIG Packet and CONFIG command

Send the CONFIG command #18 without an argument to have MARCOS send back a CONFIG packet type 32 (0x20) containing the robot's current operational parameters. Use the CONFIG packet to examine many of your robot's default settings and their working values, where appropriate, as changed by other client commands, such as SetV and RotKV.

The information in this packet is automatically used by ARIA internally, and is also made available through interface classes, such as ArRobot and ArRobotConfigPacketReader.

Additionaly configuration and other information is stored in the robot parameters, (see ArRobot::getRobotParams()), which ARIA determines from the robot subtype and by loading robot parameter files.

CONFIG packet contents:

Label	Data	Description
Packet Header	int	Common packet header = 0xFAFB
Packet Byte count	byte	Number of following data bytes
Packet type	byte	CONFIG packet type identifier = 0x20
Robot type	str	"MTX"
Subtype	str	"pioneer-lx" (or "marc-devel" or early revisions)
Sernum	str	Serial number for the robot.
4mots	byte	unused
Rotveltop	int	Maximum rotation velocity; deg/sec
Transveltop	int	Maximum translation speed; mm/sec
Rotacctop	int	Maximum rotation (de)acceleration; deg/sec^2
Transacctop	int	Maximum translation (de)acceleration; mm/sec^2
PWMmax	int	unused on Pioneer LX
Name	str	Robot name.
SIPcycle	byte	Server information packet cycle time; ms.
Hostbaud	byte	Baud rate for client-server HOST serial: 0=9.6k, 1=19.2k, 2=38.4k, 3=56.8k, 4=115.2k.
Aux1baud	byte	Unused on Pioneer LX
Gripper	int	0 if no Pioneer Gripper; else 1. Always 0 on Pioneer LX,
Front Sonar	int	Unused on Pioneer LX. See robot parameter file instead.
Rear Sonar	byte	Unused on Pioneer LX. See robot parameter file instead.

Lowbattery	int	Unused on Pioneer lX
Revcount	int	Unused on Pioneer LX
Watchdog	int	Time (ms) before robot automatically stops if it has not received a command from the client. Restarts on restoration of connection.
P2mpacs	byte	Unused.
Stallval	int	Unused on Pioneer LX
Stallcount	int	Unused on Pioneer LX
Joyvel	int	Joystick translation velocity setting, mm/sec
Joyrvel	int	Joystick rotation velocity setting in deg/sec
Rotvelmax	int	Current max rotation speed; deg/sec.
Transvelmax	int	Current max translation speed; mm/sec.
Rotacc	int	Current rotation acceleration; deg/ sec^2
Rotdecel	int	Current rotation deceleration; deg/ sec^2
Rotkp	int	Current Proportional PID for rotation
Rotkv	int	Current Derivative PID for rotation
Rotki	int	Current Integral PID for rotation
Transacc	int	Current translation acceleration; mm/ sec^2
Transdecel	int	Current translation deceleration; mm/ sec^2
Transkp	int	Current Proportional PID for translation.
Transkv	int	Current Derivative PID for translation.
Transki	int	Current Integral PID for translation.
Frontbumps	byte	Number of front bumper segments.
Rearbumps	byte	Number of rear bumper segments.
Charger	byte	Always 0 on Pioneer LX. (All Pioneer LX robots are capable of using a recharging station.)
SonarCycle	byte	Not used on Pioneer LX.
Autobaud	byte	1 if the client can change baud rates; 2 if auto-baud implemented.
HasGyro	byte	Always 2 on Pioneer LX. (All Pioneer LX robots have a gyro, which is automatically used to determine position estimate.)
Driftfactor	int	Unused on Pioneer LX
Aux2baud	byte	Unused on Pioneer LX
Aux3baud	byte	Unused on Pioneer LX
Ticksmm	int	Unused on Pioneer LX
Shutdownvolts	int	DC volts X10 at or below which the onboard PC will shut down
Firmware Version	str	Null-terminated string containing firmware version identifier.
GyroCW	int	Gyro calibration factor clockwise
GyroCCW	int	Gyro calibration factor counterclockwise
KinematicsDelay	byte	Time delay (ms) between acquisition and reporting of rotation
LatVelTop	Int	Absolute maximum lateral velocity allowed (mm/sec) (Pioneer LX Only.)
LatAccTop	Int	Absolute maximum lateral acceleration allowed (mm/sec^2) (Pioneer LX Only.)

LatVelMax	Int	Currently set lateral velocity maximum (mm/sec) (Pioneer LX Only)
LatAccel	Int	Currently set lateral acceleration (mm/sec^2) (Pioneer LX Only)
LatDec	Int	Currently set lateral deceleration (mm/sec^2) (Pioneer LX Only)
PChargeThresh	Int	Unused on Pioneer LX
PowerCommands	Int	Power command availability for PatrolBot compatibility
BatteryType	byte	Battery type. 1 = Lead, 2=NiMH.
LowSOC	Int	Threshold state of charge value at which to warn (default is 10%)
ShutdownSOC	Int	Threshold state of charge value at which to shut down the robot (default is 5%)
Packet checksum	2bytes	Packet checksum

10.8 Joystick Packet

Use the JoyRequest command #17 with an argument value of 0, 1 or 2 to request data from the robot joystick. An argument value of 1 requests a single JOYSTICK packet (type = 248) to be sent by the next client-server communications cycle. An argument value of 2 requests that packets are sent continuously, after each standard SIP, at approximately one per cycle depending on serial port speed and other pending packets. Use argument value 0 to stop continuous JOYSTICK packets.

ARIA provides an interface to the robot joystick in its ArRobotJoyHandler class.

JOYSTICK packet contents:

Field	Size	Value	Description
Packet header	2	0xFA, 0xFB	Common header
Byte count	1	11	Number of following bytes
Packet type	1	0xF8	Joystick packet type identifier
Connected	1	0 or 1	1 if joystick is connected, 0 if joystick is not connected or disconnect button is engaged.
Button	1	0 or 1	1 while wheel re-align button is pressed, 0 otherwise. Pioneer LX will always re-align the wheels if this button is pressed, but it may be monitored here for software to perform any additional actions.
Rotation	2	varies 0-1023	0 is fully to the left, 1023 is fully to the right. (ARIA converts this to [-1.0,1.0])
Forward/Back	2	varies 0-1023	0 is fully back, 1023 is fully forward. (ARIA converts this to [-1.0,1.0])
Speed	2	varies 0-1023	Speed knob setting
Packet checksum	2	varies	Computed checksum

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