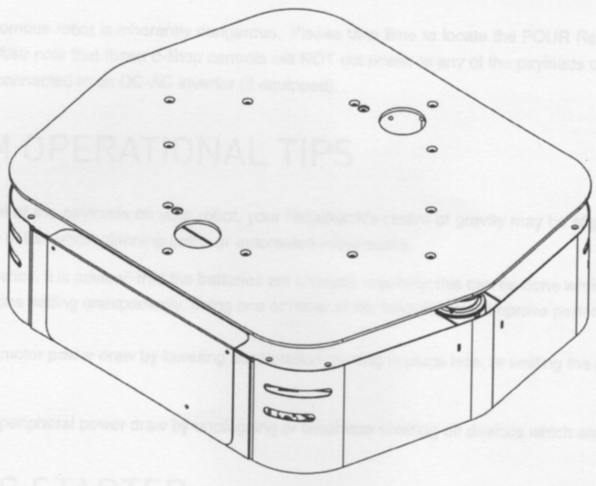
CLEARPATH ROBOTICS™

PAC01 RIDGEBACK



UNIQUELY INTEGRATED PLATFORM

CUSTOM ROBOT QUICKSTART GUIDE

CLEARPATH ROBOTICS™

1 FROM THE DESK OF THE ROBOTSMITHS

Thank you Pace University for your Ridgeback order! As part of the integration, we have prepared this quick reference sheet for you and your team detailing your specific package.

2 SAFETY WARNING

Use of an autonomous robot is inherently dangerous. Please take time to locate the FOUR Red E-STOP buttons on the Ridgeback. Also note that these E-Stop controls will NOT cut power to any of the payloads connected to the robot, including those connected to an DC-AC inverter (if equipped).

3 SYSTEM OPERATIONAL TIPS

Due to the weight of the payloads on your robot, your Ridgeback's centre of gravity may be slightly shifted off-centre. Please be aware of this when planning paths or automated movements.

For best performance, it is advised that the batteries are charged regularly; this can be done while the system is in use. If the vehicle begins halting unexpectedly, doing one or more of the following may improve performance:

- Reducing motor power draw by lowering acceleration, turning in place less, or limiting the grade of terrain being traversed.
- Reducing peripheral power draw by unplugging or otherwise shutting off devices which are not in use.

4 GETTING STARTED

Your system has been configured to allow you to get started immediately after receipt. Follow these instructions to get moving:

1. The power button is located on the rear of the Ridgeback, on the right side. Pressing the button should momentarily illuminate all the lights.
2. Release all the e-stop buttons.
3. When the system is ready to be enabled/driven, the status lights will alternate between yellow and red.
4. Press the E-Stop Release button. The status lights will turn solid, with the front lights illuminated white and the rear lights illuminated red
5. Press the "PS" button in the middle of the gamepad controller to activate it.

5 NETWORK INFORMATION

Parameter	Value
Robot Static IP	192.168.131.1
Robot Hostname	cpr-r100-0071
ROS Version	Kinetic
Computer Username	administrator
Computer Password	clearpath
Jetson Static IP	192.168.131.5
Jetson Hostname	cpr-r100-0071-jetson
Jetson Username	nvidia
Jetson Password	nvidia
Serial Number	r100-0071
Front Hokuyo UST10LX IP	192.168.131.20
Rear Hokuyo UST10LX IP	192.168.131.22
Velodyne IP	192.168.131.21
Kinova GEN3 1 Serial	W0519573-0
Kinova GEN3 1 IP	192.168.131.40
Kinova GEN3 2 Serial	W0519099-0
Kinova GEN3 2 IP	192.168.131.41

6 WIRELESS

To set up the wireless communications on your Ridgeback, connect your computer to an Ethernet port inside the side panel. Set a static IP on your computer to 192.168.131.19 (for example). Then, ssh into the Ridgeback computer with:

```
ssh administrator@192.168.131.1
```

Enter the login information when prompted.

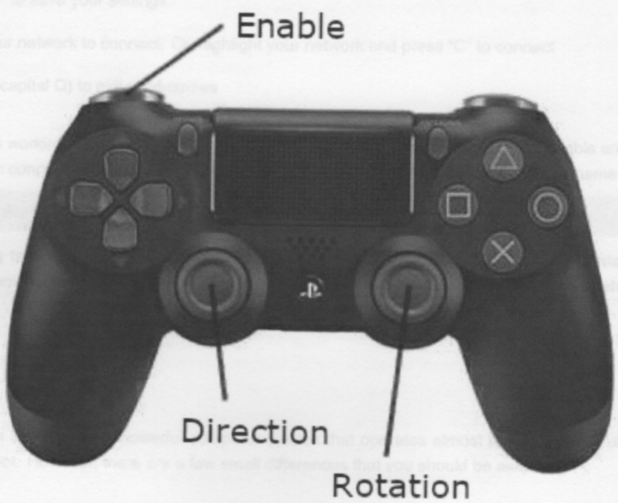
Access the wicd-curses wifi manager:

```
wicd-curses
```

A basic GUI prompt will be presented, which may be used to connect the robot to your site's wifi network. Follow these steps for the configuration:

1. Use the Up and Down arrows to choose your desired network
2. Press the Right arrow to enter the configuration page
3. Enable "Use DHCP Hostname"
4. Enable "Use these settings for all networks sharing this essid"

6. Once Bluetooth is connected (solid white light), use the gamepad to control Ridgeback's motion.



5. Enable "Automatically connect to this network"
6. In the "Key" field, enter your wifi password
7. Press "F10" to save your settings
8. Wait for your network to connect. Or, highlight your network and press "C" to connect
9. Press "Q" (capital Q) to exit wicd-curses

You may continute working on the robot via the wired connection, or disconnect the Ethernet cable and connect to it via wifi instead. When connecting to the robot computer by wifi, it should be accessible via its hostname:

```
ssh administrator@cpr-r100-0071
```

If you are having trouble establishing or maintaining a reliable wifi connection, please contact your network administrator. Some building wifi infrastructures require special permissions to be granted before a connection is allowed.

7 NVIDIA JETSON

The NVidia Jetson is a compact, powerful computer system that operates almost identically to a standard computer system in your robot. However, there are a few small differences that you should be aware of.

- The Jetson runs a full Ubuntu Desktop. While the robot is still accessible and operable via ssh, you may also connect a monitor, keyboard and mouse for direct access.
- The "sudo reboot" command may cause the robot to shut off, rather than reboot.
- The Jetson comes with a built-in 32GB eMMC Flash drive. Additional storage may be added by connecting a 2.5" SSD to the open SATA port.

More information on the Jetson developer kits is available here:

Jetson TX2: `https://elinux.org/Jetson_TX2`

Jetson Nano: `https://elinux.org/Jetson_Nano`

Jetson Xavier NX: `https://elinux.org/Jetson_Xavier_NX`

Jetson Xavier AGX: `https://elinux.org/Jetson_AGX_Xavier`

8 CONNECTING THE JETSON TO WIFI

To configure the wireless interface on your robot, you must first connect to it directly via Ethernet, as described in the section titled "Communicating with the Robot." Then, launch an SSH session with the robot.

It is also possible to carry out this configuration by connecting a monitor, keyboard, and mouse directly to the Jetson computer. Once logged in, open a terminal window.

As the Jetson is not compatible with wicd-curses, we will be using network manager instead. Follow these steps to connect to an available wifi network with the Jetson:

To view available networks:

```
nmcli d wifi list
```

To connect to an available network:

```
nmcli d wifi connect <WIFI SSID> password <PASSWORD>
```

You may continute working on the Jetson via the wired connection, or disconnect the Ethernet cable and connect to it via wifi instead. When connecting to the robot computer by wifi, it should be accessible via its hostname:

```
ssh administrator@cpr-r100-0071-jetson
```

If you are having trouble establishing or maintaining a reliable wifi connection, please contact your network administrator. Some building wifi infrastructures require special permissions to be granted before a connection is allowed.

9 COMMUNICATING WITH THE ROBOT

To communicate directly with the robot PC, you can SSH in. It will be necessary to ssh into the robot for tasks such as installing, modifying or removing software and files on the robot. If this is your first time connecting to the robot, it will be necessary to connect an Ethernet cable between your own computer an an open port on the robot. Manually set your computer to the same subnet as the robot's IP address.

Note that you will not be able to use GUI tools such as rviz over an SSH connection:

ssh administrator@192.168.131.1

OR

ssh administrator@cpr-r100-0071

In order to use rviz and other visualization tools, you must declare the robot as master, and set the user computer IP. In a console on the user pc, type:

```
export ROS_MASTER_URI=http://cpr-r100-0071:11311
```

You should then be able to view a list of topics published by the robot with:

```
rostopic list
```

It will be necessary to declare the robot as master in every new terminal window, unless you change the master permanently in your ROS environment variables. If you are unable to connect with the robot via its hostname, your computer or network equipment may not be routing hostnames properly. In Ubuntu on your local computer, open your /etc/hosts file:

```
sudo nano /etc/hosts
```

Add the following line immediately below the line that contains 127.0.1.1, substituting in the robot's current wifi IP address. This address may be obtained by connecting directly to the robot via Ethernet, and using the "ifconfig" command. You may want to talk to your system administrator about giving the robot a permanent wifi address to ensure it always connects with the same IP address. The below example shows the setting if wired directly into the robot lan.

```
192.168.131.1       cpr-r100-0071
```

To ease communications between the robot and your computer, you can also add a similar entry in the robot's computer, pointing at one or more development computers.

10 SETTING UP YOUR WORKSPACE

There is a workspace installed in your robot for development and custom packages. You will likely want to be able to use these packages on your local machine. To do this, make a new folder on your local computer:

```
mkdir catkin_ws && cd catkin_ws
mkdir src && cd src
```

Then copy all of the packages from the robot to your local machine

```
scp -r administrator@cpr-r100-0071:~/catkin_ws/src/*
```

Now, make sure you have all of the dependencies needed to build these packages:

```
cd ..
rosdep install --from-paths src --ignore-src --rosdistro=$ROS_DISTRO -i -y
catkin_make
source ~/catkin_ws/devel/setup.bash
```

11 FLIR E46 PAN-TILT UNIT

The FLIR E46 PTU is connected directly to the robot's computer by serial, and be controlled by sending it Joint State messages. For your convenience, one-off messages may also be sent to the PTU using the cmd_angles script:

```
rosrun flir_ptu_driver cmd_angles -0.6 0.3
```

On power-up, the PTU will go through a self-test where the mounting platform is first tilted and then panned to its end stops. Prior to powering on the robot, ensure the PTU and any devices connected to it are FREE AND CLEAR of any cables or other payloads.

The PTU can be disabled by turning the power switch on its controller to the OFF position.

12 ZED CAMERA

The ZED camera generates both a pointcloud and live image streams. This data cannot be viewed via ssh. Declare the robot as ROS Master, then from the command line:

```
rosrun image_view image_view image:=/zed/zed_node/left/image_rect_color
rosrun image_view image_view image:=/zed/zed_node/right/image_rect_color
```

The ZED image streams may also be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the desired "/image" stream (NOT /camera).

The ZED Pointcloud may be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the "point_cloud/cloud_registered/Pointcloud2" topic.

13 HOKUYO UTM-10LX

The Hokuyo UTM-10LX is an Ethernet-connected single-beam LIDAR. The data it produces is best viewed from within rviz, but you can check that it is publishing data using the hz command:

```
rostopic hz /front/scan
```

```
rostopic hz /rear/scan
```

The Hokuyo LIDAR data may be easily added to rviz, by navigating to the "Sensing" sub-folder and adding the relevant Hokuyo topic to "LaserScan."

14 VELODYNE LIDAR

The data produced by the Velodyne LIDAR is best viewed from within rviz, but you can check that it is publishing data using the hz command in ROS. The LIDAR should publish at a rate of about 10Hz or 20Hz, depending on the model:

```
rostopic hz /velodyne_points
```

The Velodyne will also publish a single-beam output to the /scan topic, at the same rate as the pointcloud:

```
rostopic hz /scan
```

Add Velodyne laser data to rviz by navigating to the "Sensing" sub-folder, and adding the relevant Velodyne topic to "LaserScan" and/or "PointCloud2."

15 KINOVA GEN3

The Kinova GEN3 arm must be powered on separately the rest of the system. To do so, press and hold the power button on its base for a second or two, until the blue light flashes. Once it is finished powering on a green light will illuminate next to the power button.

Since the GEN3 powers on much later than the robot base, its ROS driver must be launched manually. We have created a custom launch file that will load drivers for both arms, along with a MoveIt! path planner:

```
roslaunch pac01_ridgeback_bringup pac01_gen3.launch
```

WARNING: When the robot is powered down, the arm will cease to hold its position. Prior to powering down the robot, move the arm into a safe, supported position using ROS or the gamepad controller. Or, you may "catch" the arm and move it manually once power is removed.

The GEN3 User Manual is available here:

https://www.kinovarobotics.com/sites/default/files/UG-014_KINOVA_Gen3_Ultra_lightweight_robot-User_guide_EN_R01.pdf

Please see the Kinova ROS github page for more information:

https://github.com/Kinovarobotics/ros_kortex

16 MOVEIT!

View the robot in rviz using the instructions in the section titled "Visualizing in RViz." To add MoveIt! control, click the "Add" button at the bottom left, then select the "MotionPlanning" option. If everything is set properly, "OMPL" should appear under the title "Planning Library."

To control the arm, switch the mode to "Interact" by clicking the Interact button in the top left of the rviz window. Under "Displays" expand the "MotionPlanning" menu. Expand the "Planning Request" option, then set the "Interactive Marker Size" to 0.2. This should cause a blue sphere to appear at the tool end of the Kinova arm. From here, you can drag the sphere or use the direction arrows to move the arm. Go to the "Planning" tab just below, then click "Plan." if the route that MoveIt! has chosen looks sensible (no collisions or extreme movements) then click "Execute" to move the arm to the new position!

WARNING: While grippers and other payloads attached to the arm (and accurately described in a URDF) should allow the system to avoid collisions, the system is unaware of any cables or brackets! It is possible that rviz will choose a path or position that will strain the cables or cause them to snag. Always be aware of the limits of the cables.

MoveIt! is extremely sensitive to proper hostname resolution, so if you're having trouble getting it to launch or operate, make sure you have added routes to both the robot and user computer /etc/hosts files. See the section titled "Communicating with the Robot" for more information.

17 ROBOTIQ GRIPPER

WARNING: When ROS launches, the gripper may perform a self-test where it closes and opens again. Objects being held by the gripper may be dropped!

It is possible to command the gripper by publishing to its goal topic. Enter the following, then tab-complete to view the rest of the message header.

```
rostopic pub -1 /right_kinova_arm/robotiq_2f_85_gripper_controller/gripper_cmd/goal control_msgs/
    GripperCommandActionGoal
```

```
rostopic pub -1 /left_kinova_arm/robotiq_2f_85_gripper_controller/gripper_cmd/goal control_msgs/
    GripperCommandActionGoal
```

Populate the header with the following parameters, then press <enter>:

```
position: [0.0 to 0.8]
max_effort: [0.1 to 1.0]
```

Please note that "0.0" is fully open, where "0.8" is fully closed.

18 RESPEAKER MICROPHONE ARRAY

The ReSpeaker Microphone Array data can be accessed with the following:

```
rostopic echo /sound_direction # Result of DoA
rostopic echo /sound_localization # Result of DoA as Pose
rostopic echo /is_speeching  # Result of VAD
rostopic echo /audio         # Raw audio
rostopic echo /speech_audio  # Audio data while speeching
```

Please see the following github repository for additional information:

`https://github.com/furushchev/respeaker_ros`

19 VISUALIZING IN RVIZ

You can visualize your robot using rviz. To do so, you must first move a copy of any extra customizations from the robot into a workspace on your local computer (See "Setting Up Your Workspace.") Then, source the workspace:

CLEARPATH ROBOTICS™

```
source ~/catkin_ws/devel/setup.bash
```

Declare the robot as ROS Master:

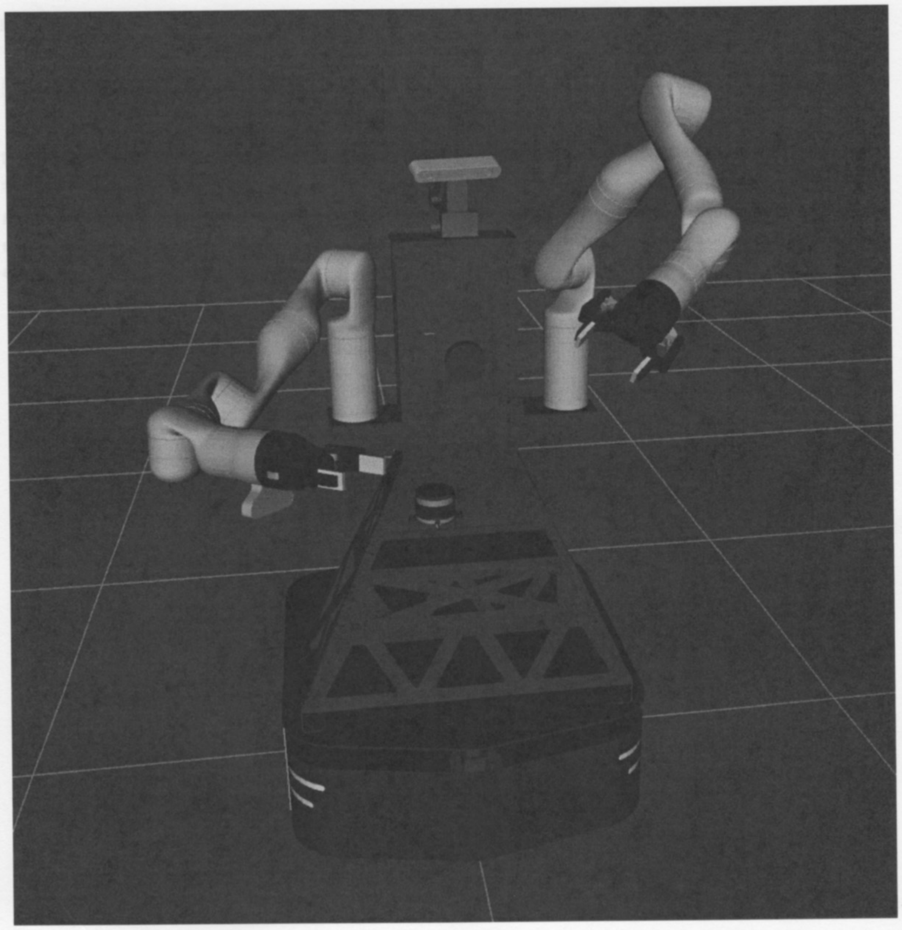
```
export ROS_MASTER_URI=http://cpr-r100-0071:11311
```

Launch rviz:

```
roslaunch ridgeback_viz view_robot.launch
```


You can rotate the model using your cursor, and zoom in or out by scrolling up or down. Strafe by holding down Shift and dragging the model. The robot itself may be driven directly from rviz by changing to Interact mode. In this mode, arrows appear around the model. Drag the arrows to make the robot move.

Additional sensor topics may be added to the rviz interface by clicking the "Add" button in the bottom left, selecting "By topic," then choosing the desired topic from the list.



You can rotate the model using your cursor, and zoom in or out by scrolling up or down. Strafe by holding down Shift and dragging the model. The robot itself may be driven directly from rviz by changing to interact mode. In this mode, arrows appear around the model. Drag the arrows to make the robot move.

Additional sensor topics may be added to the rviz interface by clicking the "Add" button in the bottom left, selecting "By topic," then choosing the desired topic from the list.

More information on rviz is available here: wiki.ros.org/rviz

20 LEARNING

If you are new to using ROS, please visit our support page for information on how to get started using your new robot: support.clearpathrobotics.com

Please contact our support team directly at support@clearpathrobotics.com if you have any questions that aren't answered on our support page. For ROS-specific questions, we recommend visiting answers.ros.org, which we also keep an eye on.

1 MAIN PLATFORM

1.1 Serial Number

r100-0071

2 JETSON TX2

2.1 Serial Number

1424919040731

3 FRONT HOKUYO UST10LX

3.1 Serial Number

L1901462E

4 REAR HOKUYO UST10LX

4.1 Serial Number

L1901481E

5 LEFT GEN3

5.1 Serial Number

W0519573-0

6 RIGHT GEN3

6.1 Serial Number

W0519099-0

7 LEFT ROBOTIQ C

7.1 Serial Number

C-43668

8 RIGHT ROBOTIQ C

8.1 Serial Number

C-43485

9 FLIR E46

9.1 Serial Number

9959

10 ZED

10.1 Serial Number

4263224

11 VELODYNE VLP16

11.1 Serial Number

11002200260533

12 MICROPHONE ARRAY

12.1 Serial Number

107990053

1 SYSTEM

Project	PAC01
Platform	Ridgeback (r100-0071)
Date	Friday, February 26, 2021

2 NETWORKING TESTS

Status	ID	Target	Notes
PASS	GEN31IP_PingTest	192.168.131.40	Verify IP Address
PASS	PCHostname_PingTest	cpr-r100-0071	Verify IP Address
PASS	HokuyoUST10LX2IP_PingTest	192.168.131.22	Verify IP Address
PASS	Velodyne1IP_PingTest	192.168.131.21	Verify IP Address
PASS	GEN32IP_PingTest	192.168.131.41	Verify IP Address
PASS	CustomerIP_PingTest	192.168.131.1	Verify IP Address
PASS	HokuyoUST10LX1IP_PingTest	192.168.131.20	Verify IP Address

3 TOPIC TESTS

Status	ID	Target	Notes
PASS	ZED_zedpoint_cloudcloud_registered_AdvertiseTest	/zed/point_cloud/cloud_registered	Verify Topic Existence
PASS	ZED_zedpoint_cloudcloud_registered_RateTest	3Hz	Verify Topic Frequency
PASS	HokuyoUST10LX1_frontscan_AdvertiseTest	/front/scan	Verify Topic Existence
PASS	HokuyoUST10LX1_frontscan_RateTest	40Hz	Verify Topic Frequency
PASS	HokuyoUST10LX2_rearscan_AdvertiseTest	/rear/scan	Verify Topic Existence
PASS	HokuyoUST10LX2_rearscan_RateTest	40Hz	Verify Topic Frequency
PASS	BuiltinIMU_imudata_AdvertiseTest	/imu/data	Verify Topic Existence
PASS	BuiltinIMU_imudata_RateTest	50Hz	Verify Topic Frequency
PASS	Velodyne1_velodyne_points_AdvertiseTest	/velodyne_points	Verify Topic Existence
PASS	Velodyne1_velodyne_points_RateTest	10Hz	Verify Topic Frequency
PASS	FLIRD46_ptucmd_AdvertiseTest	/ptu/cmd	Verify Topic Existence

4 MISCELLANEOUS TESTS

Status	ID	Target	Notes
PASS	ROSWTFTest	N/A	General ROS Test