

VISION 60

USER GUIDE 5.3





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This user guide can also be found digitally in the Ghost App.

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SAFETY



DANGER

INJURY OR DEATH may occur if these instructions and warnings are not read, understood and followed. These instructions and warnings must stay with the robot at all times.

This is a complex device intended to be used only by a person who has read, understood, and who will follow these instructions and warnings.

All users must become familiar with operating the robot before attempting more advanced movements. Learning to use the robot must be done in an open environment where the robot cannot make contact with persons or property. DO NOT attempt advanced operation (such as running, full speed, cruise control, and operation on inclines/declines/stairs, to name a few) until you determine that you have sufficient experience operating the robot.

It is impossible to foresee all of the ways that users may find the Vision 60 useful. This is a heavy robot that will move quickly and with great force and it can cause injury/damage to anything that it comes into contact with. It is the user's responsibility to use common sense and prioritize safety (including safety of others) at all times when operating the Vision 60. For all warnings and safety precautions, please see the safety section at the end of this guide.

If you are not able to read and understand these instructions, do not attempt to use the Vision 60. Foreign language instructions are available upon request.

We're here to help

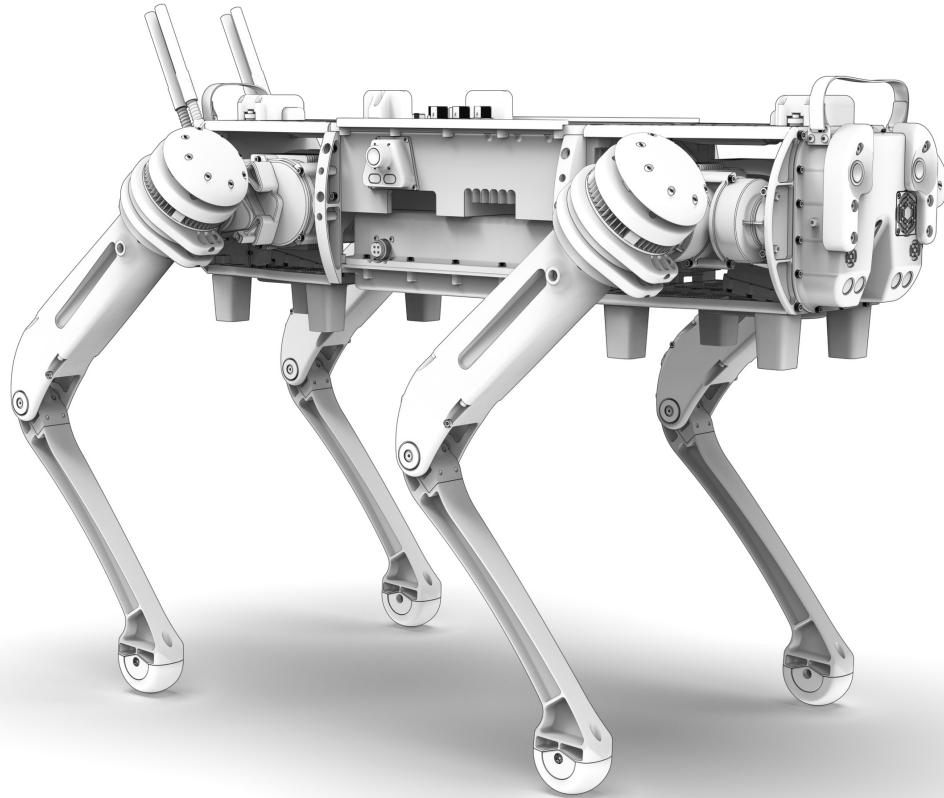
We recommend scheduling an intro call with a Ghost customer success manager to run you through the robot by emailing support@ghostrobotics.io.





INTRODUCTION

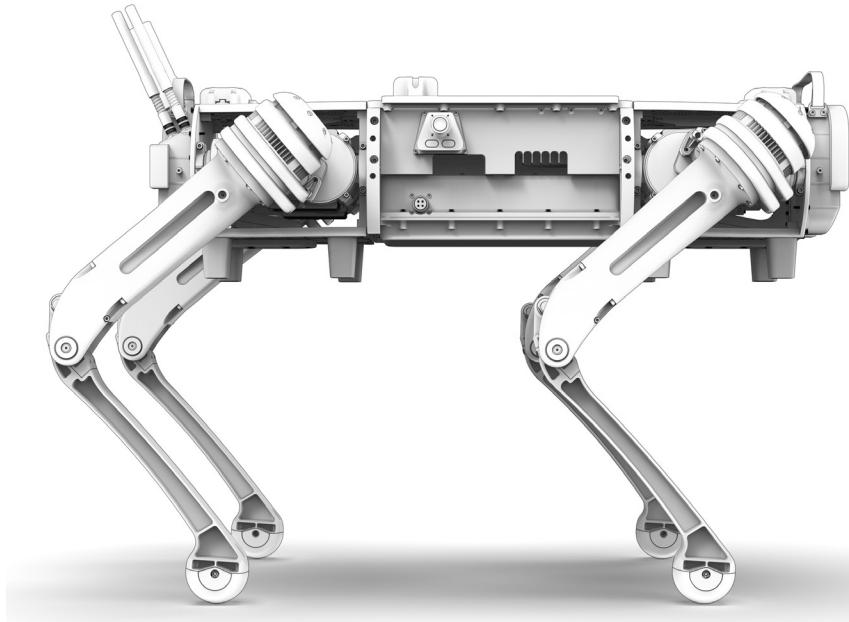
The Vision 60 is a tele-operable and autonomous Quadrupedal Unmanned Ground Vehicle (Q-UGV) that can be used for a variety of applications including, perimeter security, asset protection, CBRN, EOD, ISR, and other use cases.



This guide applies to Vision 60 V5.3+ and robot software version 0.22.0+.
If you are not able to read and understand these instructions, do not attempt to use the Vision 60.
Please email support@ghostrobotics.io for further instructions.



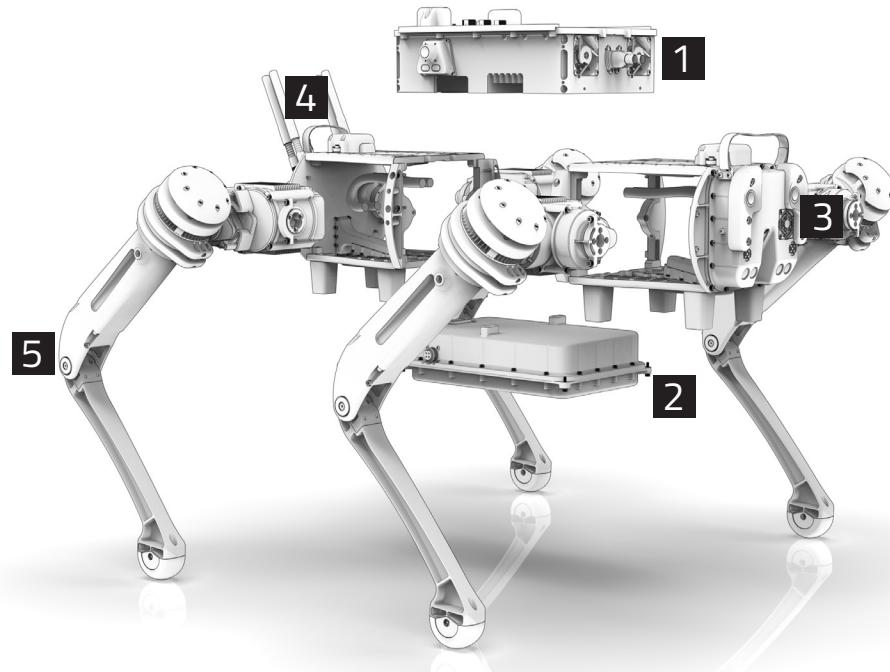
BOX CONTENTS



- Vision 60 robot
- Controller, tablet, USB-C charger
- Robot charger
- 8 spare treads
- 2 WiFi antennas
- 4 Picatinny rails and t-nuts
- Camera calibration board
- Maintenance toolkit
- 2 LTE antennas



OVERVIEW



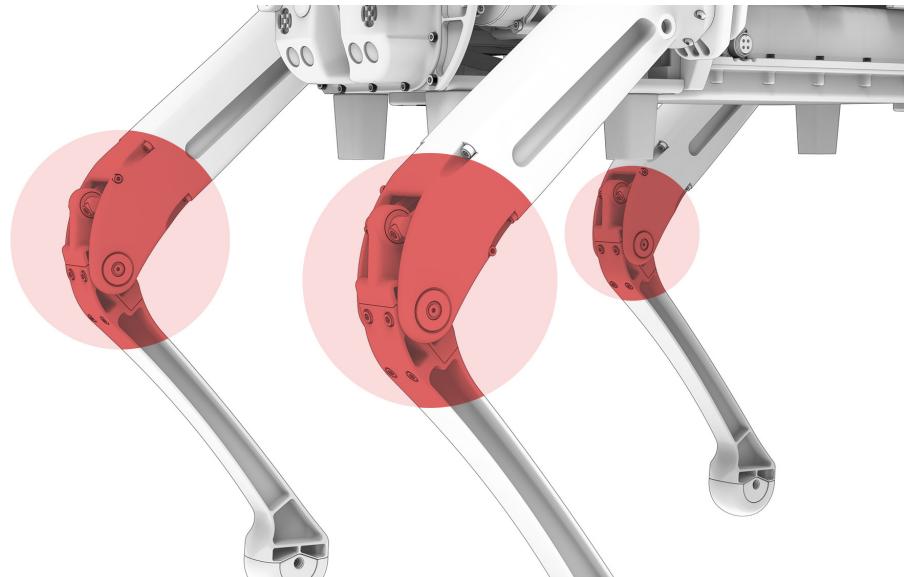
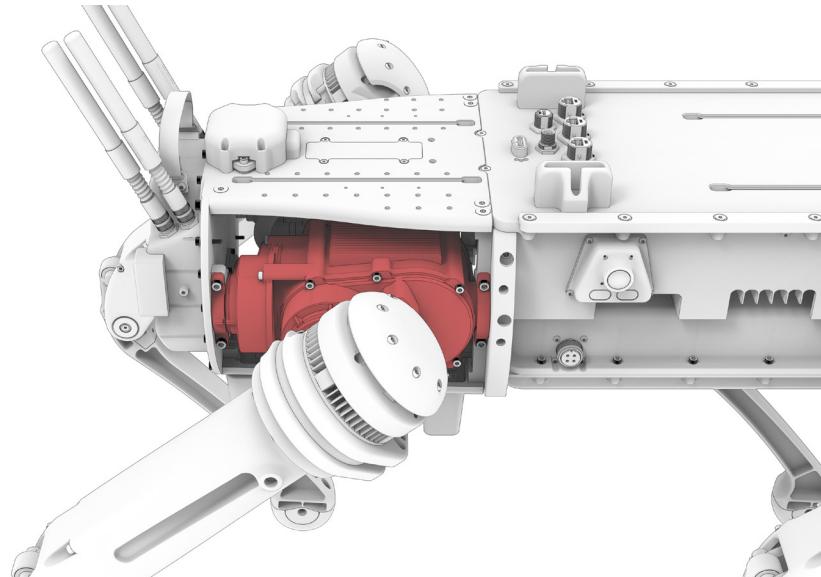
The Vision 60 is made of five main components that work together. These are:

- 1 Compute Box
- 2 Battery
- 3 Front Sensorhead
- 4 Rear Sensorhead
- 5 Legs

Other payloads may be included that will need to connect to the Vision 60, depending on the configuration of your robot.



UNPACKING



WARNING

Pinch Point. Keep hands clear during operation.

Be careful of pinch points. To avoid injury, keep hands and fingers away from joints and pivots whenever moving or adjusting the robot.



DANGER

Do not place your hands between the leg pods and the body plates, or injury may occur.

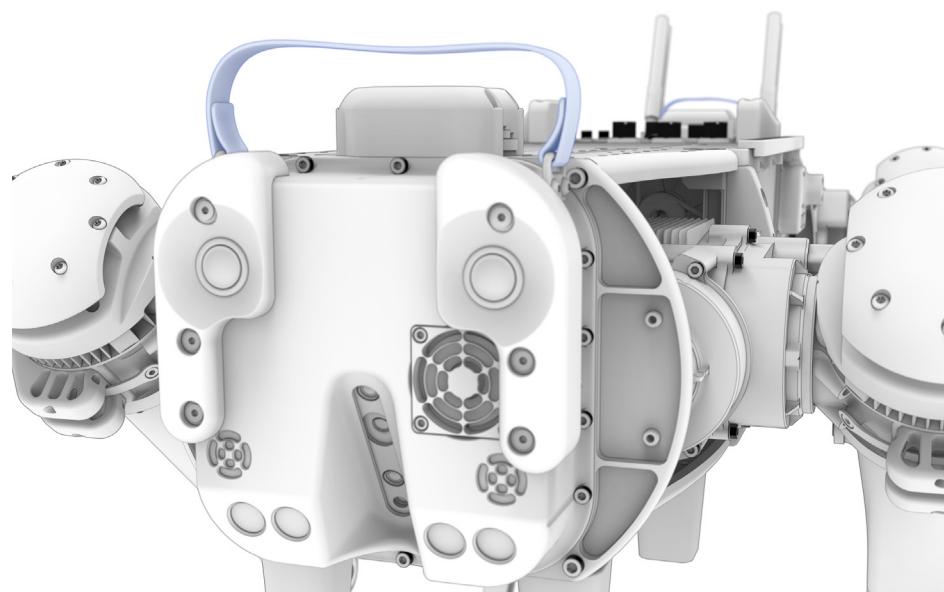
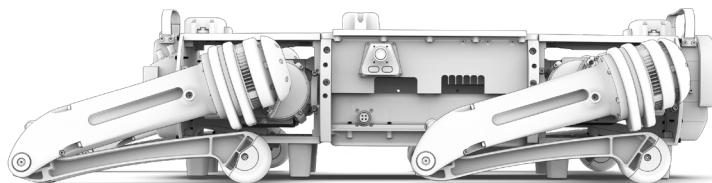
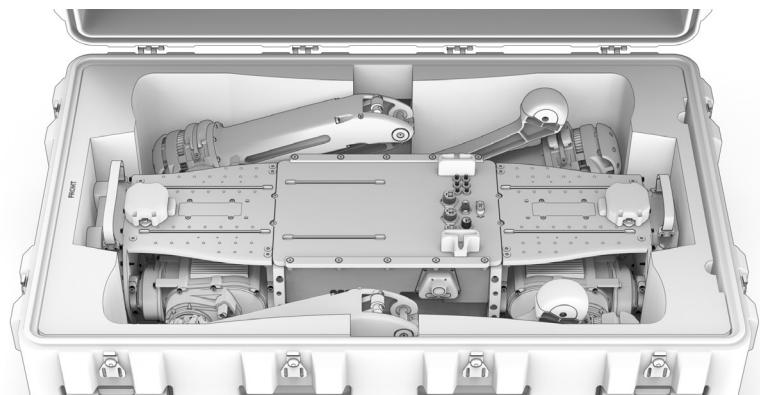


UNPACKING



WARNING

ALWAYS lift robot with two people, using ONLY front and rear lifting straps.



The Vision 60 is heavy, so two people should move the robot. Never move the robot alone. When lifting, only use the front and back handles. Be careful that the legs may move due to gravity when lifting.

Place the robot on flat ground and untuck the back two legs as shown above.



BATTERY

The Vision 60 is powered by a lithium battery with a Battery Management System (BMS).

The current battery level is indicated at the top of the Ghost App, from 0% to 100%.

Here are a few tips to keep in mind to get the most out of your robot:

- Recharge the battery before it reaches 10%. The robot will sit down when the battery is very low.
- An estimated run time remaining is shown at the top of the Ghost App.

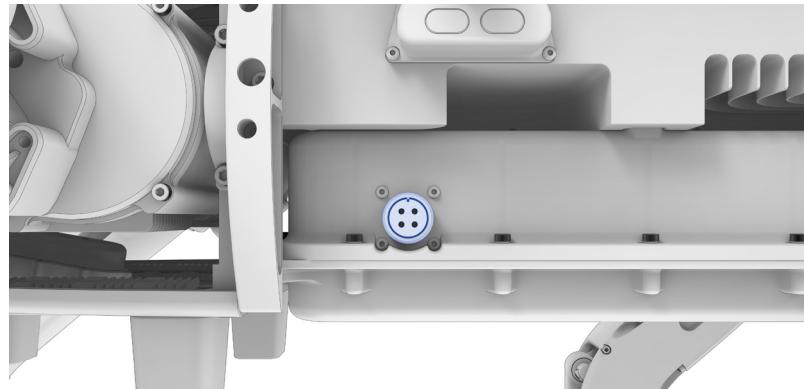
SAFETY INSTRUCTION

To charge the battery, sit down the robot and turn it off by pushing the on/off button on the back and plug the charger into the side of the robot.

When plugged in, the charger will indicate it is charging at eight amps. If it isn't indicating a charge, press and hold the lower button on the charger to start charging. The robot can be turned on while charging, though it is not recommended to stand until charging is complete.



CHARGING



Before powering on the robot, you must make sure the robot and controller battery are charged. To do this, remove both the robot charger from the case, and the controller charger from the included toolkit within the case. Then plug the robot charger into the robot and the controller charger into the controller.





STATUS LIGHTS

The Vision 60 has four LED status lights on its sides. These indicate the state of the robot:



Yellow: Starting



Green: manual control
Green fading: robot ready, remote control not detected



Blue: Vision/autonomous mode



Red: Emergency stopped, or error

POWERING ON

Before using the robot for the first time, make sure the robot and controller are fully charged.

To turn the robot on or off, push the **On/Off Button** on the back of the robot.

DANGER

Make sure that all body parts are away from the robot when turning the robot on or off to avoid injury, as the robot will collapse.

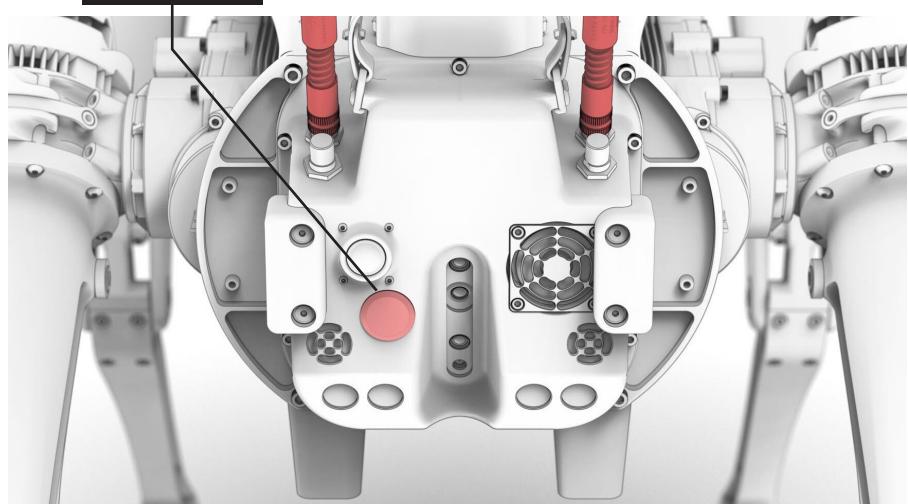
WARNING

To turn the robot off, ensure robot is at a complete stop, ensure the remote control is not providing input to the robot, and push the On/Off button. All power is cut to the robot when turned off.

CAUTION

Do not move the robot while it is starting up, as it can cause calibration issues.

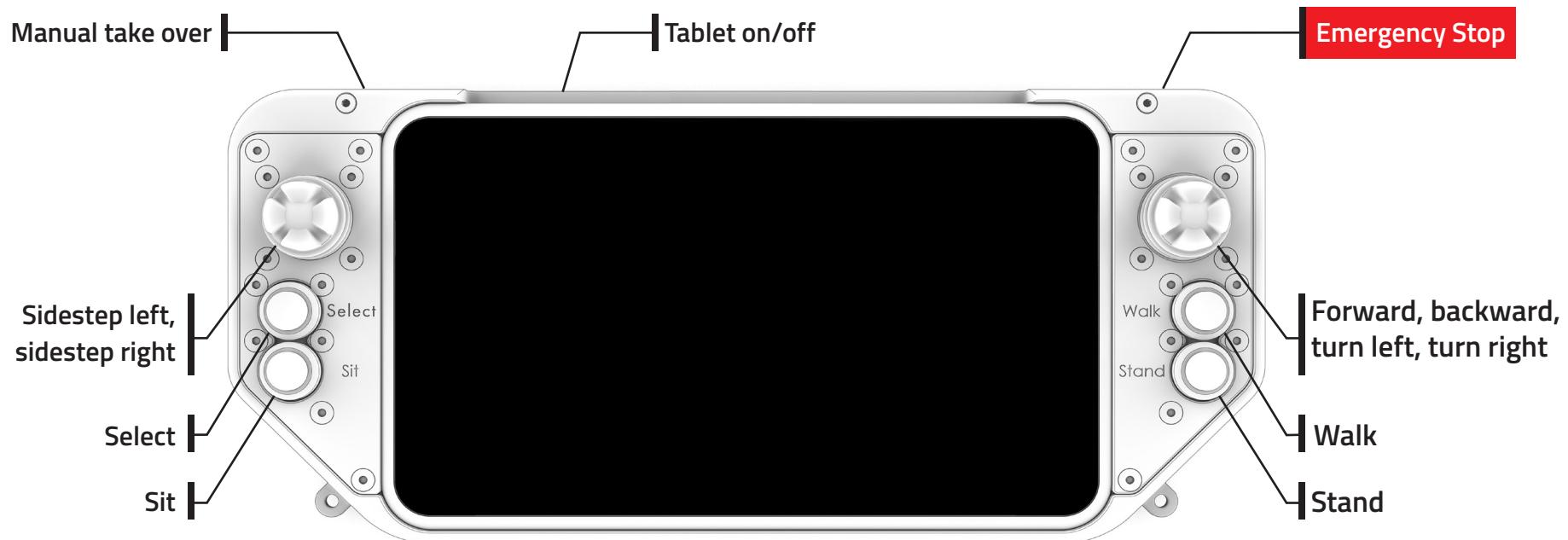
On/Off Button





REMOTE CONTROL

The robot is operated with a Samsung Galaxy Tab Active3 and the joysticks controller.



To power on the remote

Turn the tablet on by holding down the top black button for two seconds, and start the Ghost App. Tap the "Allow" button that pops up to allow the joysticks to connect.



WIFI

The robot broadcasts a WiFi access point named Vision60_*(where the * will be your robot serial number) one minute after it is turned on. The tablet will connect to this WiFi network automatically.

If "No WiFi" is shown at the top of the app, open the Android settings (press the tablet's home button) and connect to the robot's WiFi network.

The robot's WiFi password is:

vision60

If the WiFi network doesn't appear after the robot is on, or if the app isn't connected, turn the robot off and then back on again using the robot's on/off button.



WARNING

Risk of Injury Do not add secondary WiFi as this may result in unanticipated operation / movement of robot. Such operation / movement may injure persons or property.



EMERGENCY STOP

On the remote control, the top right button under the red metal guard is the remote **EMERGENCY STOP** button. When pressed, all of the robot's motors will immediately turn off, and the robot will de-energize and fall to the ground.

SAFETY INSTRUCTION

The Emergency Stop button on the remote is designed to stop the robot in emergency situations only.



WARNING

The user must account for persons and property when pushing the emergency stop button. The robot will fall onto anything when the emergency stop button is pressed.

NON-EMERGENCY STOP

In all other situations, simply press the **SIT** button at any time to make the robot stop and sit down. If the robot is in autonomous mode, press the physical Manual take over button first on the top left of the controller.





GETTING STARTED

Once you have read this guide and understand the warning instructions, charge the battery and start the robot.

DRIVING INSTRUCTIONS

1. Unpack robot from case.
2. Turn the robot on by pushing the on/off button on the back of robot.
3. Start the Ghost App. When it connects to the robot's WiFi after one minute, the screen will show a visualization of the robot.
4. Press the **STAND** button. The robot will stand up. Use the joysticks gently to look around.
5. Press the **WALK** button. Move the right joystick forward and the robot will take steps. Use the joysticks to walk around, pushing them only a small amount from their center.
6. Press the **SIT** button.



OPERATION

ENVIRONMENTS

The robot is able to move over a range of built and natural environments. For optimal performance in the challenging environments listed below, the operator must select the appropriate locomotion mode in the app (or via APIs):

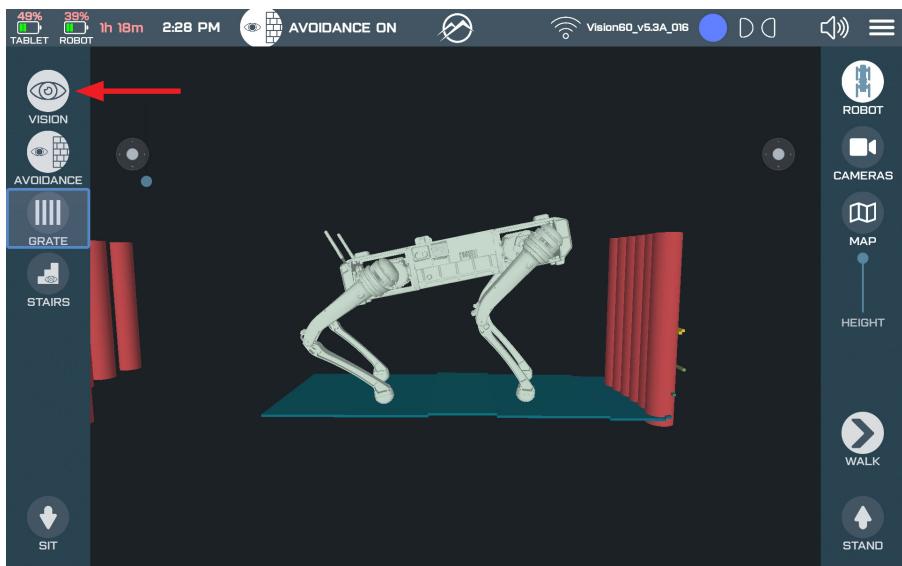
Mode	Environment
Blind walk	Grass, brush, foliage
Vision walk	Curbs, steps, short grass
Vision Stairs	Stairs
Hill mode	Deep inclines
Hill or blind curb	Rough terrain
Blind curb	Thick brush or large rocks
Sand	Loose, sandy terrain



OPERATION

VISION MODE

In vision mode, the robot uses its depth cameras to sense its environments such as up and down curbs, crossing gaps, going up steps, stairs, etc. The robot uses this vision information to select safe footholds.



Tap the **WALK** button, and then the **VISION** icon to enable vision mode.

COLLISION AND CLIFF AVOIDANCE

In this mode, the robot will avoid collisions with fore/aft obstacles and avoid walking off cliffs.

To enable:

- Press the **WALK** button, tap **VISION**, or press the **SELECT** button while **VISION** is highlighted blue.
- Ensure that the **AVOIDANCE** button is highlighted white.
- The robot's side LEDs should be blue, and the on-screen graphics should display the floor.
- If the robot is driven up to an obstacle, it will stop and the obstacle will appear as cylinders.

The robot recognizes and stops for obstacles that are taller than 35cm and climbs over shorter obstacles.

The depth cameras only have visibility directly in front of, behind, and under the robot. The robot cannot detect obstacles on its sides, and will collide with obstacles if turning sharply or moving laterally even if this mode is enabled.

You can tap the **AVOIDANCE** button to disable collision and cliff avoidance while staying in vision mode.



OPERATION

VISION CURBS

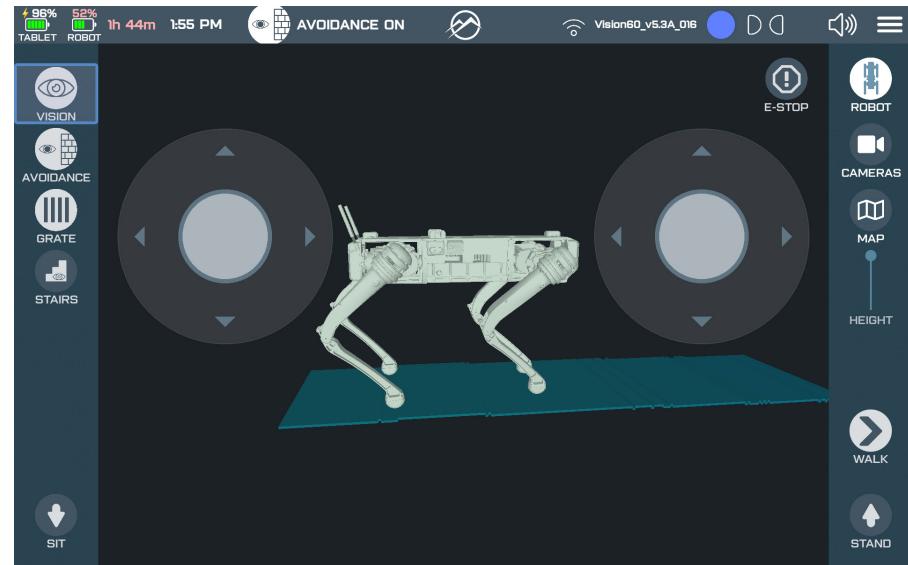
The maximum step height is 25cm. To ascend a single step, use vision mode and push forward gently but consistently on the joystick. For best results, the robot should not have to step down right after a large step up. Operators should approach curbs head-on and avoid stepping on tall but narrow obstacles such as logs.

VISION GRATES

The **GRATE** button allows the robot to enter grate mode. Grate mode allows the robot to walk on grated surfaces such as storm drains and grated stairs. While it should be fine to leave grate mode on even on normal, non-grated surfaces, it is recommended that users turn off grate mode when not required.

VISION GAPS

If a gap is shorter than 35 cm, the robot will step over it in vision mode. To get the best performance while crossing gaps, it is recommended that users drive forward consistently.





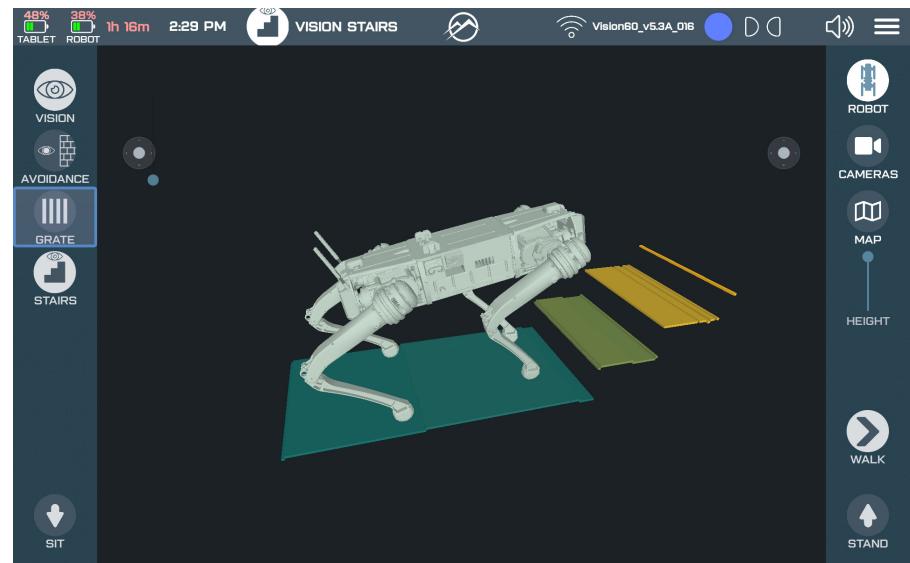
OPERATION

VISION STAIRS

The vision stairs mode allows the robot to climb staircases. The recommended staircase dimensions are < 9 in (23 cm) rise and > 10.5 in (27 cm) run.

To enable:

- Tap **VISION** to enable vision mode.
- Verify that "stairs" option is highlighted when using Vision mode on stairs.
- If the stairs have a grated surface, enable grate mode by pressing the grate button. (Note: In grate mode, the maximum speed for stair climbing is lower than non-grate mode.)
- Push fully forward on the joystick (Note: giving the robot small jerky inputs is much worse for robot stability than pushing fully forward on the joystick in stairs mode.)
- The robot includes an assist to automatically correct small alignment errors with respect to the stairs.



Press walk, then tap the Vision button on the left, and then the Stairs button on the left and walk up to stairs.



WARNING

Position the robot on a landing facing up stairs.

Note: when descending stairs, the robot should be oriented facing up stairs, and always descend going backwards.



OPERATION

WHEN TO NOT USE VISION MODE

Vision mode may not work in some challenging conditions such as:

- Stark shadows in bright sunlight: the robot may try to avoid stepping on shadowed areas.
- Dusty environments.
- Tall grass, brush, or vegetation: the robot may try to step on top of vegetation.
- Rugged natural environments with rocks and undulating surfaces like a hiking trail.
- When the depth cameras are occluded by rain or mud on the camera.

In these conditions, the operator should disable vision mode, and use blind modes such as hill, curb and stairs.



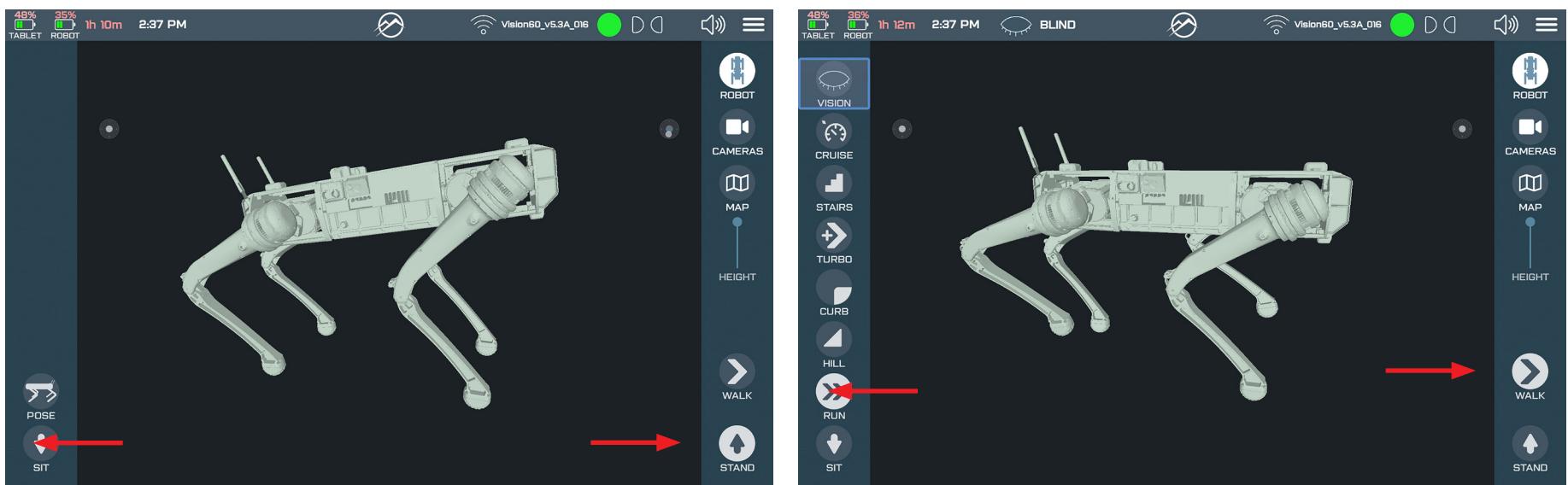


OPERATION

BLIND MODE

Blind mode does **not** use the robot's depth cameras, and can be used on moderate terrain with occasional grass and brush.

- **SIT:** The robot will sit down.
- **STAND:** The robot will stand up. In this mode, the robot can look around by moving the joysticks.
- **WALK:** The robot can be commanded to walk forward/backward, laterally, and turn.
- **RUN:** The robot will have access to significantly higher speeds. It is not recommended to use this mode in confined spaces. The robot takes a few steps to slow down and stop, so the operator should be careful about approaching obstacles too fast. Turbo mode can be selected along with run mode.





OPERATION

BLIND CURB

The blind curb mode allows the robot to step over obstacles or curbs without using the depth cameras. The robot raises its feet higher in curb mode. Use blind curb mode instead of vision mode when the solid ground is obscured.

To enable, tap **WALK**, then tap **CURB**.

BLIND STAIRS

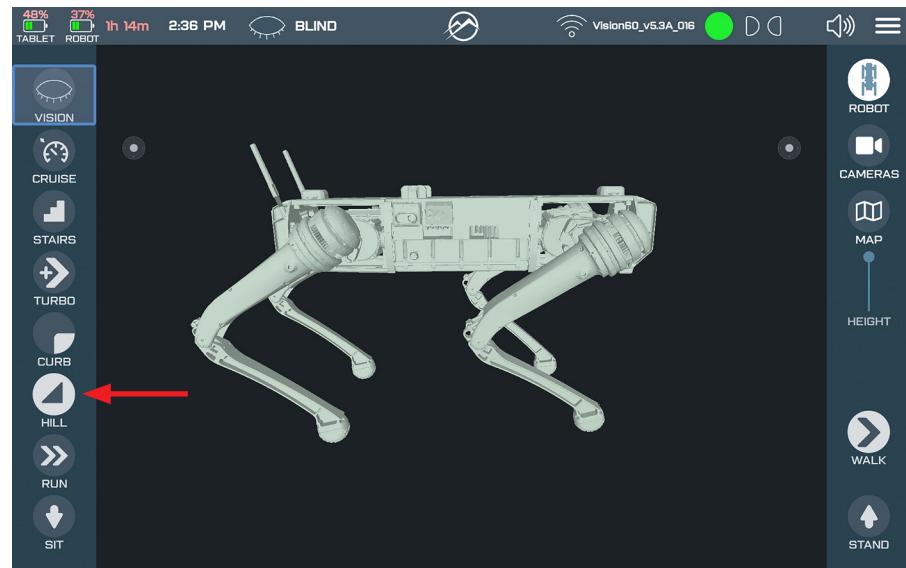
The robot adjusts its leg step height to clear stairs up to 8" (20cm). Use blind stairs mode instead of vision stairs mode only when the robot's depth cameras cannot detect the stairs correctly.

To enable, tap **WALK**, then tap **STAIRS**.

BLIND HILL

Hill mode is effective on steep inclines, shifting terrain, and/or soft sand. The robot should perform well on hills with slopes that are less than 40 degrees, depending on traction. To get the best performance, the robot should be driven directly up or down the hill, rather than across it at an angle.

To enable, tap **WALK**, then tap **HILL**.



The arrow is pointing to the **HILL** button. Above the **HILL** button you'll find the additional functions and their buttons referenced in this page.



OPERATION

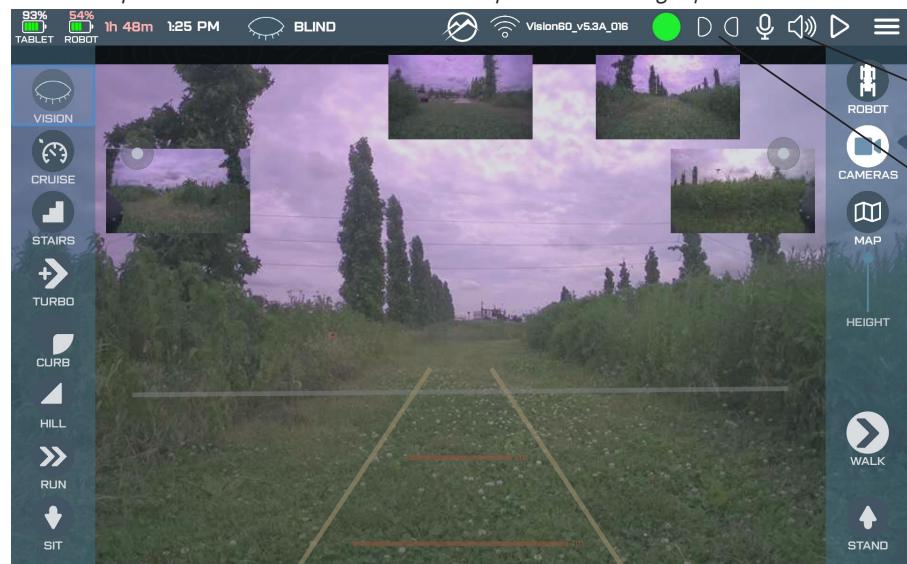
CAMERAS

Tap the **CAMERAS** icon to view the robot's five built-in surround color cameras. Tap one of the preview windows to switch to that view. Hold down the **CAMERAS** icon to access a full list of cameras available on the robot.

HEADLIGHTS

The robot's front headlights can be turned on by tapping the headlight icon in the top right of the app screen. Tap once for low-beam, tap again for high beam, and tap once more for off. The rear taillights can be turned on using the taillights icon to the left of the headlights icon.

*Tap the **CAMERAS** button on the top right to see streaming video from the RGB cameras surrounding the robot. Tap the inset views to switch which camera provides the enlarged fullscreen view.*



TWO-WAY AUDIO

Tap the microphone icon to speak into the tablet and have your voice relayed out of the robot's speakers.

Tap the **SPEAKER** icon to hear the sounds around the robot and play them on the tablet's speakers.

Tap the **PLAY SOUND** icon to play a preset sound out of the robot's speakers. Hold down the play sound icon to switch the sound played.





OPERATION

Once you're familiar with the basics you'll be ready to dive into some of the more advanced modes the Vision 60 offers.

- Pose mode is available by pressing **POSE** when standing. This will allow you to pose the robot slowly and accurately, and it will hold its pose until holding **POSE** again.
- Cruise control is available by pressing the **CRUISE** button in walk mode. This allows you to push the right joystick forward to increase the constant walk forward speed, and the robot will continue to walk forward until cruise control walk is disabled by pulling back on the joystick, pressing **CRUISE** again, or pressing **WALK**.



OPERATION

ENTER WAYPOINTS (GPS)

Tap the **MAP** icon to access the map screen. On the map screen, tap the **ENTER** button and tap points on the map to add waypoints for the robot to navigate toward.

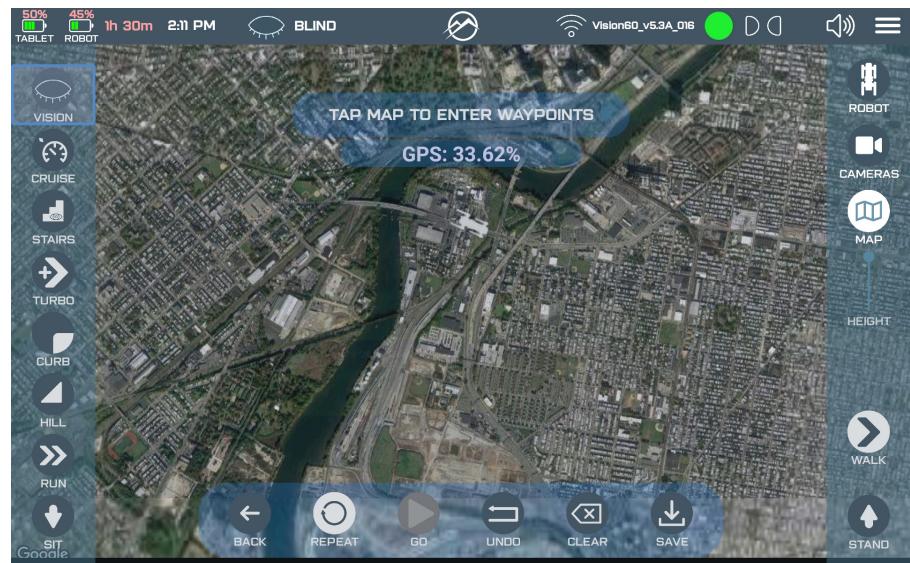
If no map is displayed, connect the tablet to the internet first and restart the app, to download the map tiles. Once the robot is outside with a clear view of the sky for up to five minutes, the GPS accuracy should be below the threshold of 0.20 meters before proceeding. Press the **GO** button to start the robot on its journey.

Press the top left physical button on the controller to stop the robot at any time, or the on-screen Take Over button.

ROUTE RECORD AND PLAYBACK (GPS)

You can have your robot automatically repeat a route it's been driven over. On the map screen, press the **RECORD** button to record a GPS route. While recording, drive the robot manually with the joysticks, then press **FINISH** when done. The route is not shown on the screen, but is stored on the robot.

Press **PLAY** to start the robot playing the recorded route.



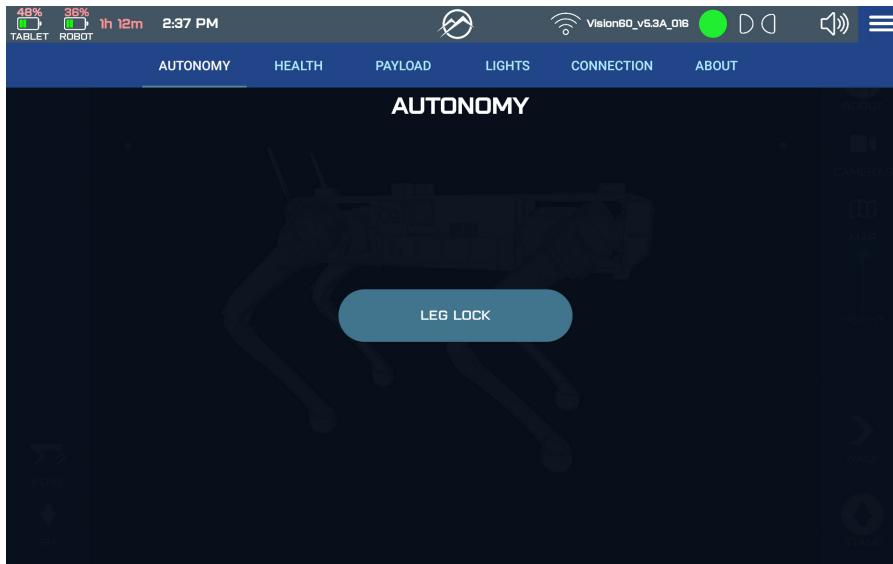
Tap the **MAP** button on the top right to switch to the map screen, where the waypoint navigation menu appears along the bottom of the screen.





MENU

Press the top right three lines button in the app to access the menu for payload and other robot settings.



LEG LOCK

Tap the **LEG LOCK** button on the **AUTONOMY** screen to make the robot fold its legs into a carrying and packing position. Push the **E-STOP** button on the top right to exit leg lock mode and the robot can stand up again.



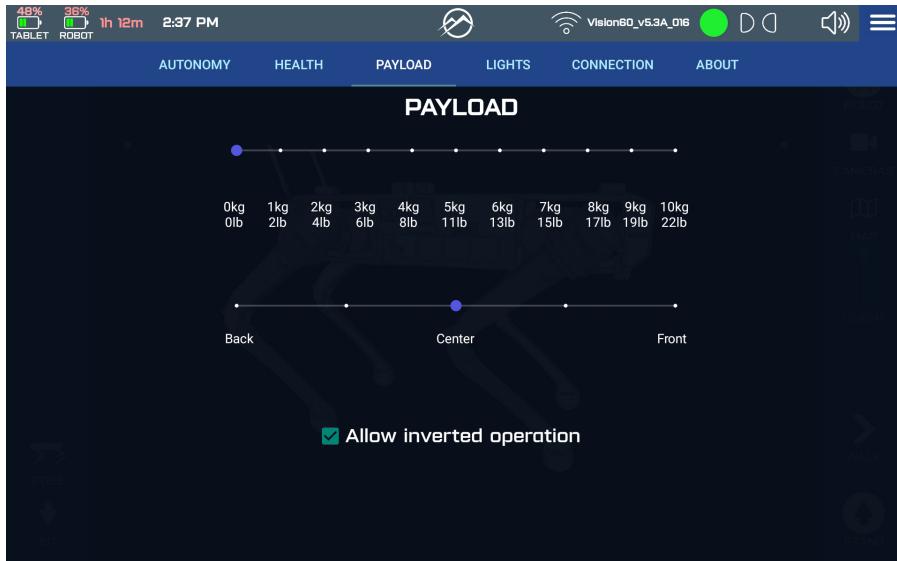
HEALTH

Shows robot health data. Peak joint currents are shown. All joints should stay under 90A. Over 90A indicates an uncalibrated joint and will need recalibration.

If you suspect recalibration is needed, contact support at support@ghostrobotics.io.



MENU

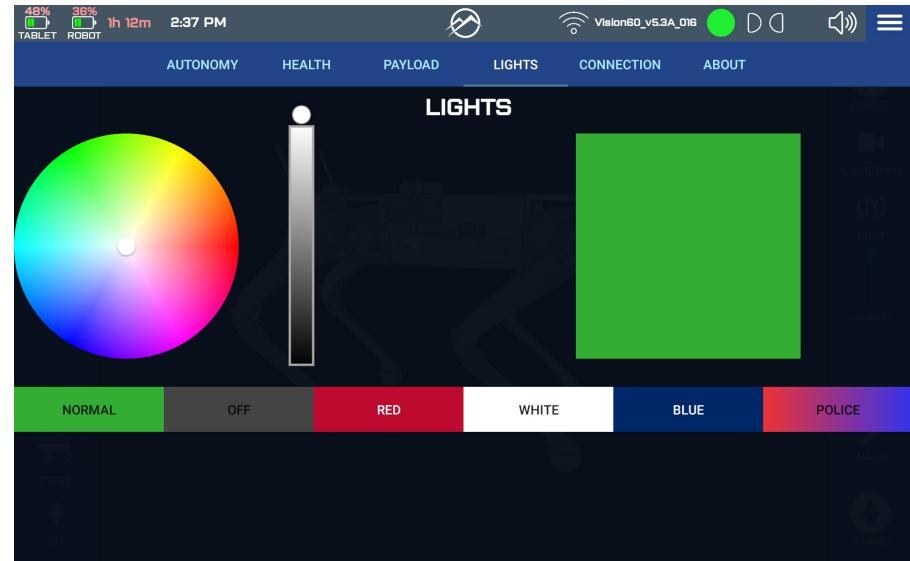


PAYLOADS

When a payload is added to the robot, the payload weight and position must be set, to allow the robot to compensate for the added weight. Set the payload weight and forward / backward position in the **PAYOUT** screen. This will be persistent over app and robot restarts, and shown as a status at the bottom of the screen.

INVERTED OPERATION

By default, the robot will operate inverted if flipped upside down. Deselect the **ALLOW INVERTED OPERATION** checkbox to stop the robot from standing up inverted.

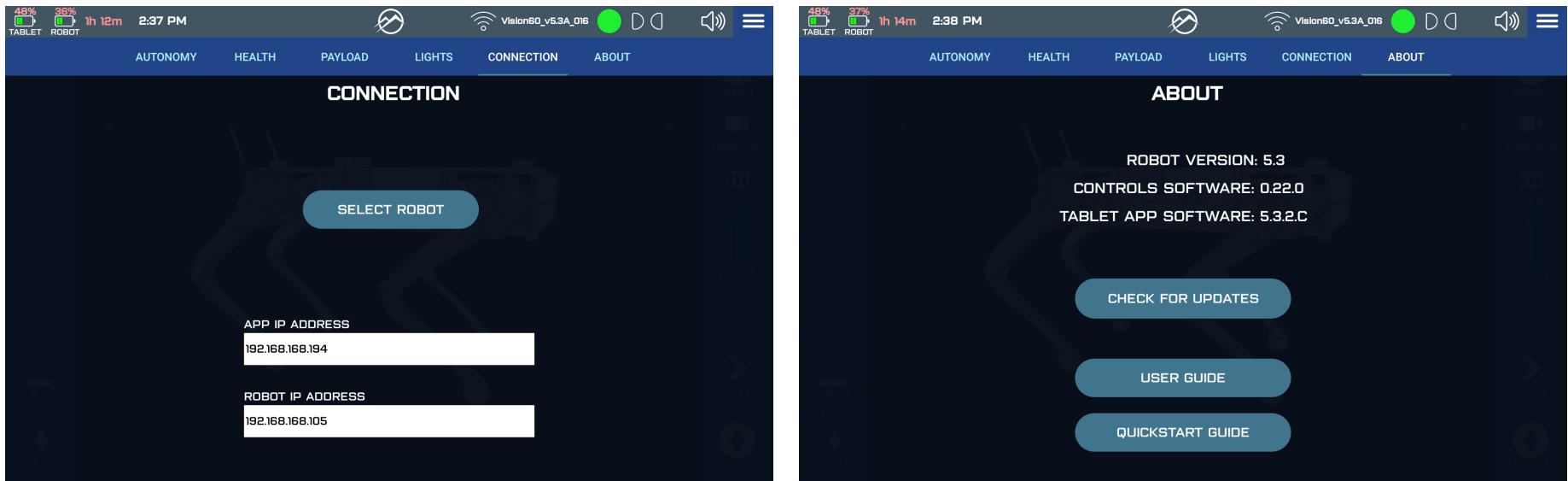


STATUS LIGHTS

Change the color of the robot's side status lights from the LIGHTS tab in the app. They can also be turned off when required. Note: When set to a color, the status lights will override the manual, vision, or autonomy status.



MENU



CONNECTION

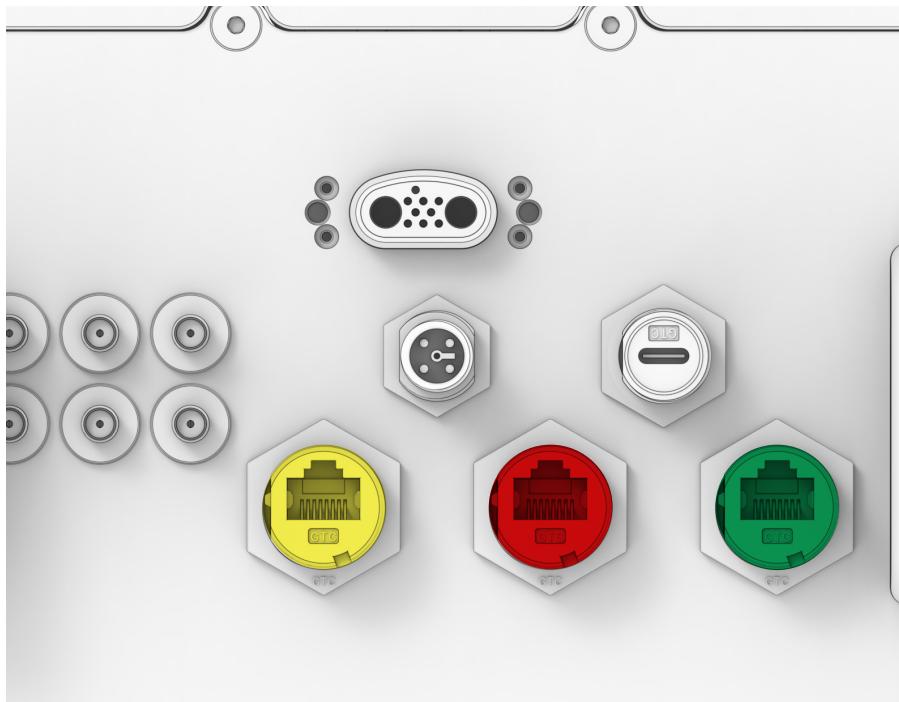
When operating the robot over LTE or with an external network, the IP address of the robot needs to be entered here.

ABOUT

Shows the robot's hardware version, software version, app version, and allows the app to update.



COMPUTE BOX



WARNING

RISK OF INJURY

Do not add secondary WiFi as this may result in unanticipated movement or operation of the Vision 60. Such operation / movement may injure persons or property. Use the WAN port to provide internet to the robot instead.

The compute box houses the computer and radio electronics of the robot. The primary computer inside is the NVIDIA Xavier.

The ports on top of the robot are:

- **Power:** Provides power to user payloads such as sensors or the arm. Available voltages: 12V and 24V, regulated up to 240W. See the end of this guide for more details, including ICD.
- **USB-C:** Connected to the Xavier, for use by payload sensors.
- **LAN Ethernet (Yellow):** Connected to the Microhard LAN port. Plug sensors into this port. You can use a network switch, if you need to connect more than one sensor.
- **WAN Ethernet (Red):** Connected to the Microhard WAN port. Plug a router into this port to provide internet to the robot for software updates.
- **Xavier Ethernet (Green):** Connected to the Xavier ethernet port. Plug high-bandwidth payloads such as LIDAR into this port.
- **6x MCX:** Connected to GMSL2 interface board on the Xavier, for use by cameras.

Note: Please use the mating connectors specified in the ICD (Found at the end of this User Guide) for all interfacing, to ensure proper waterproof seal.





SUPPORT

How do I operate the robot via a radio such as Persistent Systems or Silvus?

To control the robot with an IP radio such as the Persistent Systems or Silvus, first configure the IP radio to be in flat network mode, and then plug it into the LAN ethernet port on top of the robot, which connects into the robot's internal switch. Give it an IP address on the robot's network (e.g. 192.168.168.10), and do the same with the user-controller-side radio, with a different IP address (e.g. 192.168.168.20). The tablet remote controller is then connected to the controller-side radio via short range WiFi, and the remote controller will be able to send and receive comms to the robot over the radio link.

How are future updates and functions added to the robot?

The robot receives software and hardware updates by plugging an internet-connected ethernet cable into the robot's WAN port and scheduling an upgrade with the Ghost team. The software (high level, gait control, and tablet controller app) updates are released quarterly. These enable new features such as improved gaits (running, stepping, climbing, etc), improved perception (collision avoidance), improved autonomy (GPS, indoor, missions, etc), improved user interface (app screen), and bug fixes.

How does collision avoidance work?

Collision avoidance allows the robot to be operated in "Vision" mode and uses the forward and rear facing depth sensors to avoid colliding with static and dynamic obstacles such as people, vehicles, walls, posts, etc. It is enabled by tapping the eye icon at the top of the controller screen.

Ghost Robotics is here to help. For the fastest answers to your questions, email

support@ghostrobotics.io



REMOVING A LEG

This section explains how to remove and reattach a leg from the Vision 60 V5 robot. You'll need access to two tools provided in our robot toolkit:

- Metric 4 hex key
- Metric 3 hex key (Ball end)

First, ensure that the robot is powered off.

Take note of the type of robot you are working on. The different variations of robot have different leg components, and some may not be interchangeable.

DO NOT use legs from one group with legs of another group. This can cause irregular behavior and may damage your robot.

Physically, these legs can be identified by their thickness:



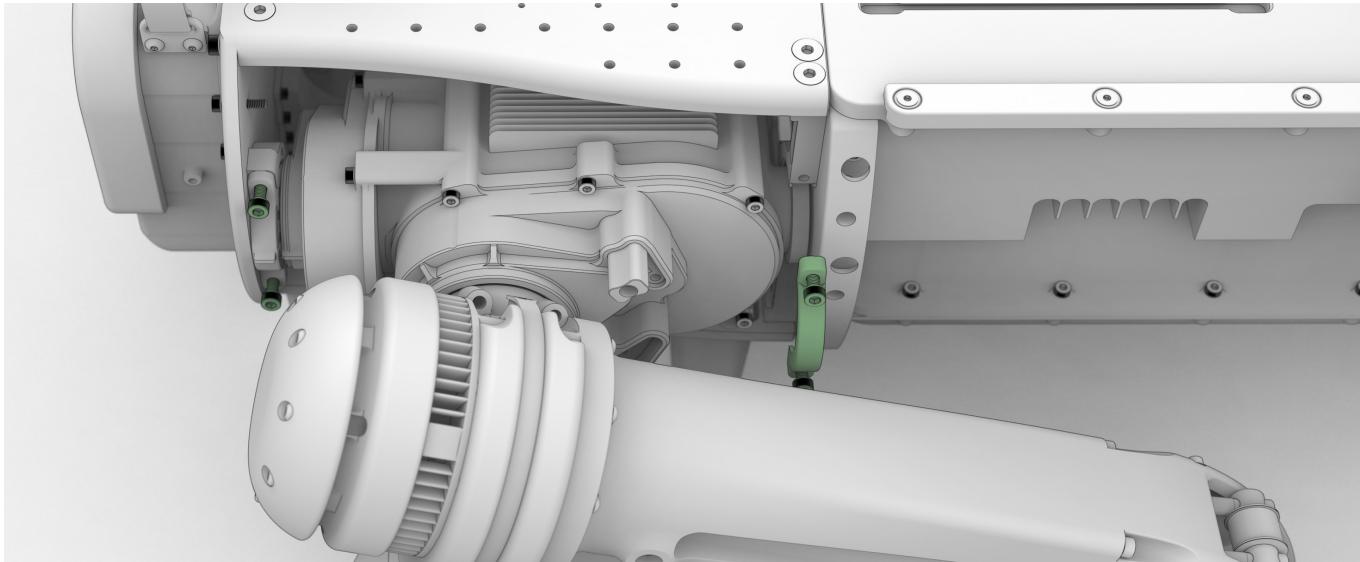
Shown: Leg thickness typical of a
5.1A - 5.2A robot



Shown: Leg thickness typical of a
5.2B - 5.3 robot



REMOVING A LEG

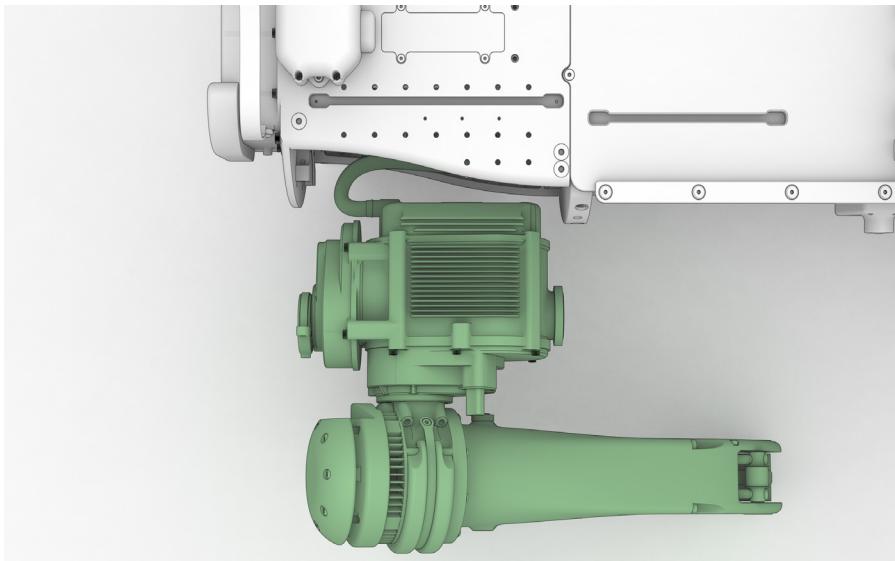


Next, remove the four (4) screws holding the leg to the robot frame, shown circled in teal. Use the metric 4 hex key to remove these bolts.

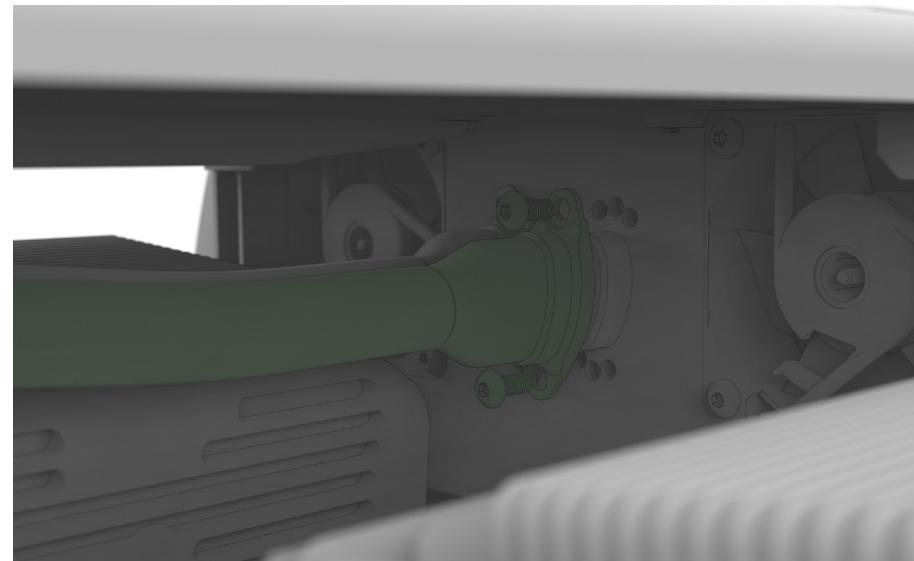
It may be difficult to access the bolts closer to the center of the robot. In this case, you may rotate the leg to a different position.



REMOVING A LEG



Next, move the leg out of the robot frame cavity. As shown, the passive clamp mount will also be removed from the robot frame.

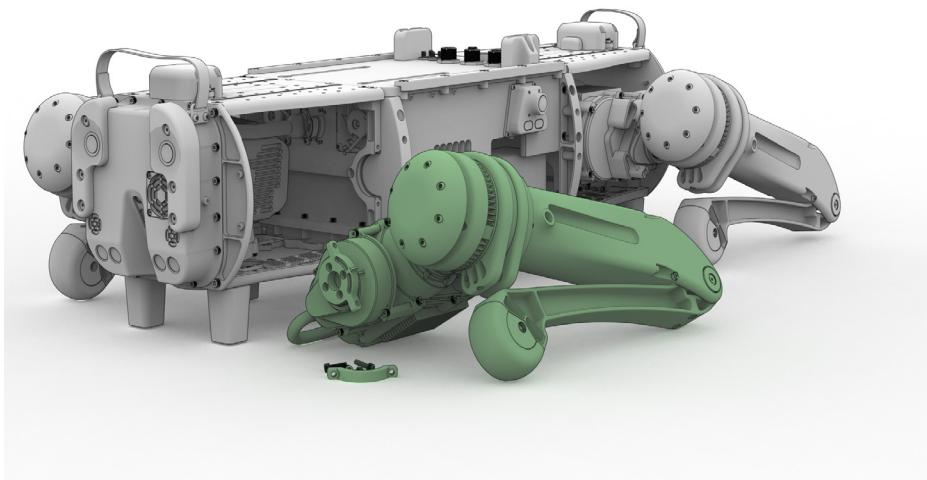


With the leg out of the way, you may remove the two bolts attaching the leg cable to the chassis of the robot. Use the metric 3 hex key for this. It is suggested to use the ball end of the metric 3 hex key, in order to insert the tool at a slight angle.

The top bolt is difficult to see. It may be advantageous to place your head lower than the upper surface of the robot, looking “up” into the leg cavity, to better see the bolts.



REMOVING A LEG



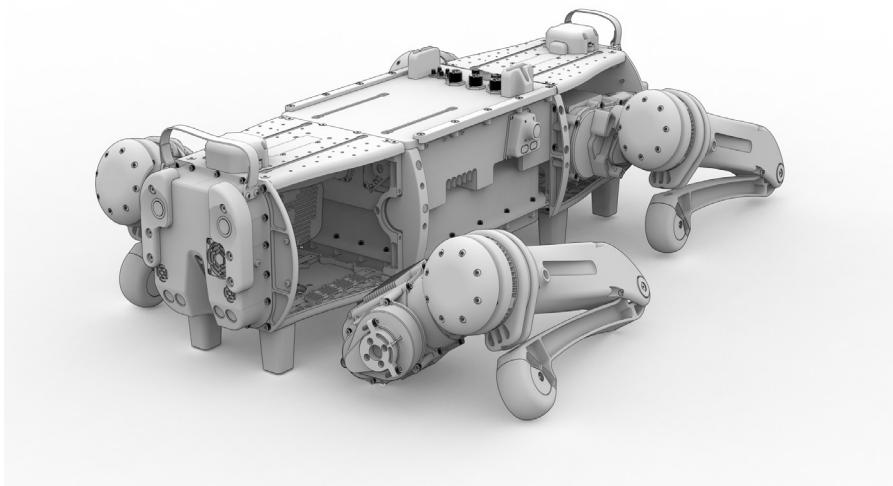
With these bolts removed, you may unplug the leg cable. You have now successfully removed your leg. Congratulations!



RE-ATTACHING A LEG

To reattach, please follow the above guide in reverse, noting the additional information below as necessary.

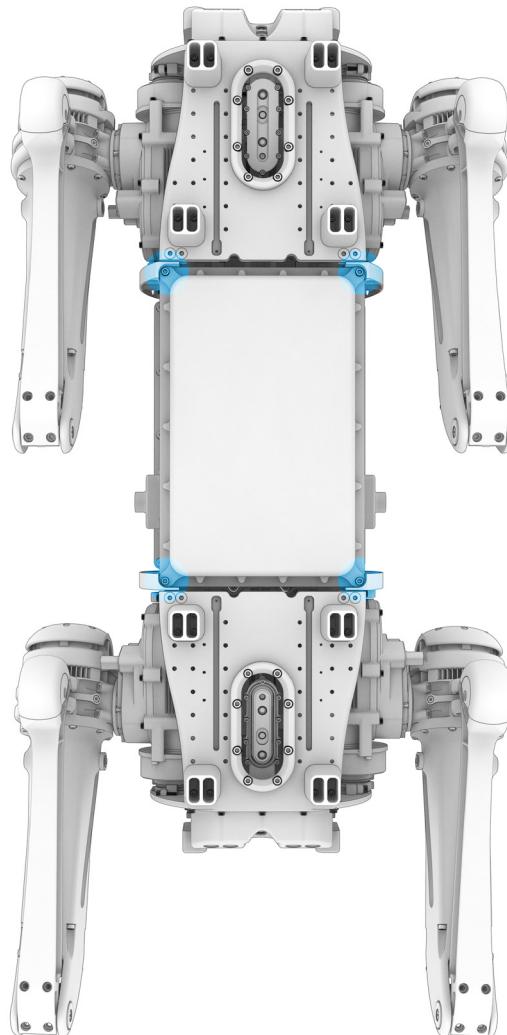
Please first note the positioning of the leg's abduction motor, ensuring its output is placed "outboard" of the center of the robot.



Second, please note the directionality of the leg cable. There is a small tab on the cable, and a similar removed portion of material on its port on the robot. When plugging the cable into the robot, if the cable does not insert on your first attempt, please rotate the cable's end 180 degrees and try again.



REMOVING THE BATTERY



Removal of the Vision 60's battery should be completed by two people.

To remove the Vision 60's battery, first place the robot on its nose. Be sure to have one person hold the robot in this position, taking care not to let the robot fall onto their partner.

Next, use a metric 4 hex key to remove the four bolts attaching the battery to the robot.

Finally, firmly tug on the battery to remove from the robot. Place all contents safely on the ground.



DEVELOPER GUIDE

SDK

Please see <https://ghostusers.gitlab.io/docs/> to keep up to date with the latest SDK, robot firmware upgrades, app updates, and documentation.

We're here to help

We recommend scheduling an intro call with a Ghost customer success manager to run you through the robot by emailing support@ghostrobotics.io.

WiFi

The WiFi Access Point broadcast by robot is:

Network: Vision60***

Password: vision60 (lowercase)

SSH

The NVIDIA Xavier on-board computer IP address is: 192.168.168.105.

To log in, connect to the robot's WiFi, and run:

ssh [ghost@192.168.168.105](ssh://ghost@192.168.168.105)

Password: ghost

Once logged in, to use ROS1, run:

ross

To use ROS2, run:

ros2s

If the connection fails, check that the Xavier and radio are both turned on, and that you are on the robot's network.



DEVELOPER GUIDE

WiFi/LTE Microhard Radio/Switch

The radio acts as the switch to connect the Xavier, WiFi, and ethernet. Admin settings can be accessed here:

<http://192.168.168.1>

Username: admin (lowercase)

Password: ghost2021!! (lowercase)

Users

The Xavier has been configured with two users:

- User nvidia
- User ghost, which runs the Ghost software in the **/home/ghost/current_ros2/** directory.



DEVELOPER GUIDE

Ghost software

The Ghost mobility and low-level software is launched by **ghost_lowlevel.service**, and the Ghost ROS2-based GPS waypoint and mission control software is launched by **ghost_ros2.service**.

Important packages:

ghost_manager: Contains launch files, Ghost Manager node, startup scripts, and URDF files.

web_video_server: Serves camera video feeds as an HTTP service.

Starting and stopping

The ghost service will start automatically on startup, so to stop it, run:

```
sudo service ghost_ros2 stop
```

To start it running in the background:

```
sudo service ghost_ros2 start
```

To run it manually to inspect ROS terminal output, stop the service, and then run:

```
cd /home/ghost/current_ros2/  
./ghost_ros2.sh
```





SAFETY

Users and bystanders should be aware that the Vision 60

- Is self-propelled and remote-operated
- Is suitable to carry passive or active payloads
- Is controllable either manually or through autonomous programming and sensory perception
- Is not suitable to carry living persons or animals

The Vision 60, while a capable machine, is not statically stable. Environmental conditions also affect its stability. When walking on inclines or declines, loose terrain, or other uneven environments, the Vision 60 may move quickly and unexpectedly in an attempt to maintain balance. The Vision 60 may also unexpectedly fall in such environments. Use caution at all times, and especially when the Vision 60 is operating over uneven terrain.

It is the user's responsibility to ensure safety of persons in the operating area of the robot. The Vision 60 is capable of carrying payloads. However, payloads may decrease the robot's stability, and may make the environment more hazardous to those nearby.



SAFETY

! CAUTION

The Vision 60 may move in unexpected ways when in operation. Please review this document and follow all safety recommendations.

! WARNING

Users and bystanders must remain at least two meters (2m) away from the robot at all times during operation.

! WARNING

Pinch Point. Keep hands clear during operation

The Vision 60 has many moving parts, especially near the abductor, hip, and knee joints of the robot. These areas should be avoided while the robot is in operation, and care should be taken even while the robot is turned on to prevent injury. Keep hands away from all joints. Do not attempt to reach into the robot while in operation.

! DANGER

OPERATION ON STAIRS/ELEVATED SURFACES

STAY BACK

Plan as if the robot will fall and keep all persons a safe distance away.

STAY ABOVE THE ROBOT

Position all persons above the elevation of the robot.

CRUSH HAZARD

The robot is heavy and may crush people or things it falls upon.

! DANGER

Hazardous conditions during locomotion could result in the following behaviors:

- Falls
- Re-stabilization attempts
- Quick or sudden acceleration of robot or components of the robot
- Tipping
- Sliding and tumbling following a robot fall
- Any combination of the above

! DANGER

The Vision 60 is capable of operation on stairs. However, it is advised that users and persons near the Vision 60 execute higher levels of caution when the robot is operating on stairs. The robot is at increased risk of falling and thus poses a more immediate danger to persons in its surrounding area. Users should not operate the robot at a lower elevation than the robot wherever possible, to minimize the possibility of the robot falling onto the operator.

! WARNING

STAY BACK Users and bystanders must remain at least two meters (2m) away from the robot at all times.

ROBOT MAY FALL OVER unexpectedly at any time and onto anything near the robot.

! WARNING

Do not operate the robot in salt water. If the robot is subject to salt water or other corrosive materials, please rinse the robot immediately with fresh water.



SAFETY



DANGER

DO NOT LIFT ROBOT WHILE IT IS STANDING

Robot will react with sudden movements and cause injury if lifted while it is standing.

SAFE LIFTING PROCEDURE

1. Sit down robot using tablet controller.
2. Power down robot by pressing On/Off button on robot.
3. Fold rear legs up and forward, placing under front leg elbows. Elbow joints should interlock.
4. With two people, lift robot from attached lifting straps at front and rear of robot. Keep hands clear of pinch points and joints.

Note: Never lift the robot or adjust leg position when the robot is powered on.



SAFETY

DANGER

HAZARDOUS SITUATIONS

Plan ahead to avoid hazards.

Cliff edge

CRUSH HAZARD The Vision 60 can see sudden vertical drops in vision mode. However, if ground is unstable, the Vision 60 may disturb ground where its foot is, causing a slip and the robot to fall over the edge.

Surface conditions, such as sand and oil

SUDDEN MOVEMENT / STAY BACK The Vision 60 **CANNOT** determine surface conditions. The robot will attempt to remain stable, but difficult terrain will hinder stability.

Cabling and other loose, thin equipment

SUDDEN MOVEMENT / STAY BACK The Vision 60 will not detect thin obstacles. If commanded to drive into a cable, the robot may become entangled, causing a loss of stability and sudden movements or falls. Ensure the operator is cautious when in the presence of cables or other thin equipment.

Wireless connection

SUDDEN MOVEMENT / STAY BACK The Vision 60 relies on its wireless connection to its controller for operation. Thus, any degradation of its WiFi signal may cause the robot to enter a disconnected state.

Robot driven into persons

STAY BACK In blind mode, the robot can drive into a person, as collision avoidance is turned off. In vision mode, if a person is standing near the periphery of collision avoidance viewport, it is possible for the robot to not see the person, allowing the robot to move into the person, potentially causing injury.

The robot will automatically sit down when it reaches 0% battery, which may result in injury. Battery faults may result in flames, explosions, hazardous liquids.



MISUSE OF VISION 60

DANGER

Robot misuse can cause death, severe personal injuries or result in significant material hazards.

WARNING

Fire In the case of a fire, a fire extinguisher rated for use on lithium-ion batteries must be used. Should the battery be damaged, do not attempt to handle it, and contact your local fire department immediately.



DO NOT STAND UNDER ROBOT

WARNING

Battery

- Do not place the battery in potentially-damaging environments such as fires or extreme heat
- Do not drop, puncture, or otherwise damage the battery
- Should a battery fire start, use a lithium ion rated fire extinguisher, as other extinguishers will not successfully put out the flames. The Vision 60 battery may create toxic fumes, and **cannot** be extinguished with a conventional fire extinguisher
- To reduce the risk of shock and fire:
 - Use a properly grounded outlet when charging
 - Do not touch uninsulated components of output connector or battery
 - Do not open or disassemble charger
 - Do not use robot or charger if any portion of cable is damaged.
 - Contact support@ghostrobotics.com if battery is damaged to obtain replacement battery.

TROUBLESHOOTING

The Vision 60 is designed to be user servicable. If errors occur with the robot, it is advised to first reboot the robot. Should errors persist, please email support@ghostrobotics.io for further assistance.

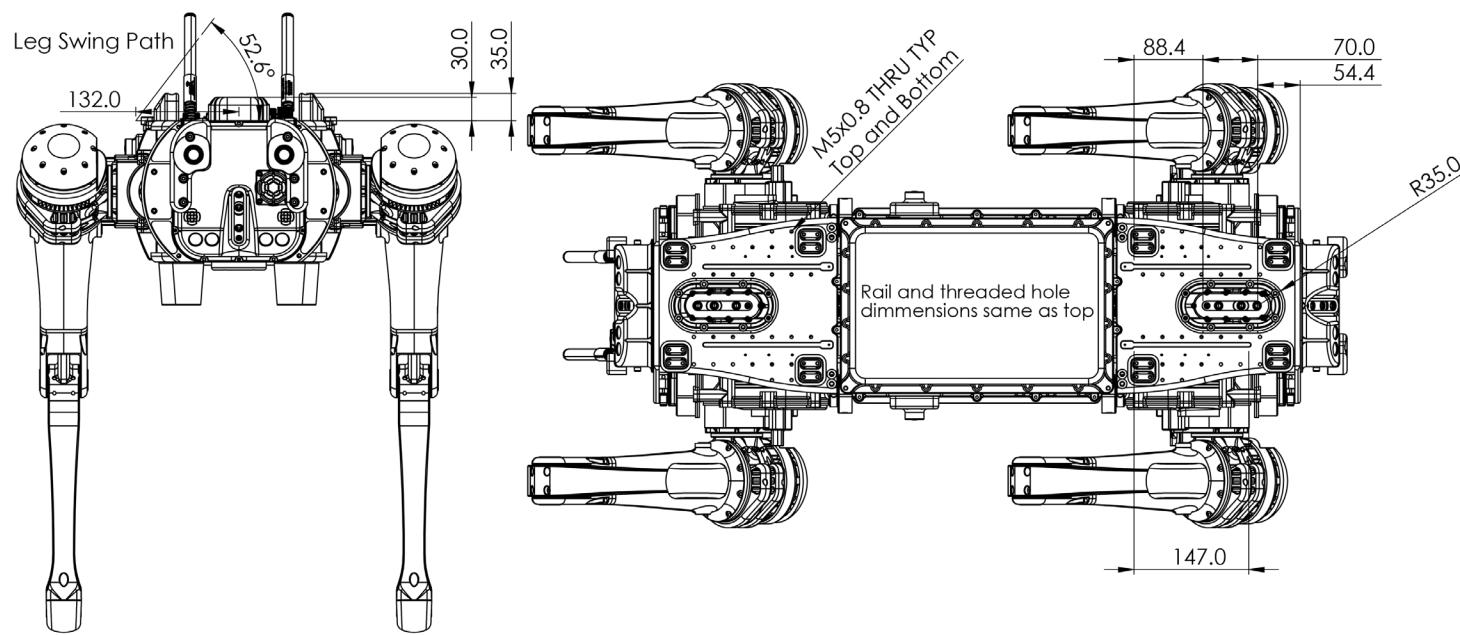
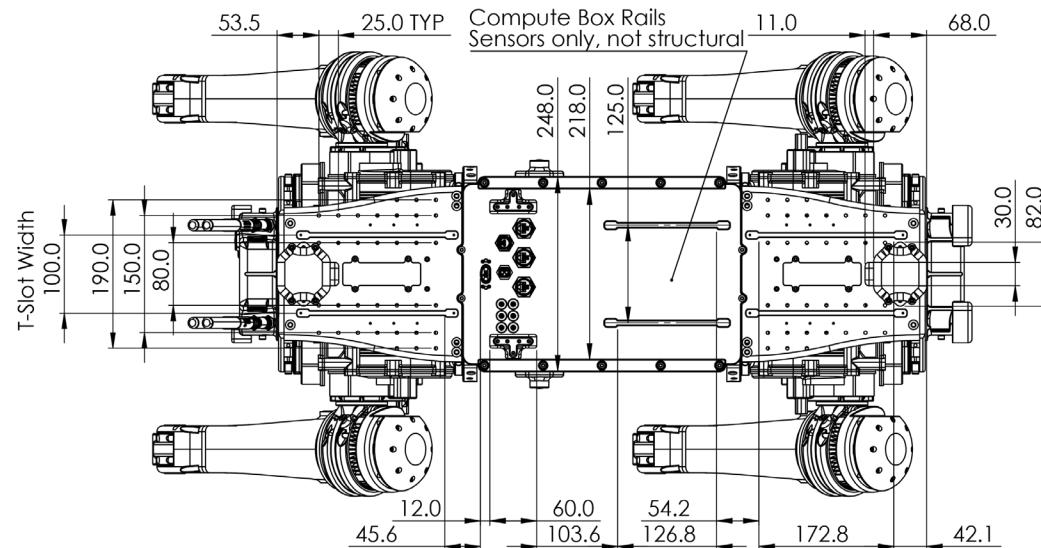
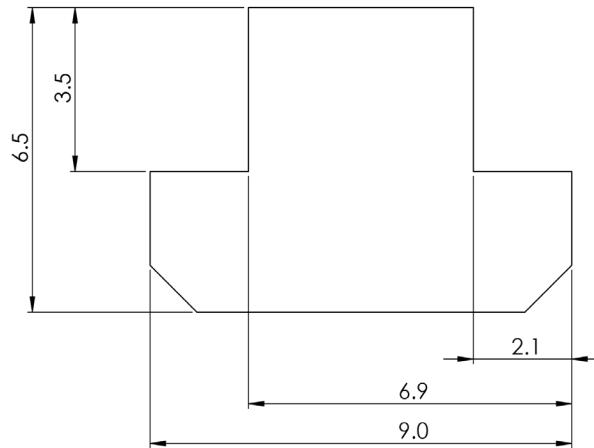
When emailing support@ghostrobotics.io, please include information about your robot and the specific issues occurring. Information should include the robot serial number, as listed by its WiFi network name, such as 5.1A_001.

In the case of any event where Vision 60 damages property or causes bodily injury to a person, follow local emergency response procedures. Report the incident to support@ghostrobotics.io. All communications will be recorded in our support system.



VISION 60 DETAILS

T-Slot Nut
Mcmaster PN: 90510A231

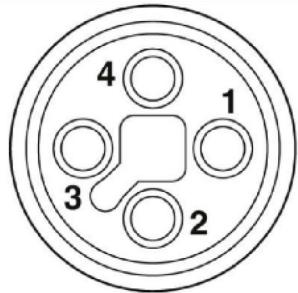


VISION 60 V5.3A
Mounting Points



VISION 60 DETAILS

Mating Connector Pinout
View is mating side



Regulated Power Breakout
Mating connector PN:
Phoenix Contact - SACC-M12FRT-4CON-PG11-M 1408989

Pin 1: 12V
Pin 2: 24V
Pin 3: GND
Pin 4: GND

Ghost Aux Connector
For use with Ghost approved devices only

USB 3.1, C

Mating Connector Options:
USBFireWire - RR-21C320-01-40
USBFireWire - RR-21C320-01-78

6x GMSL2
SMA Sensor Input

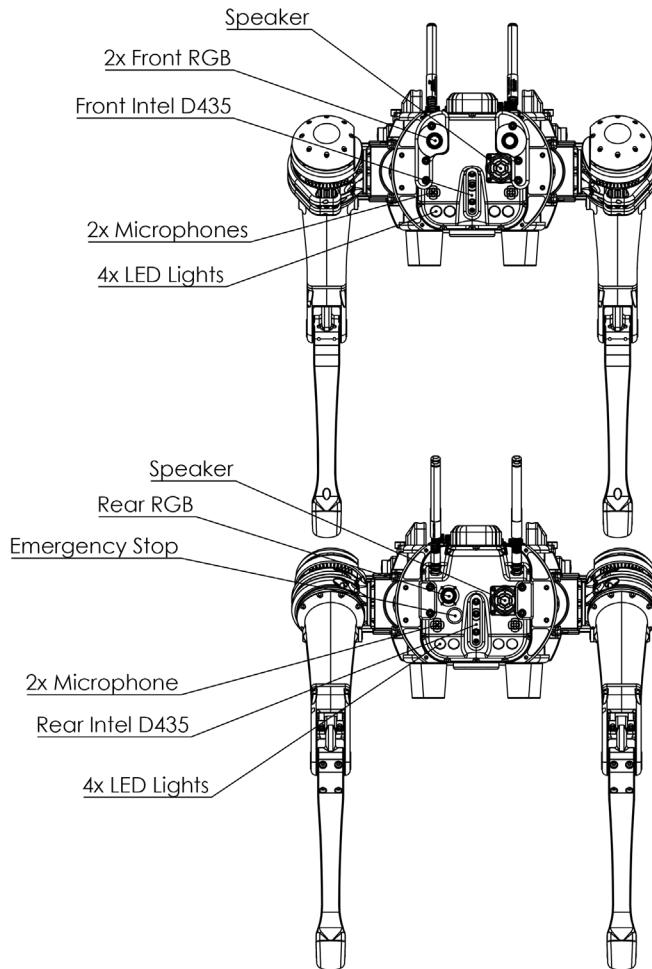
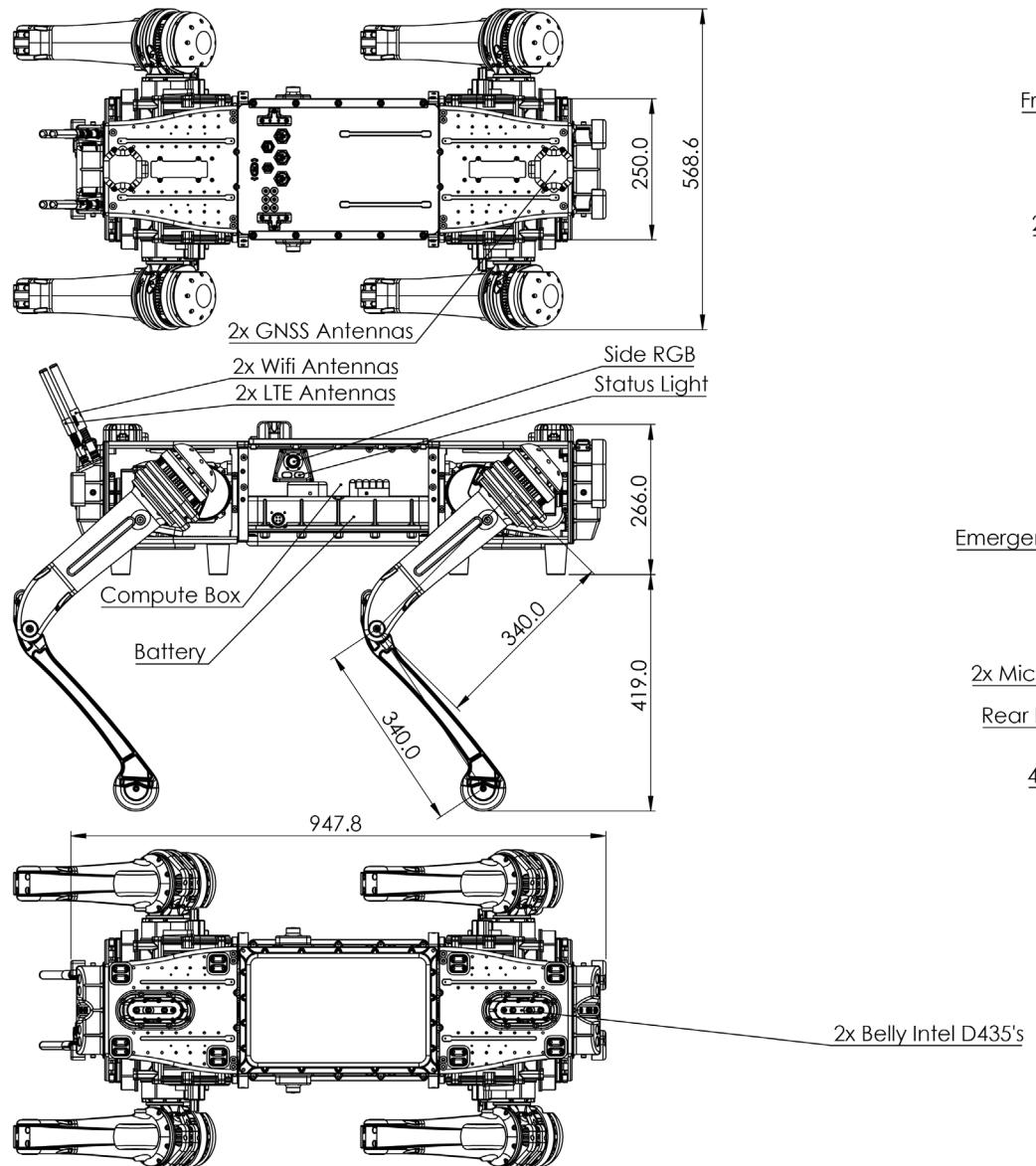
RJ45, LAN RJ45, WAN/LAN RJ45, WAN

Mating Connector Options:
USBFireWire - RR-225320-06-118
USBFireWire - RR-225330-00

VISION 60 V5.3A
Electronics Breakout



VISION 60 DETAILS



VISION 60 V5.3A
Features



GHOSTROBOTICS

ROBOTS THAT FEEL THE WORLD®