

WARTHOG

UNMANNED GROUND VEHICLE

USER MANUAL

CONTENTS

1	Introduction	4
1.1	What's Included	4
1.2	Hardware Overview	5
1.2.1	Battery Charger	6
1.2.2	Bilge Pumps	6
1.2.3	User Panel	6
1.2.4	Payload Integration Area	6
1.3	Technical Specifications	7
2	Getting Started	8
2.1	Wireless Stop Remote	8
2.2	Futaba Controller	9
2.3	Body Lights	10
2.4	Wireless Access	11
2.5	Remote ROS Connectivity	12
2.6	Visualizing Warthog	12
2.7	Drive Train	13
3	Safety Considerations	16
3.1	General Warnings	16
3.2	Maneuverability in Water	16
3.3	Pinch Points	16
3.4	Stop Buttons	17
3.4.1	Hardwired Stop	17
3.4.2	Wireless Remote Stop	17
3.5	Electrical System	18



4	Payload Integration Guide	19
4.1	System Architecture	19
4.2	Mechanical Mounting	22
4.2.1	Payload Integration Guidelines	22
4.3	Electrical Integration	23
4.4	Software Integration	24
5	Maintenance	29
5.1	Battery & Charging	29
5.1.1	General	29
5.1.2	Long-term Storage	29
6	Contact	30



INTRODUCTION

Clearpath Robotics Warthog is a rugged, all-terrain unmanned ground vehicle capable of travelling on land and in water. Warthog fully supports the Robot Operating System (ROS) and can be equipped with a variety of payloads, including sensors and manipulators, to accommodate a wide range of robotics applications in mining, agriculture and environmental monitoring. This guide contains information about the setup, safe operation, and maintenance of your Warthog. Please read the entire manual and safety warnings prior to operating the Warthog.

What's Included

Included with each Warthog are the following:

- 1x Warthog UGV
 - Onboard computer
 - User Panel with power, Ethernet, Serial(RS232) and USB connectivity
 - 48V Lead Acid Battery Pack
 - Battery Charger
- 1x Futaba Remote Control (R/C)
- 1x Warthog User Manual
- 1x Wireless Stop Remote

Hardware Overview

Please see Figure 1 for a view of some of Warthog's key external-facing features.

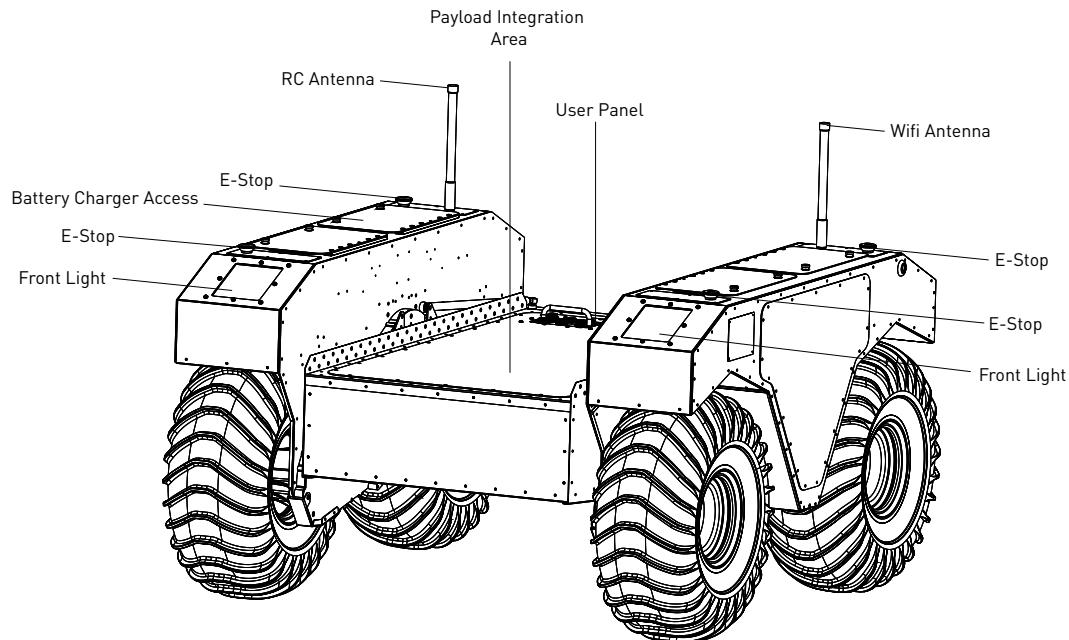


Figure 1: Warthog Hardware Overview



Battery Charger

Please see Appendix for information about the provided charger.

Bilge Pumps

The Warthog has two bilge pumps, with one situated in each of the drive units underneath the motor.

The bilge pumps are used to remove water from the main chassis and drive units during operation in water. At initial startup, an audible sound can be heard from the bilge pumps being initiated. These pumps are an automatic pumping system that check for water levels inside the drive units. The pumps automatically come on every two minutes and check for water levels. If the water level inside the drive unit exceeds a predetermined level, the pumps will remain on, otherwise they will shut off. During prolonged use in water, some water may appear in the drive unit. This is normal and acceptable.

This outlet leads from the pump to the exterior of the Warthog. It is used to remove excess water from the chassis and drive units. No obstructions should be placed in front of or around this area. Obstruction of water flow may result in damage to the internal electrical components and loss of function in the Warthog.

User Panel

The User Panel provides access to the user power panel, as well as USB, serial, and ethernet ports. The power panel can be used to power your payloads. The USB 3.0 and ethernet ports are connected directly to the onboard PC. To connect a device to the onboard network, it's suggested to give it a static IP in the 192.168.131.x subnet, avoiding IPs in use by the following pre-existing devices:

192.168.131.1	Onboard PC (all ports, br0 network interface).
192.168.131.2	Ethernet-connected MCU.
192.168.131.14	Front-facing LIDAR (optional).
192.168.131.13	Rear-facing LIDAR (optional).

Table 1: Warthog Onboard Network Devices

For more information on electrical integration, please see subsection 4.3 on page 23.

Payload Integration Area

All payloads should be mounted to the central chassis when traversing through water to prevent rolling. The primary payload of the unit should be placed on the central chassis. If necessary loading can be placed on the drive units however payloads should not exceed 50 lbs on each drive unit.

For more information and guidance on mounting payload structures on top of Warthog, please refer to subsection 4.2 on page 22.

Technical Specifications

Key specifications of Warthog are shown in Table 2.

External Dimensions (L x W x H)	1.52 x 1.38 x 0.83 m (4.9 x 4.5 x 2.72 ft)
Base Weight	280 kg (551 lbs)
Ground Clearance	254 mm (10 in)
Max Payload	272 kg (600 lbs)
Max Incline	35-45°
Max Speed	18 km/h (11 mph)
Suspension	Geometric Passive Articulation
Drive Configuration	4x4 Skid Steer
Operating Environment	Outdoor
Traction	24" Argo tire (24" Turf tire or 12" wide Quad Track System optional)
Battery Chemistry	AGM sealed lead acid (Li-ion optional)
Capacity	105 Ah at 48 V, expandable to 200 Ah with Li-ion option
Nominal Run Time	Lead acid: 2.5 hrs, Li-ion: 6 hrs
Charge Time	4 Hours approx
User Power	5 V, 12 V Fused (24 V, 48 V optional)
Control Modes	Remote control, computer controlled velocity commands, indoor/outdoor autonomy packages
Feedback	Battery voltage, motor currents, wheel odometry, control system status, temperature, safety status
Communication	Ethernet, USB, Remote Control, Wi-Fi
Drivers and APIs	Packaged with ROS Indigo (includes RViz, Gazebo support), Matlab API available

Table 2: Warthog System Specifications

GETTING STARTED

The first step is to read this manual and safety warnings. The next step is to power up your Warthog and have some fun driving it around!

Twist the red power button on the back of Warthog. Once the body lights are flashing red, twist (to reset) all four stop buttons (if necessary), and press go on the Wireless Stop Remote (next section). In a moment, Warthog should go to solid red lights in back, and solid white in front.

Wireless Stop Remote

Included with the Warthog is a wireless stop remote, shown in Figure Figure 2 below, which is needed for operation. If the wireless stop remote is out of range (900m), it will cause the system to stop. Likewise, if the wireless stop remote is inactive for 15 minutes, it will cause the system to stop.

To turn on the remote, hold down the red 'POWER' button until the battery and signal strength flash. The vehicle's lights will give an indication of the state of the stop system.

To assert a stop during operation, simply press the 'Stop' button which will be verified by the Warthog's lights flashing red. Similarly, to release the stop system to resume operation, press 'Stop' followed by 'GO'.



Figure 2: Warthog's Wireless Stop Remote

If you're not seeing any change in behaviour, please contact our support team.

Futaba Controller

The long range remote control (RC) Futaba radio transmitter can be used to tele-operate the Warthog. To begin, slide the power switch to the ON position which is labelled in Figure ??.

Caution: The speed adjustment knob should be turned initially all the way to the left while familiarizing yourself with the transmitter and slowly increasing it to get it moving.

The position of the speed adjustment scale is shown in Figure 4 as 'CH4'. The transmitter needs to be enabled which is done using the Enable/Disable switch that is a three position switch where only the down position enables it.

The left joy stick is used for the forward and reverse motion of the robot and the right joystick is used for turning.

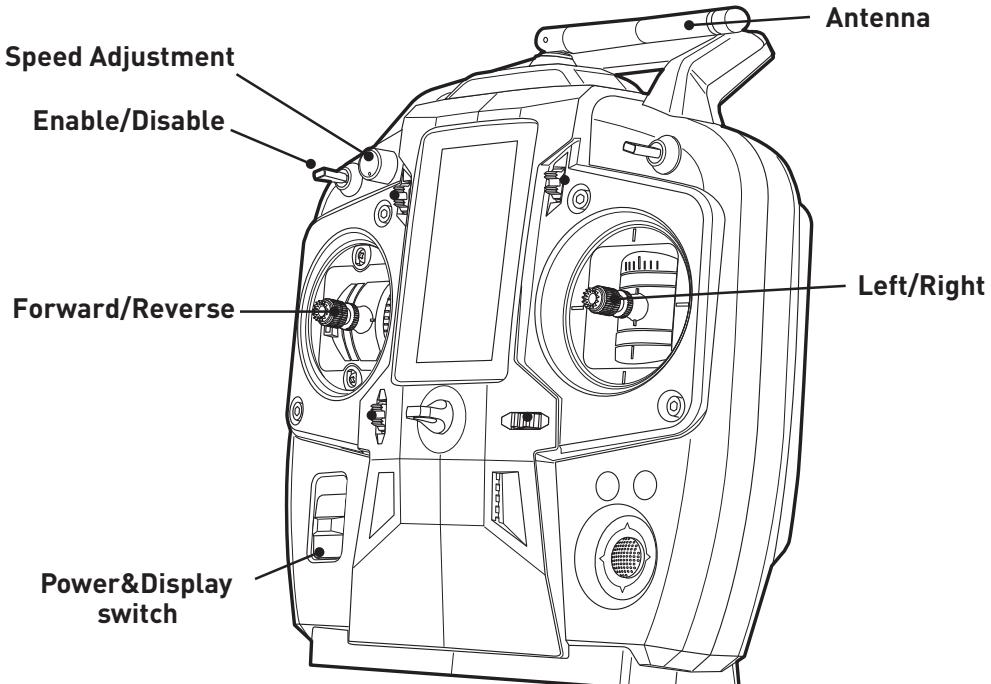


Figure 3: Futaba Radio Transmitter

If you're not seeing any action, check Contact on section 6 to get in touch with support.

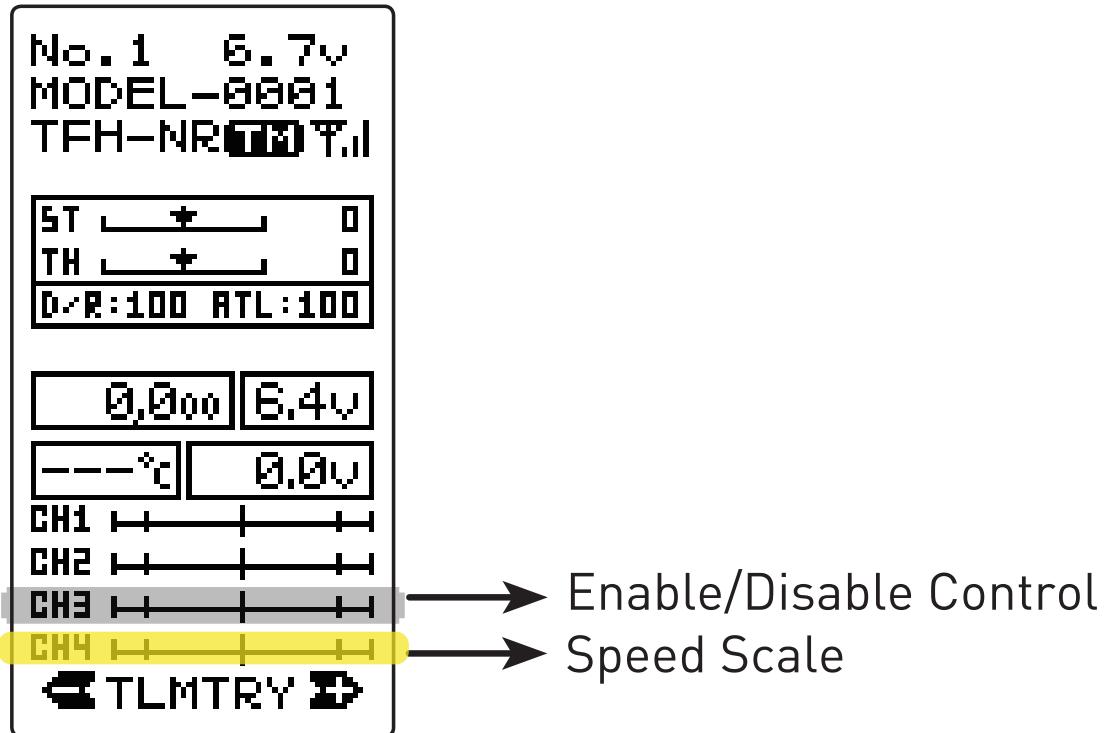


Figure 4: Futaba Radio Transmitter Screen

Body Lights

Warthog includes eight RGB body lights, stacked in a pair on each corner of the chassis. These lights express system status according to Table 3, but in the absence of one of the low-level conditions, they can be commanded from ROS to display indications from autonomy or other higher-level software.

See http://wiki.ros.org/warthog_base for information on commanding the body lights.

Solid red	The MCU is not in contact with the computer. That is, the rosserial connection is not active. This condition will be seen briefly on startup while Warthog's computer is booting up. If it persists, or is seen after initialization, either the base node on the PC has crashed, the network switch has failed, or a serious MCU error has occurred. If you suspect one of these conditions, please contact our support team.
Red flashing	Stop circuit is broken. Twist the mushroom buttons to ensure that they are unlatched, and check any external stop hardware, if present.
Flashing yellow	Motor drivers not yet ready to drive. The motors have a brief initialization sequence which must complete after a stop condition clears before they are ready to drive. If this condition persists, please contact our support team.
Headlights/tailights	When Warthog is ready to drive, the front will change from red to white. The intensity of the head and tail lights will increase slightly when actually in motion. This is the status which may be overridden by publishing your own light patterns to the cmd_lights ROS topic.

Table 3: Warthog Body Light Indications

Wireless Access

To get Warthog connected to your local wifi, you must first access the internal computer using a wired connection. Connect to one of the the network ports with a standard ethernet cable. Now, set your laptop's ethernet port to a static IP such as 192.168.131.51, and connect via SSH to `administrator@192.168.131.1`. The default password is `clearpath`.

Once connected via wire, execute `connmanctl` to enter the command line interface for Connman, from which you can configure Warthog to either join an existing network, or supply its own standalone access point. An example session to connect to an existing network:

```
connmanctl> enable wifi
connmanctl> scan wifi
connmanctl> services
connmanctl> agent on
connmanctl> connect wifi_123456_123456789123456789_managed_psk
```

After the `connect` line, connman will prompt you for your network's passphrase. Once connected, connman will remember and attempt to reconnect on successive power-ons.



Remote ROS Connectivity

Now that Warthog is on the wireless network, you can access it via SSH or as a remote ROS master. Note that in the default configuration, the background ROS process running on Warthog launches with the `robot_upstart` package, which is configured to set the `ROS_HOSTNAME` environment variable to the Warthog PC's hostname.

If your network resolves hostnames properly, connecting should be a matter of executing the following two lines in your desktop (or sourcing a script containing these lines):

```
export ROS_MASTER_URI=http://cpr-warthog:11311      # Your robot's hostname  
export ROS_IP=192.168.131.1                          # Your computer's wireless IP address
```

If your network doesn't resolve hostnames, you may need to add the following line to your `/etc/hosts` file:

```
192.168.131.1 cpr-warthog                         # The robot's wireless IP address.
```

Once everything is set up correctly, try running `rostopic list`, which will verify that your machine can see the robot's ROS master, and `rostopic echo /mcu/status`, which will verify that the robot PC can see your machine in order to stream topics to it.

Please contact Clearpath Support if guidance is required in selecting and executing a remote access strategy. For more general details on how ROS works over TCP with multiple machines, please see:

<http://wiki.ros.org/ROS/Tutorials/MultipleMachines>

For help troubleshooting a multiple machines connectivity issue, see:

<http://wiki.ros.org/ROS/NetworkSetup>

Visualizing Warthog

To command or observe Warthog from your desktop computer, first set up a basic ROS installation. See the following page for details:

<http://wiki.ros.org/indigo/Installation/Ubuntu>

When your ROS install is set up, install the Warthog desktop packages:

```
sudo apt-get install ros-indigo-warthog-desktop
```

Once your remote access to Warthog's ROS master is configured (as above), you can launch `rviz`, the standard ROS robot visualization tool:

```
roslaunch warthog_viz view_robot.launch
```

From within `rviz`, you can use interactive markers to drive Warthog, you can visualize its published localization estimate, and you can visualize any attached sensors which have been added to its robot description XML (URDF).

From your desktop, you can also launch the standard RQT Robot Monitor, which reports the diagnostic output from Warthog's self-monitoring capabilities, as shown in Figure 5:

```
rosrun rqt_robot_monitor rqt_robot_monitor
```

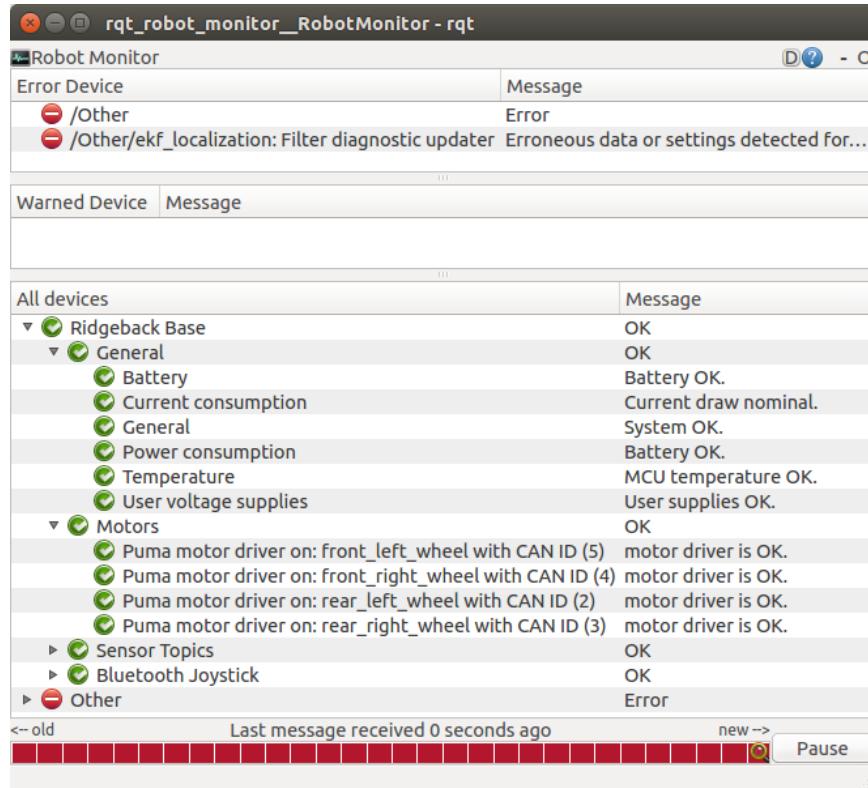


Figure 5: Robot Monitor

Drive Train

The Warthog has the ability to be put into neutral which is controlled by the four levers (two per side) in the rockers. The lever can be seen in Figure 6. Use the bolts to restrict the lever from moving as down in Figure 7 where the drivetrain is in neutral. The groove for the neutral position is marked with white and the bolt is also marked. Pull the handle on the lever to move it into gear which can be seen in Figure 8. Ensure the lever is in the green groove. If the lever is difficult to move, rock the Warthog back and forth. Do not try to force the lever to move.

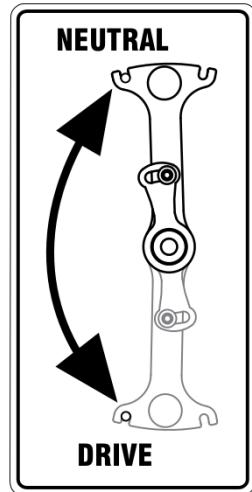


Figure 6: Drivetrain lever

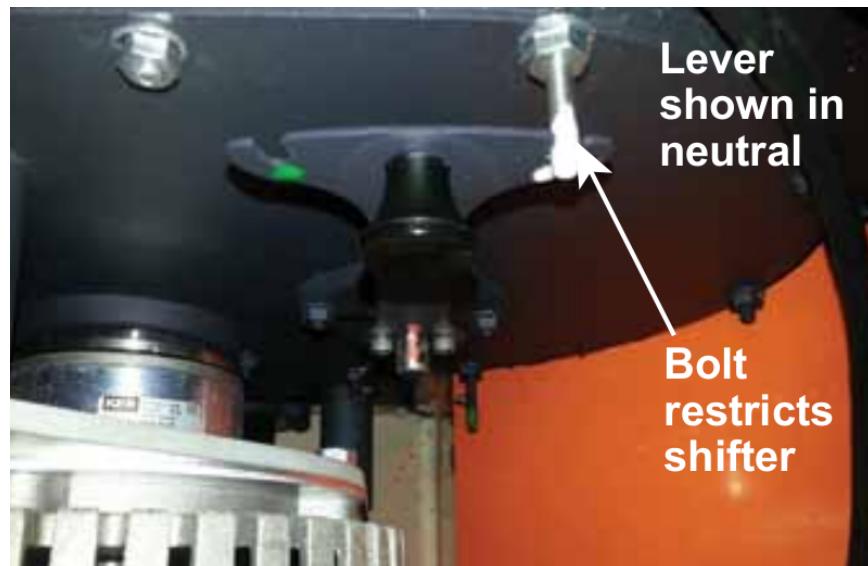


Figure 7: Drivetrain in Neutral



Figure 8: Drivetrain in Gear



SAFETY CONSIDERATIONS

Warthog is a powerful, heavy, fast moving robotic platform. Please read the following safety information carefully.

General Warnings

For the safety of yourself and others, always conduct initial experiments and software development with the motors not engaged. Whenever the robot is not being operated and the motors are engaged, keep it in a stop state. Do not ride on the vehicle, it can accelerate and brake quickly.

When starting out, favour slower wheel speeds. Warthog's control loops can accurately maintain velocities as low as 0.1 m/s. Operating at such speeds will give you more time to react if things don't go quite as you expect.

When enabling the system using the GO button on the wireless remote, be sure to stand well back from the Warthog. User code running on the Warthog may still be trying to command the motors, and this can result in sudden and unexpected movement of the vehicle. Be prepared to stop the system again using the wireless remote.

Maneuverability in Water

Before entering the water it is important to ensure that:

- Bilge pumps are functioning properly. See Bilge Pump section on page 6 for more information.
- The side panels and top cover are properly fastened down
- All access panels are fastened down

Pinch Points

When operating the Warthog it is important to maintain a safe distance away from the unit. The suspension seen in Figure 9 has the ability to pivot. Do not place fingers anywhere along the suspension link as it can result in injury.



Figure 9: Warthog Pinch Points

Stop Buttons

The Stop system on the Warthog has two major components: The hardwired Stop switches and the wireless stop remote.

Hardwired Stop

Pressing down one of the 4 red mushroom Stop buttons around the Warthog will disable power to the SEVCON devices (Key switch input on PIN 1). This disables the large contactors and also enables the brakes (passive, spring activated when not powered). The status indicator lights around the Warthog will flash red.

To reset a Stop button, the top of the button should be twisted until the button pops out again. The GO button on Wireless remote must then pressed. The Warthog is fully enabled once a relay click is heard, and the front lights change to white.

Wireless Remote Stop

To operate the Warthog, the wireless remote stop also has to be powered on (by holding the Power button for at least 1 second). The remote Stop button toggles the Stop status, so it must be pressed once to enable Stop, and pressed again to return to an Stop reset ready state, much like the hardwired Stop buttons. The GO button on the remote will then reset the stop condition. The wireless remote will shut itself off after 15 minutes of inactivity. Thus, the user is suggested to toggle the reset button (or either AUX 1 or 2) every few



minutes to keep the remote awake. This is done to ensure that the user does not forget about the wireless remote, leading to a safety hazard.

Always ensure the Stop button is accessible at all times. Avoid mounting payloads that extend over the rear of Warthog and would occlude the Stop buttons.

Electrical System

The largest electrical safety consideration with the Warthog system is the VBat connection. As it is pulled straight from the batteries, it may have a voltage of 48V (depleted) - 62V (Charging) and can be used to power large external devices. This voltage can cause electrical shock if directly contacted, and is fused internally with an inline fuse at 10A. In general, take care to connect or disconnect devices preferably only when the entire system is powered off via the external switch on the rear (main power switch).

Take note that triggering a Stop condition only disables voltage to the SEVCON drivers and motors, not the rest of the system which includes the connectors.

The labelled status LEDS on the user panels indicate status of the system voltages. If an LED is not lit, most likely a system fuse has blown, and contacting Clearpath support is the best option.

To ensure safety, please also observe the following precautions:

- Do not tamper with the battery terminals or wiring.
- Consult Clearpath Robotics support if you need to service the battery pack.
- Do not lay tools or other objects on top of the battery.
- Do not move the robot while charging the battery.
- Charge the battery only with the charger provided by Clearpath Robotics.
- Please dispose of the batteries properly, or return the batteries to Clearpath Robotics to do so.

PAYOUT INTEGRATION GUIDE

If you want to attach custom hardware to Warthog, you will have to take care of mechanical mounting, electrical supply, and software integration. This section aims to equip you with respect to these challenges.

System Architecture

Like most robotic systems, Warthog has an onboard PC coupled to a custom microcontroller board. The microcontroller board handles IO, system and battery monitoring, and provides an interface to the CAN-controlled motor drivers. See the diagram in Figure 10 for more details.

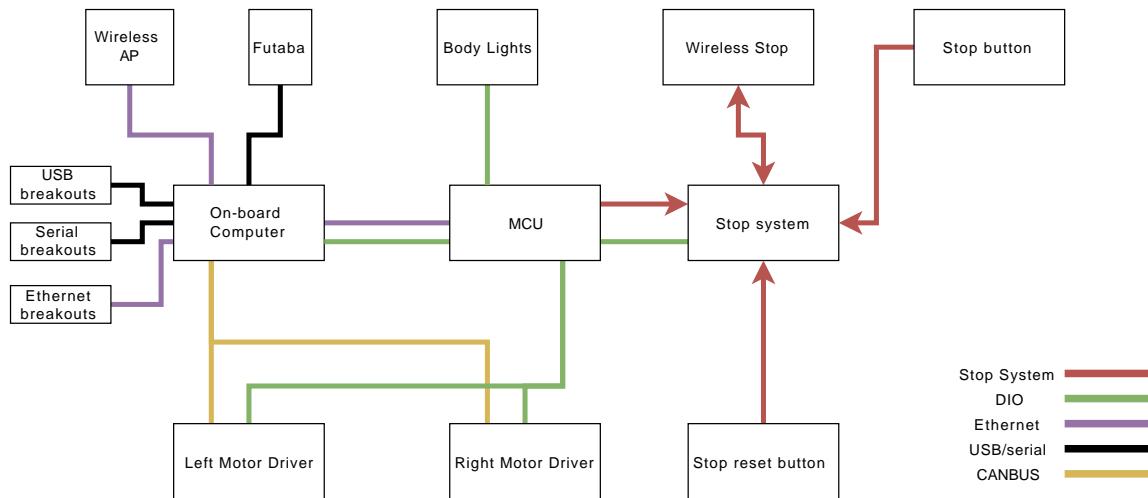


Figure 10: System Architecture

Using ROS to interface with the Warthog, the ROS API described in Table 4 can be used and the node connections can be seen in Figure 11

Topic	Message Type	Purpose
/cmd_vel	geometry_msgs/Twist	Input to Warthog's kinematic controller. Publish here to make Warthog go.
/odometry/filtered	nav_msgs/Odometry	Published by <code>robot_localization</code> , a filtered localization estimate based on wheel odometry (encoders) and integrated IMU.
/imu/data	sensor_msgs/IMU	Published by <code>imu_filter_madgwick</code> , an orientation estimate based on Warthog's internal gyroscope, accelerometer, and magnetometer.
/status	warthog_msgs/Status	Low-frequency status data for Warthog's systems. This information is republished in human readable form on the <code>diagnostics</code> topic and is best consumed with the Robot Monitor.
/cmd_lights	warthog_msgs/Lights	Input to controlling the Warthog's body lights when not in an error state.
/SIDE/speed	std_msgs/Float64	Input velocity for each motor where <i>SIDE</i> is either left or right. This should not be published directly, commands from <code>/cmd_vel</code> will be converted to this.
/SIDE/status/speed	std_msgs/Float64	Reported velocity from each motor's encoder where <i>SIDE</i> is either left or right.
/SIDE/status/fault	std_msgs/Bool	Reported state from each motor controller where <i>SIDE</i> is either left or right.
/SIDE/status/motor_temperature	std_msgs/Int32	Reported temperature from each motor controller where <i>SIDE</i> is either left or right.

Table 4: Warthog ROS API Topics

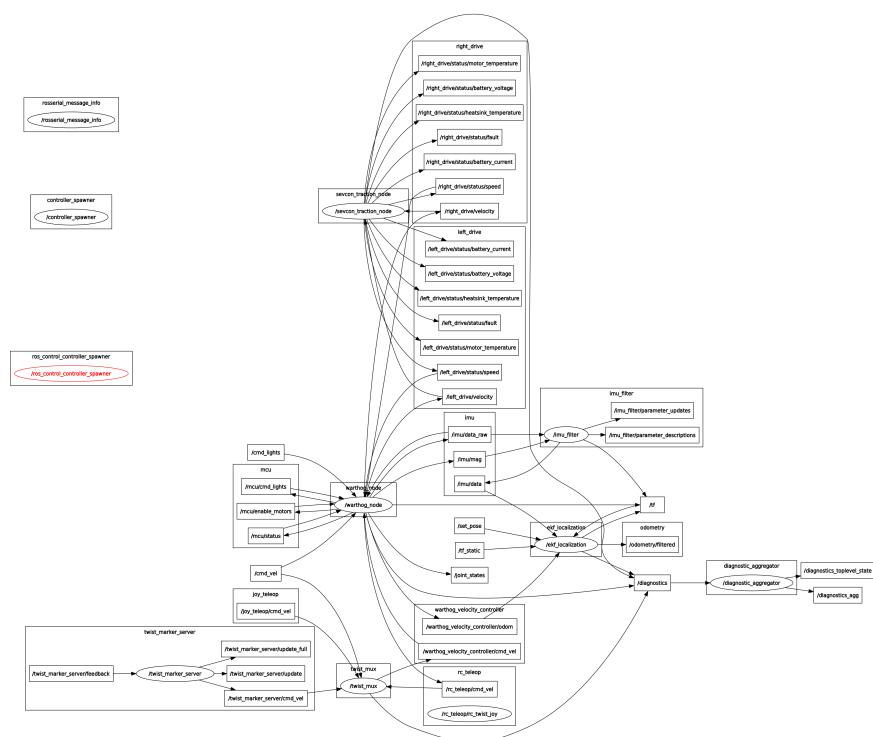


Figure 11: Warthog Node and Topic connections



Mechanical Mounting

The payload integration area can be used to mount external payloads on top of the Warthog.

Payload Integration Guidelines

- 27.75" is the maximum allowed width of any installed payload (this assumes that the payload is also centered across the width of the UGV chassis).
- No part of the payload may extend over the sheet metal housings of the drive units or into the small (2") gaps between the chassis and drive units. Damage to both the UGV and the payload WILL result.
- The chassis has a removable access cover measuring 46.25" x 26.25". This access cover is supported underneath by two adjustable cross members. Regardless of payload, it is imperative that both cross members remain installed (approximately evenly spaced) to provide required support to the access cover. Consider that any payload installed above the top deck will prevent access to the chassis through the access cover, without first removing the installed payload.
- The rotation of the suspension differential link in the horizontal plane will allow the payload to extend beyond the chassis top deck in both fore and aft locations. The amount of this payload extension (overhang) is dependent on several factors, including the weight and method of attachment of the payload as well as the terrain in which the UGV will operate. Ensure that the amount of overhanging payload allows the UGV to operate safely and does not contact the terrain, especially when crossing steep and/or deep gullies.
- The available internal chassis volume is approximately 17.5" long x 26" wide x 9.5" high. This space is located at the center of the chassis between two battery packs. Consider that anything placed inside the chassis MUST be secured as to not move or shift during UGV operation. Any payload secured inside the chassis must also be insulated from coming into contact with the battery wiring and terminals.

Permanent damage resulting from custom modifications to the mounting plate is not covered under warranty and may not be supported by Clearpath Support. Please contact our support team if you require assistance or have any questions relating to custom modifications.

Electrical Integration

The user power receptacles located in the User Panel are capable of supplying 5Vdc, 12Vdc, and unregulated battery voltage (approximately 48Vdc) for powering Warthog's payloads. See Figure 12 for an labelled illustration and Figure 13 the pin assignments. Ensure you select contact appropriate for the gauge of wire used. The electrical system for the chassis can be seen in Figure 14. Additionally, left and right drive units electrical system is described in Figure 15 and Figure 16 respectively.

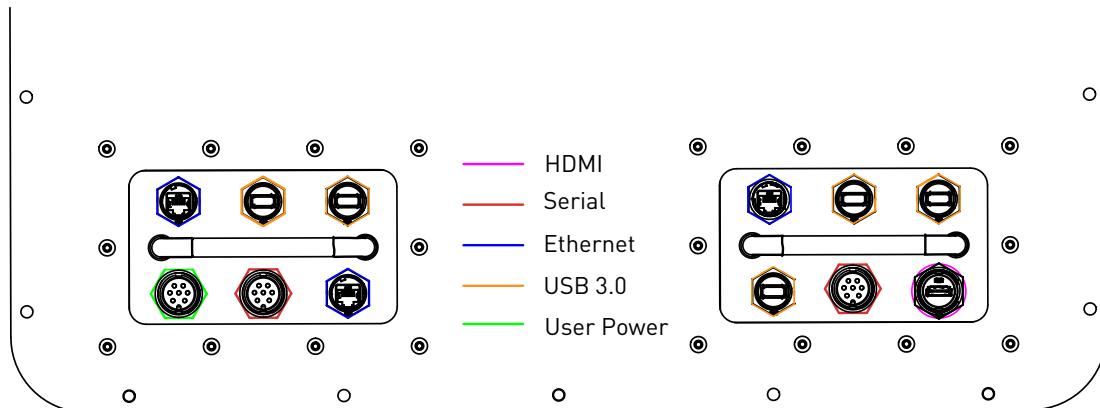


Figure 12: Warthog User Panel

Risk of Fire

For continued protection against risk of fire, always replace fuses only with those of the same type and rating.

Unregulated Rail

The unregulated battery output may range from as low as 40Vdc up to 60Vdc or more depending on the state of charge of the battery pack and the electrical loading on the system. Ensure any accessories connected to that rail are able to deal with unregulated battery voltages.



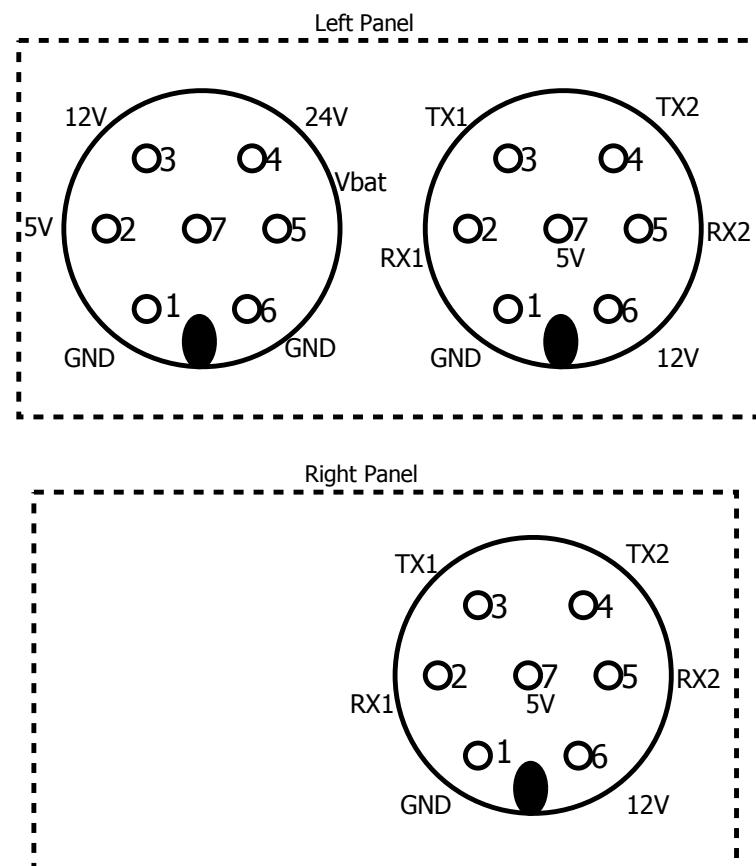
Software Integration

ROS has a large ecosystem of sensor drivers, some of which include pre-made URDF description and even simulation configurations. Please see the following page on the ROS wiki for a partial list:

<http://wiki.ros.org/Sensors>

For the best experience, consider purchasing supported accessories from Clearpath Robotics for your Warthog, which will include simulation, visualization, and driver support. However, we will happily help you get started with integrating your own devices as well.

User Connector Diagram



Note: View from Top, connector side
 Note 2: TX1, RX1 and TX2, RX2 are duplicated

Figure 13: Warthog Power User Connector Pinout

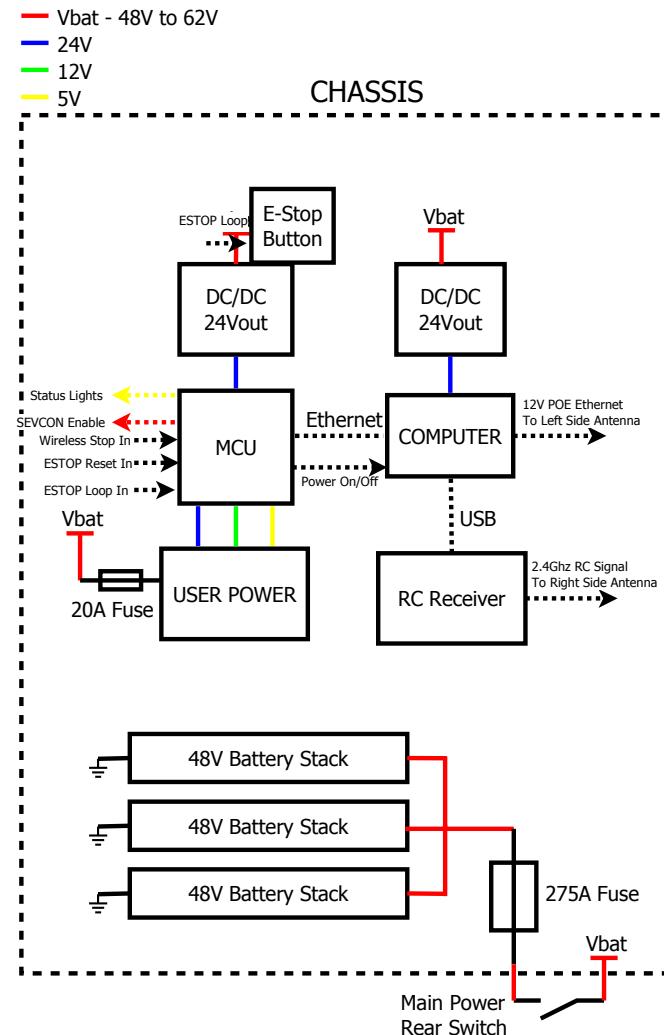


Figure 14: Warthog Chassis Electrical System

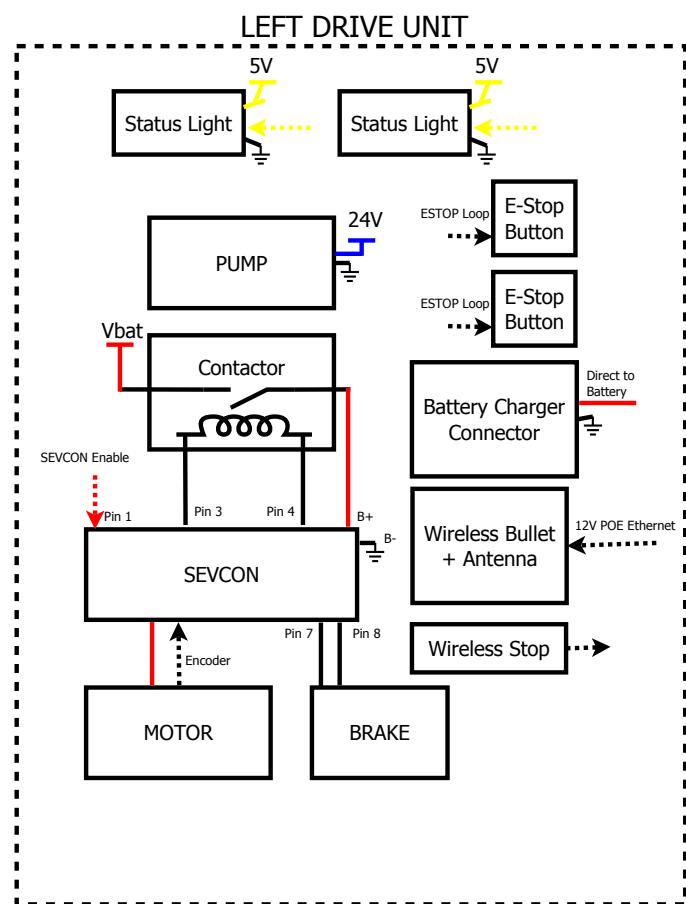


Figure 15: Warthog Left Drive Unit Electrical System

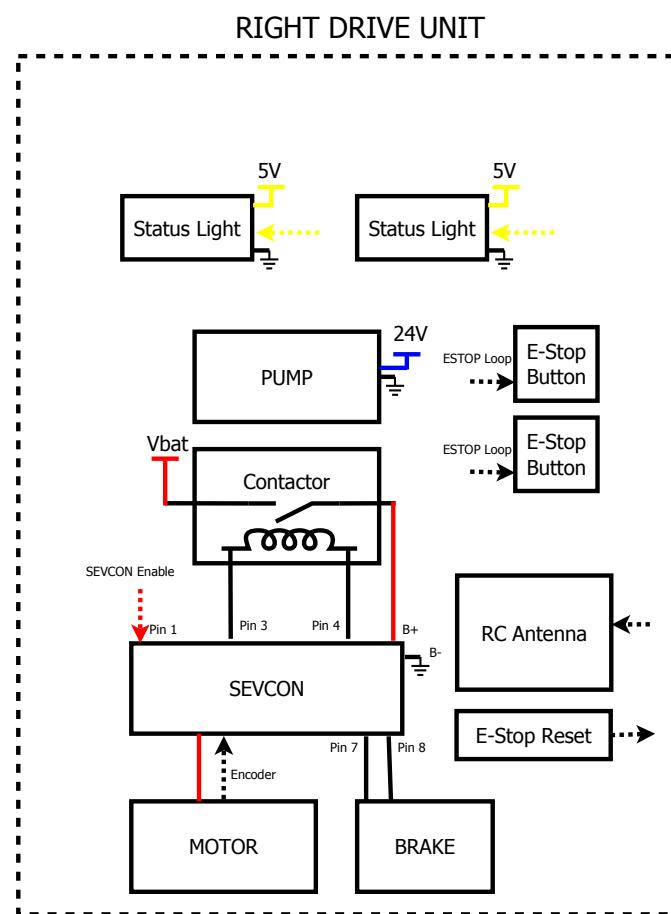


Figure 16: Warthog Right Drive Unit Electrical System

MAINTENANCE

Battery & Charging

General

Warthog contains 48V lead-acid or lithium-ion battery packs. Each battery pack consists of four 12V lead-acid or lithium-ion batteries.

Battery configuration may vary with each unit. In order to maximize performance it is important to ensure that the battery level across each set of lead-acid or lithium-ion batteries is within 0.1-0.2V of each other. If the battery packs exceed this tolerance, it is advised to charge them to within tolerance before wiring these packs in parallel. The overall battery life will vary depending upon the usage of the unit.

Always exercise caution and observe the following safety practices connecting, disconnecting or handling batteries:

- Batteries are high voltage, high current
- Battery packs must be properly fastened down to ensure they do not move when the Warthog is in operation.
- Ensure that the battery packs are evenly distributed throughout the Warthog to maximize stability.
- Battery levels on the unit should be checked on a regular basis. It is important to maintain the battery voltage at a suitable level for proper operation.
- When additional battery packs are added to the system it is important to connect the positive terminal first to the main power of the Warthog before connecting ground.
- When installing additional battery packs, disconnect the ground on all battery packs presently in the unit before connecting the positive terminal of the new battery packs.

Long-term Storage

When storing Warthog for long periods of time, its important to properly maintain the batteries to fully maximize their life. Consider one of the following two procedures when placing Warthog in long-term storage:

- Fully charge Warthog, turn it off and put it into storage. Once a week, connect power to the charger and allow the charger to top up the battery for an hour or so.
- Fully charge Warthog, turn it off and put it into storage, but leave the charger connected and powered the entire time Warthog is in storage. The charger will monitor the battery and will automatically charge it up as needed.

Please contact Clearpath Robotics for additional information about Warthog's battery pack.



CONTACT

Clearpath is committed to your success with Warthog. Please get in touch with us and we'll do our best to get you rolling again quickly: support@clearpathrobotics.com.

To get in touch with a salesperson regarding Warthog or other Clearpath Robotics products, please email sales@clearpathrobotics.com.

If you have an issue that is specifically about ROS and is something which may be of interest to the broader community, consider asking it on answers.ros.org. If you don't get a satisfactory response, please ping us and include a link to your question as posted there. If appropriate, we'll answer in the ROS Answers context for the benefit of the community.

Delta-Q IC650

650W Industrial Battery Charger



Product Manual

This manual contains important safety and operating instructions for the Delta-Q IC650 Industrial Battery Charger. Please read this information in its entirety before using your Delta-Q IC650 Charger. For technical support, please contact the manufacturer of your vehicle or machine, as their version of this charger may require special instructions.



Warning

Use charger only with an algorithm selected that is appropriate to the specific battery type. Other usage may cause personal injury and damage. Lead acid batteries may generate explosive hydrogen gas during normal operation. Keep sparks, flames, and smoking materials away from batteries. Provide adequate ventilation during charging. Never charge a frozen battery. Observe all battery manufacturers' specific precautions (e.g. maximum charge rates and if cell caps should be removed while charging).



Danger

Risk of electric shock. Connect charger power cord to an outlet that has been properly installed and grounded in accordance with all local codes and ordinances. A grounded outlet is required to reduce risk of electric shock—do not use ground adapters or modify plug. Do not touch uninsulated portions of output connector or uninsulated battery terminals. Disconnect the AC supply before making or breaking the connections to the battery. Do not open or disassemble charger. Do not operate this charger if the AC supply cord is damaged or if the charger has received a sharp blow, been dropped, or is damaged in any way. Refer all repair work to the manufacturer, or qualified personnel. This charger is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or lack of experience and knowledge on electrical systems and battery charging, unless they have been given supervision or instruction concerning use of the charger by a person responsible for their safety. Children should be supervised to ensure that they do not play with the charger.



Attention

Utiliser le chargeur seulement avec un algorithme approprié au type spécifique de batterie. D'autres types de batteries pourraient éclater et causer des blessures ou dommages. Les batteries peuvent produire des gaz explosifs en service normal. Ne jamais fumer près de la batterie et éviter toute étincelle ou flamme nue à proximité des batteries. Fournissez une ventilation adéquate du chargement. Ne jamais charger une batterie gelée. Prendre connaissance des mesures de précaution spécifiées par le fabricant de la batterie, p. ex., vérifier s'il faut enlever les bouchons des cellules lors du chargement, et les taux de chargement.



Danger

Risque de décharge électrique. Ne pas toucher les parties non isolées du connecteur de sortie ou les bornes non isolées de la batterie. Toujours connecter le chargeur à une prise de courant mise à la terre. Déconnectez la source AC avant de faire ou défaire les connections à la batterie en chargement. Ne pas utiliser le chargeur si le cordon d'alimentation AC est endommagé ou si le chargeur est abîmé suite à une chute ou autre incident. Ne pas ouvrir ni désassembler le chargeur – référer toute réparation aux personnes qualifiées. Cet appareil n'est pas destiné à un usage par des personnes (dont les enfants) avec des facultés motrices, sensorielles ou mentales réduites, ou ayant une expérience et des connaissances insuffisantes, à moins qu'elles sont sous la supervision ou reçoivent les instructions sur l'utilisation de l'appareil d'un répondant garant de leur sécurité. Les enfants devraient être surveillés afin qu'il ne jouent en aucun temps avec l'appareil.

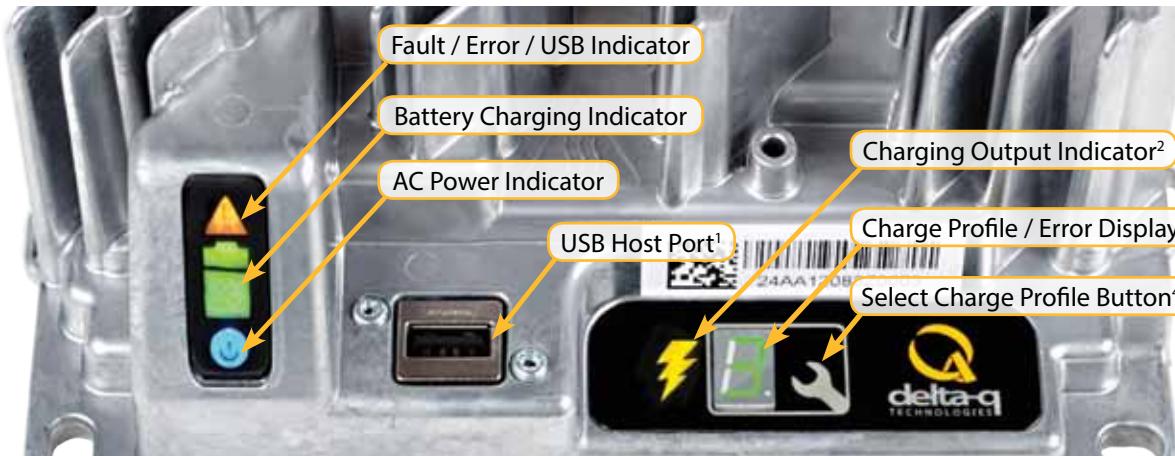
Maintenance Instructions

1. Do not expose charger to oil, dirt, mud or direct heavy water spray when cleaning.
2. The enclosure of the charger meets IP66, making it dust-tight and protected against powerful water jets. The AC inlet connection itself, when mated, is rated to IP20, which is not protected against water. Protect the AC connection if used in wet or dusty environments.
3. If the detachable input power supply cord set is damaged, replace with a cord that is appropriate for your region:
 - + North America: UL or CSA listed / approved detachable cord at least 1.8m in length (\geq 6 feet), 3 conductor, 16AWG minimum and rated SJT; terminated in a grounding type IEC 60320 C14 plug rated 250V, 13A minimum.
 - + All other regions: Safety approved detachable cord, 3 conductor, 1.5mm² minimum, rated appropriately for industrial use. The cord set must be terminated on one end with a grounding type input connector appropriate for use in the country of destination and, on the other end, an output grounding type IEC 60320 C14 plug.



Operating Instructions

- + The charger may become hot during charging. Use hand protection to safely handle the charger during charging.
- + Extension cords must be 3-wire cord no longer than 30m (100') at 10 AWG or 7.5m (25') at 16 AWG, per UL guidelines.



Solid red = Charger fault
See display panel for details



Flashing amber = External error condition - caution
See display panel for details



Flashing green = USB port active
Solid green = Safe to remove USB flash drive



Solid blue = AC power available



Flashing green = Low state of charge
Solid green = High state of charge



Flashing green = High state of charge
Solid green = charge completed

1. The USB Host Port allows data to be transferred to and from the charger using a standard USB flash drive, including the downloading of charge tracking data and updating of the charger's software and / or charge profiles.
2. The Charging Output Indicator means that the charger output is active, and there is a potential risk of electric shock.
3. The Charge Profile / Error Display shows one of four possible codes to indicate different conditions:
 - + 'F' codes meaning that an internal fault condition has caused charging to stop.
 - + 'E' codes meaning that an external error condition has caused charging to stop.
 - + 'P' code meaning that the charger programming mode is active.
 - + 'USB' code meaning that the USB interface is active, and the USB flash drive should not be removed.

The 'E', 'F' and 'P' codes will appear, then are followed by three numbers and a period to indicate different conditions (e.g. E-0-0-4). See the "Charger Fault Codes" or "Charger Error Codes" sections for details on these conditions and their solutions.

4. The Select Charge Profile Button is used to select a charge profile from those stored on the charger. Up to 25 charge profiles can be stored. See the "Selecting A Charge Profile" section for instructions.

Selecting A Charge Profile

1. Disconnect AC input from the charger, or from the wall outlet. Wait 30 seconds for the input relay to open.



Figure 1:
Disconnect AC
input from the
charger.

2. While reconnecting AC input, press and hold the Select Charge Profile Button. Hold the button until Error Indicator is on and Battery Charging Indicator starts flashing.



Figure 2:
Reconnect AC
input while
holding the
Select Charge
Profile Button.

3. Press and release the Select Charge Profile Button to advance through charging profiles loaded on the charger. The selected charging profile will be displayed up to three times (e.g. "P-0-1-1" for Profile 11).*



Figure 3:
Press the
Select Charge
Profile Button
to advance
through
the charge
profiles. Hold
the button for
10 seconds to
confirm your
selection.

*Process will time out and the robot will remain uncharged if there is 15 seconds of inactivity. Robot tag number is allowed to display three times, or if AC power is cycled.

- Once desired charging profile is displayed, press and hold button for 10 seconds (see Figure 3) to confirm selection and exit Profile Selection Mode.

5. Press the Select Charge Profile Button to check that the desired profile is selected.

Use this table to record the charging profiles on your charger.

Charger Fault Codes

Code	Solution
F-0-0-1, F-0-0-2	Internal charger fault. Remove AC and battery for minimum 30 seconds and retry charger. If it fails again, please contact the manufacturer of your vehicle or machine.
F-0-0-3, F-0-0-4	
F-0-0-6	



Charger Error Codes

Code	Description	Solution
E-0-0-1 E-0-2-1	Battery high voltage	Check the battery voltage and cable connections. Check battery size and condition. This error will automatically clear once the condition has been corrected.
E-0-0-2 E-0-2-2	Battery low voltage	Check the battery voltage and cable connections. Check battery size and condition. This error will automatically clear once the condition has been corrected.
E-0-0-3	Charge timeout caused by battery pack not reaching required voltage within safe time limit.	Possible causes: Charger output reduced due to high temperatures, poor battery health, very deeply discharged battery and /or poorly connected battery. Possible solutions: Operate at lower ambient temperature. Replace battery pack. Check DC connections. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-4	Battery could not meet minimum voltage	Check for shorted or damaged cells. Replace battery pack. Check DC connections. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-5	Charger temperature limit exceeded	Ensure sufficient cooling air flow and reset charger by disconnecting DC or AC for 10 minutes, then reconnect. This error will automatically clear once the condition has been corrected.
E-0-0-6	Low AC voltage error	Connect charger to an AC source that provides stable AC between 85 - 270 VAC / 45-65 Hz. This error will automatically clear once the condition has been corrected.
E-0-0-7	Battery amp hour limit exceeded	Possible causes include poor battery health, very deeply discharged battery, poorly connected battery, and / or high parasitic loads on battery while charging. Possible solutions: Replace battery pack. Check DC connections. Disconnect parasitic loads. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-8	Battery temperature is out of range	Possible battery temperature sensor error. Check temperature sensor and connections. Reset charger. This error will automatically clear once the condition has been corrected.
E-0-1-2	Reverse polarity error	Battery is connected to the charger incorrectly. Check the battery connections. This error will automatically clear once the condition has been corrected.
E-0-1-6 E-0-1-8 E-0-2-6	USB operation failed	Software upgrade failure or script operation failure. Ensure the USB flash drive is properly formatted and retry inserting the USB flash drive into the charger.
E-0-2-3	High AC voltage error (>270VAC)	Connect charger to an AC source that provides stable AC between 85 - 270 VAC / 45-65 Hz. This error will automatically clear once the condition has been corrected.
E-0-2-4	Charger failed to initialize	The charger has failed to turn on properly. Disconnect AC input and battery for 30 seconds before retrying.
E-0-2-5	Low AC voltage oscillation error	AC source is unstable. Could be caused by undersized generator and /or severely undersized input cables. Connect charger to an AC source that provides stable AC between 85 - 270 VAC / 45-65 Hz. This error will automatically clear once the condition has been corrected.